Benha Faculty of Engineering
5th Year (Comm. & Comp.)
Examiner: Dr. Hatem ZAKARIA

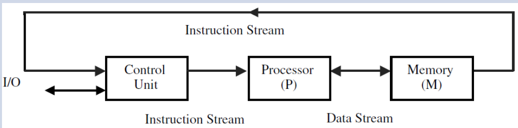
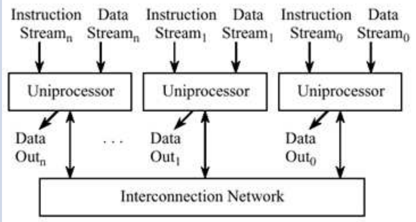
Electrical Engineering Department
Final Exam: 08 January 2014
Time allowed: 3 Hours

Distributed Processing (E521)

Model Answer

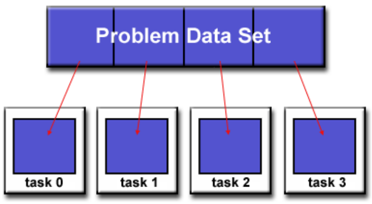
Question (1) (11 Marks)

a. (1)

Aspect	Von Neumann Machine	Parallel Processor
Architecture		
Ease of programming	Simple Sequential fashion.	Need to parallelize the program: may be harder.
Need for synchronization	No need. It is only 1 machine.	Important aspect, since processors will be sharing the memory
Performance evaluation	For large parallelizable problems, uniprocessor systems are expensive	For sequential problems (by nature), parallelizing is expensive
Run time system limitations	Limited factors affect this aspect (speed of execution, memory access time).	Additional factors are involved (processors' synchronization, communication time, delays on the interconnection network, etc.).

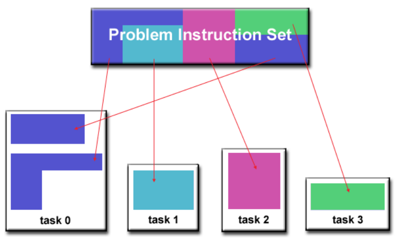
(2) **Domain Decomposition (Data Parallelism)**

- Data associated with a problem is decomposed
- Each parallel task then works on a portion of the data
- (SIMD architecture "image processing")

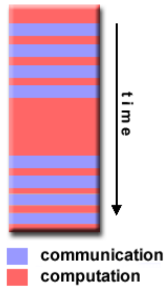


Functional Decomposition (Functional Parallelism)

- Focus is on the computation that is to be performed rather than on the data manipulated by the computation
- The problem is decomposed according to the work that must be done, each task then performs a portion of the overall work.
- (MIMD architecture "Signal Processing")



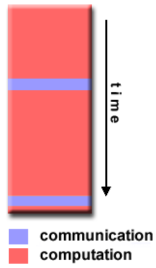
(3) Fine-grain and Coarse-grain parallelism of distributed programs.



Fine-grain Parallelism

- Small amounts of computational work are done between communication events → low computation to communication ratio
- Facilitates load balancing
- Implies high communication overhead and less opportunity for performance enhancement

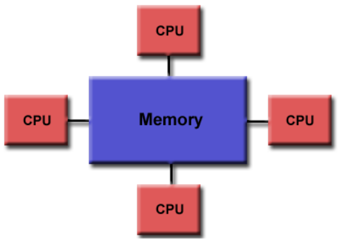
Coarse-grain Parallelism



- Relatively large amounts of computational work are done between communication/synchronization events
- High computation to communication ratio
- Implies more opportunity for performance increase
- Harder to load balance efficiently

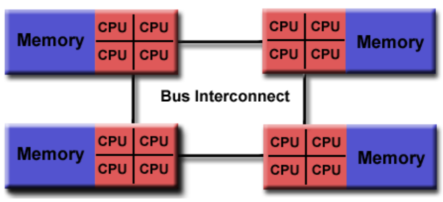
b. The two main types of the shared memory

Uniform Memory Access (UMA)



- Shared memory is accessible by all processors in the same way a single processor accesses its memory
- Identical processors
- Equal access and access times to memory

Non-Uniform Memory Access (NUMA)



- Each processor has part of the shared memory attached (memory banks)
- NUMA systems include additional hardware or software to move data between banks.
- Memory access time depends on the memory location relative to a processor

- **Cache coherent means**: If one processor updates a location in shared memory, all the other processors know about the update.

c.

- A SIMD system having 4 processing elements connected in nearest neighbor fashion. Consider that each processor has only its local memory

T_{add} = 3ns and T_{com} = 1ns
No. of processors = 4
Total No. of add operations/clock cycle = |32/4|+|16/4| + |8/4| + |4/4| + |2/4| + |1/4| = 8 + 4 + 2 + 1 + 1 + 1 = 17
Execution time = 17*4 = 68 ns

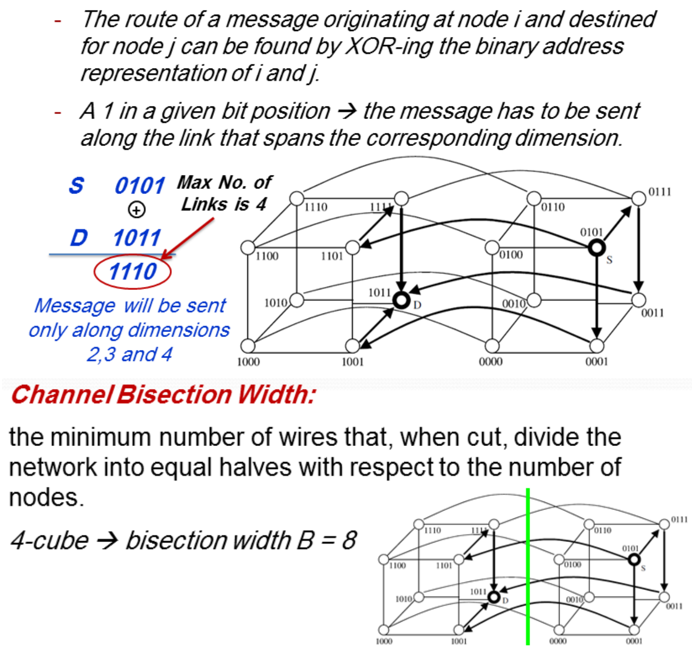
- A MIMD system having 4 processing elements accessing a shared memory through an interconnection network.

No. of processors = 4
Total No. of add operations = 32 + 16 + 8 + 4 + 2 + 1 = 63
Execution time with (pipelining) = 35 + 19 + 11 + 7 + 5 + 4 = 81 ns

<u>Question (2)</u> **(8 Marks)**

a. <u>Discuss</u> the following sentences and use block diagram drawings:

   i. The maximum number of links a message has to path in a hypercube “4-cube” network are 4, and its channel bisection width is 8.

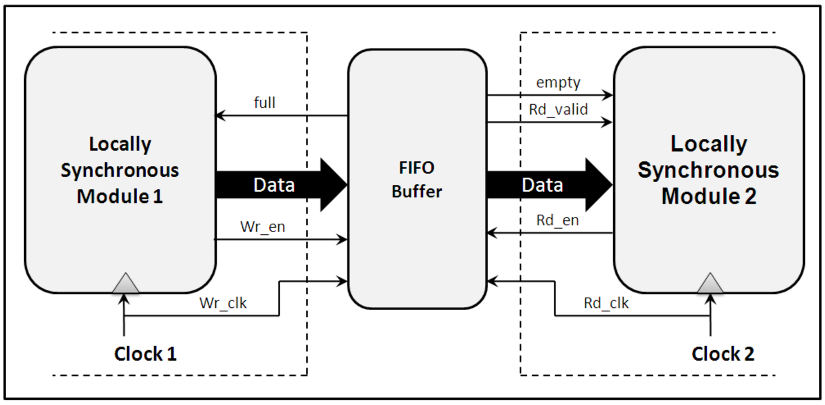


   ii. Synchronous Communications are blocking communications, while Asynchronous Communications are non-blocking communications.

<u>Synchronous communications</u> require some type of "handshaking" between tasks that are sharing data. Synchronous communications →***blocking*** communications as other work must wait until the communications have completed.

<u>Asynchronous communications</u> allow tasks to transfer data independently from one another. Task 1 can prepare and send a message to Task 2, then immediately begin doing other work, while task 2 is receiving the data. Asynchronous communications → **non-blocking** communications as other work can be done while the communications are taking place. Interleaving computation with communication is the single greatest benefit for using asynchronous communications.

a. <u>Draw</u> a block diagram showing the asynchronous inter-task communication between two different clock modules using a FIFO buffer.



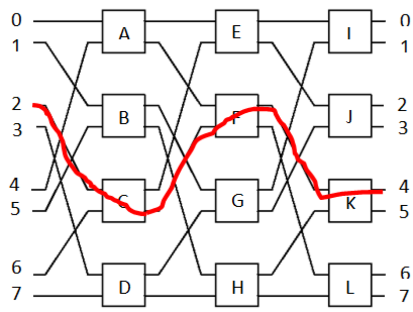
b.

- MIN with 2×2 switches, the cost of each switch is proportional to 2^2
- There are $1024/2$ ($\log_2 1024$) total switches
- There are Log_2 1024 stages of *1024* unidirectional links per stage from the switches plus *1024* links to the MIN from the end nodes.
- $\text{cost(crossbar)}_{switches} = 1024^2$, $\text{cost(crossbar)}_{links} = 2048$
- $\text{Relative\_cost}(2 \times 2)_{switches} = 1024^2 / (2^2 \times 1024/2 \times \log_2 1024) = \mathbf{51.2}$ → 2 Marks
- $\text{Relative\_cost}(2 \times 2)_{links} = 2048 / (1024 \times (\log_2 1024 + 1)) = 2/11 = \mathbf{0.182}$ → 2 Marks

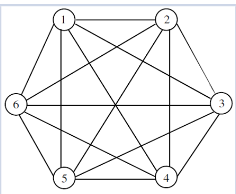
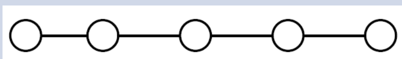
<u>Question (3)</u> (12 Marks)

a. <u>The routing</u> of the message in the following Omega MIN from the processing node No. 010 to the processing node No. 100.

- The 2nd connection is blocked by switch C
- MINs Network has the property of being *blocking*.
- *Contention* is more likely to occur on network links where paths from different sources to different destinations share one or more links



b.

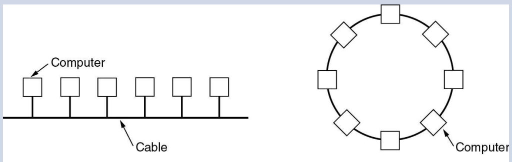
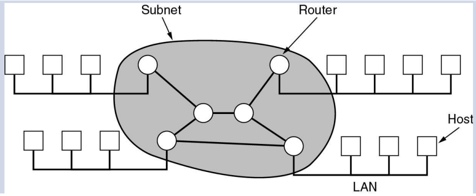
Aspect	Completely Connected Network	Linear Array Network
Architecture		
Link Cost	*N(N-1)/2*	*N*-1
Worst Delay	1	*N*
Degree	*N-1*	2
Symmetry	Yes	No
Diameter	1	*N*-1

c. $\boldsymbol{BW = M(1-(1-(\rho/M))^n) = 4(1-(1-(0.5/4))^4) = 1.6552}$

d. **Answer:** The condition is expressed as follows: 0.4*f + (1-f) * 0.4 *N > 30
For f = 20% → 0.4*0.2 + (1 - 0.2)*0.4*N > 30 → N = 94 processor
$S(n)$ = N/[1+f(N-1)] = 94 / [1 + 0.2 (94 - 1)] = 4.8
Maximum speedup factor = 1/f = 1/0.2 = 5 Efficiency η = s(n) / N = 5.1 %

Question (4) (15 Marks)

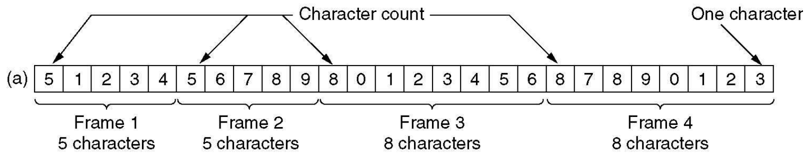
a. Compare between:

Architecture		
Scaling	*Single building or campus (up to few kilometers)*	*Span large geographical area (country or continent)*
Connections	Connect PCs and workshops in company offices and factories to share resources (e.g. Printers) and exchange information	*- Contains a collection of machines "hosts" intended for running user programs* *- Hosts are connected by a communication subnet* *- The subnet carry messages from host to host*
Transmission Technology	*Broadcasting*	Point to Point
Topology	Various possible forms (Bus, Ring, …)	Various possible forms (Star, Complete, …)
Transmission Media	Twisted Pair	Fiber Optics

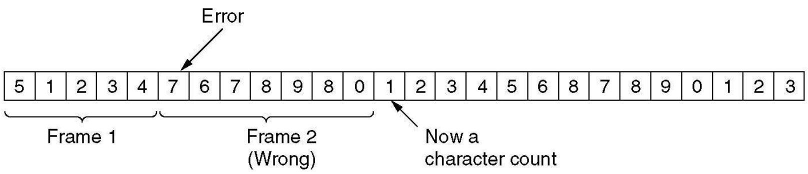
Issue	Datagram Subnet	VC Subnet
Circuit Setup	Not required	Required
Addressing	Each packet contains the full source and destination address	Each packet contains short VC number
Routing	Each packet is routed independently	All packets follow the same chosen rout
Effect of router failure	None except for packet lost during the crash	All VCs that passes through the failed router are terminated
Congestion Control	Difficult	Easy if enough buffers can be allocated in advance for each VC

Character count

A field in the header specifies the number of characters in the frame. When the data link layer at the destination sees the character count, it knows how many characters follow, and hence where the end of the frame is.

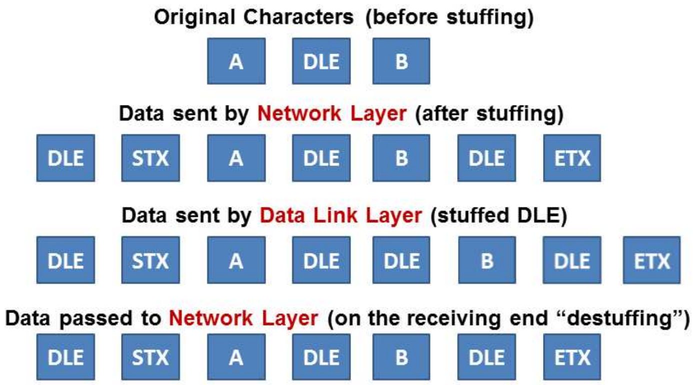


The trouble with this algorithm is that the count can be corrupted by a transmission error. Thus, the destination will get out of synchronization and will be unable to locate the start of the next frame. For this reason the character count method is rarely used anymore



Character Stuffing

This method gets around the problem of resynchronization after an error. The frame starts with the ASCII character sequence DLE STX (Data Link Escape, Start of Text) and end with DLE ETX (Data Link Escape, End of Text). If the destination loses track of the frame boundaries, all it has to do is look for DLE STX or DLE ETX characters to find out where it is. It may happen that the characters for **DLE STX** or **DLE ETX** occur in the data, which will interfere with the framing. To solve this problem, the sender's data link layer insert the ASCII **DLE** character just before each accidental **DLE** character in the data. The data link layer on the receiving end removes the **DLE** before the data are given to the network layer. A framing **DLE STX** or **DLE ETX** can be distinguished from one in the data by the absence or presence of a single **DLE**



b. Only three different objectives of computer networks.

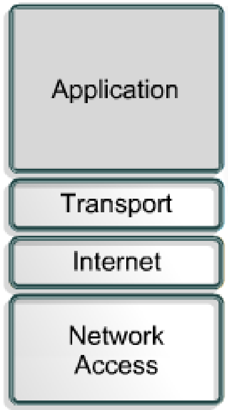
Resource sharing: All programs, equipment and data are available to anyone on the network. No regard to the physical location of the resource "*server*" and the user "*client*".
High Reliability: Multiple CPUs, If one goes down, the other may be able to take over its work.
Cooperative Computing: The main problem can be divided into sub-problems. Each processor solves a certain part of the problem.
Communication Medium: 2 or more people who live far apart can write a report together. A change to an online document can be seen by the immediately.
Saving Money: Small PCs have a much better price/performance ratio than large ones. Mainframes are a factor of 10 faster than small PCs, but have very high cost. Designers build systems consisting of PCs, with data kept on one or more shared file server machine

c. **Generator G(x) = 10011** **Checksum CS = 1110**
Transmitted Frame T(x) = 11010110111110

d.

TCP/IP (*Transmission Control Protocol / Internet Protocol).* It's a framework (guideline) for network implementation and troubleshooting. Divides complex functions into 4 simpler components (layers).

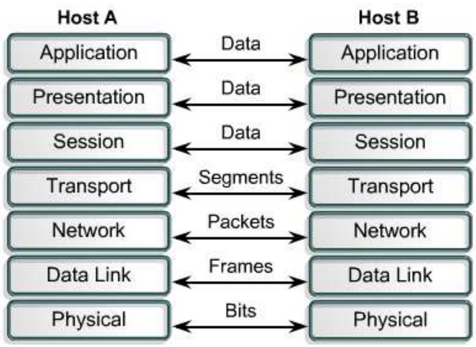
1. Application Layer used by the router → File Transfer 'TFTP, NFS, ..', E-mail, Remote Login, Network Management, Name Management DNS
2. Transport Layer → TCP 'Connection oriented', UDP 'Connectionless'
3. Internet Layer → IP and routing protocols, ARP, ICMP
4. Network Access → Ethernet, Token ring, point to point, ATM



e. **Protocol Data Unit (PDU)** - The form that a piece of data takes at any layer. At each stage of the process, a PDU has a different name to reflect its new appearance. PDUs are named according to the protocols of the TCP/IP suite.

Data - The general term for the PDU used at the Application layer

Segment - Transport Layer PDU
Packet - Internetwork Layer PDU
Frame - Network Access Layer PDU
Bits - A PDU used when physically transmitting data over the medium



The MAC address unique on every Network interface device and is embedded in the circuitry of the NIC card.
The IP address assigned by a DHCP server or manually configured in the device when it is connected to the network, and can be changed

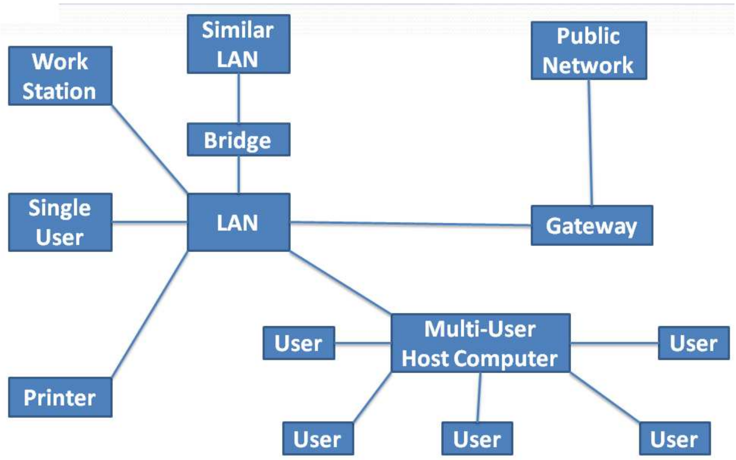
f. A sufficient condition for all double errors to be detected is that *G(x)* does not divide $x^k + 1$ for any k up to the maximum value of i - j (maximum frame length)

Question (5) **(14 Marks)**

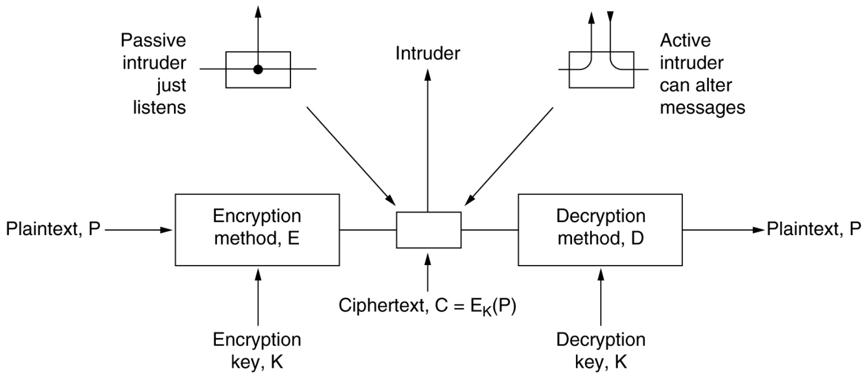
a. What are the main functions of the NIC? State three different features of fiber optics showing why it is a preferred transmission media in computer networks.

b. **Passive Wiretapping**

An intruder simply monitors at some point without interfering with the information flow. Such unauthorized observation of information is referred to as ***release of message content***. When the message content is not available, the wire tapper can examine the quantities, lengths, and frequencies of the message transmission. These types of passive attacks are referred to as ***traffic analysis*** "i.e. learn about the character of the data being exchanged" c.



d.



e.

Encrypted message (cryptogram): O L G Q F X J R B E A Y P A X R C Q C S X B D O B
Ciphertext alphabet: D E F G H I J K L M N O P Q R S T U V W X Y Z A B C
Plaintext alphabet : A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Main Message before KE1 (plaintext): I have just graduated from BFE.

(Good Luck)