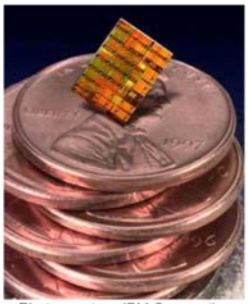
How Microprocessors Work.doc

Freitag, 14. Januar 2022 09:25

[From Sand to Silicon: The Making of a Microchip | Intel]

How Microprocessors Work

by Marshall Brain



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"Copper chip" on a stack of pennies

The microprocessor is the heart of any normal computer, whether it is a desktop machine, a server or a laptop. The microprocessor you are using might be a Pentium core, AMD Ryzer or any of the many other brands and types of microprocessors, but they all do approximately the same thing in approximately the same way.

If you have ever wondered what the microprocessor in your computer is doing, or if you have ever wondered about the differences between types of microprocessors, then read on. In this article, you will learn how fairly simple digital logic techniques allow a computer to do its job, whether its playing a game or spell checking a document!

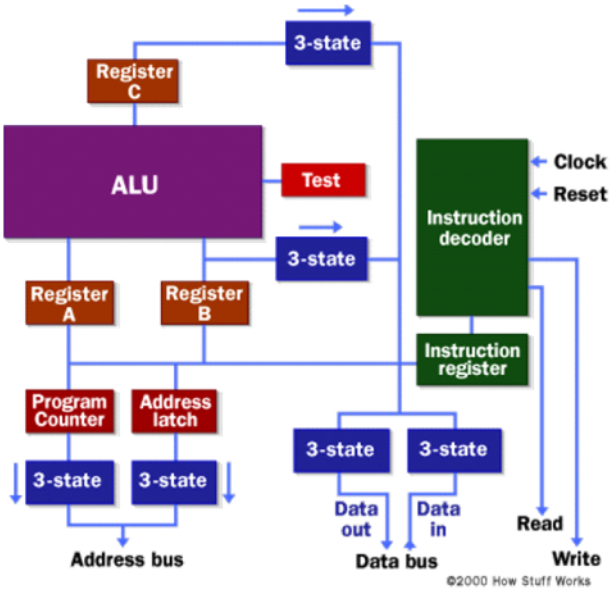
Inside a Microprocessor

To understand how a microprocessor works, it is helpful to look inside and learn about the logic used to create one. In the process you can also learn about **assembly language** -- the native language of a microprocessor -- and many of the things that engineers can do to boost the speed of a processor.

A microprocessor executes a collection of machine instructions that tell the processor what to do. Based on the instructions, a microprocessor does three basic things:

- Using its ALU (Arithmetic/Logic Unit), a microprocessor can perform mathematical operations like addition, subtraction, multiplication and division. Microprocessors contain floating point units that can perform extremely sophisticated operations on large floating point numbers.
- A microprocessor can move data from one memory location to another.
- A microprocessor can make decisions and jump to a new set of instructions based on those decisions.

There may be very sophisticated things that a microprocessor does, but those are its three basic activities. The following diagram shows an extremely simple microprocessor capable of doing those three things:



This is about as simple as a microprocessor gets. This microprocessor has:

- An **address bus** that sends an address to memory
- A **data bus** that can send data to memory or receive data from memory
- An **RD** (read) and **WR** (write) line to tell the memory whether it wants to set or get the addressed location
- A **clock line** that lets a clock pulse sequence the processor
- A **reset line** that resets the program counter to zero (or whatever) and restarts execution

Let's assume that both the address and data buses are 8 bits wide in this example.

Here are the components of this simple microprocessor:

- Registers A, B and C are simply latches made out of flip-flops.
- The address latch is just like registers A, B and C.
- The program counter is a latch with the extra ability to increment by 1 when told to do so, and also to reset to zero when told to do so.
- The ALU could be as simple as an 8-bit adder, or it might be able to add, subtract, multiply and divide 8-bit values. Let's assume the latter here.
- The test register is a special latch that can hold values from comparisons performed in the ALU. An ALU can normally compare two numbers and determine if they are equal, if one is greater than the other, etc. The test register can also normally hold a carry bit from the last stage of the adder. It stores these values in flip-flops and then the instruction decoder can use the values to make decisions.
- There are six boxes marked "3-State" in the diagram. These are **tri-state buffers**. A tri-state buffer can pass a 1, a 0 or it can essentially disconnect its output (imagine a switch that totally disconnects the output line from the wire that the output is heading toward). A tri-state buffer allows multiple outputs to connect to a wire, but only one of them to actually drive a 1 or a 0 onto the line.
- The instruction register and instruction decoder are responsible for controlling all of the other components.

How Microprocessors Work – a closer look

1. Underline the following words in the text and give their German meaning.

English	German	English	German
approximately	ungefähr	a flip-flop	bistabile Kippstufe
to boost	verstärken	ability	fähigkeit
to execute	etwas ausführen	to increment	schrittweise erhöhen
floating point unit	Gleitkommaeinheit	to reset	zurücksetzen
sophisticated	anspruchsvoll	a value	wert
capable	fähig	a comparison	vergleich
to assume	etwas annehmen	to determine	bestimmen
a latch	ein Riegel	an adder	Addierer

2. Answer the following questions according to the text.

a) What is the native language of a microprocessor?
assembly language

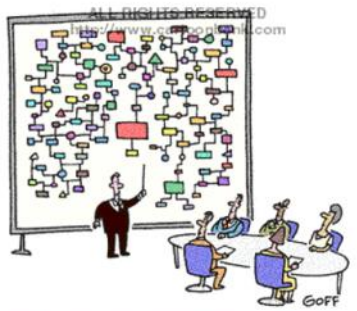
b) On what are the three basic things a microprocessor does based?
using its ALU(perform mathematical operations), move data, make decisions

c) What are registers A,B, and C made out of?
latches out of flip flops

d) What is the extra ability of the program counter?
can increment by 1 or reset to 0 when told to do so

e) What is the test register?
holds values from comparisons performed by the ALU

f) How many tri-state buffers are in the diagram?
six



"And that's why we need a computer."