A Holistic View of Memory Utilization on Perlmutter

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ABSTRACT

HPC systems are at risk of being underutilized due to various resource requirements of applications and the imbalance of utilization among subsystems. This work provides a holistic analysis and view of memory utilization on a leadership computing facility, the Perlmutter system at NERSC, through which we gain insights about the resource usage patterns of the memory subsystem. The results of the analysis can help evaluate current system configurations, offer recommendations for future procurement, provide feedback to users on code efficiency, and motivate research in new architecture and system designs.

BACKGROUND

Perlmutter¹:
• Ranked 7th in the top500 list².
• More than 1,500 GPU nodes and over 3,000 CPU nodes.
• GPU node: four NVIDIA A100 Tensor Core GPUs, one AMD “Milan” CPU, 16GB of HBM2, and 256GB of DRAM.
• CPU node: two AMD “Milan” CPUs and 512GB of DRAM.

Data Collection:
• LDMS collects system-level metrics on GPU and CPU nodes; DCGM collects GPU metrics.
• Metrics are collected from June 15 to July 1, 2022 at an interval of 10 seconds and are saved in CSV files.
• LDMS, ETL joins CSV files with SLURM Sacct data and saves merged metrics including Job ID and Job Steps info in parquet files.

JOB SIZE DISTRIBUTION

Observation:
• CPU nodes have more middle-scale (4-64 nodes) jobs.
• GPU nodes have more small-scale jobs (<4 nodes) and large-scale jobs (>64 nodes).

Conclusion:
• Small-scale jobs on GPU nodes could be attributed to the emerging ML/DL applications.
• The extremely large-scale jobs prefer to exploit GPU nodes to achieve a faster simulation or training process.

NODE-LEVEL MEMORY UTILIZATION

Observation:
• About 93% of CPU jobs use less than 25% of the total memory capacity.
• Moderate and high memory intensity jobs only take up 7% of the total jobs but consume about 28% of the node-hours; 44% of DRAM intensive CPU jobs account for 68% of the node-hours.

Conclusion:
• Moderate and high memory intensity jobs likely use more nodes and/or run longer time.
• Most of CPU jobs can be accommodated with reduced memory capacity nodes.

GPU MEMORY (HBM2) UTILIZATION

Observation:
• Only a small fraction of jobs can take full advantage of HBM2.
• Most of GPU jobs cannot use HBM2 resources effectively.

Conclusion:
• For 90% of the time, the HBM2 utilization is nearly 90%.
• About 10% of jobs use over 95% of the total HBM2 capacity.

SUMMARY AND FUTURE WORK

Summary:
• Memory resources are under-utilized/over-provisioned both on CPU nodes and GPU nodes.
• Most of GPU jobs cannot use HBM2 resources effectively.

Future work:
• Analyzing the memory resources in temporal and in spatial.
• Extending the analysis on other subsystems.

REFERENCES


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