Noise in the Clouds: Influence of Network Performance Variability on Application Scalability

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# HPC in the cloud

| Provider | CPU | Net. Bw. | Network | Transp. Prot. |
|----------|-----|----------|---------|--------------|
| AWS      | 2x18C Intel Xeon Platinum @ 3GHz | 100 Gb/s | Fat Tree | SRD           |
| Azure    | 2x22C Intel Xeon Platinum @ 2.7GHz | 100-200 Gb/s | Non-blocking Fat Tree | InfiniBand |
| GCP      | 2x15C Intel Cascade Lake @ 3.1GHz | 100 Gb/s | 3:1 blocking Fat Tree | TCP/IP + Intel QuickData |
| Oracle   | 2x18C Intel Xeon Gold @ 3GHz | 100 Gb/s | Non-blocking Fat Tree | RoCEv2 |
| Daint    | 2x18C Intel Xeon E5-2695 v4 @2.1GHz | 82 Gb/s | Cray Aries (Dragonfly) | FMA |
| Alps     | 2x64C AMD EPYC 7742 @ 2.25GHz | 100 Gb/s | HPE Cray Slingshot (Dragonfly) | RoCEv2 |
| DEEP-EST | 2x12C Intel Xeon Gold @3.2GHz | 100 Gb/s | Mellanox Infiniband EDR (Fat Tree) | InfiniBand |
Target

Compare **network performance** of cloud HPC vs on-premise HPC

Analyze **network noise** of cloud HPC vs on-premise HPC and its impact **at scale**
Network Performance
Bandwidth and latency
HPC vs. normal instances

![Bandwidth Comparison Graphs]

- **AWS**: Normal, HPC, HPC (Metal), HPC (200 Gb/s)
- **Azure**: Normal, HPC, HPC (Metal), HPC (200 Gb/s)
- **GCP**: Normal, HPC, HPC (Metal), HPC (200 Gb/s)
- **Oracle**: Normal, HPC, HPC (Metal), HPC (200 Gb/s)

Message Size: 1B, 256B, 64KiB, 16MiB

Bandwidth (Gb/s): 0, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200
Network Noise
Bandwidth noise

Cloud systems are more affected by bandwidth noise than premise systems.
Noise impact at scale
Noise

\[ H_0 \xrightarrow{\text{COMP}} \xrightarrow{\text{COMP}} \xrightarrow{\text{COMP}} \]

\[ H_1 \xrightarrow{\text{COMP}} \xrightarrow{\text{COMP}} \xrightarrow{\text{COMP}} \]

\[ H_2 \xrightarrow{\text{COMP}} \xrightarrow{\text{COMP}} \xrightarrow{\text{COMP}} \]

\[ H_3 \xrightarrow{\text{COMP}} \xrightarrow{\text{COMP}} \xrightarrow{\text{COMP}} \]
Methodology

Get network performance measurements... ...and OS and network noise measurements...

...and simulate performance at scale
Simulation validation (16 nodes)

[Bar charts showing comparison between simulated and real times for Daint, Alps, DEEP-EST, Azure (200 Gb/s), AWS, GCP, and Oracle in Dissemination and Ring scenarios.]
512 MiB Ring collective simulation

Bandwidth noise can increase the runtime by 50% even when running at small scale (4 nodes)
Impact of bandwidth noise on monetary cost

Dummy application: 8192x8192 matrix multiplication followed by 512MiB allreduce (20% of time spent in communication)

Network noise impacts the monetary cost, even for applications not dominated by communication.

| AWS HPC (Metal) | Azure HPC |
|----------------|-----------|
| OS Noise | Network Noise | OS+Network Noise |

| GCP HPC | Oracle HPC (Metal) | Daint HPC (Metal) |
|---------|---------------------|-------------------|
| Nodes   | Cost Increase (%)   | Nodes             |
| 4       | 0                   | 4                 |
| 16      | 0                   | 16                |
| 64      | 20                  | 64                |
| 256     | 20                  | 256               |
| 1024    | 10                  | 1024              |

Network noise impacts the monetary cost, even for applications not dominated by communication.
Conclusions

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[https://github.com/DanieleDeSensi/cloud_noise](https://github.com/DanieleDeSensi/cloud_noise)
[https://github.com/DanieleDeSensi/cloud_noise_data](https://github.com/DanieleDeSensi/cloud_noise_data)
