Internet Protocols EBU5403

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	Part 1	Part 2	Part 3	Part 4
Ecommerce + Telecoms 1	Richard Clegg		Cunhua Pan	
Telecoma 2	Michael Chai			

Aims

- To introduce communication networks in general
- To provide knowledge of Internet Protocols
  - insight into functionality and inter-relationship.
- To enable design of basic intranet and internet architectures, including both bridged and routed networks.
- To provide in-depth knowledge of Transport Control Protocols
  - insight into features built on underlying network.

Key learning outcomes of EBU5403

- Explain the protocols that provide the Internet infrastructure, their role, how they operate and a number of implementation details.

- Design simple network architectures.

- Perform basic configuration and fault diagnosis in an Interior Gateway Routed environment using IOS-like scripts and utilities such as TCPDump, Ping and TraceRoute

Assessments

- Exam – 75%
- Coursework – 25%
  - Lab assessment (15%) in December.
  - 2 class tests (10%) half way through module and at the module end – closed book tests

- Structure of module. Prerecorded lectures telling you about the material.
- Interactive tutorials. You must watch the lectures before doing these tutorials. (If you have not watched the lecture you will find the tutorial hard to understand).

Course information

- QMPlus
  - All teaching materials (lecture slides and tutorial questions)
  - Lab information
- Check your QM email account regularly and you can email us by using your QM email address only.
  - Include your name in Pinyin (Not Chinese.)
- Module Representations
  - 2 students to volunteer.
  - Quick feedback meeting after class during the week.
- Course structure
  - Divided into four parts (used to be four weeks)
  - Call these parts A, B, C, D
- How to follow this course:
  - Watch online lectures before class.
  - Class will reinforce the points from these lectures.
  - If you haven't watched lectures you won't be able to follow the class

Part A Introduction

Many of these slides (and the theme) come from the course text book by Jim Kurose and Keith Ross
The original slides are freely available to download online.

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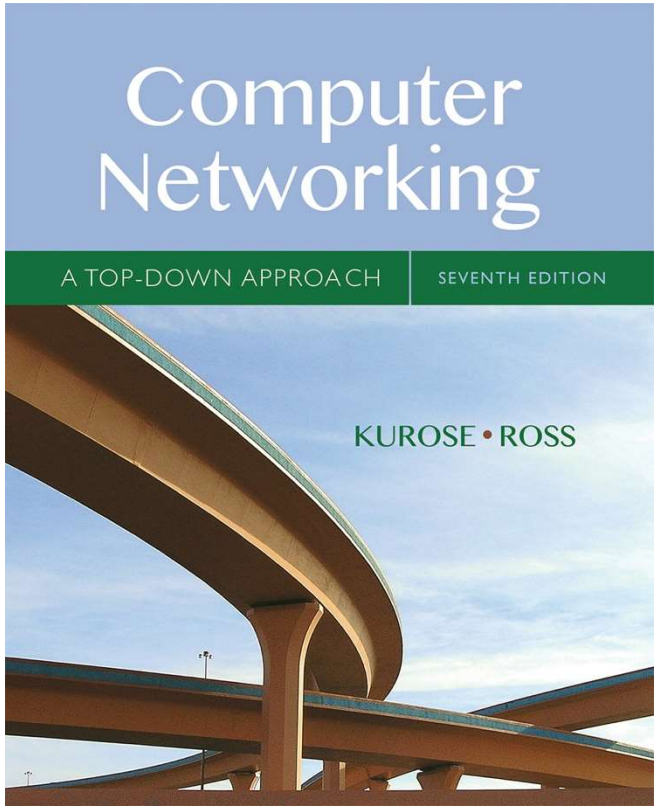

Computer Networking: A Top Down Approach

7th edition
Jim Kurose, Keith Ross
Pearson/Addison Wesley
April 2016

Structure of course

- Part A
  - Introduction to IP Networks
  - The Transport layer (part I)
- Part B
  - The Transport layer (part II)
  - The Network layer (part I)
  - Class test on part A and part B material
- Part C
  - The Network layer (part II)
  - The Data link layer (part I)
  - Router lab tutorial (assessed lab work after this week)
- Part D
  - The Data link layer (part II)
  - Network management and security
  - Class test on part C and part D material

Part A: IP networks introduction

our goal:

- get "feel" and terminology
- more depth, detail *later* in course
- approach:
  - use Internet as example

overview:

- what's the Internet?
- what's a protocol?
- network edge; hosts, access net, physical media
- network core: packet/circuit switching, Internet structure
- performance: loss, delay, throughput
- protocol layers, service models
- history

Introduction to IP: roadmap

1.1 what *is* the Internet?

1.2 network edge

- end systems, access networks, links

1.3 network core

- network structure

Lecture 1

1.4 delay, loss, throughput in networks

1.5 protocol layers, service models

1.6 history

Lecture 2

Introduction to IP: roadmap

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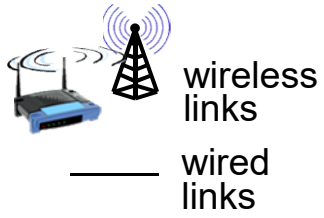
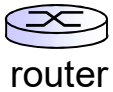
What's the Internet: "nuts and bolts" view

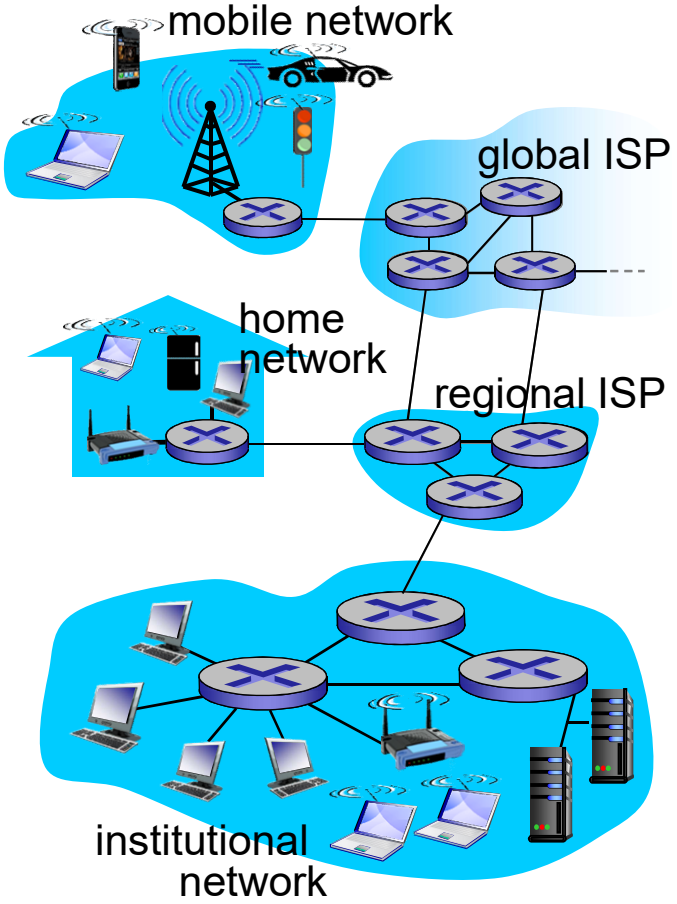
- billions of connected computing devices:
  - *hosts* = *end systems*
  - running *network apps*



- *communication links*
  - fiber, copper, radio, satellite
  - transmission rate: *bandwidth*



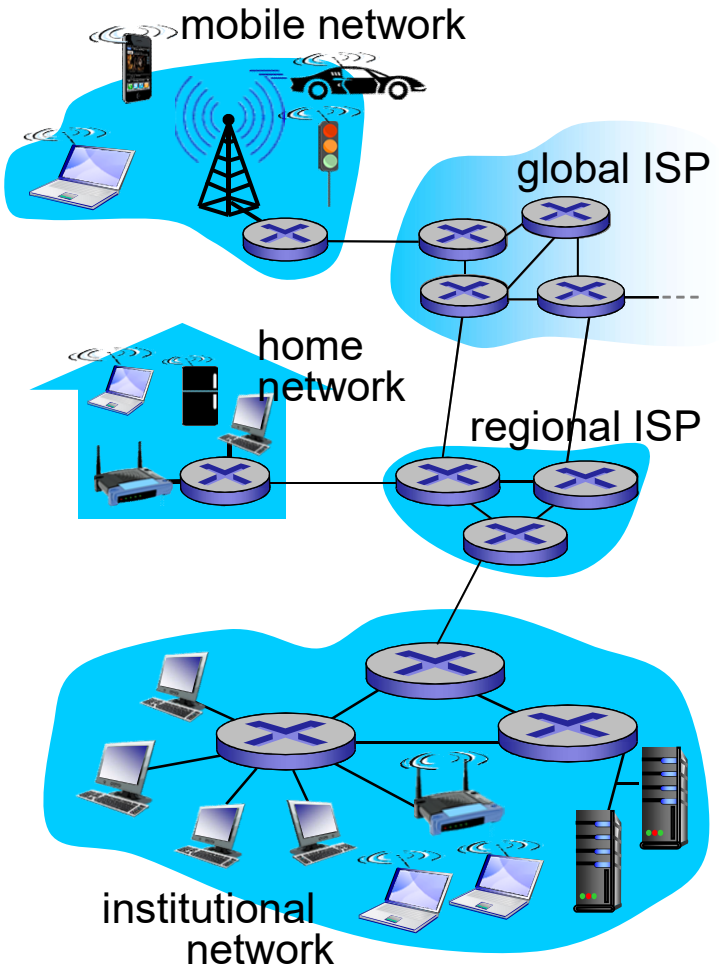
- *packet switches:* forward packets (chunks of data)
  - *routers* and *switches*



ISP (Internet Service Provider)

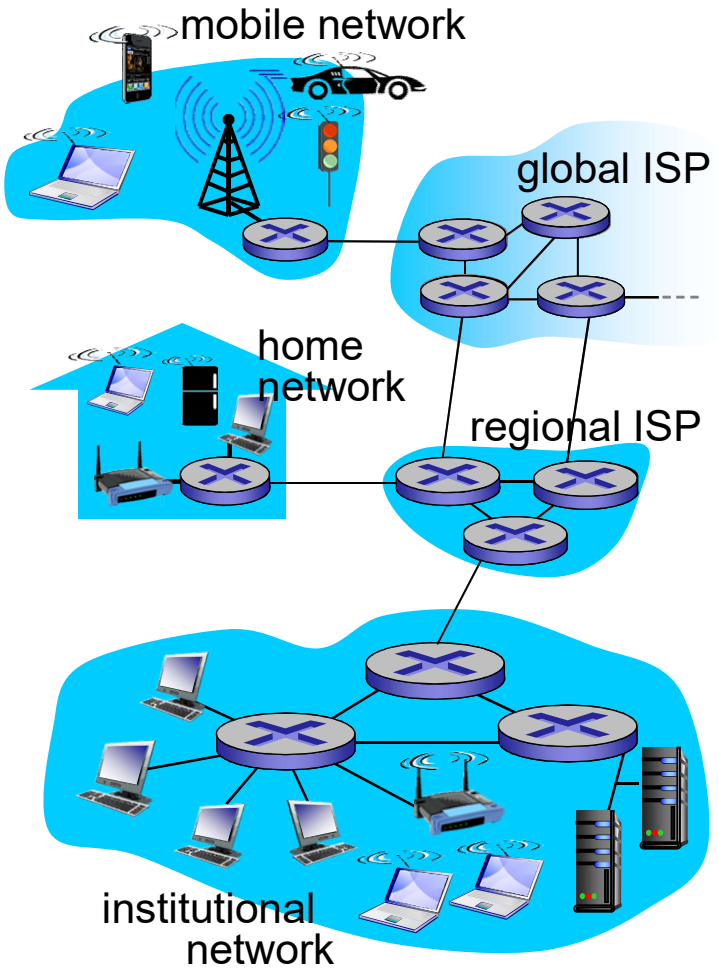
What's the Internet: "nuts and bolts" view

- *Internet:* "network of networks"
  - Interconnected Internet Service Providers (ISPs)
- *protocols* control sending, receiving of messages
  - TCP (Transmission Control Protocol)
  - IP (Internet Protocol)
  - HTTP (HyperText Transfer Protocol)
  - 802.11 (WiFi standard)
  - Many many more
- *Internet standards*
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



What's the Internet: a service view

- *infrastructure that provides services to applications:*
  - Web, VoIP (Voice over IP), email, games, e-commerce, social nets, …
- *provides programming interface to apps*
  - hooks that allow sending and receiving app programs to "connect" to Internet
  - provides service options, analogous to postal service



What's a protocol?

human protocols:

- "what's the time?"
- "I have a question"
- introductions

… specific messages sent

… specific actions taken when messages received, or other events

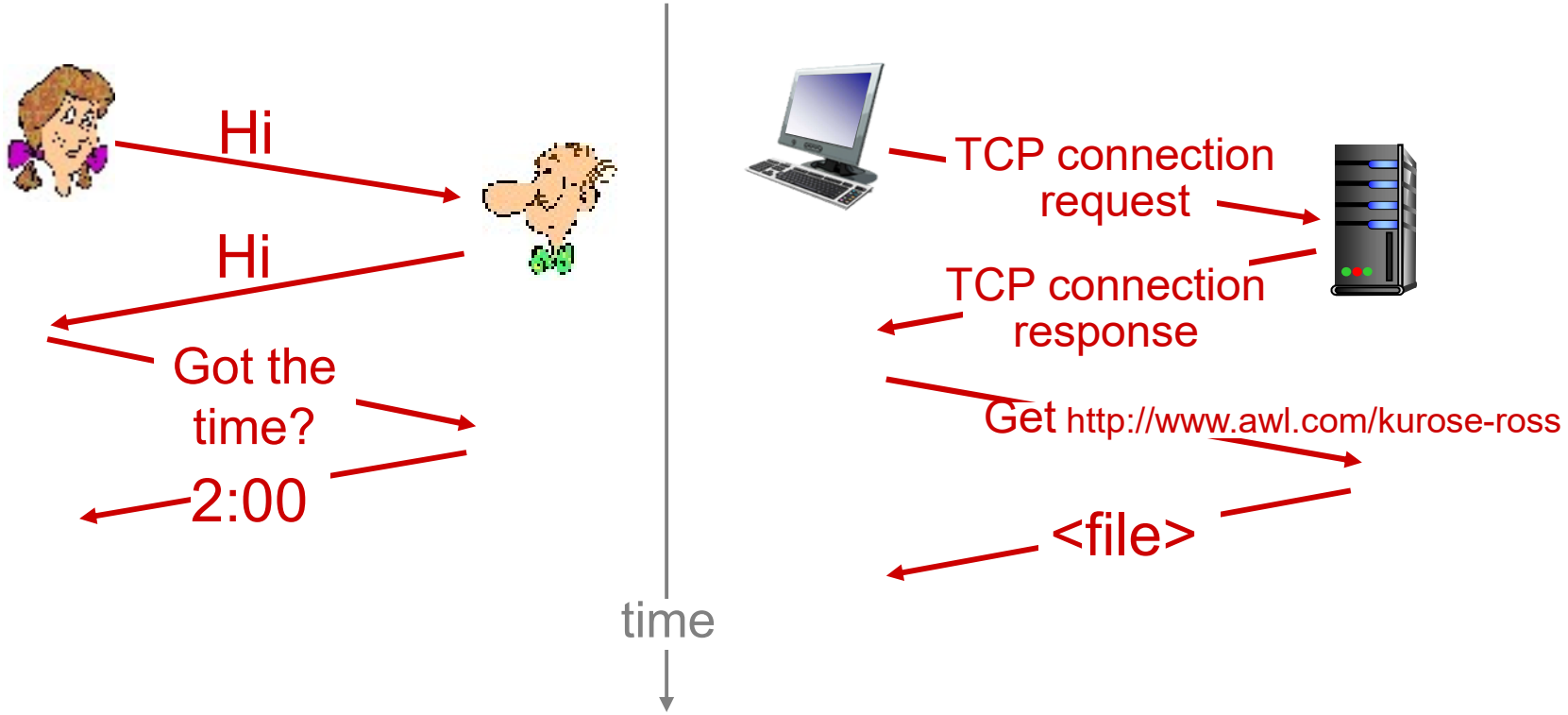
network protocols:

- machines rather than humans
- all communication activity in Internet governed by protocols

protocols define format, order of messages sent and received among network entities, and actions taken on message transmission, receipt

What's a protocol?

a human protocol and a computer network protocol:



Q: other human protocols?

Introduction to IP: roadmap

1.1 what *is* the Internet?

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- network structure

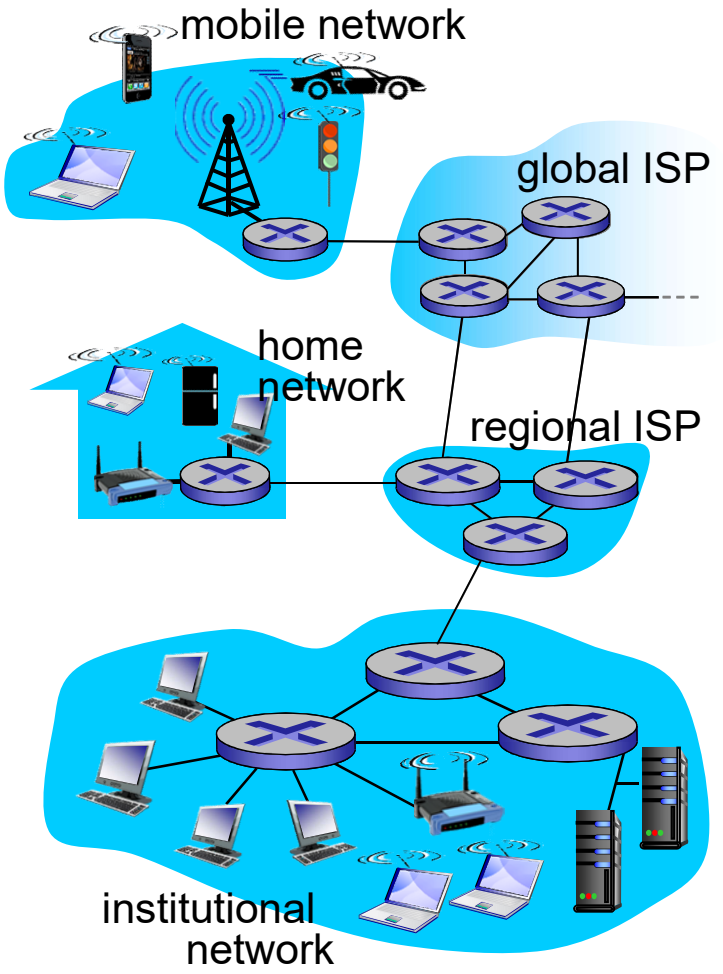
1.4 delay, loss, throughput in networks

1.5 protocol layers, service models

1.6 history

A closer look at network structure:

- *network edge:*
  - hosts: clients and servers
  - servers often in data centers
  - part of the network with the users and computers
- *access networks, physical media:* wired, wireless communication links
  - part of network connecting edge to rest of network
- *network core:*
  - the "middle" of the network
  - interconnected routers
  - network of networks



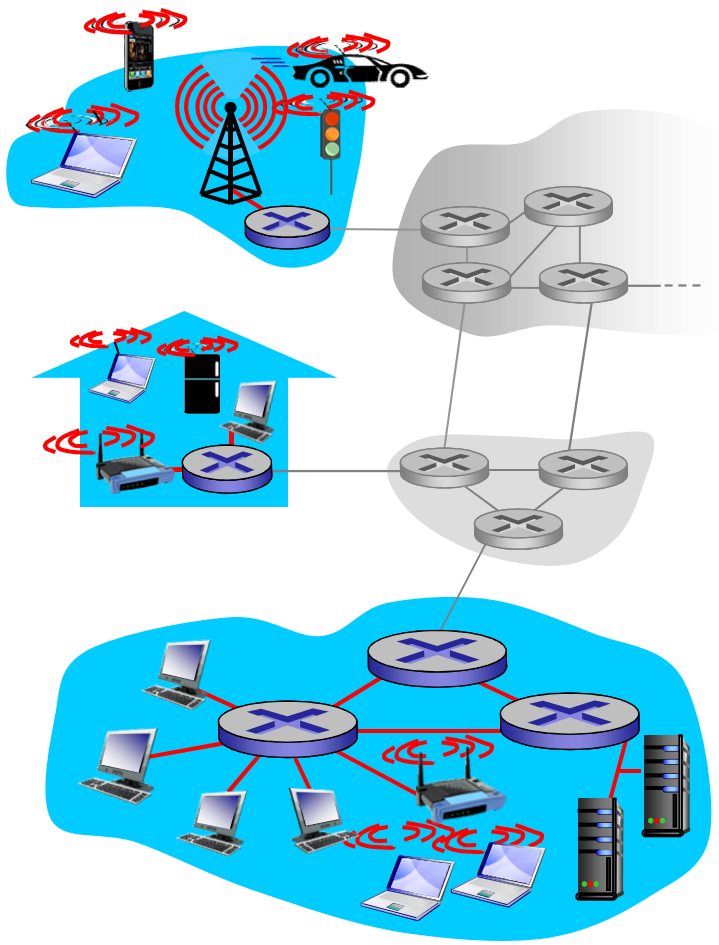
Access networks and physical media

Q: How to connect end systems to edge router?

- residential access nets
- institutional access networks (school, company)
- mobile access networks

keep in mind:

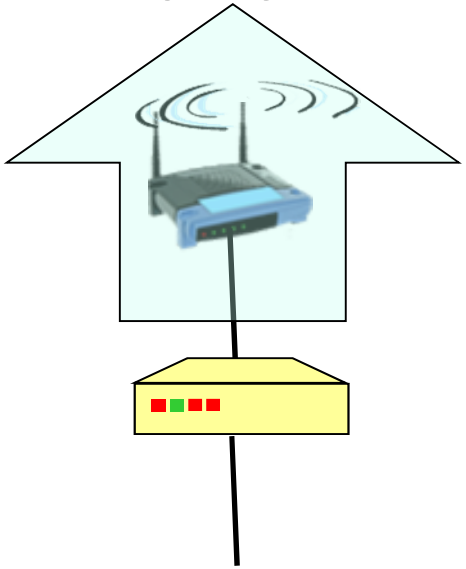
- bandwidth (bits per second) of access network?
- shared or dedicated?



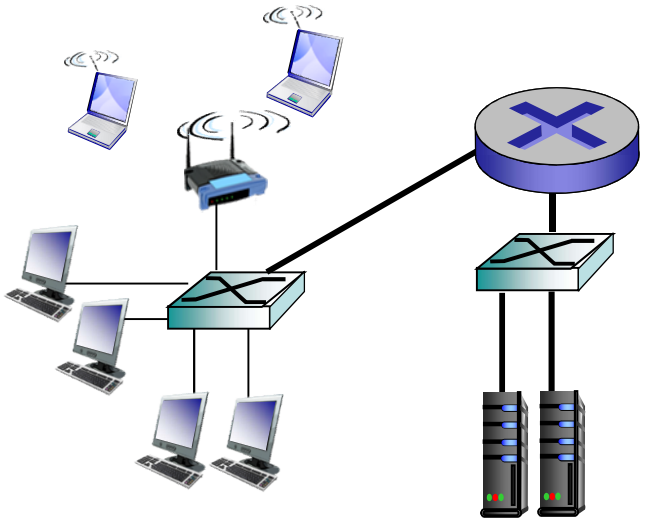
Access networks:

- These networks connect end users to the rest of the internet.

Home network



Office network



Mobile phone network

Network basics bits and bytes

- A bit is a "binary digit" – a single 0 or 1.
- A byte is a group of eight bits – can be thought of as a number from 0 to 255 (or -128 to 127) or as two digits of "hexadecimal" (eg A0, FF, 10).
- Amounts of data are usually specified in bytes.
  - 1KB = 1 kilobyte = 1000 bytes = 8000bits
  - 1MB = 1 megabyte = 1 million bytes = 8 million bits
  - 1GB = 1 gigabyte = 1000 million bytes = 8000 million bits
- BUT speeds are usually in bits per second (not bytes)
  - 1b/s (or bps) = 1 bit per second
  - 1Kb/s = 1000 bits per second
  - 1Mb/s = 1 million bits per second
  - 1Gb/s = 1000 million bits per second

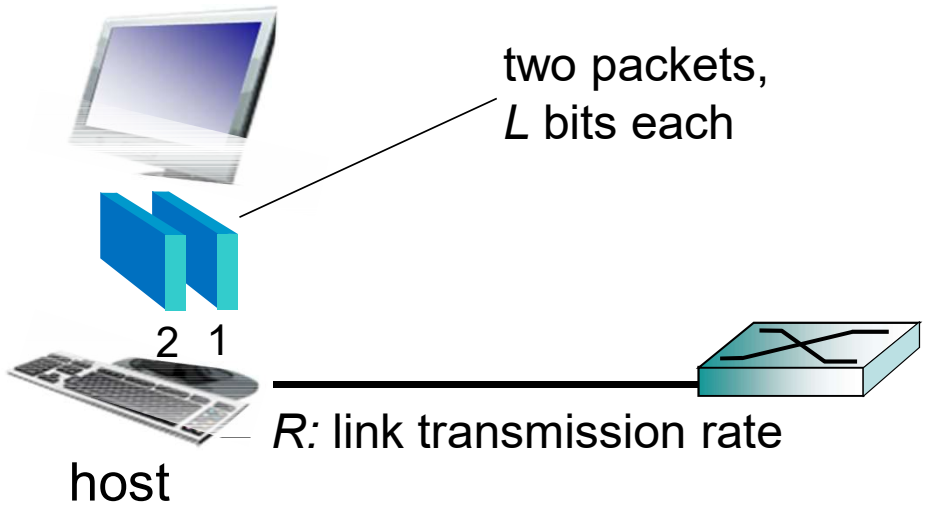
Network basics – packets

- Imagine we want to transmit 10GB of data.
- This may take several hours to send.
- It is useful to split the data down into smaller units (known as packets).
- This "packet" of data can be sent relatively quickly.
- The packet can be, for example, checked for errors.
- The packet could be retransmitted if a problem was detected.

Host: sends *packets* of data

host sending function:

- takes application message
- breaks into smaller chunks, known as *packets*, of length *L* bits
- transmits packet into access network at *transmission rate R*
  - link transmission rate, aka link *capacity, aka link bandwidth*



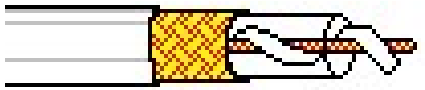
$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

Physical media

- Physical media represent the actual hardware that carries the data. Think about physical wires or radio transmissions (wireless).

Ethernet cable

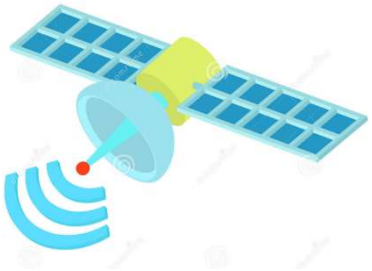
Fibre optic



Coaxial cable

WiFi (802.11)

3/4/5G mobile (mobile phone)



Satellite

Example of bandwidth

- A packet of 1500B is transmitted by a network which has a bandwidth of 1Mb/s. How long does it take?
- Formula L (length, bits)/ R(rate, bits/second)
- 1500B = 1500x8 bits = 12,000 bits
- 1Mb/s= 1,000,000 bits per second.
- Time = 12,000/1,000,000 sec
- = 0.012 sec
- = 12 ms

What have we learned?

- Internet
  - A network of networks. Inter = in between.
  - Protocols govern how systems connect.
  - Later lectures will explain these protocols in detail.

- Bandwidth: Measure of how much data we can send
- Packet: a basic unit of data