King Fahd University of Petroleum & Minerals
Computer Engineering Dept

COE 540 –Computer Networks

Term 071

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Lecture Contents

1. Historical Overview
2. Messages and Switching
3. Layering
   a. The OSI model
   b. The TCP/IP model

Reading Assignment

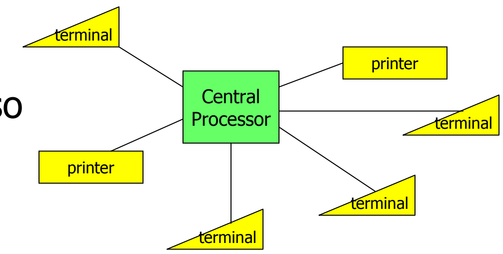
- You are required to read the following chapters:
  - Chapter 1 of Gallager's textbook
  - Chapter 1 of Kurose's textbook
- The material is an overview of the field and serves as very "*basic*" introductory text.
- The material is required for subsequent quizzes and exam

Historical Overview

- Forms of data networks
  - Smoke signals - ?
  - Telegraphy – 19s century
- Very primitive – manual "signal" encoding

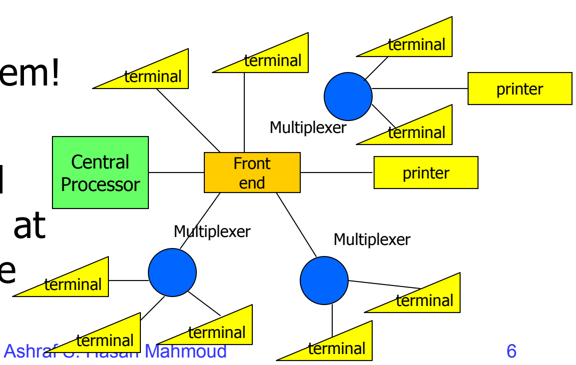
Historical Overview (2)

- Time-shared Processors
  - 1950s
  - Proliferation of communication links
  - Peripheral devices (printers, terminals, etc.) connect to the "expensive" CPU.
- Note that the central CPU is also managing the communication links!



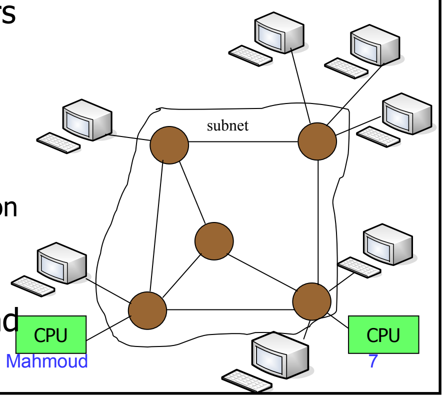
Historical Overview (3)

- Time-shared Processors – cont'd
- To relief the processor – a specialized "front end" processor is attached to the central processor to handle all communications
- Centralized system!
- Note the central processor is still at the center of the network



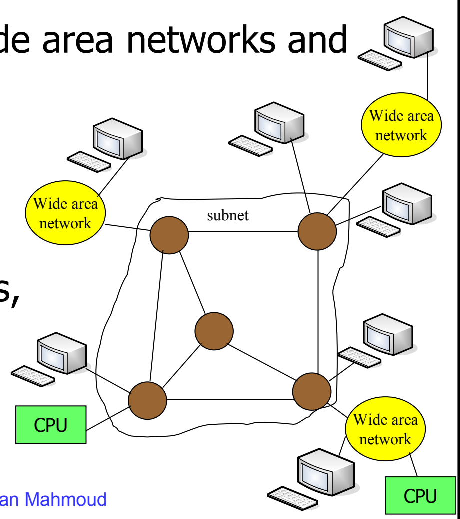
Historical Overview (4)

- ARPANET and TYMNET - ~70s
- General purpose data-networks
- Geographically distributed computer systems
- Interface Message Processors (IMPs) – computers specialized in routing messages
  - Routers/Switches
  - Connected using communication links
- Note, the "subnet" is now at the center of the network and not the shared computer



Historical Overview (5)

- Network of interconnected networks
- Explosive growth of wide area networks and local area networks
- The need for control algorithms or PROTOCOLs to handle data, gateways, bridges, etc.
- This shown network is similar to today's Internet!



Historical Overview (6)

- What do think future networks will look like?
  - High speed (broadband)?
  - Integrated services: voice, data, multimedia, etc.
  - Quality of service (QoS) capable networks
  - Seamless services
  - Ubiquitous
  - Etc.

Factors

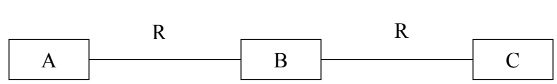
- Technological and economy
  - Thanks to advances in VLSI, CPU prices are halved every six-to-twelve months with more processing power built in
  - Computers can do more – network has to cope
- Communication Technology
  - Evolution of link speeds: 2.4, 4.8, 9.6 and 56 kb/s
  - New links – 64 kb/s, 1.5 Mb/s, 45 Mb/s, etc.
  - Bandwidth sharing
  - Cost for media – TP versus optical
- Applications for data networks
  - Remote access of "super" computers – early
  - Email, FTP, HTTP – now (killer application?)
  - (distributed) database access
  - Etc.

Messages and Switching

- What is a message? – give a definition
- Depend on the application/context
  - Email – document or file
  - Interactive system – transaction
- Representation of messages
  - String of bits
  - Compression – how?
- Is transferring long messages between network entities efficient? Why?
- Usually, long message are broken into "packets"
- The network must "switch" or direct packets to the destination

Exercise:

- Consider the simple network shown in figure. One file of K>>1 bits must be sent from A to C. The file is decomposed into packets of P bits each. Each packet contains 16 error-control bits 32 bits of address and sequence number, in addition to the P data bits. The transmission rate is R bits/sec. Each packet is first sent from A to B and then from B to C.
  a) Find the value of P that minimizes the transmission time from A to C, neglecting the propagation time.
  b) Repeat the problem when the file must go through N communication nodes between A and C.



Sessions

- What is a session?
- Connection versus connectionless services
- Think of a "voice" session or an "HTTP" session

- What the characteristics for connection-oriented communication?
- What the characteristics for connectionless communication?
- Modeling of Traffic/Arrivals
  - Messages arrive at random points in time
  - Poisson process – approximations
  - Accuracy of model – voice (good), data (?)
  - On/Off models

important topic

Characteristics of Sessions

- Message arrival rate and variability of arrivals
- Session holding time
- Expected message length and length distribution
- Allowable delay
- Reliability
- Message and packet ordering

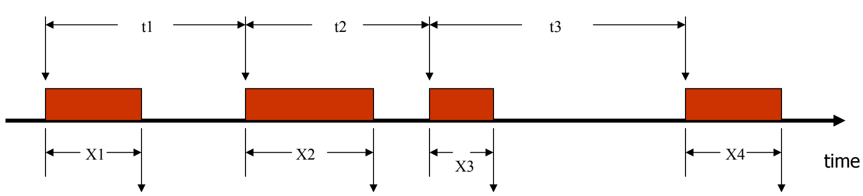
Circuit Switching versus Store-and-Forward Switching

- Circuit switching:
  - A dedicated path is established between two ends
  - Resources are reserved for session – justified when link utilization is expected to be high
  - Usually FDM, TDM, or CDMA based
  - Appropriate for CBR type traffic – rarely used for data
  - Eg. Telephony
  - Involves: call setup, data exchange, call termination
- Store-and-Forward switching:
  - The processing is done on the packet level
  - Intermediate nodes receive and process (switch) packets
  - Different packets may go different routes
  - No call setup
  - Resources are not reserved but utilized as required
  - Appropriate for VBR type traffic

Link Utilization

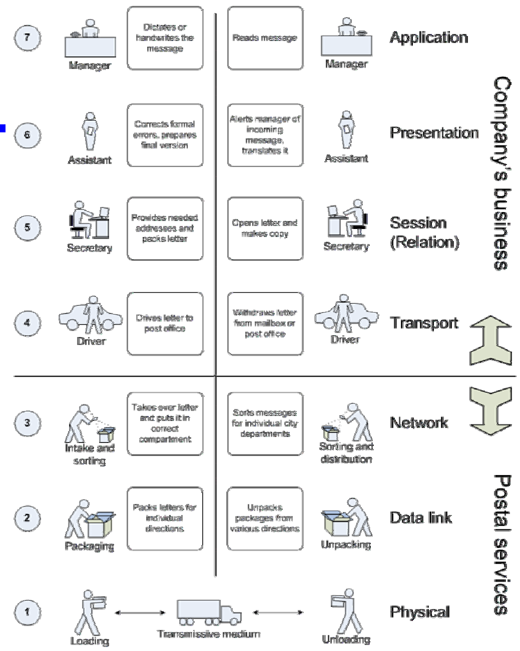
More on this topic to be covered when queueing theory is discussed.

- Variables of interest:
  - t1, t2, t3, … : interarrival times
  - X1, X2, X3, … : message duration
- Arrival rate, $\lambda = E[ti]$
- Link utilization, $\rho = \lambda E[Xi] = E[Xi]/E[ti]$
  - $\rho << 1 \rightarrow$ low utilization,
  - $\rho = 1 \rightarrow$ 100% utilization
  - $\rho > 1 \rightarrow$ unstable link/system



The Concept of Layering

- **Source: http://en.wikipedia.org/wiki/OSI_model**



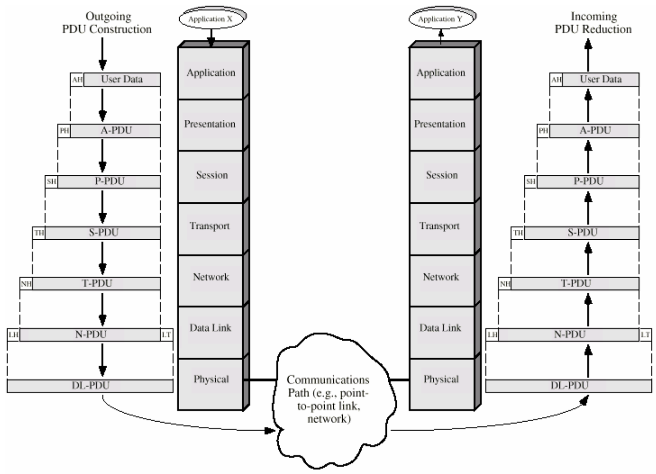
RM – OSI and letter communication parallel

Protocols - Definition

- **What is a Protocol:**
  - **Convention between two communicating entities governing exchange of data**
- **Elements of Protocol:**
  - **Syntax: data format, signal levels, etc.**
  - **Semantics: control info coordination and error handling**
  - **Timing: matching speeds and sequencing (synchronization)**
- **What is a "*communicating entity*"?**
  - **Node,**
  - **Module,**
  - **Process,**
  - **Etc.**

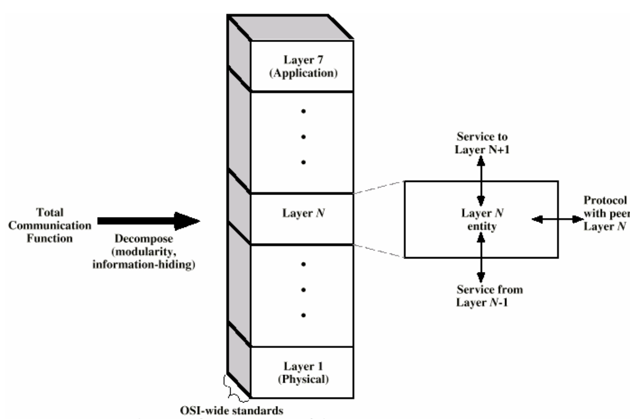
The OSI Model - Environment

- Layer i establishes a PEER relationship with layer i on the target node
- This means Layer i requires service from layer i-1
- And so on
- The use of the PDUs
- No direct communication except for the physical layer – all other communication is indirect or virtual
- Encapsulation of user data
- Each layer may segment SDU to accommodate its own requirement – These are reassembled at the other end



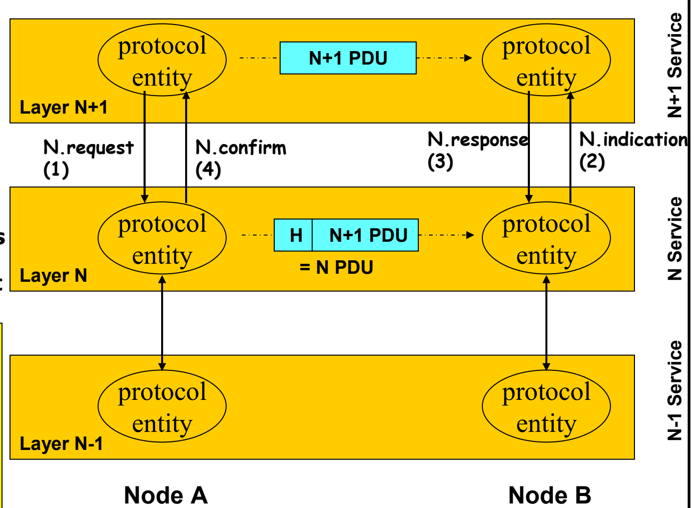
The OSI Model - Framework

- Very similar to subroutine or function design in software engineering
- Boundaries and functionalities are well designed – development of one layer has little or no effect on other layers
- Protocol specification:
  - Format of PDUs, and the semantic of each field
- Service definition:
  - What are the services provided to upper layer and the lower one
- Addressing:
  - E.g: NSAP is the address of an entity in the transport layer who uses the network service



The OSI Model - Framework

- **Service Primitives:**
  - **Request:**
  - **Indication:**
  - **Respond**
  - **Confirm**
- **Note:**
  - **Encapsulation**
  - **Peer communication is virtual (dashed lines) – except at physical layer**
  - **Figure shows confirmed services case – For non confirmed services, the initiator receives no confirmation.**



The OSI Model – Physical Layer

- **Specifications:**
  - **Mechanical: dimensions, connectors, etc.**
  - **Electrical: signal levels, rates of change, etc**
  - **Functional: functions performed by each circuit**
  - **Procedural: steps required to transport bits from one end to the other**
- **Provides service to do "transmission of raw bits"**

The OSI Model – Data Link Layer

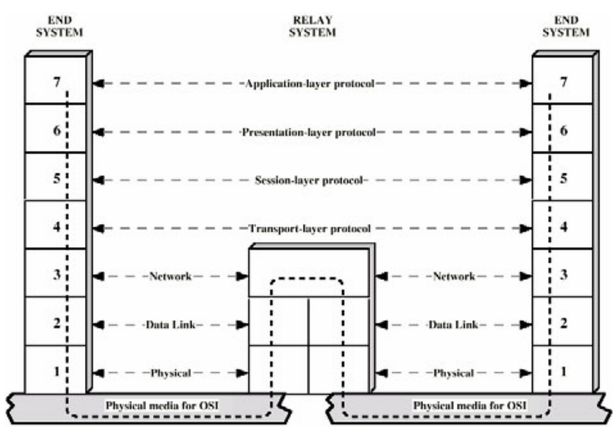
- **Coverts the raw bit stream service provided by the physical layer to a reliable stream:**
  - **Performs error detection and error control**

- **Examples: HDLC, LAPB, LLC, etc**

The OSI Model – Network Layer

- **Service: transfer of information between two end systems across communication network – End to end delivery of packets**

- **Two end systems may be connected by:**
  - **Point-2-point: no need for network layer**
  - **Same network (see figure)**
  - **Different network**



The OSI Model – Transport Layer

- Service: mechanism of exchanging data (or messages) between the two end systems:
  - For connection oriented networks:
    - Error-free delivery
    - Ordered delivery
    - No loss or duplication
    - Attempts to provide a certain quality of service (QoS) {certain max error rate, delay jitter, etc) through optimizing the the network layer services
- Example: TCP (connection oriented), UDP (connectionless)

The OSI Model – Session Layer

- Service: mechanism of controlling the dialogue between applications at end systems
  - Dialogue Discipline
  - Grouping
  - Recovery

The OSI Model – Presentation

- **Service: defines format of data (format, encryption, and compression) to be exchanged between applications**

The OSI Model – Application

- **Service: A means for user applications (email, ftp, etc) to access the services provided by the OSI model**

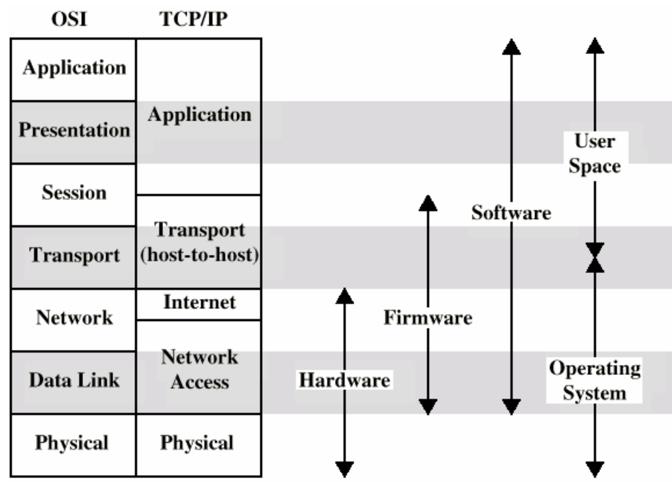
The TCP/IP Model

- TCP/IP is the result of R&D conducted on experimental packet switched network (ARPANET) and funded by Defense Advanced Research Agency (DARPA)
- TCP/IP is NOW the dominant commercial architecture – The foundation of the internet and its applications

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

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

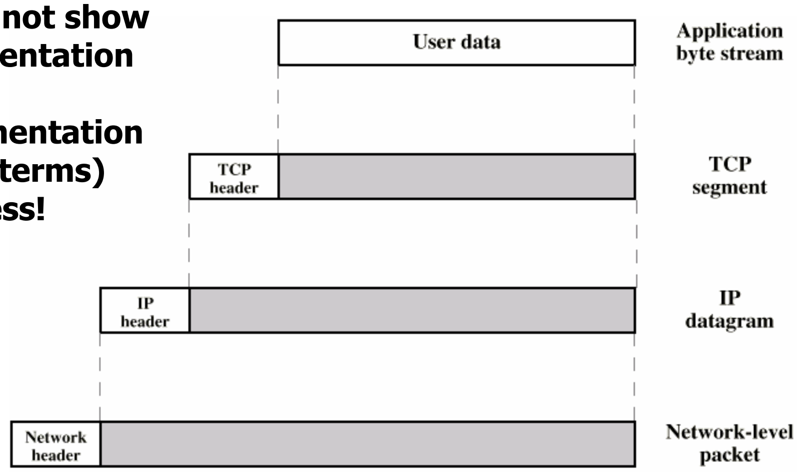


Example of TCP/IP Communications

- A process (has port 1) on host A needs to communicate to another process: port 2 at host B
- The application layer on A hands the msg down to TCP with instructions to deliver it to (port2,host B)
- TCP hands msg down to IP with instructions to send it to host B:
  - The IP layer knows how to reach host B (or at least the first hop of the route) – does not care about port info
- IP hands down packets to network access (say Ethernet) with instructions to pass it to next router (first hop on the way to B)

Example of TCP/IP Communications

- **Does not show segmentation (or fragmentation in IP terms) process!**



TCP/IP Control Information (Partial)

- **TCP control info:**
  - **Destination port number**
  - **Sequence number**
  - **Checksum**
- **IP control info:**
  - **IP address**
- **Network Access control info:**
  - **Destination network access address (this is not the IP!!)**
  - **Facilities request (e.g. priorities)**

TCP/IP Control Information (Partial)