TCP/IP PROTOCOL SUITE - EXAMPLES

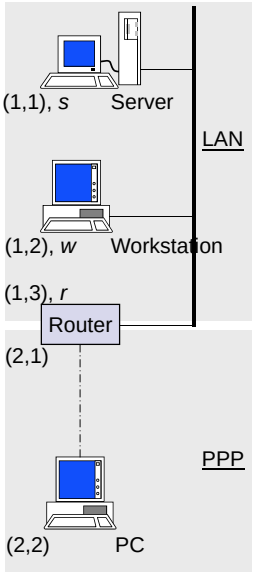
1

Examples

To reinforce understanding of TCP/IP

- protocol suite
- operations
- encapsulation
- addressing

HTTP and Web Browsing



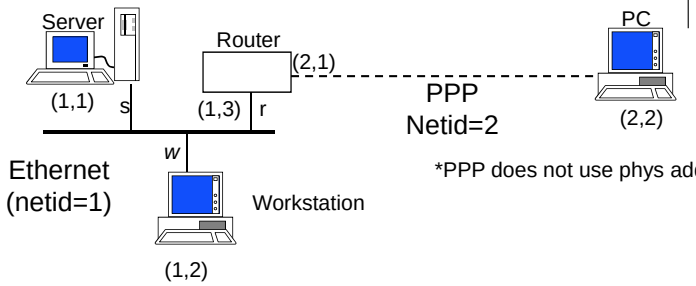
Infrastructure:

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*

3

Example

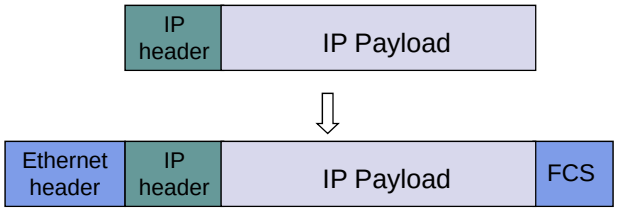


*PPP does not use phys addresses

	netid	hostid	Physical address
server	1	1	s
workstation	1	2	w
router	1	3	r
router	2	1	-
PC	2	2	-

4

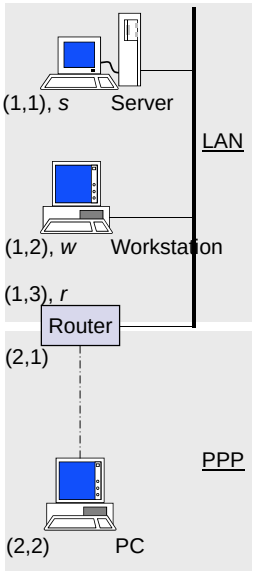
Encapsulation



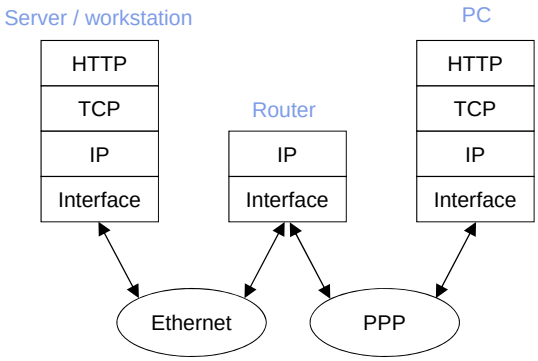
- Ethernet header contains:
  - source and destination physical addresses
  - network protocol type (e.g. IP)

5

HTTP and Web Browsing (2)



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



6

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.

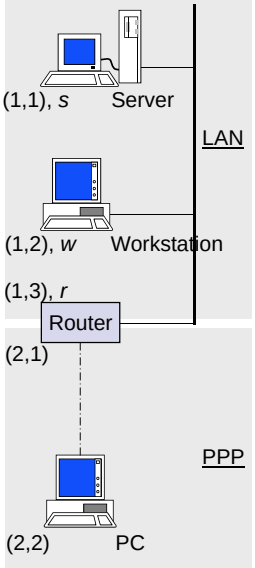
Uniform Resource locator (URL) of the server: 1st part typically translated to an address by Domain Name Server (DNS), 2nd part specifies document

- 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)

7

HTTP and Web Browsing (4)



Task: Transfer of an HTTP 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

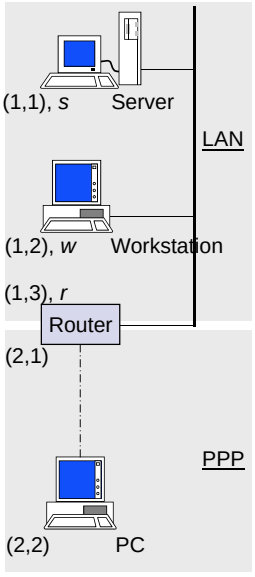
3. TCP segment is passed to IP layer that creates an IP datagram where protocol field (PF) shows that upper layer has asked for the information. IP datagram is passed on to interface layer.

....	(1,1)	(2,2)	PF	TCP segment

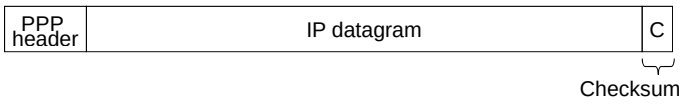
Header

8

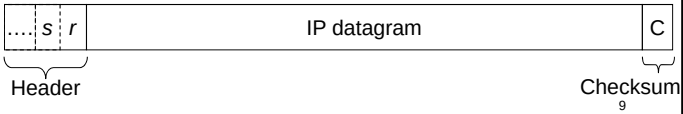
HTTP and Web Browsing (5)



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

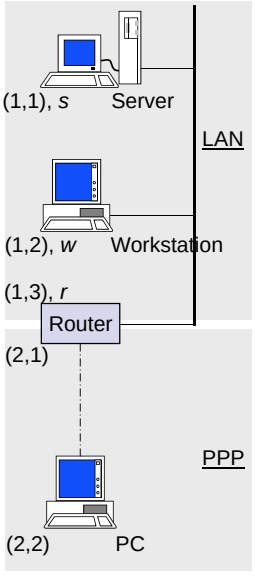


5. The IP datagram is extracted by the interface layer of the router and passed on to the Internet layer. The Internet layer extracts the destination address (1,1) and checks the routing table for a match.
6. Since a match exists, the Interface layer prepares an Ethernet frame encapsulating the IP datagram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

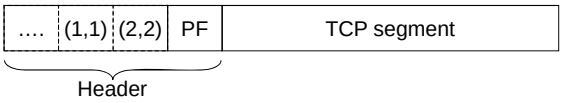


9

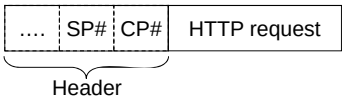
HTTP and Web Browsing (6)



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.

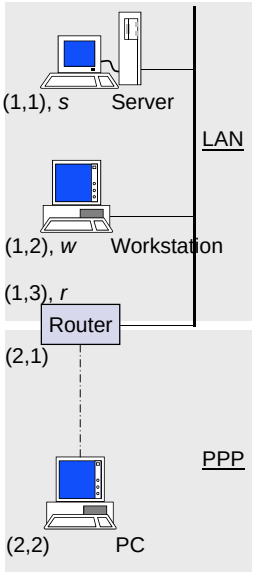


6. The Internet layer maps the IP address and sees that the IP datagram is meant for it. It extracts the TCP segment and passes it on to the TCP layer



10

HTTP and Web Browsing (7)

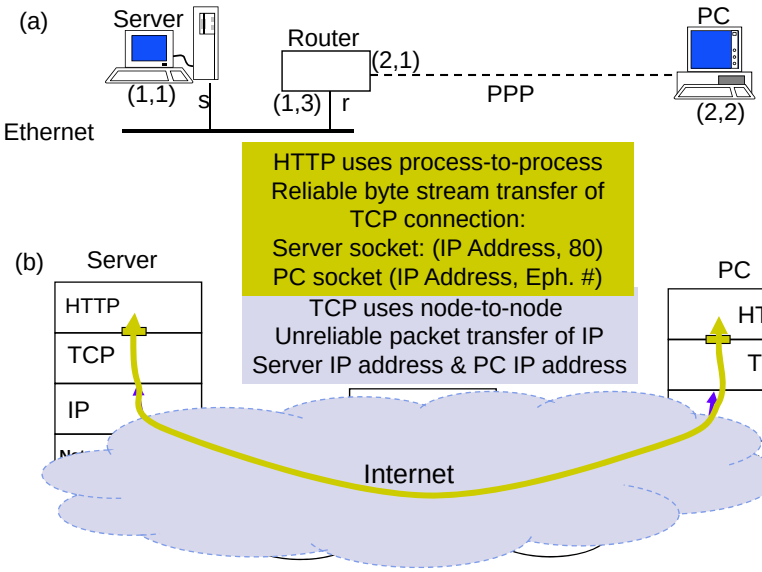


7. HTTP request is extracted by TCP layer and passed on to specified port number.
8. Recall that the protocol used by the Transport layer is TCP, which is a reliable connection-oriented protocol. An acknowledgment is therefore sent to the PC in exactly the same manner as the request was received.

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

11

How the layers work together



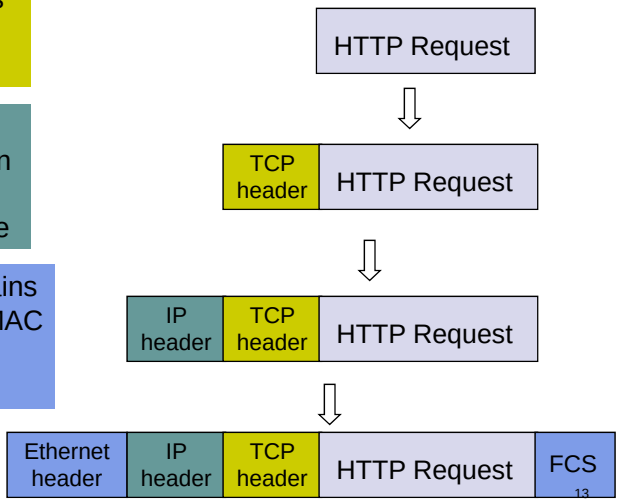
12

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



13

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

14

Domain Name System

- Domain Name System (Service) (DNS) links names to IP addresses in the Internet.
- The system uses a hierarchical tree topology to reflect different administrative levels.

  Example: www.cs.yorku.ca (130.63.96.20)
- DNS servers are distributed databases strategically located on the Internet.
- Most Internet service providers have DNS servers.
- Converting domain names to IP addresses & vice versa:

  www.whatismyipaddress.com

  www.hcidata.co.uk/host2ip.htm

  nslookup program (“man nslookup” on Unix for info)

15

DNS Query

- In the previous HTTP example, the client first needs to perform a DNS query to obtain the IP address corresponding to the domain name.
- Send a message to a DNS server.
- DNS queries use UDP (why?)
- The following example assumes that the client and the DNS server are located on the same LAN.

16

- Finding out the network address of "www.cs.fsu.edu"
  - netscape goes to a domain name server (DNS) to find out the IP address of "www.cs.fsu.edu"

    host = gethostbyname("www.cs.fsu.edu");
  - DNS server in our department:

    nu.cs.fsu.edu (128.186.121.10) at 8:0:20:7d:4f:49
  - How does netscape know the address of the DNS server?
    - Hard-coded at system (network) configuration. E.g. /etc/resolv.conf in my Linux system.

17

- Getting the IP address from the DNS server
  - Netscape, using UDP transport sets up a dialogue with the DNS Server at 128.186.121.10/53 to get the desired address
    - TCP/IP protocol uses IP to send a datagram to 128.186.121.10.
      - Turns out that 128.186.121.10 and my IP address are on the same Ethernet domain; can send the DNS query directly via the Ethernet.
      - Needs to find out the Ethernet address of 128.186.121.10.
      - Uses ARP protocol, sends an ARP packet over the network

        What is the address of 128.186.121.10?

        Host 128.186.121.10 replies: result: 8:0:20:7d:4f:49.
      - IP asks Ethernet to send an Ethernet frame to 8:0:20:7d:4f:49.
      - Ethernet on nu.cs.fsu.edu (DNS server) receives a frame, turns out to be an IP packet destined for it, passes it to the IP module.
      - IP module finds out that it is a UDP packet and passes it to the UDP module.
      - UDP realizes that a process is listening to port 53, notifies the process.
      - Process handles the message and replies to Netscape host.
    - DNS client dialogue involves several message exchanges
  - The DNS server eventually sends a message back: 128.186.121.41 is the network address of www.cs.fsu.edu

18

SMTP and E-mail

A sends an email to B ⇒ 3 transactions

1. A sends the message to the local SMTP server.
2. Local SMTP server transfers the message to the destination SMTP server.
3. Destination SMTP server delivers the message to B.

- SMTP works best when the receiver machine is always available.
- Users in a PC environment usually retrieve their email from a mail server using the Post Office Protocol (POP3) (working in conjunction with SMTP).

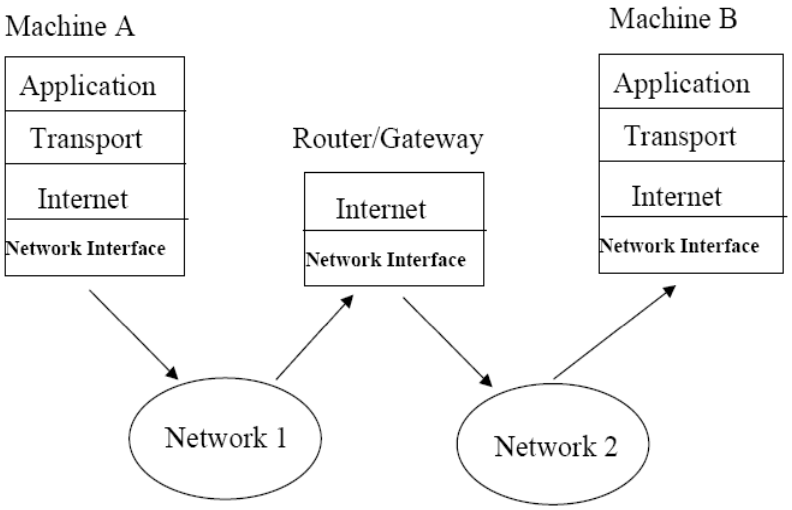
19

More Protocols and Utilities

- Telnet (port 23, unencrypted text)
- FTP (port 20 for data, 21 for control)
- IP utilities
  - ping: determines if a host is online and available
    Example: ping –s gardiner.cs.utoronto.ca
  - echo (port 7): echoes a character back to sender
  - daytime (port 13): returns time and date
  - traceroute (port 33434): returns the source-to-destination route
  - netstat (port 15): queries a host about its TCP/IP network status
- For more utilities: http://www.caida.org/tools/taxonomy/

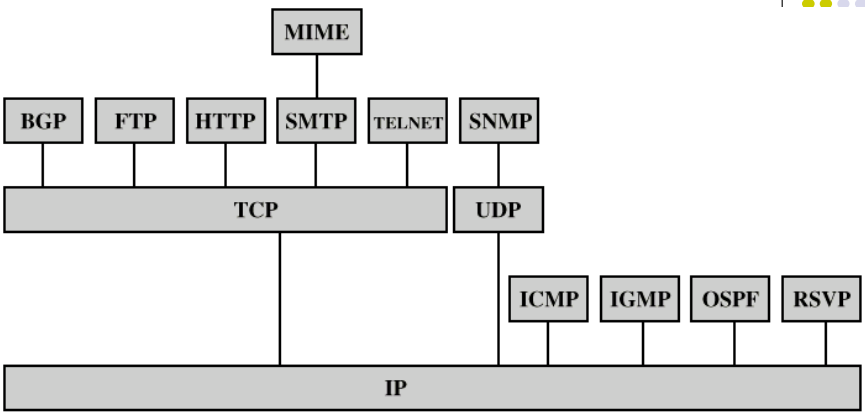
20

Summary of TCP/IP Model



21

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

Connectionless vs. Connection-Oriented Services

- Connection-Oriented
  - Three-phases:
    1. Connection setup between two SAPs to initialize state information
    2. Data unit transfer
    3. Connection release
  - Examples: TCP, ATM
- Connectionless
  - Immediate data unit transfer
  - No connection setup
  - Examples: UDP, IP
- Layered services need not be of same type
  - TCP operates over IP
  - IP operates over ATM

23

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

24

Examples of Connection-oriented 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

25

Reading

The above examples are taken from

Chapters 1 and 2 of "Communication Networks: Fundamentals Concepts and Key Architectures," 2nd edition by Alberto Leon-Garcia and Indra Widjaja, McGraw-Hill, 2004

26