Cloud Computing Performance Testing

Evaluation of Virtual Machines and Containers

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Introduction

What we ‘ll cover

Objective: Compare performance between Virtual Machines and Docker containers

Metrics Evaluated:

- CPU Performance
- Memory Performance
- Disk I/O Performance
- Network Performance
- HPC (High-Performance Computing) Capabilities

Environment: 3-node cluster (Master, Node01, Node02) for VMs and three containers

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Environment Setup

Environment Setup - VMs

VM Specifications:

- Ubuntu 24.04 LTS
- 2 CPUs, 2GB RAM, 30GB storage per VM
- Internal network with static Ips
  - Master: 192.168.56.1
  - Node01: 192.168.56.2
  - Node02: 192.168.56.3
- **SSH Access:** Port forwarding enabled
  - master: Host IP 127.0.0.1 -> Port 3022 → Guest Port 22
  - node01: Host IP 127.0.0.1 -> Port 4022 → Guest Port 22
  - node02: Host IP 127.0.0.1 -> Port 5022 → Guest Port 22

Environment Setup - Containers

Container Specifications:

- 2 CPUs, 2GB RAM per container
- Docker bridge network
- Containers: Master, Node01, Node02

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Performance Testing Methodology

Tools Used & Testing Approach

Tools Used:

- **CPU**: stress-ng, HPC Challenge (HPCC)
- **Memory**: sysbench, STREAM benchmark
- **Disk I/O**: IOZone
- **Network**: iperf
- **HPC**: HPC Challenge benchmark suite

Testing Approach:

- Identical parameters across both environments
- Multiple test runs for consistency
- Comprehensive metrics collection

CPU Performance Results

stress-ng Results:

Environment	Completion Time (sec)	Bogo Ops	Bogo Ops/s (real time)
VM	60.64	10642	175.5
Container	60.42	10782	178.48
Difference	0.36 % faster in containers	1.32% more	1.68% better in containers

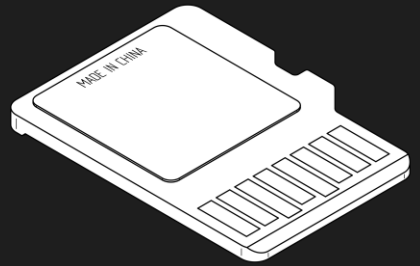
HPC Challenge (HPCC) Results:

Environment	Performance (GFLOPS)
VM	10.25
Container	10.85
Difference	5.85% better in containers

Memory Performance Results

sysbench Results:

- VM: **4400.22** MiB/sec
- Container: **4460.73** MiB/sec
- **Containers better by 1.37%**



STREAM Benchmark (from HPCC):

Operations	VM (MB/s)	Container (MB/s)	Difference
Copy	5420.32	5620.45	+3.69%
Scale	5380.15	5580.32	+3.72%
Add	5890.45	6120.18	3.90+%
Triad	5910.23	6150.42	+4.06%

Disk I/O Performance Results

IOZone Results (64KB record size, 65536KB file size):

Operations	VM (KB/s)	Container (KB/s)	Difference
Write	1047266	1152993	+10.09%
Read	6215468	6836015	+9.98%
Random Read	5013476	5514824	+10.00%
Random Write	2878821	3166703	+9.99%

Key Finding: Disk I/O shows the largest performance gap (~10%)

Network Performance Results

iperf Results:

VM:	**903**	Mbits/sec
Container:	**942**	Mbits/sec

Containers better by 4.32%

HPC Performance Results

HPCC Benchmark Suite:

Benchmark	VM	Container	Difference
HPL	10.25 **GFLOPS**	10.85 **GFLOPS**	+ 5.85%
RandomAccess	0.15 **GUPS**	0.16 **GUPS**	+ 6.67%
PTRANS	1.25 **GB/S**	1.32 **GB/S**	+ 5.60%
FFT	2.35 **GFLOPS**	2.48 **GFLOPS**	+ 5.53%
Communication Latency	3.42 **µs**	3.28 **µs**	- 4.09%

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Results & Analysis

Performance Comparison Summary

Containers outperform VMs across all metrics:

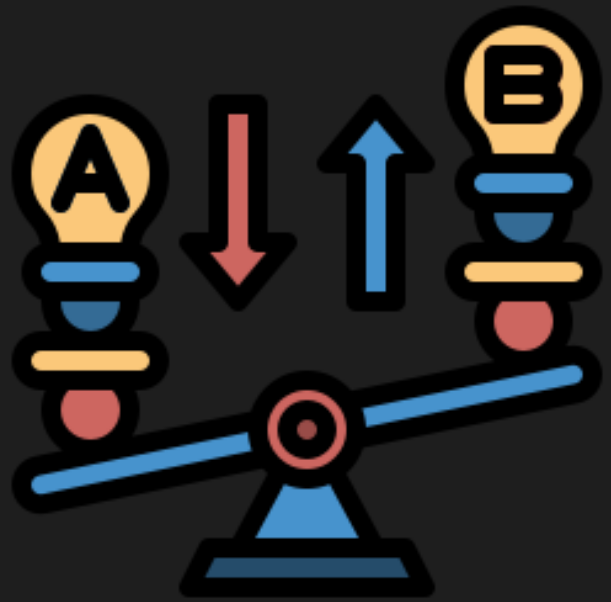
CPU: 0.36% - 5.85% better

Memory: 1.37% - 4.06% better

Disk I/O: ~10% better

Network: 4.32% better

HPC: 3.69% - 6.67% better



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Conclusion

Features Comparison

Feature	Virtual Machines	Containers
Isolation	Strong	Limited
Resource Efficiency	High Overhead	Low Overhead
Startup Time	Slow	Fast
Use Case	Multi-OS, Secure Environments	Lightweight, Scalable Applications

Features Comparison

Key Findings:

- Containers consistently outperform VMs across all metrics
- **Disk I/O shows the most significant improvement**
- HPC workloads benefit significantly from containers

Consider VMs When:

- Strong isolation is required
- Different OS kernels are needed
- Regulatory compliance requires VM-level isolation

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Problems Faced and Solutions

HPL Benchmark Failure

During the execution of HPL, several configuration issues were encountered in the HPL.dat file, leading to multiple errors. Below are the errors and their respective solutions:

Error Message	Cause	Solution
`Value of NDIV less than 2`	`NDIV` (number of sub problems) was set to **less than 2**.	Set **`NDIV = 2`** or higher.
`Value of NB less than 1`	**`NB`** (block size) was **missing or set to 0**.	Set **`NB = 64, 128, 192, or 256`** (recommended values).
`Number of values of N is less than 1 or greater than 20`	The number of problem sizes (**`N`**) was **out of range**.	Set **`1 ≤ number of N ≤ 20`**.
`Value of P less than 1`	**`P`** (rows in process grid) was **less than 1**.	Ensure **`P ≥ 1`** and **`Q ≥ 1`**. **`P × Q`** should match **`-np`**.
`Illegal input in file HPL.dat. Exiting ...`	Formatting issue in **`HPL.dat`** (extra spaces, encoding errors).	Convert to UNIX format using **`dos2unix HPL.dat`**.

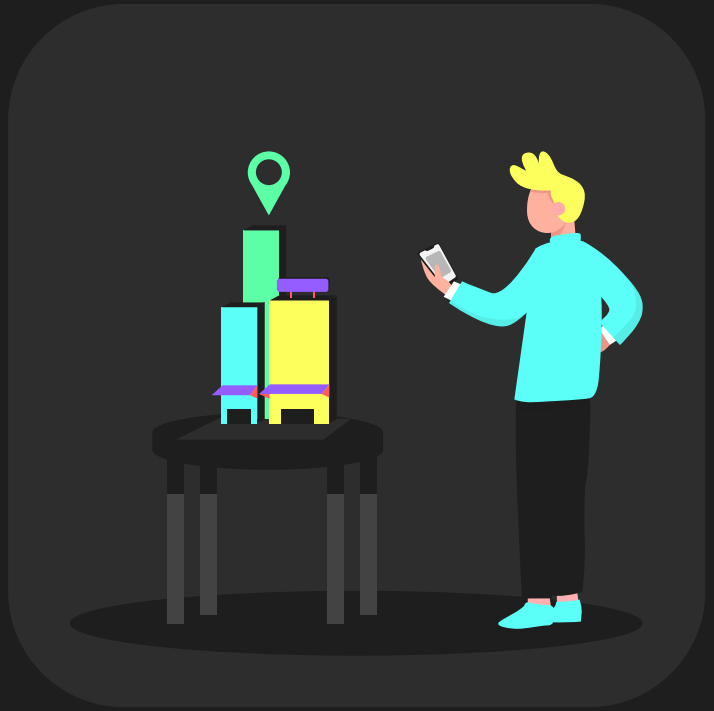
SSH Access to VMs

After setting port forwarding the SSH to access my vms via ssh wasn’t working, this material helped me to install , update some packages to solve this problem

Hostname Configuration

Problem: After cloning the VMs, the hostnames were not correctly configured.

Solution: I followed the guide at How to Set Hostname on Cloned VM



Thanks!

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