

24/11/2020

## DEFINITION - ASSIGNMENT: I

[1.]

### Application programming interface (API)

- A standardized library of programming tools used by software developers to write applications that are compatible with a specific operating system or graphic user interface.

[2.]

### Base address

- An address that is used as the origin in the calculation of addresses in the execution of computer program.

[3.]

### Batch processing

- Pertaining to the technique of executing a set of computer programs such that each is completed before the next program of the set is started.

[4.]

### Binary semaphore

- A semaphore that takes on only the values 0 and 1. A binary semaphore allows only one process or thread to have access to a shared critical resource at a time.

### 15. Block

- A collection of contiguous records that are processed as a unit; the units are separated by interblock gaps. A group of bits that are transmitted as a unit.

### 16. B-tree

- A technique for organizing indexes. In order to keep access time to a minimum, it stores the data keys in a balanced hierarchy that continually reorganizes itself as items are inserted and deleted. Thus, all nodes always have a similar no. of keys.

### 17. Busy waiting

- The repeated execution of a loop of code while waiting for an event to occur.

### 18. Cache memory

- A memory that is smaller and faster than main memory and that is interposed between the processor and main memory. The cache acts as a buffer for recently used memory locations.

## 19. Central Processing Unit (CPU)

- A portion of a computer that fetches and executes instructions. It consists of an Arithmetic and Logic Unit (ALU), a control unit and registers. Referred to as a processor.

## 10. Cluster

- A group of interconnected, whole computers working together as a unified computing resource. that can create the illusion of being one machine. The term whole computer means a system that can run on its own, apart from the cluster.

## 11. Concurrent

- Pertaining to processes or threads that take place within a common interval of time during which they may have to alternately share common resources.

## 12. Consumable Resource

- A resource that can be created (produced) and destroyed (consumed). When a resource is acquired by a process, the resource ceases

to exist. Examples of consumable resources are interrupts, signals, messages and information in I/O buffers.

### 13.] Database

- A collection of interrelated data, often with controlled redundancy, organized according to a scheme to serve one or more applications; the data are stored so that they can be used by different programs without concern for the data structure or organization. A common approach is used - to add new data and to modify and delete existing data.

### 14.] Deadlock

- An impasse that occurs when multiple processes are waiting for the availability of a resource that will not become available because it is being held by another process that is in a similar way as wait state.  
An impasse that occurs when multiple processes are waiting for an action by as a response from another process that is in a similar wait state.

### [15.] Demand paging

- The transfer of a page from secondary memory to main memory storage at the moment of need. Compare prepaging.

### [16.] Device Driver

- An operating system module (usually in kernel) that deals directly with device or I/O module.

### [17.] Direct access

- The capability to obtain data from a storage device or to enter data to a storage device in a sequence independent of their relative position, by means of addresses that indicate the physical location of the data.

### [18.] Direct memory access (DMA)

- A form of I/O in which a special module called a DMA module, controls the exchange of data between main memory and an I/O devices. The processor sends a request for the transfer of a block of data to the DMA module and is interrupted only after the entire block has been transferred.

19.]

## Disabled interrupt

- A condition, usually created by the operating system, during which the processor will ignore interrupt request signals of a specified class.

20.]

## Disk allocation table

●

- A table that indicates which blocks on secondary storage are free and available for allocation to files.

21.]

## Dispatch

●

- To allocate a time on a processor to jobs or tasks that are ready for execution.

22.]

## Distributed operating system

●

- A common operating system shared by a network of computers. The distributed operating system provides support for interprocess communication, process migration, mutual exclusion and the prevention or detection of deadlock.

23.]

## Dynamic relocation

●

- A process that assigns new absolute addresses

to a computer program during execution so that the program may be executed from a different area of main storage.

#### [24] Enabled Interrupt

- A condition, usually created by operating system, during which the processor will respond to interrupt request signals of a specified class.

#### [25] External fragmentation

- Occurs when memory is divided into variable-size partitions corresponding to the blocks of data assigned to the memory. As segments are moved into and out of the memory, gaps will occur between the occupied portion of memory.

#### [26] Field

- Defined logical data that are part of a record. The elementary unit of a record that may contain a data item, a data aggregate, a pointer or a link.

#### [27] File

- A set of related records treated as a unit.

28.

## File allocation table (FAT)

- A table that indicates the physical location on secondary storage of the space allocated to a file. There is one file allocation table for each file.

29.

## File management system

- A set of system software that provides services to users and applications in the use of files, including file access, directory maintenance and access control.

30.

## File organization

- The physical order of records in a file, as determined by the access method used to store and retrieve them.

31.

## First come first served (FCFS)

32.

## First in First out

- A queuing technique in which the next item to be serviced is the item that has been in the queue for the longest time.

### 33. Hash File

- A file in which records are accessed according to the values of a key field. Hashing is used to locate a record on the basis of its key value.

### 34. Hashing

- The selection of a storage location for an item of data by calculating the address as a function of the contents of the data. This technique complicates the storage allocation function but result in rapid random retrieval.

### 35. Hit ratio

- In a 2-level memory, the fraction of all memory accesses that are found in the faster memory (e.g. the Cache).

### 36. Indexed Access

- Pertaining to the organization and accessing of the records of a storage structure through a separate index to the locations of the stored records.

37.]

## Indexed file

- A file in which records are accessed according to the value of key fields. An index is required that indicates the location of each record on the basis of each key value.

38.]

## Indexed sequential access

39.]

## Indexed sequential file

40.]

## Instruction cycle

1

- The time period during which one instruction is fetched from memory and executed when a computer is given an instruction in machine language.

141.

## Interrupt

- A suspension of a process, such as the execution of a computer program, caused by an event external to that process and performed in such a way that the process can be resumed.

142.

## Internal fragmentation

- Occurs when memory is divided into fixed-size partitions (e.g. page frame in main memory). If a block of data assigned to one or more partitions, then there may be wasted space in the last partition. This will occur if the last portion of data is smaller than the last partition.

143.

## Interrupt handler

- A routine, generally part of the operating system. When an interrupt occurs, control is transferred to the corresponding interrupt handler, which takes some action in response to the condition that caused the interrupt.

144.

## Job

- A set of computational steps packaged to run as a unit.



[45.]

## Kernel

- A portion of the operating system that includes the most heavily used portion of software. Generally, the kernel is maintained permanently in main memory. The kernel runs in a privileged mode and responds to calls from processes and interrupt from devices.

[46.]

## Kernel mode

- Also referred to as privileged mode or system mode. A privileged mode of execution reserved for the kernel of the operating system. Typically, kernel mode allows access to regions of main memory that are unavailable to programs executing in a less-privileged mode, and also enables execution of certain machine instructions that are restricted to the kernel mode.

[47.]

## Last in first out (LIFO)

- A queuing technique in which the next item to be retrieved is the item most recently placed in the queue.

[48.]

## Lightweighted process

- A thread.

[49.]

## Livelock

- A condition in which 2 or more processes continuously change their state in response to changes in the other processes without doing any useful work. This is similar to deadlock in that no progress is made, but it different in that neither process is blocked nor waiting for anything.

[50.]

## Logical address

- A reference to a memory location independent of the current assignment of data to memory. A translation must be made to a physical address before the memory access can be achieved.

[51.]

## Logical record

- A record independent of its physical environment, portions of one logical record may be located in different physical records or several logical records or parts of logical records may be located in one physical record.

[52.]

## Main memory

Memory that is internal to the computer system, is program addressable, and can be loaded into registers for subsequent execution or processing.

153.]

### Malicious software

- Any software designed to cause damage to or use up the resources of a target computer. Malicious software (malware) is frequently concealed within a masquerades as legitimate software. In some cases, it spreads itself to other computer via emails or infected disks. Types of malware includes viruses, trojan horses, worms, and hidden software for launching denial-of-service attack.

154.]

### Memory cycle time

- The time it takes to read one word from or write one word to memory. This is the inverse of the rate at which words can be read from or written to memory.

155.]

### Memory partitioning

- The subdividing of storage into independent sections.

## [56] Microkernel

- A small privileged operating system core that provides process scheduling, memory management, and communication services. And allows other processes to perform some of the functions traditionally associated with the operating system.

## [57] Multiprocessing

- A mode of operation that provides for parallel processing by two or more processors of a multiprocessor.

## [58] Multiprocessor

- A computer that has 2 or more processors that have common access to a main storage.

## [59] Multiprogramming

- A mode of operation that provides for the interleaved execution of two or more computer programs by a single processor. The same as multitasking, using different terminology.

## [60] Multiprogramming level

- The number of processes that are partially or fully resident in main memory.

#### [61.] Multitasking

- A mode of operation that provides for the concurrent performance or interleaved execution of 2 or more computer tasks. The same as multi-programming, using different terminologies.

#### [62.] Mutual exclusion

- A condition in which there is a set of processes, only one of which is able to access a given resource or perform a given function at any time.

#### [63.] Critical section

- In an asynchronous procedure of a computer program, a part that can't be executed simultaneously with an associated critical section of another asynchronous procedure.

#### [64.] Operating system

- Software that controls the execution of programs and that provides services such as resource allocation, scheduling, I/O control, and data management.

### 165. Page

- In virtual storage, a fixed-length block that has a virtual address and that is transferred as a unit between main memory and secondary memory.

### 166. Page fault

- Occurs when the page containing a referenced word is not in main memory. This causes an interrupt and requires that the proper page be brought into main memory.

### 167. Page frame

- A fixed-size contiguous block of main memory used to hold a page.

### 168. Paging

- The transfer of pages between main memory and secondary memory.

### 169. Physical address.

- The absolute location of unit of data in memory. (Eg. word or byte in main memory, block on secondary memory).

## 70. Pipe

- A circular buffer allowing 2 processes to communicate on the producer-consumer model. Thus, it is a FIFO queue, written by one process, read by another. In some systems, the pipe is generalized to allow any item in the queue to be selected for consumption.

## 71. Preemption

- Reclaiming a resource from a process before the process has finished using it.

## 72. Prefraging

- The retrieval of pages other than one demanded by a page fault. The hope is that the additional pages will be needed in near future, conserving disk I/O.

## 73. Process

- A program in execution. A process is controlled and scheduled by the operating system.

## 74. Process Control Block

- The manifestation of a process in an operating system. It is a data structure containing information about the characteristics and the state of process.

### 75. Process State

- All the information that the operating system needs to manage a process and that the processes need to properly execute the process. The process state includes the contents of the various processor registers, such as the program counter and data registers; it also includes information of use to the operating system, such as the priority of the process and whether the process is waiting for the completion of a particular I/O event.

### 76. Processors

- In a computer, a functional unit that interprets and executes instruction. A processor consists of at least one instruction control unit and an arithmetic unit.

### 77. Program Counter

- Instruction address register.

178.]

## Programmed I/O

- A form of I/O in which the CPU issues an I/O command to an I/O module and must then wait for the operation to be complete before proceeding

179.]

## Race Condition

- Situation in which multiple processes access and manipulate shared data with the outcome dependent on relative timing of the processes.

180.]

## Real-time system

- An operating system that must schedule and manage real-time tasks.

181.]

## Real address

- A physical address in main memory

182.]

## Real-time task

- A task that is executed in connection with some process or function or set of events external to computer system that must meet one or more deadlines to interact effectively and correctly with the external environment.

### 183.] Registers

- High speed memory internal to the CPU. Some registers are user visible, that is, available to the programmes via the machine instruction set. Other registers are used only by the CPU, for control purpose.

### 184.] Relative addresses

- An address calculated as a displacement from a base address.

### 185.] Remote procedure call (RPC)

- A technique by which 2 programs on different machines interact using procedure call / return syntax and semantics. Both the called and calling program behave as if the partner program were running on the same machine.

### 186.] Response time

- In a data system, the elapsed time between the end of transmission of an enquiry message and the beginning of the receipt of a response message, measured at the enquiry terminal.

### 87. Round Robin

- A scheduling algorithm in which processes are activated in a fixed cyclic order, that is, all processes are in circular queue. A process that can not proceed because it is waiting for some event (e.g. termination of a child process). returns control to the scheduler.

### 88. Scheduling

- To select jobs or tasks that are to be dispatch. In some operating system, other units of work, such as I/O operations, may also be scheduled.

### 89. Secondary Memory

- Memory located outside the computer system itself; that is, it can't be processed directly by the processor. It must first be copied into main memory.

### 90. Segment

- In virtual memory, a block that has a virtual address. The blocks of a program may be of unequal length and may even be of dynamically varying lengths.

## 191.] Segmentation

- The division of a program or application into segments as part of a virtual memory scheme.

## 192.] Semaphore

- An integer value used for signalling among processes. Only three operations may be performed on a semaphore, all of which are atomic: Initialize, decrement and increment. Depending on the exact definition of the semaphore, the decrement operation may result in the blocking of a process, and the increment operation may result in the unblocking of a process. Also known as a counting semaphore or a general semaphore.

## 193] Sequential file

- A file in which records are ordered according to the values of one or more key fields and processed in the same sequence from the beginning of the file.

## 194.] Shell

- The portion of the operating system that

interprets interactive user commands and job control language commands. It functions as an interface between the user and the OS.

### 195. Stack

- An ordered list in which items are appended to and deleted from the same end of the list, known as top. That is, the next item appended to the list is put on the top, and the next item to be removed from the list is the item that has been in the list the shortest time. This method is characterized as LIFO - last in first out.

### 196. Starvation

- A condition in which a process is indefinitely delayed because other processes are always given preference.

### 197. Strong Semaphore

- A semaphore in which all processes waiting on the same semaphore are queued and will eventually proceed in the same order as they executed the wait (P) operations (FIFO) order.

198.

## Swapping

- A process that interchanges the contents of an area of main storage with the contents of an area of secondary memory.

199.

## Symmetric multiprocessing

- A form of multiprocessing that allows the OS to execute on any available processor or on several available processors simultaneously.

200.

## Synchronous operation

- An operation that occurs regularly or predictably with respect to the occurrence of a specified event in another process, for example, the calling of an I/O routine that receives control at a preordained location in a computer program.

201.

## Synchronization

- Situation in which 2 or more processes coordinate their activities based on a condition.

202.

## System Bus

- A bus used to interconnect major computer components (CPU, memory, I/O).

### 1103.] Thread

- A dispatchable unit of work. It includes a processor context (which includes the program counter and stack pointer) and its own data area for a stack (to enable subroutine branching). A thread is a lightweighted process that executes sequentially and is interruptible so that the processor can turn to another thread. A process may consist of multiple threads.

### 1104.] Thread switch

- The act of switching processor control from one thread to another within the same process.

### 1105.] Time sharing

- The concurrent use of a device by a number of users.

### 1106.] Time slice

- The maximum amount of time that a process can execute before being interrupted.

### 1107.] Trap

- An unprogrammed conditional jump to a specified address that is automatically activated by hardware; the location from which the jump was made is recorded.

### [108] Trojan Horse

- Secret undocumented routine embedded within a useful program. Execution of the program results in execution of the secret routine.

### [109] User mode

- The least-privileged mode of execution. Certain regions of main memory and certain machine instructions can't be used in this mode.

### [110] Virtual address

- The address of a storage location in virtual memory.

### [111] Virtual memory

- The storage space that may be mapped to addressable main storage by the use of a computer. It's mapped into real addresses. The size of virtual storage is limited by the addressing

scheme of the computer system and by the amount of secondary memory available and not by the actual no of main storage locations.

112

Virus

- Secret undocumented routine embedded within a useful program. Execution of the program results in execution of secret routine.

113

Weak semaphore

- A semaphore in which all processes waiting on the same semaphore proceed in an unspecified order (i.e. the order is unknown or indeterminate).

114

Word

- An ordered set of bytes or bits that is normal unit in which information may be stored, transmitted or operated on within a given computer.

115

worm

- Program that can travel from computer to computer across network connection. May contain a virus or a bacteria.

30/11/2020

## NUMERICALS : ASSIGNMENT - 2

### \* PAGE REPLACEMENT ALGORITHMS

1. A system uses 3 page frames for storing process pages in main memory. It uses the First in First out (FIFO) page replacement policy. Assume that all the pages frames are initially empty. What is the total number of page faults that will occur while processing the page reference string given below:

4, 7, 6, 1, 7, 6, 1, 2, 7, 2.

Calculate the hit ratio and miss ratio.

- Total number of references = 10

4	7	6	1	7	6	1	
		6	6	6	6	6	6
	7	7	7	7	7	7	7
4	4	4	1	1	1	1	1
✓	✓	✓	✓	✗	✗	✗	
2	7	2					
6	7	7					
2	2	2					
1	1	1					
✓	✓	✗					

From here,

Total number of page fault occurred = 6.

Total number of page hits  
= Total number of references - Total number of page misses or page fault

$$= 10 - 6$$

$$= 4$$

∴ Hit ratio

= Total number of page hits / Total number of references.

$$= 4/10$$

$$= 0.4 \text{ or } 40\%.$$

Now,

Miss ratio

= Total number of page misses / Total number of references

$$= 6/10$$

$$= 0.6 \text{ or } 60\%.$$

→ If we use (LRU) i.e. Least recently used page replacement policy, then the hit ratio and miss ratio are same as FIFO page replacement policy.

[2.] A system uses 3 page frames for storing process pages in main memory. It uses Optimal page replacement policy. Assume that all the page frames are initially empty. What is the total number of page faults that will occur while processing the page reference string given below:

4, 7, 6, 1, 7, 6, 1, 2, 1, 2.

Also calculate hit ratio and miss ratio.

- Total number of references = 10

4	7	6	1	7	6	1	6	1
	7	7	7	7	7	7	7	7
4	4	4	1	1	1	1	1	1
✓	✓	✓	✓	X	X	X		
9	7	2						
2	2	2						
7	7	7						
1	1	1						
✓	X	X						

From here,

Total number of page fault occurred = 5

Total number of page hits  
= Total number of references - Total number of page misses or page faults

$$= 10 - 5$$

$$= 5$$

∴ Hit ratio

$$= \text{Total number of page hits} / \text{Total number of references}$$

$$= 5 / 10$$

$$= 0.5 \text{ or } 50\%$$

Now,

Miss ratio

$$= \text{Total number of page misses} / \text{Total number of references}$$

$$= 5 / 10$$

$$= 0.5 \text{ or } 50\%$$

## \* BANKER'S ALGORITHM

[1.] A single processor system has three resources types X, Y, Z which are shared by 3 processes. There are 5 units of each resource type. Consider the following scenario, where the column Alloc denotes the number of units of each resource type allocated to each process and the column request denotes the number of units of each resource type requested by a process in order to complete execution. Which of these processes will finish LAST (P0, P1, P2, none of the above since the system is in a deadlock)

	Alloc			Request		
	X	Y	Z	X	Y	Z
P0	1	2	1	1	0	3
P1	2	0	1	0	1	2
P2	2	2	1	2	0	0

$$\begin{aligned} - \quad \text{Total} &= [X \ Y \ Z] = [5 \ 5 \ 5] \\ \text{Total Allocation} &= [X \ Y \ Z] = [5 \ 4 \ 3] \end{aligned}$$

Now

$$\begin{aligned} \text{Available} &= \text{Total} - \text{Total Allocation} \\ &= [5 \ 5 \ 5] - [5 \ 4 \ 3] \\ &= [0 \ 1 \ 2] \end{aligned}$$

(a) With the instances available currently, only the requirement of the process P<sub>1</sub> can be satisfied.

So, process P<sub>1</sub> is allocated the requested resources.

It completes its execution and then free up the instances of resources held by it.

$$\begin{aligned}\text{Available} &= [0 \ 1 \ 2] + [2 \ 0 \ 1] \\ &= [2 \ 1 \ 3]\end{aligned}$$

(b) With the instances available currently, only the requirement of the process P<sub>0</sub> can be satisfied.

So, process P<sub>0</sub> is allocated the requested resources.

It completes its execution and then free up the instances of resources held by it.

$$\begin{aligned}\text{Available} &= [1 \ 3] + [1 \ 2 \ 1] \\ &= [3 \ 3 \ 4]\end{aligned}$$

(C) With the instances available currently, the requirement of the process  $P_2$  can be satisfied.

So, process  $P_2$  is allocated the suggested resources.

It completes its execution and then free up the instances of resources held by it.

$$\begin{aligned}\text{Available} &= [334] + [221] \\ &= [555]\end{aligned}$$

Thus,

There exist a safe sequence  $P_1, P_0, P_2$  in which all the processes can be executed.

So, the system is in a safe state.

Process  $P_2$  will be executed last.

Q2.] A system has 4 processes and 5 allocatable resources. The current allocation and maximum needs are as follows -

		Allocated			Maximum			
		A	B	C	D	E	F	G
	A	1	0	2	1	1	1	2
	B	2	0	1	1	0	2	2
	C	1	1	0	1	1	2	1
	D	1	1	1	1	0	1	1

If Available = [0 0 x 1 1], what is the smallest value of x for which this is a safe state?

- Need = Maximum - Allocation

		Need					
		A	B	C	D	E	F
	A	0	1	0	0	2	
	B	0	2	1	0	0	
	C	1	0	3	0	0	
	D	0	0	1	1	0	

(a) For x = 0

- If x = 0, then

$$\text{Available} = [0 \ 0 \ 0 \ 1 \ 1]$$

With the instances available currently, the requirement of any process can not be satisfied.

So, for  $X = 0$ , system remains in a deadlock which is an unsafe state.

(b) For  $X = 1$

- If  $X = 1$ , then

$$\text{Available} = [0 \ 0 \ 1 \ 1 \ 1]$$

With the instances available currently, only the requirement of the process D can be satisfied.

So, process D is allocated the requested resources.

It completes its execution and then free up the instances of resources held by it.

$$\begin{aligned}\text{Available} &= [0 \ 0 \ 1 \ 1 \ 1] + [1 \ 1 \ 1 \ 1 \ 0] \\ &= [1 \ 1 \ 2 \ 2 \ 1]\end{aligned}$$

With the instances available currently, the requirement of any process can't be satisfied.

So, for  $X = 1$ , system remains in a deadlock which is an unsafe state.

(C) For  $X = 2$

- If  $X = 2$ , then

$$\text{Available} = [0 \ 0 \ 2 \ 1 \ 1]$$

With the instances. Available currently, only the requirement of all the processes A, B, C and D can be satisfied.

So, processes A, B, C, D are allocated the requested resources one by one.

They complete their execution and then free up the instances of resources held by it.

$$\begin{aligned}\text{Available} &= [0 \ 0 \ 2 \ 1 \ 1] + [1 \ 1 \ 1 \ 1 \ 0] + [1 \ 1 \ 0 \ 1 \ 1] \\ &\quad + [1 \ 0 \ 2 \ 1 \ 1] + [2 \ 0 \ 1 \ 1 \ 0] \\ &= [5 \ 2 \ 6 \ 5 \ 3]\end{aligned}$$

There exists a safe sequence in which all the processes can be executed.

So, the system is in a safe state.

Thus, the minimum value of  $X$  that ensures system is in safe state = 2.

## \* BELADY'S ANOMALY PAGE FAULT

→ Consider the reference string is :

0, 1, 2, 3, 0, 1, 4, 0, 1, 2, 3, 4.

Perform belady's anomaly page fault for

(i) Optimal Page Replacement Algorithm.

- When frame size = 3

0	1	2	3	0	1	4
		2	3	3	3	4
	1	1	1	1	1	1
0	0	0	0	0	0	0

0	1	2	3	4	
4	4	4	4	4	Number of
1	1	1	1	1	page fault = 7
0	0	2	3	3	

- When frame size = 4

0	1	2	3	0	1	4
			3	3	3	4
		2	2	2	2	2
	1	1	1	1	1	1
0	0	0	0	0	0	0
0	1	2	3	4		
4	4	4	4	4	4	Number of
2	2	2	2	2	2	page fault = 6
1	1	1	1	1	1	
0	0	0	3	3		

(ii) LRU page replacement algorithm

- When page / frame size = 3

Total number of page fault = 10

- When frame size = 4

Total number of page fault = 8

So from both optimal and LRU page replacement algorithm, we can conclude that :

- At all stage in Case - 02 (frame size = 4) main memory compulsorily contains the set of pages that are present in the corresponding stages in Case - 01 (frame size = 3).

- Thus, LRU and optimal page replacement algorithm follows the stick property.

- Hence it does not suffer from Belady's Anomaly.

- As a result, number of page fault decreases when the number of frames is increased from 3 to 4.