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ZVR-ZSB-7.0
Zerto Scale And Benchmarking Guidelines

This document provides the user with an understanding of the performance and scale capabilities of Zerto Virtual Replication. It presents best practices regarding performance and scale considerations when designing a Zerto Virtual Replication solution. The document should not be used to determine precise sizing of a specific configuration. For assistance with final system specifications to meet your requirements, consult your Zerto sales representative. Users should be familiar with Zerto Virtual Replication and have basic knowledge of storage technologies and virtualization technologies.

The following guidelines are provided:

- **Zerto Performance Fundamentals on page 3**
- **Zerto Sizing Limits on page 13**
- **Zerto Benchmarking Test Results on page 13**
- **Estimating WAN Bandwidth for VMware and Hyper-V on page 20**

Related Documentation:

- Installation Guides
- Administration Guides
- Using the Zerto WAN Estimator
- Enterprise Guidelines (Prerequisites and Requirements)
- Release Notes

Zerto Performance Fundamentals

- **Protected VMs on page 4**
- **Application IOs on page 4**
- **What is a VPG? on page 4**
- **Disk Considerations on page 4**
- **VRA Considerations on page 4**
- **ZVM Considerations on page 4**
- **ZVM Database Considerations on page 5**
- **Recommendations and Considerations When Using an External SQL Server on page 7**
- **ZCC Considerations on page 7**
- **Public Cloud Considerations on page 9**
- **Networking Considerations on page 10**
- **WAN Optimization Considerations on page 10**
Protected VMs

Protected VMs are the VMs on the production site that are being protected on the recovery site by Zerto Virtual Replication. The Zerto Virtual Manager on the production site is paired with a ZVM (or ZVM in a ZCA) on the recovery site.

Application IOs

The VRA only replicates application writes to its peer VRA or ZCA. To estimate the performance of a VRA’s replication load, only the application writes to paired VRAs need to be considered. On the recovery site VRA, the performance is estimated from all the replication streams from peer VRAs plus the journal writes.

What is a VPG?

A VPG is a logical grouping of VMs and their associated disks that is replicated together in a way that ensures write-order consistency.

Disk Considerations

Each VRA can manage a set maximum of volumes, whether these are volumes being protected or recovered.

You can only protect a virtual machine in a VPG when the virtual machine has no more than 60 disks.

- In VMware vSphere environments, this requires 4 SCSI controllers each with a maximum of 15 disks.
- In Microsoft Hyper-V environments, this can be a combination of IDE and SCSI disks, where the total of IDE and SCSI disks must not exceed 60 disks. Each virtual machine can have up to:
  - 2 IDE controllers each with a maximum of 4 IDE disks
  - 4 SCSI controllers each with a maximum of 15 disks

VRA Considerations

A VRA is a Zerto Virtual Replication virtual machine that manages the replication of virtual machines across sites. A VRA must be installed on every hypervisor host with virtual machines that require protecting in the protected site and on every host to which VMs may recover to in the recovery site. The VRA compresses the data that is passed across the WAN from the protected site to the recovery site.

Each VRA can be configured with 1 or 2 vCPUs.

The VRA memory allocation can range from 1GB to 16GB. The amount of memory allocated to a VRA when it is installed determines the maximum buffer size for the VRA for buffering IOs written by the protected virtual machines before the writes are sent over the network to the recovery VRA. The recovery
VRA also buffers the incoming IOs until they are written to the journal. If a buffer becomes full, a Bitmap Sync is performed after space is freed up in the buffer. Depending on the replication rate from the production site VRA, you can estimate the number of vCPUs and memory. If the production site VRA is replicating to multiple VRAs or replicating multiple VMs with a high change rate (over 100MBPS), then consider allocating more vCPUs and memory to the VRA.

On the recovery site VRA, the number of vCPUs and memory is like the production site VRA except the allocation needs to accommodate the replication data being written to the mirror disks, journal updates and checkpoints. If there are multiple production VRAs replicating to a single recovery site VRA and generating high incoming traffic to the recovery VRA, then consider allocating more vCPUs and memory to the recovery VRA.

**ZVM Considerations**

Each ZVM monitors the virtualization management system such as VMware vCenter and Microsoft System Center for status of the protected VMs.

ZVM performance can be impacted by:

- Number of VPGs managed by the ZVM
- Ongoing error states & alerts
- ZVM or VRA restarts & intermediate disconnection issues
- Number of peers & VRA
- Use of APIs

**ZVM Database Considerations**

Zerto Virtual Replication requires a database to manage information for disaster recovery. Zerto requires a database to manage data for scalable business continuity software solutions.
During the Zerto Virtual Manager installation, the user is able to select whether to install and use an embedded SQL Server (localDB) as the database.

Alternatively, and also during the installation, the user is able to choose whether to instead select and use an external SQL Server instance.

When upgrading to Zerto Virtual Replication version 6.5, the internal ZVM database is converted to an embedded SQL Server (localDB).

The larger the environment protected by Zerto Virtual Manager, the larger the database size required to support it.

When using a localDB, the size of the environment that can be protected by Zerto Virtual Manager, is limited.

Failure to follow the sizing guideline can result in software errors, and not just performance degradation.

After installing Zerto Virtual Manager, you are able to migrate from using an embedded SQL Server, to using an external SQL Server. For guidelines, considerations and procedures, see Migrating the Zerto Virtual Replication Database to Microsoft SQL Server.

For a list of supported external SQL server databases, see Interoperability Matrix.

Zerto recommends placing external SQL server on a separate VM from where the Zerto Virtual Manager is running.

**Note:** If SQL Server is used, it is your responsibility to make sure that database downtime is planned in coordination with your disaster recovery and business continuity requirements. During database downtime, there will be inconsistencies between the Zerto Virtual Managers, such as the management of checkpoints.

Use the following table to determine the deployment size and thus, the database to use for Zerto.

The criteria used to determine the deployment size are:

- sites
- VPGs

When the deployment sizes are different across the criteria, always choose the database based on the larger deployment size.

<table>
<thead>
<tr>
<th>Database Type</th>
<th>Max number of VPGs Which Can Replicate to the Current/Local Site</th>
<th>Max number of peer sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embedded SQL Server (localDB) / SQL Express Server</td>
<td>2,000</td>
<td>10</td>
</tr>
<tr>
<td>External SQL Server</td>
<td>10,000</td>
<td>Up to 100</td>
</tr>
</tbody>
</table>
Recommendations and Considerations When Using an External SQL Server

Before migrating your database, you must review this section.

NOTE:
To perform a database migration, Zerto version must be 4.5Ux and later. For details, refer to Migrating the Zerto Virtual Replication Database to Microsoft SQL Server.

- Zerto recommends running the external database on a separate VM.
- Zerto recommends using faster storage for the database. For a Zerto site protecting more than 250 incoming VPG, we highly recommend using fast storage for the database (SSD).
- The SQL Server must use at least 4 CPUs. See the following table:

<table>
<thead>
<tr>
<th>Number of VPG protecting to a site</th>
<th>SQL Server memory</th>
<th>Disk space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1000 incoming VPG</td>
<td>8 GB</td>
<td>10 GB</td>
</tr>
<tr>
<td>1000 - 2000 incoming VPG</td>
<td>16 GB</td>
<td>25 GB</td>
</tr>
<tr>
<td>2000 - 5000 incoming VPG</td>
<td>16 GB</td>
<td>50 GB</td>
</tr>
<tr>
<td>5000 - 10000 incoming VPG</td>
<td>16 GB</td>
<td>100 GB</td>
</tr>
</tbody>
</table>

ZCC Considerations

A Zerto Cloud Connector is used in multi-tenancy solutions in which disaster recovery services are offered to internal or external customers. The ZCC requires the following, regardless of the size of the site:

- 4GB disk space
- At least 1GB of reserved memory
- 2 vCPU
- 2 vNICs

Zerto recommends using a 10Gbps vNIC for each Zerto Cloud Connector, enabling it to handle 10Gbps of traffic.

Long Term Retention Considerations

The Long Term Retention feature provides longer term recovery from a retention repository by protecting the relevant virtual machines in virtual protection groups.

When using the Long Term retention features, additional considerations are needed for an optimum experience.

Repositories

Repository capacity estimation depends on several factors:
**VM Size:** Total size of VMs being protected.

**Frequency:** Frequency of LTR processes such as Dailies and Weeklies.

**Retention Period:** Time until checkpoint will be expired.

**Data daily change rate:** Typical daily change rate is ~5%. This is subject to change per use case.

**LTR Process type:** Full or Incremental.

**Data reduction ratios:** Deduplication and compression rates. This number varies between types of data, as well as between deduplicating storage/PBBA vendors. This estimation is preferred to be conservative if the actual rates are not known.

**Capacity Buffer:** Considers spare capacity for cases like overcoming gaps in change rate estimations, or change in LTR process’ frequency. This is at least the size of one additional full copy of the data.

### Example

**Use case:**
- 100 VMs, each with 1x250GB disks, 70% capacity utilized
- Daily change rate: 5%
- Frequency: 7 daily (incremental), 4 Weekly (full), 12 Monthly (full) and 7 Yearly (full)
- Data reduction rate: 1:4

**Calculations:**
- Full copy of the data: \((100*175GB \text{ used capacity})*25\% \text{ Data Reduction})*(4+12+7 \text{ copies})/1024=98TB\)
- Incremental copy of the data: \((100*175GB*25\%*5\%(\text{change rate})*7 \text{ copies})/1024=30TB\)
- Spare Capacity: 98TB *1.25 = 122.5TB
- Total: 98+30+122.5+~1\% (metadata)=~253TB

**Note:** Metadata consumed capacity is negligible.

### Indexing

There are several limitations to consider when using indexing:
- Storing the index for 100 restore points (incremental or full) will consume between 5-10% of the original VM size.
- Zerto guardrails the replication so that other processes will not be affected, including indexing.
- Indexing is done on the ZVM machine using a service called VBA.
- The VBA is limited to running 3 indexing tasks in parallel, and not more than one VRA.
- The impact on each VRA is similar to having a single VM mounted for File Level Restore.
Public Cloud Considerations

When protecting VMs in Azure and AWS, there are some additional considerations. The Zerto Virtual Replication solution with Azure and AWS includes deployment of one or more Zerto Cloud Appliances (ZCAs). The ZCA is a combination of a VRA and a ZVM that runs in an Azure or AWS instance in the public cloud.

When planning for a Public Cloud deployment, consider each major condition in the solution:

1. Steady State Replication to the Public Cloud on page 9
2. Resource Availability in the Public Cloud on page 9
3. Failover Handling to Public Cloud on page 10

Additionally, if the RPO is rising, you can consider scaling up the ZCA and scaling out the ZCA. When scaling up the ZCA, you upgrade to a higher performance instance from the Public Cloud in terms of CPUs, memory and bandwidth. When scaling out the ZCA, you add more instances of the ZCA and configure the VPGs to use the scale-out ZCAs.

Steady State Replication to the Public Cloud

For steady state replication to the Public Cloud the following factors impact performance:

- Replication traffic from the protected VMs. Please see the Public Cloud instance limitations on bandwidth:
  - AWS bandwidth information: https://aws.amazon.com/ec2/instance-types/#instance-type-matrix
  - Size of the protected disks. Please see the below section on Sizing Limits for additional information.
  - WAN networking: direct connection from the protected site to the ZCA in the Public Cloud and adequate networking bandwidth for initial sync and replication.

We recommend monitoring the ZCA in the performance monitor in the Public Cloud instance to baseline and manage performance and scale. Key items to monitor are: CPU consumption and incoming/outgoing network throughput.

Resource Availability in the Public Cloud

The ZCA instance in Azure and AWS should have 4 cores and 8GiB of memory. Each ZCA Public Cloud account needs to have adequate CPU resources to handle a failover of all VPGs which have that ZCA for the recovery site. Usually the default number of CPUs allocated to each account is not enough to handle all the CPUs in the VMs/VPGs that have the Public Cloud for the recovery site. Please see the following for the default vCPUs for Public Cloud:

Failover Handling to Public Cloud

When failing over to Public Cloud, the journal data is written to the recovery disk before the recovery VM is powered on. This process is called promotion. The promotion process is a significant part of the RTO.

There are a few best practices for optimization the failover to the Public Cloud:

- Wait for the initial sync data to be applied from journal to mirror before doing any failover testing. Use the Journal History UI to check that the earliest recovery point is after the VPG was created.
- Reduce the configured history to the minimal value for the fastest RTO.

Networking Considerations

The connectivity between the production and recovery sites must have the bandwidth capacity to handle the data to be replicated between the sites. The minimum dedicated bandwidth must be at least 5 Mb/sec. The latency between peered VRAs must be 120ms or less.

Please refer to the WAN Sizing estimator document for best practices in allocating enough bandwidth between ZVR sites.

Zerto Virtual Replication does not support replicating through NAT translated devices via port forwarding. For replication to occur through NAT translated devices, all replication traffic must be within a VPN.

WAN Optimization Considerations

There are some factors that can affect system optimization that should be considered in addition to estimating the networking bandwidth. Zerto Virtual Replication uses the maximum bandwidth available as well as optimization and internal compression to maintain low RPOs. This removes the need to use third-party WAN acceleration devices. However, Zerto Virtual Replication does work with third-party WAN acceleration devices.

Note: Zerto Virtual Replication WAN compression can be disabled for any VPG as required.

In addition, bandwidth can be throttled as necessary on each ZVM and QoS priorities can be specified for each VPG. If the WAN link becomes saturated, disconnected, or the data change rate is too high to maintain continuous replication, Zerto Virtual Replication enters a Bitmap sync mode. In this mode, VRA driver stores an index of which blocks have changed. When the condition causing the Bitmap sync is resolved, the bitmap changes are read from the source disk and replicated, and continuous replication resumes.

See the following sections:

- Bandwidth Throttling to Temporarily Free Bandwidth on page 11
- Using Swap Disks to Lessen the Bandwidth Load on page 11
- Preseeding to Initially Lessen the Bandwidth Load on page 11
- Setting the Priority for Using the WAN by Multiple VPGs on page 12
- Pausing Replication on page 12
Bandwidth Throttling to Temporarily Free Bandwidth

Zerto can be configured to throttle the bandwidth it uses during a specific time period. During this period, replication does not use more than the bandwidth selected. At the end of the period, bandwidth throttling ends.

**To configure time-based throttling:**

1. In the Zerto user interface, select **Site Settings > Performance and Throttling**. The Performance and Throttling window is displayed.

2. Select **Time-based Throttling**.

3. To limit the MB/sec, select **Limited**, and enter a value.

4. To throttle the bandwidth during specific times, select a period of time:
   - **From**: The hour and the minute to start the throttling, using a 24-hour clock.
   - **To**: The hour and the minute to end the throttling, using a 24-hour clock.

   *For Example*: If you know that the bandwidth needs specific throttling during a certain period, during the daily peak transaction period you can override the throttling of the bandwidth for these specific times.

5. Click **APPLY** or **SAVE**.

   **Important:**

   IO Throttling values should be changed *only* in coordination with Zerto support.

Using Swap Disks to Lessen the Bandwidth Load

A swap disk is a virtual disk that Zerto replicates and then isolates from further changes. If temporary files on a protected virtual machine are moved to a swap disk, although the disk itself is replicated to the recovery site, changes to it are not replicated. This reduces replication traffic, journal size, and storage use.

Swap disks are configured for the individual disk in the virtual machine in the VPG definition.

Preseeding to Initially Lessen the Bandwidth Load

In preseeding, the entire virtual machine is block-copied and moved to the recovery site. Only changes made after the preseeding are replicated.
Setting the Priority for Using the WAN by Multiple VPGs

Zerto enables prioritizing replication for each VPG. The priorities are:

- High
- Medium
- Low

Prioritization is used when there is bandwidth contention between sites or when the load on the VRA is more than can be accommodated. It enables maintaining a low RPO on the most critical VPGs. As bandwidth becomes available, lower priority VPGs are synchronized and returned to a continuous protection state.

Pausing Replication

Zerto enables VPG replication to be paused, for example, during maintenance.

Journal Considerations

Journal considerations are different between on-premise recovery sites and Public Cloud recovery sites. Zerto’s Public Cloud architecture requires applying journal data to the recovery disk to happen before the recovery VM can be powered-on. This behavior is different than the Hypervisor-based recovery sites where Zerto can instantly create a "view" of the recovery disk without applying any data. Consequently, public cloud RTO is longer than on-premise solutions.

For more details about Journal Sizing, please see the ZVR Journal Sizing and Best Practices document for initial sizing. Additionally, the Journal reports in Zerto Analytics can be used to monitor actual Journal usage by a VPG.

VMware and Hyper-V On-Premise Recovery Sites - Journal Sizing

For on-premise solutions, the general formula to calculate Journal size is:

\[ \text{Journal size} = \text{History in seconds} \times \text{Average throughput of all VM volumes} \times \text{Average compression ratio} \]

For example, if the history is 3 days (259,200 seconds) and:

- the average throughput is 10 MBPS and
- the data is 50% compressible on average

Then the journal size for this VM would be:

\[ 259,200 \times 10 \times 0.5 = 1,296,000 \text{ MBPS} (\sim 1266 \text{ GB}) \]

Public Cloud Recovery Sites - Journal Sizing

Due to the difference in the architecture of Public Cloud solutions, configured history should be as short as possible to achieve the fastest RTOs.
Best Practices for Multiple VRA Pairings

When multiple protected source VRAs are peered to a single VRA on the recovery site, then you can consider using 2 CPUs on the recovery VRA.

Zerto Sizing Limits

The following table specifies the scale limitations for Zerto v7.0. Most of these limits are not enforced by the system, which means that a system with higher scale can be deployed; however, exceeding these limits may result in unpredictable system behavior, and is therefore not recommended.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit VMware &amp; Hyper-V Platform</th>
<th>Limit Public Cloud</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMs per ZVM</td>
<td>10,000</td>
<td>100</td>
</tr>
<tr>
<td>VPGs per ZVM</td>
<td>10,000</td>
<td>100</td>
</tr>
<tr>
<td>ZVMs per vCenter / System Center</td>
<td>1</td>
<td>NA</td>
</tr>
<tr>
<td>VRAs per host</td>
<td>1</td>
<td>NA</td>
</tr>
<tr>
<td>Volumes per VRA</td>
<td>1500</td>
<td>250</td>
</tr>
<tr>
<td>Disks per VM</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>VMs per VRA</td>
<td>1500</td>
<td>120</td>
</tr>
<tr>
<td>Size of total protected disks per VRA</td>
<td>96TB</td>
<td>NA</td>
</tr>
<tr>
<td>Max size of a single disk being protected</td>
<td>96TB* *Contact Zerto Support for extending this limit.</td>
<td>Azure: 4TB AWS: 16TB</td>
</tr>
<tr>
<td>Concurrent ZVM operations</td>
<td>50 VMs and 150 volumes</td>
<td>50 VMs and 20 volumes</td>
</tr>
<tr>
<td>Max disk size for JFLR</td>
<td>32TB</td>
<td>Azure: 4TB AWS: 1TB</td>
</tr>
<tr>
<td>LTR Indexing per VM max folders or files</td>
<td>100 million</td>
<td>NA</td>
</tr>
<tr>
<td>LTR Indexing disk max</td>
<td>10TB</td>
<td>NA</td>
</tr>
</tbody>
</table>

Zerto Benchmarking Test Results

The following sections cover the benchmark testing configuration and results.
vSphere Environment for ZVM Benchmarks

The vSphere benchmark testing environment consists of:

- Running ZVR 6.5, VMware vSphere 6.5, 6.0 and 5.5, Windows Server 2016
- 6000 VMs and 6000 VPGs configured
- Each host has:
  - 4 CPU with 16 GB memory
  - 200 GB storage space assigned
- VRAs configured with 1 CPU and 3GB memory
- ZVMs configured with:
  - 16 GB and 12 CPUs for recovery and production ZVMs
  - External ZVM database on SQL
    - recovery 16GB and 12 CPUs
    - production 16GB and 2 CPUs

Hyper-V Environment for ZVM Benchmarks

The Hyper-V benchmark testing environment consists of:

- 2000 VMs and 2000 VPGs configured
- Each host has:
  - 4 CPU with 16 GB memory
  - 200 GB storage space assigned
- VRAs configured with 1 CPU and 3GB memory
- ZVMs configured with:
  - 16 GB and 8 CPUs for production ZVM
  - 16GB and 12 CPUs for recovery ZVM
• External ZVM database on SQL
  • recovery 16GB and 4 CPUs
  • production 8GB and 4 CPUs

**ZVM Initialization and Pairing Times**

These benchmarks measure the time it takes until the system resumes replication after restart. The following benchmarks cover the time in minutes to recover with 2000 VPGs configured:

1. Initialize production and recovery ZVMs
2. Connect the production and recovery ZVMs for the first time
3. Pair the production and recovery ZVMs with a VRA

**Production Site ZVM Benchmarks**

<table>
<thead>
<tr>
<th></th>
<th>Zerto 7.0 Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZVM Restart</td>
<td>3:00</td>
</tr>
<tr>
<td>ZVM - ZVM pairing</td>
<td>1:30</td>
</tr>
<tr>
<td>ZVM - VRA pairing</td>
<td>1:06</td>
</tr>
</tbody>
</table>

**Recovery Site ZVM Benchmarks**

<table>
<thead>
<tr>
<th></th>
<th>Zerto 7.0 Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZVM Restart</td>
<td>3:50</td>
</tr>
<tr>
<td>ZVM - ZVM pairing</td>
<td>1:40</td>
</tr>
<tr>
<td>ZVM - VRA pairing</td>
<td>3:00</td>
</tr>
</tbody>
</table>

**RTO Benchmarks - vSphere Production and vSphere Recovery**

These benchmark tests were performed on the above vSphere environment. The following benchmarks were taken on different numbers of VPGs and VMs failing over at the same time. In vSphere environments, the recovery VM is available before promotion of the journal is complete.
<table>
<thead>
<tr>
<th># of VPGs</th>
<th># of VMs in VPG</th>
<th>Total VMs</th>
<th>Total RTO Measured on Zerto 7.0 {MM:SS}</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1</td>
<td>20</td>
<td>00:48</td>
</tr>
<tr>
<td>40</td>
<td>1</td>
<td>40</td>
<td>01:25</td>
</tr>
<tr>
<td>1</td>
<td>40</td>
<td>40</td>
<td>01:51</td>
</tr>
<tr>
<td>60</td>
<td>1</td>
<td>60</td>
<td>02:14</td>
</tr>
<tr>
<td>80</td>
<td>1</td>
<td>80</td>
<td>02:50</td>
</tr>
<tr>
<td>100</td>
<td>1</td>
<td>100</td>
<td>03:11</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>100</td>
<td>06:27</td>
</tr>
</tbody>
</table>

**RTO Benchmarks - vSphere Production and vCloud Director Recovery**

These benchmark tests were performed on the above vSphere environment on the production site. The recovery site was vCloud Director. The following benchmarks were taken on different numbers of VPGs and VMs failing over at the same time. In vSphere environments, the recovery VM is available before promotion of the journal is complete.

<table>
<thead>
<tr>
<th># of VPGs</th>
<th># of VMs in VPG</th>
<th>Total VMs</th>
<th>Total RTO Measured on Zerto 7.0 {MM:SS}</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1</td>
<td>20</td>
<td>04:18</td>
</tr>
<tr>
<td>40</td>
<td>1</td>
<td>40</td>
<td>05:50</td>
</tr>
<tr>
<td>60</td>
<td>1</td>
<td>60</td>
<td>08:42</td>
</tr>
<tr>
<td>80</td>
<td>1</td>
<td>80</td>
<td>09:58</td>
</tr>
<tr>
<td>100</td>
<td>1</td>
<td>100</td>
<td>13:33</td>
</tr>
</tbody>
</table>

**ZVM GUI Response Times**

Alerts generally populate in 5 seconds from the detection time. The GUI is updated in intervals of up to 12 seconds.

The below benchmarks for GUI response times in seconds were measured for typical GUI tasks in the vSphere environment:
<table>
<thead>
<tr>
<th>Activity</th>
<th>Production Site (seconds)</th>
<th>Recovery Site (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>List VPGs</td>
<td>2-3</td>
<td>2-3</td>
</tr>
<tr>
<td>General VMs view</td>
<td>2-3</td>
<td>2-3</td>
</tr>
<tr>
<td>Sites tab</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>VRAs tab</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Datastores tab</td>
<td>&lt;1</td>
<td>&gt;3</td>
</tr>
<tr>
<td>Alerts monitor</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Events monitor</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>VPG performance report</td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td>Outbound protection over time report</td>
<td>1-2</td>
<td>1-2</td>
</tr>
<tr>
<td>Protection over time by site</td>
<td>&lt;1</td>
<td>2-3</td>
</tr>
<tr>
<td>Recovery report</td>
<td>1-2</td>
<td>1-2</td>
</tr>
<tr>
<td>Resources report</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Dashboard</td>
<td>&gt;3</td>
<td>&gt;3</td>
</tr>
<tr>
<td>Create VPG</td>
<td>2-3</td>
<td>1-2</td>
</tr>
<tr>
<td>Edit VPG</td>
<td>&lt;1</td>
<td>1-2</td>
</tr>
</tbody>
</table>

**API Response Times**

The below table shows measured API response times in the vSphere environment.

<table>
<thead>
<tr>
<th>API</th>
<th>Production Site Response Time (Seconds)</th>
<th>Recovery Site Response Time (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Events</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Alerts</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>VMs</td>
<td>1-2</td>
<td>1-2</td>
</tr>
<tr>
<td>Tasks</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>
Initial Synchronization Benchmarks

In benchmarking tests, the maximum initial sync rate on the above VMware environments is 150 MBPS.

VRA Steady State Replication Benchmarks

The following table summarizes the benchmark testing for steady state replication between a pair of production and recovery VRAs. The benchmark testing was performed with a steady state replication rate of 150 MBPS.

<table>
<thead>
<tr>
<th>Write MBPS</th>
<th>IO Size</th>
<th>IOPS</th>
<th># of VRA CPUs</th>
<th>Compression</th>
<th>Production VRA CPU Utilization</th>
<th>Recovery VRA CPU Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>4K</td>
<td>18000</td>
<td>1</td>
<td>No</td>
<td>50%</td>
<td>46%</td>
</tr>
<tr>
<td>50</td>
<td>4K</td>
<td>13000</td>
<td>1</td>
<td>No</td>
<td>38%</td>
<td>40%</td>
</tr>
<tr>
<td>50</td>
<td>16K</td>
<td>3300</td>
<td>1</td>
<td>No</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>50</td>
<td>64K</td>
<td>760</td>
<td>1</td>
<td>No</td>
<td>19%</td>
<td>22%</td>
</tr>
<tr>
<td>100</td>
<td>64K</td>
<td>1500</td>
<td>1</td>
<td>No</td>
<td>33%</td>
<td>26%</td>
</tr>
<tr>
<td>38</td>
<td>4K</td>
<td>9448</td>
<td>1</td>
<td>No</td>
<td>44%</td>
<td>44%</td>
</tr>
<tr>
<td>35</td>
<td>16K</td>
<td>2200</td>
<td>1</td>
<td>No</td>
<td>22%</td>
<td>25%</td>
</tr>
<tr>
<td>100</td>
<td>16K</td>
<td>6000</td>
<td>1</td>
<td>No</td>
<td>49%</td>
<td>49%</td>
</tr>
<tr>
<td>150</td>
<td>32K</td>
<td>4800</td>
<td>2</td>
<td>50%</td>
<td>48%</td>
<td>25%</td>
</tr>
</tbody>
</table>
VRA on Recovery Site Benchmarks

Throughput of multiple VRAs paired to a single VRA showed the recovery VRA had 100MBPS throughput with 1 CPU on the recovery VRA. This was tested with 63 peer VRAs and 16KB IO. More peers or smaller IO may require additional CPU on the recovery VRA.

Long Term Retention Benchmarks

**Configuration of Benchmarking:**

LTR repository appliance model: HPE StoreOnce 3100
- 100 GB disk
- Networking speed to the repository: 1 Gbps
- Repository protocol: NFS
- 1 host running vSphere 6.5, 1 VM with a single 100 GB volume

LTR repository appliance model: Dell EMC DataDomain DD3300
- 100 GB disk
- Networking speed to repository: 1 Gbps
- Repository protocol: NFS
- 1 host running vSphere 6.5, 1 VM with a single 100 GB volume

Long Term Retention Throughput

Long Term Retention throughput represent the rate of writing the data in a single stream to LTR repository, over NFS protocol. This benchmark was done in Zerto labs, when only LTR was activated.

The following throughput numbers were measured:

<table>
<thead>
<tr>
<th>LTR Repository Type</th>
<th>Single Volume LTR only Rate (MB/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPE StoreOnce</td>
<td>93</td>
</tr>
<tr>
<td>DataDomain</td>
<td>94</td>
</tr>
</tbody>
</table>

Indexing Rate

In Zerto labs, the following indexing rates were measured. As part of the retention process, once the system finishes saving the retention sets of all the VMs in the VPG on the repository successfully, Zerto initiates indexing the VMs that were selected for indexing in the VPG.

- Indexing rate NTFS: 1900 Files per second
- Indexing rate EXT: 1400 Files per second
Public Cloud Benchmarks

The promotion part of failing over to Public Cloud was benchmarked using 32kB IOs on a single volume. In both the Azure and AWS cases, the RTO consists of additional steps which are not benchmarked yet. The measured promotion rate is:

- 70 MBps for the promotion rate of failing over to Azure
- 12 MBps for the promotion rate of failing over to AWS

Estimating WAN Bandwidth for VMware and Hyper-V

Note: With Zerto Planner, you can perform the tasks described in this section more efficiently.

Estimating the bandwidth requirements between the protected and recovery sites involves the following:

1. **Collecting data characteristics for protected VMs.** See the following:
   - vSphere Environments: Collecting Data Characteristics for VMs on page 20
   - Hyper-V Environments: Collecting Data Characteristics for VMs on page 25

2. **Calculating the estimated bandwidth requirements.** See the following:
   - Calculating the Estimated Bandwidth Requirement on page 27

Note: When the recovery site is Amazon Web Services (AWS), you estimate the required bandwidth for the protected machines, either in vSphere or Hyper-V as described below.

vSphere Environments: Collecting Data Characteristics for VMs

Before you can collect the required data, you must first enable data collection in vCenter Server.

- Enabling vCenter Server Data Collection on page 20
- Collecting Data Characteristics for VMs on page 22

Enabling vCenter Server Data Collection

To enable vCenter Server data collection:

1. Connect to the vCenter Server.
2. In the Administration menu item, select **vCenter Server Settings**.
   
   The vCenter Server Settings dialog is displayed.
3. Select **Statistics**.
4. Make sure that the **Statistics Level** value for all interval durations up to and including the one day duration is at least 2.

If any of the durations have a value less than 2, do the following, starting with the smallest interval:

a. Select the interval and click **Edit**.

b. Change **Statistics Level** to **Level 2**.

c. Click **OK**.

5. Repeat step 4 for all the values up to and including the 1 day interval duration.

6. Click **OK** and wait for at least a day before using the aggregate usage data.
Collecting Data Characteristics for VMs

You can collect data characteristics for the virtual machines in a VPG in one of the following ways:

- **Via vSphere Client** console performance statistics. See Collecting Data Characteristics for VMs via vSphere Client Console Performance Statistics on page 22.

- **Or**-

- By running a **script** to collect the data characteristics. See Running a Script to Collect the Data Characteristics on page 24.

  **Note:** The script samples supplied with the download, require vSphere PowerCLI and permissions to access the vCenter Server using the script.

- **Or**-

- By using operating system performance monitors, such as the Microsoft Performance Monitor utility for Windows operating systems, or the `iostat` command for Linux operating systems.

Collect data for a **minimum of one day**. Collecting this information impacts on performance and therefore the collection period should be long enough to gather a true representation of usage, but not too long.

Use one of the following procedures:

- **Collecting Data Characteristics for VMs via vSphere Client Console Performance Statistics** on page 22 uses a timeframe of one day.

- **Running a Script to Collect the Data Characteristics** on page 24 uses a timeframe of seven days.

  **Note:** When running vCenter Server versions before version 5.x, if any of the virtual machines use **NFS storage**, metrics for the NFS storage are not generated by the vCenter Server.

Collecting Data Characteristics for VMs via vSphere Client Console Performance Statistics

Use the following procedure to collect data characteristics for the VMs via the vSphere Client console performance statistics.

**To collect data characteristics for the VMs via the vSphere Client console performance statistics:**

1. In the vSphere Client console select the VM and open the **Performance** tab.

2. Click **Advanced**.

3. Click the **Charts Options** link.

   The Customize Performance Chart dialog is displayed.
4. In the area Chart Options, drill-down in Disk and select Past day.

5. In the area Counters, click None to clear all the selections and then select Disk Write Rate or Write Rate.

6. Click OK.

A chart similar to the following is generated:
Zerto Scale And Benchmarking Guidelines

Running a Script to Collect the Data Characteristics

Use the following procedure to run a script to collect the data characteristics.

**Note:** The following script and the samples supplied with the download, require **vSphere PowerCLI** and **permissions** to access the vCenter Server using the script.

To collect data characteristics for the VMs via a script:

1. Run a script similar to the following:

```powershell
$report = @()
Get-VM | %{
    $stats = Get-Stat -Entity $ -Stat disk.write.average -Start (Get-Date).adddays(-7) -ErrorAction SilentlyContinue
    if($stats){
        $statsGrouped = $stats | Group-Object -Property MetricId
        $row = "" | Select Name, WriteAvgKBps, WriteAvgMBps
        $row.Name = $_.Name
        $row.WriteAvgKBps = ($statsGrouped | where {$_-Name -eq "disk.write.average"} | %($_.Group | Measure-Object -Property Value -Average)).Average
        $row.WriteAvgMBps = $row.WriteAvgKBps/1024
        $row.WriteAvgKBps = "{0:N2}" -f $row.WriteAvgKBps
        $row.WriteAvgMBps = "{0:N2}" -f $row.WriteAvgMBps
        $report += $row
    }
}
```
$report | Export-Csv "C:\ZertoOutput.csv"

2. If you want a value other than seven days, change the value of the `addays()` function. For example to collect data for three days, use `addays(-3)`.

3. Use the resulting file, `C:\ZertoOutput.csv`, for the average write rate of the VM.

   **Note:** Versions of this script are included in the download with this document.

4. Continue with Calculating the Estimated Bandwidth Requirement on page 27.

Hyper-V Environments: Collecting Data Characteristics for VMs

You can collect data characteristics for the virtual machines in a VPG in one of the following ways:

- By using operating system performance monitors, such as the Microsoft Performance Monitor utility for Windows operating systems or the `iostat` command for Linux operating systems.
- By using Windows PowerShell in Windows Server 2012 to collect network utilization (and other information). When using metering ACLs, you can measure the total network traffic sent and received by a virtual machine. To collect performance characteristics for the virtual machines in a VPG, using PowerShell, do the following:
  - Turn on resource metering for the relevant virtual machines, if it is not already enabled.
  - Adjust the collection frequency, if necessary.
  - Collect the relevant statistics.

Zerto recommends that you collect data for a minimum of one day. When you have enough statistics, you may want to turn off resource metering since data collection can impact performance.

- **Turning on Resource Metering** on page 25
- **Adjusting the Collection Frequency** on page 26
- **Collecting and Viewing the Relevant Statistics** on page 26
- **Turning off Resource Metering** on page 26

**Turning on Resource Metering**

By default, resource metering is not enabled. To turn on resource metering for one virtual machine, enter the following PowerShell command:

```
Get-VM <VM-name> | Enable-VMResourceMetering
```

To turn on monitoring for all virtual machines on a server at one time, enter the following PowerShell command:

```
Get-VM | Enable-VMResourceMetering
```
Once you enable resource metering, Hyper-V begins to collect data. You can reset metering at any time, which discards the data that has been collected up to that point.

If resource metering is enabled but no NetworkAdapterAcls are configured, Hyper-V configures them to measure total network traffic. To measure network traffic through an IP range, configure the NetworkAdapterAcls for the IP range before running `Enable-VMResourceMetering`.

### Adjusting the Collection Frequency

By default, the collection frequency is once every hour. You can change the collection frequency, but understand that data collection can impact performance. To change the collection frequency, enter the following command:

```
Set-VMHost -ComputerName <host-server-name> -ResourceMeteringSaveInterval <HH:MM:SS>
```

The collection frequency is always set at the host server level. You cannot adjust the collection frequency per virtual machine.

For example, if you enter 01:30:00, resource consumption will be collected every hour and a half.

### Collecting and Viewing the Relevant Statistics

To view resource usage for one virtual machine, enter the following command:

```
Get-VM <VM-name> | Measure-VM
```

Resource metering data can be displayed for all of the virtual machines that are running on a host. To see data for all of the virtual machines on a host, enter the following command:

```
Get_VM | Measure-VM
```

You can configure PowerShell to display only certain statistics. To do this, you must know the object names that PowerShell assigns to each statistic. You can see the object names by entering the following command:

```
Get-VM | Measure-VM | Select-Object *
```

For example, when working with Zerto, you are interested in network traffic. To list the network traffic for each virtual machine, enter the following command:

```
Get-VM | Measure-VM | Select-Object VMName, NetworkMeteredTrafficReport
```

You can use VM Network Adapter ACLs to measure network activity to and from a specific network. For example, to meter network traffic for a special subnet or IP address:

```
Add-VMNetworkAdapterAcl -VMName <VM-name> -Action Meter -RemoteIPAddress 10.10.0.0/16 -Direction Outbound
```

### Turning off Resource Metering

To disable the collection of performance statistics, enter the following PowerShell command:

```
Disable-VMResourceMetering -VMName <VM-name>
```

Continue with Calculating the Estimated Bandwidth Requirement on page 27.
Calculating the Estimated Bandwidth Requirement

Note: The Zerto WAN Sizing Estimator is included in the download with this document.

Use the average write rate for the virtual machines in a VPG in the Zerto WAN Sizing Estimator to estimate the minimum bandwidth required.

For each VM you also must decide whether compression will be enabled for the VM, based on the data characteristics.

Use one of the following procedures:

- Estimating sizing using the Zerto WAN Sizing Estimator on page 27
- Estimating sizing without using the Zerto WAN Sizing Estimator on page 27

Estimating sizing using the Zerto WAN Sizing Estimator

To estimate sizing using the Zerto WAN Sizing Estimator:

1. Open the Zerto WAN Sizing Estimator.
2. Enter the following information in the VM data sheet:
   - The VM name.
   - The Write KB/s data, based on the statistics gathered in the previous task. Use a period for the decimal mark.
   - Define whether compression is enabled for this VM: Select Yes or No.
   - The application data characteristics: Select Compressed or Compressible.
3. The Zerto WAN Sizing Estimator estimates the total bandwidth needed for your deployment, using a minimum value of 5 Mb/sec.
   - The estimation is displayed on the top of each page of the Zerto WAN Sizing Estimator.

To estimate the WAN sizing required without using the Zerto WAN Sizing Estimator, using the following procedure.

Estimating sizing without using the Zerto WAN Sizing Estimator

To estimate sizing without using the Zerto WAN Sizing Estimator:

1. For each virtual machine in the VPG multiply the KB/sec (which is based on the statistics gathered) by 8, and divide the result by 1024 to provide an answer in Mb/sec.
   - If compression is enabled for the VM and the data is compressible, divide this result by 2.
2. Sum the results of step 1.
WAN Mb/sec = SUM(KB/sec * (8/1024/(1 or 2 if compressible data that will be compressed)))

The result is an estimate of the required Mb/sec for the WAN.

**Note:** If the result is less than 5 Mb/sec, see Zerto Scale and Benchmarking Guidelines for minimum bandwidth requirements.
NEW Zerto 7.0 enhances the Zerto IT Resilience Platform by converging disaster recovery and backup to deliver continuous availability within a simple, scalable platform. Zerto 7.0 delivers enhanced analytics, platform improvements and cloud performance upgrades required in the future of IT resilience.

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