

## Topic 2D: Install and Configure CPUs:

### CPU Architecture:

CPU process and executes all program instructions code. When a program runs, the CPU fetches the instructions, decode it, and execute it. During its cycle, it uses register to temporarily store the data. The registers has the same clock speed as the CPU.

Cache is a high-speed small block of memory that works at the speed of the CPU or very close to it, depending on its level. Cache enhances performance by storing frequently accessed instructions and data by the CPU.

### x86 Architecture:

**x86 architecture** means 32-bit architecture. It basically means that each instruction can be upto **32-bits wide**. It means this type of CPU can handle **32** bits of data at a time. It can access upto **4GB** of **RAM**. It is suitable for older software or OS like 32-bit versions of Windows or Linux. **x86** PC processors are designed and manufactured by **Intel** and **Advanced Micro Devices (AMD)**.

### x64 Architecture:

**x64 architecture** means 64-bit architecture. It means this type of CPU can handle 64-bits of data at a time. It can access upto unlimited GBs or RAM, theoretically 16 exabytes. It can run both 64-bit and 32-bit applications but 32-bit architecture cannot run 64-bit applications.

### ARM CPU Architectures:

**ARM CPU architecture**, developed by Advanced RISC Machines, is a popular alternative to the traditional **x86/x64 architecture**. Unlike AMD and Intel, ARM doesn't manufacture CPUs; instead, it designs processors that other companies customize and produce. It is used mostly in Apple smartphones and other smartphones as well. It implements a **System-on-Chip (SoC)** design. **SoC** means all the controllers like video, sound, networking, and storage are the part of the CPU.

### RISC and CISC architecture:

**CISC (Complex Instruction Set Computing)** and **RISC (Reduced Instruction Set Computing)** are two different CPU design philosophies that determine how processors handle instructions from software. **CISC** can perform multiple operations like 1000 instructions at a time and may take multiple clock cycles to execute. This type of architecture is often used in Computers.

**RISC (Reduced Instruction Set Computing)** use a small number of simple instructions that perform one task at a time. All instructions are designed to execute in **one clock cycle**. Typically includes **fewer than 100 instructions**. Relies on **CPU registers and cache** for speed, reducing dependency on slower memory. **ARM architecture** used in smartphones, tablets, and lightweight laptops.

### CPU Features:

Whenever we play games and do other high-speed memory consuming applications, CPU needs higher speed to perform these tasks. This makes the CPU gets heated faster. Thermal and power performance impose limits to running the CPU faster and faster. One of the way to make the CPU perform faster is **Simultaneous Multithreading (SMT)**.

## Simultaneous Multithreading:

**Simultaneous Multithreading** is a clever way for a CPU to handle more work at the same time by using its existing resources more efficiently. A **thread** is a small piece of program that the CPU processes. Each core in the CPU can work on one thread at a time. However, working on one thread, parts of the core often sit idle because some instructions take longer like waiting for data from the memory. **Simultaneous Multithreading (SMT)** enables a single CPU core to handle two or more threads at the same time. Instead of letting parts of the core sit idle, it fills in those gaps by processing instructions from another thread. SMT is also referred to as **HyperThreading by Intel**. In **SMT, OS** thinks that there is two or more CPUs installed.

## Symmetric Multiprocessing (SMP):

Symmetric Multiprocessing means using two or more physical CPUs. In this processing, OS can make efficient use of processing resources available to run applications on whichever CPUs is available. Each processor has equal access to memory and I/O devices and operates under the same set of instructions provided by the operating system.

The primary advantage of SMP is its ability to enhance performance by enabling parallel processing. Since multiple processors share the workload, the system can handle more tasks simultaneously, leading to faster processing speeds and better utilization of resources. For example, in a multi-threaded application, different threads can run on separate processors, reducing the time required to complete the overall task. Additionally, SMP systems are highly scalable; as computational demands increase, more processors can be added to the system to meet the workload.

However, **multi-socket** motherboard is very expensive and mostly implemented on **servers** and **workstations**. The CPUs used in each socket must be identical models and specifications and must be models that support SMP. A single-core CPU has a single execution unit and set of registers implemented on a single package. A dual-core CPU is essentially two processors combined in the same package.

## Virtualization:

Virtualization allows a computer to run multiple operating systems at the same time using **virtualization software**, which creates **virtual machines (VMs)**. Modern CPUs support **hardware-assisted virtualization** to make VMs run faster, with Intel offering **Virtualization Technology (VT)** and AMD providing **AMD-V**. These features are found in premium processors.

Virtual machines can run directly on hardware (be. VMWare, Microsoft Hyper-V) and on an OS as well (like VMware Workstation, VirtualBox), etc.

Second Level Address Translation (**SLAT**) improves memory management in VMs, reducing overhead and increasing efficiency. Intel calls this **Extended Page Table (EPT)**, and AMD refers to it as **Rapid Virtualization Indexing (RVI)**. These technologies are important for efficient virtualization, especially in systems running many VMs.

## CPU Socket Types:

**Intel and AMD CPUs use different socket types**, making them incompatible with each other's motherboards. All CPU sockets use a **Zero Insertion Force (ZIF)** mechanism, allowing easy insertion without pressure to prevent damage to the fragile pins. CPUs are sensitive to **Electrostatic Discharge (ESD)**. Always use anti-ESD measures (like wrist straps or anti-static bags) when handling or storing CPUs.

There are two types of CPU Sockets mainly:

### 1. Intel (LGA - Land Grid Array)

- Pins are on the **motherboard socket**, not the CPU.
- The CPU is placed on a **hinged plate** and secured with a **locking lever**.

### 2. AMD (PGA - Pin Grid Array)

- Pins are on the **underside of the CPU**, not the socket.
- The CPU is placed gently into the socket and secured with a **locking lever**.
- Care is needed to align **Pin 1** of the CPU with **Pin 1** of the socket to avoid bending pins.

## Removing and Reinstalling a CPU

### 1. Removing the Heat Sink

- Use a **gentle twist** to detach the heat sink to avoid pulling the CPU along with it.
- Release the locking mechanism securing the CPU before removing it.

### 2. Reinstalling the Heat Sink

- **Clean old thermal grease** from both the CPU and heat sink surfaces.
- Apply a small amount of **new thermal grease** in an **X pattern** to ensure even heat transfer.
- Avoid applying too much grease, as excess can spill over and damage the socket.

## Different CPUs:

1. Desktops: Like personal computers at home.
2. Workstations: Often used in businesses which require high performance speeds like graphics/video editing, software development, etc.
3. Servers: Server motherboards are often **multi-socket**, means that multiple CPUs packages can be installed. Each of these CPU has multiple cores and support for multithreading, which offers the servers more power to manage request from the clients. Servers motherboards are named as **Intel Xeon CPUs and AMD's Epyc brands**. These are incompatible with each other.
4. Mobiles: Uses ARM based CPUs.

## Some Questions and Answers:

### Why Can Cache Improve Performance?

Cache improves performance because a CPU often repeats the same routines and accesses the same data. When these routines and data are stored in **fast cache memory**, the CPU can retrieve them much faster than fetching them from slower system memory (RAM). This reduces processing time and speeds up performance.

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**2. A workstation has a multi-socket motherboard but only a single LGA 1150 socket is populated. The installed CPU is a Xeon E3 1220. You have a Xeon E3-1231 CPU in store that also uses the LGA 1150. Should this be used to enable symmetric multiprocessing and upgrade system performance?**

You **cannot** use a Xeon E3-1231 to enable symmetric multiprocessing with a Xeon E3-1220, even though both use the LGA 1150 socket. For SMP to work, the CPUs must be **identical models**. Mixing CPU models can prevent the system from booting or lead to unreliable operation.

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**3. You are specifying a computer for use as a software development workstation. This will be required to run multiple virtual machines (VMs). Can any x64-compatible CPU with sufficient clock speed be used**

Not all x64-compatible CPUs with sufficient clock speed can support multiple VMs. You must ensure the CPU supports **hardware-assisted virtualization extensions** such as **Intel VT-x** or **AMD-V**. Without these extensions, VM performance will be significantly degraded.

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#### 4. What to Check When Inserting a PGA CPU

When inserting a **PGA (Pin Grid Array)** CPU:

1. Ensure **Pin 1** on the CPU aligns with **Pin 1** on the socket (marked with a triangle or dot).
2. Verify the CPU's pins are properly aligned with the socket holes.
3. Do not force the CPU into place; use the **Zero Insertion Force (ZIF)** mechanism to avoid bending or damaging the pins.