Computer Networks Foundations: Architecture

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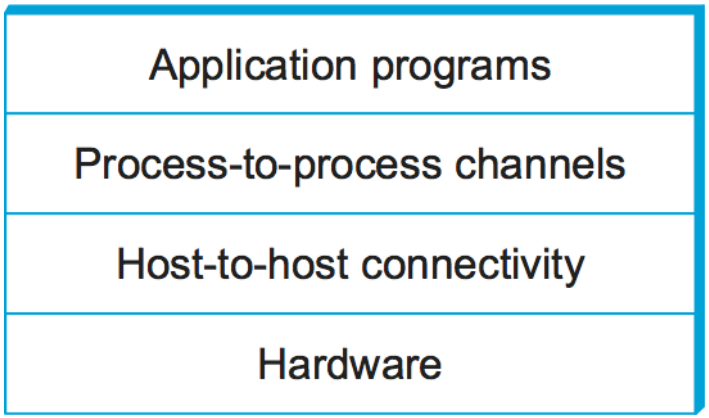
Network Architecture

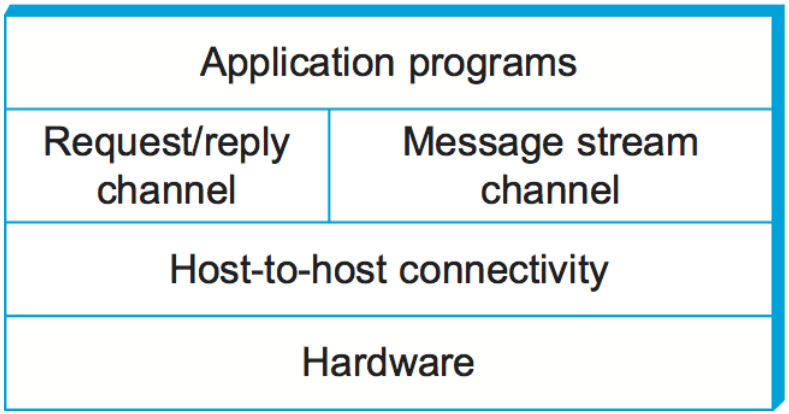
- General blueprints that guide the design and implementation of networks.
- Protocols and layering
- The OSI (or 7-layer) architecture and the Internet architecture.

Layered Architecture

- Network Architecture
  - A structured set of protocols that implement the exchange of information between computers/parties
- Use **abstractions** to hide complexity
- Abstraction naturally leads to layering
- Alternative abstractions at each layer

Example Layers

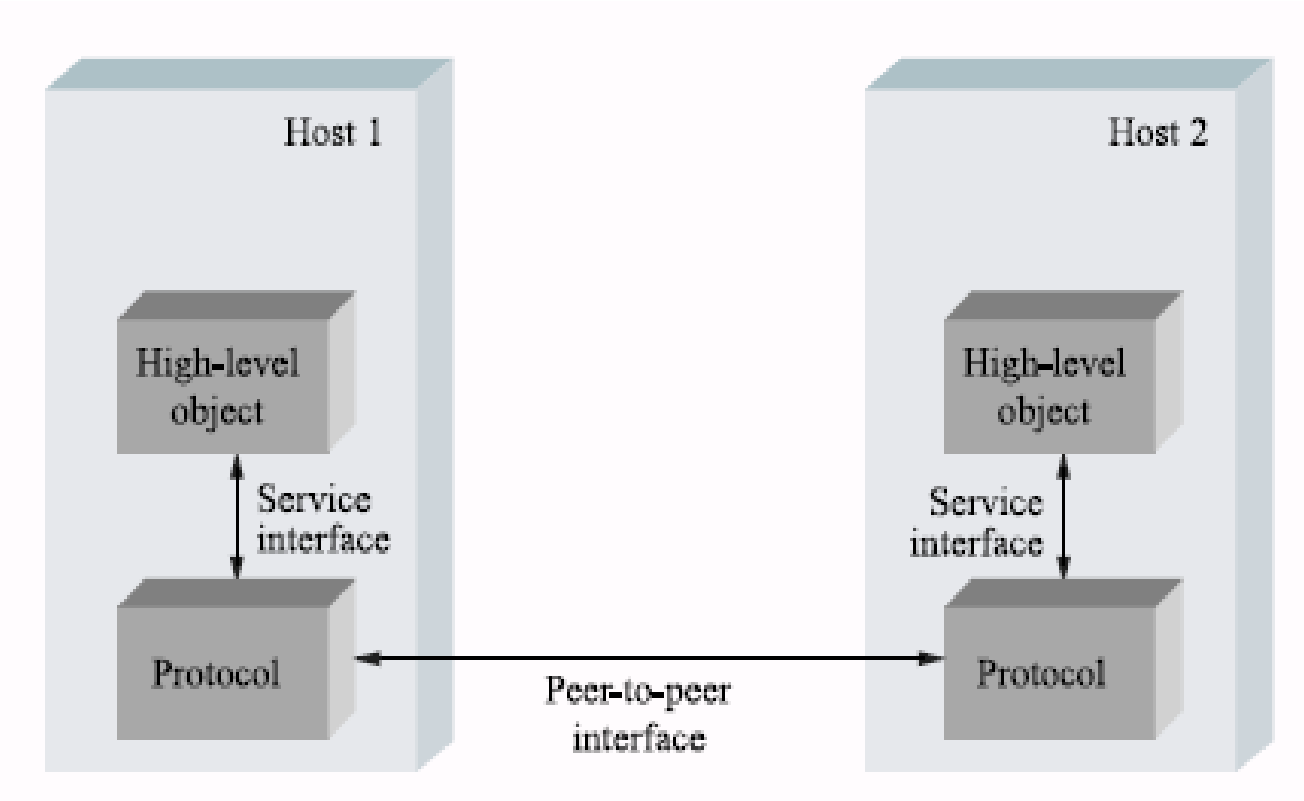




Protocols

- The abstract objects that make up the layers of a network system are called protocols.
- Well-defined procedure that runs on multiple parties
- A set of rules and conventions
- Two interface
  - Service interface: operations on this protocol
  - Peer-to-peer interface: message exchanged with peer
- Building blocks for a network architecture
- Term “protocol” is overloaded
  - Specification of peer-to-peer interface
  - Module that implements this interface

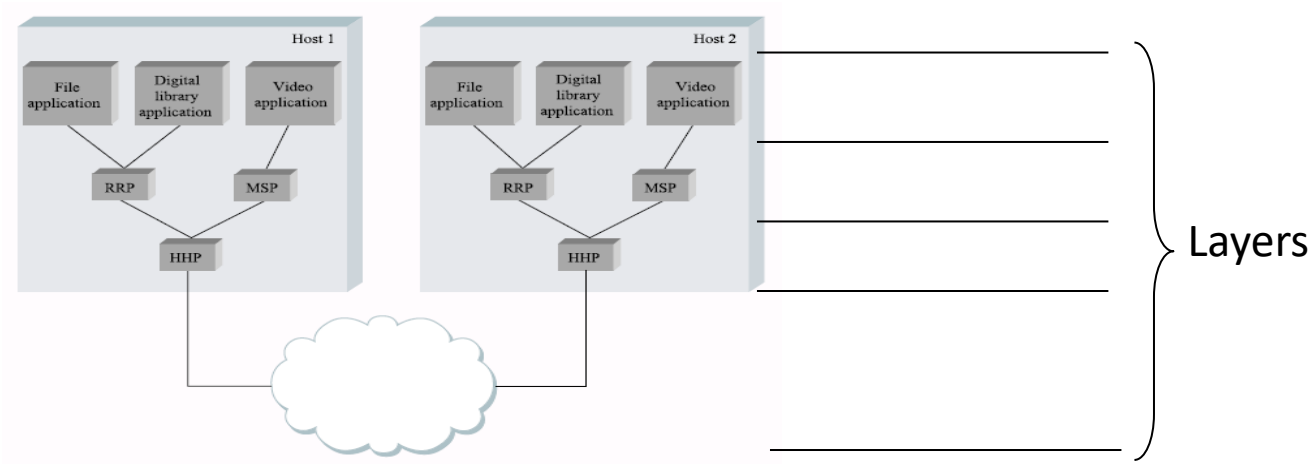
Service and Peer Interfaces



Service and peer interfaces

Example of Protocol Machinery

- Most peer-to-peer communication is indirect
- Peer-to-peer is directly only at hardware level



Service are grouped in a hierarchy of layers, which provide service interface

Layer N protocols only use *services* provided by layer N-1

Layer N protocols only provide *services* to layer N+1

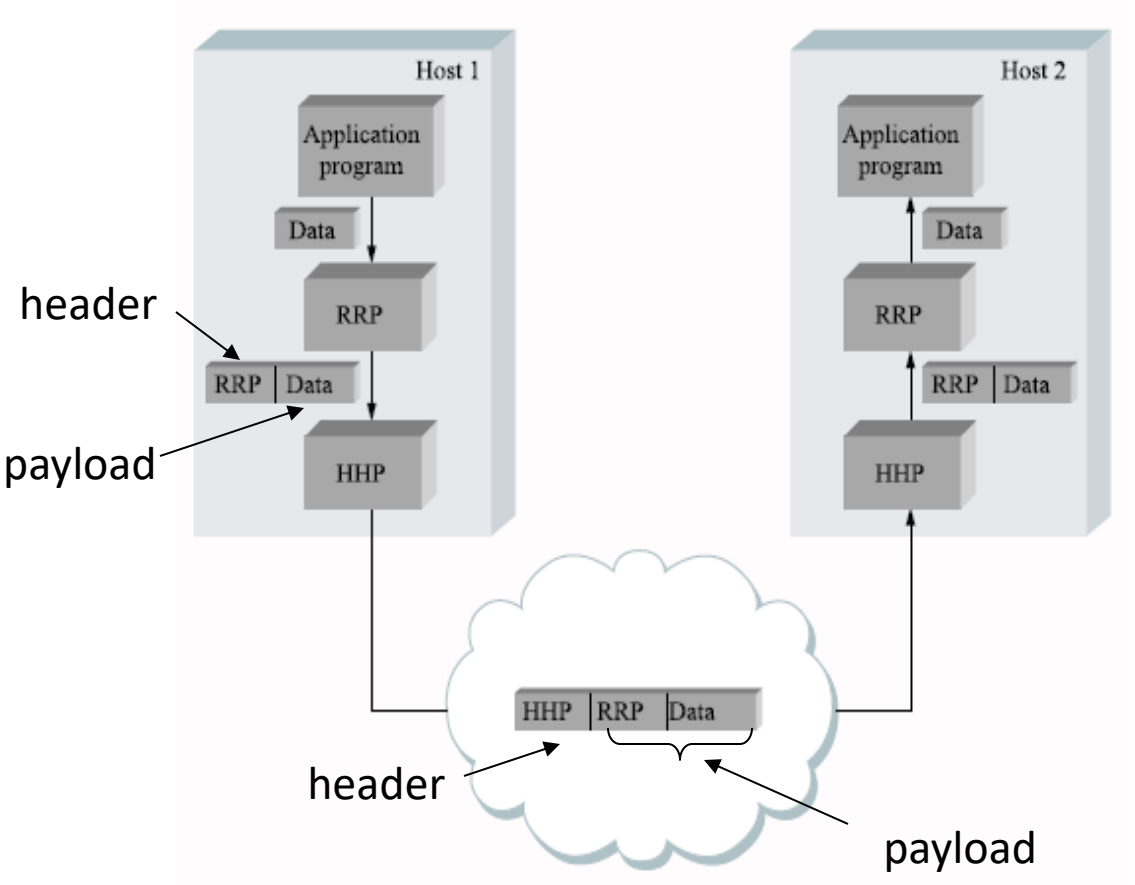
Q: does layer N needs to know the inner-working of layer N-1 or layer N+1?

Encapsulation

- Lower layer encapsulates upper layer's data

Encapsulation and Multiplexing/Demultiplexing

- *Header can have demultiplexing key*



High-level messages are encapsulated inside of low-level messages

Supporting Multiplexing and Demultiplexing

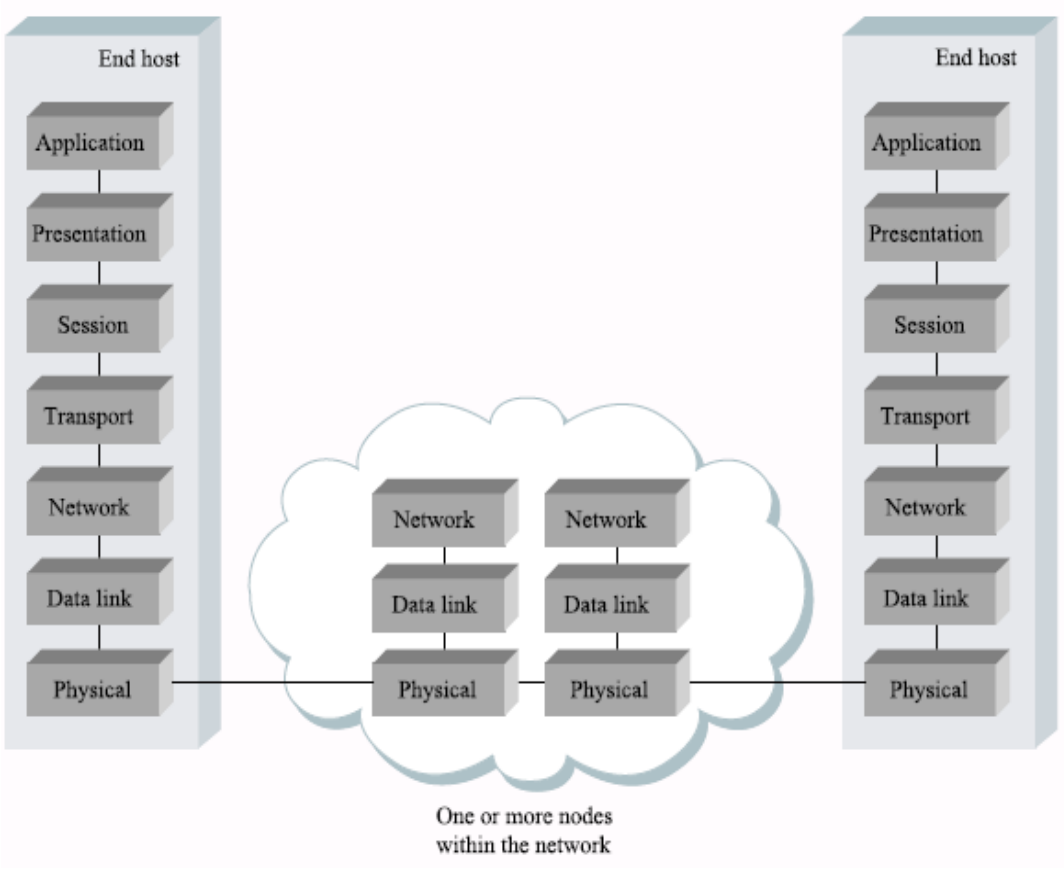
- Message headers provide necessary keys to aid multiplexing and demultiplexing between layers

OSI Model

- The ISO was one of the first organizations to formally define a common way to connect computers.
- OSI: the *Open Systems Interconnection* (OSI) architecture
  - Partition network functionality into 7 layers
    - One or more protocols implement the functionality assigned to a given layer.
  - The 7-layer design is not a protocol graph, *per se*, but rather a *reference model* for a protocol graph.
  - It is often referred to as the 7-layer model.

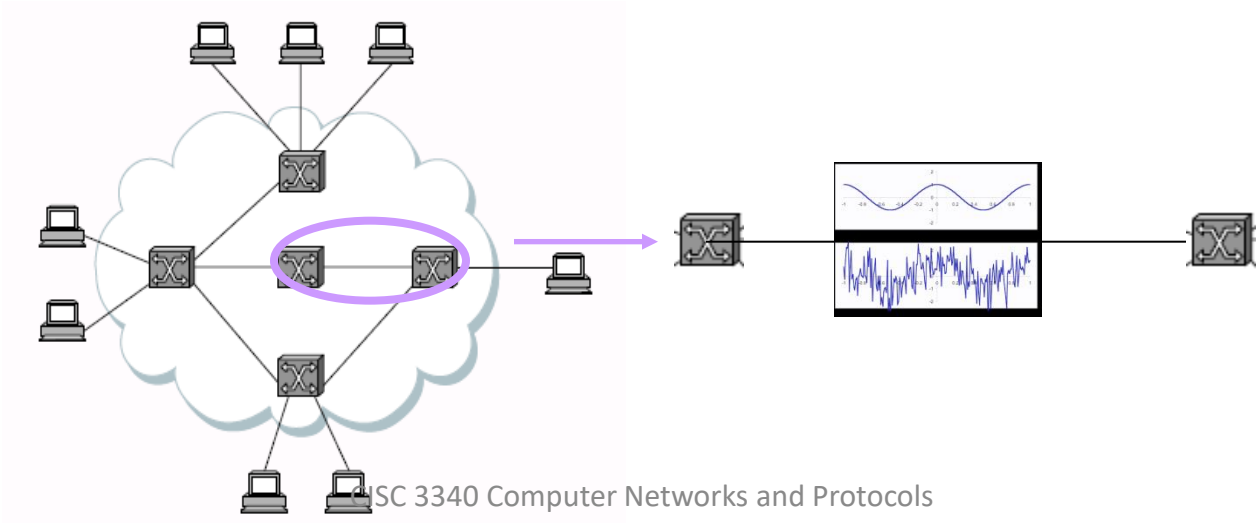
OSI (Open System Interconnection) Architecture

- Defined by ISO. Used as a reference model



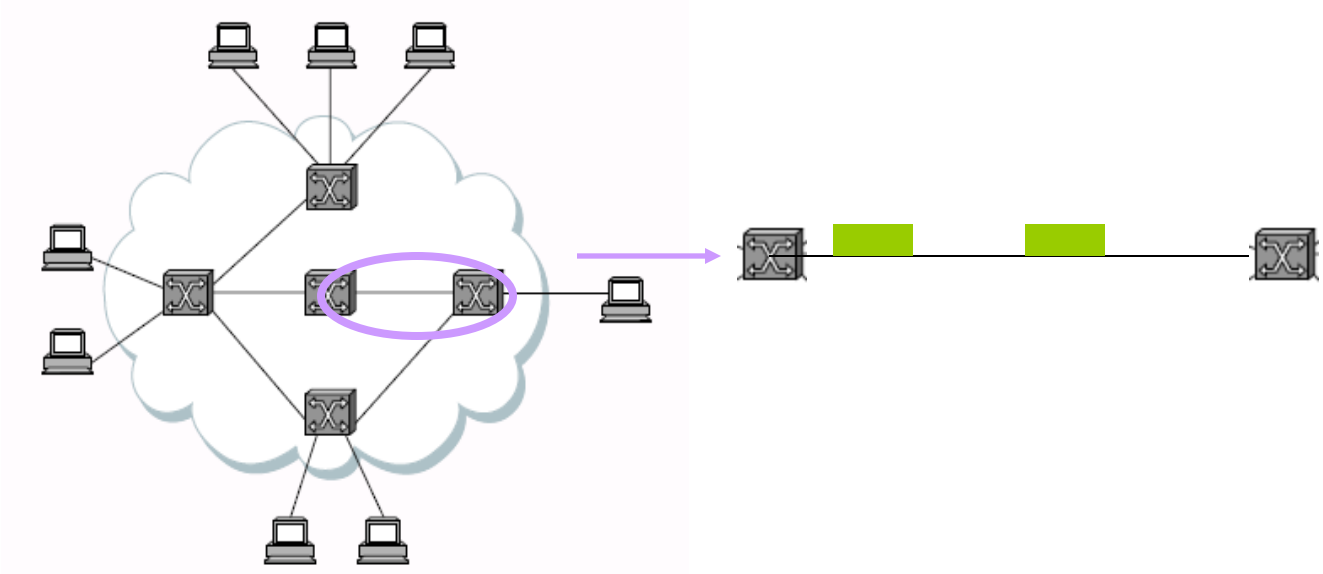
OSI: Physical Layer (Layer 1)

- Converts bits into physical signals such as electrical, optical, acoustic signals …
- Transmits these signals over the hardware communication medium such as twisted pair cable, coaxial cable, fiber optics, open/free space, water …



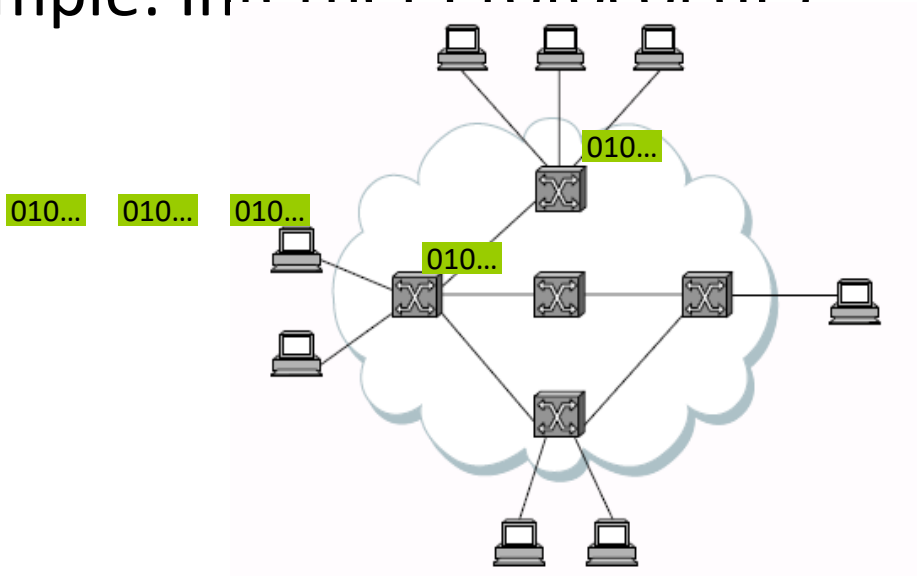
OSI: Data Link Layer (Layer 2)

- Reliably transfers data frames over a link
- Performs synchronization, error control, and flow control
- Example: Point-to-Point Protocol (PPP)



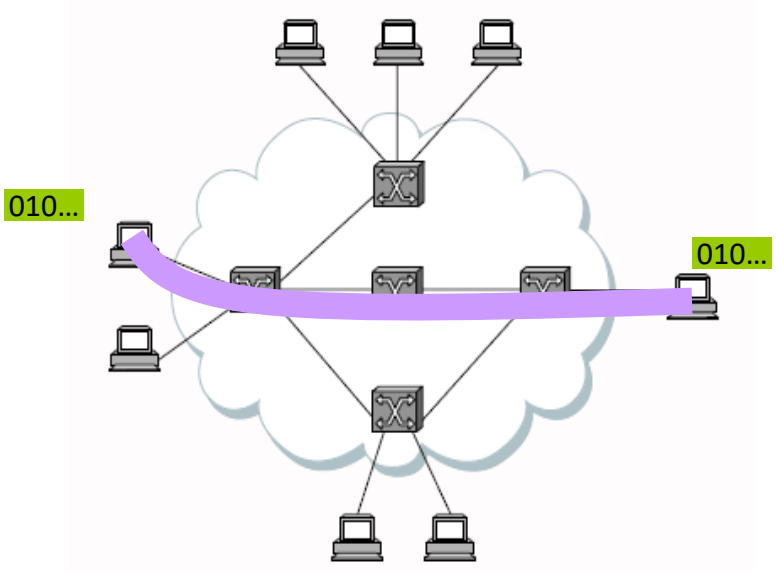
OSI: Network Layer (Layer 3)

- Moves packets inside the network
- Performs routing, addressing, switching, congestion control
- Example: Internet Protocol (IP)



OSI: Transportation Layer (Layer 4)

- Controls delivery of data between hosts
- Connection management, error control, flow control, multiplexing
- Example: Transmission Control Protocol (TCP) and User Datagram Protocol (UDP)



OSI: Session Layer (Layer 5)

- Support dialog between application programs
- Session management, synchronization
- Example: Remote-Procedure-Call (RPC)

OSI: Presentation Layer (Layer 6)

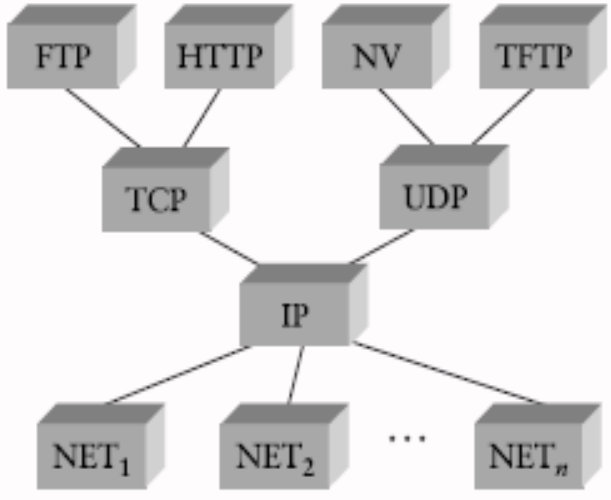
- Data conversion into application format
- Encryption and decryption
- Example: Secure Sockets Layer (SSL)

OSI: Application Layer (Layer 7)

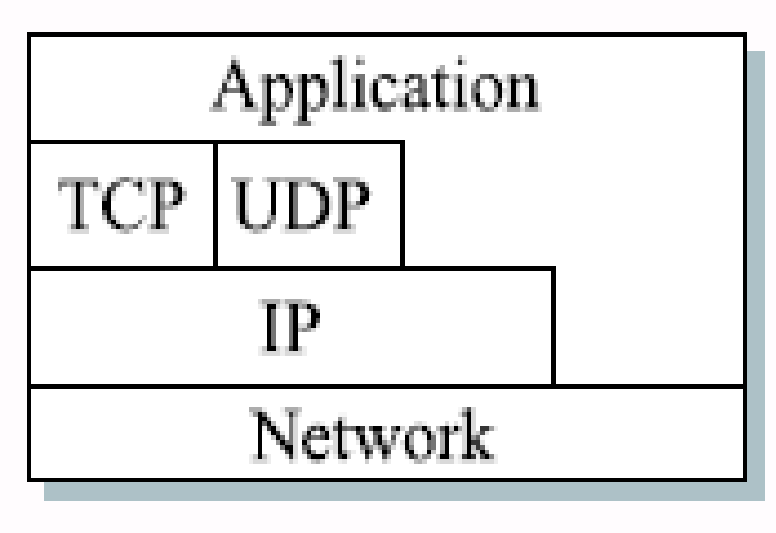
- Provides network access to application programs
- Application specific
- Example: File Transfer, Electronic Mail

Internet (TCP/IP) Architecture

- Defined Internet Engineering Task Force (IETF)

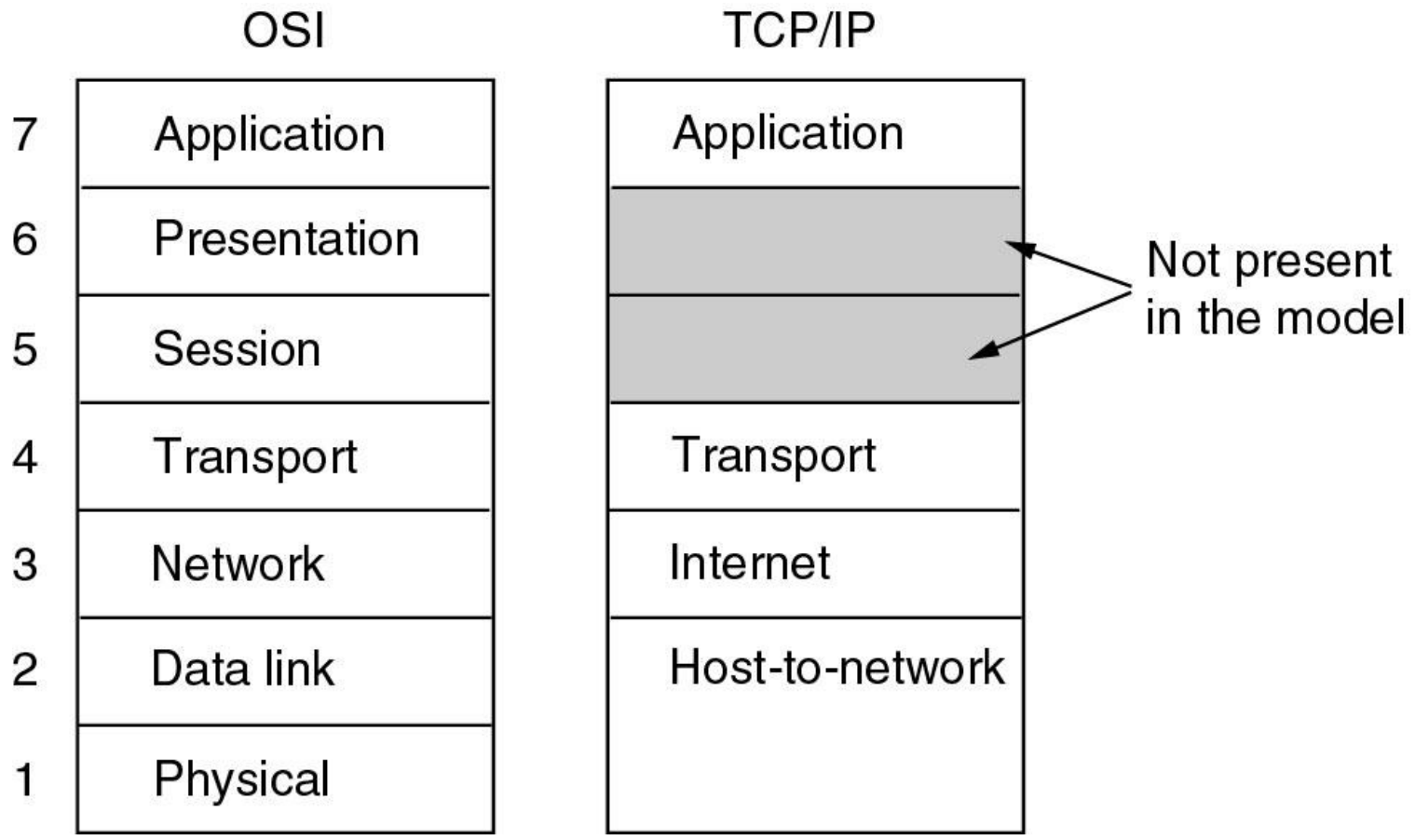


Internet protocol graph.



Internet architecture.

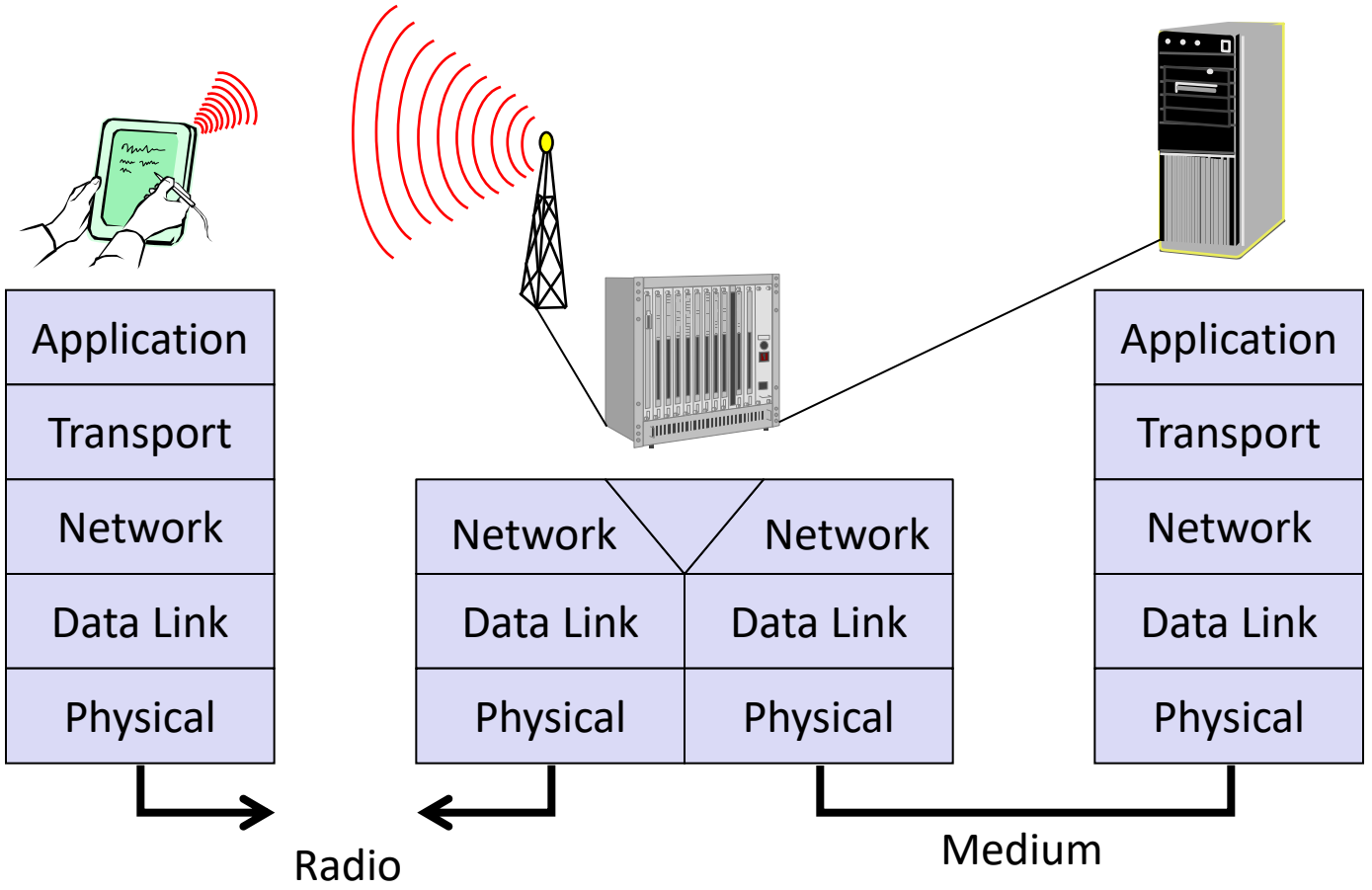
OSI and Internet Architectures



Key Characteristics of Internet Architecture

- Layering is not strict
- Hourglass design with IP as focal point
- Protocol specification + 1 (preferable 2) representative implementation

The Layered Reference Model



Often we need to implement a function across multiple layers.

Summary

- What is a computer network?
- Basic requirements
  - General purpose
  - Cost-effective network sharing
  - Fair network link allocation
  - Robust connectivity
- Layered architecture
- *Question:*
  - *How is the performance (see next lecture)?*

Additional Reading Assignment

- Leonard Kleinrock, An Early History of Internet, IEEE Communications Magazine, Vol. 48, No. 8, pp. 26-36, Available: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5534584