EDPAC : EVENT-DRIVEN POWER AWARE PERVASIVE COMPUTING FOR EFFECTIVE POWER UTILIZATION IN GREEN COMPUTING

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ABSTRACT

Nature with its mystique powers have always cared for survival of human beings by providing all means of resources for acquiring energy. Now comes the turn of humans to show our gratitude by conserving the energy by adopting techniques for better energy utilization. Green computing is the universal term used for environment-friendly computing. It utilizes the computing resources in the most efficient way without causing harm to our habitat. Green computing goals include reducing the use of hazardous materials, maximizing energy efficiency during the product's lifetime, and promoting recyclability or biodegradability of defunct products and factory waste. The main purpose of this paper is to integrate the advanced wireless communication strategies and smart hardware into our real life for the implementation of green computing. This paper discusses the role of pervasive computing towards achieving green computing by introducing pervasiveness in utilizing computing systems much efficiently in support with environmental well being. And also the paper tries to explore the concept of power aware computing and its implementation using event driven pervasive computing with the support of a handheld device such as a smart phone.

KEYWORDS

Green computing, Event driven computing, Pervasive computing, Power awareness.

1. INTRODUCTION

Computing and computing devices have evolved to be a primary necessity of our day-to-day life. With the advent of advanced gadgets from laptops to smart phones and communication facilities from LANs to portable internet packages, modern technologies have helped us to make computing much easily accessible and simple. The increased number of advanced computing devices adds to utilization of large amount of power around the globe. The large volume of heat thus dissipated add to the global warming in addition to e-waste getting accumulated everywhere.

Researches towards environment-friendly computing methodologies have been going on for about a decade now. Green computing, also known as green IT, aims at developing efficient computing techniques which utilizes energy efficiently, without creating hazardous issues for the environment, and also promotes recycling and reuse of components used to develop such

DOI : 10.5121/ijait.2012. 2105

computing devices. In this paper we discuss the concept of pervasive computing and try to reduce the power wastage in green computing by the maximum awareness of power.

The rest of this paper is organized as follows. The need and rise of green computing is explained in section 2. Section 3 gives a brief introduction to green computing. The current status and issues of present scenario is described in section 4. Section 5 describes the impact of event driven computing on green computing. Section 6 and 7 gives the key features of the new approach. Future enhancement is given in section 8 and a conclusion is given in section 9.

2. NEED AND RISE OF GREENNESS IN COMPUTING

Computing requirements were always considered to be consisting of enough processing power, data storage resources and computing speed. A significant turn of events took place with the rise in concerns about the safety of our environment around the beginning of the millennium. Issues related to global warming, rising energy costs, e-waste accumulation, carbon emission and the like paved the way towards adopting methods for integrating greenness in computing. Endeavors to convert digital world into an eco-friendly habitat are being adopted by the top commercial manufacturers of computing devices.

Several rules and restrictions came into being to ensure the greenness of computing and communication equipments around the globe. Degradable hardware components constructed with carbon free materials replaced the hazardous complex equipments used beforehand. A prominent example is the replacement of polybrominated diphenyl which was used in the construction of computer and laptop cabinets according to the European Union's Restriction of Hazardous Substances directive.

Nokia also introduced a "Go Green" campaign by collecting used mobiles phones, chargers and batteries for a price and recycling them, motivating other green movements around the world. Also, the Electronic Product Environmental Assessment Tool (EPEAT) ensures the purchase of greener products. To measure a product's recyclability with this tool a total of 51 criteria is considered in which 23 are required and the other 28 are optional.

3. GREEN COMPUTING TECHNIQUES : GRATITUDE TO NATURE

Green computing is eco-friendly computing done in support with environmental well-being. It plays an important role in reducing power consumption by the whole lot of computers being used around the globe and improving the energy efficiency during their lifetime [6]. It also replaces the hazardous materials being used in the manufacturing of advanced computing devices with biodegradable and recycled materials to reduce e-waste.

Green computing techniques can be mainly classified into hardware and software areas. Innovative techniques for ensuring greener computing by utilizing components belonging to both these areas of computing are being developed by researchers and scientists. These methods should be able to deal with excess power consumption, heat emission, carbon generation and improper utilization of resources available. They can also increase the deployable life of our devices. The green hardware environment is given in the figure1.

The main phases in the development and usage of hardware components are known as the four D's. These are design, development, deployment and disposal. In the design, the materials to be selected should be having more power efficiency and less carbon emission. Second is the

development phase. In this actual development of the design takes place with the power efficient components. Deployment is where we utilize the computing systems developed. The utilization must be made efficient by adopting methods to prevent extra power usage and heat dissipation. Idle time power leakage should also be prevented. The last phase is the disposal phase. Here the non degradable materials should be properly recycled and reused by the use of proper disposal measures.

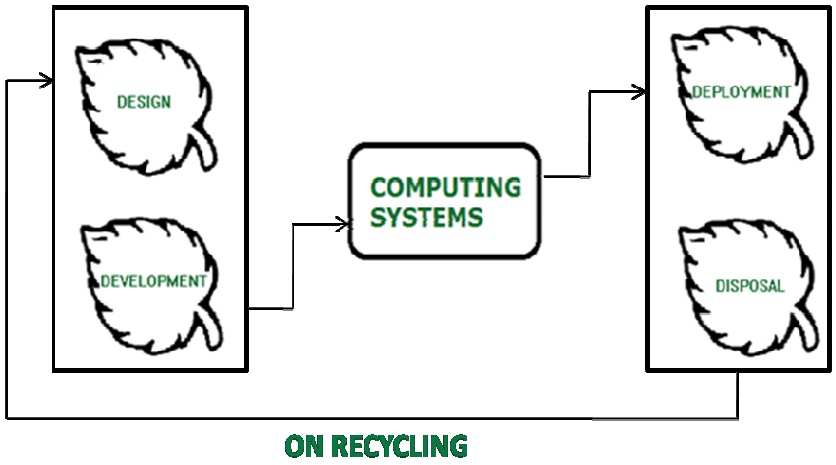

Figure 1.

The figure shows the 4 Ds in the green computing environment

Green software components can be utilized mainly to reduce idle time power leakage. This is illustrated with describing the following scenario. Suppose we are working on a computing system. We left it for a while for some other work. All this time power is wasted for the idle time of the system. Of course screensavers can save almost 5% of the power wasted. Also hibernation of the system into sleep state, which is enabled in most of the systems nowadays, can save another 10%. But still the external peripherals connected to the system draws power even in this sleep state. This eliminates the 15% we saved. So it is better to use control plugs for external peripherals to avoid this idle time power leakage. The various power usages in computing devices are shown in the figure 2.

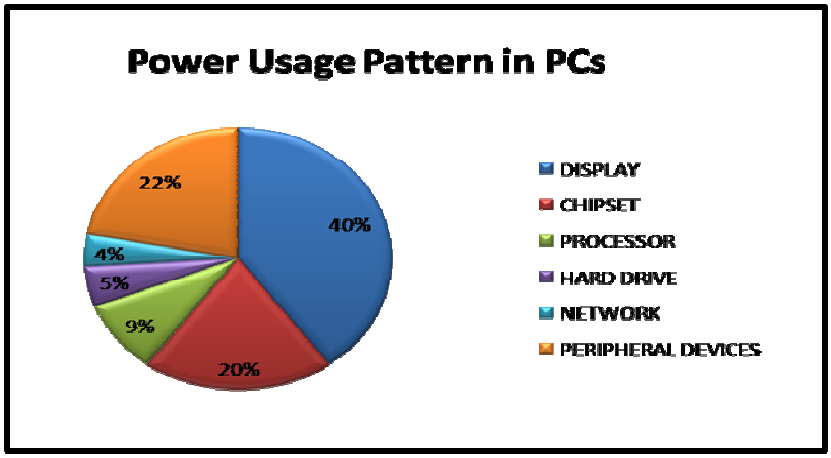

Figure. 2. The figure shows the usage of power in various components

Another method to reduce power usage is virtualization. Here multiple applications can be executed in the same system simultaneously. This enables sharing of processing power. By sharing memory and storage using cloud we can reduce number of storage cells and computing time as well. Sharing of display devices during execution can also reduce the power usage. Display unit can be allotted on the basis of order of completion of execution. This reduces the total power usage as well as the total heat dissipation.

4. BOTTLENECKS OF POWER AWARENESS IN GREEN COMPUTING

Adapting green technologies for conversion into green systems is not an easy process for today's computing systems. Several researches have been going on from the beginning of this millennium to enable green technologies. Scientists from all over the world have been working on eco-friendly projects to implement green computing environments to replace the existing systems. But most of them on implementation could not keep up to the performance improvements towards green computing as they claimed.

Major challenge faced by the researchers in green computing is efficient utilization of power. Most of the power consumed by the computing systems gets converted into heat energy while executing computing processes. This heat energy, generated in large volumes in the long run, could deteriorate the performance of the system and also affect the environment adversely. The computing systems must be able to do computing tasks in balance with the power required for the execution of those tasks. Idle time power leakage is another major issue in computing environment.

Control measures such as hibernation and screensavers are used nowadays. One solution proposed by researchers is event driven pervasive computing. In this once the important events occur, users will be informed at the earliest. So the user can control the usage of unnecessary power. Even if these measures are implemented, still it is difficult to manage the consumption of unnecessary power completely.

Other issues in the green computing are e-waste disposal, heat dissipation and carbon emission. Rather than disposing e-waste by dumping them, we need an efficient mechanism to recycle and reuse it. Excess heat generated by the systems raise the temperature in the environment Measures to cool or remove the excess heat emission should be sought for and implemented. The harmful particles, like carbon, lead and so on, being emitted from these systems adds to the global warming issue of the environment. The above mentioned issues have been the motivation of developing the new approach to improve the power aware computing.

5. PERVASIVE AND POWER AWARE COMPUTING CONCEPTS

Pervasive computing aims at making our lives much simpler by using advanced tools to manage information by integrating communication technologies in our daily life [4]. Event driven computing has its roots from event driven programming and pervasive computing. It is typically based on Event-Condition-Action (ECA) policy.

As shown in figure 3, events are anything which happens in the system which can trigger Actions in the behaviour of the system to adapt to the new situation. Conditions are constraints or rules according to which these actions take place and these can be preset. These events and actions can be monitored through our handheld device which gets us alerted if ECA occurs. Also we can send

commands through various message services in case of unexpected events or to reset actions for particular events.

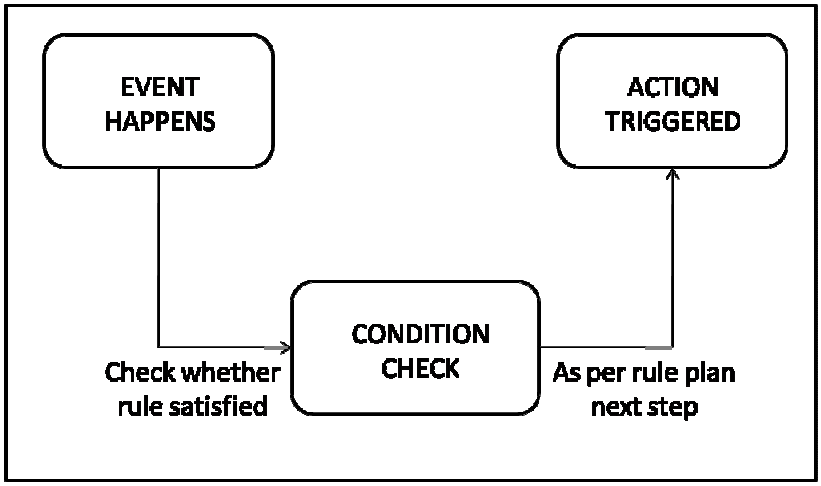

Figure 3. The figure shows the ECA policy, the basic principle used in Event-driven computing

Power aware computing (PAC) includes techniques to distribute power required by processes among themselves before the commencement of execution. But these techniques need constant supervision since each computing processes might be unique with unique power utilization and processing. Also with any small diversion in the execution routine due to some emergency events or happenings the power requirement may change. Figure 4 shows steps in PAC.

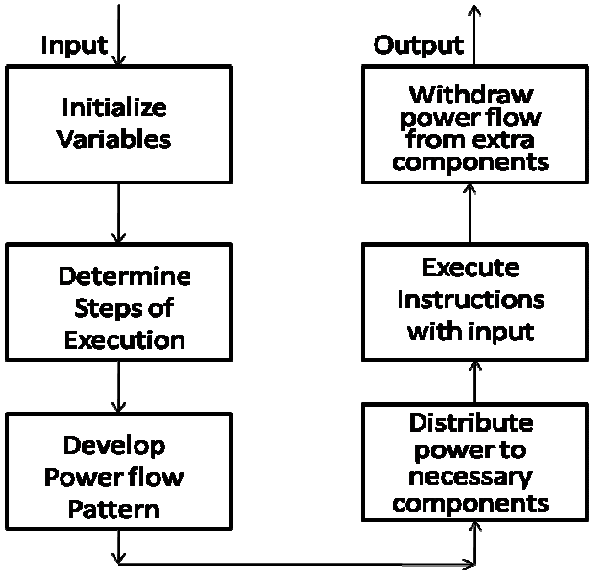

Figure 4. The figure shows the major steps in performing Power Aware Computing

This is where pervasive computing techniques to handle events could do its magic by keeping an eye on processing all the time. Introducing this concept into green computing gives rise to a new concept by merging power awareness with event driven computing. This can take care of any emergency power requirement or diverting situations. So finally the users get the control of power distribution and usage in their own computing systems.

6. DEVELOPMENT OF A NEW METHOD EDPAC

Power awareness computing aims at efficient management of power usage by introducing some constraints to control the power utilized for executing computing processes. This includes techniques like hibernation during idle time, control of the power flowing into the system for each execution processes, cutting off power from inactive components of the systems during computing and so on. Even if these measures are implemented, still it is difficult to monitor the consumption of power completely and continuously for each processing activity.

Applying Event Driven Computing in Power Awareness gives rise to Event Driven Power Aware Computing (EDPAC). Here we merge the properties of power aware computing with event driven computing. This gives us continuous control over power flow to computing procedures without interruption. Merging the pervasiveness of event driven computing in power aware computing can increase its efficiency for achieving greenness in its computing procedures by almost 15 percentages. Figure 5 illustrates functioning of EDPAC enabled computer.

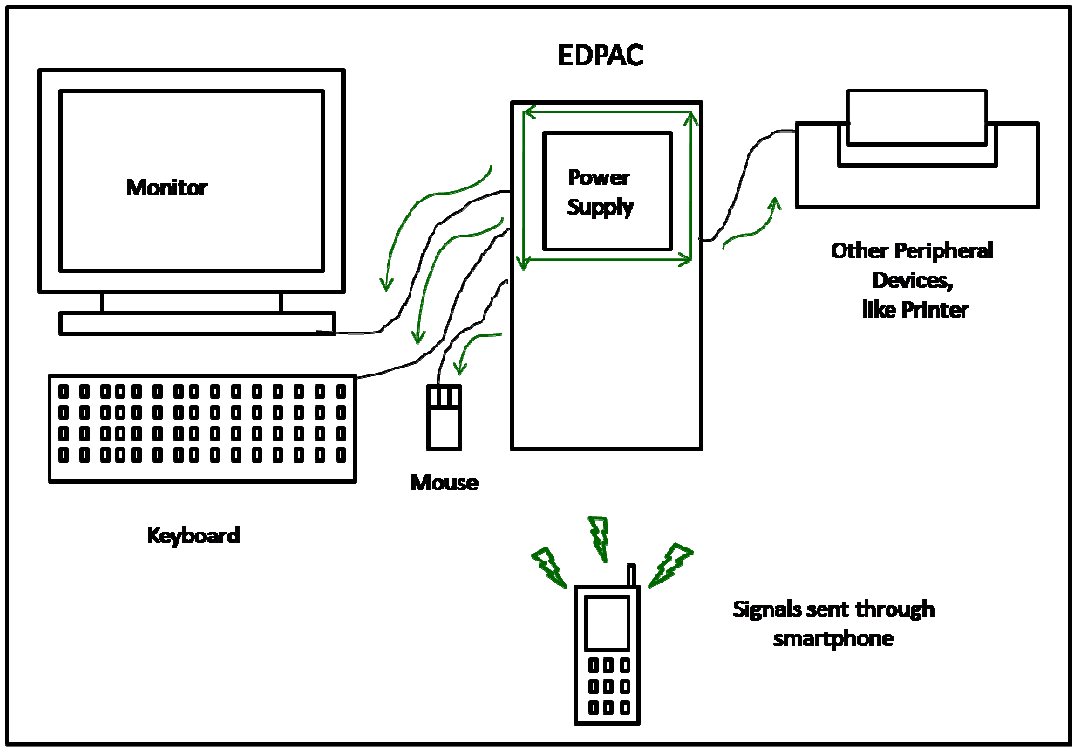

Figure 5. The figure shows the functioning of Event Driven Power Aware Computing

It gives us the power to manipulate the processing and regulate power flow in our system from any part of the world at any time. Also, any emergency situations, like short circuits or power

failure during execution of some significant operations, can be handled effectively with the implementation of EDPAC. Avoiding power loss could be the top priority while implementing this system. The programming could also be done to regulate power flow even through the subcomponents of devices like circuits.

7. PROMINENT FEATURES OF EDPAC

Event Driven Power Aware Computing (EDPAC) gives the maximum control of power usage in pervasive computing. The new approach enables constant continuous monitoring over our computing system processing from anywhere anytime. With EDPAC we can divert the power usage in right direction. Apart from the normal power control, our system is enriched with the following features.

7.1. Power flow regulation

EDPAC gives us the control to regulate the flow of power through different components in computing systems. If only some components are active during a particular computing procedure, power flow through the system can be restricted to these components.

7.2. Efficient power utilization

Power consumed by the whole system can be efficiently utilized by implementing EDPAC, which ensures adequate power supply for computing procedures. Hence it improves the performance and thus enables faster yet green computing.

7.3. Reduction in power conception and leakage

By monitoring the total consumption and usage pattern of power for a system we can identify the leakage percentage in power during active and idle time. Thus we can prevent leakage of power through peripheral devices by issuing commands through message services enabled by pervasiveness in our handheld devices.

7.4. Continuous power monitoring

With the help of continuous monitoring, we can keep track of power aware events happening and the necessary actions performed in the system. If we need any changes, in the current scenario, to the actions preset with constraint matching, we can issue commands through our handheld device accordingly.

7.5. Power allocation to computing procedures

We can regulate the power allocated to different computing procedures as per the demands of the scenario. For instance, if the procedure to be executed is not an urgent or complex one we can issue commands accordingly to perform them with medium power in a moderate pace.

7.6. Emergency power control

For emergency situations, EDPAC empowers us to create and perform new power regulation constraints and actions through message services as soon as the events are triggered. This gives us the power to take control of any worst case situations affecting power utilization.

7.7. Saves total global power

EDPAC saves the total global power by reducing leakage and wastage. This can eventually reduce the ever-rising energy cost due to the availability of abundant power thus saved. Hospitals and industries may even be provided with required power free of cost. Energy efficiency can thus be achieved within a short period of time.

7.8. Independent of architectures

EDPAC functioning is independent of architectures. Since the program execution is controlled and monitored by our smartphone, programming done is portable between architectures. So it is adaptable to dynamic situations and advanced programming technologies to be integrated in the future.

World has redefined the concept of primary necessities of life with the new list, which includes food, clothes, shelter, education and electricity, around the beginning of this millennium. As fossil fuels will be almost completely consumed in the recent future, we need to develop methods to save electrical energy. EDPAC is thus a novel idea which saves our future primary fuel for all machineries and computing devices. Figure 6 shows the comparison of existing system of power aware computing and our proposed system Event Driven Power Aware Computing.

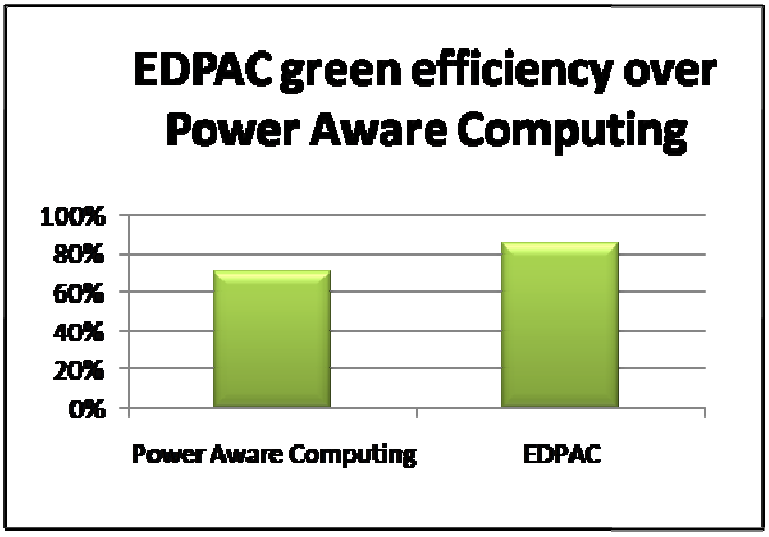

Figure 6. The figure shows the comparison of efficiency in achieving Green computing between EDPAC and PAC

8. FUTURE ENHANCEMENTS

In future, EDPAC can be extended to control over heat dissipation issues in green computing. Since the primary reason for heat dissipation is inefficient power utilization, implementing EDPAC can reduce much of the impact of the issue. This will aid the users to get aware of the situation and use the computing system in an efficient and eco-friendly manner. Development of

advanced ubiquitous devices can still improve the power utilization since these devices would be able to perform actions with sensor-actuator interactions and without continuous monitoring. Also research on new green materials suitable for hardware for computing requires much attention.

9. CONCLUSION

As in the old English saying, "to realize the value of water when the well is dry", we'll only realize the value of energy we are wasting when we'll be craving for a good source of energy after everything is destroyed. Therefore advancements in research and development of green computing techniques should be the top priority of people around the globe. In this paper we have listed the advantages of pervasive computing and its role in green computing. With the awareness of this we have developed a power aware computing system EDPAC, which will lead to extended event driven approach in green computing thus creating an environment of power awareness. It also deals with emergency situations like power failures, thus ensuring power conservation throughout the execution of computing processes.

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