**Project Proposal**

**Kubernetes Dynamic Volume Provisioning Benchmark**

CS-550 Advanced Operating Systems

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**Under the Guidance of Phd lead - Meng Tang**

**By**

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1. **Introduction:**

In today’s world, the cluster storage systems are continuously pressured for storage space. The ever-growing data due to rapid increase in High Performance Computing (HPC) Systems has raised issues like the IO bottleneck problem.

The capacity to dynamically provision containers to run large-scale applications has been significantly improved by the advent of container orchestration tools like Kubernetes. Resource management, load balancing, disaster recovery, networking is some of Kubernetes's usages which can be valuable for building High Performance Computing Systems (HPCs). Considering the above points, we are motivated to study the storage performance of Kubernetes by dynamic volume provisioning to explore how it can be utilized in High Performance systems.

1. **Background information:**

Kubernetes is an open-source container orchestration engine for automating deployment, scaling, and management of containerized applications. Kubernetes, as mentioned earlier, enhances its ability to dynamically provision containers to run large-scale applications.

Developed and designed for high-performance computing, BeeGFS is a parallel file system which is hardware independent. In order to be flexible and scale well, BeeGFS has a distributed metadata design. BeeGFS may be utilized with container orchestrators like Kubernetes thanks to an open-source Container Storage Interface (CSI) driver. The driver is intended to enable settings where workloads managed by traditional HPC workload managers and containers managed by Kubernetes must share access to the same BeeGFS file system.

Intel PAT (Performance Monitoring Unit Advanced Topics) is a tool provided by Intel that allows software developers to monitor the performance of their applications at a very fine-grained level. Specifically, it enables the monitoring of events that occur at the micro-architectural level of the CPU, such as cache misses, branch mispredictions, and retired instructions. One potential use case for Intel PAT is in machine monitoring. By monitoring the performance of a machine over time, developers can identify patterns and trends that may be indicative of underlying issues or problems.

We propose to study and run Kubernetes storage volumes using its Container Storage Interface (CSI) by integrating it with BeeGFS file system. The performance of parallel storage systems can be evaluated utilizing a variety of interfaces and access patterns using the parallel IO benchmark known as IOR.  By integrating Kubernetes with IOR at application side we will benchmark the storage performance. This storage performance will then be compared against default linux file systems. By using Intel PAT, we can gain insight into the performance characteristics of their applications, and identify potential bottlenecks that may be slowing them down. We will be using the intel PAT tool to analyze the performance of the CPU.

1. **Problem statement:**

The study of dynamic volume provisioning will plot an idea of performance of Kubernetes in HPC’s. By studying the dynamic volume provisioning of Kubernetes, we can understand how well it can be utilized in High Performance systems.

1. **Related work:**

The [1], evaluates the results of the proposed hyperconverged system as compared with a traditional configuration using local storage, with the intention of verifying the viability of its use in place of direct-attached storage. The evaluation of performance of container’s storage is done by running an hyperconverged system inside Docker container. In [2], they have described a hybrid architecture consisting of an HPC cluster and a Cloud cluster, wherein the Cloud cluster's Kubernetes container orchestration can manage containers on the HPC cluster. The study in [3] investigates how Kubernetes might be used by the scientific community on HIPC infrastructure. A direct contrast of its capabilities and performance with those of HPC application execution on bare metal and Docker Swarm is done. In this paper [4], the authors examine the I/O performance of different container solutions on OrangeFS, a parallel storage system, specifically Singularity, Docker, LXC, Podman, and Charlie-Cloud. They deploy five containers and use a single server-single client OrangeFS setup to test the I/O performance of each container. The authors use Intel's Performance Analysis Tool on both the server and client nodes to measure the performance of the host machine on CPU and memory utilization, disk I/O, and network throughput.

1. **Proposed Solution:**

In this study we are proposing to study the storage performance of dynamic volumes of Kubernetes by integrating with DFS backends like BeeGFS using Kubernetes’s Container Storage Interface (CSI).

1. **Evaluation:**

The storage performance of BeeGFS will be compared with the traditional default linux systems by requesting dynamic Kubernetes volume through IOR.

1. **Deliverables:**

A final report in PDF form

Final Powerpoint Presentation

1. **Timelines:**

|  |  |  |
| --- | --- | --- |
| **Week** | **Task** | **Distribution of work** |
| 1 | Read and study various research papers on this topic. | Prajakta and Amith |
| 2 | Install and learn kubernetes | Prajakta and Amith |
| 3 | Deploy and learn basics of BeeGFS | Amith |
| 3 | Deploy and learn Intel(PAT) | Prajakta |
| 4 | Try integrating BeeGFS using CSI drivers of Kubernetes and test the same | Amith |
| 4 | Try configuring Intel(PAT) for kubernetes to take advantage of it | Prajakta |
| 5 | Study and install IOR and integrate it with Kubernetes | Prajakta and Amith |
| 6 | Start learning shell scripting and write scripts to automate the BeeGFS, kube start process | Prajakta and Amith |
| 7 | Write the final report | Prajakta and Amith |
| 8 | Write the final presentation | Prajakta and Amith |

**References**

[1] Rodrigo Leite, Priscila Solis and Eduardo Alchieri, “Performance Analysis of an Hyperconverged Infrastructure using Docker Containers and GlusterFS”, *9th International Conference on Cloud Computing and Services Science*

[2] Naweiluo Zhou1, Yiannis Georgiou2, Marcin Pospieszny3, Li Zhong1, Huan Zhou1, Christoph Niethammer1, Branislav Pejak4, Oskar Marko4 and Dennis Hoppe1, “Container orchestration on HPC systems through Kubernetes”, *Journal of Cloud Computing: Advances, Systems and Applications, 2021*

[3] Angel Beltrel, Pankaj Sahal, Madhusudhan Govindaraju1, Andrew J. Younge2, and Ryan Eric Grant2, “Enabling HPC workloads on Cloud Infrastructure using Kubernetes Container Orchestration Mechanisms”

[4] Izzet Yildirim1, Meng Tang1, Anthony Kougkas1 Xian-He Sun1, “Performance Analysis of Containerized OrangeFS in HPC Environment”