

MODULE 5: Assembly Language + Processor Control + Examples

Lecture 5.4

Real World Processor Examples

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Lecture 5.4 Objectives

- Compare and contrast RISC and CISC architectures
- Discuss the reasons for the success of the Intel x86 architecture
- Describe some features in the evolution of the Intel family of microprocessors
- Enumerate the main characteristics of the MIPS family of processors and the MIPS architecture

RISC and CISC

- Complex Instruction Set Computer (CISC)
 - Many instructions, of variable length, with complex layouts
 - A single instruction can perform a complex set of operations (but may take several cycles)
 - Example: Intel x86 family
- Reduced Instruction Set Computer (RISC)
 - Few, simple instructions that execute quickly
 - Compiler's responsibility to produce efficient code
 - Examples: Pentium, MIPS

The Intel x86 Family of Processors (1)

- The Intel x86 family of processors has been extremely long-lived and successful
 - One family has spanned more than two-thirds of the total history of microprocessors
 - The industry-standard ISA for the PC market
- A CISC architecture

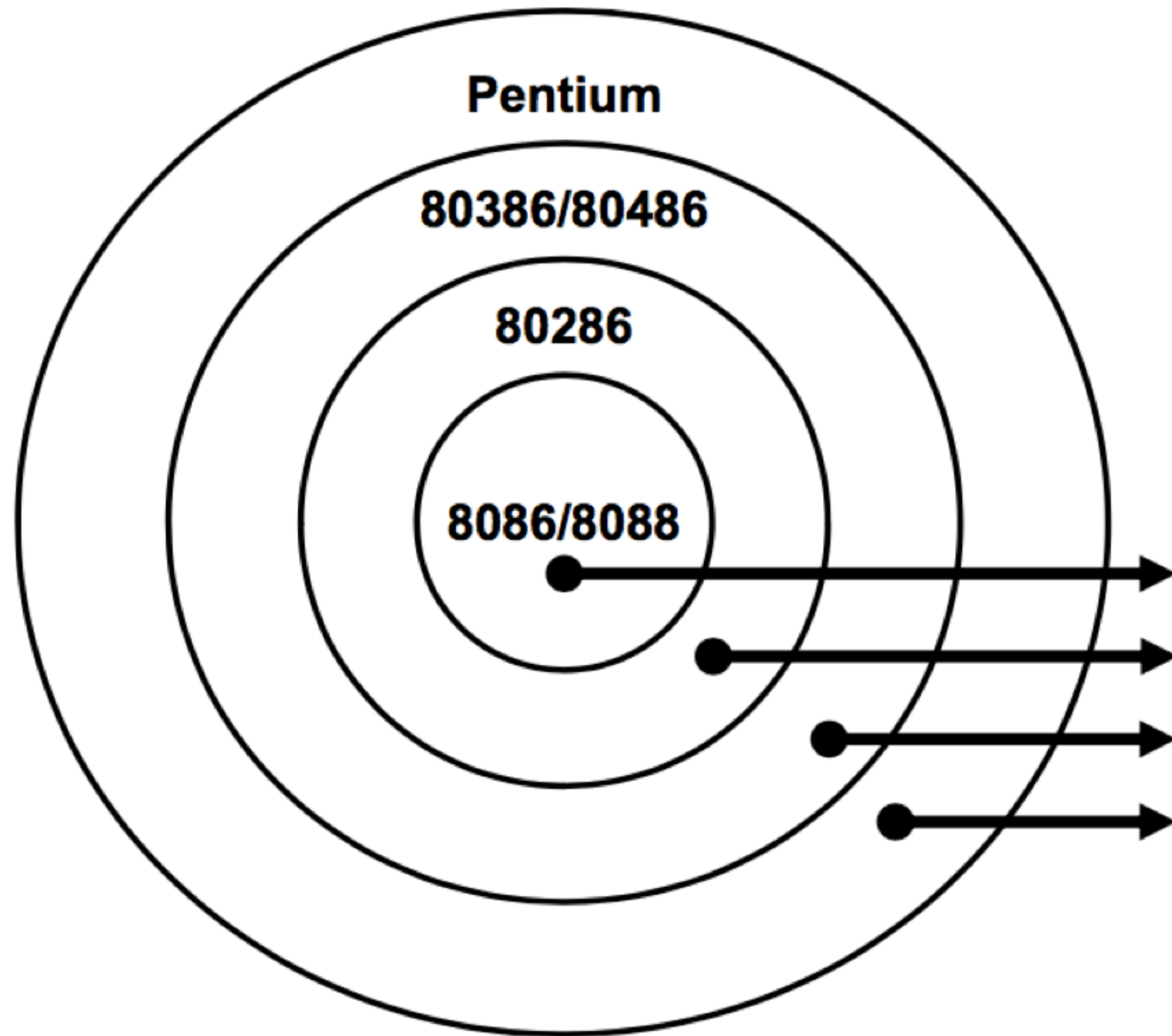
The Intel x86 Family of Processors (2)

- Reasons for success
 - Selection by IBM for its PC product in 1980 coupled with the importance of ISA compatibility for software
 - ISA extensions to improve performance and increase functionality
 - Aggressive use of new technologies to improve implementations
 - Reduced die sizes for integrated circuits for lower costs
 - Faster clock rates
 - Increased integration of functions

Brief Partial History

- 1971: 4004 (4-bit), Intel's first microprocessor
- 1972: 8008 (8-bit)
- 1978: 8086 (16-bit), beginning of the x86 family
- 1979: 8088 (16-bit internal, 8-bit external), used in PC
- 1982: 80286 (16-bit), used in PC AT
- 1985: 80386 (32-bit)
- 1992: Pentium (32-bit)
- 1997: Pentium II (CISC architecture with RISC cores)
- 2000: Pentium IV (NetBurst microarchitecture)
- 2001: Itanium (64-bit)
- 2015: Skylake (64-bit, multiple cores)

Compatibility



- Older software, at the machine code level, can run on newer ISAs
- Software written for newer ISAs may not run on processors with older ISAs

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Compare and contrast RISC and CISC architectures
- Discuss some reasons for the success of the Intel x86 family of processors

If you have any difficulties, please review the lecture video before continuing.

Forms of Evolution (1)

- Wider internal and external data paths
 - From 8 bits to 16 bits to 32 bits to 64 bits to...
 - Provided at the cost of transistors (for internal data paths) and I/O pins (for external data paths)
- Larger address space
- Wider registers and processing units
- Increased functionality
 - Increased number of instructions
 - Integrated floating point arithmetic hardware
 - Specialized support, e.g. for multimedia (MMX)

Forms of Evolution (2)

- Architectural performance improvements
 - Pipelining
 - Multiple instructions can be active at the same time, just in different stages of the fetch-execute cycle
 - Super-scalar operation
 - Some functional units are duplicated so that more than one instruction can be executing in the same stage at a given time
 - Cache
 - Very fast memory to hold like instructions and data to be fetched (much faster than normal access to main memory)

Forms of Evolution (3)

- Memory model changes
 - Real mode: Segmented memory model
 - Protected mode: Flat memory model
- Fabrication improvements
 - Applied even within a single ISA version
 - Smaller transistor dimensions
 - Benefits
 - Improved clock rates
 - Reduced die size to increase yield and lower cost

Intel Architecture Overview (1)

- The 8086 operated on 16-bit data words and supported 20-bit memory addresses
 - Supported four 16-bit general-purpose registers that could be accessed by the half-word
 - Other registers: flags register, instruction register, stack accessed through the values in two other registers, the base pointer and the stack pointer
 - No built in floating-point processing
- In 1980, Intel released the 8087 numeric coprocessor
 - Few users elected to install them because of cost

Intel Architecture Overview (2)

- In 1985, Intel introduced the 32-bit 80386
 - Still no built-in floating-point unit
- The 80486 was introduced in 1989
 - An 80386 that had built-in floating-point processing and cache memory
 - The 80386 and 80486 offered backward compatibility with the 8086 and 8088
 - Software written for the smaller word systems was directed to use the lower 16 bits of the 32-bit registers
- 32-bit Pentium IV introduced in 2000
 - Speed enhancing features include multilevel cache and instruction pipelining

The MIPS Family

- MIPS chips used in embedded systems, some computers, computerized toys, network routers
 - SGI workstations, TiVO, Windows CE devices, Cisco routers, Sony PlayStation 2, etc.
- A RISC architecture
- In 1986 the first MIPS CPU was announced
 - It had a 32-bit word size and could address 4GB of memory
- The MIPS architecture now offers 32- and 64-bit versions (MIPS32 and MIPS64)

MIPS Architecture

- MIPS was one of the first RISC microprocessors
- The original MIPS architecture had only 55 different instructions
 - Compare with the 8086, which had over 100
- MIPS was designed with performance in mind
 - A load/store architecture: only the load and store instructions can access memory
- The large number of registers in the MIPS architecture keeps bus traffic to a minimum

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Discuss some features in the evolution of the Intel processors
- Enumerate the main characteristics of the MIPS family of processors and the MIPS architecture

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Summary

- CISC architectures employ many instructions, each capable of performing a complex function and possibly taking several clock cycles
- The Intel family of processors evolved from the 8086, a CISC architecture employed in the IBM PC
- RISC architectures employ few simple instructions that execute quickly
- The MIPS architecture is one of the first and most successful RISC architectures, employed today in embedded devices and computers

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