Subject Name Solutions

4331602 – Winter 2023

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Draw the architecture of Linux and explain various layers in brief.

Solution

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[User Applications] {-{-}{} B[System Call Interface]}
    B {-{-}{} C[Kernel]}
    C {-{-}{} D[Device Drivers]}
    D {-{-}{} E[Hardware]}

    C {-{-}{} F[Process Management]}
    C {-{-}{} G[Memory Management]}
    C {-{-}{} H[File System]}
    C {-{-}{} I[Network Management]}
{Highlighting}
{Shaded}
```

- **User Space**: Contains user applications and system utilities
- **System Call Interface**: Provides interface between user programs and kernel
- **Kernel Space**: Core operating system with process, memory, file management

Mnemonic

"Users System Kernel Drives Hardware"

Question 1(b) [4 marks]

What is a race condition? Explain with a suitable example.

Solution

Aspect	Description
Definition	Multiple processes accessing shared resource simultaneously
Problem	Unpredictable results due to timing dependency
Example	Bank account balance update by two transactions

Example Process:

- **Process A**: Reads balance = 1000, adds 100
- **Process B**: Reads balance = 1000, subtracts 50

- **Result**: Final balance could be 1050, 950, or 1100 instead of correct 1050

Mnemonic

"Race Results Random Resources"

Question 1(c) [7 marks]

List different types of Operating systems. Explain the working of multiprogramming operating systems with a suitable example.

Solution

Table 1: Types of Operating Systems

Type	Characteristics	Example
Batch	Jobs processed in batches	IBM mainframes
Time-sharing	Multiple users simultaneously	UNIX
Real-time	Immediate response required	Air traffic control
Distributed	Multiple connected computers	Google cluster
Multiprogramming	Multiple programs in memory	Windows, Linux

Multiprogramming Working:

- **Memory Management**: Multiple programs loaded simultaneously
- **CPU Scheduling**: Switches between programs when I/O occurs
- **Resource Sharing**: Efficient utilization of CPU and memory
- **Example**: Word processor, music player, and browser running together

Mnemonic

"Multiple Programs Maximize Performance"

Question 1(c OR) [7 marks]

List different types of Operating systems. Explain the Batch operating systems in detail.

Solution

Types of Operating Systems: Same table as above.
Batch Operating System Details:

- **Job Collection**: Jobs collected offline and grouped into batches
- **Sequential Processing**: Jobs executed one after another without user interaction
- **No Direct Interaction**: User submits job and collects output later
- **Efficiency**: High throughput for similar type jobs
- **Disadvantages**: No real-time processing, long turnaround time

Mnemonic

"Batch Brings Better Business"

Question 2(a) [3 marks]

Draw and explain the Process life cycle.

Solution

Diagram:

```
stateDiagram{-v2}
  direction LR
    [*] {-{-} New}
    New {-{-} Ready : Admitted}
    Ready {-{-} Running : Scheduler\_dispatch}
    Running {-{-} Ready : Interrupt}
    Running {-{-} Waiting : I/O\_request}
    Waiting {-{-} Ready : I/O\_completion}
    Running {-{-} Terminated : Exit}
    Terminated {-{-} [*]}
```

- **New**: Process being created
- **Ready**: Process waiting for CPU assignment
- **Running**: Process currently executing
- **Waiting**: Process waiting for I/O operation
- **Terminated**: Process has finished execution

Mnemonic

"New Ready Running Waiting Terminated"

Question 2(b) [4 marks]

Define deadlock and discuss necessary conditions for a deadlock to occur.

Solution

Definition: Deadlock occurs when processes wait indefinitely for resources held by other processes.

Table 2: Deadlock Conditions

Condition	Description
Mutual Exclusion	Resources cannot be shared
Hold and Wait	Process holds resource while waiting for another
No Preemption	Resources cannot be forcibly taken
Circular Wait	Processes form circular chain of resource dependencies

Mnemonic

"My Hold Never Circles"

Question 2(c) [7 marks]

Describe the Round Robin algorithm. Calculate the average waiting time & average turn-around time along with Gantt chart for the given data. Consider context switch = 01 ms and quantum time = 05 ms.

Solution

Round Robin Algorithm:

- **Time Quantum**: Fixed time slice for each process
- **Preemptive**: Process preempted after quantum expires
- **Fair Scheduling**: Equal CPU time distribution

Given Data:

- Context Switch = 1 ms, Quantum = 5 ms

Gantt Chart:

```
|P1|CS|P2|CS|P3|CS|P4|CS|P1|CS|P3|CS|P1|CS|P3|CS|
0  5  6 10 11 16 17 22 23 28 29 34 35 40 41 46 47
```

Calculations Table:

Process	Arrival	Burst	Completion	Turnaround	Waiting
P1	0	12	40	40	28
P2	3	4	10	7	3
P3	2	15	46	44	29
P4	5	5	22	17	12

- **Average Waiting Time**: (28+3+29+12)/4 = 18 ms
- **Average Turnaround Time**: (40+7+44+17)/4 = 27 ms

Mnemonic

"Round Robin Rotates Regularly"

Question 2(a OR) [3 marks]

Differentiate: CPU bound process v/s I/O bound process.

Solution

Table 3: CPU vs I/O Bound Processes

Aspect	CPU Bound	I/O Bound
CPU Usage	High CPU utilization	Low CPU utilization
I/O Operations	Minimal I/O	Frequent I/O
Examples	Mathematical calculations	File operations
Scheduling	Needs longer time quantum	Benefits from shorter quantum
Performance	Limited by CPU speed	Limited by I/O speed

Mnemonic

"CPU Computes, I/O Interacts"

Question 2(b OR) [4 marks]

Define Critical Section and discuss the general structure of a critical section solution.

Solution

Definition: Critical section is code segment where shared resources are accessed and must be executed atomically.

Table 4: Critical Section Structure

Section	Purpose
Entry Section	Request permission to enter critical section
Critical Section	Code accessing shared resources
Exit Section	Release permission
Remainder Section	Other code not accessing shared resources

Solution Requirements:

- **Mutual Exclusion**: Only one process in critical section
- **Progress**: Selection of next process cannot be postponed indefinitely
- **Bounded Waiting**: Limit on waiting time

Mnemonic

"Enter Critical Exit Remainder"

Question 2(c OR) [7 marks]

Describe the SJF algorithm. Calculate the average waiting time and average turn-around time along with Gantt chart for the given data.

Solution

SJF Algorithm:

- **Shortest Job First**: Process with smallest burst time scheduled first
- **Non-preemptive**: Process runs to completion
- **Optimal**: Minimizes average waiting time

Execution Order: P2(4), P4(5), P1(8), P3(9)

Gantt Chart:

```
|  P1  |  P2  |  P4  |     P3     |
0      8      12     17           26
```

Calculations Table:

Process	Arrival	Burst	Start	Completion	Turnaround	Waiting
P1	0	8	0	8	8	0
P2	3	4	8	12	9	5
P3	5	9	17	26	21	12
P4	6	5	12	17	11	6

- **Average Waiting Time**: (0+5+12+6)/4 = 5.75 ms
- **Average Turnaround Time**: (8+9+21+11)/4 = 12.25 ms

Mnemonic

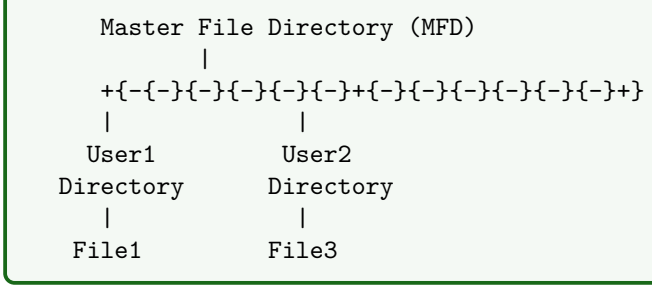
"Shortest Jobs Start Soon"

Question 3(a) [3 marks]

Explain two-level directory structure.

Solution

Diagram:



```
File2          File4
```

- **Master File Directory**: Contains entries for each user
- **User File Directory**: Separate directory for each user's files
- **Path Structure**: /user/filename
- **Advantages**: Solves naming conflicts, provides user isolation

Mnemonic

"Two Tiers Tackle Troubles"

Question 3(b) [4 marks]

Explain the different file operations.

Solution

Table 5: File Operations

Operation	Purpose	Example
Create	Make new file	touch file.txt
Open	Access file for operations	fopen()
Read	Retrieve data from file	fread()
Write	Store data to file	fwrite()
Close	Terminate file access	fclose()
Delete	Remove file	rm file.txt

Mnemonic

"Create Open Read Write Close Delete"

Question 3(c) [7 marks]

List the different file allocation methods and explain contiguous allocation with necessary diagram.

Solution

File Allocation Methods:

- **Contiguous Allocation**
- **Linked Allocation**
- **Indexed Allocation**

Contiguous Allocation:

Diagram:

```
File A: |Block1|Block2|Block3|
File B: |Block4|Block5|
File C: |Block6|Block7|Block8|Block9|
```

Table 6: Contiguous Allocation

Aspect	Description
Storage	Files stored in consecutive blocks
Access	Direct access to any block
Advantages	Fast access, simple implementation
Disadvantages	External fragmentation, difficult expansion

Directory Entry: (Start block, Length)

Mnemonic

"Contiguous Creates Continuous Clusters"

Question 3(a OR) [3 marks]

Describe the types of file structures.

Solution

Table 7: File Structure Types

Type	Organization	Access
Sequential	Records in order	Sequential only
Direct/Random	Records by key	Direct access
Indexed	Index points to records	Key-based access
Hierarchical	Tree structure	Path-based

Mnemonic

"Sequential Direct Indexed Hierarchical"

Question 3(b OR) [4 marks]

Explain the different file attributes.

Solution

Table 8: File Attributes

Attribute	Description	Example
Name	File identifier	document.txt
Type	File format	.txt, .exe
Size	File length in bytes	1024 bytes
Location	Physical storage address	Block 150
Permissions	Access rights	rwx-rwx-rwx
Timestamps	Creation, modification dates	2023-01-16

Mnemonic

"Name Type Size Location Permissions Time"

Question 3(c OR) [7 marks]

List the different file allocation methods and explain linked allocation with necessary diagram.

Solution

File Allocation Methods: Same as previous answer.
Linked Allocation:

Diagram:

```
File A: Block1  Block5  Block9  NULL
File B: Block2  Block7  NULL
File C: Block3  Block4  Block8  NULL
```

Table 9: Linked Allocation

Aspect	Description
Storage	Files stored in linked blocks
Pointers	Each block contains pointer to next
Advantages	No external fragmentation, dynamic size
Disadvantages	Sequential access only, pointer overhead

Directory Entry: (Start block pointer)

Mnemonic

"Links Lead Logical Locations"

Question 4(a) [3 marks]

Define Program threats and explain its types.

Solution

Definition: Program threats are malicious programs that compromise system security and integrity.

Table 10: Program Threat Types

Type	Description
Trojan Horse	Hidden malicious code in legitimate program
Virus	Self-replicating code that infects other programs
Worm	Standalone program that replicates across networks
Logic Bomb	Code triggered by specific conditions

Mnemonic

"Trojans Viruses Worms Logic-bombs"

Question 4(b) [4 marks]

Explain System Authentication.

Solution

Definition: Process of verifying user identity before granting system access.

Table 11: Authentication Methods

Method	Description	Example
Password	Secret text string	username/password
Biometric	Physical characteristics	Fingerprint, retina
Token	Physical device	Smart card, USB key
Multi-factor	Combination of methods	Password + OTP

Authentication Process:

- **Identification**: User claims identity
- **Verification**: System validates claim
- **Authorization**: Access rights granted

Mnemonic

"Passwords Biometrics Tokens Multi-factor"

Question 4(c) [7 marks]

Explain Access Control List in detail.

Solution

Definition: ACL specifies permissions for each user/group on system resources.

Table 12: ACL Components

Component	Purpose	Example
Subject	User or group	john, admin_group
Object	Resource	file.txt, directory
Permission	Allowed operations	read, write, execute
Action	Allow or deny	permit, deny

ACL Structure:

```
User: john    File: /etc/passwd    Permission: read    Action: allow
Group: users  File: /tmp/*        Permission: write   Action: allow
User: guest   File: /etc/*        Permission: write   Action: deny
```

Advantages:

- **Granular Control**: Fine-grained permissions
- **Flexibility**: Per-resource access control
- **Scalability**: Handles complex organizations

Mnemonic

"Access Controls Limit Users"

Question 4(a OR) [3 marks]

Define System threats and explain its types.

Solution

Definition: System threats target operating system components and system integrity.

Table 13: System Threat Types

Type	Description
Denial of Service	Overwhelm system resources
Privilege Escalation	Gain unauthorized higher privileges
Buffer Overflow	Exploit memory management flaws
Rootkit	Hide malicious activities from detection

Mnemonic

"Denial Privilege Buffer Rootkit"

Question 4(b OR) [4 marks]

Discuss the needs and goals of protection in OS.

Solution

Table 14: Protection Needs and Goals

Need	Goal	Implementation
Confidentiality	Prevent unauthorized access	Access controls
Integrity	Maintain data accuracy	Checksums, validation
Availability	Ensure resource access	Redundancy, backup
Authentication	Verify user identity	Login mechanisms

Protection Mechanisms:

- **Access Control**: Limit resource access
- **Capability Lists**: Define user permissions
- **Security Domains**: Isolate processes

Mnemonic

"Confidentiality Integrity Availability Authentication"

Question 4(c OR) [7 marks]

Discuss various operating system security policies and procedures.

Solution

Table 15: Security Policies and Procedures

Policy Type	Description	Procedure
Access Control	Define user permissions	Regular audit, role-based access
Password Policy	Password requirements	Complexity rules, expiration
Backup Policy	Data protection strategy	Regular backups, testing
Incident Response	Security breach handling	Detection, containment, recovery

Security Procedures:

- **Regular Updates**: Patch management
- **Monitoring**: Log analysis, intrusion detection

- **Training**: User security awareness
- **Audit**: Compliance checking

Mnemonic

"Access Password Backup Incident"

Question 5(a) [3 marks]

Explain the following commands: (i) pwd (ii) cd (iii) comm

Solution

Table 16: Linux Commands

Command	Purpose	Example
pwd	Print working directory	pwd → */home/user*
cd	Change directory	cd /tmp
comm	Compare sorted files	comm file1.txt file2.txt

- **pwd**: Shows current directory path
- **cd**: Navigate between directories
- **comm**: Displays common and unique lines between files

Mnemonic

"Print Working Directory, Change Directory, Compare Common"

Question 5(b) [4 marks]

Write a shell script to concatenate the contents of two files in a third file.

Solution

Shell Script:

```
\#!/bin/bash
\# Script to concatenate two files into third file

echo "Enter first file name:"
read file1
echo "Enter second file name:"
read file2
echo "Enter output file name:"
read file3

\# Check if input files exist
if [ {-f} "$file1" ] \&\& [ {-f} "$file2" ]; then
    cat "$file1" "$file2" {} "$file3"
    echo "Files concatenated successfully into $file3"
else
    echo "Error: Input files not found"
fi
```

Mnemonic

"Cat Combines Content Correctly"

Question 5(c) [7 marks]

Write a shell script to find the sum of all the individual digits in a given 5 digit number.

Solution

Shell Script:

```
\#!/bin/bash
\# Script to find sum of digits in 5{-digit number}

echo "Enter a 5{-digit number:"}
read number

\# Validate input
if [ $\{\#number\} {-ne} 5 ]; then
    echo "Error: Please enter exactly 5 digits"
    exit 1
fi

sum=0
temp=$number

\# Extract and sum each digit
while [ $temp {-gt} 0 ]; do
    digit=$(($temp \% 10))
    sum=$(($sum + $digit))
    temp=$(($temp / 10))
done

echo "Sum of digits in $number is: $sum"
```

Algorithm:

- **Input Validation**: Check for 5-digit number
- **Digit Extraction**: Use modulo operation
- **Sum Calculation**: Add each digit
- **Display Result**: Show final sum

Mnemonic

"Sum Separates Single Symbols"

Question 5(a OR) [3 marks]

Explain the following commands: (i) man (ii) mkdir (iii) grep

Solution

Table 17: Linux Commands

Command	Purpose	Example
man	Display manual pages	man ls
mkdir	Create directories	mkdir newdir
grep	Search text patterns	grep "hello" file.txt

- **man**: Provides documentation for commands
- **mkdir**: Creates new directories with specified names
- **grep**: Searches for patterns in files using regular expressions

Mnemonic

"Manual Make Directories, Grep Examines Patterns"

Question 5(b OR) [4 marks]

Write a shell script to generate and display Fibonacci series.

Solution

Shell Script:

```
\#!/bin/bash
\# Script to generate Fibonacci series

echo "Enter number of terms:"
read n

\# Validate input
if [ $n {-le} 0 ]; then
    echo "Error: Please enter positive number"
    exit 1
fi

\# Initialize first two terms
a=0
b=1

echo "Fibonacci Series:"
echo {-n} "$a "

if [ $n {-gt} 1 ]; then
    echo {-n} "$b "
fi

\# Generate remaining terms
for ((i=3; i{=}n; i++)); do
    c=$(($a + $b))
    echo {-n} "$c "
    a=$b
    b=$c
done
echo
```

Mnemonic

"Fibonacci Follows Forward Formula"

Question 5(c OR) [7 marks]

Write a shell script to determine whether a given string is palindrome.

Solution

Shell Script:

```
\#!/bin/bash
\# Script to check if string is palindrome

echo "Enter a string:"
read string

\# Convert to lowercase and remove spaces
clean\_string=$(echo "$string" | tr {[:upper:]} {[:lower:]} | tr {-d} { })

\# Get string length
```

```
length=$\{\#clean\_string\}

\# Initialize flag
is\_palindrome=true

\# Check palindrome
for ((i=0; i{}length/2; i++)); do
    if [ "$\{clean\_string:$i:1\}" != "$\{clean\_string:$((length{-}1{-}i)):1\}" ]; then
        is\_palindrome=false
        break
    fi
done

\# Display result
if [ "$is\_palindrome" = true ]; then
    echo "{}$string{ is a palindrome"}
else
    echo "{}$string{ is not a palindrome"}
fi
```

Algorithm:

- **String Cleaning**: Convert to lowercase, remove spaces
- **Character Comparison**: Compare characters from both ends
- **Palindrome Check**: Verify if all comparisons match

Mnemonic

"Palindromes Proceed Perfectly Parallel"