Optimal Power Management & Regeneration Schema to Support Green Technology In Mobile Computing Devices for Better Battery Backup

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Abstract

It is the Era of mobile Technology where the connectivity is required all time. So, the demand to increase the battery backup time for these mobile computing devices becomes essential., This situation becomes more demanding in the field with no power resources where critical tasks have to be done. These tasks can vary from medical assistance to providing regular services. The aim of this research is to provide design improvements that can enhance the battery usage time of mobile computing devices. The paper discusses the power demands for different components of mobile computing devices such as, Notebook and laptop Also; it suggests some procedures that would be helpful to optimally increase the usage mobile computing devices battery. A novel model of the hardware for better management and utilization of power is proposed. This model will ultimately support green technology by regenerating power and reducing the power cost for computing task. Hardware comparison is also discussed in this paper among different generation of Microprocessor of Intel and AMD.

Keywords: *Green technology***,** Power Management, Mobile Computing Devices, Fan Utilization, power, supply circuits, scheduling, secondary cells, AMD, Core Technology.

1. Introduction

Traditionally the need for the increase in the battery consumption for laptops is increasing rapidly, Due to that many architectures have been designed in which the most successful is Intel Core technology. This paper studies this core technology and suggests some improved model to increase the battery back time for mobile computing devices.

The block diagram of Core Technology is shown below.

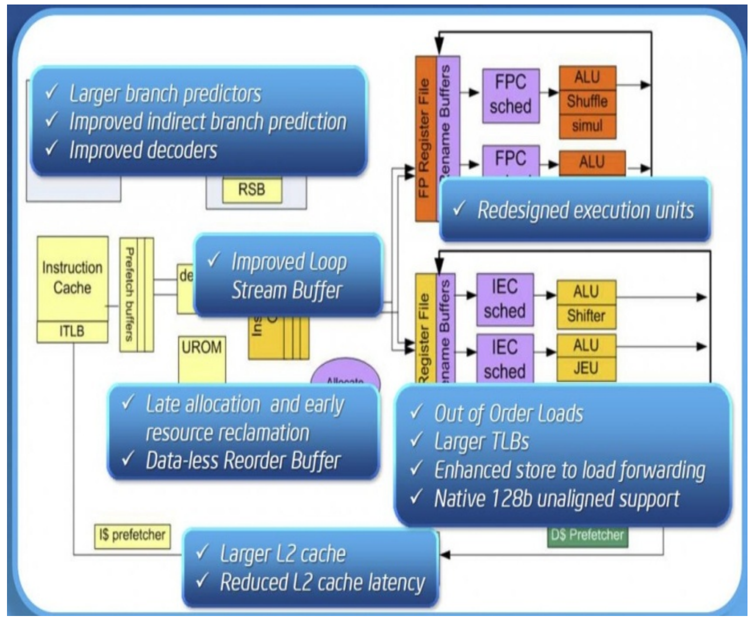

Figure 1: Block Diagram of Core Technology

Figure 1 show the block diagram of Core Technology and its relation with various input and output devices. Core Technology yields less power consumption compared to other available technologies with the same kind of processing.

Power Usage by Different Components

Brief introduction of different Components of mobile computing devices (laptop/Notebook) and their power usage are given below

a. Motherboard

It's the main component on which all the other components are installed and it provides space to install different components. It is the most important component in the computer since it connects all the other components of a PC together. The power usage varies *from 22-40 watts* for low end motherboard and *45-80 watts* for high end motherboard.

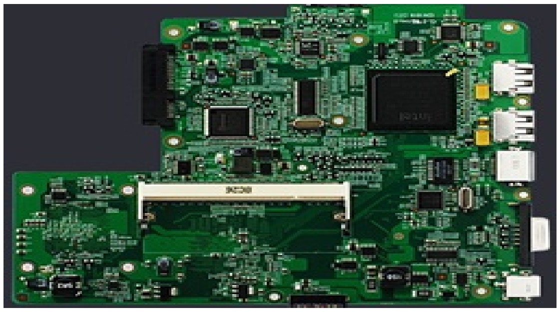

Figure 2: Motherboard Diagram

a. Central Processing Unit

It is the main chip in the computer and is located on the Motherboard.

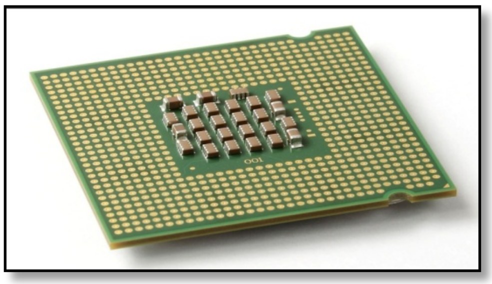

Figure 3: CPU figure

It's also called the brain of computer which is responsible for the processing of all kinds of jobs given to a mobile computing device.

b. Hard Disk

The most common name is HDD (Hard disk Drive). HDD can read and write on a magnetically coated platter, that spins at a high speed.

Figure 4: Standard HDD for Laptop

There can be more than one patter (disk) in the hard drive. It is available in different flavors. The most common flavor is SSD due to its speed to read and write. HDD use *0.7 -3.0 watts* while SSD uses *0.6-2.8 watts.*

c. VGA Card

Video Graphics Array (VGA) is a card with high resolution standard for displaying text, graphics, an d colors on computer monitors. The main two functions of the Video Card is to provide Video Random Access Memory for image storage and video processing circuitry

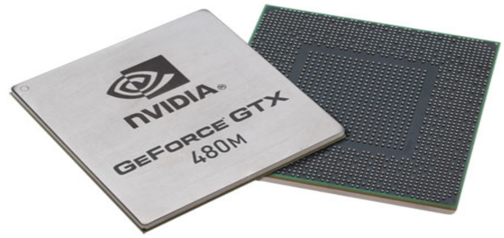

Figure 5: Standard Laptop Graphic card

d. Random Access Memory (RAM)

RAM is the short term memory. Whenever the applications or programs are running, the RAM stores bits and pieces of data until it can be processed by the CPU.

The two types of RAM: DRAM and SRAM. DRAM is the most commonly used type, but it needs to be refreshed very frequently. SRAM is faster than DRAM.

Figure 6: Standard RAM diagram

e. DVD/Combo Drive

Combo drive is multi Optical drive that's capable of reading and writing data to optical media such as DVD-RW, DVD+RW, CD ROM, CD R, CD RW, all in one single drive.

Figure 7: Standard DVD/Combo Drive

PC Components with Power Consumption (in Watts)		
Component Type	*Minimum Use*	*Maximum Use*
CPU Intel Core i3	*55*	*73*
CPU Intel Core i5	*73*	*95*
CPU Intel Core i7	*77*	*95*
CPU AMD 2 cores	*65*	*65*
CPU AMD 4 cores	*65*	*125*
CPUAMD 8 cores	*95*	*125*
Regular Motherboard	*22*	*40*
High End Motherboard	*45*	*80*
DDR1 RAM	*4*	*5.5*
DDR2 RAM	*3*	*4.5*
DDR3 RAM	*2*	*3*
Low End Graphics Card	*25*	*86*
Middle End	*110*	*164*
High End Graphics Card	*162*	*258*
Top End Graphics Card	*240*	*350*
SSD	*0.6*	*2.8*
2.5" HDD	*0.7*	*3*
3.5" HDD	*6.5*	*9*
SATA DVD	*15*	*27*
SATA Blu-ray	*25*	*30*
FAN 2000 RPM	*0.6*	*1.8*
FAN 3000 RPM	*3.6*	*6*

Table 1: Individual Power consumption by Components

Figure 8 depicts the detail of power usage (Min. & Max.) among different components of mobile computing devices in terms of watts.

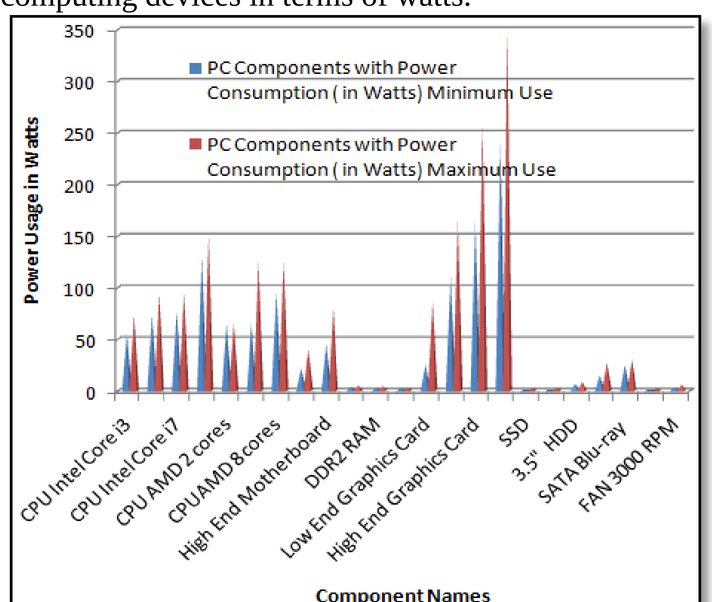

Figure 8: Power Usage Comparison by different components

Table 2 describes the power consumption of different devices for a low-end laptop.

PC Components with Power Consumption (in Watts)		
Component Type	**Minimum Use**	**Maximum Use**
CPU Intel Core i3	55	73
CPU AMD 2 cores	65	65
Regular Motherboard	22	40
DDR1 RAM	4	5.5
Low End Graphics Card	25	86
SSD	0.6	2.8
SATA DVD	15	27
FAN 1200 RPM	0.6	1.8
Total	187.2	301.1

Table 2: Power Consumption of Low End System

The power requirements for a middle-end Laptop's components are shown in Table 3.

PC Components with Power Consumption (in Watts)		
Component Type	**Min. Use**	**Max. Use**
Intel Core i5	73	95
AMD 4 cores	65	125
Regular Motherboard	22	40
DDR2 RAM	3	4.5
Middle End	110	164
2.5" HDD	0.7	3
SATA DVD	15	27
FAN 2000 RPM	0.6	1.8
Total	289.3	460.3

Table 3: Power Consumption for a Middle End System

The details for high-end system's components are described in Table 4.

PC Component with Power Consumption (in Watts)		
Component Type	**Min. Use**	**Max. Use**
Intel Core i7-E	130	150
AMD 8 cores	95	125
High End Motherboard	45	80
DDR3 RAM	2	3
Top End Graphics Card	240	350
SSD	0.6	2.8
SATA Blu-ray	25	30
FAN 3000 RPM	3.6	6
Total	**541.2**	**746.8**

Table 4: Power Consumption for a High End System

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Considering the given data stated in the tables above, a novel design is proposed to alter the Basic Architecture of Motherboard.

2. REVIEW OF RELATED STUDIES

According to the ISO14020 standard, the eco-labeling of products guides consumers toward more environment-friendly segment of products. A life cycle assessment (LCA) model is created for, up-to-date laptops. The constraints imposed by two different eco-labels for laptops: EPEAT (based in the US) and TCO (based in Sweden). The analysis of the eco-labels criteria revealed that the labels impose few changes on the design of the laptop as describe in the LCA model and their influence on the life cycle impact is minimal. The labels promote energy efficiency, but the marked demand for long battery life is a push so strong that the average lap top on the market well fulfills these criteria. It was notable that the lap top power efficiency together with short product life, resulted in that the use phase environmental impacts was less compared to the production phase environmental impacts (partly opposed to some earlier studies, where the electricity consumption during use was a more important driver). To promote better environmental performance the energy efficiency could be improved further; but useful life of lap tops is an increasingly important issue to be addressed. Criteria for eco-labels must be continuously updated to actually guide toward a more environmentally friendly market segment for fast developing products like electronics [3].

Many wearable and portable devices, like personal communicators, cellular phones, laptops, are equipped with two or more battery packs. That leads to remarkable tradeoff between the device weight and/or size and the desired battery lifetime. to increase user flexibility in selecting the optimal form-factor/weight versus required lifetime trade off. For instance, the Compaq IPAQ PDA is equipped with an add-on module that contains PCMCIA expansion and an auxiliary battery pack. The user has the flexibility of selecting the optimal device with reasonable battery lifetime and weight/size. Recent work on battery-driven power management has demonstrated that: (1) sequential discharge is suboptimal in multi-battery systems and (2) lifetime can be maximized by distributing (steering) the current load on the available batteries, thereby discharging them in a partially concurrent fashion. Based on these observations, we formulate multi-battery lifetime maximization as a continuous, constrained optimization problem. That can be efficiently solved by nonlinear optimizers. While previously the lifetime has increased by 12% using scheduling algorithm. We show that a significant lifetime extensions (up to 160%) can be obtained with respect to standard sequential discharge. From the manufacturing standpoint, numerous issues must be faced when multiple batteries have to be accommodated into the case of a portable electronic appliance. They range from the selection of battery capacities and shapes to the design of the power supply circuitry (including the switching regulator that interfaces the various batteries to the current load). One degree of freedom that, so far, has not been fully exploited, is the policy to be used for discharging the available batteries. The main contribution of this paper is to develop new class battery lifetime maximization policies and state an approach for optimally tuning the policies for a given battery system [4]. Extending battery life for portable computing systems not only requires new power management techniques and high efficiency power delivery systems but also must addresses low power consumption modes. Mobile systems spend most of their operating time in very low power modes, in which the voltage regulators (VRs) that feed the different components typically exhibit low efficiencies. Variable frequency control is one of the most commonly used methods to minimize both driving and switching losses by scaling the switching frequency at light loads. However, further benefit can be achieved if the input voltage scales as well. This paper proposes a novel reconfigurable battery pack (RBP) concept to improve power conversion efficiency of VRs under light load conditions. It describes a methodology to change the input voltage of VRs based on load conditions by changing the internal connection of battery cells to provide a variable input bus voltage to the system and extend battery life as a result of power loss reduction. Experimental results show ~15 min battery life improvement for a typical Thin & Light Laptop [5]. The advances in battery technology are not coping with the rapidly growing energy demands. Most laptops, handheld PCs, and cell phones use batteries that take anywhere from 1.5 to 4 hours to fully charge but can run on this charge for only a few hours. The battery has thus become a key control parameter in the energy management of portables. To meet the stringent power budget of these devices, researchers have explored various architectures, hardware, software and system-level optimizations to minimize the energy consumed per useful computation. Research in battery-aware optimization is now moving from stand-alone devices to networks of wireless devices, specifically, ad hoc and distributed sensor networks. Computationally feasible mathematical models are now available that capture battery discharge characteristics in sufficient detail to let designers develop an optimization strategy that extracts maximum charge [12]. Rao et.al presented a new battery management system for a lithium ion battery pack for more efficient operation and sturdy. The new system contains an embedded microcontroller to track the energy content of cell battery, optimize the output current, and provide extensive feedback of all the measurements taken. This system sends all data to a telemetry system so that the data can be relayed to a laptop via wireless signal. Two unique advanced features of the BMS are: the capability to optimize the battery pack energy and the ability to provide cell equalization. Since the BMS is used in an electric vehicle, very low power consumption is essential [8]. The experiments for this research work are done on different machines by running Win 7 OS . The installed operating system and other software are utilizing 32GB of the hard disk (10%). The display used in the studies laptop is the Super Extended Graphics Array Plus (SXGA+). It is a standard computer display with resolution of 1400×1050 pixels and ratio of 4:3. The screen resolution can be changes and varies down to 1024 x 768 pixels due to display preference or memory consumption. Also, the color quality can be set from low to high. The brightness can be reduced to the level of user comfort, which play big factor in saving battery power [8,9]. The consumption of battery's power can be reduce by using optical drives, wireless communications devices, PC Cards, Express Cards, media memory cards, or USB devices. Also, using high-brightness display settings, 3D screen savers, or other power-intensive programs such as 3D games can consume more of the battery. Spectacular consumption cab be done by running the computer in maximum performance mode. On the other hand, the conserving of battery power can be attained by plugging the laptop to electrical outlet when possible, using power management modes such as standby and hibernate wisely. The life or charge of the battery can be checked by Dell QuickSet Battery Meter, the Microsoft Windows Power Meter, the battery charge gauge and health gauge. As stated by the manufacturer the full charge of the battery takes two hours while the laptop is off. The increase of number of battery charges causes loose of charge capacity [8,9].

The laptop under study is equipped with standard four-cell battery (32Whr). According to the Battery Life benchmark test performed by Dell Labs on the above specifications, the battery maximum life is 2.7 hours [11].

Hendrickson et. al discussed that portable computers are a rapidly growing segment of the computer market. They analyzed the environmental issues associated with disposal and reuse of these computers. They suggested a new design which alleviates the environmental burdens. As portable computers use batteries with toxic components, so disposing them off or recycling them is a major problem. They also discussed a machine design with provision to upgrade that can be expected to have a longer useful life[12].

Warnulkar et. al focused on optimizing the energy consumption by electronic and electrical applications which employ battery grid network. They presented some proves for electric vehicles, industries and portable electric gadgets. They used Grid Network Assembly (GNA) technique as a solution of the problem. GNA uses a inexpensively available processor such as 8086 and 8085 to mechanically choose the best batteries in a grid network and mechanically brings them in series which can be used for power exaction. They suggested to charge only the required batteries in a given grid network, which is economically affordable as compared to available battery management system. They suggested the same system to be used in laptops to maintain the health of the batteries [13].

Imai, T. & Yamaguchi, H suggested to keep the battery fully charged, because its lifespan is reduced due to storage deterioration. When a battery is often charged and discharged, battery lifespan is also reduced due to cycle deterioration. They introduced a Dual Mode battery that provides runtime mode and lifespan mode for laptop PCs to balance the battery runtime and lifespan. They charged it by a higher charging voltage in runtime mode to get the longer battery runtime. They charged it by a lower charging voltage in lifespan mode to get the longer battery lifespan. Also, they discussed the automatic mode that switches between runtime mode and lifespan mode by monitoring battery usage, and proposed the algorithm to get both the long battery runtime and the longer battery lifespan[14].

Fratta et.al presented a novel DC-AC conversion strategy with outstanding performances in DC-supplied AC motor drives. Theoretical power system design analyses and wide experimental verifications that suggested the adoption of regulated H-bridge boost DC-DC converter stage and improved overall cost and efficiency of direct PWM VSI connection to variable voltage battery supply. They also investigated the modulation and control strategies which are suitable for the best exploitation of the power system capabilities [15].

1. PROBLEM FORMULATION

The battery consumption of the laptops is very high which limit the use of portable devices without main source of power. The major power consumption areas are: (1) CPU where processing is consumed most of the power. (2) Cooling the processor; power is consumed by the fans. (3) HDD where power is consumed in reading data.

and where we can reduce the power usage by updated design.

2.1 Heat generation due to power consumption and its cooling.

Figure 11 shows the block diagram of the thermal sensor

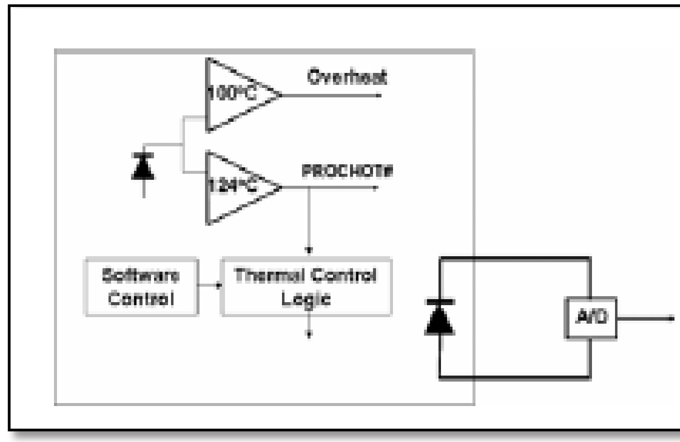

Figure 9: Block Diagram of Thermal Sensor

The processor can be heated up to 124 degree Celsius. In order to cool this temperature the thermal logic is formulated to cool down the CPU. We have used a heat which absorbs the heat and the fan which cools the heat sink as shown in Figure 12.

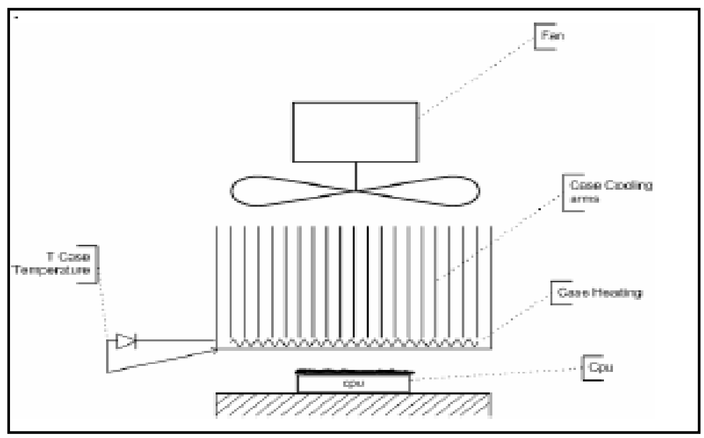

Figure 10: Architecture of Heat Sink of Processor

As the arrow depicts that the processor is cooled down by the heat sink and then the heat sink's heat is blown off by the fan. The basic idea of this description is that the laptop battery can be saved from the fan movement just by simply adding the electric circuitry and counting the revolution of fan in order to charge the battery of laptops.

3. PROPOSED SOLUTION

We have used two techniques in order to reduce the battery consumption of laptops:

a. Using the fan to recharge the battery

The circuitry in figure 11 is the symbolic diagram in order to charge the battery by using the fan revolution technology. When that occurs, the revolution in the fan generates some charges around it. That charges can be captured by electric circuitry while the battery is supplying charges to the various parts of laptops. so the battery becomes deficient of charges and those charges that are captured by the fan complete that deficiency. Let us examine a practical example in order to demonstrate our search. Typical 4 cell battery is supplying charges at the rate of 1000 electrons / sec. The battery serves the laptop for 2 hour and 30 minutes at this rate. This is the configuration that is defined when there is no charge collection form the processor fan. If the fan is revolving at the speed of 20 rev/ sec. Then the time required for 1 revolution is T=1/20. T=0.05 sec or 50 ms on this revolution rate the charges produced by the fan are 180 electrons /sec. So the number of electrons that are going to battery are 180 electrons /sec. The total number of electrons that the battery is supplying is 1000 electrons/sec. Here electrons per second becomes = 1000 electrons + 180 electrons = 1180 electrons. So, 1000 electrons are serving the laptop for 180 minutes (10800 sec). Total number of electrons in 10800 sec becomes = 10800 x $1000=10.8x10^6$ If 1180 electrons are to serve laptop for 10800 seconds then = 1180 x 10800 = $12.744x10^6$ so the battery time is increased by 5.6% which is approximately 16.8 minutes. The battery time is increased by 16.8 minutes by adding a circuitry of 1-2 oz.

2. Using Old Greek Theory to recharge the battery of Laptop

So far we have seen that the battery time is increased by 5.6 %. The second proposed method is the generation of static electricity. Then use the electricity dynamic to charge the battery of the Laptop. For this purpose, we have again utilize the fan of the processor, as every material have got some charges in it which are randomly distributed all over the body of that material [1]. We use an insulator to be attached to the back side of the laptop fan. When the fan is working, it is rotating the insulator material and touches it smoothly. Here we will use the first ever theory of electric charge generation proposed by old Greek the theory states "Whenever an insulator is rubbed with sum other material it will become charged these charges can be transferred to the other bodies to make them charges also"[2]. when the insulator is constantly rubbing with the fan of the laptop it becomes. Charged. Then this charge is transferred to the laptop battery by connecting that insulator with a conductor and making the farther end of the conductor highly positively charged. So the negative charge of the insulator will be attracted to the conductor and then it will move towards the battery hence fulfilling our need.

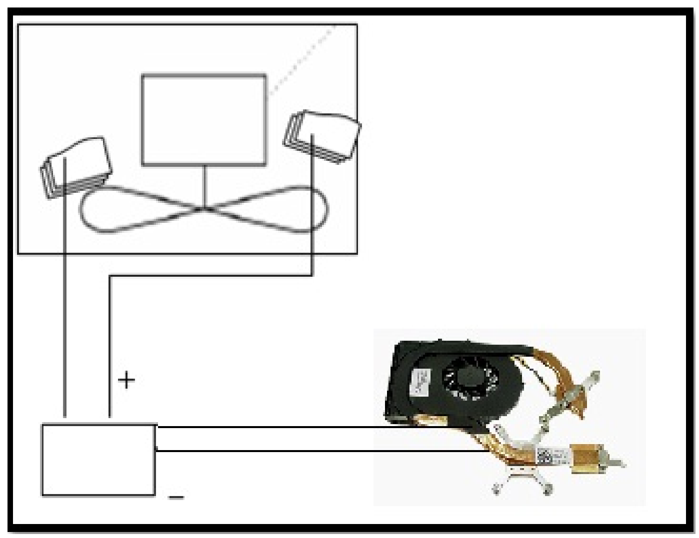

Figure 11: Fan Processor Architecture with Magnets

2. PROPOSED MATHEMATICAL MODEL

Previously the calculation shows an increase of 5.6% to the battery time. Now if the number of the charges generated by rubbing the surface is 100 electrons /sec. As from the previous discussion that charges supplied by the battery are 1000 electrons/sec and by our experiment we discovered that 180 electrons/sec are supplied by the fan revolution. When an insulator is connected to the fan the revolution of fan is reduced from 20 rev/sec to 18 rev/sec, so the charge is also reduced from 180 electrons/sec to 162 electrons/sec.

With this scenario the electrons supplied by the battery is 1000 electrons/sec. The number of electrons supplied to the battery are 162 electrons/sec + 100 electrons/sec that is total of 262 electrons/sec, So the total number of electrons from the battery is 1000 electrons/sec + 262 electrons/sec which yields to 1262 electrons/sec. If 1262 electrons are to serve laptop for 10800 seconds then 1262 x 10800 = 13.62×10^6.So by using this technique the battery time is increased by 8.97 %.

3. EXPERIMENTAL RESULTS

In the first part of our research, we have charged the Laptop battery by the processor's fan.

Table 5 shows the power management scheme designed by us which has increased the battery timings on normal processing. Time to drain a battery has shown in this table and its comparison with existing architecture.

CPU	Normal Usage	Our Research
Intl Core i3	3	3.2
Intel Core i5	3.5	3.7
Intel Core i7	2.9	3
Intel Core i7E	3.1	3.2
AMD 2 cores	4	4.3
AMD 4 cores	3.5	3.7
AMD 8 cores	3	3.1

Table 5: Major CPU's Power Usage Chart

From the above table we can generate a graph to compare the increase in time for battery backup of a laptop after applying our modified technique with normal processing needs and find the difference between both the techniques as shown in Figure 9.

Its always considered the best one to be used if having no side effects or in other words without effecting the performance in other areas.

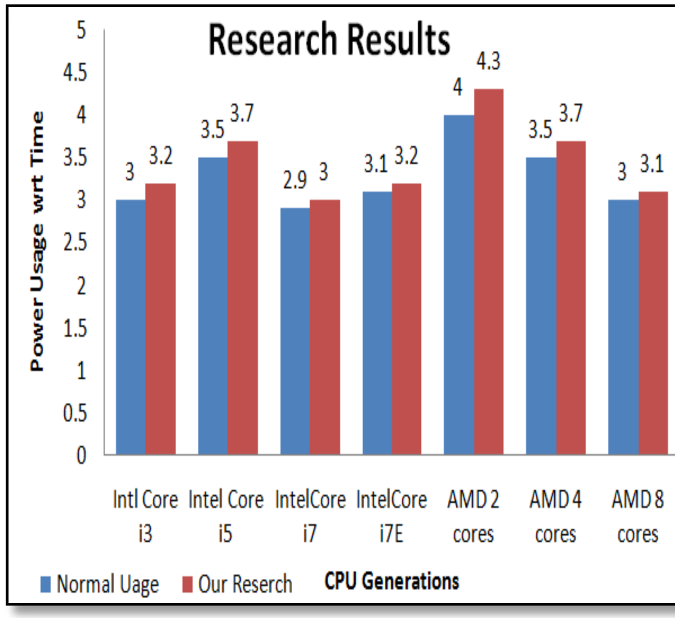

Figure 14: Effects on battery Life of Mobile Computing

Figure 15 shows the battery backup increased time after using our novel technique.

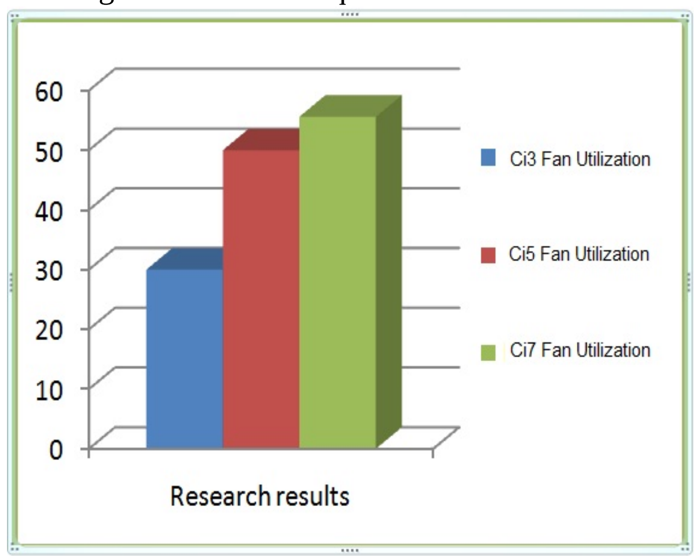

Figure 15: Our Research Work

4. CONCLUSION

Our research concluded with the following results:

i. Using the proposed architecture the battery time will increase from 5% to 7 % by utilizing the laptop processor's cooling fan.

ii. Applying the second scenario in this paper, increases the generation of static electricity and then its conversion to dynamic electricity. In result, will be recharging the laptop battery from 3% to 4% .Hence the total battery charge is up to 8% to 11% .

iii. This is ultimately support for green technology for optimal use of energy.

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