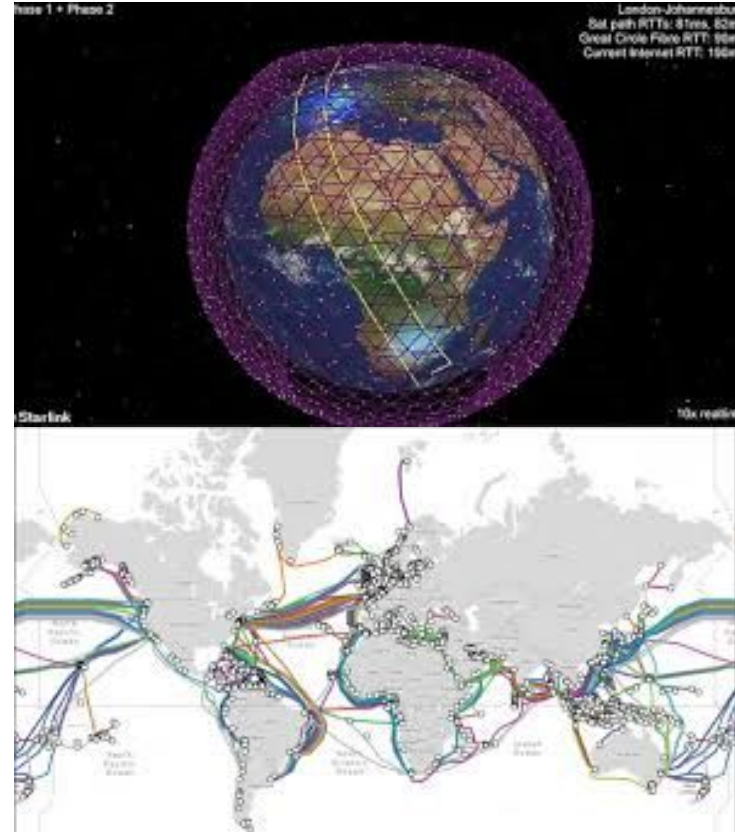


Computer Networks

Backbone Networks

Jianping Pan
Fall 2022



First things first

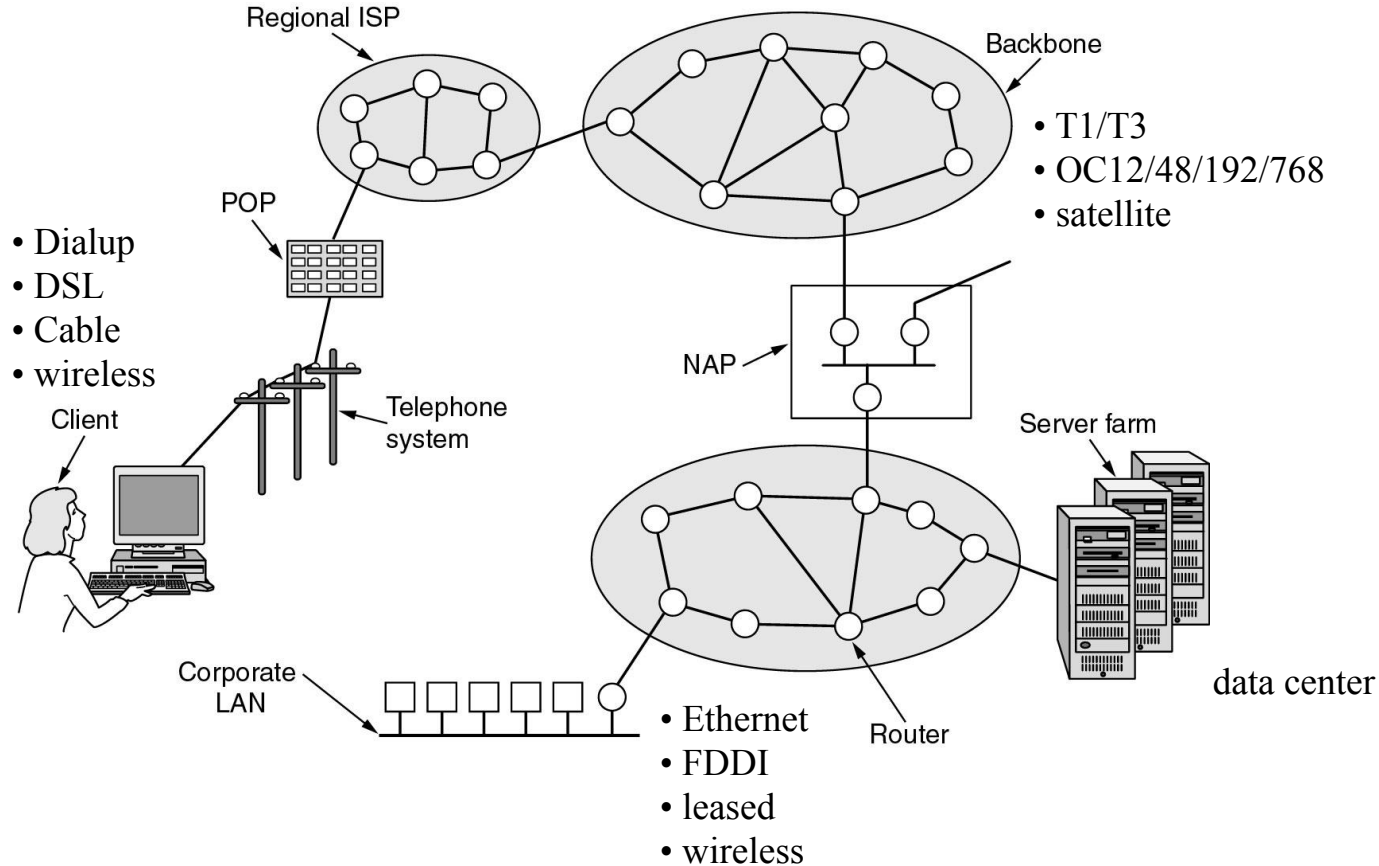
- Lab, tutorial, assignment and homework
 - start(ed) this week: see bright for details
 - all materials/submissions through brightspace
 - only attend the lab section you registered for
 - sorry, there is a space/attention limit for students/TA
 - in ECS360 (you need a keycard to access)
 - programming assignment 1 (p1) will be out **today**
 - weekly homework due every week of tutorials
 - homework a1 due on Sept 16, **5pm**, through bright

Reminder: Too challenging for you?

- We are here to help
 - **Brighspace discussion forum**
 - get help and help others!
 - *CSC consultant office (now mainly for 1xx courses)*
 - *2nd floor, ECS building*
 - your lab/tutorial instructors
 - make the best out of your lab and tutorial hours
 - your lecture instructor
 - in class, during **zoom office hours**, or by appointment
 - A quick google (not Ctrl-C/V) often can help too!

* ^{9/14/22}check ^{CSc 361}brighspace discussion forum for similar questions asked already ³

“The Internet”

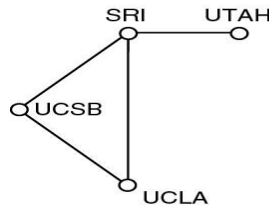


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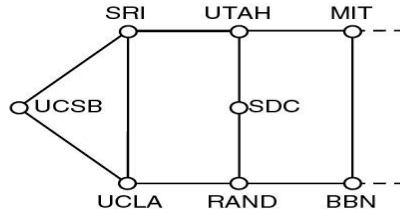
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* and a lot of wireless/mobile access nowadays

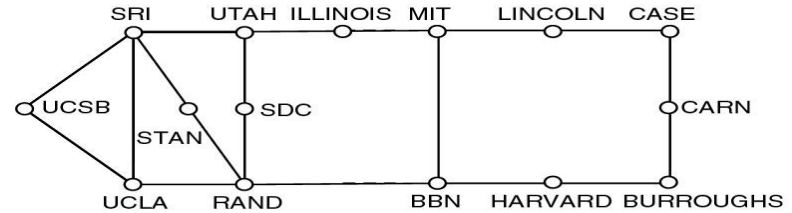
Internet history: ARPAnet (70's)



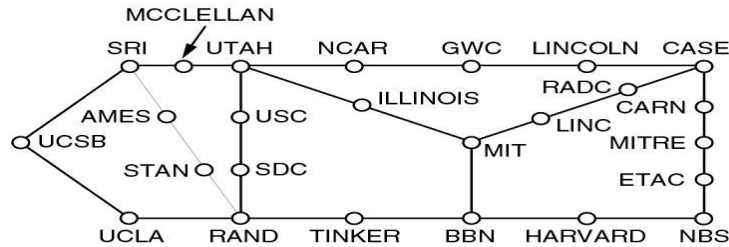
(a)
Dec. 1969



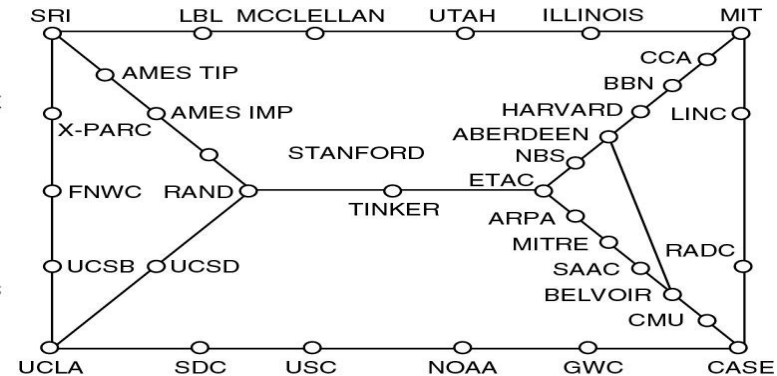
(b)
July 1970



(c)
March 1971



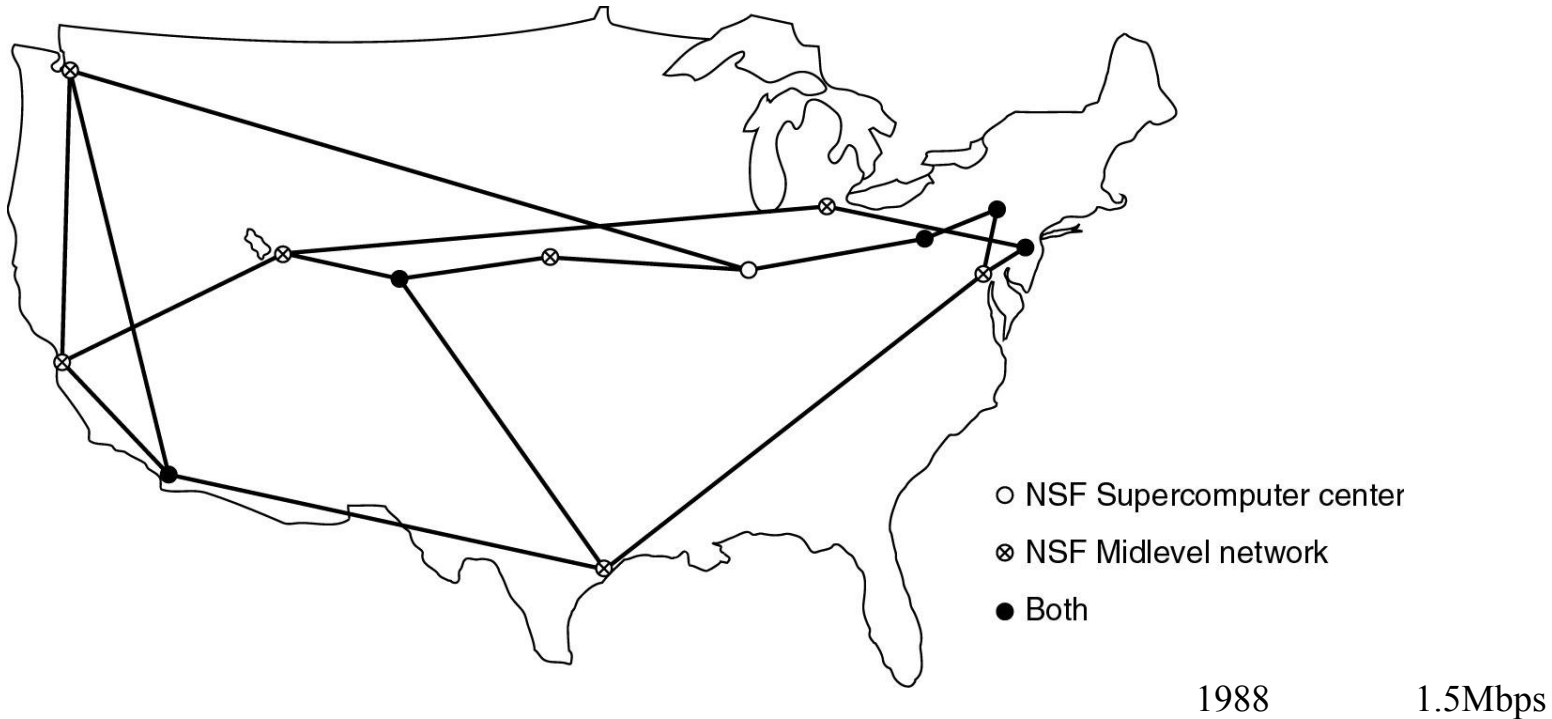
(d)
Apr. 1972



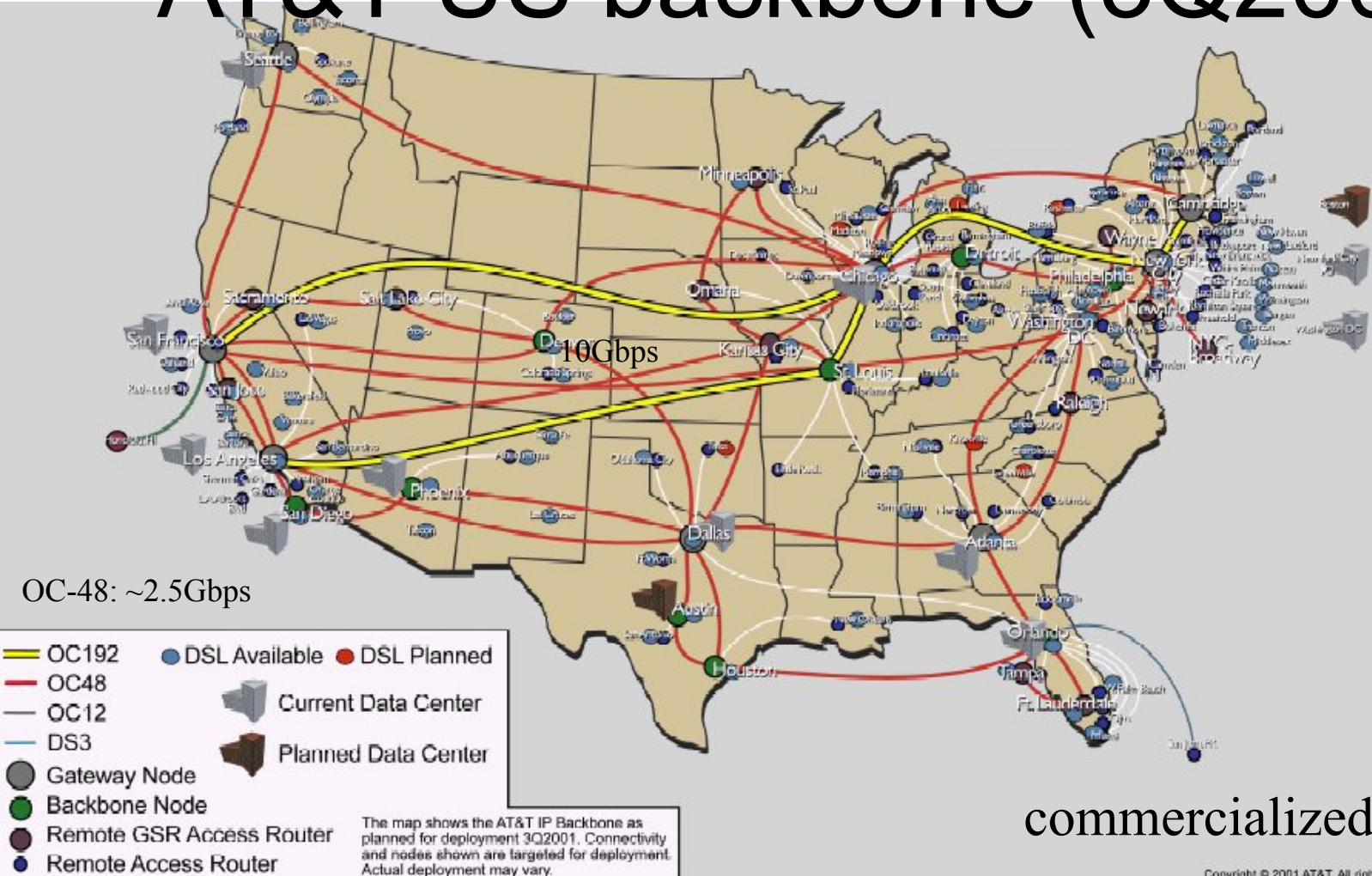
(e)
Sep. 1972

56Kbps

Internet history: NSFnet (80's)



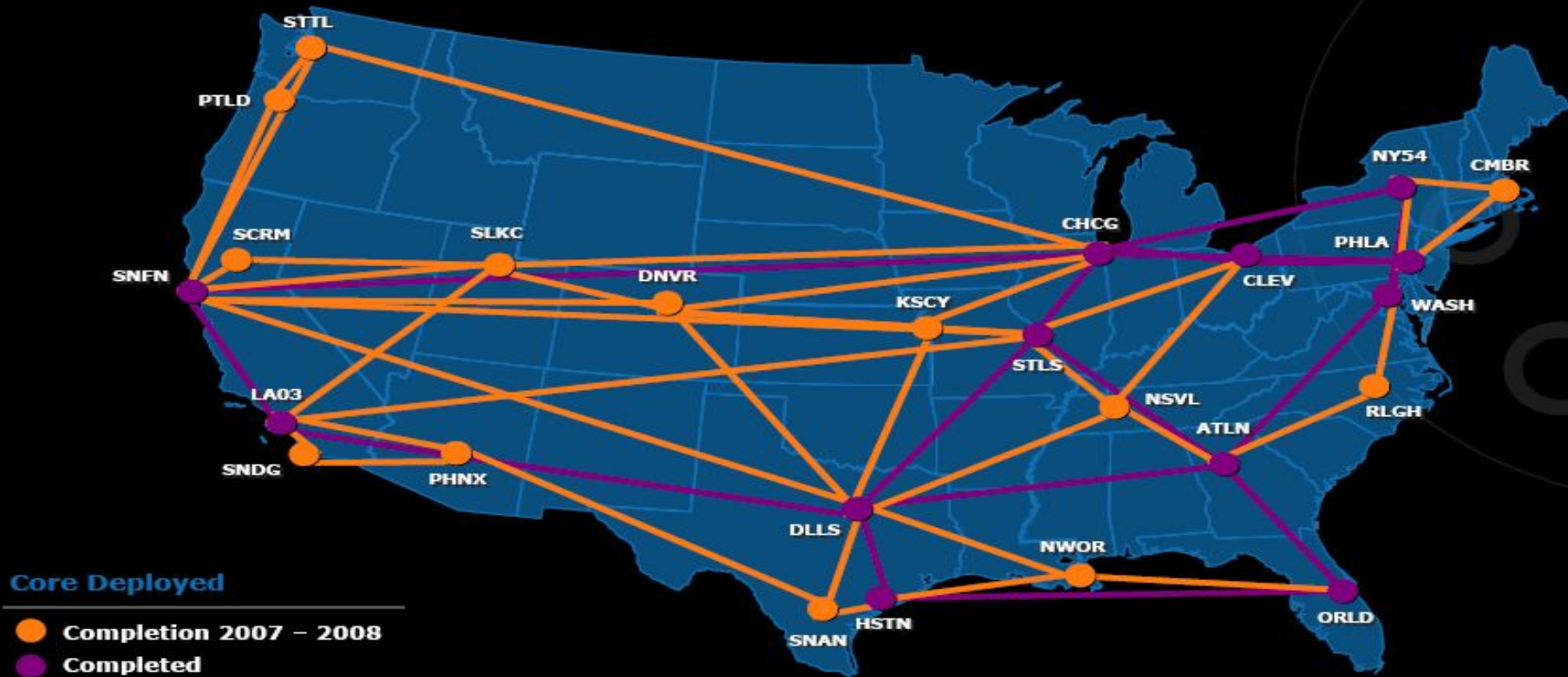
AT&T US backbone (3Q2001)



commercialized

AT&T OC768 (40Gbps)

Next-Generation IP MPLS Backbone



Internet backbone structures

- Tier-1

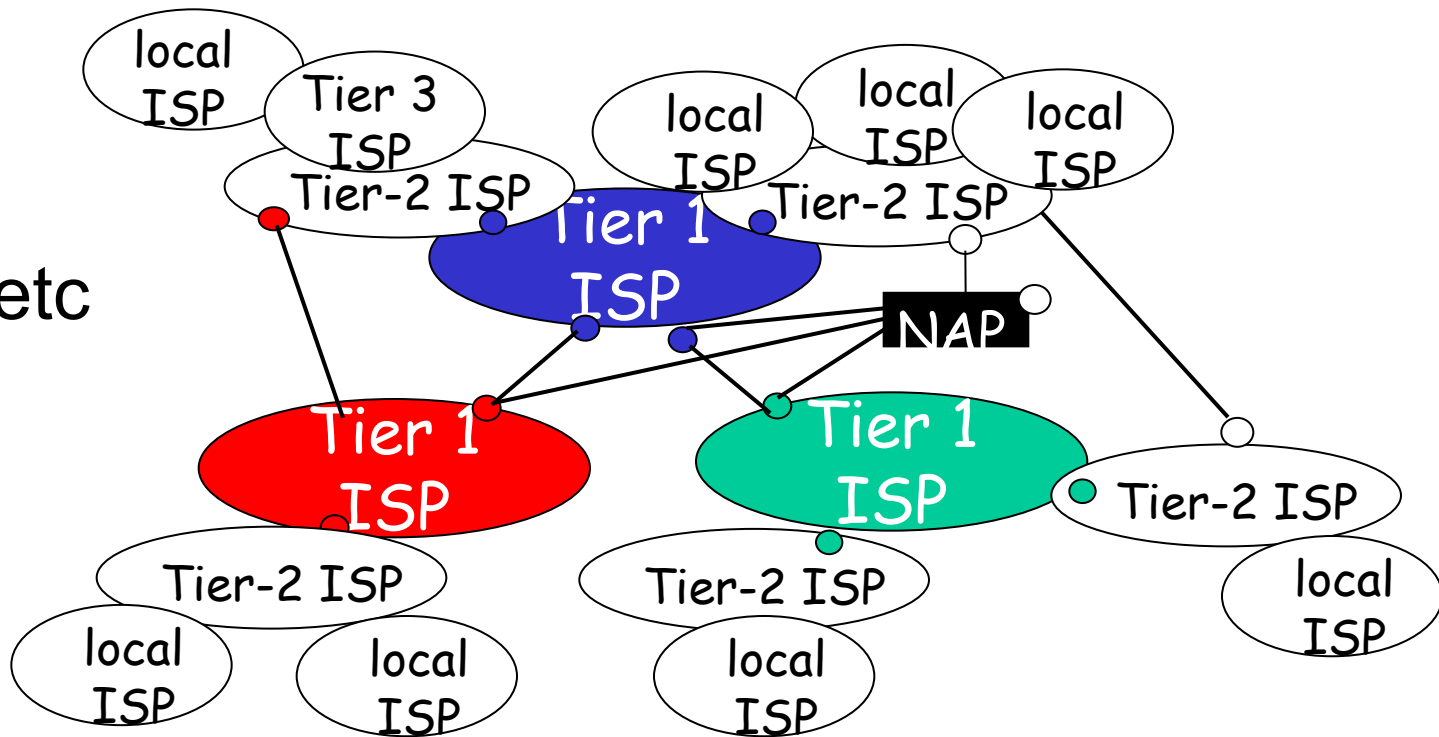
- AT&T
- Sprint
- Level 3, etc

- Tier-2

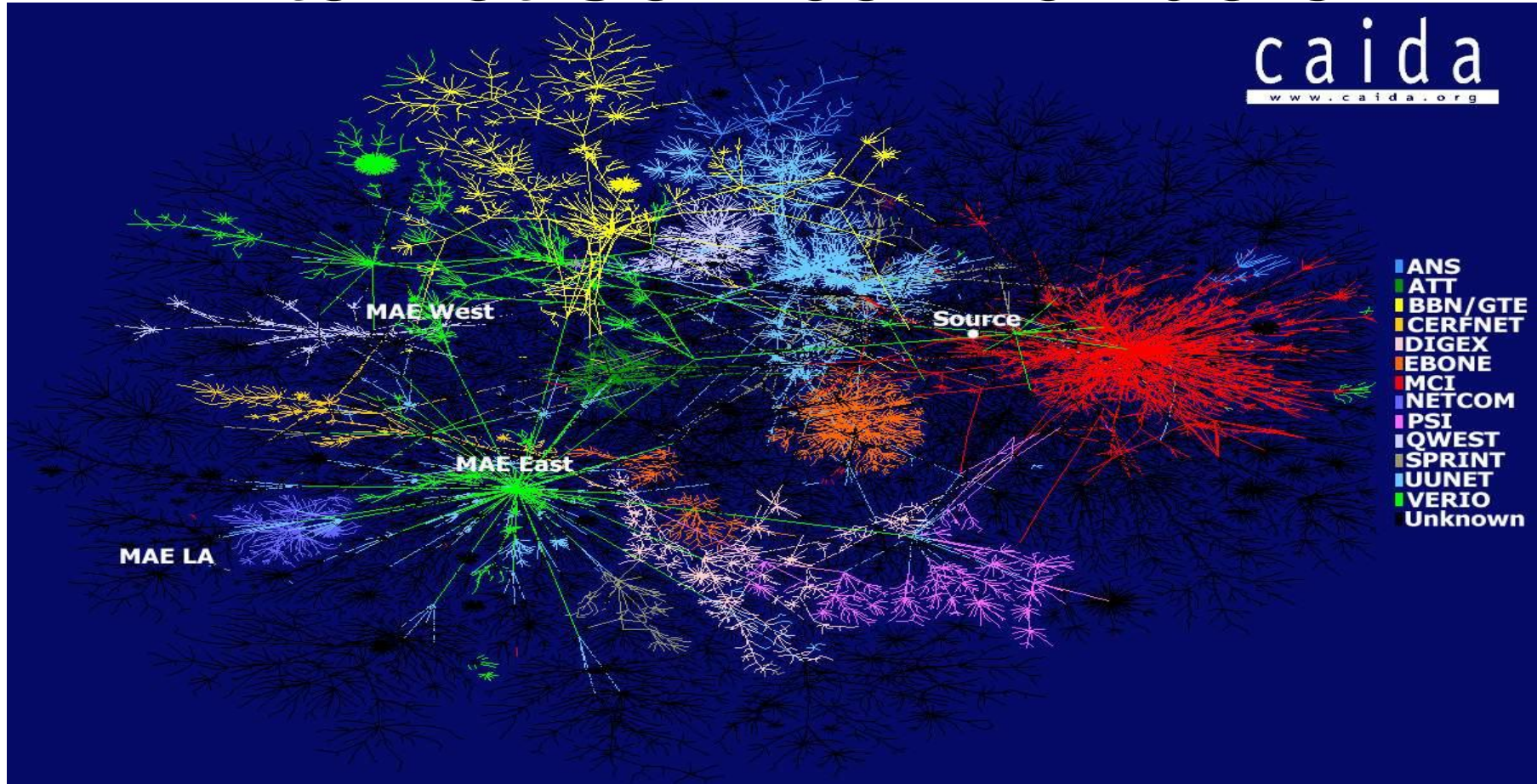
- regional

- Tier-3

- local

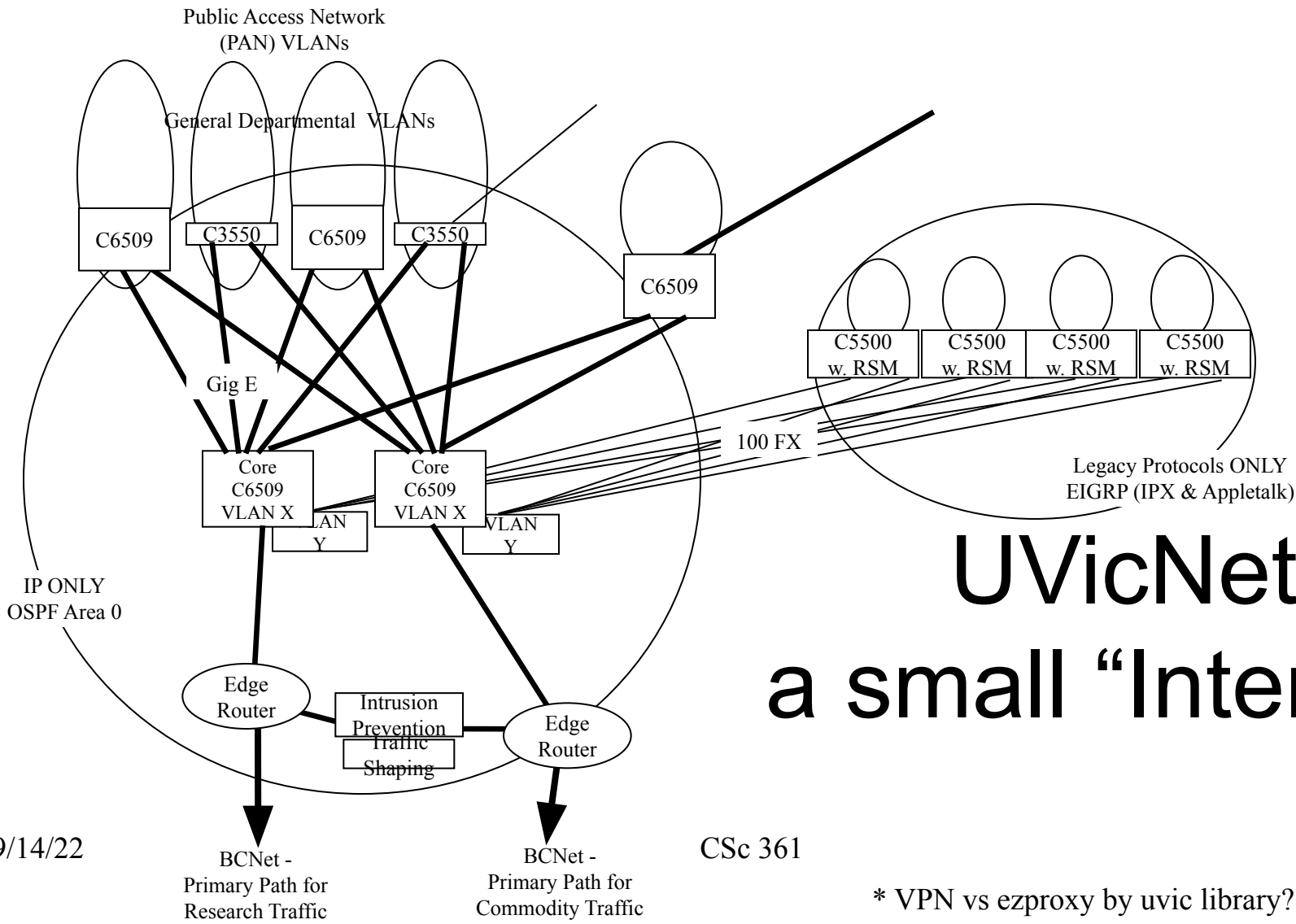


Internet Service Providers



Pass your mouse over the Canadian cities to see a complete list of CA*net 4 connected institutions





UVicNet

a small "Internet"

Internet backbone: big pipes!

SONET		SDH	Data rate (Mbps)		
Electrical	Optical	Optical	Gross	SPE	User
STS-1	OC-1		51.84	50.112	49.536
STS-3	OC-3	STM-1	155.52	150.336	148.608
STS-9	OC-9	STM-3	466.56	451.008	445.824
STS-12	OC-12	STM-4	622.08	601.344	594.432
STS-18	OC-18	STM-6	933.12	902.016	891.648
STS-24	OC-24	STM-8	1244.16	1202.688	1188.864
STS-36	OC-36	STM-12	1866.24	1804.032	1783.296
STS-48	OC-48	STM-16	2488.32	2405.376	2377.728
STS-192	OC-192	STM-64	9953.28	9621.504	9510.912

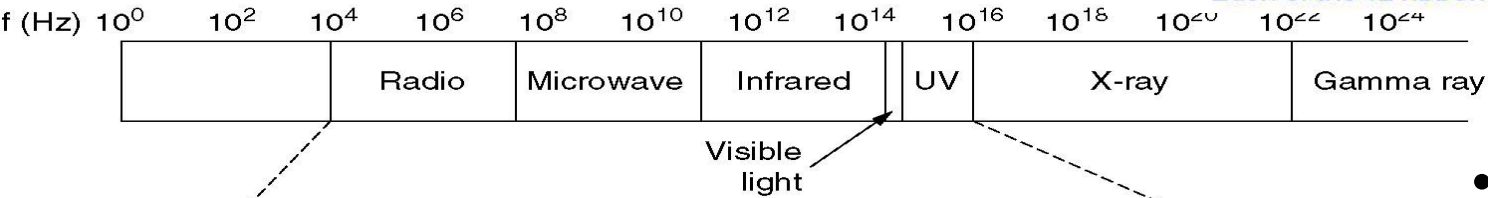
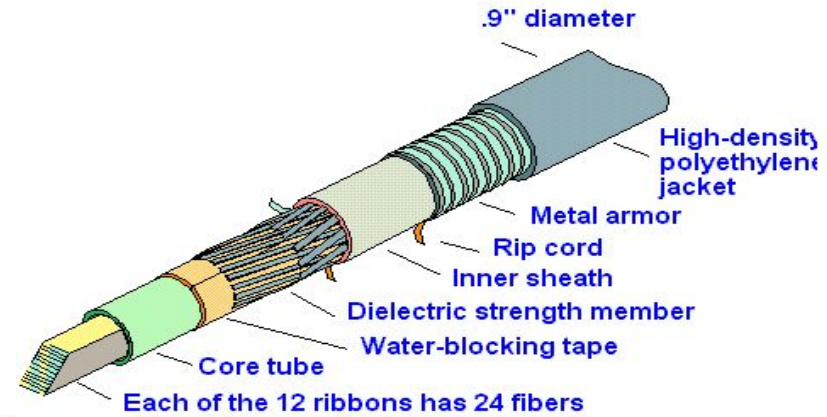
OC-768/STM-265: 40Gbps

OC-1920/STM-640: 100Gbps

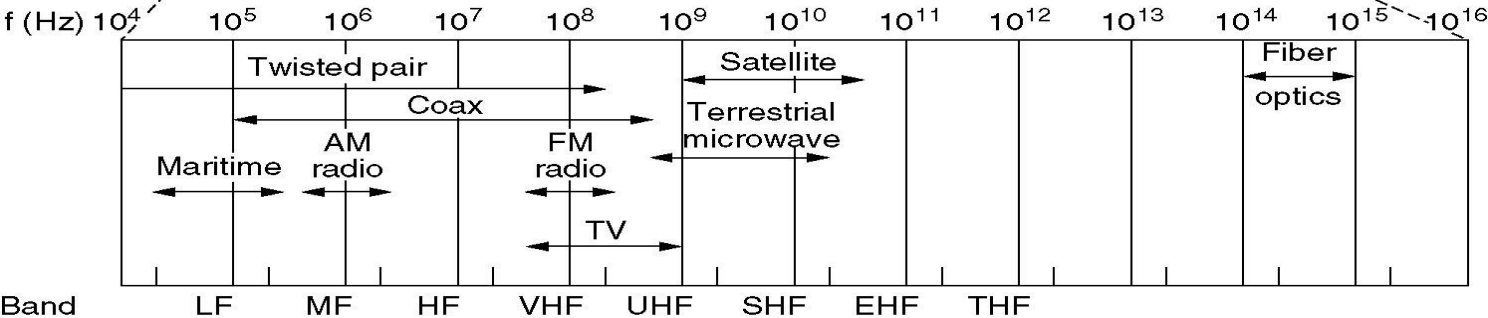
OC-3840/STM-1280: 200Gbps

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Fiber optics

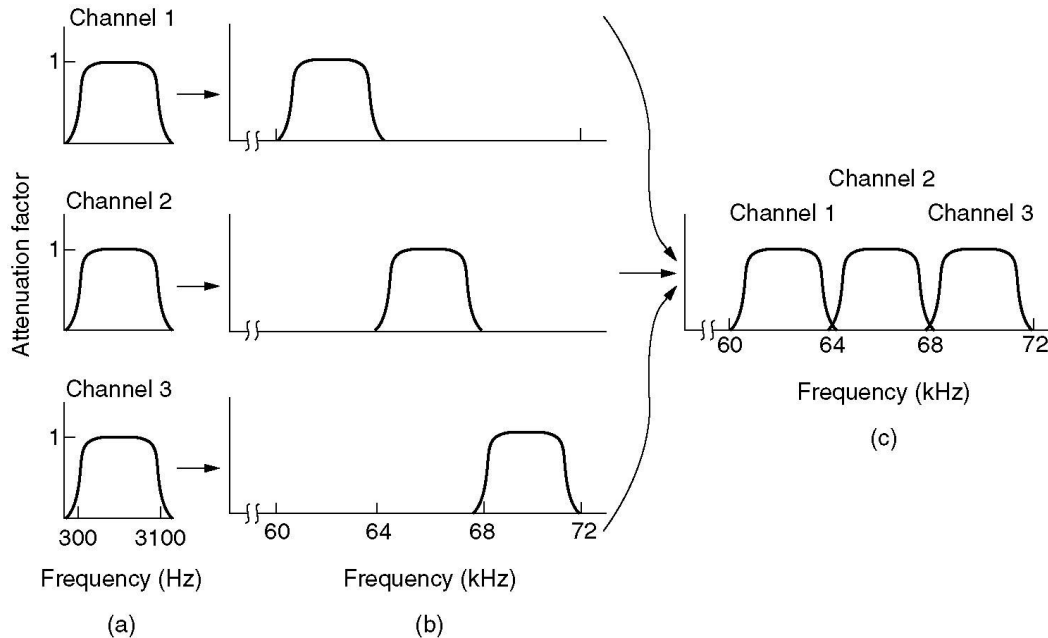


- single-mode
- multi-mode

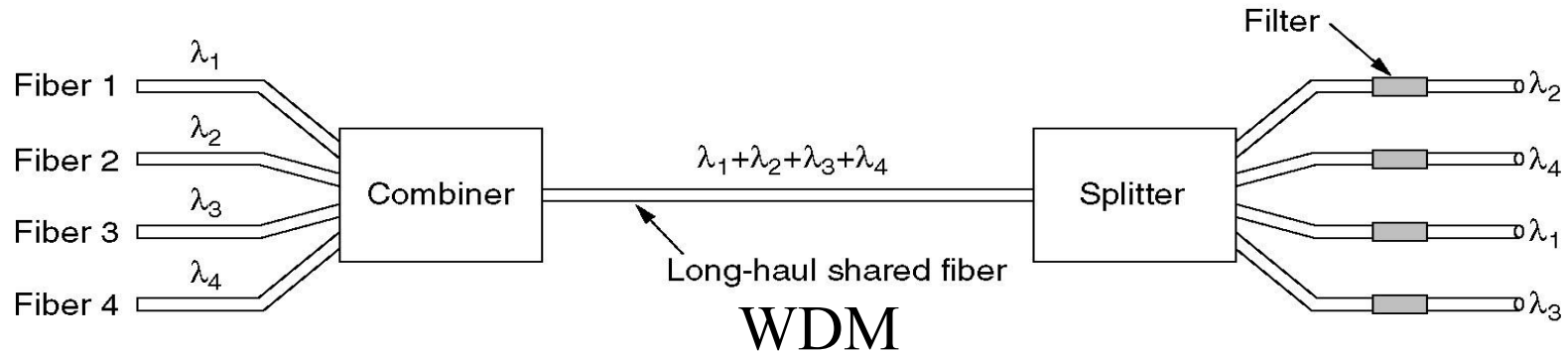
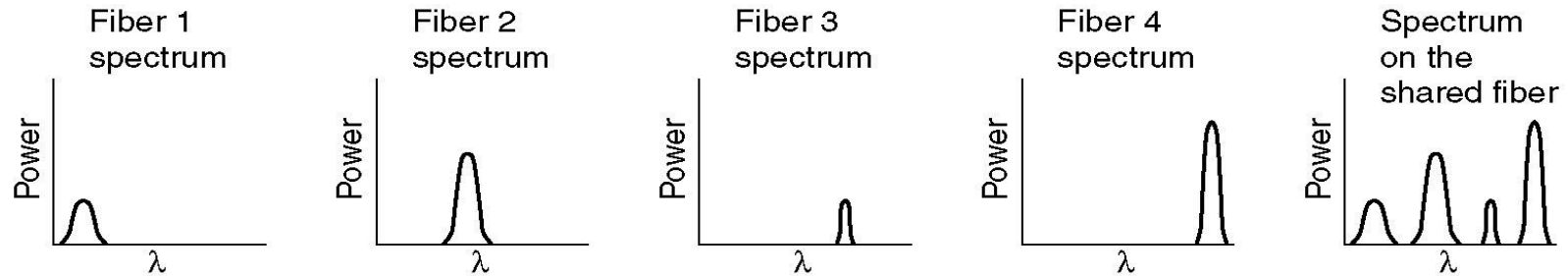


Multiplexing technologies

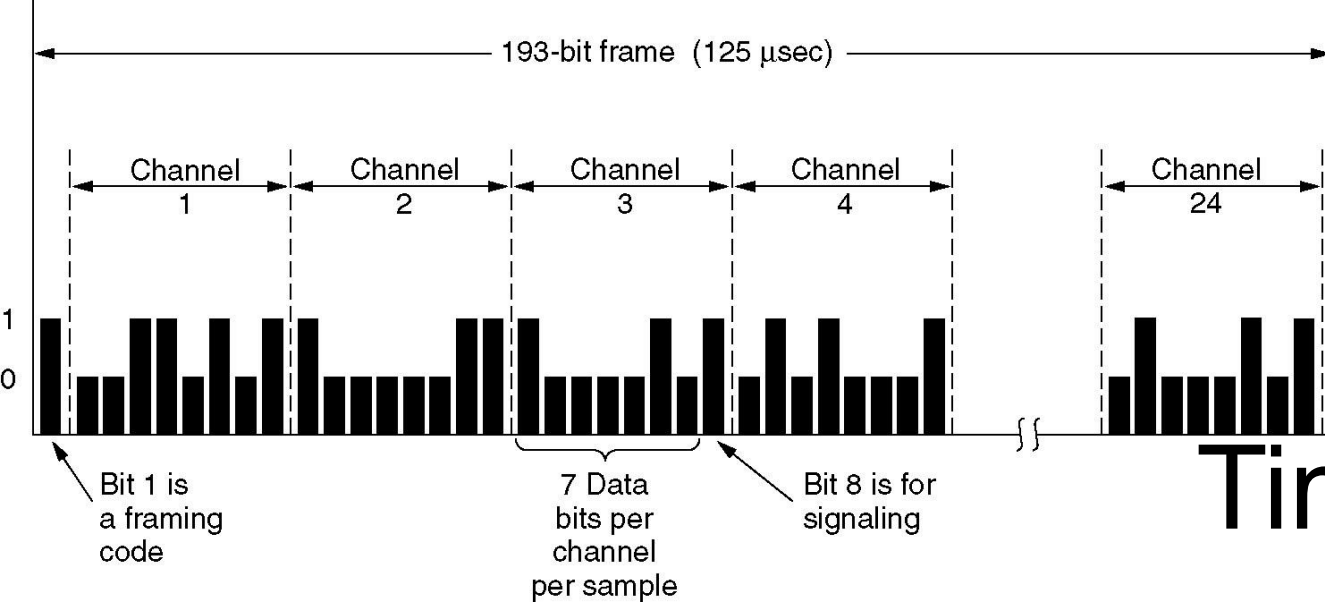
- Frequency division multiplexing (FDM)



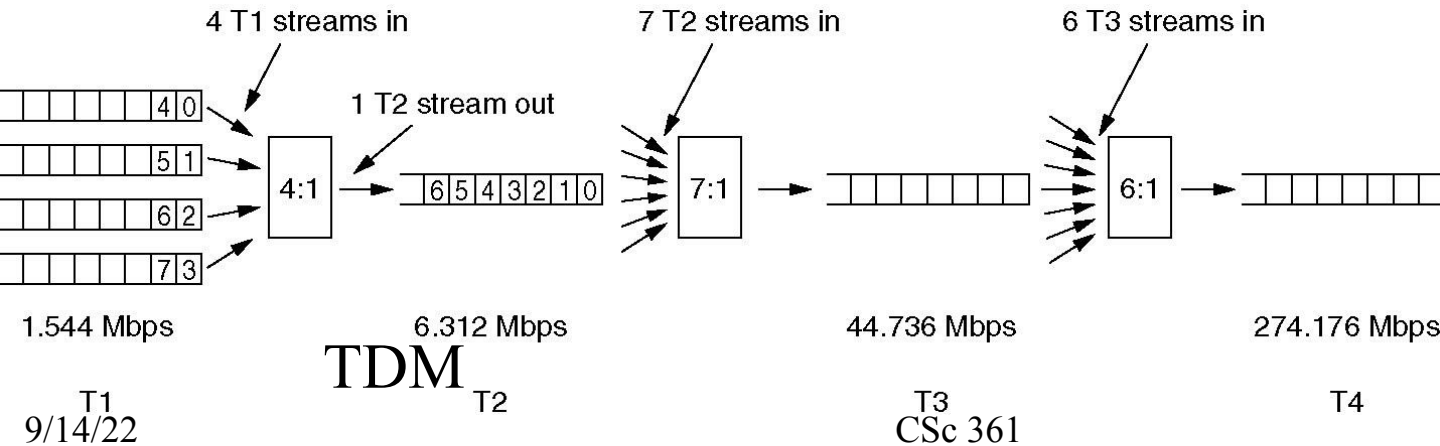
Wavelength division multiplexing

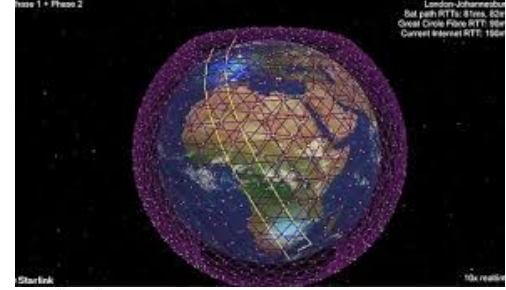


$$\text{freq} * \text{wavelength} = \text{the speed of signal}$$

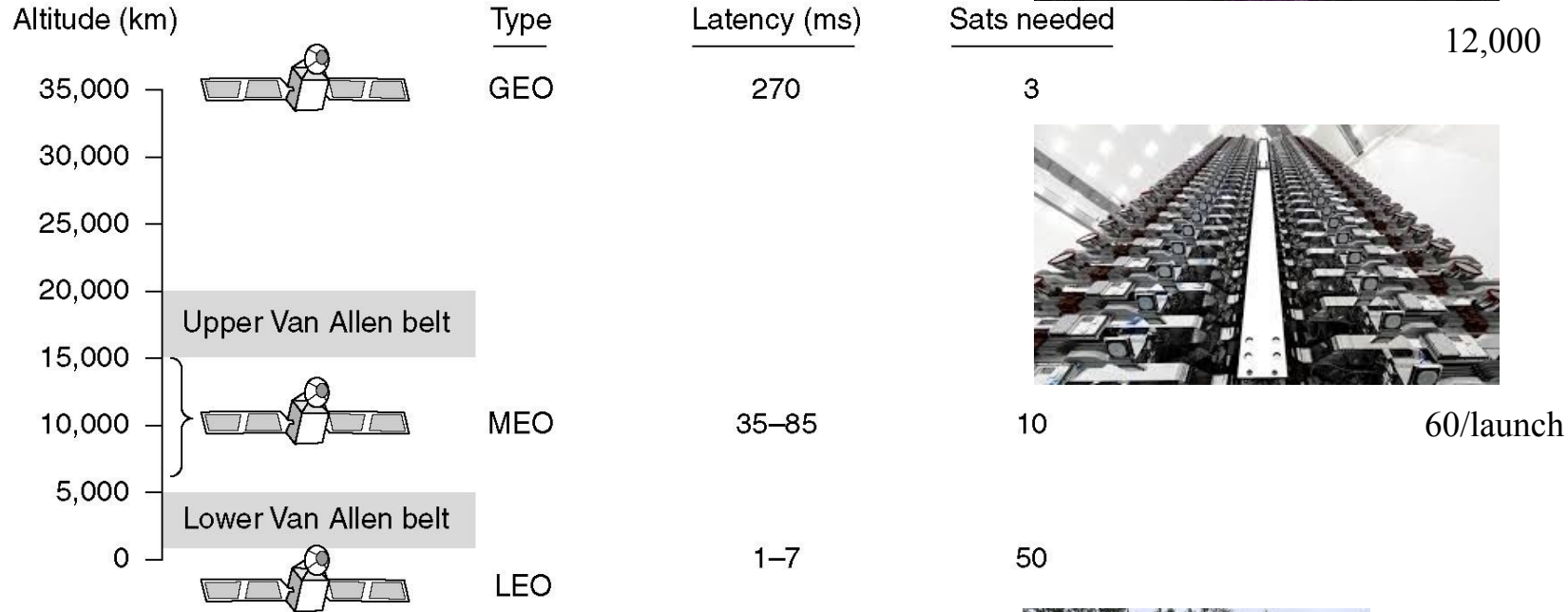


Time division multiplexing





Communication satellite



• Satellite vs fiber

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* a lot of small satellites? the “latency” war?



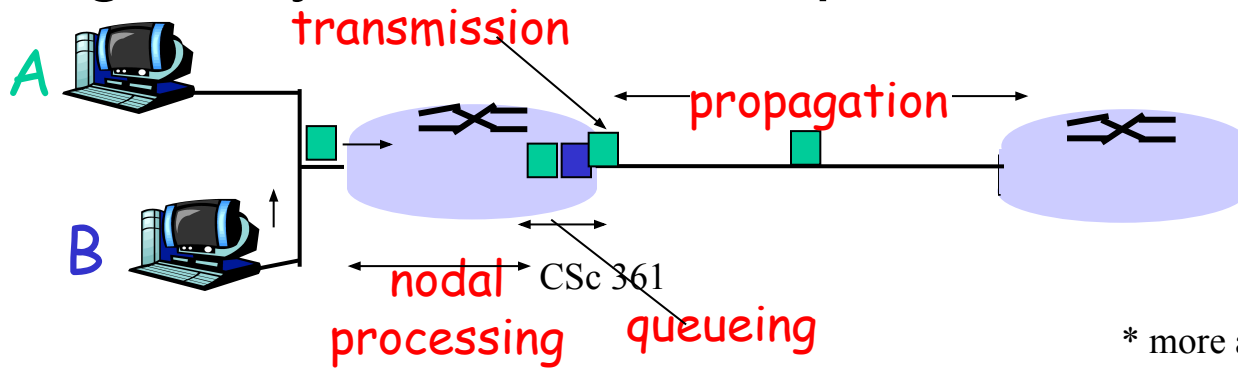
Ground
station

Internet backbone evolution

- IP/ATM/SONET/WDM
 - IP: datagram
 - ATM: virtual circuit
 - SONET: circuit switching
 - WDM: lights in different color
- IP/SONET/WDM
- IP/WDM
 - newer technology

Link characteristics

- Speed (bandwidth)*: bit-per-second
- Delay: millisecond
 - transmission delay: packet length / link speed
 - propagation delay: travel distance / signal speed
 - processing delay
 - queuing delay: the most complicated one



More on **link characteristics**

- Loss: percentage
 - transmission error
 - congestion loss
 - router buffer
 - packets enqueue when output is busy
 - packet dequeue when output is idle
 - if buffer is full
 - some packets have to be dropped

This lecture

- Internet backbone
 - So far, access and backbone technologies covered
 - **link characteristics**
- Explore further
 - Internet backbone and tier-1 networks
 - http://en.wikipedia.org/wiki/Internet_backbone
 - Rocketfuel*: an ISP topology mapping engine
 - <http://www.cs.washington.edu/research/networking/rocketfuel/>
 - * ACM Sigcomm 2014 test-of-time award

Next lecture

- Application layer
 - Read K&R4: Computer Networking
 - Chapter 2
- Lab started this week
 - Install Wireshark etc on your computer
 - access the lab platform in ECS360
 - Get familiar with PicoNet, tcpdump and Wireshark
 - try some examples seen in lectures and tutorial too

