COMPSCI 314 S2T

Data Communications Fundamentals

- Introduction
- Basic concepts
- Assignment 1

COMPSCI 314 S2 T 2009
Data Communications Fundamentals

Lecturers

- Cris Calude – Room 575, cristian@cs.auckland.ac.nz
- Brian Carpenter – Room 587, brian@cs.auckland.ac.nz
- Nevil Brownlee – Room 590, n.brownlee@auckland.ac.nz

Test Date

Friday 14 August, 9:35 – 10:20 am

Assignments due

(via the CS DropBox, dates subject to revision)

Monday	24 August
Friday	25 September
Friday	16 October

Course web pages - keep an eye on them!

http://www.cs.auckland.ac.nz/compsci314s2t/

Other matters

- Class representative

  Your name could be here: _________________

- Tutor

  DongJin Lee

- Assignment extensions

  We will consider extensions to the assignment due date only for —

  1. Illness or other unforeseeable emergency
  2. Conflicts with other assignments, but only if the request is made
     within *one* week of the assignment being distributed

  We will not be sympathetic if told "The 314 assignment is due tomorrow and I have 3 other assignments also due then; can I please have an extension?"

  The dates have been published weeks ahead; you should have planned your work better or arranged earlier for an extension

There are no stupid questions...

. . . only stupid answers

- Questions

  If you're stuck or don't understand, please contact any of your lecturers.

  Or consider using the class forum.

- Email

  Email must include the course number (314) and your UPI.

  A name is nice, too.

Approach to material

- We (mostly) follow the textbook (Shay, 3rd edition)
- The lectures will provide in-depth discussion and comment on the course material.
  - Students who miss the lectures tend to get lower grades
  - You should also read the relevant sections in the textbook
- The course does *not* cover *all* of the textbook. The sections that are covered are shown on the lecture outline, as it appears on the *lectures* page linked off the *course web page*
- *Changes* to the course outline and/or content will be notified on the course web page
- We assume that students already have some understanding of Data Communications.
  - If not, you may need to read ahead in Shay
  - Assignment 1 is designed to bring you up to speed

Approximate plan of course

Week starting	Tuesday	Thursday	Friday	
20 July 2009	1 Introduction	2 Signals	3 Codes	
27 July 2009	4 Analog & Digital	5 Analog & Digital	6 Compression	
3 Aug 2009	7 Compression	8 Data Integrity	9 Data Integrity	
10 Aug 2009	10 Encryption	11 Authentication	Test	***TEST: Fri 14 Aug***
17 Aug 2009	12 Flow Control	13 Flow Control	14 LAN: link control	
24 Aug 2009	15 Ethernet	16 Ethernet	17 Wireless, 802.11	***Ass 1 due 24 Aug***
31 Aug 2009 7 Sept 2009	— Mid Semester Break —			
14 Sept 2009	18 Bridges	19 Switches	20 Routing	
21 Sept 2009	21 Routing	22 IPv4 basics	23 IPv4 and DNS	***Ass 2 due 25 Sept***
28 Sept 2009	24 IPv6	25 TCP	26 UDP, sockets	
5 Oct 2009	27 Applications	28 P2P applications	29 P2P applications	
12 Oct 2009	30 HTTP, the web	31 Loose ends	32 Course overview	***Ass 3 due 16 Oct***
19 Oct 2009	*No lectures – just lots of time to study*			

Changes are possible at any time!

Main objectives

- Explain how signals and data are transmitted over various media. This is a prerequisite for understanding how networks are constructed and made reliable and secure.
- Introduce the principles of Local Area Networks. This material allows one to understand how larger-scale networks - such as the Internet - are built up from LANs.
- Explain how network protocols, especially TCP/IP, are designed and fitted together, and how they form the basis for the Internet and for distributed computing.

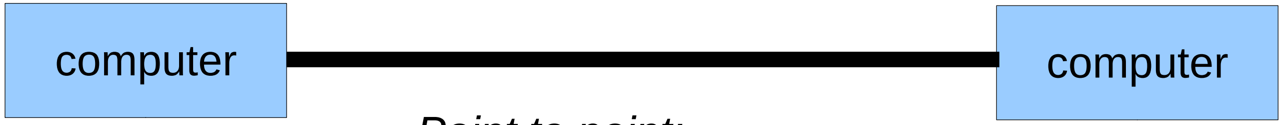
➔ Our focus is on *how things work*, especially on the underlying principles and protocols – we won’t look at ‘how to configure a router,’ etc.

Overview

See Chapter 1 of Shay

- Data communications is often (mostly) implemented using various layers in a protocol stack
- The layers are: 1 (physical) 2 (link), 3 (network), 4 (transport) and 5..7 (Applications)
- The need for these layers arises from the structure of networks and the needs of applications.

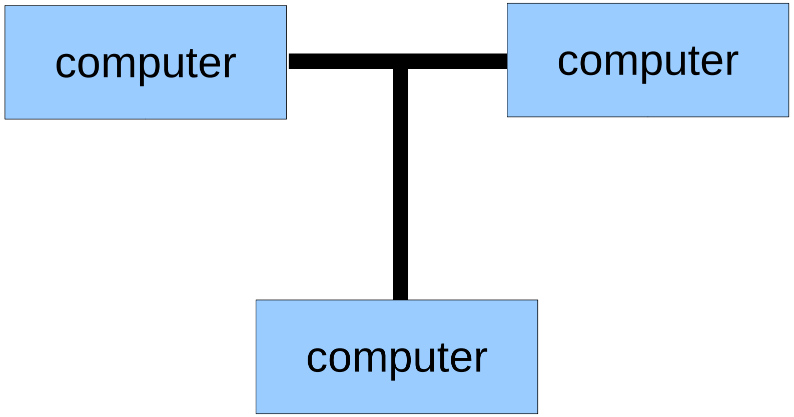
Network types



computer

computer

Point to point:
How to send bits?



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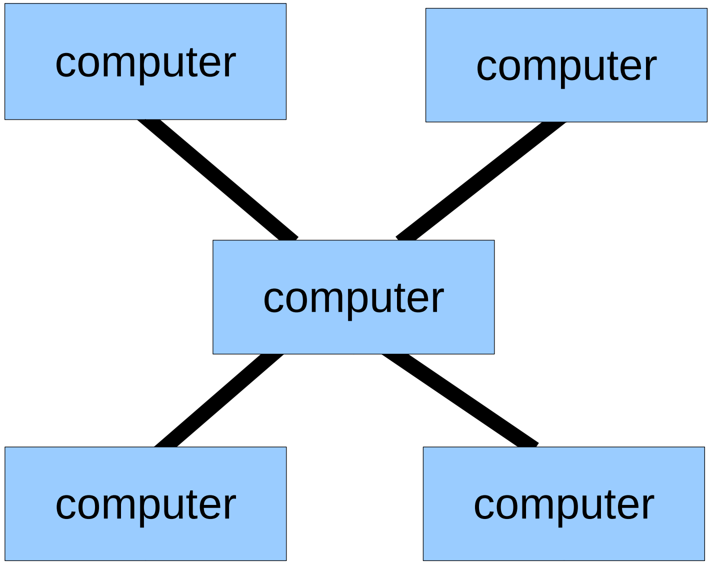
Shared link:
How to send bits to the right destination?



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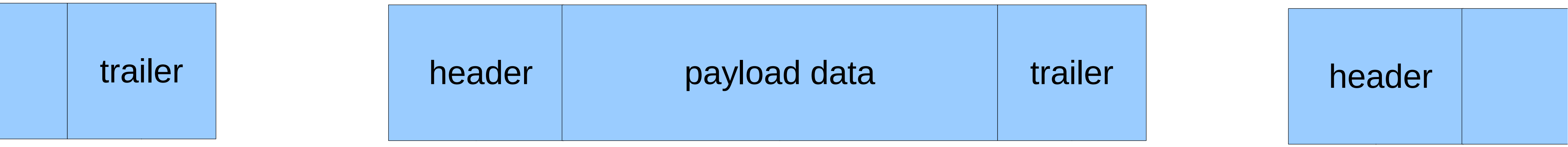
Mesh:
How to send bits indirectly to the right destination?

Addressing

- As soon as we have more than two devices talking to each other, we need to have an address for each device.
  - Where devices are on the same cabling system or wireless system, usually a *Local Area Network*, the addresses are called *physical, hardware* or *link-level* addresses.
  - Where devices are indirectly connected, the addresses are logical addresses usually called *network* addresses.

Packets

- Data flows over the network in *packets.*
  - Packets are sometimes called *datagrams*.
  - Packets are known as *frames* when considering the physical layer.
  - There are gaps between the frames.
  - Packets allow many users to share one network
  - Packets include *headers* and optional *trailers* as well as useful data (called the *payload*).
  - Headers include source and destination *addresses*.



Things to do in a network

1. Transmit bits from one place to another (Physical)
2. Assemble bits into bytes and messages, check for reliable transmission, deliver to correct destination (Link)
3. Send messages indirectly between end-nodes in mesh-type network (Network)
4. In a mesh network, handle lost packets, broken links etc (Transport)

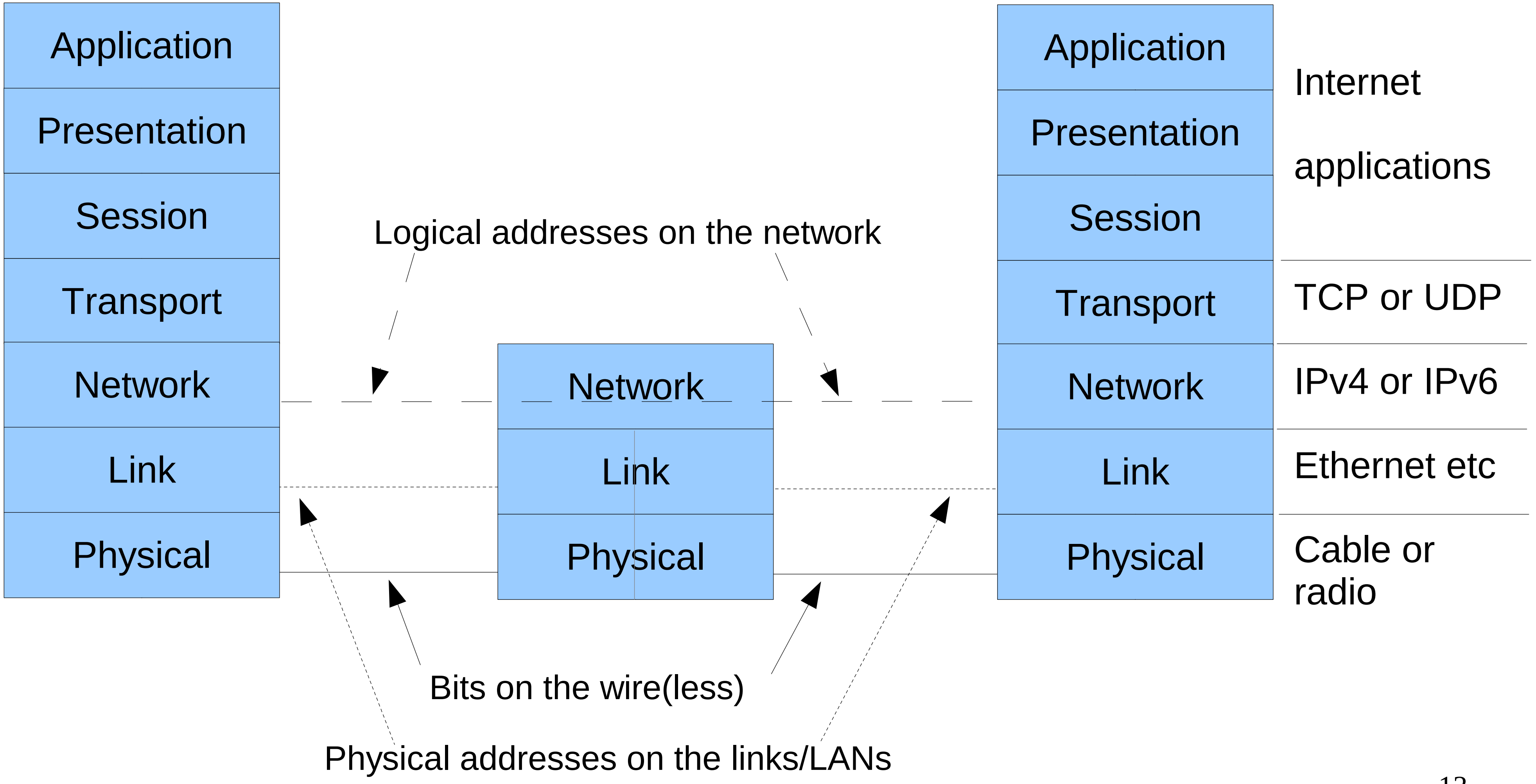
5. Handle extended connections between endpoints, LANs, etc.
6. Resolve differences between data representation in different computers
7. Do something useful (User application)

These are the seven layers of the “Open Systems Interconnection” (OSI) communications model.

TCP/IP (Internet) combines layers 5-7, into a single Application layer.

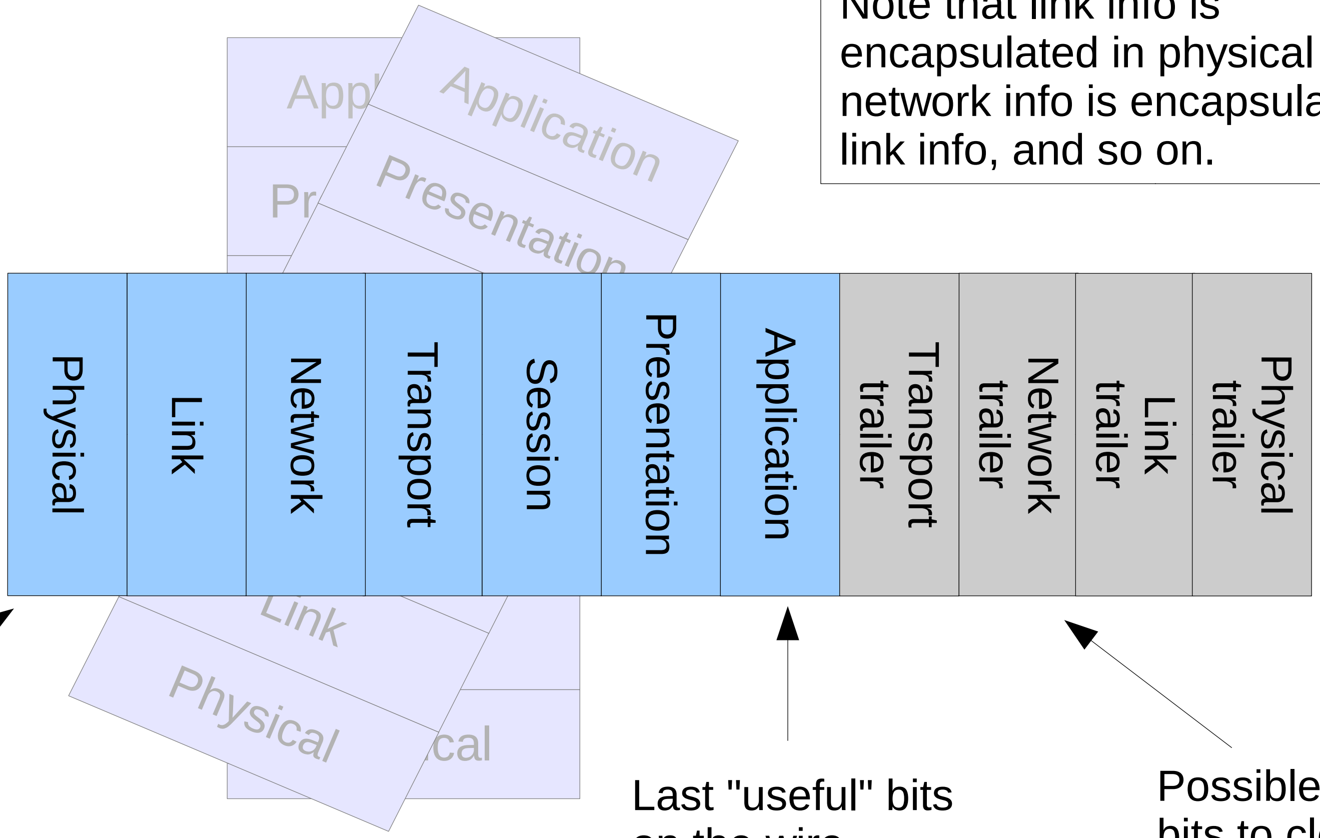
We focus on the Internet, i.e. on TCP and related protocols.

The formal model



Data packets on the wire (or on a radio link)

Note that link info is encapsulated in physical info, network info is encapsulated in link info, and so on.



First bits on the wire

Last "useful" bits on the wire

Possible trailer bits to close off layers 1-4

A real packet that you might see

Ethernet preamble	Ethernet link header	IP header	TCP header	HTTP header+data	Ethernet trailer

1 2 3 4 5,6,7 ...2,1

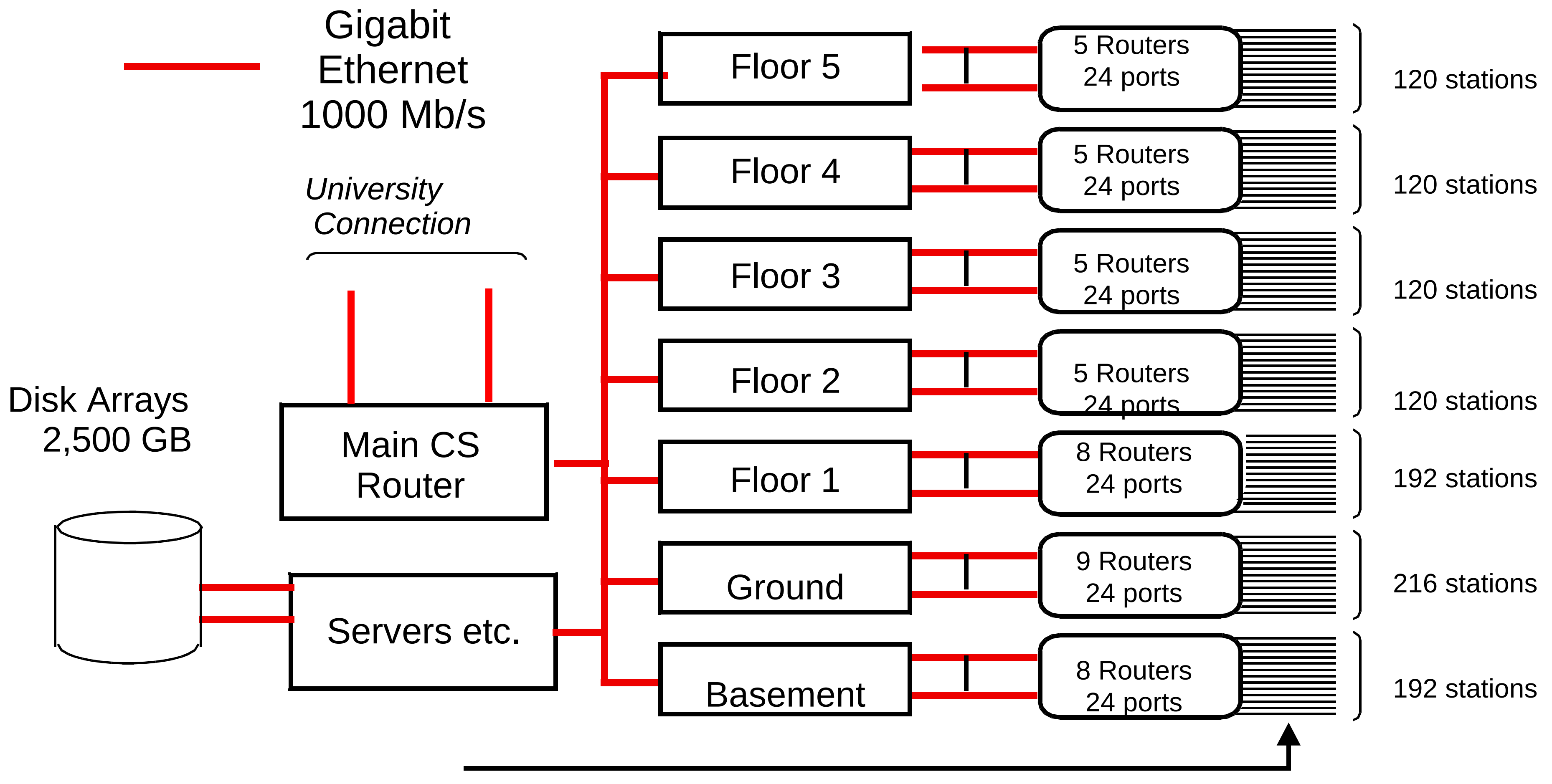
(most layers don't require trailers in practice)

- Ethernet physical layer encapsulates
  - Ethernet link layer encapsulates
    - IP encapsulates
      - TCP encapsulates
        - HTTP

A real network

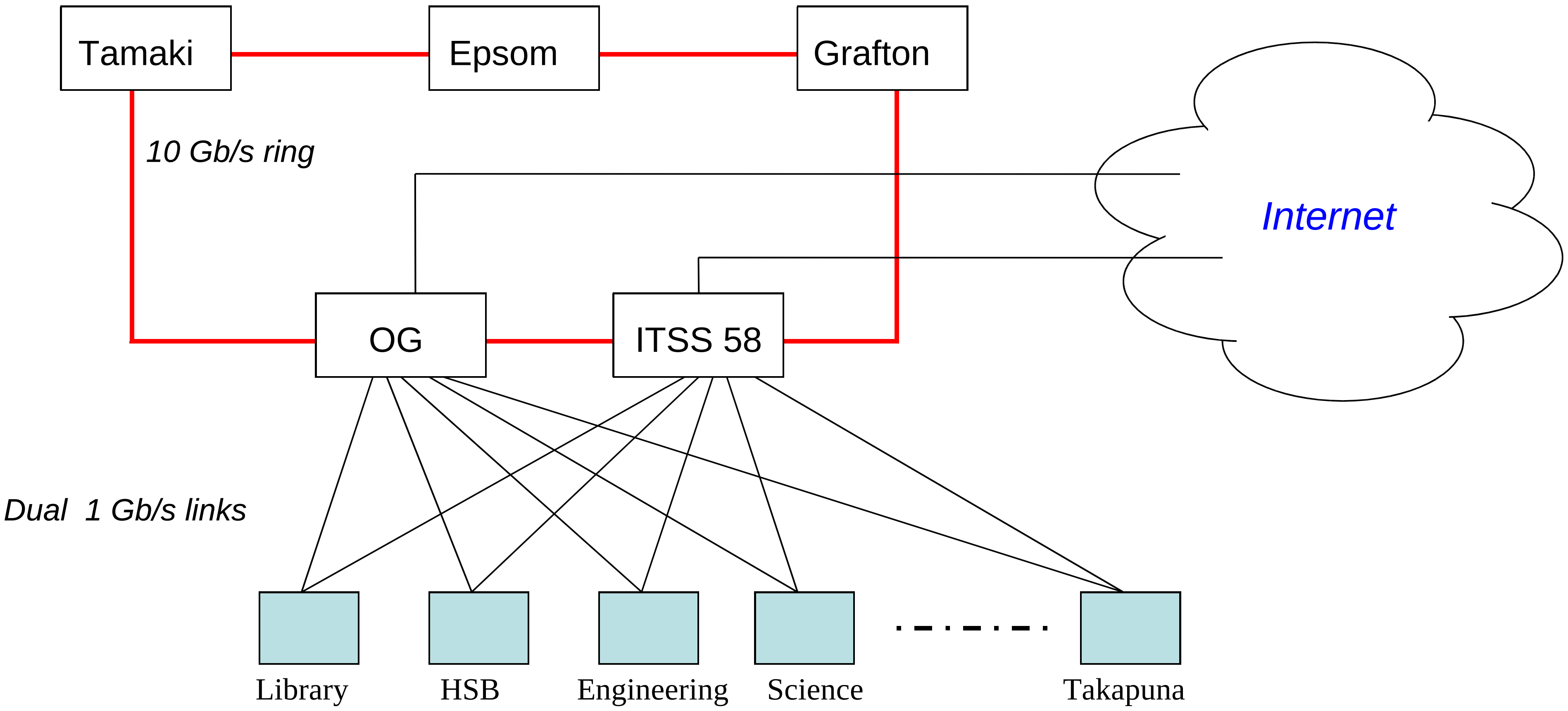
- Here's a (very brief) overview of the U Auckland network.

Simple view of Computer Science Network, 2003



All final links are 10/100 Mb/s Ethernet

The U Auckland Network, early 2007



Communications basics

See Shay 2.1-2.3

- Data is sent from / received by an *interface* on a device (e.g. a PC)
- It may be sent directly, using *baseband* transmission, or it may be mixed with a carrier signal, i.e. sent using *modulated* transmission
- The time taken to transmit one bit (‘0’ or ‘1’) is called the *bit cell period*. Within each such period, a receiver must decide whether the incoming bit is ‘1’ or ‘0’

Important information on transmission of bits

Bits, as electrical or optical signals, always travel at a ‘propagation speed’ of

- 300,000 km/s in “free space” (radio, satellites, etc) (30cm per nanosecond)
- 200,000 km/s on copper or fibre-optic cables (20cm per nanosecond)

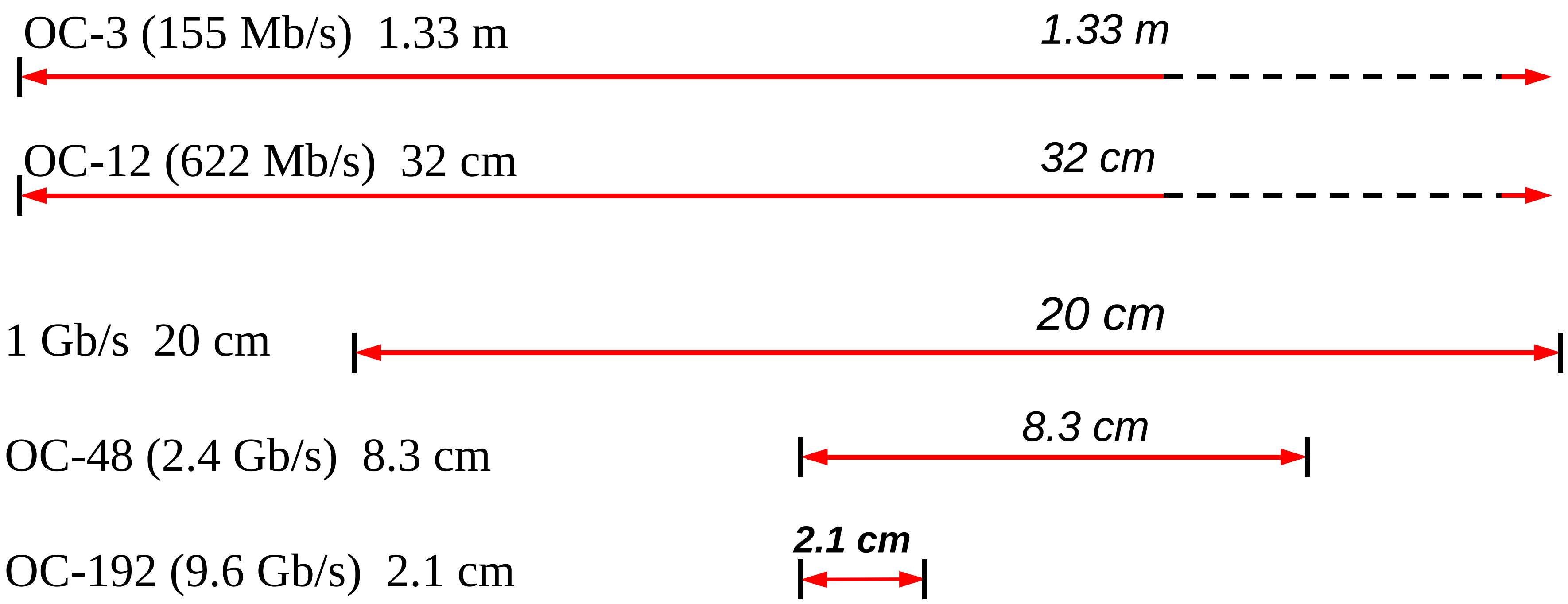
A ‘faster’ link has the bits arriving *more often* (say 1000 per microsecond, rather than 100 per microsecond), but they *never travel any faster*.

- The circumference of the Earth is 40,000 km (by the original definition of the metre)
- The distance from New Zealand to North America, South America, Japan or Singapore is close to 10,000 km.
- The delay or “latency” from New Zealand to almost anywhere except Australia is at least 1/20 second (50 ms). This delay cannot be reduced!

Distances between bits, on optical fibre

Assume propagation speed of 200,000 km/s in glass fibre

(These distances are nearly correct if the page is printed on A4 paper).



OC-3 (155 Mb/s) 1.33 m

1.33 m

OC-12 (622 Mb/s) 32 cm

32 cm

1 Gb/s 20 cm

20 cm

OC-48 (2.4 Gb/s) 8.3 cm

8.3 cm

OC-192 (9.6 Gb/s) 2.1 cm

2.1 cm

Communication Media: Conductive Metal

- Co-axial Cable (2.3)
  - Centre conductor, surrounded by a metal screen
  - Signal carried by the centre conductor, screened from electrical *noise*
- Twisted Pair (2.2)
  - Carries *balanced* signals, so as to minimise electrical *noise*
  - Cheaper and easier to install and use than co-ax
  - UTP cable has 4 pairs in an outer covering
  - Cat (Category) 5 UTP used for 100 Mb/s, cat 6 for 1 Gb/s

Communication Media: Optical Fibre (2.3)

- Uses thin (about 50 micron) glass fibre to carry pulses of light
- Fibre is either *graded index* or *step index,* restricting the light’s *propagation mode* so as to confine it inside the fibre
- Attenuation in fibre is low, making it suitable for long-haul (70 km or more) links
- Submarine cables can use optical amplifiers. For example, Southern Cross connects Sydney-Auckland-Fiji-Honolulu-Los Angeles

- Immune to electrical noise

Communication Media: Wireless (2.4)

- Use electromagnetic waves to carry the signal in air (terrestrial) or free space (satellite)
- Wireless LANs (*802.11*) commonly used to link laptop PCs to an Internet *access point*
  - Range usually inside a room or building, say 50m
  - One access point can handle many laptops
- 802.11 can be used (with directional antennas) for much longer hops, so as to form regional networks
- Bluetooth used to link devices without wires
  - Cell ‘phone to laptop, mouse to PC
  - Range about 10m or less

Assignment 1

- Due August 14 and you can start immediately
    - worth 5% of the final grade
- Understand the basic concepts of protocol layers and encapsulation by <u>practical observation</u> in the CS lab.
- Read and understand the tutorial document (13 pages) linked as "support material" at http://www.cs.auckland.ac.nz/compsci314s2t/assignments/
- Learn to use the packet capture tools provided.
- Capture data for each part of the assignment, and analyse the results to answer the questions.
    - don't forget to include captured data in your PDF file

Background for Assignment 1

- Revise the material about TCP/IP from CompSci 215, or look ahead in Shay Chapters 9, 10 and 11.
- Packets include a sequence of *headers* corresponding to protocol layers.
- If we can inspect the packets, we can see and understand the headers.
- The CS lab machines have some tools for 314 students to allow capture and inspection of your packets.
  - capture packets to and from your IP address only, for privacy reasons

Tools installed on CS lab Windows

- wincap - a simple library supporting the windump command line utility.
- wireshark - a packet capture tool with a GUI.
- Using the tutorial, try out some packet captures like the examples in sections VI and VII.
- Then you should be ready to start the assignment.