

King Fahd University of Petroleum & Minerals Computer Engineering Dept

COE 540 – Computer Networks
Term 121
Dr. Ashraf S. Hasan Mahmoud
Rm 22-420
Ext. 1724
Email: ashraf@kfupm.edu.sa

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

1

Lecture Contents

1. Uses of Computer Networks
2. Network Hardware
3. Network Software
4. Reference Models
5. Example Networks
6. Network Standardization

These slides are based on the Tanenbaum's
textbook and original author slide

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

2

Computer Network Versus Distributed System

- Computer Network: collection of autonomous computers interconnected a single technology
- Examples:
 - Two computers in LAN
 - Internet – network of networks
- Distributed System: collection of independent computers that appears to users as a single coherent system
 - Single model or paradigm that is presented (or apparent) to users
 - Middleware – layer of software (above the OS) responsible for implementing the model
 - Software system built on top of network
 - Example: World Wide Web

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

3

Uses of Computer Networks – Business Applications

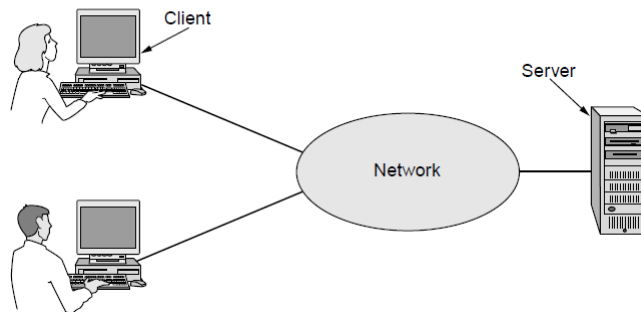
- Resource sharing – make all programs, equipment, and especially data available regardless of physical location of the resource or user.
 - Example – sharing of printers, backup systems, etc.
- Tools and Models:
 - Virtual Private Network (VPN) – joins individual networks at different sites into one extended network
 - Client-Server model - Example – Web applications, Databases, etc.
 - Electronic mail (email) – powerful communication medium for work environment
 - IP telephony or voice over IP (VoIP)
 - Desktop sharing
- Doing business electronically – electronic commerce (e-commerce)

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

4

Client-Server Model



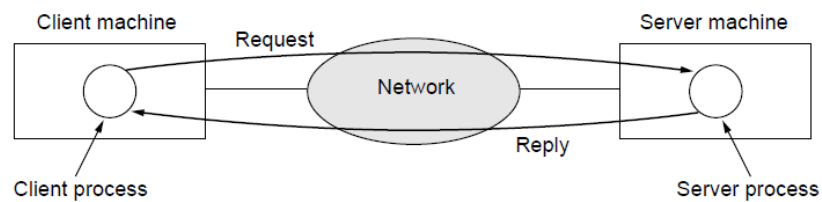
Example of a network with two clients and one server.

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

5

Client-Server Model – cont'd



The client-server model involves requests and replies

- Client process – issues requests
- Server process – receives/interprets requests and produces replies

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

6

Uses of Computer Networks – Home Applications

Person-to-remote database (info) (1)

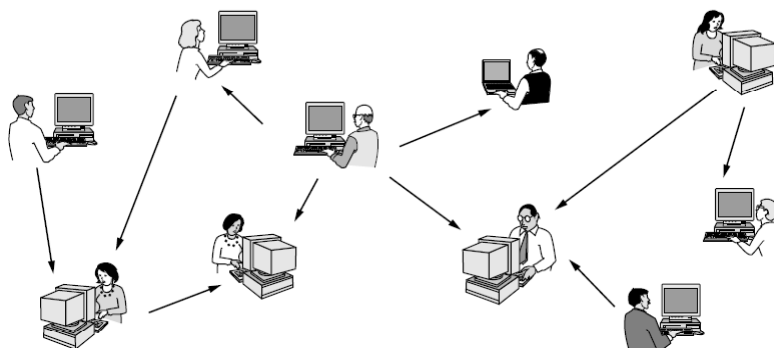
- Why to have a computer at home:
 - Word processing and games
 - Internet access (to be connected!)
- Internet connectivity
 - Metcalfe's law: the value of the network is proportional to the square of the number of users
- Access to remote information
 - WWW – all kinds of info
- Models:
 - Client-Server model
 - Peer-to-Peer model

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

7

Peer-to-Peer Model



- In a peer-to-peer system there are no fixed clients and servers.
- No central database
- Example – BitTorrent
- Sharing of music, videos, etc.
- Napster shut down early 2000s

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

8

Home Applications – Person-to-Person Communication (2)

- Instant messaging – (old UNIX talk program)
 - multi-person messaging (Twitter service – tweets to circle of friends)
- Audio and video between people
 - Telelearning
- Social networking
 - Facebook, Twitter
 - Wikis – collaborative effort to create a content – example Wikipedia

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

9

Home Applications – Electronic Commerce (3)

- Buying products over the Internet
- Paying bills
- Managing bank accounts

- Electronic flea markets – online auctions (follow the peer-to-peer model)

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

10

Home Applications – Entertainment (4)

- Distribution of music, radio, television programs, and movies over the Internet
- IP TeleVision (IPTV)
- Game playing
 - Multi-team real-time simulation games – example hide-and-seek in a virtual dungeon; flight simulators with players shooting at each other; etc.

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

11

Home Applications – Ubiquitous Computing

- Computing embedded into everyday life.
- Security systems connected to doors and windows – calling police department
- Smoke/fire detectors – calling fire department

- Consumer electronics (cameras, DVD players, etc) are seamlessly connected to other consumer electronics
- Two technologies - facilitate ubiquitous computing at home
 - Power-line networks
 - Radio frequency identification (RFID)

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

12

Mobile Users

- Connectivity to the Internet is the main drive
- Hotspots – e.g. Laptops/Mobile phones connect the Internet using wireless LAN
- Mobile phone - Text messaging (Short Message Service) very popular application
- Smart phones – convergence of telephony and the Internet
 - E.g. iPhone (3G and 4G phones)
- Location dependant services for mobile phones equipped with GPS receivers
 - E.g. searching for nearby restaurants, etc.
- Mobile-Commerce (m-commerce) – short text messages from mobile phone are used to authorize payments for food in vending machines, movie tickets, and other small items
- Useful (growing) technologies – Sensor Networks, Wearable computers

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

13

Social Issues

- Social networks – message boards, content sharing sites, etc.
- Network neutrality
- Digital Millennium Copyright Act (DMCA) – automated systems that search peer-to-peer networks and fire off warnings to network operators and users for suspected copyright infringement
- User profiling – cookies, Gmail (?)
- Spam email
- Phishing – messages masquerade as originating from a trustworthy party

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

14

Network Hardware

- Transmission technologies typically used:
 - Broadcast
 - Point-to-point (unicast)
- Packets – unit of transmission
- Classification based on physical size

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	
100 m	Building	Local area network
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

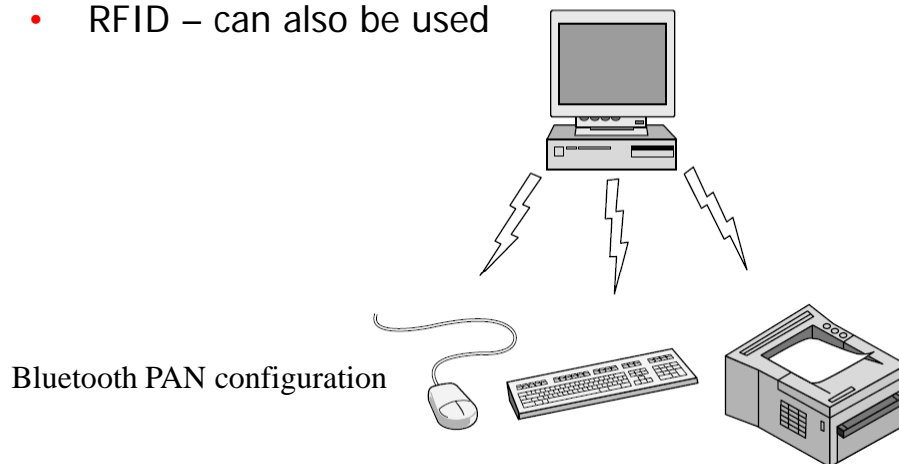
9/1/2012

Dr. Ashraf S. Hasan Mahmoud

15

Personal Area Networks (PANs)

- Main technology – Bluetooth
- RFID – can also be used



9/1/2012

Dr. Ashraf S. Hasan Mahmoud

16

Local Area Networks (LANs)

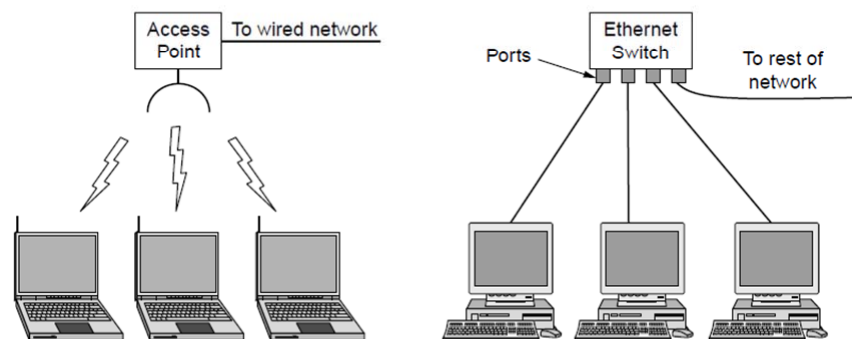
- Typically privately owned and operates with or nearby a building (home, office, factory, etc.)
- Wireless LAN – IEEE802.11 versus WiFi
 - Access point (aka wireless router or basestation)
 - 100s of Mb/s
- Wired LAN – IEEE 802.3 or (switched) Ethernet is the main technology
 - Speed ranging from Mb/s to 10 Gb/s
 - Switch – ports
- Power-line networks – competing technology

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

17

Local Area Networks (LANs) – cont'd



Wireless and wired LANs. (a) 802.11. (b) Switched Ethernet.

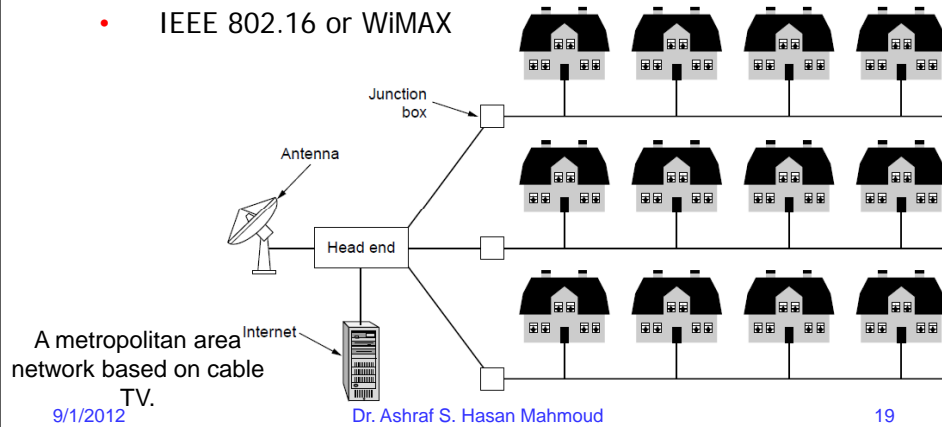
9/1/2012

Dr. Ashraf S. Hasan Mahmoud

18

Metropolitan Area Networks (MANs)

- Covers a city
- Examples:
 - Cable television distribution network
 - IEEE 802.16 or WiMAX

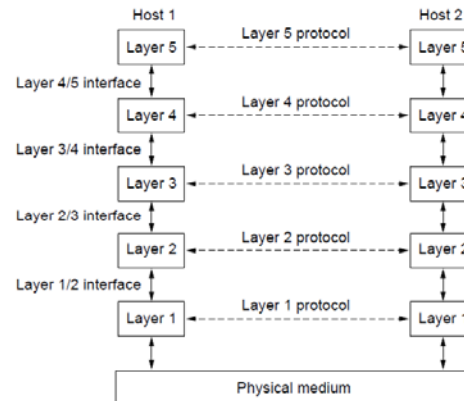


Wide Area Networks (WANs)

- Typically

Network Software

- Stack of layers or levels – abstraction of network functions and grouping them into different layers
- Protocol – convention governing communication between entities
- 5-layer architecture is shown in figure
- Peer entities – software processes or hardware devices
- Each layer ($n > 1$) utilizes the services of the layer below to communicate with its peer entity
 - Interface or Service Access Point (SAP)
- Only true physical communication occurs on the physical medium



9/1/2012

Dr. Ashraf S. Hasan Mahmoud

21

Network Architecture

- Set of layers and corresponding protocols
- Protocol stack – set of protocols used by a particular system (one protocol per layer)
 - TCP/IP protocol stack

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

22

Connection-Oriented Versus Connectionless Services

- Connection-oriented
 - Similar to circuit switched
 - Three main phases: dial-up (set up), data transfer, tear-down.
- Connectionless
 - Unreliable delivery of packets – datagram service
- Upper layers may convert unreliable datagram service into reliable connection
- Unit of transmission – Packet
- Routing function
 - Store-and-forward switching
 - Cut-through switching

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

25

Service Primitives

- Operations or function calls available to entity process to access service from lower layer and communicate with peer entity on the other machine
- Example: 6 primitives that can be used to establish connection oriented service

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
ACCEPT	Accept an incoming connection from a peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

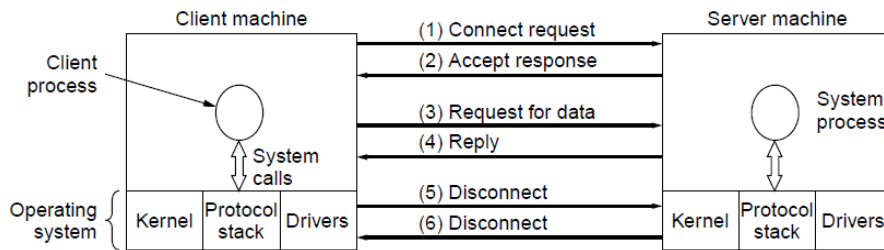
9/1/2012

Dr. Ashraf S. Hasan Mahmoud

26

Service Primitives – cont'd

- Simple client-server interaction using acknowledged datagrams



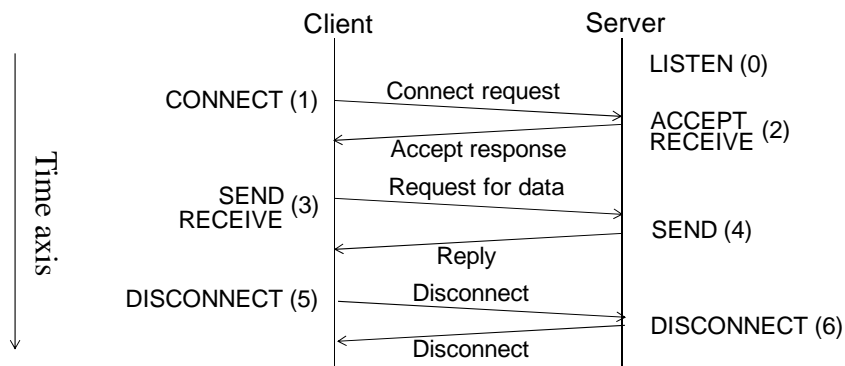
9/1/2012

Dr. Ashraf S. Hasan Mahmoud

27

Service Primitives – cont'd

- Using message exchange timing diagram



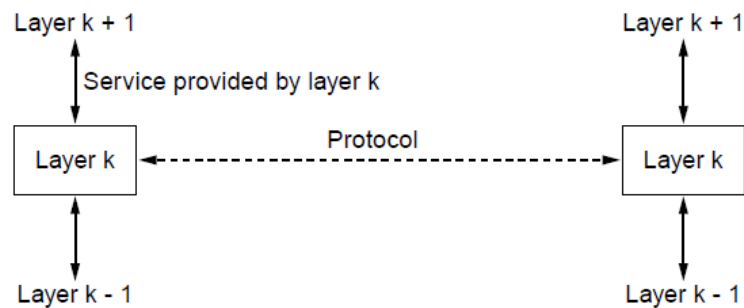
9/1/2012

Dr. Ashraf S. Hasan Mahmoud

28

Relationship of Services to Protocols

- Service – set of primitives that a layer provides to the layer above
- Protocol – set of rules governing the format and the meaning of the packets



9/1/2012

Dr. Ashraf S. Hasan Mahmoud

29

Reference Models

- Open Systems Interconnection (OSI)
 - General specification/model
 - Its protocols are not used
- TCP/IP – most popular
 - Protocols are most utilized in the Internet.

9/1/2012

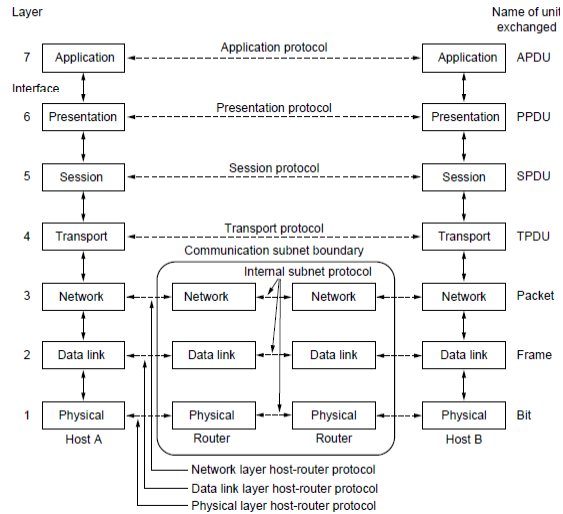
Dr. Ashraf S. Hasan Mahmoud

30

The OSI Reference Model

- Model principles:

1. Layers created for different abstractions
2. Each layer performs well-defined function
3. Function of layer chosen with definition of international standard protocols in mind
4. Minimize information flow across interfaces between boundaries
5. Number of layers optimum



9/1/2012

Dr. Ashraf S. Hasan Mahmoud

31

The OSI Reference Model – Layers Functions

1. Physical
 - Transmission of raw bits (1s and 0s)
2. Data link layer
 - Converting the raw stream of bits into a reliable exchange of data frames
 - Use of acknowledgement frames, error control, etc.
 - Medium access control – sublayer controlling access to the shared medium
3. Network layer
 - Deciding on routes for packets and forwarding packet in the direction of the destination
 - Controls the operation of the subnet
4. Transport
 - Accepting data from one end and reliably transferring it to the other end
 - Operates end-to-end
5. Session
 - Establishing sessions between the two parties
 - Functions include dialog control, token management, synchronization, etc.
6. Presentation
 - Syntax and semantics of information transmitted
7. Application
 - Email (SMTP), WWW (HTTP), file transfer (FTP), etc.

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

32

The TCP/IP Model

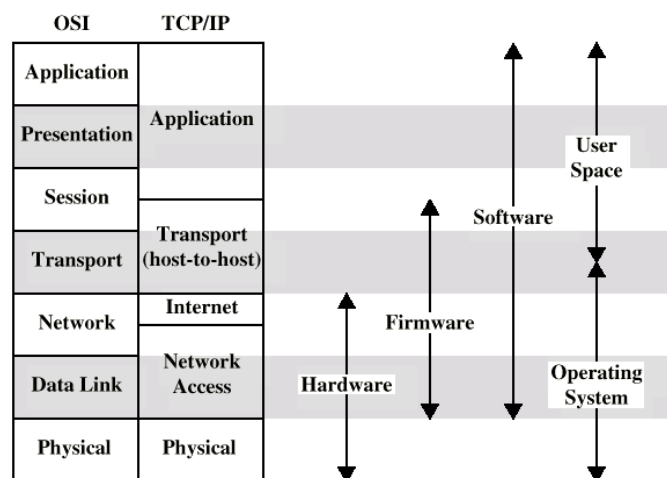
- **Model has five independent layers:**
 - **Application layer:** comm between processes or applications on separate hosts
 - **Transport layer:** end-2-end transfer service – may include reliability mechanisms
 - **Internet layer:** routing data from source to destination through one or more networks
 - **Network access layer:** logical interface between end systems and the network
 - **Physical layer:** defines mechanism of transmitting raw bits depending on media characteristic

9/1/2012

Dr. Ashraf S. Hasan Mahmoud

33

The TCP/IP Model (using the OSI Model as a reference)



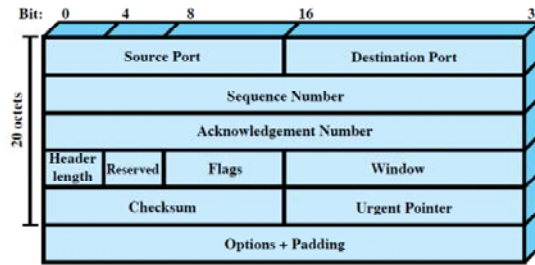
9/1/2012

Dr. Ashraf S. Hasan Mahmoud

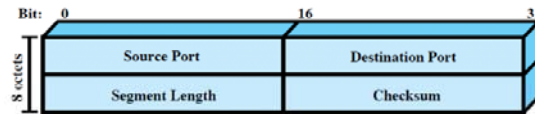
34

TCP Headers

- TCP control info:
 - Destination port number
 - Sequence number
 - Checksum



(a) TCP Header



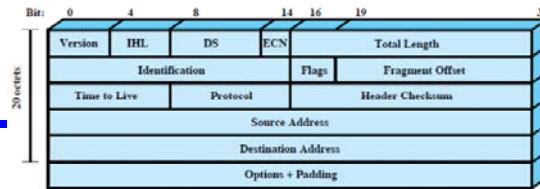
(b) UDP Header

9/1/2012

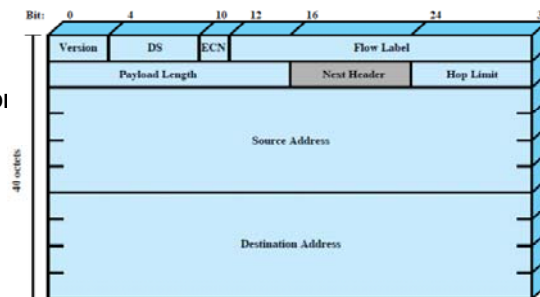
Dr. /

IP Header

- IP control Info
 - Version
 - Source Address
 - Destination Address
 - Protocol
- Note the 32-bit address for IPv4 versus the 128-bit address for IPv6.



(a) IPv4 Header



(b) IPv6 Header

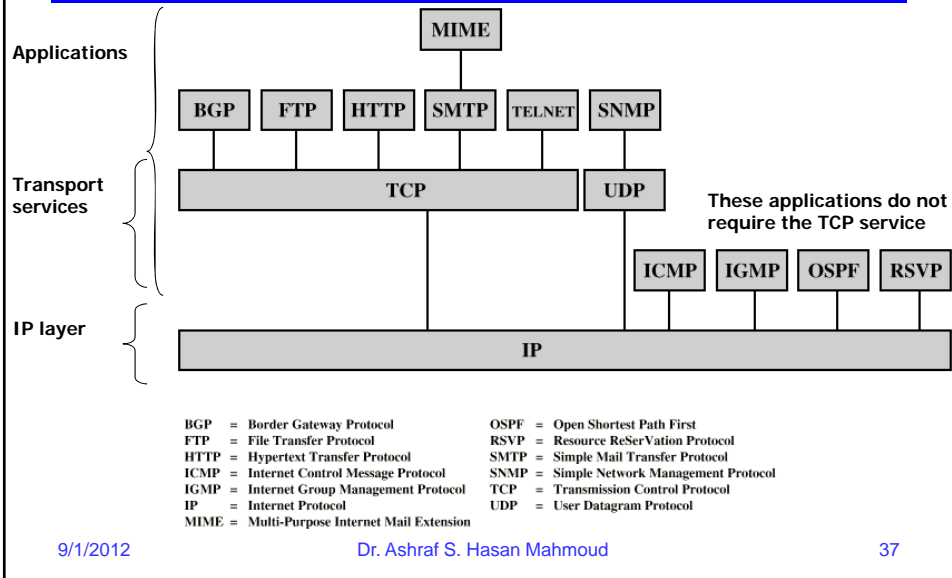
DS = Differentiated services field
ECN = Explicit congestion notification field

Note: The 8-bit DS/ECN fields were formerly known as the Type of Service field in the IPv4 header and the Traffic Class field in the IPv6 header.

9/1/2012

Dr. Ash

TCP/IP Protocols



Comparing OSI and TCP/IP and Critique of the two Models

- Read textbook

Example Networks

- The Internet
- 3G/4G Mobile networks
- Wireless LANs
- RF and wireless sensor networks