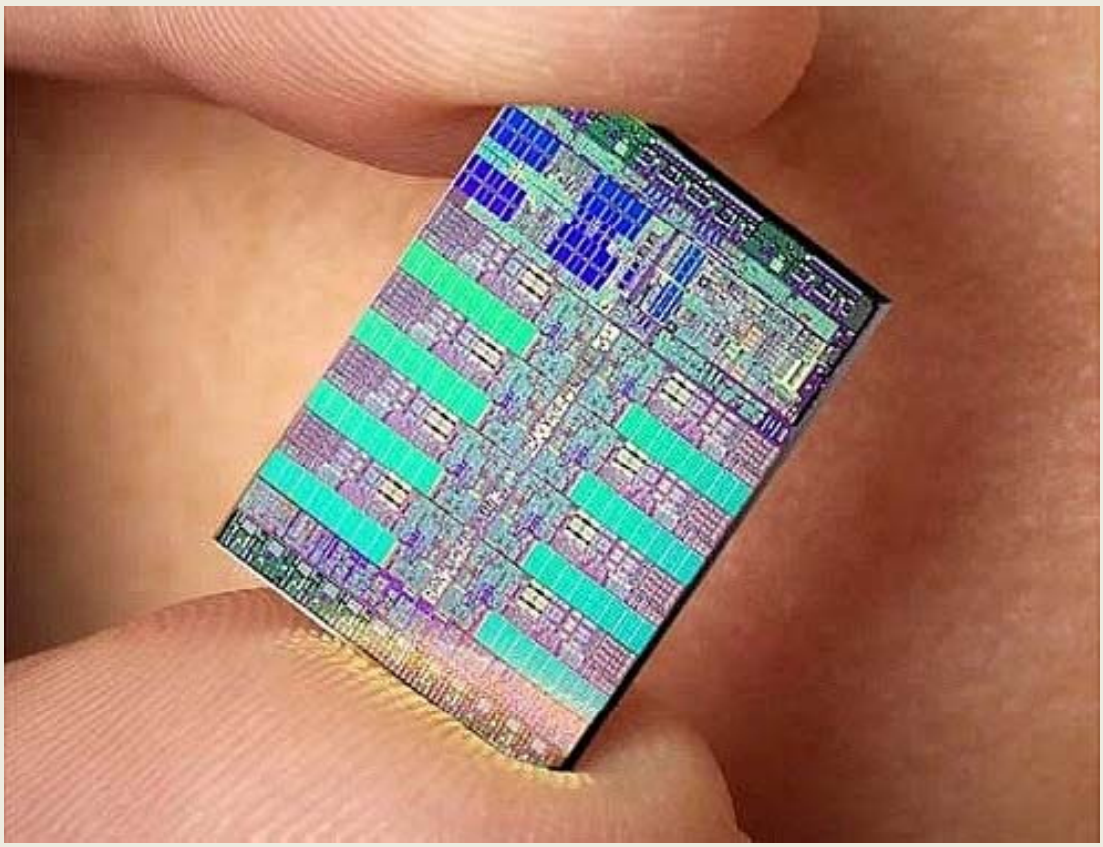


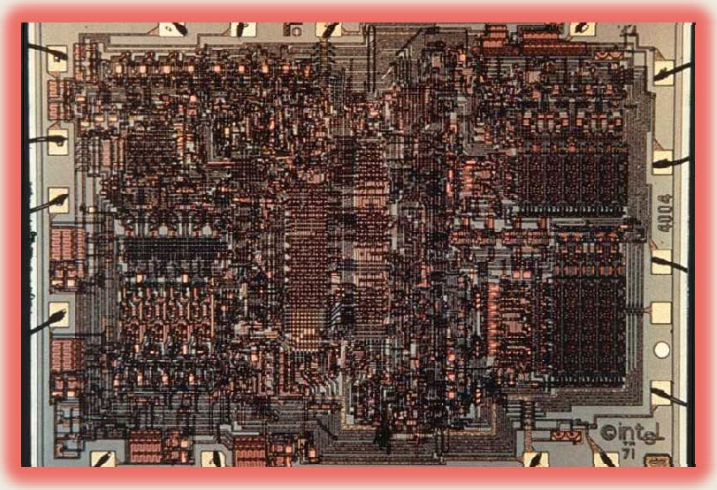
History of Microprocessor: Past, Present, and Future

Professor Won Woo Ro, School of Electrical and Electronic Engineering
Yonsei University

The 1st Microprocessor

The Intel® 4004 microprocessor, introduced in **November 1971**

An electronics revolution that changed our world.



There were no **customer-programmable microprocessors** on the market before the 4004.

It propelled **software** into the limelight as a key player in the world of digital electronics design.

4004 Microprocessor Display at New Intel Museum

A Japanese calculator maker (Busicom) asked to design:

A set of **12 custom logic chips** for a line of **programmable calculators**.

Marcian E. "Ted" Hoff

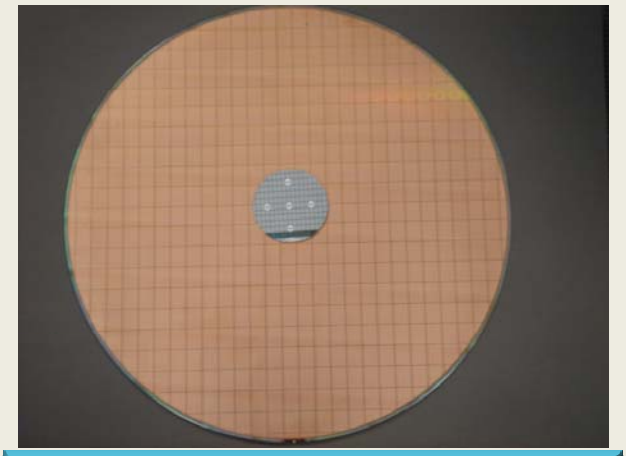
Recognized the integrated circuit technology (of the day) had advanced enough **to build a single chip, general purpose computer**.

Federico Faggin

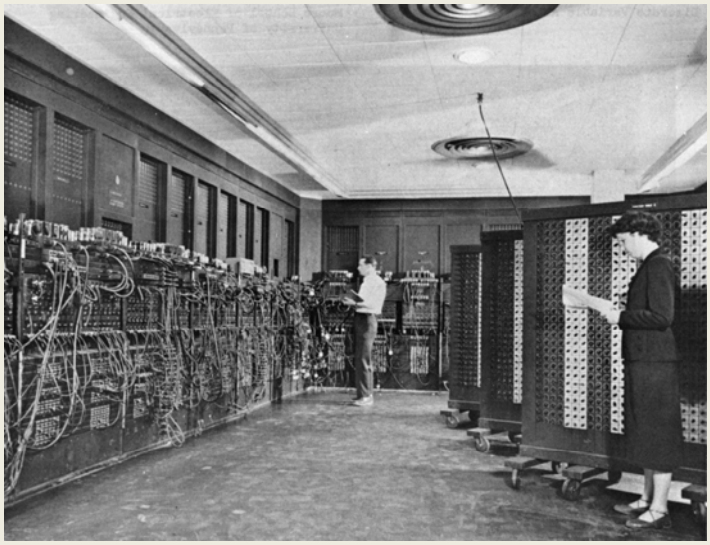
to turn Hoff's vision into a silicon reality. (In less than one year, Faggin and his team delivered the 4004, which was introduced in November, 1971.)

The world's first microprocessor application was this Busicom calculator. (sold about 100,000 calculators.)

Measuring **1/8 inch wide by 1/6 inch long**, consisting of 2,300 transistors, Intel's 4004 microprocessor had as much computing power **as the first electronic computer, ENIAC**.

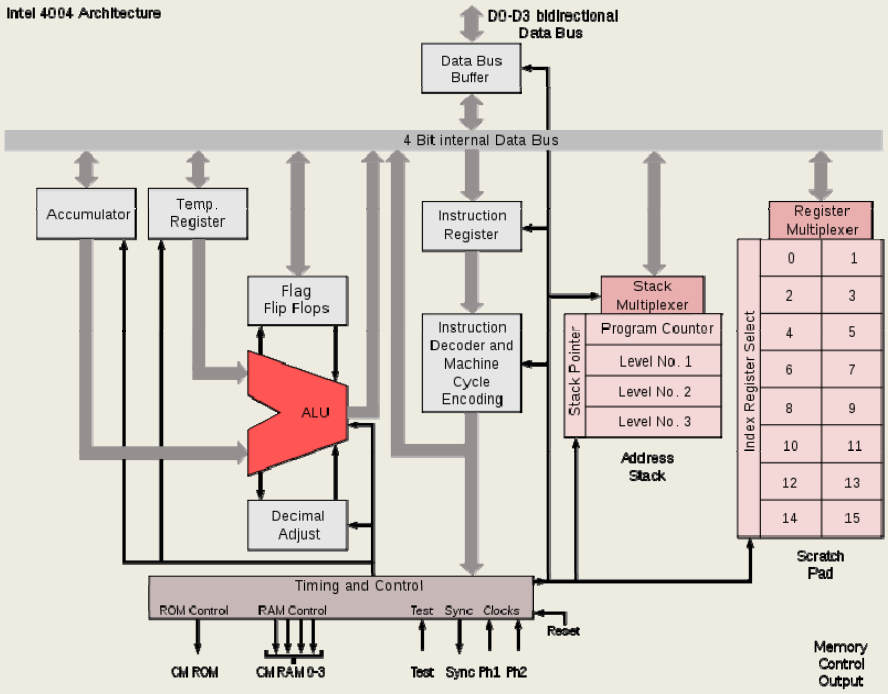


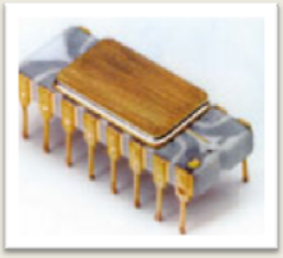
2 inch 4004 and 12 inch Core™2 Duo wafer

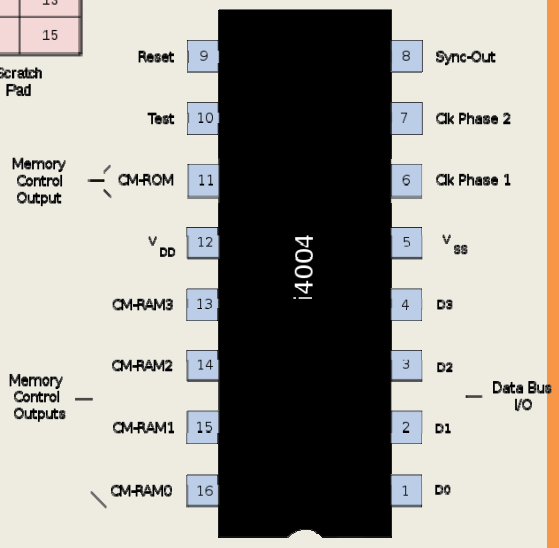


ENIAC, built in 1946, filled 3000-cubic-feet of space and contained 18,000 vacuum tubes.

The 4004 microprocessor could execute 60,000 operations per second

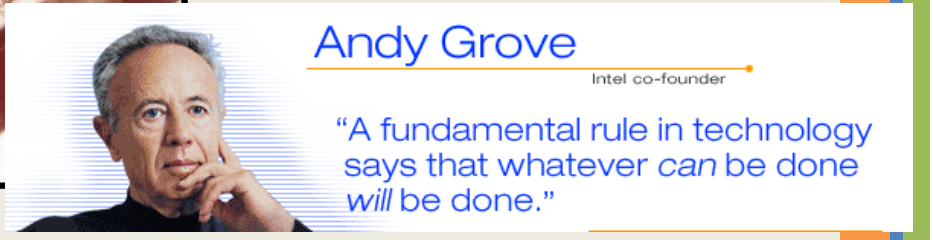






Running frequency: 108 KHz

Founders wanted to name their new company *Moore Noyce*. However the name sounds very much similar to "*more noise*".



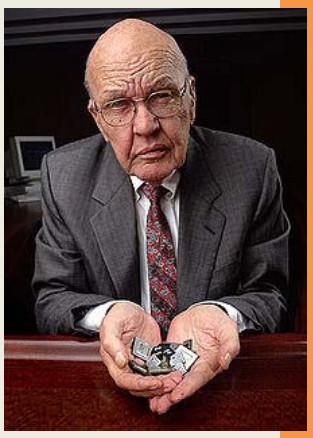
"Only the paranoid survive".

Moore received a B.S. degree in Chemistry from the University of California, Berkeley in 1950 and a **Ph.D. in Chemistry** and minor in Physics from the California Institute of Technology (Caltech) in 1954.

Noyce received his **Ph.D. in physics** from Massachusetts Institute of Technology in 1953. He is nicknamed "**the Mayor of Silicon Valley**" and also credited (along with **Jack Kilby**) with the invention of the integrated circuit (IC).

Noyce was also a mentor and father-figure to an entire generation of entrepreneurs, including Steve Jobs at Apple, Inc.

While Kilby's invention was **six months earlier**, neither man rejected the title of co-inventor.



Jack Kilby was a **Nobel Prize** laureate in physics in 2000 for his invention of the integrated circuit in 1958 while working at Texas Instruments (TI). He is also the inventor of the handheld calculator and thermal printer.

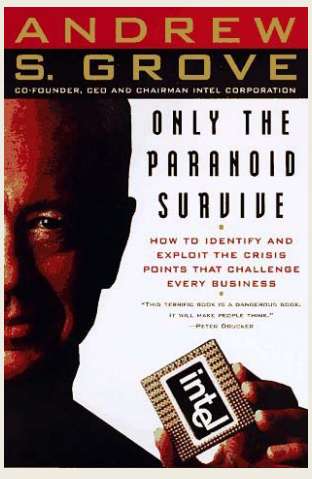
Grove earned a bachelor's degree in chemical engineering from the City College of New York in 1960, and earned a Ph.D. in chemical engineering from the University of California, Berkeley in 1963.

Grove worked at Fairchild Semiconductor before becoming the third employee at the Intel Corporation. He became Intel's president in 1979, its CEO in 1987, and its Chairman and CEO in 1997.

Grove is credited with having transformed Intel from a manufacturer of memory chips into one of the world's dominant producers of microprocessors. During his tenure as CEO, Grove oversaw a 4,500% increase in Intel's market capitalization from $4 billion to $197 billion, making it, at the time, the world's most valuable company.

Grove was fiercely competitive, and he and the company became known for his guiding motto: "Only the paranoid survive".

Noyce was essentially anti-competitive: This difference in styles reputedly caused some degree of friction between Noyce and Grove.

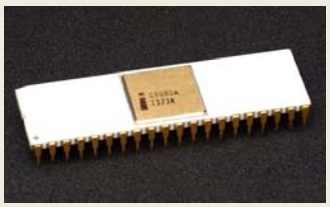


Early Intel: 8008 and 8080

The **Intel 8008:** 8-bit byte-oriented microprocessor (April 1972).

The **Intel 8080** (April 1974):

- Running at 2 MHz (at up to 500,000 instructions per second), - Sometimes considered to be the first truly usable microprocessor.



Shortly after the launch of the 8080, the Motorola 6800 competing design was introduced. Zilog introduced the Z80, which had a compatible machine-language instruction set and initially used the same assembly language as the 8080.

At Intel, the 8080 was followed by the compatible and electrically more elegant 8085, and later by the assembly language compatible 16-bit 8086 and then the 8/16-bit 8088, which was selected by IBM for its new PC to be launched in 1981.

The MITS Altair 8800 was a microcomputer design from 1975 based on the Intel 8080

Originally for a few hundred build-it-yourself kits to hobbyists
Sold thousands in the first month

Today the Altair is widely recognized as the spark that led to the microcomputer revolution of the next few years - First programming language for the machine was Microsoft's founding product, Altair BASIC

A letter from a Seattle company asking if the company would be interested in buying the BASIC programming language (sent by Bill Gates and Paul Allen from the Boston area, and they had no BASIC yet to offer.)

The two started work on their BASIC interpreter using a self-made simulator for the 8080 on a PDP-10 minicomputer. They figured they had 30 days before someone else beat them to the punch, and once they had a version working on the simulator, Allen flew to Albuquerque to deliver the program, Altair BASIC.

The first time it was run, it displayed "Altair Basic," then crashed, but that was enough for them to join

Apple Inc.

Apple was founded on April 1, 1976 by Steve Jobs, Steve Wozniak, and Ronald Wayne to sell the Apple I personal computer kit.

They were hand-built by Steve Wozniak in the living room of Jobs' parents' home, and the Apple I was first shown to the public at the Homebrew Computer Club. Eventually 200 computers were built.

He (Steve Wozniak) looked at the Intel 8080 chip (the heart of the Altair), but at $179 decided he couldn't afford it. Another chip, the Motorola 6800, interested Wozniak .

Allen Baum discovered a chip that was almost identical to the 6800, while considerably cheaper. MOS Technology sold their 6502 chip for $25, as opposed to the $175 Motorola 6800

And… Now

The first Apple II computers went on sale on June 5, 1977] with a MOS Technology 6502 microprocessor running at 1 MHz, 4 KB of RAM

Throughout the 1980s and much of the 1990s, the Apple II was the *de facto standard computer* in American education

Welcome, IBM.

Seriously.

Welcome to the most exciting and important marketplace since the computer revolution began 35 years ago.

And congratulations on your first personal computer.

Putting real computer power in the hands of the individual is already improving the way people work, think, learn, communicate and spend their leisure hours.

Computer literacy is fast becoming as fundamental a skill as reading or writing.

When we invented the first personal computer system, we estimated that over 140,000,000 people worldwide could justify the purchase of one, if only they understood its benefits.

Next year alone, we project that well over 1,000,000 will come to that understanding. Over the next decade, the growth of the personal computer will continue in logarithmic leaps.

We look forward to responsible competition in the massive effort to distribute this American technology to the world. And we appreciate the magnitude of your commitment.

Because what we are doing is increasing social capital by enhancing individual productivity.

Welcome to the task.

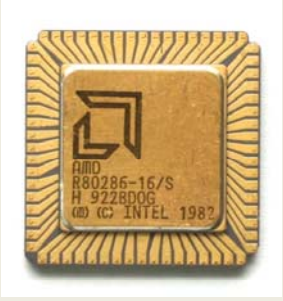
apple

1981: Welcome IBM Seriously

IBM PC + Intel Processor

On July 3, 1991, IBM offered to help Apple finish Pink, its object oriented operating system for Jaguar, if Apple would adopt the PowerPC processor. Motorola was brought in to help manufacture the new processors, and the deal was sealed, creating the **Apple-IBM-Motorola (AIM)** alliance.

A 8MHz Intel 80286 Microprocessor



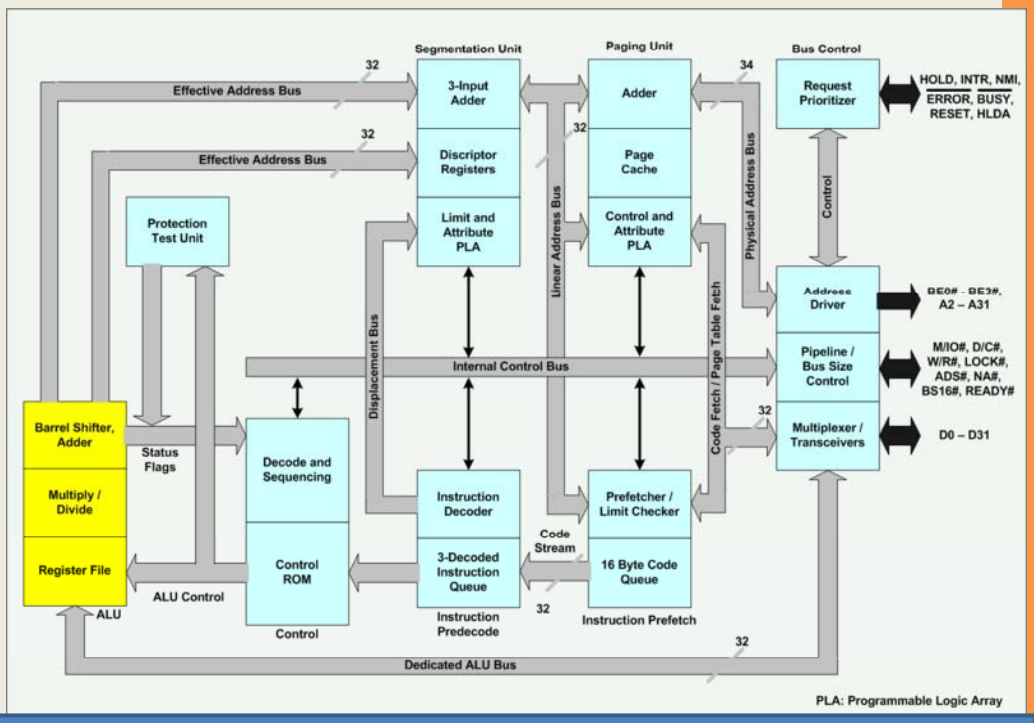
AMD 80286 (16 MHz version)

An 16-bit x86 microprocessor with 134,000 transistors (February 1, 1982)

It was employed for the IBM PC/AT, introduced in 1984, and then widely used in most PC/AT compatible computers until the early 1990s.

Intel 80386 DX
rated at 16 MHz

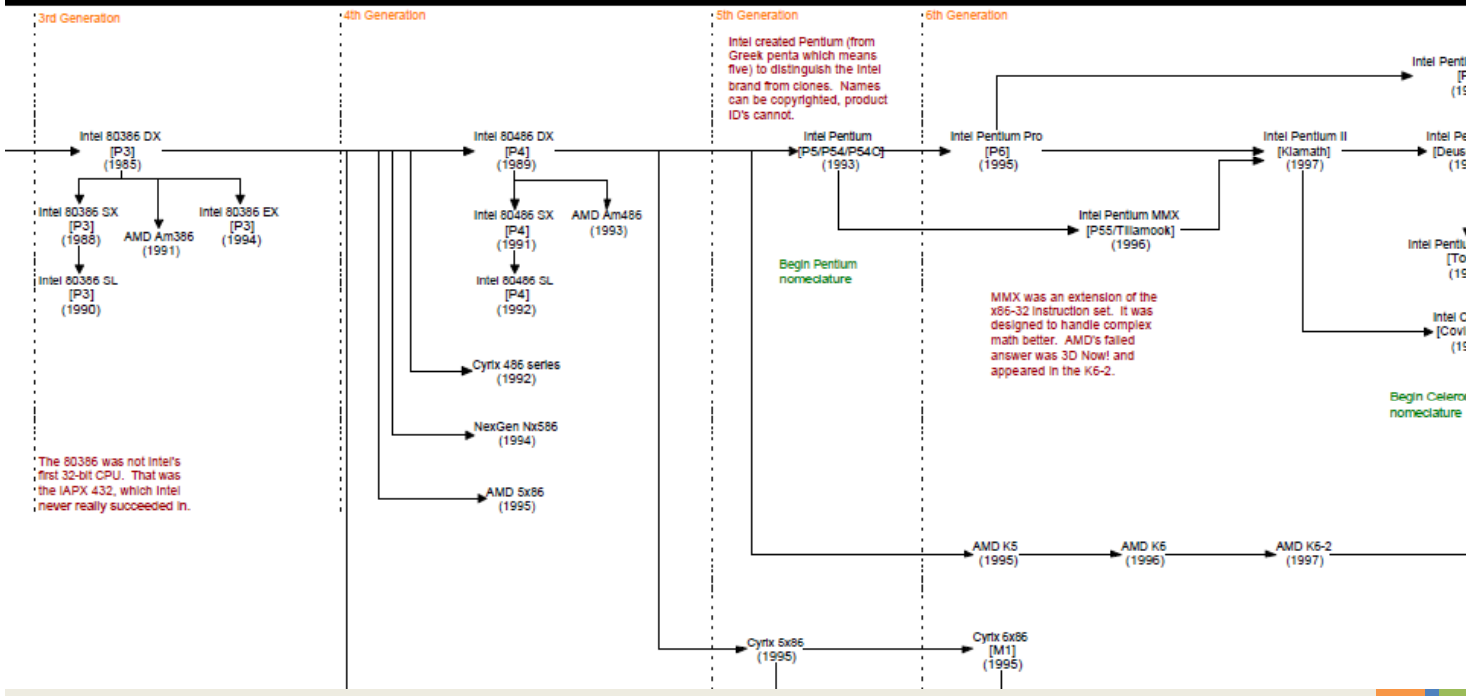
The Intel 80386 (AKA the i386, or just 386)

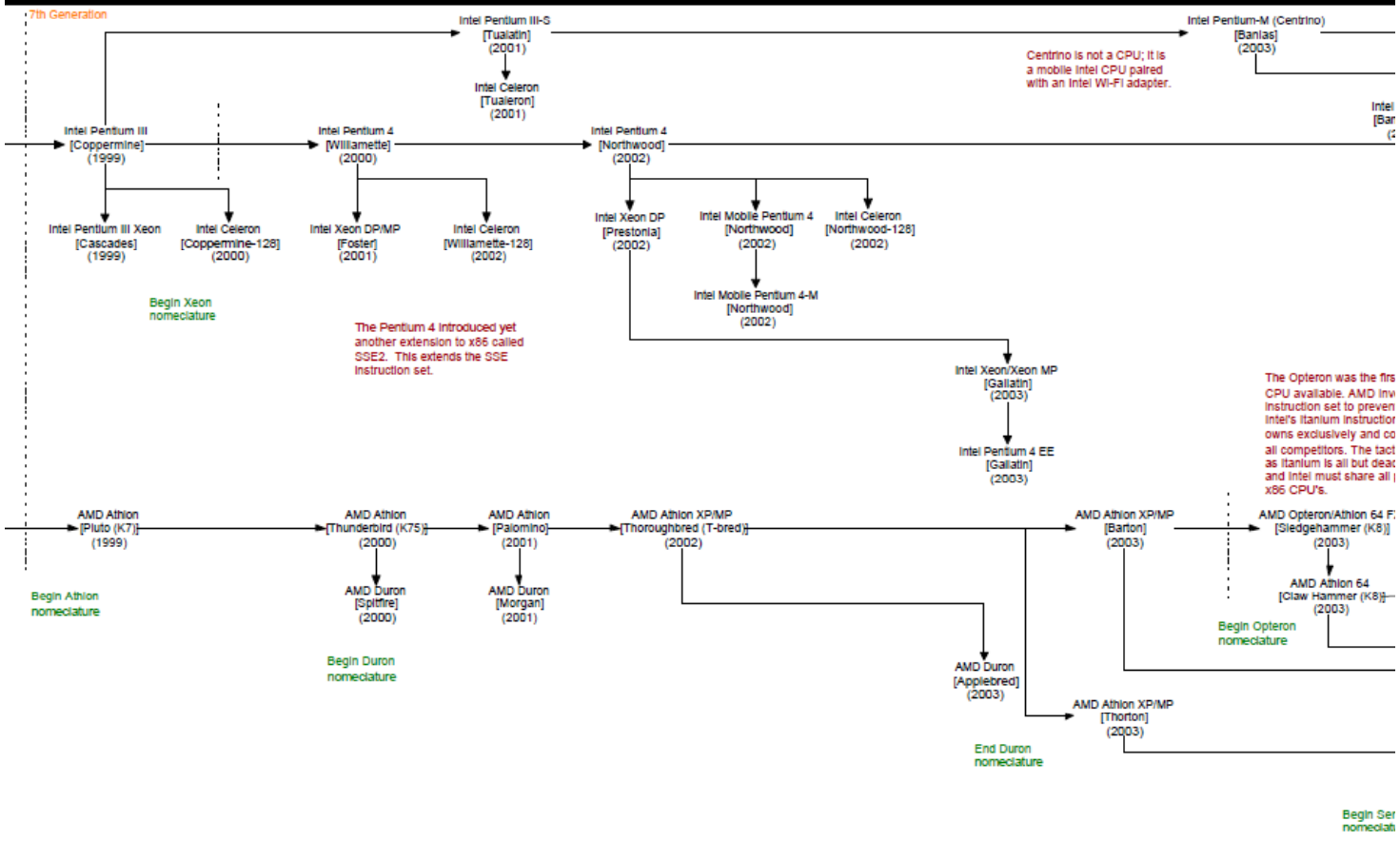


A 32-bit microprocessor (1985): the first versions had 275,000 transistors

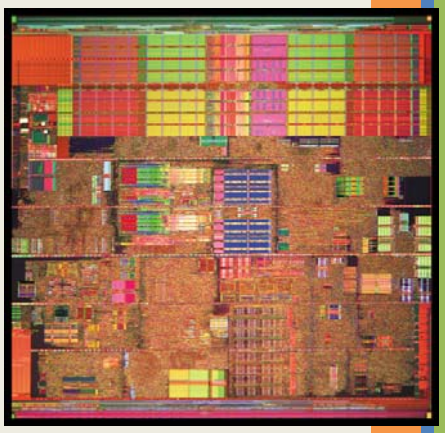
The 32-bit extensions to the 8086 architecture, the 80386 instruction set

Still the denominator for all 32-bit x86 processors (x86, IA-32, or the i386-architecture)


3rd Generation
4th Generation
5th Generation
6th Generation
Intel created Pentium (from Greek penta which means five) to distinguish the Intel brand from clones. Names can be copyrighted, product ID's cannot.
Intel 80386 DX [P3] (1985)
Intel 80386 SX [P3] (1988)
AMD Am386 (1991)
Intel 80386 EX [P3] (1994)
Intel 80386 SL [P3] (1990)
Intel 80486 DX [P4] (1989)
Intel 80486 SX [P4] (1991)
AMD Am486 (1993)
Intel 80486 SL [P4] (1992)
Cyrix 486 series (1992)
NexGen Nx586 (1994)
AMD 5x86 (1995)
Intel Pentium [P5/P54/P54C] (1993)
Intel Pentium Pro [P6] (1995)
Intel Pentium II [Klamath] (1997)
Intel Pentium MMX [P55/Tillamook] (1996)
Begin Pentium nomeclature
MMX was an extension of the x86-32 instruction set. It was designed to handle complex math better. AMD's failed answer was 3D Now! and appeared in the K6-2.
AMD K5 (1995)
AMD K6 (1996)
AMD K6-2 (1997)
Cyrix 5x86 (1995)
Cyrix 5x86 [M1] (1995)
The 80386 was not Intel's first 32-bit CPU. That was the IAPX 432, which Intel never really succeeded in.


7th Generation
Intel Pentium III-S [Tualatin] (2001)
Intel Celeron [Tualeron] (2001)
Intel Pentium-M (Centrino) [Banias] (2003)
Centrino is not a CPU; it is a mobile Intel CPU paired with an Intel Wi-Fi adapter.
Intel Pentium III [Coppermine] (1999)
Intel Pentium 4 [Willamette] (2000)
Intel Pentium 4 [Northwood] (2002)
Intel Pentium III Xeon [Cascades] (1999)
Intel Celeron [Coppermine-128] (2000)
Intel Xeon DP/MP [Foster] (2001)
Intel Celeron [Willamette-128] (2002)
Intel Xeon DP [Prestonia] (2002)
Intel Mobile Pentium 4 [Northwood] (2002)
Intel Celeron [Northwood-128] (2002)
Intel Mobile Pentium 4-M [Northwood] (2002)
Begin Xeon nomeclature
The Pentium 4 introduced yet another extension to x86 called SSE2. This extends the SSE instruction set.
Intel Xeon/Xeon MP [Gallatin] (2003)
Intel Pentium 4 EE [Gallatin] (2003)
AMD Athlon [Pluto (K7)] (1999)
AMD Athlon [Thunderbird (K75)] (2000)
AMD Athlon [Palomino] (2001)
AMD Athlon XP/MP [Thoroughbred (T-bred)] (2002)
AMD Athlon XP/MP [Barton] (2003)
AMD Opteron/Athlon 64 F [Sledgehammer (K8)] (2003)
AMD Athlon 64 [Claw Hammer (K8)] (2003)
Begin Athlon nomeclature
AMD Duron [Spitfire] (2000)
AMD Duron [Morgan] (2001)
Begin Duron nomeclature
Begin Opteron nomeclature
AMD Duron [Applebred] (2003)
AMD Athlon XP/MP [Thorton] (2003)
End Duron nomeclature

Pentium 4 ….



Intel's single core microprocessor:
The firs model: 1.5GHz, November, 2000.

It includes several important new features and innovations that will allow the Intel Pentium 4 processor to deliver industry-leading performance for the next several years.

Produced: 2000 ~ 2008
Max. CPU rate: 1.3 GHz to 3.8 GHz

At the launch of the Pentium 4, Intel stated NetBurst-based processors were expected to scale to **10 GHz** (which should be achieved over several fabrication process generations). However, the NetBurst microarchitecture ultimately hit a frequency ceiling far below that expectation – the fastest clocked NetBurst-based models reached a peak clock speed of 3.8 GHz.

Intel had not anticipated a rapid upward scaling of **transistor power leakage** that began to occur as the chip reached the 90 nm process node and smaller. This new power leakage phenomenon, along with the standard thermal output, **created cooling and clock scaling problems** as clock speeds increased.

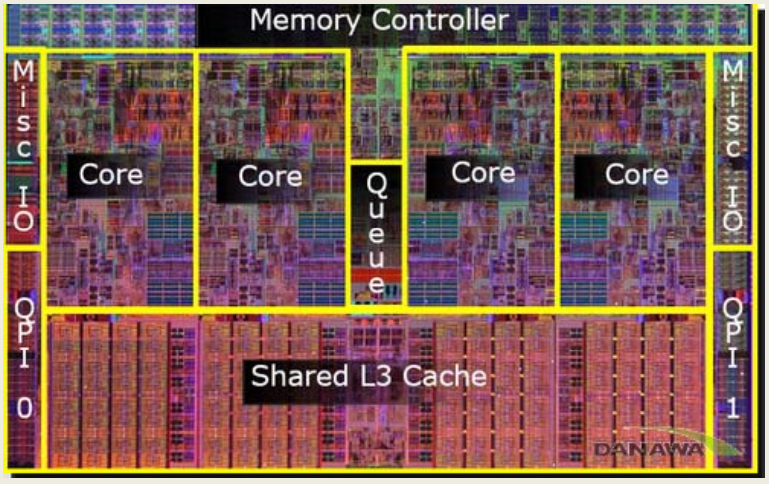
The Pentium III was eventually superseded by the Pentium 4, but its **Tualatin** core also served as the **basis for the Pentium M CPUs**, which used many ideas from the Intel P6 microarchitecture.

Subsequently, it was the P-M microarchitecture of Pentium M branded CPUs, and not the NetBurst found in Pentium 4 processors, **that formed the basis for Intel's energy-efficient Intel Core microarchitecture of CPUs branded Core 2 and Xeon**.

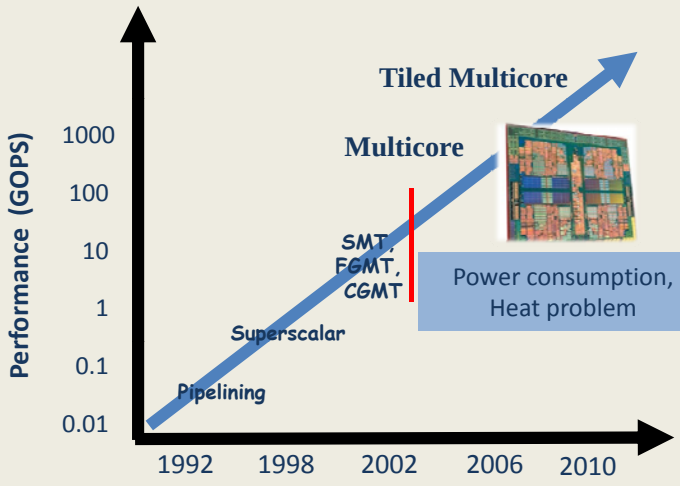
August 8, 2008: The Last Pentium 4

Santa Clara (CA) – Intel today officially announced the Xeon X5365 – a quad-core processor that so far only has been available in limited quantities. The company also quietly announced that it has begun phasing out all remaining Pentium 4 and Pentium D processors.

Intel's 9th Generation Microarchitecture

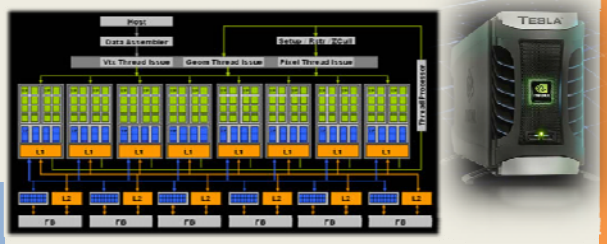


Multi-Core Era

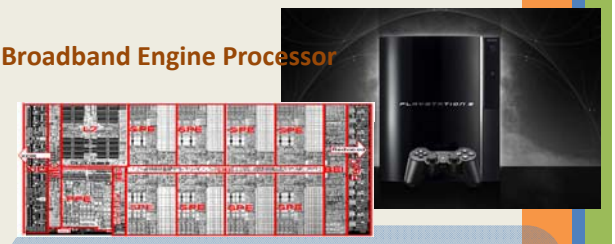


Popular Moore's Law:
Processor (core) performance doubles every two years.

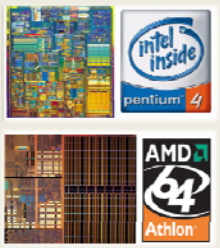
Multi -Core in Graphics Device



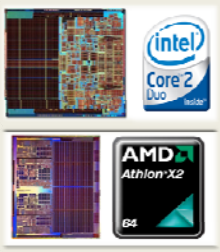
CELL Broadband Engine Processor



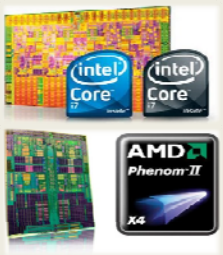
- 1 PPE + 8 SPU architecture
- Maximum 10 threads performs concurrently
- PowerPC instruction set based
- High bandwidth memory interface(25.6GB/s)



Single-Core CPUs



Dual-Core CPUs



Quad-Core CPUs

Trends : High-Performance Mobile CPU + GPU

3D User Interface

Mobile web browsing

3D Mobile game

The user's demands for mobile systems have been increased.
Various mobile applications have been developed.

Mobile GPUs

Mali- 55
1 fragment processor
1M tri/s, 100Mpix/s

PowerVR MBX
3.4-7.4M tri/s, 270-600Mpix/s

⋮

Innovation

Latest Mobile GPUs

Mali- 400MP
4 fragment processor
15-30M tri/s, 275M-1.1Gpix/s

PowerVR SGX
Multi-threaded shader engine
7-40M tri/s, 250M-1Gpix/s

Tegra APX 2600
ARM11 MP core, OpenGL ES 2.0
Programmable pixel shader

⋮

Influence

Desktop GPUs

Tesla S1070
960 cores , 4.1T(single)-345G(double)FLOPS

FireStream9270
800 cores, 1.2T(single)-240G(double)FLOPS

Future trends for high performance mobile applications:
Parallel computing on heterogeneous MP-SoC with GPGPU