Advanced Computer Communications

G54ACC

Lecture 1

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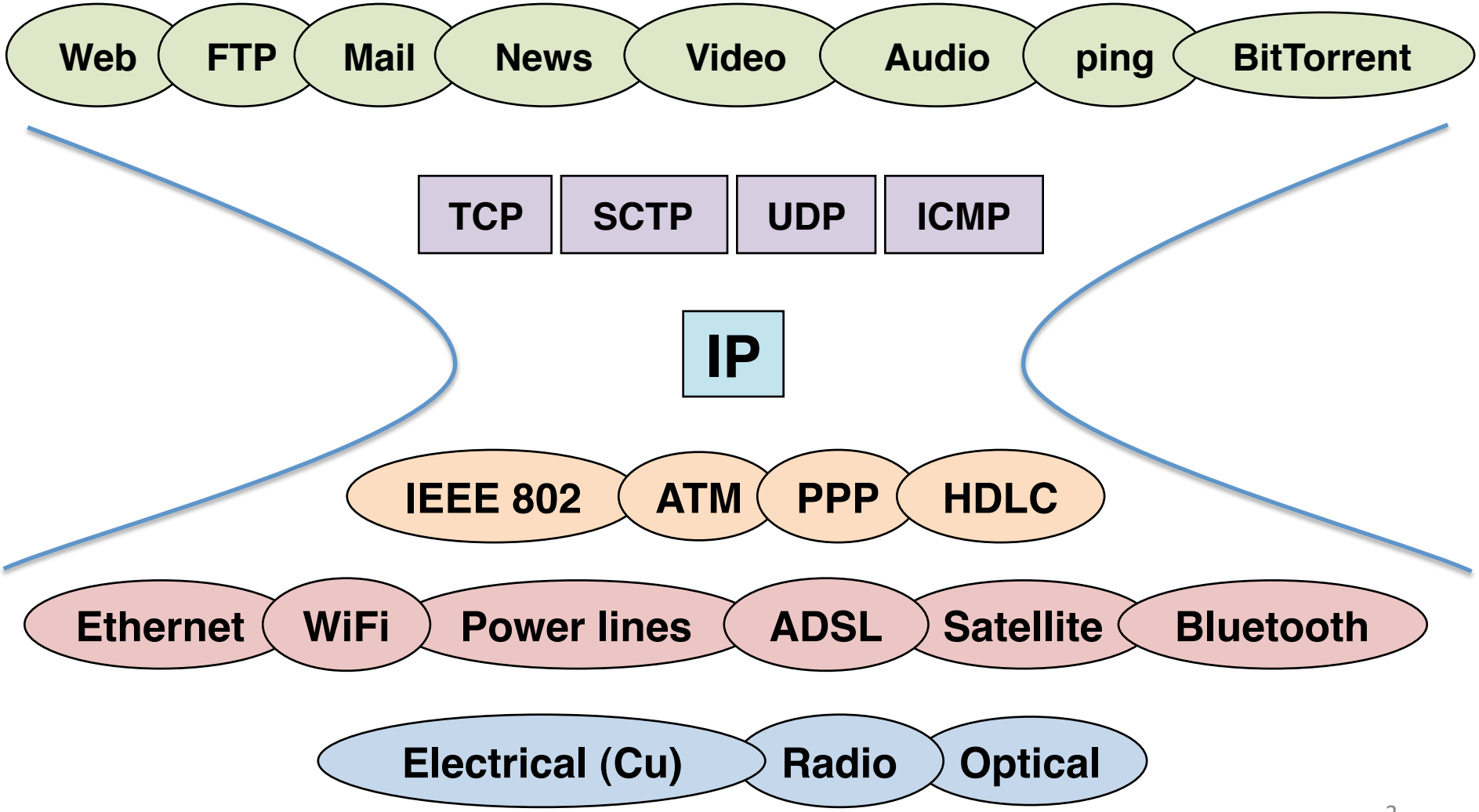
The Internet Hourglass



Outline

Taking IP as the starting point, we will…

- Head down to the physical layer and work back upwards, seeing a range of technologies that support IP
- Head upwards from IP, taking in several core Internet protocols
- Finish with higher layer concerns, including applications

Content

Number	Date	Topic	Number	Date	Topic
1	Jan 31	Introduction	10	Mar 13	Routing
2	Feb 02	IP Networks	11	Mar 15	Transport
3	Feb 07	Multiplexing	12	Mar 20	Reliability
–	Feb 09	–	13	Mar 22	Connecting
4	Feb 14	Physical Layer	–	Mar 27	–
5	Feb 16	Optical Networks	14	Mar 29	Applications
6	Feb 21	Ethernets	15	May 01	Management
7	Feb 23	ATM/ADSL	16	May 03	Programming
–	Feb 28	–	17	May 08	Security
–	Mar 01	–	18	May 10	Revision
8	Mar 06	Switching	19	May 14	?
9	Mar 08	Revision	20	May 17	?

NB. This is probably optimistic, and likely to be updated

Schedule

- Tuesday 1500—1600, JC-EXCHANGE C.LT2
- *Tuesday 1600—1700, CompSci A32 (lab)*
- Thursday 1100—1200, JC-EXCHANGE B.LT1

- There will be no lecture on:
  - Thursday February 9th (probably)
  - Tuesday February 28th
  - Thursday March 1st (probably)
  - Tuesday March 27th

Material

- Check my web pages!
  - http://cs.nott.ac.uk/~rmm/teaching/2011-g54acc/
  - Will be updated as the course progresses
  - Links to external matter (papers &c) are included for background, context, detail, breadth
- Read books!
  - No specific text will be followed directly
  - A selection of the many good books that exist is listed on the web pages
  - The catalogue claims at least several of these are available through the university library

Assessment

- One exam paper, answer 3 questions of 5
  - There is **no assessed coursework**
- You have lab sessions timetabled – **use them**!
  - There are practical exercises on the webpages
  - There will be questions at the end of every lecture
  - There are past exam questions from last year
- I am also happy to answer questions by email
  - richard.mortier@nottingham.ac.uk

Pop Quiz

- Can anyone give some examples of protocols?

- What's an IP address?
- Why does TCP have port numbers?
- How does `ping` work?
- What is ATM?
- How are OpenID and Oauth different?

A Word of Warning

- This module has a pre-requisite, G52CCN
  - Second year, Computer Communication Networks
- **Its material really is a pre-requisite!**
  - The experience following last year's exam is that you are unlikely to do well if you aren't reasonably familiar with the material from G52CCN
- ***Please*** *come and talk to me afterwards if you've questions about this!*

Connectivity

- What do computer networks do?
  - Transfer data between hosts (computers)
- What does the *Internet* do?
  - Transfer data between *networks*
- Increasingly, we rely on network connectivity
  - Other networks
  - Fixed and mobile devices
  - Wired and wireless access
  - Cloud services

Network Constraints

- Design, throughput, capacity
  - Bottleneck resource: the most constrained
- Latency: *c*, the speed of light
- Standards compliance
- Market conditions, economic sustainability
- Future proofing: times change

Network Resources

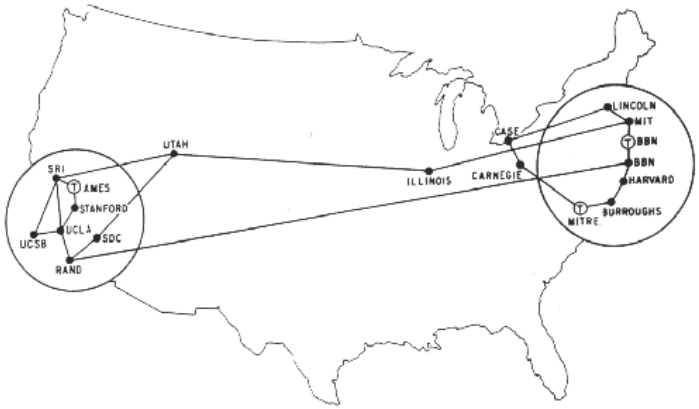
- Reliability
  - How much data is lost in transfer?
- Latency
  - How long does it take to get there?
- Bandwidth
  - How fast can data be transferred?
- Bandwidth *vs*. Throughput *vs*. Goodput
  - Raw signal
  - *vs*. Impact of encoding
  - *vs*. Impact of loss

Internet Performance Variability

- Loss
  - Generally zero until something goes wrong
  - Loss due to overload *vs.* error
- Latency
  - Speed of light, switching, queuing
  - San Francisco—New York, Transatlantic ~ 75ms
- Bandwidth http://bit.ly/u6lzpQ
  - 2G = 14.4 kb/s ; 2.5G = 57.6 kb/s ; 3G = 384 kb/s
  - ADSL ~ 8 Mb/s ; Cable modem (DOCSIS) ~ 50 Mb/s
  - Wireless Ethernet = 2 – 600 Mb/s
  - Wired Ethernet = 100 Mb/s – 100 Gb/s
  - Disk ~ 3 Gb/s ; HDMI = 10.2 Gb/s ; RAM ~ 256 Gb/s

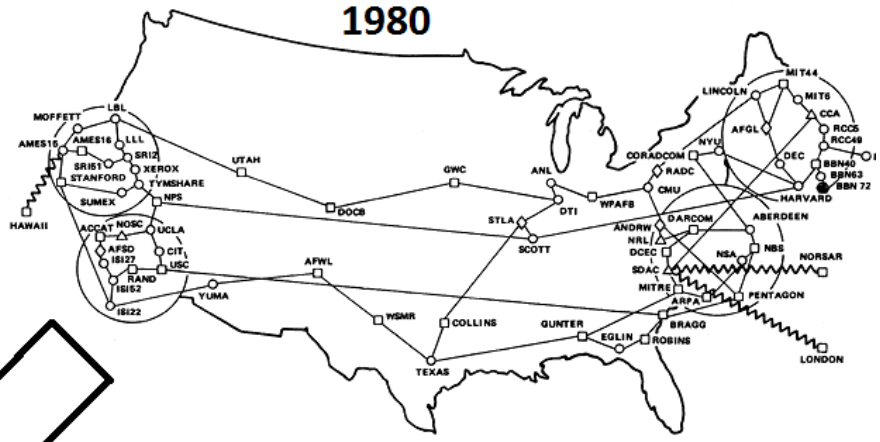
Networks

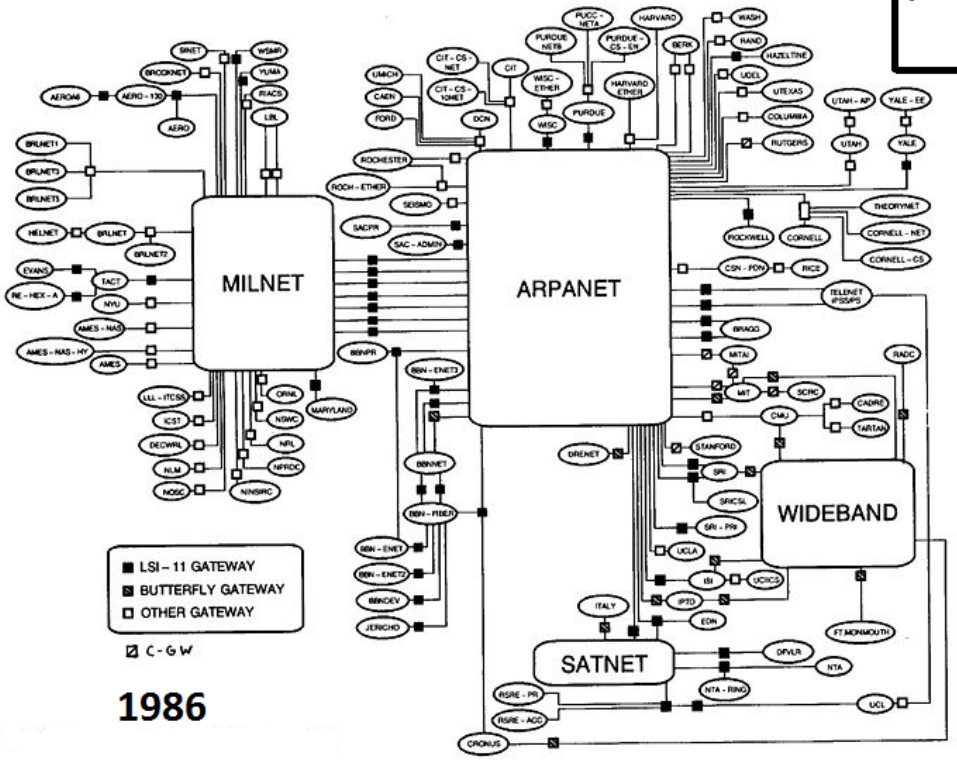
- A hierarchy of providers
- Local Area Network (LAN)
  - School, University
- Metropolitan Area Network (MAN)
  - University, EMMAN
- Wide Area Network (WAN)
  - National: JANET
  - International: Sprint, AT&T



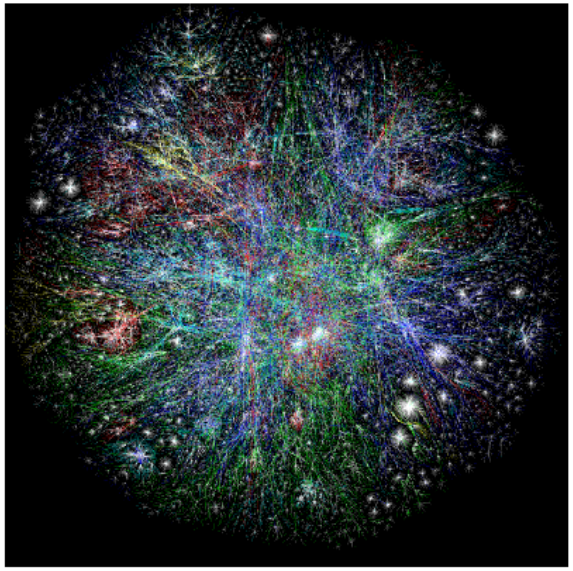
1971

1980





1986



2003

IP is about Internetworking

- IP interconnects heterogeneous networks
- Everyday examples include:
  - Ethernet
  - WiFi
  - GPRS/3G
  - ADSL
  - Cable
  - Fibre optic
- Hundreds of types!
- Standardization via the IETF – RFCs (ietf.org)

Why 100s? The Non-technical

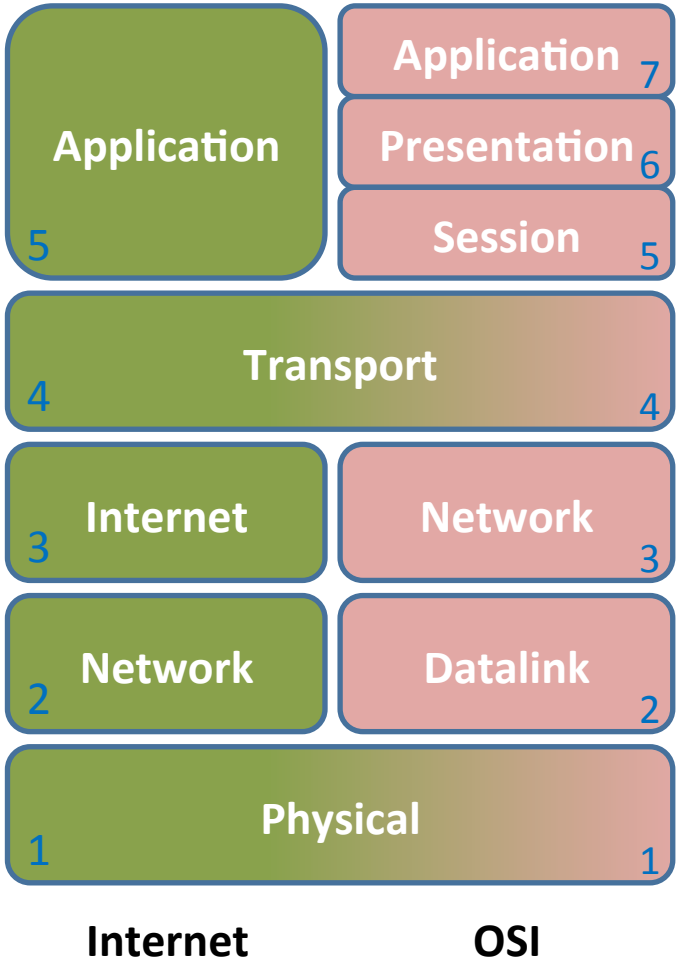
- Fundamentalist principles
  - Telephone companies (*bellheads*)
    vs. computer networking (*netheads*)
    www.wired.com/wired/archive/4.10/atm.html (1996)
- Proprietary technologies
  - IBM Token Ring/DECNET LAT/CISCO ISL
  - Protectionism
  - Customer lock-in
- Monitoring

Why? The Technical

- Different media have different characteristics
  - Radio (free space and wave guides)
  - Optical (free space and fibre)
  - Electrical
  - Broadcast & point-to-point
- How far?
  - Bluetooth *vs*. NASA deep space network
- The real world, e.g.,
  - Vacuum cleaners → radio noise
  - Installation → photons fall out if you bend fibre too much
  - Cost → cheap connectors mean poor electrical signal

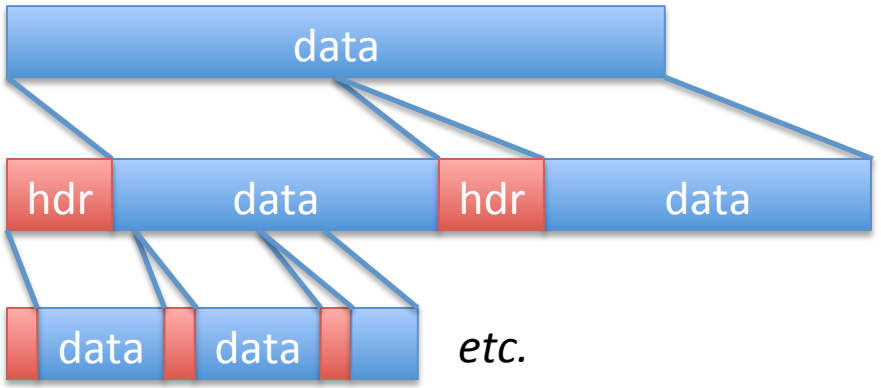
Layering

- Use of *abstraction* to contain complexity
- IP sits at layer 3
  - OSI *vs.* TCP/IP
- Approximates a *fully-connected network* abstraction
- IP packets are *hop-by-hop* routed by *store-and-forward* devices



Encapsulation

- Data comes down from higher layer in chunks
- Packetize to generate suitable sized chunks
- Encapsulate by prepending header
- Example: IP header




```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version|  IHL  |Type of Service|          Total Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Identification        |Flags|      Fragment Offset    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Time to Live |    Protocol   |         Header Checksum       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Source Address                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination Address                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Options                    |    Padding    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             data                              ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Questions?

http://cs.nott.ac.uk/~rmm/teaching/2011-g54acc/

mailto:richard.mortier@nottingham.ac.uk