Basics of Computer Organization

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Book Chapter

- “Computer Organization and Architecture”
- Author “William Stallings”
- 8th Edition
- Chapter 2
- Chapter 3
  - Section 3.1
  - Section 3.2

Architecture and Organization (1/2)

- Architecture is those attributes visible to the programmer
  - Instruction set, number of bits used for data representations, I/O mechanism, addressing techniques etc.
  - e.g. is there an instruction for subtraction?
- Organization is how features are implemented
  - Control signals, interfaces, memory technology
  - e.g. is there a hardware unit for subtractor or is it done by addition operations?

Architecture and Organization (2/2)

- All Intel x86 family share the same basic architecture
- The IBM System/370 family share the same basic architecture
- It gives backward code compatibility
- Organization differs in different versions

Outline

- Computer Evolution and Performance
- Von Neumann Architecture
- A top level view of computer function
  - Computer Components
- Interconnection Structure
- Bus Interconnection
- Computer Memory System Overview

Computer Evolution

- It is widely accepted to classify computers into generations based on the fundamental hardware technology employed

Generation	Approximate Dates	Technology	Typical Speed (Operations/second)
1	1946 – 1957	Vacuum tube	40,000
2	1958 – 1964	Transistor	200,000
3	1965 – 1971	Small and Medium Scale Integration	1,000,000
4	1972 – 1977	Large Scale Integration	10,000,000
5	1978 – 1991	Very Large Scale Integration	100,000,000
6	1991 –	Ultra Large Scale Integration	1,000,000,000

Computer Evolution

- First Generation of Computers
  - Use of vacuum tubes
- Second Generation of Computers
  - Transistors replaced vacuum tubes
- Third Generation of Computers
  - Integrated Circuits were introduced
- Later Generations
  - Large Scale Integration (LSI)
  - Very Large Scale Integration (VLSI)

First Generation of Computers

- Electronic Numerical Integrator And Computer (ENIAC) was first general purpose computer
- Very expensive
  - Weighted 30 tons
  - Occupied 1500 square feet
  - Contained more than 18000 vacuum tubes
  - Consumed 140 kilowatts when operating
- Used decimal system rather than binary system

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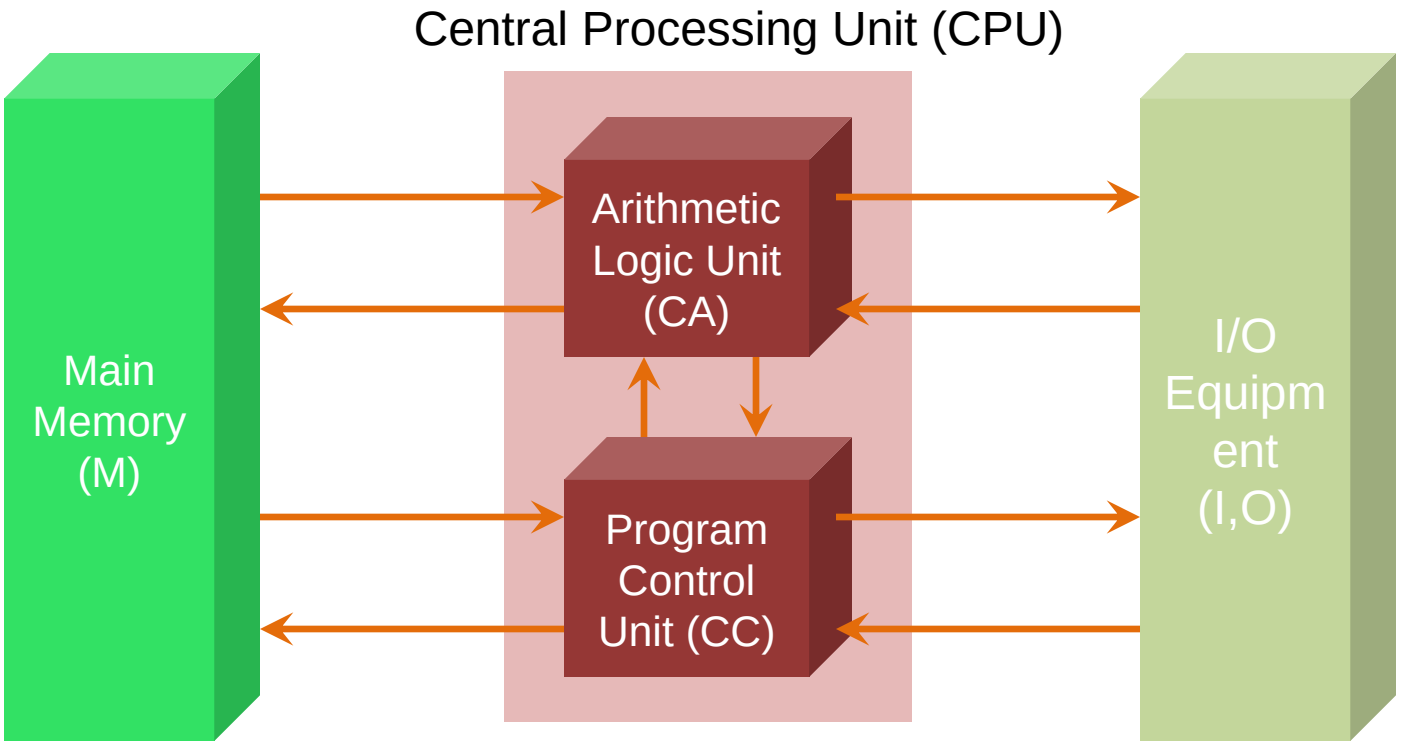
von Neumann Architecture

- ENIAC did not provide the facility to store programs
- Stored-Program Concept proposed by John von Neumann
- Much similar to modern machines
  - …that's why today's computers are referred to as Von Neumann Machines

IAS Computer (1/2)

- Followed stored-program concept
- It contained
  - Main memory storing programs and data
  - ALU operating on binary data
  - Control Unit interprets instructions from memory and causes them to be executed
  - Input and Output equipment operated by control unit

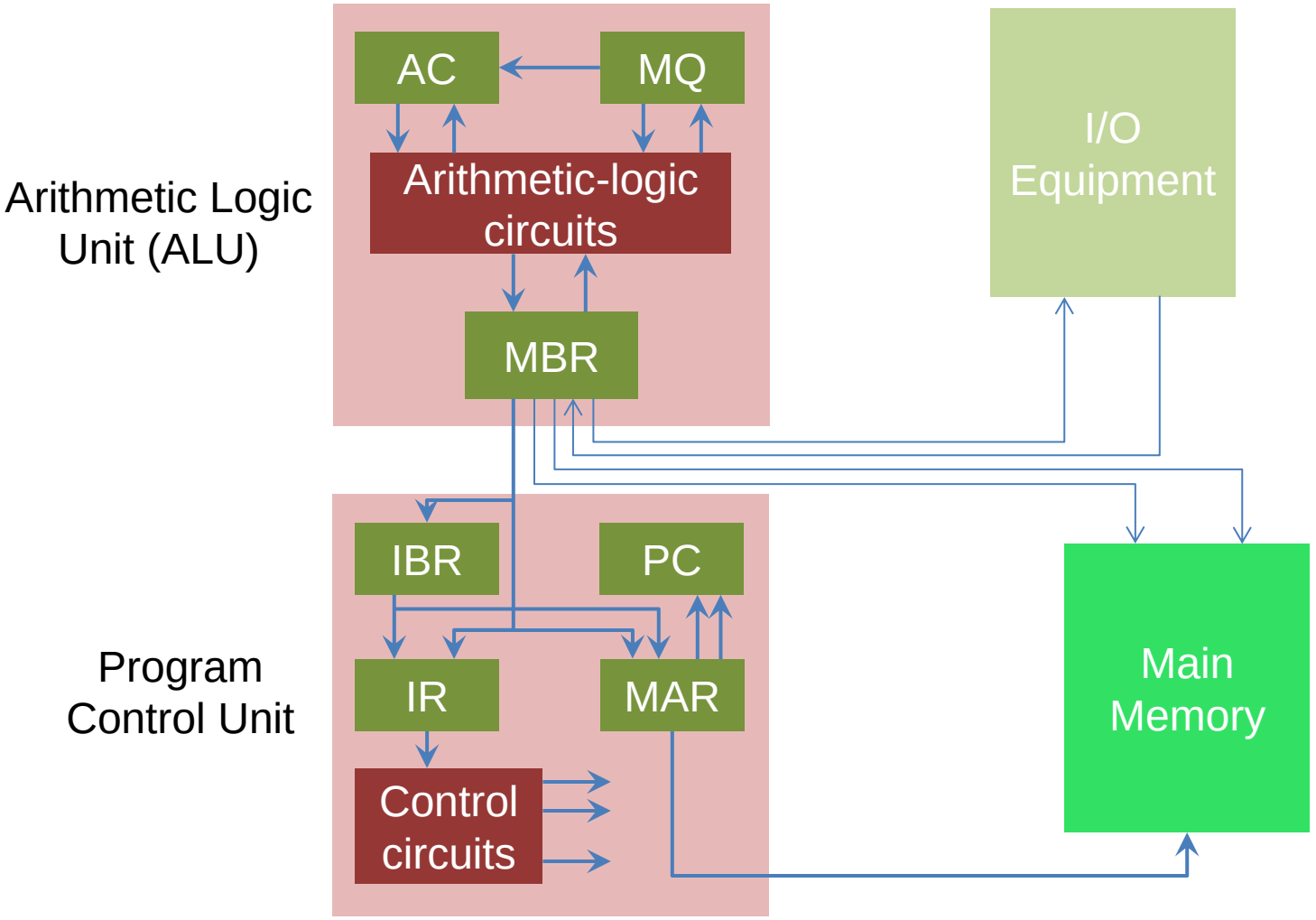
IAS Computer (2/2)



IAS Details

- 1000 words each of 40 bits
  - Binary Numbers
  - 2x20 bit instructions
- Set of registers (storage in CPU)
  - Memory Buffer Register (MBR)
  - Memory Address Register (MAR)
  - Instruction Register (IR)
  - Instruction Buffer Register (IBR)
  - Program Counter (PC)
  - Accumulator (AC)
  - Multiplier Quotient (MQ)

IAS Expanded Structure



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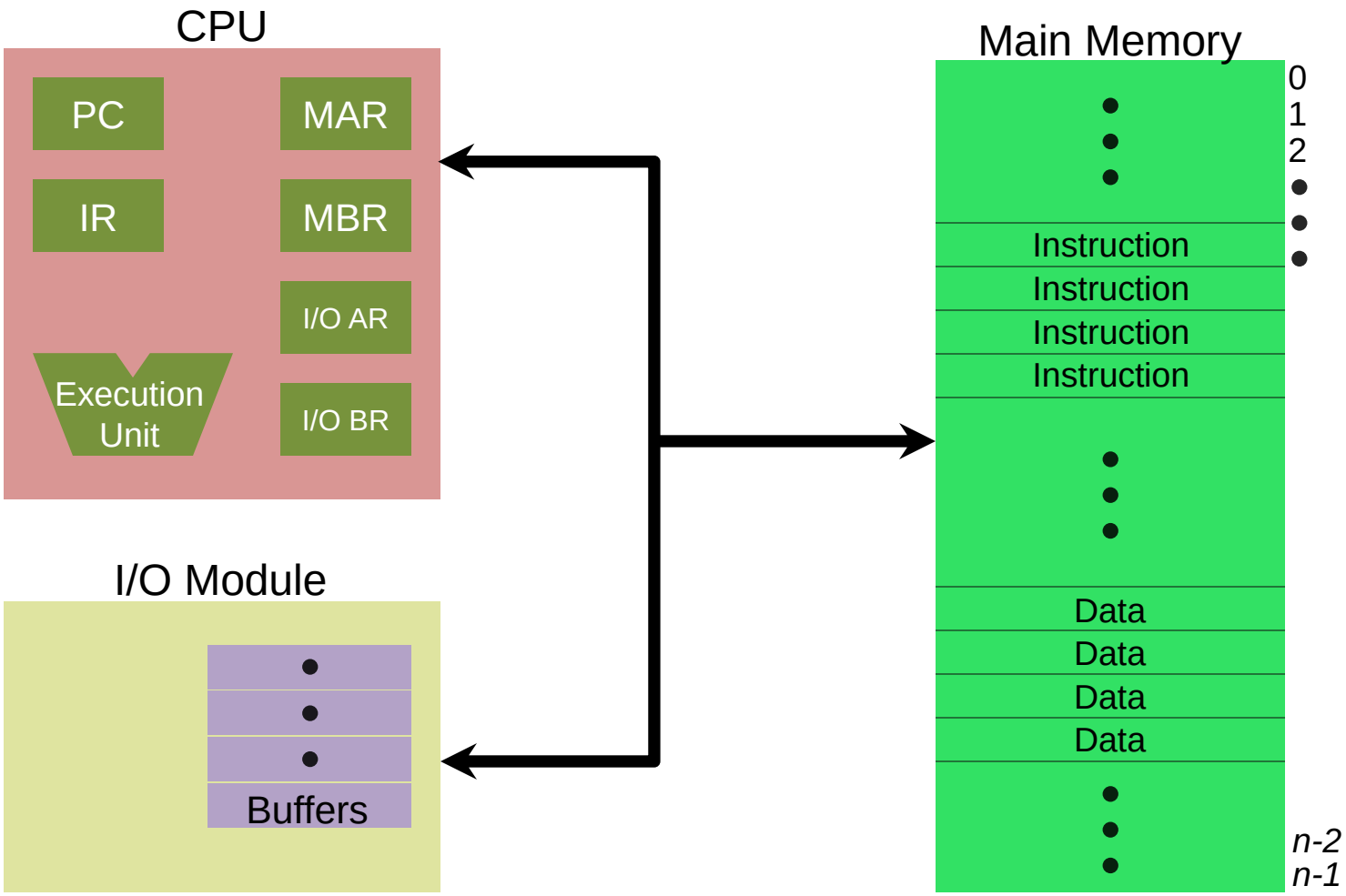
Computer Components

- According to von Neumann machine architecture, a computer has the following components
  - Central Processing Unit (CPU)
  - Main Memory
  - I/O Components
- A top level view of computer components is shown in next slide

Computer Components



Interrupts

- Mechanism by which other modules may interrupt normal sequence of processing
- If normal execution of current program must be interrupted, the device raises an interrupt signal
- Interrupt-service routine
- Current system information is backed up before calling interrupt handler
- After interrupt completion, the previous system information is restored

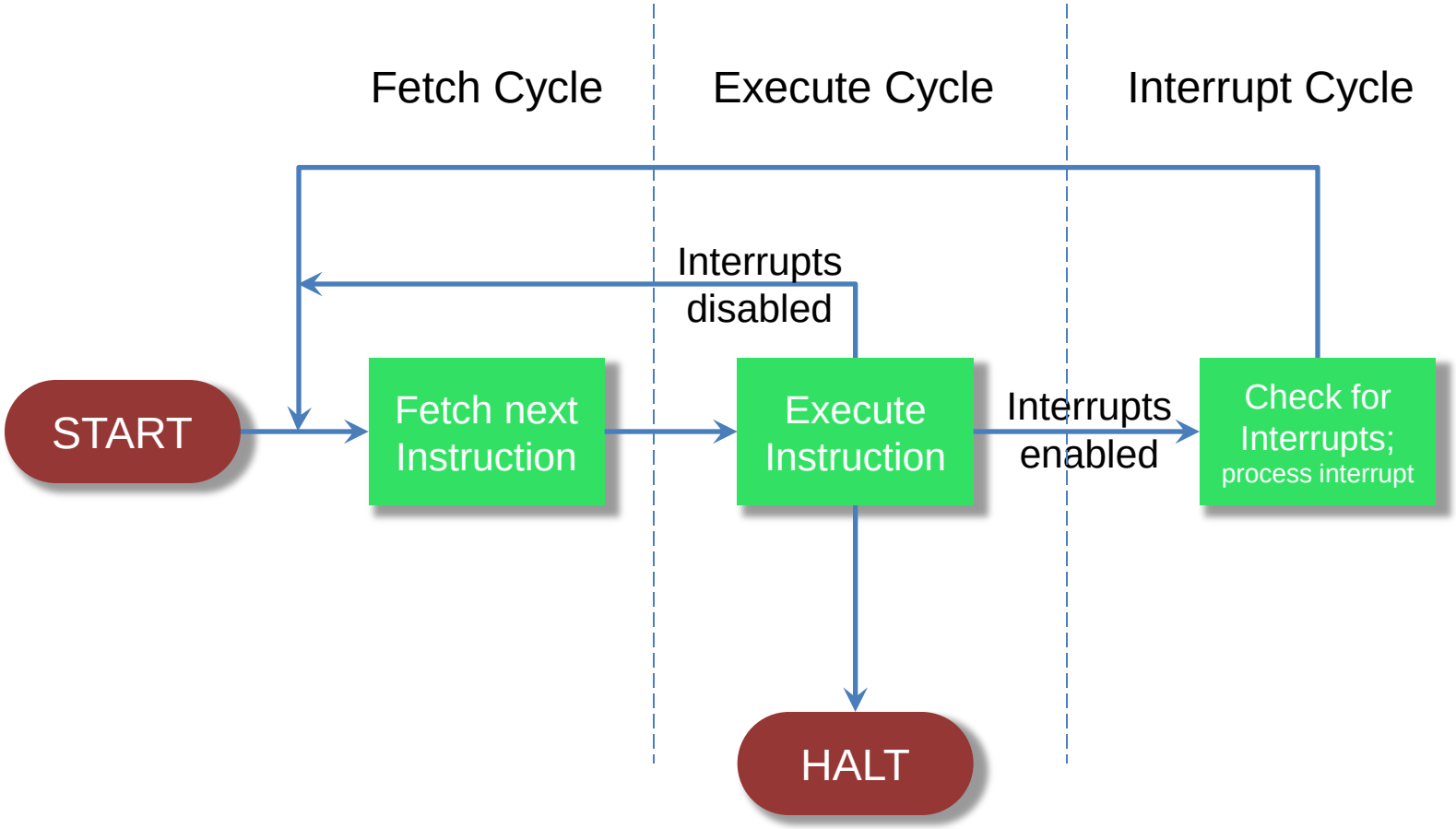
Classes of Interrupts

- 4 different classes of interrupts
- Program
  - Generated by program executions
  - Arithmetic overflow, division by zero
- Timer
  - Generated by internal processor timer
  - Used in pre-emptive multi-tasking
- I/O
  - From I/O controller
- Hardware failure
  - Power failure, memory parity error

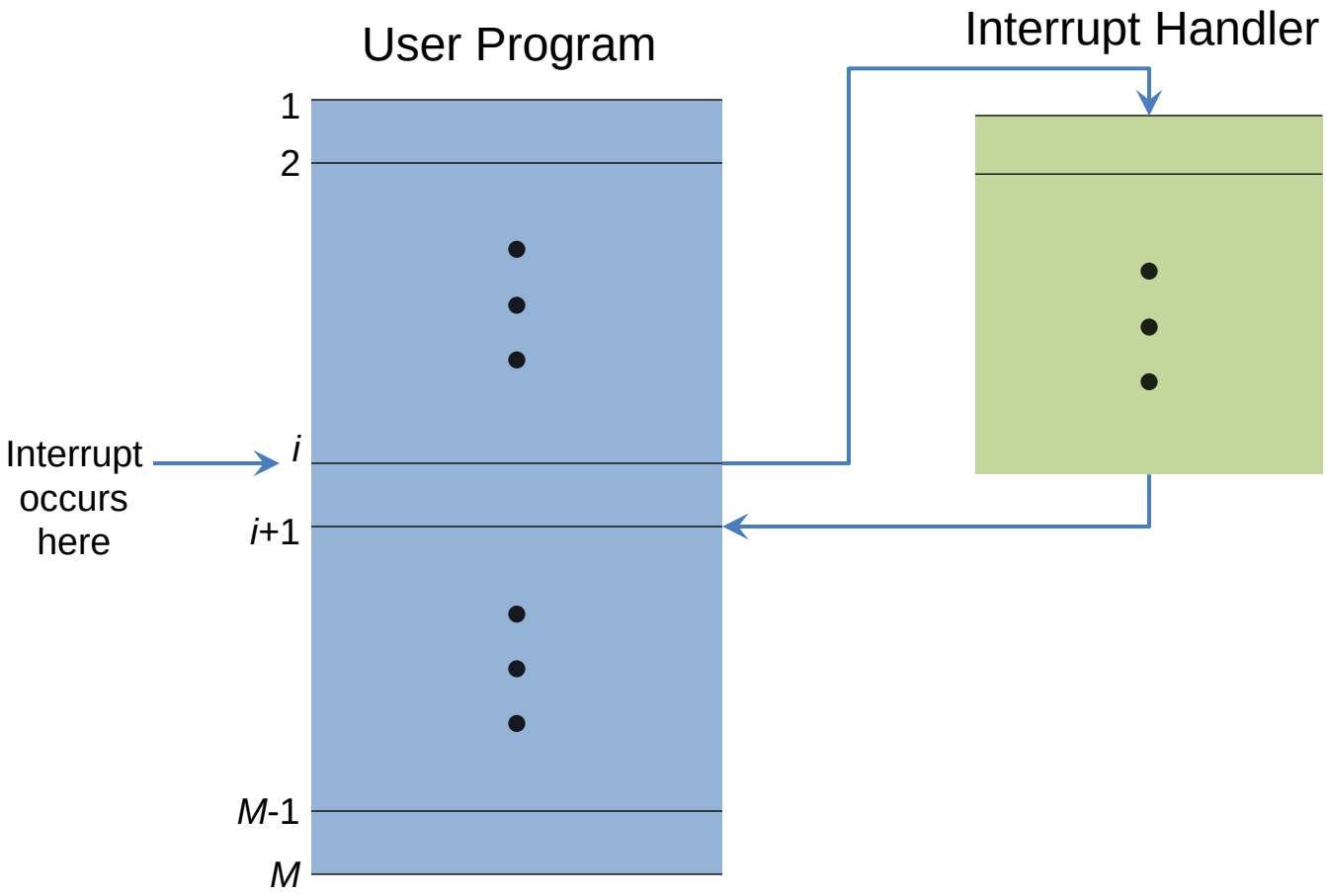
Interrupt Cycle

- Added to instruction execution cycle
- Processor checks for interrupts
  - Indicated by an interrupt signal
- If no interrupt, fetch next instruction
- If interrupt pending…
  - Suspend execution of current program
  - Save context
  - Set PC to start address of interrupt handler routine
  - Process interrupt
  - Restore context and continue interrupted program

Instruction Execution Cycle with Interrupts



Transfer of Control via Interrupts

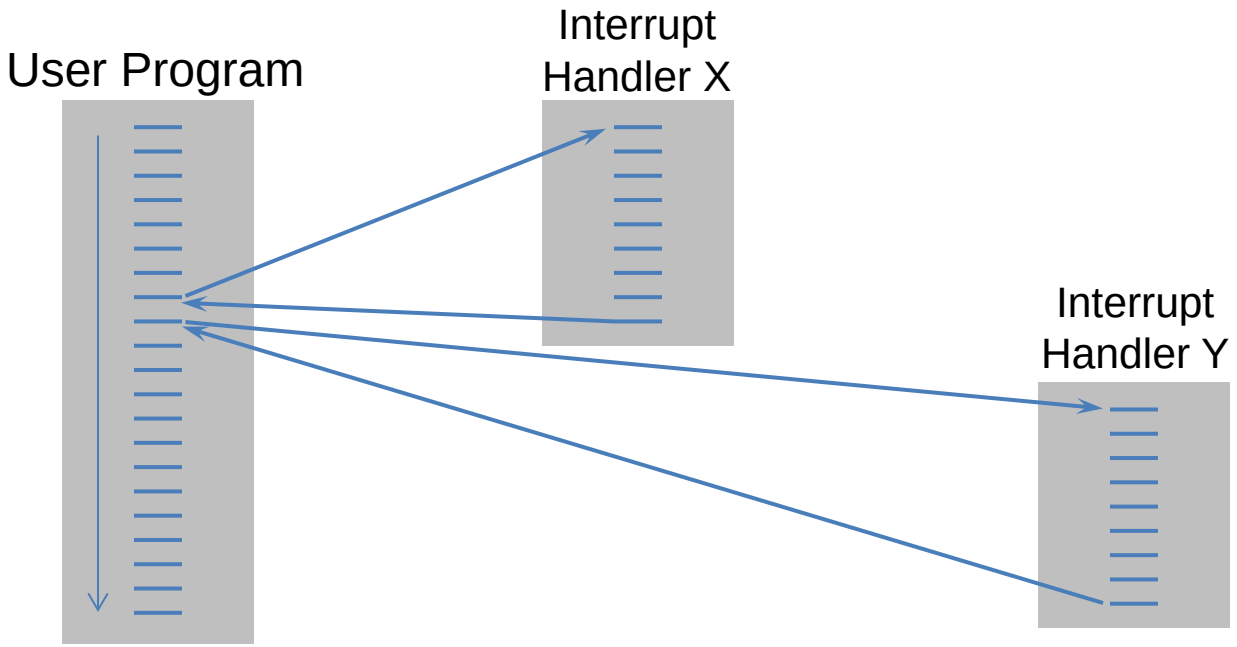


Multiple Interrupts

- Multiple interrupts can occur in some situations
- Multiple interrupts can be handled using two approaches
  - Disabling Interrupts
  - Defining properties of interrupts

Disabling Interrupts

- Processor can ignore further interrupts whilst processing one interrupt
- Interrupts remain pending and are checked after first interrupt has been processed
- Interrupts are handled in sequence as they occur hence called Sequential Interrupts



Defining Properties of Interrupts

- Low priority interrupts can be interrupted by higher priority interrupts
- When higher priority interrupt has been processed, processor returns to previous interrupt
- These types of interrupts are called Nested Interrupts