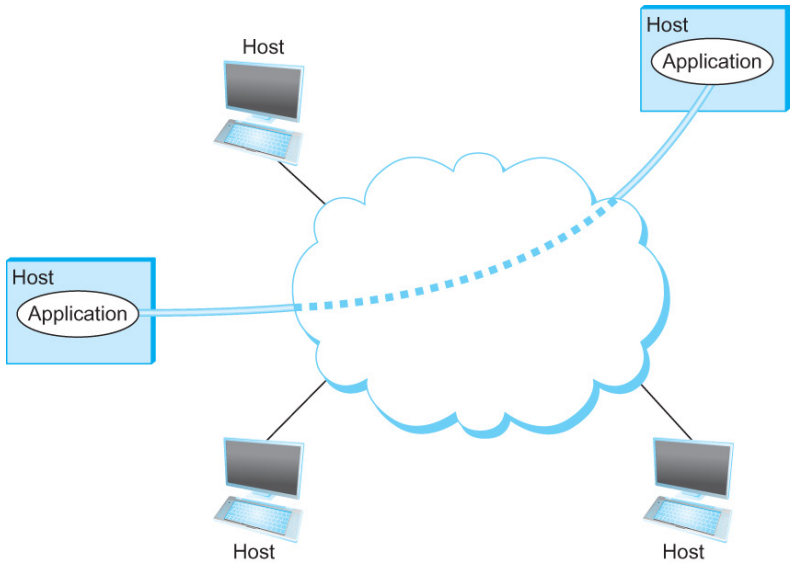
Network Protocols and Architecture

- Goal is to provide applications transparent communication across hosts
- Abstraction of a channel or “pipe”



- We have seen pipes on local machine, how to provide similar abstraction across machines?

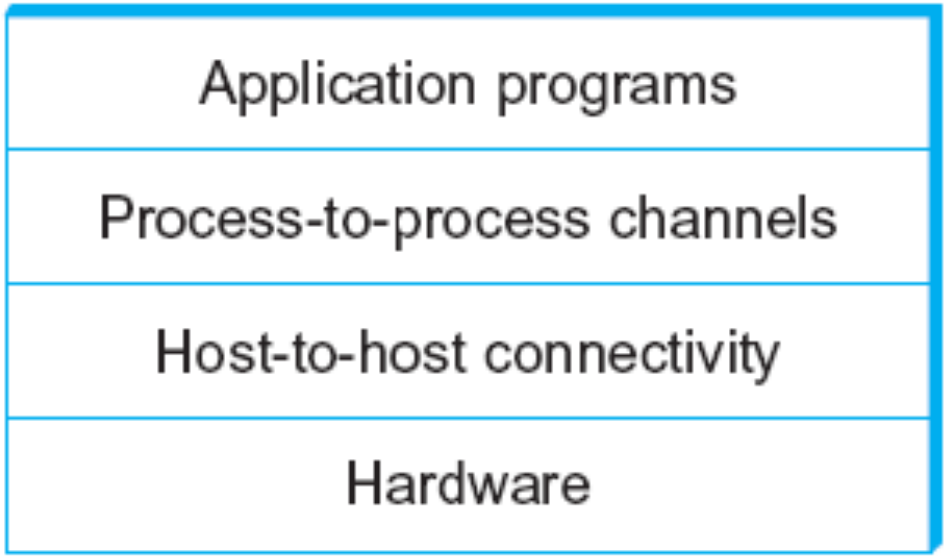
Communication Patterns

- Client/Server
- Two types of communication channel
  - Request/Reply Channels
  - Message Stream Channels

Reliability

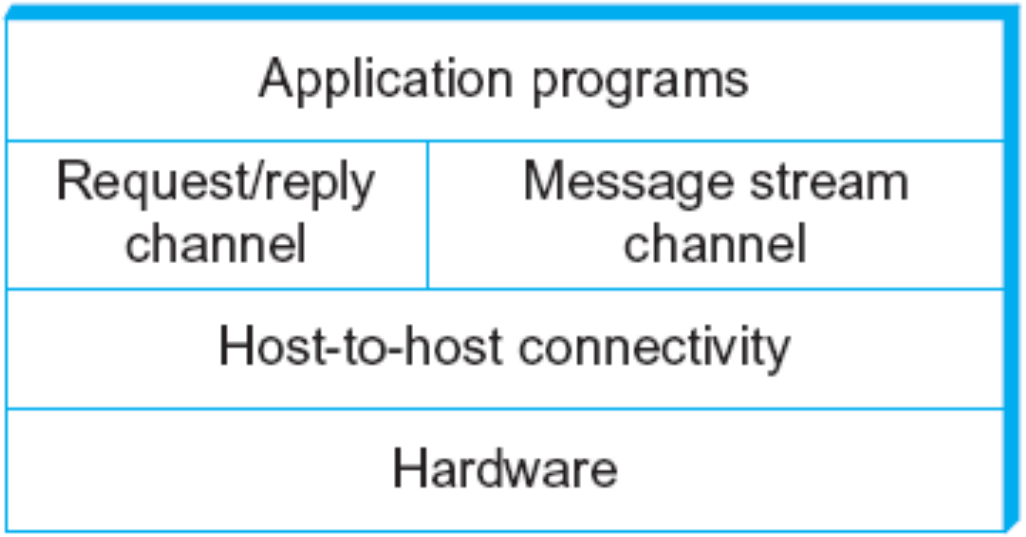
- Application has expectation that messages are delivered without corruption or loss
- Many sources of errors, network should hide them
  - Bits are lost
    - Bit errors (1 to a 0, and vice versa)
    - Burst errors – several consecutive errors
  - Packets are lost (Congestion)
  - Links and Node failures
  - Messages are delayed
  - Messages are delivered out-of-order
  - Third parties eavesdrop

Network Architecture



Example of a layers of abstraction in network system

Network Architecture Alternatives

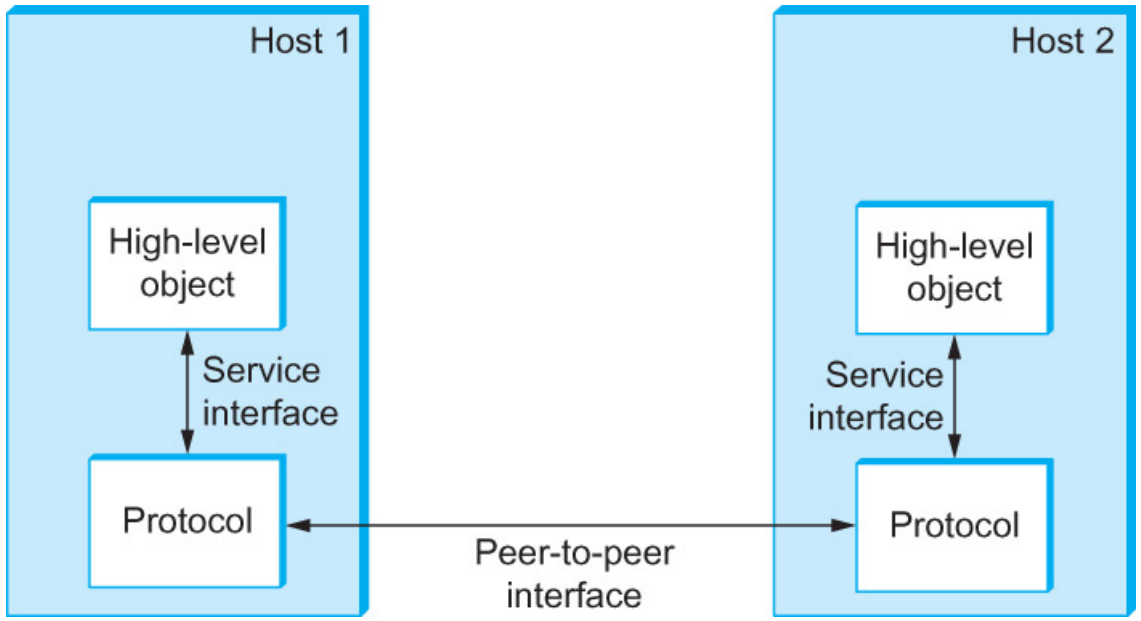


Layered system with alternative abstractions available at a given layer

Protocols

- Protocol defines the interfaces between the layers in the same system and with the layers of peer system
- Building blocks of a network architecture
- Each protocol object has two different interfaces
  - service interface: operations on this protocol called by other layers (e.g., application writes message to protocol)
  - peer-to-peer interface: messages exchanged with peer (e.g., layer 1 on machine A talks with layer 1 on machine B)
- Term “protocol” is overloaded
  - specification of peer-to-peer interface
  - module that implements this interface

Interfaces

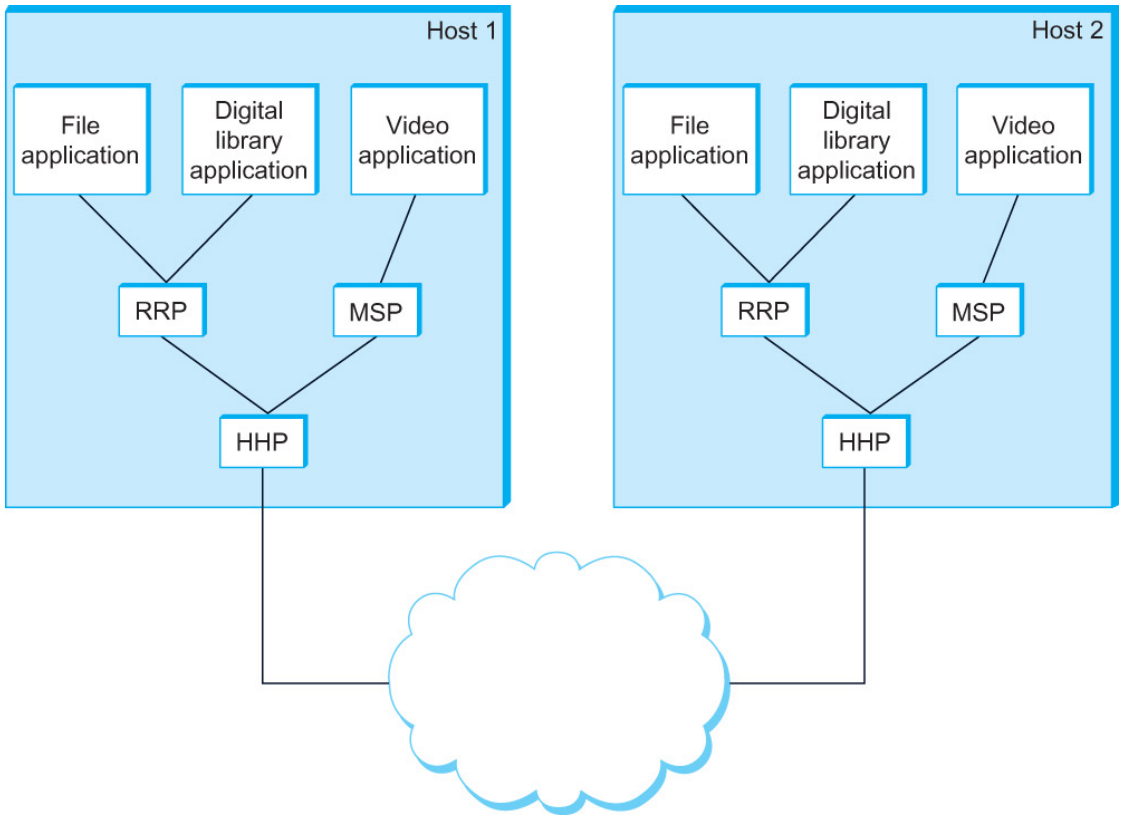


Service and Peer Interfaces

Protocols

- Protocol Specification: prose, pseudo-code, state transition diagram
- Interoperable: when two or more protocols that implement the specification accurately
- IETF: Internet Engineering Task Force

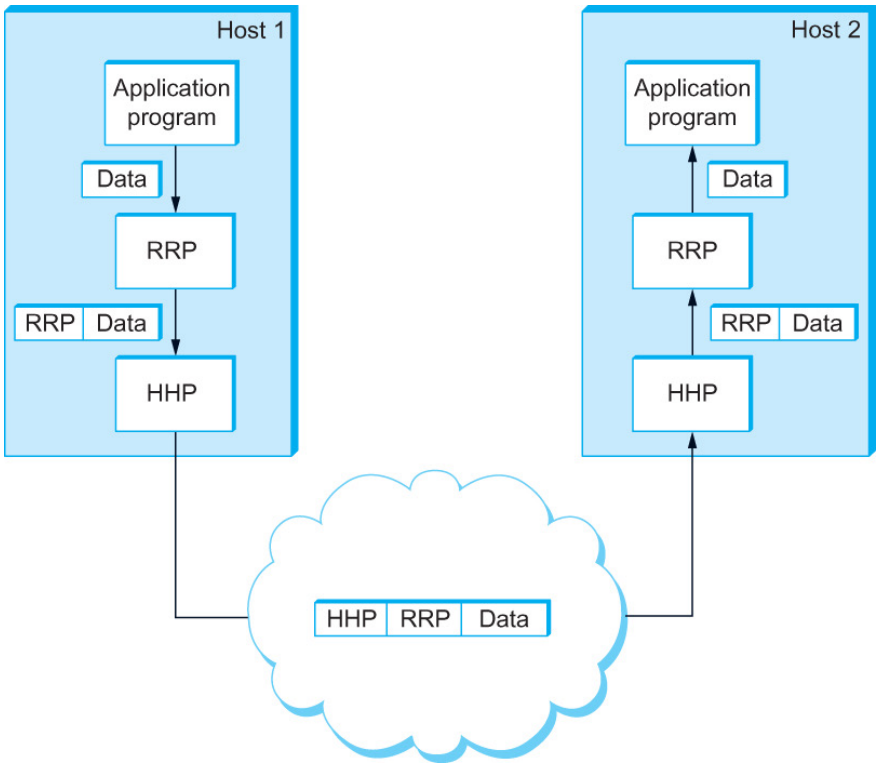
Protocol Graph



Example of a protocol graph

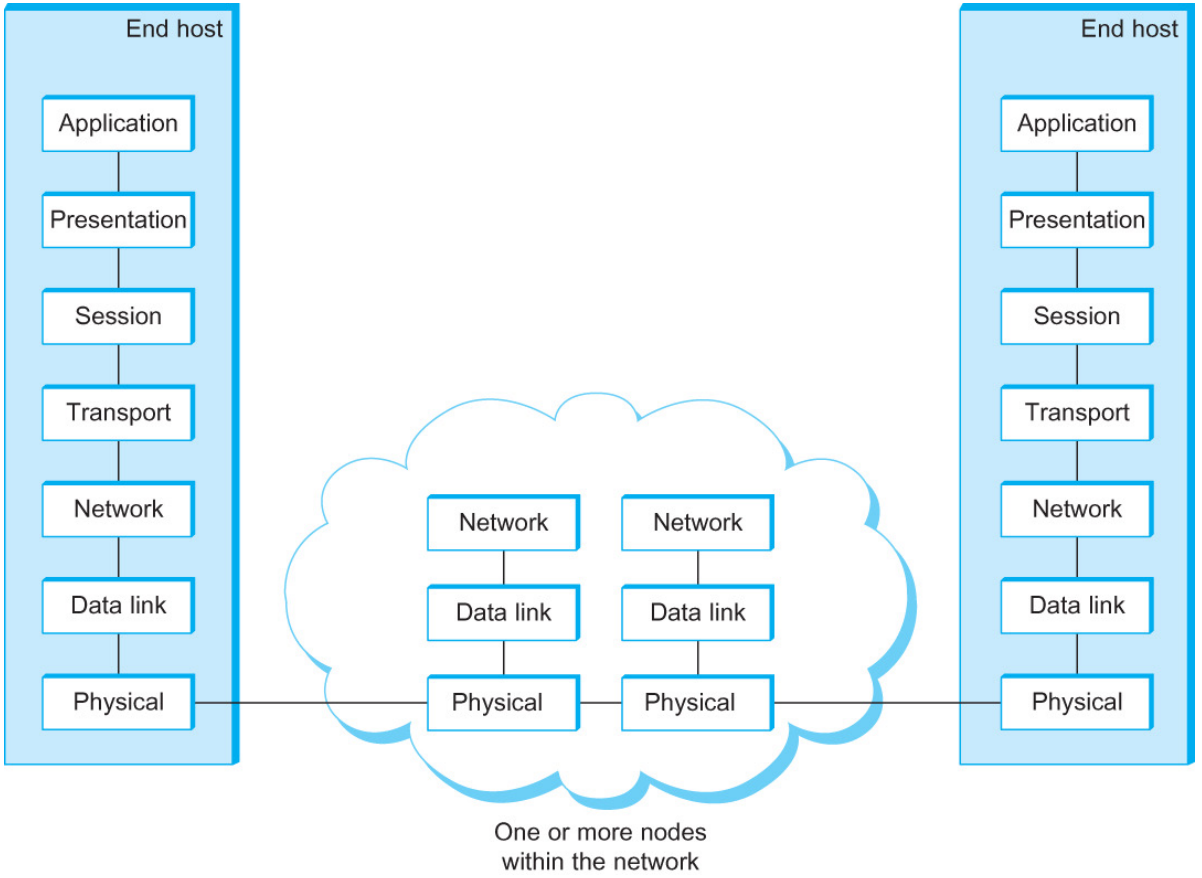
nodes are the protocols and links the “depends-on” relation

Encapsulation



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

OSI Architecture



The OSI 7-layer Model

OSI – Open Systems Interconnection

Description of Layers

- Physical Layer
  - Handles the transmission of raw bits over a communication link
- Data Link Layer
  - Collects a stream of bits into a larger aggregate called a *frame*
  - Network adaptor along with **device driver** in OS implement the protocol in this layer
  - Frames are actually delivered to hosts
- Network Layer
  - Handles routing among nodes within a packet-switched network
  - Unit of data exchanged between nodes in this layer is called a *packet*

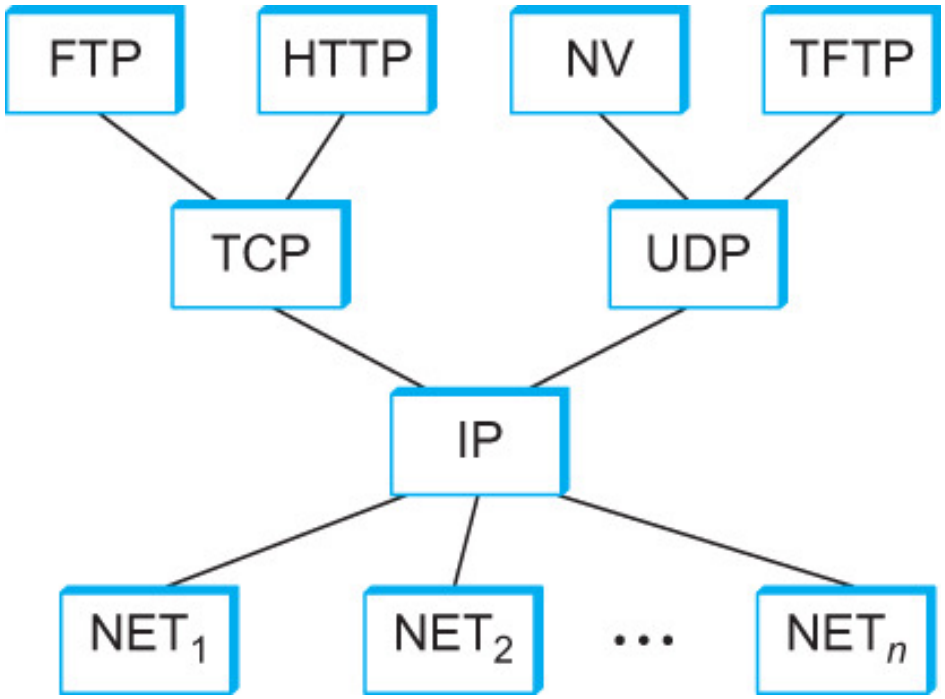
The lower three layers are implemented on all network nodes

Description of Layers

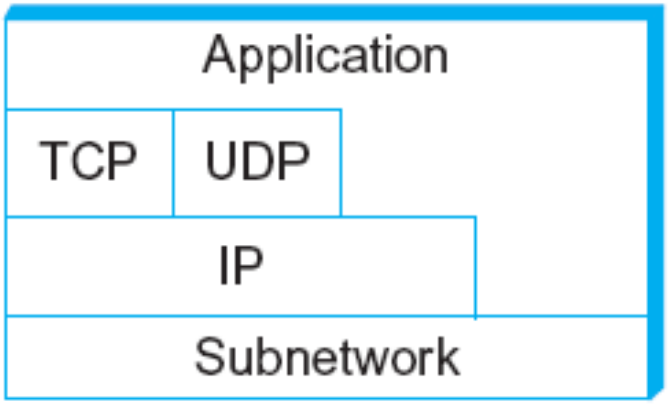
- Transport Layer
  - Implements a process-to-process channel
  - Unit of data exchanges in this layer is called a *message*
- Session Layer
  - Provides a name space that is used to tie together the potentially different transport streams that are part of a single application
- Presentation Layer
  - Concerned about the format of data exchanged between peers
- Application Layer
  - Standardize common type of exchanges

The transport layer and the higher layers typically run only on end-hosts and not on the intermediate switches and routers

Internet Architecture



Internet Protocol Graph



Alternative view of the Internet architecture. The "Network" layer shown here is sometimes referred to as the "sub-network" or "link" layer.

Internet Architecture

- Defined by IETF
- Three main features
  - Does not imply strict layering. The application is free to bypass the defined transport layers and to directly use IP or other underlying networks
  - An hour-glass shape – wide at the top, narrow in the middle and wide at the bottom. IP serves as the focal point for the architecture
  - In order for a new protocol to be officially included in the architecture, there needs to be both a protocol specification and at least one (and preferably two) representative implementations of the specification