Debugging is finding and fixing errors, or bugs.

Failure of an application can generate **core dump** file capturing memory of the process

Operating system failure can generate **crash dump** file containing kernel memory

Profiling is periodic sampling of instruction pointers to look for statistical trends.

Kernighan's Law: "Debugging is twice as hard as writing the code in the first place. Therefore, if you write the code as cleverly as possible, you are, by definition, not smart enough to debug

UX - User Experience, UI - User Interface

Thread: is the segment of a process means a process can have multiple threads and these multiple threads are contained within a process.

• A thread has **3 states: running, ready, and blocked.**

• Thread takes less time to terminate as compared to process

A thread is a **path of execution within a process**. A process can contain **multiple threads.**

Why Multithreading? A thread is also known as **lightweight process**

Process vs Thread? The primary difference is that threads within the same process run in a shared memory space, while processes run in separate memory spaces.

Threads are not independent of one another like processes are.

Advantages of Thread over Process

1. Responsiveness: If the process is divided into multiple threads, if one thread completes its execution, then its output can be immediately returned.

2. Faster context switch: Context switch time between threads is lower compared to process context switch. Process context switching requires more overhead from the CPU.

3. Effective utilization of a multiprocessor system: If we have multiple threads in a single process, then we can schedule multiple threads on multiple processors. This will make process execution faster.

4. Resource sharing: Resources like code, data, and files can be shared among all threads within a process. Note: stack and registers can't be shared among the threads. Each thread has its own stack and registers.

Types of Threads: There are two types of threads. 1) User Level Thread 2) Kernel Level Thread

Process means any program is in execution. **Process control block (PCB)** controls the operation of any process. Process execution must progress in **sequential fashion**

Process **Concept**: Program is a **passive** entity stored on disk (executable file); the **process is active**. Program becomes a process when an executable file is loaded into memory. Execution of a program started via GUI mouse clicks, command line entry of its name, etc One program can be several processes. Consider multiple users executing the same program.

Process **State**: As a process executes, it changes state **1) New**: The process is being created **2) Running:** Instructions are being executed **3) Waiting:** The process is waiting for some event to Occur **4) Ready:** The process is waiting to be assigned to a Processor **5) Terminated:** The process has finished execution.

Multithreading Models: Many-to-One, One-to-One, Many-to-Many

S.NO	PROCESS	THREAD
1.	Process means any program is in execution.	Thread means segment of a process.
2.	Process takes more time to terminate.	Thread takes less time to terminate.
3.	It takes more time for creation.	It takes less time for creation.
4.	It also takes more time for context switching.	It takes less time for context switching.
5.	Process is less efficient in term of communication.	Thread is more efficient in term of communication.
6.	Process consume more resources.	Thread consume less resources.
7.	Process is isolated.	Threads share memory.

1. **List types of Threads?** User level thread, Kernel level thread
2. **List 3 definitions of Threads?** a) A thread is a path of execution within a process. b) A thread is a lightweight process. c) Thread is a segment of process.
3. **States of Threads?** Running, Ready, Blocked
4. **Define Process?** A program in execution
5. **List States of Process?** States of process: New, Running, Waiting, Ready, Terminated
6. **List types of Pipes?** Ordinary Pipes, Named pipes
7. **Big Pic of OS:** User -> List of Services -> System Calls -> Kernel -> Interrupt -> CPU -> Processes -> Thread
8. **3 advantages of Threads?** Resource sharing, Responsiveness, Effective Utilization
9. **types of CPU Buses ?** Address Bus, Control Bus, Data Bus
10. **List elements of the CPU?** Control Unit, Arithmetic Logic Unit, Register, System Bus
11. **Define CISC and RISC?** CISC- Complex Instruction Set Computing, RISC- Reduced Instruction Set Computing
12. **4 hardware classifications of CPU?** Speed, Cache, Address bus, Data bus, Control bus, CPU scheduling
13. **3 components of OpenStack:** Compute, Storage, Image Service
14. **4 Core Components of OpenStack?** Nova, Swift, Cinder, Neutron
15. **OpenStack?** OpenStack is an open source infrastructure as a service initiative for creating and managing large groups of virtual private servers in a cloud computing environment.

Quiz Class: 1. 3 components of Openstack- Compute, Storage, Image Service
2. 4 core components of OpenStack- Nova, Swift, Cinder, Neutron, Keystone, horizon
3. OpenStack is an open source infrastructure as a service (IaaS) initiative for creating and managing large groups of virtual private servers in a cloud computing environment.
4. Types of cloud computing: public, private, hybrid
5. 3 services of cloud computing: infrastructure, software, platform

Instruction set – list of commands the CPU can understand and carry out
Main difference between the two design types is the number of **different instructions the chip can process.**
CISC and RISC CPUs differ in the following ways: 1) Complex versus simple instructions 2) Clock cycles 3) Pipelining: The ability of the CPU to perform more than one task on a single clock cycle 4) Hardware versus microcode 5) Compiler
The speed of a CPU defines how fast it can perform operations. Most obvious indicator is the **internal clock speed**
Cache There are different levels of cache
Level 1 (L1) cache is the fastest and usually runs at the same speed as the CPU
Level 2 (L2) cache is slower but much larger
Level 3 (L3) cache, until the last several years, was not part of the CPU chip, but part of motherboard
Level 4 (L4) cache will usually be found on motherboard (if it exists)
Cache controller – predicts what data will be needed and makes the data available in cache before it is needed
CPU Scheduling – determines which process to start given the multiple processes waiting to run
Control bus to keep the CPU informed about the status of resources and devices connected to the computer
Address Bus – internal communications pathway that specifies the source and target addresses for memory reads and writes
The data bus allows computer components, such as CPU, display adapter, and main memory, to share information
Interrupt request (IRQ) – a request to the processor to "interrupt" whatever it is doing to take care of a process, which in turn might be interrupted by another process.
processors include the Motorola, PowerPC, the SPARC, and the Alpha
three main cloud service models: **IaaS (infrastructure as a service), PaaS (platform as a service), and SaaS (software as a service)**.
XaaS stands for "Anything as a Service"
Summary of **OS Flow:**
1. **User interact**s with the system via services.
2. **System calls** request OS functionalities.
3. The **kernel** manages resources.
4. **Interrupts** handle system events.
5. The **CPU** executes processes.
6. **Processes** contain multiple **threads** for parallel execution.

List of Services: File Management – Opening, closing, reading, and writing files., **Process Management** – Running applications and allocating CPU resources.,
Device Management – Handling input/output devices like keyboards, printers, and storage.**Memory Management**
System calls are the interface between user applications and the OS kernel. When a program needs to perform an action requiring OS intervention, it makes a system call.
The **kernel** is the core component of the OS, responsible for managing system resources like CPU, memory, and I/O devices.

Nova is the primary computing engine.
Swift is a storage system for objects and files
Cinder is a block storage component,
Neutron provides the networking capability for OpenStack.
Horizon is the dashboard behind OpenStack.
Keystone provides identity services for OpenStack.
Glance provides image services to OpenStack.
Ceilometer provides telemetry services
Heat is the orchestration component of OpenStack,