Computer Architecture
CSL3020

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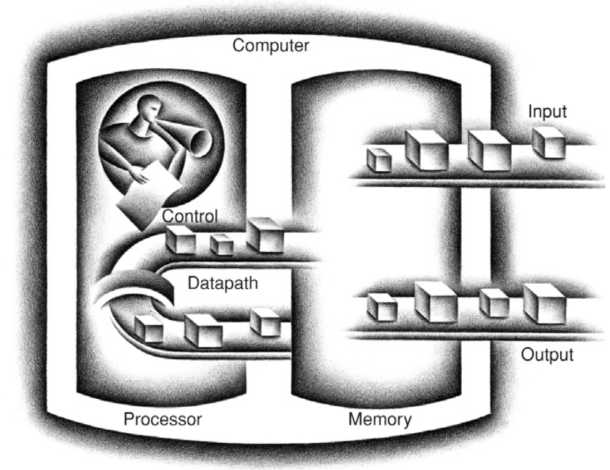
I/O Devices

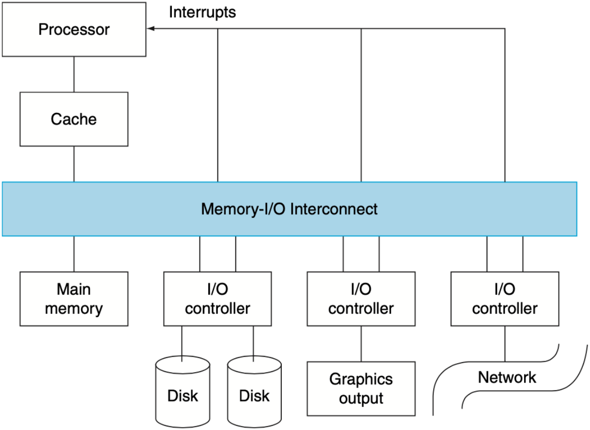


Peripheral devices are auxiliary devices that are connected to a computer to enhance its functionality.

I/O Devices

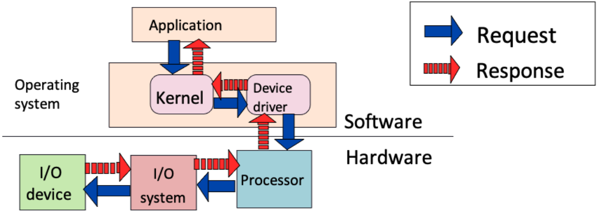
Device	Behavior
Keyboard	Input
Mouse	Input
Voice input	Input
Sound input	Input
Scanner	Input
Voice output	Output
Sound output	Output
Laser printer	Output
Graphics display	Output
Cable modem	Input or output
Network/LAN	Input or output
Network/wireless LAN	Input or output
Optical disk	Storage
Magnetic tape	Storage
Flash memory	Storage
Magnetic disk	Storage

I/O Devices



The connections between the I/O devices, processor, and memory are historically called **buses**.

I/O Devices



A request goes through the kernel, device driver, processor, and I/O system.

Source: Basic Computer Architecture by SR Sarangi

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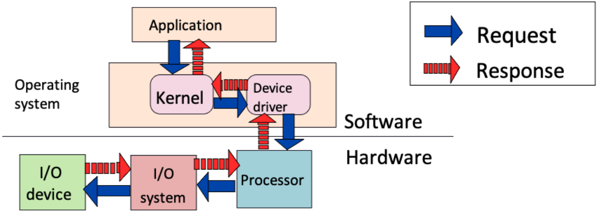

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I/O devices are connected to the motherboard via add-on cards, or directly

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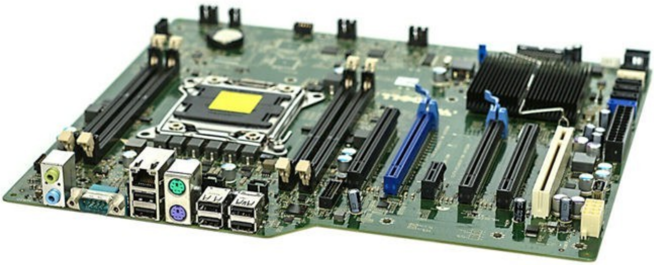
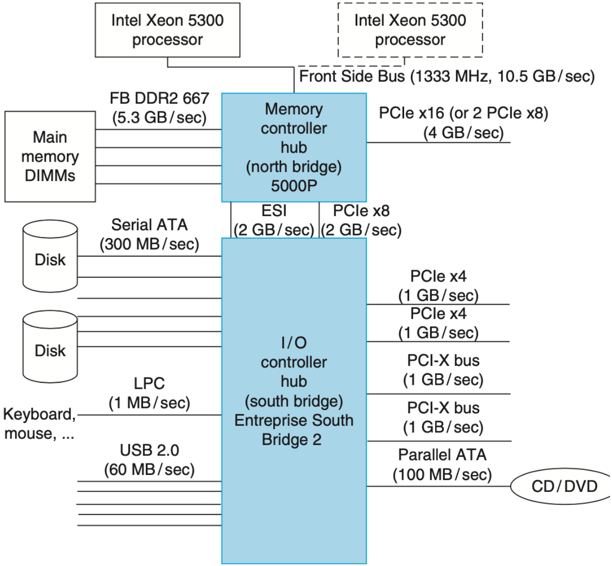


Dell Precision T3600 System Motherboard

Architecture of Motherboard



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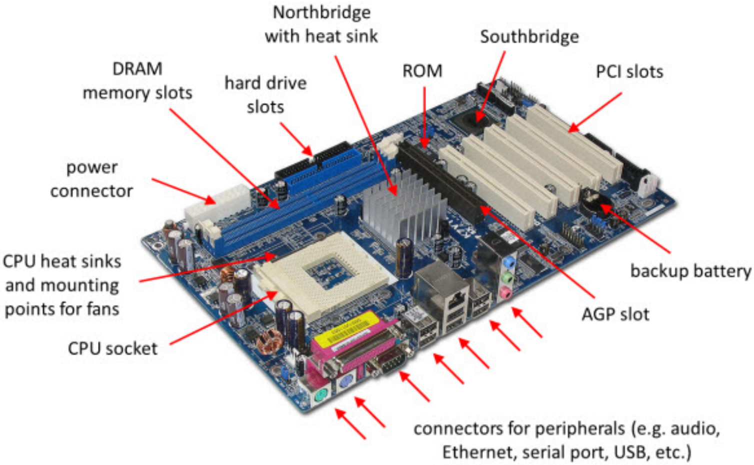

Source: blogger.googleusercontent

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- Processor-memory buses, I/O buses, Backplane bus etc.

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- These problems led to asynchronous interconnects.
  - can accommodate a wide variety of devices of differing speeds.
- To coordinate the transmission of data between sender and receiver, an asynchronous bus uses a *handshaking* protocol.

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Interfacing I/O Devices

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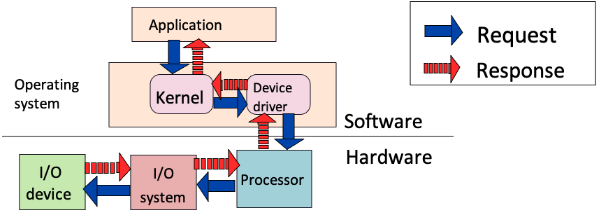
- There are several other tasks that must be performed to actually cause data to be transferred



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- The same I/O program can run on multiple machines.

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  - Polling
  - Interrupts
  - Direct Memory Access (DMA)

Interfacing I/O Devices – Polling

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- It can waste a lot of processor time.

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Type of event	From where?	MIPS terminology
I/O device request	External	Interrupt
Invoke the operating system from user program	Internal	Exception
Arithmetic overflow	Internal	Exception
Using an undefined instruction	Internal	Exception
Hardware malfunctions	Either	Exception or interrupt

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MIPS includes a status register (called the Cause register), which holds a field that indicates the reason for the exception.

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  - The DMA starts the operation on the device and arbitrates for the interconnect.
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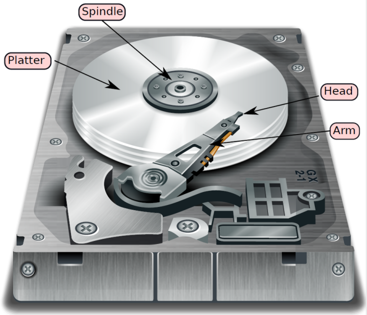
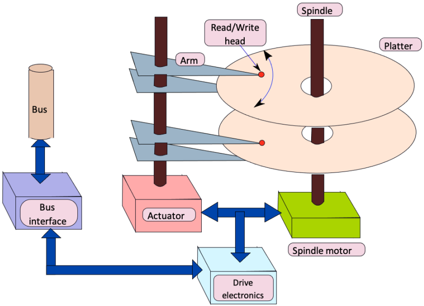
- Unlike polling or interrupt-driven I/O, DMA can be used to interface a hard disk without consuming all the processor cycles for a single I/O.

I/O Devices – Hard Disks

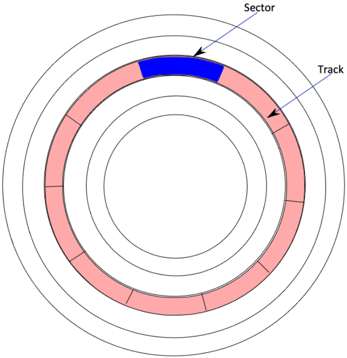




Hard Disk Drives (HDDs) commonly referred to magnetic disks that rely on a rotating platter coated with a magnetic surface (sequence of tiny magnets) and use a movable read/write head to access the disk.

Source: Basic Computer Architecture by SR Sarangi

I/O Devices – Hard Disks



- Each disk surface is divided into concentric circles, called *tracks*.
- Each track is in turn divided into *sectors* that contain the information; each track may have 100 to 500 sectors.
- Sectors are typically 512 bytes in size.

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Disk access time = Seek time + Rotational delay + Transfer time + Controller overhead

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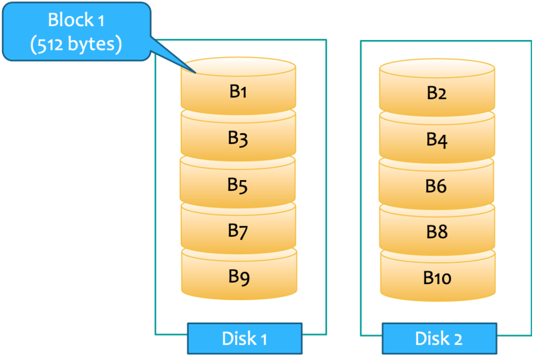
RAID 0: No redundancy, only data stripping.



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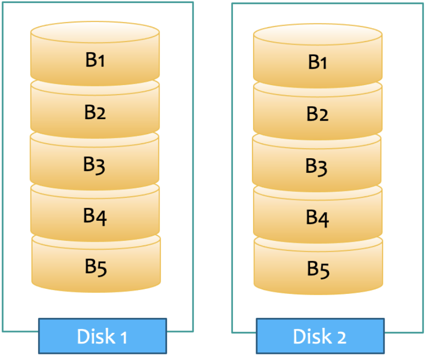
RAID 1: Mirroring, immune to one disk failure, 100% overhead in storage.



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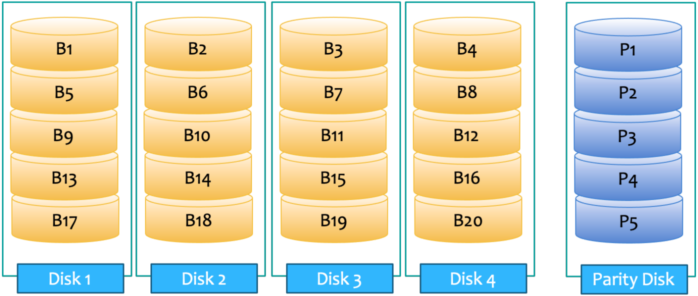
RAID 2: Rarely used in practice, stripes data at the bit (rather than block) level, and uses a Hamming code for error correction.

RAID 3: uses striping and dedicates one drive for storing *parity* information.



$$P1 = B1 \oplus B2 \oplus B3 \oplus B4$$

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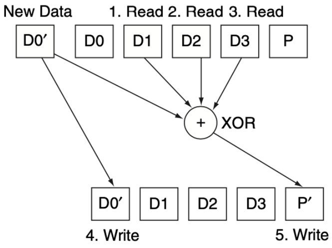
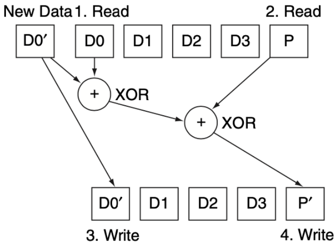
RAID 4: Improvised version of RAID 3.

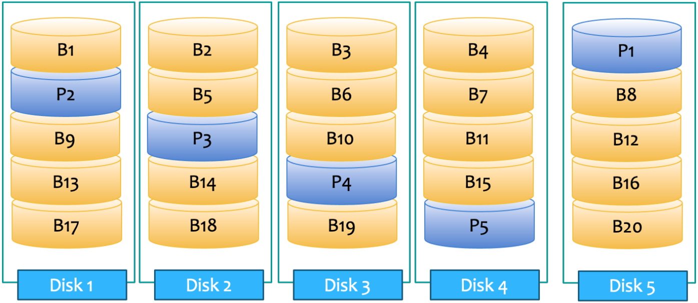


RAID 3 Write



RAID 4 Write

RAID 5: Distributes the parity blocks across the disks. High bandwidth.



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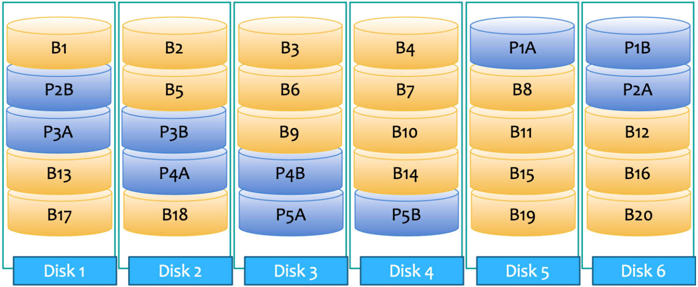
RAID 6: Immune to two disk failures. High reliability at the cost of increased storage overhead.



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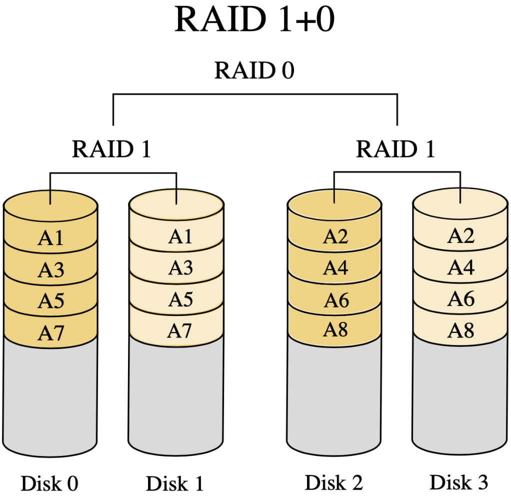
RAID 10: Nested RAID level, also called RAID 1+0. RAID 0 array of mirrors.



Source: Wikipedia

I/O Devices – SSD

- A solid-state drive (SSD) uses integrated circuits to store data.
- SSDs rely on non-volatile memory, typically NAND flash.
- Latency is 100–1000 times faster than disk.
- It is comparatively smaller, more power efficient, and more shock resistant.