THEORY ASSIGNMENT

TOPIC:

PROCESSOR ARCHITECTURE OF INTEL, APPLE MCINTOSH AND SUN MICROSYSTEM

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SECTION : C

DEPT : CSE

COURSE : COMPUTER ORGANIZATION AND ARCHITECTURE.

PROCESSOR ARCHITECTURE OF INTEL

The Intel Core microarchitecture (previously known as the Next-Generation Micro-Architecture) is a multi-core processor microarchitecture unveiled by Intel in 2006. It is based on the Yonah processor design and can also be considered an iteration of the P6 microarchitecture introduced in 1995 with Pentium Pro.

The first processors that used this architecture were code-named Merom, Conroe, and Woodcrest. Merom is for mobile computing, Conroe is for desktop systems and Woodcrest is for servers and workstations. While architecturally identical, the three processors line differ in the socket used, bus speed, and power consumption. The initial mainstream Core-based processors were branded Pentium Dual-Core or Pentium and low end branded Celeron server and workstation Core-based processors were branded Xeon, while Intel's first 64-bit desktop and mobile Core-based processors were branded Core 2.

One new technology included in the design is Macro-Ops Fusion, which combines two x86 instructions into a single micro-operation. For example, a common code sequence like a compare followed by a conditional jump would become a single micro-op. Unfortunately, this technology does not work in 64-bit mode.

Other new technologies include 1 cycle throughput (2 cycles previously) of all 128-bit SSE instructions and a new power saving design. All components will run at minimum speed, ramping up speed dynamically as needed. It is similar to AMD's Cool'n'Quiet power-saving technology, as well as Intel's own SpeedStep technology from earlier mobile processors. This allows the chip to produce less heat, and consume as little power as possible.

Microarchitectures x86

8086

First x86 processor; initially a temporary substitute for the iAPX 432 to compete with Motorola, Zilog, and National Semiconductor and to top the successful Z80. 8088 version, with an 8-bit bus, used in the original IBM Personal Computer.

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Included a DMA controller, interrupt controller, timers, and chip select logic. A small number of additional instructions. The 80188 was a version with an 8-bit bus.

286

First x86 processor with protected mode including segmentation based virtual memory management. Performance improved by a factor of 3...4 over 8086. Included instructions relating to protected mode.

i386

First 32-bit x86 processor. Introduced paging on top of segmentation which is the most commonly used memory protection technology in modern operating systems ever since. Many additional powerful and valuable new instructions.

i486

Intel's second generation of 32-bit x86 processors, introduced built-in floating point unit (FPU), 8 KB on-chip L1 cache, and pipelining. Faster per MHz than the 386. Small number of new instructions.

P5

Original Pentium microprocessors, first x86 processor with super-scalar Architecture and branch prediction.

P6

Used in Pentium Pro, Pentium II, Pentium II Xeon, Pentium III, and Pentium III Xeon microprocessors. First x86 processor to support SIMD instruction with XMM register implemented, RISC pop decode scheme, integrated register renaming and

out-of-order execution. Some important new instructions, including conditional moves, which allow the avoidance of costly branch instructions. Added 36-bit physical memory addressing, "Physical Address Extension (PAE)".

NetBurst

Commonly referred to as P7 although its internal name was P68. Used in Pentium 4, Pentium D, and some Xeon microprocessors. Very long pipeline. The Prescott was a major architectural revision. Later revisions were the first to feature Intel's x86-64 architecture, enhanced branch prediction and trace cache, and eventually support was added for the NX bit to implement executable-space protection.

Pentium M

Updated version of Pentium III's P6 microarchitecture designed from the ground up for mobile computing and first x86 to support micro-op fusion and smart cache.

Enhanced Pentium M was updated, dual core version of the Pentium M microarchitecture used in Core microprocessors, first x86 to have shadow register architecture and speed step technology.

Intel Core

Reengineered P6-based microarchitecture used in Core 2 and Xeon microprocessors, built on a 65 nm process, supporting x86-64 level SSE instruction and macro-op fusion and enhanced micro-op fusion with a wider front end and decoder, larger out-of-order core and renamed register, support loop stream detector and large shadow register file.

Penryn: 45 nm shrink of the Core microarchitecture with larger cache, higher FSB and clock speeds, SSE4.1 instructions, support for XOP and F/SAVE and F/STORE instructions, enhanced register alias table and larger integer register file.

Nehalem

Released November 17, 2008, built on a 45 nm process and used in the Core i7, Core i5, Core i3 microprocessors. Incorporates the memory controller into the CPU die. Added important powerful new instructions, SSE4.2.

Westmere: 32 nm shrink of the Nehalem microarchitecture with several new features.

Bonnell

45 nm, low-power, in-order microarchitecture for use in Atom processors.

Saltwell: 32 nm shrink of the Bonnell microarchitecture.

Larrabee (cancelled in 2010)

Multi-core in-order x86-64 updated version of P5 microarchitecture, with wide SIMD vector units and texture sampling hardware for use in graphics. Cores derived from this microarchitecture are called MIC (Many Integrated Core).

Sandy Bridge

32 nm microarchitecture, released January 9, 2011. Formerly called Gesher but renamed in 2007. First x86 to introduce 256 bit AVX instruction set and implementation of YMM register.

Ivy Bridge: successor to Sandy Bridge, using 22 nm process, released in April 2012.

Silvermont

22 nm, out-of-order microarchitecture for use in Atom processors, released May 6, 2013.

Airmont: 14 nm shrink of the Silvermont microarchitecture.

Haswell

22 nm microarchitecture, released June 3, 2013. Added a number of new instructions, including FMA.

Broadwell: 14 nm shrink of the Haswell microarchitecture, released in September 2014. Formerly called Rockwell.

Skylake

14 nm microarchitecture, released August 5, 2015.

Kaby Lake: successor to Skylake, released in August 2016, broke Intel's Tick-Tock schedule due to delays with the 10 nm process.

Amber Lake: ultra low power, mobile-only successor to Kaby Lake, using 14+ nm process, released in August 2018 (no architecture changes).

Whiskey Lake: mobile-only successor to Kaby Lake Refresh, using 14++ nm process, released in August 2018 (has hardware mitigations for some vulnerabilities).

Coffee Lake: successor to Kaby Lake, using 14+ nm process, released in October 2017.

Cascade Lake: server and high-end desktop successor to Kaby Lake-X, using 14 nm process, released in April 2019.

Comet Lake: successor to Coffee Lake, using 14++ nm process, released in August 2019.

Cooper Lake: server-only architecture, optimized for AI oriented workloads using bfloat16, with limited availability only to Intel priority partners, using 14++ nm process, to be released in 2020.

Goldmont

14 nm Atom microarchitecture iteration after Silvermont but borrows heavily from Skylake processors, released April 2016.

Goldmont Plus: successor to Goldmont microarchitecture, still based on the 14 nm process, released December 11, 2017.

Tremont

10 nm Atom microarchitecture iteration after Goldmont Plus.

Palm Cove

Successor to the Skylake core, first consumer core to include the AVX-512 instruction set. That's if we don't count Skylake-X as consumer core, which also has AVX-512 and appeared on the market 11 months before Cannon Lake.

Cannon Lake: mobile-only successor of Kaby Lake, using 10 nm process, first and only microarchitecture to implement the Palm Cove core, released in May 2018. Formerly called Skymont, discontinued in December 2019.

Sunny Cove

Successor to the Palm Cove core, first core to include hardware acceleration for SHA hashing algorithms.

Ice Lake: low power, mobile-only successor to Whiskey Lake, using 10+ nm process, released in September 2019.

Ice Lake-SP: server-only successor to Cascade Lake, using 10+ nm process, to be released in 2020.

Willow Cove

Successor to the Sunny Cove core, includes new security features and redesigns the cache subsystem.

Tiger Lake: successor to Ice Lake, using 10++ nm process, released in 2020

Rocket Lake: successor to Comet Lake, using 14++ nm process, to be released in 2021.

Sapphire Rapids: server-only, successor to Ice Lake-SP, using 10++ nm process, to be released in 2021.

Golden Cove

Successor to the Willow Cove core, includes improvements to single threaded performance, AI performance, network and 5G performance and new security features.

Alder Lake: successor to Tiger Lake, using 10++ nm process, to be released in 2021.

Ocean Cove

Successor to the Golden Cove core.

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PROCESSOR ARCHITECTURE OF APPLE MACHINTOSH

The Apple–Intel architecture or Mactel, is an unofficial name used for Apple Macintosh personal computers developed and manufactured by Apple Inc. that use Intel x86 processors, rather than the PowerPC and Motorola 68000 ("68k") series processors used in their predecessors.

With the change in architecture, a change in firmware became necessary. Apple selected the Intel-designed Extensible Firmware Interface (EFI) as its comparable component to the Open Firmware used on its PowerPC architectures which is not verified in body and as the firmware-based replacement for the PC BIOS from Intel. With the change in processor architecture to x86, Macs gained the ability to boot into x86-native operating systems, such as Microsoft Windows, while Intel VT-x brought near-native virtualization with Mac OS X as the host OS.

History

1980s

Apple's efforts to transition to Intel hardware date back to 1985, when the company, shortly following Jobs' departure from the company, proposed such a transition. The proposal, however, was quickly denied by management at the time.

1990s

The first known attempt by Apple to actually move to Intel's platform was the Star Trek project, a code name given to a secret project to run a port of Classic Mac OS System 7 and its applications on an Intel-compatible personal computer. The effort began on February 14, 1992, with the blessing of Intel's then CEO, Andy Grove. Apple's leadership at the time placed an October 31 deadline to create a working prototype, which was met. A functional demo was ready by December that year.

John Sculley's departure during the Star Trek project, was a factor in the project's termination. Michael Spindler, who took over as Apple's CEO, devoted most of Apple's resources to transition to PowerPC instead, thus initiating Apple's first processor transition.

Early 2000s

Then-CEO Steve Jobs announces the Intel transition at WWDC **2005**.

In the years since the end of the Star Trek project, there were reports of Apple working to port its operating system to Intel's x86 processors, with one engineer managing to get Apple's OS to run on a number of Intel-powered computers.

In **2001**, Jobs and then Sony president Kunitake Andō reportedly had a meeting to discuss the possibility of running Apple's operating system on Vaio, which was owned by Sony at the time. Jobs even presented a Vaio running Mac OS. Such negotiations ultimately came to nothing.

In **2002**, it was reported that Apple had more than a dozen software engineers tasked to a project code-named "Marklar," with a mission to steadily work on maintaining PC-compatible builds of Mac OS X.

It was noted in **2003** by IBM in an article published to its intranet that Apple felt a transition to Intel presents massive software changes that it wanted to avoid. Nevertheless, rumors of an impending announcement of a transition to Intel cropped up in **2000** and **2003**.

2005

News reports of an impending announcement by Apple to transition to Intel processors surfaced in early June 2005 also close to that year's WWDC. The announcement was made during that year's WWDC Keynote Address.

At the time Apple announced the transition, Jobs attributed the switch to a superior product roadmap that Intel offered, as well as an inability to build products envisioned by Apple based on the PowerPC product roadmap. Meanwhile, pricing disputes with IBM, in addition to a desire by Apple to give its computer the ability to run Microsoft Windows, were reportedly factors for the switch as well.

INTEL

At the time the transition was announced, it was noted that a degree of enmity towards Intel exists amongst some fans of Apple products, due to Intel's close identification with Microsoft. In addition, it was noted by Intel's then CEO, Paul Otellini, that Apple and Intel's relationship were strained at times, especially due to Apple's commission of an ad that shows Intel processors being outperformed by PowerPC processors.

While there were questions over whether Apple would put the Intel Inside stickers on its products, Jobs dispelled such a possibility, saying it is redundant when Apple's use of Intel processors is well-known. "Intel Inside" stickers have never been included on any Apple product.

Technical issues

In the years prior to Apple's announcement of the transition, it was noted that there was a debate over the difference of endianness between Intel and non-Intel processors, as well as the merits of each CPU architecture. The difference in endianness meant that some software could not simply be recompiled; it required changes to make it work on processors of either endianness.

Transition process

Steve Jobs reveals Mac OS X running on Pentium 4 hardware.

2005

During Apple's 2005 WWDC, the company introduced a Developer Transition Kit consisting of a prototype Intel-based Mac computer, along with preliminary versions of Mac OS X Tiger and Xcode, which allowed developers to prepare future versions of their software to run on both PowerPC and Intel-based Macs.

To allow apps built for PowerPC-based Macs to run on Intel-based Macs without recompilation, a dynamic binary translation software called Rosetta was created.

2006

On January 10, Apple unveiled an Intel-based iMac, as well as a 15-inch MacBook Pro laptop, which replaced the similarly-sized PowerBook.

On February 28, a Mac mini featuring an Intel Core Duo processor was unveiled.

On April 5, the dual-boot software Boot Camp was released as a trial version, which allowed Intel-based Mac owners to run Mac OS X and Microsoft Windows. On April 24, a MacBook Pro replacement for the 17-inch PowerBook was announced.

On May 16, a replacement for the iBook, called MacBook, was announced, thus completing the transition of Apple's laptop line to Intel processors.

On July 5, a replacement for the eMac, a special education configuration of a 17-inch iMac, was announced.

On August 7, Apple unveiled a replacement for the PowerMac, Mac Pro and an Intel-based version of Xserve. The unveiling of the Mac Pro was touted by Apple as a completion of its transition to Intel and said the entire process took 210 days.

Ongoing support for PowerPC following transition

The first MACOS to require a Mac with Intel processors, thus dropping support for PowerPC-based Macs, was 10.6 Snow Leopard. Snow Leopard was shipped in August 2009, three years after the transition was complete. Support for Rosetta was dropped from macOS on 10.7 Lion, which was released in July 2011. By that point, five years had passed since the transition to Intel was complete.

The last Apple app to feature support for PowerPC processors was iTunes 10.6.3, which was released on June 11, 2012.

Apple has a policy of placing products that have not been sold for more than five years, but less than seven years, on "vintage" status, meaning hardware services from Apple service providers, including Apple Stores, are subjected to availability of inventory, or as required by law. A product is considered obsolete after it has not been sold for more than seven years, which also stops hardware support. Based on this policy, all PowerPC-based Macs are now considered obsolete.

Legacy

On June 22, 2020, Apple announced plans to transition the Macintosh to ARM processors over a two-year period, following a roadmap similar to the Intel transition, including universal binaries and a Rosetta 2 compatibility program. Apple had been using ARM in its other products and designing its own ARM chips for many years.

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PROCESSOR ARCHITECTURE OF SUN MICROSYSTEM

Sun Microsystems, Inc. (Sun for short) was an American company that sold computers, computer components and software and information technology services and created the Java programming language, the Solaris operating system, ZFS, the Network File System (NFS) and SPARC microprocessors. Sun contributed significantly to the evolution of several key computing technologies, among them Unix, RISC processors, thin client computing, and virtualized computing. Sun was founded on February 24, 1982. At its height, the Sun headquarters were in Santa Clara, California (part of Silicon Valley), on the former west campus of the Agnews Developmental Center.

On April 20, 2009, it was announced that Oracle Corporation would acquire Sun for US$7.4 billion. The deal was completed on January 27, 2010.

High-performance computing

Sun marketed the Sun Constellation System for high-performance computing (HPC). Even before the introduction of the Sun Constellation System in 2007, Sun's products were in use in many of the TOP500 systems and supercomputing centers:

Lustre was used by seven of the top 10 supercomputers in 2008, as well as other industries that need high-performance storage: six major oil companies, including BP, Shell, and ExxonMobil, chip-designs including Synopsys and Sony and the movie-industry including Harry Potter and Spider-Man.

Sun Fire X4500 was used by high-energy physics supercomputers to run dCache

Sun Grid Engine was a popular workload scheduler for clusters and computer farms

Sun Visualization System allowed users of the TeraGrid to remotely access the 3D rendering capabilities of the Maverick system at the University of Texas at Austin

Sun Modular Datacenter (Project Blackbox) was two Sun MD S20 units used by the Stanford Linear Accelerator Center

The Sun HPC ClusterTools product was a set of Message Passing Interface (MPI) libraries and tools for running parallel jobs on Solaris HPC clusters. Beginning with version 7.0, Sun switched from its own implementation of MPI to Open MPI, and donated engineering resources to the Open MPI project.

Sun was a participant in the OpenMP language committee. Sun Studio compilers and tools implemented the OpenMP specification for shared memory parallelization.

In 2006, Sun built the TSUBAME supercomputer, which was until June 2008 the fastest supercomputer in Asia. Sun built Ranger at the Texas Advanced Computing Center (TACC) in 2007. Ranger had a peak performance of over 500 TFLOPS, and was the sixth-most-powerful supercomputer on the TOP500 list in November 2008. Sun announced an OpenSolaris distribution that integrated Sun's HPC products with others.

Sun acquisitions

Sun server racks at Seneca College (York Campus)

Sun Microsystems at the Computer Museum of America in Roswell, Georgia. Besides that:

1987: Trancept Systems, a high-performance graphics hardware company.

1987: Sitka Corp, networking systems linking the Macintosh with IBM PCs.

1987: Centram Systems West, maker of networking software for PCs, Macs and Sun systems.

1988: Folio, Inc., developer of intelligent font scaling technology and the F3 font format.

1991: Interactive Systems Corporation's Intel/Unix OS division, from Eastman Kodak Company.

1992: Praxsys Technologies, Inc., developers of the Windows emulation technology that eventually became Wabi.

1994: Thinking Machines Corporation hardware division

1996: Lighthouse Design, Ltd.

1996: Cray Business Systems Division, from Silicon Graphics.

1996: Integrated Micro Products, specializing in fault tolerant servers

1996: Thinking Machines Corporation software division

February 1997: LongView Technologies, LLC.

August 1997: Diba, technology supplier for the Information Appliance industry.

September 1997: Chorus Systems, creators of ChorusOS.

November 1997: Encore Computer Corporation's storage business.

1998: RedCape Software

1998: i-Planet, a small software company that produced the "Pony Espresso" mobile email client—its name which is “Sans Hyphen” for the Sun-Netscape software alliance

June 1998: Dakota Scientific Software, Inc.—development tools for high-performance computing.

July 1998: NetDynamics.—developers of the NetDynamics Application Server.

October 1998: Beduin, small software company that produced the "Impact" small-footprint Java-based Web browser for mobile devices.

1999: Star Division, German software company and with it StarOffice, which was later released as open source under the name OpenOffice.org

1999: MAXSTRAT Corporation, a company in Milpitas, California selling Fibre Channel storage servers.

October 1999: Forté Software, an enterprise software company specializing in integration solutions and developer of the Forte 4GL

1999: TeamWare

1999: NetBeans, produced a modular IDE written in Java, based on a student project at Charles University in Prague

March 2000: Innosoft International, Inc. a software company specializing in highly scalable MTAs (PMDF) and Directory Services.

July 2000: Gridware, a software company whose products managed the distribution of computing jobs across multiple computers.

September 2000: Cobalt Networks, an Internet appliance manufacturer for $2 billion.

December 2000: HighGround, with a suite of Web-based management solutions.

2001: LSC, Inc., an Eagan, Minnesota company that developed Storage and Archive Management File System (SAM-FS) and Quick File System QFS file systems for backup and archive

March 2001: InfraSearch, a peer-to-peer search company based in Burlingame.

March 2002: Clustra Systems.

June 2002: Afara Websystems, developed SPARC processor-based technology.

September 2002: Pirus Networks, intelligent storage services.

November 2002: Terraspring, infrastructure automation software.

June 2003: Pixo, added to the Sun Content Delivery Server.

August 2003: CenterRun, Inc.

December 2003: Waveset Technologies, identity management.

January 2004 Nauticus Networks.

February 2004: Kealia, founded by original Sun founder Andy Bechtolsheim, developed AMD-based 64-bit servers.

January 2005: SevenSpace, a multi-platform managed services provider.

May 2005: Tarantella, Inc. (formerly known as Santa Cruz Operation (SCO)), for $25 million.

June 2005: SeeBeyond, a Service-Oriented Architecture (SOA) software company for $387M.

June 2005: Procom Technology, Inc.'s NAS IP Assets.

August 2005: StorageTek, data storage technology company for $4.1 billion.

February 2006: Aduva, software for Solaris and Linux patch management.

October 2006: Neogent.

April 2007: SavaJe, the SavaJe OS, a Java OS for mobile phones

September 2007: Cluster File Systems, Inc.

November 2007: Vaau, Enterprise Role Management and identity compliance solutions.

February 2008: MySQL AB, the company offering the open source database MySQL for $1 billion.

February 2008: Innotek GmbH, developer of the VirtualBox virtualization product.

April 2008: Montalvo Systems, x86 microprocessor startup acquired before first silicon.

January 2009: Q-layer, a software company with cloud computing solutions.

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