CS 494 - Cloud Data Center Systems

Final Project

Apache Solr on PEDs
(Performance Enhancing Dataflows)

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1 Abstract

As large-scale data centers continue expand computing resources over the network, SDN methodologies can optimize utility of these resources. In order to measure the impact of new SDN technology, benchmarking must be completed. Benchmarking can be complicated and ambiguous if not done carefully. In our research, we propose deconstructing popular distributed applications like Apache Solr to learn about their networking stack, and test it's efficacy (utility of resources) using a number of different workloads to get a clear performance benchmark. Then, as a stretch goal, we intend to port the application to high impact HPC technologies like eRPC (efficient RPC), and hardware accelerators like RDMA NICS (RNICs) and evaluate any changes in performance.

2 Problem Statement

If we intend to demonstrate the impact of accelerated hardware for SDN in HPC distributed environments, the first step is selecting the application to benchmark. Since our goal for this project is establishing a benchmark for applications that can benefit from RNIC, we need the selected application to consume resources affected by the RNICs. RNICs allow applications to 1) bypass the kernel, 2) offload processing and 3) eliminate data copying, they can offer lower latency, lower CPU utilization, and higher single-core throughput than traditional kernel-based networking. Furthermore, for our research to be validated by many people in the industry, the application must be widely-adopted and mature. Therefore, we looked for these properties in the application: wide-adoption, distributed, mature and well documented, CPU and Disk intensive. Apache Solr was the best choice considering these prerequisites.

RNICs have been a computing conundrum for many years because the aforementioned capabilities of RNICs come at a cost when implementing at scale:

- Many RNIC frameworks are not sufficiently fault tolerant.
- RNICs exhibit highly variable performance.
- Current RNIC interfaces are too low level.

Therefore, this research must consider fault tolerance and the highly variable performance when benchmarking Apache Solr.

3 Project Description

We will install Apache Solr on a 4 node distributed cluster where each node has the following configuration:

- Dual socket machine with two `Intel(R) Xeon(R) Silver 4114 CPU @ 2.20GHz`
- 188GB of RAM
- Ubuntu 18.04.1 LTS

Once configured and working with Solr-provided example sets, we will write scripts that execute different experiments. An experiment is defined as a task performed over three small to large data sets. Each of these experiments will be designed to selectively pressure test the application based on our benchmarking criteria identified as: CPU, Disk, and Network.

For the stretch goal, our proposed work believes that Apache Solr is a CPU-bound application, and that integrating a network stack utilizing the Mellenox VMA RNIC library will demonstrate enhanced performance. However, the difficulties with RDMA NICs highlight the need for a dynamic system that uses both RDMA NICs and other leading HPC technology. Our work intends to benchmark enhanced RPCs within the Solr environment to see how non-RDMA HPC technology impacts search applications like Solr. A stretch goal for us will be to see if we can port the application to both VMA and eRPC in effort to mitigate overloading the NIC. This could demonstrate that eRPC can underpin the work of the RDMA NICs while maintaining throughput.

4 Previous Work

- "Datacenter RPCs can be General and Fast"
  https://www.usenix.org/conference/nsdi19/presentation/kalia
- "FreeFlow: Software-based Virtual RDMA Networking for Containerized Clouds"
  https://www.usenix.org/conference/nsdi19/presentation/kim
- "Slim: OS Kernel Support for a Low-Overhead Container Overlay Network"
  https://www.usenix.org/presentation/zhuo

5 Expected Outcome

Our experiments will demonstrate which dimensions the application is bounded. We expect to clearly express each of our experiments along with the performance of each. These benchmarks will be used to gauge the performance delta of integrating RNIC frameworks into these experiments. We expect RNIC-enabled experiments to demonstrate higher throughput and lower latency due to lower CPU utilization.