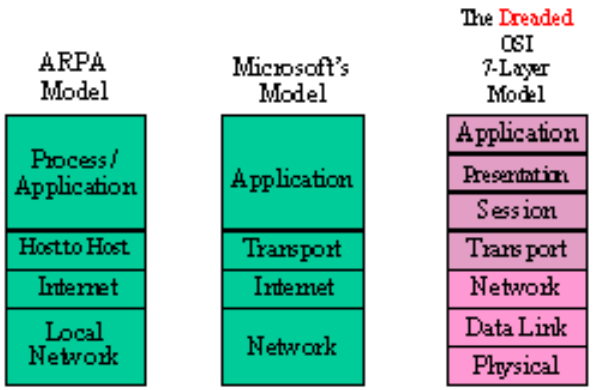
Network Layers

The OSI and Internet Models

What is a layered model?

- Models help us to visualize different aspects of complex abstract systems



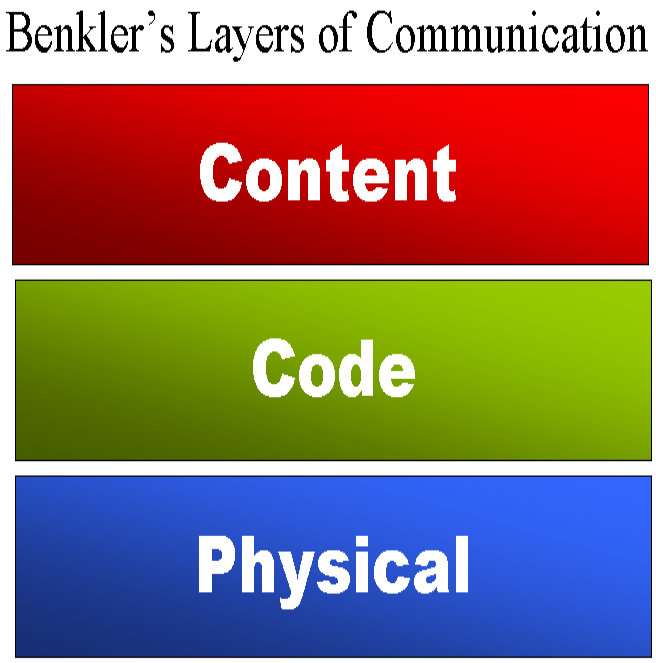
Layers represent independent components that can be examined separately or in relation to each other

What is a layered model?

Almost all communication can be broken down into independent layers that work interdependently.

The ‘layers' (and protocols between them) conceptually represent negotiations between aspects of communication: Content, logical (encoding) and physical delivery of messages.

Communication theorist Yochai Benkler's layers of communication.



What is a layered model?

Example (Benkler's layers in action…)

- My brother in Sweden wants the recipe for my famous 7-layer dip
- What will we need to negotiate to communicate?

What is a layered model?

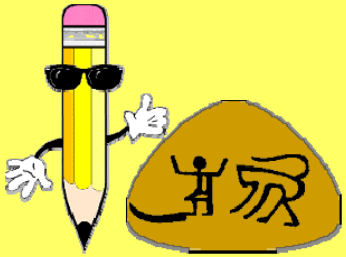
Content

What are the ingredients?
What is the recipe?

Code

What language will we use? Swedish or English?

How will we communicate? Verbally, writing, pictures?



Physical

How will we physically transport the message? E-mail, snail-mail, video, telephone?

What is a layered model?

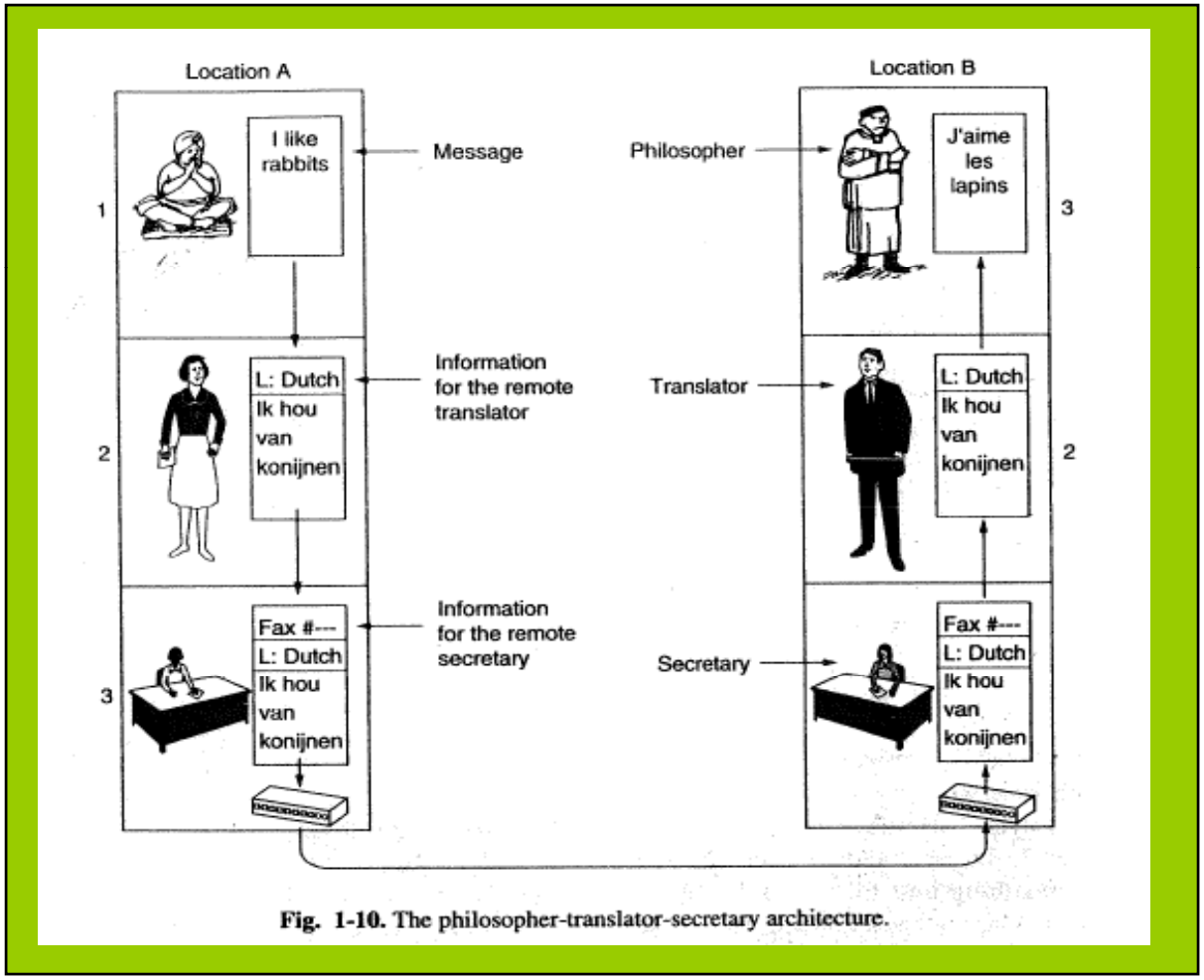


Fig. 1-10. The philosopher-translator-secretary architecture.

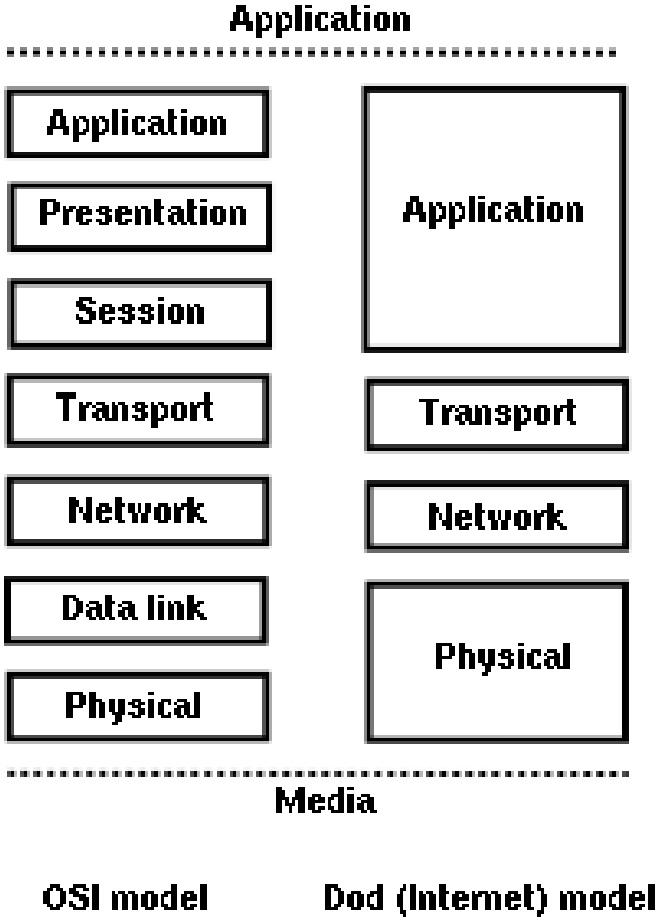
What is a layered model?

Terminology

- Service
  - Performance of a specific communication function
- Layer
  - Self contained set of related services
- Interface
  - Defines which operations and services are offered between layers, from lower to the next layer up
- Protocol
  - An agreement between communicating parties on how the communication is to proceed (i.e., “handshake”)
- Stack
  - List of protocols used by a particular system

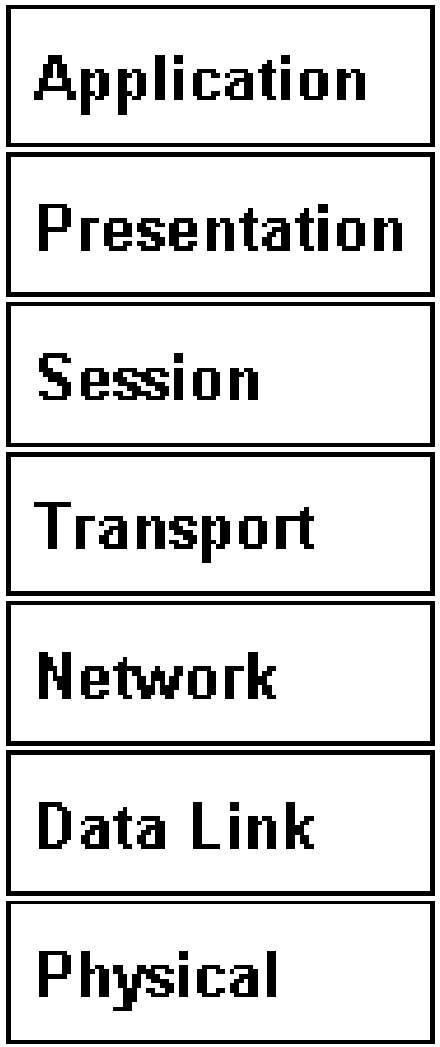
What is a layered model?

2 models for network communications



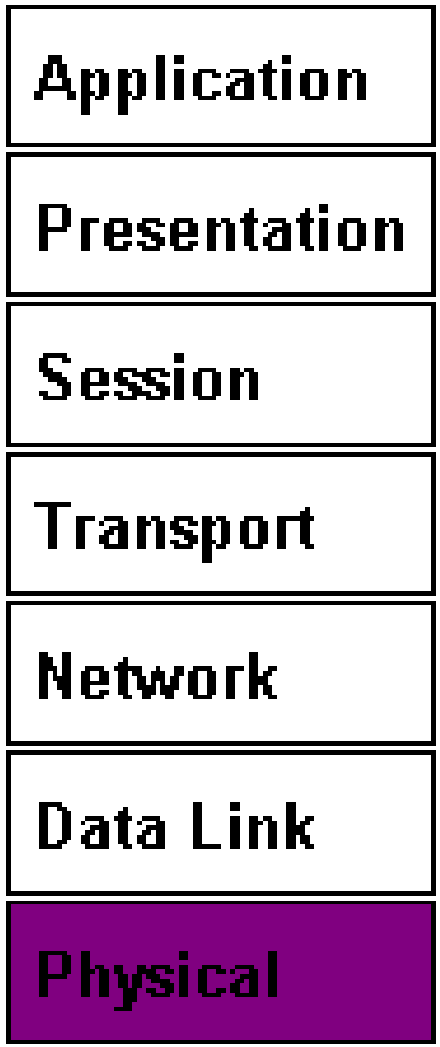
- OSI 7-Layer Model
  - International Standards Organization's Open Systems Interconnection model
- TCP/IP Model
  - Developed by the Department of Defense

The OSI Layered Model



- OSI – Open System Interconnection
- Layered Approach
- Allows better interoperability between software and hardware
- Allows design of elaborate but highly reliable protocol stacks

OSI Layers - What does each layer do?



The Physical Layer

- Defines all electrical and physical specifications for devices.
- Major Functions
  - Establishment & Termination of Connections
  - Connection Resolution & Flow Control of Communication Resources
  - Modulation & Conversion between Digital Data
- Example – radio, SCSI (Small Computer System Interface)

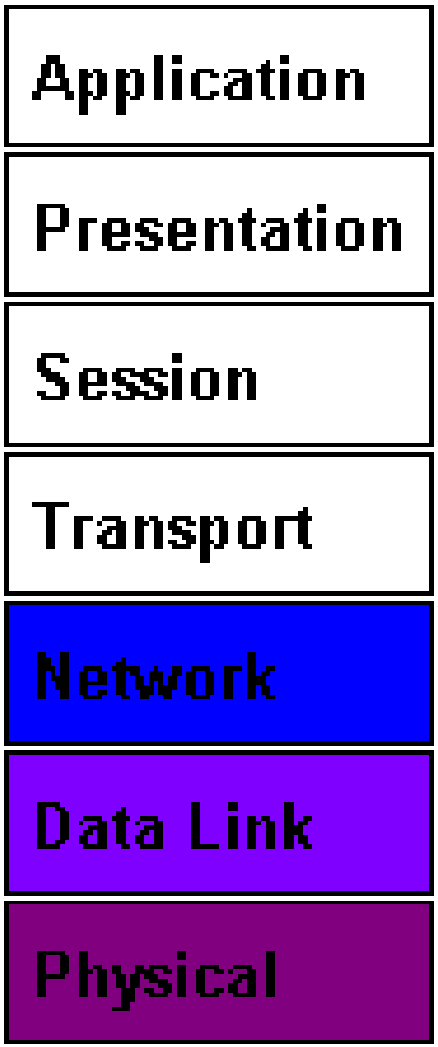
OSI Layers - What does each layer do?

- Application
- Presentation
- Session
- Transport
- Network
- **Data Link**
- Physical

The Data Link Layer

- Controls data transfer between network entities
- Performs error detection & correction
- Uses physical/flat Addressing Scheme
- Example - Ethernet

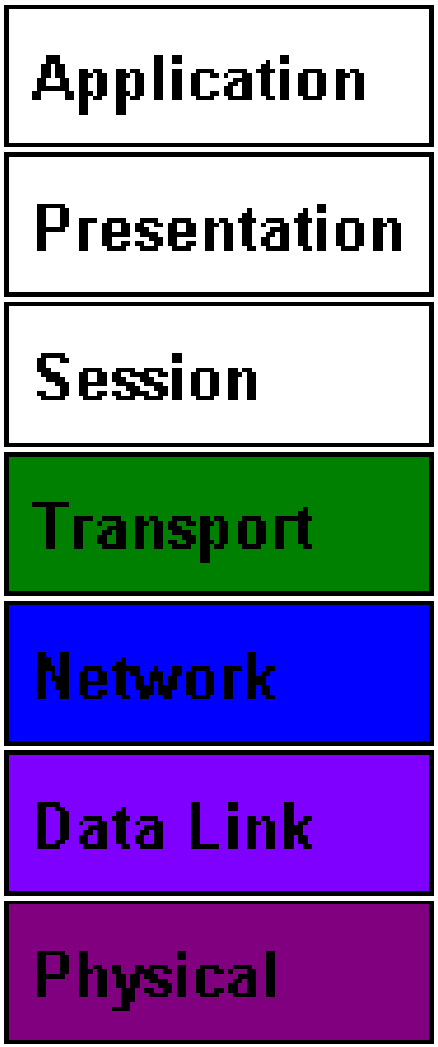
OSI Layers - What does each layer do?



The Network Layer

- Performs network routing, flow control, segmentation, and error control functions
- The router operates at this layer
- Uses local addressing scheme
- Example – IP, token ring

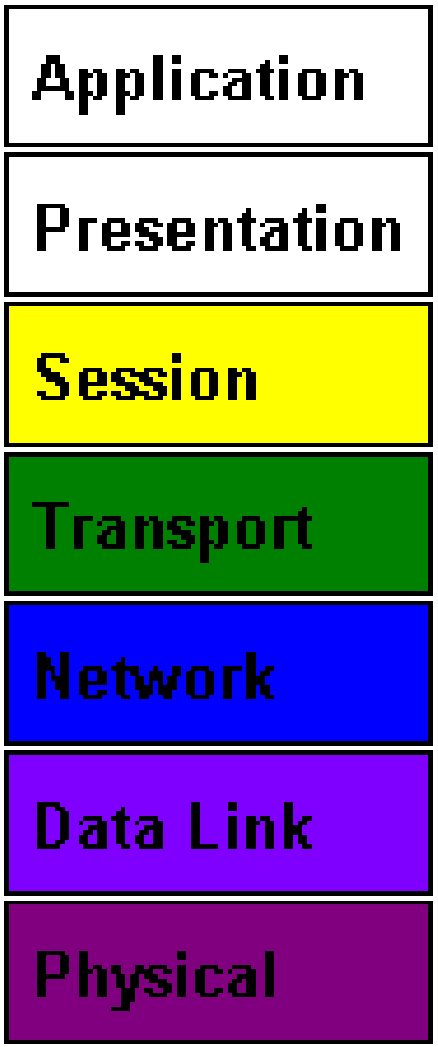
OSI Layers - What does each layer do?



The Transport Layer

- Provide transparent transfer of data between end users
- Controls reliability of a given link
- Some protocols are stateful and connection oriented (cookies)
- Example – TCP / UDP

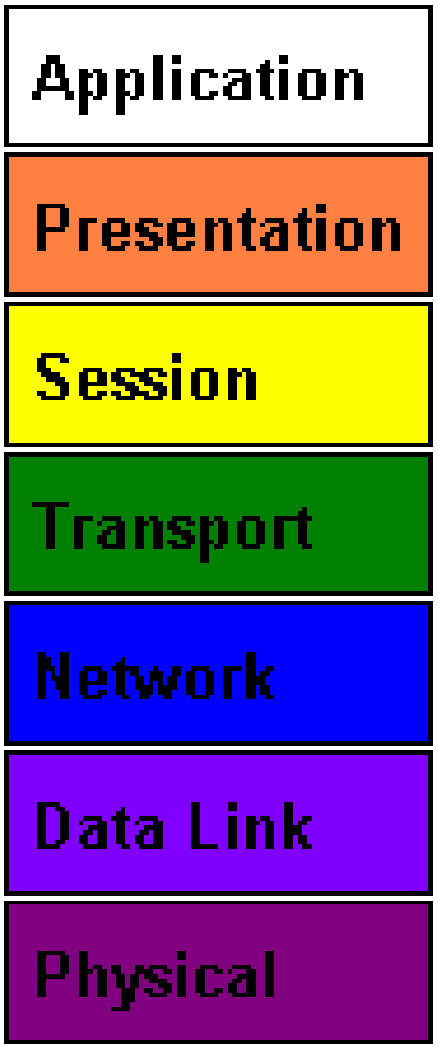
OSI Layers - What does each layer do?



The Session Layer

- Provides mechanism for managing the dialogue between end-user application processes
- Provides for either duplex or half-duplex operation
- Responsible for setting up and tearing down TCP/IP sessions
- Example – NetBIOS

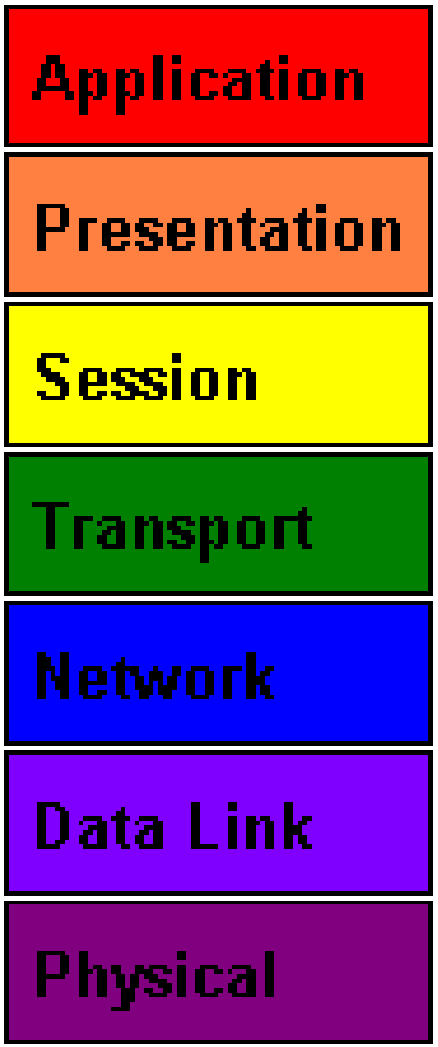
OSI Layers - What does each layer do?



The Presentation Layer

- Little to do with PowerPoint
- Controls syntactical differences in data representation within end-user systems
- MIME encoding is done at this layer
- Example - XML

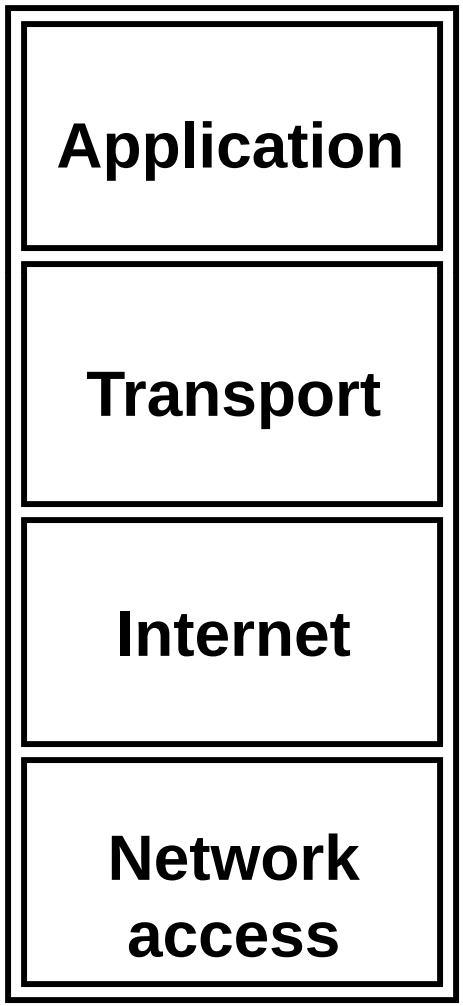
OSI Layers - What does each layer do?



The Application Layer

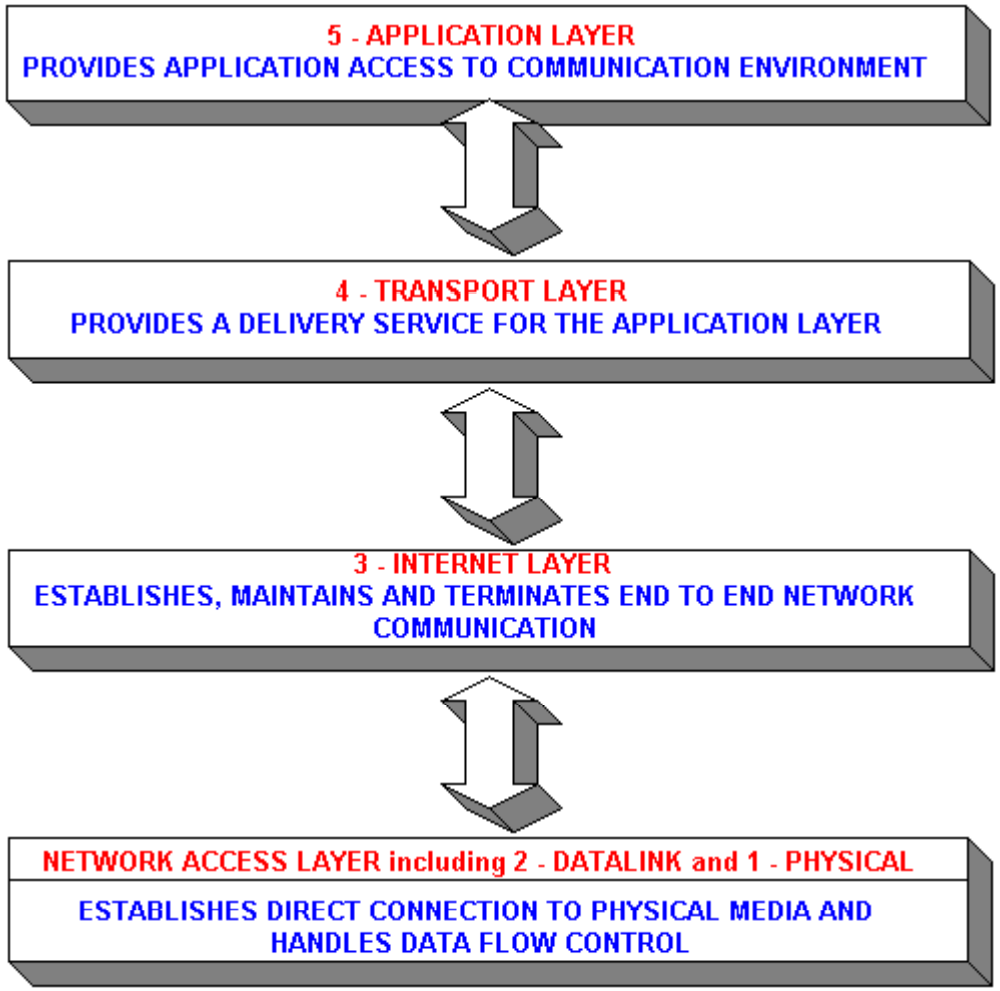
- Provide semantic conversion between associated application processes
- Interfaces directly to and performs common application services for the application processes
- Example – Telnet, Virtual Terminal

TCP/IP layered network model

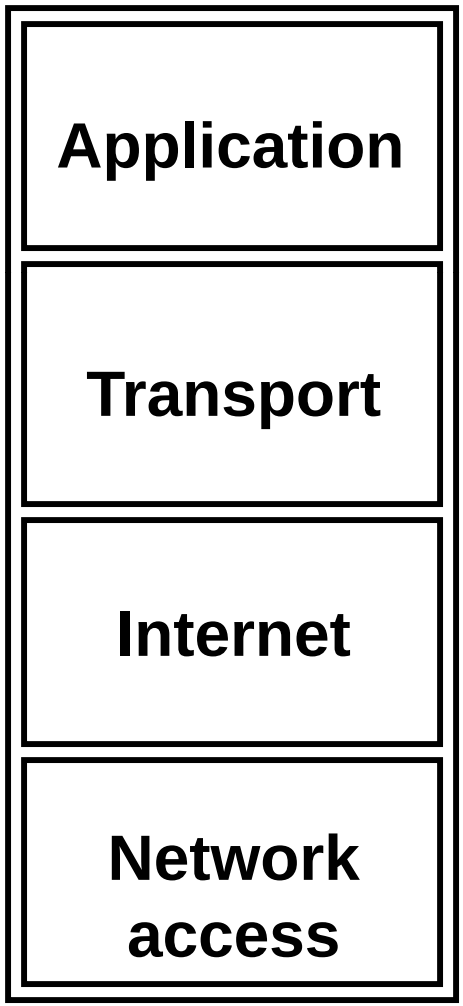


- Transmission Control Protocol and Internet Protocol
- TCP/IP is a suite of protocols, also known as the Internet Protocol Suite
- It was originally developed for the US Department of Defense Advanced Research Project Agency (DARPA) network, but it is now the basis for the Internet

TCP/IP network model layers

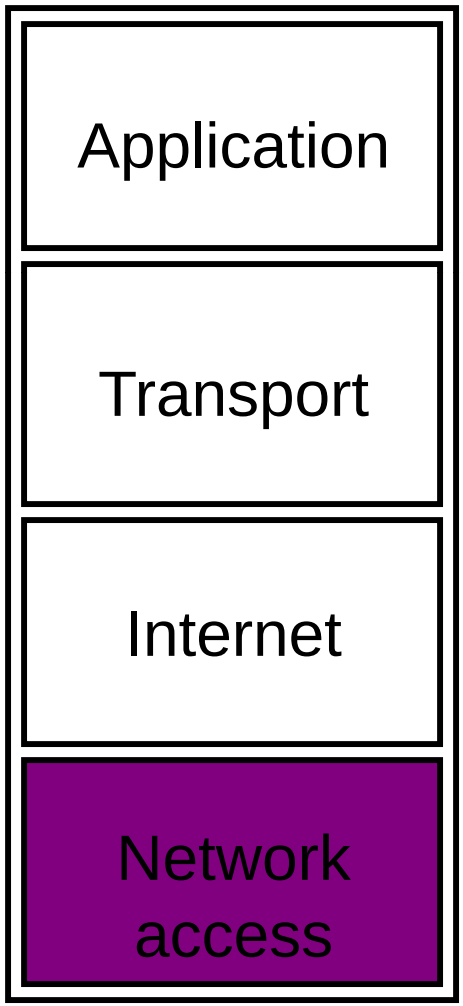


TCP/IP Layers - What does each layer do?



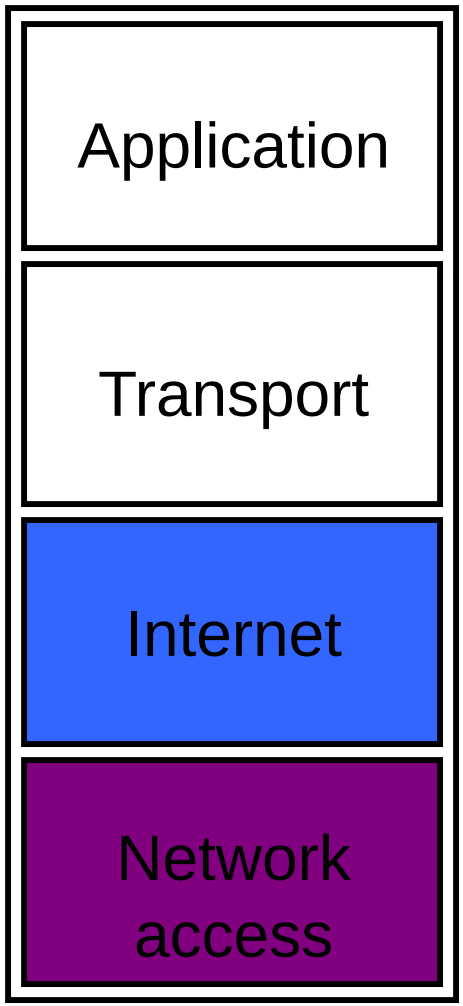
- As with the OSI model, the TCP/IP suite uses a layered model.
- TCP/IP model has four or five - depending on who you talk to and which books you read!
- Some people call it a four layer suite - **Application**, **Transport**, **Internet** and **Network Access**, others split the **Network Access** layer into its **Physical** and **Datalink** components.

TCP/IP Layers - What does each layer do?



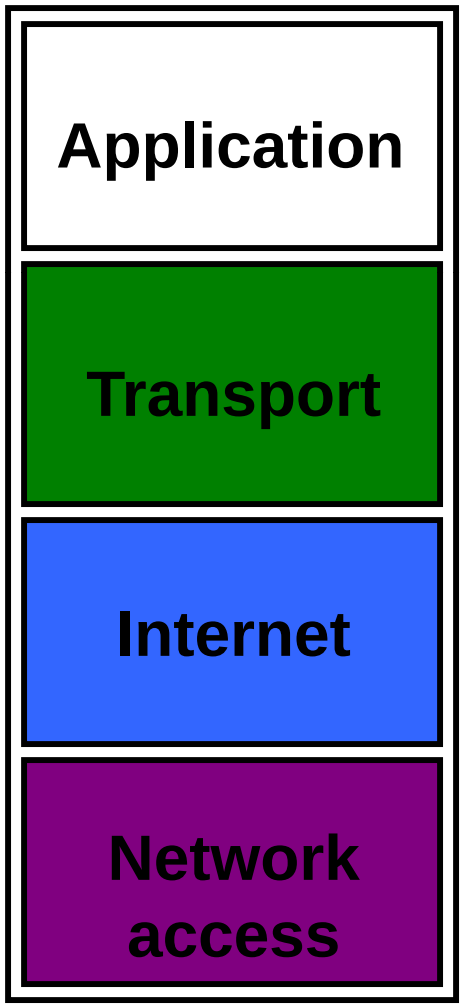
- The combination of datalink and physical layers deals with pure hardware (wires, satellite links, network interface cards, etc.)
- Access methods such as **CSMA/CD** (carrier sensed multiple access with collision detection)
- Ethernet exists at the network access layer - its hardware operates at the physical layer and its medium access control method (CSMA/CD) operates at the datalink layer.

TCP/IP Layers - What does each layer do?



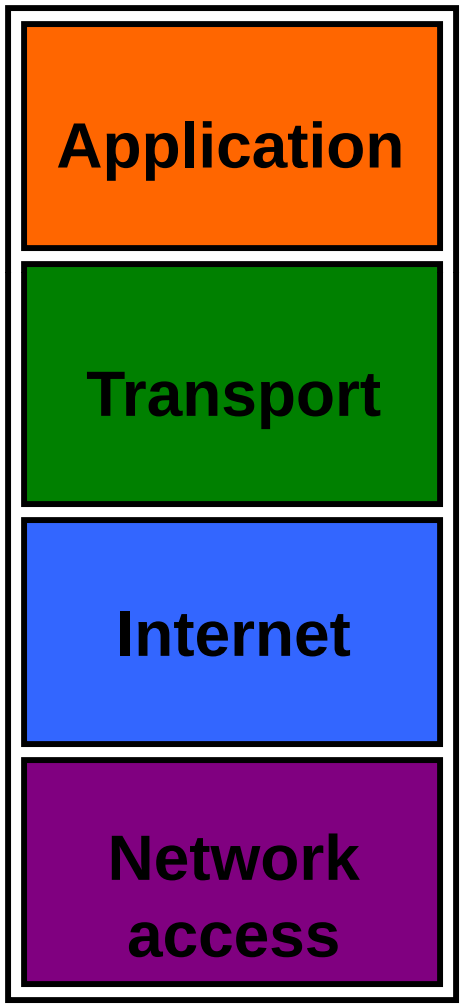
- This layer is responsible for the routing and delivery of data across networks.
- It allows communication across networks of the same and different types and carries out translations to deal with dissimilar data addressing schemes. IP (Internet Protocol) and ARP (Address Resolution Protocol) are both to be found at the Internet layer.

TCP/IP Layers - What does each layer do?



- The transport layer is similar to the OSI transport model, but with elements of the OSI session layer functionality.
- The two protocols found at the transport layer are:
  - TCP (Transmission Control Protocol): reliable, connection-oriented protocol that provides error checking and flow control through a virtual link that it establishes and finally terminates. Examples include FTP and Email
  - UDP (User Datagram Protocol): unreliable, connectionless protocol that not error check or offer any flow control. Examples include SNMP

TCP/IP Layers - What does each layer do?



- This layer is broadly equivalent to the application, presentation and session layers of the OSI model.
- It gives an application access to the communication environment.
- Examples:
  - Telnet
  - HTTP (Hyper Text Transfer Protocol)
  - SMTP (Simple Mail Transfer Protocol)

OSI & TCP/IP: How do they compare?

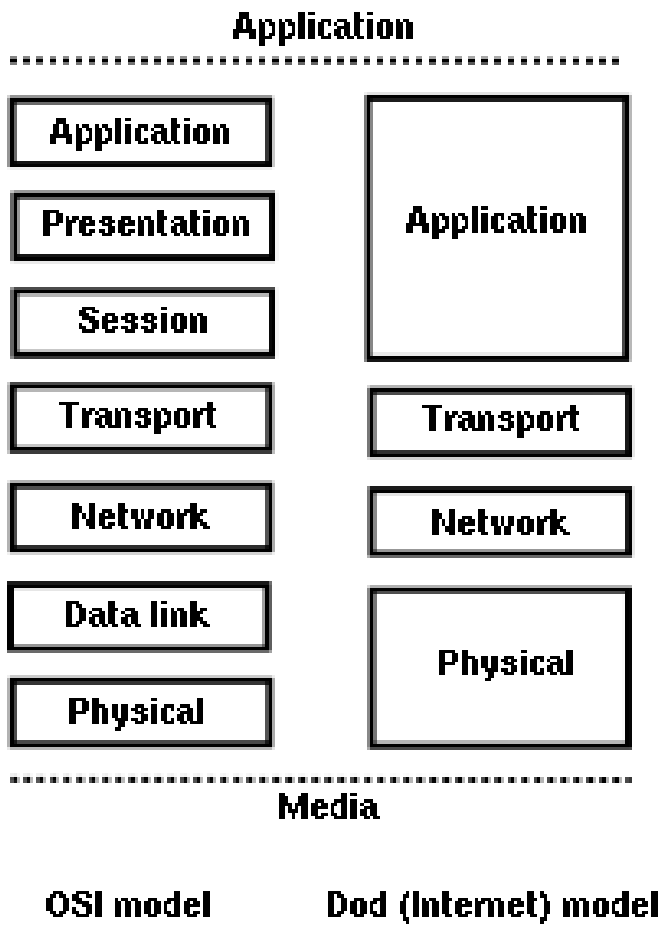
- Similarities
  - Based on a stack of independent protocols
  - Layers have roughly same functionality
    - Transport layer and below provide network-independent transport services
    - Layers above transport are application-oriented
- Why is this important?
  - Easier to blend, use what works best

OSI & TCP/IP: How do they compare?

- OSI: General model before protocols
  - Model was conceptual, designers didn't know what functionality to put in the layers
  - Model is general, easier to replace protocols
  - Model had to adjust when networks didn't match the service specifications (wireless networks, internetworking)
- TCP/IP: model describes existing protocols
  - Model only describes TCP/IP – not useful for describing any other networks (such as telephone networks)
- Why does this matter?
  - Knowing which model to use for your context

OSI & TCP/IP: How do they compare?

- Number of layers
  - OSI has 7, TCP/IP has 4
- Why does this matter?
  - Real world vs. conceptual



OSI & TCP/IP: How do they compare?

- Connectionless vs. connection-oriented
  - OSI
    - Network layer supports both
    - Transport layers supports only connection-oriented
  - TCP/IP
    - Network layer supports only connectionless
    - Transport layers supports both
  - Why does this matter?
    - What do you need for your situation?

OSI & TCP/IP: How do they compare?

- OSI Flaws
  - Bad Timing
    - TCP/IP already well-established in academia
  - Bad Technology
    - Complicated, controversial model
    - Unbalanced layers
    - Repeating functions
    - Designed for communications, not computing

OSI & TCP/IP: How do they compare?

- OSI Flaws (cont'd)
  - Bad Implementations
    - Complicated to understand and implement
  - Bad Politics
    - Seen as biased toward European telecom, European Community and U.S. government
- Why does this matter?
  - Knowing which model to use for your context

OSI & TCP/IP: How do they compare?

- TCP/IP Flaws
  - Blurred lines
    - Doesn't clearly distinguish between
      - services (what a layer does),
      - interfaces (how the layer communicates) and
      - protocols (how the layer does what it does).
  - Too specific
    - Model is only suited to describing TCP/IP, not other networks
    - Protocols can be very specific, inflexible

OSI & TCP/IP: How do they compare?

- TCP/IP Flaws (cont'd)
  - No distinction between physical and data link layers
    - No description of transmission media, nor frame delimiters
- Why does this matter?
  - Model is too specific, not specific enough

Conclusion

- Layered models are useful in describing complex communication systems
  - Allows developers to focus on layers independently
  - Applies to conceptualization as well as implementation
- Models vs. protocols
  - OSI model is useful in describing networks, but protocols are too general
  - TCP/IP model is weak, but protocols are specific and widely used