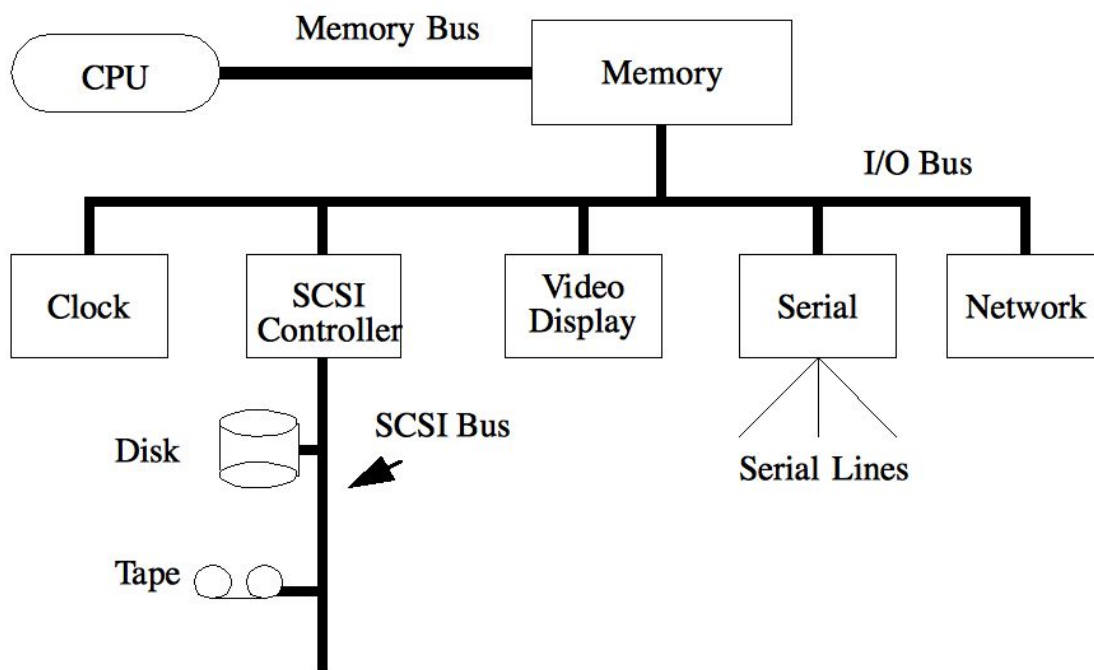


Topic 10: I/O Devices

Reading: None

Next Reading: 7.1, 7.4

- A computer is more than just a CPU and memory; it also includes I/O devices that are used to communicate with the outside world and to store information.
- A canonical personal computer has the following hardware organization:



- Memory is connected to the CPU via a high-performance memory bus.

- Fast, wide, short, specialized, internal.
- I/O devices are plugged into an I/O bus.
 - Slow, narrow, long, general-purpose, can be external.
 - Each device has a controller, electronics that control the device and implement the I/O bus protocol.
 - Each controller has a set of registers that control its operation and report its status. The CPU reads and writes these registers to interact with the controller.
- Common I/O devices:
 - Clock
 - Free-running counter.
 - Count-down counter that generates interrupts.
 - SCSI Controller
 - **Small Computer Systems Interface**
 - A SCSI bus is an external bus that connects external peripherals such as disks and tapes.
 - Each device on the SCSI bus also has its own controller.
 - IDE and SATA are similar. SCSI comes from higher-end computers, IDE/SATA is from the bottom-up.

- Video Display
 - Video RAM, bit-mapped display, or graphics processor.
 - Graphics processor now connected via special-purpose bus.
- Serial Controller
 - Adapter between parallel I/O bus and serial lines (RS-232).
 - Serial lines send bits one-at-a-time.
 - Long, slow, cheap.
 - Serial lines connect keyboard, mouse, terminal, printer, modem, etc.
 - Largely replaced by USB, which is much more complicated.
- Network
 - Adapter that allows the computer to send and receive network packets.
 - Network consists of a very long bus either copper or fiber, also wireless.
- A distinction is often made between block devices and character devices.

- Block device: stores information in fixed-size blocks that are individually addressable. E.g. disk
- Character device: transmits and receives a stream of characters. E.g. printer, terminal
- This distinction doesn't always make sense. E.g. clock, tape?
- There are two standard methods by which the CPU accesses I/O devices:
 - *Memory-mapped I/O*: The CPU's address space is partitioned into a region that accesses memory, and a region that accesses the I/O bus. The address space of the I/O bus is often sub-partitioned, one partition for each device.
 - *I/O instructions*: instruction sends signal that access is for an I/O device.
 - What type of I/O does USLOSS have?
- There are also two standard methods by which data are transferred between the memory and I/O devices:
 - *Programmed I/O*: CPU copies data to and from the I/O device. UARTS often work this way.
 - *Direct memory access (DMA)*: device controller accesses memory itself. CPU provides starting address and length, the controller does the rest.