Factors Determining the Speed and Efficiency of a Micro-Processor in a PC

Shivam Thakur, Hari Mohan Rai, Sidharth Kumar and Suman Pawar

Abstract: A Microprocessor/ Central Processing Unit (CPU) is a hardware within the computer that carries out the instructions of a computer program by performing basic logical, arithmetic, input/output operations of a system. Processors were originally developed with only one core but a computer can have more than one CPU this is called multiprocessing. A computer having more than one CPU on a single chip is called multi core processors. Processors ranging from dual core (2 cores) to deca-core (10 cores) are available in the market. The aim of this paper is to determine the factors on which the speed and efficiency of a microprocessor in a PC depends. We will test the processor for different applications and games to analyse how the microprocessor react under different circumstances. Apart from the software we will also study the hardware accessories which can boost the speed of the microprocessor.

Keywords: Microprocessor, IPC (Instructions Per Cycle), FLOPS (Floating Point Operations Per Second).

I. INTRODUCTION

A Microprocessor is an electronic device that does the function of a computer's central processing unit (CPU) on a single Integrated Circuit (IC) or at most a few integrated circuit. A microprocessor is a programmable device that accepts data in digital form and processes it according to the instructions stored in its memory unit and it provides the result as output. Microprocessors also have an internal memory and they can be used for multiple purposes [1].

Intel introduced its first 4-bit microprocessor the Intel 4004 in 1971 and its 8-bit microprocessor Intel 8008 in 1972.32-bit hardware and software is often referred to as x86 or x86-32. 64-bit hardware and software is often referred to as x64 or x86-64 [2]. 32-bit system utilizes data in 32-bit pieces while a 64-bit system utilizes data in 64-bit pieces. As the number of bits increase there are two important benefits. More bits means data can be processed in larger chunks which means data can be processed more accurately and quickly. More bits means that our processor can point to or address to a larger number of locations in physical memory. 32-bit systems were once desired because they could address up to 4 Gb (Gigabyte) of memory in one go, which simply means that a 32-bit system can support at most 4Gb of RAM or Memory.

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But some modern applications require more than 4 GB of memory so theoretically a 64-bit architecture system can allow us to use 16EB (Exabyte) of memory. That's about 16.7 billion gigabytes, but this is yet to be done practically as a motherboard that can support that much memory is still not available. Majority of the processors now available in the market are based on the 64-bit architecture and support 64-bit operating systems. In general, more data can be processed in 64-bit system so they are comparatively faster than the 32-bit systems [3].

The processor which we are using in this paper is an Intel i5 (3 Gen – 22nm architecture / Ivy Bridge). Intel's Ivy Bridge processors (22nm architecture) are faster and more capable than their predecessor Sandy Bridge processors (32nm architecture) because of the die shrink phenomenon. The term die shrink (sometimes optical shrink or process shrink) refers to a simple semiconductor scaling of semiconductor devices, mainly transistors [4-5]. The act of shrinking a die is to create a somewhat identical circuitry using a more advanced fabrication process, usually involving an advance of lithographic node. This reduces overall costs of a chip company, as the absence of major architectural changes to the processor lowers research and development costs, while at the same time allowing more processor dies to be manufactured on the same piece of silicon wafer, resulting in less cost per product sold. Die shrinks are beneficial to end-users as shrinking a die reduces the current used by each transistor switching on or off in semiconductor devices while maintaining the same clock frequency of a chip, making a product with less power consumption (and thus less heat production), increased clock rate headroom, and lower prices [6]. We are currently using the 22nm technology and 14nm technology will be available by 2014 and 5nm technology will hit the markets by 2022.

Now when we talk about the clock speed or the frequency of a microprocessor what does it mean? A Hertz is equal to "1 Cycle per second". So a 2.0GHz Processor does 2,000,000,000 Cycles per second. The vast majority of processors do more than 1 "process" or instruction per cycle. For example, the Ivy Bridge i7 processors. They do a whopping 3.5 Instructions per cycle. This means that, if the processor was set to 2.0GHz, it would be capable of the following 3.5IPC*2.0GHz = 7,000,000,000 Instructions per Second [7].

Another more common measurement is the FLOPS measurement, or Floating Point Operations per Second. An i7 3770k is capable of roughly 150GFLOPS, or

150,000,000,000 Floating Point Operations per Second. This number tells us the actual calculations per second.

Fig.1 Intel I5 Microprocessor Installed in a Motherboard

Computer processing capability depends on several factors such as CPU clock speed, Cache memory size and speed, the availability of multi core technology, Front Side Bus (FSB) – this is an interface between CPU and chipsets or memory controllers. 32-bit and 64-bit wide data buses are the main types found in modern CPUs. Actually, 64-bit becomes the main stream in modern laptop and desktop computers. Due to this CPU architecture, application developers are also updating their programs to benefit from 64-bit wide bus architecture, Hyper-threading technology, Computer RAM, Hard disk access and rotational speed and other related technologies [8].

Processor speed can be gauged by factors such as machine cycle, clock speed and Bus speed. Machine cycle is the time taken by a processor to complete both the instruction and execution phase of a single task. Modern processors are capable of completing millions and billions of instructions per second depending on the type of processor you have. The other factor is processor speed. It is also referred as clock speed; the clock is a device that sends series of electronic pulses to the CPU at a predetermined time. These pulses affects the machine cycle of a processor. Processor speed is measured in megahertz (MHz) and gigahertz (GHz).One hertz is equal to one cycle per second. So, Megahertz means millions of cycles per second, and gigahertz means billions of cycles per second [9]. Generally, before choosing any type of processor, you should always remember the factors related with better performing processor and the specific task it is designed for.

II. HARDWARE USED

The hardware used to determine the speed of microprocessor and PCs are detailed in Table 1 & fig. 2, 3.

Table 1 – Hardware used in Benchmarking/ Tests

S.No	*COMPONENT*	*PRODUCT NAME*
1.	PROCESSOR	Intel Core i5 (3 Gen-22nm) – 3750K (3.4 GHz)
2.	MOTHERBOARD	ASRock Z77 Pro 4
3.	CHIPSET	Intel Z77 Chipset
4.	RAM	10 GB
5.	VIDEO CARD	NVIDIA GeForce GTX 550 Ti
6.	HARD DISK	500GB
7.	PSU	Seasonic 600W

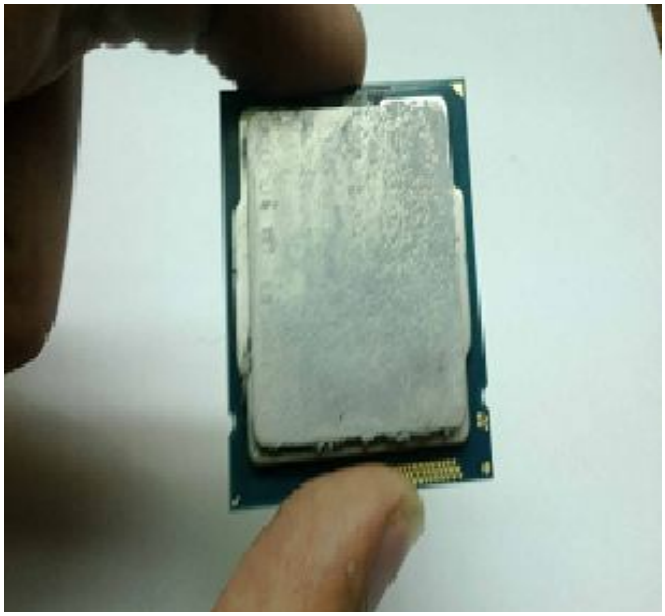

Fig 2 – Front View of a Microprocessor/CPU

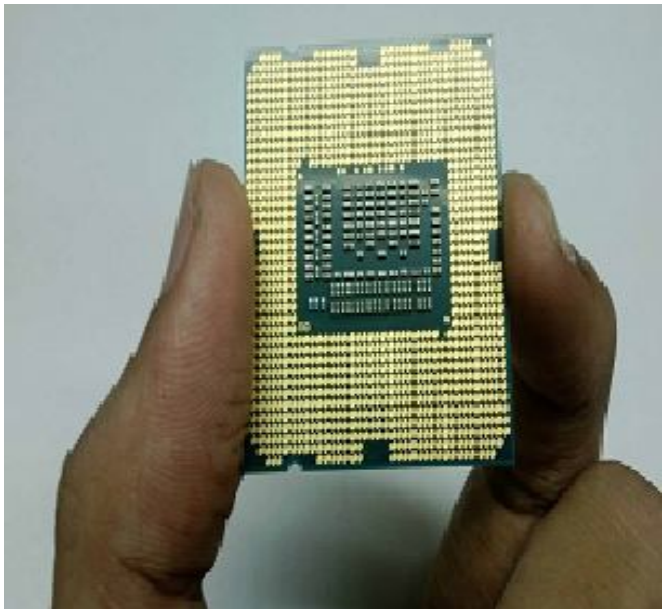

Fig 3 – Back View of a Microprocessor/CPU

III. SOFTWARE USED

The hardware used to determine the speed of microprocessor and PCs are detailed in Table 2

Table 2 – Software used in Benchmarking/Tests

S.No	NAME	SIZE
1.	Microsoft Windows 8 Pro 64-bit	3.4 GB
	GAMES	
2.	SLEEPING DOGS	10 GB
3.	FIFA 2013	6.62 GB
4.	COUNTER STRIKE GLOBAL OFFENSIVE	5.19 GB
5.	COUNTER STRIKE SOURCE	4.26 GB
	APPLICATIONS	
6.	VLC	21.5 MB
7.	WINDOWS MEDIA PLAYER	24.56 MB
8.	GOOGLE CHROME	33.03 MB
9.	ADOBE PHOTOSHOP CS6	1.8 GB
10.	MICROSOFT WORD 2010	0.99 GB

IV. TESTS/BENCHMARKING

We will be using the FLOPS (Floating Point Operations Per Second) method to analyse our CPU.The theoretical FLOPS value of the CPU which we are using is i5 3570K = 3.4GHz * 4 DP Vectors * 2 uops/cycle * 4 cores = 109 GFLOPS.

That is 109 Billion Floating Point Operations per Second (GFLOPS).

After certain benchmarking tests for all the given applications and games we got the following values of CPU and memory usage. With the help of this data we find out the Floating Point Operations Per Second in Millions (MFLOPS). Values of CPU usage, Memory usage and MFLOPS for various applications of a PC are detailed in Table 3.

Table 3 – Values of CPU usage, Memory usage and MFLOPS for various applications

S.NO	APPLICATION	CPU USAGE	MEMORY USAGE	MFLOPS
1.	Sleeping Dogs	53.9%	1230 MB	58750
2.	FIFA 2013	56.6%	459.1 MB	61440
3.	CS- Source	20.3%	268.3 MB	22080
4.	CS- Global Offensive	68%	573.8 MB	73020
5.	VLC Audio	1.8%	16.6 MB	1950
6.	VLC Video	8.8%	101.2 MB	9280
7.	WMP Audio	14.7%	27 MB	15680
8.	WMP Video	21.8%	56.1 MB	23680
9.	Google Chrome	6.4%	52.2 MB	6720
10.	Microsoft Word	2.8%	25.5 MB	3040
11.	Adobe Photoshop	35.1%	89.7 MB	4180

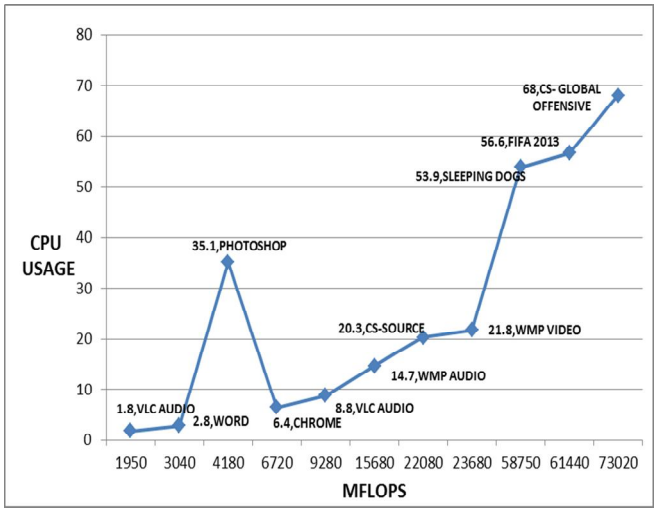

Fig 4 – Graph between CPU usages And MFLOPS (Million Floating Point Operations per Second) for various applications

V. RESULTS

From the benchmarking tests we performed for different softwares we came to know that the softwares having the large file size tend to use more CPU than the ones having file size lower than them. This can be seen as all the games which were used in the tests (i.e Sleeping Dogs,FIFA 2013, CS-Global Offensive) have large area than other softwares and as a result they use more CPU. Which we can clearly study from the graph above that the Instructions Processes per Second (FLOPS-Floating Point Operations Per Second) for these games is higher. Comparison between CPU usages And MFLOPS (Million Floating Point Operations per Second) for various applications have been shown in fig. 4.

Whereas this is does not hold true for the memory used. As CS-Global Offensive uses the most CPU but the memory usage of the same is comparatively quite low. So we found out that File size of the software being used and the memory it uses to process the data are not the only reasons which determine the speed of the CPU. Thus along with these reasons the type of file being processed plays an important role in determining the speed and efficiency of the microprocessor.

VI. CONCLUSION

Therefore we can conclude that size of the program, memory it uses to process the data and the type of file being processed are the main factors which determine the speed and efficiency of the CPU and ultimately how quickly the file gets processed. Apart from these factors there are a no of physical factors (hardware) which can also increase the speed and efficiency of the microprocessors. These can be

stated as :-

(i). CPU clock speed, Cache memory size and speed, the availability of multi core technology, Front Side Bus (FSB)

(ii). Using microprocessor with latest architecture (64-bit and 22nm technology)

(iii). Using more memory (RAM and Graphic Processing Memory).

(iv). Using SSD (Solid State Drives) in place of HDD (Hard Disk Drive) as they have no rotating parts so they have high file transfer speed and more durability.

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