
The performance measurement and evaluation of all proposed DLBAs are done in the chapters 5, 6, 7, and 8 using the real-time dataset of The University of Luxemburg Gaia Cluster Log. The details of the dataset are given in section 4.4.1. We have concluded that proposed DLBAs are balancing the load among the eight clusters of Gaia cluster. Here, in this chapter, the objective is to check the performance of proposed DLBAs in another dataset and prove that the algorithm can work in any kind distributed environment. The MetaCentrum dataset is selected for the said purpose, details of it are given in section 4.4.2.

10.1 Result Analysis of PS, PDLB, P2S_DLB, and PP2S_DLB Algorithms in MetaCentrum Dataset

The existing and proposed algorithms are simulated in ALEA simulator using MetaCentrum dataset and MetaCentrum cluster configuration. As explained in section 4.5.2, MetaCentrum cluster is collection of 14 heterogeneous clusters. The average cluster utilization, standard deviations, and load imbalance metric are calculated for as performance evaluation.

10.1.1 Result Analysis regarding Cluster Utilization

Table 10.1 shows the cluster utilization, average cluster utilization, and standard deviation of all the algorithms. The result shows that the PS algorithm overcivilized the Meta-12, Meta-7, and Meta-11 clusters, while all the other clusters remain underutilized. The utilization of Meta-2, Meta-3, Meta-5, Meta-6, Meta-9, Meta-10, Meta-13, and Meta-14 clusters are less then the 10%. It indicates the level of imbalance is very high in the PS algorithm. Therefore, the ACU is only 18.10% in PS algorithm.

The problem is resolved in the all the proposed DLBAs, as the ACU is increased to 32.46%, 27.07%, and 30.63% in PDLB, P2S_DLB, and PP2S_DLB algorithm respectively. It indicates the proposed DLBAs can increase the ACU in MetaCentrum dataset.
as well. Both the predictive algorithms (PDLB and PP2S_DLBDLB) are giving the best result regarding ACU. However, the result may vary in next execution cycle in both the algorithms because the performance depends upon the predicted load status of the clusters, while the performance of P2S_DLBDLB always remains stable as the balancing done by current load status of the clusters.

The SD result of PS algorithm is 20.55%, highest compared to all proposed DLBAs, indicates the load imbalance level is highest in the PS algorithm. The problem is resolved in all proposed DLBAs as the SD values are decreased to 5.21%, 7.41%, and 5.98% in PDLB, P2S_DLBDLB, and PP2S_DLBDLB algorithms respectively. It indicates all the three proposed algorithms have reduced the variation between the individual cluster utilization in MetaCentrum dataset.

The PDLB and the PP2S_DLBDLB algorithms are given the best performance regarding SD. The PDLB and PP2S_DLBDLB algorithm are predicted the overloaded as well as the underloaded condition of the clusters and scheduled the jobs accordingly. The results of PDLB and PP2S_DLBDLB may change as it works by the predicted status of the cluster, but the variation is less in case of PP2S_DLBDLB as it also looking current
status of the cluster at the time of scheduling. The PDLB is outperformed in all the proposed DLBAs for MetaCentrum dataset.

### 10.1.2 Result Analysis regarding Day wise Cluster Utilization

Figures [10.1][10.2][10.3] and [10.4] show the individual cluster usage on a day-to-day basis in PS, PDLB, P2S_DLB, and PP2S_DLB algorithms respectively in graphical format. In figures, the X-axis represents days, and Y-axis represents the clusters in descending order of CPUs. The green, yellow, and red colors represent under, medium, and over-utilization of clusters.

![Cluster Utilization per day in PS Algorithm for MetaCentrum Dataset](image1)

Figure 10.1: Cluster Utilization per day in PS Algorithm for MetaCentrum Dataset

![Cluster Utilization per day in PDLB Algorithm for MetaCentrum Dataset](image2)

Figure 10.2: Cluster Utilization per day in PDLB Algorithm for MetaCentrum Dataset
The rows separated by thin white lines in the figures represent the load status of the individual cluster. There are total fourteen rows display in the figures because the MetaCentrum data-set has fourteen clusters. In figures, rows are colored for 198 days because the MetaCentrum data-set log is having data of 198 days from 10\textsuperscript{nd} December 2008 to 26\textsuperscript{th} June 2009 as explained in section 4.4.2. The other details required to understand the graphs are the same as the explained in section 6.2.2.

All the fourteen rows colored green for the first 20 days and last 20 days in all the four figures indicate there is not a single job coming for the particular duration in the MetaCentrum dataset. Therefore, the further discussion in this section concerns the remaining days. In figure 10.1, first, three rows are colored red and remaining rows are colored green for most of the days, which shows that first three clusters (Meta-12, Meta-7, and Meta-11) are overpublicized for most of the days, and other clusters are underutilized for most of the days. It indicates the level of imbalance load is high in PS algorithm for all the days in the MetaCentrum dataset.

Figure 10.3: Cluster Utilization per day in P2S_DLB Algorithm for MetaCentrum Dataset

Figure 10.2 shows that PDLB can predict the loaded situation of Meta-12, Meta-7, and Meta-11 clusters and it schedule incoming jobs to other underutilized clusters which increases the overall utilization of available resources. Figure 5.3 shows that for the first 20 days as well as for the last 90 days there is an improvement regarding load balancing in the prediction approach, but in between the PDLB performs same like PS algorithm for the 45 days. It reflects PDLB algorithm fails to predict the cluster load
status for those 45 days and schedule incoming jobs as per the priority. Therefore, we concluded that PDLB is not best suitable DLBA for the MetaCentrum dataset.

The problem of imbalance load is solved perfectly in P2S_DLB, and PP2S_DLB algorithms as all the rows are colored yellow for most of the days in figures 10.3 and 10.4. It indicates the performance of P2S_DLB and PP2S_DLB is remain stable for most of the days in the MetaCentrum dataset. Therefore, we have concluded that P2S_DLB and PP2S_DLB are the best suitable DLBA for MetaCentrum dataset from the proposed DLBAs.

**10.1.3 Result Analysis regarding Load Imbalance Metric**

Figure 10.5 shows the load imbalance metric of each cluster between PS, PDLB, P2S_DLB, and PP2S_DLB algorithms in graph format for MetaCentrum dataset. The X-axis of the graph represents the percentage of load imbalance metric, and the Y-axis represents clusters. The total of fourteen columns in the graph represent the total fourteen clusters of MetaCentrum cluster configuration. The cluster configuration on which MetaCentrum dataset was generated is explained in section 4.5.2.

As explained in section 3.4.3, the ideal situation or the expected output in this graph is when all points are plotted on the X-axis. In the figure, 10.5 lines connecting all the plotted points of PDLB, P2S_DLB, and PP2S_DLB are closer to X-axis

Figure 10.5: Load Imbalance Metric of PS, PDLB, P2S_DLBB, PP2S_DLBB Algorithms for MetaCentrum Dataset

compared to a line connecting all the plotted points of the PS algorithm. It indicates all the proposed DLBAs can decrease the level of imbalance load in a MetaCentrum dataset.

10.2 Conclusion

All the proposed DLBAs are simulated in ALEA simulator using MetaCentrum dataset. The comparative analysis of the simulation results of all the proposed DLBAs and the PS algorithm is done by different evaluation parameters. The comparative results show that the performance of all the proposed DLBAs are better compared to the PS algorithm. The last objective is archived as the performance measurement, and evaluation of algorithms is done in more than one dataset. Therefore, we have concluded that the proposed DLBAs can balance the load among the cluster for any distributed clustered environment.