

8086 Interrupts

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Course Title: Microprocessor and Assembly Language

Lecture References:

- ▶ **Book:**

- ▶ *Microprocessors and Interfacing: Programming and Hardware, Chapter # 08, **Author:** Douglas V. Hall*
- ▶ *Microprocessor and Microcomputer – Based System Design, **Author:** Mohamed Rafiquzzaman*

- ▶ **Lecture Materials:**

- ▶ *M.A. Sattar, BUET, Dhaka, Bangladesh.*

Interrupt and Its Classifications

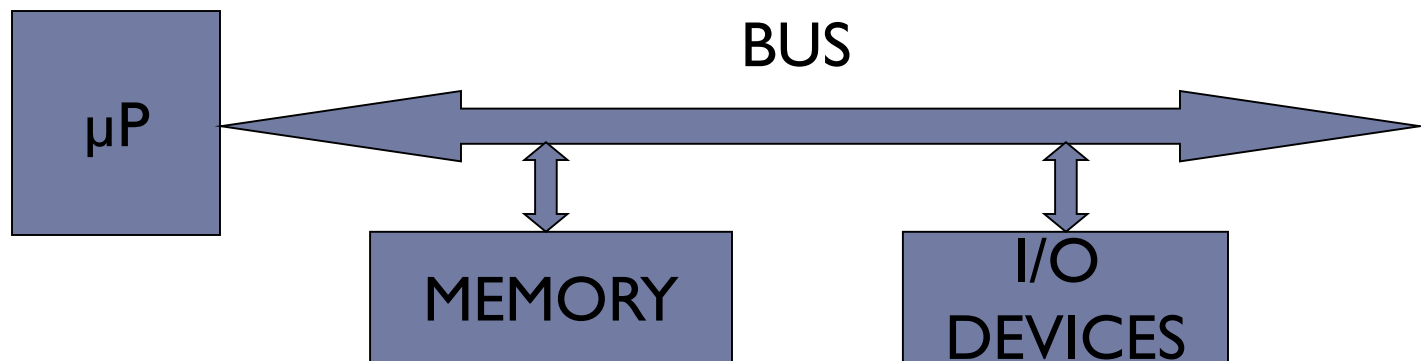
- ▶ Interrupt is a process where a normal program execution to be interrupted by some external signal or by a special instruction in the program.
- ▶ Microprocessor pay attention to the interrupt stopping the the current execution.
- ▶ Classification of Interrupts
 - ▶ Interrupts can be classified into two types:
 - ▶ Maskable Interrupts (Can be delayed or Rejected)
 - User-defined interrupts
 - ▶ Non-Maskable Interrupts (Can not be delayed or Rejected)
 - System Interrupts

Interrupt & Its Consequences over MP

- ▶ An interrupt is considered to be an emergency signal that may be serviced.
 - ▶ The Microprocessor may respond to it as soon as possible.
- ▶ **What happens when MP is interrupted ?**
 - ▶ When the Microprocessor receives an interrupt signal, it suspends the currently executing program and jumps to an **Interrupt Service Routine (ISR)** to respond to the incoming interrupt.
 - ▶ Each interrupt will have its own ISR.
 - ▶ After finishing the second program/interrupt, automatically return to the first program and start execution from where it was left

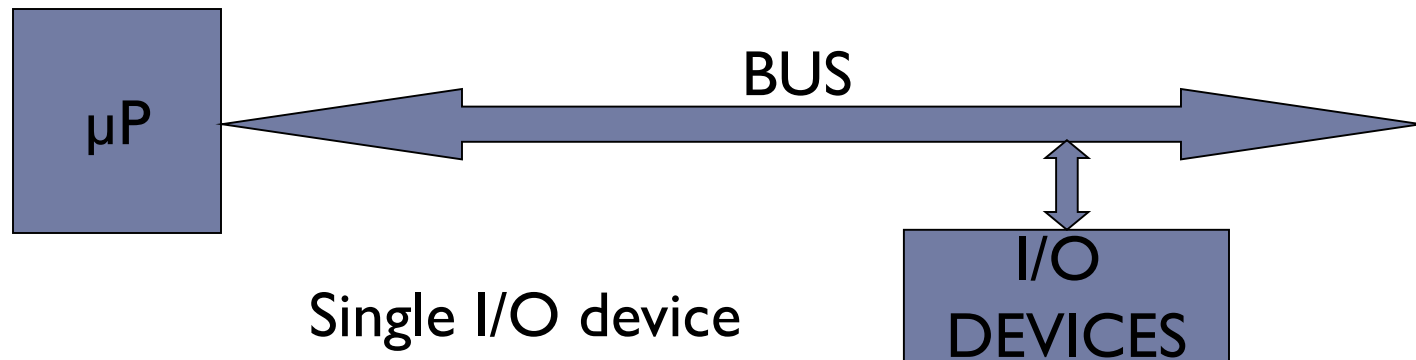
Why Interrupt is Necessary?

- ▶ To understand this we will have to review how $\mu\text{P}/\mu\text{C}$ communicate with the outside world.



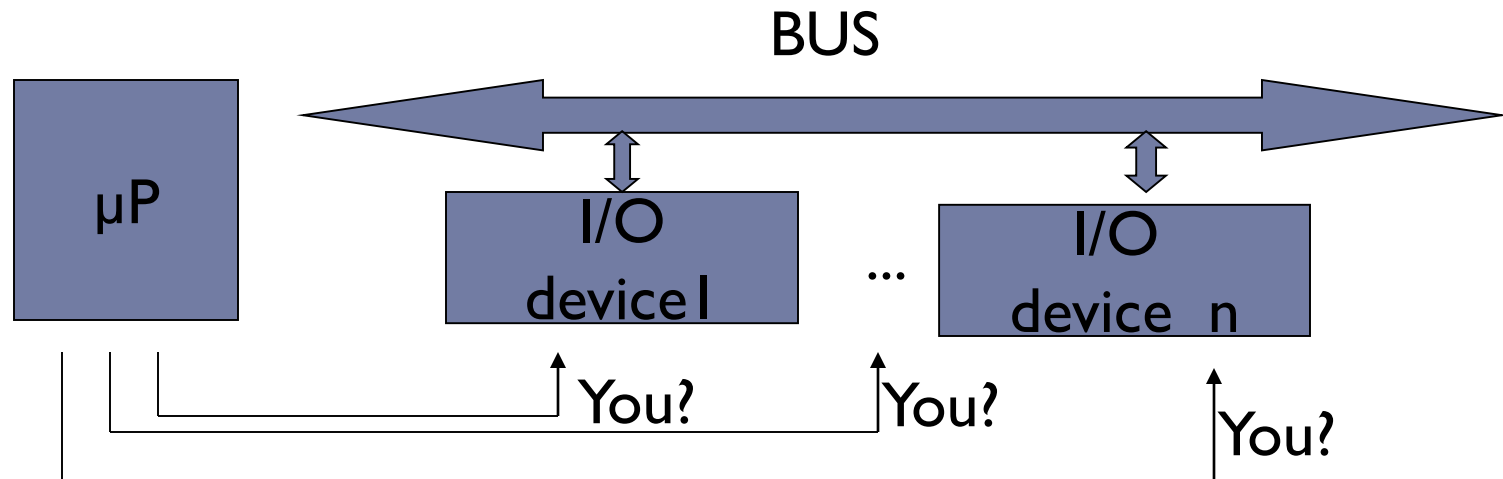
Why Interrupt is Necessary?

- ▶ **First Type: DEDICATED** communication between MP and I/O devices.



Why Interrupt is Necessary?

- ▶ **Second Type:** POLLED I/O or PROGRAMMED I/O communication between MP and I/O devices.

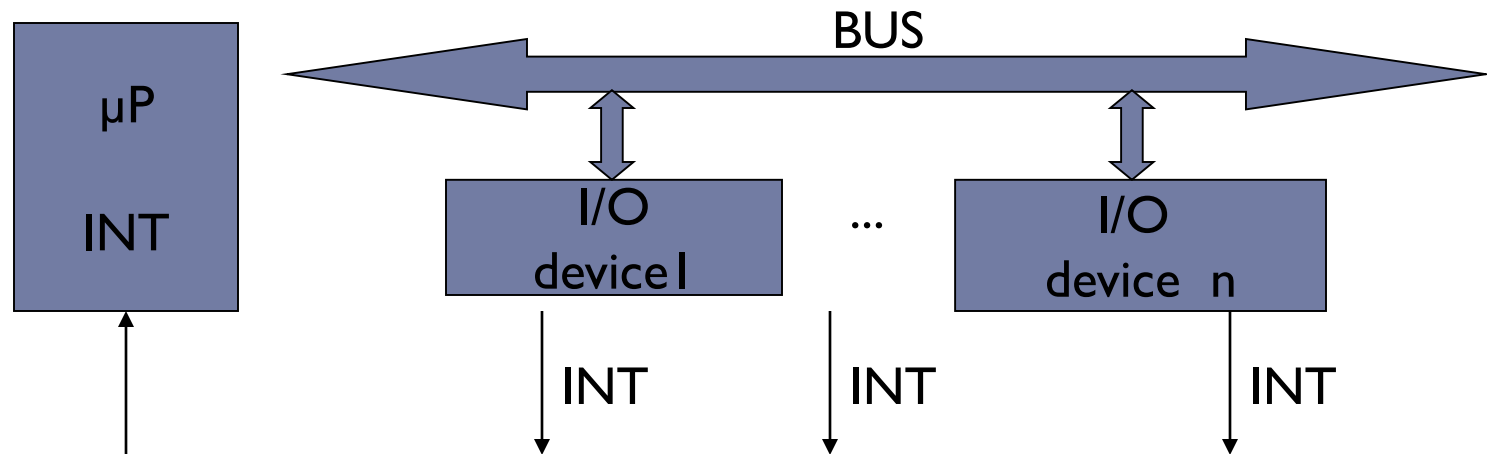


Disadvantages of Second Type Communication:

- ▶ not fast enough
- ▶ waste too much microprocessor time

Why Interrupt is Necessary?

- ▶ **Third Type: INTERRUPTED I/O** communication between MP and I/O devices.



Interrupts are particularly useful when I/O devices are slow

Polling and Interrupt

- ▶ Both are methods to notify processor that I/O device needs attention
- ▶ **Polling**
 - ▶ simple, but slow
 - ▶ processor check status of I/O device regularly to see if it needs attention
 - ▶ *similar to checking a telephone without bells!*
- ▶ **Interrupt**
 - ▶ fast, but more complicated
 - ▶ processor is notified by I/O device (interrupted) when device needs attention
 - ▶ *similar to a telephone with bells*

Interrupt Concept

- ▶ Intel processors include two hardware pins (INTR and NMI) that request interrupts.
- ▶ And one hardware pin (INTA) to acknowledge the interrupt requested through INTR.
- ▶ The processor also has software interrupts INT, INTO and INT 3.
- ▶ Flag bits IF (interrupt flag) and TF (trap flag), are also used with the interrupt structure.

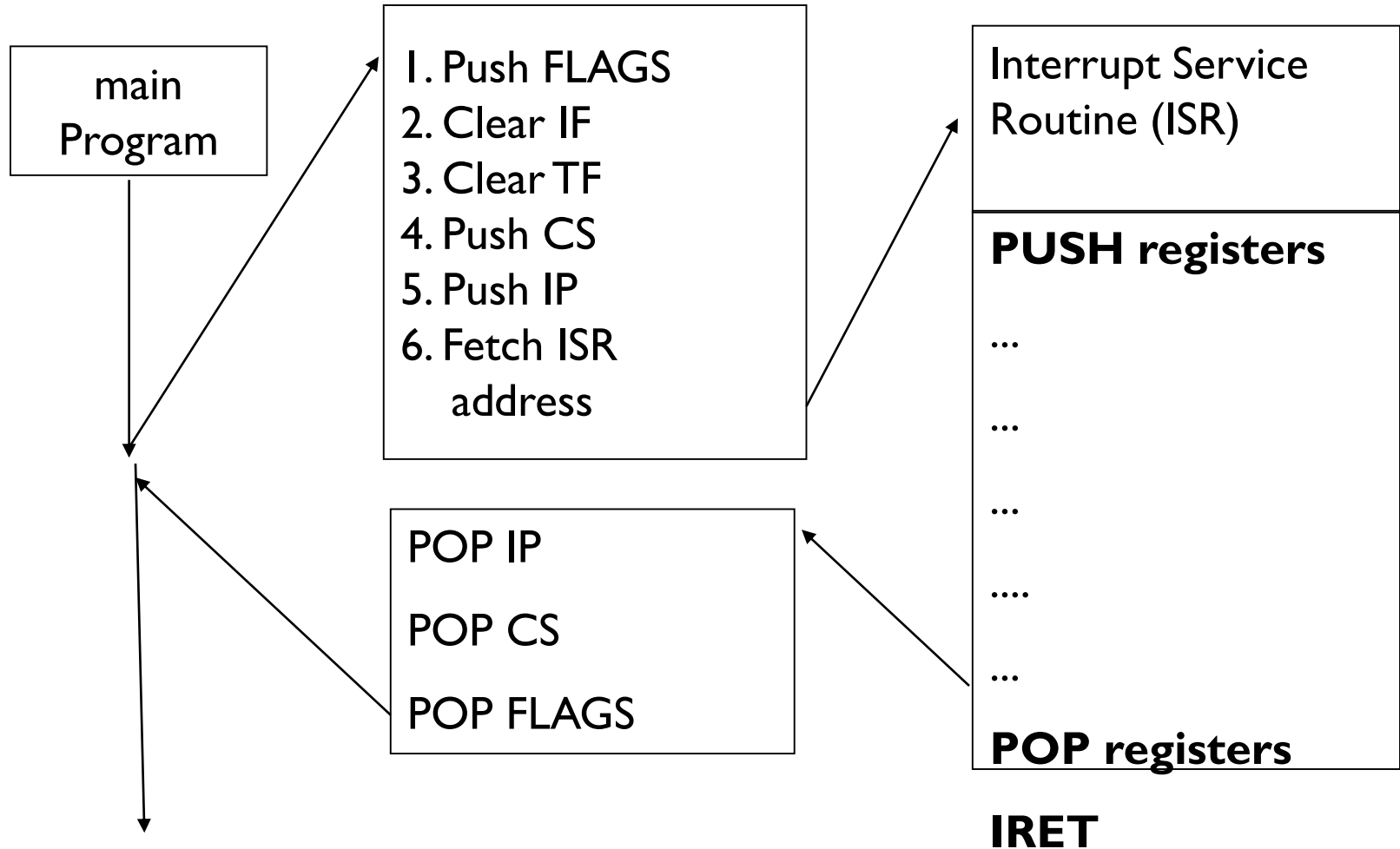
Classifications of 8086 Interrupts

- ▶ An 8086 interrupt can come from any of the **three** sources:
 - ▶ An **external signal** applied to NMI or INTR pin.
 - known as **hardware interruption**
 - *It is a **user-defined interrupt***
 - *Example: Connecting I/O Device*
 - ▶ Execution of interrupt instruction **INT**.
 - referred as **software interruption**
 - *It is also a **user-defined interrupt***
 - *Example: INT 21h, INTO, INT 3*
 - ▶ Some error condition produced by execution of an instruction, e.g., trying to divide some number by zero.
 - ▶ It is known as **pre-defined interrupt**

Function of 8086 during Interrupts

- ▶ At the end of each instruction cycle, 8086 checks to see if any interrupts have been requested.
- ▶ If yes, then 8086 responds to the interrupt by stepping through the following series of major actions:
 - ▶ It decremented SP by 2 and pushes **Flag register** on the stack.
 - ▶ It disables 8086 **INTR** input by clearing **IF (Interrupt) flag** in Flag register, IF=1.
 - ▶ It resets the **TF (Trap) flag** in Flag register
 - ▶ It decremented SP again by 2 and pushes current **CS (Code Segment)** contents on the stack.
 - ▶ It decremented SP again by 2 and pushes current **IP (Instruction Pointer)** contents on the stack.
 - ▶ It does an indirect far **Jump** to the start of the procedure (**ISR**) written to respond to the interrupt.

Function of 8086 during Interrupts



Interrupt Vectors and Vector Table

- ▶ An **interrupt vector** is a **pointer** to where the ISR is stored in memory.
- ▶ All interrupts (vectored or otherwise) are mapped onto a memory area called the **Interrupt Vector Table (IVT)**.
 - ▶ The IVT is usually located in the first 1 Kbyte of memory segment (from 00000 H - 003FF H).
 - ▶ The purpose of the IVT is to hold the vectors that redirect the microprocessor to the right place when an interrupt arrives.
- ▶ The starting address of an ISR is often called
 - ▶ the ***interrupt vector*** or the ***interrupt pointer***.
- ▶ So the Table is referred to as
 - ▶ ***interrupt-vector table*** or ***interrupt-pointer table***.

Interrupt Types based on ISR ID

- ▶ Note that
 - ▶ The **IP** value is put in as the **low word** of the vector
 - ▶ **CS** as **high word** of the vector
- ▶ 4 bytes are required to store the CS and IP values for each interrupt service procedure, the ***interrupt-vector table*** can hold starting addresses for up to 256 interrupt procedures.
- ▶ Each ***Double Word*** interrupt vector is identified by a number from 0 to 255
- ▶ *INTEL* calls this number the ***TYPE*** of the interrupt

Interrupt Types based on ISR ID

AVAILABLE FOR USER (224)		3FFH	TYPE 255
		080H	...
RESERVED (27)			TYPE 32
			...
Predefined/ Dedicated/Internal Interrupts Pointers (5)		014H	TYPE 31
			...
			TYPE 5
			TYPE 4
		010H	INTO OVERFLOW
			TYPE 3
		00CH	INT
			TYPE 2
		008H	NON-MASKABLE
			TYPE 1
		004H	SINGLE STEP
CS Base Address	IP Offset		TYPE 0
		000H	DIVIDE ERROR

Interrupt Types based on ISR ID

- ▶ The first five interrupt vectors are identical in all Intel processors
- ▶ Intel reserves the first 32 interrupt vectors
- ▶ The last 224 interrupt vectors are user-available
- ▶ Each is four bytes long in real mode and contains the starting address of the interrupt service procedure.
 - ▶ The first two bytes contain the offset address
 - ▶ The last two contain the segment address

Interrupt Types based on ISR ID

▶ **Type 0**

- ▶ The **divide error** whenever the result from a division overflows or an attempt is made to divide by zero.

▶ **Type 1**

- ▶ Single-step or trap occurs after execution of each instruction if the trap (TF) flag bit is set.
- ▶ Upon accepting this interrupt, TF bit is cleared so the interrupt service procedure executes at full speed.

Interrupt Types based on ISR ID

▶ **Type 2**

- ▶ The **non-maskable interrupt** occurs when a logic 1 is placed on the NMI input pin to the microprocessor.
- ▶ Non-maskable—it cannot be disabled

▶ **Type 3**

- ▶ A special one-byte instruction (INT 3) that uses this vector to access its interrupt-service procedure.
- ▶ Often used to store a breakpoint in a program for debugging

Interrupt Types based on ISR ID

▶ **Type 4**

- ▶ **Overflow** is a special vector used with the INTO instruction. The INTO instruction interrupts the program if an overflow condition exists.
- ▶ As reflected by the overflow flag (OF)

Summary of 8086 Interrupt Function ...

- ▶ **How does 8086 get to Interrupt Service Routine (ISR)?**
 - ▶ Simple. It loads its CS and IP registers with the address of ISR.
 - ▶ So, the next instruction to be executed is the first instruction of ISR.
- ▶ **How does 8086 get the address of Interrupt Service Routine (ISR)?**
 - ▶ It goes to **specified memory location** to fetch **four consecutive bytes**
 - ▶ higher two bytes to be used as CS (Code Segment)
 - ▶ lower two bytes to be used as IP (Instruction Pointer)

Summary of 8086 Interrupt Function ...

- ▶ **How does 8086 get the address of that specified memory location?**
 - ▶ In an 8086 system, the first 1Kbytes of memory, from 00000 to 003FF, is set aside as a **Table** for storing the starting addresses of **Interrupt Service Routines (ISR)**.
 - ▶ Since 4 bytes are required to store **CS and IP** values for each ISR, the **Table** can hold the starting addresses for up to 256 ISRs.

Summary of 8086 Interrupt Function ...

▶ **How does 8086 get the address of a particular ISR?**

- ▶ In an 8086 system, each “interrupter” has an id #
- ▶ 8086 treat this id # as interruption type #
- ▶ After receiving INTR signal, 8086 sends an INTA signal
- ▶ After receiving INTA signal, interrupter releases it's id #, i.e., type # of the interruption.
- ▶ 8086 multiplies this id# or type# by 4 to produced the desired address in the **vector table**
- ▶ 8086 reads 4 bytes of memory starting from this address to get the starting address of ISR
 - ▶ lower 2 byte is loaded in to IP
 - ▶ higher 2 bytes to CS

Summary of 8086 Interrupt Function ...

- ▶ **What happens if two or more interrupts occur at the same time?**
 - ▶ Higher priority interrupts will be served first

Interrupt Type	Priority
DIVIDE ERROR, INT n, INTO	HIGHEST
NMI	
INTR	
SINGLE STEP	LOWEST

Thank You !!

