Course Content and Goals

5DV118 — Computer Organization and Architecture

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Target Audience of the Course

- The course is oriented towards the needs of technical computer scientists.
- It is not a course on how to organize and design computers.
- Rather, it is a course about the design and organization of existing computers.
- The overall goal is to provides the technical computer scientist with the understanding of computer hardware which is necessary to work with modern computer systems.
- This involves in particular a study of the services which a modern computer provides, with a focus on performance.
- Such an understanding is a prerequisite for the understanding of how modern operating systems function and the performance issues associated with the services which they provide.
- A secondary goal is to gain a working knowledge of "real" hardware, and how to make intelligent decisions about acquisitions of computer systems.

Major Topics of the Course

- An introduction to the evolution of computer hardware and what to expect in the near future.
- A basic understanding of how the performance of a computer is measured.
- An understanding of the instruction set of a modern (RISC) computer and how the basic constructs of high-level imperative languages are implemented.
- A basic understanding of computer arithmetic, including the representation of floating-point numbers and control of errors in their arithmetic operations.
- The implementation of a modern CPU with a focus on performance (particularly pipelining).
- The hierarchical organization of computer memory and the use of caches.
- The operation and performance of computer I/O devices.
- A short introduction to parallelism in computer hardware.

The Context of the Study

- The focus is the *MIPS* processor architecture.
- It is a so-called *RISC* (Reduced Instruction-Set Computer) architecture.
- It is similar in principle to the Sun/Oracle *Sparc* processor and processors using the *ARM* architecture, widely used in smartphones and tablets.
- It has a very clean and simple design.

  Question: Why not focus on one of the following?

  x86: the dominant architecture in desktop and server systems.

  ARM: the dominant architecture in smartphones and tablet computers.
- Surely it is more useful to know their architecture and implementation.

The Context of the Study vs. the x86 Architecture

Question: Why not focus on the x86 architecture, since it is so widely used?

Answer: It is a complex architecture which evolved over more than 30 years, while the MIPS design has remained basically the same.

- The x86 architecture began life in 1978 as the 16-bit 8086, which in turn was based upon the eight-bit 8080 from 1974.
- It was extended to the 16-bit 80186 and 80286, the 32-bit 80386, 80486, Pentium, I, Pro, II, III, IV, and now to a 64-bit architecture.
- Other manufacturers, AMD in particular, have developed their own long line of variants.
- The transition from 16-bit to 32-bit in particular involved retrofitting the architecture with many new instructions (because of the need to support multiprogramming and protected addresses spaces).
- A course based upon the x86 would be consumed by details, and the principles would be lost.
- See Section 2.17 of the textbook for a comparison of the architectures.

The Context of the Study vs. the ARM Architecture

Question: Why not focus on the ARM architecture, since it is so widely used?

Excuse: Nobody has written a top-notch textbook (comparable to Patterson-Hennessy) for ARM.

Other answers: There are several.

- MIPS and ARM are similar in many ways; if you know MIPS, it will be easy to learn ARM.
- See Section 2.16 of the textbook for a comparison of the architectures.
- Although ARM is dominant, there are smartphones and tablets which are designed around the MIPS architecture.
- There is a port of *Android* to MIPS.
- MIPS is architecturally simpler than ARM, and so it is less complex to study its implementation.
- John L. Hennessy was one of the original architects of MIPS.

The Context of the Study — Summary

- MIPS is a real processor which has reasonably widespread use.
- It is not a toy architecture which is used only for instructional purposes.
- It is one of the simplest, if not the simplest, architectures with this property.
- If you learn the principles of computer organization and design for the MIPS RISC processor, you will be in a good position to learn about all of the idiosyncratic aspects of the modern processors in the x86 family, as well as make a rapid transition to the ARM family..
- Also, keep in mind that many real computers use processors based upon RISC architectures.
- Almost all smartphones and tablet computers employ processors using the *ARM* architecture, which is also a RISC architecture and similar to MIPS.