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Computer Organization
and Architecture
6th Edition

Chapter 3

System Buses

Program Concept

- Hardwired systems are inflexible
- General purpose hardware can do different tasks, given correct control signals
- Instead of re-wiring, supply a new set of control signals

What is a program?

- A sequence of steps
- For each step, an arithmetic or logical operation is done
- For each operation, a different set of control signals is needed

Function of Control Unit

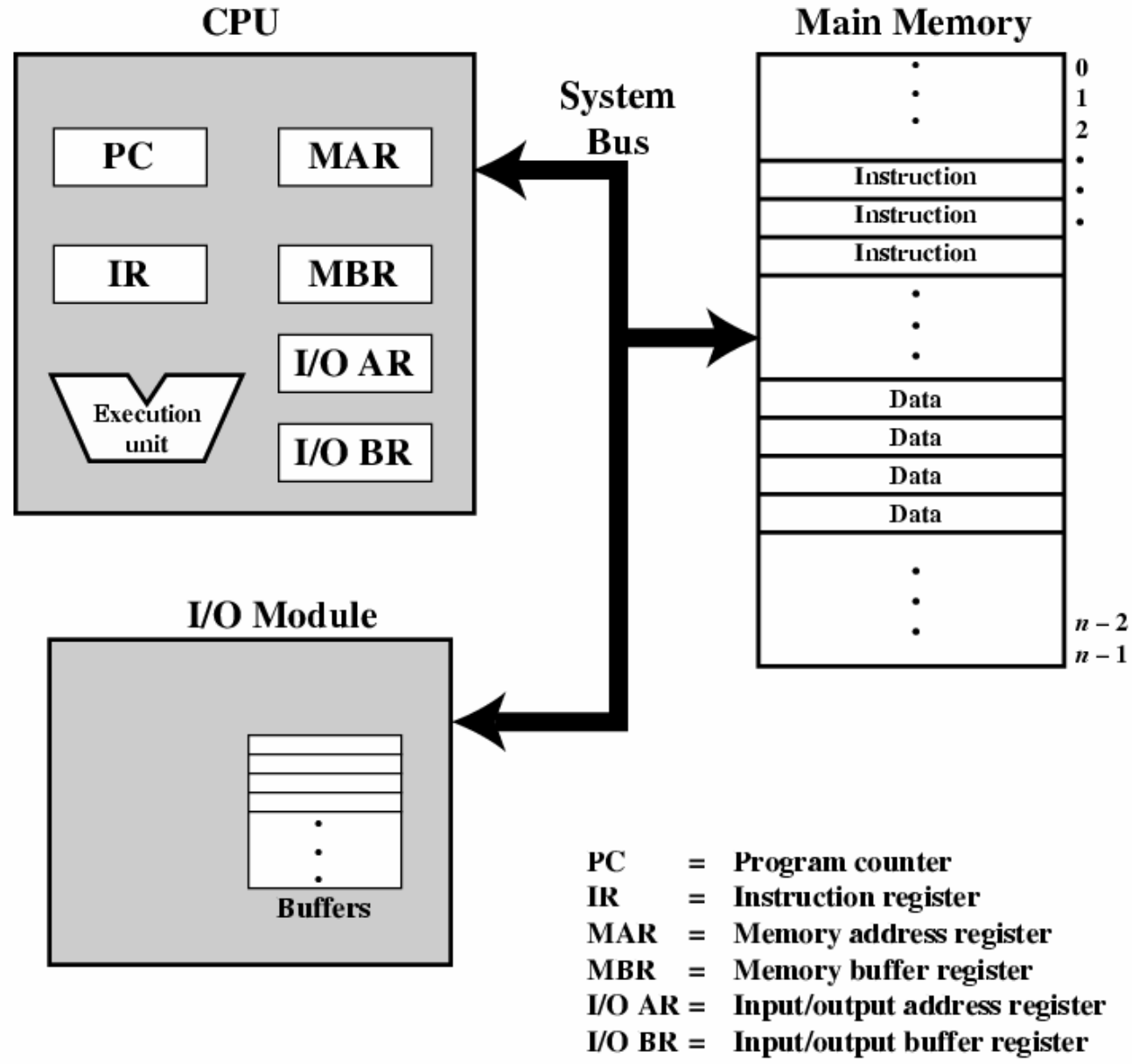
- For each operation a unique code is provided
  - —e.g. ADD, MOVE
- A hardware segment accepts the code and issues the control signals

- We have a computer!

Components

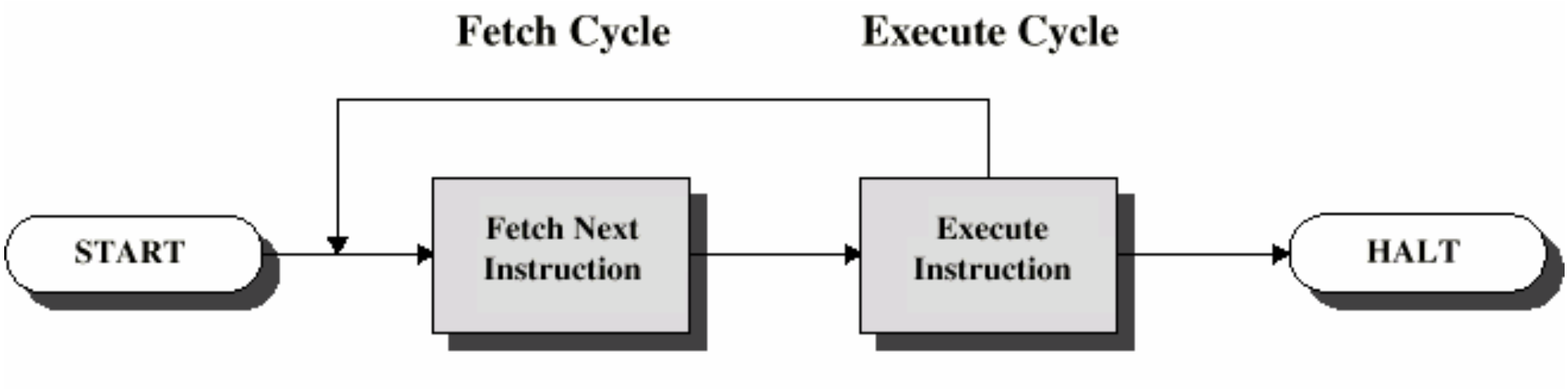
- The Control Unit and the Arithmetic and Logic Unit constitute the Central Processing Unit
- Data and instructions need to get into the system and results out
  - —Input/output
- Temporary storage of code and results is needed
  - —Main memory

Computer Components: Top Level View



Instruction Cycle

- Two steps:
  - —Fetch
  - —Execute



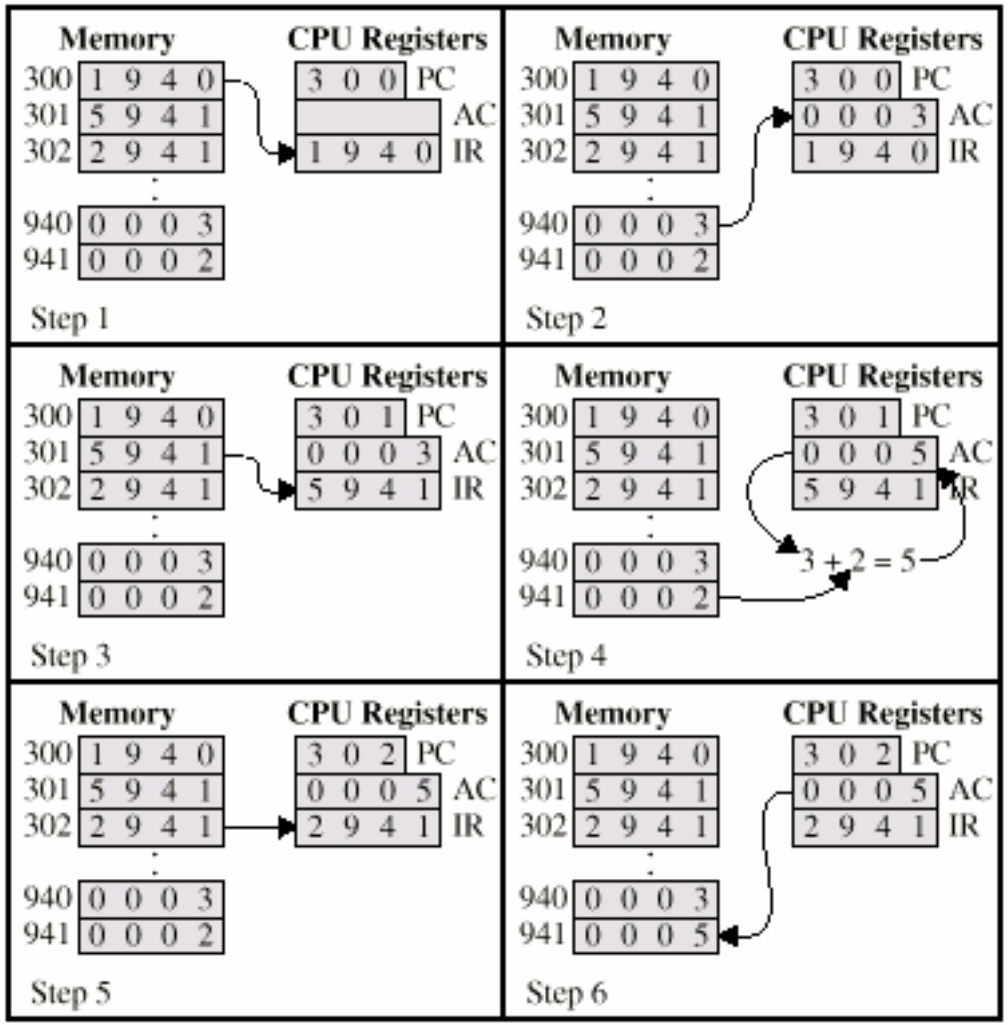
Fetch Cycle

- Program Counter (PC) holds address of next instruction to fetch
- Processor fetches instruction from memory location pointed to by PC
- Increment PC
  - —Unless told otherwise
- Instruction loaded into Instruction Register (IR)
- Processor interprets instruction and performs required actions

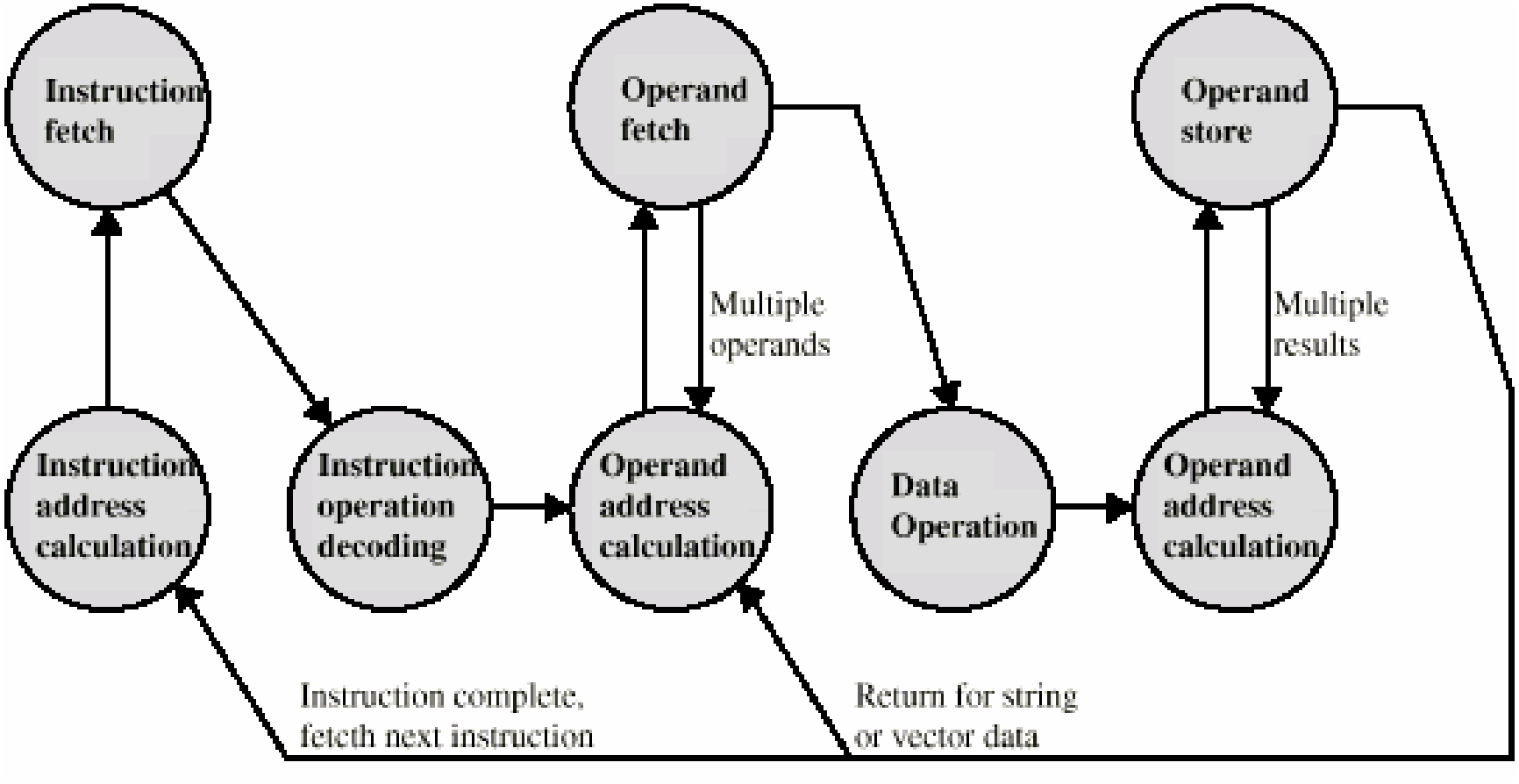
Execute Cycle

- Processor-memory
  - —data transfer between CPU and main memory
- Processor I/O
  - —Data transfer between CPU and I/O module
- Data processing
  - —Some arithmetic or logical operation on data
- Control
  - —Alteration of sequence of operations
  - —e.g. jump
- Combination of above

Example of Program Execution



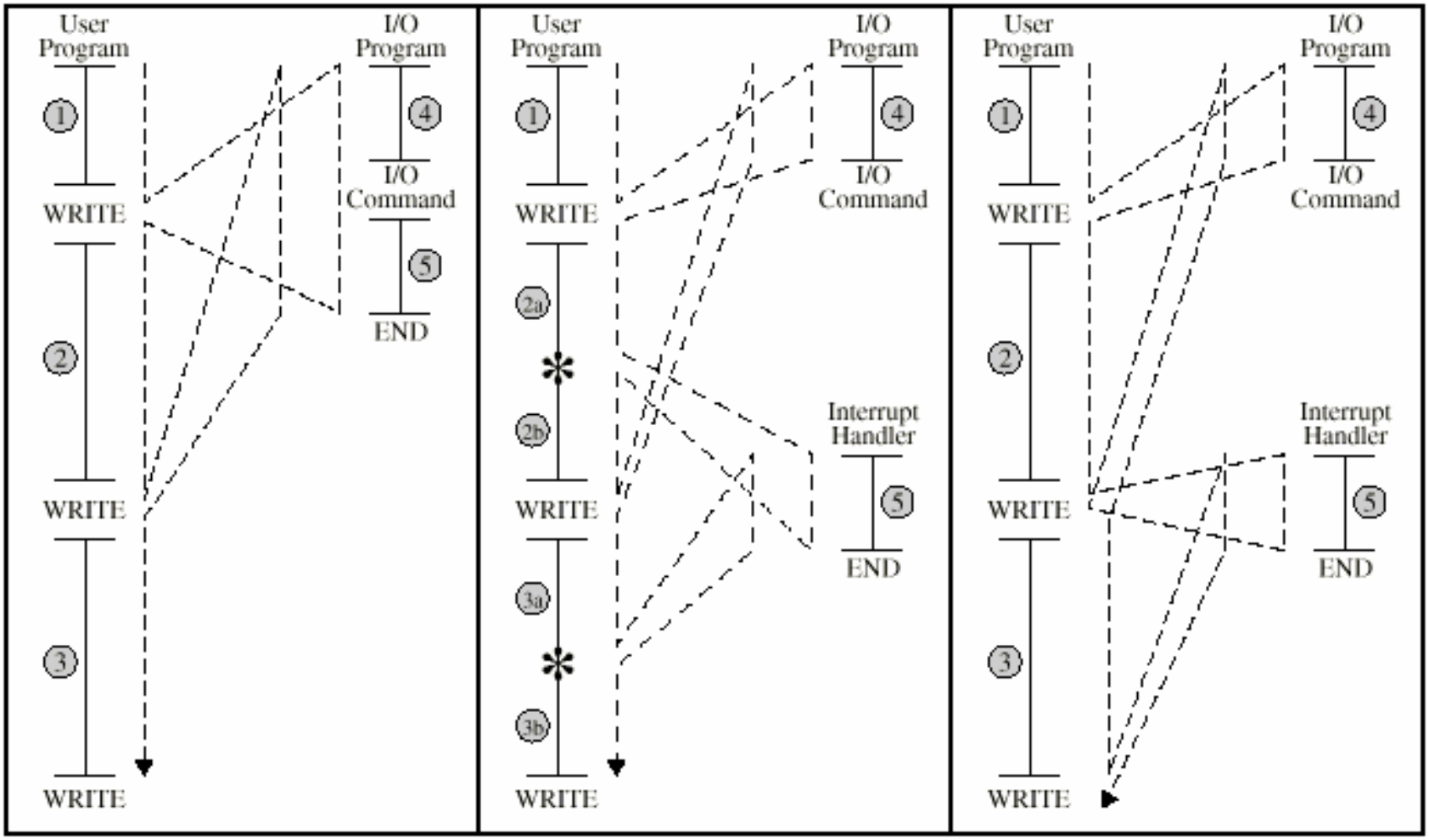
Instruction Cycle - State Diagram



Interrupts

- Mechanism by which other modules (e.g. I/O) may interrupt normal sequence of processing
- Program
  - e.g. overflow, division by zero
- Timer
  - Generated by internal processor timer
  - Used in pre-emptive multi-tasking
- I/O
  - from I/O controller
- Hardware failure
  - e.g. memory parity error

Program Flow Control



(a) No interrupts

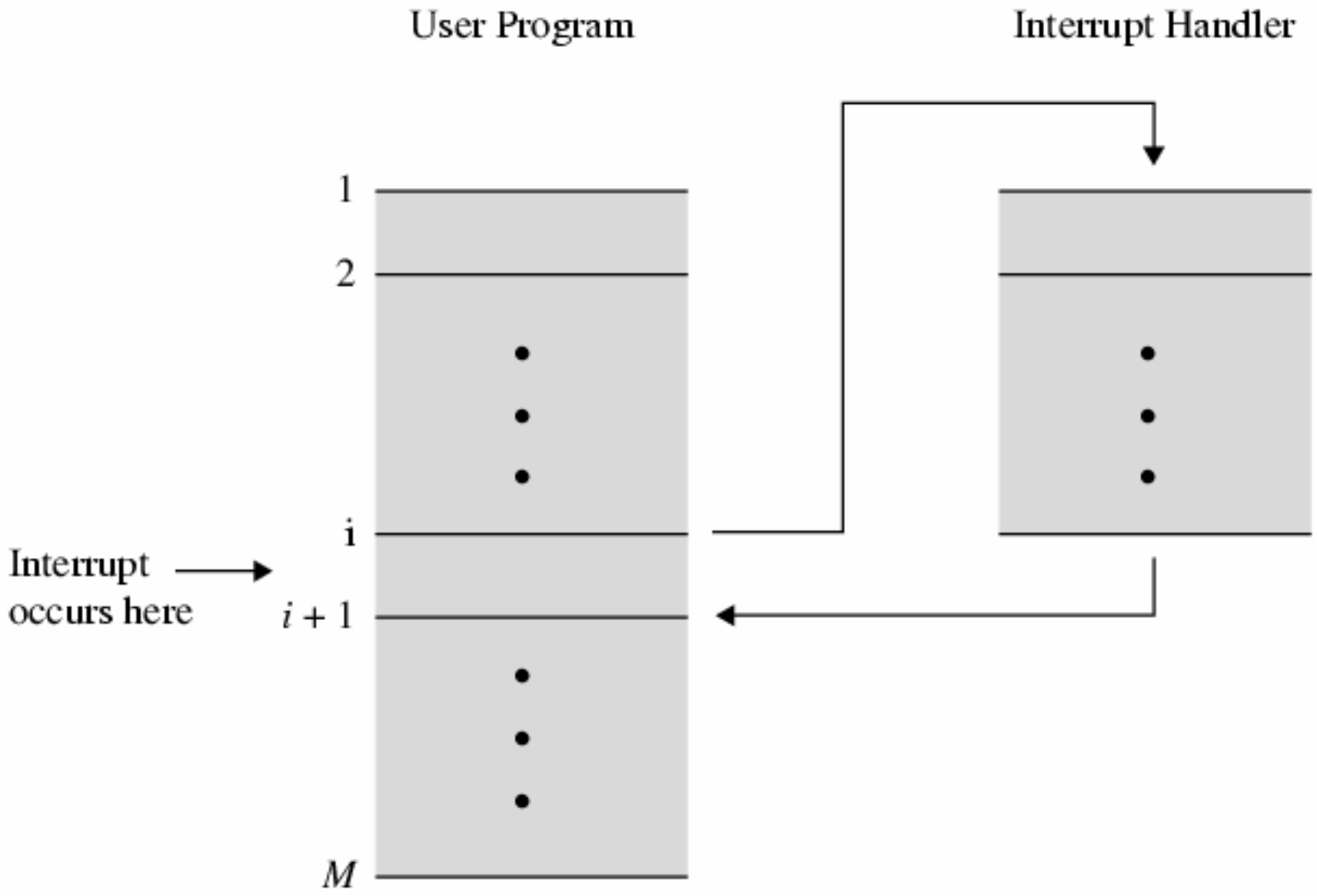
(b) Interrupts; short I/O wait

(c) Interrupts; long I/O wait

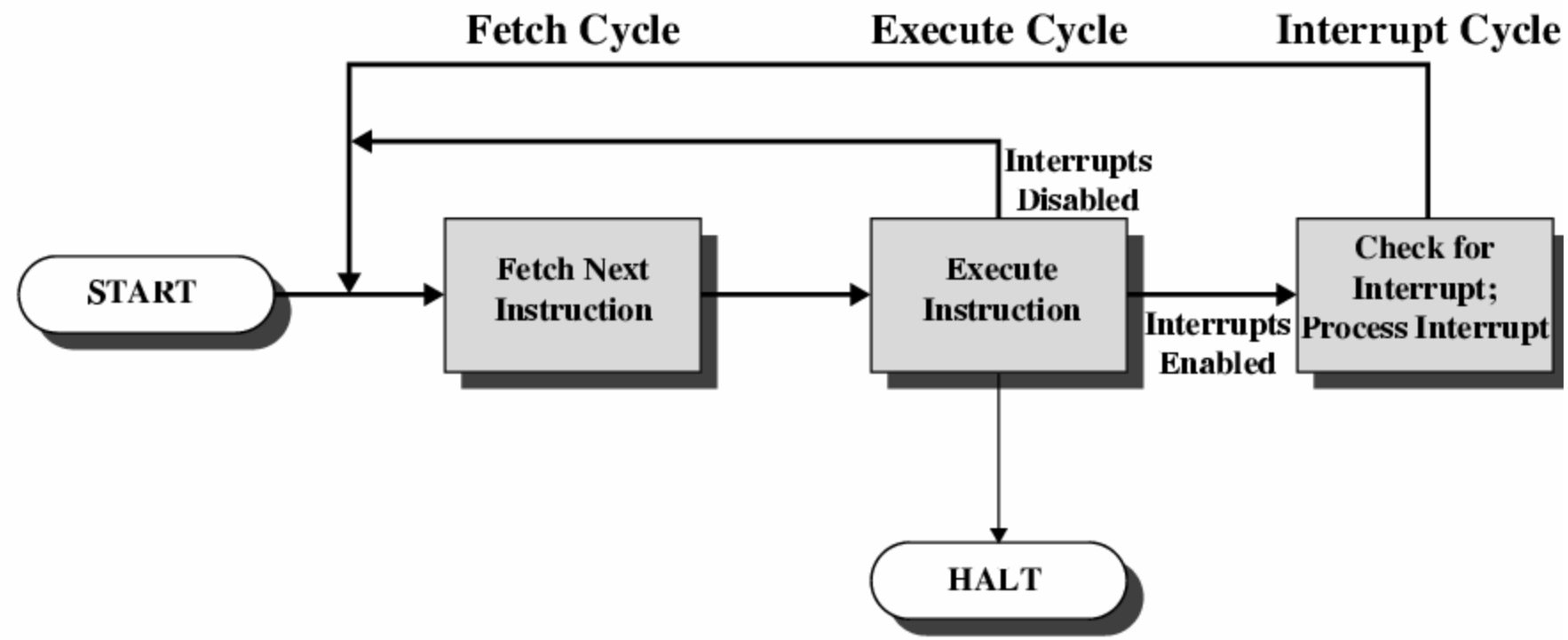
Interrupt Cycle

- Added to instruction cycle
- Processor checks for interrupt
  - 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

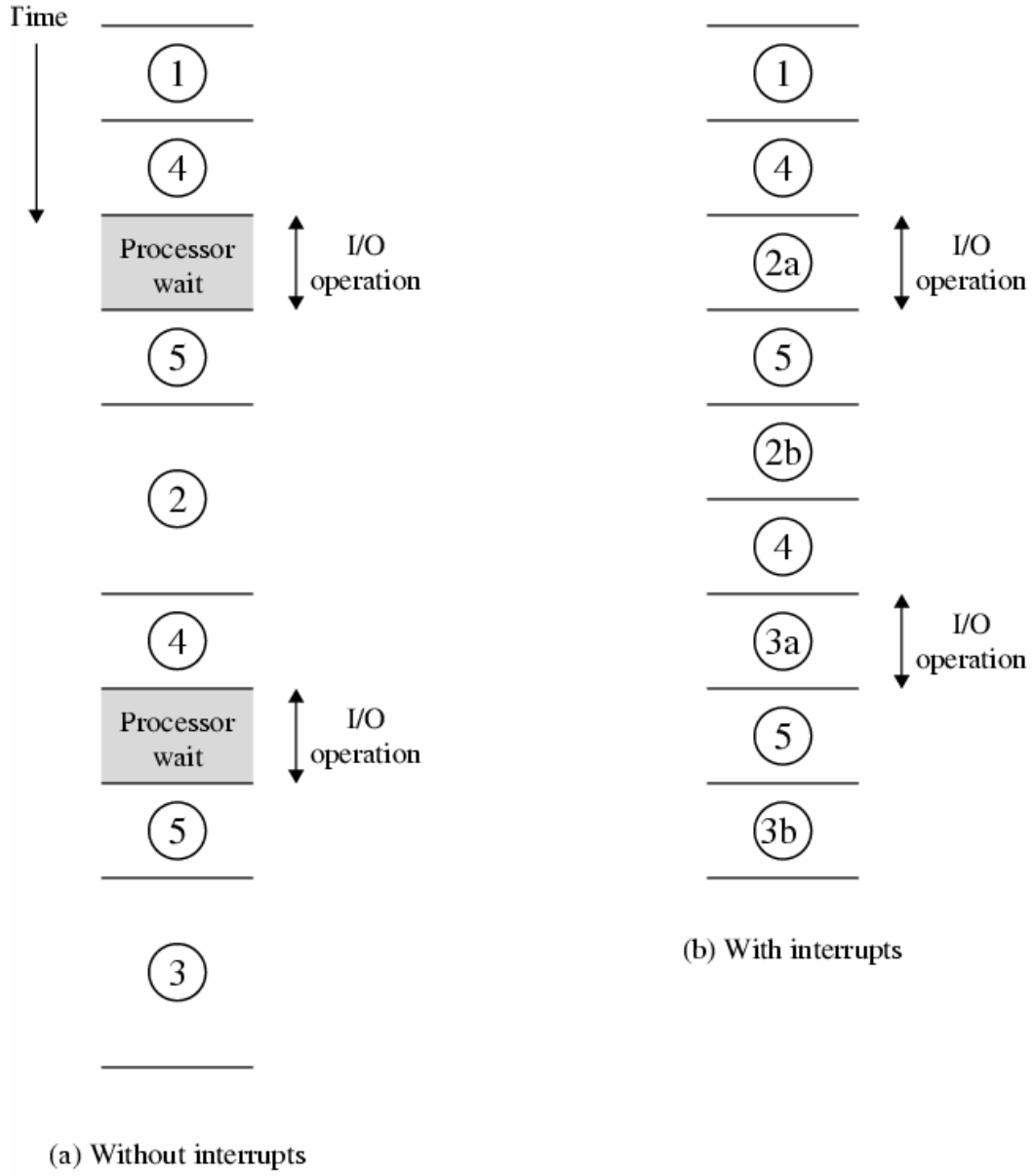
Transfer of Control via Interrupts



Instruction Cycle with Interrupts



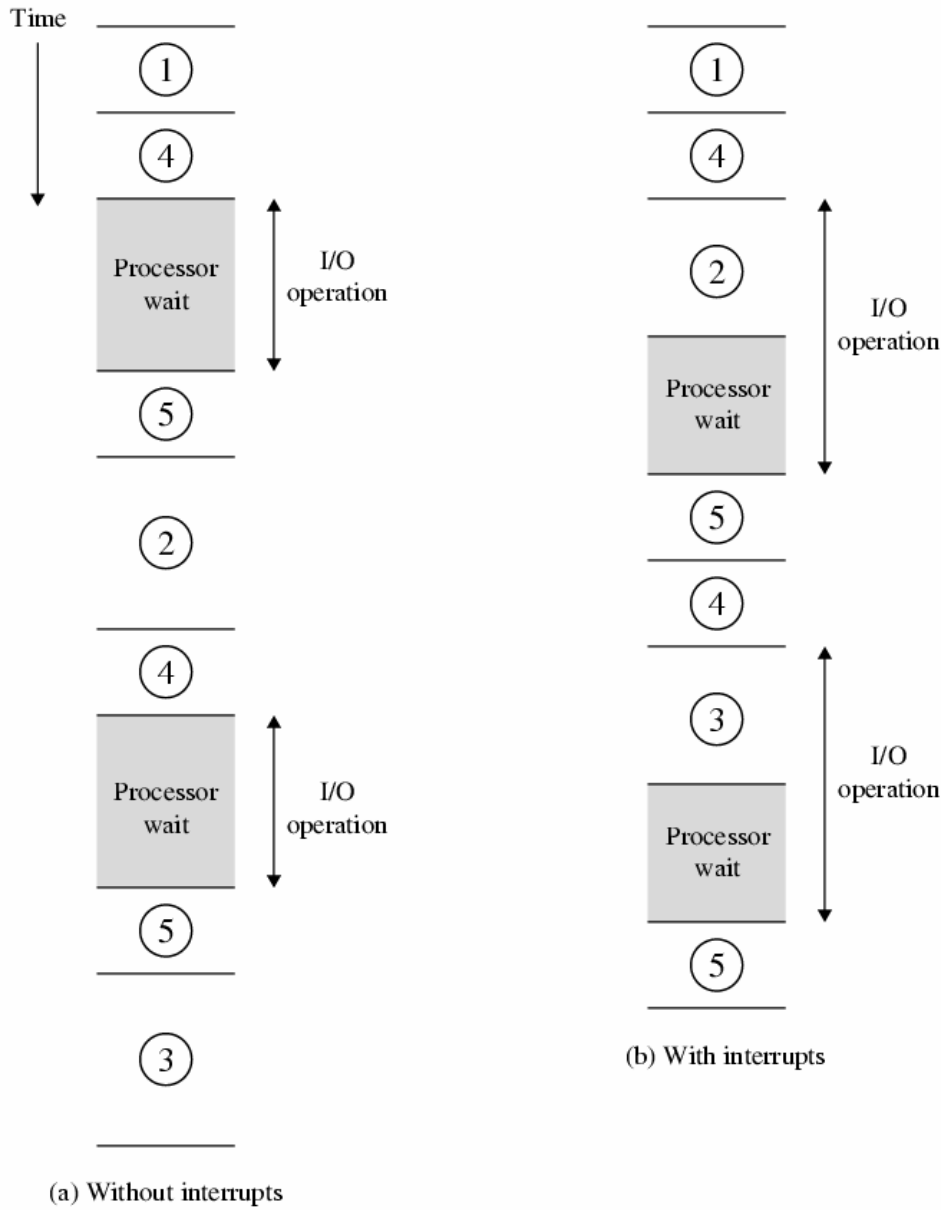
Program Timing
Short I/O Wait



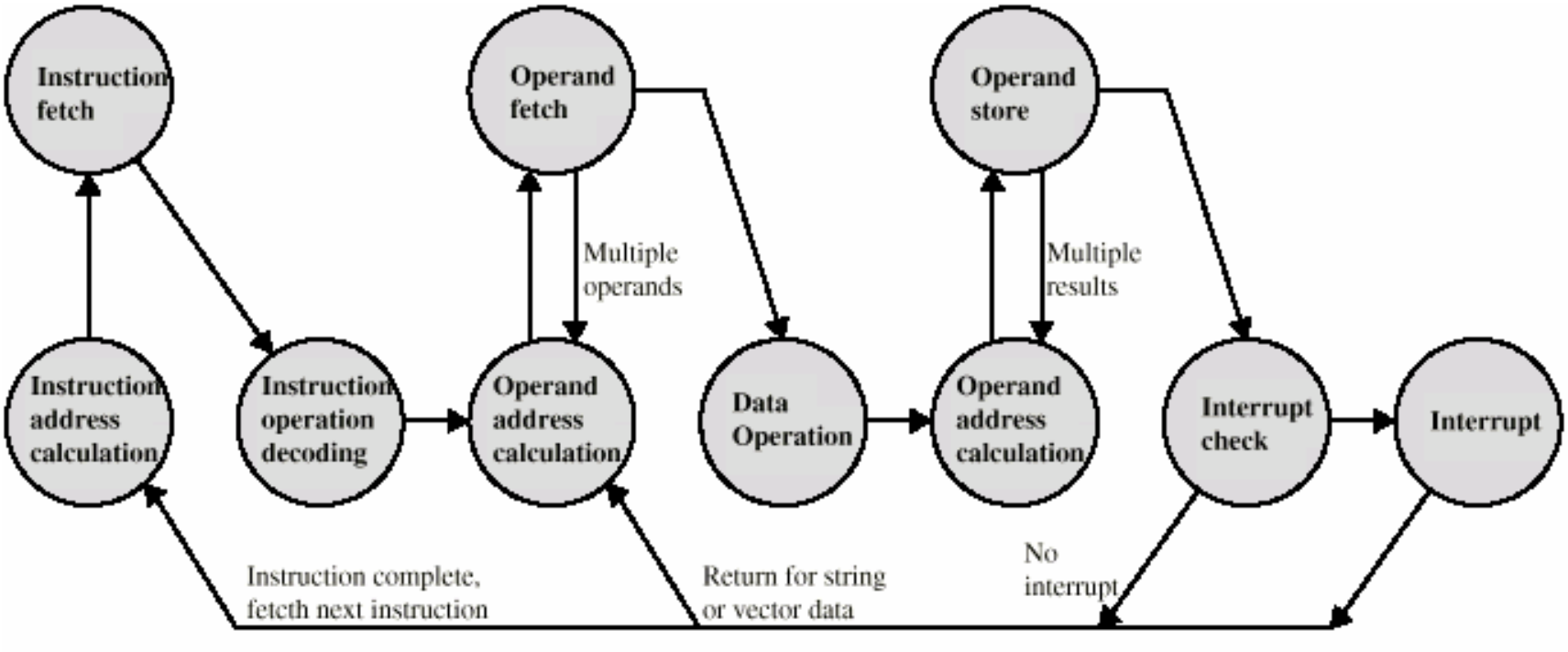
(a) Without interrupts

(b) With interrupts

Program Timing
Long I/O Wait



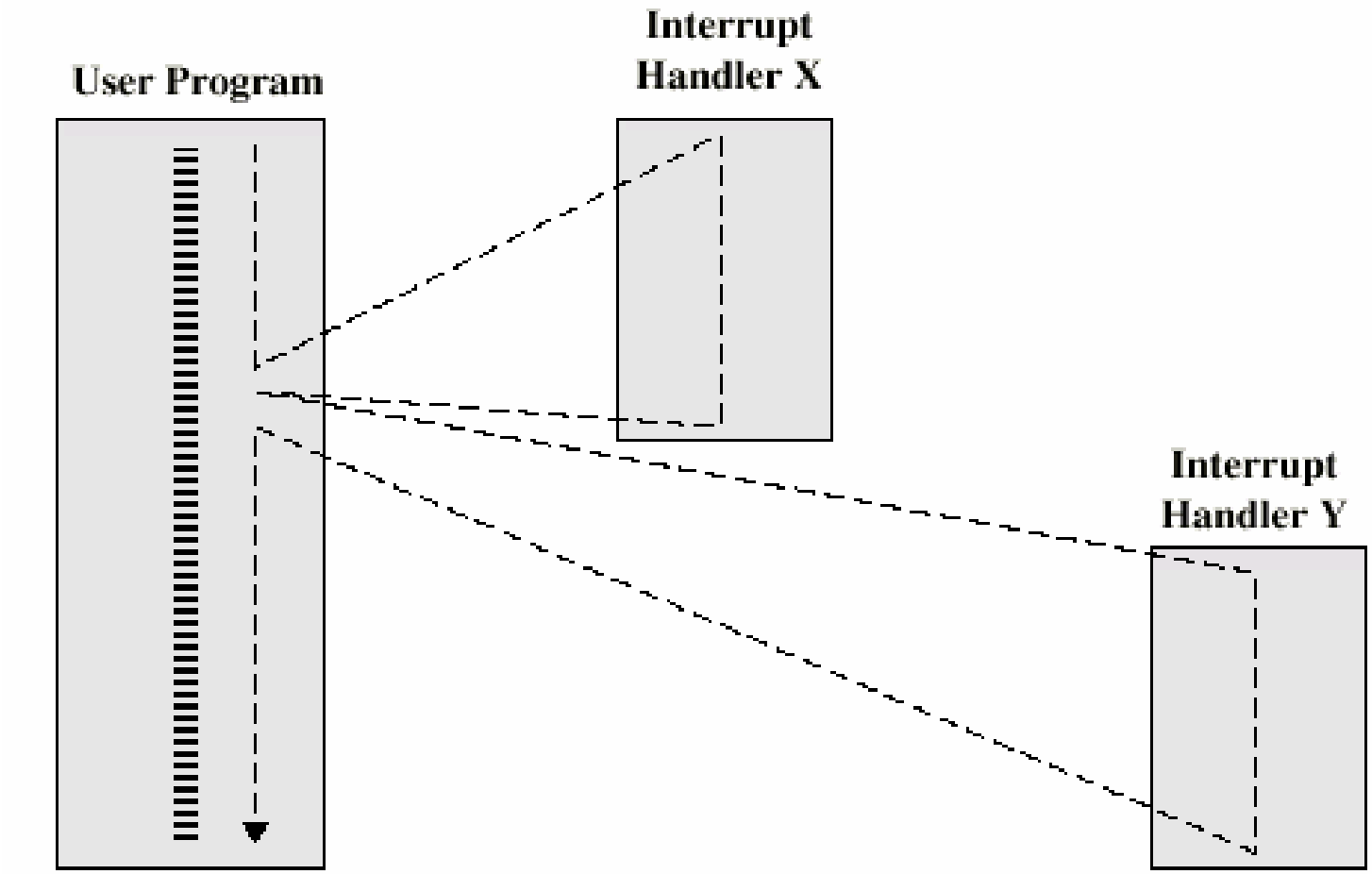
Instruction Cycle (with Interrupts) - State Diagram



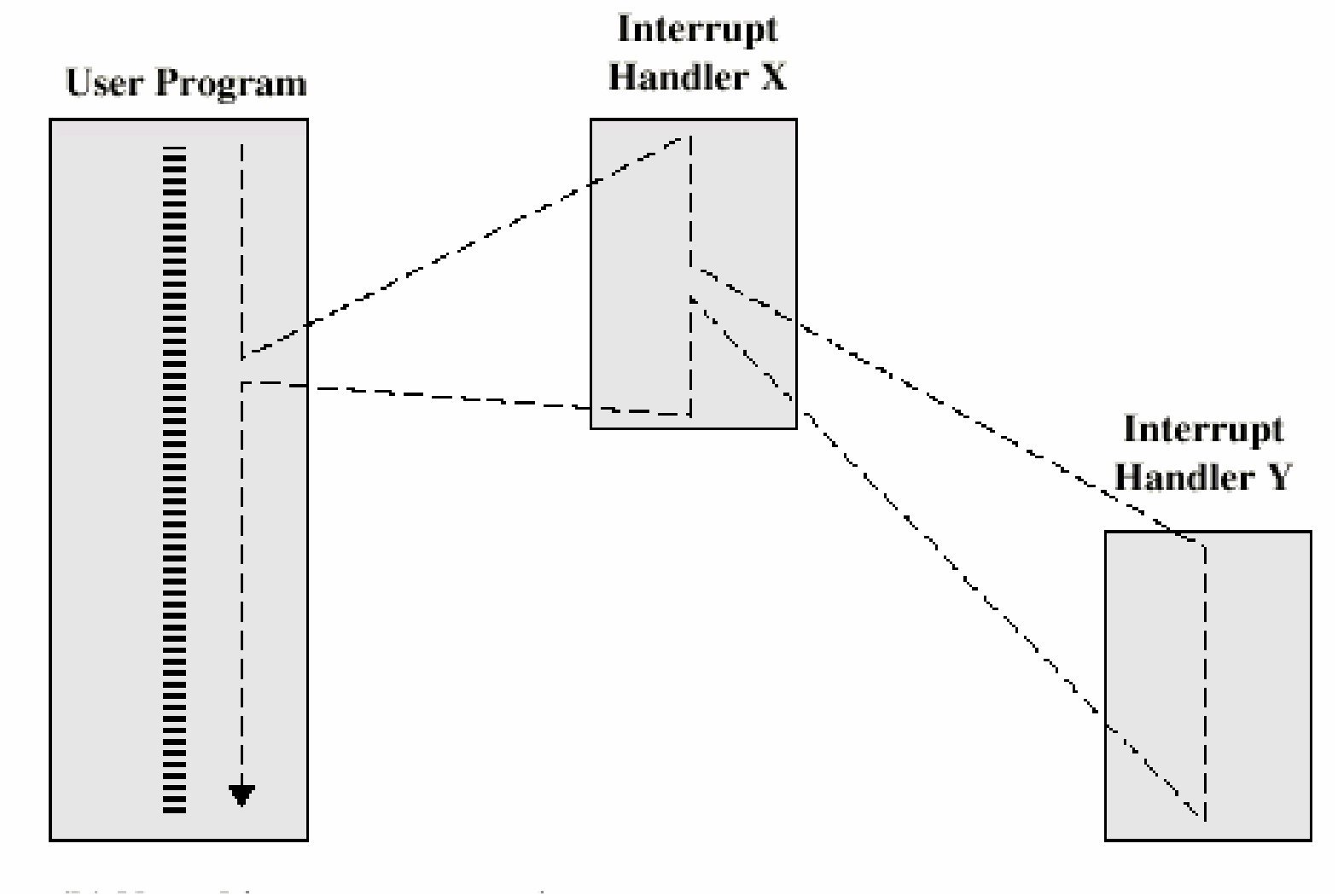
Multiple Interrupts

- Disable interrupts
  - Processor will ignore further interrupts whilst processing one interrupt
  - Interrupts remain pending and are checked after first interrupt has been processed
  - Interrupts handled in sequence as they occur
- Define priorities
  - Low priority interrupts can be interrupted by higher priority interrupts
  - When higher priority interrupt has been processed, processor returns to previous interrupt

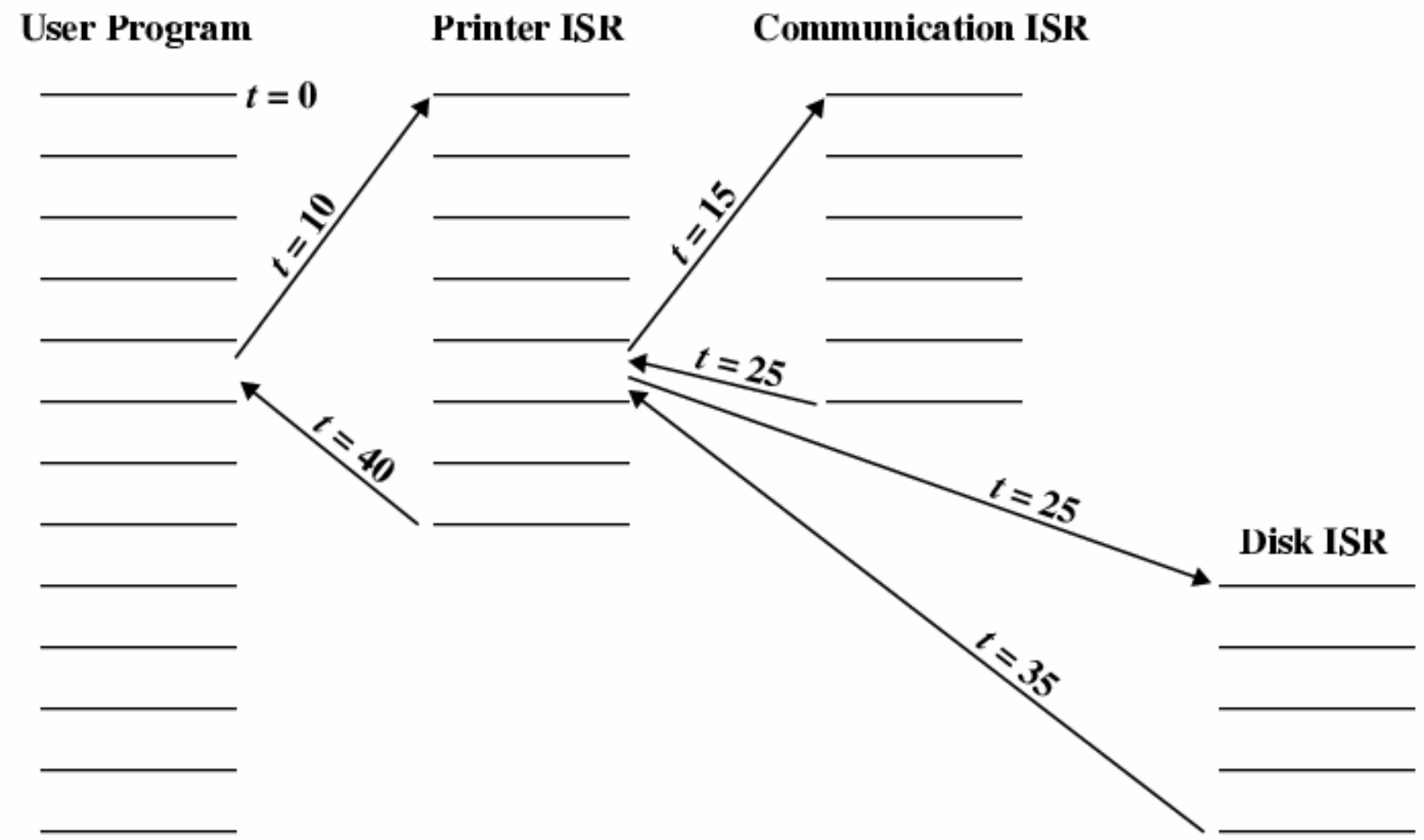
Multiple Interrupts - Sequential



Multiple Interrupts – Nested



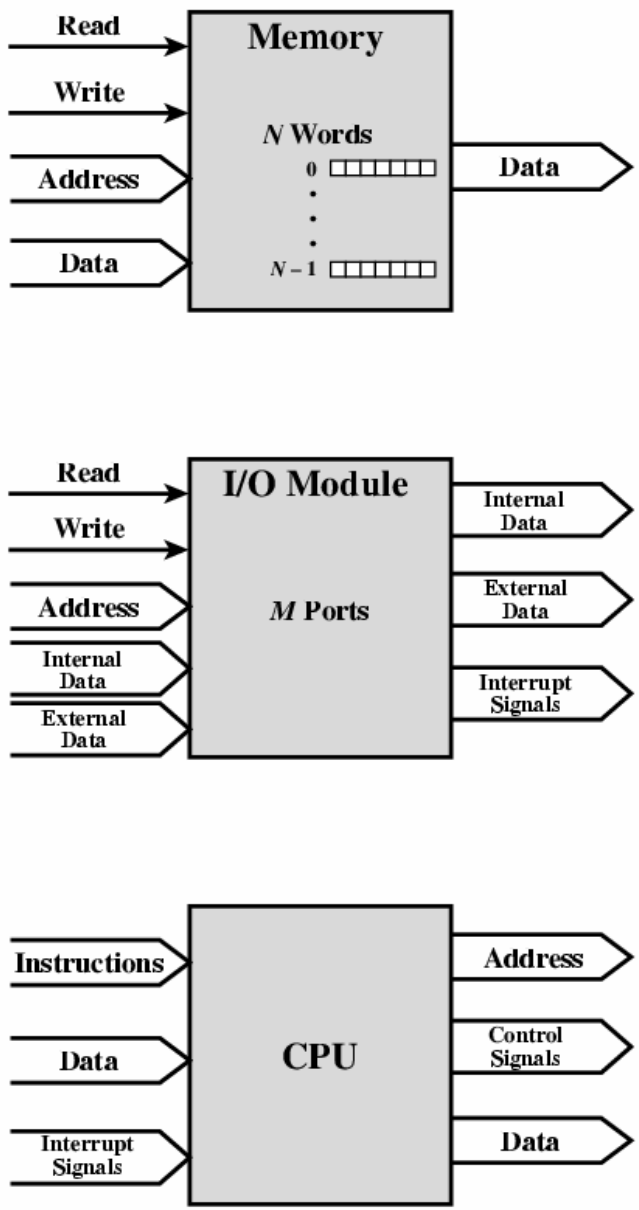
Time Sequence of Multiple Interrupts



Connecting

- All the units must be connected
- Different type of connection for different type of unit
  - Memory
  - Input/Output
  - CPU

Computer Modules



Memory Connection

- Receives and sends data
- Receives addresses (of locations)
- Receives control signals
  - Read
  - Write
  - Timing

Input/Output Connection(1)

- Similar to memory from computer's viewpoint
- Output
  - —Receive data from computer
  - —Send data to peripheral
- Input
  - —Receive data from peripheral
  - —Send data to computer

Input/Output Connection(2)

- Receive control signals from computer
- Send control signals to peripherals
  - —e.g. spin disk
- Receive addresses from computer
  - —e.g. port number to identify peripheral
- Send interrupt signals (control)

CPU Connection

- Reads instruction and data
- Writes out data (after processing)
- Sends control signals to other units
- Receives (& acts on) interrupts