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Network Essentials
Session 1

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Outline

- Session 1
  - 7-Layer OSI Model
  - Network Layer protocols (Internet Protocol)
  - Transport Layer protocols (TCP and UDP)

Acknowledgments

This presentation has been adapted from presentations available at:

2. Prof. Shivkumar Kalyanaraman (http://www.ecse.rpi.edu/Homepages/shivkuma/)
3. Prof. Sneha Kumar Kasera (http://www.cs.utah.edu/classes/cs5480/)
4. Prof. David Hollinger (http://www.cs.rpi.edu/~hollingd/netprog)
5. South Asian Network Operators Group (http://ws.edu.isoc.org/workshops/2004/SANOG-IV/ip-services/presentations/ip-intro/ipbasics.ppt)

Network Models

- Formal models allow us to deal with various aspects of networks abstractly
  - One such model is the OSI reference model

"Open Systems Interconnection Basic Reference Model"

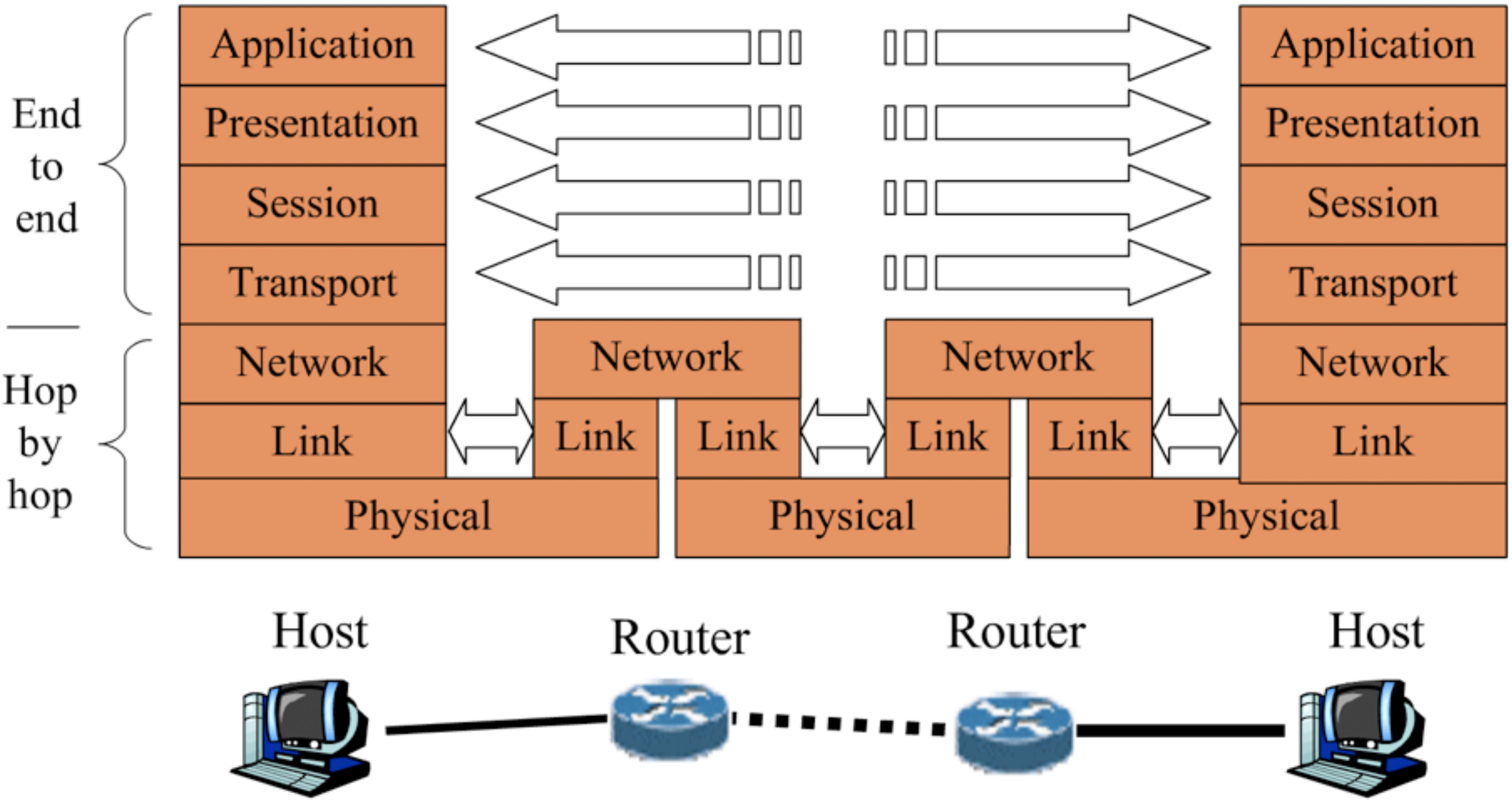
- The OSI reference model is a *layered* model
  - Divide a task into pieces and then solve each piece independently
  - Establishing a well defined interface between layers

- Major Advantages:
  - Each layer can be implemented independently
  - Adaptability
  - Code Reuse
  - Extensibility

OSI 7-Layer Model

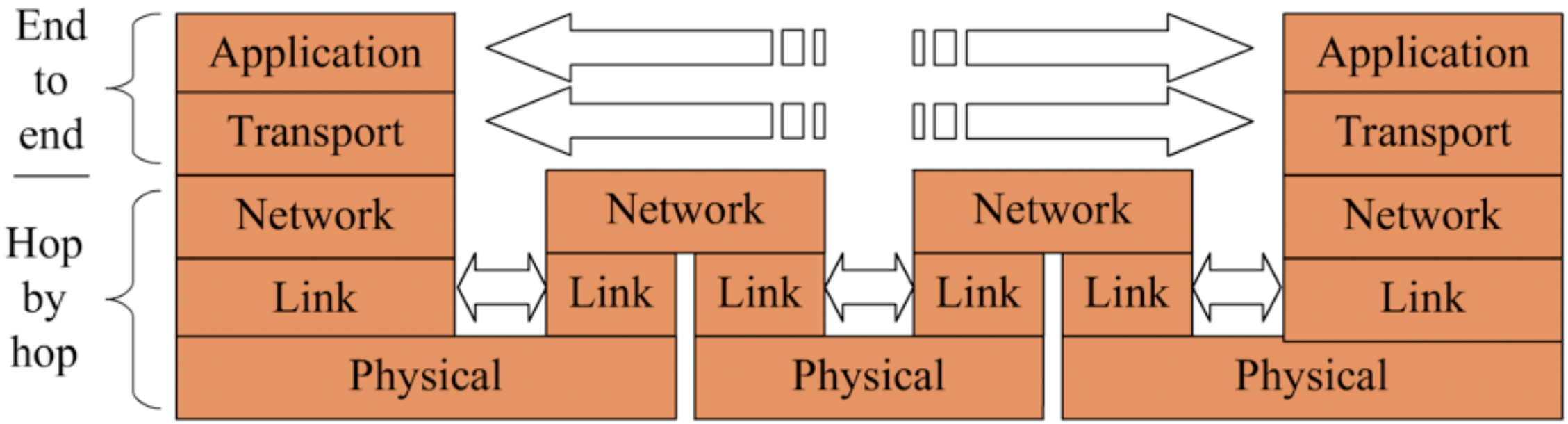
	Layers	Examples	Funtionality
7	Application	Mail, Web, etc.	
6	Presentation		Data encryption,compression
5	Session		Managing sessions
4	Transport	TCP/UDP	Virtual End-to-end connectivity
3	Network	IP	Path selection, Internetworking
2	Data Link	Ethernet	Error-free communication links
1	Physical		Transmission of raw signal

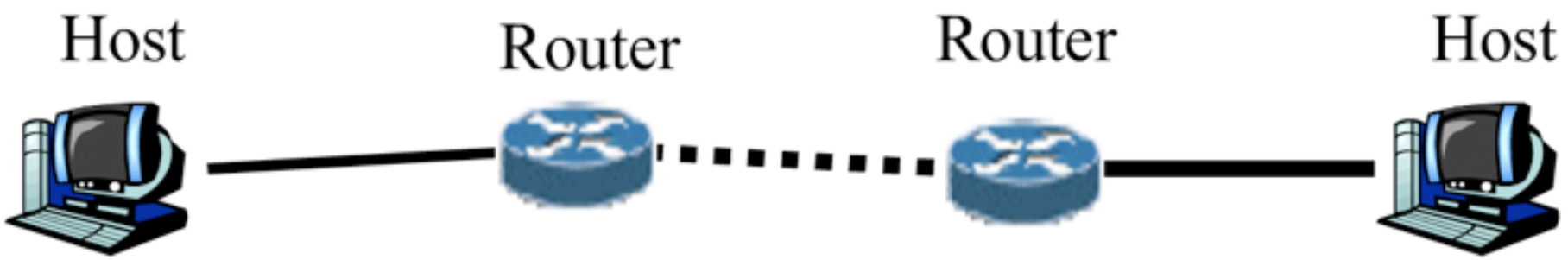
OSI 7-Layer



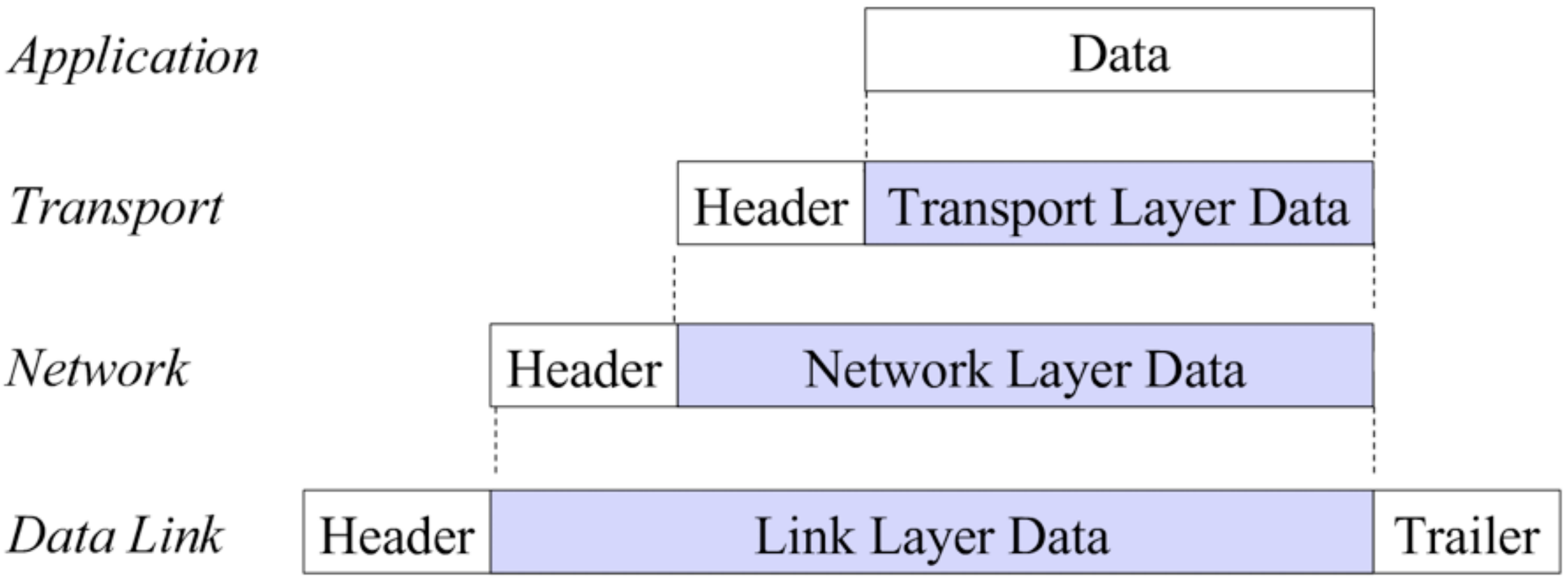
TCP/IP Model

No session or presentation layers in TCP/IP model





Packet structure



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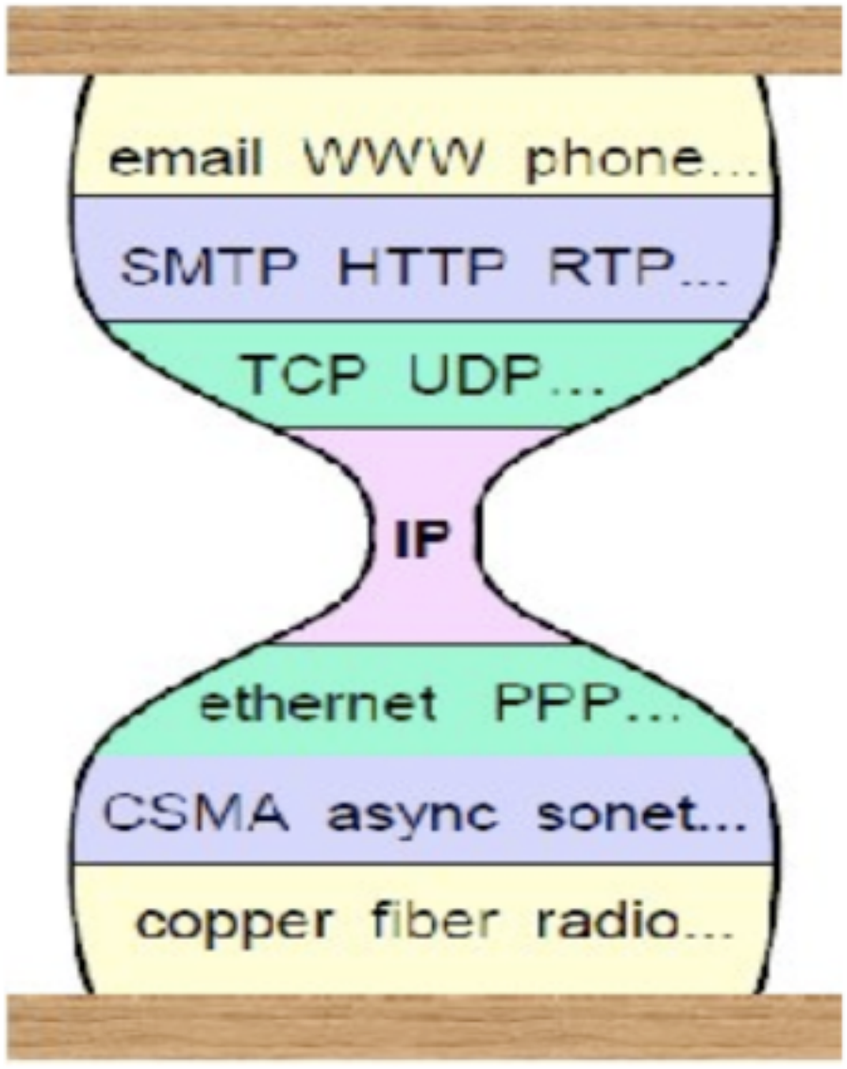
Network Layer

Internet Architecture

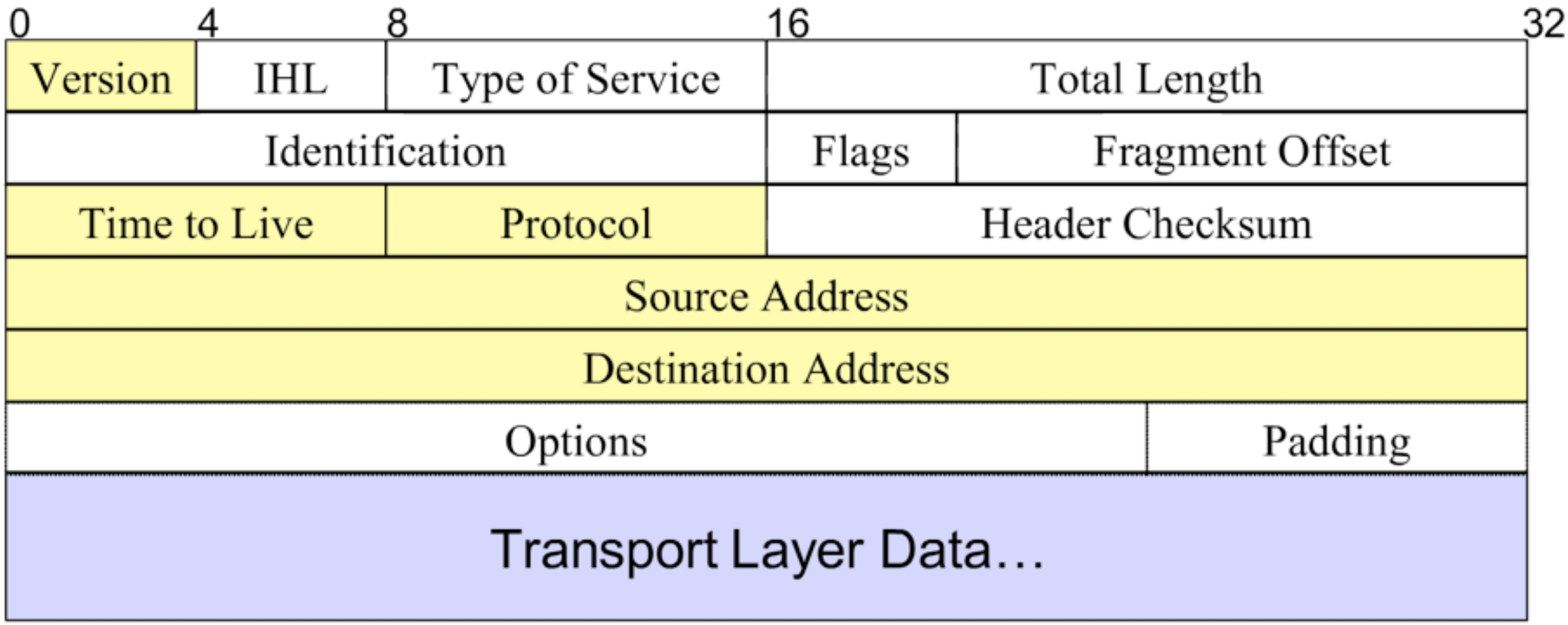
- Packet-switched, connectionless datagram network
- IP is *the* network layer protocol
  - Acts as a glue
- Hourglass concept
  - all hosts and routers run IP
- Stateless architecture
  - no per flow state inside the network
- Hop-by-hop packet forwarding
  - Header contains all the information



IP - Minimalist Approach

- Dumb network
  - *Connectivity* is the key
  - Network provides minimal functionalities to support connectivity
  - Addressing, forwarding, routing
- Smart end systems
  - Transport layer or application performs more sophisticated functionalities
  - Flow control, error control, congestion control
- Advantages
  - High scalability
  - Works across heterogeneous technologies (Ethernet, modem, satellite, wireless)
  - Supports diverse applications (telnet, ftp, Web, media streaming)
  - Decentralized network administration

IPv4 Header



IP Address

- IP address: Unique identification of the end-system from a network-layer perspective

- IP address is 32-bits long (version 4)
- Contains a network ID and host ID
  - Use subnet mask to detect the network ID

- Example of IP address:
  - 133.27.162.125

Decimal	133	27	162	125
Binary	10000101	00011011	10100010	01111101
HEX	85	1B	A2	7D

Network Mask

- Define which bits are used to describe the network ID

- Different Representations:
  - Decimal dot notation: 255.255.224.0
  - Number of network bits: /19

- Bitwise-AND of 32-bit IP address with 32-bit netmask yields network ID part of the address (truncated appropriately)

Network Mask Examples

137.158.128.0/**17** (netmask **255.255.128.0**)

1111 1111	**1111 1111**	**1**	**000 0000**	**0000 0000**
1000 1001	1001 1110	1	000 0000	0000 0000

198.134.0.0/**16** (netmask **255.255.0.0**)

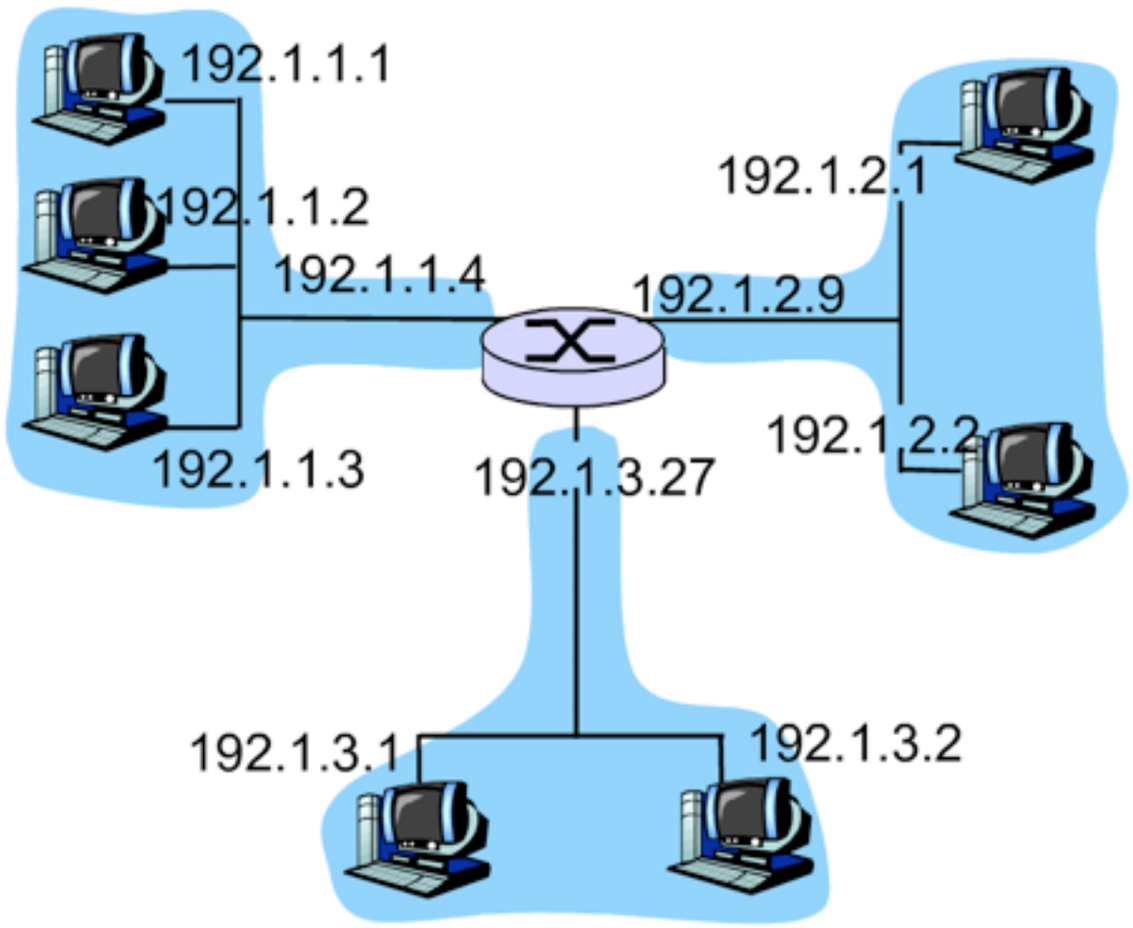
1111 1111	**1111 1111**	**0000 0000**	**0000 0000**
1100 0110	1000 0110	0000 0000	0000 0000

205.37.193.128/**26** (netmask **255.255.255.192**)

1111 1111	**1111 1111**	**1111 1111**	**11**	**00 0000**
1100 1101	0010 0101	1100 0001	10	00 0000

Subnets

- All device interfaces having the same network ID are part of the same subnet



- Devices within a subnet can communicate with each other without an intervening router

Network consisting of 3 subnets

IP router

- A device with more than one link-layer interface
  - Each interface identified by a different IP address (from different subnets)

- Packets arriving at one interface are forwarded out on another interface to get them closer to the destination

- Creates and maintains forwarding tables
  - Tables help in making forwarding decisions
  - Tables created and updated based on routing information exchanged between routers
  - Each router maintains its own forwarding table

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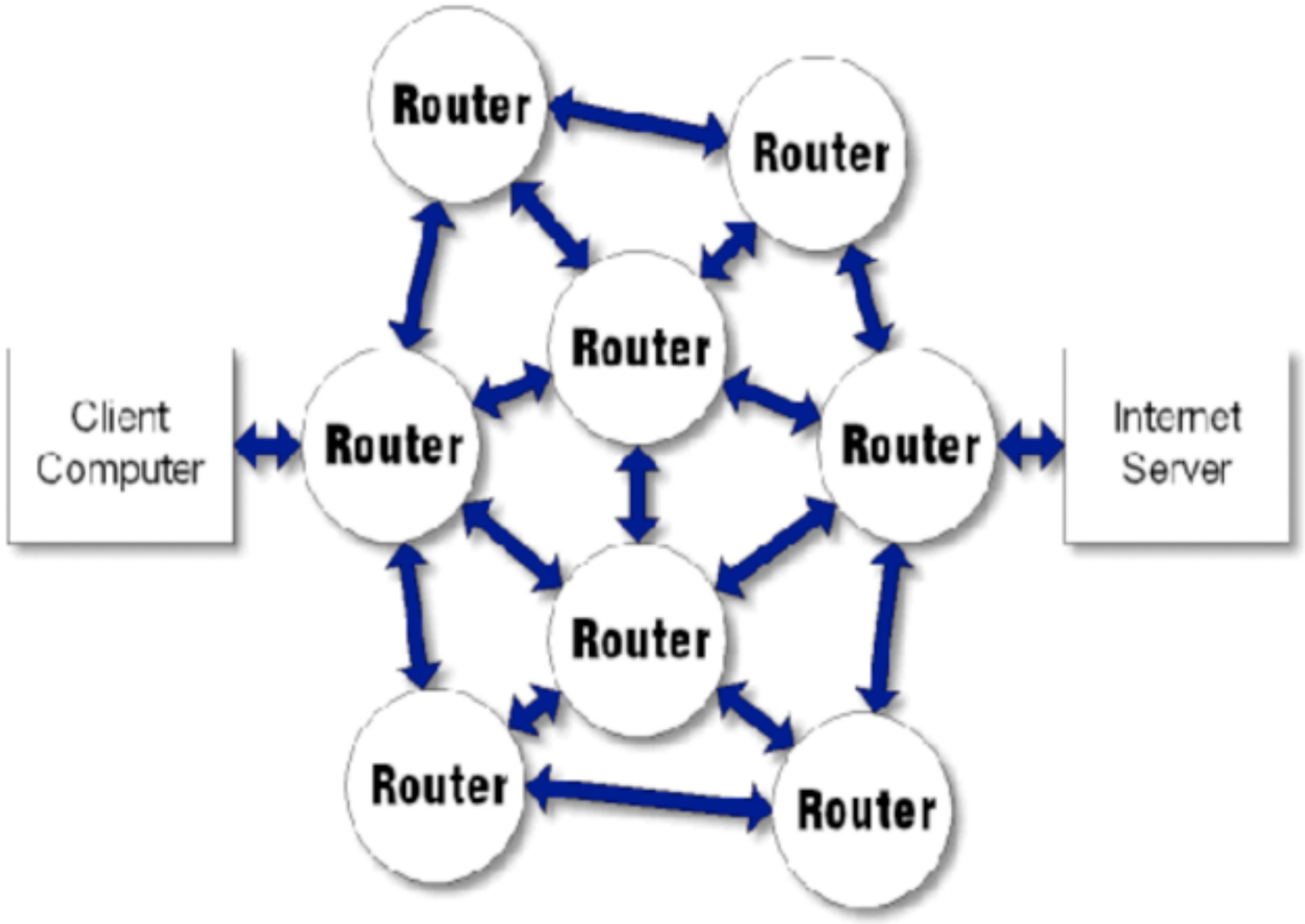
Hop by Hop Forwarding



IP Forwarding Rules - I

- Destination is in the same subnet (direct connectivity)
  - Recognize that destination IP address is on same subnet
  - Find the destination's datalink-layer address
  - IP packet encapsulated and sent directly to the destination's datalink-layer address

- Destination is in a different subnet (indirect connectivity)
  - Recognize that destination IP address is on different subnet
  - Look up destination IP address in a (L3 forwarding) table to find a match, called the next hop router IP address
  - Find the next hop router's datalink-layer address
  - IP packet encapsulated and sent directly to the next hop router's datalink-layer address

IP Forwarding Rules - II

- Problem 1: Recognize if destination is on the same subnet
  - Use netmask to compute network ID of the destination and match it with device's network ID
- Problem 2: Find a device's datalink-layer address
  - Static mapping
  - Dynamic mapping using Address Resolution Protocol (ARP)
    - Sender host broadcasts a request: "*What is the Ethernet address of 192.1.1.4?*"
    - The device whose IP address is 192.1.1.4 replies back: "*The Ethernet address for 192.1.1.4 is* 00-0C-F1-4E-2A-E2 "
    - ARP responses are cached at the sender
    - Use `arp` command to view/modify the cache

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Thank You !