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| <br><b>EQUINIX</b> | <b>Project</b>      | Cloud Interconnection Performance Benchmarking for Oracle database backup and restore over Equinix Fabric vs. Internet |
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# Cloud Interconnection Performance Benchmarking for Oracle Database Backup and Restore over Equinix Fabric vs. Internet

## Technical Paper

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## Executive Summary

This Benchmarking exercise demonstrated the performance benefits of Oracle Cloud Infrastructure (OCI) [FastConnect](#) via [Equinix Fabric](#) when compared to the Internet. Testing was performed at 10Gbps for both FastConnect and Internet, using various performance parameter combinations of Packet Delivery Class and Round-Trip Delay listed in Table 1.

|  |   |
|--|---|
| Packet Delivery Class  | <ul style="list-style-type: none"> <li>• <b>High</b> - 99.9% packet delivery rate (0.1% packet loss)</li> <li>• <b>Medium</b> - 99.5% packet delivery rate (0.5% packet loss)</li> <li>• <b>Low</b> - 99% packet delivery rate (1% packet loss)</li> </ul>  |
| Round-Trip Delay (RTD) in ms<br><br>(With examples of corresponding approximate geographical distance)   | <ul style="list-style-type: none"> <li>• City (&lt;2ms)</li> <li>• Inter-city (5ms) (Ashburn, VA to Philadelphia, PA)</li> <li>• Regional (10ms) (Ashburn, VA to Pittsburgh, PA)</li> <li>• Inter-regional (20ms) (Ashburn, VA to Chicago, IL)</li> <li>• National (35ms) (Ashburn, VA to Dallas, TX)</li> <li>• International (50ms) (Ashburn, VA to Mexico City, Mexico)</li> <li>• Continental (75ms) (Ashburn, VA to Vancouver, Canada)</li> <li>• Intercontinental (100ms) (Ashburn, VA to Zurich, Switzerland)</li> </ul> |
| (Source for the approximate distance for the corresponding latency <a href="https://wondernetwork.com/pings/Washington">https://wondernetwork.com/pings/Washington</a> ) |   |

*Table 1 – Performance Parameters*

It was observed that using FastConnect via Equinix Fabric significantly improved performance when compared to an Internet service falling within the abovementioned packet delivery classes, especially at higher latencies. For example, using the **High** delivery class and imposing 100ms of latency, restoration of a 1TB database backup over the Internet took over 7 hours (443 minutes). Comparatively, the same database was restored in 16 minutes from Equinix's cloud proximate datacenter offering sub-2 ms latency over FastConnect via Equinix Fabric. An overall improvement of **28x** and a restore time shortened by as much as **7 hours**.

There are three main performance parameters contributing to this improvement – Cloud Proximity, Packet Delivery, and Jumbo Frames. The Figure 1 details the performance improvement of Fabric vs. public Internet for each individual performance parameter. When combined, the resultant impact is not additive, but compounded.

**Scenario Tested:** 1 TB database Restore from OCI Object Storage

|   | Fabric + FastConnect<br>Restore time<br>(minutes) | Internet<br>Restore time<br>(minutes)   | Time<br>Saved<br>(up to minutes) | Multiple<br>Faster<br>(up to ~x) |
|---|---|---|----------------------------------|----------------------------------|
| <b>Overall</b>  | 16<br>[<2ms, 0%, 9000] <sup>1</sup>               | 443<br>[100ms, 0.1%, 1500] <sup>1</sup> | 427 (7 hours)                    | <b>28x</b>                       |
| <b>Breakdown of individual performance parameters</b> |   |   |                                  |                                  |
| <b>Cloud Proximity</b>                                | 17<br>[<2ms, 0%, 1500] <sup>1</sup>               | 48<br>[100ms, 0%, 1500] <sup>1</sup>    | 31                               | <b>3x</b>                        |
| <b>Packet Delivery</b>                                | 31<br>[100ms, 0%, 1500] <sup>1</sup>              | 443<br>[100ms, 0.1%, 1500] <sup>1</sup> | 412                              | <b>14x</b>                       |
| <b>Jumbo Frames</b>                                   | 28<br>[100ms, 0%, 9000] <sup>1</sup>              | 48<br>[100ms, 0%, 1500] <sup>1</sup>    | 20                               | <b>2x</b>                        |

<sup>1</sup> [ Delay, Packet Loss %, Maximum Transmission Unit (MTU) ]

*Figure 1 – Overall Performance Improvement of Equinix Fabric + FastConnect vs Internet*

In addition to performance benefits, customers choose private connectivity using Equinix Fabric for other reasons, including but not limited to security (Internet avoidance), compliance, rapid provisioning, ease of use and improved total cost structure as detailed in this [blog](#).

# Cloud Interconnection Performance Benchmarking Test

## Scope of Test

The scope for this benchmarking test was limited to backup and restore use cases focusing only on the network performance aspects of FastConnect via Equinix Fabric versus public Internet. Commercial aspects like data egress costs from cloud providers were considered beyond the scope of this whitepaper.

- Tests were performed using 10 Gbps for internet connectivity and a 10 Gbps FastConnect connection via Equinix Fabric.
- Only a single FastConnect virtual circuit was setup. Redundant setup was out of scope.
- Only FastConnect's Private Peering option was tested. OCI Public Peering was out of scope.
- Tests were conducted with Oracle Database only. Other database solutions were out of scope.
- Oracle Recovery Manager ([RMAN](#)) was used for backup and restore using OCI's Object Storage, a highly reliable and horizontally scalable storage solution. Other 3rd Party backup solutions and destinations were out of scope.
- To limit the amount of time spent on each test, the database size was fixed to approximately 1TB. Larger database sizes were out of scope.
- While additional manual TCP tuning might have yielded higher throughput; it was a conscious decision to leave TCP settings to operating system defaults to emulate most customer environments.
- Oracle object storage API calls are natively protected using TLS (Transport Layer Security). Therefore, the use of OCI VPN Connect was out of scope for this test.

## Desired Output of the Benchmarking Test Results

- Provide a reference table with the time to complete the workload for each combination of performance parameters
- Establish "Tipping Points". Data points showing when the benefits of FastConnect via Equinix Fabric exceed 2x and 10x performance improvement over an Internet service experiencing various loss and latency parameters as previously defined in Table 1.

## Test Environment

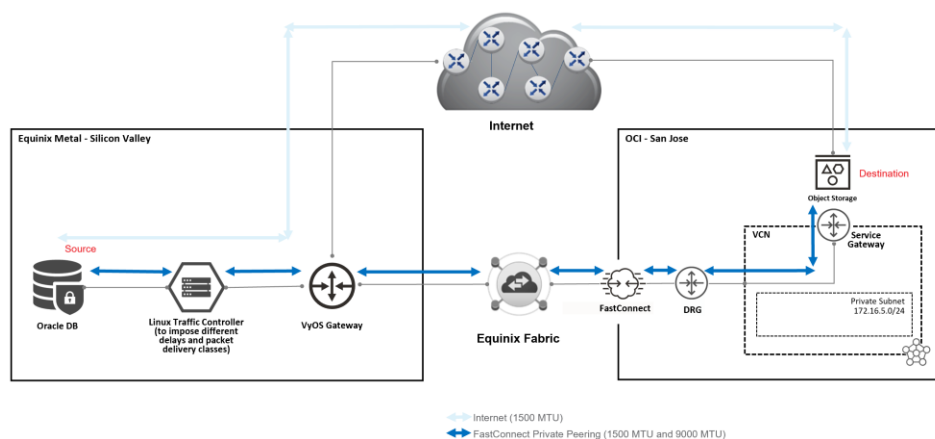


Figure 2 – Test Environment

Testing consisted of backing up to, and restoring from, Oracle Cloud Object Storage using RMAN. OCI's San Jose Region served as the Oracle Cloud backup destination and restoration point.

Equinix Metal bare metal servers were used for the on-premises test environment and hosted the following functions:

- 1) Oracle Database
- 2) [Linux Traffic Controller](#) – to impose performance parameters from Table 1.
- 3) [VyOS Gateway](#) - provided routing for Internet and FastConnect.

## Network Connectivity

Public Internet – Equinix Metal provided Internet access to Oracle Cloud While the capacity of Equinix Metal’s Internet Service exceeds 10Gbps, all tests performed in this technical paper were capped at 10 Gbps, the physical port speed of the VyOS gateway Network Interface Cards (NICs).

Created a dedicated, private connection between Equinix Metal VyOS gateway and OCI. FastConnect via Fabric provides lower latency, private connectivity as well as a more consistent networking experience when compared to Internet-based connections.

- Private Peering was used to extend connectivity from the existing infrastructure into a Virtual Cloud Network (VCN) in OCI.
- The [Service Gateway](#) was used to reach the object storage public services via Private Peering as described [here](#).

## Degree of Parallelism

The [Degree of Parallelism](#) (DOP) is a metric which indicates how many operations can be or are being simultaneously executed by a computer. Enterprises typically use parallelism to upload to backup and restore large amounts of data.

The RMAN tool from Oracle provides the desired parallelism using “[channels](#)”. These channels were tuned to adjust the degree of parallelism for the backup and restore tests. Oracle’s [Recovery Manager \(RMAN\) Performance Tuning Best Practices](#) white paper was used to ensure neither disk throughput nor CPU was a bottleneck. As such the optimum initialization parameters and number of channels, 35, for benchmark testing was identified. Detailed diagnostic stats for CPU, disk IO and network speed during testing can be found in the [Appendix](#).

## Maximum Transmission Unit (MTU)

The maximum frame size, MTU, supported on the Internet is 1500 bytes. FastConnect supports both “Jumbo”, 9000 bytes, and “Standard”, 1500 byte, frames. Both frame sizes were tested over FastConnect while only the standard frame size of 1500 bytes was tested over the Internet.

## Test Environment Details

### Hardware

| Server Name              | Equinix Metal Instance        | CPU                      | Cores        | Boot           | Storage         | Memory (GB RAM) | Network     |
|--------------------------|-------------------------------|--------------------------|--------------|----------------|-----------------|-----------------|-------------|
| VyOS Gateway             | <a href="#">n2.xlarge.x86</a> | 2 x Intel Xeon Gold 5120 | 28 @ 2.20GHz | 2 x 120 GB SSD | 1 x 3.8 TB NVMe | 384             | 4 x 10 Gbps |
| Linux Traffic Controller | <a href="#">n2.xlarge.x86</a> | 2 x Intel Xeon Gold 5120 | 28 @ 2.20GHz | 2 x 120 GB SSD | 1 x 3.8 TB NVMe | 384             | 4 x 10 Gbps |
| Oracle Database          | <a href="#">m3.large.x86</a>  | 1x AMD EPYC 7502P        | 32 @ 2.5Ghz  | 2 x 240 GB SSD | 2 x 3.8 TB NVMe | 256             | 2 x 25 Gbps |

Table 2 – Hardware

The Oracle Database server’s storage disks were configured in a RAID 0 (disk striping) configuration to provide best possible IOPS for the database.

## Network

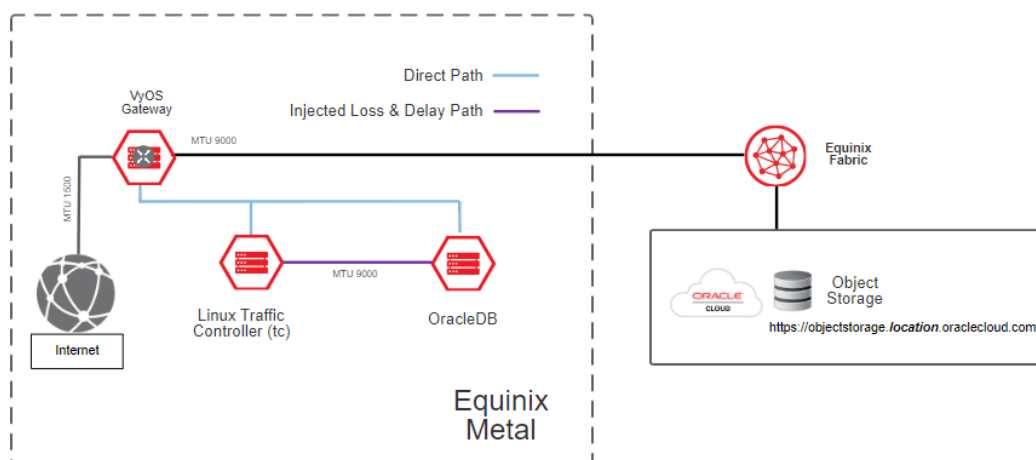


Figure 3 – Test Network

## Software

| Software  | Operating System        | Kernel / Version             |
|---|-------------------------|------------------------------|
| VyOS Gateway (Version 1.2.5)                          | CentOS 8                | 4.19.106-amd64-vyos          |
| Linux Traffic Controller (tc utility, iproute2-5.9.0) | CentOS 8                | 4.18.0-240.22.1.el8_3.x86_64 |
| Oracle DB (Version 19.3.0.0.0)                        | Oracle Linux Server 7.9 | 3.10.0-1160.24.1.el7.x86_64  |

Table 3 – Software

## Oracle Database with RMAN

RMAN was configured to perform a full backup writing the database backup files directly to OCI Object Storage. Similarly, RMAN tablespace point-in-time recovery (**TSPITR**) was used to restore from the backup stored in OCI Object Storage. The size of the backup was kept constant at 1.06TB and the number of RMAN channels was set to 35. To keep the setup simple, and to focus on the performance benefit derived from FastConnect, the backups were not compressed and TDE was also not configured for encryption.

The database was populated with sample data using [Swingbench](#) tool using the command:

```
/home/oracle/swingbench/bin/oewizard -cl -create -cs //oracle-poc/EQXFC -u soe1 -p
<soepassword> -scale 420 -tc 32 -dba "sys as sysdba" -dbap <pwd> -ts SOE8 -df
/oracle/app/oracle/oradata/EQXFC/soe08.dbf
```

## Linux's Traffic Controller (tc)

The purpose of tc was to introduce different delay and packet delivery rates as highlighted in the [Executive Summary](#) and depicted in Table 1. Delay was divided in half and imposed equally in both directions, enabling the total delay configured to match the desired round-trip delay (RTD). The Packet delivery rate (loss) was imposed in only one direction, the data transfer side of the connection. I.e., the data path for traffic towards OCI, Backup, and from OCI, Restore.

To avoid unintended packet loss at higher speeds the default packet buffer size of 1000 used by Network Emulator ([NetEm](#)), included in tc, was modified to 187500. This number was derived by dividing the bandwidth (10Gb) by the smallest MTU (1500) and then multiplying by the maximum delay, 150 ms. A 50% buffer was then added to this number resulting in the 187500 limit size used for testing. The following commands were used to configure tc for backup and restore:

```
# For Backup
tc qdisc add dev <interface to OCI> root netem limit 187500 delay "$1"ms loss "$2"%"
tc qdisc add dev <interface to database> root netem limit 187500 delay "$1"ms"
```

```
# For Restore
tc qdisc add dev <interface to OCI> root netem limit 187500 delay "$1"ms
tc qdisc add dev <interface to database> root netem limit 187500 delay "$1"ms loss "$2"%"
```

*Note: During the early stages of testing the intent was to also test at 150 ms. Due to the time involved to complete such test the decision was made to strike the 150 ms tests from the benchmark.*

The following scripts were developed:

#### *Backup Script*

1. Setup the Linux tc setting for different latency and packet delivery class settings
2. Backup the database using RMAN
3. Cleanup the object storage and repeat the script from the beginning three times
4. Repeat the script with the next tc configuration.

#### *Restore Script*

1. Perform the initial backup to OCI object storage and capture the date / time outputted by the script.
2. Update the restore script with the above date / time.
3. Setup the Linux tc setting for different latency and packet delivery class settings
4. Restore the database using RMAN. This will drop the current tablespace and restore it from the backup created in Step#1
5. Repeat the script from Step#3 with the next tc configuration.

### Test Execution

Network connectivity options - Internet, FastConnect with jumbo frames and FastConnect with standard frames, were setup manually. For each network connectivity option results from ping / traceroute commands as well as the applied MTU settings were captured as detailed in the [Appendix](#).

Thereafter, the above-mentioned [scripts](#) were kicked off and backup / restore times were captured by querying V\$RMAN\_BACKUP\_JOB\_DETAILS and V\$RMAN\_STATUS tables, respectively.

A total of 384 tests were executed and it took over 2 months (192 tests over 1 month for each backup and restore operation). Average time was calculated from the results of three runs of each delay and packet delivery class combination. Average throughput was then calculated using total database size and average time. The average throughput of the two FastConnect connectivity options was then compared with that of Internet as detailed in the [results](#).

The MTU setting on the database server was kept at 9000 except when testing FastConnect with standard frames sizes. It was manually set to 1500 using the following command:

```
ifconfig <interface_name> mtu 1500 up
```

All scripts, stored procedures and detailed setup documentation can be found on GitHub at <https://github.com/equinix/cloud-interconnection-benchmarking>.

### Results

Detailed comparisons when latency is kept the same for both FastConnect and Internet can be found below. For each comparison the results are depicted in two formats, graphical and tabular.

The graphical representation is shown to easily identify the extrapolated tipping points (2x and 10x performance improvement markers) while the tabular format shows the raw data. The tabular format classifies the data into 3 categories – Yellow (1x to 2x improvement), Green (2x to 10x improvement) and Dark Green (10x+ improvement).



## Restore: Equinix Fabric + FastConnect (9000 MTU) vs Internet

### Equinix Fabric + FastConnect (9000 MTU) vs. Internet

Test Scenario: 1 TB database Restore from OCI Object Storage

#### Environment Setup

DB Backup Size: 1.06 TB  
RMAN Channels: 35  
FastConnect bandwidth: 10Gbps  
FastConnect MTU: 9000

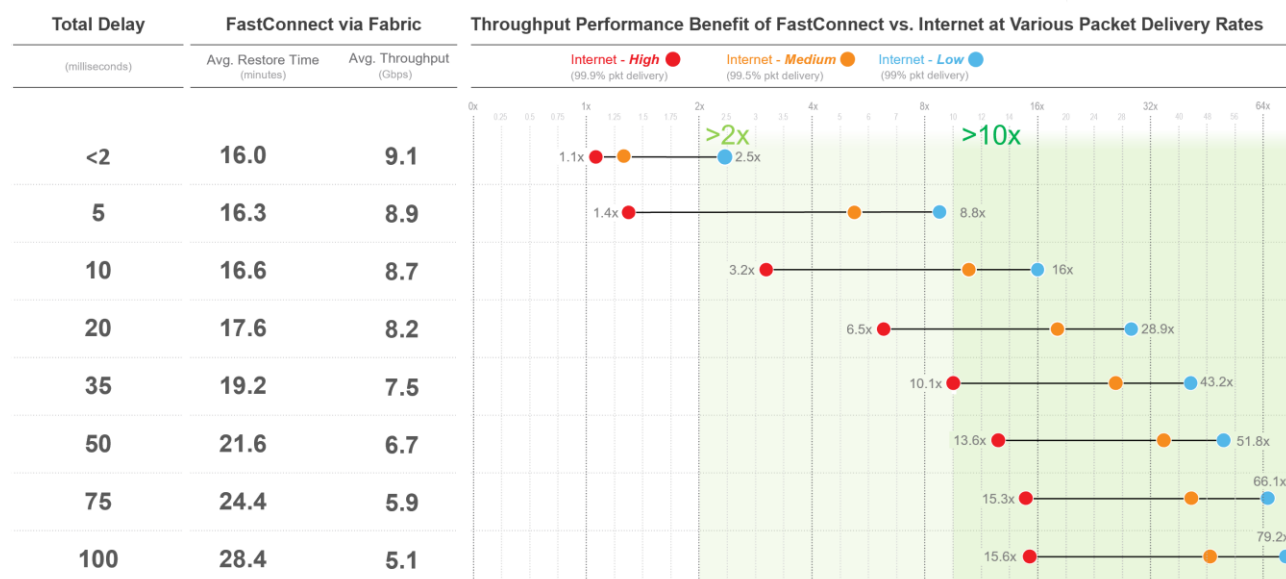


Figure 4 – Restore: Equinix Fabric + FastConnect (9000 MTU) vs Internet

| Extrapolated Tipping Points for Network Performance Improvement |      |       |
|---|------|-------|
|   | ~2x  | ~10x  |
| Internet – <b>High</b> packet delivery class                    | ~8ms | ~35ms |
| Internet – <b>Medium</b> packet delivery class                  | ~3ms | ~10ms |
| Internet – <b>Low</b> packet delivery class                     | <2ms | ~7ms  |

Table 4 – Restore: Equinix Fabric + FastConnect (9000 MTU) vs Internet, Tipping Points

| Total delay<br>(ms)<br>(including tc imposed delay) | Run 1<br>(mins) | Run 2<br>(mins) | Run 3<br>(mins) | Fabric + FastConnect     |                        | Internet - High        |                                 | Internet - Medium      |                                 | Internet - Low         |                                 |
|---|-----------------|-----------------|-----------------|--------------------------|------------------------|------------------------|---------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|   |                 |                 |                 | Avg. Restore Time (mins) | Avg. Throughput (Gbps) | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple |
| <2  | 16.0            | 16.0            | 16.0            | 16.0                     | 9.1                    | 8.15                   | 1.1                             | 6.74                   | 1.3                             | 3.66                   | 2.5                             |
| 5   | 16.4            | 16.3            | 16.3            | 16.3                     | 8.9                    | 6.34                   | 1.4                             | 1.62                   | 5.5                             | 1.01                   | 8.8                             |
| 10  | 16.8            | 16.7            | 16.5            | 16.6                     | 8.7                    | 2.69                   | 3.2                             | 0.79                   | 11.0                            | 0.54                   | 16.0                            |
| 20  | 17.6            | 17.5            | 17.6            | 17.6                     | 8.2                    | 1.27                   | 6.5                             | 0.44                   | 18.9                            | 0.29                   | 28.9                            |
| 35  | 19.3            | 19.2            | 19.2            | 19.2                     | 7.5                    | 0.75                   | 10.1                            | 0.27                   | 27.5                            | 0.17                   | 43.2                            |
| 50  | 21.5            | 21.6            | 21.6            | 21.6                     | 6.7                    | 0.49                   | 13.6                            | 0.19                   | 35.4                            | 0.13                   | 51.8                            |
| 75  | 24.4            | 24.2            | 24.5            | 24.4                     | 5.9                    | 0.39                   | 15.3                            | 0.14                   | 43.4                            | 0.09                   | 66.1                            |
| 100   | 28.5            | 28.4            | 28.5            | 28.4                     | 5.1                    | 0.33                   | 15.6                            | 0.10                   | 49.0                            | 0.06                   | 79.2                            |

Table 5 – Restore: Equinix Fabric + FastConnect (9000 MTU) vs Internet, Raw Data

- The observed range for the **High** class is 1.1x through 15.6x
- The observed range for the **Medium** class is 1.3x through 49x
- The observed range for the **Low** class is 2.5x through 79.2x

## Restore: Equinix Fabric + FastConnect (1500 MTU) vs Internet

### Equinix Fabric + FastConnect (1500 MTU) vs. Internet

Test Scenario: 1 TB database Restore from OCI Object Storage

#### Environment Setup

DB Backup Size: 1.06 TB  
RMAN Channels: 35  
FastConnect bandwidth: 10Gbps  
FastConnect MTU: 1500

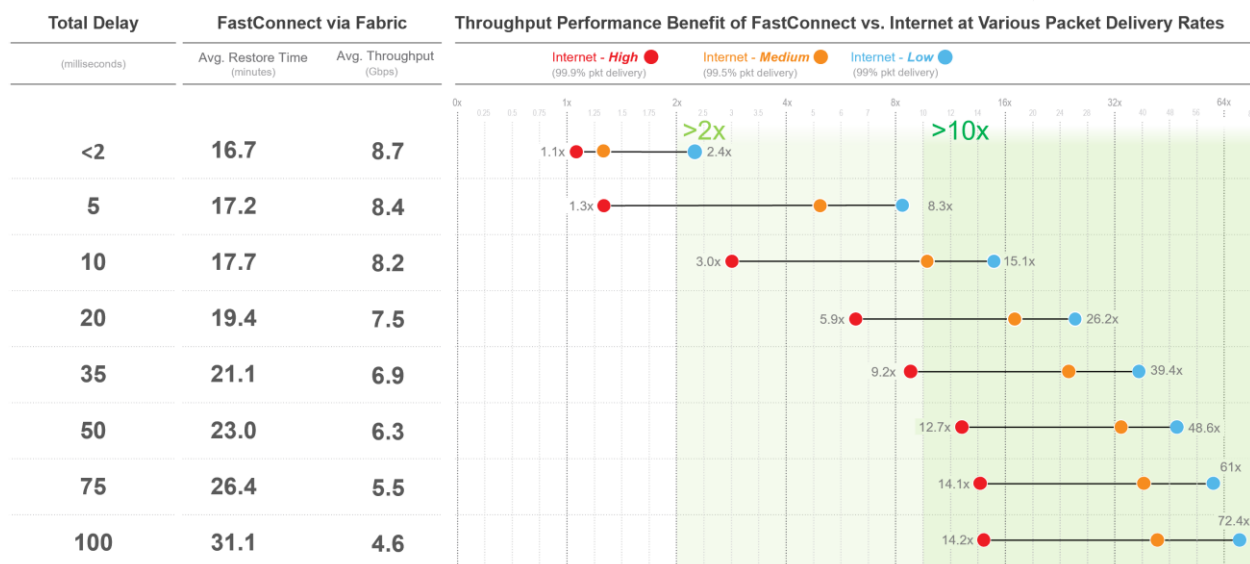


Figure 5 – Restore: Equinix Fabric + FastConnect (1500 MTU) vs Internet

| Extrapolated Tipping Points for Network Performance Improvement |      |       |
|---|------|-------|
|   | ~2x  | ~10x  |
| Internet – <b>High</b> packet delivery class                    | ~8ms | ~40ms |
| Internet – <b>Medium</b> packet delivery class                  | ~3ms | ~10ms |
| Internet – <b>Low</b> packet delivery class                     | <2ms | ~7ms  |

Table 6 – Restore: Equinix Fabric + FastConnect (1500 MTU) vs Internet, Tipping Points

| Total delay<br>(ms)<br>(including tc<br>imposed<br>delay) | Run 1<br>(mins) | Run 2<br>(mins) | Run 3<br>(mins) | Fabric + FastConnect              |                              | Internet - High              |                                       | Internet - Medium            |                                       | Internet - Low               |                                       |
|---|-----------------|-----------------|-----------------|-----------------------------------|------------------------------|------------------------------|---------------------------------------|------------------------------|---------------------------------------|------------------------------|---------------------------------------|
|   |                 |                 |                 | Avg.<br>Restore<br>Time<br>(mins) | Avg.<br>Throughput<br>(Gbps) | Avg.<br>Throughput<br>(Gbps) | Throughput<br>Performance<br>Multiple | Avg.<br>Throughput<br>(Gbps) | Throughput<br>Performance<br>Multiple | Avg.<br>Throughput<br>(Gbps) | Throughput<br>Performance<br>Multiple |
| <2  | 16.7            | 16.7            | 16.7            | 16.7                              | 8.7                          | 8.15                         | 1.1                                   | 6.74                         | 1.3                                   | 3.66                         | 2.4                                   |
| 5   | 17.2            | 17.1            | 17.2            | 17.2                              | 8.4                          | 6.34                         | 1.3                                   | 1.62                         | 5.2                                   | 1.01                         | 8.3                                   |
| 10  | 17.8            | 17.8            | 17.7            | 17.7                              | 8.2                          | 2.69                         | 3.0                                   | 0.79                         | 10.3                                  | 0.54                         | 15.1                                  |
| 20  | 19.5            | 19.4            | 19.3            | 19.4                              | 7.5                          | 1.27                         | 5.9                                   | 0.44                         | 17.1                                  | 0.29                         | 26.2                                  |
| 35  | 21.1            | 21.0            | 21.0            | 21.1                              | 6.9                          | 0.75                         | 9.2                                   | 0.27                         | 25.1                                  | 0.17                         | 39.4                                  |
| 50  | 22.9            | 23.1            | 23.0            | 23.0                              | 6.3                          | 0.49                         | 12.7                                  | 0.19                         | 33.2                                  | 0.13                         | 48.6                                  |
| 75  | 26.7            | 26.3            | 26.3            | 26.4                              | 5.5                          | 0.39                         | 14.1                                  | 0.14                         | 40.1                                  | 0.09                         | 61.0                                  |
| 100   | 31.0            | 31.4            | 31.0            | 31.1                              | 4.6                          | 0.33                         | 14.2                                  | 0.10                         | 44.7                                  | 0.06                         | 72.4                                  |

Table 7 – Restore: Equinix Fabric + FastConnect (1500 MTU) vs Internet, Raw Data

- The observed range for the **High** class is 1.1x through 14.2x
- The observed range for the **Medium** class is 1.3x through 44.7x
- The observed range for the **Low** class is 2.4x through 72.4x

## Backup: Equinix Fabric + FastConnect (9000 MTU) vs Internet

### Equinix Fabric + FastConnect (9000 MTU) vs. Internet

Test Scenario: 1 TB database Backup to OCI Object Storage

**Environment Setup**  
DB Backup Size: 1.06 TB  
RMAN Channels: 35  
FastConnect bandwidth: 10Gbps  
FastConnect MTU: 9000

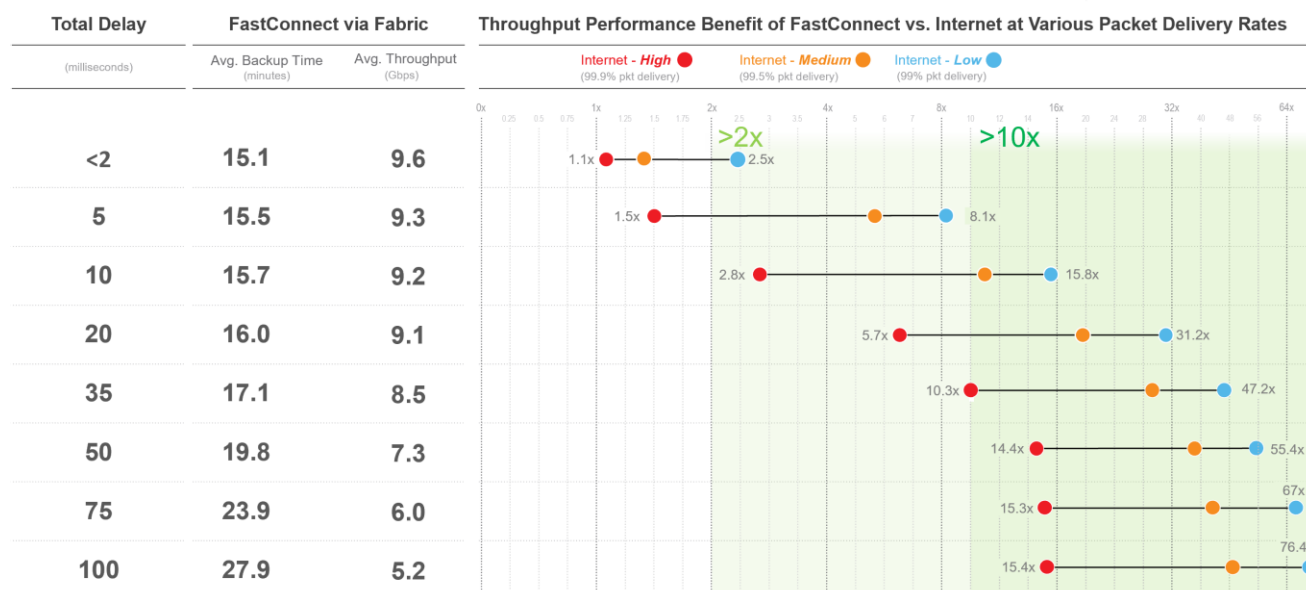


Figure 6 – Backup: Equinix Fabric + FastConnect (9000 MTU) vs Internet

| Extrapolated Tipping Points for Network Performance Improvement |      |       |
|---|------|-------|
|   | ~2x  | ~10x  |
| Internet – <b>High</b> packet delivery class                    | ~8ms | ~35ms |
| Internet – <b>Medium</b> packet delivery class                  | ~3ms | ~10ms |
| Internet – <b>Low</b> packet delivery class                     | <2ms | ~7ms  |

Table 8 – Backup: Equinix Fabric + FastConnect (9000 MTU) vs Internet, Tipping Points

| Total delay<br>(ms)<br>(including<br>tc imposed<br>delay) | Run 1<br>(mins) | Run 2<br>(mins) | Run 3<br>(mins) | Fabric + FastConnect             |                              | Internet - High              |                                       | Internet - Medium            |                                       | Internet - Low               |                                       |
|---|-----------------|-----------------|-----------------|----------------------------------|------------------------------|------------------------------|---------------------------------------|------------------------------|---------------------------------------|------------------------------|---------------------------------------|
|   |                 |                 |                 | Avg.<br>Backup<br>Time<br>(mins) | Avg.<br>Throughput<br>(Gbps) | Avg.<br>Throughput<br>(Gbps) | Throughput<br>Performance<br>Multiple | Avg.<br>Throughput<br>(Gbps) | Throughput<br>Performance<br>Multiple | Avg.<br>Throughput<br>(Gbps) | Throughput<br>Performance<br>Multiple |
| <2  | 15.1            | 15.2            | 15.1            | 15.1                             | 9.6                          | 8.33                         | 1.1                                   | 6.97                         | 1.4                                   | 3.77                         | 2.5                                   |
| 5   | 15.5            | 15.6            | 15.5            | 15.5                             | 9.3                          | 6.38                         | 1.5                                   | 1.65                         | 5.7                                   | 1.15                         | 8.1                                   |
| 10  | 15.7            | 15.7            | 15.7            | 15.7                             | 9.2                          | 3.24                         | 2.8                                   | 0.84                         | 11.0                                  | 0.58                         | 15.8                                  |
| 20  | 15.9            | 16.0            | 16.0            | 16.0                             | 9.1                          | 1.60                         | 5.7                                   | 0.46                         | 19.9                                  | 0.29                         | 31.2                                  |
| 35  | 17.2            | 16.9            | 17.1            | 17.1                             | 8.5                          | 0.83                         | 10.3                                  | 0.29                         | 29.4                                  | 0.18                         | 47.2                                  |
| 50  | 19.6            | 20.1            | 19.8            | 19.8                             | 7.3                          | 0.51                         | 14.4                                  | 0.19                         | 38.0                                  | 0.13                         | 55.4                                  |
| 75  | 24.0            | 24.1            | 23.7            | 23.9                             | 6.0                          | 0.40                         | 15.3                                  | 0.14                         | 43.4                                  | 0.09                         | 67.0                                  |
| 100   | 27.9            | 28.0            | 27.9            | 27.9                             | 5.2                          | 0.34                         | 15.4                                  | 0.11                         | 49.1                                  | 0.07                         | 76.4                                  |

Table 9 – Backup: Equinix Fabric + FastConnect (9000 MTU) vs Internet, Raw Data

- The observed range for the **High** class is 1.1x through 15.4x
- The observed range for the **Medium** class is 1.4x through 49.1x
- The observed range for the **Low** class is 2.5x through 76.4x

## Backup: Equinix Fabric + FastConnect (1500 MTU) vs Internet

### Equinix Fabric + FastConnect (1500 MTU) vs. Internet

Test Scenario: 1 TB database Backup to OCI Object Storage

#### Environment Setup

DB Backup Size: 1.06 TB  
RMAN Channels: 35  
FastConnect bandwidth: 10Gbps  
FastConnect MTU: 1500

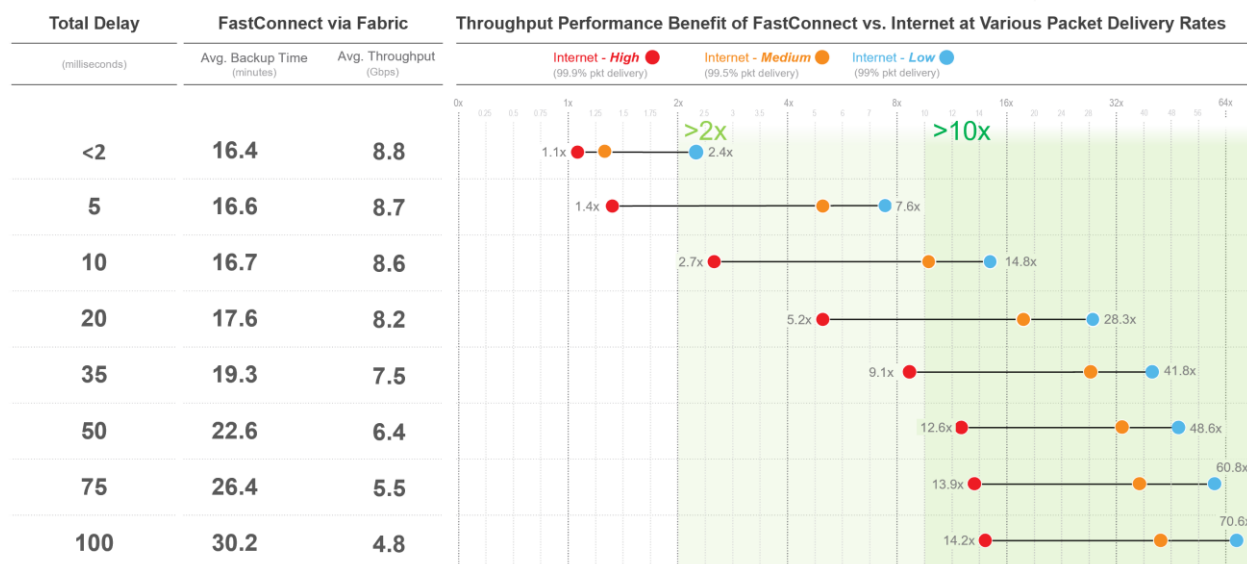


Figure 7 – Backup: Equinix Fabric + FastConnect (1500 MTU) vs Internet

| Extrapolated Tipping Points for Network Performance Improvement |      |       |
|---|------|-------|
|   | ~2x  | ~10x  |
| Internet – <b>High</b> packet delivery class                    | ~8ms | ~40ms |
| Internet – <b>Medium</b> packet delivery class                  | ~3ms | ~10ms |
| Internet – <b>Low</b> packet delivery class                     | <2ms | ~7ms  |

Table 10 – Backup: Equinix Fabric + FastConnect (1500 MTU) vs Internet, Tipping Points

| Total delay<br>(ms)<br>(including tc<br>imposed<br>delay) | Run 1<br>(mins) | Run 2<br>(mins) | Run 3<br>(mins) | Fabric + FastConnect             |                              | Internet - High              |                                       | Internet - Medium            |                                       | Internet - Low               |                                       |
|---|-----------------|-----------------|-----------------|----------------------------------|------------------------------|------------------------------|---------------------------------------|------------------------------|---------------------------------------|------------------------------|---------------------------------------|
|   |                 |                 |                 | Avg.<br>Backup<br>Time<br>(mins) | Avg.<br>Throughput<br>(Gbps) | Avg.<br>Throughput<br>(Gbps) | Throughput<br>Performance<br>Multiple | Avg.<br>Throughput<br>(Gbps) | Throughput<br>Performance<br>Multiple | Avg.<br>Throughput<br>(Gbps) | Throughput<br>Performance<br>Multiple |
| <2  | 16.4            | 16.4            | 16.3            | 16.4                             | 8.8                          | 8.33                         | 1.1                                   | 6.97                         | 1.3                                   | 3.77                         | 2.3                                   |
| 5   | 16.6            | 16.7            | 16.6            | 16.6                             | 8.7                          | 6.38                         | 1.4                                   | 1.65                         | 5.3                                   | 1.15                         | 7.6                                   |
| 10  | 16.7            | 16.8            | 16.7            | 16.7                             | 8.6                          | 3.24                         | 2.7                                   | 0.84                         | 10.3                                  | 0.58                         | 14.8                                  |
| 20  | 17.5            | 17.7            | 17.6            | 17.6                             | 8.2                          | 1.60                         | 5.2                                   | 0.46                         | 18.0                                  | 0.29                         | 28.3                                  |
| 35  | 19.1            | 19.4            | 19.3            | 19.3                             | 7.5                          | 0.83                         | 9.1                                   | 0.29                         | 26.1                                  | 0.18                         | 41.8                                  |
| 50  | 22.2            | 22.7            | 22.9            | 22.6                             | 6.4                          | 0.51                         | 12.6                                  | 0.19                         | 33.3                                  | 0.13                         | 48.6                                  |
| 75  | 26.2            | 26.6            | 26.3            | 26.4                             | 5.5                          | 0.40                         | 13.9                                  | 0.14                         | 39.4                                  | 0.09                         | 60.8                                  |
| 100   | 30.3            | 30.3            | 30.1            | 30.2                             | 4.8                          | 0.34                         | 14.2                                  | 0.11                         | 45.3                                  | 0.07                         | 70.6                                  |

Table 11 – Backup: Equinix Fabric + FastConnect (1500 MTU) vs Internet, Raw Data

- The observed range for the **High** class is 1.1x through 14.2x
- The observed range for the **Medium** class is 1.3x through 45.3x
- The observed range for the **Low** class is 2.3x through 70.6x

In the above scenarios, the packet delivery classes were not tested on FastConnect via Fabric on the premise that Equinix Fabric offers a very reliable and deterministic service.

Refer to the [Appendix](#) for further comparisons scenarios. Including where the **High** packet delivery class was also imposed on FastConnect via Fabric.

## Key Considerations

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Three key takeaways were identified during testing that should be considered for maximum performance:

- **Network Distance** – Physical distance to the cloud directly impacts latency and ultimately defines the overall network performance. Selection of a location is influenced by several factors, like geo-political boundaries, compliance and/or DR requirements, etc. Equinix plays a key role in proximity. Select the closest possible cloud region or move the on-prem database closer to a pre-selected cloud region. All Equinix datacenter locations can be found [here](#).
- **Cloud Interconnection** – For Enterprise workloads there are clear performance benefits such as deterministic routing and low latency provided by Equinix Fabric when compared to public Internet as demonstrated in this report. Equinix Fabric is also backed by a service level agreement ([SLA](#)) for availability and performance.
- **System Setup** – Every organization's deployment is different but there are some basic recommendations to help optimize performance including, but not limited to, implementing jumbo frames, increasing storage IOPS as much as feasible, and using parallel channels:
  - **Jumbo Frames (Networking)** – Unlike public internet, using FastConnect via Equinix Fabric provides enterprises enhanced control over their hybrid multicloud network. This includes the freedom to configure jumbo frames. As showcased in these tests, enabling jumbo frames will provide a network efficiency of up to 2x. However, it is important to note that this needs to be enabled end-to-end within the enterprise network in addition to cloud connectivity.
  - **Disk Throughput (Storage)** - For any RDBMS system, high disk IOPS is of paramount importance. Network bandwidth will not make a difference if the database's storage I/O is a bottleneck. The database server used for these tests was deployed on a bare metal instance with high performance NVMe disks. To further ensure maximum throughput, a RAID0 configuration was also implemented. Always ensure that on-premises network and storage systems can support at least the total bandwidth of your FastConnect circuit.
  - **Degree of Parallelism (Application)** - All tests listed in this whitepaper were done using 35 RMAN channels to ensure consistency.  
Note: Increasing the number of channels can be very useful. However, it is a balancing act and configuring a high number of parallel channels could result in unexpected or undesirable results within a network without proper tuning and testing. It is important to be aware of the impact multiple parallel channels can have on the utilization of the internal network as well. In short, use of parallel channels will need to be fine-tuned for a given environment.

The performance of your hybrid / multicloud environment is a complex topic. Equinix's Global Solutions Architect Team can play a key advisory role in planning / refining your cloud journey. For more information, or to talk to Equinix solutions team, please [contact us](#).

## Appendix

### Output from Ping, Traceroute and MTU settings

As part of testing, after setting up each type of network connectivity option, the results of ping, traceroute and MTU settings were captured. Below are relevant sections, captured results and inline annotations to highlight relevant information.

#### Connectivity Type: Internet

```
[oracle@oracle-poc oci_installer]$ ping objectstorage.us-sanjose-1.oraclecloud.com -c 10
PING objectstorage.us-sanjose-1.oci.oraclecloud.com (134.70.124.2) 56(84) bytes of data.
...
--- objectstorage.us-sanjose-1.oci.oraclecloud.com ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9013ms
rtt min/avg/max/mdev = 1.381/1.460/1.529/0.065 ms
### 1.46 ms avg RTT
[root@oracle-poc ~]# traceroute objectstorage.us-sanjose-1.oraclecloud.com
traceroute to objectstorage.us-sanjose-1.oraclecloud.com (134.70.124.2), 30 hops max, 60 byte
packets
 1  10.2.2.1 (10.2.2.1)  0.160 ms  0.144 ms  0.133 ms
 2  169.254.21.0 (169.254.21.0)  0.236 ms  0.251 ms  0.274 ms
 3  10.253.32.26 (10.253.32.26)  0.236 ms  10.253.32.28 (10.253.32.28)  0.212 ms  0.210 ms
 4  10.253.32.6 (10.253.32.6)  0.676 ms  10.253.32.2 (10.253.32.2)  1.153 ms  10.253.32.6
(10.253.32.6)  0.640 ms
 5  * 0.et-0-0-23.bsrl.sv5.packet.net (147.28.130.50)  1.767 ms *
 6  sjo-b21-link.ip.twelve99.net (62.115.180.192)  1.439 ms  1.424 ms sjo-b21-
link.ip.twelve99.net (62.115.180.194)  1.994 ms
 7  * * *
...
30  * * *
### Clearly using Equinix Metal's (f.k.a. packet) Internet
[oracle@oracle-poc oci_installer]$ ping objectstorage.us-sanjose-1.oraclecloud.com -c 2 -M do -s
8900
PING objectstorage.us-sanjose-1.oci.oraclecloud.com (134.70.124.2) 8900(8928) bytes of data.
ping: local error: Message too long, mtu=1500
ping: local error: Message too long, mtu=1500
...
--- objectstorage.us-sanjose-1.oci.oraclecloud.com ping statistics ---
2 packets transmitted, 0 received, +2 errors, 100% packet loss, time 999ms
### 1500 MTU in effect
```

#### Connectivity Type: Fabric + FastConnect with Jumbo Frames (9000 MTU)

```
[oracle@oracle-poc version5]$ ping objectstorage.us-sanjose-1.oraclecloud.com -c 10
PING objectstorage.us-sanjose-1.oci.oraclecloud.com (134.70.124.2) 56(84) bytes of data.
...
--- objectstorage.us-sanjose-1.oci.oraclecloud.com ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9016ms
rtt min/avg/max/mdev = 1.859/1.906/2.043/0.075 ms
### 1.906 ms avg RTT
[root@oracle-poc ~]# traceroute objectstorage.us-sanjose-1.oraclecloud.com
traceroute to objectstorage.us-sanjose-1.oraclecloud.com (134.70.124.2), 30 hops max, 60 byte
packets
 1  10.2.2.1 (10.2.2.1)  0.144 ms  0.129 ms  0.140 ms
 2  * * *
 3  * * *
 4  134.70.124.2 (134.70.124.2)  0.995 ms  0.925 ms  1.636 ms
#### Only 4 hops to the Cloud!!!
[oracle@oracle-poc version5]$ ping objectstorage.us-sanjose-1.oraclecloud.com -c 2 -M do -s 8900
traceroute objectstorage.us-sanjose-1.oraclecloud.com
ping objectstorage.us-sanjose-1.oraclecloud.com -c 10
PING objectstorage.us-sanjose-1.oci.oraclecloud.com (134.70.124.2) 8900(8928) bytes of data.
8908 bytes from 134.70.124.2 (134.70.124.2): icmp_seq=1 ttl=61 time=13.2 ms
8908 bytes from 134.70.124.2 (134.70.124.2): icmp_seq=2 ttl=61 time=2.03 ms

--- objectstorage.us-sanjose-1.oci.oraclecloud.com ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 2.031/7.658/13.286/5.628 ms
#### Jumbo Frames are in effect!!!
```

## Connectivity Type: FastConnect with Standard Data Frames (1500 MTU)

```
[root@oracle-poc ~]# ping objectstorage.us-sanjose-1.oraclecloud.com -c 10
PING objectstorage.us-sanjose-1.oc1.oraclecloud.com (134.70.124.2) 56(84) bytes of data.
...

--- objectstorage.us-sanjose-1.oc1.oraclecloud.com ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9015ms
rtt min/avg/max/mdev = 1.859/1.883/1.928/0.058 ms
### 1.883 ms avg RTT
[root@oracle-poc ~]# traceroute objectstorage.us-sanjose-1.oraclecloud.com
traceroute to objectstorage.us-sanjose-1.oraclecloud.com (134.70.124.2), 30 hops max, 60 byte packets
 1  10.2.2.1 (10.2.2.1)  0.128 ms  0.116 ms  0.075 ms
 2  * * *
 3  * * *
 4  134.70.124.2 (134.70.124.2)  1.343 ms  1.062 ms  1.444 ms
#### Only 4 hops to the Cloud!!!
[root@oracle-poc ~]# ping objectstorage.us-sanjose-1.oraclecloud.com -c 2 -M do -s 8900
PING objectstorage.us-sanjose-1.oc1.oraclecloud.com (134.70.124.2) 8900(8928) bytes of data.
ping: local error: Message too long, mtu=1500
ping: local error: Message too long, mtu=1500

--- objectstorage.us-sanjose-1.oc1.oraclecloud.com ping statistics ---
2 packets transmitted, 0 received, +2 errors, 100% packet loss, time 999ms
### 1500 MTU in effect
```

## RMAN Configuration

```
[oracle@oracle-poc oci_installer]$ rman target /

Recovery Manager: Release 19.0.0.0.0 - Production on Tue Aug 23 18:02:58 2022
Version 19.3.0.0.0

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connected to target database: EQXFC (DBID=2662249905)

RMAN> show all;

using target database control file instead of recovery catalog
RMAN configuration parameters for database with db_unique_name EQXFC are:
CONFIGURE RETENTION POLICY TO REDUNDANCY 1; # default
CONFIGURE BACKUP OPTIMIZATION ON;
CONFIGURE DEFAULT DEVICE TYPE TO DISK; # default
CONFIGURE CONTROLFILE AUTOBACKUP ON;
CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE SBT_TAPE TO '%F'; # default
CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '%F'; # default
CONFIGURE DEVICE TYPE 'SBT_TAPE' PARALLELISM 35 BACKUP TYPE TO BACKUPSET;
CONFIGURE DEVICE TYPE DISK PARALLELISM 1 BACKUP TYPE TO BACKUPSET; # default
CONFIGURE DATAFILE BACKUP COPIES FOR DEVICE TYPE SBT_TAPE TO 1; # default
CONFIGURE DATAFILE BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
CONFIGURE ARCHIVELOG BACKUP COPIES FOR DEVICE TYPE SBT_TAPE TO 1; # default
CONFIGURE ARCHIVELOG BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
CONFIGURE CHANNEL DEVICE TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/oracle/app/oracle/product/19.0.0/dbhome_1/lib/libopc.so,
SBT_PARMS=(OPC_PFILE=/oracle/app/oracle/product/19.0.0/dbhome_1/dbs/opcRMANTEST.ora)';
CONFIGURE MAXSETSIZE TO UNLIMITED;
CONFIGURE ENCRYPTION FOR DATABASE OFF; # default
CONFIGURE ENCRYPTION ALGORITHM 'AES128'; # default
CONFIGURE COMPRESSION ALGORITHM 'BASIC' AS OF RELEASE 'DEFAULT' OPTIMIZE FOR LOAD TRUE ; #
default
CONFIGURE RMAN OUTPUT TO KEEP FOR 7 DAYS; # default
CONFIGURE ARCHIVELOG DELETION POLICY TO NONE; # default
CONFIGURE SNAPSHOT CONTROLFILE NAME TO
'/oracle/app/oracle/product/19.0.0/dbhome_1/dbs/snapcf_EQXFC.f'; # default
```



## Output from Oracle's Diagnostic Tools

Diagnostic tools - [OSWatcher](#) and [netspeed.sh](#) were installed and run as root. OSWatcher captured diagnostics for the IO to the local disks and CPU usage, whereas netspeed.sh monitored the throughput on the network interface. Here are the results for each of the network paths when using tc setting of 0ms latency and 0% loss:

### Connectivity Type: Internet

#### For Restore

```
[root@oracle-poc ~]# ./netspeed.sh bond0
...
2022-07-22 19:54:04 |bond0 (MB/s) |Node1(tx): 12|TOTAL(tx): |Node1(rx):1156|TOTAL(rx):
2022-07-22 19:54:05 |bond0 (MB/s) |Node1(tx): 11|TOTAL(tx): |Node1(rx):1157|TOTAL(rx):
2022-07-22 19:54:06 |bond0 (MB/s) |Node1(tx): 11|TOTAL(tx): |Node1(rx):1156|TOTAL(rx):
2022-07-22 19:54:07 |bond0 (MB/s) |Node1(tx): 10|TOTAL(tx): |Node1(rx):1158|TOTAL(rx):
...
[root@oracle-poc ~]# cat /opt/oswatcher/oswbb/archive/oswiostat/oracle-poc_iostat_22.07.22.1900.dat
...
zzz ***Fri Jul 22 19:55:58 PDT 2022
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           5.64    0.00   6.45    0.51    0.00   87.40

Device:            rrqm/s   wrqm/s     r/s     w/s    rkB/s    kB/s avgrq-sz avgqu-sz   await r_await w_await svctm  %util
nvme0n1              0.00   1650.00    0.00  5022.00     0.00 564472.00   224.80     1.18    0.23    0.00    0.23   0.20   99.10
nvme1n1              0.00   1639.00    0.00  4970.00     0.00 564332.00   227.10     1.24    0.25    0.00    0.25   0.20   99.60
...
```

#### For Backup

```
[root@oracle-poc ~]# ./netspeed.sh bond0
...
2022-08-11 00:08:06 |bond0 (MB/s) |Node1(tx):1164|TOTAL(tx): |Node1(rx): 7|TOTAL(rx):
2022-08-11 00:08:07 |bond0 (MB/s) |Node1(tx):1153|TOTAL(tx): |Node1(rx): 13|TOTAL(rx):
2022-08-11 00:08:08 |bond0 (MB/s) |Node1(tx):1136|TOTAL(tx): |Node1(rx): 9|TOTAL(rx):
2022-08-11 00:08:09 |bond0 (MB/s) |Node1(tx):1165|TOTAL(tx): |Node1(rx): 8|TOTAL(rx):
...
[root@oracle-poc ~]# cat /opt/oswatcher/oswbb/archive/oswiostat/oracle-poc_iostat_22.08.11.0000.dat
...
zzz ***Thu Aug 11 00:16:31 PDT 2022
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           13.15    0.00   2.06    0.00    0.00   84.80

Device:            rrqm/s   wrqm/s     r/s     w/s    rkB/s    kB/s avgrq-sz avgqu-sz   await r_await w_await svctm  %util
nvme0n1              0.00    0.00 4994.00    0.00 616140.00     0.00   246.75     1.75    0.35    0.35    0.00   0.10   47.60
nvme1n1              0.00    0.00 4872.00    0.00 615924.00     0.00   252.84     1.71    0.35    0.35    0.00   0.10   47.80
...
```

### Connectivity Type: FastConnect with Jumbo Frames (9000 MTU)

#### For Restore

```
[root@oracle-poc ~]# ./netspeed.sh bond0
...
2022-07-20 20:44:19 |bond0 (MB/s) |Node1(tx): 4|TOTAL(tx): |Node1(rx):1185|TOTAL(rx):
2022-07-20 20:44:20 |bond0 (MB/s) |Node1(tx): 4|TOTAL(tx): |Node1(rx):1185|TOTAL(rx):
2022-07-20 20:44:21 |bond0 (MB/s) |Node1(tx): 3|TOTAL(tx): |Node1(rx):1178|TOTAL(rx):
2022-07-20 20:44:22 |bond0 (MB/s) |Node1(tx): 4|TOTAL(tx): |Node1(rx):1184|TOTAL(rx):
...
cat /opt/oswatcher/oswbb/archive/oswiostat/oracle-poc_iostat_22.07.20.2000.dat
...
zzz ***Wed Jul 20 20:55:47 PDT 2022
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           5.58    0.00   5.34    0.39    0.00   88.69

Device:            rrqm/s   wrqm/s     r/s     w/s    rkB/s    kB/s avgrq-sz avgqu-sz   await r_await w_await svctm  %util
nvme0n1              0.00   2406.00    0.00  5928.00     0.00 619620.00   209.05     0.75    0.13    0.00    0.13   0.17  100.00
nvme1n1              0.00   2383.00    0.00  5919.00     0.00 619636.00   209.37     0.79    0.13    0.00    0.13   0.17  100.00
...
## As disks utilization is 100% capacity 35 channels is the sweet spot for this environment. Adding more channels will not help!
```

#### For Backup

```
[root@oracle-poc ~]# ./netspeed.sh bond0
...
2022-08-10 15:48:54 |bond0 (MB/s) |Node1(tx):1213|TOTAL(tx): |Node1(rx): 2|TOTAL(rx):
2022-08-10 15:48:55 |bond0 (MB/s) |Node1(tx):1190|TOTAL(tx): |Node1(rx): 3|TOTAL(rx):
2022-08-10 15:48:56 |bond0 (MB/s) |Node1(tx):1189|TOTAL(tx): |Node1(rx): 2|TOTAL(rx):
2022-08-10 15:48:57 |bond0 (MB/s) |Node1(tx):1185|TOTAL(tx): |Node1(rx): 2|TOTAL(rx):
...
[root@oracle-poc ~]# cat /opt/oswatcher/oswbb/archive/oswiostat/oracle-poc_iostat_22.08.10.1500.dat
...
zzz ***Wed Aug 10 15:58:38 PDT 2022
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           14.39    0.00   2.18    0.00    0.00   83.43

Device:            rrqm/s   wrqm/s     r/s     w/s    rkB/s    kB/s avgrq-sz avgqu-sz   await r_await w_await svctm  %util
nvme0n1              0.00    0.00 5998.00    1.00 754048.00    16.00   251.40     2.01    0.33    0.33    0.00   0.09   55.90
nvme1n1              0.00    0.00 5979.00    1.00 753920.00    16.00   252.15     2.04    0.34    0.34    0.00   0.09   55.80
...
```



## Connectivity Type: FastConnect with 1500 MTU

### For Restore

```
[root@oracle-poc ~]# ./netspeed.sh bond0
...
2022-07-21 12:58:41 |bond0 (MB/s) |Node1(tx): 14|TOTAL(tx): |Node1(rx):1152|TOTAL(rx):
2022-07-21 12:58:42 |bond0 (MB/s) |Node1(tx): 13|TOTAL(tx): |Node1(rx):1154|TOTAL(rx):
2022-07-21 12:58:43 |bond0 (MB/s) |Node1(tx): 13|TOTAL(tx): |Node1(rx):1154|TOTAL(rx):
2022-07-21 12:58:44 |bond0 (MB/s) |Node1(tx): 14|TOTAL(tx): |Node1(rx):1152|TOTAL(rx):
...
cat /opt/oswatcher/oswbb/archive/oswiostat/oracle-poc_iostat_22.07.21.1300.dat
...
zzz ***Thu Jul 21 13:02:12 PDT 2022
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           5.42    0.00   6.31    0.62    0.00   87.66

Device:            rrqm/s   wrqm/s     r/s     w/s    rkB/s    kB/s   avgrq-sz  avgqu-sz   await  r_await  w_await  svctm  %util
nvme0n1             0.00   1599.00    0.00  4987.00    0.00 565508.00   226.79     1.23    0.25    0.00    0.25   0.20   99.10
nvme1n1             0.00   1617.00    0.00  4982.00    0.00 565676.00   227.09     1.20    0.24    0.00    0.24   0.20   99.30
...
```

### For Backup

```
[root@oracle-poc ~]# ./netspeed.sh bond0
...
2022-08-10 17:12:32 |bond0 (MB/s) |Node1(tx):1157|TOTAL(tx): |Node1(rx): 10|TOTAL(rx):
2022-08-10 17:12:33 |bond0 (MB/s) |Node1(tx):1160|TOTAL(tx): |Node1(rx): 14|TOTAL(rx):
2022-08-10 17:12:34 |bond0 (MB/s) |Node1(tx):1155|TOTAL(tx): |Node1(rx): 13|TOTAL(rx):
2022-08-10 17:12:35 |bond0 (MB/s) |Node1(tx):1156|TOTAL(tx): |Node1(rx): 12|TOTAL(rx):
...
[root@oracle-poc ~]# cat /opt/oswatcher/oswbb/archive/oswiostat/oracle-poc_iostat_22.08.10.1700.dat
...
zzz ***Wed Aug 10 17:12:46 PDT 2022
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           15.27    0.00   2.82    0.00    0.00   81.91

Device:            rrqm/s   wrqm/s     r/s     w/s    rkB/s    kB/s   avgrq-sz  avgqu-sz   await  r_await  w_await  svctm  %util
nvme0n1             0.00    0.00  5342.00   45.00 666944.00   680.00   247.86     1.68    0.31    0.31    0.00   0.09   49.00
nvme1n1             0.00    0.00  5254.00   25.00 667504.00   388.00   253.04     1.73    0.33    0.33    0.00   0.09   48.00
...
```

## Additional Results

The results depicted in the [summary](#) were observed when loss of 0.1% was imposed on internet. Here are the results when 1% packet loss is imposed.

Scenario Tested: 1 TB database Restore from OCI Object Storage

|  | Fabric + FastConnect<br>Restore time<br>(minutes) | Internet<br>Restore time<br>(minutes)  | Time<br>Saved<br>(up to minutes) | Multiple<br>Faster<br>(up to -x) |
|--|---|--|----------------------------------|----------------------------------|
| <b>Overall</b>                                 | 16<br>[<2ms, 0%, 9000] <sup>1</sup>               | 2253<br>[100ms, 1%, 1500] <sup>1</sup> | 2237 (37 hours)                  | 141x                             |
| Breakdown of individual performance parameters |   |  |                                  |                                  |
| Cloud Proximity                                | 17<br>[<2ms, 0%, 1500] <sup>1</sup>               | 48<br>[100ms, 0%, 1500] <sup>1</sup>   | 31                               | 3x                               |
| Packet Delivery                                | 31<br>[100ms, 0%, 1500] <sup>1</sup>              | 2253<br>[100ms, 1%, 1500] <sup>1</sup> | 2222                             | 72x                              |
| Jumbo Frames                                   | 28<br>[100ms, 0%, 9000] <sup>1</sup>              | 48<br>[100ms, 0%, 1500] <sup>1</sup>   | 20                               | 2x                               |

<sup>1</sup> Delay, Packet Loss %, Maximum Transmission Unit (MTU)

Here are the results at 1% packet loss when Packet Delivery and jumbo frames are combined into a single performance parameter when using Equinix Fabric.

Scenario Tested: 1 TB database Restore from OCI Object Storage

|  | Fabric + FastConnect<br>Restore time<br>(minutes) | Internet<br>Restore time<br>(minutes)  | Time<br>Saved<br>(up to minutes) | Multiple<br>Faster<br>(up to -x) |
|--|---|--|----------------------------------|----------------------------------|
| <b>Overall</b>                                 | 16<br>[<2ms, 0%, 9000] <sup>1</sup>               | 2253<br>[100ms, 1%, 1500] <sup>1</sup> | 2237 (37 hours)                  | 141x                             |
| Breakdown of individual performance parameters |   |  |                                  |                                  |
| Cloud Proximity                                | 17<br>[<2ms, 0%, 1500] <sup>1</sup>               | 48<br>[100ms, 0%, 1500] <sup>1</sup>   | 31                               | 3x                               |
| Equinix Fabric                                 | 31<br>[100ms, 0%, 9000] <sup>1</sup>              | 2253<br>[100ms, 1%, 1500] <sup>1</sup> | 2222                             | 79x                              |

<sup>1</sup> Delay, Packet Loss %, Maximum Transmission Unit (MTU)

Similarly, here are the results at 0.1% packet loss when Packet Delivery and jumbo frames are combined into a single performance parameter when using Equinix Fabric.

Scenario Tested: 1 TB database Restore from OCI Object Storage

|  | Fabric + FastConnect<br>Restore time<br>(minutes) | Internet<br>Restore time<br>(minutes)   | Time<br>Saved<br>(up to minutes) | Multiple<br>Faster<br>(up to -x) |
|--|---|---|----------------------------------|----------------------------------|
| <b>Overall</b>                                 | 16<br>[<2ms, 0%, 9000] <sup>1</sup>               | 443<br>[100ms, 0.1%, 1500] <sup>1</sup> | 427 (7 hours)                    | 28x                              |
| Breakdown of individual performance parameters |   |   |                                  |                                  |
| Cloud Proximity                                | 17<br>[<2ms, 0%, 1500] <sup>1</sup>               | 48<br>[100ms, 0%, 1500] <sup>1</sup>    | 31                               | 3x                               |
| Equinix Fabric                                 | 28<br>[100ms, 0%, 9000] <sup>1</sup>              | 443<br>[100ms, 0.1%, 1500] <sup>1</sup> | 412                              | 16x                              |

<sup>1</sup> Delay, Packet Loss %, Maximum Transmission Unit (MTU)

In the comparison scenarios showcased under the [results](#) section, there were no packet delivery classes being imposed on FastConnect via Equinix Fabric. In the following scenarios, the **High** packet delivery class was imposed on the FastConnect connection. While Equinix Fabric has historically provided a much higher delivery rate than 99.9%, the following tests were conducted at the Equinix Fabric's committed packet delivery SLA of 99.9%.

#### *Restore: Fabric + FastConnect (9000 MTU & High Class) vs. Internet*

| Total delay (ms)<br>(including tc imposed delay) | Run 1 (mins) | Run 2 (mins) | Run 3 (mins) | Fabric + FastConnect – High |                        | Internet – High        |                                 | Internet – Medium      |                                 | Internet - Low         |                                 |
|--|--------------|--------------|--------------|-----------------------------|------------------------|------------------------|---------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|  |              |              |              | Avg. Restore Time (mins)    | Avg. Throughput (Gbps) | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple |
| <2   | 16.0         | 16.0         | 16.0         | 16.0                        | 9.1                    | 8.15                   | 1.1                             | 6.74                   | 1.3                             | 3.66                   | 2.5                             |
| 5  | 16.3         | 16.2         | 16.3         | 16.3                        | 8.9                    | 6.34                   | 1.4                             | 1.62                   | 5.5                             | 1.01                   | 8.8                             |
| 10   | 17.2         | 17.2         | 17.1         | 17.2                        | 8.4                    | 2.69                   | 3.1                             | 0.79                   | 10.6                            | 0.54                   | 15.6                            |
| 20   | 25.6         | 25.6         | 25.5         | 25.6                        | 5.7                    | 1.27                   | 4.5                             | 0.44                   | 13.0                            | 0.29                   | 19.8                            |
| 35   | 41.5         | 41.1         | 41.2         | 41.2                        | 3.5                    | 0.75                   | 4.7                             | 0.27                   | 12.8                            | 0.17                   | 20.1                            |
| 50   | 53.4         | 53.1         | 52.9         | 53.1                        | 2.7                    | 0.49                   | 5.5                             | 0.19                   | 14.4                            | 0.13                   | 21.1                            |
| 75   | 66.8         | 66.5         | 67.8         | 67.0                        | 2.2                    | 0.39                   | 5.5                             | 0.14                   | 15.8                            | 0.09                   | 24.0                            |
| 100  | 81.7         | 81.4         | 80.9         | 81.3                        | 1.8                    | 0.33                   | 5.5                             | 0.10                   | 17.1                            | 0.06                   | 27.7                            |

#### *Restore: Fabric + FastConnect (1500 MTU & High Class) vs. Internet*

| Total delay (ms)<br>(including tc imposed delay) | Run 1 (mins) | Run 2 (mins) | Run 3 (mins) | Fabric + FastConnect – High |                        | Internet – High        |                                 | Internet – Medium      |                                 | Internet - Low         |                                 |
|--|--------------|--------------|--------------|-----------------------------|------------------------|------------------------|---------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|  |              |              |              | Avg. Restore Time (mins)    | Avg. Throughput (Gbps) | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple |
| <2   | 17.1         | 16.8         | 17.0         | 17.0                        | 8.5                    | 8.15                   | 1.0                             | 6.74                   | 1.3                             | 3.66                   | 2.3                             |
| 5  | 22.9         | 22.2         | 22.5         | 22.5                        | 6.4                    | 6.34                   | 1.0                             | 1.62                   | 4.0                             | 1.01                   | 6.3                             |
| 10   | 52.7         | 51.8         | 52.2         | 52.2                        | 2.8                    | 2.69                   | 1.0                             | 0.79                   | 3.5                             | 0.54                   | 5.1                             |
| 20   | 104.5        | 102.7        | 101.9        | 103.0                       | 1.4                    | 1.27                   | 1.1                             | 0.44                   | 3.2                             | 0.29                   | 4.9                             |
| 35   | 183.1        | 182.1        | 184.6        | 183.3                       | 0.8                    | 0.75                   | 1.1                             | 0.27                   | 2.9                             | 0.17                   | 4.5                             |
| 50   | 242.0        | 247.1        | 239.9        | 243.0                       | 0.6                    | 0.49                   | 1.2                             | 0.19                   | 3.1                             | 0.13                   | 4.6                             |
| 75   | 316.5        | 330.3        | 310.2        | 319.0                       | 0.5                    | 0.39                   | 1.2                             | 0.14                   | 3.3                             | 0.09                   | 5.0                             |
| 100  | 358.0        | 368.8        | 349.8        | 358.9                       | 0.4                    | 0.33                   | 1.2                             | 0.10                   | 3.9                             | 0.06                   | 6.3                             |

#### *Backup: Fabric + FastConnect (9000 MTU & High Class) vs. Internet*

| Total delay (ms)<br>(including tc imposed delay) | Run 1 (mins) | Run 2 (mins) | Run 3 (mins) | Fabric + FastConnect – High |                        | Internet – High        |                                 | Internet – Medium      |                                 | Internet - Low         |                                 |
|--|--------------|--------------|--------------|-----------------------------|------------------------|------------------------|---------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|  |              |              |              | Avg. Backup Time (mins)     | Avg. Throughput (Gbps) | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple |
| <2   | 15.4         | 15.4         | 15.5         | 15.4                        | 9.4                    | 8.33                   | 1.1                             | 6.97                   | 1.3                             | 3.77                   | 2.5                             |
| 5  | 15.7         | 15.7         | 15.7         | 15.7                        | 9.2                    | 6.38                   | 1.4                             | 1.65                   | 5.6                             | 1.15                   | 8.0                             |
| 10   | 16.9         | 16.8         | 16.9         | 16.9                        | 8.6                    | 3.24                   | 2.7                             | 0.84                   | 10.2                            | 0.58                   | 14.7                            |
| 20   | 23.7         | 24.0         | 23.9         | 23.9                        | 6.1                    | 1.60                   | 3.8                             | 0.46                   | 13.3                            | 0.29                   | 20.9                            |
| 35   | 39.7         | 39.8         | 38.7         | 39.4                        | 3.7                    | 0.83                   | 4.4                             | 0.29                   | 12.8                            | 0.18                   | 20.4                            |
| 50   | 49.3         | 49.8         | 50.1         | 49.7                        | 2.9                    | 0.51                   | 5.7                             | 0.19                   | 15.2                            | 0.13                   | 22.1                            |
| 75   | 65.2         | 64.6         | 64.4         | 64.7                        | 2.2                    | 0.40                   | 5.7                             | 0.14                   | 16.1                            | 0.09                   | 24.8                            |
| 100  | 79.5         | 78.6         | 79.4         | 79.2                        | 1.8                    | 0.34                   | 5.4                             | 0.11                   | 17.3                            | 0.07                   | 27.0                            |

### Backup: Fabric + FastConnect (1500 MTU & High Class) vs. Internet

| Total delay (ms) (including tc imposed delay) | Run 1 (mins) | Run 2 (mins) | Run 3 (mins) | Fabric + FastConnect – High |                        | Internet – High        |                                 | Internet – Medium      |                                 | Internet - Low         |                                 |
|---|--------------|--------------|--------------|-----------------------------|------------------------|------------------------|---------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|   |              |              |              | Avg. Backup Time (mins)     | Avg. Throughput (Gbps) | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple |
| <2  | 16.6         | 16.5         | 16.6         | 16.6                        | 8.7                    | 8.33                   | 1.0                             | 6.97                   | 1.3                             | 3.77                   | 2.3                             |
| 5   | 21.6         | 22.0         | 21.9         | 21.8                        | 6.6                    | 6.38                   | 1.0                             | 1.65                   | 4.0                             | 1.15                   | 5.8                             |
| 10  | 44.5         | 45.2         | 44.3         | 44.7                        | 3.2                    | 3.24                   | 1.0                             | 0.84                   | 3.9                             | 0.58                   | 5.5                             |
| 20  | 83.4         | 84.2         | 84.9         | 84.2                        | 1.7                    | 1.60                   | 1.1                             | 0.46                   | 3.8                             | 0.29                   | 5.9                             |
| 35  | 157.9        | 155.9        | 156.2        | 156.7                       | 0.9                    | 0.83                   | 1.1                             | 0.29                   | 3.2                             | 0.18                   | 5.1                             |
| 50  | 227.2        | 235.7        | 242.0        | 235.0                       | 0.6                    | 0.51                   | 1.2                             | 0.19                   | 3.2                             | 0.13                   | 4.7                             |
| 75  | 288.8        | 274.8        | 285.9        | 283.2                       | 0.5                    | 0.40                   | 1.3                             | 0.14                   | 3.7                             | 0.09                   | 5.7                             |
| 100   | 291.2        | 348.1        | 358.0        | 332.4                       | 0.4                    | 0.34                   | 1.3                             | 0.11                   | 4.1                             | 0.07                   | 6.4                             |

The sweet spot for restore workload testing was 35 channels, as mentioned in the [diagnostics section](#), backups had more room to grow and were also tested at **65 channels**. Here are the performance results using 65 channels for backups.

### Backup 65 channels: Fabric + FastConnect (9000 MTU) vs. Internet

| Total delay (ms) (including tc imposed delay) | Run 1 (mins) | Run 2 (mins) | Run 3 (mins) | Fabric + FastConnect – High |                        | Internet – High        |                                 | Internet – Medium      |                                 | Internet - Low         |                                 |
|---|--------------|--------------|--------------|-----------------------------|------------------------|------------------------|---------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|   |              |              |              | Avg. Backup Time (mins)     | Avg. Throughput (Gbps) | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple |
| <2  | 16.4         | 16.4         | 16.2         | 16.3                        | 9.53                   | 8.86                   | 1.1                             | 8.83                   | 1.1                             | 6.20                   | 1.5                             |
| 5   | 16.3         | 16.4         | 16.5         | 16.4                        | 9.49                   | 8.22                   | 1.2                             | 3.67                   | 2.6                             | 2.03                   | 4.7                             |
| 10  | 16.5         | 16.5         | 16.4         | 16.5                        | 9.45                   | 4.95                   | 1.9                             | 1.54                   | 6.1                             | 0.91                   | 10.4                            |
| 20  | 16.3         | 16.5         | 16.7         | 16.5                        | 9.43                   | 2.41                   | 3.9                             | 0.72                   | 13.1                            | 0.49                   | 19.2                            |
| 35  | 16.6         | 16.4         | 16.4         | 16.5                        | 9.43                   | 1.33                   | 7.1                             | 0.45                   | 21.1                            | 0.30                   | 31.6                            |
| 50  | 17.0         | 17.1         | 17.1         | 17.1                        | 9.12                   | 0.77                   | 11.8                            | 0.33                   | 27.4                            | 0.21                   | 42.8                            |
| 75  | 17.5         | 17.7         | 17.3         | 17.5                        | 8.89                   | 0.60                   | 14.7                            | 0.23                   | 38.4                            | 0.15                   | 59.2                            |
| 100   | 18.8         | 18.9         | 19.1         | 18.9                        | 8.22                   | 0.54                   | 15.2                            | 0.18                   | 45.6                            | 0.12                   | 70.2                            |

### Backup 65 channels: Fabric + FastConnect (1500 MTU) vs. Internet

| Total delay (ms) (including tc imposed delay) | Run 1 (mins) | Run 2 (mins) | Run 3 (mins) | Fabric + FastConnect – High |                        | Internet – High        |                                 | Internet – Medium      |                                 | Internet - Low         |                                 |
|---|--------------|--------------|--------------|-----------------------------|------------------------|------------------------|---------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|   |              |              |              | Avg. Backup Time (mins)     | Avg. Throughput (Gbps) | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple |
| <2  | 17.4         | 17.6         | 17.5         | 17.5                        | 8.89                   | 8.86                   | 1.0                             | 8.83                   | 1.0                             | 6.20                   | 1.4                             |
| 5   | 17.6         | 17.7         | 17.6         | 17.6                        | 8.83                   | 8.22                   | 1.1                             | 3.67                   | 2.4                             | 2.03                   | 4.4                             |
| 10  | 17.6         | 17.8         | 17.8         | 17.7                        | 8.78                   | 4.95                   | 1.8                             | 1.54                   | 5.7                             | 0.91                   | 9.6                             |
| 20  | 17.9         | 18.0         | 18.0         | 18.0                        | 8.66                   | 2.41                   | 3.6                             | 0.72                   | 12.1                            | 0.49                   | 17.6                            |
| 35  | 18.4         | 18.2         | 18.6         | 18.4                        | 8.46                   | 1.33                   | 6.4                             | 0.45                   | 18.9                            | 0.30                   | 28.3                            |
| 50  | 18.7         | 18.6         | 18.7         | 18.7                        | 8.34                   | 0.77                   | 10.8                            | 0.33                   | 25.1                            | 0.21                   | 39.1                            |
| 75  | 19.1         | 19.1         | 19.5         | 19.2                        | 8.09                   | 0.60                   | 13.4                            | 0.23                   | 35.0                            | 0.15                   | 53.9                            |
| 100   | 19.9         | 19.8         | 19.6         | 19.8                        | 7.87                   | 0.54                   | 14.5                            | 0.18                   | 43.7                            | 0.12                   | 67.2                            |

### Backup 65 channels: Fabric + FastConnect (9000 MTU & High Class) vs. Internet

| Total delay (ms)<br>(including tc imposed delay) | Run 1 (mins) | Run 2 (mins) | Run 3 (mins) | Fabric + FastConnect – High |                        | Internet – High        |                                 | Internet – Medium      |                                 | Internet - Low         |                                 |
|--|--------------|--------------|--------------|-----------------------------|------------------------|------------------------|---------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|  |              |              |              | Avg. Backup Time (mins)     | Avg. Throughput (Gbps) | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple |
| <2   | 16.3         | 16.4         | 16.3         | 16.3                        | 9.53                   | 8.86                   | 1.1                             | 8.83                   | 1.1                             | 6.20                   | 1.5                             |
| 5  | 16.3         | 16.3         | 16.5         | 16.4                        | 9.51                   | 8.22                   | 1.2                             | 3.67                   | 2.6                             | 2.03                   | 4.7                             |
| 10   | 16.4         | 16.4         | 16.4         | 16.4                        | 9.49                   | 4.95                   | 1.9                             | 1.54                   | 6.2                             | 0.91                   | 10.4                            |
| 20   | 17.3         | 17.9         | 17.7         | 17.6                        | 8.83                   | 2.41                   | 3.7                             | 0.72                   | 12.3                            | 0.49                   | 18.0                            |
| 35   | 23.9         | 26.9         | 27.1         | 26.0                        | 5.99                   | 1.33                   | 4.5                             | 0.45                   | 13.4                            | 0.30                   | 20.1                            |
| 50   | 44.1         | 44.1         | 38.3         | 42.2                        | 3.69                   | 0.77                   | 4.8                             | 0.33                   | 11.1                            | 0.21                   | 17.3                            |
| 75   | 63.2         | 62.5         | 52.1         | 59.3                        | 2.63                   | 0.60                   | 4.3                             | 0.23                   | 11.3                            | 0.15                   | 17.5                            |
| 100  | 64.0         | 64.3         | 64.6         | 64.3                        | 2.42                   | 0.54                   | 4.5                             | 0.18                   | 13.4                            | 0.12                   | 20.7                            |

### Backup 65 channels: Fabric + FastConnect (1500 MTU & High Class) vs. Internet

| Total delay (ms)<br>(including tc imposed delay) | Run 1 (mins) | Run 2 (mins) | Run 3 (mins) | Fabric + FastConnect – High |                        | Internet – High        |                                 | Internet – Medium      |                                 | Internet - Low         |                                 |
|--|--------------|--------------|--------------|-----------------------------|------------------------|------------------------|---------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|  |              |              |              | Avg. Backup Time (mins)     | Avg. Throughput (Gbps) | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple | Avg. Throughput (Gbps) | Throughput Performance Multiple |
| <2   | 17.6         | 17.4         | 17.5         | 17.5                        | 8.89                   | 8.86                   | 1.0                             | 8.83                   | 1.0                             | 6.20                   | 1.4                             |
| 5  | 18.8         | 18.8         | 18.6         | 18.7                        | 8.31                   | 8.22                   | 1.0                             | 3.67                   | 2.3                             | 2.03                   | 4.1                             |
| 10   | 29.8         | 29.7         | 29.8         | 29.8                        | 5.23                   | 4.95                   | 1.1                             | 1.54                   | 3.4                             | 0.91                   | 5.7                             |
| 20   | 60.5         | 59.5         | 60.0         | 60.0                        | 2.59                   | 2.41                   | 1.1                             | 0.72                   | 3.6                             | 0.49                   | 5.3                             |
| 35   | 116.5        | 116.7        | 117.7        | 117.0                       | 1.33                   | 1.33                   | 1.0                             | 0.45                   | 3.0                             | 0.21                   | 6.2                             |
| 50   | 186.9        | 188.0        | 187.5        | 187.5                       | 0.83                   | 0.77                   | 1.1                             | 0.33                   | 2.5                             | 0.21                   | 3.9                             |
| 75   | 259.0        | 249.5        | 254.3        | 254.3                       | 0.61                   | 0.60                   | 1.0                             | 0.23                   | 2.6                             | 0.15                   | 4.1                             |
| 100  | 283.6        | 280.7        | 282.2        | 282.2                       | 0.55                   | 0.54                   | 1.0                             | 0.18                   | 3.1                             | 0.12                   | 4.7                             |

## References

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## Acronyms

| Acronyms    | Definitions  |
|-------------|--|
| DB          | Database   |
| DOP         | Degree of Parallelism  |
| ECMP        | Equal-cost multipath   |
| Jumbo Frame | A jumbo frame is an Ethernet frame with a payload greater than the standard maximum transmission unit (MTU) of 1,500 bytes   |
| MTU         | Maximum Transmission Unit: The measurement representing the largest data packet that a network-connected device will accept. |
| OCI         | Oracle Cloud Infrastructure  |
| RMAN        | Recovery Manager tool from Oracle  |
| ROI         | Return On Investment   |
| RTT         | Round-Trip Time  |
| RTD         | Round-Trip Delay   |
| Swingbench  | Swingbench is a Java based load generator for Oracle. It was used to populate dummy data inside the Oracle database.         |
| TB          | Terabytes  |
| TC          | Linux's Traffic Controller   |
| TLS         | Transport Layer Security   |
| DR          | Disaster Recovery  |
| ms          | Milliseconds   |
| Fabric      | Equinix Fabric   |
| TSPITR      | RMAN Tablespace Point-in-Time Recovery   |
| NIC         | Network Interface Card   |
| VCN         | Virtual Cloud Network  |
| DOP         | Degree of Parallelism  |
| NetEm       | Network Emulator   |