International Journal of Advance Research in Science and Engineering
Vol. No.5, Special Issue No. (01), February 2016
www.ijarse.com
IJARSE
ISSN 2319 - 8354

AN EFFICIENT APPROACH FOR SCHEDULING IN GREEN DATA CENTERS

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ABSTRACT

This paper presents an optimum job scheduling for green datacenters so that the jobs are executed within time using a large extent of green energy only irrespective of the amount of execution time. This job scheduling minimizes the usage of cheap brown energy so effectively it minimizes the consumption of cost related energy sources .This paper discusses the inherent advantages of our proposed scheduling algorithm. Energy predictions of the job can be made by considerations on the nature of the job. Jobs can be processor intensive or memory operations also. Our algorithm works well under condition of right mix of processor intensive as well as memory intensive operations.

***Keywords:* Brown energy ,Data centers ,Green energy , Prediction, Scheduling.**

I. INTRODUCTION

Datacenters consume an enormous amount of energy: estimates for 2015 indicate that they consume around 1.8% of the total electricity used world-wide Electricity cost thus represents a significant burden for datacenter operators. Moreover, this electricity consumption contributes to climate change, since most of the electricity is produced by burning fossil fuels. A 2008 study estimated world-wide datacenters to emit 116 million metric tons of carbon, slightly more than the entire country of Nigeria . We refer to the energy produced by carbon-intensive means and distributed via the electrical grid as ‘‘brown energy’’.

These cost and environmental concerns have been prompting many ‘‘green’’ energy initiatives. One initiative is for datacenters to either generate their own renewable energy or draw power directly from a nearby renewable power plant. This approach is being implemented by many small and medium datacenters (partially or completely) powered by solar and/or wind energy all over the globe . Larger companies are also investing in this direction. For example, Apple is building a 40 MW solar array for its North Carolina datacenter. McGraw-Hill has recently completed a 14 MW solar array for its datacenter.

We expect that this trend will continue, as these technologies’ capital costs keep decreasing (e.g., the inflation-adjusted cost of solar panels has decreased by 10-fold in the last three decades) and governments continue to provide generous incentives for green power generation (e.g., federal and state incentives for solar power in the United States can reduce capital costs by up to 60%). In fact, the trend may actually accelerate if carbon taxes and/or cap-and-trade schemes spread from Europe and Asia to the rest of the world. For example, a cap-and-trade scheme in the UK imposes caps on the brown energy con-sumption of large consumers.

We argue that the ideal design for green datacenters connects them to both the solar/wind energy source and the electrical grid (as a backup). The major research chal-lenge with solar and wind energy is that, differently from brown energy drawn from the grid, it is not always available. For example, photovoltaic (PV) solar energy is only available during the day and the amount produced depends on the weather and the season. Datacenters sometimes can ‘‘bank’’ green energy in batteries or on the grid itself (called net metering) to mitigate this variability. However, both batteries and net metering have problems: (1) batteries involve energy losses due to internal resistance and self-discharge; (2) the cost of purchasing and maintaining batteries can dominate in a solar system; (3) today's most popular battery technology for datacenters (lead-acid) uses chemicals that are harmful to the environment; (4) net metering incurs energy losses due to the voltage transformation involved in feeding the green energy into the grid; (5) net metering is not available in many parts of the world; and (6) where net metering is available, the power company may pay less than the retail electricity price for the green energy.

In particular, we design a efficient scheduler for parallel batch jobs, , in a datacenter powered by an array of PV solar panels and the electrical grid. Jobs submitted to GreenSlot come with user-specified numbers of nodes, expected running times, and deadlines by which they shall have completed. The deadline information pro-vides the flexibility that GreenSlot needs to manage energy consumption aggressively.

GreenSlot seeks to maximize the green energy con-sumption (or equivalently to minimize the brown energy consumption) while meeting the jobs' deadlines. If brown energy must be used to avoid deadline violations, it schedules jobs for times when brown energy is cheap. In more detail, Green Slot combines solar energy prediction, energy-cost-awareness, and least slack time first (LSTF) job ordering]. It first predicts the amount of solar energy that will likely be available in the future, using his-torical data and weather forecasts. Based on its predictions and the information provided by users, it schedules the workload by creating resource reservations into the future. When a job's scheduled start time arrives, Green-Slot dispatches it for execution. Clearly, Green Slot differs significantly from most job schedulers, which seek to reduce completion times or bounded slowdown. Green datacenters and green-energy-aware scheduling can have a significant role in building a more sustainable information Technology ecosystem.

Solar energy and datacenters. Solar is a promising clean energy technology, as it does not cause the environmental disruption of hydroelectric energy and does not have the waste storage problem of nuclear energy. Wind energy is also promising, but is not as abundant in many locations. Except for our (solar) energy predictions, our work is directly applicable to wind energy as well.

Transforming solar energy into (direct-current or DC) electricity is commonly done using PV panels. The panels are made of cells containing PV materials, such as mono-crystalline and polycrystalline silicon. The photons of sunlight transfer energy to the electrons in the material. This energy causes the electrons to transfer between the two regions of the material, producing a current that is driven through the electrical load (e.g., a datacenter).There are multiple ways to connect solar panels to a datacenter. Fig. 1 shows an example. The AC Load is the server and cooling equipment, which typically runs on alternating-current (AC) electricity. The DC electricity is converted to AC using an inverter. Excess solar energy can be stored in batteries via a charge controller. The controller may also connect to the electrical grid, in case the datacenter must operate even when solar energy is not available. Where net metering is available, one can feed excess solar energy into the grid for a reduction in brown energy costs.

Brown energy prices: Datacenters often contract with their power companies to pay variable brown energy prices, i.e. different dollar amounts per kWh of consumed brown energy. The most common arrangement is for the datacenter to pay less for energy consumed during an off-peak period than during an on-peak period. Typically, off-peak prices are in effect during the night, whereas on-peak prices apply during the day. Thus, it would be profitable for the datacenter to schedule part of its workload (e.g., maintenance or analytics tasks, activities with loose deadlines) during the night

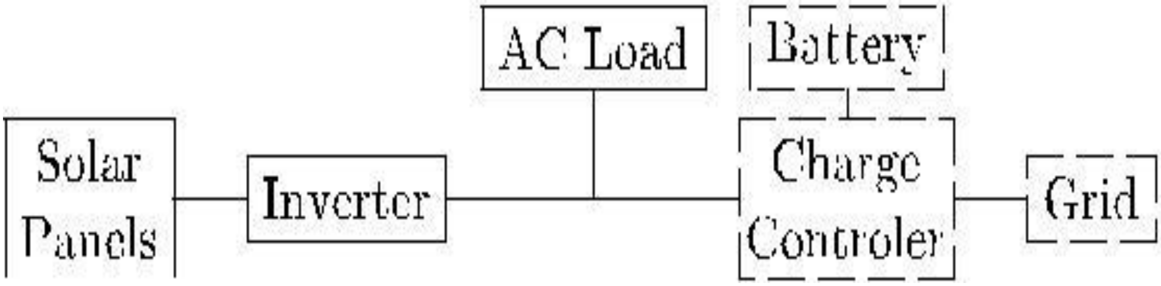

Fig. 1. Components of a solar-powered system. ***Dashed boxes represent optional components.***

II. EXISTING SCHEDULING MECHANISM

In existing scheduling mechanisms , parallel job scheduler including solar panels ,grids are used following a greedy scheduling algorithm. The concept is named as green slot scheduling which classifies jobs according to their energy needs. If the job needs zero energy its in category of green energy else if it needs few energy units for processing then its categorized under brown energy .Green Slot is cost-aware in that it favors scheduling jobs in time slots when energy is cheapest. To prioritize green energy over brown energy, green energy is assumed to have zero cost. In contrast, brown energy prices often depend on time of use, as aforementioned. When the price is not fixed and brown energy must be used, Green Slot favors the cheaper time slots. To avoid selecting slots that

may cause deadline violations, Green Slot assigns a high cost penalty to those slots. Any penalty that is large compared to the highest possible cost of a usable slot is appropriate. Green Slot is greedy in two ways:

(1) it schedules jobs that are closer to violating their deadlines first;

(2) once it determines the best slots for a job, this reservation does not change (unless it decides to prepare a new schedule during a later scheduling round). The next job in the queue can only be scheduled on the remaining free slots.

Moreover, Green Slot constrains its scheduling decisions based on workflow information, i.e. a job belonging to phase i of a workflow cannot begin before all jobs of phases < i have completed.

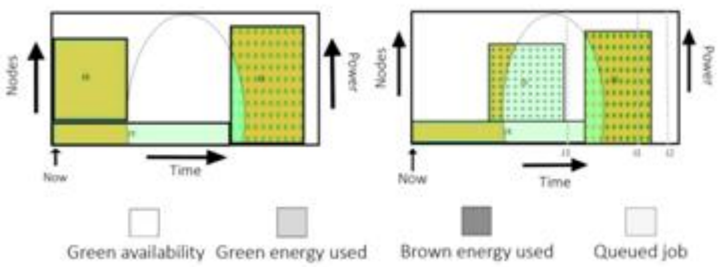

Fig 2 : Scheduling 3 jobs (J1–J3) with backfilling (left) and GreenSlot (right). The jobs' deadlines are the vertical lines.

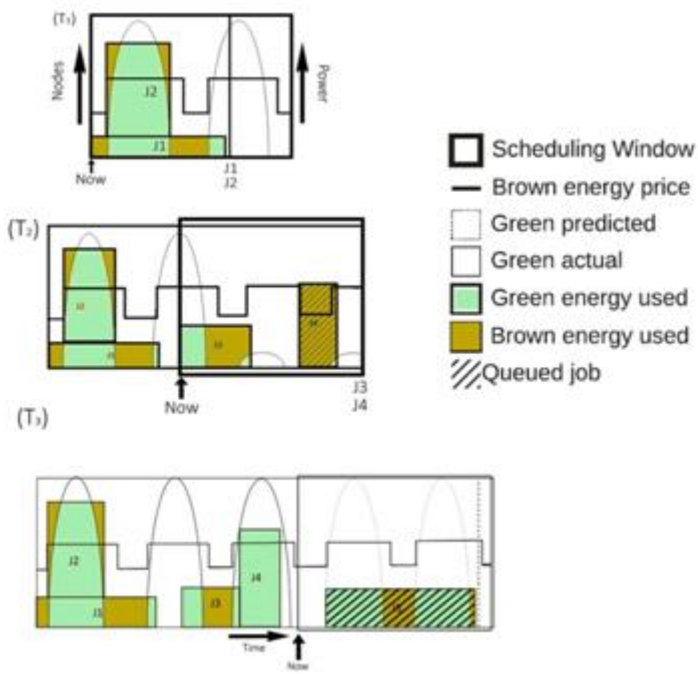

Fig 3: GreenSlot scheduling window at times T1 (top), T2 (middle), and T3 (bottom).

III. PROPOSED SCHEDULING ALGORITHM

1.Users indicate count of nodes, expected execution time ,deadline for each job at the start of each time slot.

2.Use the green energy predictions for jobs with highest execution time first ,followed by jobs with next highest green energy predictions.

3.No new jobs are to be included in the existing schedule until all jobs are executed.

4.If the job execution time is less but it consumes brown energy then its priority in scheduling is after scheduling all green energy consuming jobs.

5.Hence,we develop a optimum schedule with jobs of green energy predictions followed by jobs with brown energy predictions.

3.1 Illustrations

Consider jobs;J1,J2,J3,J4,J5,J6 with processing time T1,T2,T3,T4,T5,T6.Now,introduice the energy prediction for each job say, job{J1,J3,J5} consume green energy when compared to jobs{J2,J4,J6} which consume brown energy.

In our approach ,irrespective of processing time ,we schedule J1,J3,J5 prior to J2,J4,J6.

Internally; J1,J3,J5 can be scheduling depending on proceeds times. If $T_{J1} > T_{J3} > T_{J5}$ then scheduled order is {J1,J3,J5} then similarly; we may schedule J2,J4,J6 in case $T_{J2} > T_{J4} > T_{J6}$

Our prime concern is that jobs with green energy prediction should be processed so as to maximize the green energy consumption only. In case any of the jobs,J1,J3,J5 are unable to complete their execution then they proceed to consumption of cheap brown energy predictions.

IV. OUR ALGORITHM HAS FOLLOWING ADVANTAGES

1. We don't have any type of tolerance towards expected running times.
2. Our concern is the strict processing time of jobs and if a job is facing difficulties to run up to finish time ,it will be simply preempted and scheduler again after the next job is finished. By this mechanism the green energy will be saved significantly.
3. We don't use a greedy mechanism for scheduling the jobs in slots. Greedy approach introduces some degree of green energy wastage by using slots.
4. Our proposed algorithm does not reject any job & there is no danger of missing the deadlines of execution as all jobs irrespective of the execution time are given equal chanced for execution.
5. Our goal is maximum usage of green energy & allocating only few jobs to cheap brown energy enhances the applicability of our approach.

V. FUTURE WORK

Our algorithm generalizes the nature of jobs while scheduling them in predicted green energy sources. But in reality the nature of jobs may be different .The jobs which are green energy predicted may be sometimes processing intensive jobs so the rate of execution may be less. In future we plan to work on this aspect of intensive study in nature of the jobs .Deciding the priority of the jobs while any type of scheduling in green datacenters is challenging due to the fact that jobs maybe suspended due to various reasons. This suspension of jobs may introduce some slackness in scheduling the next job. In future , we plan to conduct intensive experiments on the effect of this slack time between scheduling jobs on the overall energy saving ability of our model.

VI. CONCLUSION

This paper proposes a novel scheduling mechanism to minimize the usage of brown energy by prioritizing jobs while scheduling for their execution based on their predicted green energy levels. We discuss the steps for carrying out job scheduling and due to the approach we obtain few advantages. Though there exists some challenges to our proposed scheduling mechanism extensive experimental setups are being considered actively so that the threats to the validity of this model are mitigated .This proposed algorithm can be applied in green data centers as a cost effective mechanism as compared to the green slot mechanism which is somewhat complex to maintain due to its greedy approach during job scheduling.

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