2581-4575

International Journal For Recent Developments in Science & Technology

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CHALLENGES IN CHIP/PROCESSOR LEVEL THERMAL ENGINEERING

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Abstract: Central Processing Unit CPU popularly called "Processor" is termed the brain of the computer. This is where all processing of information takes place. Processor a very sensitive part and a determinant of what happens. This article runs a study on how a processor can perform under various degrees of temperature. Chip a third world and developing do experience very high temperature especially in the northern part. The writer saw this as a great setback in using computer systems in the country's rural schools due to inability to acquire special cooling devices, hence affecting the processors (CPU) negatively. The article sought to proffer solution to this issue as the study was able to review on Turbo Booster of Intel and AMD processors as kind of processors capable of withstanding various degrees of temperature change. Experimental test and analysis carried out and possible results are discussed. Recommendations on what schools in the rural areas of northern Chip should do were enumerated.

Keywords- Central Processing Unit CPU, Processor, Temperature, Rural schools

INTRODUCTION

A processor is the electronic circuitry within a computer that carries out the instructions of a computer program by performing the basic arithmetic, logical, control and input/output (I/O) operations specified by the instructions [1]. Is a small chip that resides in computers and other electronic devices. Its basic job is to receive input and provide the appropriate output. While this may seem like a simple task, modern processors can handle trillions of calculations per second. As for the use of terms Rousse, stated that the term processor has generally replaced the term central processing unit (CPU) [2]. The processor in a personal computer or embedded in small devices is often called a microprocessor. Technically in the article [3] a comprehensive description on the operation of a computer processor is outlaid. It described processor as a collection of billions of off/on switches. The article

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explains further that these switches use the most basic logic known to man, known as Boolean logic that is, everything is either on, or off, either a one (on) or a zero (off). These switches are of course tiny, around 32nm, depending upon the transistor in question, and have been described as containing "merely a couple of electrons". A single silicon chip can contain thousands of transistors [4]. To clarify on the concept CPU, is necessary to understand the fundamental issues at hand here, the switch; understand this elusive switch; how it works and what it is made of. This switch is a switch whose state as "on" or "off" is governed by voltage; unlike the lighting switch at home, where up perhaps is "on", in the case of the switches we are talking about (High K Metal Gate Transistors), a high voltage is "on", and a low voltage is "off"[5] [3].

BASIC OPERATIONS OF A COMPUTER PROCESSOR

Processors manipulate information in a signal like structure. As earlier stated, these signals are basically collections of binary zeros and ones (0's and 1's) represented in "on" and "off" manner. To understand this operations there are foundational ideas that must be understood as the writer explains;

Clock Cycles-Frequency, Speed:

Clock speed is the rate at which a processor can complete a processing cycle. It is typically measured in megahertz or gigahertz. One megahertz is equal to one million cycles per second, while one gigahertz equals one billion cycles per second. This means a 1.8 GHz processor has twice the clock speed of a 900 MHz processor [6]. The frequency or speed of a processor is, of course, related to the underlying structure of the switch. All of these terms are roundabout ways of describing the rate at which processor's switches can turn on and off, or switch between the high voltage that designates "on" and the low voltage that designates "off" (Vcc and Vss). The rate at which this switching occurs is really, very rapid. This entails that clock speed can be best imagined as a pulse- like signal, switching rapidly back and forth from on to off. The description is shown in Figure 1. The diagram depict an ideal binary situation showing the voltage at exactly "on" or "off" but in real situation it is not so. In true situation, our switches work on tolerances, accepting anything over some value Vcc as "on," and anything less as "off". It also takes some time to transit from one state to another, as shown in Figure 2.

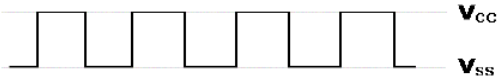

Figure.1. Where Vcc is the high, "on", and Vss is the low "off" voltage. The Y axis here is Voltage, the X axis here is time.

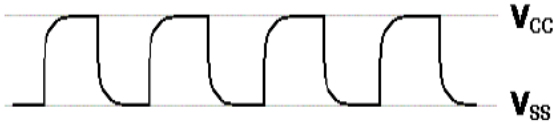

Figure.2

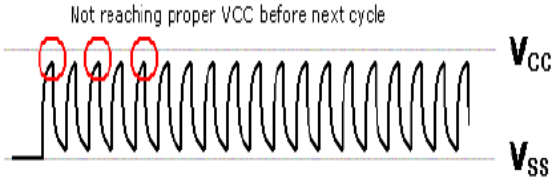

Figure.3

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TEMPERATURE CHALLENGES ON COMPUTER SYSTEMS

The article principally wishes to answer questions raised by computer users and school proprietors in developing countries on equipping their study centers with computer systems. In developing countries like Chip, there are so much infrastructural deficiencies in the rural areas; these include inadequate power supply, lack of good roads to reach enthusiastic expecting school children and a lot more [9]. The writer saw the need for such localities to enhance their academic shortfalls with the use of computers, yet so much fears elude them with regards to the following retrospect facts;

• Computers are expensive and require expensive means to keep, use and maintain.

• There is lack of electric power supply enough not just to operate the system but the accessories that can maintain these systems. One of the major fears is their inability to obtain good means of providing desired temperature that will sustain these items.

The writer saw that must of Chipn localities experience excessive high temperature through the year and without adequate facilities can computers in such areas be sustained? In addition to the problem of excessive heat experienced in such areas ability to purchase cooling systems like electric fans, air conditioners etc. remains impossible, this greatly affect any attempts to acquire computer systems to ease learning among the students. Chip, like the rest of West Africa and other tropical lands, has only two seasons these are the Dry season and the Rainy season. The whole of West Africa is heated intensely as result of the increased insolation received from the sun being overhead over West Africa and temperatures can climb as high as 35°C (95.0 °F) over West Africa during this time. In fact temperatures in the northern part of Chip can go as high as 48°C (118.4 °F) in cities like Maiduguri [10].

STUDY REVIEW

The writer made reviews with regard to how processors perform under temperature change, and the facts from the reviews agreed with reasons why the writer embarked on the study. These reviews are stated thus; Bates, [7] asserts that room temperature, affects the internal workings of a computer. And further stated that higher room temperatures can affect performance, especially exceeding 80°F/27°C since the computer's internal heat will be greater. Yet Bates concludes that performance though affected but not greatly affected; in fact, mostly, is not noticeable but that does not mean overheating in itself does not have greater consequences. Another similar view says the ideal operating temperature of a computer's environment ranges from 50 degrees F to 82 degrees, though it should be as close as possible to room temperature, 72 degrees. It says laptops should operate between 50 and 95 degrees [12]. It further explained that excessive heat lowers the electrical resistance of objects, therefore increasing the current. In addition, slowdown is a result of overheating. Components can shut down when

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overheated and the motherboard temperature sensor instructs hardware such as the hard drive and processor to slow down. the Intel CPU thermal limit is 100°C, one can quantify the amount of overheating by measuring the amount of time the CPU temperature was running at > 99°C. This is graphically represented in Figure 4. It became a surprised when the testing showed that while the minimum CPU load frequency started to drop as soon as the CPU hit 100°C, the average CPU frequency didn't drop by more than .1GHz until the CPU was overheating more than 30% of the time. In fact, Intel CPUs are surprisingly good at being able to handle this much heat with such a small reduction in the average frequency.

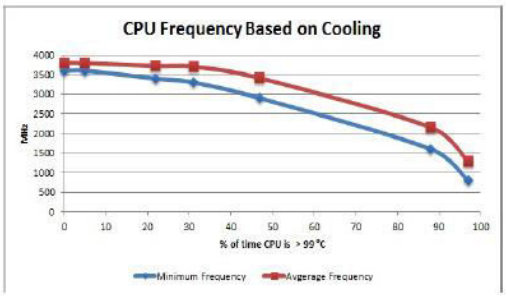

Figure.4. CPU behavior from frequency stand point.

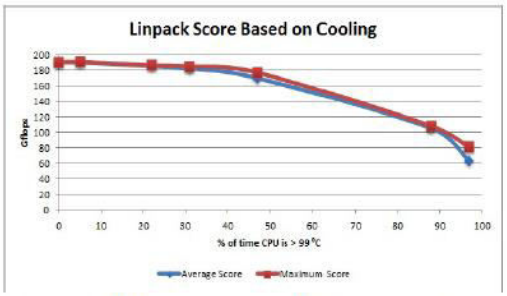

Figure.5. CPU behavior from Actual Performance stand point.

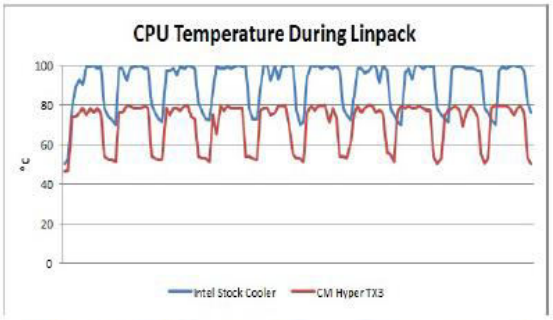

Figure.6. CPU performance using non-manual coolers CM Hyper TX3 and Intel Stock.

FORMAL IMPLEMENTATION

Depicting from Bach experiment is really interesting, but it may be hard to translate into a real world situation. To accomplish this, the exact same Linpack test is performed except that instead of altering the cooling manually two different CPU coolers were used - the stock cooler that came bundled with the Core i7 4790 and the budget-friendly Cooler Master Hyper TX3 which only costs about $20. To make this as real-world as possible, a test hardware (Asus Sabertooth Z97 Mark II, Intel Core i7 4790, 4x

Kingston HyperX LoVo DDR3-1600 4GB, NVIDIA GeForce GTX 980) was installed into a Fractal Design Define R4 chassis with the stock fans running at 5V. Linpack test results is shown in Figures 6 and 7.

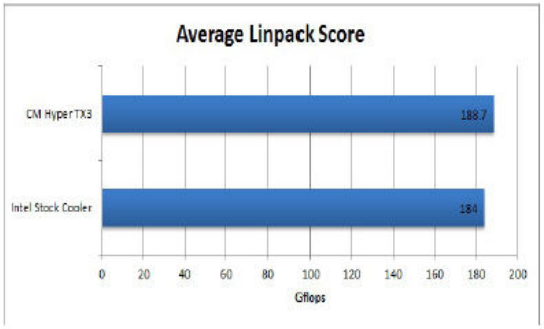

Figure.7. CPU performances from previous graph.

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DISCUSSION OF RESULTS / ANALYSIS

The results of our testing can pretty much be summarized with the following three points:

1. Modern Intel CPUs run at full speed (including the full Turbo Boost allowed based on the number of cores and workload) all the way up to 100°C
2. Even after the CPU hits 100°C, the performance is not greatly affected until the CPU spends about 20% of the time > 99 °C
3. While stock cooling only causes around a 2.5% drop in performance, even a budget after-market cooler will dramatically improve CPU temperatures

SUMMARY AND CONCLUSION

In summary, is very right to say high temperatures possess great threat to computer systems and it remains unadvisable to subject them to high temperatures unnecessarily. This article tried to solve problem regarding situation where temperature problem serves as a barrier to computer usage meaning on extreme cases. For instance in Chip some parts of the country temperature is quite high and access to required facilities to maintain low temperature is unobtainable. Schools in the rural areas are badly affected whereby having good computer laboratories is difficult for ideal situation. Fears to spend money in purchase of systems has eluded such schools thereby necessitating the need to know if there are systems that can tolerate these situations to a bearable level. The article was able to come up with a useful solution whereby it discovered that there are processors that can assist to greatB extend in tolerating this temperature change even though not absolute. Intel processors could be of help provided they are not over stretched beyond recommended level. There are other aided mechanism capable of assisting in maintaining good temperature level; using giant liquid cooling loops, insanely high flow fans, or even things like liquid nitrogen to keep a CPU extremely well cooled. The article already showed that coolers like CM Hyper TX3 or Gelid Tranquillo would be a better match for CPU.

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