Operating Systems

Key functions and structures of operating Systems.
CHAPTER 10

Chapter Goals

- Describe the two main responsibilities of an operating system
- Define memory and process management
- Explain how timesharing creates the virtual machine illusion
- Explain the relationship between logical and physical addresses
- Compare and contrast memory management techniques

Chapter Goals

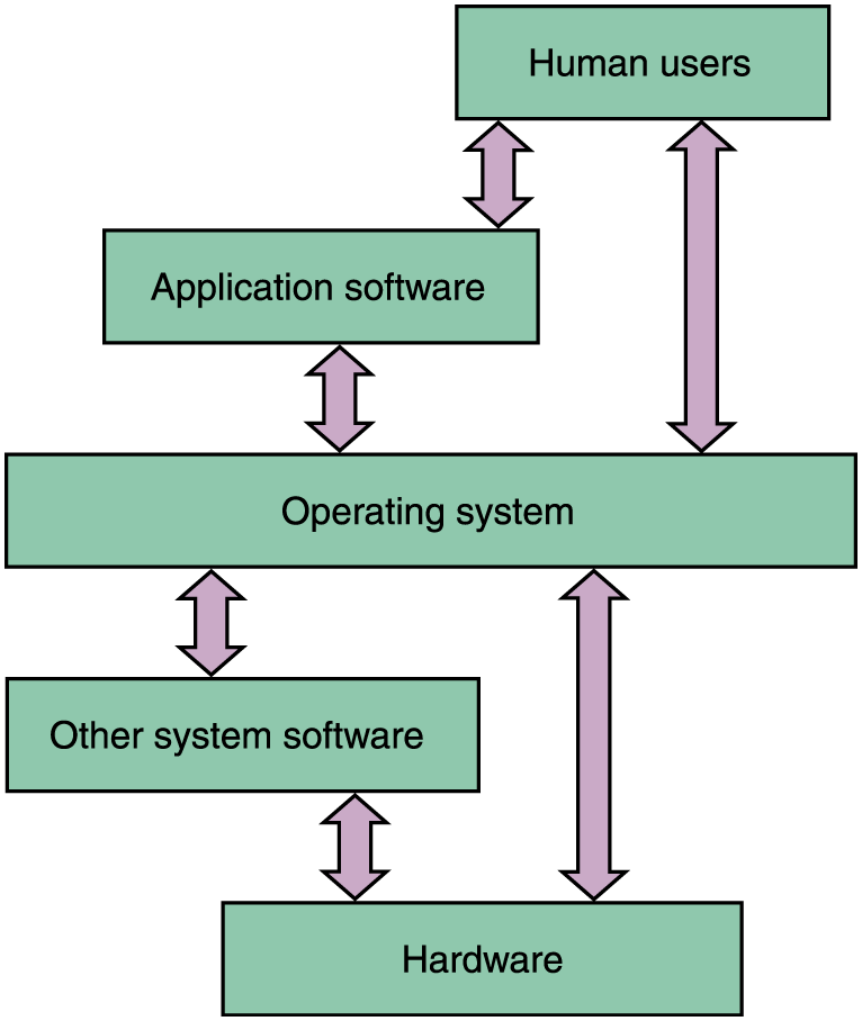
- Distinguish between fixed and dynamic partitions
- Define and apply partition selection algorithms
- Explain how demand paging creates the virtual memory illusion
- Explain the stages and transitions of the process life cycle
- Explain the processing of various CPU scheduling algorithms

Roles of an Operating System

Operating system

System software that

- **manages** computer resources, such as memory and input/output devices
- **provides** an interface through which a human can interact with the computer
- **allows** an application program to interact with these other system resources


Human users
Application software
Operating system
Other system software
Hardware

Roles of an Operating System

The various roles of an operating system generally revolve around the idea of "sharing nicely"

An operating system manages resources, and these resources are often shared in one way or another among programs that want to use them

Resource Management

Multiprogramming

The technique of keeping multiple programs that compete for access to the CPU in main memory at the same time so that they can execute

Memory management

The process of keeping track of what programs are in memory and where in memory they reside

Resource Management

Process

A program in execution

Process management

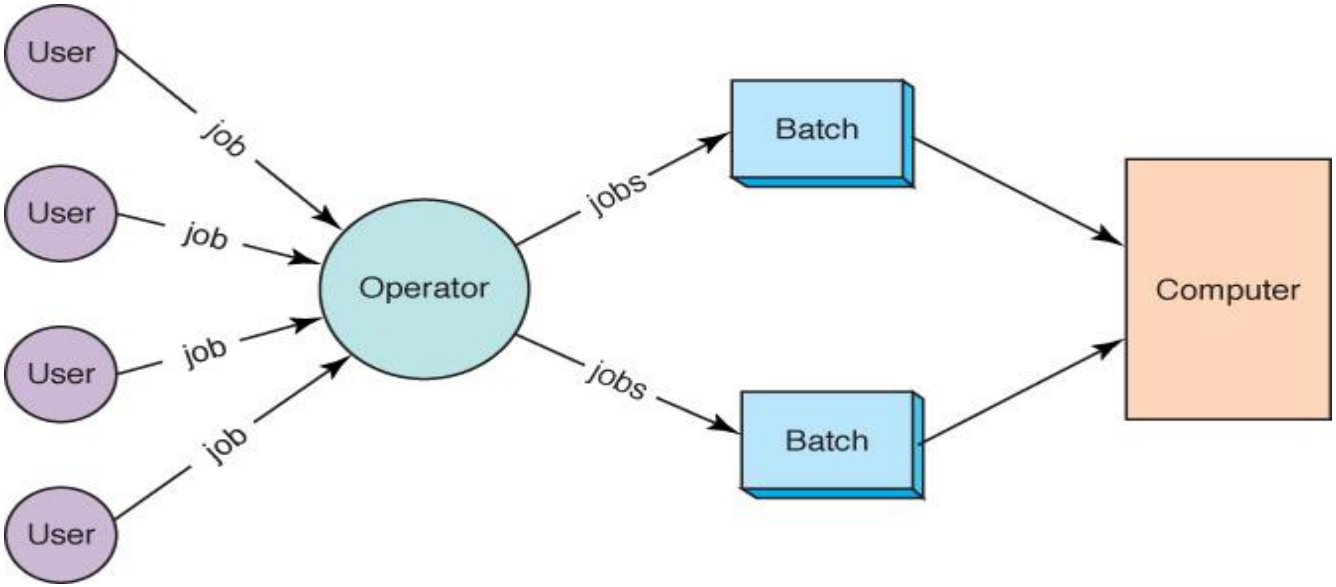
The act of carefully tracking the progress of a process and all of its intermediate states

CPU scheduling

Determining which process in memory is executed by the CPU at any given point

Batch Processing

The first operating system was a human operator, who organized various jobs from multiple users into *batches* of jobs that needed the same resources



Timesharing

Timesharing system

A system that allows multiple users to interact with a computer at the same time

Virtual machine

The illusion created by a time-sharing system that each user has his/her own machine

Other Factors

Real-time System

A system in which response time is crucial given the nature of the application

Response time

The time delay between receiving a stimulus and producing a response

Device driver

A small program that "knows" the way a particular device expects to receive and deliver information

Memory Management

Operating systems must employ techniques to

- Track where and how a program resides in memory
- Convert **logical addresses** into actual **addresses**

Logical address

Reference to a stored value relative to the program making the reference

Physical address

Actual address in main memory

Single Contiguous MM

Figure 10.4 **Main memory divided into two sections**

There are only two programs in memory

- The operating system
- The application program

This approach is called **single contiguous memory management**

Single Contiguous MM

In concrete terms:

A logical address is simply an integer value relative to the starting point of the program

A physical address is a logical address added to the starting location of the program in main memory

Single Contiguous MM

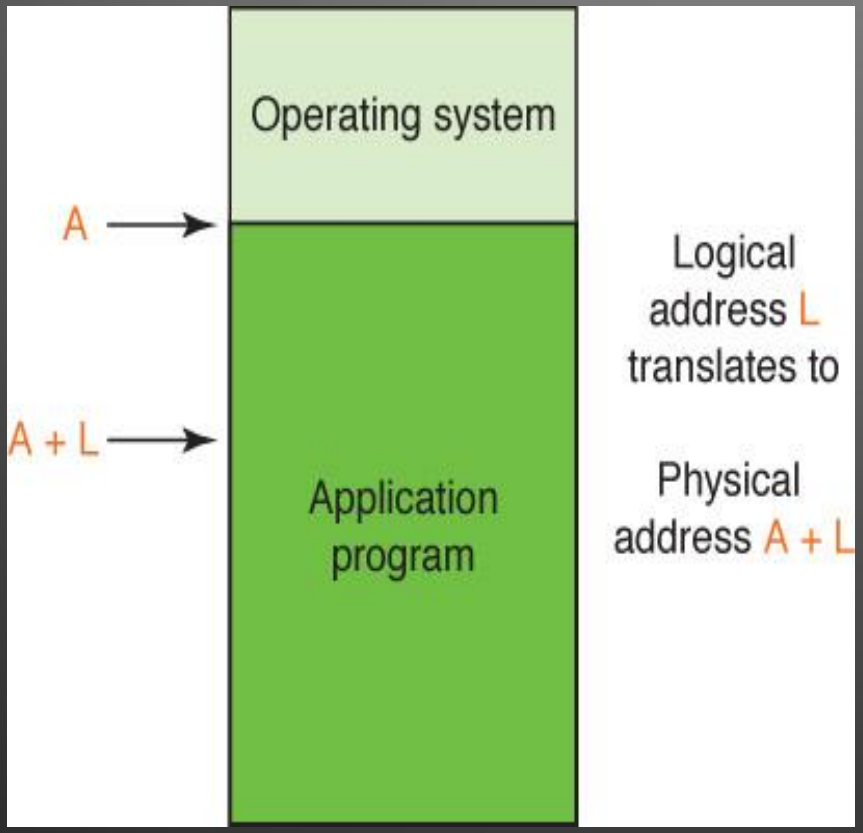


Figure 10.5 **Binding a logical address to a physical one**

Partition Memory Management

Single contiguous MM has only the OS and one other program in memory at one time

Partition MM has the OS and any number of other programs in memory at one time

There are two schemes for dividing up memory for programs:

- **Fixed partitions** Main memory is divided into a fixed number of partitions into which programs can be loaded
- **Dymanic partitions** Partitions are created as needed to fit the programs waiting to be loaded

Partition Memory Management

Memory is divided into a set of partitions, some empty and some allocated to programs

Base register

A register that holds the beginning address of the current partition (the one that is running)

Bounds register

A register that holds the length of the current partition

Partition Memory Management

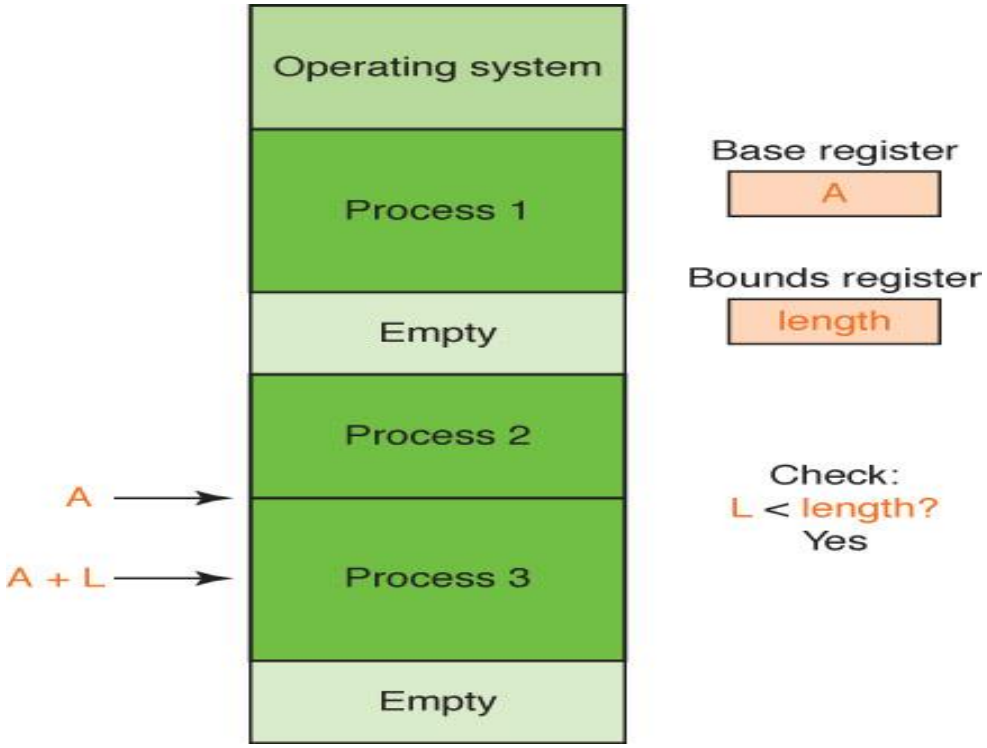


Figure 10.6
Address resolution in partition memory management

Partition Selection Algorithms

Which partition should we allocate to a new program?

- **First fit** Allocate program to the first partition big enough to hold it
- **Best fit** Allocated program to the smallest partition big enough to hold it
- **Worst fit** Allocate program to the largest partition big enough to hold it

Partition Selection Algorithms

A: 1000
B: 700
C: 750
D: 1500
E: 300
F: 350

Requests come in for blocks of the following sizes:
1000, 25, 780, 1600, and 325

What block will be assigned to each request if the

- *first-fit algorithm is used?*
- *best-fit algorithm is used?*
- *worst-fig algorithm is used?*

(Treat each request as an independent event)

Paged Memory Management

Paged memory technique

A technique in which processes are divided into fixed-size **pages** and stored in memory **frames** when loaded

Frame

A fixed-size portion of *main memory* that holds a process page

Page

A fixed-size portion of a *process* that is stored into a memory frame

We assume that a frame and a page are the same size

Paged Memory Management

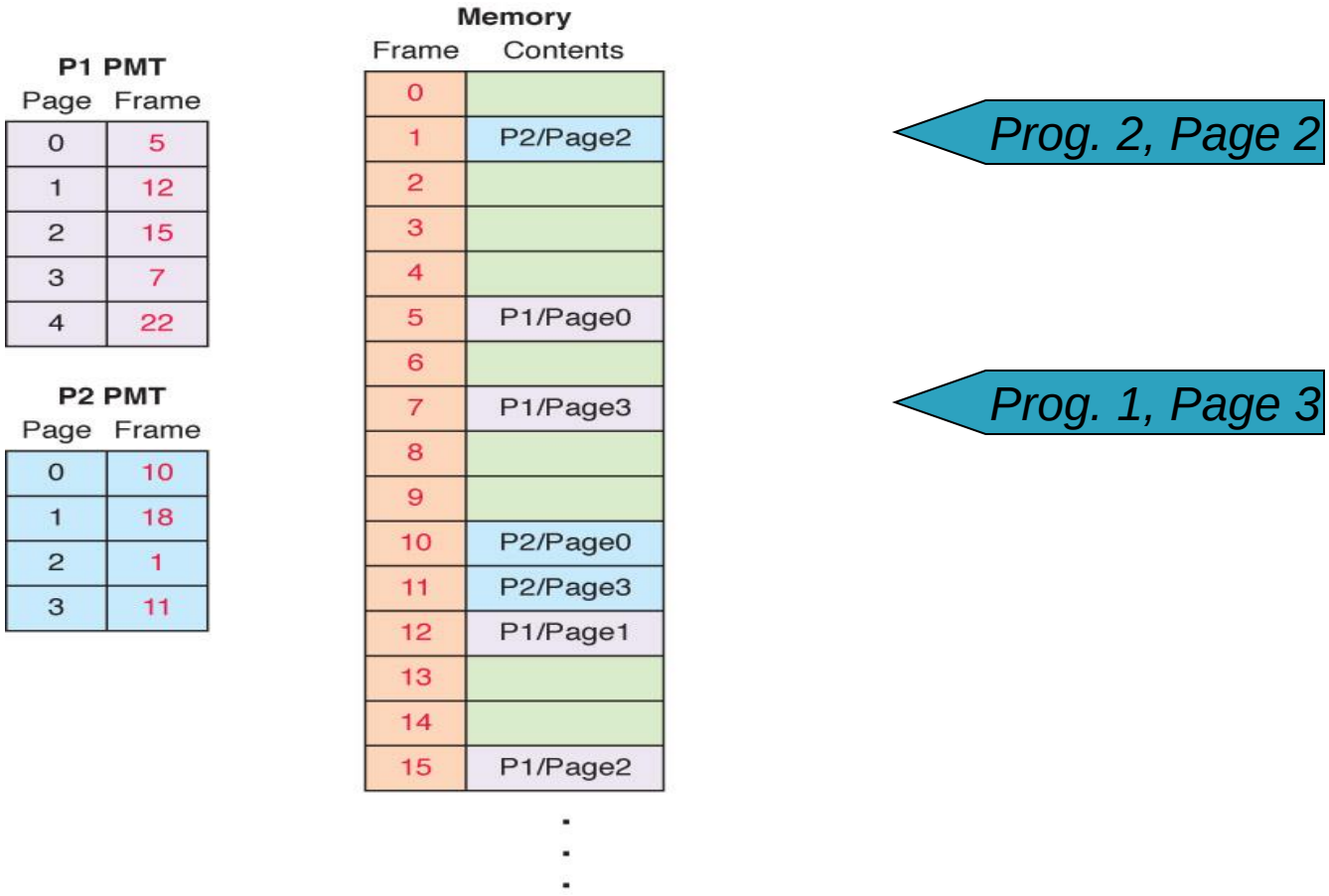


Figure 10.7
A paged memory management approach

Paged Memory Management

P1 PMT

Page	Frame
0	5
1	12
2	15
3	7
4	22

P2 PMT

Page	Frame
0	10
1	18
2	1
3	11

Memory

Frame	Contents
0	
1	P2/Page2
2	
3	
4	
5	P1/Page0
6	
7	P1/Page3
8	
9	
10	P2/Page0
11	P2/Page3
12	P1/Page1
13	
14	
15	P1/Page2

This new logical address is mapped to a physical address with the help of a page-map table (PMT)

Every program has a PMT that shows into which frame each page of the program is stored

What is the physical address of <2, 518>?

Paged Memory Management

Demand paging

An extension of paged memory management in which pages are brought into memory on demand

Page swap

The act of bringing in a page from secondary memory, which often causes another page to be written back to secondary memory

Paged Memory Management

Virtual memory

The illusion that there are no restrictions on the size of a program because an entire process doesn't have to be in memory at the same time

Thrashing

Inefficient processing caused by constant page swaps

Process Management

Process management

The act of managing the use of the CPU by individual processes

Recall that a process is a program in execution

What stages does a process go through?

Process Management

The Process States

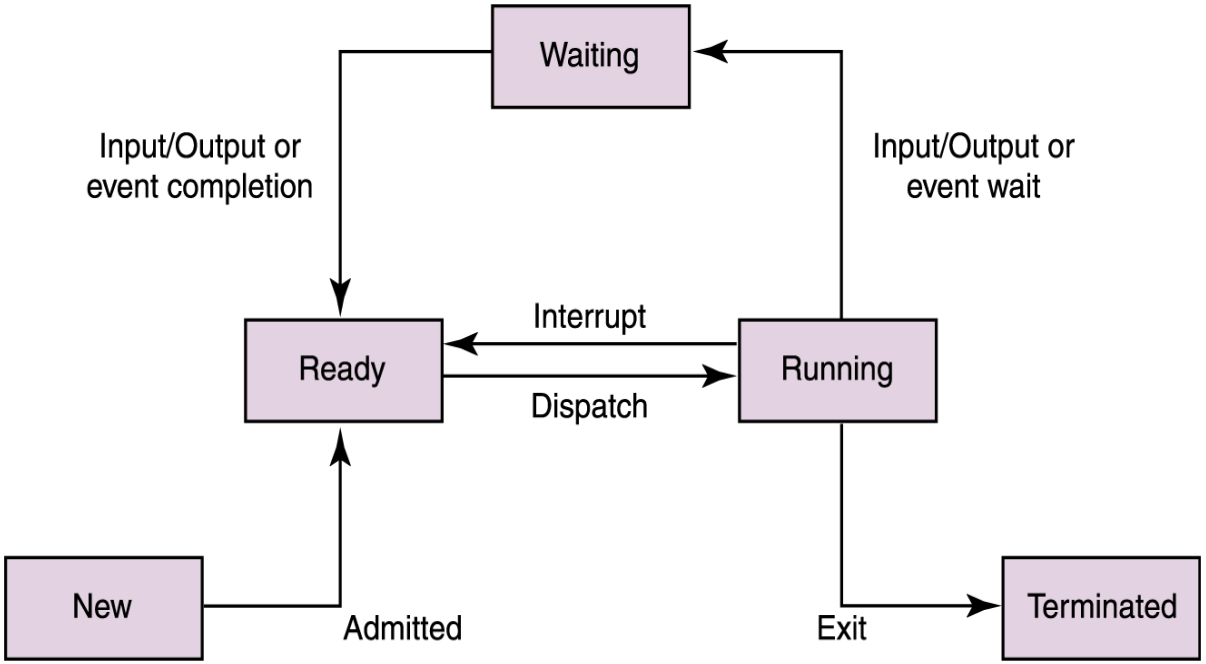


Figure 10.8 **The process life cycle**

Process Management

Process control block (PCB)

A *data structure* used by the OS to manage information about a process, including

- current value of the program counter
- values of all CPU registers for the process
- base and bound register values (or page tables)
- accounting information

Each *state* is represented by a list of PCBs, one for each process in that state

Process Management

There is only one CPU and therefore only one set of CPU registers, which contain the values for the currently
executing process

Each time a process is moved to the running state:

- Register values for the currently running process are stored into its PCB
- Its PCB is moved to the list of the state into which it goes
- Register values of the new process moving into the running state are loaded into the CPU
- This exchange of register information is called a **context switch**

CPU Scheduling

CPU Scheduling

The act of determining which process in the *ready* state should be moved to the *running* state

- Many processes may be in the ready state
- Only one process can be in the running state, making progress at any one time

Which one gets to move from ready to running?

CPU Scheduling

Nonpreemptive scheduling

The currently executing process gives up the CPU voluntarily

Preemptive scheduling

The operating system decides to favor another process, preempting the currently executing process

Turnaround time

The amount of time between when a process arrives in the ready state the first time and when it exits the running state for the last time

CPU Scheduling Algorithms

First-Come, First-Served

Processes are moved to the CPU in the order in which they arrive in the running state

Shortest Job Next

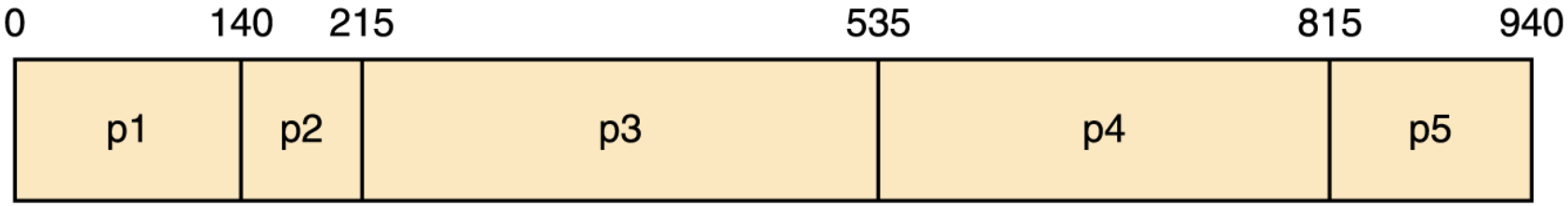
Process with shortest estimated running time in the ready state is moved into the running state first

Round Robin

Each process runs for a specified time slice and moves from the running state to the ready state to await its next turn if not finished

First-Come, First-Served

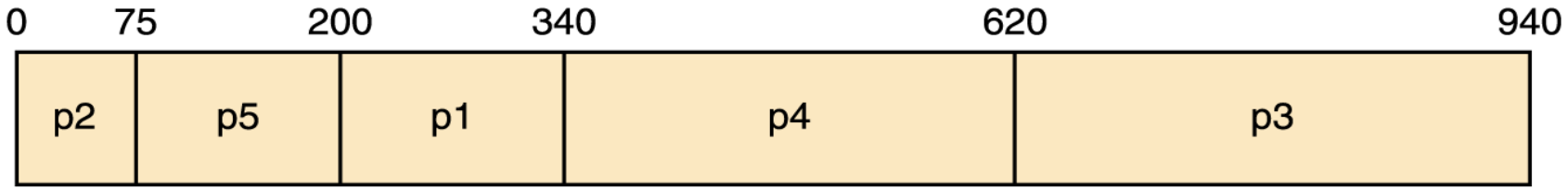
Process	Service time
p1	140
p2	75
p3	320
p4	280
p5	125



Average turnaround time = (140+215+535+815+940)/5
=529

Shortest Job Next (SJN)

Process	Service time
p1	140
p2	75
p3	320
p4	280
p5	125



Average turnaround time = (75+200+340+620+940)/5
=435

Round Robin

Every process is treated the same!

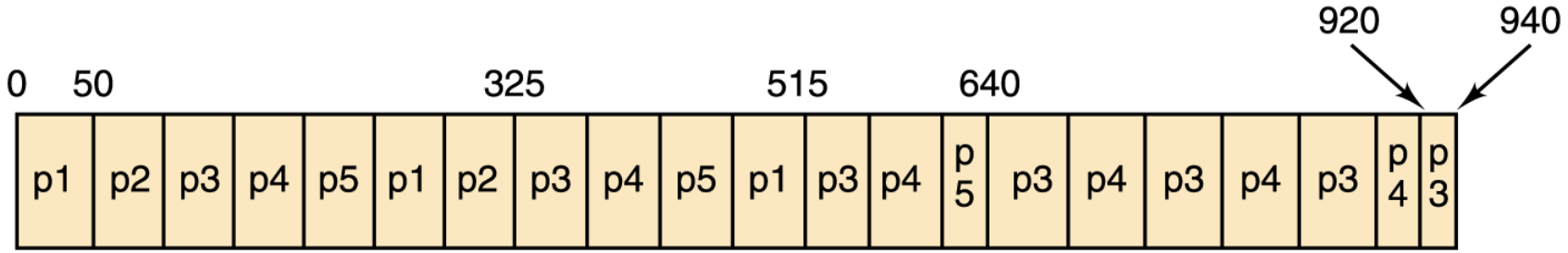
Time slice (quantum)

The amount of time each process receives before being preempted and returned to the ready state to allow another process its turn

Round Robin

Process	Service time
p1	140
p2	75
p3	320
p4	280
p5	125

Suppose the time slice is 50



Average turnaround time = (515+325+940+920+640)/5
= 668