CS118: Lecture 4, Media

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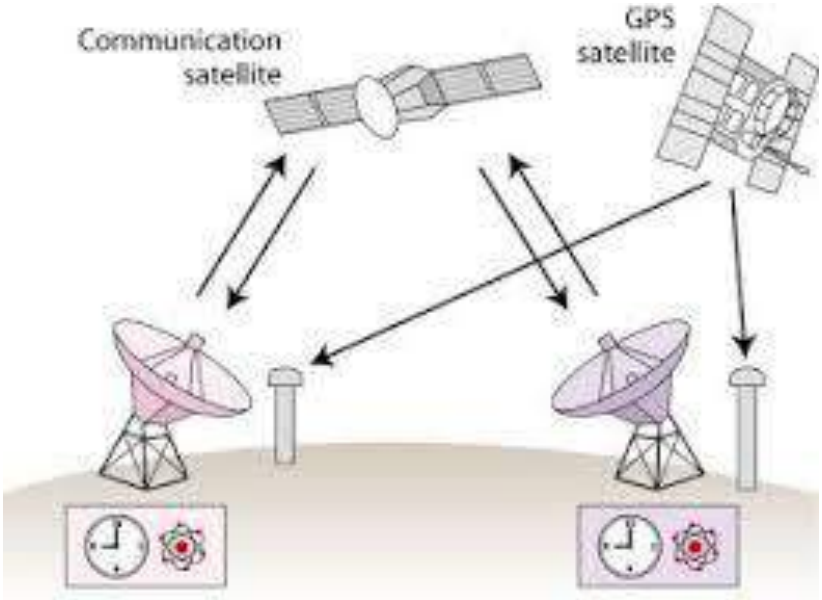
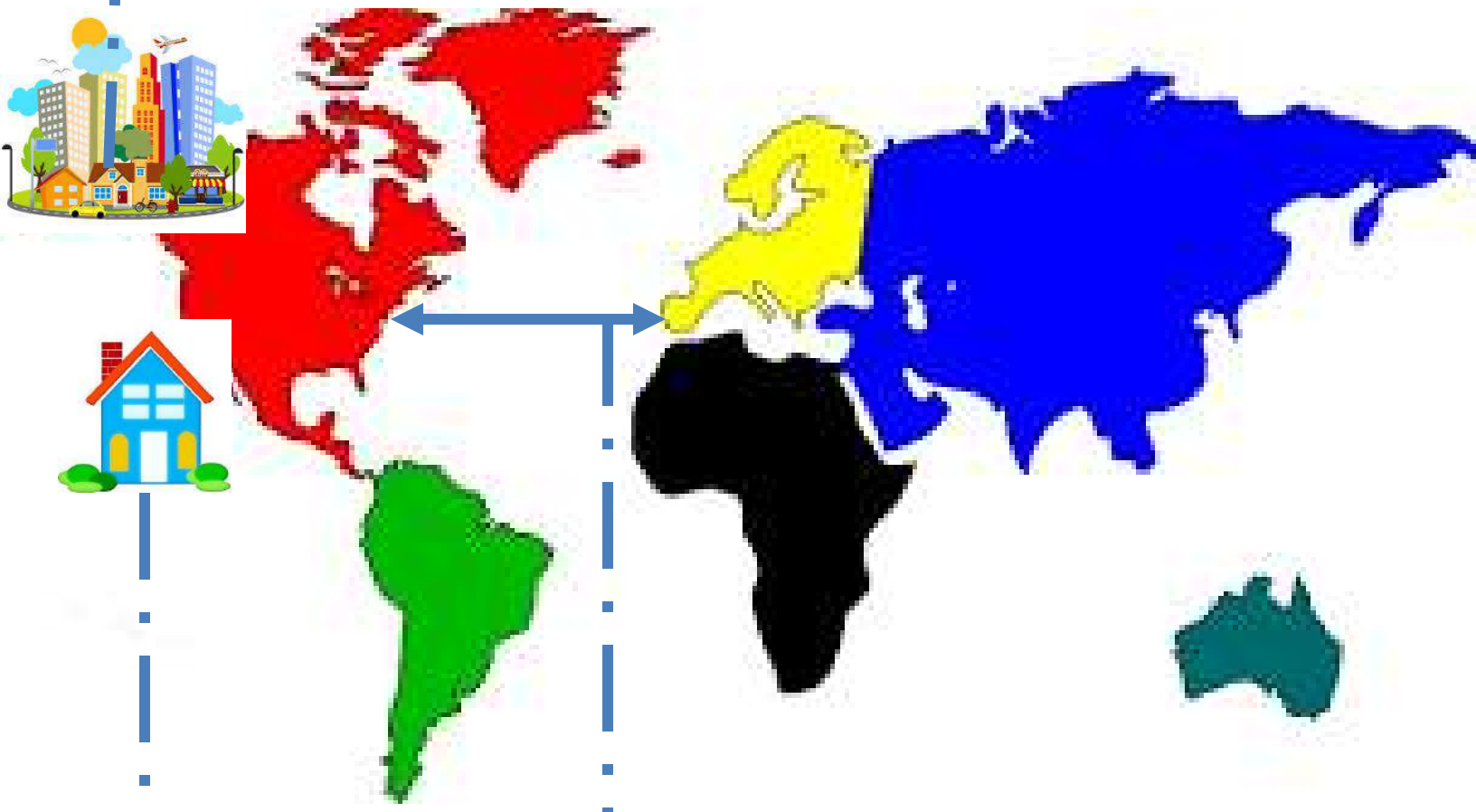
October 5, 2022



Main Idea: To architect a large network, one needs to use different types of media at different places in the network, so its worth studying

Imagine you work in Facebook's global network architecture group (Internet.org) and you are trying to figure what types of links you need to reach folks in certain villages of India. To do so, you need to understand media tradeoffs!

Crowded City Bottleneck,
Microwave, Radio



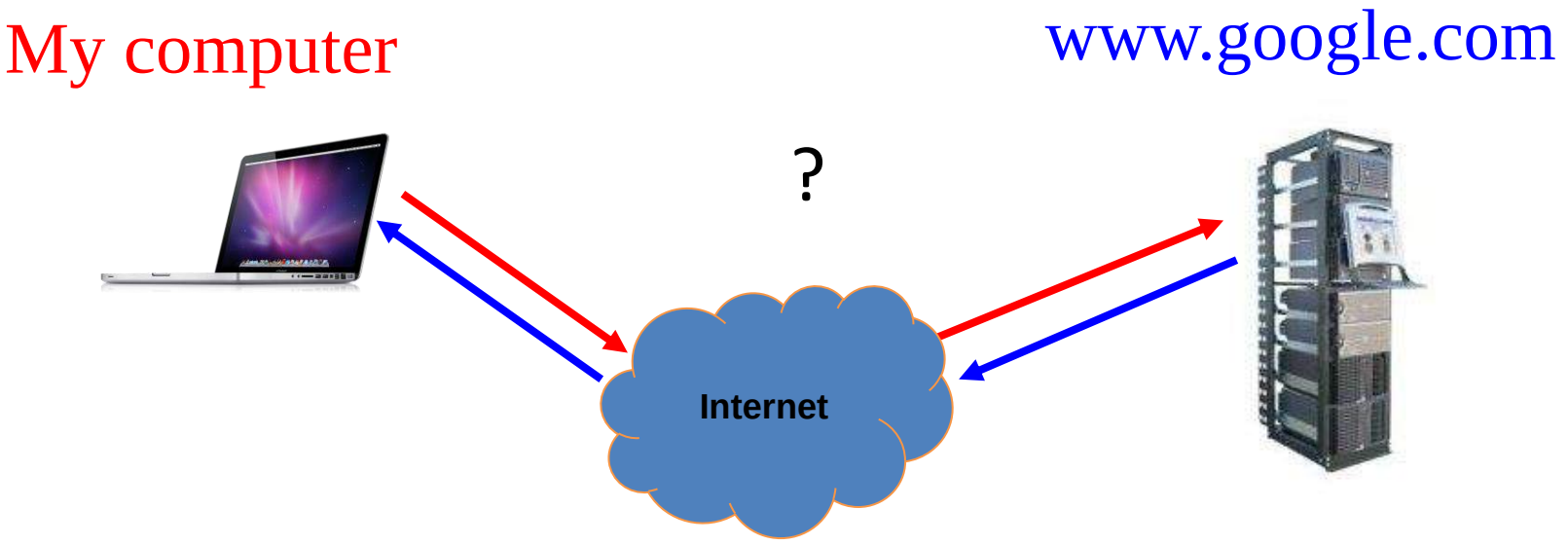
Trans-oceanic
Bottleneck
fiber, satellite

Last Mile
Bottleneck
Twisted Pair, cable, radio

PUMPING BITS GLOBALLY

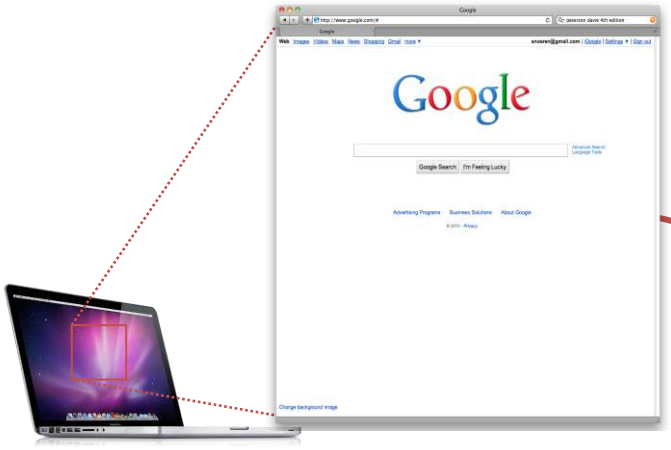
FIRST LETS, REVIEW: WHERE IS THE PHYSICAL LAYER?

ROUGHLY, what happens when I click on a Web page from UCLA?



Web request (HTTP)

Turn click into HTTP request



GET http://www.google.com/ HTTP/1.1
Host: www.google.com
Connection:keep-alive
…

Name resolution (DNS)

Where is www.google.com?

My computer
(132.239.9.64)

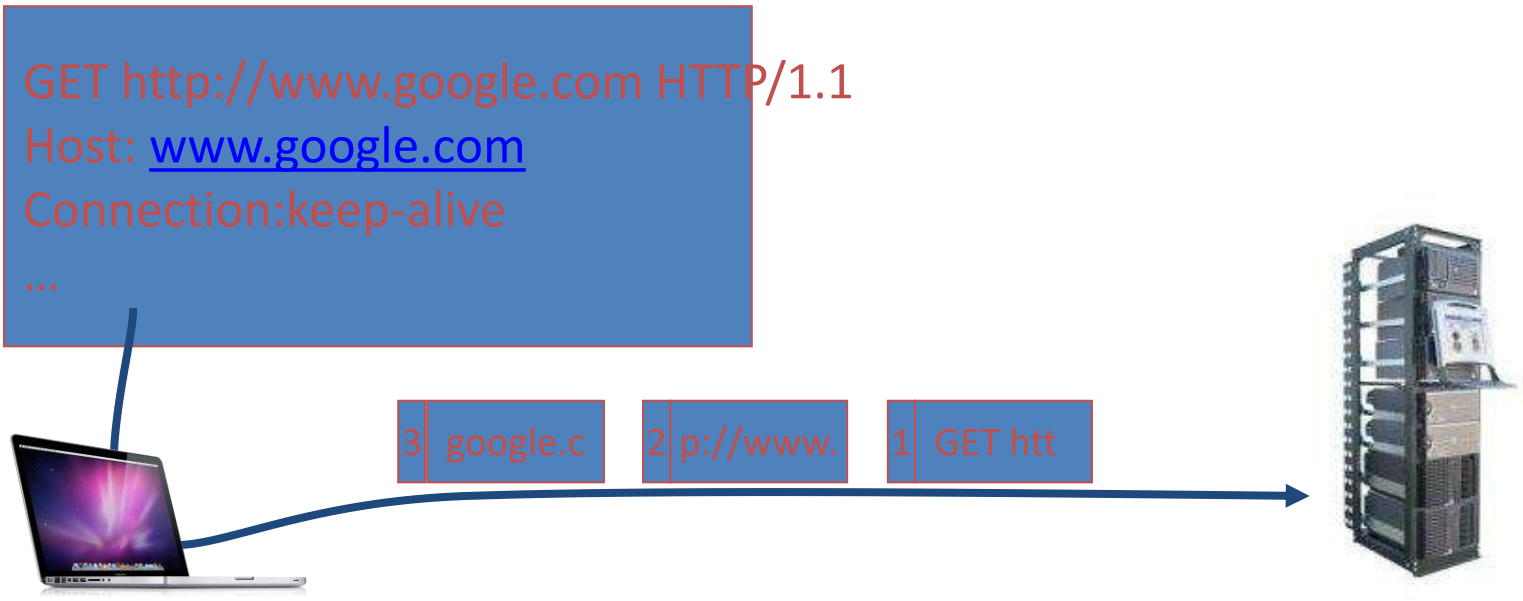
Local DNS server
(132.239.51.18)

What's the address for www.google.com

Oh, you can find it at 66.102.7.104

Data transport (TCP)

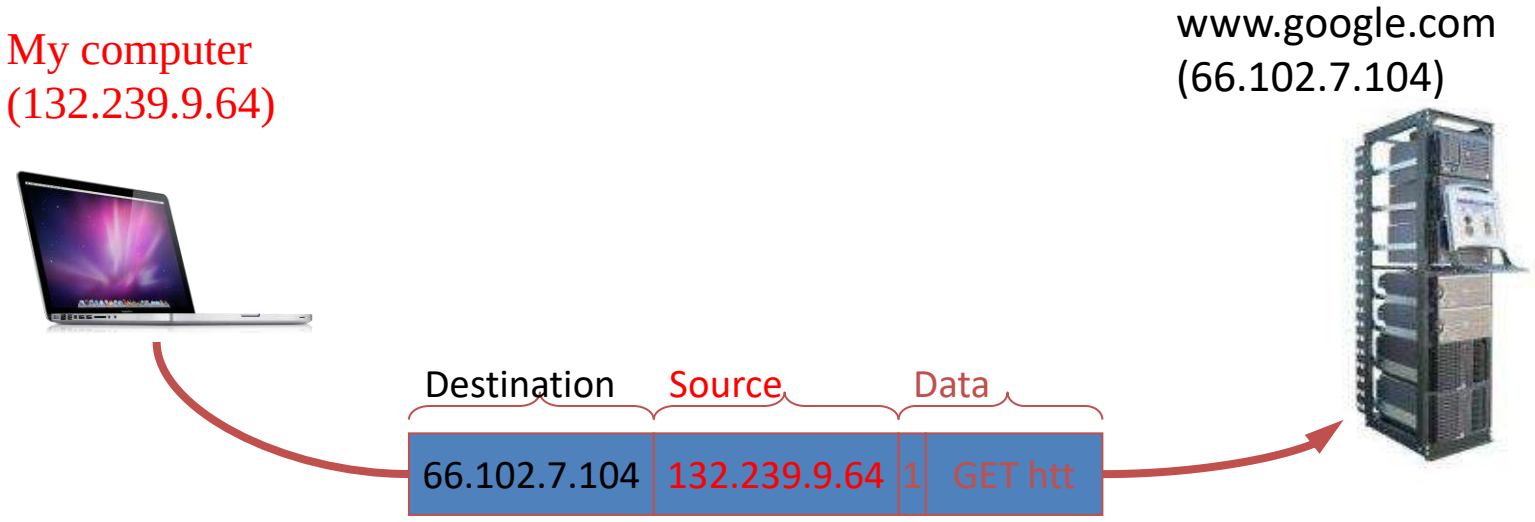
Break message into packets (TCP segments)
Should be delivered reliably & in-order



"and let me know when they got there"

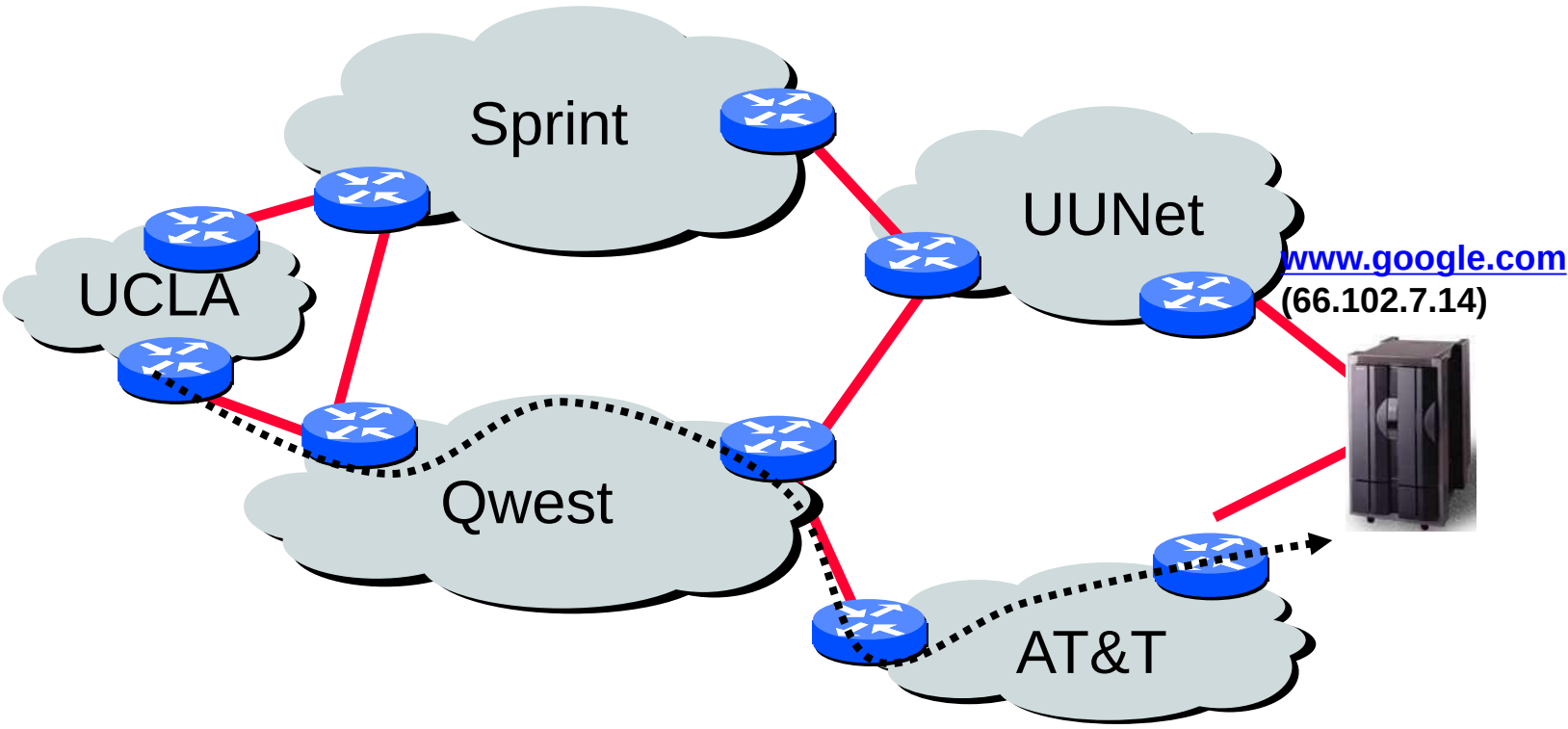
Network Layer: Global Network Addressing in IP

Address each packet so it can traverse network and arrive at host



Network Routing in IP

Each router forwards packet towards destination



What happened a year ago

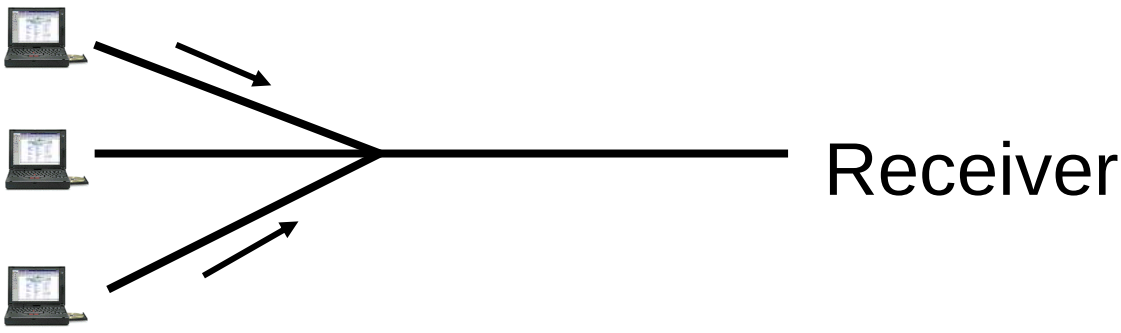
- Facebok's DNS servers went down.
- Each network (like Facebook) announces network addresses that they can reach via BGP.
- Somehow Facebook did a "withdraw" (stopped announcing) their DNS name server prefixes
- I hope to teach you how BGP and DNS works in a month. Stay tuned.

Data Link scheduling (Ethernet)

Break message into frames

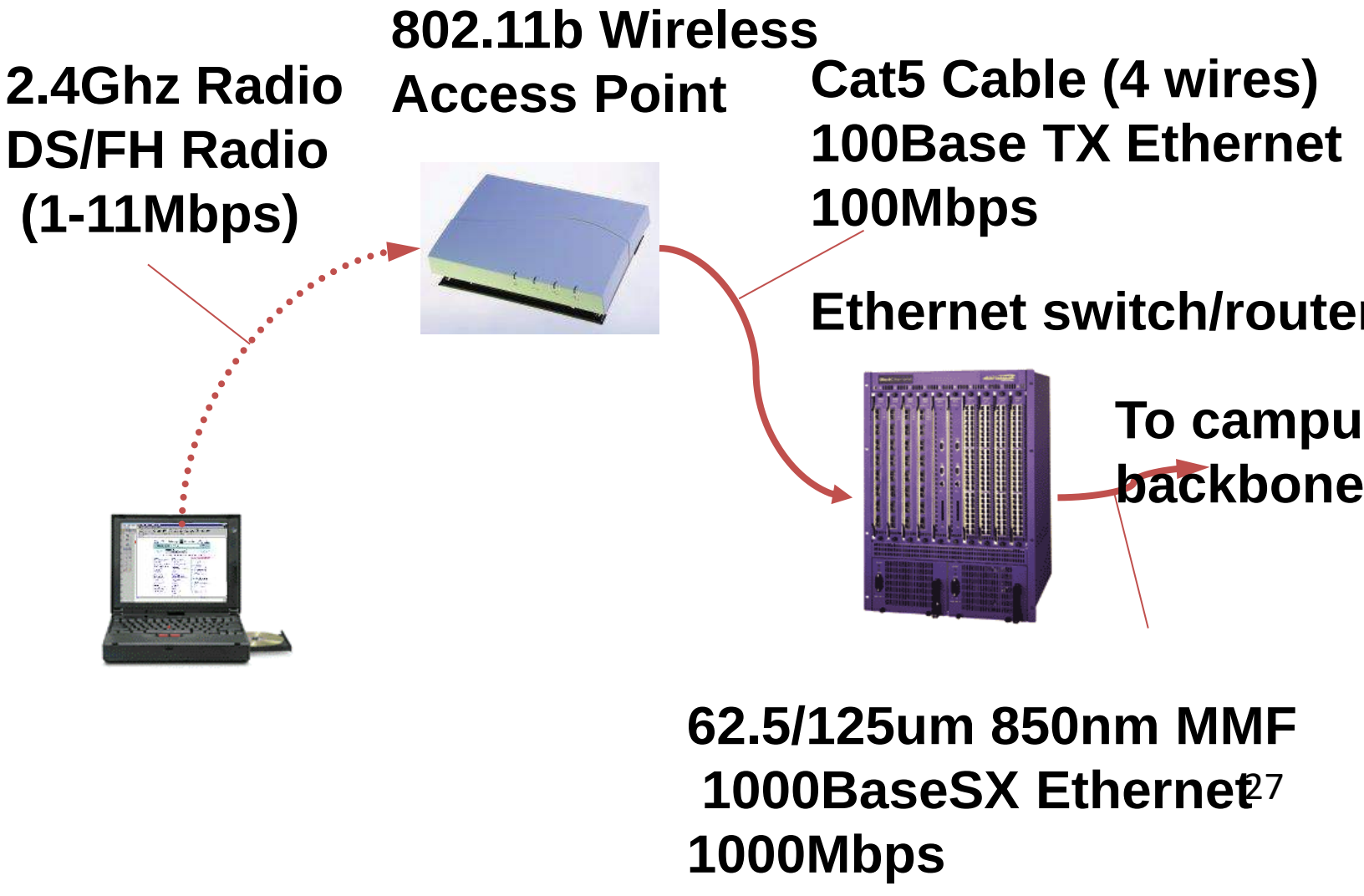
Media Access Control (MAC)

Can I send now? Can I send now?

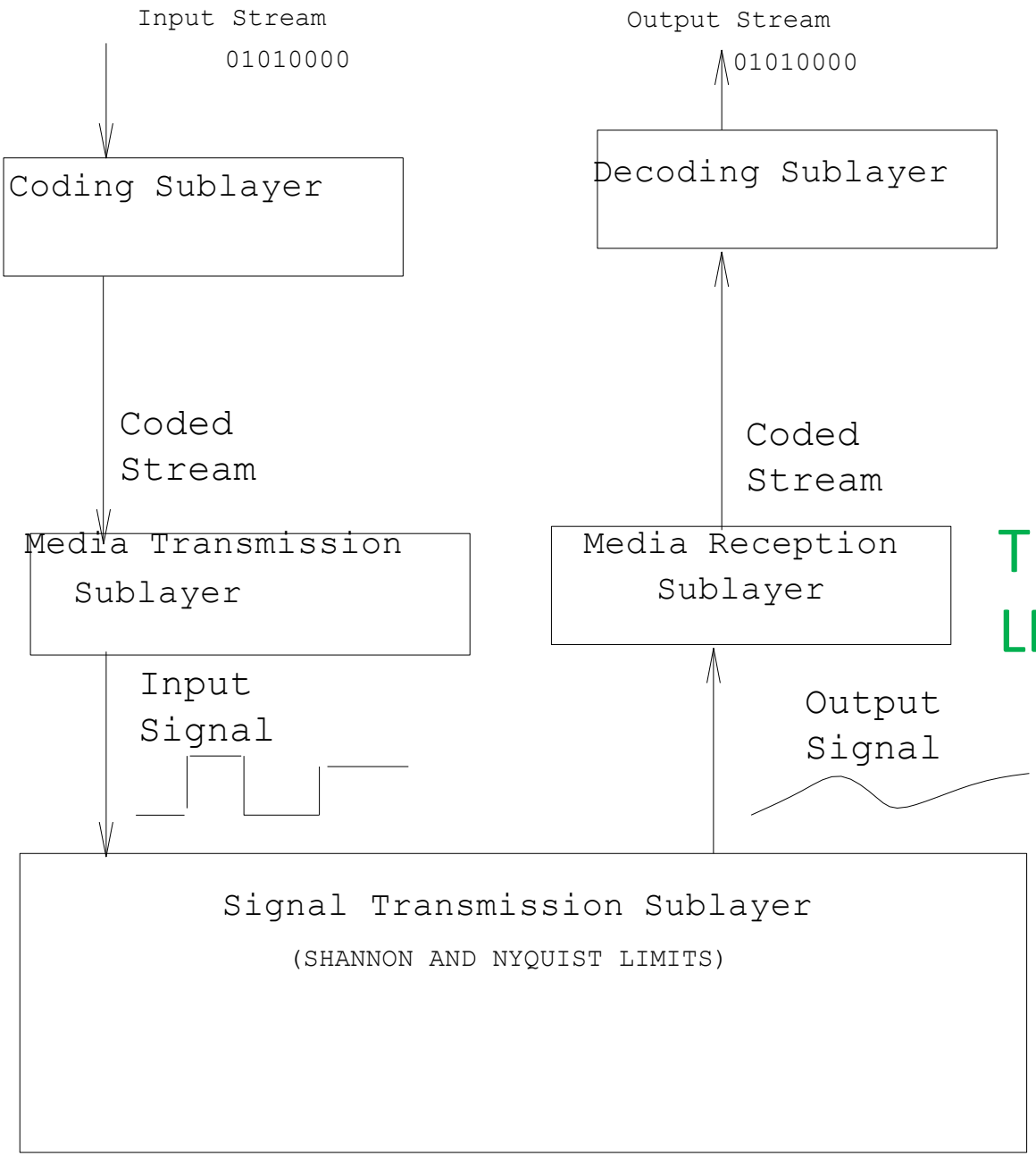


Send frame

Physical layer



PHYSICAL LAYER: SUBLAYERS



Why Study Media

- Media affects Protocol Design
  - Reinforced Concrete to Skyscrapers
- We need to understand media tradeoffs when architecting networks
  - Think of flashlights versus semaphores

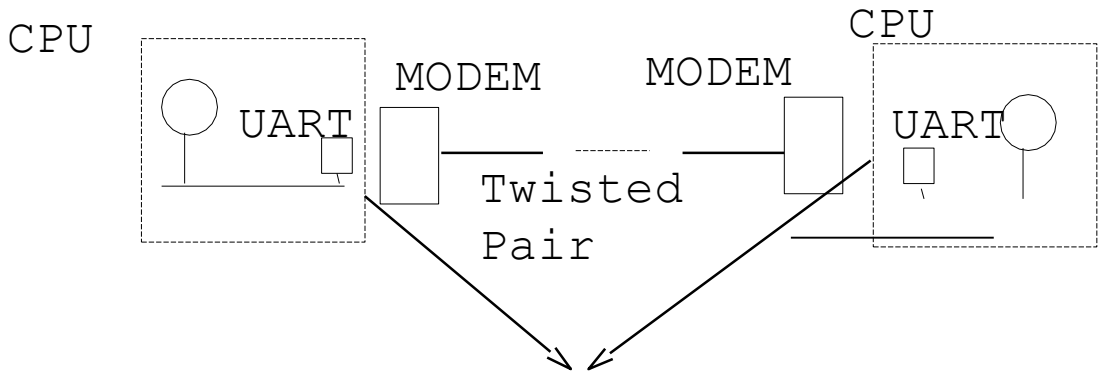
Media Affects Protocols

- Low Bandwidth led to tight encoding: Early Phone lines, not needed on LANs
- Broadcast LANs led to use of Multicast: Initialization and free copies, to IP multicast.
- Building wiring led to Switching: Wiring closets to hubs to ATM switches.
- Fiber led to rings: Point-to-point fibers lead to rings.
- Fiber led to Digital: Long haul telephone network becomes digital.
- Wireless leads to low bandwidths again: Laptops. Need Ipv6 compression on wireless links!

Breakout

- Imagine you are the CTO of a medium size company that spans 10 cities in the US, has three major campuses in Seattle and SJ, and Beijing.
- What media would you use in your campus network?

TWISTED PAIR COPPER



RS-232

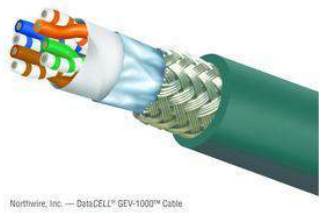
Low bandwidth

Cheap, Easy to Install

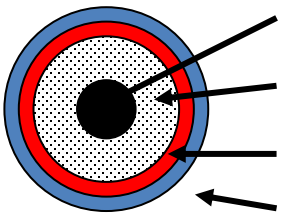
TWISTED PAIR INSIDER VIEW

- Typical examples
  - Category 5/6 Twisted Pair 10M-10Gbps 50-100m
  - Coaxial Cable 10-100Mbps 200m

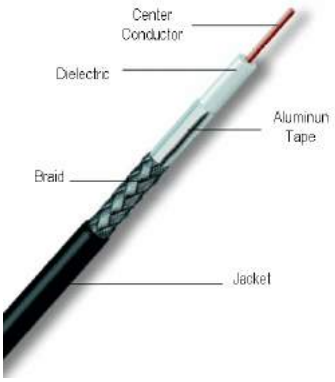
twisted pair



coaxial cable (coax)



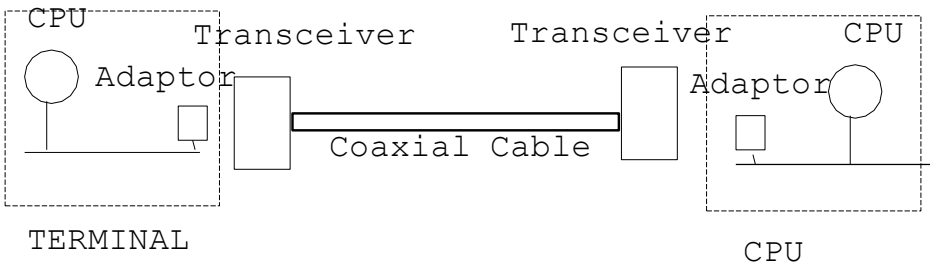
copper core
insulation
braided outer conductor
outer insulation



Using Twisted Pair for Higher Rates Today

- Standard twisted pair is limited by loading cables by telephone company to 4 Mhz. Shannon limit is around 56 Kbps (not counting compression). Two alternatives:
- Better quality twisted pair cables for local area networks e.g., Cat 3 (10 Mbps, Manchester), Cat 5 (100 Mbps, 100 Mhz bandwidth uses 4-5 coding)
- Telephone company removes loading cables, reduces your length, and gives you ADSL. Asymmetrical.

BASEBAND CABLE (e.g. ETHERNET)



High bandwidth (10–100 MHz)

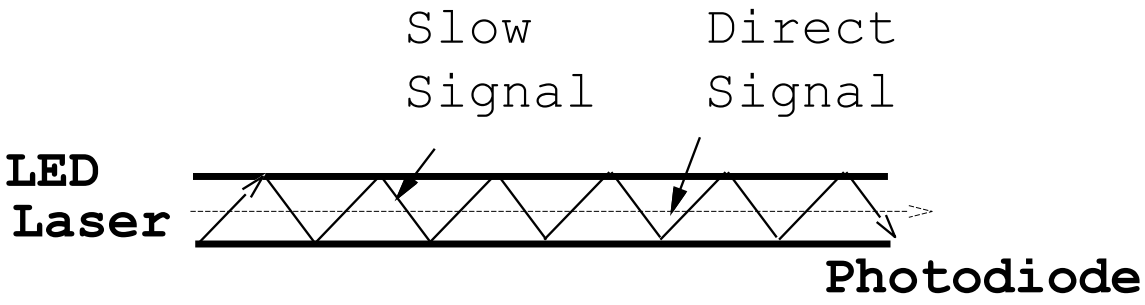
Hard to tap, expensive to Install

Small Distance (1 – 3 km without repeaters)

Using Coaxial Cable Today

- Coaxial cable has high bandwidth. Used for original 10 Mbps Ethernet but very clunky. Twisted pair (e.g. Cat 5) used today at various speeds like 10 Base T (10 Mbps), 100 Base-T etc.
- Cable still used in cable networks for cable TV and for data via cable modems. Divide bandwidth into 6 Mhz channels for each TV channel and one 6 Mhz channel for downstream data. Theoretically can reach 30 Mbps but beware other users and bandwidth limits. Upstream much less.

FIBRE OPTICS



Huge Bandwidth (10 Million Mhz!)

Can span continents with repeaters!

Almost Imposible to Tap

Point-to-point Secure

Excellent Electrical Isolation

Thin and Easy to Install

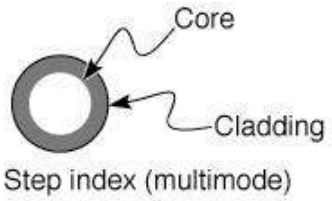
Optics still expensive

Unidirectional

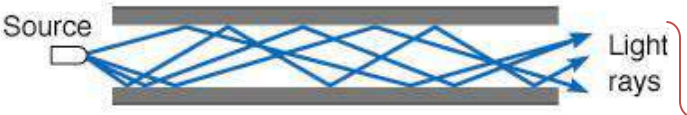
Modal Dispersion: more physical view

- Typical examples
  - Multimode Fiber 100Mbps-10Gb 500-2000m

  Problem: The long path reaches more slowly to output. . Can't send next bit if fast of second bit can catch up slow of first bit Inter symbol interference
  - Solution: Single Mode Fiber: 1-100Gbps 100m-40km

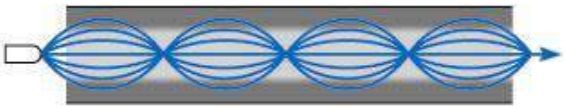


Step index (multimode)



Cheaper to drive (LED vs laser) & terminate


Graded index (multimode)

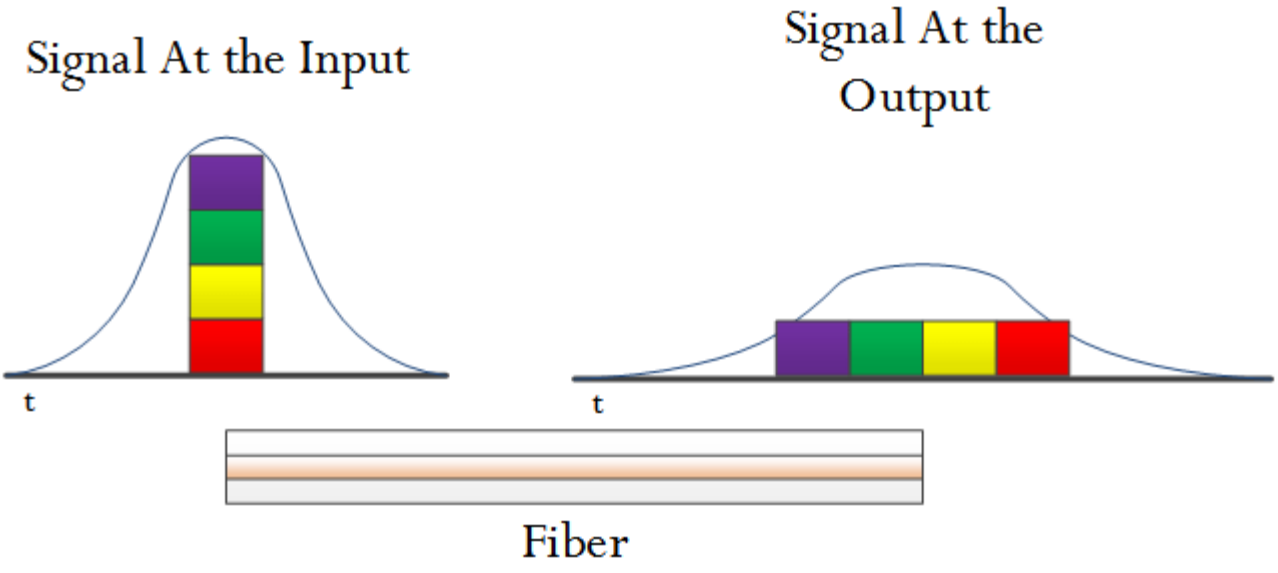



Single mode

Longer distance (low attenuation)
Higher data rates (low dispersion)

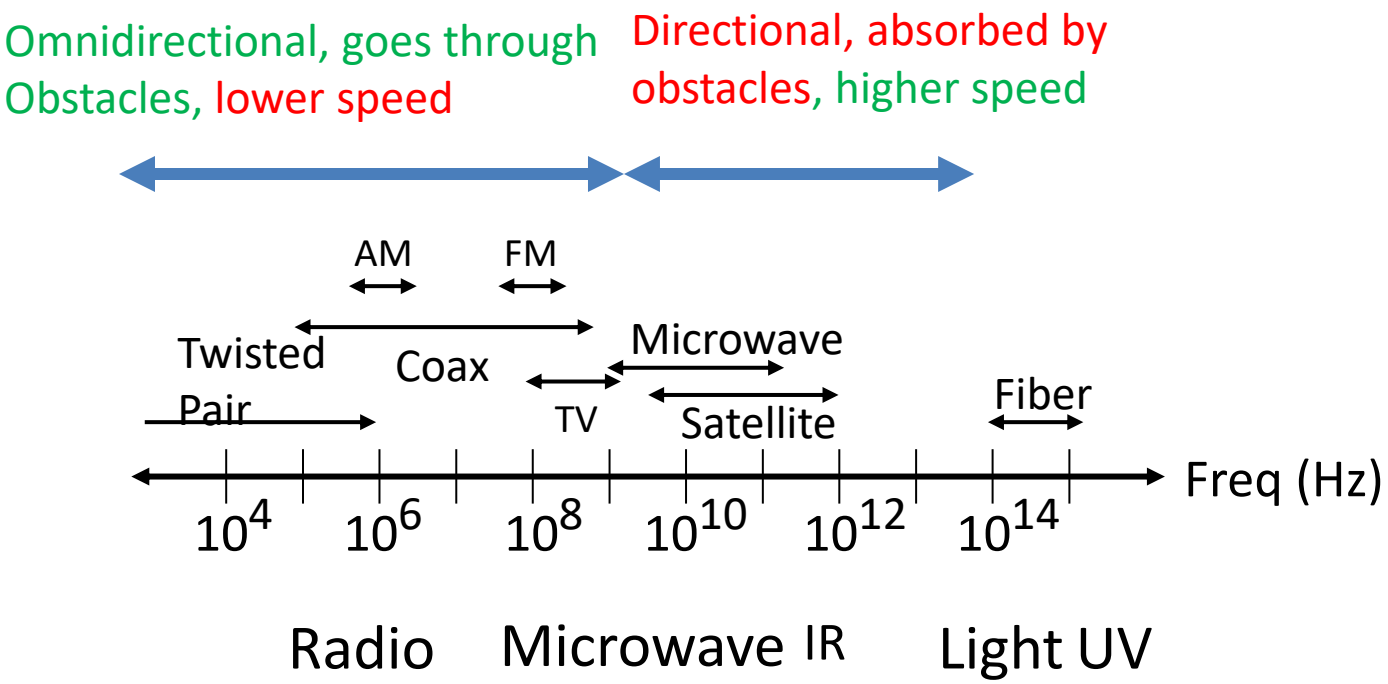
Chromatic Dispersion

- Different lights go at different speeds through glass
  - Problem: spreads out signal at output. Can't send next bit till output width or you get inter symbol interference (non –Nyquist related)
  - Solution: Use monochromatic light (lasers)



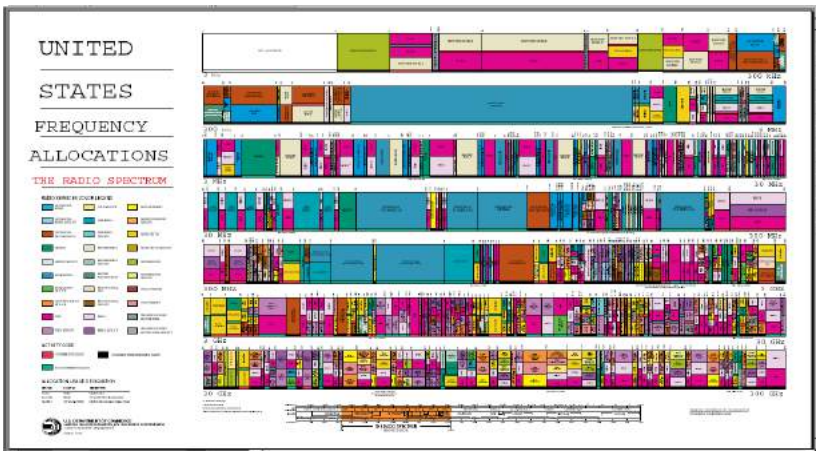
Wireless

Widely varying channel bandwidths/distances
Extremely vulnerable to noise and interference

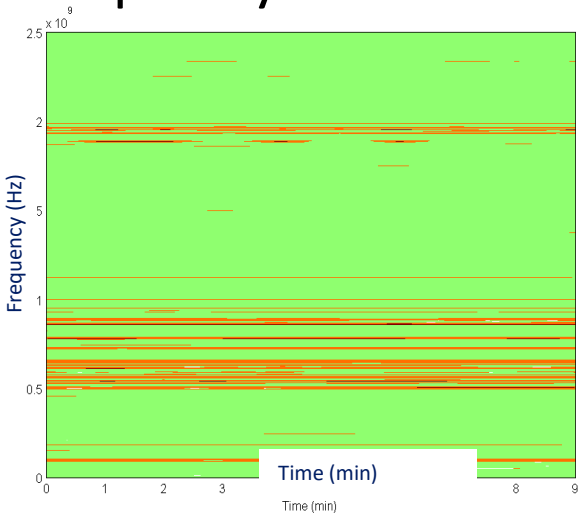


Spectrum Allocation

- Policy approach forces spectrum to be allocated like a fixed spatial resource (e.g. land, disk space, etc)

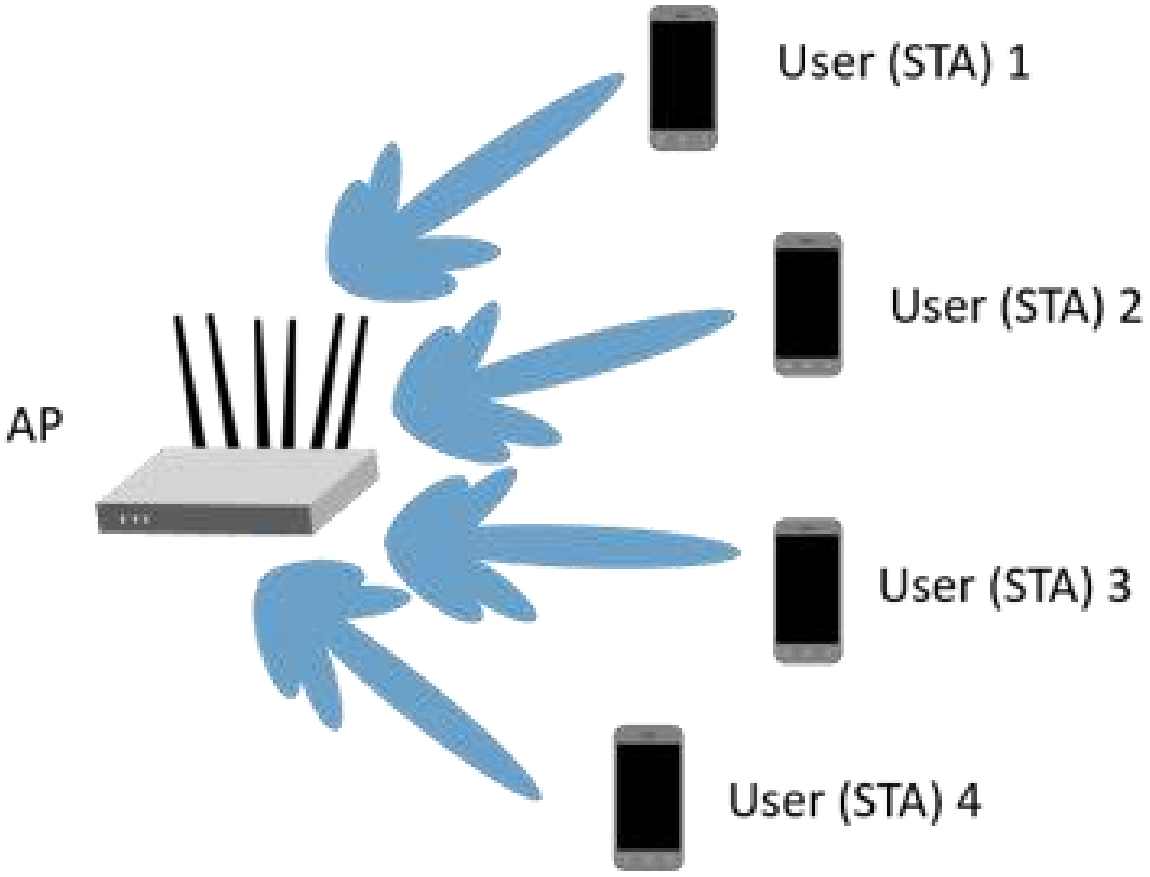


- Reality is that spectrum is time and power shared
- Measurements show that fixed allocations are poorly utilized



Hot topic: Whitespace communication

Basic Wireless: 802.11



Wireless Data Options

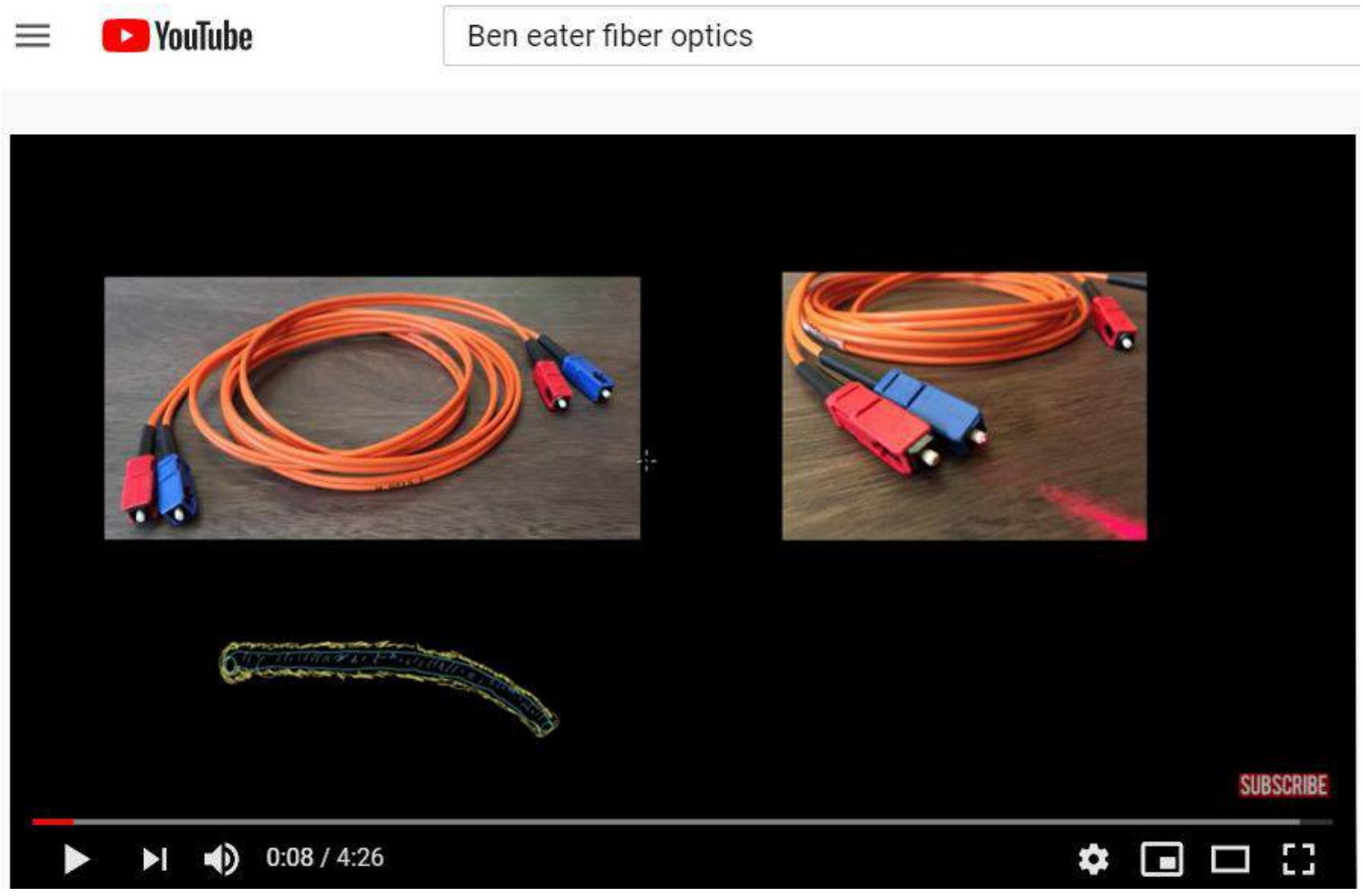
- 802.11: Wireless LANs using a wireless access point (AP) at hot spot using unlicensed frequency band 2.4 to 4.485 Ghz (radio frequency) 100 metres. 11 Mbps with 802.11b. Needs hotspot but common and very cheap!
- Bluetooth: ad hoc personal area networks with no AP. Master-slave. 4 Mbps
- WiMax: broader geographical range smaller bandwidth of a few Mbps
- 3G(Cellular telephone networks carrying data) at a few Mbps such as EVDO. Unlimited geographical range and true mobility. 5G is coming!

802.11b in some more detail

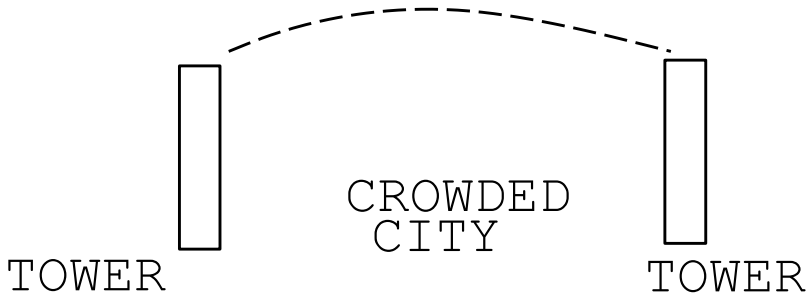
- AP configured with a SSID that you can see when doing View Available Networks and a channel number from 1 to 11. Non-overlapping channels (1 6, 11) can be used to triple bandwidth
- Each AP periodically sends a beacon containg SSID.
- Each station scans all 11 channels looking for beacons to get a list of networks. Some choice of AP and then mobile sets up an association
- Access protocol to send data tricky because of hidden terminal problem. Mobile A can send to base station and so can Mobile B, but A and B cannot hear each other but can interfere at base station. Needs careful protocol design (later)

BEN EATER VIDEO: FIBER AND WIRELESS

https://www.youtube.com/watch?v=lUo45NqPyq8



MICROWAVE



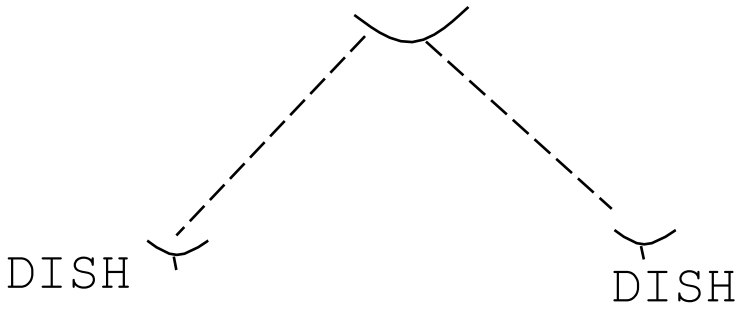
Avoids Right of Way

May be cheaper than installing cable Reasonable Bandwidth

Has problems with Rain

Upto 100 km distance

GEOSYNCH SATELLITE



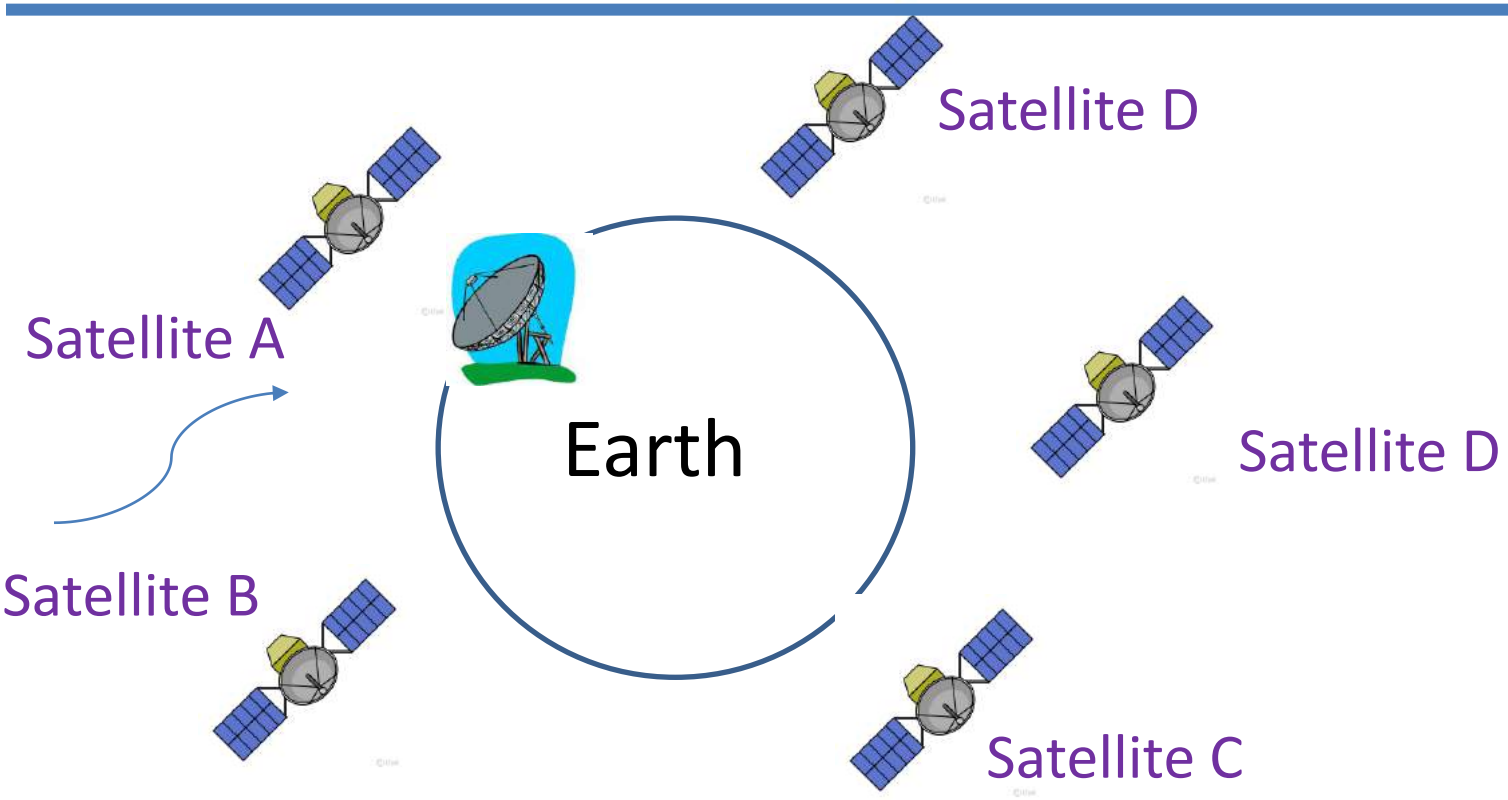
Avoids Right of Way Good Bandwidth (Gbps in total) World Wide Span

Large Latency: 125 msec caused by need to be Geosynchronous

Antenna Cost: Geosynchronous: antenna need not be steerable

Low orbiting Satellites

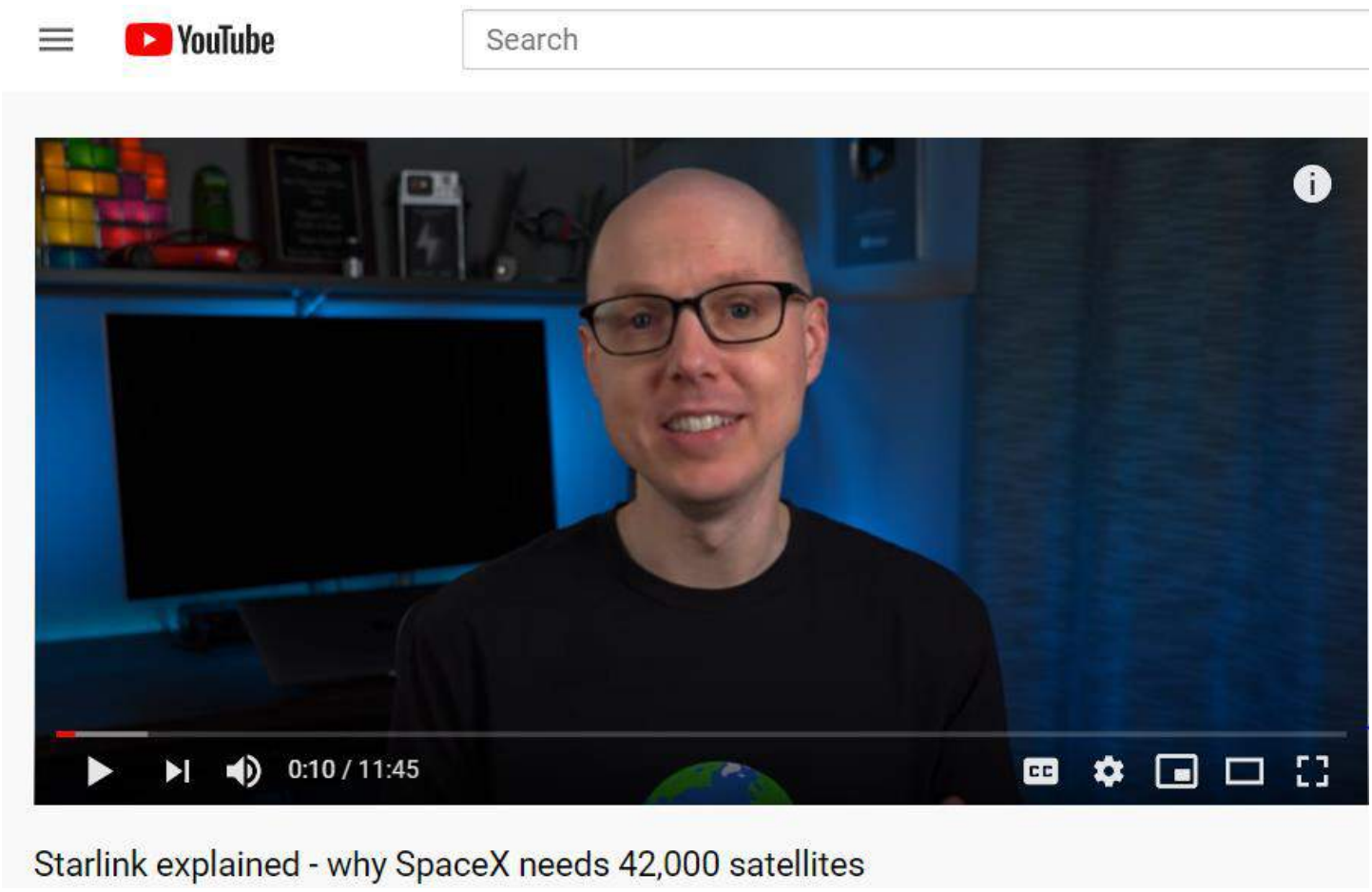
CELL PHONES: PEOPLE MOVE



LEO: “BASE STATION”MOVES

SPACE X VIDEO: LEOS

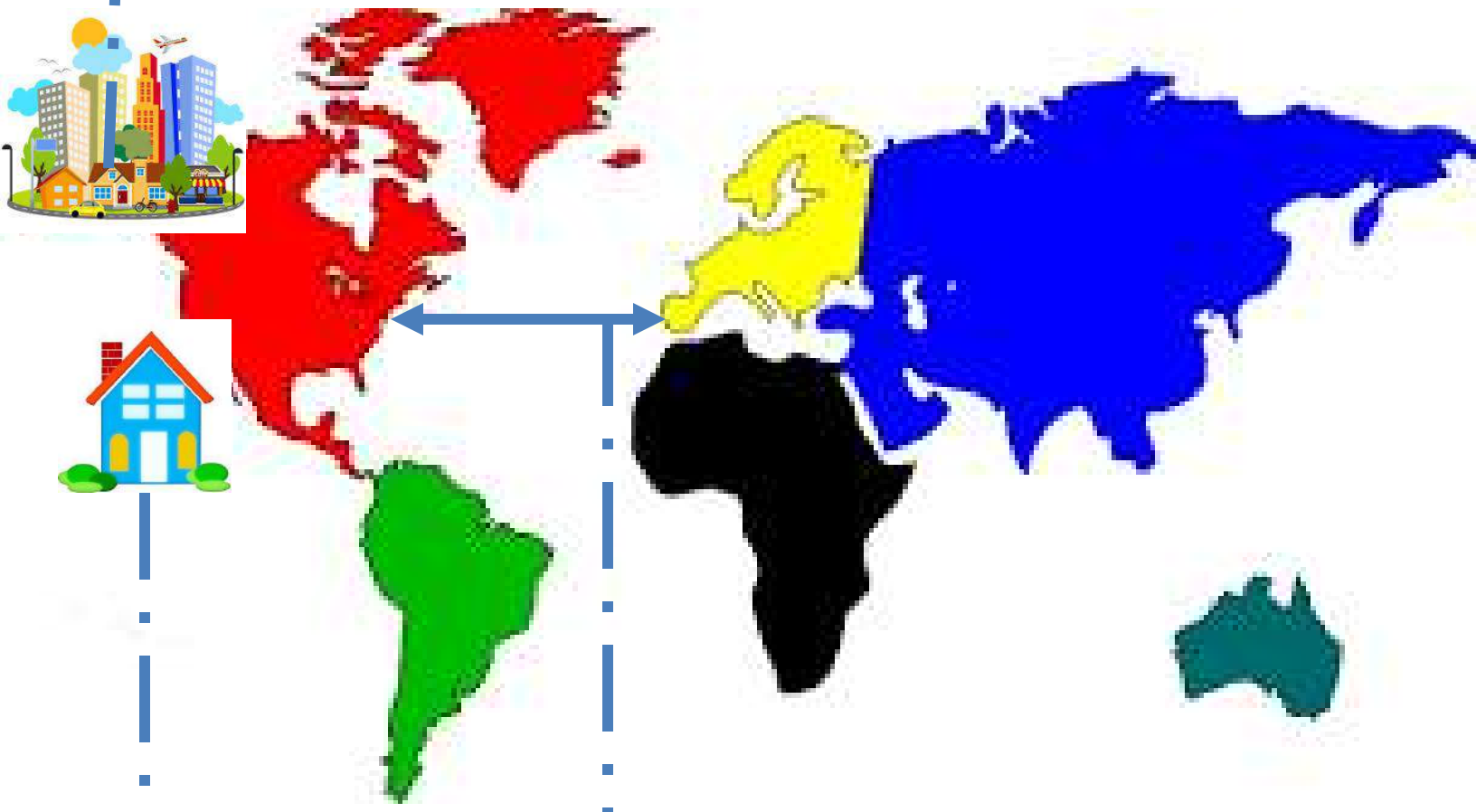
https://www.youtube.com/watch?v=tuFS0zOwyBg. 0:5.21



MEDIA PROS AND CONS

Medium	Speed	Distance Span	Pros	Cons
Twisted Pair	1 Mps -1 G (Cat 1 – Cat 5)	1 – 2 Km	Cheap, easy to install	Low distance
Digital Coax	10-100 Mbps	1- 2 km	broadcast	Hard to install in building
Analog Coax	100-500 Mbps	100 Km	Cable companies Use it now	Expensive amplifiers
Fiber	Terabits	100 km	Security, low noise, BW	No broadcast, Needs digging
Microwave	10-100 Mbps	100 km	Bypass, no right Of way need	Fog outages
Satellite	100-500 Mbps	worldwide	Cost independent of distance	250 msec delay Antenna size
RF/Infrared	1 – 100 Mbps, < 4 Mbps	1 km 3 m	wireless	Obstacles for infrared

Crowded City Bottleneck,
Microwave, Radio



Trans-oceanic
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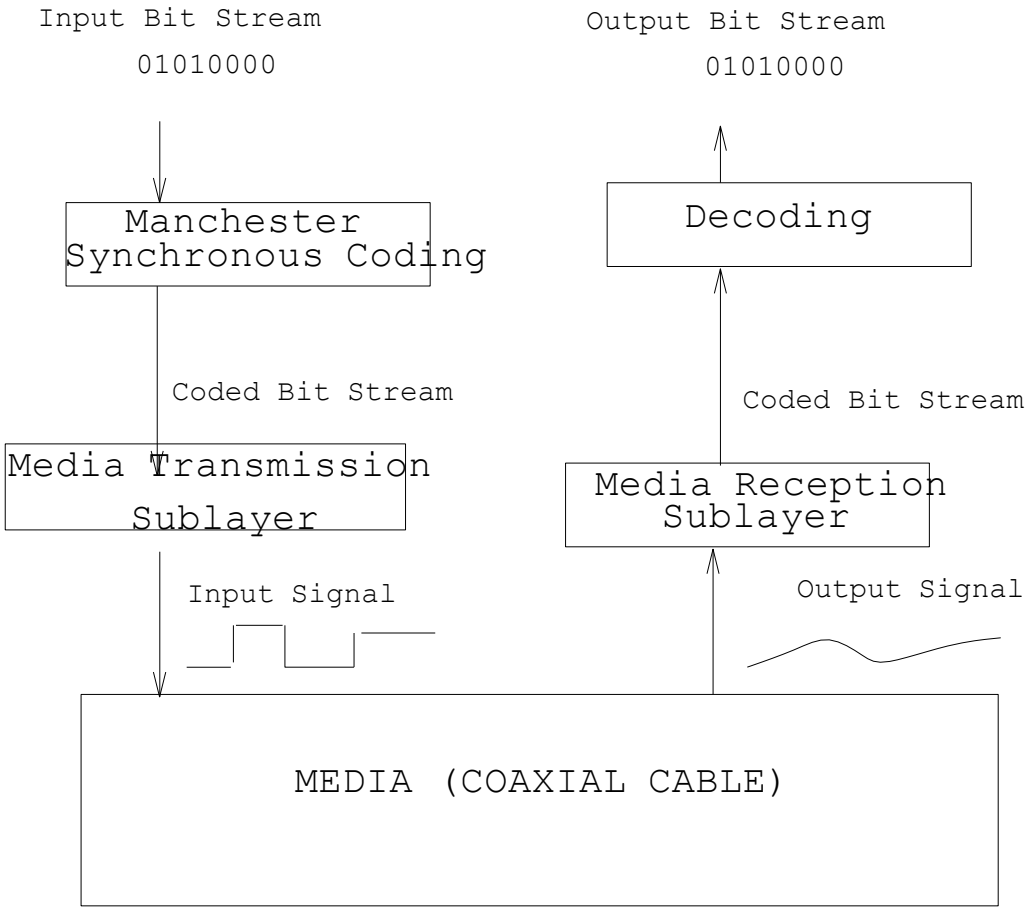
PUMPING BITS GLOBALLY

Prize question

The US Government decides to set up genomic processing in the cloud and has to ship 250 Gbytes for 1000s of individuals. What is *highest throughput* network:

a) Routers connected by fiber
b) Routers with satellite
c) UPS trucks carrying disks
d) Carrier pigeon network

ETHERNET SUBLAYERS

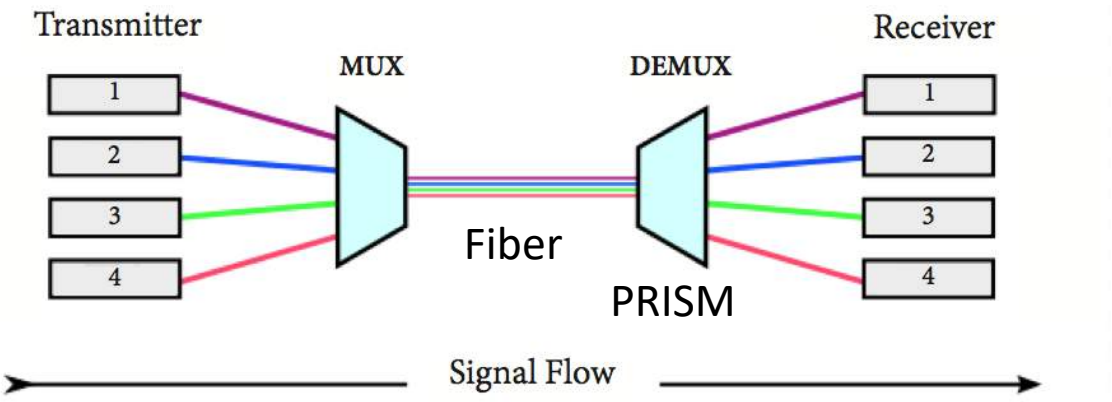


REPEATERS & MULTIPLEXING

Input Bit Stream

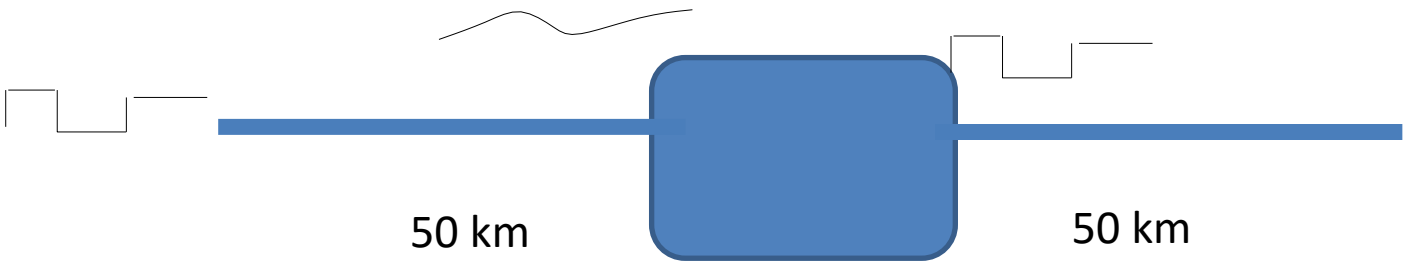
Output Bit Stream 01010000
01010000

Wavelength Division Multiplexing (WDM)



Bits are dropping

Refresh Bits



REPEATER

Problems in all layers

- Resource Sharing: FDM/TDM/WDM
- Addressing: TDM time slots
- Synchronization: clock recovery, spacing apart levels
- Interconnection Physical layer repeaters are called hubs