Operating System

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Review

- Which of the following is not a part of an OS kernel ?
  A. Process management
  B. Network management
  C. Memory management
  D. Database management systems

Review

- Which of the following should NOT be fixed in an OS?
  A. SATA driver (a disk driver)
  B. Process management module
  C. Network management
  D. Memory management

Review

- Which of the following is incorrect about a time sharing OS?
  A. Allow multiple processes to run on a single CPU machine
  B. Utilize resources more effectively
  C. Only utilize CPU more effectively
  D. Even suitable for multi-CPU machines

Review

- Which of the following is incorrect about a batch OS?
  A. A simple type of OSes
  B. It works in First-comes-first-served order
  C. Allow multiple users to use the system concurrently
  D. Not the same as multiprogramming systems

Review

- Which of the following is incorrect about a multi-user OS?
  A. Allow multiple processes to run on a single CPU machine
  B. Allow each user run multiple processes
  C. Allow multiple users to use the system concurrently
  D. Be the same as multiprogramming systems

Review

- Which of the following devices DOESN'T have an embedded system?
  A. mp3 player
  B. TV
  C. calculator
  D. laptop

Process and Process Scheduling

Objectives

- Present what a process is
- Present 4 process scheduling approaches
- Scheduling in multi-queue systems
- Implement the scheduling algorithms

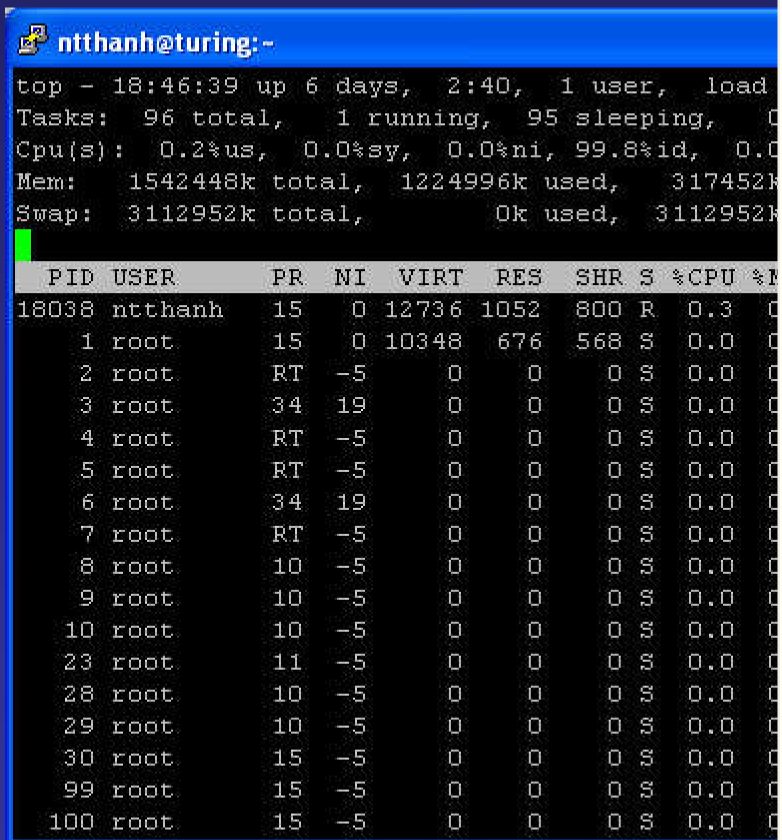
Reference

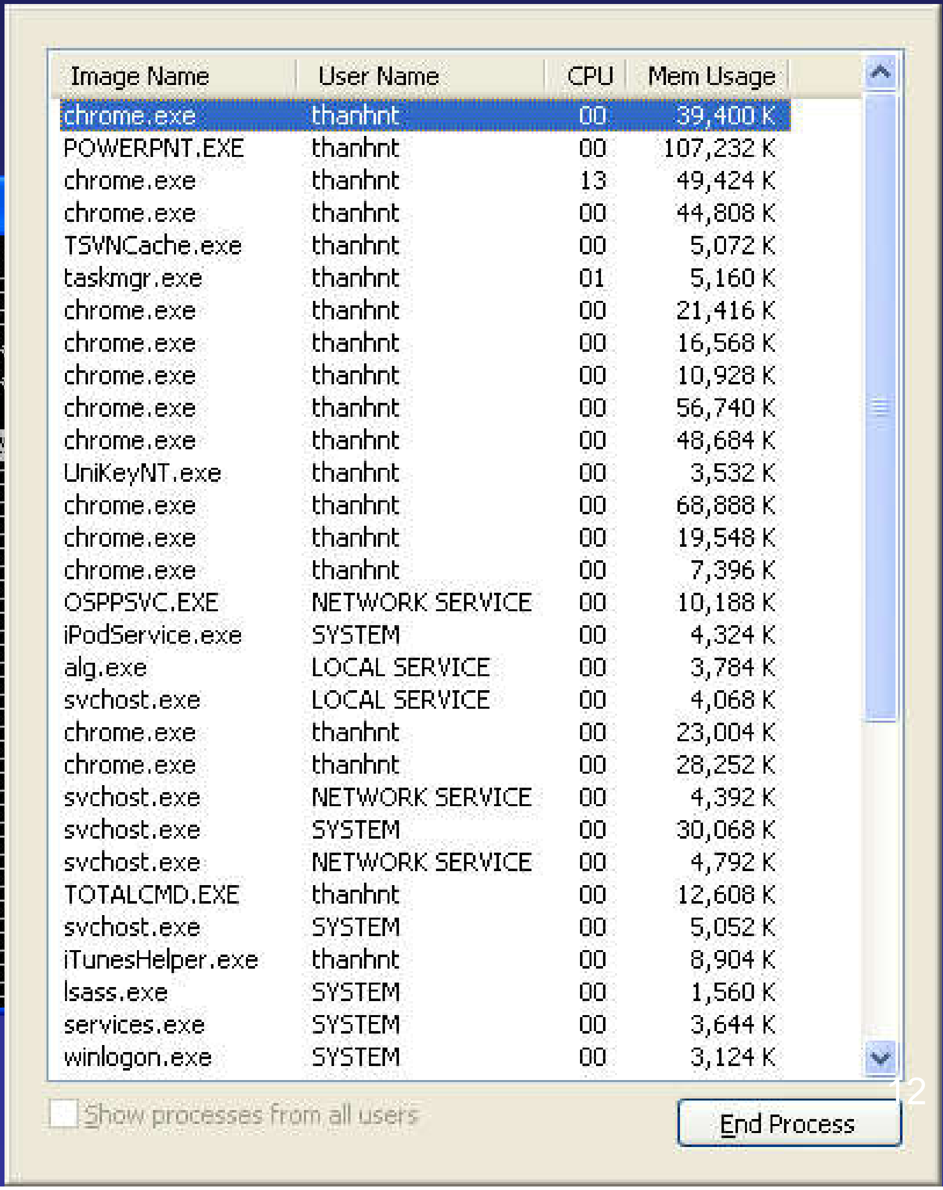
- Chapter 3, 5 of Operating System Concepts

Question

- What is a process?
  A. A file on disk
  B. An application
  C. A program running on the system
  D. A library
- Job, task and process may be used interchangeably

Process statistic





Process classification

Processes are classified into 2 categories

A. System processes
   - ✓ Created by system account
   - ✓ Run essential services

B. User processes
   - ✓ Created by user accounts
   - ✓ Usually are application processes (Word, Excel, YM,…)

Question

What is the correct relation among application, process and program concepts

A. An application may have multiple processes, a process may have multiple programs
B. An application only has one program, a program only has one process
C. An application may have multiple programs, a program may have multiple processes
D. An application may have many programs, a program only has one process

Question

Select the best description of resources a pure computer may have

A. CPU, RAM and anything that can connect to the computer, such as CD, network card, …

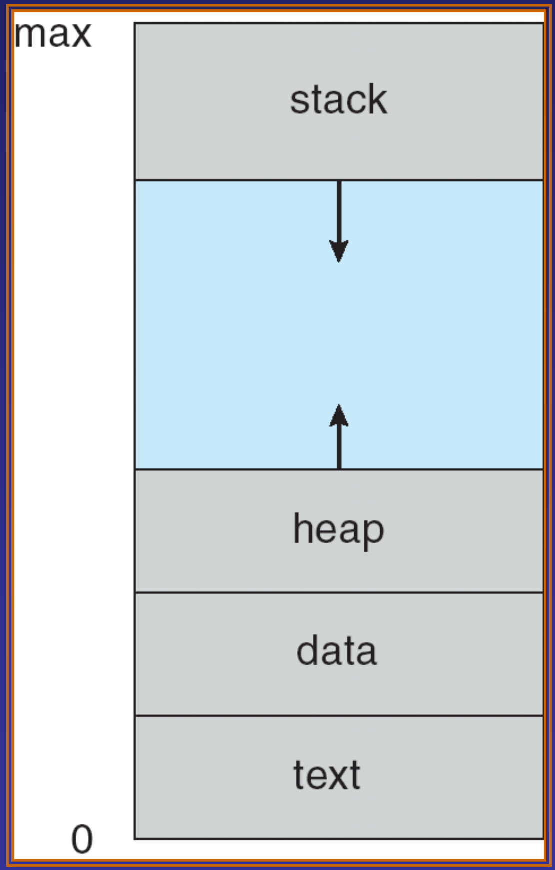
B. CPU, RAM, Disks

C. CPU, RAM, Disk, printer

D. CPU, RAM, Disk, printer, monitor

Process structure

- A process at least consists of
  1. A program counter (Instruction Pointer)
  2. Text (code)
  3. Stack + Heap
  4. Data section
- Other information is included
- The process structure is different among OSes



Process control block (PCB)

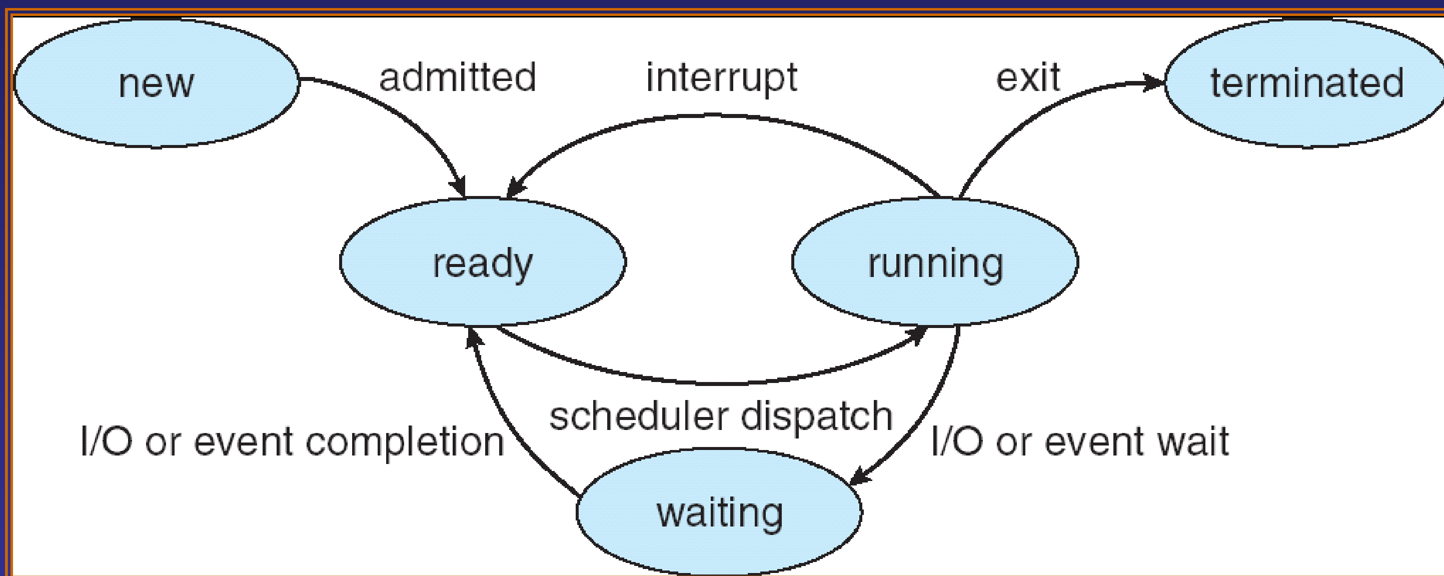
Information associated with each process

- Process state
- Program counter
- CPU registers
- CPU scheduling information
- Memory-management information
- Accounting information
- I/O status information

- PCB is different among OSes

Process states

- A process has many states during its life



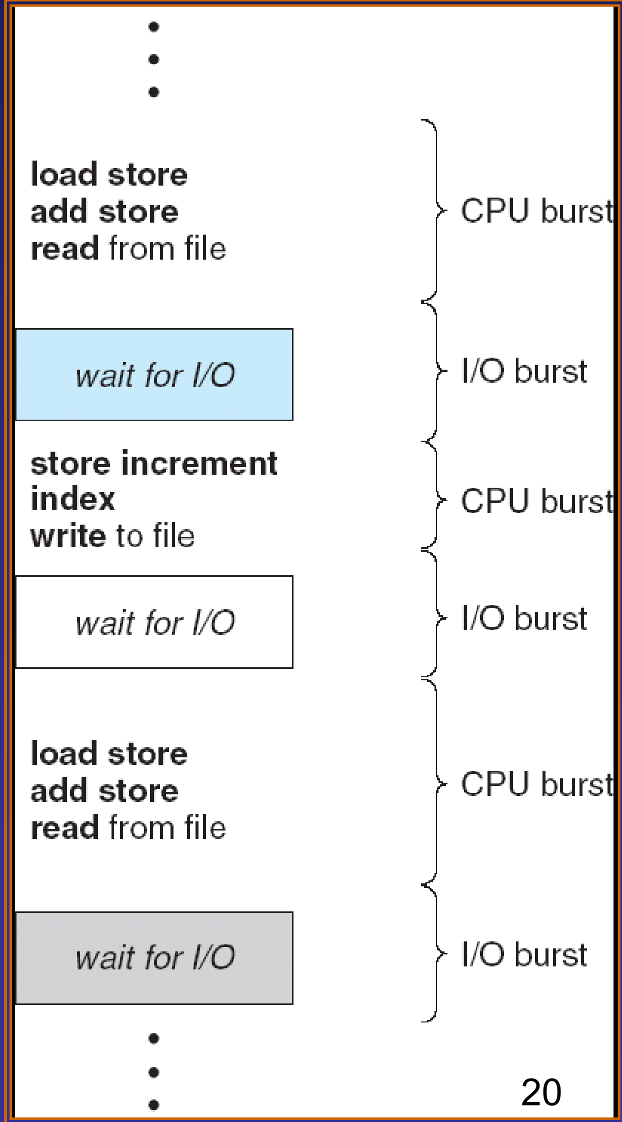
- The number of states is different among OSes

Process states

- New
  - a new process is initiated
- Running
  - Process instructions are being run
- Waiting
  - Process is waiting for a certain resource or event
- Ready
  - Process just waits for its turn to run
- Terminated
  - The process completes

CPU And I/O Bursts

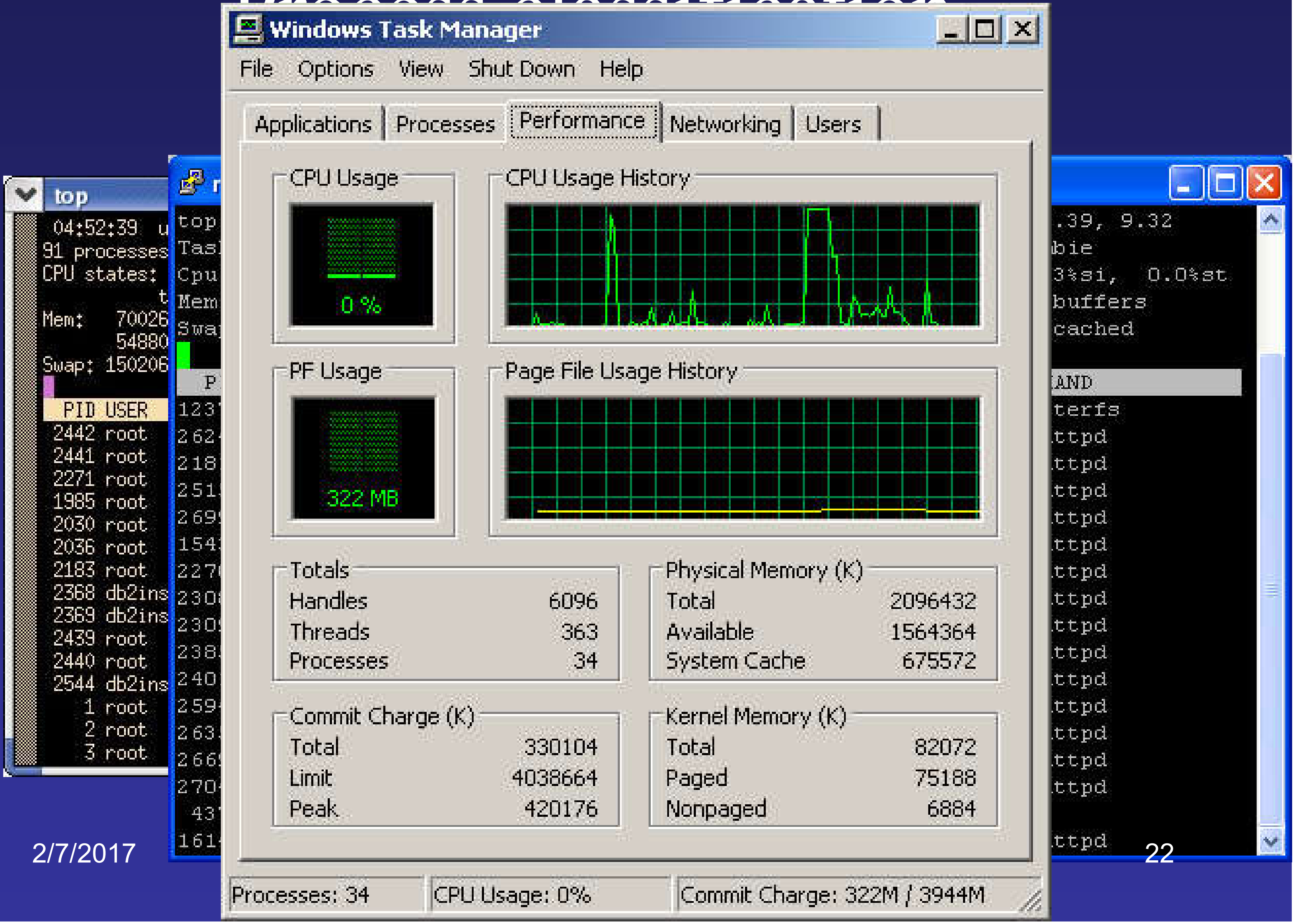
- Burst – a time span (duration)
- Two burst types
  - IO burst
  - CPU burst



Process classification

- CPU-bound process
  - uses CPU a lot (for computation)
- IO-bound process
  - does IO a lot (data manipulation)
- These types of processes affect schedulers

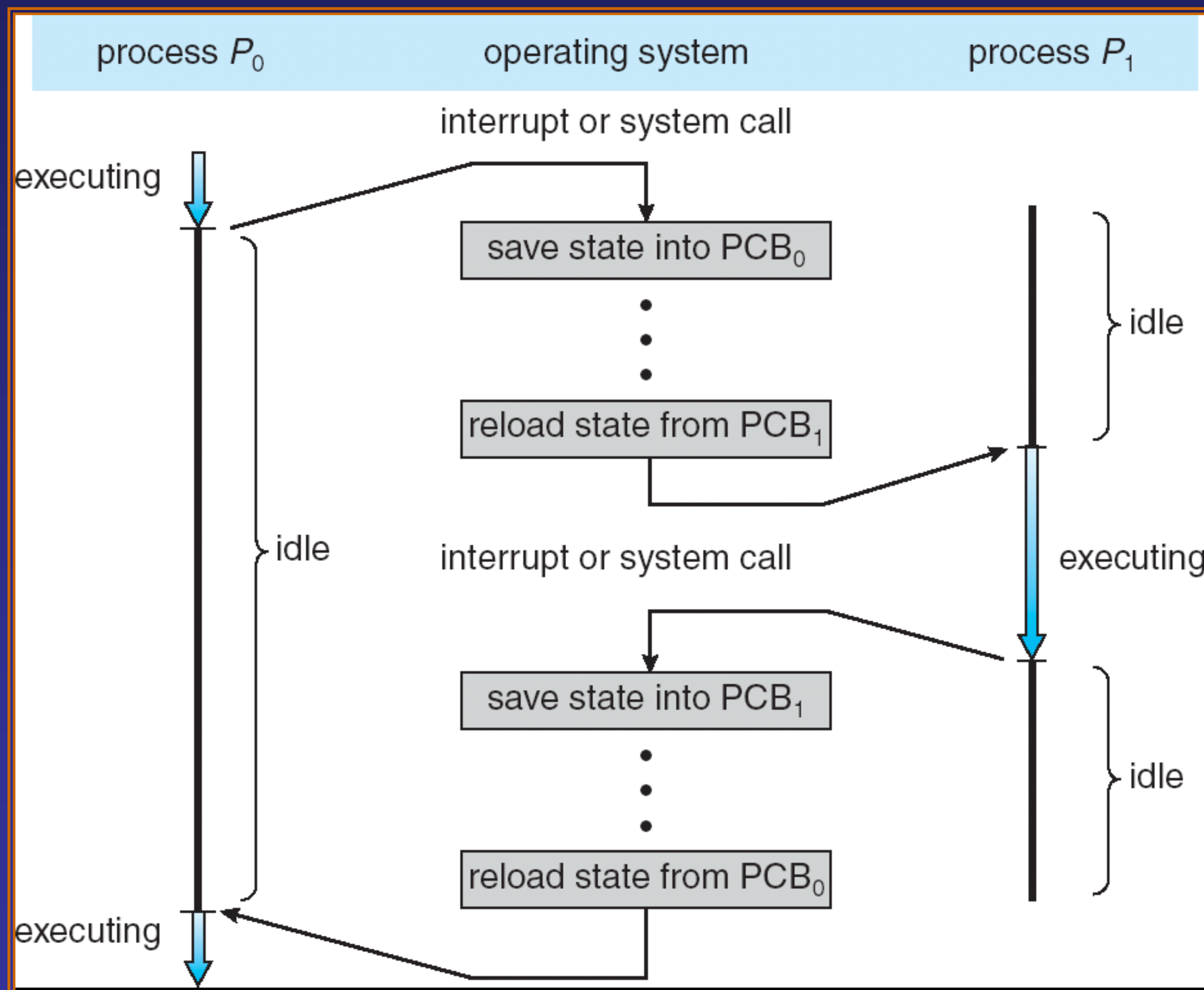
Process classification



Process context switch

- Context switch
  - CPU stops current process and runs another one
- Progress steps
  - save the state of the current process
  - put it into the READY queue
  - pick the target process
  - restore the state of the target process
  - run the target process

Process context switch



Question

- Which of the following is incorrect about context switch?
  A. the steps of changing from current process to the target one
  B. the current process will be put into the waiting queue
  C. the target process will be run
  D. the state of the current process will be saved

Process scheduling introduction

Problem

- You have 5 exams within a week
  - How do you manage to study?
- You have serveral courses to select
- A shop saler has many customers waiting
  - How does he/she do?
- At a buffet where sereral disks are availble
  - How do you eat?
- A CPU has several processes
  - How does it run them

Problem

How to run these processes?

Image Name	User Name	CPU	Mem Usage
chrome.exe	thanhnt	00	39,400 K
POWERPNT.EXE	thanhnt	00	107,232 K
chrome.exe	thanhnt	13	49,424 K
chrome.exe	thanhnt	00	44,808 K
TSVNCache.exe	thanhnt	00	5,072 K
taskmgr.exe	thanhnt	01	5,160 K
chrome.exe	thanhnt	00	21,416 K
chrome.exe	thanhnt	00	16,568 K
chrome.exe	thanhnt	00	10,928 K
chrome.exe	thanhnt	00	56,740 K
chrome.exe	thanhnt	00	48,684 K
UniKeyNT.exe	thanhnt	00	3,532 K
chrome.exe	thanhnt	00	68,888 K
chrome.exe	thanhnt	00	19,548 K
chrome.exe	thanhnt	00	7,396 K
OSPPSVC.EXE	NETWORK SERVICE	00	10,188 K
iPodService.exe	SYSTEM	00	4,324 K
alg.exe	LOCAL SERVICE	00	3,784 K
svchost.exe	LOCAL SERVICE	00	4,068 K
chrome.exe	thanhnt	00	23,004 K
chrome.exe	thanhnt	00	28,252 K
svchost.exe	NETWORK SERVICE	00	4,392 K
svchost.exe	SYSTEM	00	30,068 K
svchost.exe	NETWORK SERVICE	00	4,792 K
TOTALCMD.EXE	thanhnt	00	12,608 K
svchost.exe	SYSTEM	00	5,052 K
iTunesHelper.exe	thanhnt	00	8,904 K
lsass.exe	SYSTEM	00	1,560 K
services.exe	SYSTEM	00	3,644 K
winlogon.exe	SYSTEM	00	3,124 K

Show processes from all users

End Process

Question

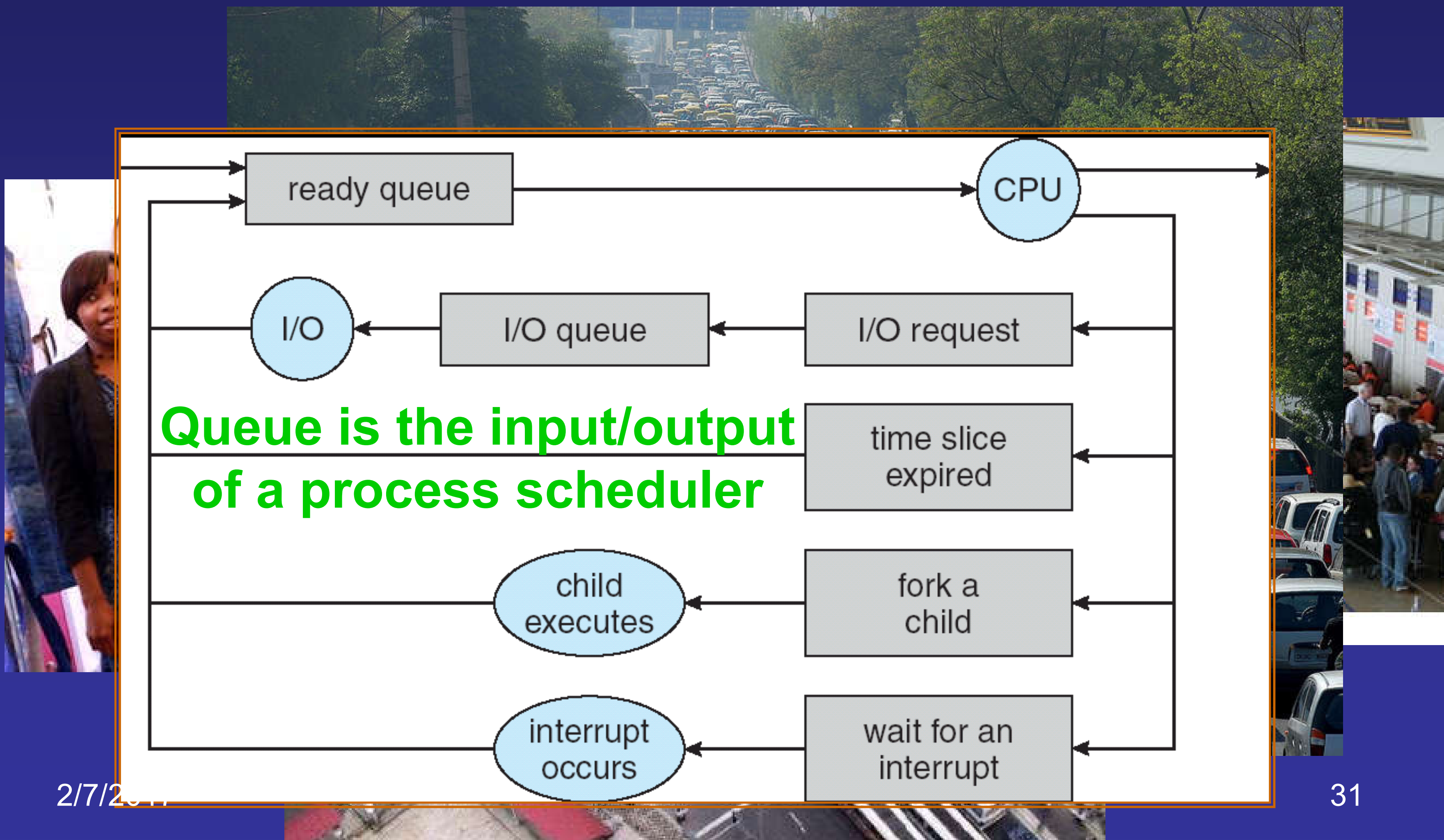
Which best describes the reason why we need process scheduling?

A. Because we have many processes
B. Because we have many processes and want them to be treated fairly
C. Many reasons
   - Many processes
   - Utilize resources effectively
   - Don't let users wait
   - …
D. Because we want to utilize RAM effectively

Queue

- When there are several people waiting at the counter (in a supermarket)
  - What do they do?

Queue

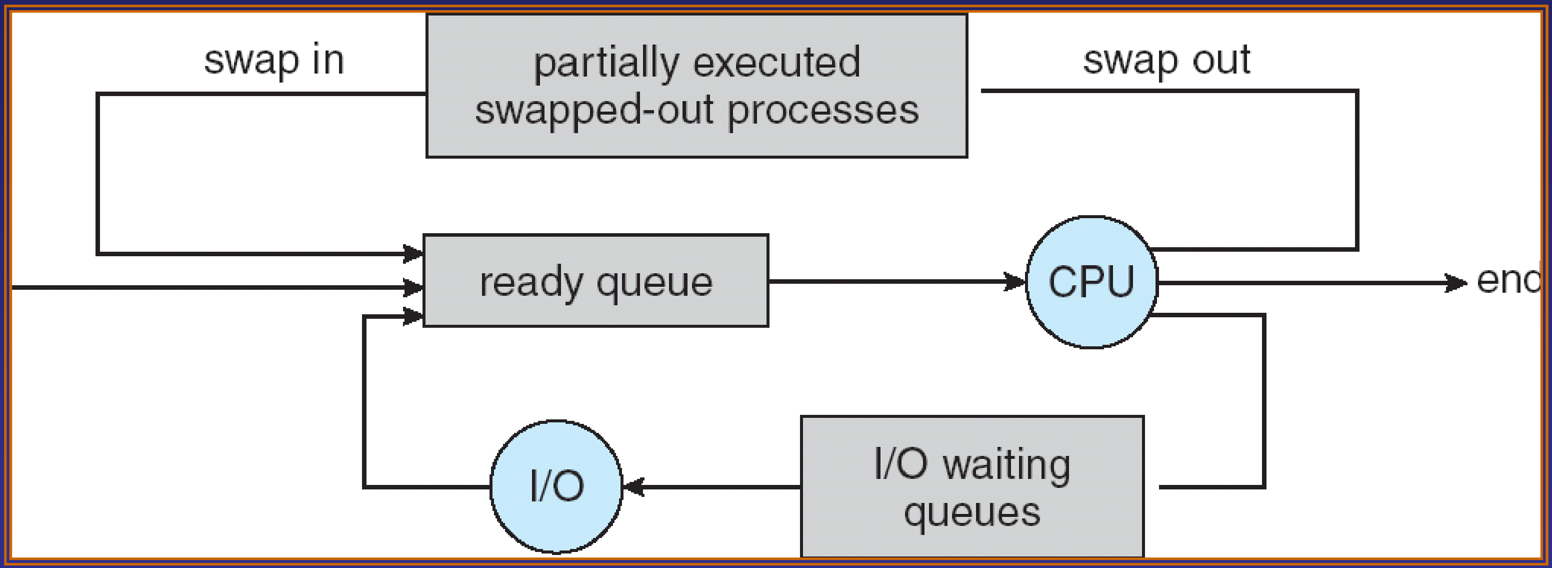


Queue is the input/output of a process scheduler

Different schedulers

- **Long-term scheduler** (or job scheduler)
  - selects which processes should be brought into the ready queue
- **Short-term scheduler** (or CPU scheduler)
  - selects which process should be executed next
- **Medium-term scheduler**
  - selects which process to temporarily swap out (of the MEM)

Different schedulers



Where is the position of the 3 schedulers?

Question

What is wrong when the CPU scheduler is called?

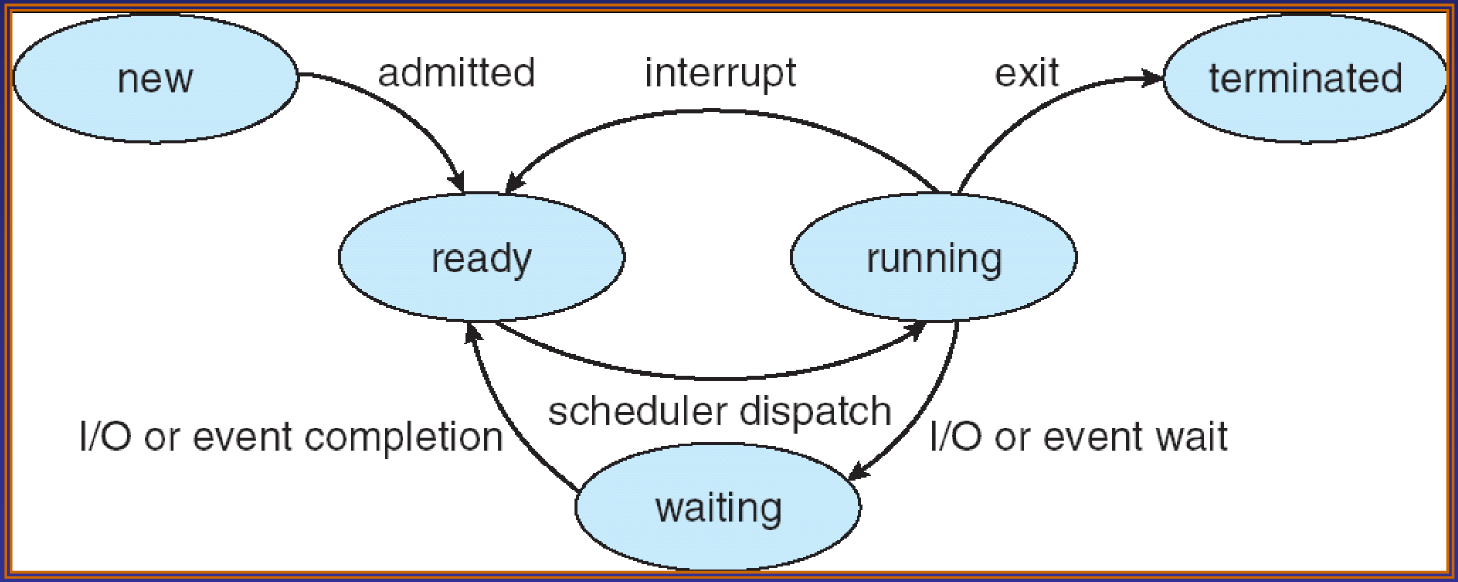
~~A.~~ A process changes from RUNNING to READY

B. A process is stopped

C. A process is admitted

D. A different process will be run

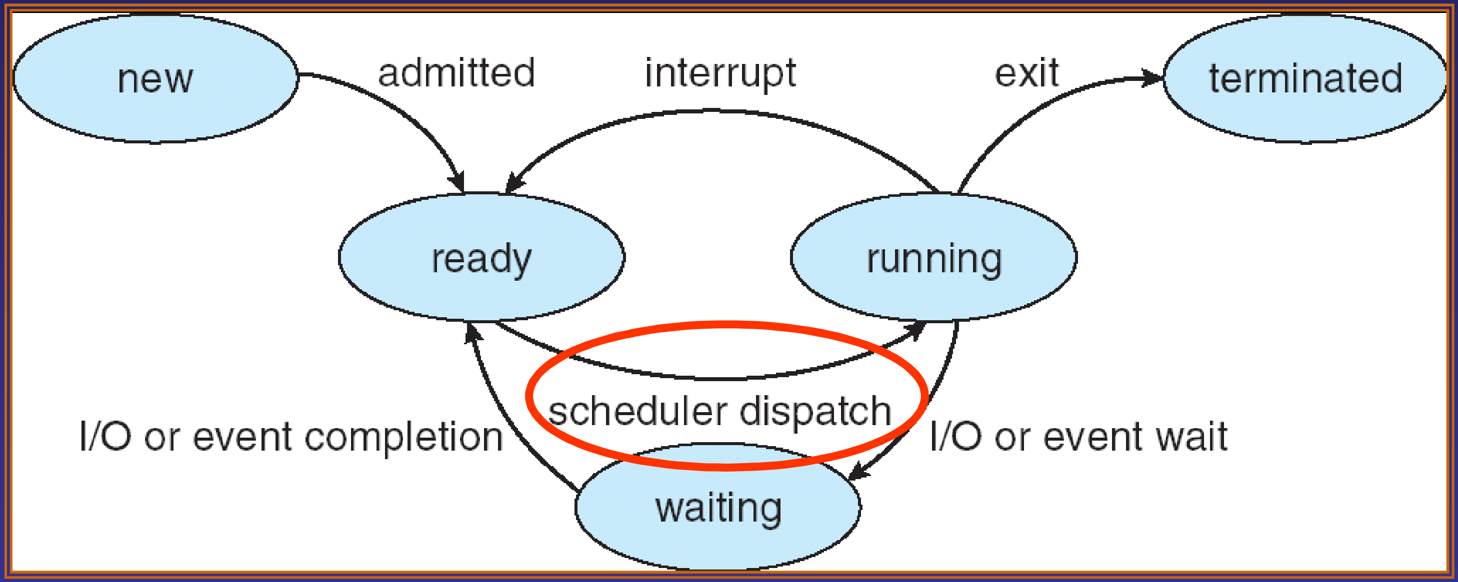
Position of CPU scheduler



Dispatcher

- Dispatcher module gives control of the CPU to the process selected by the short-term scheduler; this involves:
  - switching context
  - switching to user mode
  - run the process
- *Dispatch latency* – time it takes for the dispatcher to stop one process and start another running

Dispatcher


new
admitted
interrupt
exit
terminated
ready
running
scheduler dispatch
I/O or event completion
I/O or event wait
waiting

CPU scheduling

CPU scheduling

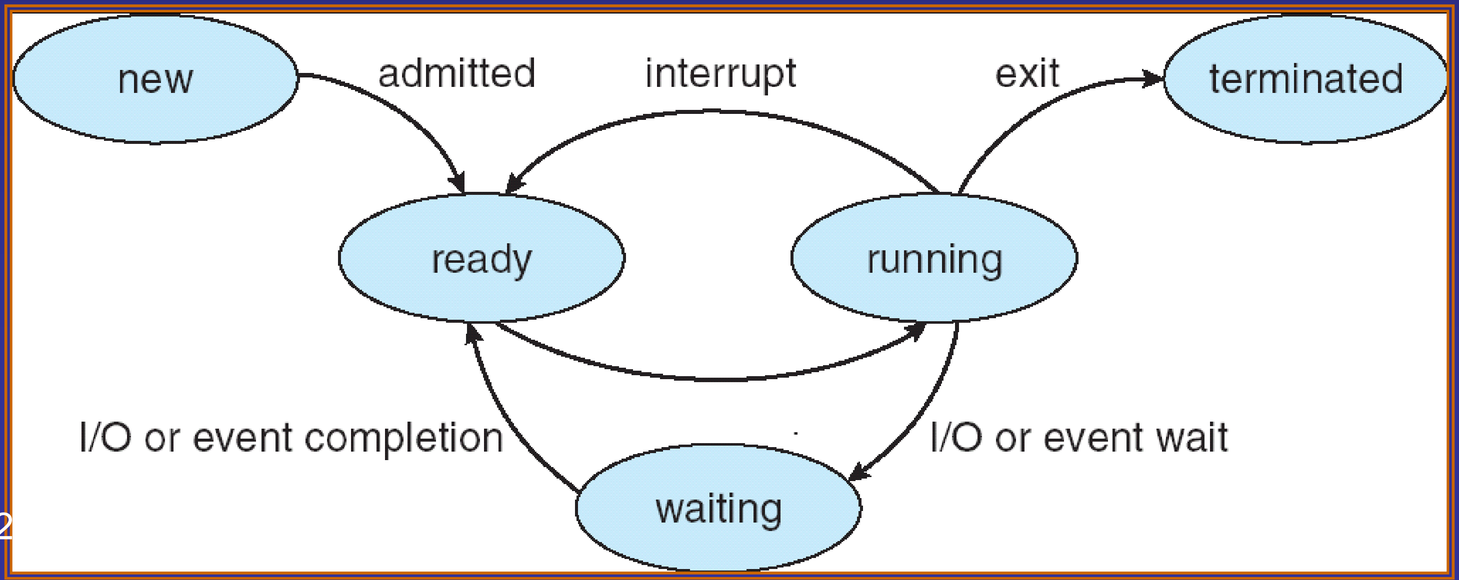
What is CPU scheduling?

A. Select program to be initialized
B. Select process to swap out
C. Select process to change into the idle state
D. Select process to run

CPU scheduling

Where is the position of CPU scheduler?

A. Between NEW and READY states
B. Between RUNNING and READY states
C. Between RUNNING and TERMINATED states
D. Between RUNNING and WAITING states

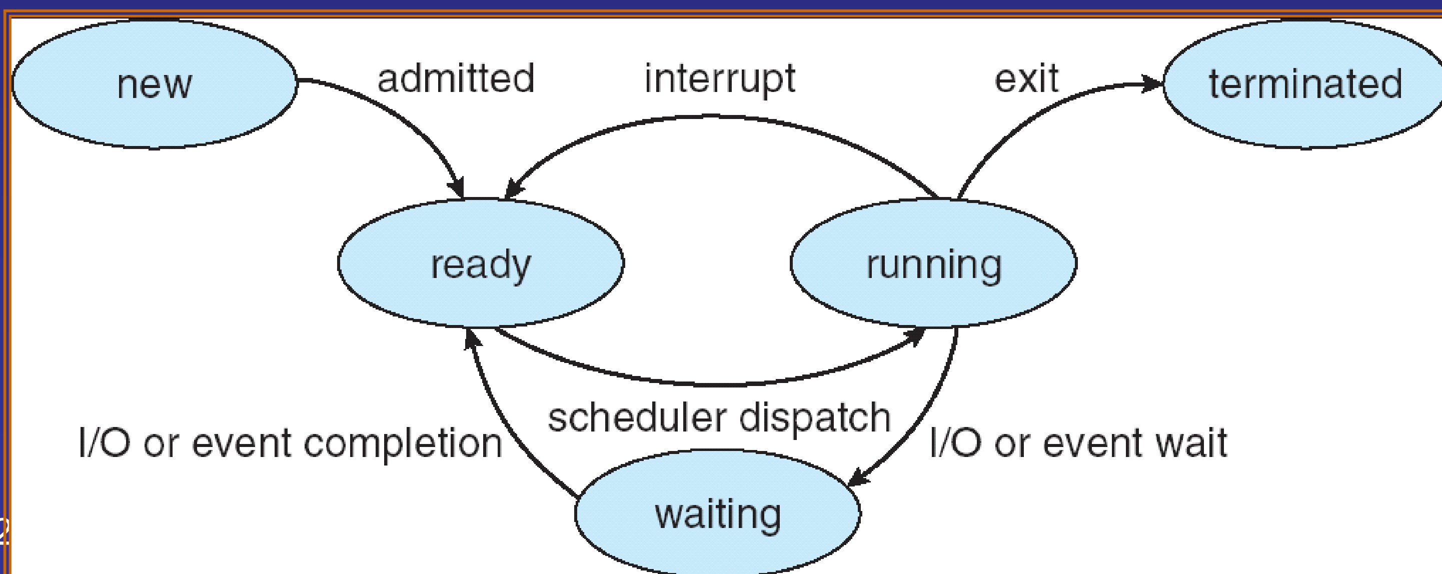


CPU scheduler type

- Non pre-emptive
  - running process has privilege to use CPU until it terminates or changes into WAITING state
  - Ex: Apple Macintosh, Windows 3.1
- Pre-emptive
  - running process may be forced to release CPU
  - Ex: Current Windows versions, Linux, Unix
- Which type is more effective?

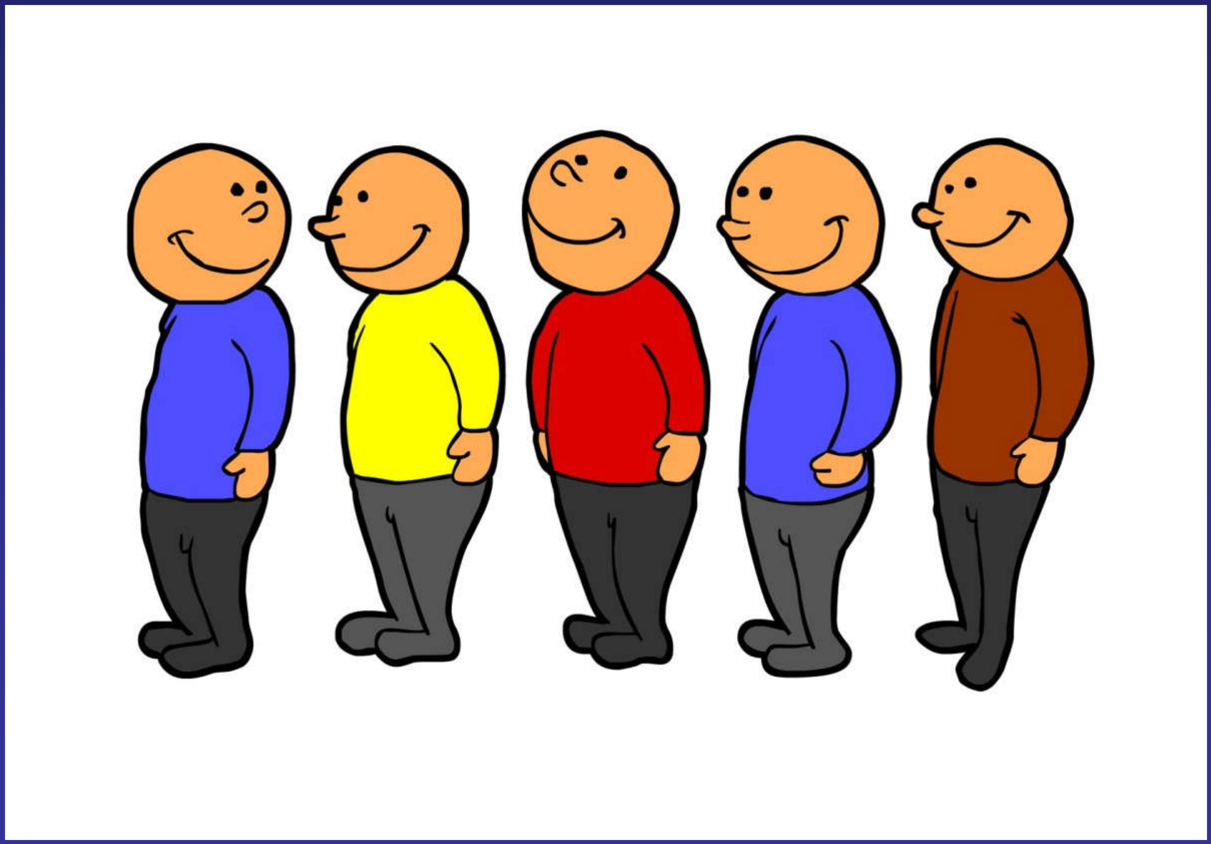
Question

- Which is correct about non-preemptive scheduler?
  A. no arc from RUNNING to READY states
  B. no arc from RUNNING to WAITING states
  C. no arc from WAITING to READY states
  D. no arc from READY to RUNNING states



First comes first served (FCFS)

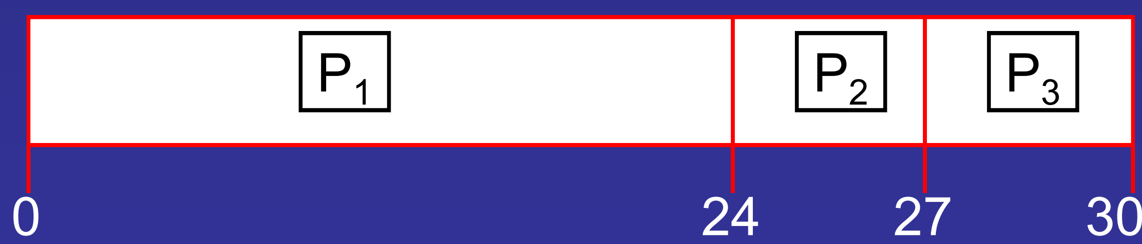
- Use FIFO queue
- Process at the head of the queue is run first



First comes first serves (FCFS)

Process	Burst Time
P_1	24
P_2	3
P_3	3

- Suppose that the processes arrive in the order: P_1 , P_2 , P_3
The Gantt Chart for the schedule is:



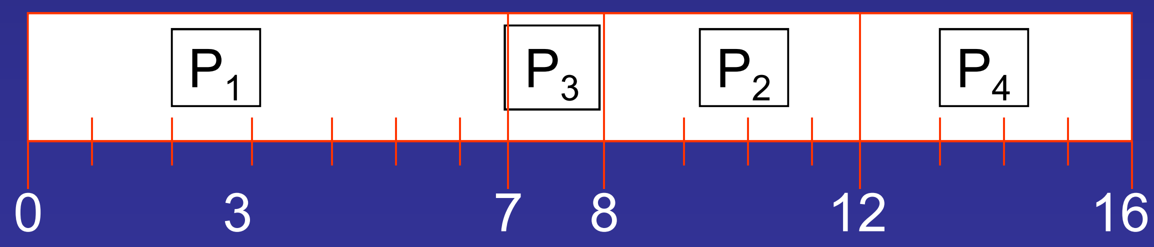
Shortest Job First (SJF)

- Also called Shortest Job Next (SJN)
- Shortest job in the queue is selected to be run
- There are two flavors
  - Non-preemptive
  - Preemptive (Shortest Remaining Time First – SRTF)

Shortest Job First (SJF)

Example of Non-Preemptive SJF

Process	Arrival Time	Burst Time
P_1	0	7
P_2	2	4
P_3	4	1
P_4	5	4



Example of Preemptive SJF

Process	Arrival Time	Burst Time
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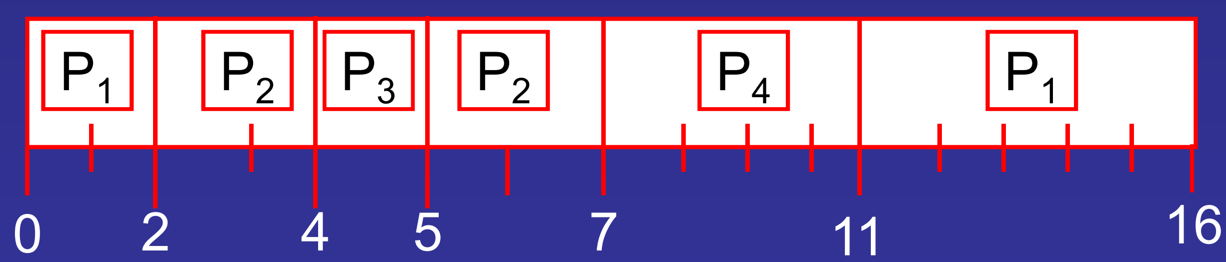


Next CPU burst estimation

- What if we don't know the length of burst time?
- Can only estimate
- Can be done by using the length of previous CPU bursts, using exponential averaging

1. $t_n =$ actual length of n^{th} CPU burst
2. $\tau_{n+1} =$ predicted value for the next CPU burst
3. $\alpha, 0 \leq \alpha \leq 1$
4. Define: $\tau_{n+1} = \alpha\, t_n + (1-\alpha)\tau_n .$

Examples

- $\alpha = 0$
  - $\tau_{n+1} = \tau_n$
  - Recent history does not count
- $\alpha = 1$
  - $\tau_{n+1} = \alpha\, t_n$
  - Only the actual last CPU burst counts
- If we expand the formula, we get:

$$\tau_{n+1} = \alpha\, t_n + (1 - \alpha)\alpha\, t_n - 1 + \ldots$$
$$+ (1 - \alpha)^j \alpha\, t_{n-j} + \ldots$$
$$+ (1 - \alpha)^{n+1} \tau_0$$

- Since both α and $(1 - \alpha)$ are less than or equal to 1, each successive term has less weight than its predecessor

Priority Scheduling

- A priority number (integer) is associated with each process
- The CPU is allocated to the process with the highest priority (smallest integer ≡ highest priority)
  - Preemptive
  - Non-preemptive
- SJF is a priority scheduling where priority is the predicted next CPU burst time
- Problem ≡ Starvation (low priority processes may never execute)
- Solution ≡ Aging (as time progresses increase the priority of the process)

Round Robin (RR)

- Each process gets a small unit of CPU time
  - *time quantum* (usually 10-100 milliseconds)
  - After time quantum, the process is preempted and added to the end of the READY queue.
- Performance
  - q large $\Rightarrow$ FIFO
  - q small $\Rightarrow$ q must be large with respect to context switch, otherwise overhead is too high

Round R

h.p. turbine
l.p. turbine
i.p. turbine
annular combustors
heat resistant tailcone
cooled air casing
h.p. compressor discs
fan casing
guide vanes
titanium fan (26 blades)

ion

W

Example of RR

Process	Burst Time
P_1	53
P_2	17
P_3	68
P_4	24

- Quantum is 20

P_1	P_2	P_3	P_4	P_1	P_3	P_4	P_1	P_3	P_3

0 20 37 57 77 97 117 121 134 154 162

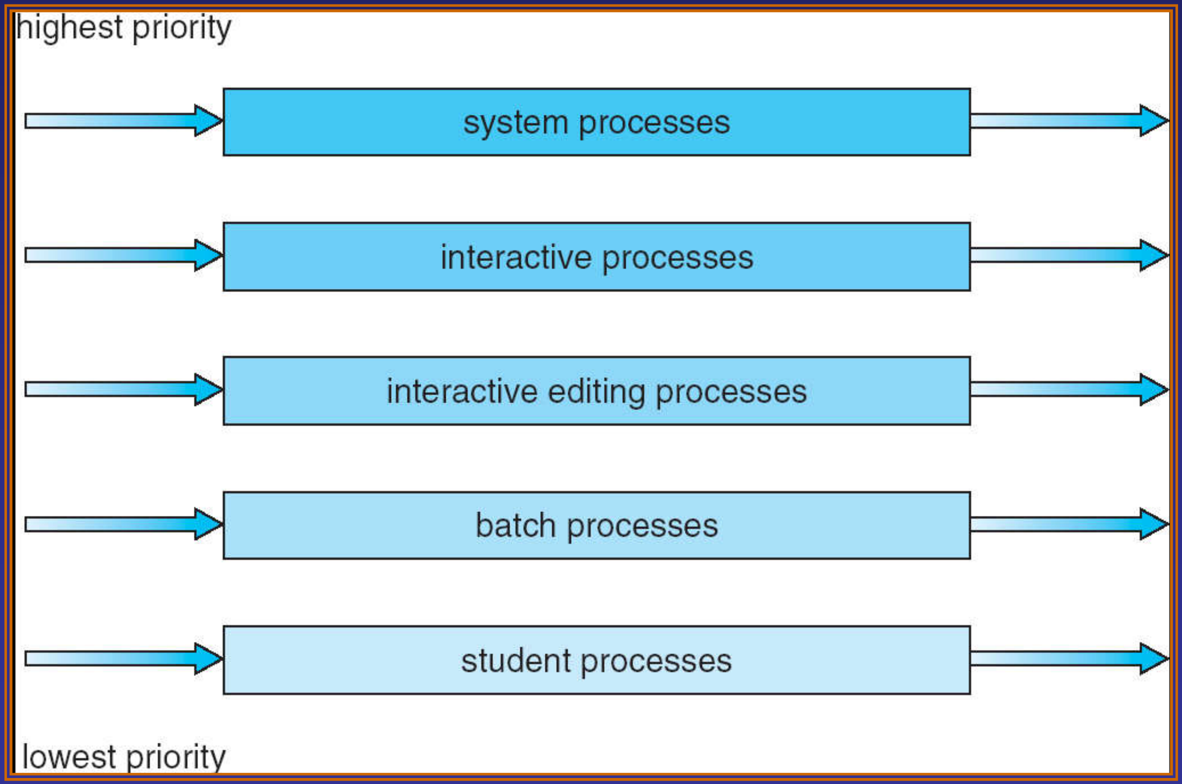
Multilevel Queue

- Ready queue is partitioned into separate queues
  - foreground (interactive)
  - background (batch)
- Each queue has its own scheduling algorithm
  - foreground – RR
  - background – FCFS

Multilevel Queue (cont'd)

- Scheduling must be done between the queues
  - Fixed priority scheduling
    - (i.e., serve all from foreground then from background)
    - Possibility of starvation
  - Time slice
    - each queue gets a certain amount of CPU time which it can schedule amongst its processes
      - i.e., 80% to foreground in RR
      - 20% to background in FCFS

Multilevel Queue Scheduling



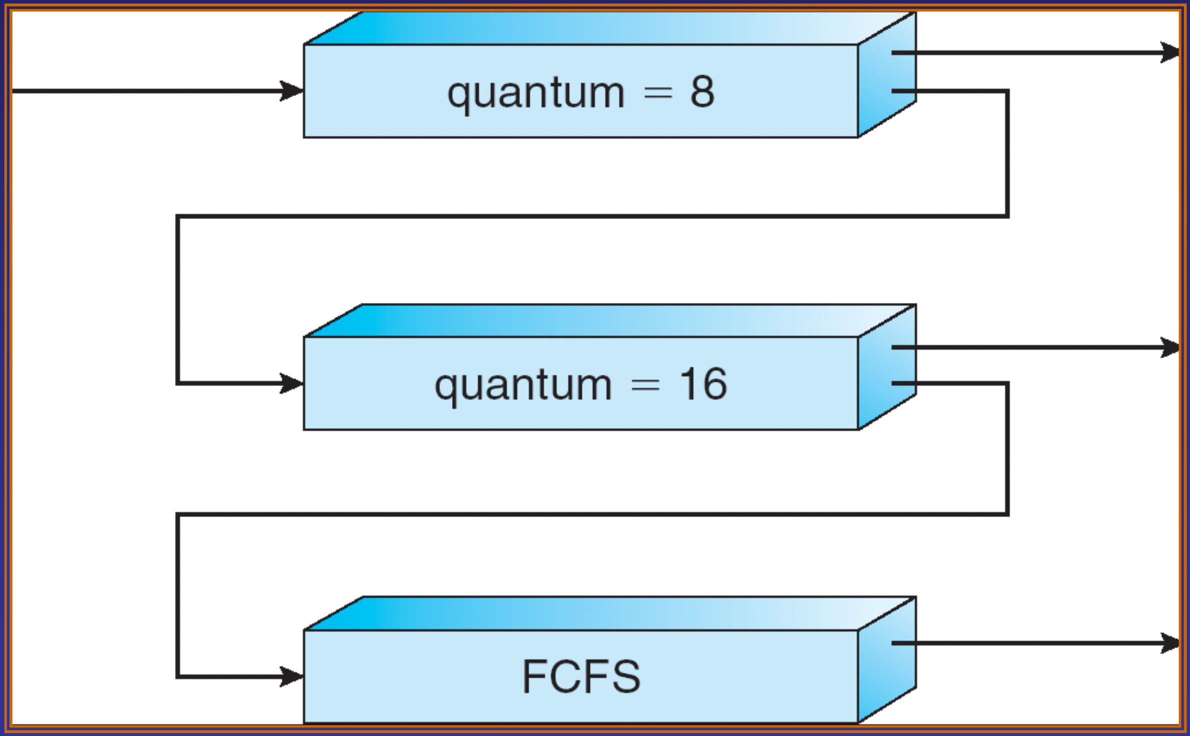
Multilevel Feedback Queue

- A process can move between the various queues
  - aging can be implemented this way
- Multilevel-feedback-queue scheduler defined by the following parameters
  - number of queues
  - scheduling algorithms for each queue
  - method used to determine when to upgrade a process
  - method used to determine when to demote a process
  - method used to determine which queue a process will enter when that process needs service

Example

- Three queues:
  - Q_0 – RR with time quantum 8 milliseconds
  - Q_1 – RR time quantum 16 milliseconds
  - Q_2 – FCFS
- Scheduling
  - A new job enters queue Q_0. When it gains CPU, job receives 8 milliseconds. If it does not finish in 8 milliseconds, job is moved to queue Q_1.
  - At Q_1 job receives 16 additional milliseconds. If it still does not complete, it is preempted and moved to queue Q_2.

Example



Multiple-Processor Scheduling

- CPU scheduling more complex when multiple CPUs are available
  - *Homogeneous processors* within a multiprocessor
  - *Load sharing*
- *Asymmetric multiprocessing*
  - only one processor accesses the system data structures, alleviating the need for data sharing

Scheduling criteria

- CPU utilization
  - keep the CPU as busy as possible
- Throughput
  - # of complete processes per time unit
- Turnaround time
  - amount of time to execute a particular process
- Waiting time
  - amount of time waiting in the ready queue
- Response time
  - amount of time it takes from when a request was submitted until the first response is produced, **not** output (for time-sharing environment)

Question

Which is incorrect about scheduling optimization?

A. Maximize turnaround time
B. Maximize throughput
C. Minimize waiting time
D. Minimize response time

First comes first serves (FCFS)

Process	Burst Time
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P_2	3
P_3	3

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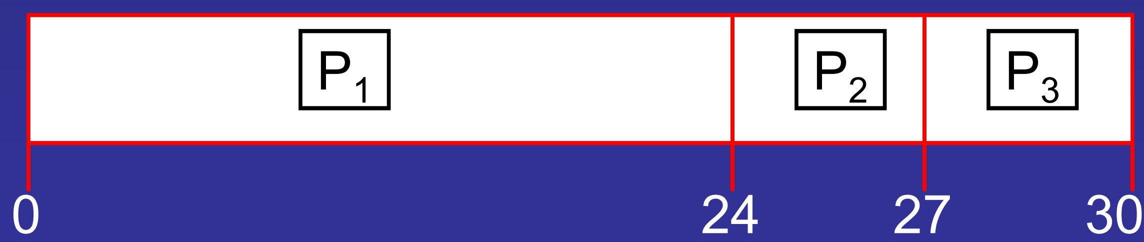


Question

Which is the total waiting time in FCFS example?

A. 21
B. 31
C. 41
D. 51

Question

Which is the average waiting time in FCFS example?

A. 15
B. 16
C. 17
D. 18

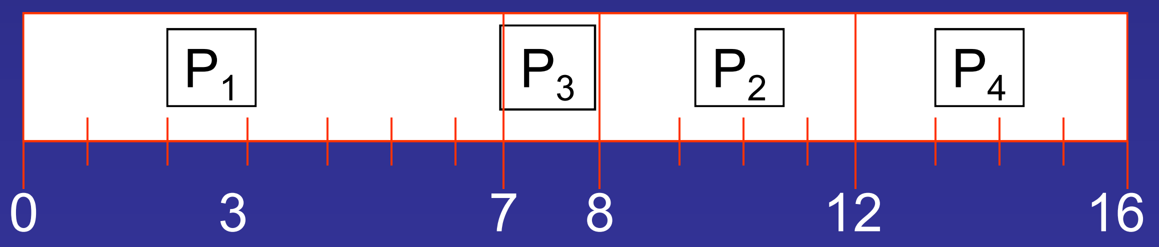
Question

Which is the throughput in FCFS example?

A. 0.1
B. 0.2
C. 0.3
D. 0.4

Example of Non-Preemptive SJF

Process	Arrival Time	Burst Time
P_1	0	7
P_2	2	4
P_3	4	1
P_4	5	4



Question

Which is the total waiting time in non-preemptive SJF example?

A. 15
B. 16
C. 17
D. 18

Question

Which is the average waiting time in the non-preemptive SJF example?

A. 2
B. 3
C. 4
D. 6

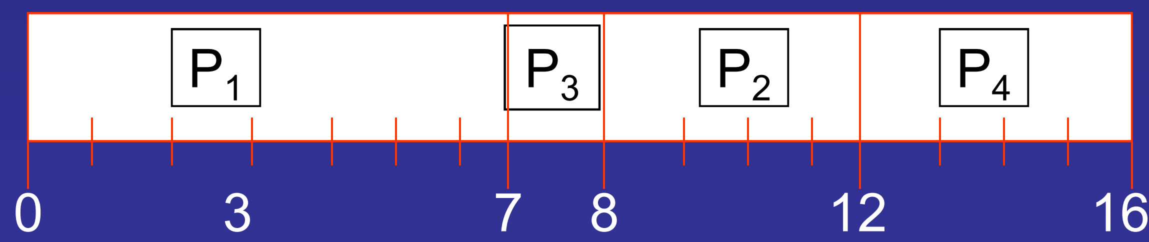
Question

Which is the throughput in the non-preemptive SJF example?

A. 0.65
B. 0.25
C. 0.35
D. 0.45

Example of Non-Preemptive SJF

Process	Arrival Time	Burst Time
P_1	0	7
P_2	2	4
P_3	4	1
P_4	5	4



Question

What is the turnaround time of P_2 in the SJF example?

A. 6
B. 8
C. 10
D. 12

Question

What is the response time of P_2 in the SJF example?

A. 6

B. 8

C. 4

D. 0


Please wait...
Microsoft
Windows 2000
Professional
Microsoft
Windows is shutting down...

Question?