Introduction to Networks (2)

Networked Systems Architecture 3
Lecture 2

UNIVERSITY
of
GLASGOW

Lecture Outline

- Network Protocols

- Protocol Layering

    - OSI Reference Model

- Protocol Standards

Network Protocols

- Communication occurs when hosts exchange messages across a channel

- For meaningful communication, those messages must be in a common language, and obey some common rules – these form a *network protocol*
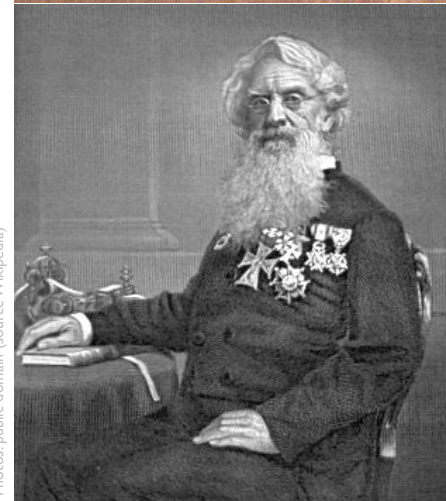
Network Protocols: Language

- Are messages textual?

    - What character set?

    - Internationalisation and language?

    - How is the grammar specified?
      What is the syntax? Semantics?

    - Can binary data be embedded?

- Or binary?

    - Big or little endian? 32 or 64 bit?

    - Fixed or variable length codes?

    - Alignment requirements?

    - How is the grammar specified?
      What is the syntax? Semantics

- Are messages framed?

    - How to signal start and end of
      message?

Example: Morse Code

- An simple network protocol: telegraph using Morse code

  - Signal keyed on electrical cable forms channel

  - Patterns of dots and dashes is a protocol:

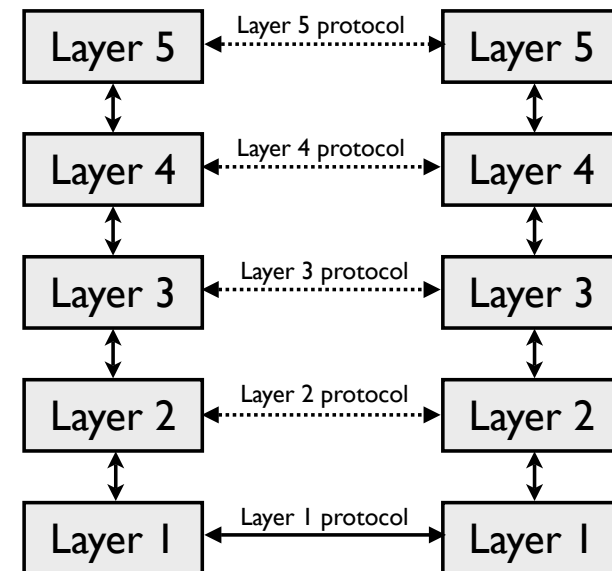| | | | | | | |
|---|---|---|---|---|---|
| A | • – | J | • – – – | S | • • • |
| B | – • • • | K | – • – | T | – |
| C | – • – • | L | • – • • | U | • • – |
| D | – • • | M | – – | V | • • • – |
| E | • | N | – • | W | • – – |
| F | • • – • | O | – – – | X | – • • – |
| G | – – • | P | • – – • | Y | – • – – |
| H | • • • • | Q | – – • – | Z | – – • • |
| I | • • | R | • – • | | |

Photos: public domain (source Wikipedia)

Samuel Morse

Network Protocols: Rules

- Is the protocol client-server? Peer-to-peer? Multicast? Broadcast?

- How is access to the channel arbitrated?

  - What happens if two hosts try to send at the same time?

  - How is data encoded? How are hosts named?

- How are error reports handled? How do you know if messages were successfully received?

- Who is allowed to send messages? When?

  - How fast can messages be sent?

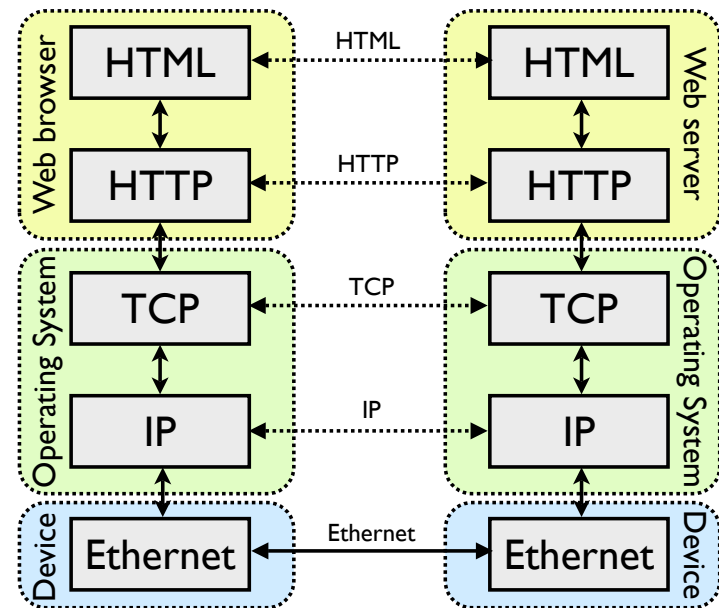 - Do you need to wait for a reply before sending next message?

Protocol Layering

- Communications systems are typically organised as a series of *protocol layers*

  - Structured design to reduce complexity

  - Each layer offers *services* to the next higher layer, which it implements using the services of the lower layer – well defined *interfaces*

    - Highest layer is the communicating application

    - Lowest layer is the physical communications channel

  - Peers at some layer, *i*, communicate via a layer *i* protocol, using lower layer services

Layer 5	← Layer 5 protocol →	Layer 5
Layer 4	← Layer 4 protocol →	Layer 4
Layer 3	← Layer 3 protocol →	Layer 3
Layer 2	← Layer 2 protocol →	Layer 2
Layer 1	← Layer 1 protocol →	Layer 1

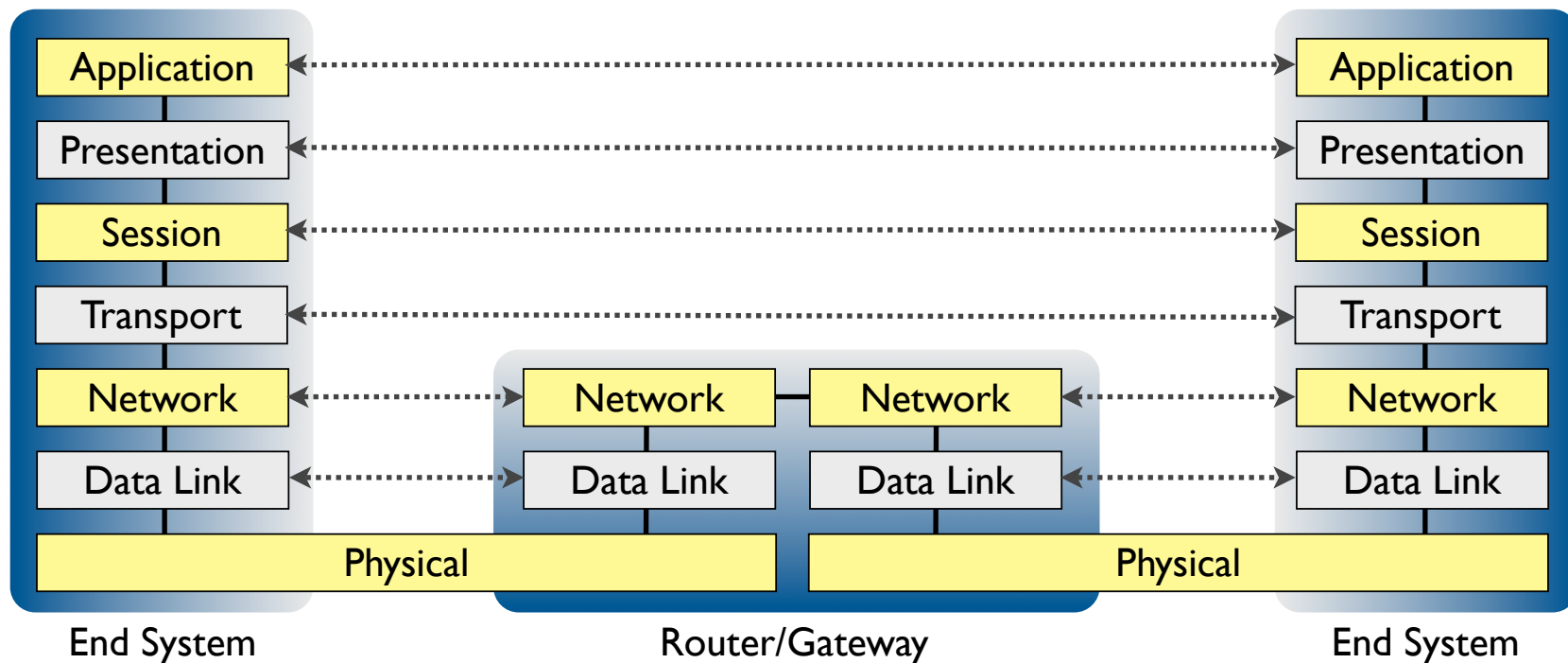# Protocol Layering: Example

- Web browser talking to a web server

- Simplified view with five protocol layers:
  - HTML
  - HTTP
  - TCP
  - IP
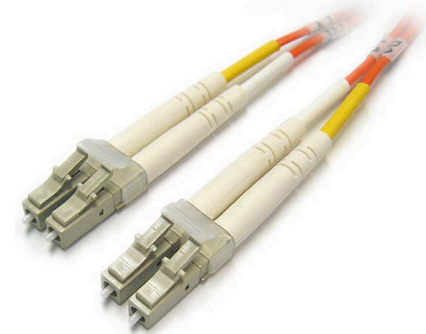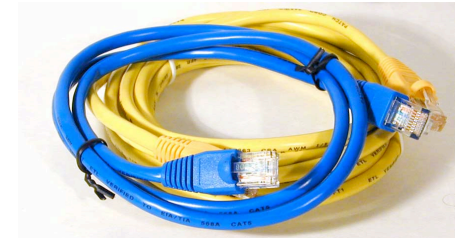 - Ethernet

OSI Reference Model

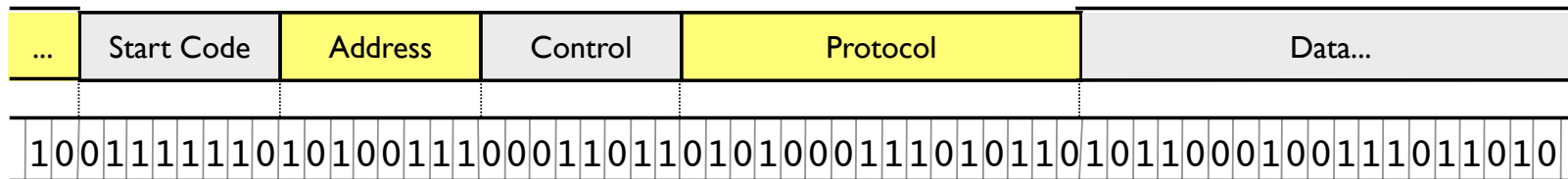| End System		Router/Gateway		End System
Application				Application
Presentation				Presentation
Session				Session
Transport				Transport
Network	Network	Network		Network
Data Link	Data Link	Data Link		Data Link
Physical		Physical		

Physical Layer

- Defines characteristics of the cable or optical fibre used:

  - Size and shape of the plugs

  - Maximum cable/fibre length

  - Type of cable: electrical voltage, current, modulation

  - Type of fibre: single- or multi-mode, optical clarity, colour, power output, and modulation of the laser

- For wireless links:

  - Radio frequency, transmission power, modulation scheme, type of antenna, etc.

Data Link Layer (1)

- Structure and frame bit stream provided by the physical layer

...	Start Code	Address	Control	Protocol	Data...

100111111010101001110001101101010100011101011010110001001110 11010

- Detect and correct errors on the link

  - Parity and error correcting codes

  - (Negative) acknowledgements + retransmission

Data Link Layer (2)

- Media access control

  - Some physical links (e.g. Wi-Fi) shared between multiple hosts

  - Requires link layer addresses

    - Hosts have addresses on the link

    - Messages include source and destination addresses

  - Arbitrate requests for access to the media; resolve collisions

  - Ensure fair access to the link and provide flow control

00:14:51:04:27:ea   00:08:74:4f:aa:7c

00:E0:81:52:65:17
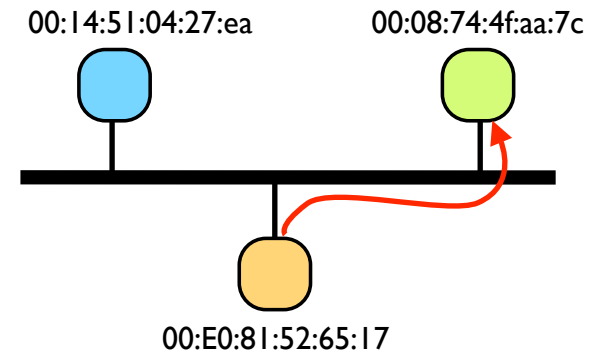
Example: Ethernet with CSMA-CD

Network Layer

- Interconnects multiple links to form a wide area network from source host to destination host

  - Data delivery

  - Naming and addressing

  - Routing

  - Admission/Flow control

- Example: IP

Transport Layer

- End-to-end transfer of data from the source to the destination(s)

    - Transfers data between a session level *service* at the source, and corresponding *service* at the destination

    - May provide reliability, ordering, framing, congestion control, etc.

        - Depends on guarantees provided by the network layer

- Example: TCP

Session Layer

- Manages (multiple) transport layer connections

- Example session layer functions:

    - Open several TCP/IP connections to download a web page using HTTP

    - Use SMTP to transfer several email messages over a single TCP/IP connection

    - Coordinate control, audio and video flows making up a video conference

Presentation Layer

- Manages the presentation, representation, and conversion of data:

    - Internationalisation, languages, and character sets

    - Data markup languages (e.g. XML, HTML)

    - Data format conversion (e.g. big or little endian)

    - Content negotiation (e.g. MIME, SDP)

- Common services used by many applications
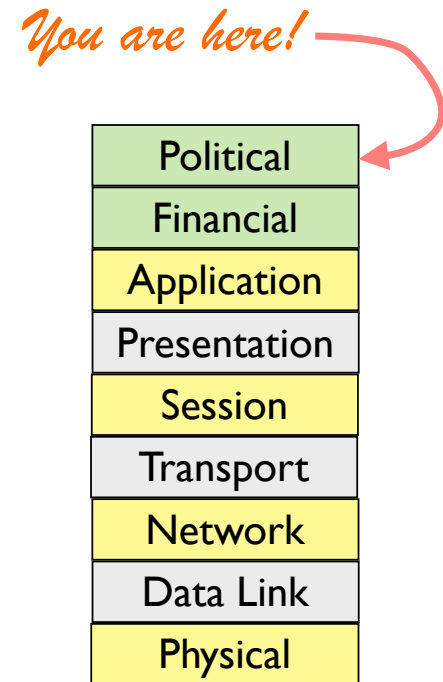
Application Layer

- User application protocols

  - *Not* the application programs themselves

- Examples:

  - Flickr, Facebook, Google Maps, etc.

  - Web services

  - Grid computing

OSI Reference Model

- Definition of OSI model was *extremely* political

  - None of the layers or layer boundaries should be considered sacrosanct

  - Doesn't reflect *any* deployed system architecture

  - But… very useful to guide thinking about systems architectures and implementations

Protocol Standards

- A (mostly) formal description of a protocol

- To ensure interoperability amongst diverse implementations

- Variety of standards setting procedures:

  - Open or closed standards development process

  - Free or restricted standards availability

  - Individual vs. corporate vs. national membership

  - Lead technical development or document existing practice

You are here!

| Political |
| Financial |
| Application |
| Presentation |
| Session |
| Transport |
| Network |
| Data Link |
| Physical |

Key Standards Organisations

- Internet Engineering Task Force
  - http://www.ietf.org/ and http://www.rfc-editor.org/

- International Telecommunications Union
  - http://www.itu.int/ (part of the United Nations)

- 3rd Generation Partnership Project
  - http://www.3gpp.org/

- World Wide Web Consortium
  - http://www.org/

Questions?