Review of Lectures 15-23

ELEC1200

- **What are the most important ideas and concepts?**

The most important idea or concept?

Questions are more important than answers

Knowledge and answers, by themselves, are no longer enough

Curiosity is essential
Asking probing questions is essential
Knowing how to find the answers to your questions is critical

The most important idea or concept?

Always be Honest and act with Integrity

HKUST's honor code
http://www.ust.hk/vpaao/integrity/honor.html

Over the long term being honest and decent will be the most rewarding thing you can ever do

Topics Covered in Lectures 15-23

- Signal Transmission
  - Modulation and Demodulation
- Communication Networks
  - Key concepts
- Link Layer
  - Aloha
- Network Layer
  - IP addresses and routing
- Transport Layer
  - Reliable data transfer, pipelining and congestion
- Application Layer

Signal Transmission

Concept of channel for transmission

Why do we need to share channels?

How do we share a channel?

What are the key steps needed to share channel?

FDM

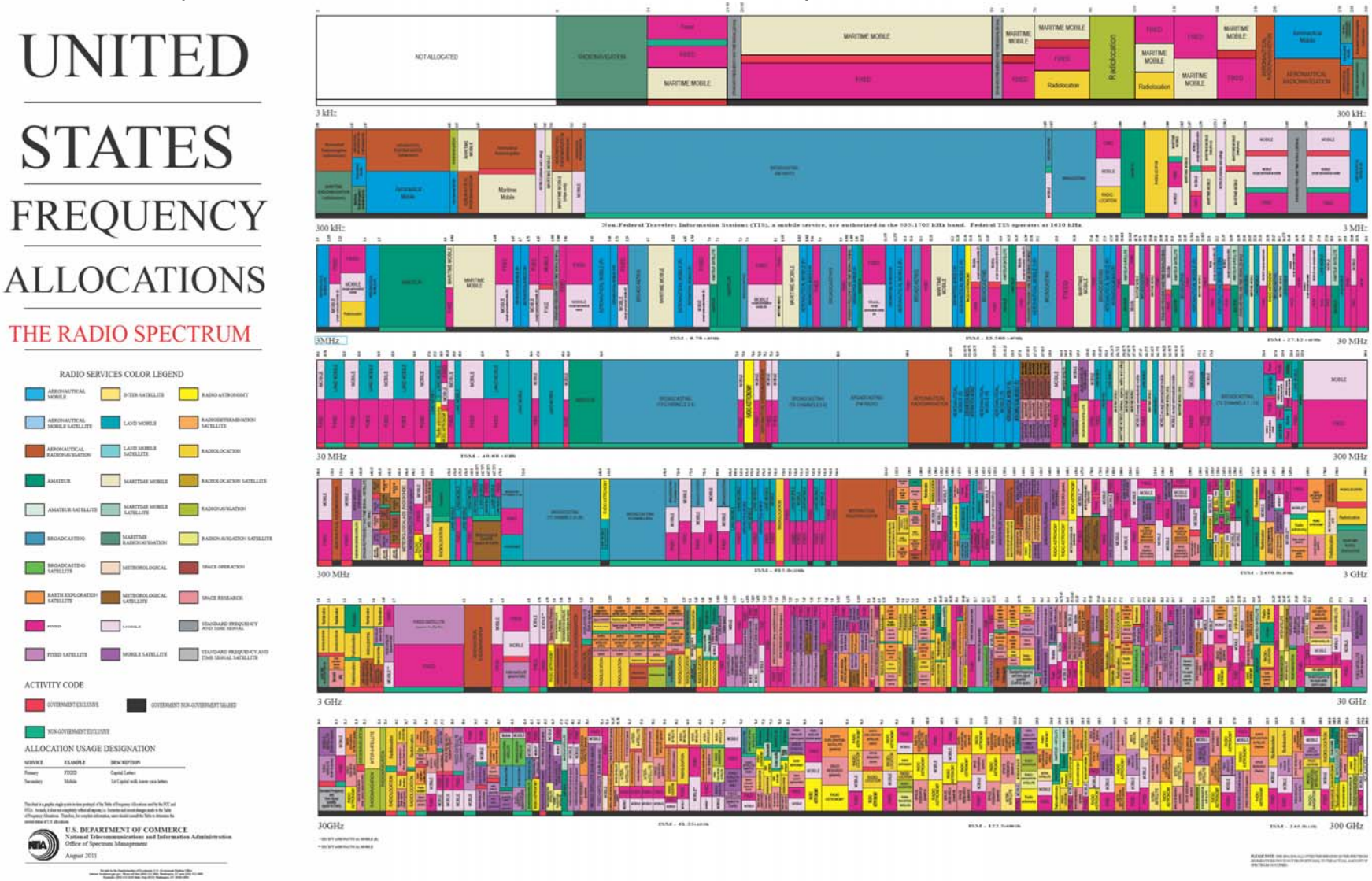
Modulation

Demodulation

Key issues and problems that may occur?

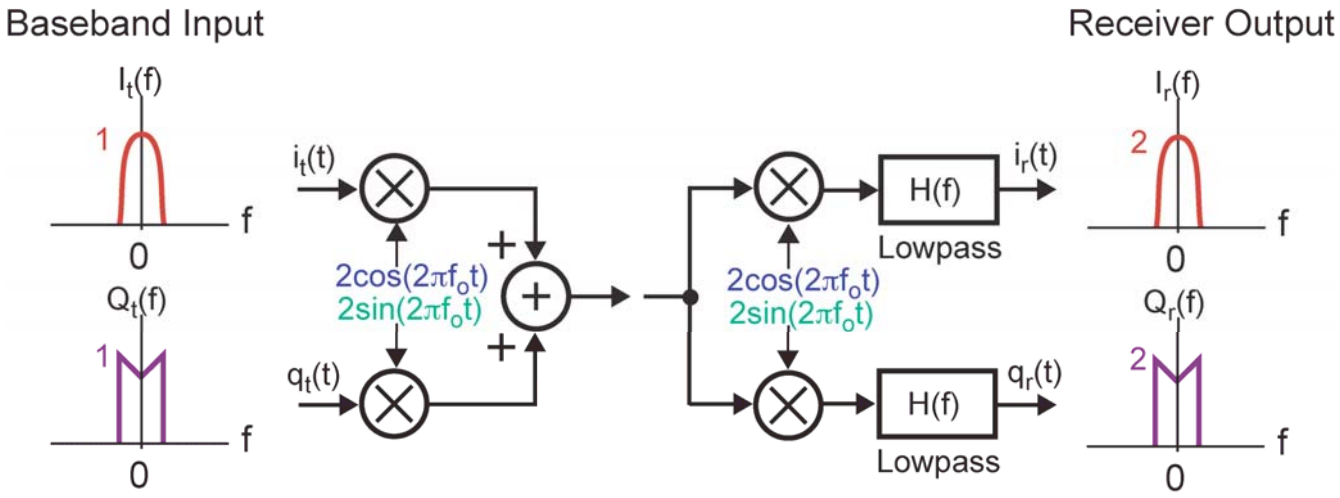
Radio Spectrum

- **Many users share the radio spectrum!**

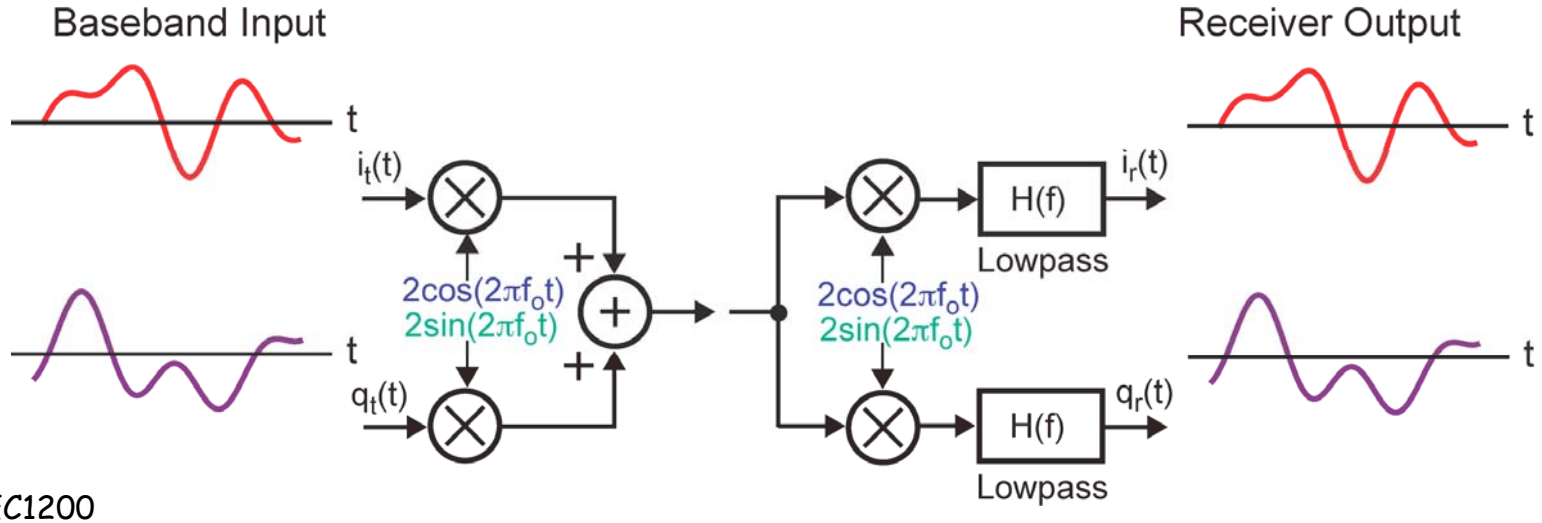


Summary of I/Q Modulation

- **Frequency domain view**



- Time domain view



Communication Networks

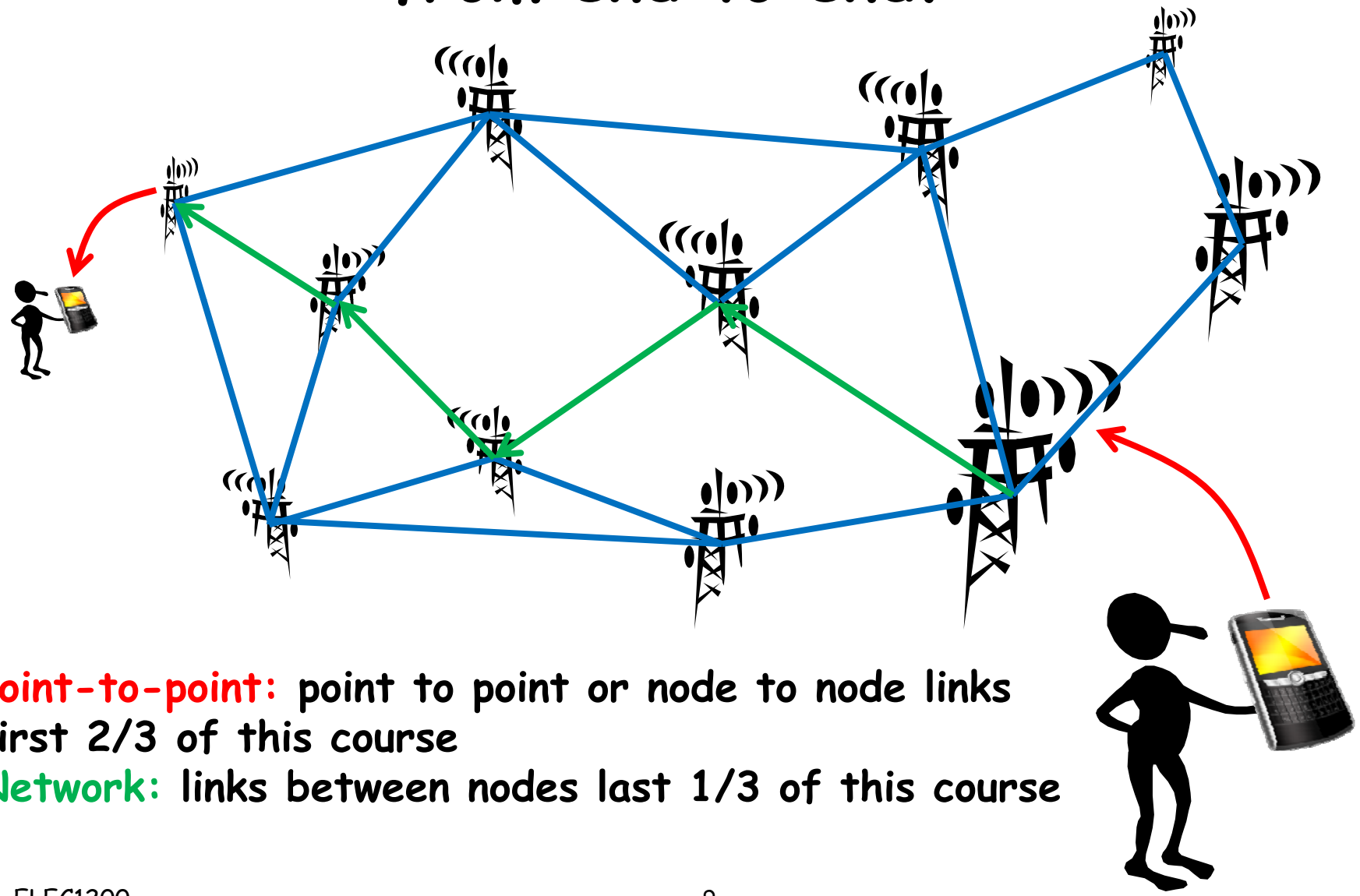
Why do we need communications networks?

How do we make communication networks?

What are the problems?

What are some common everyday networks?

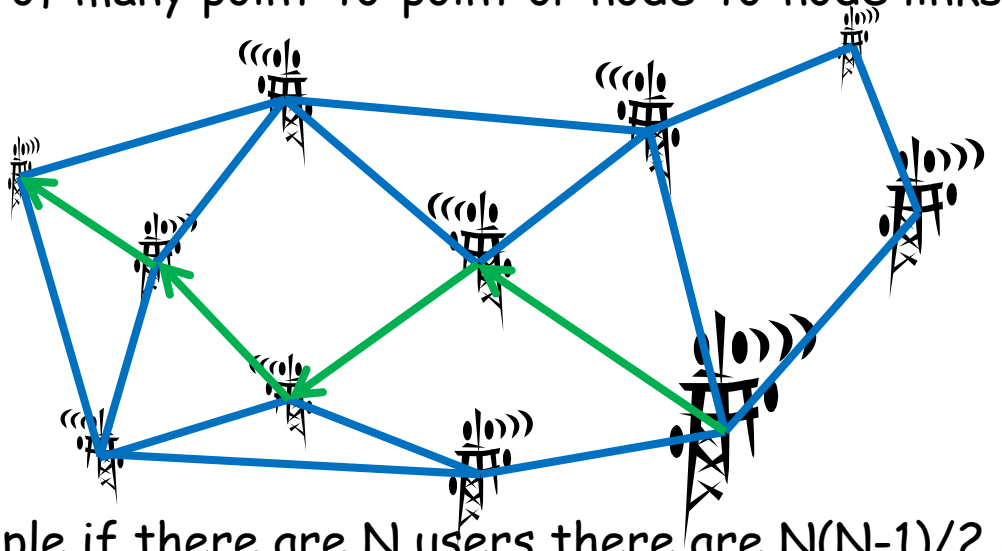
Our Question: How to transmit information from end to end?



Point-to-point: point to point or node to node links
first 2/3 of this course
Network: links between nodes last 1/3 of this course

Network-connecting many users together

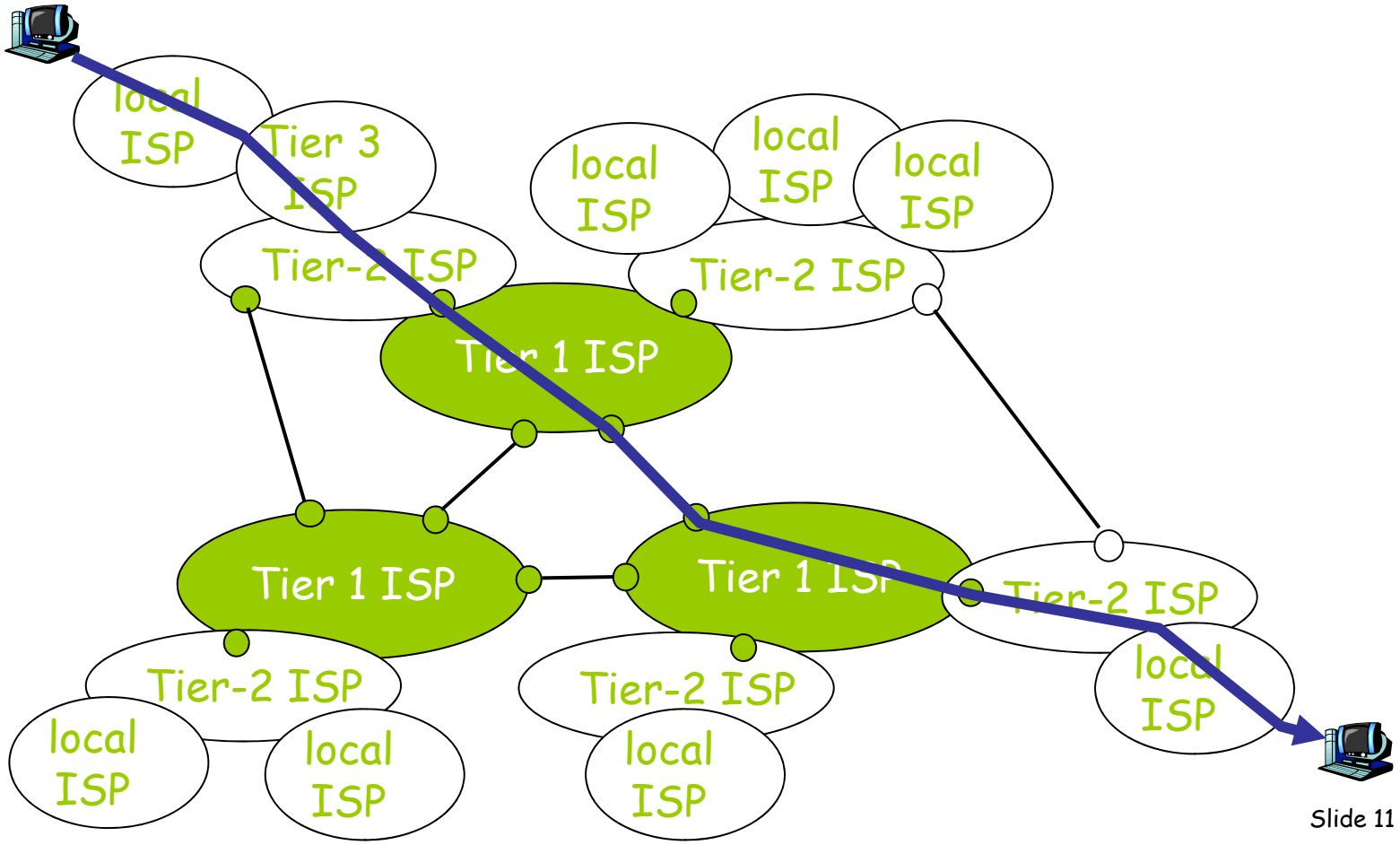
- A network allows us to connect many users together
- Consists of many point-to-point or node-to-node links



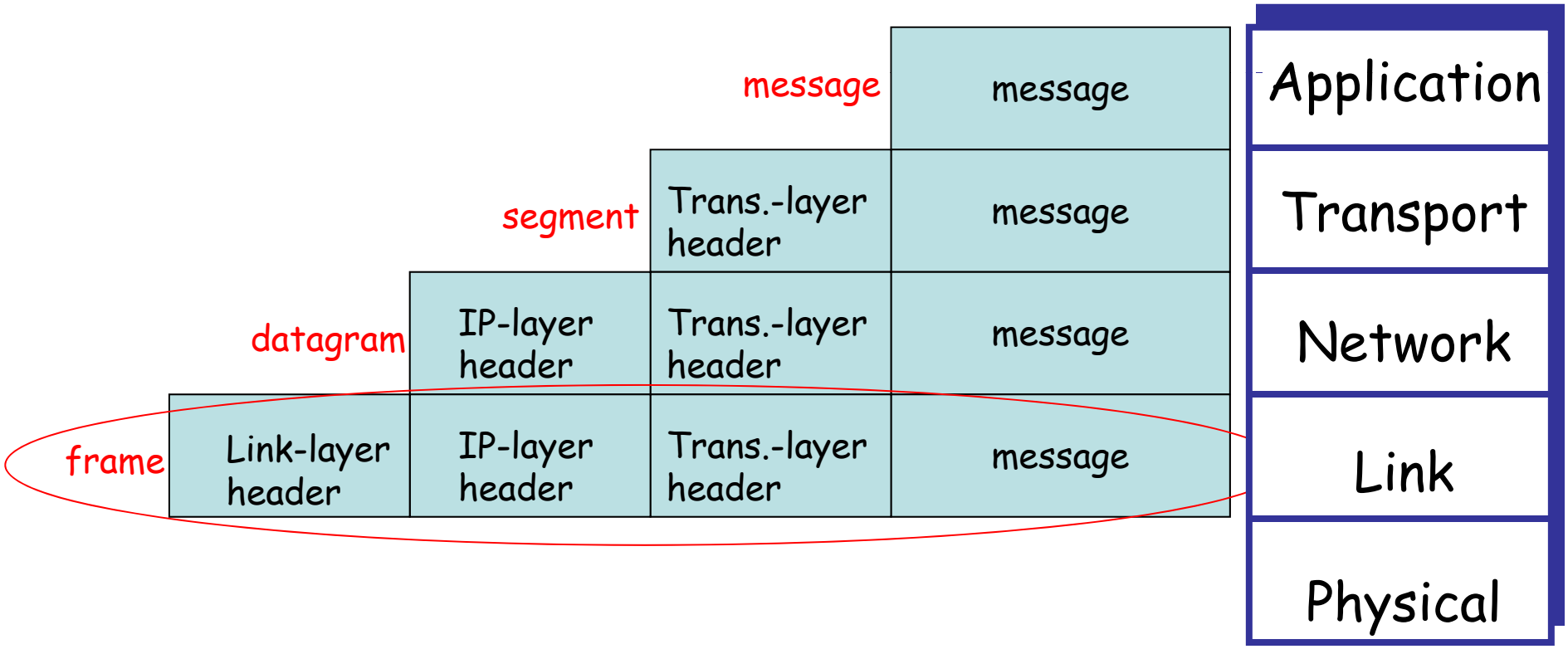
- In principle if there are N users there are N(N-1)/2 connections but this does not scale well to billions of users!
- Solution: Use a hierarchy of switches or networks

Internet: network of networks

- a packet passes through many networks!



Layered System



Link layer

Why do we need a link layer?

Why do we need to share the channel?

What are the problems or difficulties?

What are common link layers?

Link Layer Services

- *framing, link access:*
  - encapsulate datagram into frame, adding header, trailer
  - channel access if shared medium
  - "MAC" addresses used in frame headers to identify source, dest
    - different from IP address!
- *error detection:*
  - errors caused by signal attenuation, noise.
  - receiver detects presence of errors:
    - signals sender for retransmission or drops frame
- *error correction:*
  - receiver identifies *and corrects* bit error(s) without resorting to retransmission

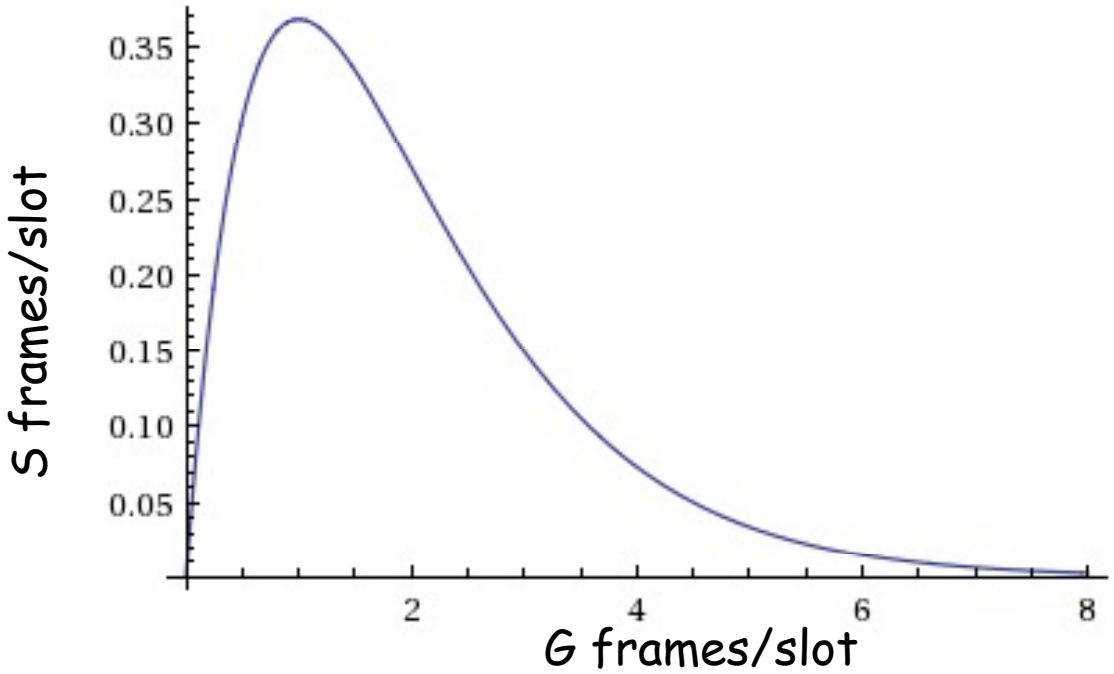
Slotted ALOHA efficiency

Efficiency : long-run fraction of successful slots (equivalent to throughput measured per slot)

- ***Suppose:*** **N nodes with many frames to send, each transmits in a slot with probability *p***
- **The average offered traffic is therefore *G*=Np in frames/slot**
- **Need to calculate the average amount of offered traffic that gets successfully received and this is known as throughput S in frames/slot**
- **Prob that a node is successful in a slot = $p(1-p)^{N-1}$**
- **Prob that *any* node is successful = $Np(1-p)^{N-1}$ or $G(1-G/N)^{N-1}$ and is the throughput S in frames/slot**

Slotted ALOHA efficiency

- Let N become large and tend to infinity
- We can then write $S = G(1-G/N)^N$
- Also remember that $\lim_{n\to\infty}\left(1-\frac{x}{n}\right)^n = e^{-x}$
- Therefore when N is large $S = Ge^{-G}$

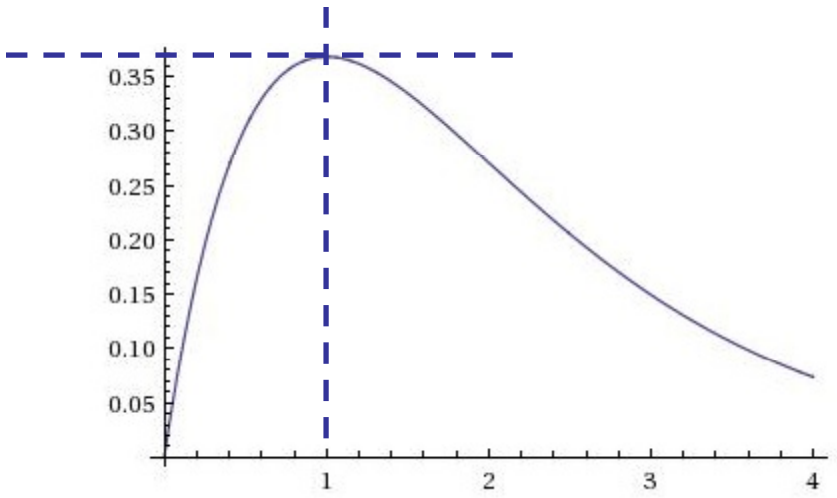


Slotted ALOHA efficiency

- At what G is the throughput maximum?
- Maximum is when derivative is zero (slope is flat)

$$\frac{dS}{dG} = e^{-G} - Ge^{-G} = e^{-G}(1 - G)$$

- Derivative is zero when G=1 so this is where maximum throughput occurs
- Maximum S is therefore S= $e^{-1} = 0.37$



At best: channel used for useful transmissions 37% of time!

!

Network layer

Why do we need a Network layer?

How are ip addresses defined?

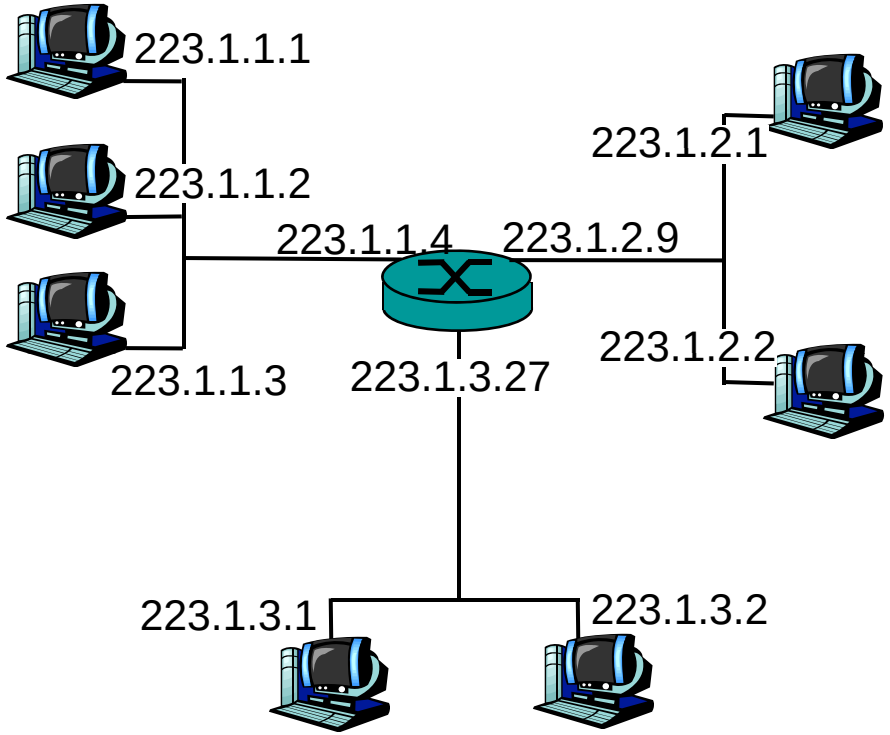
What are link state routing algorithms?

What are the problems or difficulties?

What are common network layers?

IP Addressing: introduction

- **IP address:** 32-bit identifier for host, router *interface*
- ***interface:*** connection between host/router and physical link
  - router's typically have multiple interfaces
  - host typically has one interface
  - IP addresses associated with each interface



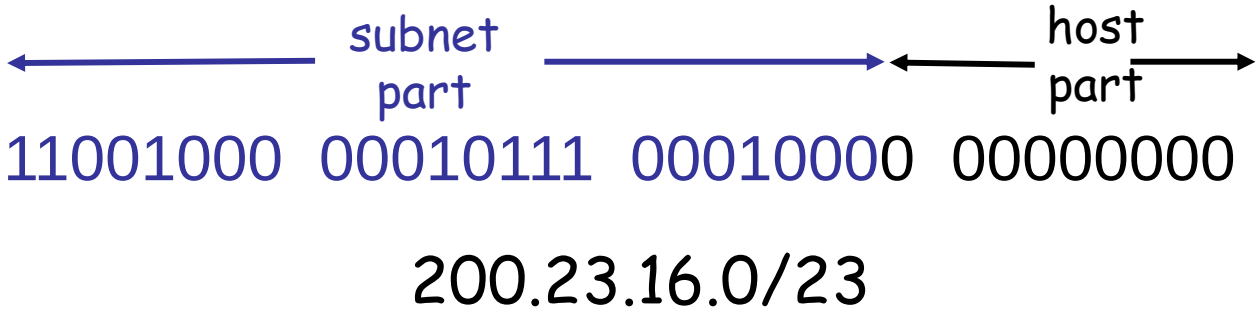
223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

IP addressing: CIDR

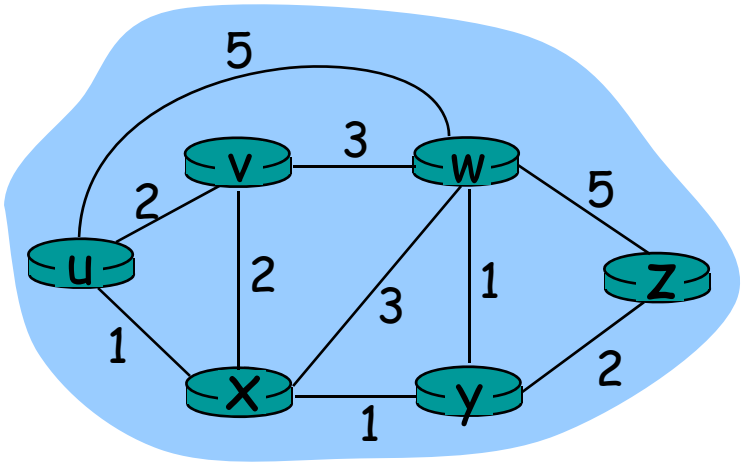
CIDR: Classless InterDomain Routing

- subnet portion of address of arbitrary length
- address format: a.b.c.d/x, where x is # bits in subnet portion of address



Dijkstra's algorithm: example

Step	N'	D(v),p(v)	D(w),p(w)	D(x),p(x)	D(y),p(y)	D(z),p(z)
0	u	2,u	5,u	1,u	∞	∞
1	ux	2,u	4,x		2,x	∞
2	uxy	2,u	3,y			4,y
3	uxyv		3,y			4,y
4	uxyvw					4,y
5	uxyvwz					



Transport layer

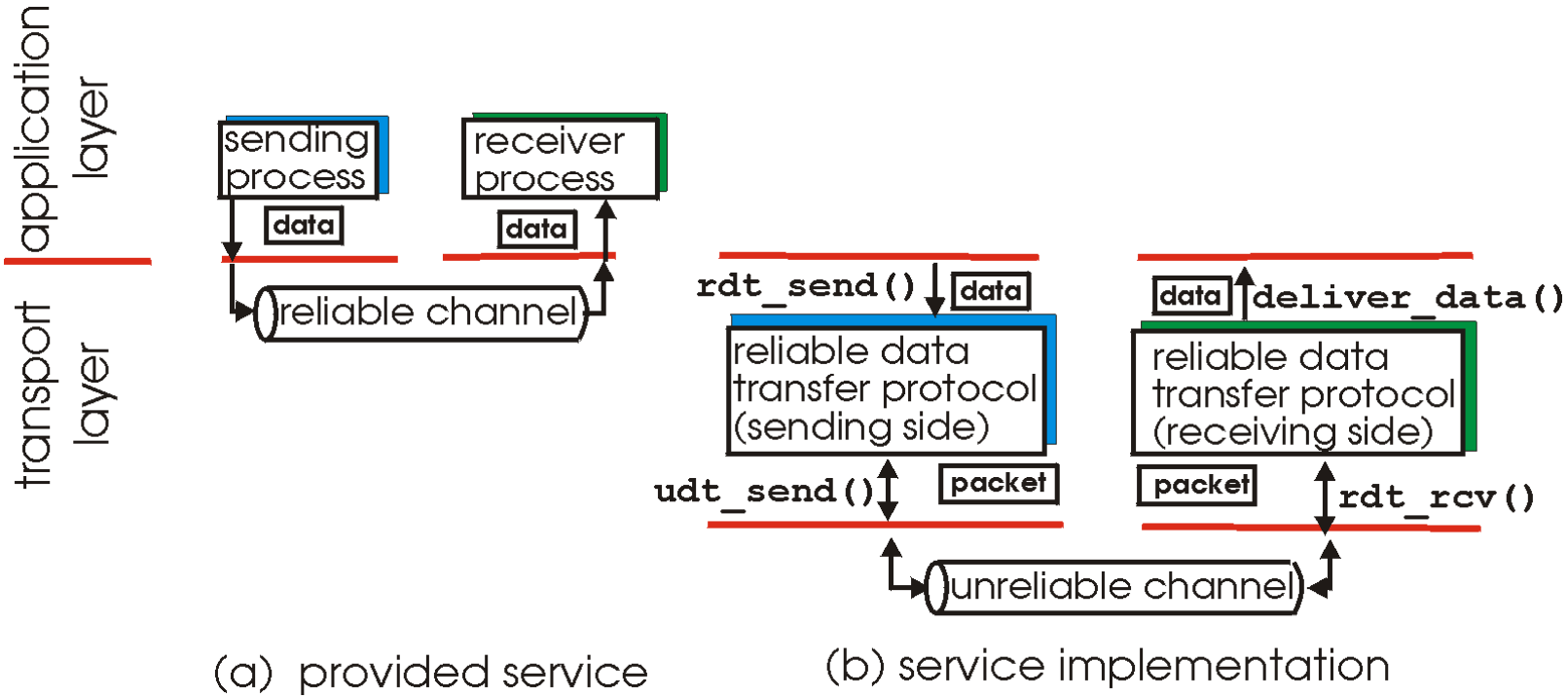
Why do we need a transport layer?

What are the problems or difficulties?

What are common transport layers?

Principles of Reliable data transfer

- important in app., transport, link layers
- top-10 list of important networking topics!

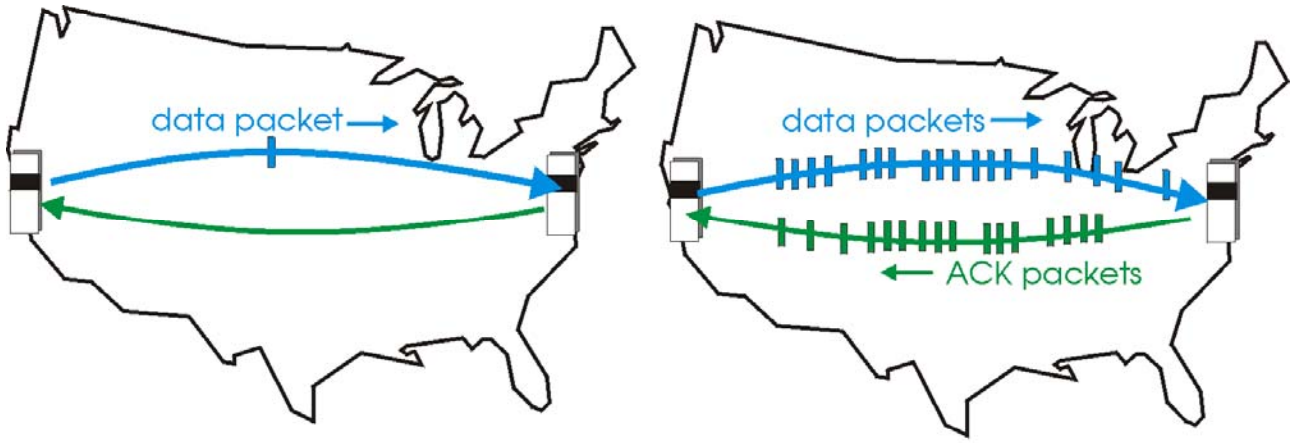


- characteristics of unreliable channel will determine complexity of reliable data transfer protocol (rdt)

Some issues….

Pipelining: sender allows multiple, "in-flight", yet-to-be-acknowledged pkts

- range of sequence numbers must be increased
- buffering at sender and/or receiver



(a) a stop-and-wait protocol in operation

(b) a pipelined protocol in operation

Application Layer

Why do we need applications!!

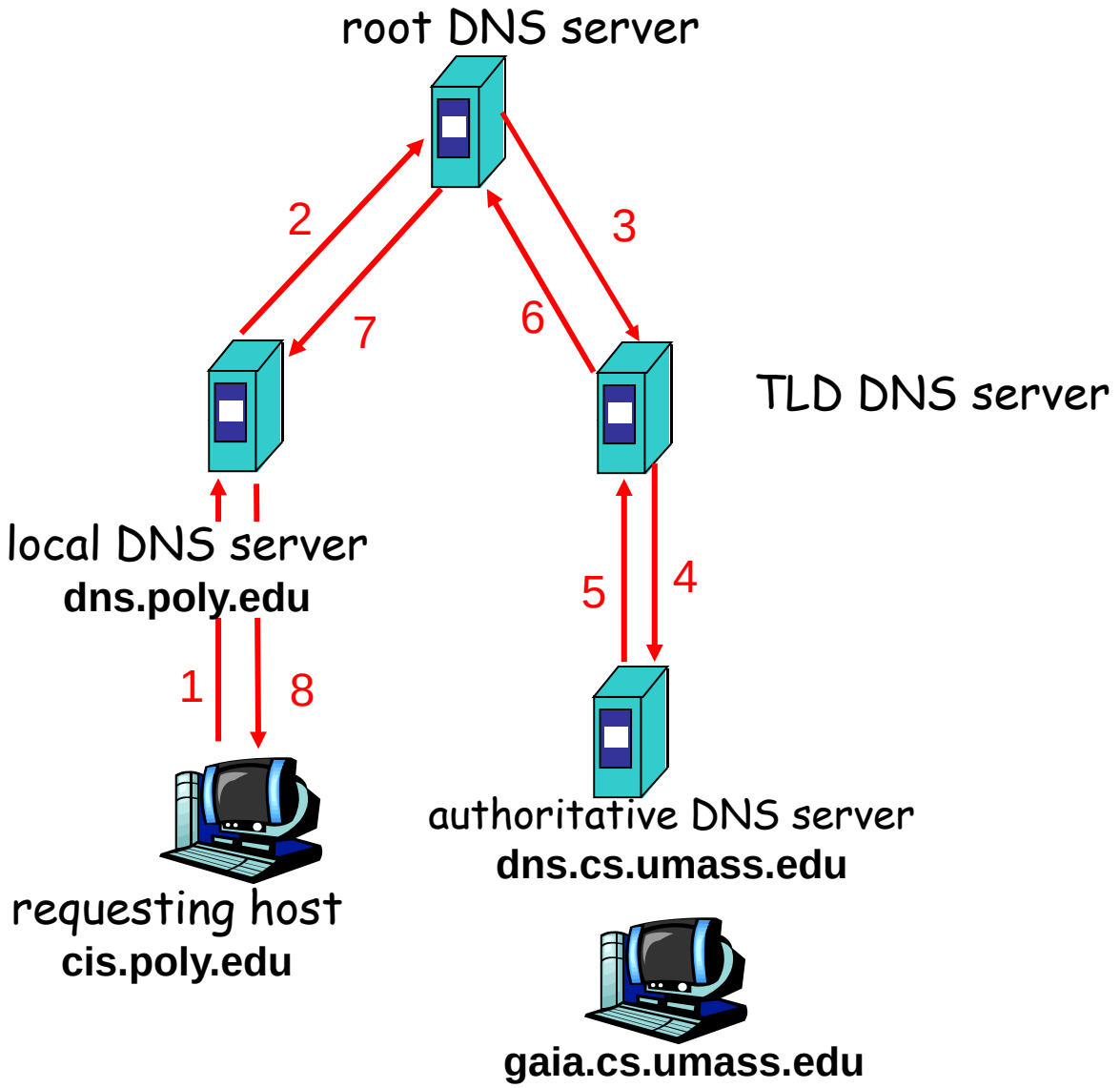
What are some common applications?

Any limitations or problems?

DNS name resolution example

recursive query:

- puts burden of name resolution on contacted name server
- heavy load?



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