

# 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  $x \gg p + h$ . 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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24-Aug-2017

# 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

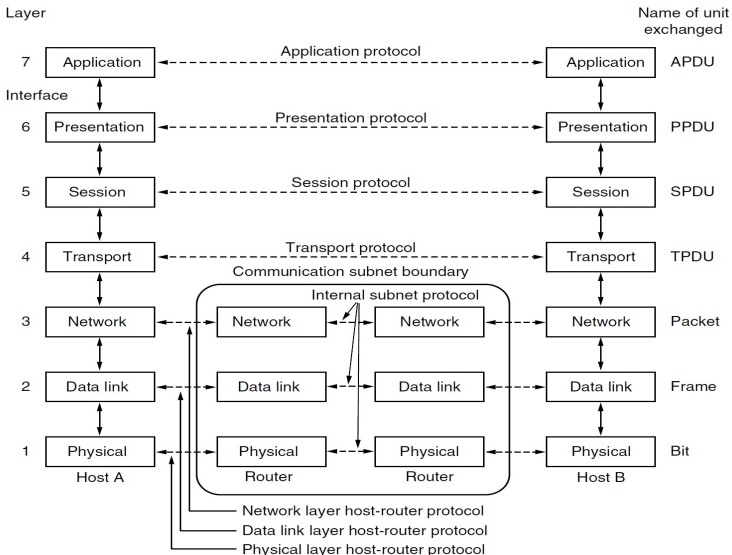
# Advantages of Layered Architecture

- 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



# 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