CS2507 Computer Architecture

Credit Weighting: 5

Pre-requisite(s): CS1101

Co-requisite(s): None

Module Objective

To introduce the student to the taxonomies of Computer Design, the basic concerns of Computer Architecture, provide an overview of the technology trends that drive the industry and how to use this information in the art of Computer Design.

Module Content

Instruction Set Design. Case study. Design of the control unit and datapath of a pipeline RISC processor. Memory Hierarchy Design. Bus architecture and interconnection strategies. Tools and techniques for performance measurement. Comparison of architectures of recent processors.

Learning Outcomes

On successful completion of this module, students should be able to: Appraise an instruction set architecture; Distinguish between an architecture and its implementation; Measure the performance of a particular implementation of an architecture; Critically evaluate a memory hierarchical design using skills and toolsets acquired during the module.

Assessment

Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (In-class Test).

What is computer architecture?

It is the specification of what a computer should do and how it should do it, at a design level, without the implementation details.

It is possible to specify an architecture without going as far as the details of an implementation.

There may be several different implementations of the same architecture.

There are different levels of architecture, for instance System Architecture, Instruction Set Architecture, Microarchitecture.

Instruction Set Architecture

Refers to the architecture at a level seen by an assembly language programmer: the registers, operations and data operand addressing modes as well as the set of instructions available for manipulating data, specifying program flow and controlling CPU activities.

Microarchitecture

The detail of how data and control signals flow in order to implement the ISA. It includes devices, registers and operations not seen by a programmer at the ISA level.

System Architecture

The architectural design of interactions between the CPU and other entities necessary to form a complete computing system, such as memory, buses, I/O units together with the operation of those entities.

What sort of architectures are there?

- Sequential architectures: Stored program architecture (Von Neumann)
- Parallel architectures, e.g. Dataflow

Concentrate on stored program model.

Early processors became increasingly complex and tried to follow advanced ideas in operating systems and programming language design. Even the more basic designs included many different ways of specifying the whereabouts of instruction operands, in other words, they had many different *addressing modes*. This design approach to stored program computers has come to be named retrospectively as CISC, Complex Instruction Set Computer.

Some designers observed that, in spite of the enthusiastic efforts to support high-level activities at ISA level, the time to execute many of these complex operations and operand accesses negated many of the supposed advantages. Also, some compilers were just not able to take advantage of the special operations provided.

Therefore, it was felt that less complex instructions might be more appropriate. The basic idea was to limit memory accesses to Load and Store operations and to perform all other operations from register to register. This design philosophy was named Reduced Instruction Set Computer (RISC). The term RISC does not mean that the number of instructions in the instruction set is necessarily less than the instruction set size of a CISC machine.

Examples of Architectures

What architectures used in Windows-supporting PCs?

Intel processors

4-bit processors

4004, 4040: 1971

8-bit processors

8008, 8080, 8085: 1972, 1974, 1976

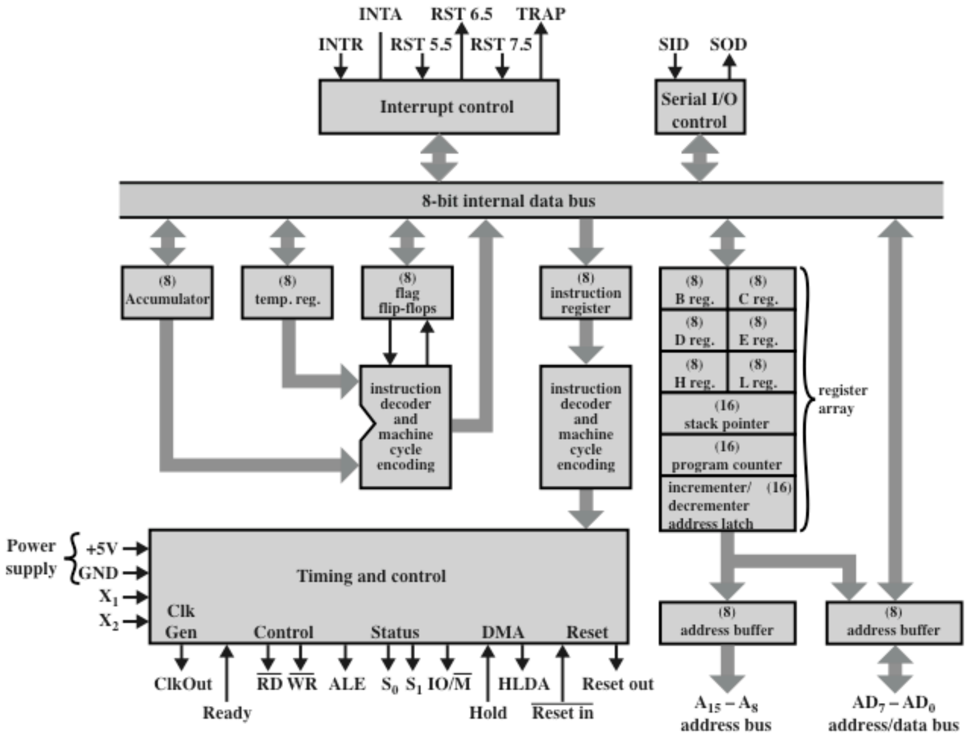

Figure 16.7 Intel 8085 CPU Block Diagram

16-bit processors: Origin of x86

8086, 8088, 80186, 80188, 80286

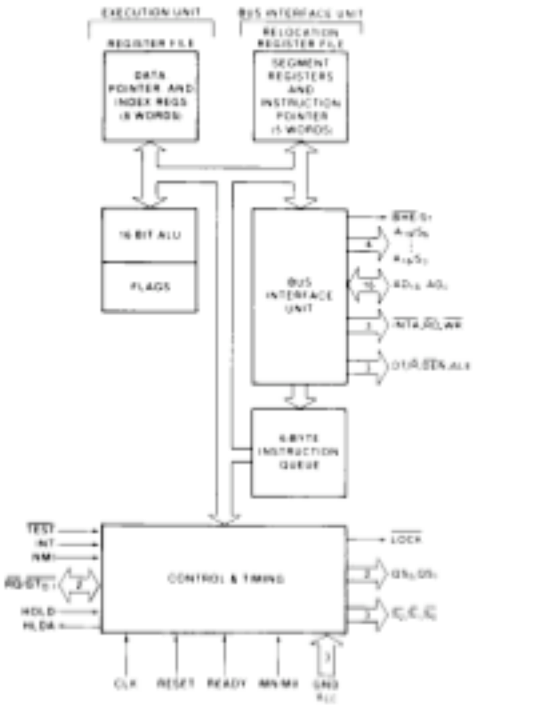

Figure 1. 8086 CPU Block Diagram 231455-1

32-bit processors: Non x86

iAPX 432 (1981), 80960, 80860, XScale

32-bit processors: x 80386 Range

80386DX, 80386SX, 80376, 80386SL, 80386EX

32-bit processors: x 80486 Range

80486DX, 80486SX, 80486DX2, 80486SL, 80486DX4

32-bit processors: x Pentium ("I")

Pentium, Pentium MMX

32-bit processors: P6/Pentium M

Pentium Pro, Pentium II, Celeron, Pentium III, PII and III Xeon

Celeron(PIII), Pentium M, Celeron M, Intel Core, Dual Core Xeon LV

32-bit processors: NetBurst microarchitecture

Pentium 4, Xeon, Pentium 4 EE

64-bit processors: IA-64

Itanium, Itanium 2

64-bit processors: EM64T-NetBurst

Pentium D, Pentium Extreme Edition, Xeon

What architectures are used in iMac?

64-bit processors: EM64T- Core microarchitecture

Xeon, Intel Core 2

iMac is Intel Core 2 Duo

What architectures used in Nokia phones?

What architectures used in iPhone?

Advanced RISC Machines (ARM) processors.

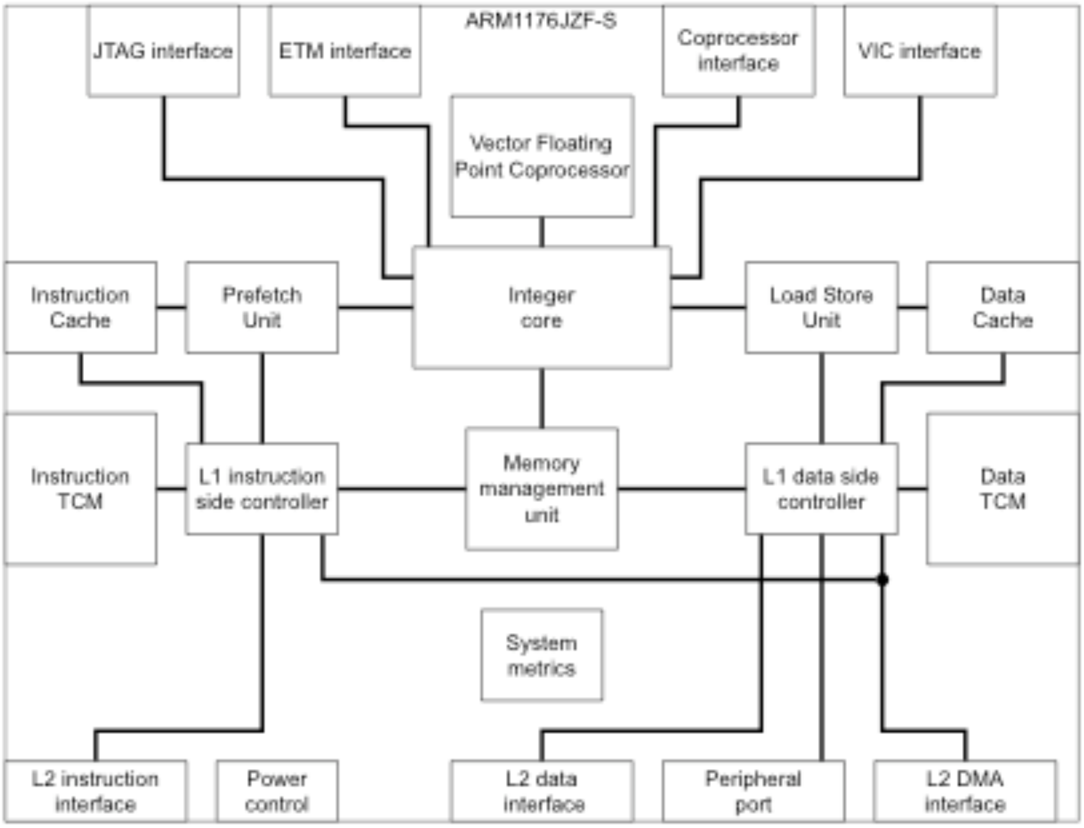

Figure 1-1 ARM1176JZF-S processor block diagram

"ARM does not manufacture processor hardware. Instead, ARM creates microprocessor designs that are licensed to our customers, who integrate them into *System-on-Chip* (SoC) devices." (ARM DHT-001A, 2009)