University of Glasgow

Introduction to Networks (2)

Networked Systems 3
Lecture 2

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

- How is the grammar specified? What is the syntax?
  - Are messages textual?
    - What character set? language? How is binary data embedded?
  - Or binary?
    - Big or little endian? 32 or 64 bit? Fixed or variable length? What are the alignment requirements? Etc.
- What do protocol messages mean?

Network Protocol: Rules

- What are the entities that communicate?
  - Peer-to-peer? Client-server? Broadcast?
  - How are entities named?
- How is access to the channel controlled?
  - How can send messages? When?
- How are errors handled?
  - How do you know if a message was received?

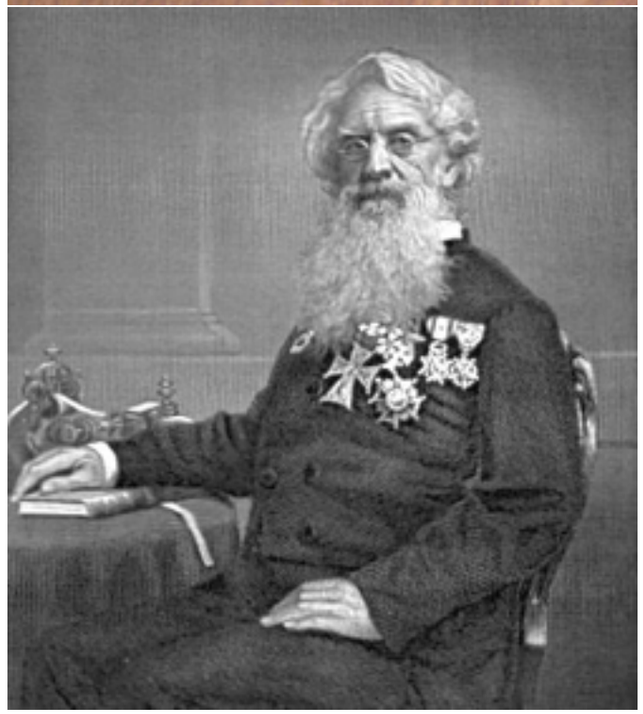
Example: Morse Code

- An simple network protocol: telegraph using Morse code
  - Signal 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	•-•		

  - Gap lengths vary between letters, words



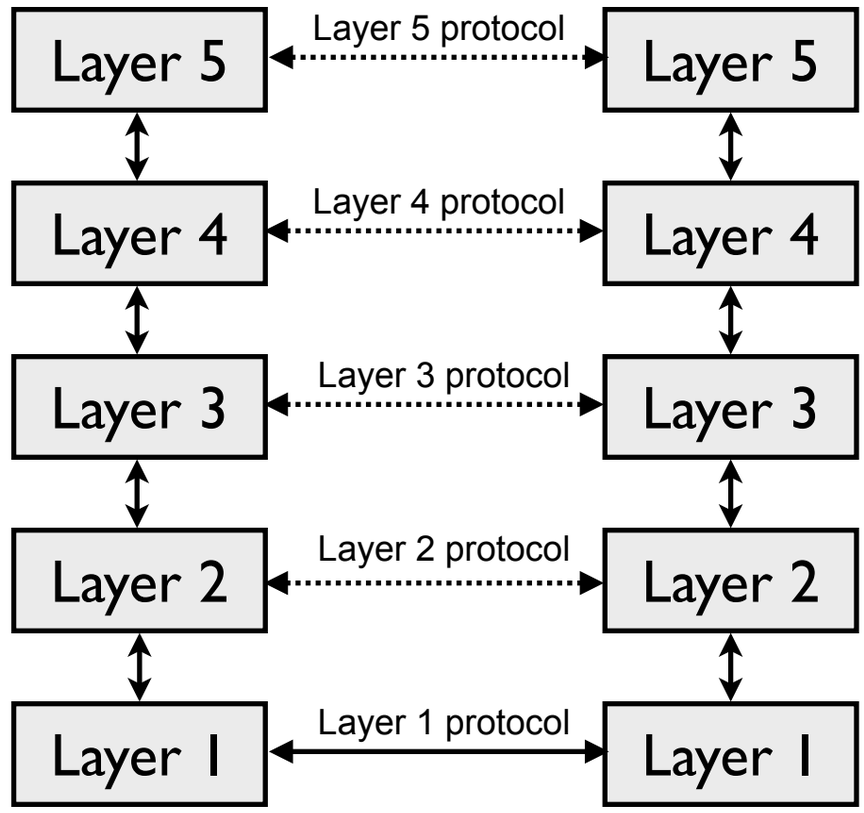


Photos: public domain (source Wikipedia)

Samuel Morse

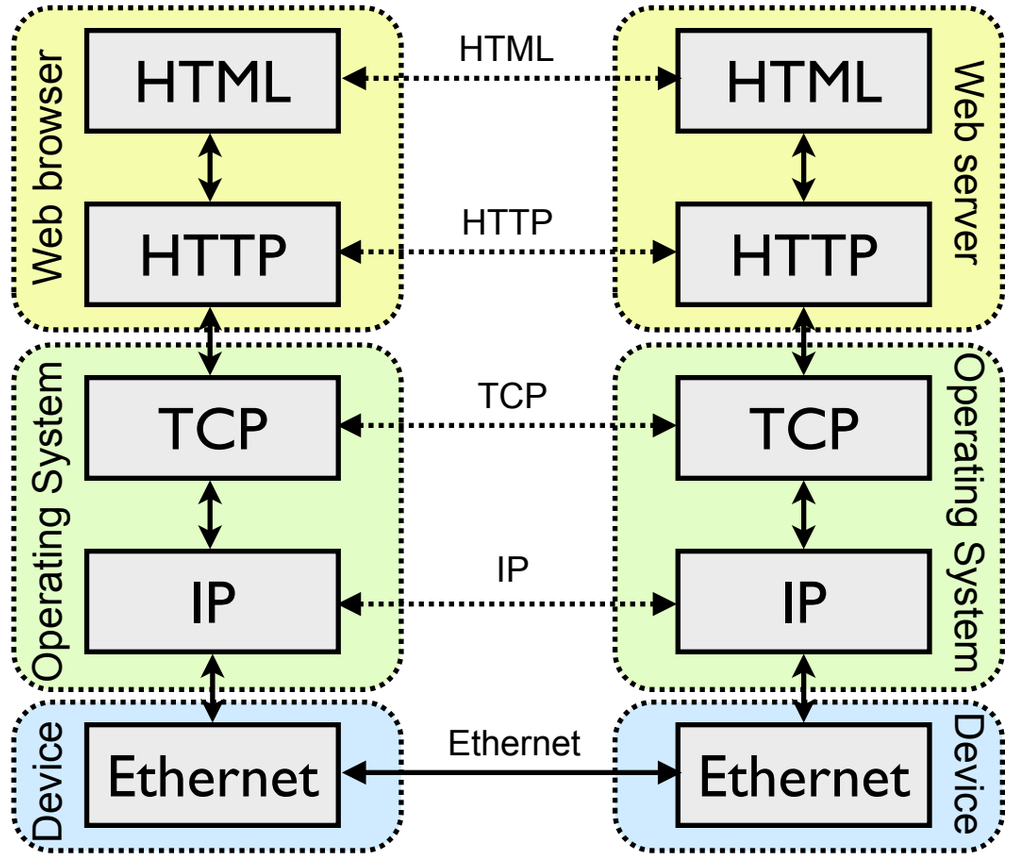
Protocol Layering

- 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

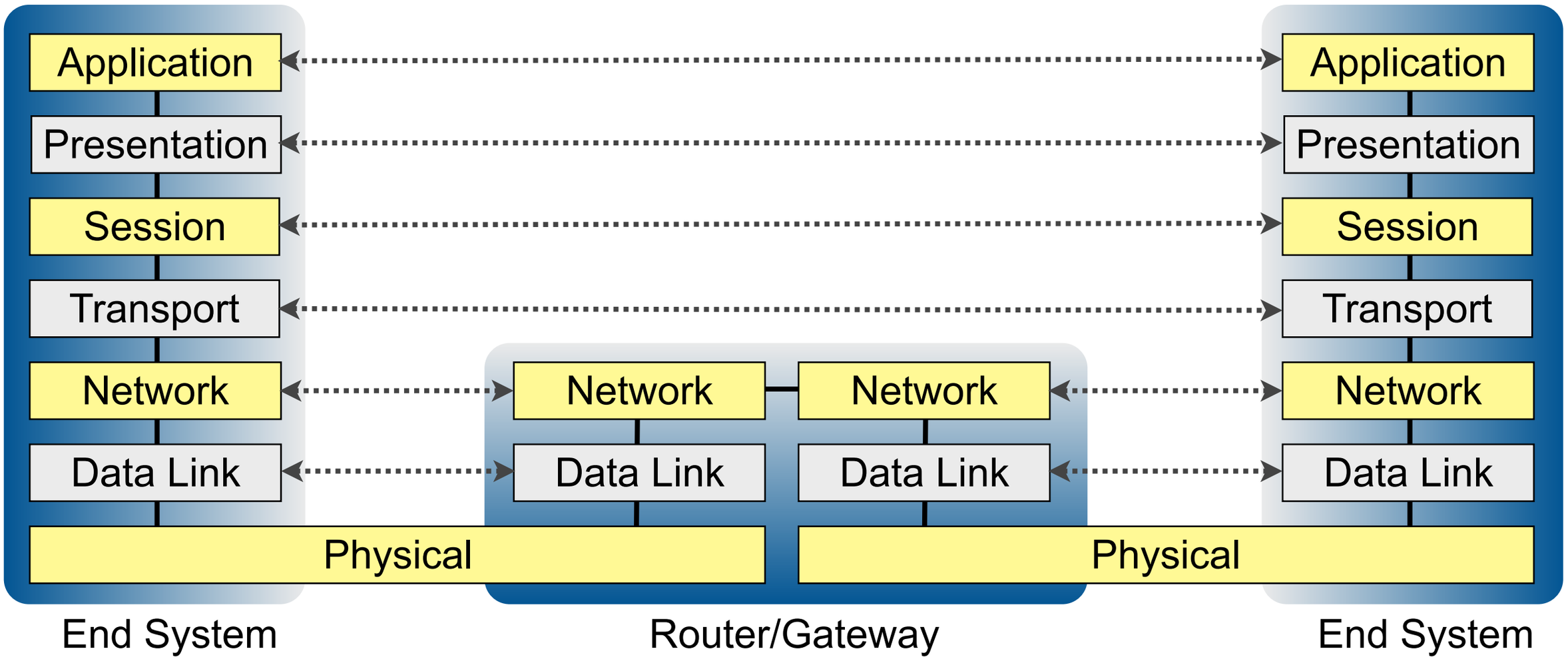


Protocol Layering: Example

- Web browser talking to a web server
- Simplified view with five protocol layers:
  - HTML
  - HTTP
  - TCP
  - IP
  - Ethernet



OSI Reference Model



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



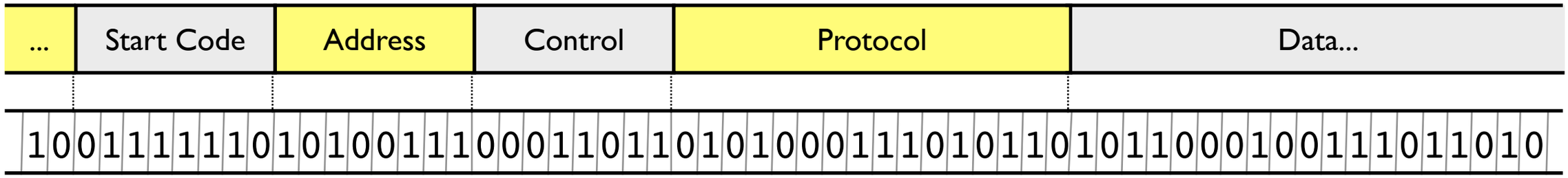


- For wireless links:
  - Radio frequency, transmission power, modulation scheme, type of antenna, etc.



Data Link Layer (1)

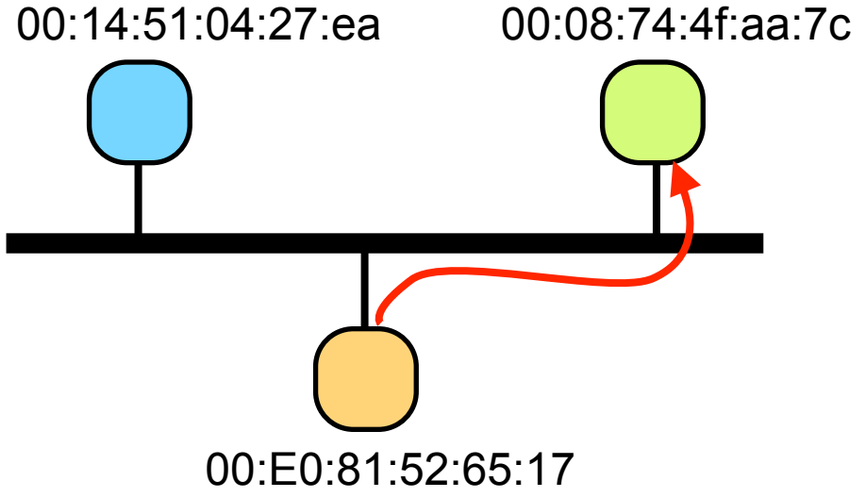
- Structure and frame bit stream provided by the physical layer



- 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



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:
  - Character set, language, etc.
  - 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

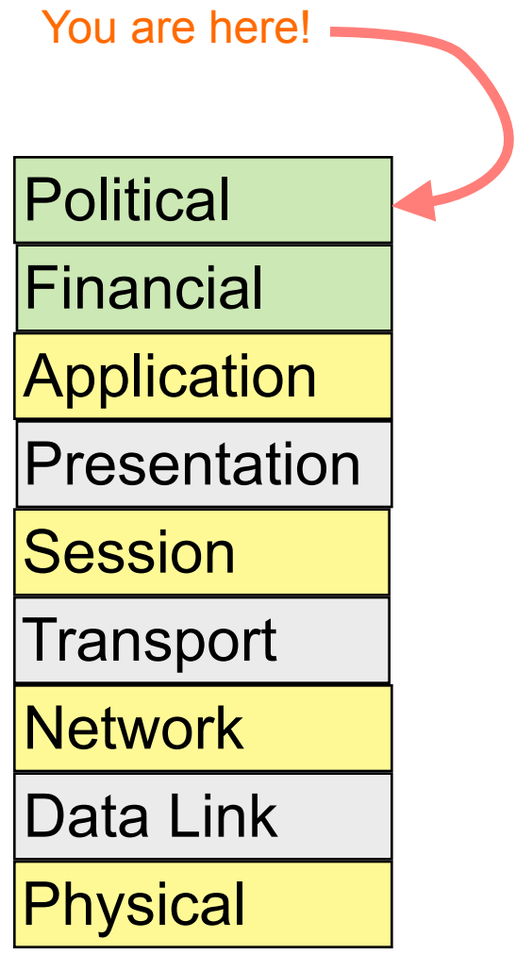
- Examples:
  - Flickr API, Facebook API, Google Maps API, etc.
  - Web services
  - Grid computing

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



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?