考试信息

英文试卷
闭卷考试，纸质词典

Introduction

uniprogramming and multiprogramming

单线程与多线程

Start on OS

- bootstrap program
  - stored in the ROM
  - known as the firmware or bootloader
- bootstrap program initialize the computer (Register content, device controller contents, etc)
- locates and loads the **OS kernel** into memory
- kernel starts the first process

User mode vs Kernel mode

user mode

protected instructions cannot be executed

kernel mode

all instructions can be executed

OS events

interrupts

are caused by external events (hardware)

traps

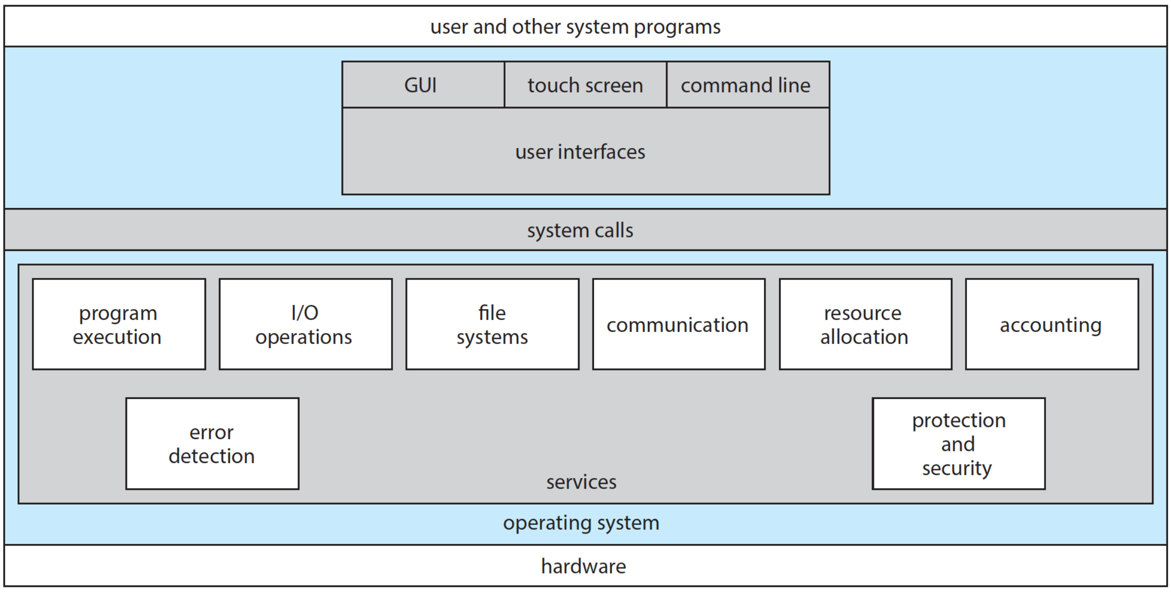
are caused by executing instructions (software)

System calls

a system call is a special kind of trap

every **Instruction Set Architecture(ISA)** provide a system call instruction

OS Structures



Components

- Process Management
- Main-Memory Management
- Secondary-Storage Management
- File Management
- I/O System management
- User Interfaces
- Networking
- Protection System

Processes

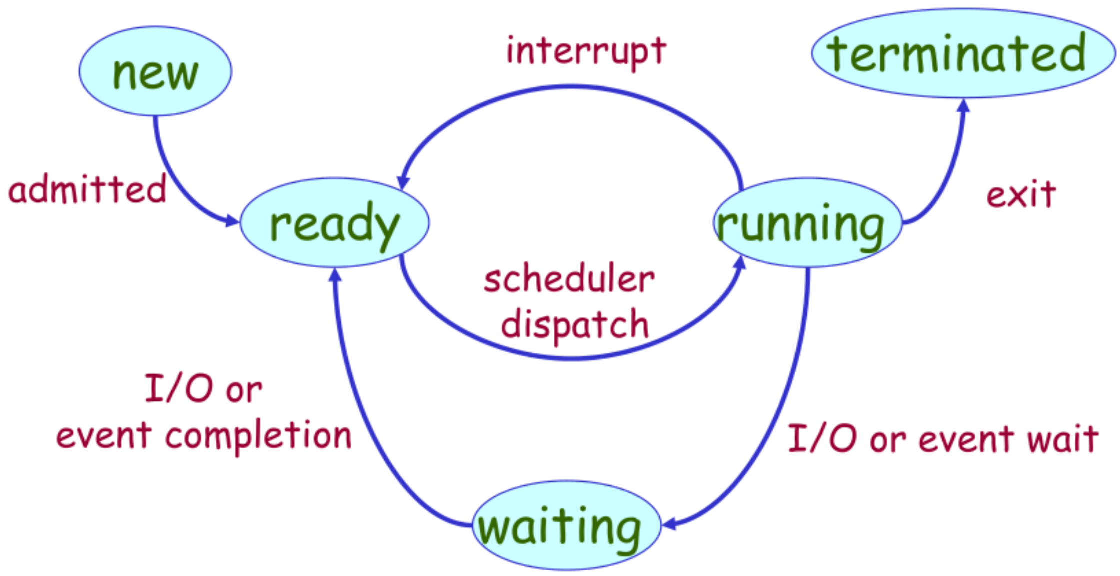
Process is an **instance** of a program running on a computer

Operating system processes and **User processes**

process **active, dynamic, temporary**
program **passive, static, permanence**

the **elements** of process and program are different

> Process: Process Control Block(PCB)
> Program: Code and Data



Scheduler

- **Long-term scheduler** - job scheduling, select job from external storage to memory and create a process
  - invoked **very infrequently** (seconds, minutes) -> (may be slow)
- **Short-term scheduler** - process scheduling, select the ready process to run on the processor
  - invoked **very frequently** (milliseconds) -> (must be fast)
- **Medium-term scheduler** - solves the problem of insufficient memory, using secondary storage to alleviate

Context switch

system must **save the state of the old process** and **load the saved state for the new process**

interprocess communication

- Shared memory
- Message system
  - message queue

- Direction communication
  name each other explictly
- Indirect communication
  from **mailboxes**

Blocking vs Non-Blocking

Blocking

is considered **synchronous**
the sender is blocked until the message is received
the reciver is blocked until a message is available

Non-Blocking

is considered **asynchronous**
the sender sends the message and continue
the receiver receives a valid message or null

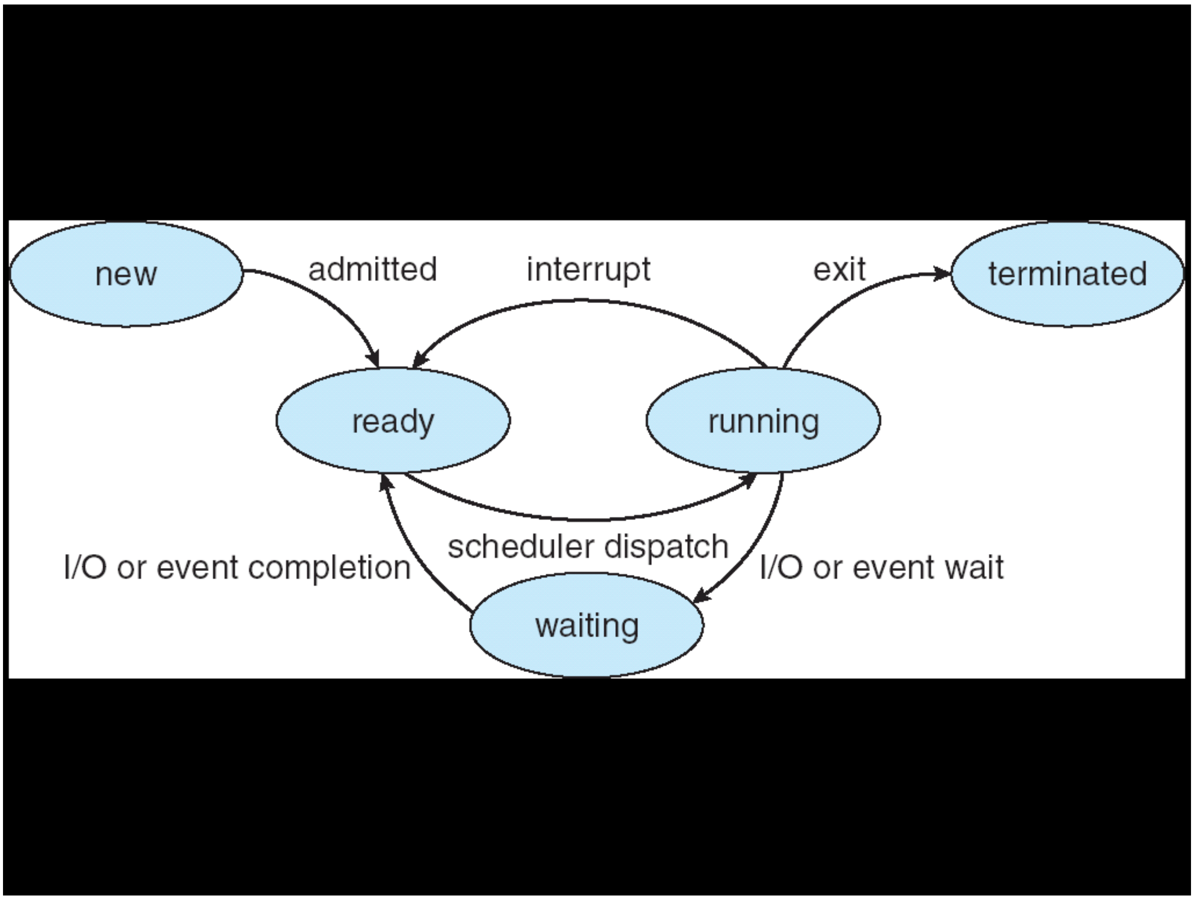
Thread

a sequential execution stream within a process

Process still contains a **single** address space
No protection between threads

Lifecycle of thread

same like process



Thread types

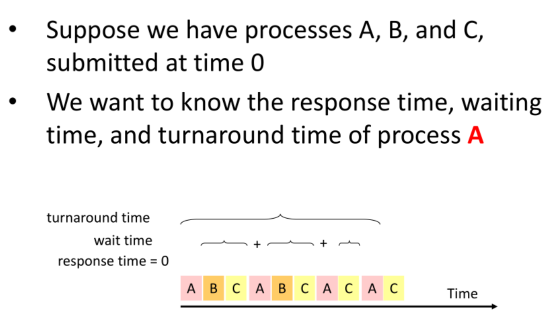
User-level threads
Kernel-supported thread 开销更大

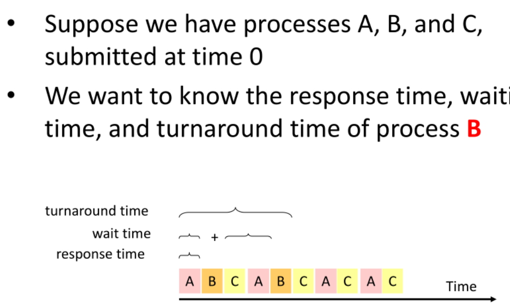
Thread pool

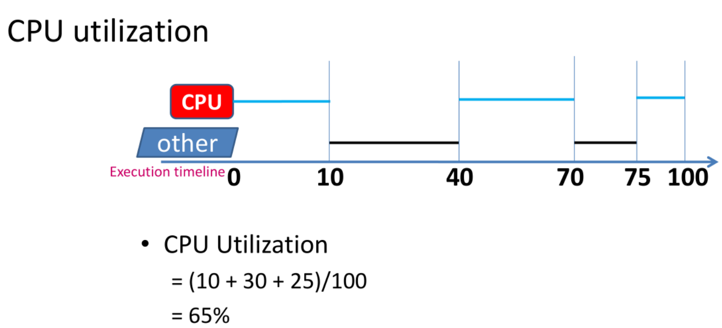
maintains **multiple threads** waiting for tasks to be allocated for concurrent execution

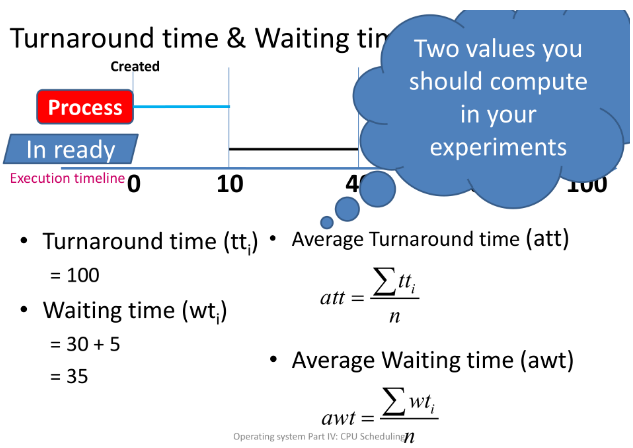
CPU Scheduling

- CPU utilization [**CPU 使用率**] (Efficiency)
  - keep the CPU as busy as possible (from 0% to 100%)
- Fairness: each process gets a “fair share” of the CPU
- Throughput [**吞吐量**]
  - of processes that complete their execution per time unit
- Turnaround time [**周转时间**]
  - amount of time to execute a particular Process
    • i.e. execution time + waiting time
- Waiting time [**等待时间**]
  - amount of time a process has been waiting in the ready queue
- Response time [**响应时间**]
  - amount of time it takes from when a request was submitteduntil the first response is produced , not output (for time-sharing environment)









Preemptive and nonpreemptive

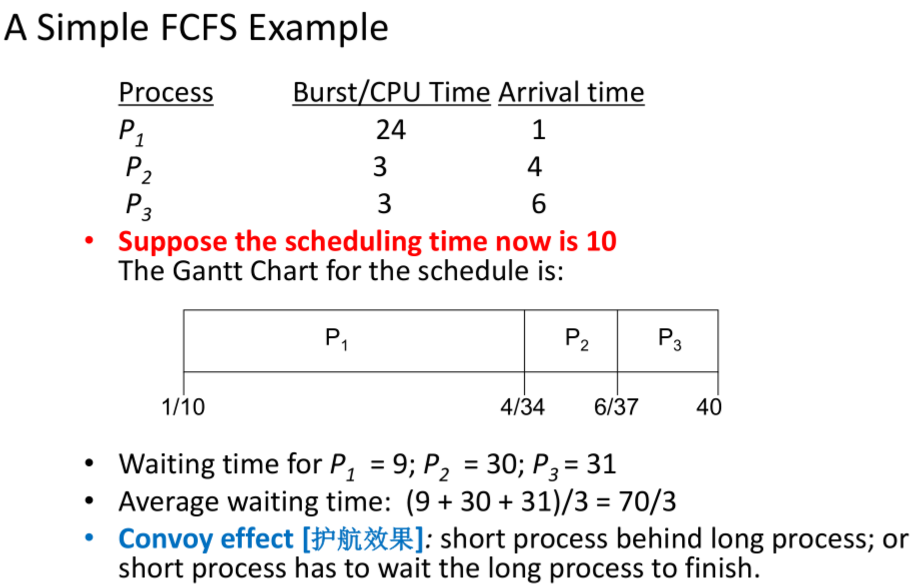
抢占和非抢占，是否实时进行监测，若非抢占直到一个process完成后才会进行调度

Different Scheduling Algorithms 必考!

FCFS first Come First Serve Scheduling

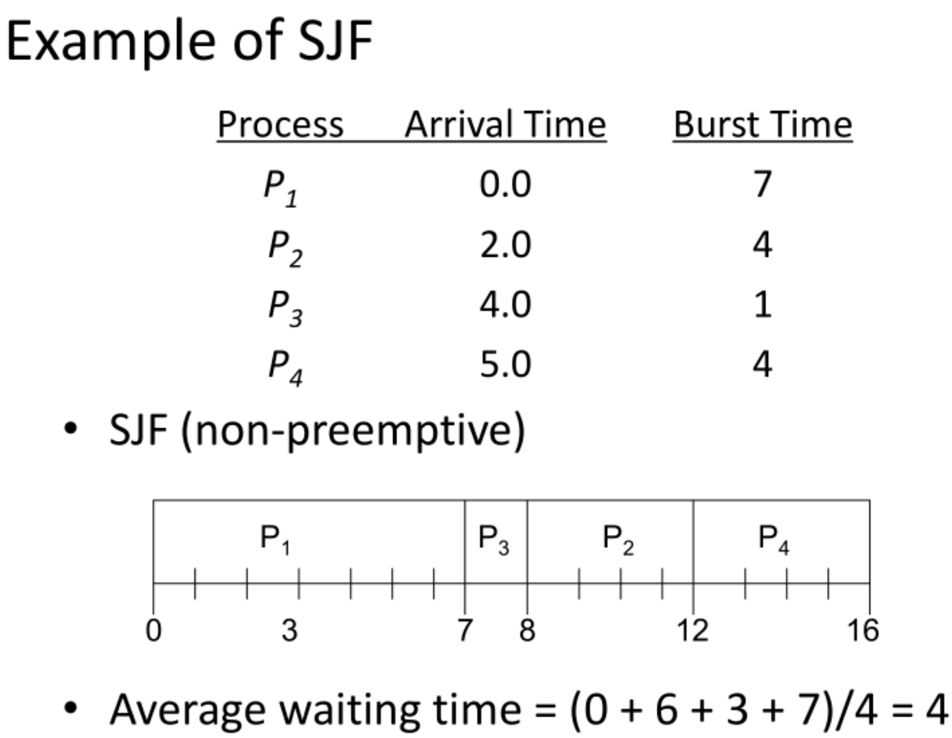
先来先做

画甘特图



Shortest Job First SJF

最短先做



Determining length of next CPU Burst

- Can only estimate the length.
- 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. $\alpha, 0 \le \alpha \le 1$
4. Define: $\tau_{n+1} = \alpha\, t_n + (1-\alpha)\tau_n.$

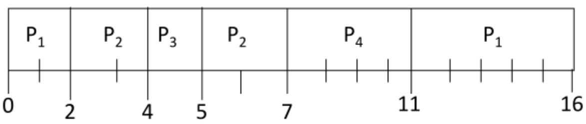
Shortest-Remaining-Job-First SRJF

剩的最少先做

Example of Preemptive SJF → SRTF

Process	Arrival Time	Burst Time
P_1	0.0	7
P_2	2.0	4
P_3	4.0	1
P_4	5.0	4

- SJF (preemptive)

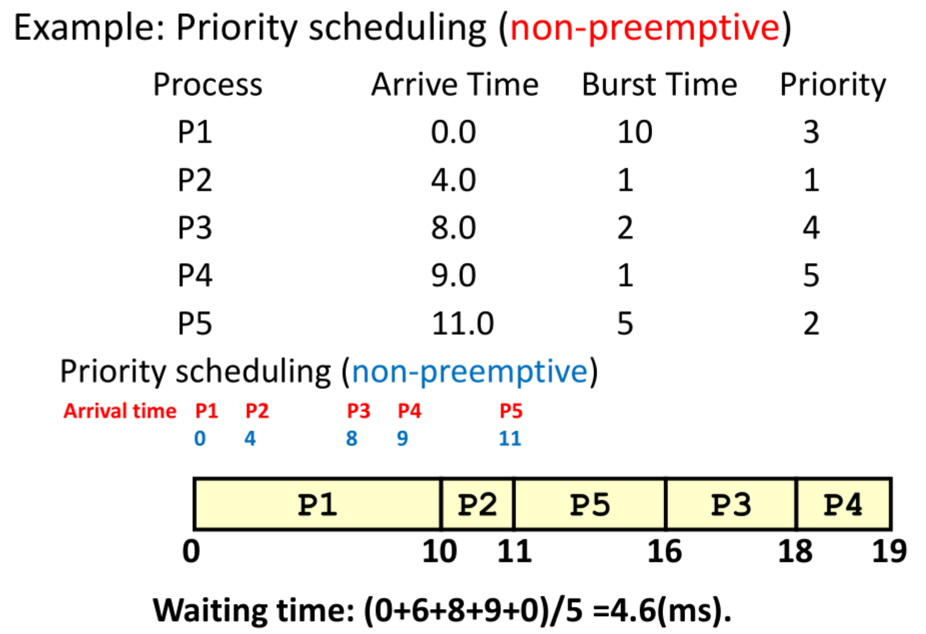


- Average waiting time = (9 + 1 + 0 +2)/4 = 3

Priority

越小等级越高

Preemptive 和 Non- preemptive的区别：Preemptive在有新进程加入中也是一个调度时间

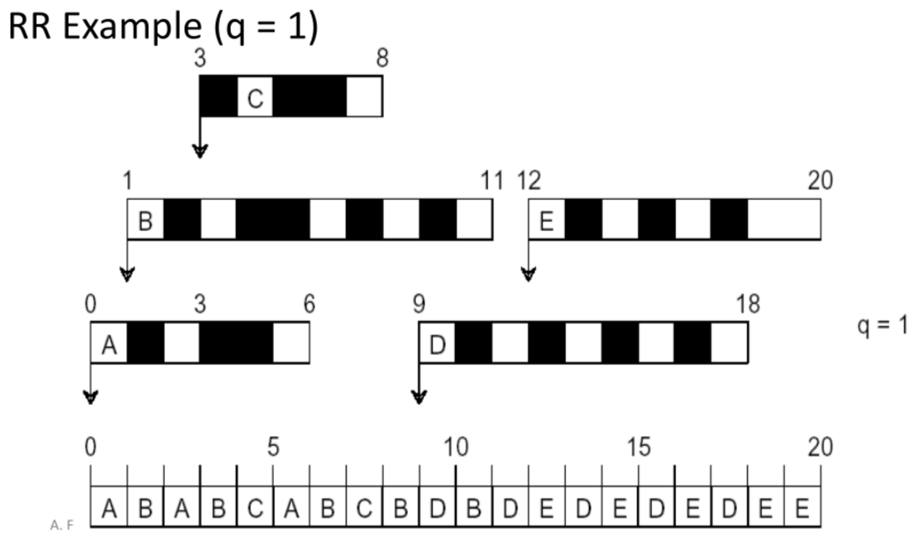

Example: Priority scheduling (non-preemptive)

Process	Arrive Time	Burst Time	Priority
P1	0.0	10	3
P2	4.0	1	1
P3	8.0	2	4
P4	9.0	1	5
P5	11.0	5	2

Aging - 随等待时间更多，优先级提高

Round-Robin Scheduling

Preemtive, 将CPU服务轮换切片



- Short quantum: great response/interactivity but high overhead
    - Hopefully not too high if the dispatcher is fast enough
- Long quantum: poor response/interactivity, but low overhead
    - With a very long time quantum, RR Scheduling becomes FCFS Scheduling

Hard vs soft realtime

- Hard real-time systems 不可出错
    - Requires to complete a critical task within a guaranteed amount of time
    - Missing a deadline is a total system failure
- Soft real-time systems 有容错
    - Requires that critical processes receive priority over less fortunate ones

- Can miss some deadlines, but eventually performance will degrade if too many are missed

Process Synchronization

Race condition竞争条件
The situation where several processes access and manipulate shared data concurrently. **The final value of the shared data depends upon which process finishes last.**
出现静态条件就会导致出现不确定性和不可重现性的现象

Atomic Operation原子操作
an operation that always runs to completion or not at all

一次不存在任何终端或者失败的操作

Mutual Exclusion互斥 (现象)
ensuring that only one process does a particular thing at a time

Critical Section临界区 (代码)
piece of code that **only one** process can execute at once. **Only one** process at a time will get into this section of code.

Critical section and mutual exclusion are two ways of describing the same thing.

Semaphore 信号量 必考！！

P(): an atomic operation that waits for semaphore to become positive, then decrements it by 1
think of this as the wait() operation

V(): an atomic operation that increments the semaphore by 1, waking up a waiting P, if any

two types semaphore

Binary semaphore - integer value can range only between 0 and 1; can be simpler to implement.
Also known as **mutex locks**
就是只有0和1两个值

Counting semaphore - integer value can range over an unrestricted domain.
Can implement a counting semaphore S as a binary semaphore.
计数信号量小于等于1

Deadlock and starvation

Deadlock死锁 - two or more processes are waiting

Starvation饥饿 - indefinite blocking. A process may never be removed from the semaphore queue in which it is suspended.

死锁一定会引起饥饿，但饥饿不一定会引起死锁

Deadlock

A set of blocked processes each holding a resource and waiting to acquire a resource held by another process in the set.

Requirement for Deadlock

- **Mutual exclusion**
  Only one process at a time can use a resource.
- **Hold and wait**
  Process is **holding** at least one resource and is **waiting** to acquire additional resources held by other processes
- **No preemption**
  Resources are released only voluntarily by the process holding the resource, after bprocess is finished with it
- **Circular wait**
  There exists a set { T 1 , ..., T n } of waiting processes

Deadlock avoidance algorithms

Single instance of a resource type
use a resource-allocation graph

Multiple instances of a resource type
use the **banker's algorithm**

银行家算法
把计算过程写出来，画整体的表格
每一次请求先判断
considers the resources currently **available** , the resources currently **allocated** , and the **future (Needed)** requests and releases of each process, and decides whether the current request can be satisfied or must wait to avoid a possible future deadlock.

Example 2:

- 5 processes P_0 through P_4;
  3 resource types:
  A (10 instances), B (5instances), and C (7 instances)

Snapshot at time T_0:

	Allocation	Max	Available
	A B C	A B C	A B C
P_0	0 1 0	7 5 3	3 3 2
P_1	2 0 0	3 2 2	
P_2	3 0 2	9 0 2	
P_3	2 1 1	2 2 2	
P_4	0 0 2	4 3 3	

available = total resource - max
然后选need再一步步来得到序列

Memory

Logical address - generated by the CPU
Physical address - address seen by the memory unit

Logical and physical addresses are **the same in compile- time and load-time address-binding schemes**
Logical and physical addresses **differ in execution-time address-binding scheme**

Storage allocation algorithm (可能考)

- **First-fit** : Allocate the **first** hole that is big enough
  首次匹配 最开始能够匹配的位置
- **Best-fit** : Allocate the **smallest** hole that is big enough; must search entire list, unless ordered by size
  Produces the smallest leftover hole
  最佳匹配找最小可以实现的
- **Worst-fit** : Allocate the largest hole; must also search entire list
  Produces the largest leftover hole
  最差匹配与best-fit相对
- **Next-fit**: Scans memory from the location of the last placement
  临近匹配 从上一次place的地方开始

Fragmentation

Internal Fragmentation
内碎片，分配在内存内部没有使用的内存

External Fragmentation
total memory space exists to satisfy a request, but it is not contiguous

Paging

page数据结构

Page	Frame

TLB

translation lookaside buffer is a memory cache that is used to reduce the time taken to access a user memory location.

Segmentation

Segmentation is a memory-management scheme that supports user view of memory

Virtual Memory

separation of user logical memory from physical memory.

Page fault

a page not in main memory

处理流程

1. Operating system looks at another table to decide:
    - Invalid reference -> abort
    - Just not in memory
2. Get empty frame
3. Swap page into frame
4. Reset table
5. Set validation bit = v
6. Restart the instruction that caused the page fault

Page replacement algorithm

FIFO/FCFS

first in first out

- 7 page faults

Memory frame	B	E	E	R	B	A	R	E	B	E	A	R
1	B				*	A					*	R
2		E	*					*	B			
3				R			*			E		

Optimal/Minimum Page Replacement

Impossible to implement (need to know thefuture) but serves as a standard to compare with the other algorithms we shall study.

- 6 page faults

Memory frame	B	E	E	R	B	A	R	E	B	E	A	R
1	B				*	A					*	R
2		E	*					*		*		
3				R			*		B			

LRU(Least Recently Used) Policy

Replaces the page that has not been referenced for the longest time recently

- 8 page faults

Memory frame	B	E	E	R	B	A	R	E	B	E	A	R
1	B				*			E		*		
2		E	*			A			B			R
3				R			*				A	

Clock Policy

- Replaces an old page, but not the oldest page
- Arranges physical pages in a circle
- Each page has a used bit
  - Set to 1 on reference
  - On page fault, sweep the clock hand
    - If the used bit == 1, set it to 0 and advance the hand
    - If the used bit == 0, pick the page for replacement

享受机会可以踢掉

7 page faults

Now put R here !

Memory frame	B	E	E	R	B	A	R	E	B	E	A	R
1	B*				*	A*			A		*	R*
2		E*	*			E		*	B*			B
3				R*		R	*		R	E*		E

File System

File System: Layer of OS that transforms block interface of disks (or other block devices) into Files,
Directories, etc.
File : user-visible group of blocks arranged sequentially in logical space
file is **a collection of blocks**
Directory : user-visible index mapping names to files (later)

Organize files on disk

Continuous Allocation 连续存储

Use continuous range of blocks in logical block space

Linked List Approach 链式存储

- Each block, pointer to next on disk
- File-Allocation Table (FAT)

Indexed Files

System allocates file header block to hold array of pointers big enough to point to all blocks

inode... 计算题或大题

> Key idea: efficient for small files, but still allow big files
> **“ inode ”** in Linux:
>
> 15 pointers
> Block size: 1KB
> Pointer length: 4Byte
> First 12 pointers are to data blocks
> Pointer 12 points to “indirect block” containing 256 block ptrs
> Pointer 13 points to “doubly indirect block” containing 256 indirect block ptrs for total of 64K blocks
> Pointer 14 points to a triply indirect block (16M blocks)
> **MAX file size: 12K+256K+64M+16G**

File control block (FCB)

All information about a file contained in its File Control Block (FCB)
UNIX calls this an “inode”

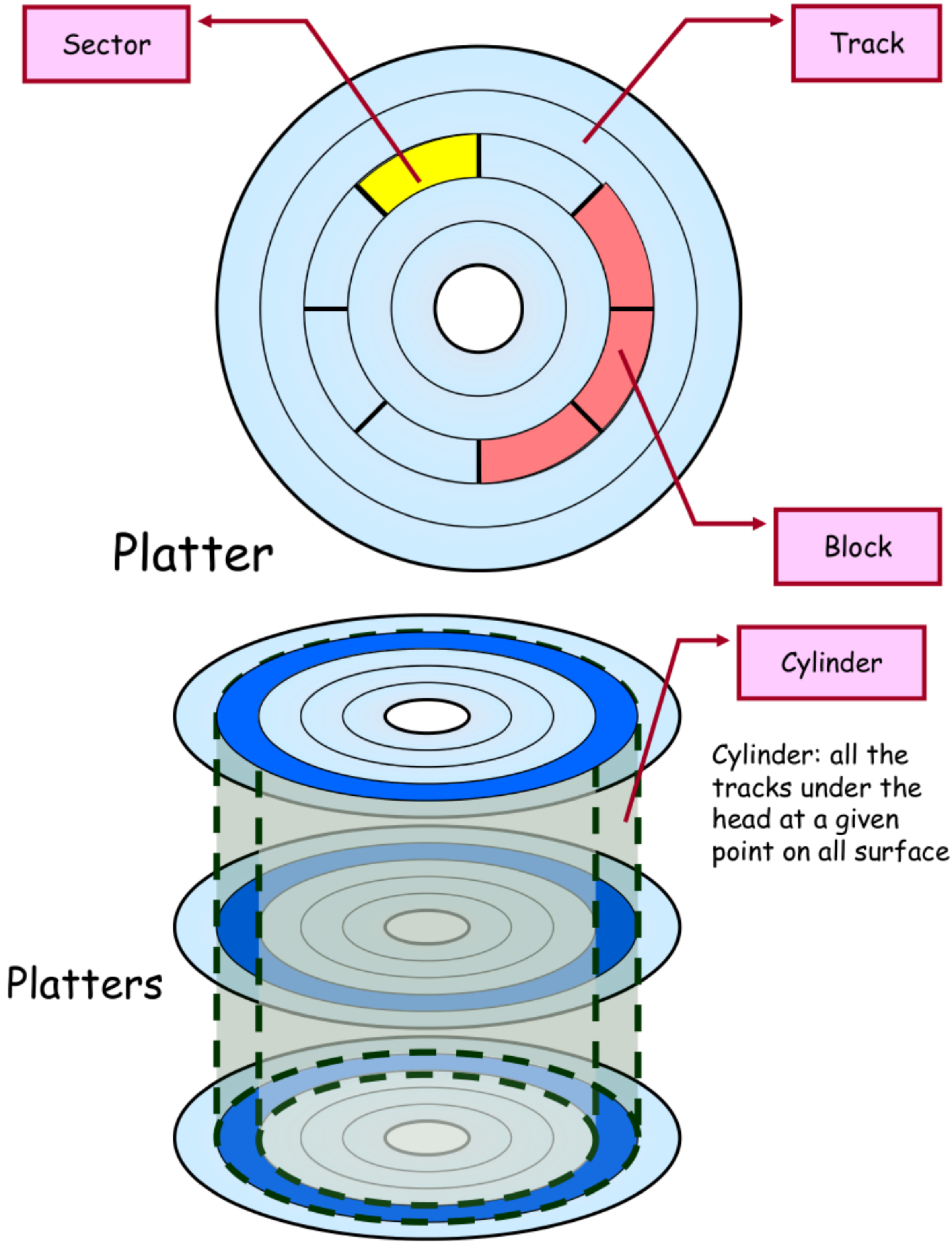
Manage free space on disk

- Linked Free Space List
- Bit map
  Bit vector (use on bit to indicate block status)
- Grouping
- Counting

Directory structures

- Single-level directory
- Two-level directory
- Tree-structured directory (more common)
- Acyclic-graph directory (cycle-detection is expensive)

Mass Storage Structure



Platter, Track, Sector, Block, Cylinder

Disk Rotational latency time
转到合适的扇区的延迟

Disk seek time
磁头找到合适的轨道的延迟

Transfer time
复制bits从磁面到内存

Random access/ Positioning Time

seek + latency

Access Time

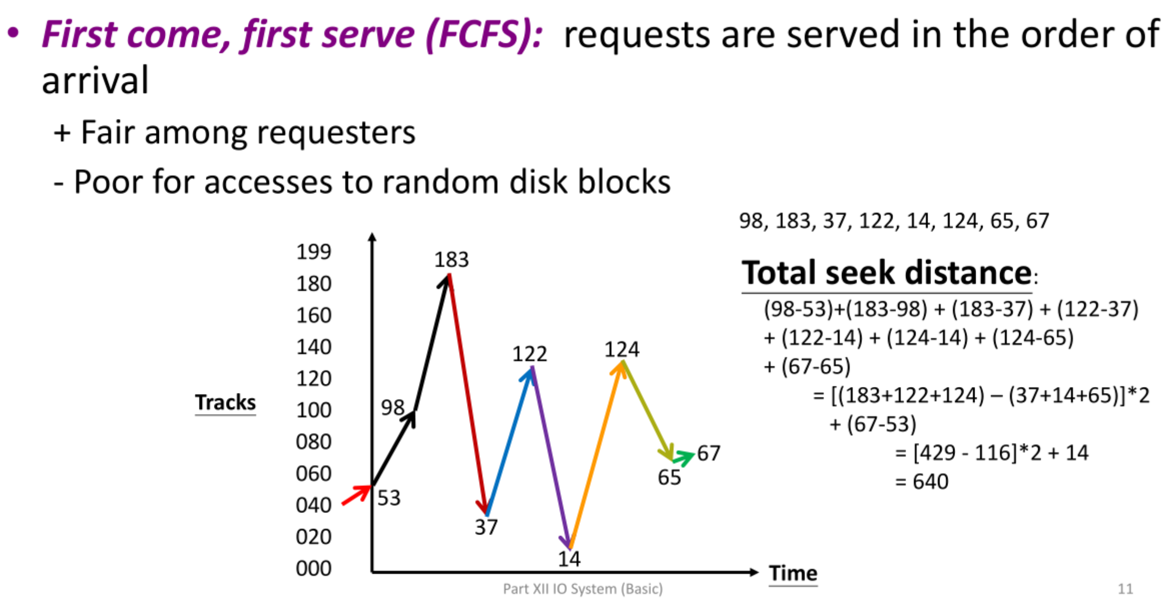
seel + latency + transfer

> 8 platter surfaces; 1024 tracks per surface; 64 sectors per track; 1KByte per sector. Average seek time is 8ms; rotate at 7200 rpm.
> • What is the size of this hard disk?
> 8×1024×64×1K = 512 MB
> • What is the average positioning time?
> 8+(60×1000)/7200/2 = 12.17 ms
> **注意rpm计算出rotational latency time需要用60000ms除以rpm除2**

I/0 requests algorithm (大概率考)

Several algorithms exist to schedule the disk I/O requests
We illustrate them **with a request queue (0-199).**
– 98, 183, 37, 122, 14, 124, 65, 67
– After visiting 40, current Head pointer is at 53

FCFS 先来先服务

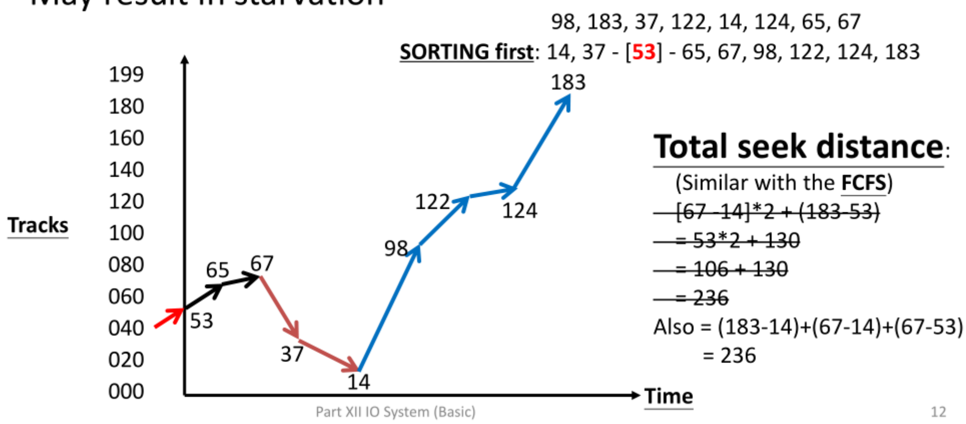


SSTF 最短寻道时间优先

- ***Shortest seek time first (SSTF):*** picks the request that is closest to the current disk arm position

  \+ Good at reducing seeks

  \- May result in starvation



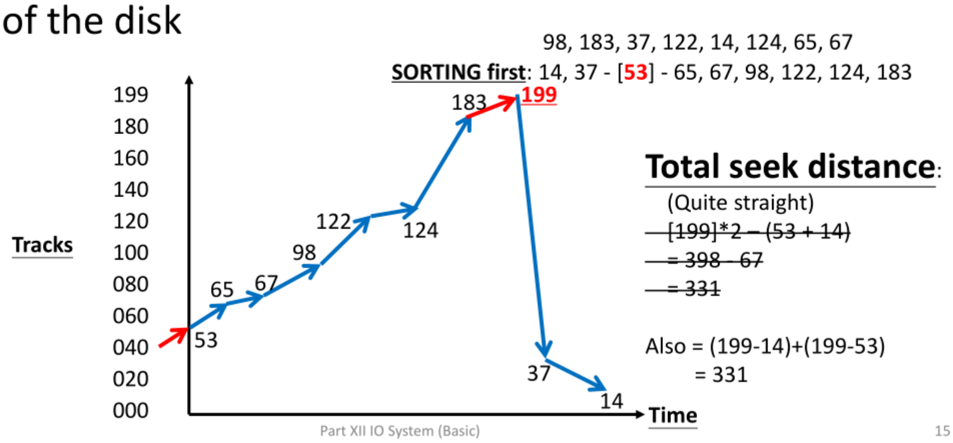
elevator algorithm电梯算法

Direction \ Go until	Go until the last cylinder	Go until the last request
Service both directions	Scan	Look
Service in only one direction	C-Scan	C-Look

SCAN

- ***SCAN:*** takes the closest request in the direction of travel (an example of elevator algorithm)

  \- a new request can wait for almost two full scans of the disk



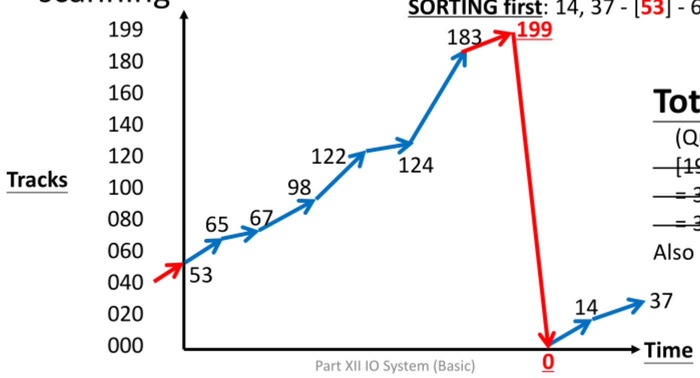
C-SCAN

C-SCAN

- ***Circular SCAN (C-SCAN):*** disk arm always serves requests by scanning in one direction.
  - Once the arm finishes scanning for one direction
  - Returns to the 0th track for the next round of scanning

98, 183, 37, 122, 14, 124, 65, 67

SORTING first: 14, 37 - [53] - 65, 67, 98, 122, 124, 183



Total seek distance:

(Quite straight)

~~[199-0]*2 + (37-53)~~

~~= 398 - 16~~

~~= 382~~

Also = (199-53)+(199-0)+(37-0)

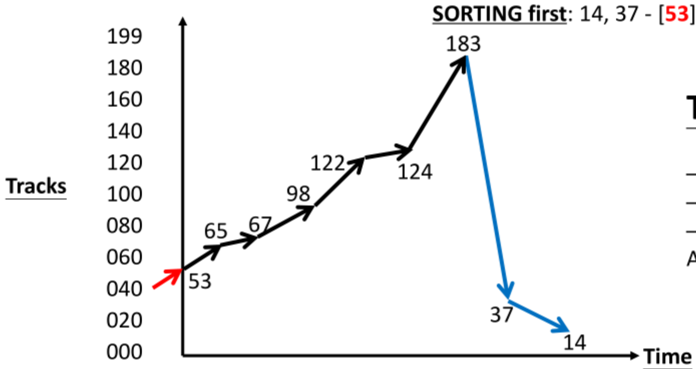
= 382

Part XII IO System (Basic) 18

LOOK

98, 183, 37, 122, 14, 124, 65, 67

SORTING first: 14, 37 - [53] - 65, 67, 98, 122, 124, 183



Total seek distance:

(Quite straight)

~~[183]*2 – (53 + 14)~~

~~= 366 - 67~~

~~= 299~~

Also = (183-53)+(183-14)

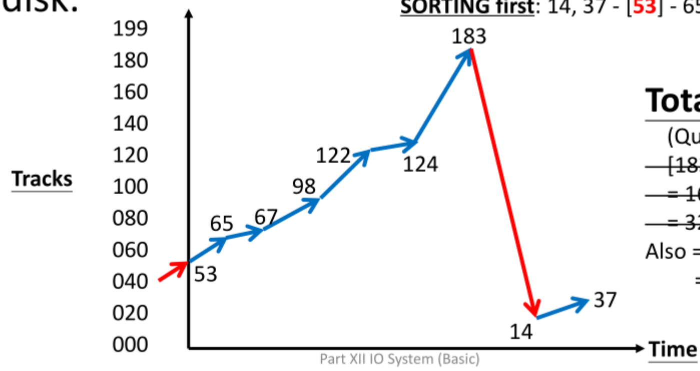
= 299

C-LOOK

- Variation of C-SCAN
- Arm only goes as far as the last request in each direction, then reverses direction immediately, without first going all the way to the end of the disk.

98, 183, 37, 122, 14, 124, 65, 67

SORTING first: 14, 37 - [53] - 65, 67, 98, 122, 124, 183



Total seek distance:

(Quite straight)

~~[183 - 14]*2 + (37-53)~~

~~= 169*2 - 16~~

~~= 322~~

Also = (183-53)+(183-14)+(37-14)

= 322

Part XII IO System (Basic) 22

IO System

Dimensions of I/O devices

- Character-stream or block
- Sequential or random-access
- Sharable or dedicated
- Speed of operation
- Read-write, read only, or write only

I/O Hardware

- Common concepts
  - Port -- address
  - Bus
  - Controller (host adapter)
    - Contains a set of registers that can be read and written
    - May contain memory
- I/O instructions control devices
- Devices have addresses

Polling, Interrupt-driven I/O, DMA

- Polling
  - The host repeatedly reads the busy bit until that bit becomes clear
- Interrupt-driven I/O
  - CPU is responsible for moving chars to/from controller buffer
  - Interrupt signal informs CPU when IO operation completes
- DMA - Direct Memory Access
  - Bypasses CPU to transfer data directly between I/O device and memory
- SPOOLing (Simultaneous Peripheral Operation On Line)
  hold output for a device
  If device can serve only one request at a time