CS322 - Computer Architecture Lab

Lab 0

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(a) A microprocessor is a computer processor that incorporates the function of a central processing unit on a single or more integrated circuit (IC) of MOSFET construction. The microprocessor is a multipurpose, clock driven, register based, digital integrated circuit that accepts binary data as input, processes it according to instructions stored in its memory ~~cells~~ and provides results (also in binary form) as output. Microprocessors contain both combinat-ional logic and sequential digital logic. Microprocessors operate on numbers and symbols represented in the binary number system.

Generations of microprocessors:

(1) First Generation:

From 1971 to 1972 the era of the first generation came which brought microprocessors like Intel 4004, Rockwell International PPS-4, Intel 8008 etc.

② Second Generation

This marked the development of 8-bit microprocessors from 1973 to 1978 Processors like Intel 8085, Motorola 6800 and 6801 etc came into existence

③ Third Generation

This brought forward the 16 bit processors like Intel 8086/ 80186/80286, Motorola 68000, 68010 etc. From 1979 to 1980, this generation used the HMOS technology.

④ Fourth Generation

It came into existence from 1981 to 1985. The 32-bit processors using HMOS fabrication came into existence. Intel 80386 and Motorola 68020 are some of the popular processors of this generation.

⑤ Fifth Generation:

This started into 1995 and runs upto the present. It marked the birth of Pentium, Celeron, with Dual, Quad and Octa core processors.

List of Intel Processors

Sno.	Company/ Architecture	No. of Transistors	CPU Clock Rate	Memory Capacity	Cache	Data Bus Width	Address Bus Width	No. of Cores or CPUs
1	8008	3500	200kHz to 800kHz	16kB		8bit	8bit	1
2	8080	6000	2MHz	64kB		8bit	16bit	1
3	8086 and 8088	29000	5MHz to 10MHz	1MB		16bit	20bit	1
4	80286	134000	4MHz to 25MHz	16MB		16bit	24bit	1
5	80386	275000	12MHz to 40MHz	4GB		32bit	32bit	1
6	80486	1180235	20MHz to 33MHz	4GB	8kB	32bit	32bit	1
7	Pentium	3.3M	60MHz	4GB	16kB	64bit	32bit	1
8	Pentium Pro	5.5M	150MHz to 200MHz	64GB	16kB + 1024kB	64bit	36bit	1
9	Pentium II	7.5M	233 MHz to 450MHz	4GB	32kB+512kB	64bit	32bit	1
10	Pentium III	9.5M	450MHz to 1.4GHz	4GB	32kB+512kB	64bit	36bit	1
11	Pentium IV	42M	1.3GHz to 3.8GHz		16kB+2kB+2kB	64bit	36bit	1
12	Pentium D	362M	2.66GHz to 3.73GHz	4GB	16kB+2kBX2	64bit	36bit	2
13	i3	1750M	2.8GHz to 3.9GHz	32GB	128kB+512kB +3MB	-	-	6

List of Intel Processors

Sno.	Company/ Architecture	No. of Transistors	CPU Clock Rate	Memory Capacity	Cache	Data Bus Width	Address Bus Width	No. of Cores/ CPUs
14	i5	3200M	3.6GHz to 4.8GHz	128GB	12MB			6
15	i7	3200M	3.8GHz to 5.1 GHz	128GB	16MB			8
16	i9	3900M	4.5GHz to 5.3GHz	128GB	20MB			10

List of ARM Processors

Sno.	Processor	No. of Transistors	CPU Clock Rate	Cache	No. of Cores or CPUs
1	ARM1	25000	6MHz		1
2	ARM2	27000	8MHz		1
3	ARM3	31000	25MHz	4KB	1
4	ARM7	35000	40MHz	8kB	1
5	ARM700	578977	40MHz	8kB	1
6	ARM Cortex A9	26M	2GHz	32kB + 128kB	4
7	ARM Cortex A12	6900M		64kB + 8MB	4

(b) List of Microcontrollers in market:

8-bit
1. PIC 18F27Q43 by Microchip Technology Inc.
2. RL78/G11 by Renesas Electronics Corporation
3. S08PA by NXP Semiconductor
4. STM8S by STMicroelectronics
5. ATmega32U4 by Altera (bought by Microchip Technology Inc.)
6. XC386MT by Infineon Technologies AG

16-bit
7. MC9S12D by NXP Semiconductor
8. XC2269I by Infineon Technologies AG
9. RL78/F13 by Renesas Electronics Corporation
10. dsPIC33CH128MP208 by Microchip Technology Inc.
11. MSP430 by Texas Instruments Inc.

32-bit
12. Aurix TC275TP by Infineon Technologies AG
13. RA4M1 by Renesas Electronics Corporation
14. S32R37 by NXP Semiconductor
15. ATSAMD09C13 by Microchip Technology Inc.

(b) ~~List of Microprocessors~~

(16) STM32F7 by STMicroelectronics

(17) TMS320F28388S by Texas Instruments Inc.

(18) ADUC832 by Analog Devices™

(19) MC5211F by NXP Semiconductors

(c) A processor simulator is a computer program that simulates the execution of a processor.

Processor Simulators are used for:

(1) Lowering cost by evaluating hardware designs without building physical hardware systems.

(2) Enabling access to unobtainable hardware.

(3) Increasing the precision & volume of processor performance data

(4) Introducing abilities that are not normally possible on real hardware such as running code backwards when an error is detected or running in faster-than-real time.

There are several types of simulators available based on the architecture of processor:

(1) x86 simulators and MIPS simulators are popular.

Popular X86 simulators are:

① gem5:

This is an open-source system-level and X86 processor-simulator. It is utilized in academic research and in industry by companies such as ARM research, AMD, Google, Samsung.

The simulator is free for use under the BSD Revised License and runs only on Linux. It is written in C++, Python.

Features:

It is an event-driven simulator with multiple execution modes.

① Full-system simulation (simulating whole OS) and syscall emulation (just user-space is emulated).

② multiple ISA's (alpha, ARM, SPARC, POWER, RISC-V and X86 ISA's)

③ timing model for full ~~scale~~ cache hierarchy with support for custom coherence protocols.

④ simplistic CPU, in-order CPU, out-of-order CPU

⑤ serialize/deserialization from checkpoints

(2) Sniper:

This is an x86 multi-core simulator based on the interval core model and Graphite simulation infrastructure, allowing for fast and accurate simulation when exploring different homogenous & heterogenous multi-core architectures. Sniper allows to perform timing simulations for both multi-program workloads and multithreaded, shared memory applications on multiple cores. This is an Open source software licensed under MIT and the Interval Academic License.

Features:

(1) Interval core model
(2) Instruction - Window Centric core model, supporting in-order & out-of-order SMT cores.
(3) Multi-threaded application sampling support.
(4) CPI stacks & advanced visualization support to gain insight into lost cycles.
(5) Parallel, multi-threaded simulator
(6) Multi-program and multi-threaded application support. X86 and X86-64, SSE2.
(7) Validated against the Intel Core 2 micro architecture.
(8) Shared & private caches
(9) Prefetchers
(10) Scheduling support.

(11) Heterogeneous configuration support.

(12) Modern Linux-OS support (Redhat-EL 5,6/Debian Lenny + /Ubuntu 10.04+ etc)

(3) Zsim:

Zsim is a fast X86-64 simulator. It was originally written to evaluate ZCache, but it has since outgrown its purpose. Zsim's goal is to be fast, simple, and accurate, with a focus on simulating memory hierarchies and large, hetero-genous systems. It is parallel and uses DBT extensively, resulting in speeds of hundreds of millions of instructions per second in a modern multicore host. Unlike conventional simulators, Zsim is organised to scale well with simulated core count, and has good trace generation.

Popular MIPS simulators:

(1) IASim:

It is an instruction accurate software simulator that can simulate individual cores & platforms containing cores. Simulations of cores and other platforms are often termed as virtual platforms. IASim is based on the Open Virtual Platforms technology from Imperas; enabling high performance simulation the software that will run on target hardware.

The virtual platform is a set of models that reflects the hardware on which the software will execute. It can represent a subset or subsystem of a single device as a System on Chip (SoC), or a complete SoC, or a board or a full system.

(2) QEMU

Quick EMUlator (QEMU) is a free and open source hosted hypervisor that performs hardware virtualization. It is a hosted virtual machine monitor which emulates central processing unit (CPUs) through dynamic binary translation and provides a set of device models, enabling it to run a variety of unmodified guest operating systems. QEMU can also be used purely for CPU emulation for user-level processes, allowing applications compiled for one architecture to be run on another.