

# Energy Aware Dynamic Slack Allocation for Multiprocessor System

Nuzhat Fathima<sup>1</sup>, P.Ramesh<sup>2</sup>, Dr.A.L.Vallikannu<sup>2</sup>

P.G. Student, Department of Electronics and Communication Engineering, Hindustan University, Padur,  
Chennai, India<sup>1</sup>

Associate Professor, Department of Electronics and Communication Engineering, Hindustan University, Padur,  
Chennai, India<sup>2</sup>

Associate Professor, Department of Electronics and Communication Engineering, Hindustan University, Padur,  
Chennai, India<sup>2</sup>

**ABSTRACT:** In the growth of technology embedded system is an advantage in order to reduce the area, operations of the system. Processor is an important computing element in battery operated system as it accepts the workload and consumes higher energy and powers to be maintained and Energy Consumption is greater issue as the performance has to be maintained and the life and energy of a battery needs to be improved. Rate Monotonic Scheduling(RMS), Earliest deadline First Scheduling(EDF), Dynamic Voltage Scaling(DVS) and dynamic slack reclamation(DSR) are few techniques used for reducing the usage of energy in the device during the uniprocessor systems. The slack produced is reclaimed by the algorithms being designed. Due to the growing technological demands for a faster and efficient multiprocessor systems are used but the problem remains the same. In this paper, the issue is being considered and an hypothetical evaluation of the scheduling algorithm is being presented. Dynamic Frequency Scaling(DFS), Pfair (Proportionate fair) scheduling and  $PD^2$  is being considered and the comparison between the algorithms being presented for the energy efficient system. The task are being allocated using the mechanism called Auctioning Mechanism. This evaluation was conducted on a homogeneous platform by considering three ARM7TDMI Processors. The softwares being used are SIMSO, MATLAB, FREE RTOS, RTLinux. In this study each algorithms prove's as a reliable choice for some subset of workload categories considered.

**KEYWORDS:** EDF, RM, DVS, DSR, DFS, Pfair,  $PD^2$ , WCET.

## I. INTRODUCTION

Due to tremendous change in technology and the system's performance benefits are raised concerns related to power density and energy consumption. Due to increase in power density its become efficient to yield the energy in not only battery operated equipments but also to the computers which are connected to power grids. As the demand increases the usage of energy in the systems is expected to increase required to manage energy in both hardware and software. Hence this becomes the major concern when the multiprocessor system is being considered. The uniprocessor has a single cpu and lots of research have being done. But comparatively for the multiprocessor system there is less reseach and algorithms being developed. In the multiprocessor system more cpu's are integrated into a board. It is intended for the processor to execute program instruction while the other processor simultaneously execute a different program instruction and hence the process of computation is speeded up. The multiprocessor scheduling system are those processors in which the systems correctness not only depends response of computaion but also at the time of output. The processor consumes large amount power and energy during the task execution. There are Two types tasks: Periodic task: it allows the similar sets of jobs that has a strict periodic interval. Aperiodic task: the task donot have a periodic parameter system designers have no prior information about the time instants at which jobs are released. Hence the

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

scheduling algorithm are used to determine which active jobs of real time application task and the execution is done on the processor platform at every instant of time. The uniprocessor scheduling uses the Rate monotonic scheduling (RM), Earliest deadline first (EDF) and Least laxity first scheduling (LLF) for the reduction of energy and power used by the processor. The task has been provided with the worst case execution time (WCET) due to this the task assigned need to complete its job within this if its been completed before then the remaining time left is called slack. Due to the slack produced the processor would be running but no job would be done hence the processor would consume energy and power. To avoid the slack problem algorithms like Dynamic voltage scaling (DVS), dynamic slack reclamation (DSR) and dynamic frequency scaling (DFS) algorithms are utilized for uniprocessor. Hence the slack is being reduced in the multiprocessor system when the task has been assigned dynamically i.e during runtime as partitioned and global scheduling. In this paper we have Partitioned scheduling algorithm is being considered. In this algorithm the taskset is being partitioned into task such as one for each processor in the multiprocessor platform. Task are executed on the processor its being assigned. Hence the lucky scheduling is being used where tasks are being given a token allocated time whenever the slack occurs the tasks are reallocated to other processors if required. The multiprocessor scheduling uses dynamic frequency scheduling algorithm (DFS), Pfair (proportionate fair) and  $PD^2$  scheduling algorithm with the allocation of slack dynamically and without slack dynamically the energy is being calculated and a comparison is being given. These algorithm are imported on the arm7tdmi processor, as its a multiprocessor system hence three arm7tdmi processor have been used. The homogeneous processor are used.

## II. RELATED WORK

There are many software and hardware models being designed to reduce the energy usage of a system by shutting down the computer, sleep mode activation or low energy and power circuits, but the dynamic power consumption is dominating the Cmos technology by utilizing the clock frequency and voltages. We can vary the frequency or the voltage by compromising on the other factors such as speed, performance etc.

For the Uniprocessor system Weiser et al. first discussed the problem of scheduling tasks to reduce the energy usage of processors [3]. Yao et al. described an off-line scheduling algorithm for independent tasks running with variable speed, assuming worst-case execution time

Weixun Wang et al. discovered the dynamic voltages scaling method along with the reclaiming slack dynamically methods were used to reduced the usage of power and obtain an energy efficient system. Dynamic voltage scaling is a power management technique in computer architecture, where they vary the voltage in order to stretch the execution of task so that it meets the deadline. To increase voltage method used is known as overvolting and to decrease voltage method used is known as undervolting. The slack is being changed dynamically when the task execution is completed before deadline is being examined. This algorithm can be executed during runtime and flexible configuration is done to make tradeoffs between running time and energy savings [4]. Dakia Zhu et al. describes the dynamic voltage/ speed configuration using the slack reclamation method. The power usage has become a problem as it reduces mission duration, increase heat dissipation and decreased reliability. There has been many techniques for uni-processor system where less amount of work done for the multiprocessor system. The scheduling techniques are used to reclaim unused time and the speed of execution is reduced of further tasks and reduces the overall energy used by the system. Its being assumed that it takes a few milliseconds to adjust processor supply voltage and speed the algorithms are used to stretch the task [4]. Vinicius Petrucci et al. describes Heterogeneous multi-core processors with greater performance and reduced usage of power being designed as an alternative design to improve energy efficiently over traditional homogeneous multi-cores. In this paper for the proportionality of shared task in processors are aimed and improve overall energy usage and performance. The task scheduling algorithm, lucky, is based on auctioning scheduling and is implemented using Linux. The auctioning mechanism provide better performance and energy savings over heterogeneous-aware scheduling technique [5]. Chen Tianzhou et al. describes the dynamic frequency scaling reduces the usage of power by reducing the processor frequency [6]. James Anderson et al. uses the proportionate mechanism where task are being divided in a fair manner by subdividing the task equally. [7].

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

## III. MODELS

In this section the application model as well the power, energy model used is being represented.

**Application Model:** We have considered a frame based application, i.e the application consists of tasks which have a common deadline. The model is realistic if each task schedule is assigned with some time to be executed. When the task completes the task before the allocated time the slack is formed and that is overcome by reclamation method or the task uses the allocation method to overcome the slack being produced. It's achieved with rtos that provide temporal protection such as rlinux.

**Energy and Power Model:** It's been assumed that the usage of power and energy is being dominated by the dynamic power consumption. This occurs due to the switching activities of the capacitor. The energy consumption is given by:  $E = C_L * V_{DD}^2$ . The power consumption is given by:  $P = E * f$ , where  $C_L$  is the switching capacitance,  $V_{DD}^2$  is the voltage applied and frequency (f). When processor speed is decreased the supply voltage is also reduced. This reduces the consumption of power and energy due to the reduction of speed linearly and increasing execution time of the task.

## IV. EXISTING SYSTEM

The existing system deals with the basic algorithm being used for reducing the energy consumption in the uniprocessor system as the energy has become the major concern for the battery operated system. In the RTS each task consists of a deadline within which the task needs to be executed. The two basic algorithms used are RMS and EDF. If the task job is being completed before time then idle time is created called SLACK because of this processor is active and consumes power and energy but no work is done. Hence the two methods are:

**Dynamic Voltage Scaling:** In this algorithm the voltage is being scaled i.e the clock cycles are being stretched resulting in the energy reduction but reducing the frequency of the processor.

**Dynamic Slack Reclamation:** In this algorithm the slack is being reclaimed by the next task which is allocated and the processor continues the processing.

Hence the dynamic slack reclamation method is used in the rms and edf algorithms as shown below:

### Rate Monotonic Scheduling:

RMS can be used to analytically determine if the given system will meet its deadline or not. The primary result of using rms is that with the shortest execution period be assigned the highest priorities with regards to how critical each task might be. RMS is used for estimation of processor utilization. This is a measure of how much of the processor's capability is being used and determines if a faster processor is needed. The term rms is derived by assigning priorities for a set of processes of their rates. The rate monotonic algorithm (RMA) is a procedure to fix priorities for tasks to maximize their "schedulability". If the tasks are completed within deadline and are executed without any error the tasks are being scheduled.

### Earliest Deadline First Scheduling

Earliest deadline first (EDF) dynamic scheduling algorithm used in real-time operating systems. Whenever a thread occurs the task with the shortest deadline is executed first. EDF is known as optimal scheduling algorithm which is used for uniprocessor scheduling.

### Dynamic Voltage Scaling

DVS is a scheduling mechanism where the voltage used can be changed based on the requirement. Once the task system is being allocated, when the task gets completed before time then slack is produced. To reduce the slack the task is being stretched till the deadline using voltage scaling.

### Dynamic Reclamation Method

Dynamic slack reclamation method is a slack scheduling method where the slack is claimed by the next task aligned and the next task is being executed.

# International Journal of Innovative Research in Science, Engineering and Technology

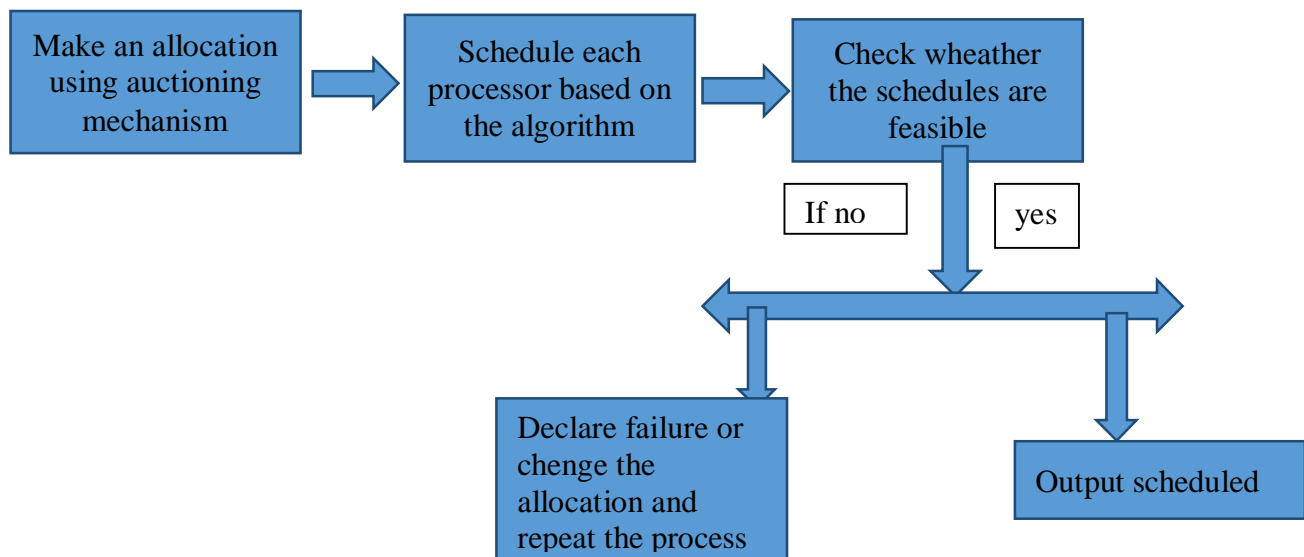
(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

## V. PROPOSED SYSTEM

Selecting appropriate scheduling activities is the important consideration to produce correct outputs as these system ensures the output to be executed at correct timeconstraint to save energy. An adaptive method to perform and comparison of DFS, Pfair and PD<sup>2</sup> for minimization and the consumption of energy in ARM7TDMI, the auctioning mechanism is being introduced for the allocation of tasks in the processors. The comparison of all the three algorithms consumption of energy in presence of slack and without slack is checked. The processor used are heterogeneous where 3 processors being used one remains the master and the others as the slave. The flowchart is as follows:



### Dynamic Frequency Scaling

DFS reduces the operating frequency of memory channel. Dynamic frequency scaling is commonly used in laptops and other mobile devices, where energy comes from a battery and thus is limited. It is also used to decrease energy and cooling costs for lightly loaded machines.

### Pfair Scheduling

Proportionately the task are being scheduled and fairly the energy is being distributed among the processor. Pfair scheduling for periodic tasks on multiple processors in a time slotted environment can not only guarantee task deadlines to be respected, but also make tasks execute at steady progressive rates.

### Pd<sup>2</sup> Scheduling

PD<sup>2</sup> algorithm is an ideal scheduling algorithm for Periodic scheduling. The swapping technique is used in this Algorithm, where the task are being swapped and allocated As per the requirement. For implementing the scheduler the hardware test beds are Being formed by the form of ARM CPU and the Performance is analysed using MATLAB as shown in Figure.6 below These algorithms have been tested using the Arm7tdmi processor and matlab in which the below result is obtained where the task time and periods are checked and the energy consumption is obtained through Arm7tdmi processor.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017



Figure.6. Analysis in MATLAB

## VI. EXPERIMENTAL RESULTS

The entire control system is based on the auctioning mechanism where the output for with slack and without slack is considered for all the three algorithms is DFS, Pfair, PD2 is compared and the analysis is done in the MATLAB software and the task is being sensed using the six temperature sensors and these are given to SIMSO simulator as inputs software and these parameters are used in Matlab.

The setup details are as follows:

### Dynamic Frequency Scaling

The task are periodic task and are being scheduled and detected using the simso software as shown in Figure.7. below

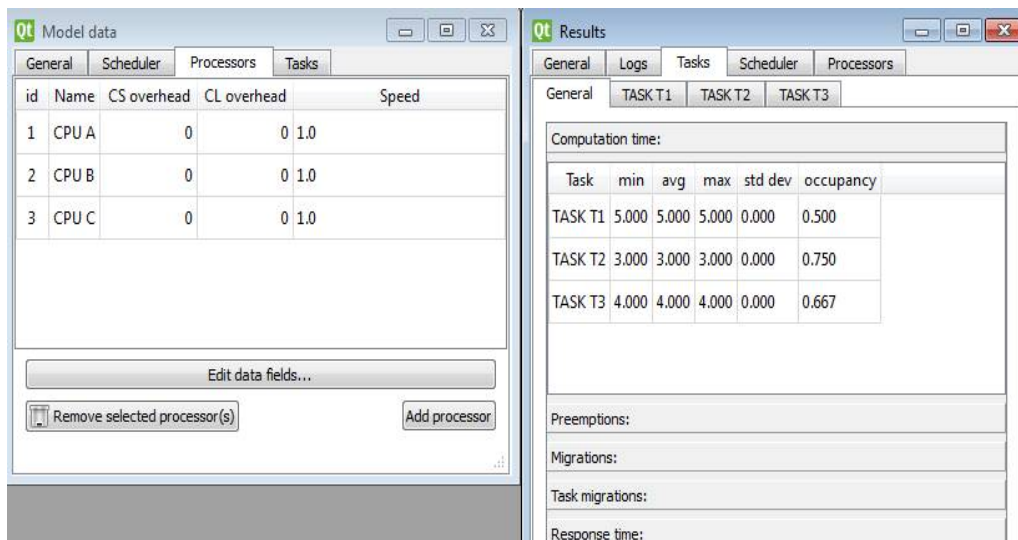


Figure.7. Task allocation using DFS algorithm.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

## Pfair Scheduling

The task are periodic task and the algorithm is checked using the software as shown in Figure.8 below

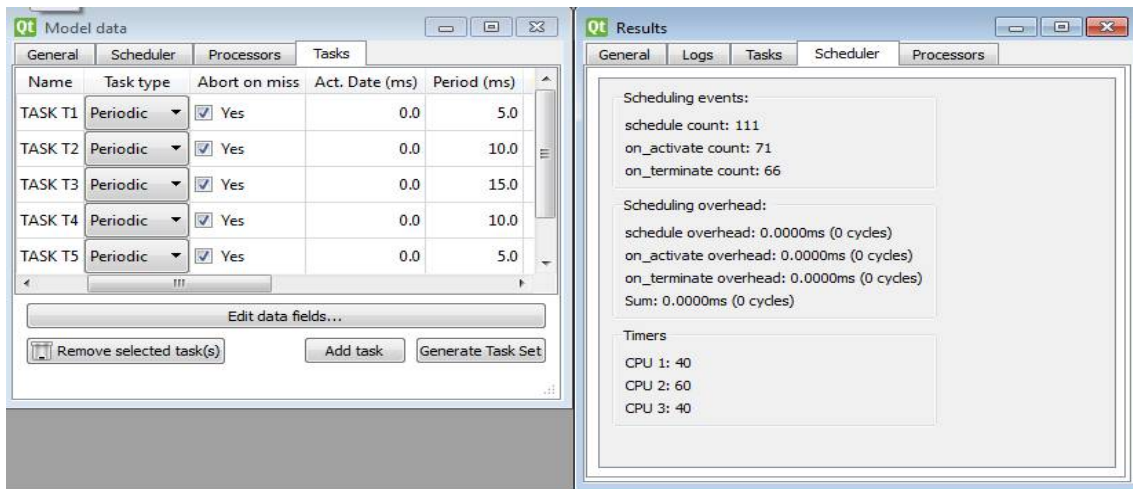


Figure.8.Task allocation using Pfair scheduling

## Pd<sup>2</sup> Scheduling

The task are periodic task and the algorithm is checked using the software as shown in Figure.9 below.

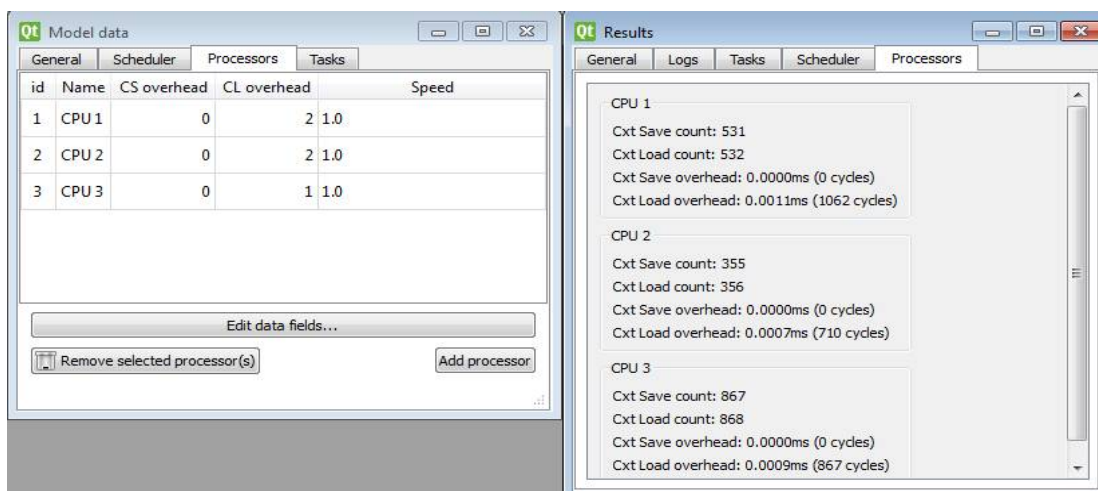


Figure.9.Task allocation using Pfair scheduling

The energy utilized when the DFS algorithm is as shown in Figure.10. The graph is based on energy consumed vs 24hours of time.



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

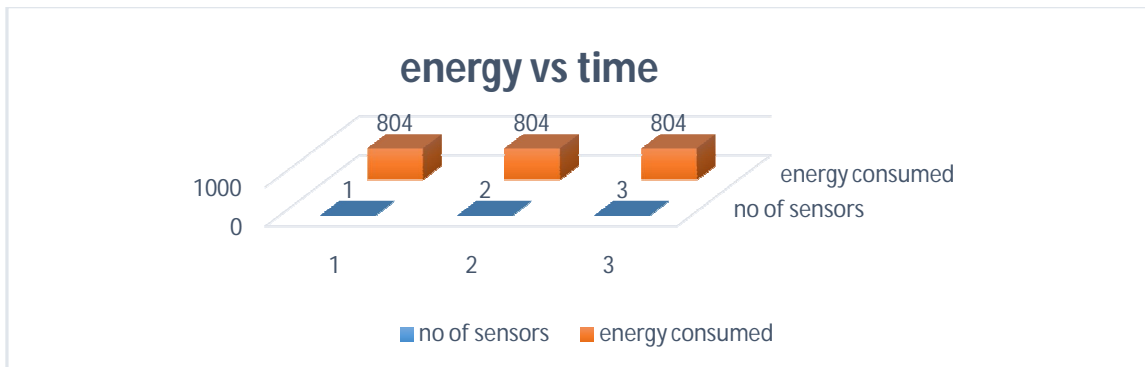


Figure.10.energy consumed vs numbet of sensors

The test beds formed are being tested on the homogenous processor i.e ARM7TDMI, 3 processors are used. Six temperature sensors have been used in order to take input and the energy consumption is calculated using the MATLAB as shown in Figure.11 according to the table shown below for both with slack and without slack. When the slack is not present the power consumption is different for each algorithm. when the slack is present the algorithms are being applied and the energy consumption is balanced as shown in graph below. The energy consumption is being reduced by 12% using these algorithm and applying the auctioning mechanism.

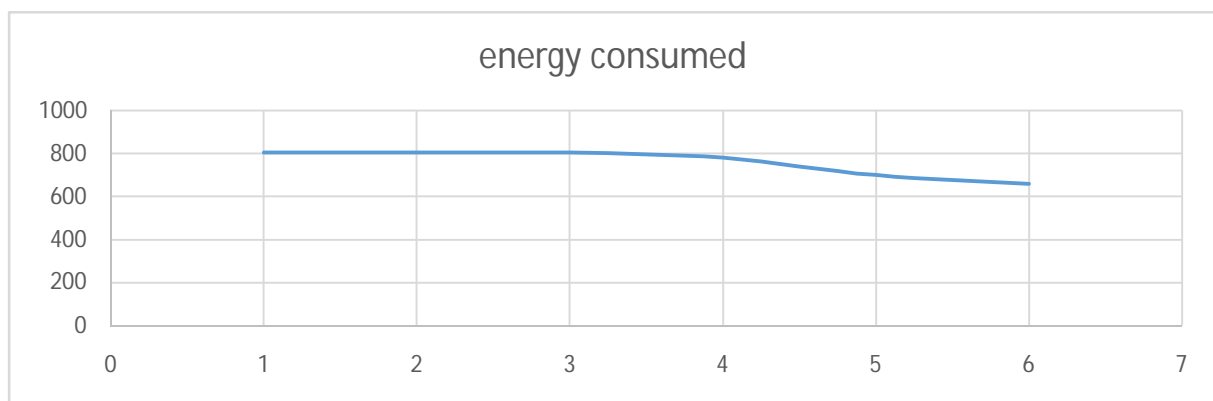


Figure.11.Energy Comsumption

## VII.CONCLUTION

As we infer from the above graphs and figure the algorithms have been tested individually for with slack and without slack on the homogeneous processor being used. when the auctioning mechanism is used the task is being allocated to the master processor and when it completes the execution and slack is produced then the next processor task is being allocated to the master processor and both the slave processor are in off position. Hence the energy consumption is reduced. The same algorithms can be applied to heterogeneous processor too and checked and verified.

## REFERENCES

- [1] Buttazzo G.C., "Rate Monotonic vs. EDF: Judgment Day", University of Pavia, Italy, 2003.
- [2] Viral Patel, Milin Patel, "Survey of different Task Scheduling Algorithm", 2014 IJEDR | Volume 2, Issue 1 | ISSN: 2321-9939.
- [3] Weixun Wang\*, Sanjay Ranka, Prabhat Mishra, "Energy-aware dynamic slack allocation for real-time multitasking systems", Sustainable Computing: Informatics and Systems (2012).
- [4] Weixun Wang, "Energy-Aware Scheduling And Dynamic Reconfiguration In Real-Time Embedded Systems", University Of Florida 2011

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

- [5] Vinicius Petrucci, Orlando Loques, Brazil Daniel Mosse” Lucky scheduling for energy-efficient heterogeneous multi-core systems”, University of Pittsburgh, USA, Universidade Federal Fluminense.
- [6] Chen Tianzhou, Huang Jiangwei, Zheng Zhenwei, Xiang Liangxiang,” A practical dynamic frequency scaling scheduling algorithm for general purpose embedded operating system”, International Journal of u- and e-Service, Science and Technology Vol. 2, No. 1, 2009.
- [7] James Anderson, Philip Holman, and Anand Srinivasan,” Fair Scheduling of Real-time Tasks on Multiprocessors”, Department of Computer Science, University of North Carolina.
- [8] Goh Lee Kee,” Design And Performance Evaluation Of Energy-Aware Dvs-Based Scheduling Strategies For Hard Real-Time Embedded Multiprocessor Systems”, National University Of Singapore 2012.
- [9] Nikhil Gupta,” Energy Efficient Scheduling For Real-Time Systems”, Texas A&M University, December 2011.
- [10] Gang Chen, Germany Kai Huang, Germany Alois Knoll,” Energy Optimization For Real-Time Multiprocessor System-on-Chip with Optimal DVFS and DPM Combination” Technical University Munich, ACM Transactions on Embedded Computing Systems, June 2013.
- [11] Björn Andersson,” Pfair scheduling scheduling”, Department of Computer Engineering, February 15, 2005, Göteborg, Sweden.
- [12] The Concise Handbook Of Real-Time Systems TimeSys Corporation Version 1.3.