UDC 621.391

ENERGY EFFICIENCY AND PERFORMANCE IMPROVING IN DATA CENTER WITH PREDEFINED LOAD TYPES

Gvozdetska N.A., Globa L.S.
Institute of Telecommunications of National Technical University of Ukraine Igor Sikorsky KPI, Ukraine
E-mail: n.gvozdetska@gmail.com

ПІДВИЩЕННЯ ЕНЕРГОЕФЕКТИВНОСТІ ТА ПРОДУКТИВНОСТІ РОБОТИ ЦЕНТРУ ОБРОБКИ ДАНИХ З ПЕРЕДБАЧУВАНИМ НАВАНТАЖЕННЯМ

Запропоновано концепцію ефективного комбінування енергоефективного підходу до планування задач у серверному кластері центру обробки даних PCPB та стратегії пакування задач Backfill. Запропонована концепція дозволяє підвищити енергоефективність обробки даних, розподіляти задачі різної розрахункової складності на сервери із відповідними розрахунковими можливостями і при цьому використовувати апаратне забезпечення якомога ефективніше.

Digital connected world is a concept of our future. In digital world the amount of data that needs to be processed is growing every day. Meanwhile, the requirements for computing rates and quality of provided services are also increasing. To deal with these new challenges large-scale data centers are developed. However, with the growth of data centers' computing power, the amount of electric energy consumed by servers is also increasing.

The structural unit of a modern data center environment is a server cluster. Clusters of servers are used for many purposes, including high availability, load balancing, and increased computational power. Let's consider the server cluster to be the main object of the proposed concept implementation with opportunity of its scaling to the data center environment.

In [1, 2] PCPB (Power Consumption and Performance Balance) scheduling algorithm is described. Its main principle is to schedule the tasks within the server cluster considering individual power consumption functions $P = f(CPU)$, – where *CPU* (Central Processing Unit) is the load of central processor in percent – and performance of each cluster node. $P = f(CPU)$ function is defined experimentally and can vary from node to node. According to PCPB approach, each node should be preliminary attested. Within the process of preliminary attestation, the individual power consumption functions $P = f(CPU)$ of each node are defined. Within the following process of tasks scheduling, the expected total power consumption of the cluster is counted according to the $P = f(CPU)$ functions of each node (in case of current task in queue allocation to each node alternately). The nodes are further sorted by their contribution to the total power consumption and their performance as well. The nodes are marked according to gotten values and that node which has the best sum of marks for power consumption and performance is chosen to process the current task in scheduling queue. The PCPB algorithm allowed reaching up to 10% energy efficiency gain and up to 49% of performance gain in heterogenous cluster

consisting of 20 nodes.

However, the problem is that the cluster nodes using PCPB are not fully loaded by tasks – some resources are idle because of the fact that the next scheduled task is too big to be processed by corresponding node until it becomes free. It is possible to solve this problem using Backfill approach in addition to PCPB using.

According to [3], Backfill is a scheduling optimization strategy which allows a scheduler to make better use of available resources by running jobs out of order.

The input information for Backfill is:

1. the time moments, when the most priority job will be able to start;

2. the requirements for this job to be processed.

Backfill output – the jobs with lower priority, that can be started before, so they do not delay the highest priority job. For the moment when the most prioritized job is able to start the resources are anyway reserved for it. It means that only those jobs, that do not interfere with this reservation, can be started before.

In [4] a modification for Backfill algorithm is proposed. Authors consider, that traditional Backfill main disadvantage is that it schedules small jobs first, which causes fragmentation. The new proposed approach is called IBA (Improved Backfill Algorithm) and it uses BS (balanced spiral) strategy additionally. To improve Backfill algorithm authors of [4] propose to take into account the consistency of free resources volume and tasks volume (requirements), not only starting scheduling from the smallest one.

In our research it is proposed to combine Backfill algorithm and PCPB scheduling methods to schedule tasks with the highest energy efficiency and use hardware as efficient as possible.

Concept description:

Tasks, that come to the server cluster of N nodes with different physical characteristics. Tasks are organized in a queue. Each task is characterized by its computational complexity (the number of floating point operations) and its requirements for the processing system *Vreq* – the minimal volume of RAM that is needed for task processing, *kcore_req* – number of cores that are going to be reserved by the task, *tmax* – maximum time of task processing (the processing is terminated, if exceeded).

Stage I. Tasks classification and PCPB scheduling

1. According to the modified PCPB approach, tasks are classified into groups according to their computation complexity (two groups of “hard” tasks and “simple” tasks, as for the simplest example). The threshold defining problem is solved for each particular situation and based on statistics data.

2. For “hard” tasks the pool of the most energy efficient servers is allocated, the pool of the least energy efficient servers is allocated for “simple” tasks as well.

3. Tasks are distributed among the servers in each servers’ pool respectively using the PCPB scheduling approach. Thus, the tasks are scheduled to the most energy efficient nodes with the best performance first (Fig.1).

Stage II. Backfill using for better hardware utilization

4. In case there is no place in server pool for the next task in queue, the Backfill approach is used. Thus, the small tasks are extracted from the queue and “backfilled”

to the first server which has free resources for it.

The Backfill is used for group of energy efficient servers first. In case of the lack of resources in the pool of energy efficient servers, Backfill algorithm is used for the group of less efficient servers.

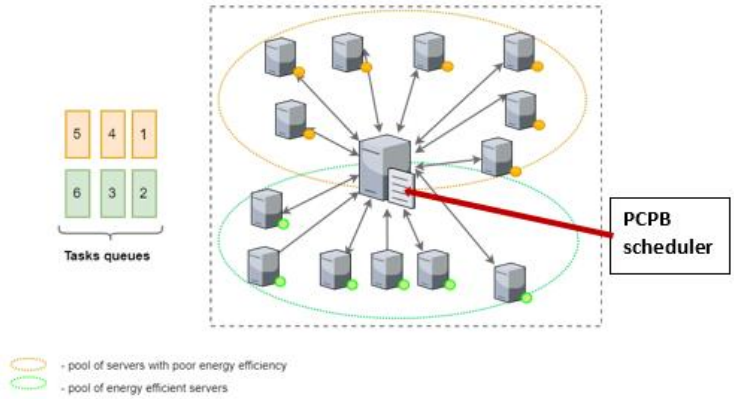

Fig. 1. PCPB scheduling according to the modified algorithm
(for two types of tasks and servers respectively)

Thus, the following goals are achieved:

- More energy efficient servers are fully loaded with the tasks – the hardware is used more efficiently;

- Servers with poor energy efficiency are loaded with those tasks that do not require high performance;

- The tasks processing performance is improved by packing tasks densely.

The proposed approach allows increasing tasks processing performance as well as energy efficiency in server cluster by using PCPB energy aware scheduling algorithm and Backfill strategy to improve hardware efficiency.

References

1. Gvozdetska N.A., Stepurin O.V., Globa L.S., “Experimental Analysis of PCPB Scheduling Algorithm” // CADSM 2017, 21-25 February, 2017, Polyana-Svalyava (Zakarpattya), UKRAINE.
2. Schill A., Globa L., Stepurin O., Gvozdetska N., Prokopets V., Power Consumption and Performance Balance (PCPB) scheduling algorithm for computer cluster // UkrMiCo 2017, Odesa, Ukraine, pp.1-8. Available online: http://ieeexplore.ieee.org/document/8095365/.
3. Suresh A., Vijayakarthick P., Improving scheduling of backfill algorithms using balanced spiral method for cloud metascheduler // Information Technology, Kalasalingam University Krishnankoil, Srivilliputtur, India.
4. Barry G. Lawson, Evgenia Smirni, Daniela Puiu, ”Self-adapting backfilling scheduling for parallel systems”.
5. Ahuva W. Mu'alem and Dror G. Feitelson,” Utilization, predictability, workloads, and user runtime estimates in scheduling the ibm sp2 with backfilling”, “IEEE transactions on Parallel and Distributed Systems,Vol. 12, no. 6, June 2001.
6. Mishra A.K., Hellerstein J.L., Cirne W. and Das C.R. (2010) Towards characterizing cloud backend workloads: insights from Google compute clusters. ACM SIGMETRICS Perform. Eval. Rev. 37, 34–41.
7. UCB/EECS-2009-28 (2010) Analysis and Lessons from a Publicly Available Google Cluster Trace . University of California at Berkeley, Berkeley, USA.