

Architectural Overview from 8086 to 80486

Vishakha Chandore

2014EE30545, Electrical (Power and Automation), Indian Institute of Technology, Delhi

Abstract: In today's context day by day the demand for new and advanced computers is increasing very rapidly at a rate close to exponential. Technology and Business can be held responsible for this increase in demand. A Microprocessor is the brain of a computer. It is an electronic device that can be programmed. It takes digital or binary data as input and processes it as per the programming instructions stored in the memory and gives the desired results as output. Intel is one of the leading companies which deals with the designing and manufacturing of the microprocessors. In more than two decades Intel has managed to introduce six generations of microprocessors. In this paper we will be focusing on a brief architectural view of these microprocessors from 8086 to 80486.

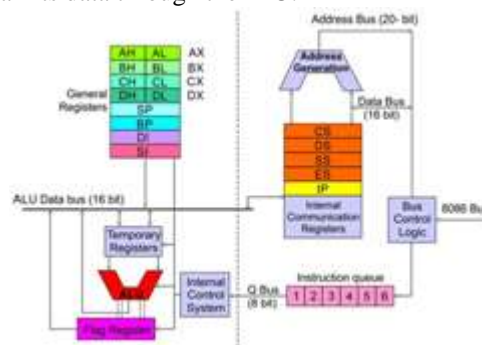
1. Introduction

From 1969 to 2015 Intel has introduced a quite large list of processors. Beginning with 4004 in 1969 was a 4-bit single chip IC processor Intel has managed to introduce 64-bit Itanium 2 (2002), Intel Core i7, and Xeon E3 and E5 series processors (2015). The no. of transistors range from few thousands to 3000 million in the microprocessors that we have today. Moore's Law is based on this observation that the number of transistors that are taken in use in a complex integrated circuit doubles in every two years approximately. Moore's law actually satisfied the goal of the microprocessor industry and therefore it was referred by mostly every competitive manufacturing company as it needed to increase the processing power. As a result clock rate of these microprocessors has increased from a few KHz to the order of GHz making the processors perform faster and faster. Basically computer architecture is the study of computers. It gives us the view of a computer presented to software designers which are then implemented together in the form of hardware known as organisation and in our discussion we will be mainly focusing on the architectural view of 16-bit microprocessors from 8086 to 80486.

A. 8086

8086 was introduced in 1978. It has a three bus system architecture. The 8086 processor comprises of 16-bit registers. Some other features include an external data bus of 16-bit, along with addressing worth 20-bit. This addressing gives an address space of 1 MB. The speed at which 8086 runs is of about 8 MHz. The number of transistors in it are 29,000 at 3 micrometer. Clock rate is 5 MHz with 0.33 MIPS. Its performance is 10 times better than 8080. It used segment registers by the virtue of which it was possible for it to handle data of about 64 KB at once. The microprocessor also has a software function. It uses Arithmetic Logical Unit to perform all sorts of logical and mathematical calculative computations after decoding programs involving such evaluations and finally executes them. It has two processors or say two functional/operating units namely the Bus-Interface Unit and the Execution Unit. The BIU supports Software functions. It looks after memory access and generation operations. It also deals with management of input and output addresses so as to facilitate interaction between the outside world and the CPU and the Execution Unit by means of transfer of data between the two. From the BIU, EU receives data along with instructions that are to be executed and store the results in general registers. EU is not

at all related to the system buses. All it does is receive and output all its data through the BIU.



B. 8088

The EU is same for both the processors and so the programming instructions are same for both and therefore programs written for 8086 can be run on 8088 without any changes. The only difference between 8086 and 8088 is the BIU. As compared to 8086's data bus of 16 bit the external BIU data bus path of 8088 is of 8 bits. As a result the speed of instruction fetch and execution gets slower by 50 percent in 8088. The 8088 instruction queue is 4 bytes long instead of six as in the case of 8086. Moreover because of this in case of prefetch queue present in 8088 which is of 4 bytes it is drained in no time by fast instructions fed to it. Introduction of segmentation has been done in this 8088 processor. This introduction has an upper limit of 64 KB. Intel 8088's average performance is of the order of half a million to about one million instructions per second. This varies and depends on the clock frequency. The characteristics of the particular application program, as well as the number of states for which memory waits also play an important role on the average performance of the processor. This processor is also known for the fact that the speed of the execution unit (EU) and the 8086 CPU bus are in accordance with each other.

The arithmetic operations done in 8086 and 8088 are very slow of the order of some hundreds of clock cycles each. This shortcoming was dealt with in the advanced microprocessors i.e. 80286 and 80386. One more feature of 8088 is that it is capable of recognizing floating point (fp) instructions. When such a fp instruction is fed to it, it simply evaluates its memory and then performs a reading operation of the floating point operand. This memory address of the FP instruction is used by the FP Unit along with the data to carry out the floating point instruction execution. It is more interesting to know that at the same time CPU gets ready to

execute the next instruction. By the virtue of this 8088 makes possible integer and floating point execution taking place simultaneously.



C. 80286

In 1982 came an even more advanced and fast micro-processor by the name 80286 which ran at 12.5 MHz of speed. It comprised of 134,000 transistors on chip. It also had some other features like advanced memory management and multitasking. It also supported better pipelining method. It has four functional parts which are independent of each other in its architecture. Apart from Bus unit and Execution unit the other two functional parts are Address unit and Instruction unit. The CPU components of 80286 comprise of 8 registers meant for some general use of 16 bit. It had 4 segment registers of 16 bit again. Instruction pointer and control register along with status register were also present in it. Various versions of 80286 are able to run at 12.5 MHz, 10 MHz, 8 MHz clock frequencies. Talking about its functionality it has two operating modes. The first mode is real address mode. The second one is the virtual address mode. In case of real address mode the amount of physical memory available is 1 Mb to which it can address upto. In virtual address mode it can address upto 16 Mb of physical memory address and 1 Gb space of virtual memory address. The limitations of 80286 that led to 80386 are that 80286 has only a 16 bit processor. Each segment can be of maximum size of 64 KB. 80286 cannot be easily switched between real mode and protected mode because resetting was required. The amount of memory addressable by the 80286 is 16M byte to increase the over all system performance.

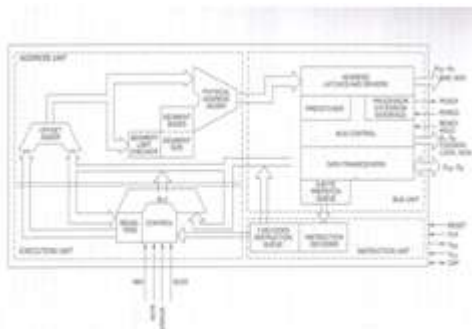
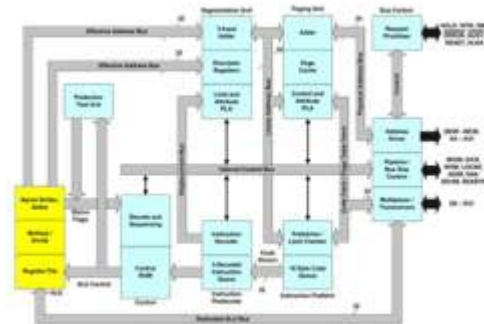


Fig. 8.2 Internal Bus Structure of 80286 (Intel Corp.)

D. 80386

The 386 processor was introduced in 1985. It was made to run at a clock frequency of 20 MHz. Parallel processing was introduced in 386 for the first time which enhanced the performance to a great extent as compared to prior processors. 386 has again a completely different and advanced feature of having six operating stages. These are not just any simple separate stages but all these six stages are parallel i.e. execution at these stages is capable of taking place simultaneously. So the very first stage is the bus interface unit which is responsible for input and output operations and

operations involving memory access. Then comes code prefetch unit. Its work is to receive instruction codes from the bus interface unit as discussed above and then feed the same into a queue of 16 bytes. Third stage is the instruction decode unit. It takes code from the prefetch unit and then as the name suggests decodes it into microcodes. Then it is the execute unit that is responsible for the execution of these generated microcodes. Fifth stage is the segment unit which does protection check and translates the address mentioned in the program to the initial address of the segment with an additional offset. At the end comes the paging unit it actually adds paging as an added feature to the processor. It also does a check on the protection of pages and by having a cache for the recently accessed pages its execution time decreases while performing such a protection check. Talking about the composition of the execution unit, it has 8 registers for general purpose and 8 registers for some special purpose. This special purpose involves data handling. These registers are also used for calculating offset addresses. The 386 processor is available in two commonly available versions namely 80386DX and 80386SX. 80386SX comprises of 32 bit address and data bus i.e. its registers of 32 bit capacity were used for calculations thereby acting as operands and they also performed addressing. It addresses 4 GB of memory and is embedded in 132 pin ceramic pin grid array. On the other hand 80386DX has address bus of 24 bit. Its 16 bit data bus is embedded in 100 pin flat package. 16 MB of memory is addressed by it. The 386 processor also has the feature of Paging in it. In 386 the page size is of 4 KB. In 80286 segments were used for the purpose of accessing pages and memory management virtually but having fixed size allotted for pages in 386 is a superior way to do the same task.



This image shows the architectural view of 80386 - 80486 family.

E. 80486

The 486 processor came into market in 1989. It ran at speed of 100 MHz. This is was its top speed as compared to its other versions. Its different versions have speed of 33 MHz, 66 MHz. A very complementary feature in 80486 is that it has a built in floating point math co-processor like 80386 but the fact that it is integrated on a chip makes execution of arithmetic instructions about three times faster. In earlier versions floating point units were on separate chips but in 486 for the first time the FPUs are on the same chip as CPU leading to the rise of speed multiplying technology. Along with the clock multiplier used, it further allows operation of the processor at higher speed as compared to speed of external memory of bus unit. Improvements made in 80486 over 80386 are that it uses

four way set associative cache. Cache is involved in the memory system of these processors. They form an integral and the most needed part which could be easily accessed anytime in less time by CPU completely apart from the main memory. The 486 processor running at 100 MHz has 16 KB Level one Cache which writes the I/O operation onto the cache and the end of the process is conveyed directly to the host. The processors running at lower rates support 8 KB Level One cache that writes the I/O operation onto the cache and goes through the main storage memory before providing confirmation to the host. The 486 processor supports second Level of cache too, making access of data in lesser time. Moreover multiprocessing is also a feature supported by 80486 and thereby bus utilization gets reduced and all the multiprocessors share just a single memory bus. It consists of 1.2 million transistors. The 486 processor is packaged into 168 pin, pin grid array package. 80486 requires only one clock as compared to two clocks in 80386. 80486 is 8 Kbyte code and data cache because of its highly pipelined Execution Unit. This feature is supported by a total of five stages. The operation of every stage takes place simultaneously and per instruction takes only requires one clock cycle. The 486 contains the 9 functional units. We have already discussed six units in 80386 the other three units in 80486 are the control unit, cache unit and a floating point unit. All these units are similar to 80386 but their functions of many of these units have been improved. For example the instructions involving coding changed to permit instructions in the ROM (to store micro codes) of the control unit so that performance is enhanced by usage of less no. of clock cycles. The Bus Interface unit has an additional parity checker/generator. Whenever a write operation takes place this parity generator as the name suggests generates a parity as an even bit and this bit is provided for every byte of memory. Now talking about read operation the same parity checker/generator acts as a checker and thereby checks parity and evaluates the parity check error. Now coming onto the segmentation unit, referring to a segment its main job is to calculate the initial address of the segment with an additional amount of offset together known as the linear address from the address mentioned in the program known as the logical address of the same segment. Just to ensure that the tasks and the operating system remain isolated and protected from each other the segmentation unit also has a feature of four level protection. Last but not least the paging unit is responsible of converting the initial address of the segment with an additional amount of offset together into the physical address within the same segment.

2. Conclusion

Beyond 80486 we have the fifth generation Intel's micro architecture i.e. the Pentium Processor. It can run all the programs written for 80486 but does so at double the speed. For the purpose of addressing memory pentium processors uses data bus of 64 bit. It addresses memory in 8 banks. And the data allocated to each bank is about 500 MB. So ultimately the main focus is on the performance of the processors needing tremendously high processing power. In the last decade Intel has mainly focused on building microprocessors that are fast and use high power but as far as future plans are concerned it is focusing more on efficiency and not on performance according to recent

updates. Today's mobile market is all based on the types of microprocessors that they use and are manufactured so rapidly by companies like Intel, nVidia, Qualcomm etc. The processors have enabled these devices to be faster than ever without any compromise being made in the size and appearance. Earlier a device with just two cores used to be astonishing if we really need so much of processing power. But now we have quad-core processors which almost replace our Personal computers in terms of the processing power used.

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