Problem 3

Suppose N packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length L bits and the link has a transmission rate of R bits/sec. What is the average queueing delay for the N packets ?

Problem 4

Suppose that x bits of user data has to be transmitted over a k-hop path in a packet switched network as a series of packets. Each packet contains p data bits and h header bits, with $x >> p + h$. The bits rate of the links is b bps. Ignoring propagation delay and processing delay find the value of p that minimizes total delay.

Layered Network Architecture

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Why Layered Architecture?

- Organizing a network is a big and complicated task.
- Divide and conquer
- Example: Organization of an institute
  - academic section
  - finance section
  - administration section
  - procurement section

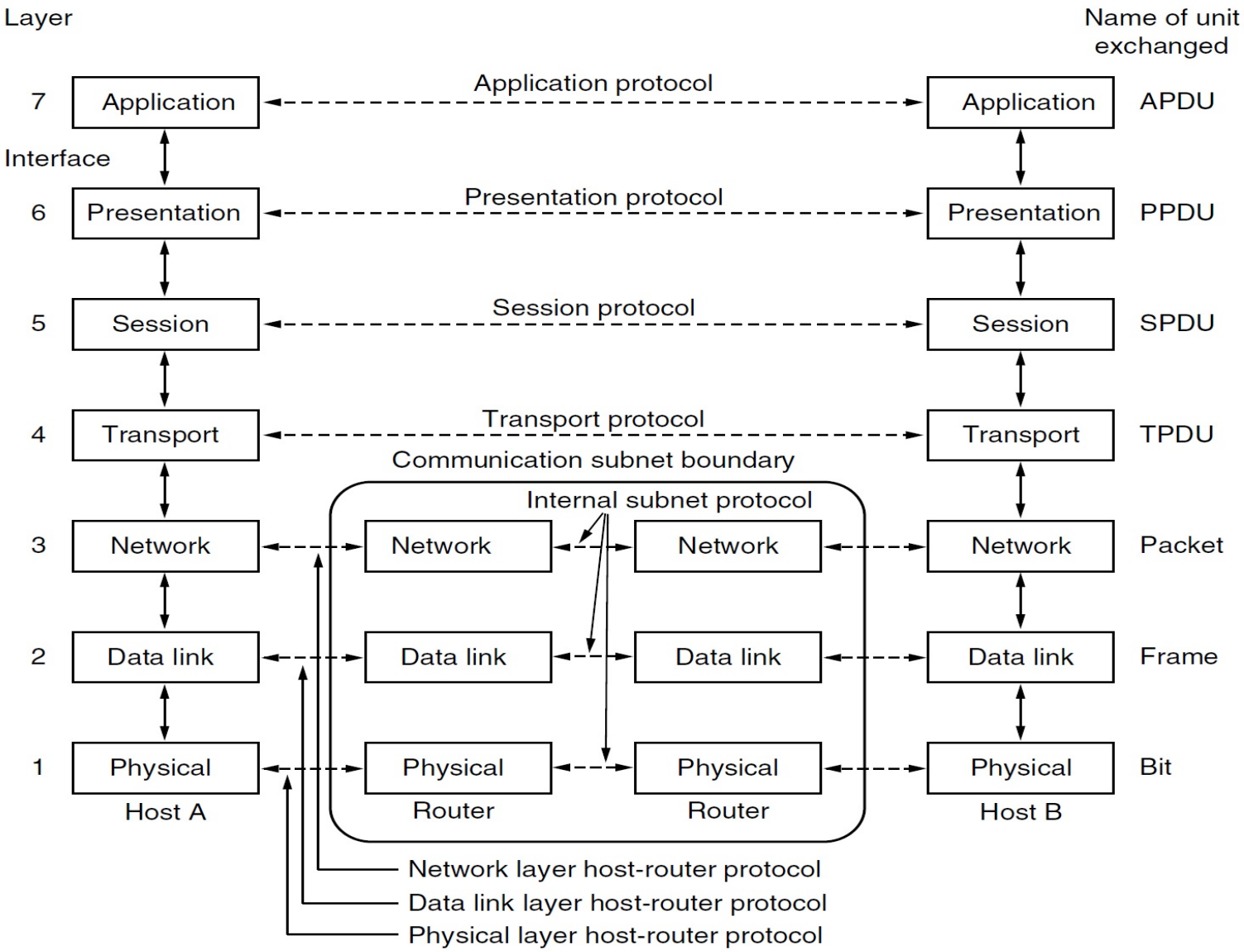
Advantages of Layered Architecture

- Divide the design issues into small pieces.
- A layer provides a service (set of actions) to the immediate higher layer.
- New technologies can be adopted in a layer without affecting other layers.
- Each layer can be analysed and tested independently.

Open System Interconnection (OSI) Reference Model

- Developed by International Organization for Standardization (ISO)
- 7-layer model:
  - Application layer
  - Presentation layer
  - Session layer
  - Transport layer
  - Network layer
  - Data-link layer
  - Physical layer

Layers


Layer
Name of unit exchanged
7
Application
Application protocol
Application
APDU
Interface
6
Presentation
Presentation protocol
Presentation
PPDU
5
Session
Session protocol
Session
SPDU
4
Transport
Transport protocol
Transport
TPDU
Communication subnet boundary
Internal subnet protocol
3
Network
Network
Network
Network
Packet
2
Data link
Data link
Data link
Data link
Frame
1
Physical
Physical
Physical
Physical
Bit
Host A
Router
Router
Host B
Network layer host-router protocol
Data link layer host-router protocol
Physical layer host-router protocol

Application Layer

- Consists of user programs, network applications that does work at hand
- Examples:
  - File transfer, Remote login, Mail, Web access
- Protocols: FTP, Telnet, Simple Mail Transfer Protocol(SMTP), HTTP.

Presentation Layer

- Concerned with syntax and semantics of information transmitted
- Translation
- Encoding data: Data compression/conversion, encryption and decryption

Session Layer

- Allows to establish a session between peers
- Dialogue control: Session can allow bidirectional traffic or only unidirectional traffic.
- Token management: In some protocols, it is required that both sides do not attempt same operation at same time. Session layer provides tokens to perform such actions
- Synchronization: Pausing and resuming a download.

Transport Layer

- Connection-oriented services to applications
  - flow control
  - guaranteed delivery of messages to destination
- Ensures data delivery is
  - error-free
  - in sequence
  - no loss, duplication and corruption of packets

Network Layer

- Interface between host and network
- Routing
- Congestion and deadlock
- Internetworking

Data-Link Layer and Physical Layer

- Data-link layer
  - Takes packet from network layer and moves it to the next router
  - error-free delivery: computes error detection information
- Physical layer
  - Controls transmission into the network cable.
  - Defines electrical signals.

Internet Protocol Stack

- Application layer
- Transport layer
- Network layer
- Data-link layer
- Physical layer