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Networks & Operating Systems Essentials

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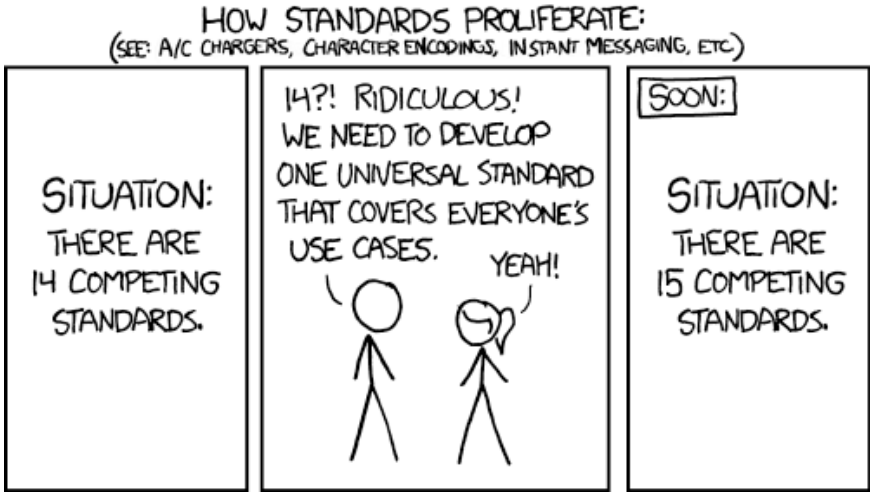
School of Computing Science

Today, on NOSE2…



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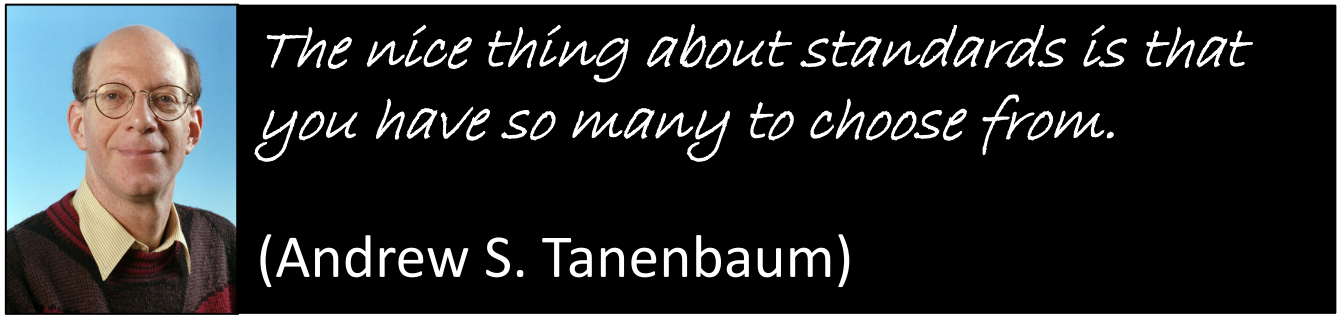

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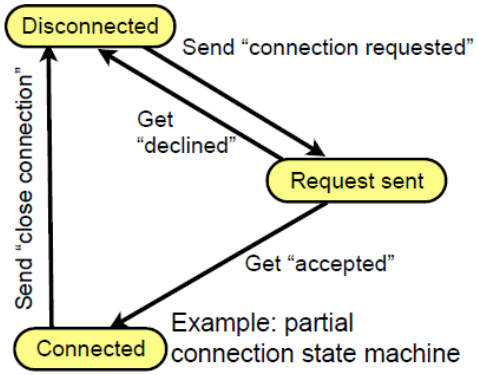
PROTOCOLS & LAYERS

Network Protocols

- Communication occurs when two (or more) hosts exchange messages across a network
- To be meaningful, the messages need to follow some well known syntax, and have agreed semantics
  - A network protocol is an agreed language for encoding messages, along with the rules defining what messages mean and when they can be sent
  - Numerous network protocols exist; some operate between hosts, some between routers, and some between hosts and routers
  - The protocols define the behaviour of the network

Network Protocols

- A protocol will comprise different types of message, known as protocol data units (PDUs)
- Each type of PDU will have a particular syntax
  - Describes what information is included in the PDU, and how it's formatted
  - PDUs may be formatted as textual information or as binary data
    - Textual PDUs have a syntax and grammar that describes their format
      - Much like a programming language has a grammar
      - Examples: HTTP/1.1, SMTP, SIP, Jabber
    - Binary PDUs similarly have rules describing their format
      - E.g., Is data big or little endian? 32 or 64 bit? Fixed or variable length? What are the alignment requirements?
      - Examples: TCP/IP, RTP
- PDUs define what messages are legal to send
- Protocol semantics define when PDUs can be sent, and what response is needed
  - Who can send PDUs, and when they can be sent
  - Roles for the hosts (e.g., client and server, peer-to-peer)
  - What are the entities that communicate and how they are named
  - How errors are handled
- Commonly described using state-transition diagram
  - States indicate stages of protocol operation
  - Transitions occur in response to PDUs, and may result in other PDUs being sent

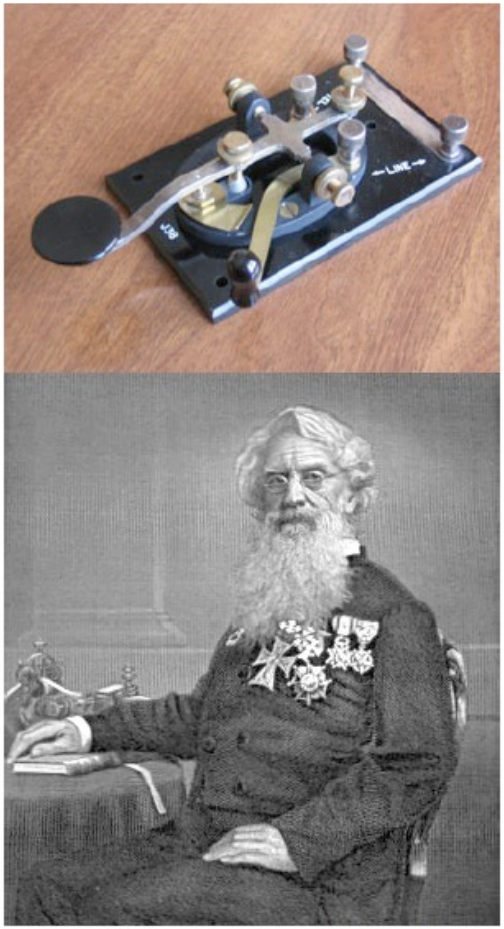


Network Protocols

- A simple network protocol: Morse code and the telegraph
  - Channel: signals on electrical cable
  - Syntax: pattern of dots and dashes signals letters

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	•-•		

  - Semantics:
    - Different gap lengths to signal end of word, end of letter
    - Use of STOP for end of message

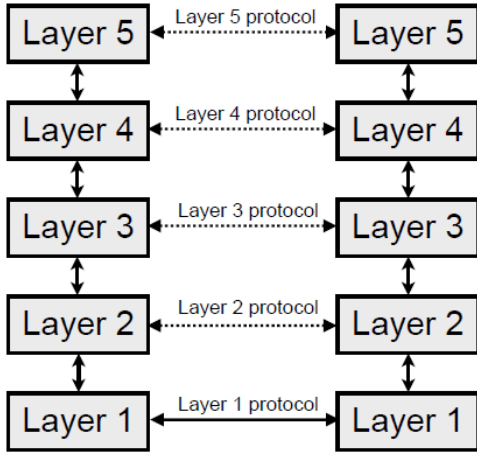


Photos: public domain (source Wikipedia)

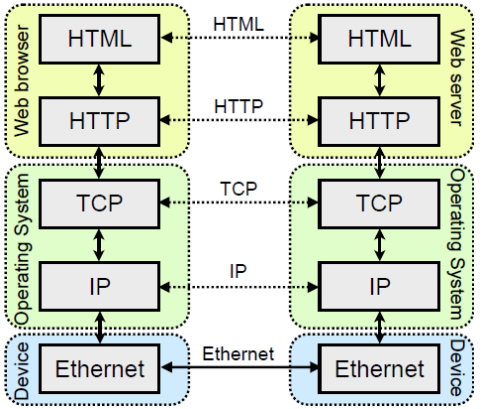
Samuel Morse

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

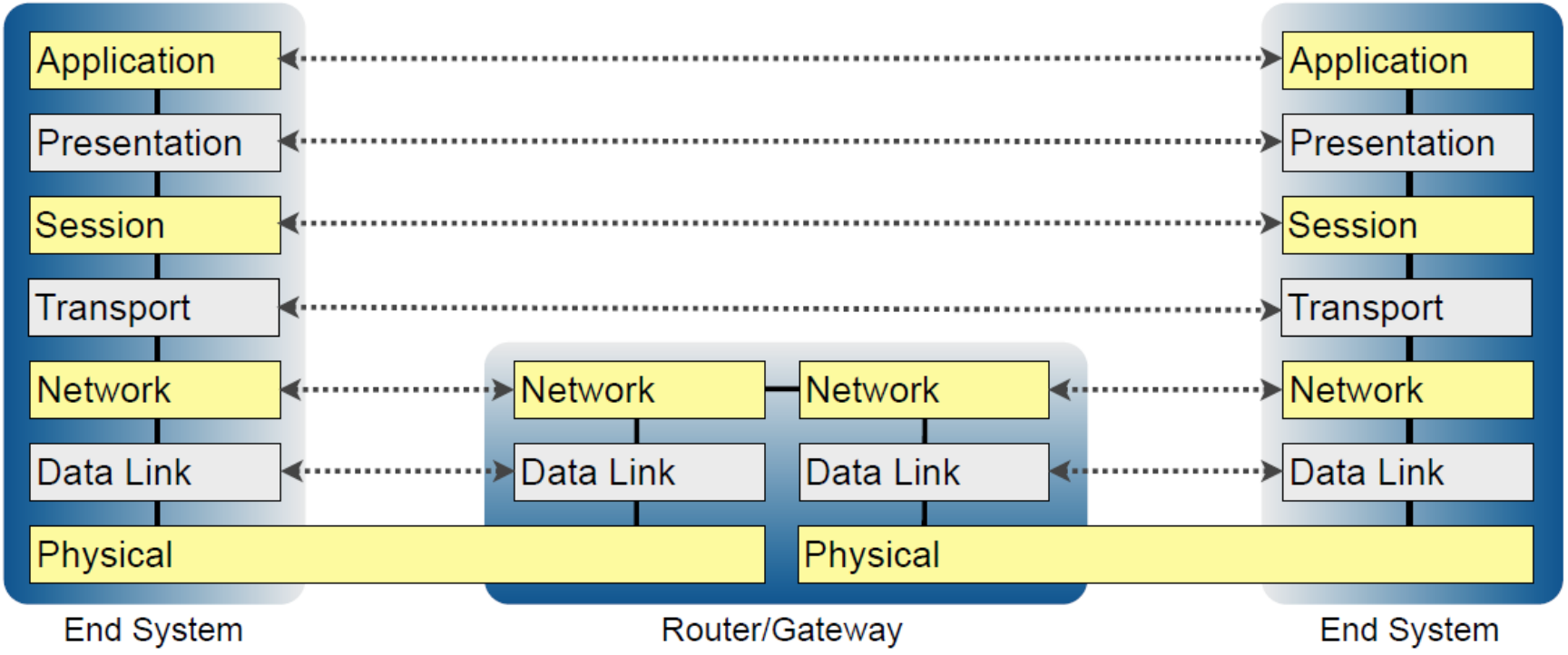


- Example: web browser talking to a web server
  - Simplified view with five protocol layers
    - HTML
    - HTTP
    - TCP
    - IP
    - Ethernet



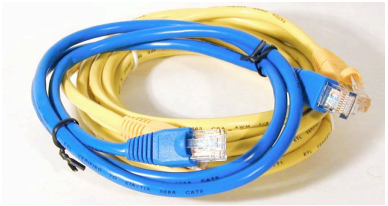
OSI Reference Model

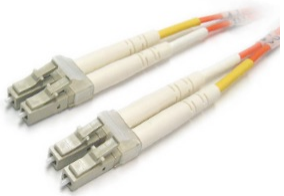
- A standard way of thinking about layered protocol design
- A design tool; real implementations are more complex

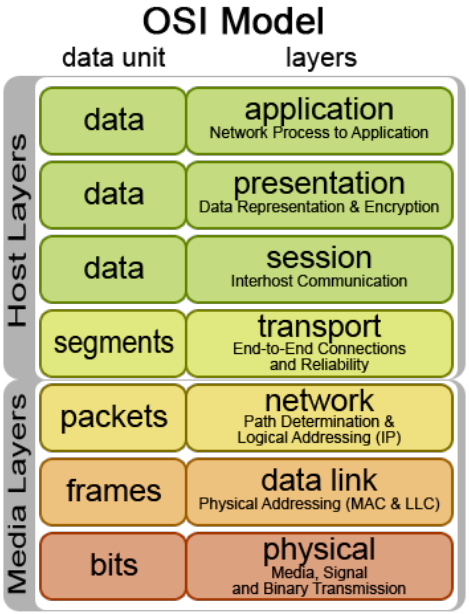


Physical Layer

- 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



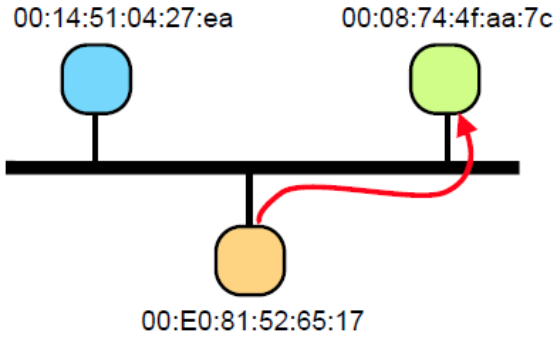


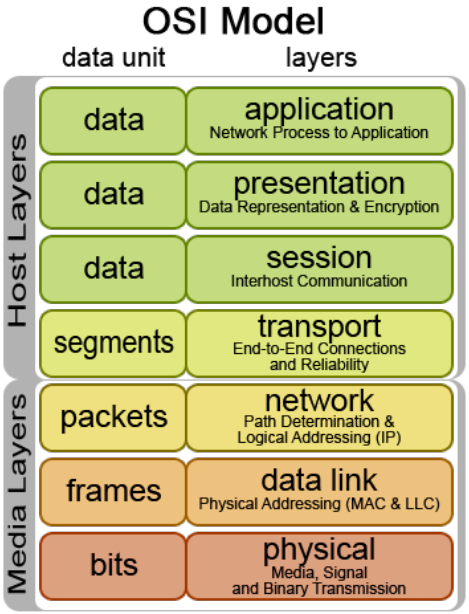


- For wireless links:
  - Radio frequency, transmission power, modulation scheme, type of antenna, etc.

Data Link Layer

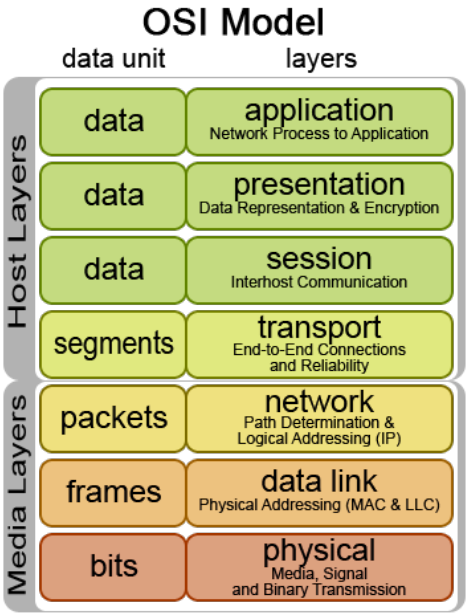
- Structure and frame physical layer bit stream
  - Split the bit stream into messages
  - Detect/correct errors in messages
    - Parity and error correcting codes
    - (Negative) acknowledgements + retransmission
  - Perform media access control
    - Assign addresses to hosts on the link
    - Arbitrate access to link, and determine when hosts are allowed to send message
    - Ensure fair access to the link and provide flow control to avoid overwhelming hosts
  - Examples: Ethernet, 802.11





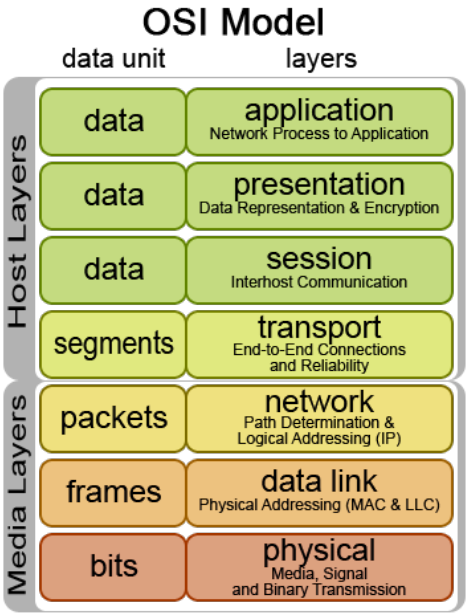
Network Layer

- Interconnects multiple links to form a wide area network from source host to destination host
  - Data delivery
  - Naming and addressing
  - Routing
  - Admission/Flow control
- Examples: IP, ICMP



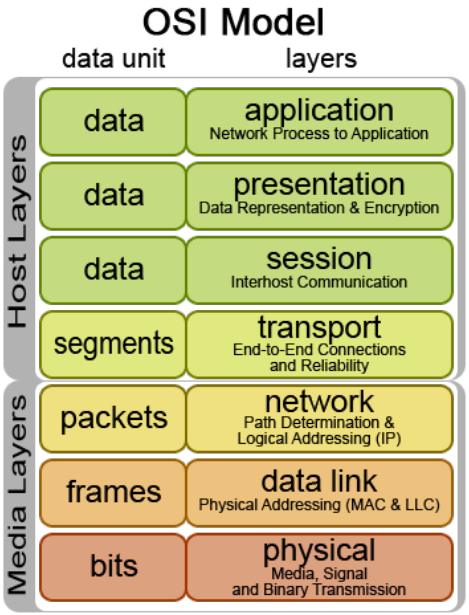
Transport Layer

- 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
- Examples: TCP, UDP



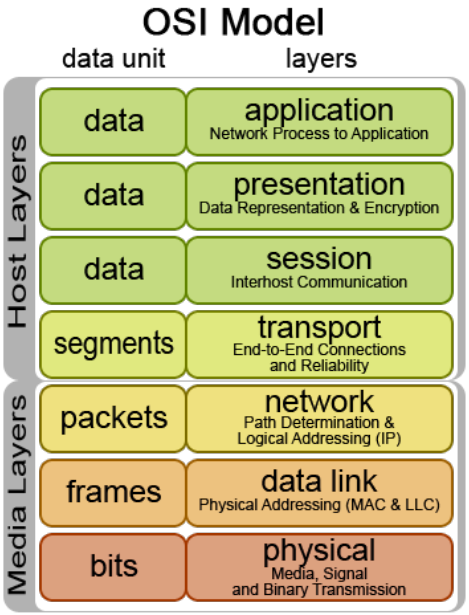
Session Layer

- 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
- Examples: NetBIOS, RPC



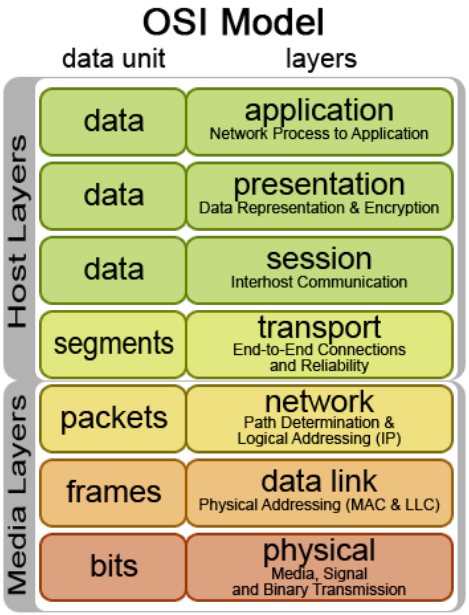
Presentation Layer

- Manages the presentation, representation, and conversion of data:
  - Character set, language, etc.
  - Data markup languages (e.g., XML, HTML, JSON)
  - Data format conversion (e.g., big or little endian)
  - Content negotiation (e.g., MIME, SDP)
- Common services used by many applications
- Examples: SSL, Telnet, HTTP/HTML(agent)



Application Layer

- User application protocols
  - Not the application programs themselves
  - E.g., WhatsApp (program) uses XMPP (protocol)
  - E.g., Facebook mobile (program) uses MQTT (protocol)
- Examples: HTTP/HTTPS, DNS, FTP



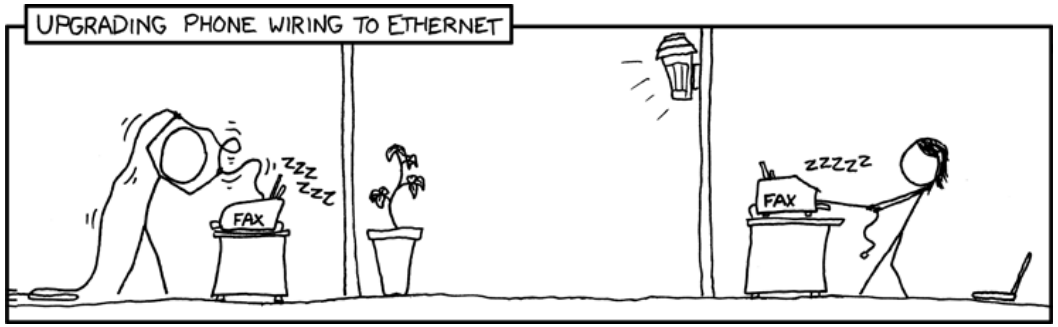
Protocol Standards

- A formal description of a network protocol
- Ensure interoperability of diverse implementations
- Variety of standards setting procedures:
  - Open or closed standards development process
  - Free or restricted standards availability
  - Rules around disclosure of intellectual property rights, use of encumbered technologies
  - Individual vs. corporate vs. national membership
  - Lead technical development vs. describe existing practices
  - Collaborative vs. combative process
- Not all players in the standards process have the same goals
  - Delaying a standard to allow a proprietary solution to gain market share
  - Incorporating intellectual property, patented technologies, etc.
  - Enhancing, or subverting, the security of a protocol
  - …

Key Standards Organisations

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

Coming up next…



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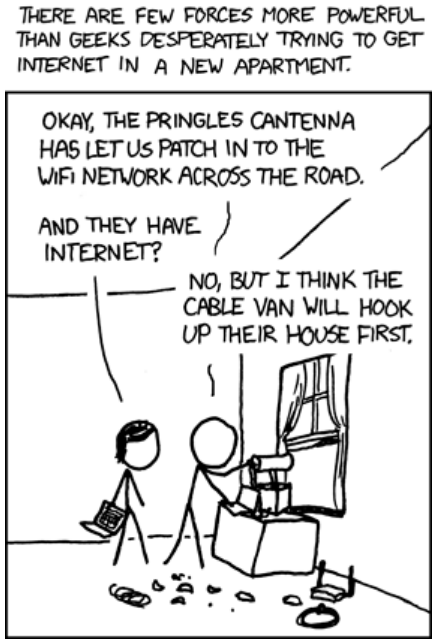

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