Networks - Basics

Overview of Computer Networks

Software and Hardware Models

- Network *models* – describe categories of needed hardware and software
  - Network hardware – connect *nodes* to each other via *media*
    - Computers, printers, routers, etc.
      - NICs – Network Interface Controller, added to nodes
    - Electrical cables, optical fiber, radio signals
  - Network software – runs on nodes, transmits/receives data over hardware
    - Complex set of operations needed to synchronize nodes
    - Quasi-hierarchical organization

Models and Protocols

- Network *models* describe the kinds of tasks that must be done to transmit data between computers
  - Overall outline of work to be done
- Network *protocols* define rules for how to do each of the needed tasks
  - Competing protocols may do similar things in different ways
- *Software stacks* implement the protocols
  - Usually separate process for each protocol

Two Competing Models

TCP / IP model

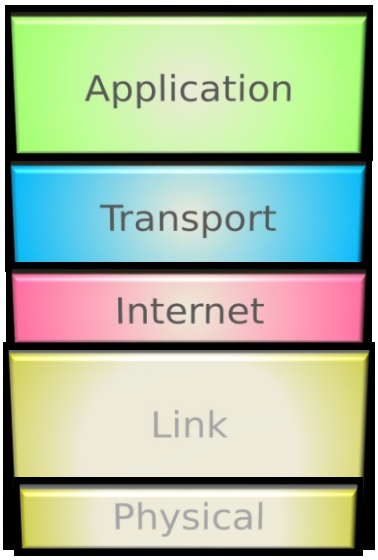
- Evolved from ARPANET / Internet software
- Describes organization of actual protocols
- Intended for use with dissimilar network nodes

OSI model

- Developed "from the ground up" by a committee of the ISO
  - "ISO/OSI", great name
- Good theoretical framework
- Too rigid and structured for most practical use

The TCP/IP Model (and Protocol Stack)

- Centered on Transport, Internet layers
  - Transport: TCP, UDP
  - Internet: IP
- Link layer exists, but not explicitly specified
  - Includes physical layer
  - Ethernet is common at the edge
    - » Internet's core uses various protocols

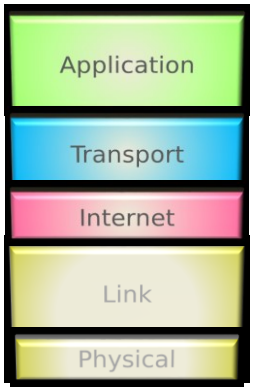


TCP/IP Origins

- 1969 – DoD authorizes development of ARPANET research network
- 1973-1974 – "TCP" protocol first developed for use on ARPANET nodes
- 1978 – "layered and modular" approach leads to separate "IP" protocol
- 1980 – formal standards published for TCP and IP version 4
  - September 1981: RFCs 791 (IP), 793 (TCP)

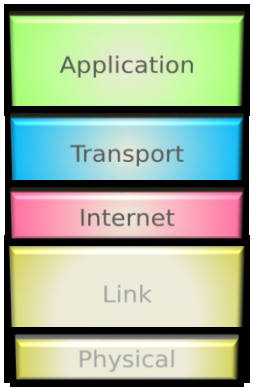
TCP/IP Layers – Layer 1, Physical Layer

- Refers to physical media and interfacing hardware
- Not specified by TCP/IP protocols
  - Individual network installations control physical equipment, make different choices
- Ethernet, WiFi are commonly used for LANs
- WANs use various technologies for long-distance transmissions

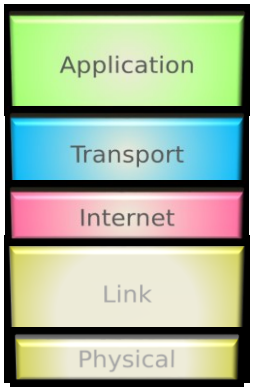


Layer 2 – Link Layer

- Refers to protocols and software for transmitting data – bits and bytes – between nodes that are connected by a physical LAN
  - Bits packaged into **frames** for transmission
- Also not specified by TCP/IP
  - Individual network installations choose layer-2 software that is compatible with their layer-1 hardware
- Ethernet (IEEE-802.3), IEEE-802.11 dominate
  - Both specify Layers 1 and 2 together

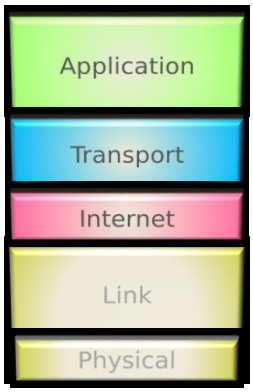


Layer 3 – Internet Layer



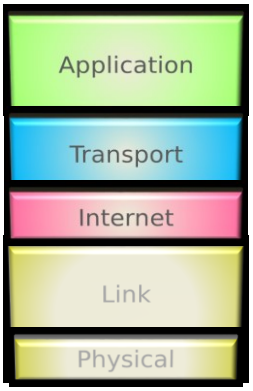
- Primary focus of TCP/IP
- Protocols needed to get data from one site's LAN to somewhere else
  - Primary protocols are IPv4, slowly being replaced by IPv6
- Data grouped into packets (aka datagrams)
- Routing of packets a major focus

Layer 4 – Transport Layer



- Also a primary focus of TCP/IP
- Protocols that package data from network applications into suitable form for network transmission
- Data grouped into segments
  - or maybe "datagrams"
    - distinct from IP datagrams
- Major protocols include TCP, UDP

Layer 5 – Application Layer



- Loose collection of protocols that network applications use for communicating with applications on different network nodes
- Examples:
  HTTP, FTP, NTP, SMTP, etc.
  - whatever it is your favorite MMORPG uses…
- Data groups often called **messages**

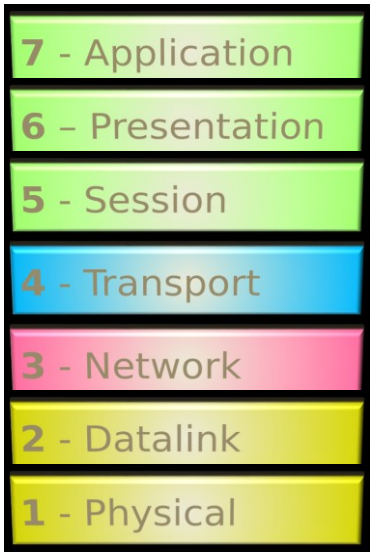
The ISO/OSI Reference Model

- **O**pen **S**ystems **I**nterconnection
  - 1977: ISO begins work on OSI
    - ISO – International Organization for Standardization ("Iso" as in "equal")
  - 1984: OSI Reference Model published
    - Based on Honeywell's "Distributed Systems Architecture" (DSA), IBM's "System Network Architecture" (SNA) – both 7-layer designs
- Seven layers describe *distinct* functions needed for a network transmission

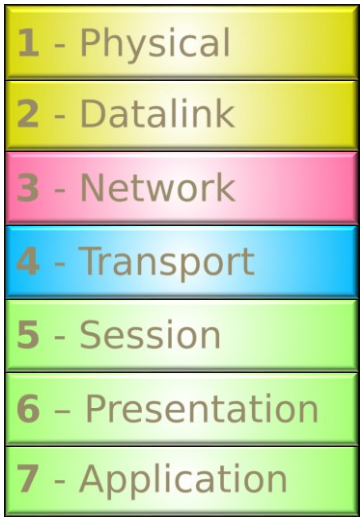
The OSI Layers – Top to Bottom

- Application set
  - What must an app do to talk to another app?
- Transport set
  - How does data get from one computer to another computer?

Cisco divides the layers into the Application set and the Transport set.



The OSI Layers – Bottom to Top



- From a network engineering perspective, the layers make more sense starting at the bottom and building up
- From a forensic perspective, the upper layers get more attention
- The Transport layer ties these groups together

...and some Mnemonics for the OSI layer names

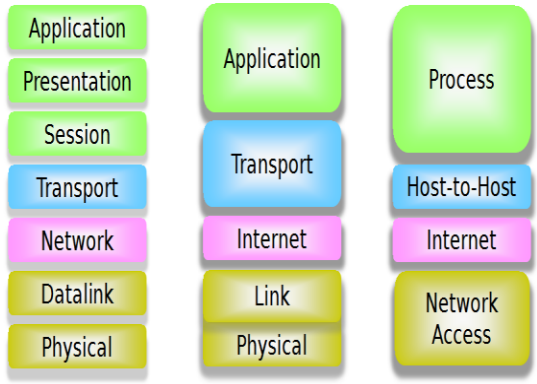
- *Top* to *bottom*:
  - **A**ll **P**eople **S**eem **T**o **N**eed **D**ata **P**rocessing
  - **A**ll **P**eople **S**tudying **T**his **N**eed **D**rastic **P**sychotherapy
- *Bottom* to *top*:
  - **P**lease **D**o **N**ot **T**hrow **S**ausage **P**izza **A**way
  - **P**eople **D**esign **N**etworks **T**o **S**end **P**ackets **A**ccurately
  - **P**urple **D**ragons **N**eed **T**o **S**mell **P**leasant **A**romas

® bob,mon!

Comparing Models

- OSI
  - Rigorously specified
    - moreso than the others
  - Real protocols not organized this way
- TCP/IP (Internet)
  - Transport layer includes some session-oriented functionality
  - Link layer not specified, includes physical layer
  - Based on actual implementations
- DoD
  - Basically an official description of TCP/IP

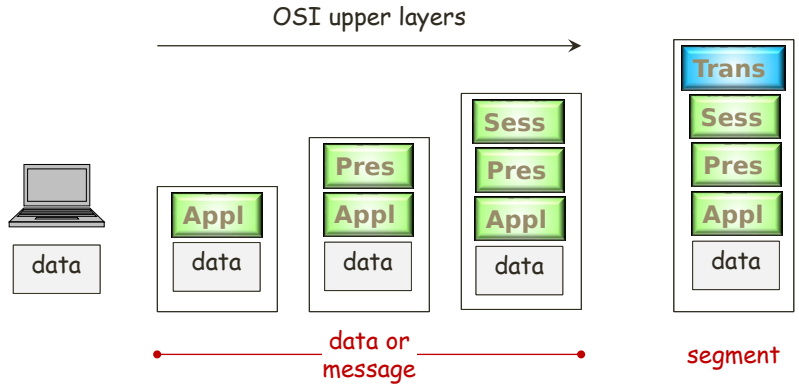
Know these!



Encapsulation

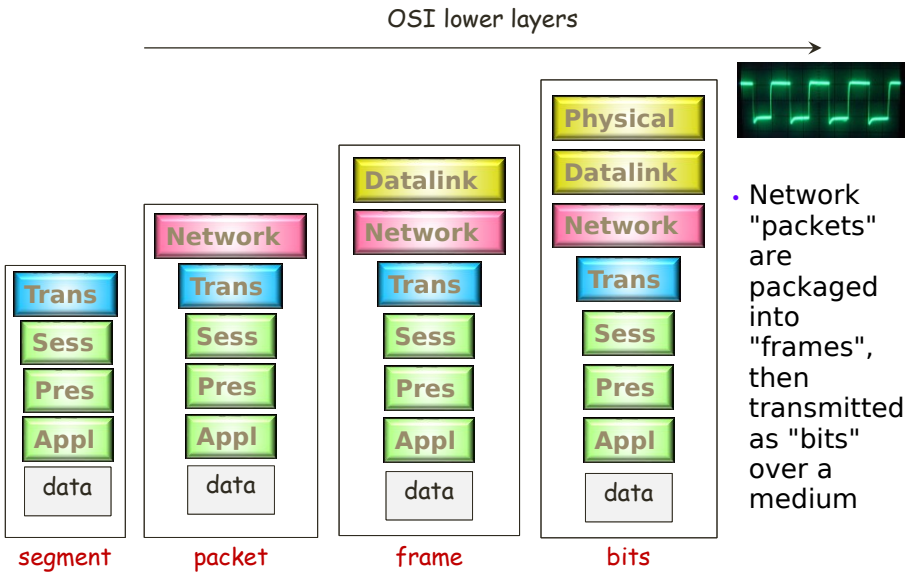
- Protocol "stack" includes software at each layer that processes data from other layers
- *Sending*: each layer wraps additional information around data from higher layer
- *Receiving*: each layer receives data from lower layer, uses info in its headers to process data and pass up to a higher layer

Encapsulation and the OSI Model



- User's data is formatted according to Application layer
  - Presentation, Session layers also involved here
- Forms a "message"
- Result has Transport layer header added
  - May be split into smaller "segments"

Encapsulation and the OSI Model



- Network "packets" are packaged into "frames", then transmitted as "bits" over a medium

What is Data Called In Each Layer?

- The content is called by different names in different layers
- Mnemonic:
  - "Messages"
    - **M**any **S**ick **P**eople **F**eel **B**ad
  - "Data"
    - **D**eathly **S**ick **P**eople **F**eel **B**ad

Message or **D**ata

Segment

Packet

Frame

Bits

...what's the point?

- Many different things may need to be done to successfully transmit some data from one computer to another.
- These things must interact. They must work even while one or both of the computers are also doing unrelated tasks.
- The OSI model is an attempt to categorize and organize the various necessary networking functions, so that programs from different vendors can interoperate.