

# ● Chapter 1. The PC, history and logic

The PC is a fascinating subject, and I want to take you on an illustrated, guided tour of its workings. But first I will tell you a bit about the background and history of computers. I will also have to introduce certain terms and expressions, since computer science is a subject with its own terminology. Then I will start to go through the actual PC architecture!

## 1. The historical PC

The PC is a microcomputer, according to the traditional division of computers based on size.

### Microcomputers

No-one uses the expression *microcomputer* much anymore, but that is what the PC actually is. If we look at computers based on size, we find the PC at the bottom of the hierarchy.

- Mainframes and super computers are the biggest computers ?million dollar machines, as big as a refrigerator or bigger. An example is the IBM model 390.
- Minicomputers are large, powerful machines which are often found at the centre of networks of “dumb?terminals and PC’s. For example, IBM’s AS/400. A definition that was used in the past, was that minicomputers cost between \$10,000 and \$100,000.
- Workstations are very powerful user machines. They have the capacity to execute technical/scientific programs and calculations, and typically use a UNIX variant or Windows NT as their operating system. Workstations used to be equipped with powerful RISC processors, like Digital Alpha, Sun Sparc or MIPS, but today workstations can be configured with one or more of Intel’s more powerful CPU’s.
- The PC is the baby of the family: Small, cheap, mass-produced computers which typically run Windows and which are used for standard programs which can be purchased anywhere.

The point of the story is that the baby has grown up, and has actually taken the lead! Today, PC’s are as powerful as minicomputers and mainframes were in the past. Powerful PC’s can now compete with the much more expensive workstations. How has the PC come so far?



Fig. 1. Data processing in 1970. Digital PDP 11/20.

## The PC's childhood

Let's take a short look at the historical background of the modern PC, which originated in 1981. In less than 20 years, the PC went through a technological development which has surpassed everything we have seen before. The PC has simply revolutionised society's production and communication in just about every sector. And the revolution appears to be set to continue for many more years.

Today the PC is an industry standard. More than 90% of all microcomputers are based on Microsoft's software (Windows) and standardised hardware designed primarily by Intel. This platform or design is sometimes called *Wintel*, a combination of the two product names.

But at the time that the PC was introduced by IBM, it was just one of many 16-bit microcomputers. For example, the company, Digital, sold many of their "Rainbow" machines in the middle of the 1980's, which I have worked with myself. These other machines were *not IBM-compatible*, but they weren't very different from IBM's machines either, since they were all based on Intel's 8088 CPU. There were actually a number of different types of PC in the 1980's.



Fig. [2](#). DEC Rainbow from 1982. It costed around Euro 8.000 then!

But over just a few years, late in the 1980's, the market got behind IBM's standards for PC architecture. Using the Intel 8086 and 8088 processors and Microsoft's operating systems (DOS initially, later Windows), the PC revolution got seriously underway. From that time on, we talked about *IBM-compatible* PCs, and as the years passed, the PC developed to become the triumphant industry standard.

In parallel with the IBM/Intel project, Apple developed the popular Macintosh computers, which from the very start were very user-friendly, with a graphical user interface. The Macintosh is a completely different platform from the platform of Windows-based pc's I am describing in this guide.

The Macintosh has also been released in generation after generation, but it is not compatible with IBM/Intel/Microsoft's PC standard.

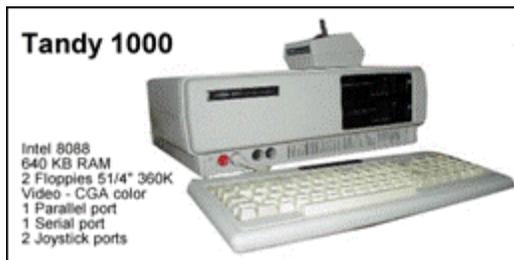


Fig. [3](#). An almost *IBM-compatible* PC from 1984.

In the table below you can see the development of the PC and it's associated operating systems. The PC was actually a further development of the 8-bit microprocessors (like the Commodore 64, etc.), which were very popular until late in the 1980's.

The computer shown in Fig. 2, is a very interesting hybrid. It marked the transition from 8 to 16-bit architecture. The computer contains two processors: an 8-bit Z80 and a 16-bit 8088. This enabled it to run several different operating systems, such as *CP/M* and MS-DOS 2. The two processors, each with their own bus, shared the 128 KB RAM. It was a particularly advanced machine.

Decade	Processors	Operating systems
1970	8-bit microprocessors (initially kits)	CP/M
1980	8086 8088 80286 80386	Various DOS-systems  MS-DOS
1990	80486 Pentium K6 Pentium II Pentium III Athlon	Windows OS/2 Windows NT Windows 95 Windows 98 & 2000  Linux
2000	Pentium 4 Athlon XP Itanium Athlon 64	Windows XP  Windows XP 64

Fig 4. The microprocessor has entered its fourth decade.

## IBM and the PC's success

If we look back at the earlier PC, there are a number of factors which have contributed to its success:

- From the very beginning the PC had a *standardised* and *open* architecture.
- It was *well-documented* and had extensive *expansion options*.
- The PC was *cheap*, *simple* and *robust* (but definitely not advanced technology)

Initially, the PC was an IBM product. It was their design, built around an Intel processor (8088) and adapted to Microsoft's simple operating system, MS-DOS.

But other companies were quick to get involved. They found that they could freely copy the important BIOS system software and the central ISA bus. None of the components were patented. That wouldn't happen today! But precisely because of this open architecture, a whole host of companies gradually appeared, which developed and supplied IBM-compatible PC's and parts.

## Clones

In the late 1980's there was a lot of talk about *clones*. A clone is a copycat machine. A machine which can do exactly the same things as an original PC (from IBM), and where the individual components (e.g. the hard disk) could be identical to the original's. The clone just has another name, or is sold without any name.

We don't distinguish as much today between the various PC manufacturers; but they can still be divided into two groups:

- Brand name PC's from IBM, Compaq, Dell, Fujitsu-Siemens, etc. Companies which are large enough to develop (potentially) their own hardware components.
- Clones, which are built from standard components. Anyone can build their own clone, like the one shown in Fig. 15 on page 10.

However, the technology is basically the same for all PC's ?regardless of the manufacturer. And this common technology is the subject I am going to expound.

Finally, I just want to mention the term *servers*. They are special PC's built to serve networks. Servers can, in principle, be built using the same components that are used in normal PC's. However, other motherboards and a different type of RAM and other controllers are often used. My review will concentrate primarily on standard PC's.

## Bit width

The very first microprocessor Intel produced (the model 4004, also discussed on page 26) was 4 bit. This meant that in a single operation, the processor could process numbers which were 4 bits long. One can say that the length of a *machine word* was 4 bits. The Intel 4004 was a 4-bit processor with a 4-bit architecture. Later came processors which could process 8 bits at a time, like the Intel 8008, 8080, and not least, the Zilog Z80 (a very large number were sold). These were used in a large number of 8-bit computers throughout the 1970's and well into the 1980's.

The PC (in the 1980's) was initially a 16-bit computer. With the development of the 80386 processor, there was a change to the 32-bit architecture which we are still using today.

Now there is a 64-bit architecture on the way, both from Intel (with the *Itanium* processor) and from AMD (with various *Athlon 64* processors). But it is still too early to predict the extent to which the 64-bit architecture will spread into normal, Windows-based PC's.

Width	Processor	Application
4 bit	4004	Pocket calculators
8 bit	8080	Small CP/M based home computers
16 bit	8086, 8088, 80286	IBM-compatible PC's running MS-DOS
32 bit	80386 - Pentium 4	32 bit versions of Windows (Windows 95/98/2000/XP)
64 bit	Athlon 64 Pentium 4 Itanium	Server software 64 bits versions of

Width	Processor	Application
		Windows, Linux etc.

Fig. ?. Today's PC's use mostly 32-bit architecture.

## The pre-history of computers

Our PC's have "spiritual roots" going back 350 years. Mathematicians and philosophers like Pascal, Leibnitz, Babbage and Boole laid the foundations with their theoretical work.

The Frenchman, Blaise Pascal, lived from 1623-1662, and was a mathematical genius from a very young age.



As an 18-year-old, he constructed a calculating machine, and his mathematical theories have had enormous significance to all later scientific research.

The Englishman, George Boole (1815-1864), was also a natural talent. He grew up in very humble surroundings, and was largely self-taught.



When he was 20 years old, Boole founded a mathematics school and then began to develop the symbolic logic which is currently the cornerstone of every program.

Another Englishman, Charles Babbage, began developing various mechanical calculating machines in 1823, which are today considered to be the theoretical forerunners of the computer. Babbage's "analytical machine" could perform data calculations using punched cards. The machine was never fully realised; the plan was to power it using steam.

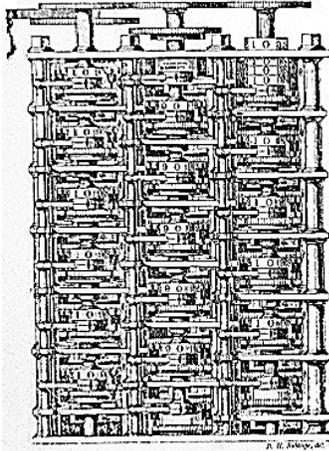


Fig. 6. A construction drawing for one of Babbage's calculating machines, which consisted of several tons of brass machinery.

Fig. 7. Charles Babbage (1791-1871) and his staff constructed various programs (software) for his calculating machine. Babbage is therefore called the "father of the computer" today.



Fig. 7.

However, it was only in the 20th century that electronics advanced sufficiently to make practical exploitation of these theories interesting.



The Bulgarian John Vincent Atanasoff (1903-1995) is the inventor of the *electronic digital computer*.

Atanasoff was a genius. At the age of nine, he

studied algebra  
with the help of  
his mother Iva  
Lucena Purdy, a  
mathematics  
schoolteacher.



In the 1930's Atanasoff was a professor of mathematics and physics at Iowa State University in the USA. Here he used the existing tools like the Monroe calculator and IBM tabulator for his calculations, but he found these machines too slow and inaccurate. For years he worked on the idea that there should be better machines for calculation. His thought was to produce a *digital machine*, since Atanasoff had concluded that mathematical devices fell into two classes, analog and digital. The term digital was not invented, so he called this class of devices "computing machines proper".

In the winter of 1939 Atanasoff was very frustrated from his lack of progress. After a long car ride (Atanasoff was fond of fast cars) he found himself drinking whisky in a bar (he was fond of scotch as well). Suddenly he had the solution. A machine built on four principles. It should work on base-two (binary) numbers instead of base-10 and use condensers for memory. Atanasoff teamed up with a brilliant young electrician Clifford Berry and later the 700 pound machine called *Atanasoff-Berry Computer* was developed. This was the first digital computer.

Another pioneer was the German Konrad Zuse (1910-1995). He was only 18 when he constructed his own mechanical binary computer called Z1.

During the Second World War Zuse's computer Z3 was used in the German aircraft industry. It was the first computer in the world to be programmed with software. It is interesting, that Zuse's computers were developed entirely independent of other contemporary scientists work.



Figur ?. Konrad Zuse. One of the first scientists to produce working computers.

During the war, the Germans also used an advanced code machine (Fig. 8), which the English expended a great deal of effort on “hacking”? They were successful, and this contributed to laying the foundation for the later development of computing.

An interesting piece of trivia: In 1947, the American computer expert, Howard Aiken, stated that there was only a need for six computers in the entire USA. History proved him wrong.



Fig. ?span style='mso-bookmark: \_Ref3800619'>9. The German ”ENIGMA”code machine.