Final exam review

Computer systems cosc 2p13

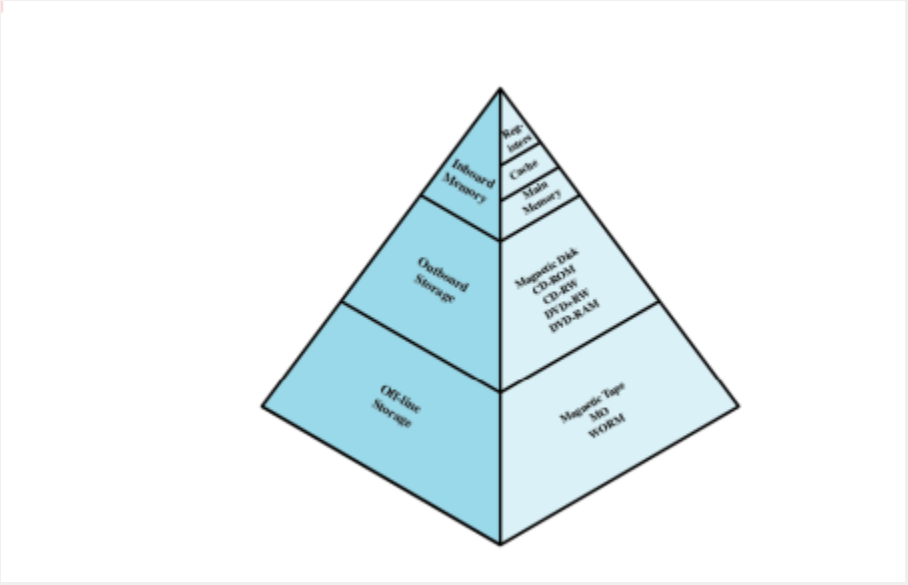
Introduction

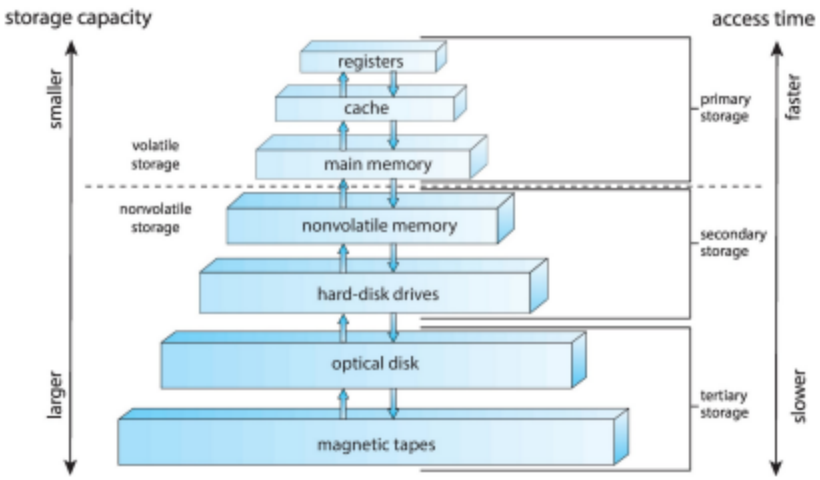
- Top level Components

> CPU connected to the main memory and I/O module using the system bus. The cpu does all the calculations, the main memory holds the data from the current processes and the I/O module is used to get more information which the main memory doesnt have access to ie. secondary memory, user input (keyboard mouse)

- Memory Hierarchy

> Faster access time, greater cost per bit
> Greater capacity, smaller cost per bit
> Greater capacity, slower access speed





- Interrupts

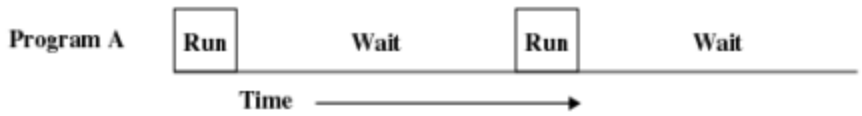
> Interrupt the normal sequencing of the processor
> Most I/O devices are slower than the processor
> Processor must pause to wait for device

- Classes of interrupts
    - **Program:** Generated by some condition that occurs as a result of an instruction execution, such as arithmetic overflow, division by zero, attempt to execute an illegal machine instruction, and refernce outside a user's allowed memory space
    - **Timer:** Generated by a timer within the processor. This allows the operating system to perform certain functions on a regular basis.
    - **I/O:** Generated by an I/O controller, to signal normal completion of an operation or to signal a variety of error conditions.
    - **Hardware failure:** Generated by a failure, such as power failure or memory parity error.
- Interupt handler

> Program to service a particular I/O device
> Generally part of the operating system

- Uniprogramming

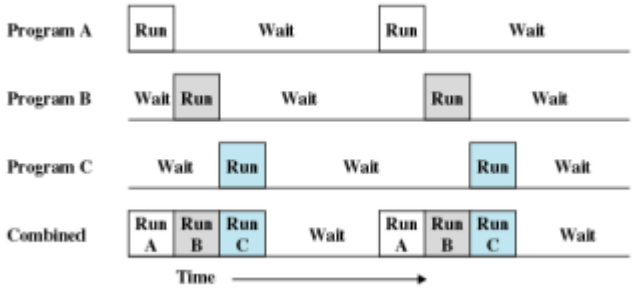
> Processor must wait for I/O instructions to complete before preceding



- Multiprogramming

When one jobes needs to wait for I/O

- The processor can switch to another other job



- Time sharing

  - Using multiprogramming to handle mutliple interactive jobs
  - Processor's time is shared among multiple users
  - Multiple users simultaneously access the system through terminals
  - **Time Slicing**
    - Regular time intervals
    - Preemption -> switch jobs(users)

- Address space

  - Space in the main memory to hold a program/process
  - Processes address up to 64 bits spaces in main memory
    - Processes requiring more than that
      - Virtual memory

- System Calls

  - Programmtice method to request a service from the kernel

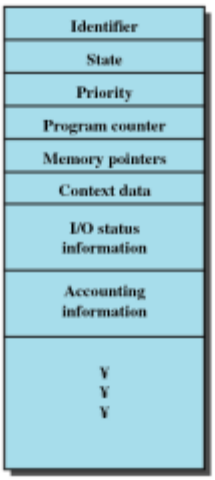
Process and Threads

Process

- PCB

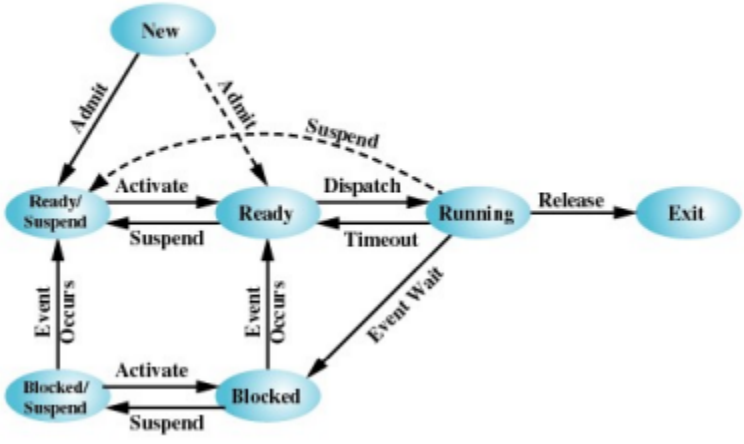
Stands for **P**rocess **C**ontrol **B**lock

- Contains the process elements
- Created and manage by operating sysem
- Allows support for multiple process



- Seven-state process model

- Process state transition diagram



> **supsended** allows the cpu to take out processes out of main memory as it waiting for the I/O to respond with the need information to finish the process
> **Blocked** is where process go when an event/interrupt occurs which doesnt always need to be taken out of the memory as the event might not last long
> **Ready/Running** all programs that are being run is being cycled through ready and running for the cpu to work a little bit then alternate between the processes to make it seem like its doing multiple things simulatinously

- Time sharing

Thread

- Definition

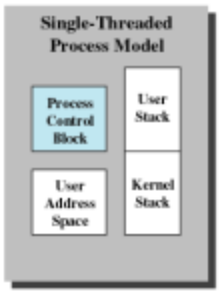
> light-weight process

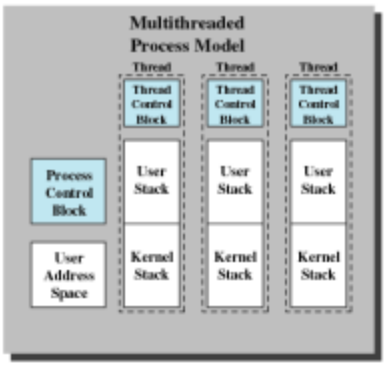
- Benefits

> - Light weight
>   - Less time to create a new thread than a process
>   - Less time to terminate a thread than a process
>   - Less time to switch between two threads within the same process
> - Sharing memory and files within same process
>   - Inter-thread communication without invoking the kernel

- Multithread process model

> Operating system supports multiple threads of execution within a single process





- Types of threads:
    - user-level
        - All thread management is done by the application
        - The kernel is not aware of the existence of threads
    - kernel-level
        - Kernel maintains context information for the process and the threads
        - Scheduling is done on a thread basis
        - Example: Windows
    - combined
        - Thread creation done in the user space
        - Bulk of scheduling and synchronization of threads within application
        - Example: Solaris
- Race conditions:

- Two processes want to access shared memory at same time
- Two or more processes are reading and writing some shared data

  To avoid this kind of situation
    - Synchronization of process
    - Mutual exclusion
        - Preventing more than one process from using the shared memory at the same time

- Critical Regions:

> • Mutual exclusion using critical regions
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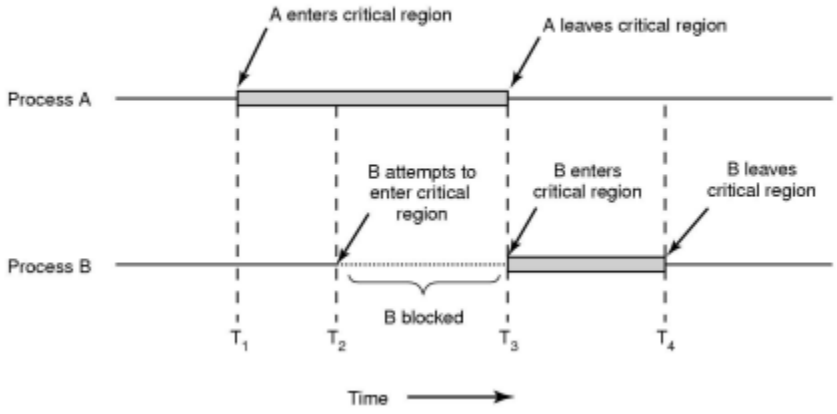
> 
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- Mutual Exclusions:

> Only one proccess can have access to a critical region in main memory

- Busy Waiting:

> Keep busy in areas that arent in the critical region until it is your turn in the critical region

- Sleep and wakeup

> process goes to sleep after asking for critical region
>
> - fatal error: if process is told to wake up before finishing to go to sleep, the process will never wake up

- semaphore

> A variable that other threads/processes can read that says the state of the process/ thread, used for syncrhonization
>
> - **Counting** used for showing how many steps into the process the process is
> - **Binary** used for showing if it is ready for a critical region or if just ready to move on

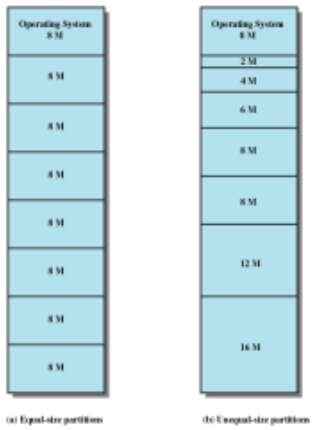
- Mutex

> short hand for mutual exclusion

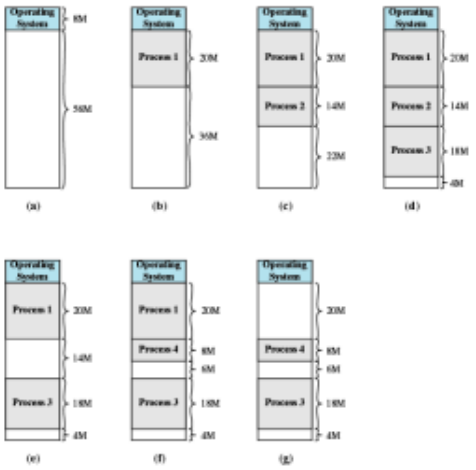
Memory management

- **Main Memory management**
    - Recolation
        - Programmer does not know where the program will be placed in memory when it is executed
        - While the program is executing
            - it may be swapped to disk and returned to main memeory at a different location
                - Relocated
        - Memory references must be translated in the code to actual physical memory address
    - Protection
        - Processes should not be able to reference memory locations in another process without permision
        - Impossible to check absolute addresses at compile time
            - It must be checked only at run-time
        - memory protection requirement must be satisfied by the processor (hardware) rather than the operating system (software)
            - Operating system cannot anticipate all of the memory references a program will make
    - Techniques
        - Fixed partitioning
            - Equal size partitions
                - any process whose size is less than or equal to the partition size can be loaded into an available partition
                - Operating system can swap a process out of partition if all partitions are full
            - Program may not fit in a partition
            - **causes internal fragmentation**

- Fixed Partitioning of a 64-MB Memory

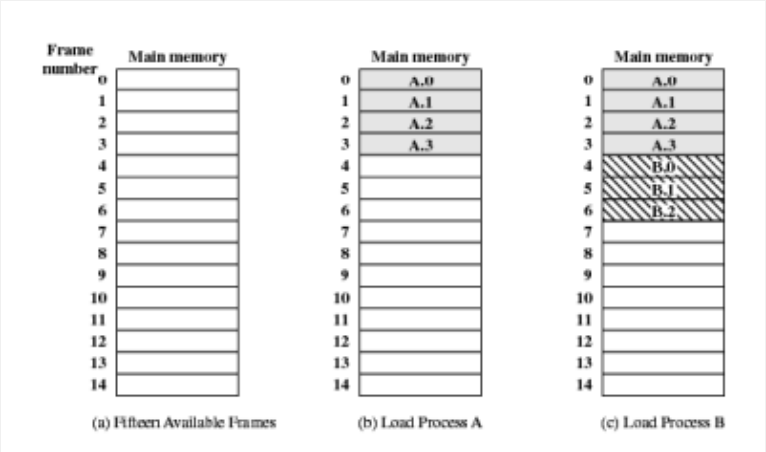


- Dynamic partitioning
  - Partitions are of variable length and number
  - Process is allocated exactly as much memory is required
  - **External fragmentation** eventually get holes in the memory (inefficiency)



- Simple paging
  - fixed and variable-size partitions are inefficient
    - internal and external fragmentation
  - Paging Scheme -> improvement
    - Partitioning memory into small equal fixed-size chunks
    - Dividing each process into the small size

chunks
        - Chunks of a process are called pages
        - Chunks of memory are called frames
    - Operating system maintain a **page table** for each process



    - reduces internal fragmentation
    - avoids external fragmentation

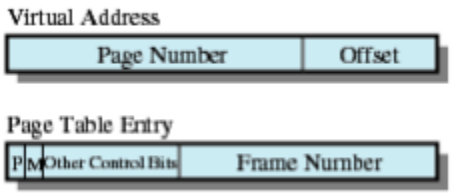
- Simple segmentation
    - all segments of all programs do not have be of the same length
    - there is a maximum segment length
    - reduces external fragmentation
    - avoids internal fragmentation

- **Virtual Memory**
    - Thrashing
        - Swapping out a piece of a process just before that piece is needed
        - The processor spends most of its time swapping pieces rather than executing user instructions

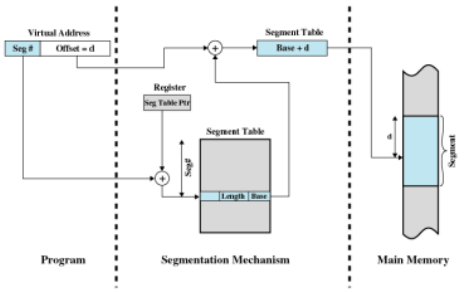
    - Principle of locality
        - Program and data references within a process tend to cluster
        - Only a few pieces of a process will be needed over a short period of time
        - Possible to make intelligent guess about which pieces will be

need in the future

- Strategies
  - Paging
    - each process has its own page table
    - each page table entry contains:
      - contains the frame number of the corresponding page in main memory
    - a bit is needed to indicate whether the page is in main memory or not



  - Segmentation
    - May be unequal -> dynamic size
    - simplifies handling of growing data structures
    - allows programs to be altered and recompiled independently
      - multiple segments



- Placement policy
  - it determines where in real memory a process peice is to reside
  - important in a segmentation system

- Replacement policy (caching concept)
  - page removed should be the page lest likely to be referenced in the near future

> ◦ most policies predict the future behaviour on the basis of past behaviour

Process Scheduling in Uniprocessor Systems

- Scheduling in Uniprocessor Systems
  - Turnaround

> (completion - submission) time

  - Response time

> request vs response (time)

  - throughput

> maximum number of processes complete per time

  - fairness

> to treat processes the same
>
> ◦ enforcing policies
> ◦ balancing resources

  - Cpu utilization

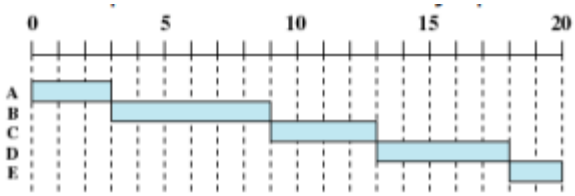
> the percentage of time the cpu is "working" during a given time

  - Preemptiveness

> time sharing
>
> ◦ running processes may be interupted
> ▪ os moves it to the ready state
> ▪ downside: more overheads
> ◦ Better service
> ▪ no process can monopolize the processor for very long

  - Scheduling policies
    - FCFS

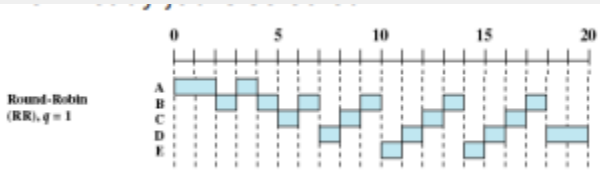
> First come first served
> ie. first in for out (FIFO)



- Round-Robin

Straightforward scheme

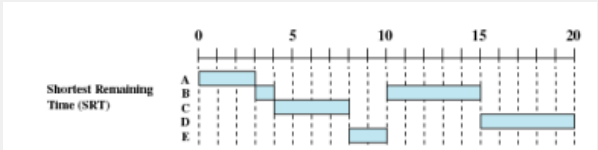
- preemption
- clock interrupt



- Shortest process next

to reduce bias in favor of long processes

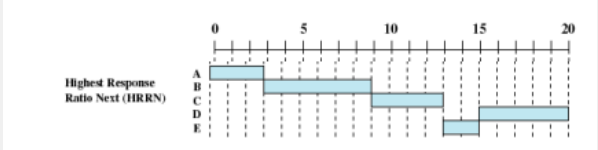
- no time slicing
- greedy approach: optimization problems
- drawbacks:
  - rely on statistics (previous runs)



- Highest response ration next

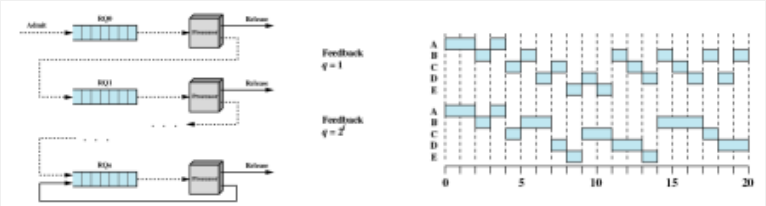
Choose next process with greatest ratio

- Ratio → (w + s) / s
  - w → time waiting for processor
  - s → expected service time



- Feedback
  - No way to estimate the relative length of a process

        - no use of SPN, SRT, HRRN
    - use of preemption and dynamic priorities
        - Multiple queues -> process move down per preemption
    - Penalizes jobs that have been running longer



Deadlocks

- deadlock definition

> A set of processes
>
> - if each process in the set waits for an event
> - event can be generated only by another process in the set that is already waiting for another "internal" event

- livelock

> where multiple processes rely on each other to continue so they are running but nothing is getting done

- starvation

> a type of livelock where nothing can start working as multiple processes want the one resource

- Resources
    - Preemptable

    > Taken away from a process with no ill effects

    - nonpreemptable

    > Cannot be taken away
    >
    > - as is would cause the process to fail

        - consumable

> resources are created and destroyed
> resources are produced and consumed
> sender/receiver

- 3 + 1 iff conditions for deadlocks

> 1. Mutual exclusion: only one process may use a resource at a time
> 2. Hold and wait : process can hold resources while waiting for more
> 3. No preemption : can't force any resources out of processes
> 4. Circular wait : a close chain of processes exists

> possibility of a deadlock if: 1, 2 and 3
> existence of a deadlock if: 1,2,3 and 4

- dealing with deadlocks
    - ignoring

> ignoring the problem ie do nothing

    - prevention

> - disallow one of the 3 deadlock conditions
> - prevent circular wait

    - avoidance

> - careful resource allocation
> - not granting resource request if leading to a deadlock

    - detection

> periodic deadlock checks

Input and Output

- Device Controllers

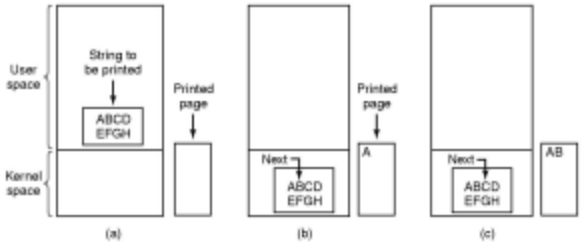
> eletronic component = device controller
> Controller's tasks
>
> - To convert serial bit stream to block of bytes

    - To perform error correction as neccesary
    - To make data available to main memory

- Role of interrupts
- Performing I/O
    - Programmed I/O

simplest way

    - ties up CPU full time with I/O operations
    - CPU busy waiting
        - okay for embedded systems
        - not ok for more complex systems



    - Interrupt-driven I/O
    - Direct Memory Access (DMA)

- Buffering
- Spooling
- Disk scheduling
    - performance
        - Seektime
        - Arm scheduling algorithms

File Systems

- File Organization
- File record organization

- Secondary storage management
    - File allocation

Networking

- End to end communication
    - loss
    - delay
    - throughput
- Protocol layers
- Application layer
- Transport layer -> ports
    - TCP
    - UDP
    - Acknowledgements
- Flow
- congestions
- window
- Networking layers - Datagrams
    - Functions
    - IP addressing
    - Routing alorithms
    - Hierarchical routing
- Link layer -> frames

- Mac protocols
- TDMA
- FDMA
- CSMA
- Adress resolution protocol (ARP)
- Switches vs routers

Multiple processor systems

- types of MPS
  - Loosely coupled
  - specialized processors
  - tightly coupled
- Parallelism granularity
- Scheduling
  - Assignment
  - multiprogramming
  - dispatching
  - thread scheduling in MPS

Real-time Systems

- Definition of real- time systems
- features of real-time systems
- Classification

        - Hard
        - Soft
        - Aperiodic
        - period
- Scheduling
    - Classification
    - Approaches
- Rate monotonic scheduling
- Priority inversion

Distributed Systems

- Difference between fat vs. thin clients
- caching
- middleware
    - classification
        - blocking vs nonblocking
        - reliable vs unreliable
    - Types
        - Message passing
        - RPC
        - Object-oriented

Distributed System Management

- process migration

        - Motivation
        - freezing a process and pending messages
    - distributed global states
        - Distributed snapshot algorithm
    - Distributed mutual exclusion
        - lamport algorithm
        - mutual exclusion algorithm
    - distributed deadlock detection

Virtualization

- Hypervisors
- Reasons for virtualization
    - consolidation ratio
- Paravirtualization
- containers

Cloud computing

- definition -> elastic, on-demand, anywhere/anytime
- service models
- deployment models
- cloud OS

Security

- CIA Triad
- Types of threats (Interruption, Interception, modification, fabrication)
- Computer System Assets
- Access control