

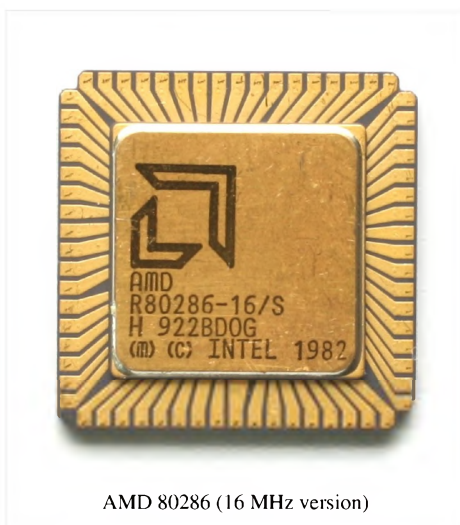
Intel 80286

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An 8MHz Intel 80286 Microprocessor	
Produced	From 1982 to early 1990s
Common manufacturer(s)	• Intel, IBM, AMD, Harris (Intersil), Siemens AG, Fujitsu
Max. CPU clock rate	6 MHz (4 MHz for a short time) to 25 MHz
Min. feature size	1.5µm
Instruction set	x86-16 (with MMU)
Predecessor	Intel 80186
Successor	Intel 80386
Package(s)	• PGA, CLCC and PLCC 68-pin

The Intel **80286**^[1] (also called **iAPX 286**), introduced on 1 February 1982, was a 16-bit x86 microprocessor with 134,000 transistors. Like its contemporary simpler cousin, the 80186, it could correctly execute most software written for the earlier Intel 8086 and 8088.^[2] 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. The 80286 is the first member of the family of advanced microprocessors with memory management and wide protection abilities.

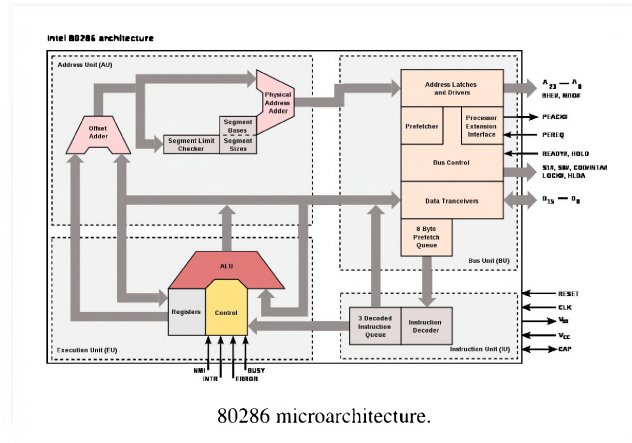
History



After the 6 and 8 MHz initial releases, it was subsequently scaled up to 12.5 MHz. (AMD and Harris later pushed the architecture to speeds as high as 20 MHz and 25 MHz (Harris), respectively.) On average, the 80286 had a speed of about 0.21 instructions per clock.^[3] The 6 MHz model operated at 0.9 MIPS, the 10 MHz model at 1.5 MIPS, and the 12 MHz model at 1.8 MIPS.^[4]

Design

The 80286's performance per clock cycle was more than twice that of its predecessors, the Intel 8086 and Intel 8088. In fact, the performance increase per clock cycle of the 80286 over its immediate predecessor may be the largest among the generations of x86 processors. Calculation of the more complex addressing modes (such as base+index) had less clock penalty because it was performed by a special circuit in the 286; the 8086, its predecessor, had to perform effective address calculation in the general ALU, taking many cycles. Also, complex mathematical operations (such as MUL/DIV) took fewer clock cycles compared to the 8086.



It is a 68-pin microprocessor. It is available in PLCC (Plastic Leaded Chip Carrier), LCC (Lead Less Chip Carrier) and PGA (Pin Grid Array).^[5] Having a 24-bit address bus, the 286 was able to address up to 16 MB of RAM, in contrast to 1 MB that the 8086 could directly access. While DOS could utilize this additional RAM (extended memory) via BIOS call (INT 15h, AH=87h), or as RAM disk, or emulation of expanded memory, cost and initial rarity of software utilizing extended memory meant that 286 computers were rarely equipped with more than a megabyte of RAM. Additionally, there was a performance penalty involved in accessing extended memory from real mode, as noted below.

The 286 was designed to run multitasking applications, including communications (such as automated PBXs), real-time process control, and multi-user systems.

The later E-stepping level of the 80286 was a very clean CPU, free of the several significant errata that caused problems for programmers and operating system writers in the earlier B-step and C-step CPUs (common in the AT and AT clones).

Features

An interesting feature of this processor is that it was the first x86 processor with protected mode. Protected mode enabled up to 16 MB of memory to be addressed by the on-chip linear memory management unit (MMU) with 1 GB logical address space. The MMU also provided protection from (crashed or ill-behaved) applications writing outside their allocated memory zones. The MMU and protection mechanisms are enabled only in case of protected mode keeping them disabled in real mode of operation. The use of additional instructions which are helpful for multitasking operating systems are allowed in protected mode of 80286. Another important feature of 80286 is Prevention of Unauthorised Access. This is achieved by:

- Forming different segments for data, code, stack and preventing their overlapping
- Assigning Privilege levels to each segment. Segment with lower privilege level cannot access the segment with higher privilege level.



The 80286 provided built-in memory protection mechanisms which was then almost exclusive to mainframes and minicomputers (CPUs like the NS320xx and M68000 needed additional components in order to implement MMU functions) and the large performance enhancements represented by the 80286 and many of its successors would pave the way for the x86 and the IBM PC architecture to extend from low performance personal computers all the way to high-end workstations and servers and even drive the market for other architectures.

In 80286, arithmetic operations can be performed on following different types of numbers:



- unsigned packed decimal,
- unsigned binary,
- unsigned unpacked decimal,
- signed binary, and
- floating point numbers.

By design, the 286 could not revert from protected mode to the basic 8086-compatible "real mode" without a hardware-initiated reset. In the PC/AT introduced in 1984, IBM added external circuitry as well as specialized code in the ROM BIOS to enable special series of program instructions to cause the reset, allowing real-mode reentry (while retaining active memory and control). Though it worked correctly, the method imposed a huge performance penalty.

In theory, real-mode applications could be directly executed in 16-bit protected mode if certain rules were followed; however, as many DOS programs broke those rules, protected mode was not widely used until the appearance of its successor, the 32-bit Intel 80386, which was designed to go back and forth between modes easily. When Intel designed the 286, it was not designed to be able to multitask real-mode applications; real mode was intended to be a simple way for a bootstrap loader to prepare the system and then switch to protected mode.

In January 1985, Digital Research previewed Concurrent DOS 286 in cooperation with Intel. The product would function strictly as an 80286 native mode operating system, allowing users to take full advantage of the protected mode to perform multi-user, multitasking operations while running 8086 emulation.^[6] This worked on the B-1 prototype step of the chip, but Digital Research discovered problems with the emulation on the production level C-1 step in May, which would not allow Concurrent DOS 286 to run 8086 software in protected mode. The release of Concurrent DOS 286 was delayed until Intel would develop a new version of the chip.^[6] In August, after extensive testing E-1 step samples of the 80286, Digital Research acknowledged that Intel corrected all documented 286 errata, but said there were still undocumented chip performance problems with the prerelease version of Concurrent DOS 286 running on the E-1 step. Intel said the approach Digital Research wished to take in emulating 8086 software in protected mode differed from the original specifications. Nevertheless, they implemented minor changes in the microcode that would allow Digital Research to run emulation mode much faster, incorporated into the E-2 step.^[7] Named IBM 4680 OS, IBM originally chose DR Concurrent DOS 286 as the basis of their IBM 4680 computer for IBM Plant System products and Point-of-Sale terminals in 1986.^[8] The same limitations affected Digital Research's FlexOS 286 version 1.0, a derivation of Concurrent DOS 286, developed in 1986, introduced in January 1987, and later adopted by IBM for their IBM 4690 OS.

The problems led to Bill Gates famously referring to the 80286 as a "brain dead chip",^[9] since it was clear that the new Microsoft Windows environment would not be able to run multiple MS-DOS applications with the 286. It was arguably responsible for the split between Microsoft and IBM, since IBM insisted that OS/2, originally a joint

venture between IBM and Microsoft, would run on a 286 (and in text mode).

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External links

- Intel Datasheets (<http://datasheets.chipdb.org/Intel/x86/286/datashts>)
- Intel 80286 Programmer's Reference Manual 1987(txt) (<http://www.ragestorm.net/downloads/286intel.txt>).
Hint: use e.g. *Hebrew (IBM-862)* encoding.
- Linux on 286 laptops and notebooks (http://tuxmobil.org/286_mobile.html)
- Intel 80286 images and descriptions at [cpu-collection.de](http://www.cpu-collection.de/?tn=1&l0=cl&l1=80286) (<http://www.cpu-collection.de/?tn=1&l0=cl&l1=80286>)
- CPU-INFO: 80286, in-depth processor history (<http://www.cpu-info.com/index2.php?mainid=286>)
- Overview of all 286 compatible chips (<http://www.cpu-info.com/index2.php?mainid=Collection&ID=80286&type=cpu>)