

Chapter 4

Programming and the Program Execution Process



Outline

- **Computer Programs**
 - **Program execution and associated hardware**
- **The Programming Process**
- **Programming languages**

Program

- The behaviour of the computer is controlled by **a set of step-by-step instructions called program.**
- Every thing interesting or useful about a **computer behaviour** results from its program rather than the hardware it carries it.
- The computer **processes information by executing a program** stored in memory.
- The execution takes place with in the CPU and is controlled by the CU.

Program Execution

- Executing a program requires the CPU to examine each program instruction in memory and send out the command signals required to perform each instruction.
- Although instructions are normally performed consecutively (sequencing), they can be skipped (branching) or repeated (looping) under program control. (**Structured Programming**)
- During execution, data can be entered by the operator (user), or from a saved file.
- After processing, the program output can be displayed or printed as a result.

Example...

- The sequence of instructions could be as follows :- (**Sequencing**)
 - Get out of bed
 - Have breakfast
 - Get dressed
 - Get into car
 - Drive to work
 - End of program

Example: Finding the square root of a number

(May use **Branching** and **Looping**)

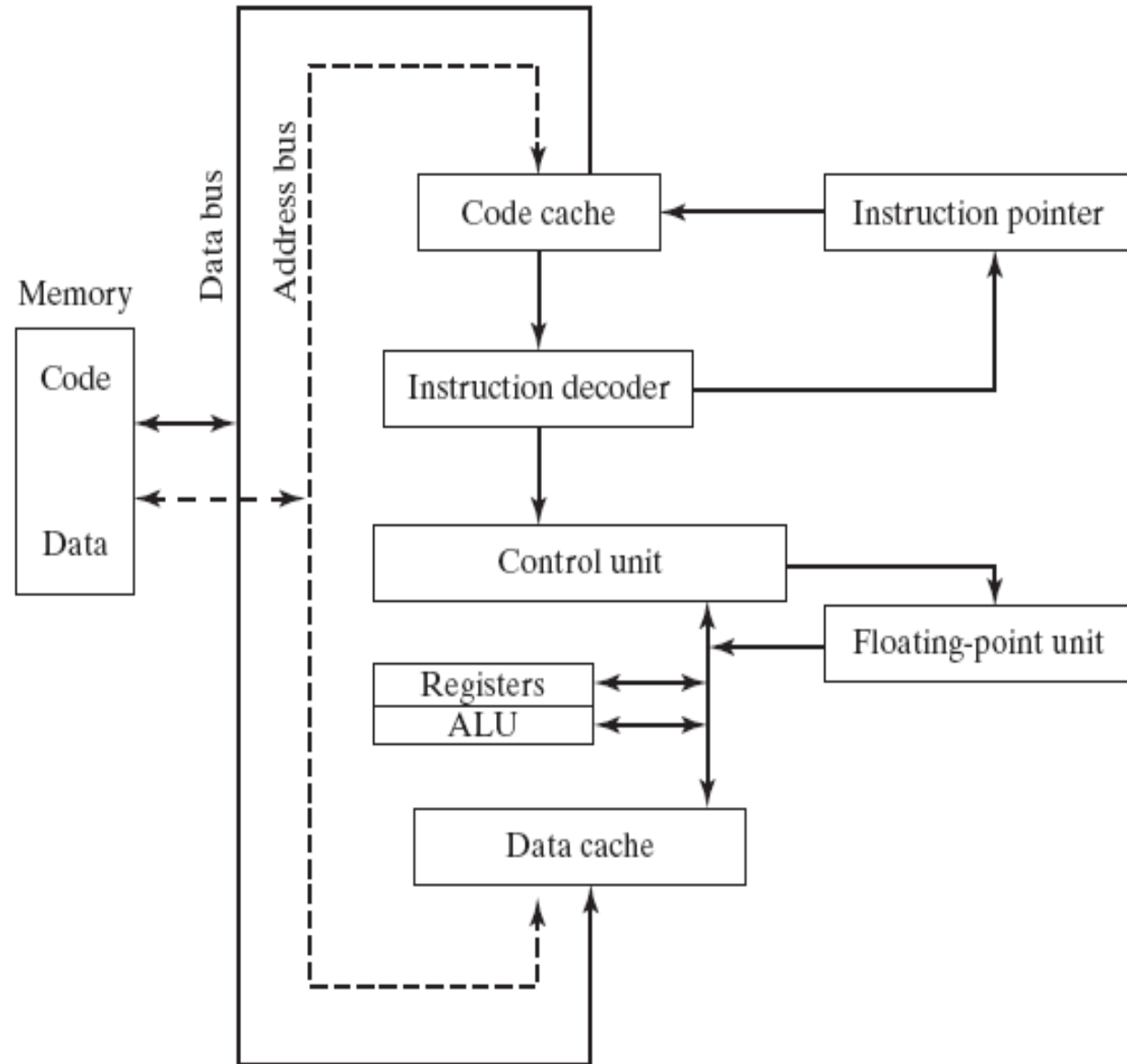
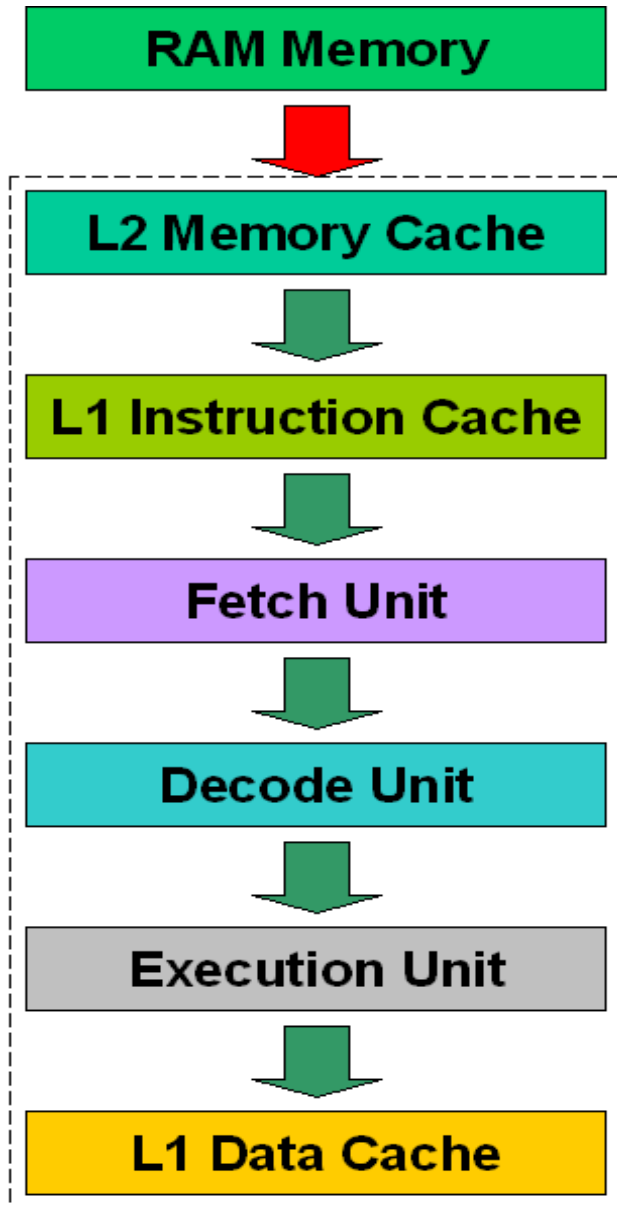
1. Start with a guess, g
2. If $g*g$ is close enough to x , then g is a good approximation of the square root of x , *jump to step 5*
3. Otherwise, create a new guess by averaging g and x/g .
i.e., $g_{new} = (g_{old} + x/g_{old})/2$
4. Using this new guess, go back to step 2
5. Stop

You can easily code this algorithm, compile the source, and run the program

When you **double click** on an icon to run a program, here is what happens:

1. The program, which is stored inside the hard disk drive, is transferred to the RAM memory.
2. The CPU, using a circuit called memory controller, loads the program data from the RAM memory. **A program is a series of instructions to the CPU.**
3. The data, now inside the CPU, is **processed**.
4. What happens next will depend on the program. The CPU could **continue to load and execute the program** or could **do something with the processed data**, like **displaying something on the screen**.

Simplified block diagrams of a modern CPU



The sequence of **CPU steps** can be expressed in pseudocode:

loop

fetch the instruction pointed by (the value in) IP

advance the instruction pointer (IP)

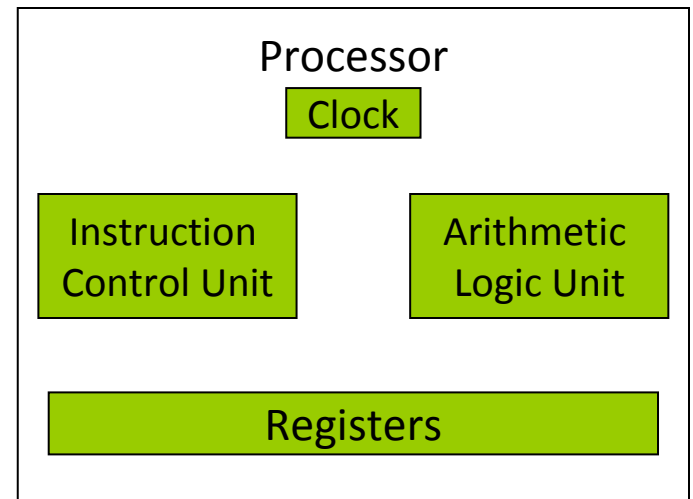
decode the instruction

if memory operand needed, read value from memory

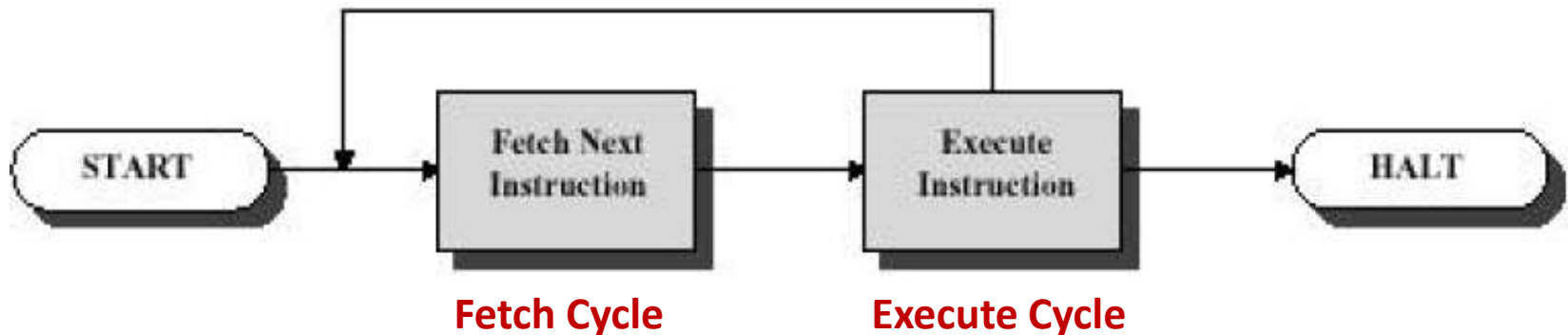
execute the instruction

if result is memory operand, write result to memory

continue loop



- Processing required for a single instruction is called an **instruction cycle** (**Fetch-Execute Cycle**), and can be viewed as shown below: **2 Steps**



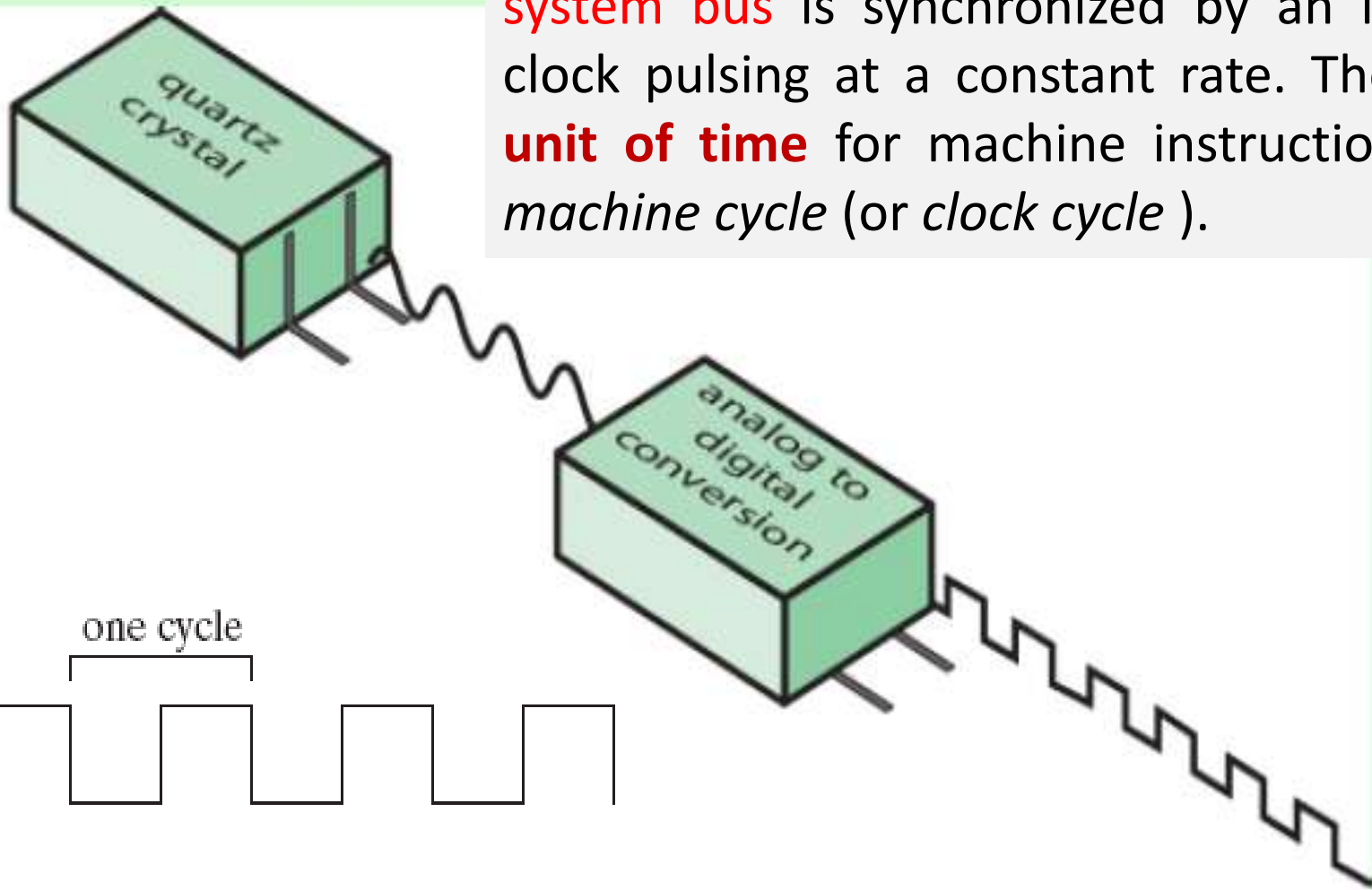
- ❑ **Fetch** – CPU(CU) reads an instruction from a location in memory and decodes the instruction (determine what it means)
 - Program counter (PC/Instruction Pointer) register keeps track of which instruction executes next
 - Normally, CPU increments PC after each fetch
 - Fetches instruction is loaded into the instruction register (IR)

❑ Execute - CPU executes the instruction

- May involve several operations
- May utilize previously changed state of CPU
- General categories:
 - **CPU-Memory**: Data may be transferred from CPU to memory or vice-versa
 - **CPU-IO**: Data may be transferred between CPU and an I/O module
 - **Data Processing**: CPU (**ALU**) may perform some arithmetic or logic operation on the data
 - **Control**: An instruction may specify that the sequence of execution be altered

System Clock

Each operation involving the CPU and the **system bus** is synchronized by an internal clock pulsing at a constant rate. The **basic unit of time** for machine instructions is a *machine cycle* (or *clock cycle*).



How much time it takes to execute an instruction that takes ten cpu cycles (10 clock ticks) in a 4 ghz processor?