TCP/IP Protocol Suite

EECS 3214

Department of Electrical Engineering & Computer Science
York University

OSI and TCP/IP Models

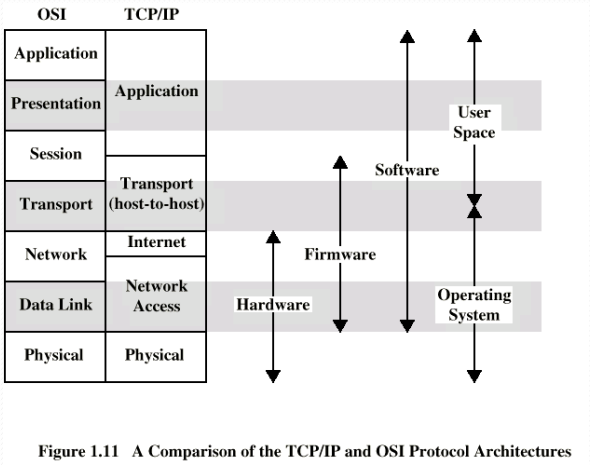
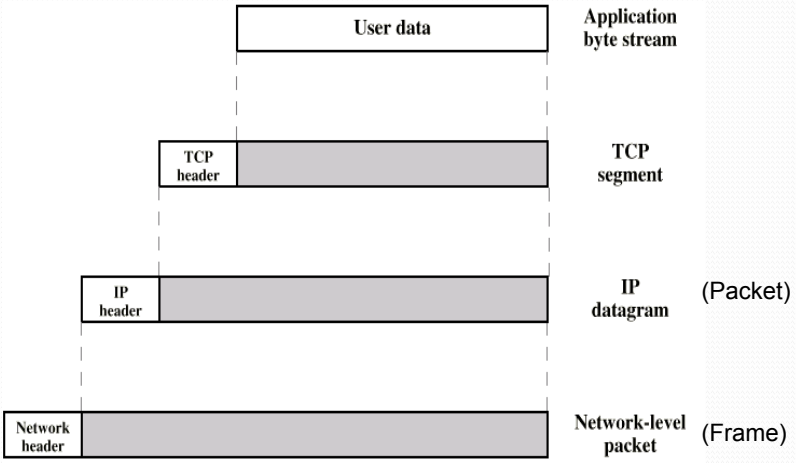


Figure 1.11 A Comparison of the TCP/IP and OSI Protocol Architectures

TCP/IP Encapsulation



3

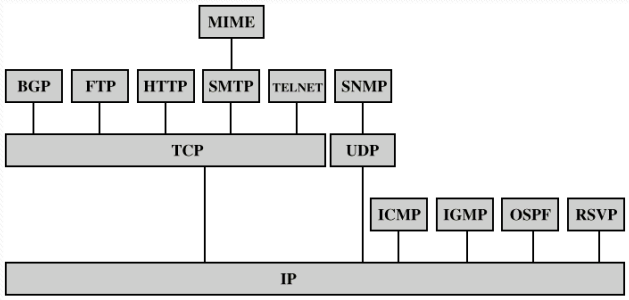
TCP/IP Model and Example Protocols

A list of protocols used in TCP/IP:

Application	DNS	FTP	SMTP	HTTP
Transport	TCP		UDP	
Internet	IP			
Network Access				
Physical	ARPANET	SATNET	Packet Radio	LAN

4

TCP/IP Protocols



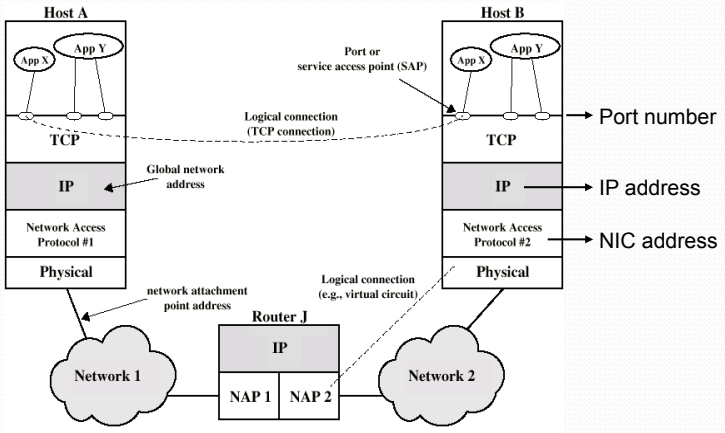
BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multi-Purpose Internet Mail Extension
OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol

Figure 2.12 Some Protocols in the TCP/IP Protocol Suite

5

TCP/IP Addressing

- Port (or SAP) numbers of processes at source and destination
- IP addresses of source and destination
- Network interface card (NIC) addresses defined by the NIC



6

IP Addresses

- Each host in the Internet is identified by a globally unique IP address
- The IP address identifies the host's network interface rather than the host itself (usually the host is identified by its physical address within a network).
- An IP address consists of two parts: network ID and host ID (more on formats of IP addresses later).
- Router: a node that is attached to two or more physical networks. Each network interface has its own IP address.

7

Physical Addresses

- On a physical network, the attachment of a device to the network is often identified by a physical address.
- The format of the physical address depends on the particular type of network.
- Example: Ethernet LANs use 48-bit addresses.
  - Ethernet: protocol for bus LANs, originally designed by Xerox, later developed into IEEE 802.3 standard.
  - Every machine in a LAN comes with a NIC that is assigned a physical address.

8

Physical Addresses (cont.)

- LANs (and other networks) assign physical addresses to the physical attachment to the network.
- The network uses its own address to transfer packets or frames to the appropriate destination.
- IP address needs to be resolved to physical address at each IP network interface.
- Example: Ethernet uses 48-bit addresses
  - Each Ethernet network interface card (NIC) has globally unique Medium Access Control (MAC) or physical address
  - First 24 bits identify NIC manufacturer; second 24 bits are serial number
  - 00:90:27:96:68:07 12 hex numbers

Intel

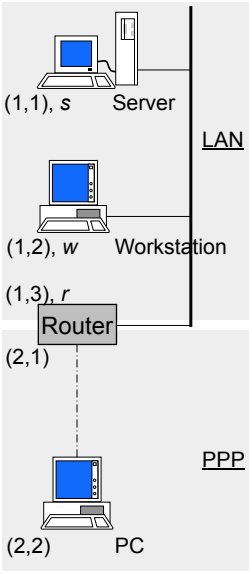
9

Network Interface Cards (NICs)

- NICs are adapters installed in a computer that provide the connection point to a network.
- Each NIC is designed for a specific type of LAN (e.g., Ethernet, token ring, FDDI).
- A NIC provides an attachment point for a specific type of cable, such as coaxial cable, twisted-pair cable, or fiber-optic cable.
- Every NIC has a **globally unique** identifying node address (globally unique physical address).
- Ethernet card addresses are hardwired on the card.
- The IEEE (Institute of Electrical and Electronic Engineers) is in charge of assigning addresses to Ethernet cards. Each manufacturer is given a unique code and a block of addresses.

10

Example: HTTP and Web Browsing

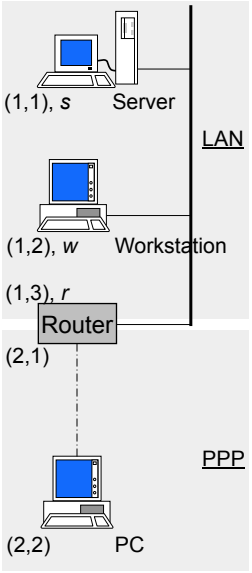


Infrastructure:

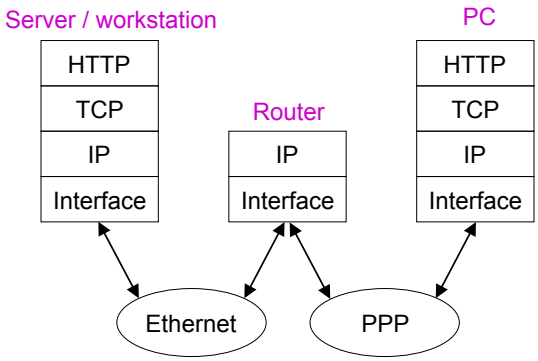
1. A LAN comprising of a server and a workstation is connected via a router to a PC. The connection between the router and PC is a point-to-point (PPP) connection.
2. Each machine on the LAN typically have two addresses:
   - An IP address known globally
   - An Ethernet address determined by its network interface card (NIC)
3. The router has as many IP addresses as the number of networks connected to it.

	Server	Work station	Router	PC	Router
IP	(1,1)	(1,2)	(1,3)	(2,2)	(2,1)
Ethernet	*s*	*w*	*r*		*r*

Example: HTTP and Web Browsing (2)



Protocols: used for an HTTP request made by PC to server



Example: HTTP and Web Browsing (3)

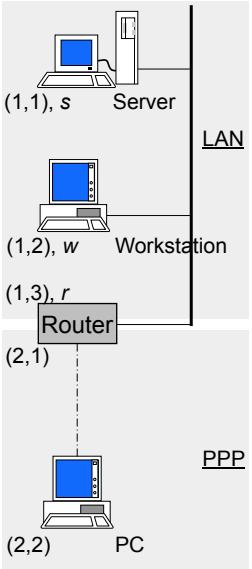
Instruction: http://www.tesla.comm.utoronto.ca/infocomm/index.html

Hypertext transfer protocol: Specifies rules by which client / server interact.	**Uniform Resource locator (URL) of the server:** 1st part typically translated to an address by Domain Name Server (DNS), 2nd part specifies document

- HTTP is only concerned with the interaction of the client with the server, not with the actual setting up of connection.
- A connection is first set up between the client and the server. For connection-oriented services, this implies setting up of a physical connection.
- HTTP requires the service of TCP to provide a reliable service between the two machines. TCP itself requires the service of IP and so on. This leads to a layered approach.

HTTP (application)
TCP (Transport)
IP (Internet)

Example: HTTP and Web Browsing (4)



Task: Transfer of an HTML request from PC to Server

1. For simplicity, assume a TCP connection is established between the server and PC (more on connections later).
2. HTTP request is passed on to the TCP layer of PC that creates a TCP segment containing server port number (SP#) and client port number (CP#)

….	SP#	CP#	HTTP request

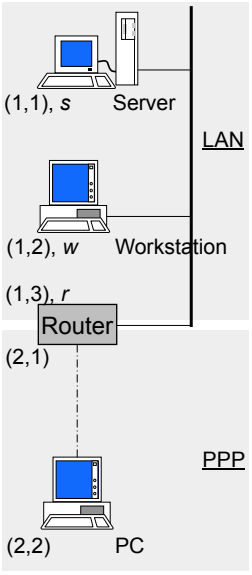
Header

3. TCP segment is passed to IP layer that creates an IP datagram where protocol field (PF) shows that upper layer has asked for the information. IP datagram is passed on to interface layer.

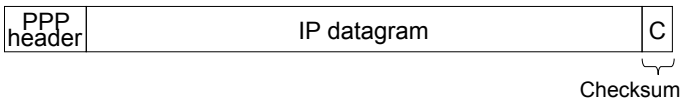
….	(1,1)	(2,2)	PF	TCP segment

Header

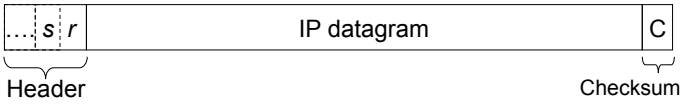
Example: HTTP and Web Browsing (5)



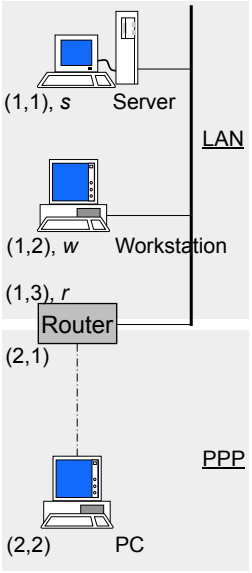
4. Interface layer encapsulates the IP datagram into a PPP frame, and sends the PPP frame to the router.



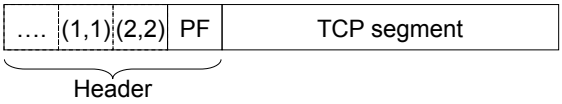
5. The IP datagram is extracted by the interface layer of the router and passed on to the Internet layer. The Internet layer extracts the destination address (1,1) and checks the routing table for a match.
6. Since a match exists, the Interface layer prepares an Ethernet frame encapsulating the IP datagram plus the Ethernet addresses in the header, and broadcasts the Ethernet frame on the LAN.



Example: HTTP and Web Browsing (6)

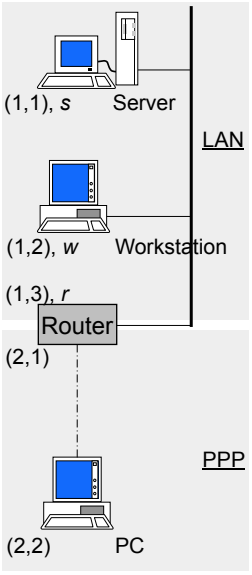


4. Interface layer of the Server compares the Ethernet address with the address on its network interface card (NIC). The address matches so the Ethernet frame is accepted.
5. A Checksum is performed to check for errors. In case of no errors, the IP datagram is extracted and passed on to the Internet layer.



6. The Internet layer maps the IP address and sees that the IP datagram is meant for it. It extracts the TCP segment and passes it on to the TCP layer

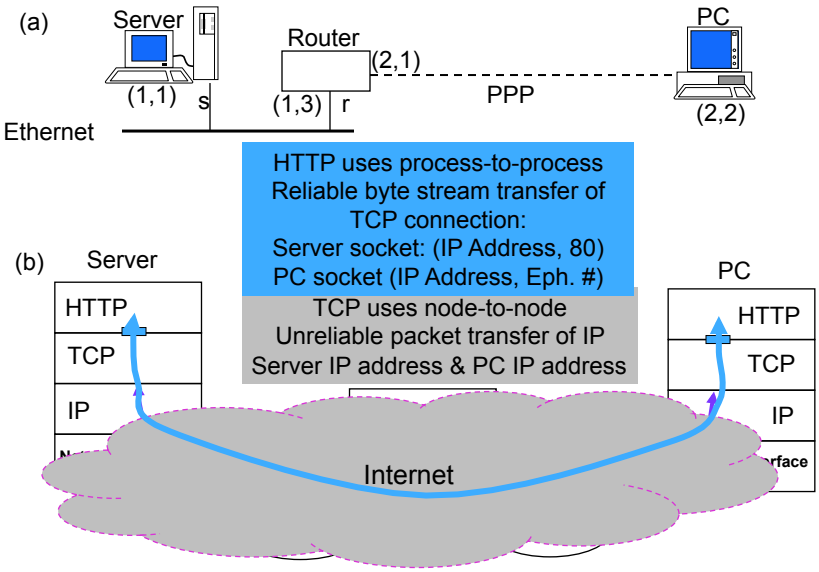
Example: HTTP and Web Browsing (7)



7. HTTP request is extracted by TCP layer and passed on to specified port number.
8. Recall that the protocol used by the Transport layer is TCP, which is a reliable connection-oriented protocol. An acknowledgment is therefore sent to the PC in exactly the same manner as the request was received.

- ❑ The Application layer retrieves the HTML document and transmits it to the PC following steps (1-8) in reverse order.

How the layers work together



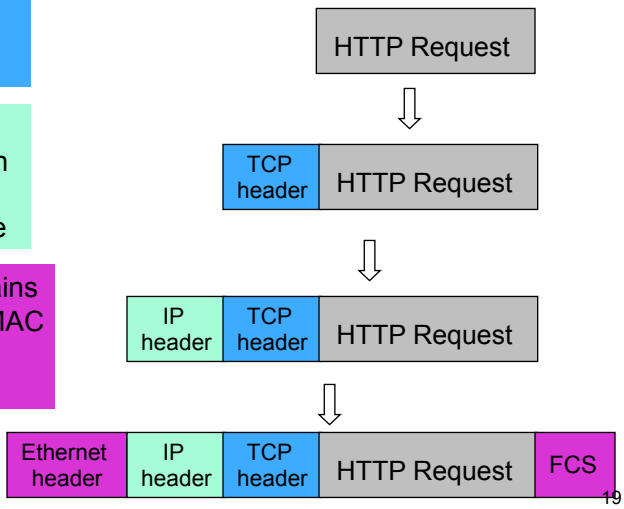
18

Encapsulation

TCP Header contains source & destination port numbers

IP Header contains source and destination IP addresses; transport protocol type

Ethernet Header contains source & destination MAC addresses; network protocol type



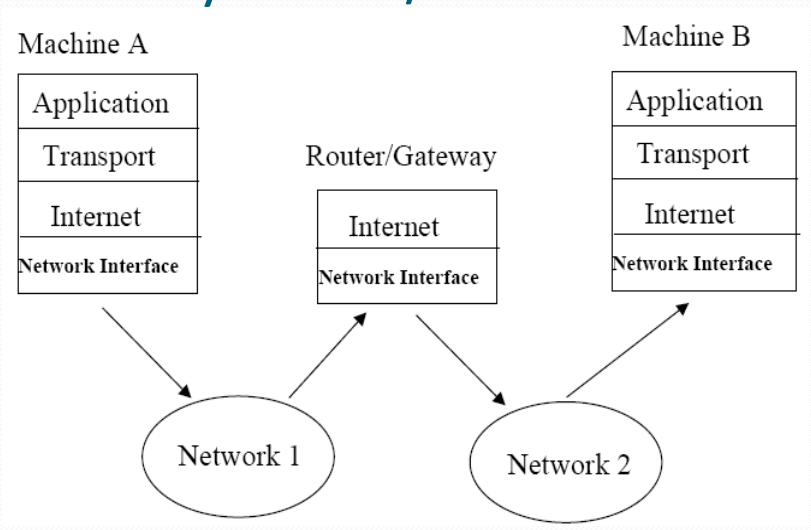
19

Summary

- Encapsulation is key to layering
- IP provides for transfer of packets across diverse networks
- TCP and UDP provide universal communications services across the Internet
- Distributed applications that use TCP and UDP can operate over the entire Internet
- Internet names, IP addresses, port numbers, sockets, connections, physical addresses

20

Summary of TCP/IP Model



21

Connection-oriented vs. Connectionless Communications

Connectionless:

- Does not requires a session connection be established before sending data
- Sender simply starts sending packets (datagrams) to the receiver
- Different packets may take different routes
- Data packets may arrive out-of-order.
- Less reliable than connection-oriented services, but more efficient for data communications

22

Examples of Connection-oriented and Connectionless Communications

- Internet:
  - One big connectionless packet switching network in which all packet deliveries are handled by IP (unreliable)
  - TCP adds connection-oriented services on top of IP (for reliable delivery)
  - UDP provides connectionless services on top of IP
- ATM: connection-oriented packet switching networks
- LANs:
  - Connectionless systems
  - TCP can be used to provide connection-oriented (reliable) services
- Reference: www.linktionary.com/c/connections.html

23

References

- Data and Computer Communications by William Stallings, section "The TCP/IP Protocol Architecture" of chapter 2.
- The example "HTTP and Web Browsing" is from the textbook by A. Leon-Garcia and I. Widjaja, section "Overview of TCP/IP Architecture" of chapter 2.

24