Computer Architecture and Operating Systems
Lecture 8: Memory-Mapped I/O (MMIO)

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# I/O Devices

- Human readable
  - Suitable for communicating with users
  - Video displays, printers
- Machine readable
  - Suitable for communicating with equipment
  - Magnetic disks, SSDs, sensors
- Communication
  - Suitable for communicating with remote devices such as a terminal or another computer
  - Network interface card

I/O Module

- Attach to the processor by a link to an I/O module
  - The link is used to exchange control, status, and data between the I/O module and the external device
- Peripheral device
  - An external device connected to an I/O module

Address Lines

Data Lines

Control Lines

System bus

I/O Module

Links to peripheral devices

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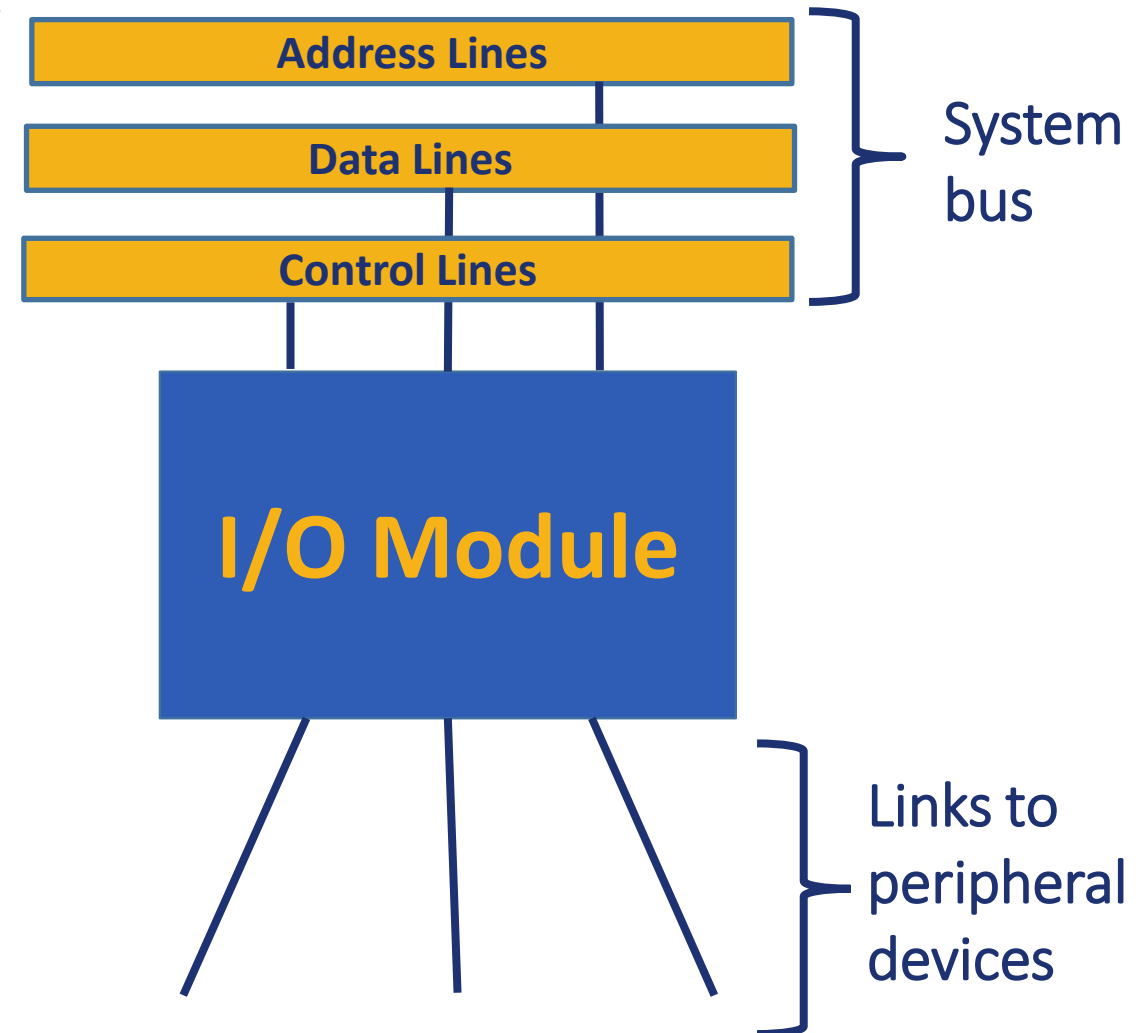
Signals

- **Control signals** determine the function that the device will perform

- **Data** are a set of bits to be sent to or received from the I/O module

- **Status signals** indicate the state of the device

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Three Techniques for I/O Operations

- Programmed I/O
  - Data are exchanged between the processor and the I/O module
  - Processor executes a program that gives it direct control of the I/O operation
  - When the processor issues a command it must wait until the I/O operation is complete
  - If the processor is faster than the I/O module this is wasteful of processor time

- Interrupt-driven I/O
  - Processor issues an I/O command, continues to execute other instructions, and is interrupted by the I/O module when the latter has completed its work

- Direct memory access (DMA)
  - The I/O module and main memory exchange data directly without processor involvement

Memory-Mapped I/O

- Processor accesses I/O devices just like memory (like keyboards, monitors, printers)

- Each I/O device assigned one or more address

- When that address is detected, data read/written to I/O device instead of memory

- A portion of the address space dedicated to I/O devices

Memory-Mapped I/O

- **Memory-Mapped I/O** is an I/O scheme in which portions of the address space are assigned to I/O devices, and reads and writes to those addresses are interpreted as commands to the I/O device

- **Direct Memory Access (DMA)** is a mechanism that provides a device controller with the ability to transfer data directly to or from the memory without involving the processor

Memory-Mapped I/O

- **Interrupt-Driven I/O** is an I/O scheme that employs interrupts to indicate to the processor that an I/O device needs attention

- **Polling** is the process of periodically checking the status of an I/O device to determine the need to service the device

- **Device Driver** is a program that controls an I/O device that is attached to the computer

Any Questions?

```
            .text
__start:    addi t1, zero, 0x18
            addi t2, zero, 0x21
cycle:      beq t1, t2, done
            slt t0, t1, t2
            bne t0, zero, if_less
            nop
            sub t1, t1, t2
            j cycle
            nop
if_less:    sub t2, t2, t1
            j cycle
done:       add t3, t1, zero
```