Chapter 4

The Variety of Processors and Computational Engines
Topics

• Introduction
• What Is A Processor?
• Range Of Processors
• Hierarchical Structure And Computational Engines
• Multiple Computation Engines
• Coprocessors
• Microcontrollers
• Microsequencers
• Coprocessors
Topics

- Stored Programs
- Processor Technologies
- General-purpose processors
- Embedded systems processors
- The Fetch-Execute Cycle
- Clock Rate and Instruction Rate
- Control
- Starting and Stopping
- Wrapup
Introduction

• Previous chapters
  − digital logic
  − data type representations
• Key elements in a computer
  − memory
  − processor
  − input and output
• Previous chapters
  − digital logic
Topics covered in this chapter: introduction to processors
- general concepts
- variety of processors
- relationship between clock and processing rate

Topics covered in this section: processors
- instruction sets
- addressing modes
- functions of CPU

Introduction
What Is A Processor?

- Central Processing Unit

- Digital device that can perform a computation involving multiple steps.

- Computes boolean arithmetic, etc.

- Need not be extensive or powerful.

Is processor = Central Processing Unit?

What is processor?
Range of Processors

- **Fixed Logic**
  - Least flexible, single built-in operation.

- **Selective Logic**
  - Several functions, exact function is determined at invocation.

- **Lexible Logic**
  - Least flexible, single built-in operation.

- **Hexd Logic**
  - Most flexible logic

Processor categories based in order of flexibility (least to most).
Range Of Processors

- parameterized logic
  * computes a predetermined function, but accepts input parameters.

- programmable logic
  * most flexible
  * processor given a program to run, typically placed in the memory.
Hierarchical Structure And Computation Engines

• CPU’s are highly complex

• Architects use hierarchical approach is used in design and testing

• Subpieces are called computational engines.
  – example of engines: trigonometry, query, graphics, pattern engines, etc.
  – each engine has a specific functionality.
An example of a CPU with multiple engines
Processor Categories

- General-purpose processors
- Embedded systems processors
- Microprocessors
- Microcontrollers
- Coprocessors
- Co-processors

Processors are used in a variety of roles. Example...
Coprocessors

- Fixed or selectable logic processors
- Example: Floating point accelerator
  - Conjunction/under the control of another processor
  - Special purpose high speed processor that operates in

Coprocessors
Microcontrollers

- Programmable device dedicated to controlling a physical system
- Examples: automobile engine, elevators

Example of steps a microcontroller performs:

```c
{ wait for the sensor to be tripped; turn on power to the door motor; delay ten seconds; wait for the sensor to reset; if door is open: wait for a signal that indicates the door is open; turn on power to the door motor; wait for the sensor to be tripped; } do forever
```

- Performs trivial functions
- Example, automobile engine, elevators
- Programmable device dedicated to controlling a physical system

Microcontrollers

Dr. Rajesh Subramaniam, 2005
Microsequencers

- Microcontroller for internal control
- Controls coprocessors & engines within larger processor
- Microcontroller for internal control

Example: Microsequencer to control data movement
Other Processors

- **Embedded Systems Processors**
  - Runs sophisticated electronics
  - Example: DVD
  - More powerful than microcontrollers, more recent

- **General-Purpose Processors**
  - Example: CPU of a PC

- **Embedded Systems Processors**
Processor Technologies

- IC
- LSI
- digital logic circuits
- Chronologically...
Stored Programs

- Processors perform a series of steps in computation.
- Programs are stored either:
  - Internally in a few cases.
  - Externally accessible locations, e.g., main memory.

Architect considers a processor programmable if processors are separate from program it runs.

ROM

- Where it is easy to change.
- In externally accessible locations, e.g., main memory.

- Internally in a few cases.

Programs are stored either:

- Processors perform series of steps in computation.
Questions:

- How is the program represented?
- How does the processor identify next step of program?
- What are the operations that can be performed and how does the processor perform them?
- Programmable processor accesses 1 step of a stored program, performs fetch-execute paradigm.

Fetch-execute cycle

Repeat above with next step.
At some level, every programmable processor implements a fetch-execute cycle.
Clock Rate And Instruction Rate

- How fast does the fetch-execute cycle operate?
- Depends on processor (clock speed)
- Program storage technology
- Time to execute each instruction
- Example: multiplication takes longer than addition.

Fetch-execute cycle does not proceed at fixed rate.
Questions with fetch-execute cycle?

- How does a processor start running the cycle?
- What happens after the processor executes the last step in a program?
• Stopping
  - processor does not stop till powered down.
  - what's the next step to execute?

• Dedicated system: repeat the program
• General purpose: run operating system programs when no user application is running

• Starting
  - depends on hardware.

Startup

Stoppimg and Starting

Stop and Start
Wrapup

Processors are digital devices that perform multiple-step computations. Processor must have some instruction to execute, never stops.

- Programmable processors
  - substances, embedded systems, general purpose.

- Categories based on roles: coprocessors, microcontrollers, microsequencers.

- Computations are digital devices that perform multiple step.