COMPSCI 314 S2C 2011

Modern Data Communications

- Introduction
- Basic concepts

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Modern Data Communications

Lecturers

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- Cris Calude - Room 575, cristian@cs.auckland.ac.nz
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Class representative

Your name could be here: ____________________

Tutor

- Habib Naderi - Room 595, hnad002@aucklanduni.ac.nz

Course web pages - keep an eye on them!

http://www.cs.auckland.ac.nz/courses/compsci314s2c/

Assessment

- Final Exam 70%
- Test 15%
  - Friday 26 August, 3:00 – 4:00 pm
- Assignments 15%
- Assignments due

  (via the CS DropBox, dates subject to revision)
  - Friday 19 August
  - Friday 23 September
  - Friday 14 October

About assignments

- Assignment extensions
  - We will consider extensions to a 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 issued.
  - We will not be sympathetic if told about conflicts at the last minute. Please plan your work.
  - Assignments must be all your own work. Cut and paste is not allowed without "..." and acknowledgment. For example,

    "To be, or not to be, that is the question" [William Shakespeare]

There are no stupid questions...

. . . only stupid answers

- Questions

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

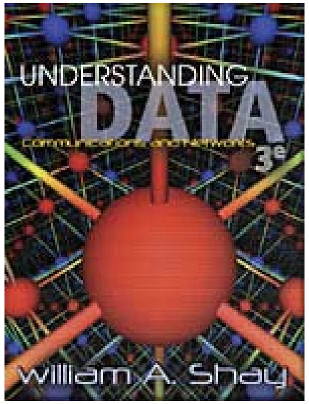
- Email

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

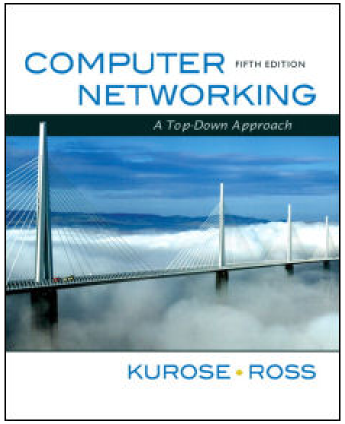
A name is nice, too.

Text book

- If you want a good grade, a textbook will help you understand the material properly.



- The recommended textbook is William A. Shay, *Understanding Data Communications and Networks* (3rd Edition).
- Unfortunately this has just gone out of print. If you can't get a copy, we suggest J.F.Kurose & K.W. Ross, *Computer Networking* (5th Edition).



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 2 is designed to bring you up to speed for later parts of the course.

Approximate plan of course

- Introduction
- 9 lectures on signals, codes, data integrity.
- 2 lectures on data communications security.
- 10 lectures on local area networks, switching, routing.
- 8 lectures on Internet protocols.
- Course review

Changes are possible at any time - check the web site:

http://www.cs.auckland.ac.nz/courses/compsci314s2c/#tt

Main objectives

- Explain how signals and data are sent over various media.
  - You need this to understand how networks are constructed and made reliable and secure.
- Introduce the principles of Local Area Networks.
  - You need this to understand how large-scale networks, like the Internet, are built up from LANs.
- Explain how network protocols, especially TCP/IP, are designed and fitted together
  - You need this to understand 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.

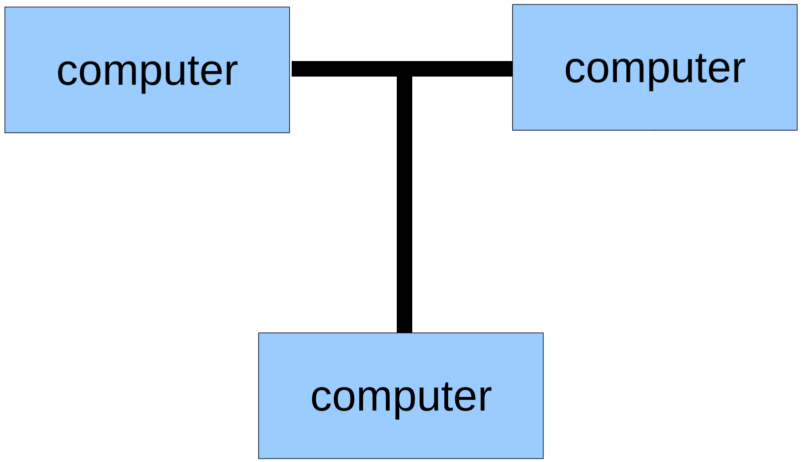
Overview

See Chapter 1 of Shay

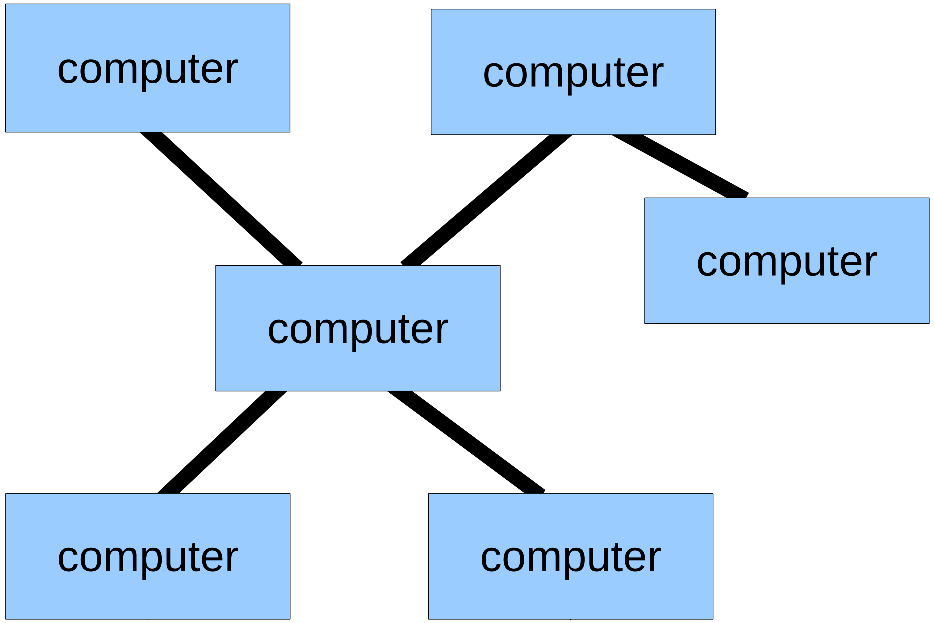
- Data communications are usually implemented using various layers in a protocol stack
  - Each software layer will be a set of data structures, processes and procedures implementing specific network protocols
  - Hardware layers are similar, but made out of electronic or optical components and circuits
  - A protocol is a set of rules about how to send bits
- The need for layers arises from the structure of networks and the needs of applications.

Network types

Point to point:
How to send bits?



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



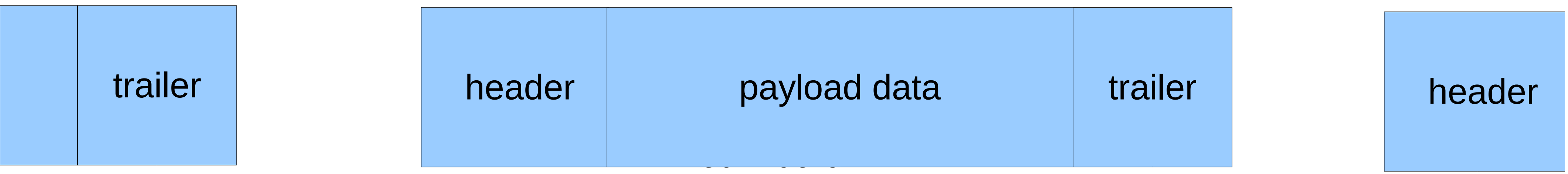
Mesh:
How to send bits indirectly to the correct destination?

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 be done 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 sessions 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.

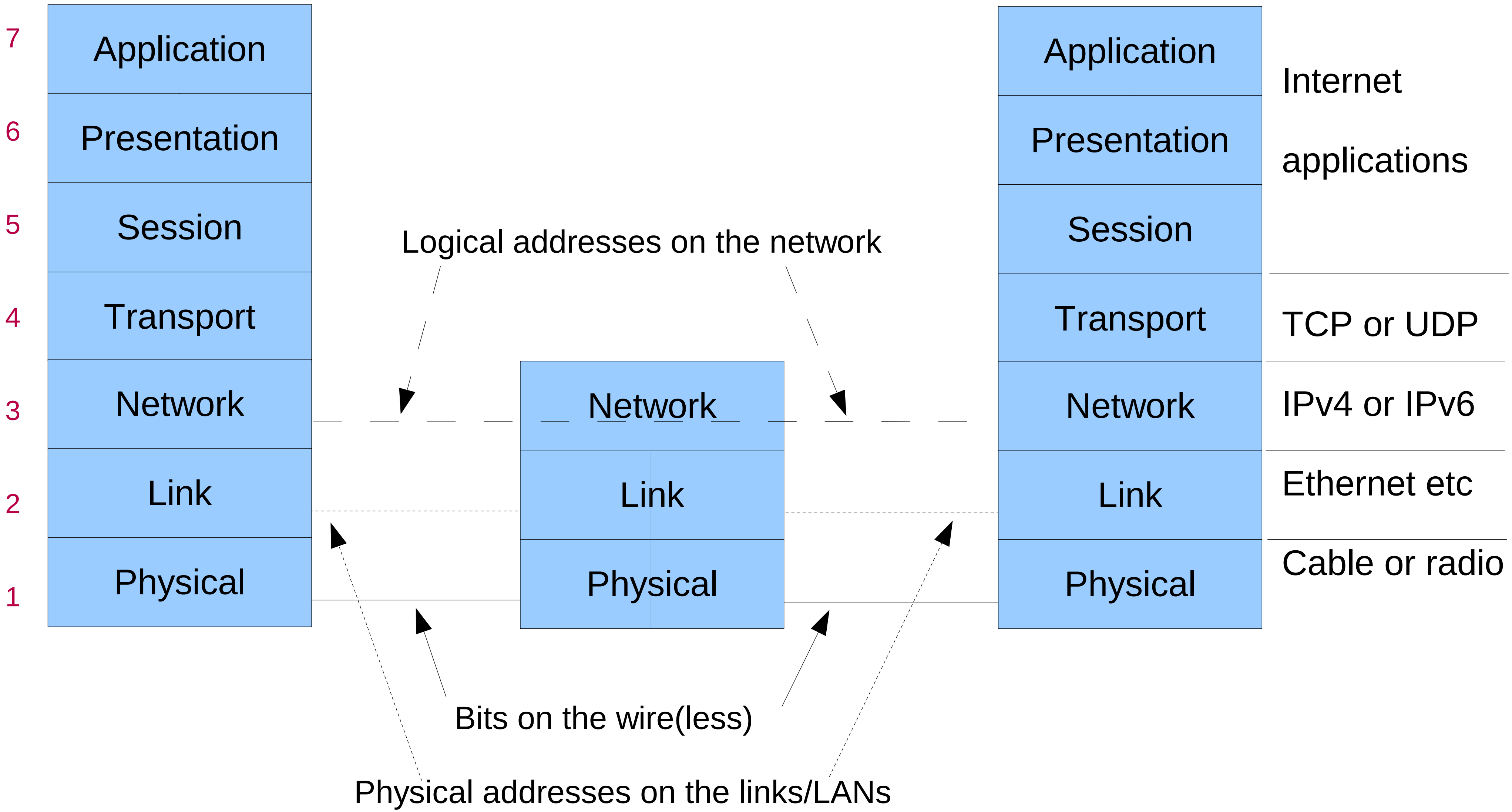
TCP/IP (Internet) combines layers 5-7, into a single Application layer.

We focus on the Internet protocols.

Why use layers?

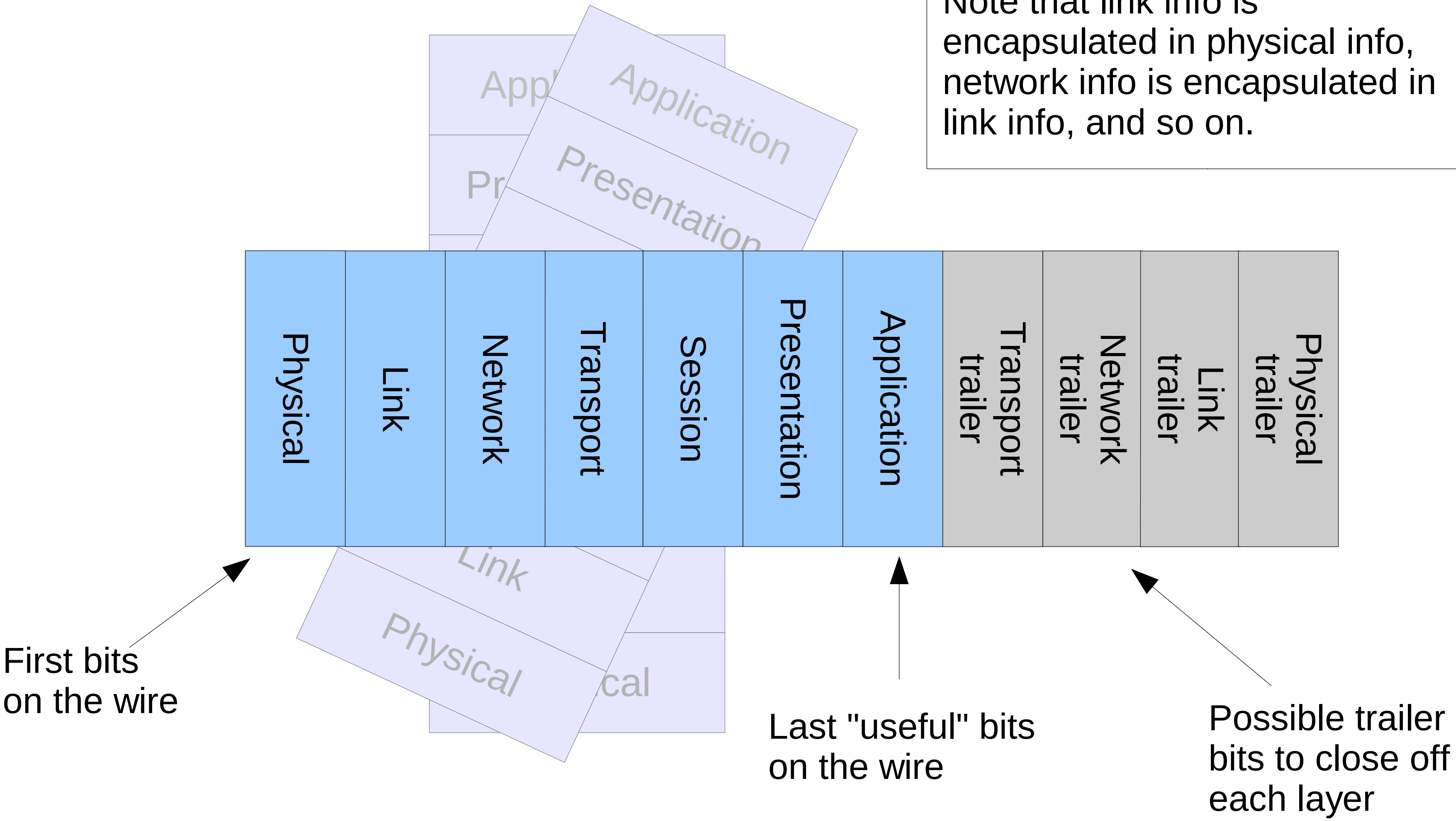
- Separate independent functions
  - e.g., physical and logical addressing
  - re-usable components (hardware and software).
- Implement common functions only once.
- Make it easier to provide alternatives
  - Layer n shouldn’t care if layer n±1 changes
  - e.g., so that the same applications can run over different types of network hardware.
- Make it easier to add or remove options.

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.



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

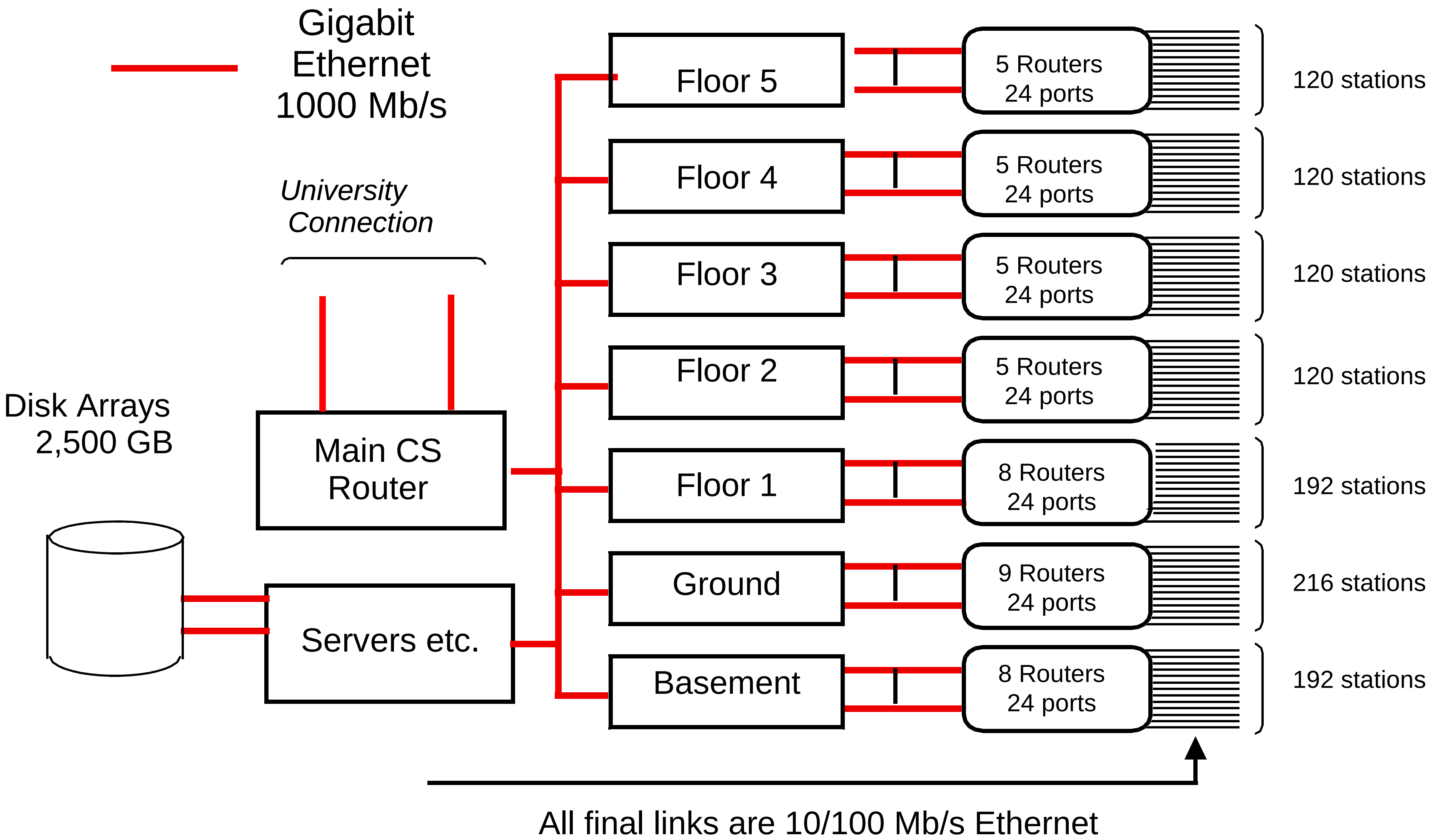
(most layers don't require trailers in practice)

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

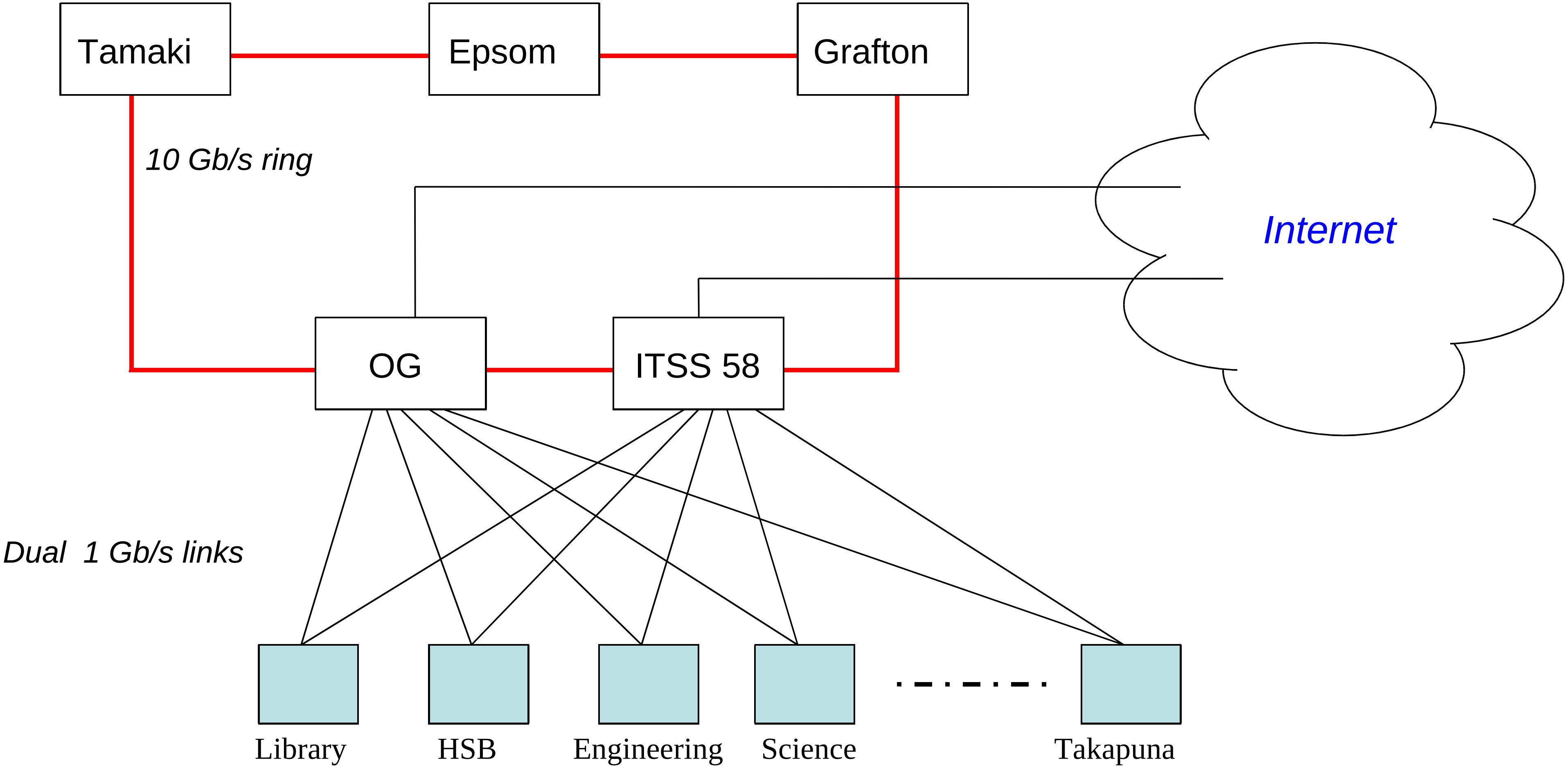
A real network

- Here's a (very brief) overview of the University of Auckland network, as it was a few years ago.
- Details change, but the principle is the same.

Simple view of Computer Science Network, 2003



The U Auckland Network, early 2007

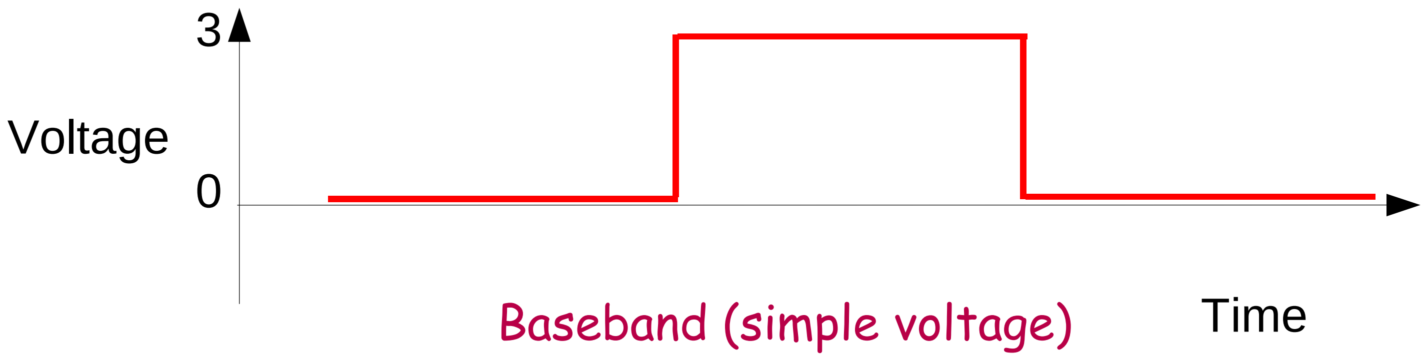


Communications basics

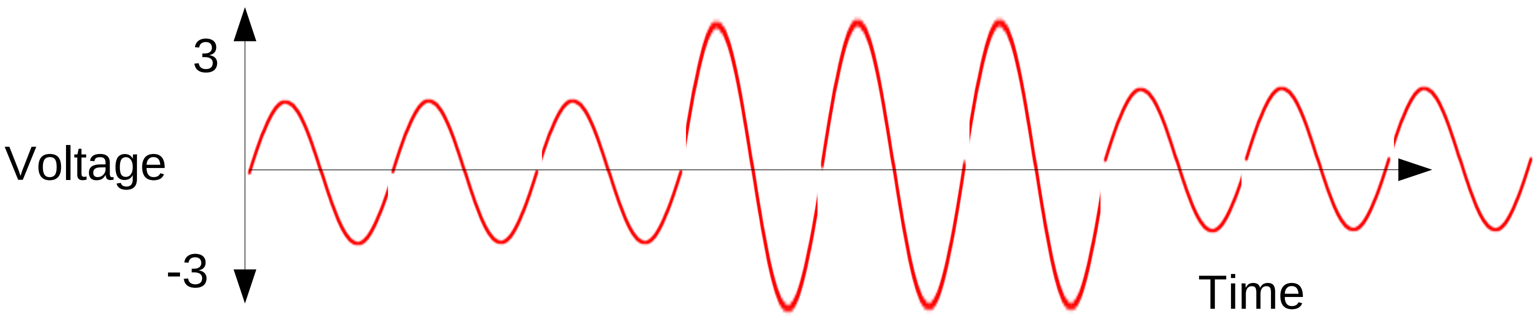
See Shay 2.1-2.3

- 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’

One bit on a wire



Baseband (simple voltage)



Modulated (sine wave)

Basic information on transmission of bits

Bits, sent 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)
- About 200,000 km/s on copper or fibre-optic cables (20cm per nanosecond)
  - Light, radio, and signals on a wire are all types of electromagnetic wave, so these speeds are in fact the speed of light in each case.

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 distance from New Zealand to North America, South America, Japan or Singapore is close to 10,000 km.
- 10,000 km at 200,000 km/sec takes 1/20 second = 50 milliseconds.
- The delay or "latency" from New Zealand to almost anywhere except Australia is therefore at least 50 ms. This delay cannot be reduced!
- Communications satellites orbit at 30,000 km, so the latency via satellite is 60,000 km at 300,000 km/sec = 1/5 second = 200 msec.

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).

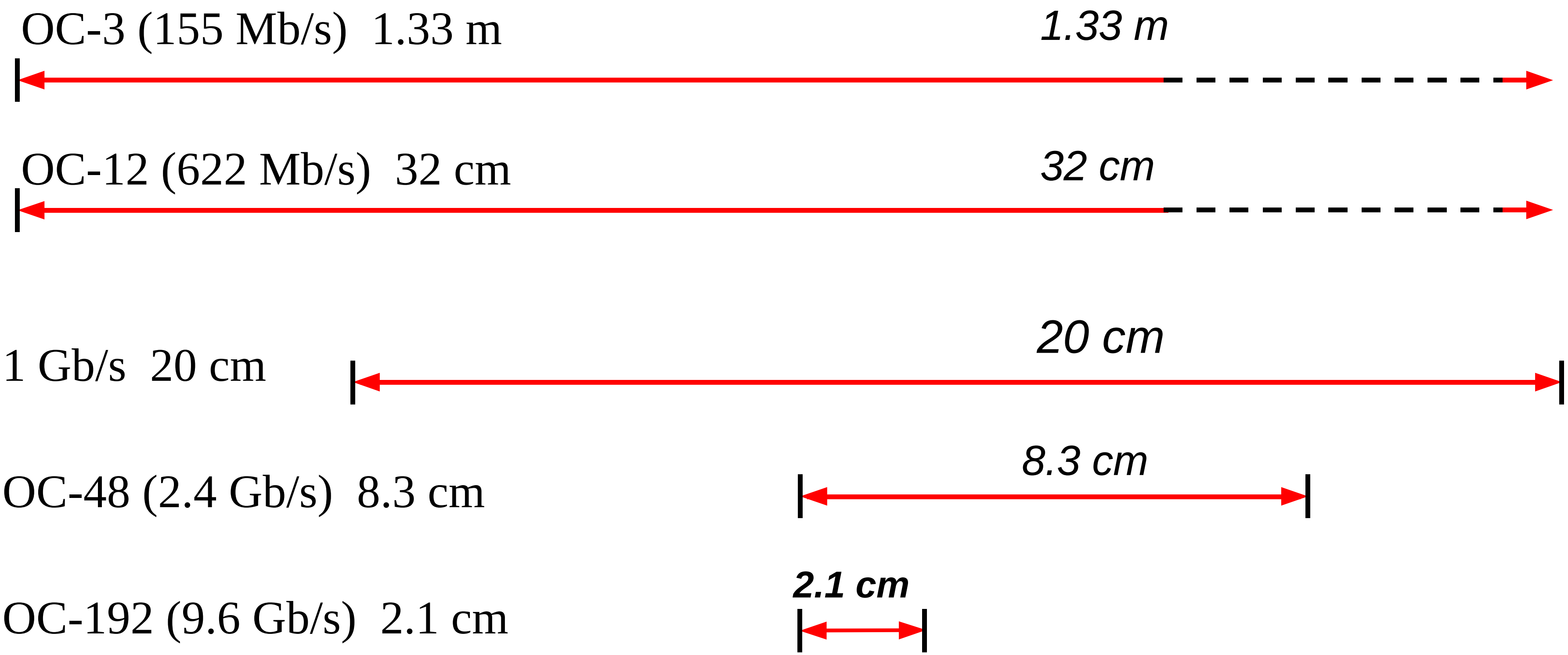
OC-3 (155 Mb/s) 1.33 m

OC-12 (622 Mb/s) 32 cm

1 Gb/s 20 cm

OC-48 (2.4 Gb/s) 8.3 cm

OC-192 (9.6 Gb/s) 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
- Cell phone technology is increasingly used for data network access from smart phones