BCN1043

COMPUTER ARCHITECTURE & ORGANIZATION

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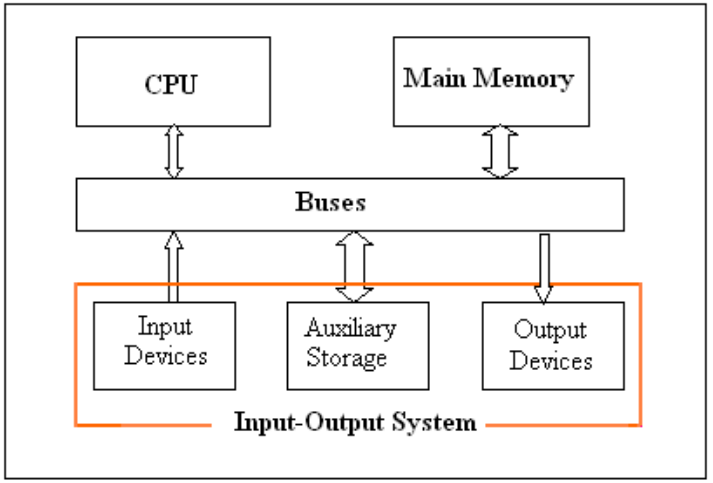
Faculty of Computer Systems & Software Engineering

Learning outcomes

- Understand and able to explain the basic concepts of interrupts and I/O operations.
- Able to explain how interrupts are used to implement I/O control and data transfers.
- Able to identify various types of buses in a computer system.
- Able to describe the advantages and limitations of RAID architectures.

Input/Output

- External device
- I/O interface
- Interrupts
- DMA
- Synchronous and Asynchronous



I/O is the communication between an information processing system (such as a computer) and the outside world, possibly a human or another information processing system

Input Devices

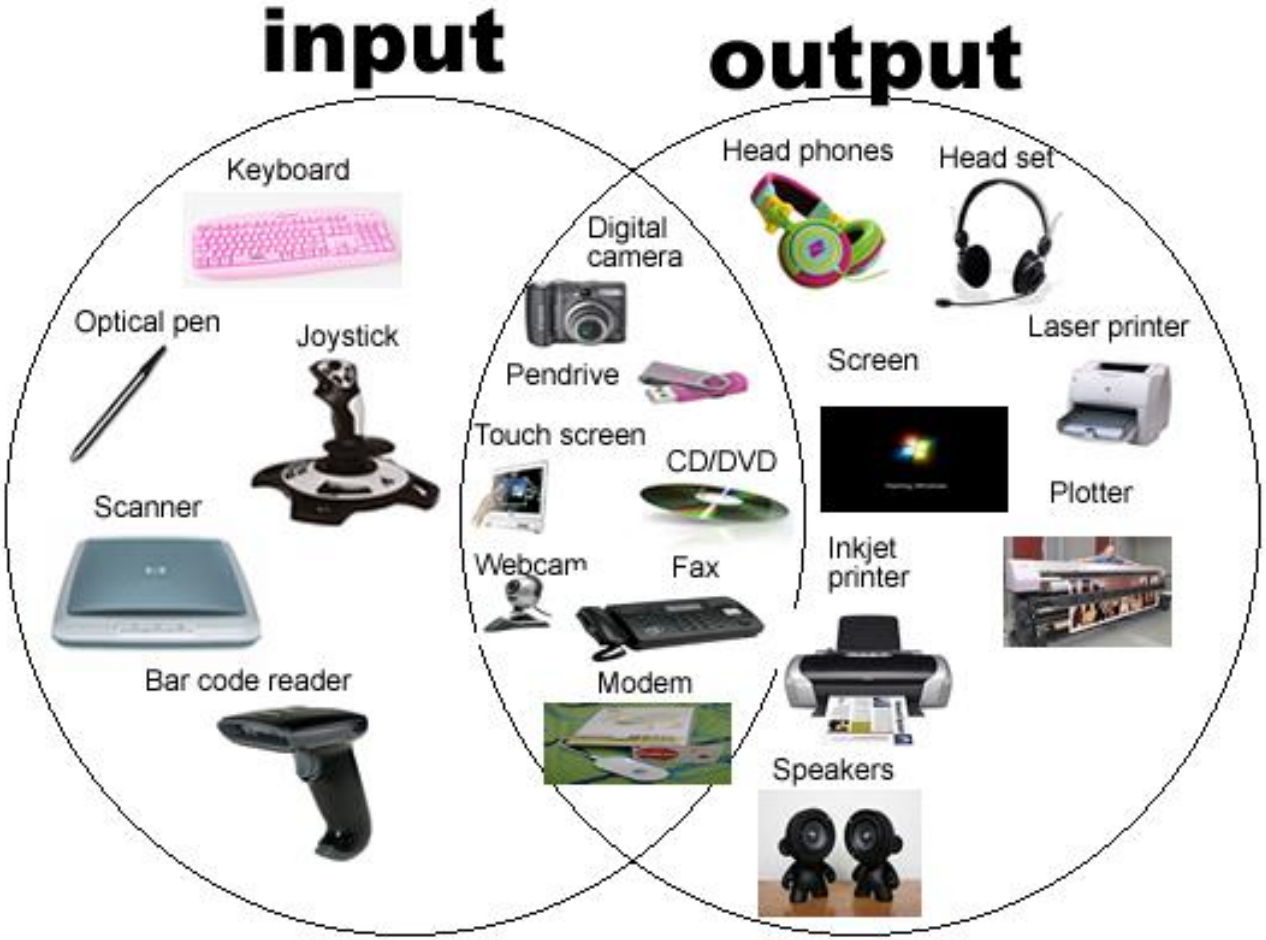
Input- signals /data that are received by computer system

- Keyboard
- Mouse
- Scanner
- Game Controller

Output Devices

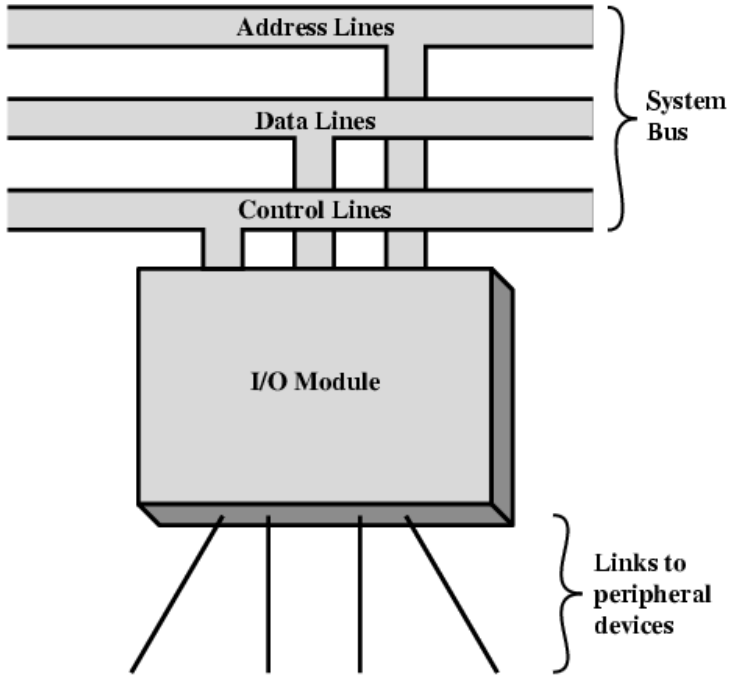
outputs - signals/data sent from computer

- Monitor
- Printers
- Disk Drive
- Floppy Drive
- Speakers


input
output
Keyboard
Optical pen
Joystick
Scanner
Bar code reader
Digital camera
Pendrive
Touch screen
CD/DVD
Webcam
Fax
Modem
Head phones
Head set
Screen
Laser printer
Plotter
Inkjet printer
Speakers

I/O Module

- I/O modules act as an:
  - Peripheral devices are for the external devices (peripherals) to CPU and memory via system bus
  - Interface to one or more external devices by a tailored links



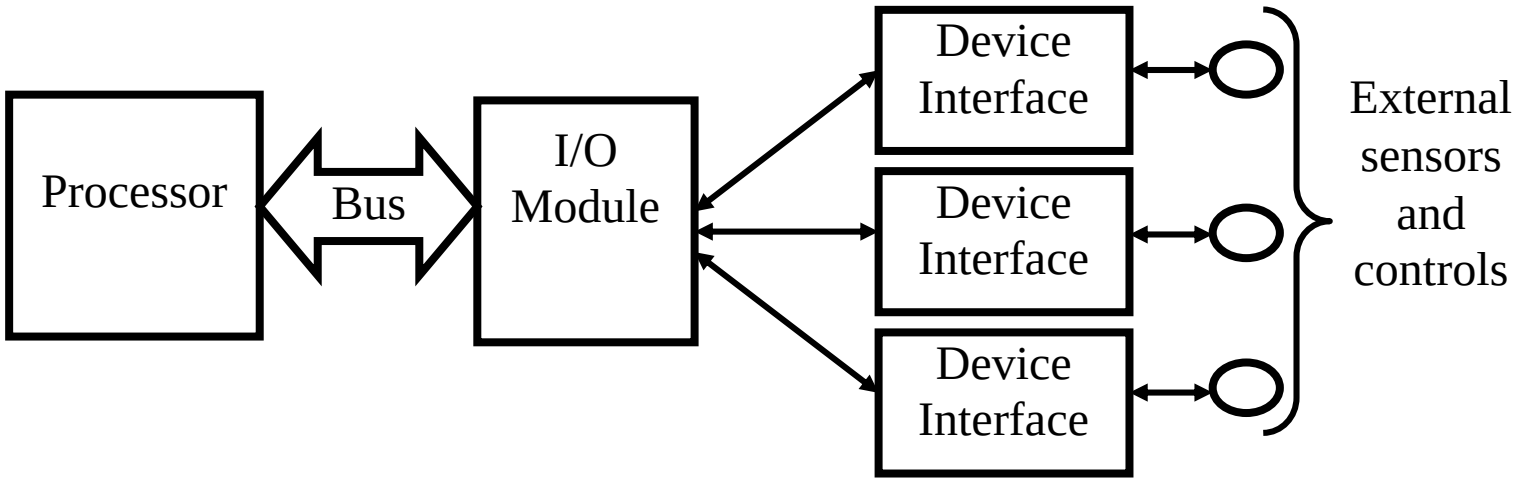
Source: William Stallings, Computer Organization and Architecture,9th Edn

General model of I/O

Closing the Gap

Why can't we connect the peripheral directly to CPU/buses. These is why?

1. Variety of peripherals, thus required different control logic
2. Different data transfer rate (fast or slow than CPU)
3. Different data format and word lengths



External or peripheral devices

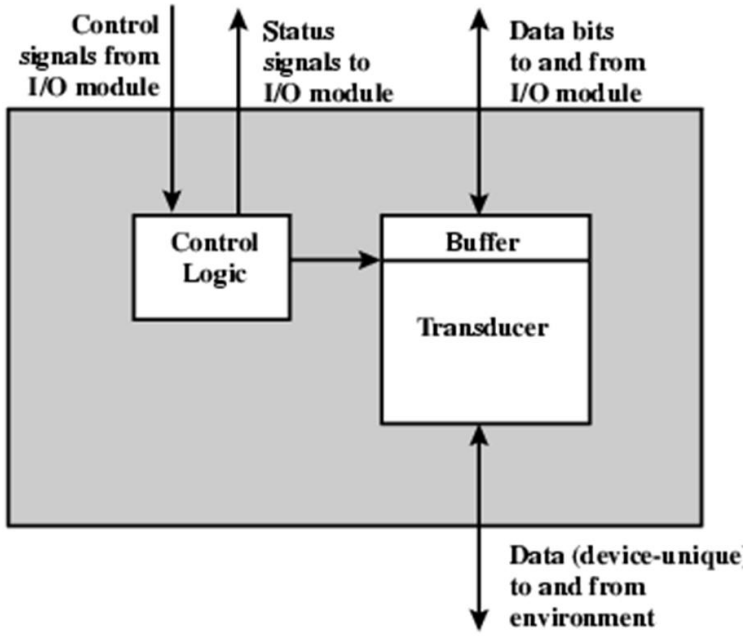
- Exchanges data between the computer and external devices
- The external devices can be classify into three categories:

- Human readable: Suitable for communicating with the computer user Example: screen, monitor, printer
- Machine readable: Suitable for communicating with equipment
  Example: magnetic disk and tape systems
- Communication: Suitable for communicating with remote devices
  Example: modem, NIC, sensors and actuators

External devices (cont…)

- interface to I/O module can be control, data and status signal.
- Control signal determine the function that the device will perform (e.g.: READ, WRITE)
- Data are in the form of a set of bits to be sent to or received from the I/O module.
- Status signals indicated the state of the device (READY, NOT READY)
- **Control logic** associated with the device, control the device operation in response to direction from the I/O
- The **transducer** converts data from electrical to other form of energy during output and from other forms to electrical during input.

External device block diagram



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components of interfacing devices

- **control logic** - I/O module interface with device
- **data channel** transfers the data from/ to the device
- **transducer** – converts the digital data of the I/O module and signals

– Keyboard converts motion of key into data representing key pressed or released
– Temperature sensor converts amount of heat into a digital value
– Disk drive converts data to electronic signals for controlling the read/write head

Keyboard /monitor

- The most common of means of computer/user interaction is a keyboard/monitor arrangement.
- This input is then transmitted to the computer and may also be displayed on the monitor
- In addition, the monitor display data provided by the computer.

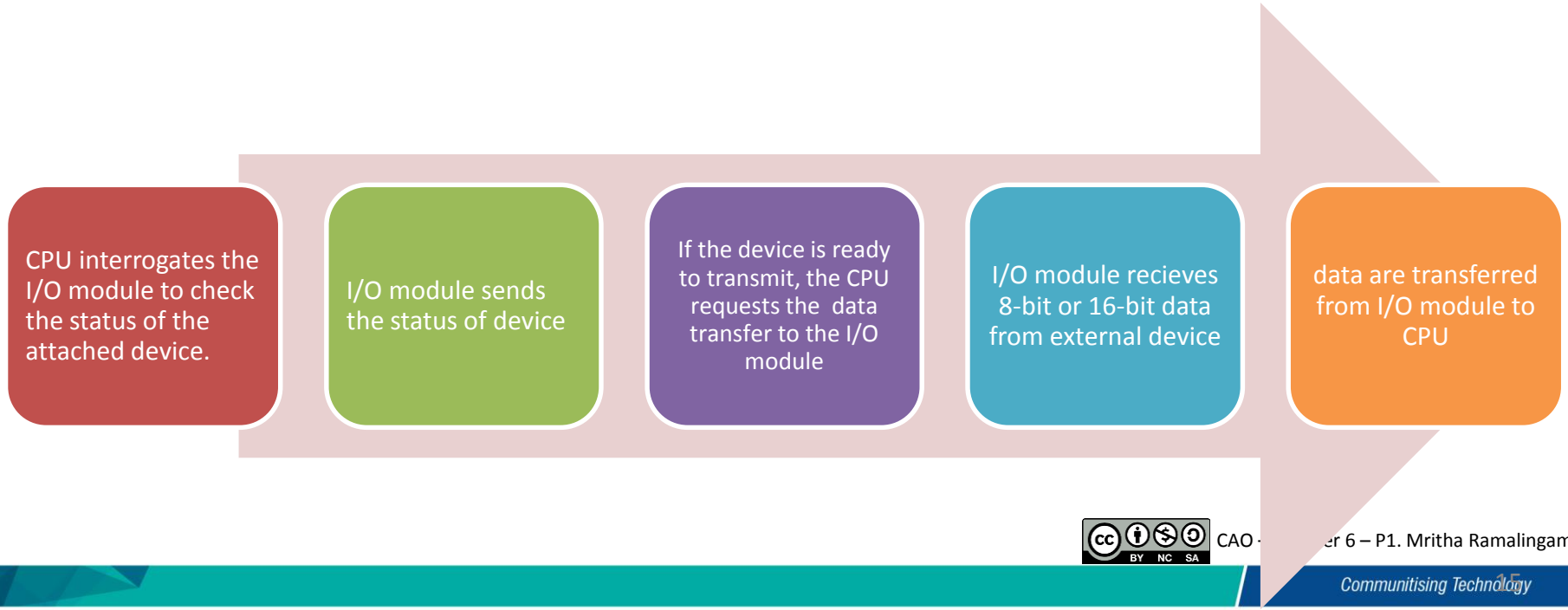
Functions of I/O module

- **Control & timing:** to coordinate the flow of traffic between internal resources (main memory, system bus) and external resources.
- **Processor communication:** communicate with processor in term of accept commands from processor (READ, WRITE), exchanged data, status reporting (BUSY, READY) and address recognition.
- **Device communication:** communicate with external devices
- **Data buffering:** temporarily hold data between being transferred between the I/O module and external devices
- **Error detection:** detects error and report errors to the processor.

Control and Timing

Coordinates traffic flow between the resources (main memory, system bus) and external resources”

- E.g - I/O steps (external devices to CPU):



I/O Module: Processor communication

"CPU communication: communicate with processor in term of accept commands from processor (READ, WRITE), exchanged data, status reporting (BUSY, READY) and address recognition"

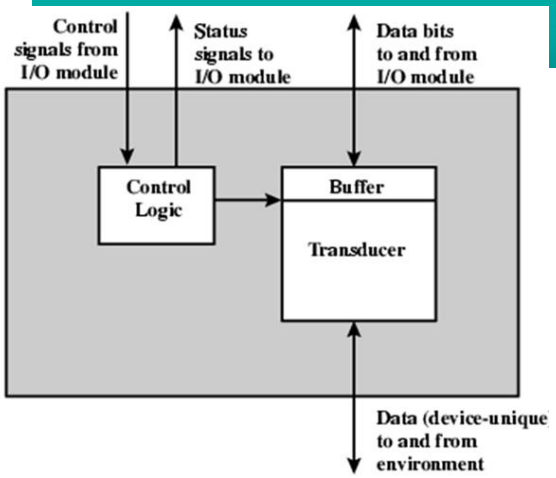
The CPU communication involve the following:

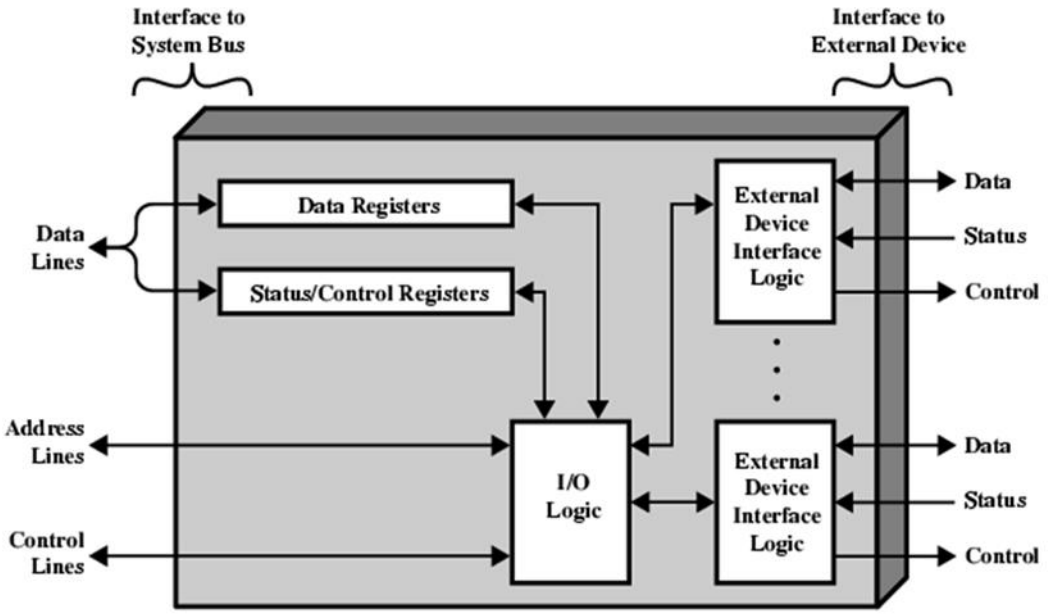
- **Commands from processor** - The I/O module accepts commands from the processor, typically sent as signals on the control bus. Examples: READ SECTOR, WRITE SECTOR etc.
- **Data** - exchanged data between processor and I/O modules over the data bus
- **Status reporting** - peripherals are slow, thus need to check the status through the I/O module → status signals, BUSY and READY
- **Address recognition** - to allow referencing

Functions -I/O Module (cont…)

- **Device Communication** – each I/O module able to establish communication. Communication involve command, status and data.
- **Data Buffering** - the I/O module ***buffers*** data to tye up with CPU's bus
- **Error Detection** -
  - Device Malfunctions (jamming of paper, bad disk track)
  - Error in Data

I/O module structure





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- The module connects to the rest of the computer through a set of system bus lines (e.g. system bus lines)
- Data transferred to and from the module are **buffered** in one or more data register
- One or more status register provide current status information
- A status register may also function as a control register, to accept detailed control information from the processor

- The logic within the module interacts with the processor via a set of control lines
- The processor uses the control lines to issue commands to the I/O module
- Some of the control lines may be used by the I/O module (for arbitration and status signal)
- Each I/O module has a unique address or a unique set of address if it controls more than one external device.

I/O instruction

Processor → I/O module

Address	I/O command

specify I/O module and external devices

(a) Control,
(b) Test,
(c) Read and
(d) Write

Memory mapped I/O and **isolated I/O**

Memory mapped I/O

single address space for memory and I/O devices.

- Processor treat the status and data registers of I/O module as memory location.
- Uses same instruction to access both memory and I/O module.
- Example: 10 address line ➔ 2^10 memory location + I/O address can be supported

Memory Mapped I/O

- The device is connected directly to certain main memory locations.
- Two types of information to/from the device
  - Status
  - Value read/write

Why use Memory Mapped I/O

- Makes programming simpler.
- Do not have special commands to access I/O devices.
- Takes some memory locations
  - Very few compared to the size of main memory.

Isolated I/O

- Address space of memory and I/O is isolated.
- the command line inform whether address refer to memory location or an I/O devices
- Example: 10 address line
  - 2^10 memory location and
  - 2^10 I/O address

Differences between Isolated I/O and Memory mapped I/O

Isolated I/O	Memory Mapped I/O
Isolated I/O uses separate memory space.	Memory mapped I/O uses memory from the main memory
Limited instructions can be used. Those are IN, OUT, INS, OUTS.	Any instruction which references to memory can be used.
The addresses for Isolated I/O devices are called ports.	Memory mapped I/O devices are treated as memory locations on the memory map.
IORC & IOWC signals expands the circuitry.	*IORC & IOWC* signals has no functions in this case which reduces the circuitry.

Will continue…