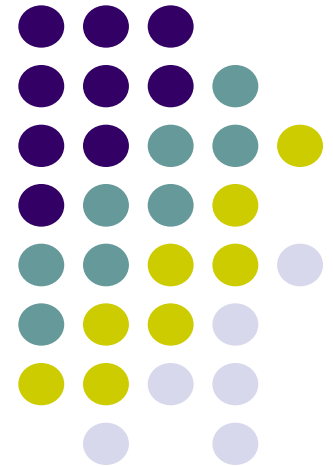
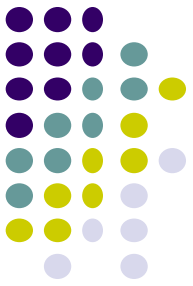


# Protocols and Layering

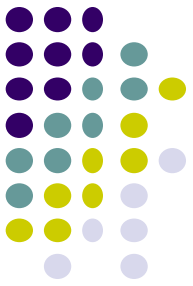
---





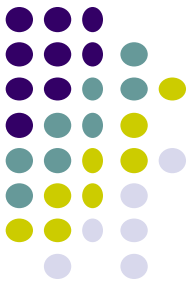
# Communication Protocol

- An agreement that specifies the format and meaning of messages computers exchange.
- Application programs that use a network do not interact directly with the network hardware.
- An application interacts with the protocol software that follows the rules of a given protocol when communicating.



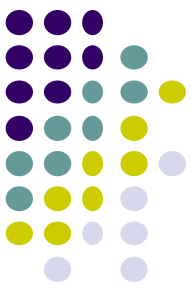
# Protocol Suites

- Communication problem is divided into subpieces
- Separate protocol is designed for each piece.
- It is easier to design, analyze, implement and test a protocol.
- Each protocol should handle part of the communication problem not handled by other protocols.



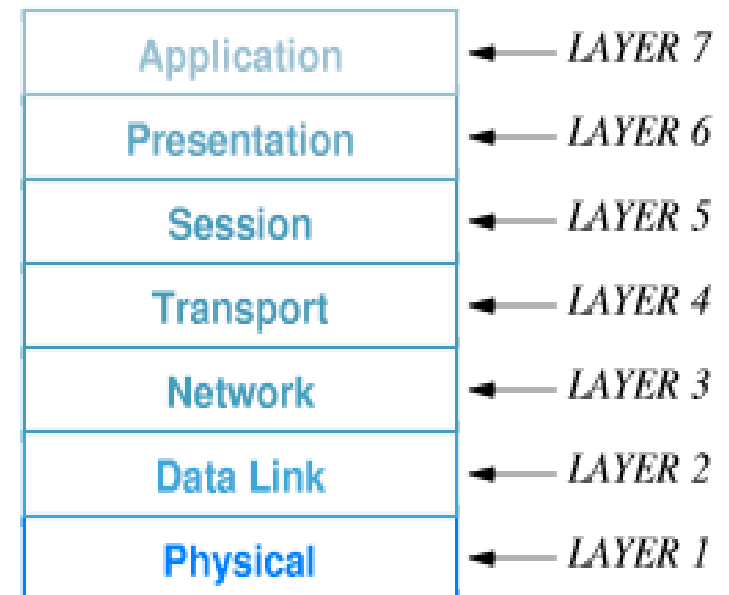
# Protocol Suite (2)

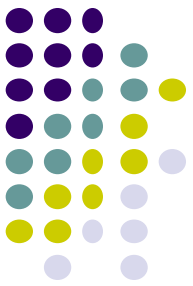
- They can share data structures and information.
- Combination of the protocols should handle all possible hardware failures or other exceptional conditions.
- To guarantee that protocols will work together, protocols are designed and developed in complete, cooperative sets called *suites* or *families*.
- Each protocol in a suite solves one part of the communication problem, together they solve the entire communication problem.



# ISO 7-Layer Reference Model (1)

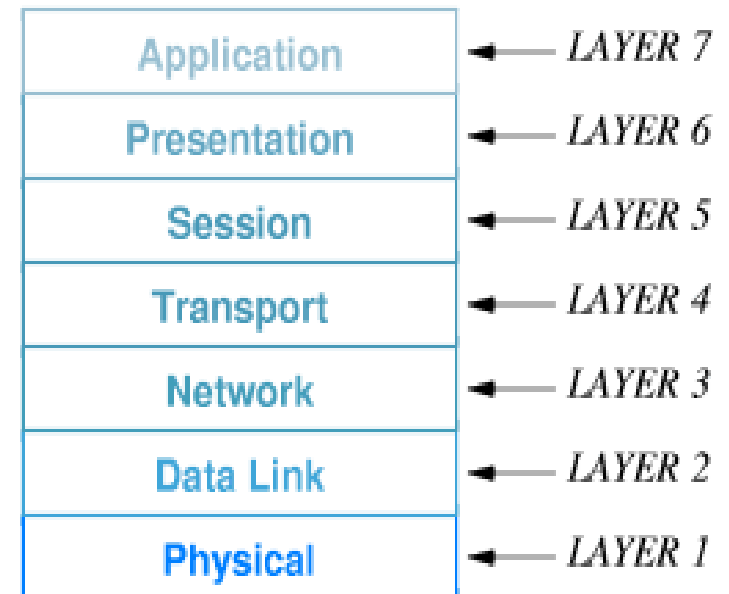
- Layer 1: Basic Network Hardware
- Layer 2: How the data is organized into frames and how to transmit frames over the network.
- Layer 3: How addresses are assigned and how packets are forwarded from one end of the network to another.



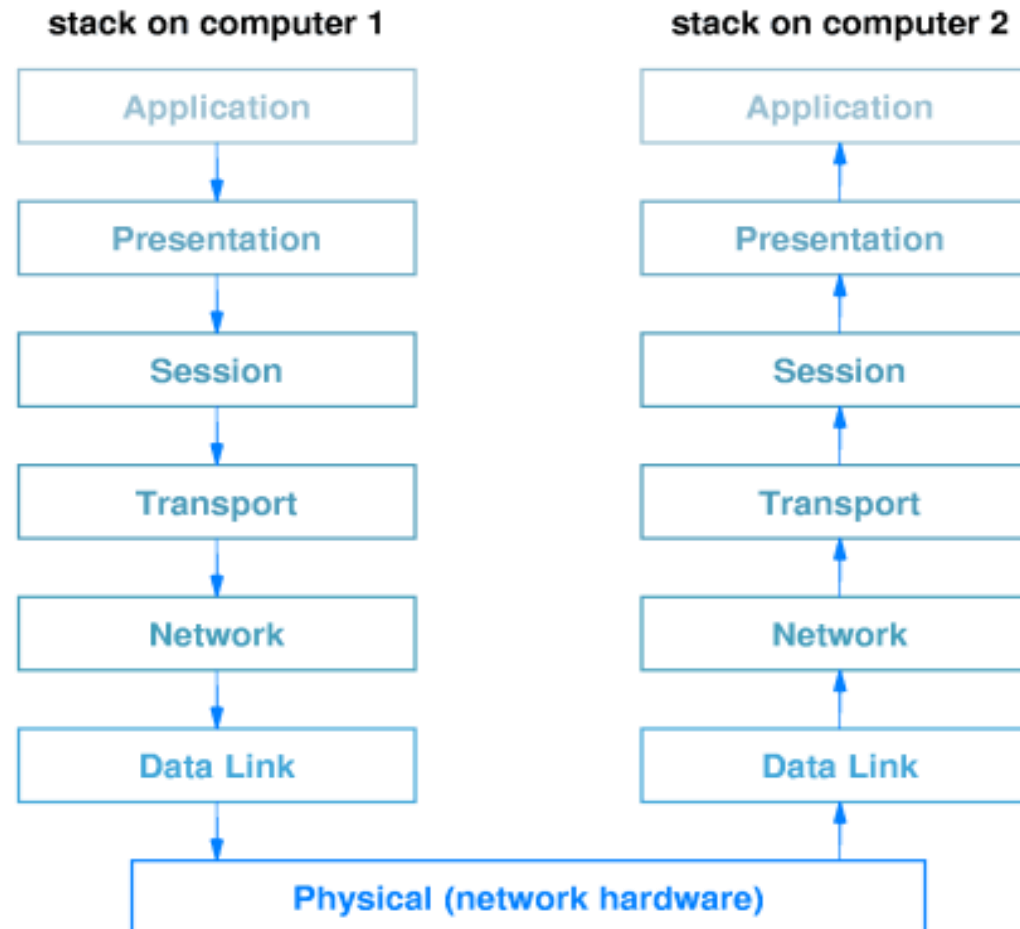
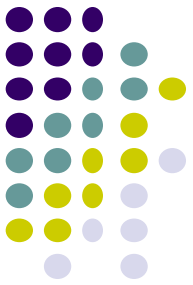


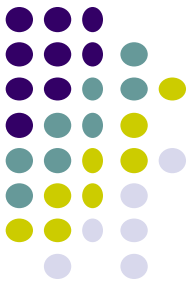
# ISO 7-Layer Reference Model (2)

- Layer 4: How to handle details of reliable transfer. They are among the most complex protocols.
- Layer 5: How to establish a communication session with a remote system.
- Layer 6: How to represent data.
- Layer 7: How one particular application uses a network.



# Conceptual Path



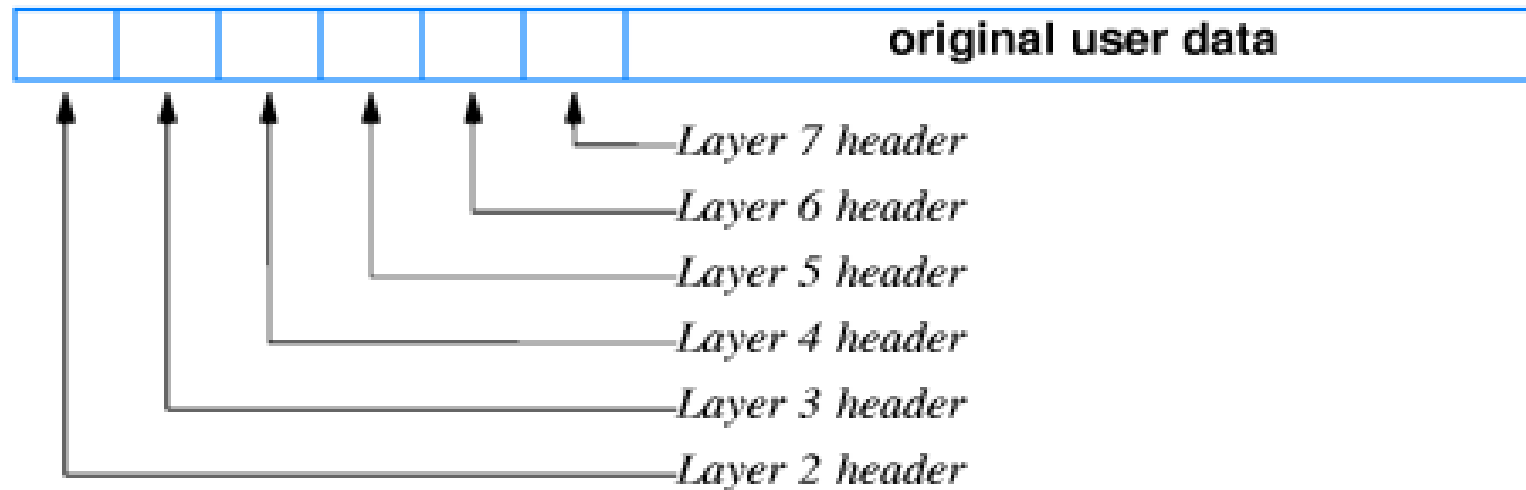


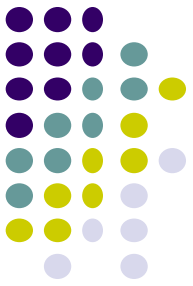
# Examples of Protocol Stacks

Vendor	Stack
Novell Corporation	Netware
Banyan System Corporation	VINES
Apple Computer Corporation	AppleTalk
Digital Equipment Corporation	DECNET
IBM	SNA



# Multiple-Nested Headers



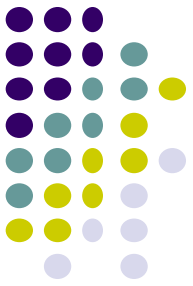


# Techniques Protocols Use

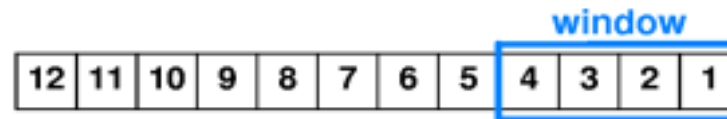
- Sequencing for Out-of Order Delivery
- Sequencing to Eliminate Duplicate Packets
- Retransmitting Lost Packets
- Avoiding Replay Caused by Excessive Delay
- Flow Control to Prevent Data Overrun
- Mechanisms to Avoid Network Congestion

# Flow Control Mechanisms

- Sliding Window
- Stop-and Go



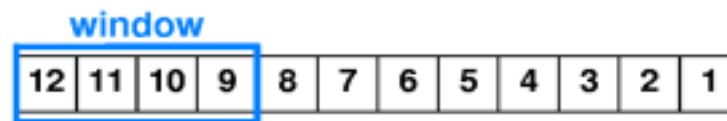
# Sliding Window



(a)

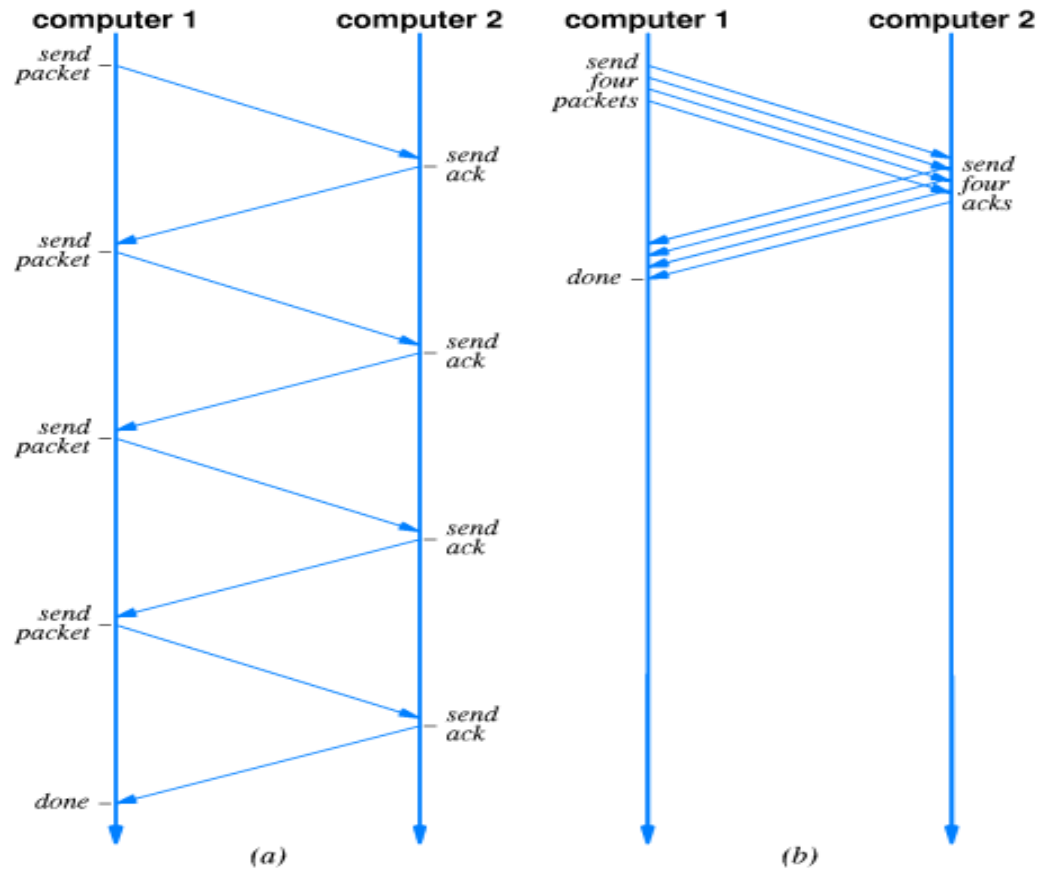
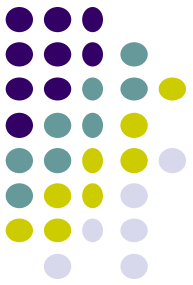


(b)

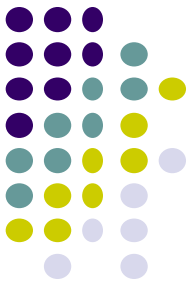


(c)

# Stop-and-Go vs Sliding Window



# Performance of Sliding Window

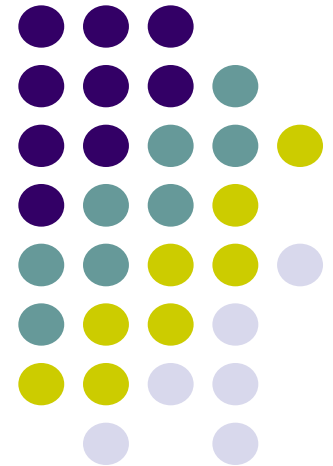


- $T_w = T_g \times W$
- $T_w = \min (B, T_g \times W)$

# Internetworking

---

Concepts, Architecture and  
Protocols

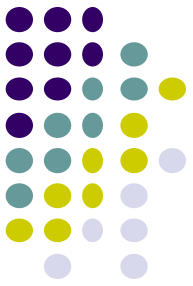




# Motivation for Internetworking

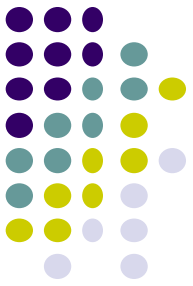
- Each network technology is designed to fit a specific set of constraints
- No single networking technology is best for all needs
- A large organization with diverse networking requirements needs multiple physical networks.
- When the networking technology which is suitable for each task, many networking technologies must be used in the organization.





# Universal Service

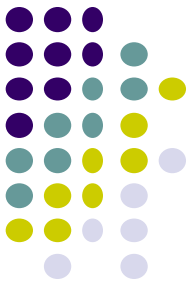
- A communication system that supplies universal service allows arbitrary pairs of computers to communicate.
- Universal service is desirable, because it increases individual productivity
- Incompatibilities among network hardware and physical addressing prevent an organization from building a bridged network that include arbitrary technologies.



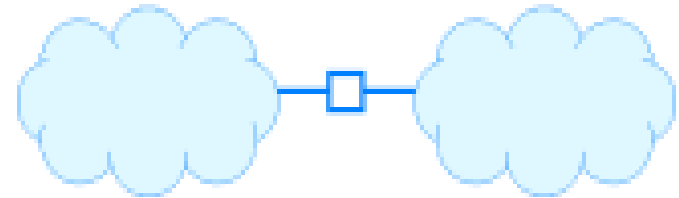
# Internetworking

- Internetworking scheme uses both hardware and software.
- Hardware is used to interconnect a set of physical networks
- Software provides universal service.
- Resulting system is known as an internetwork or internet
- Internetworking is quite general.
- It is not restricted in size
- The number of computers attached to each network in an internetwork can vary.

# Physical Network Connection with Routers



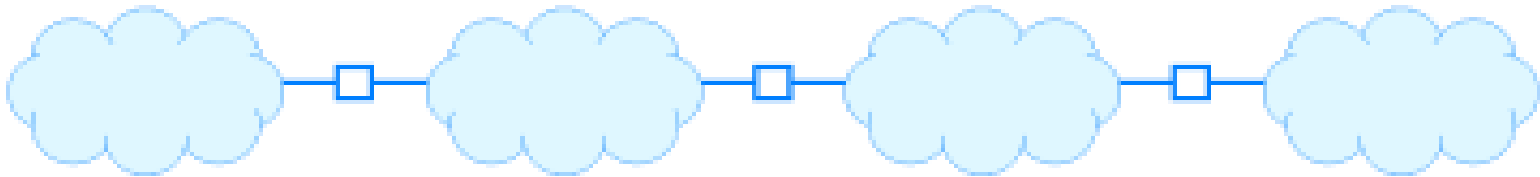
- A router is a special purpose system dedicated to the task of interconnecting networks.
- A router can interconnect networks that use different technologies, including different media, physical addressing schemes and frame formats.





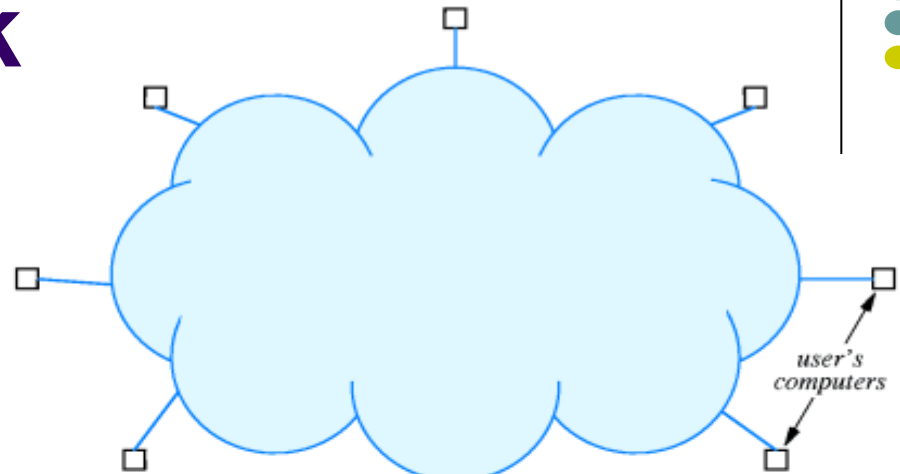
# Internet Architecture

- An internet consists of a set of networks interconnected by routers
- The internet scheme allows each organization to choose the number and type of networks, the number of routers to use to interconnect them, and the exact interconnection topology.

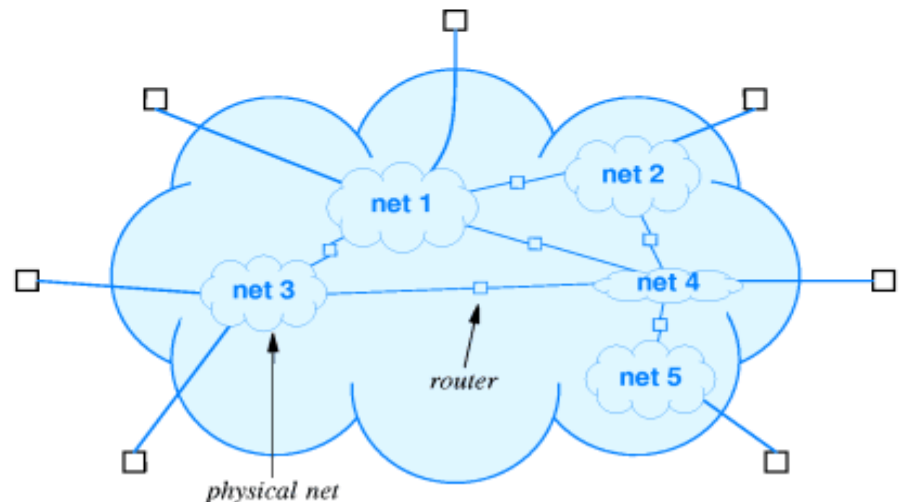


# A Virtual Network

- Internet is a virtual network system
- The communication system is an abstraction.
- Any computer can send a packet to any other.



(a)



(b)

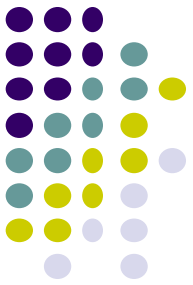




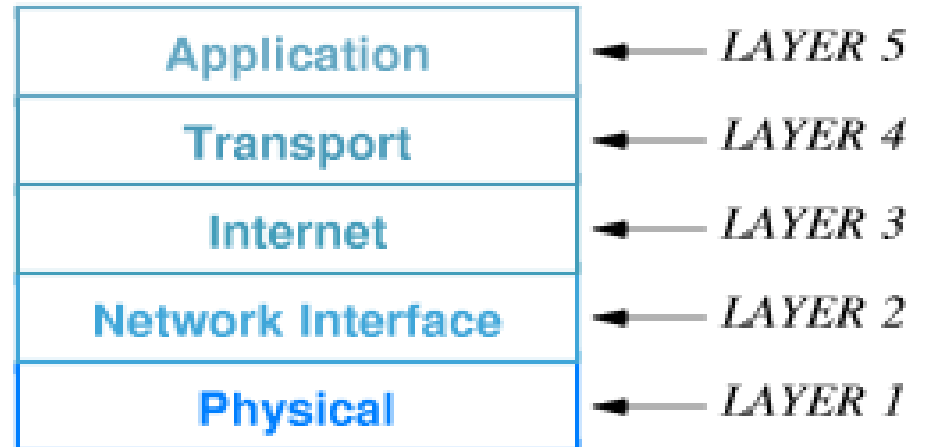
# Protocols for Internetworking

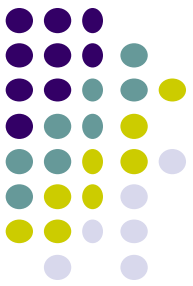
- TCP/IP Internet protocols suite
- First set of protocols developed for use on internet
- Researchers who developed TCP/IP also developed the internet architecture.

# TCP/IP Layers



- Layer1: Network Hardware
- Layer 2: How to organize data into frames and how a computer transmits frames over a network.





# TCP/IP Layers (2)

- Layer 3: Format of packets sent across an internet as well as the mechanisms used to forward packets from a computer through one or more routers to a final destination
- Layer 4: Ensure reliable transfer
- Layer 5: Layer 6 and Layer 7 in ISO model

