EMC® NetWorker®

Release 7.6

Performance Optimization Planning Guide

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EMC Corporation
Corporate Headquarters:
Hopkinton, MA 01748-9103
1-508-435-1000
www.EMC.com

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Preface

As part of an effort to improve and enhance the performance and capabilities of its product lines, EMC periodically releases revisions of its hardware and software. Therefore, some functions described in this document may not be supported by all versions of the software or hardware currently in use. For the most up-to-date information on product features, refer to your product release notes.

If a product does not function properly or does not function as described in this document, please contact your EMC representative.

Audience This document is part of the NetWorker documentation set, and is intended for use by system administrators to identify the different hardware and software components that make up the NetWorker datazone. It discusses the component's impact on storage management tasks, and provides general guidelines for locating problems and solutions

NetWorker product documentation

This section describes the additional documentation and information products that are available with NetWorker.

EMC NetWorker Release 7.6 Installation Guide
Provides instructions for installing or updating the NetWorker software for clients, console and server on all supported platforms.

EMC NetWorker Release 7.6 Cluster Installation Guide
Contains information related to installation of the NetWorker software on cluster server and clients.

EMC NetWorker Release 7.6 Administration Guide
Describes how configure and maintain the NetWorker software.

EMC NetWorker Release 7.6 Release Notes
Contain information on new features and changes, fixed problems, known limitations, environment and system requirements for the latest NetWorker software release.

EMC NetWorker Licensing Process Guide, Second Edition
A brief guide that explains the process flow of NetWorker licensing to users (system administrators, mainly). Not yet officially part of the NetWorker doc set.

NetWorker License Manager 8th Edition Installation and Administration Guide

Provides installation, set up, and configuration information for the NetWorker License Manager product.

NetWorker 7.6 Error Message Guide

Provides information on common NetWorker error messages.

NetWorker 7.6 Command Reference Guide

Provides reference information for NetWorker commands and options.

NetWorker Management Console Online Help

Describes the day-to-day administration tasks performed in the NetWorker Management Console and the NetWorker Administration window. To view Help, click **Help** in the main menu.

NetWorker User Online Help

The NetWorker User program is the Windows client interface. Describes how to use the NetWorker User program which is the Windows client interface connect to a NetWorker server to back up, recover, archive, and retrieve files over a network.

NetWorker related documentation

For more information about NetWorker software, refer to this documentation:

EMC Information Protection Software Compatibility Guide

A list of supported client, server, and storage node operating systems for the following software products: AlphaStor, ArchiveXtender, DiskXtender for Unix/Linux, DiskXtender for Windows, Backup Advisor, AutoStart, AutoStart SE, RepliStor, NetWorker, and NetWorker Modules and Options.

E-lab Issue Tracker

Issue Tracker offers up-to-date status and information on NetWorker known limitations and fixed bugs that could impact your operations. E-Lab Issue Tracker Query allows you to find issues in the Issue Tracker database by matching issue number, product feature, host operating system, fixed version, or other fields.

NetWorker Procedure Generator

The NetWorker Procedure Generator (NPG) is a stand-alone Windows application used to generate precise user driven steps for high demand tasks carried out by customers, Support and the field. With the NPG, each procedure is tailored and generated based on user-selectable prompts. This generated procedure gathers the most critical parts of NetWorker product guides and combines experts' advice into a single document with a standardized format.

Note: To access the E-lab Issue Tracker or the NetWorker Procedure Generator, go to http://www.Powerlink.emc.com. You must have a service agreement to use this site.

Technical Notes and WhitePapers

Provides an in-depth technical perspective of a product or products as applied to critical business issues or requirements. Technical Notes and White paper types include technology and business considerations, applied technologies, detailed reviews, and best practices planning.

Conventions used in this document

EMC uses the following conventions for special notices.

Note: A note presents information that is important, but not hazard-related.

CAUTION

A caution contains information essential to avoid data loss or damage to the system or equipment.

IMPORTANT

An important notice contains information essential to operation of the software.

Typographical conventions

EMC uses the following type style conventions in this document:

Normal	Used in running (nonprocedural) text for: • Names of interface elements (such as names of windows, dialog boxes, buttons, fields, and menus) • Names of resources, attributes, pools, Boolean expressions, buttons, DQL statements, keywords, clauses, environment variables, functions, utilities • URLs, pathnames, filenames, directory names, computer names, filenames, links, groups, service keys, file systems, notifications
Bold	Used in running (nonprocedural) text for: • Names of commands, daemons, options, programs, processes, services, applications, utilities, kernels, notifications, system calls, man pages
	Used in procedures for: • Names of interface elements (such as names of windows, dialog boxes, buttons, fields, and menus) • What user specifically selects, clicks, presses, or types
Italic	Used in all text (including procedures) for: • Full titles of publications referenced in text • Emphasis (for example a new term) • Variables
`Courier`	Used for: • System output, such as an error message or script • URLs, complete paths, filenames, prompts, and syntax when shown outside of running text
`Courier bold`	Used for: • Specific user input (such as commands)
`Courier italic`	Used in procedures for: • Variables on command line • User input variables
< >	Angle brackets enclose parameter or variable values supplied by the user
[ ]	Square brackets enclose optional values
|	Vertical bar indicates alternate selections - the bar means “or”
{ }	Braces indicate content that you must specify (that is, x or y or z)
...	Ellipses indicate nonessential information omitted from the example

Where to get help

EMC support, product, and licensing information can be obtained as follows.

Product information — For documentation, release notes, software updates, or for information about EMC products, licensing, and service, go to the EMC Powerlink website (registration required) at:

`http://Powerlink.EMC.com`

Technical support — For technical support, go to EMC Customer Service on Powerlink. To open a service request through Powerlink, you must have a valid support agreement. Please contact your EMC sales representative for details about obtaining a valid support agreement or to answer any questions about your account.

Your comments

Your suggestions will help us continue to improve the accuracy, organization, and overall quality of the user publications. Please send your opinion of this document to:

`ssgdocumentation@emc.com`

If you have issues, comments, or questions about specific information or procedures, include the title and, if available, the part number, the revision (for example, A01), the page numbers, and any other details that will help us locate the subject you are addressing.

1

Overview

The NetWorker software is a network storage management application that is optimized for high-speed backup and recovery operations of large amounts of complex data across an entire datazone.

The Performance Optimization Planning Guide assists administrators to:

- Understand data transfer fundamentals
- Determine requirements
- Identify bottlenecks
- Optimize and tune NetWorker performance

This Performance Optimization Planning Guide also addresses non-disruptive performance tuning options. Although some physical devices may not meet the expected performance, it is understood that when a physical component is replaced with a better performing device, another component ends up as a bottle neck.

This manual attempts to address NetWorker performance tuning with minimal disruptions to the existing environment. It attempts to fine-tune feature functions to achieve better performance with the same set of hardware.

Organization

This guide is organized into the following chapters:

- Chapter 2, "Size the NetWorker Environment," provides details on how to determine requirements.
- Chapter 3, "Test Performance," provides details on how to test and understand bottlenecks by using available tools.
- Chapter 4, "Tune Network Settings to Optimize Performance," provides details on how to tune the backup environment to optimize backup and restore performance.

2

Size the NetWorker Environment

This chapter describes how to best determine backup and system requirements. The first step is to understand the environment. Performance issues can often be attributed to hardware or environmental issues. An understanding of the entire backup data flow is important to determine the optimal performance that can be expected from the NetWorker software.

This chapter includes the following topics:

Expectations

This section describes backup environment performance expectations, and required backup configurations.

Determine backup environment performance expectations

Sizing considerations for the backup environment are listed here:

- Review the network and storage infrastructure information before setting performance expectations for your backup environment including the NetWorker server, storage nodes, and clients.
- Review and set the Recovery Time Objective (RTO) for each client .
- Determine the backup window for each NetWorker client.
- List the amount of data to be backed up for each client during full and incremental backups.
- Determine the data growth rate for each client.

It is difficult to precisely list performance expectations, while keeping in mind the environment and the devices used. It is good to know the bottlenecks in the setup and to set expectations appropriately.

Some suggestions to help identify bottlenecks and define expectations are:

- Create a diagram
- List all system, storage, network, and target device components
- List data paths
- Mark down the bottleneck component in the data path of each client

It is very important to know how much down time is possible for each NetWorker client. This dictates the RTO. Review and document the RTO for each NetWorker client.

To determine the backup window for each client:

1. Verify the available backup window for each NetWorker client.
2. List the amount of data that needs to be backed up from the clients for full or incremental backups.
3. List the average daily/weekly/monthly data growth on each NetWorker client.

Determine required backup expectations

Methods to determine the required backup configuration expectations for the environment are listed here:

- Verify the existing backup policies and ensure that the policies will meet the RTO for each client
- Estimate backup window for each NetWorker client based on information collected
- Determine the organization of the separate NetWorker client groups based on the following parameters.
  - Backup window

- Business criticality
- Physical location
- Retention policy

◆ Ensure that RTO can be met with the backup created for each client.

The shorter the acceptable downtime, the more expensive backups are. It may not be possible to construct a backup image from a full backup and multiple incremental backups if the acceptable down time is very short. Full backups might be required more frequently which results in a longer backup window. This also increases network bandwidth requirements.

System Components

Every backup environment has a bottleneck. It may be a fast bottleneck, but the bottleneck will determine the maximum throughput obtainable in the system. Backup and restore operations are only as fast as the slowest component in the backup chain.

Performance issues are often attributed to hardware devices in the datazone. This guide assumes that hardware devices are correctly installed and configured.

This section discusses how to determine requirements. For example:

- How much data must move?
- What is the backup window?
- How many drives are required?
- How many CPUs are required?

Devices on backup networks can be grouped into four component types. These are based on how and where devices are used. In a typical backup network, the following four components are present:

- System
- Storage
- Network
- Target device

System

The components that impact performance in system configurations are listed here:

- CPU
- Memory
- System bus (this determines the maximum available I/O bandwidth)

CPU requirements

Determine the optimal number of CPUs required, if 5 MHz is required to move 1 MB of data from a source device to a target device. For example, a NetWorker server, or storage node backing up to a local tape drive at a rate of 100 MB per second, requires 1GHz of CPU power:

- 500 MHz is required to move data from the network to a NetWorker server or storage node.

- 500 MHz is required to move data from the NetWorker server or storage node to the backup target device.

Note: 1GHz on one type of CPU does not directly compare to a 1GHz of CPU from a different vendor.

The CPU load of a system is impacted by many additional factors. For example:

- Drivers:

  Be sure to investigate drivers from different vendors as performance varies. Drivers on the same operating system achieve the same throughput with a significant difference in the amount of CPU used.

- Disk drive performance:
  - On a backup server with 400 or more clients in /nsr, a heavily used disk drive often results in CPU use of more than 60%. The same backup server in /nsr on a disk array with low utilization, results in CPU use of less than 15%.
  - On Windows, if a lot of time is spent on Deferred Procedure Calls it often indicates a problem with device drivers.
- High CPU load is not necessarily a direct result of insufficient CPU power, but can be a side effect of the configuration of the other system components.
- Monitor CPU use according to the following classifications:
  - User mode
  - System mode

Note: Poor performance is often due to CPU time spent in system calls resulting from slow hardware components, rather than the application workload.

Memory requirements

Table 1 on page 14 lists the minimum memory requirements for the NetWorker server. This ensures that memory is not a bottleneck.

Table 1 Minimum required memory for the NetWorker server

Number of clients	minimum required memory
less than 50	4 GB
51 - 250	8 GB
more than 250 clients	16 GB

System bus requirements

Although HBA/NIC placement are critical, the internal bus is probably the most important component of the operating system. The internal bus provides communication between internal computer components, such as CPU, memory, disk, and network.

Bus performance criteria:

- Type of bus
- Data width
- Clock rate
- Motherboard

Considerations:

- A faster bus does not guarantee faster performance
- Higher end systems have multiple buses to enhance performance
- The bus is often the main bottleneck in a system

Recommendations

It is recommended that PCI eXpress be used for both servers, and storage nodes to reduce the chance for I/O bottlenecks.

Note: Avoid using an old CPU bus as it might generate interrupts and CPU spikes at high speed.

PCI-X, and PCIeXpress considerations:

- PCI-X is a half-duplex bi-directional 64-bit parallel bus
- PCI-X bus speed may be limited to the slowest device on the bus, be careful with card placement
- PCIeXpress is full-duplex bidirectional serial bus using 8/10 encoding
- PCIeXpress bus speed may be determined per each device
- Do not connect a fast HBA/NIC to a slow bus, always consider bus requirements. Silent packet drops can occur on a PCI-X 1.0 10GbE NIC, and bus requirements can not be met.
- Hardware that connects fast storage to a slower HBA/NIC will slow overall performance.

  "The component 70% rule" on page 18 provides details on the ideal component performance levels.

Note: The aggregate number of bus adapters should *not* exceed bus specifications.

Bus speed requirements

Bus speed requirements are listed below:

- 4 Gb Fibre Channel requires 425 MB/sec
- 8 Gb Fibre Channel requires 850 MB/sec
- 10 GB Fibre Channell requires 1,250 MB/sec

Bus specifications

Bus specifications are listed in Table 2 on page 15:

Table 2 Bus specifications (page 1 of 2)

Bus type	MHz	MB/second
PCI 32-bit	33	133
PCI 64-bit	33	266
PCI 32-bit	66	266
PCI 64-bit	66	533
PCI 64-bit	100	800
PCI-X 1.0	133	1,067

Table 2 Bus specifications (page 2 of 2)

Bus type	MHz	MB/second
PCI-X 2.0	266	2,134
PCI-X 2.0	533	4,268
PCIeXpress 1.0 x 1		250
PCIeXpress 1.0 x 2		500
PCIeXpress 1.0 x 4		1,000
PCIeXpress 1.0 x 8		2,000
PCIeXpress 1.0 x 16		4, 000
PCIeXpress 1.0 x 32		8,000
PCIeXpress 2.0 x 8		4,000
PCIeXpress 2.0 x 16		8,000
PCIeXpress 2.0 x 32		16,000

Storage

The components that impact performance of storage configurations are listed here:

- Storage connectivity
  - Local verses SAN attached verses NAS attached
  - Use of storage snapshots

    The snapshot technology used determines the read performance
- Storage replication

  Some replication technologies add significant latency to write access slows down storage access.
- Storage type
  - Serial ATA (SATA) computer bus, is a storage-interface for connecting host bus adapters to storage devices such as hard disk drives and optical drives.
  - Fibre Channel (FC) is a gigabit-speed network technology primarily used for storage networking.
  - Flash is a non-volatile computer storage used for general storage and the transfer of data between computers and other digital products.
- I/O transfer rate of storage:

  I/O transfer rate of storage is influenced by different RAID levels, where the best RAID level for the backup server is RAID1 or RAID5. Backup to disk should use RAID3.
- Scheduled I/O:

  If the target system is scheduled to perform I/O intensive tasks at a specific time, schedule backups to run at a different time.

- I/O data:
  - Raw data access offers the highest level of performance, but does not logically sort saved data for future access.
  - File systems with a large number of files have degraded performance due to additional processing required by the file system.
- Compression:

  If data is compressed on the disk, the operating system or an application, the data is decompressed before a backup. The CPU requires time to re-compress the files, and disk speed is negatively impacted.

Network

The components that impact network configuration performance are listed here:

- IP network

  A computer network made of devices that support the Internet Protocol to determine the source and destination of network communication.
- Storage network

  The system on which physical storage, such as tape, disk, or file system resides.
- Network speed

  The speed at which data travels over the network.
- Network bandwidth

  The maximum throughput of a computer network.
- Network path

  The communication path used for data transfer in a network.
- Local verses remote device.
- Network concurrent load

  The point at which data is placed in a network to ultimately maximize bandwidth.
- Network latency

  The measure of the time delay for data traveling between source and target devices in a network.

Target device

The components that impact performance in target device configurations are listed here:

- Storage type:
  - Rawdisk verses Disk Appliance
    - Rawdisk: Hard disk access at a raw, binary level, beneath the file system level.
    - Disk Appliance: A system of servers, storage nodes, and software.

- Physical tape verses Virtual tape library
  - VTL presents a storage component (usually hard disk storage) as tape libraries or tape drives for use as storage medium with the NetWorker software.
  - Physical tape is a type of removable storage media, generally referred to as a volume or cartridge, that contains magnetic tape as its medium.
- Connectivity:
  - Local, SAN-attached

    A computer network, separate from a LAN or WAN, designed to attach shared storage devices such as disk arrays and tape libraries to servers.
  - IP-attached

    The storage device has its own unique IP address.

The component 70% rule

Manufacturer throughput and performance specifications based on theoretical environments are rarely, or never achieved in real backup environments. It is a best practice to never exceed 70% of the rated capacity of any component. Components include:

- CPU
- Disk
- Network
- Internal bus
- Memory
- Fibre Channel

Performance and response time significantly decreases when the 70% utilization threshold is exceeded.

Components of a NetWorker environment

This section describes the components of a NetWorker datazone. Figure 1 on page 19 illustrates the main components in a NetWorker environment. The components and technologies that make up a NetWorker environment are listed here:

- “Datazone” on page 19
- “NetWorker Management Console” on page 19
- “NetWorker server” on page 20
- “NetWorker storage node” on page 21
- “NetWorker client” on page 21
- “Optional NetWorker Application Modules” on page 22
- “Virtual environments” on page 22
- “NetWorker deduplication nodes” on page 22

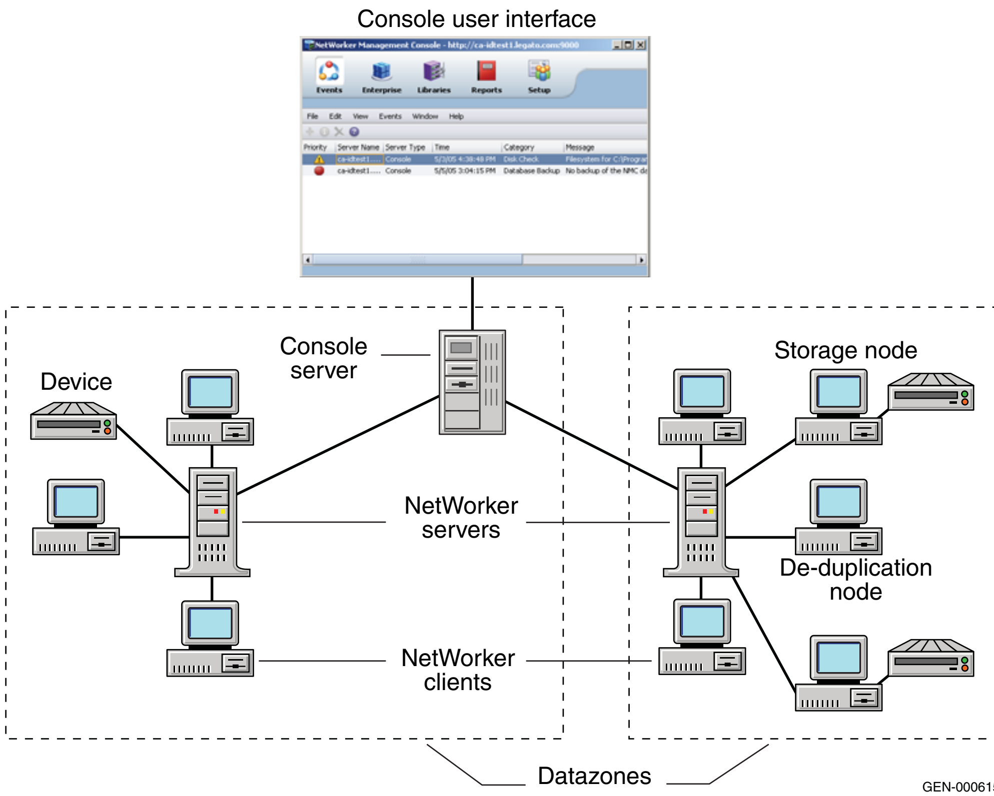

Figure 1 **NetWorker datazone components**

Datazone

A datazone is a single NetWorker server and its client computers. Datazones can be added as backup requirements increase.

NetWorker Management Console

The NetWorker Management Console (NMC) is used to administer the backup server and it provides backup reporting capabilities.

The NMC often runs on the backup server, and adds significant load to the backup server. For larger environments, it is recommended to install NMC on a separate computer. A single NMC server can be used to administer multiple backup servers.

Components that determine NMC performance

Components that determine the performance of NMC are:

- TCP network connectivity to backup server: All communication between NMC and NW server is over TCP and such high-speed low-latency network connectivity is essential.
- Memory: database tasks in larger environments are memory intensive, make sure that NMC server is equipped with sufficient memory.
- CPU: If NMC server is used by multiple users, make sure that it has sufficient CPU power to ensure that each user is given enough CPU time slices.

NetWorker server

NetWorker servers provide services to back up and recover data for the NetWorker client computers in a datazone. The NetWorker server can also act as a storage node and control multiple remote storage nodes.

Index and media management operations are some of the primary processes of the NetWorker server:

- The client file index tracks the files that belong to a save set. There is one client file index for each client.
- The media database tracks:
  - Volume name
  - Backup dates of the save sets on the volume
  - File systems in each save set
- Unlike the client file indexes, there is only one media database per server.
- The client file indexes and media database can grow to become prohibitively large over time and will negatively impact backup performance.

Components that determine backup server performance

Components that determine NetWorker server backup performance are:

- The disk used to host the NetWorker server (/nsr.)

  Note: The typical NetWorker server workload is from many small I/O operations. This is why disks with high latency perform poorly despite having peak bandwidth. High latency rates is the most common bottleneck of a backup server in larger environments.

- Avoid additional software layers as this adds to storage latency. For example, antivirus software should be on the backup exclusion list for /nsr.
- Plan the use of replication technology carefully as it significantly increases storage latency.
- Ensure that there is sufficient CPU power for large servers to complete all internal database tasks.
- Ensure that there is sufficient memory on the server to complete all internal database tasks.
- Off-load backups to dedicated storage nodes when possible for clients that must act as a storage node by saving data directly to backup server.

The system load that results from storage node processing is significant in large environments. For enterprise environments, the backup server should only backup its internal databases (index and bootstrap).

NetWorker storage node

A NetWorker storage node can be used to improve performance by off loading from the NetWorker server much of the data movement involved in a backup or recovery operation. NetWorker storage nodes require high I/O bandwidth to manage the transfer of data transfer from local clients, or network clients to target devices.

Components that determine storage node performance

Components that determine storage node performance are:

- Performance of the target device used to store the backup.
- Connectivity of the system. For example, a storage node used for TCP network backups can save data only as fast as it is able to receive the data from clients.
- I/O bandwidth: Ensure that there is sufficient I/O bandwidth as each storage node uses available system bandwidth, Therefore the backup performance of all devices is limited by the I/O bandwidth of the system itself.
- CPU: Ensure that there is sufficient CPU to send and receive large amounts of data.

NetWorker client

A NetWorker client computer is any computer whose data must be backed up. The NetWorker Console server, NetWorker servers, and NetWorker storage nodes are also NetWorker clients. NetWorker clients hold mission critical data and are resource intensive. Applications on NetWorker clients are the primary users of CPU, network, and I/O resources. Only read operations performed on the client do not require additional processing.

Client speed is determined by all active instances of a specific client backup at a point in time.

Components that determine NetWorker client performance

Components that determine NetWorker client performance are:

- Client backups are resource intensive operations and impact the performance of primary applications. When sizing systems for applications, be sure to consider backups and the related bandwidth requirements. Also, client applications use a significant amount of CPU and I/O resources slowing down backups.

  If a NetWorker client does not have sufficient resources, both backup, and application performance are negatively impacted.
- NetWorker clients with millions of files. As most backup applications are file based solutions, a lot of time is used to process all of the files created by the file system. This negatively impacts NetWorker client backup performance. For example:
  - A full backup of 5 million 20 KB files takes much longer than a backup of 0.5 million 200 KB files, although both result in a 100 GB save set.
  - An incremental/differential backup of 1 thousand 100 MB files with 50 modified files takes much longer than 100 thousand 1 MB files with 50 modified files, although both result in a 100 GB save set.

- Encryption and compression are resource intensive operations on the NetWorker client and can significantly affect backup performance.
- Backup data must be transferred to target storage and processed on the backup server:
  - Client/storage node performance:
    - A local storage node: uses shared memory and does not require additional overhead.
    - A remote storage node: receive performance is limited by network components.
  - Client/backup server load:

    Does not normally slow client backup performance unless the backup server is significantly undersized.

Optional NetWorker Application Modules

NetWorker Application Modules are used for specific online backup tasks. Additional application-side tuning might be required to increase application backup performance.

Virtual environments

NetWorker clients can be created for virtual machines for either traditional backup or VMware Consolidated Backup (VCB). Additionally, the NetWorker software can automatically discover virtual environments and changes to those environments on either a scheduled or on-demand basis and provides a graphical view of those environments.

NetWorker deduplication nodes

A NetWorker deduplication node is an EMC Avamar® server that stores deduplicated backup data. The initial backup to a deduplication node should be a full backup. During subsequent backups, the Avamar infrastructure identifies redundant data segments at the source and backs up only unique segments, not entire files that contain changes. This reduces the time required to perform backups, as well as both the network bandwidth and storage space used for backups NetWorker Management Console

Recovery performance factors

Recovery performance can be impeded by network traffic, bottlenecks, large files, and more. Some considerations for recovery performance are:

- File-based recovery performance depends on the performance of the backup server, specifically the client file index. Information on the client file index is available in “NetWorker server” on page 20.
- The fastest method to recover data efficiently is to run multiple recover commands simultaneously by using save set recover. For example, 3 save set recover operations provide the maximum possible parallelism possible given the number of processes, the volume, and the save set layout.
- If multiple, simultaneous recover operations run from the same tape, be sure that the tape does not mount and start until all recover requests are ready. If the tape is used before all requests are ready, the tape is read multiple times slowing recovery performance.
- Multiplexing backups to tape slows recovery performance.

Connectivity and bottlenecks

The backup environment consists of various devices from system, storage, network, and target device components, with hundreds of models from various vendors available for each of them.

The factors affecting performance with respect to connectivity are listed here:

- Components can perform well as standalone devices, but how well they perform with the other devices on the chain is what makes the configuration optimal.
- Components on the chain are of no use if they cannot communicate to each other.
- Backups are data intensive operations and can generate large amounts of data. Data must be transferred at optimal speeds to meet business needs.
- The slowest component in the chain is considered a bottleneck.

In Figure 2 on page 24, the network is unable to gather and send as much data as that of the components. Therefore, the network is the bottleneck, slowing down the entire backup process. Any single network device on the chain, such as a hub, switch, or a NIC, can be the bottleneck and slow down the entire operation.

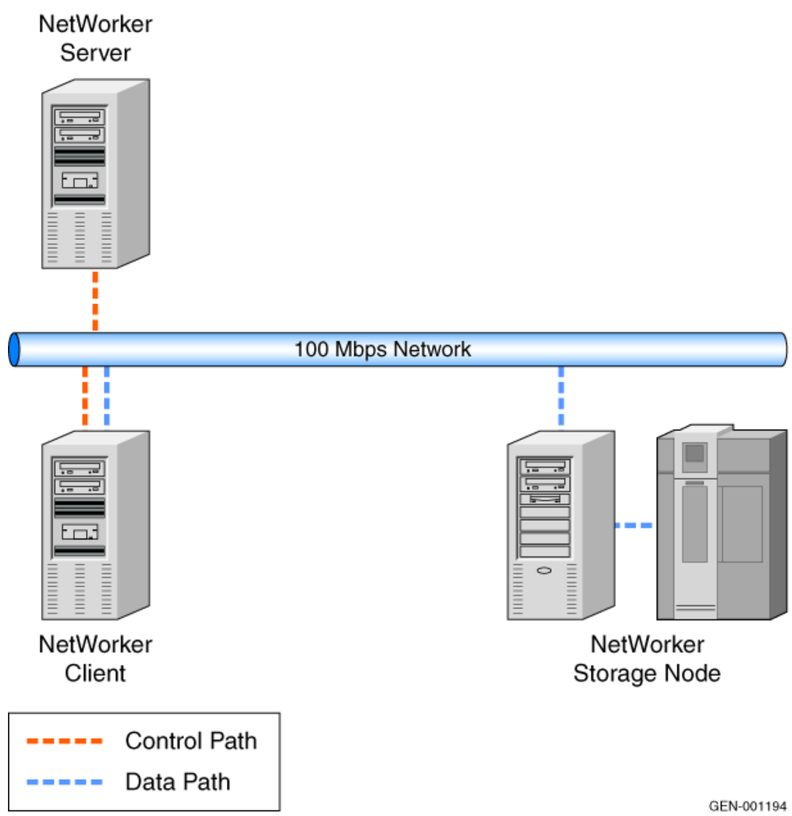

Figure 2 Network device bottleneck

As illustrated in Figure 3 on page 25, the network is upgraded from a 100 base T network to a GigE network, and the bottleneck has moved to another device. The host is now unable to generate data fast enough to use the available network bandwidth. System bottlenecks can be due to lack of CPU, memory, or other resources.

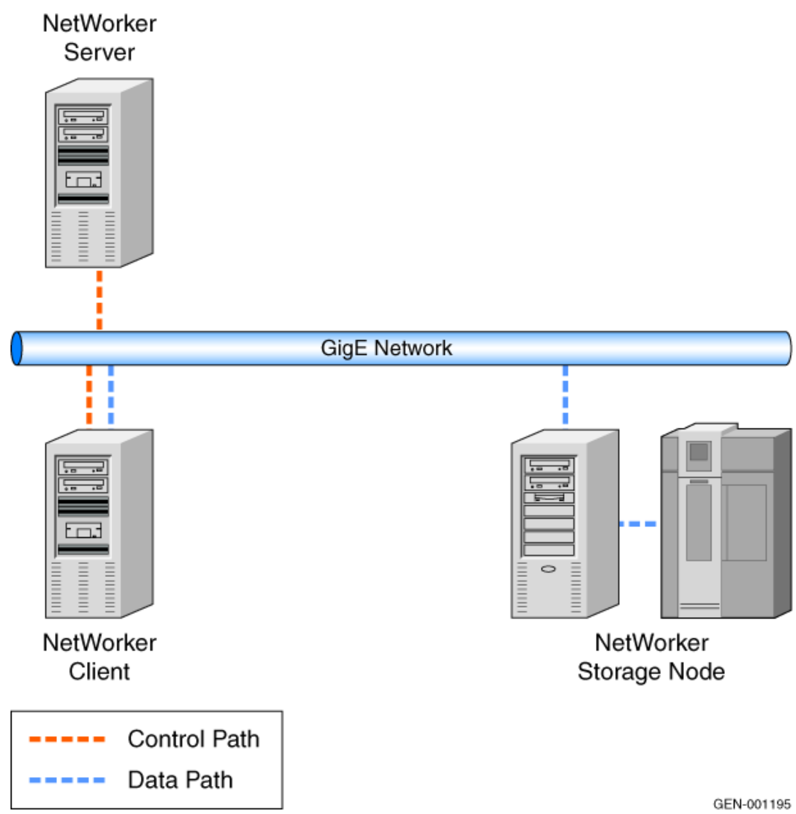

Figure 3 Updated network

As illustrated in Figure 4 on page 26, the NetWorker client is upgraded to a larger system to remove it as the bottleneck. With a better system and more network bandwidth, the bottleneck is now the target device. Tape devices often do not perform as well as other components. Some factors that limit tape device performance are:

- Limited SCSI bandwidth
- Maximum tape drive performance reached.

Improve the target device performance by introducing higher performance tape devices, such as fibre channel based drives. Also, SAN environments can greatly improve performance.

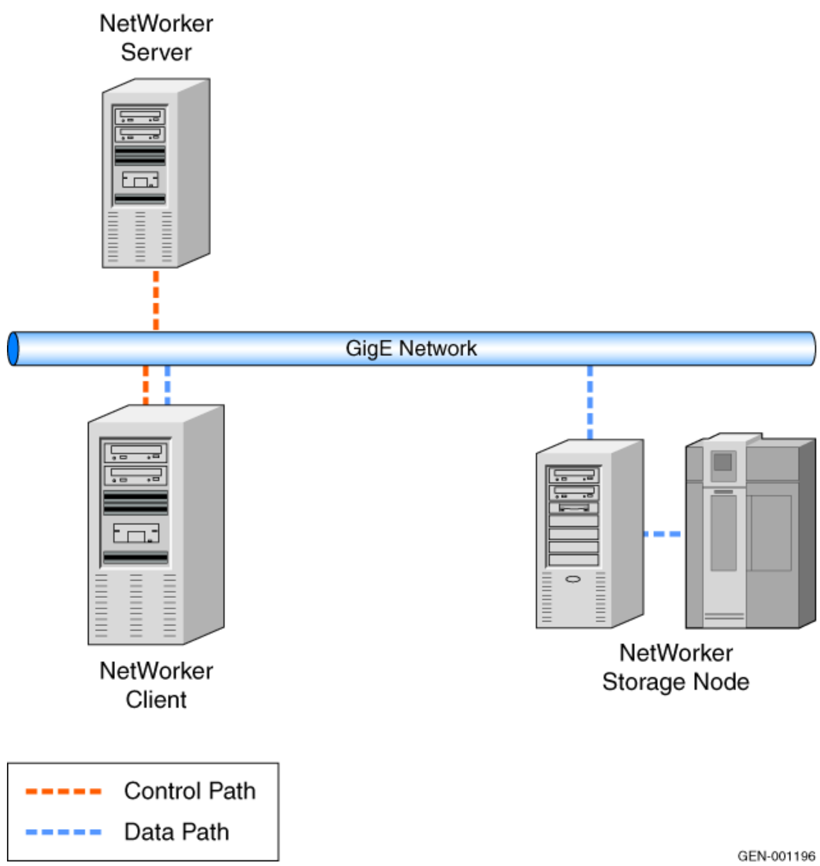

Figure 4 **Updated client**

As illustrated in Figure 5 on page 27 higher performance tape devices on a SAN remove them as the bottleneck. The bottleneck device is now the storage devices. Although the local volumes are performing at optimal speeds, they are unable to use the available system, network, and target device resources. To improve the storage performance, move the data volumes to high performance external RAID arrays.

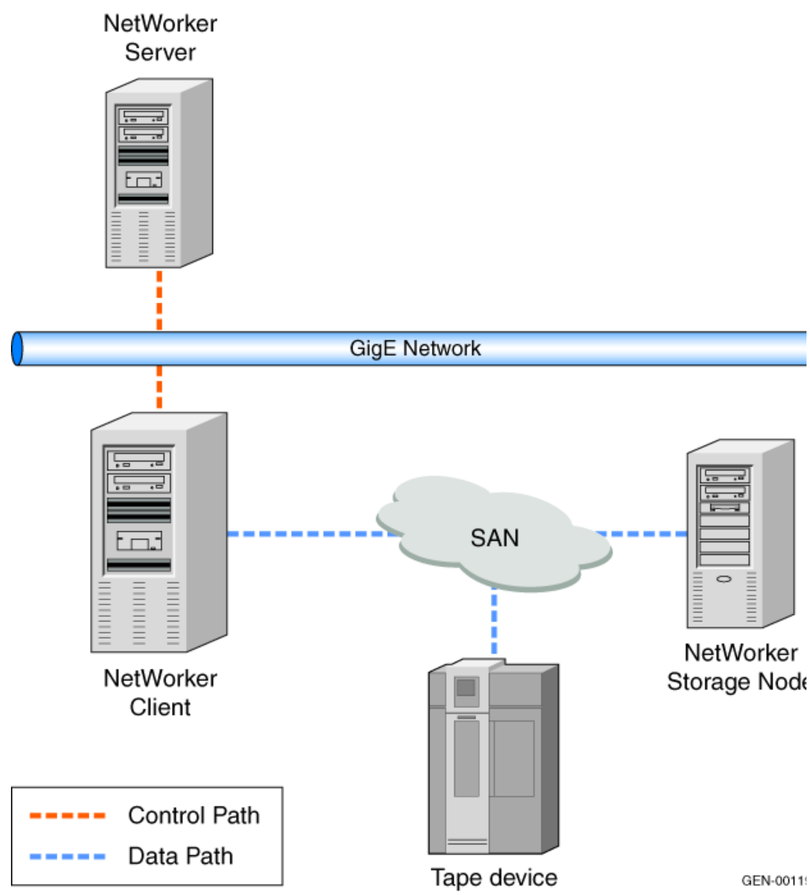

Figure 5 Dedicated SAN

Although the local volumes are performing at optimal speeds, they are unable to use the available system, network, and target device resources. To improve the storage performance, move the data volumes to high performance external RAID arrays.

As illustrated in Figure 6 on page 28, the external RAID arrays have improved the system performance. The RAID arrays perform nearly as well as the other components in the chain ensuring that performance expectations are met. There will always be a bottleneck, however the impact of the bottleneck device is limited as all devices are performing at almost the same level as the other devices in the chain.

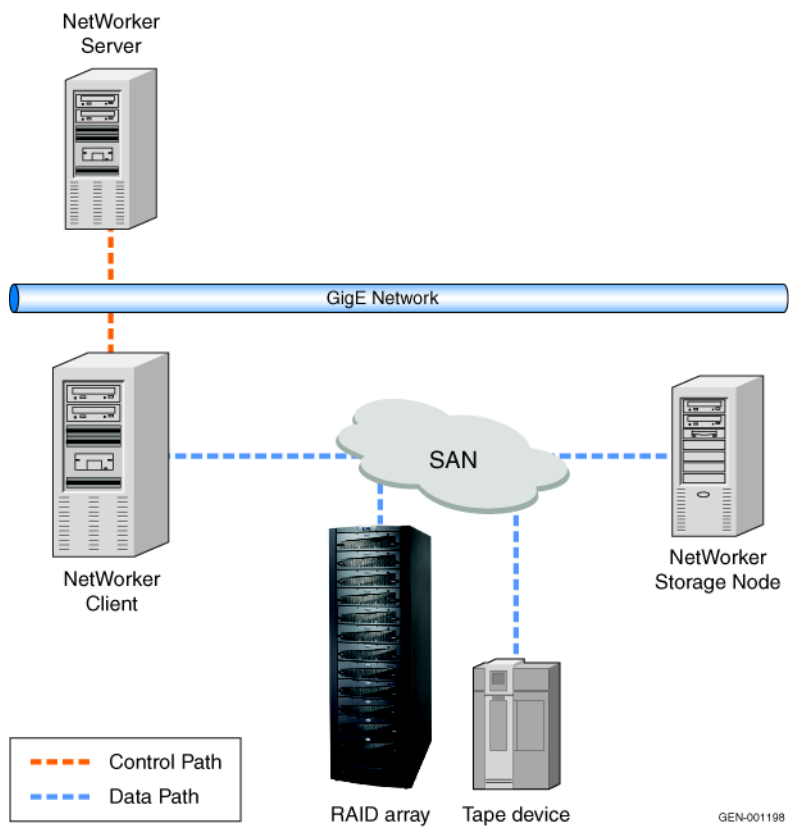

Figure 6 **Raid array**

Note: This section does not suggest that all components must be upgraded to improve performance, but attempts to explain the concept of bottlenecks, and stresses the importance of having devices that perform at similar speeds as other devices in the chain.

3

Test Performance

This chapter describes how to test and understand bottlenecks by using available tools including NetWorker programs such as bigasm, and uasm. Sections included in this chapter are:

Determine symptoms

Considerations for determining the reason for poor backupperformance are listed here:

- Is the performance consistent for the entire duration of the backup?
- Do the backups perform better when started at a different time?
- Is it consistent across all save sets for the clients?
- Is it consistent across all clients with similar system configuration using a specific storage node?
- Is it consistent across all clients with similar system configuration in the same subnet?
- Is it consistent across all clients with similar system configuration and applications?

Observe how the client performs with different parameters. Inconsistent backup speed can indicate problems with software or firmware.

For each NetWorker client, answer these questions:

- Is the performance consistent for the entire duration of the backup?
- Is there a change in performance if the backup is started at a different time?
- Is it consistent across all clients using specific storage node?
- Is it consistent across all save sets for the client?
- Is it consistent across all clients in the same subnet?
- Is it consistent across all clients with similar operating systems, service packs, applications?
- Does the backup performance improve during the save or does it decrease?

These and similar questions can help to identify the specific performance issues.

Monitor performance

Monitor the I/O, disk, CPU and network performance by using native performance monitoring tools such as:

- Windows: **Perfmon**
- UNIX: **iostat**, **vmstat**, or **netstat** commands

Unusual activity before, during, and after backups can determine that devices are using excessive resources.

By using these tools to observe performance over a period of time, resources consumed by each application, including NetWorker are clearly identified.

If it is discovered that slow backups are due to excessive network use by other applications, this can be corrected by changing backup schedules.

Note: High CPU use is often the result of waiting for external I/O, not insufficient CPU power. This is indicated by high CPU use inside SYSTEM verses verses user space.

On Windows, a lot of time is spent on Deferred Procedure Calls often indicates a problem with device drivers.

Determine bottlenecks by using a generic FTP test

Without using NetWorker components, determine whether the bottleneck is in the network or the tape device by using a generic FTP test:

1. Create a large data file on the NetWorker client and send it to the storage node by using FTP.
2. Make note of the time it takes for the file to transfer.
3. Compare the time noted in Step 2 with current backup performance.
   - If the ftp performs much faster than the backups, then the issue might be with the tape devices.
   - If the ftp performs at a similar rate, then the bottleneck might be in the network.
4. Compare results using active FTP verses passive FTP transfer. NetWorker backup performance is greatly impacted by the capabilities of the underlying network due to the network packets used by the NetWorker software.

   If there is large difference in the transfer rate, or one type of FTP transfer has spikes, it might indicate the presence of network components that perform TCP packet re-assembly. This causes the link to perform in half-duplex mode, despite all physical parts that are in full-duplex mode.

   Note: Do *not* use local volumes to create and transfer files for ftp tests, use backup volumes.

Test the performance of the setup by using dd

Without using NetWorker components, use the generic dd test to compare device throughput to the manufacturer's suggested throughput:

1. Create a large data file on the storage node and use **dd** to send it to the target device:

   ```
   date; dd if=/tmp/5GBfile of=/dev/rmt/0cbn bs= 1MB; date
   ```

2. Make note of the time it takes for the file to transfer, and compare it with the current tape performance.

Test disk performance by using bigasm and uasm

The bigasm and uasm directives are NetWorker based tests used to verify performance.

The bigasm directive

The bigasm directive generates a specific sized file, and transfers the file over a network or a SCSI connection. The file is then written to a tape or another target device. The bigasm directive creates a stream of bytes in memory and saves them to the target device that eliminates disk access. This helps to test the speed of NetWorker clients, network, and the tape devices ignoring disk access.

Create a **bigasm** directive to generate a very large save set.

The bigasm directive ignores disk access to test the performance of client, network and tape.

The uasm directive

The uasm directive reads from the disk at maximum speeds to identify disk based bottlenecks. For example:

```
uasm -s filename > NUL
```

The uasm directive tests disk read speeds, and by writing data to a null device can identify disk-based bottlenecks.

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Tune Network Settings to Optimize Performance

The NetWorker software has various optimization features that can be used to tune the backup environment, and to optimize backup and restore performance.

This chapter incudes the following topics:

Optimize NetWorker parallelism

This section describes general best practices for server, group, and client parallelism.

Server parallelism

The server parallelism attribute controls how many save streams the server accepts simultaneously. The more save streams the server can accept, the faster the devices and client disks run. Client disks can run at their performance limit or the limits of the connections between them.

Server parallelism is not used to control the startup of backup jobs, but as a final limit of sessions accepted by a backup server. The server parallelism value should be as high as possible while not overloading the backup server itself.

Client parallelism

The best approach for client parallelism values is:

- For regular clients, use the lowest possible parallelism settings to best balance between the number of save sets and throughput.
- For the backup server, set highest possible client parallelism to ensure that index backups are not delayed. This ensures that groups complete as they should.

Often backup delays occur when client parallelism is set too low for the NetWorker server. The best approach to optimize NetWorker client performance is to eliminate client parallelism, reduce it to 1, and increase the parallelism based on client hardware and data configuration.

It is critical that the NetWorker server have sufficient parallelism to ensure index backups do not impede group completion.

Recommendations for client parallelism for the NetWorker server are:

- Never set parallelism to 1
- For small environments (under 30 servers), set parallelism to at least 8
- For medium environments (31-100 servers), set parallelism to at least 12
- For larger environments (100+ servers), set parallelism to at least 16

The above recommendations assume that the backup server is a dedicated backup server. The backup server should always be a dedicated server for optimum performance.

Group parallelism

The best approach for group parallelism values is:

- Create save groups with a maximum of 50 clients with group parallelism enforced. Large save groups with more than 50 clients can result in many operating system processes starting at the same time causing temporary operating system resource exhaustion.
- Stagger save group start times by a small amount to reduce the load on the operating system. For example, it is best to have 4 save groups, each with 50 clients, starting at 5 minute intervals than to have 1 save group with 200 clients.

Multiplexing

The **Target Sessions** attribute sets the target number of simultaneous save streams that write to a device. This value is not a limit, therefore a device might receive more sessions than the **Target Sessions** attribute specifies. The more sessions specified for **Target Sessions**, the more save sets that can be multiplexed (or interleaved) onto the same volume.

Performance tests and evaluation can determine whether multiplexing is appropriate for the system. Follow these guidelines when evaluating the use of multiplexing:

- Find the maximum rate of each device. Use the **bigasm** test described in "The bigasm directive" on page 32.
- Find the backup rate of each disk on the client. Use the **uasm** test described in "The uasm directive" on page 32

If the sum of the backup rates from all disks in a backup is greater than the maximum rate of the device, do not increase server parallelism. If more save groups are multiplexed in this case, backup performance will not improve, and recovery performance could slow down.

Device performance tuning methods

These sections address specific device-related areas that can improve performance.

Input/output transfer rate

Input/output (I/O) transfer rates can affect device performance. The I/O rate is the rate at which data is written to a device. Depending on the device and media technology, device transfer rates can range from 500 KB per second to 20 MB per second. The default block size and buffer size of a device affect its transfer rate. If I/O limitations interfere with the performance of the NetWorker server, try upgrading the equipment to affect a better transfer rate.

Built-in compression

Turn on device compression to increase effective throughput to the device. Some devices have a built-in hardware compression feature. Depending on how compressible the backup data is, this can improve effective data throughput, from a ratio of 1.5:1 to 3:1.

Drive streaming

To obtain peak performance from most devices, stream the drive at its maximum sustained throughput. Without drive streaming, the drive must stop to wait for its buffer to refill or to reposition the media before it can resume writing. This can cause a delay in the cycle time of a drive, depending on the device.

Device load balancing

Balance data load for simultaneous sessions more evenly across available devices by adjusting sessions per device. This parameter specifies the minimum number of save sessions to be established before the NetWorker server attempts to assign save sessions to another device.

Network devices

If data is backed up from remote clients, the routers, network cables, and network interface cards affect the backup and recovery operations. This section lists the performance variables in network hardware, and suggests some basic tuning for networks. The following items address specific network issues:

- Network I/O bandwidth:

  The maximum data transfer rate across a network rarely approaches the specification of the manufacturer because of network protocol overhead.

  Note: The following statement concerning overall system sizing must be considered when addressing network bandwidth.

  Each attached tape drive (physical VTL or AFTD) uses available I/O bandwidth, and also consumes CPU as data still requires processing.

- Network path

  Networking components such as routers, bridges, and hubs consume some overhead bandwidth, which degrades network throughput performance.

- Network load
  - Do not attach a high number of high performance tape drives or AFTD devices directly to a backup server.
  - Do not attach a large number of high-speed NICs directly to the NetWorker server, as each IP address use significant amounts of CPU resources. For example, a mid-size system with four 1GB NICs uses more than 50 percent of its resources to process TCP data during a backup.
  - Other network traffic limits the bandwidth available to the NetWorker server and degrades backup performance. As the network load reaches a saturation threshold, data packet collisions degrade performance even more.
  - Do not overlap staging and backup operations with a VTL or AFTD solution from any SATA drive vendor. Despite the performance of the array, ATA technology has significant performance degradation on parallel read and write streams.
  - Use fewer CPUs, as systems with fewer high performance CPUs outperform systems with numerous lower performance CPUs.

Number of virtual drives versus physical drives

The following is based on the 70% utilization of a Fibre Channel port:

- For LTO-3: 3 virtual devices for every 2 physical devices planned.
- For LTO-4: 3 virtual devices for each physical device planned.

On the port:

- The first virtual drive does not exceed 150 MB per second.
- The second virtual drive does not exceed 100 MB per second.
- The third virtual drive will not exceed 70 MB per second.

Network optimization

This section explains the following:

- "Advanced configuration optimization" on page 37
- "Operating system TCP stack optimization" on page 37
- "Advanced tuning" on page 38
- "Expected throughput values" on page 38
- "Network latency" on page 38
- "Ethernet duplexing" on page 38

Advanced configuration optimization

The EMC Technical Note, *Configuring TCP Networks and Network Firewalls for EMC NetWorker* provides instructions on advanced configuration options such as multihomed systems, trunking, and more.

The default TCP operating system parameters are tuned for maximum compatibility with legacy network infrastructures, but not for maximum performance.

Operating system TCP stack optimization

The common rules for optimizing the operating system TCP stack for all use cases are listed here:

- Disable software flow control
- Increase TCP buffer sizes
- Increase TCP queue depth
- Use PCIeXpress for 10GB NICs. Other I/O architectures do not have sufficient bandwidth.

Rules that depend on environmental capabilities are listed here:

- Some operating systems have internal auto-tuning of the TCP stack. This produces good results in a non-heterogeneous environment. However, for heterogeneous, or routed environments disable TCP auto-tuning.
- Enable jumbo frames when possible.

Note: It is required that *all* network components in the data path are able to handle jumbo frames. Do not enable jumbo frames if this is not the case.

- TCP off loading is beneficial if it works properly, however it can cause CRC mis-matches. Be sure to monitor for errors if it is enabled.
- TCP windows scaling is beneficial if it is supported by all network equipment in the chain.
- TCP congestion notification can cause problems in heterogeneous environments. Only enable it in single operating system environments.

Advanced tuning

IRQ processing for high-speed NICs is very expensive, but can provide enhanced performance by selecting specific CPU cores. Specific recommendations depend on the CPU architecture.

Expected throughput values

Common throughput values are in the following ranges:

- 100Mb link = 6-8 MB/sec
- 1Gb link = 45-65MB/sec
- 10Gb link = 200-350MB/sec

With optimized values, throughput for high-speed links can be increased to the following:

- 100Mb link = 12 MB/sec
- 1Gb link = 100MB/sec
- 10Gb link = 750MB/sec

Network latency

Increased network TCP latency has a negative impact on overall throughput, despite the amount of available link bandwidth. Longer distances or more hops between network hosts results in lower overall throughput.

Ethernet duplexing

Network links that perform in half-duplex mode cause decreased NetWorker traffic flow performance. For example, a 100Mb half-duplex link results in backup performance of less than 1MB/sec.

The default configuration setting on most operating systems for duplexing is auto negotiated as recommended by IEEE802.3. However, auto negotiation requires that the following conditions are met:

- Proper cabling
- Compatible NIC adapter
- Compatible switch

Auto negotiation can result in a link performing as half-duplex.

To avoid issues with auto negotiation, force full-duplex settings on the NIC. Forced full-duplex setting must be applied to both sides of the link. Forced full-duplex on only one side of the link results in failed auto negotiation on the other side of the link.