

# Dell EMC NetWorker

Version 19.1.x

## Performance Optimization Planning Guide

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# Preface

As part of an effort to improve product lines, periodic revisions of software and hardware are released. Therefore, all versions of the software or hardware currently in use might not support some functions that are described in this document. The product release notes provide the most up-to-date information on product features.

If a product does not function correctly or does not function as described in this document, contact a technical support professional.

 **Note:** This document was accurate at publication time. To ensure that you are using the latest version of this document, go to the Support website <https://www.dell.com/support>.

## Purpose

This document describes how to size and optimize the NetWorker software.

## Audience

This document is intended for the NetWorker software administrator.

## Revision history

The following table presents the revision history of this document.

**Table 1** Revision history

Revision	Date	Description
02	August 14, 2019	Second release of this document for NetWorker 19.1.x. Updated the NetWorker kernel parameter requirements section.
01	May 20, 2019	First release of this document for NetWorker 19.1.

## Related documentation

The NetWorker documentation set includes the following publications, available on the Support website:

- *NetWorker E-LAB Navigator*  
Provides compatibility information, including specific software and hardware configurations that NetWorker supports. To access E-LAB Navigator, go to <https://elabnavigator.emc.com/eln/elhome>.
- *NetWorker Administration Guide*  
Describes how to configure and maintain the NetWorker software.
- *NetWorker Network Data Management Protocol (NDMP) User Guide*  
Describes how to use the NetWorker software to provide data protection for NDMP filers.
- *NetWorker Cluster Integration Guide*  
Contains information related to configuring NetWorker software on cluster servers and clients.
- *NetWorker Installation Guide*


Provides information on how to install, uninstall, and update the NetWorker software for clients, storage nodes, and servers on all supported operating systems.


- *NetWorker Updating from a Previous Release Guide*  
Describes how to update the NetWorker software from a previously installed release.
- *NetWorker Release Notes*  
Contains information on new features and changes, fixed problems, known limitations, environment and system requirements for the latest NetWorker software release.
- *NetWorker Command Reference Guide*  
Provides reference information for NetWorker commands and options.
- *NetWorker Data Domain Boost Integration Guide*  
Provides planning and configuration information on the use of Data Domain devices for data deduplication backup and storage in a NetWorker environment.
- *NetWorker Performance Optimization Planning Guide*  
Contains basic performance tuning information for NetWorker.
- *NetWorker Server Disaster Recovery and Availability Best Practices Guide*  
Describes how to design, plan for, and perform a step-by-step NetWorker disaster recovery.
- *NetWorker Snapshot Management Integration Guide*  
Describes the ability to catalog and manage snapshot copies of production data that are created by using mirror technologies on storage arrays.
- *NetWorker Snapshot Management for NAS Devices Integration Guide*  
Describes how to catalog and manage snapshot copies of production data that are created by using replication technologies on NAS devices.
- *NetWorker Security Configuration Guide*  
Provides an overview of security configuration settings available in NetWorker, secure deployment, and physical security controls needed to ensure the secure operation of the product.
- *NetWorker VMware Integration Guide*  
Provides planning and configuration information on the use of VMware in a NetWorker environment.
- *NetWorker Error Message Guide*  
Provides information on common NetWorker error messages.
- *NetWorker Licensing Guide*  
Provides information about licensing NetWorker products and features.
- *NetWorker REST API Getting Started Guide*  
Describes how to configure and use the NetWorker REST API to create programmatic interfaces to the NetWorker server.
- *NetWorker REST API Reference Guide*  
Provides the NetWorker REST API specification used to create programmatic interfaces to the NetWorker server.
- *NetWorker 19.1 with CloudBoost 19.1 Integration Guide*  
Describes the integration of NetWorker with CloudBoost.
- *NetWorker 19.1 with CloudBoost 19.1 Security Configuration Guide*  
Provides an overview of security configuration settings available in NetWorker and Cloud Boost, secure deployment, and physical security controls needed to ensure the secure operation of the product.

- **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 the online help, click **Help** in the main menu.
- **NetWorker User Online Help**  
Describes how to use the NetWorker User program, which is the Windows client interface, to connect to a NetWorker server to back up, recover, archive, and retrieve files over a network.

### Special notice conventions that are used in this document

The following conventions are used for special notices:

 **NOTICE** Identifies content that warns of potential business or data loss.

 **Note:** Contains information that is incidental, but not essential, to the topic.

### Typographical conventions

The following type style conventions are used in this document:

**Table 2** Style conventions

<b>Bold</b>	Used for interface elements that a user specifically selects or clicks, for example, names of buttons, fields, tab names, and menu paths. Also used for the name of a dialog box, page, pane, screen area with title, table label, and window.
<i>Italic</i>	Used for full titles of publications that are referenced in text.
Monospace	Used for: <ul style="list-style-type: none"> <li>• System code</li> <li>• System output, such as an error message or script</li> <li>• Pathnames, file names, file name extensions, prompts, and syntax</li> <li>• Commands and options</li> </ul>
<i>Monospace italic</i>	Used for variables.
<b>Monospace bold</b>	Used for user input.
[ ]	Square brackets enclose optional values.
	Vertical line indicates alternate selections. The vertical line means or for the alternate selections.
{ }	Braces enclose content that the user must specify, such as x, y, or z.
...	Ellipses indicate non-essential information that is omitted from the example.

You can use the following resources to find more information about this product, obtain support, and provide feedback.

### Where to find product documentation

- <https://www.dell.com/support>
- <https://community.emc.com>

## Where to get support

The Support website <https://www.dell.com/support> provides access to product licensing, documentation, advisories, downloads, and how-to and troubleshooting information. The information can enable you to resolve a product issue before you contact Support.

To access a product-specific page:

1. Go to <https://www.dell.com/support>.
2. In the search box, type a product name, and then from the list that appears, select the product.

## Knowledgebase

The Knowledgebase contains applicable solutions that you can search for either by solution number (for example, KB000xxxxxx) or by keyword.

To search the Knowledgebase:

1. Go to <https://www.dell.com/support>.
2. On the **Support** tab, click **Knowledge Base**.
3. In the search box, type either the solution number or keywords. Optionally, you can limit the search to specific products by typing a product name in the search box, and then selecting the product from the list that appears.

## Live chat

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1. Go to <https://www.dell.com/support>.
2. On the **Support** tab, click **Contact Support**.
3. On the **Contact Information** page, click the relevant support, and then proceed.

## Service requests

To obtain in-depth help from Licensing, submit a service request. To submit a service request:

1. Go to <https://www.dell.com/support>.
2. On the **Support** tab, click **Service Requests**.

**Note:** To create a service request, you must have a valid support agreement. For details about either an account or obtaining a valid support agreement, contact a sales representative. To get the details of a service request, in the `Service Request Number` field, type the service request number, and then click the right arrow.

To review an open service request:

1. Go to <https://www.dell.com/support>.
2. On the **Support** tab, click **Service Requests**.
3. On the **Service Requests** page, under **Manage Your Service Requests**, click **View All Dell Service Requests**.

## Online communities

For peer contacts, conversations, and content on product support and solutions, go to the Community Network <https://community.emc.com>. Interactively engage with customers, partners, and certified professionals online.

**How to provide feedback**

Feedback helps to improve the accuracy, organization, and overall quality of publications. You can send feedback to [DPAD.Doc.Feedback@emc.com](mailto:DPAD.Doc.Feedback@emc.com).



# CHAPTER 1

## Overview

This chapter includes the following topics:

- [Introduction](#)..... 16
- [NetWorker data flow](#)..... 16

## Introduction

The NetWorker software is a network storage management application that is optimized for the high-speed backup and recovery operations of large amounts of complex data across entire datazones. This guide 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 becomes a bottle neck.

This manual tries to address NetWorker performance tuning with minimal disruptions to the existing environment. It tries to fine-tune feature functions to achieve better performance with the same set of hardware, and to assist administrators to:

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

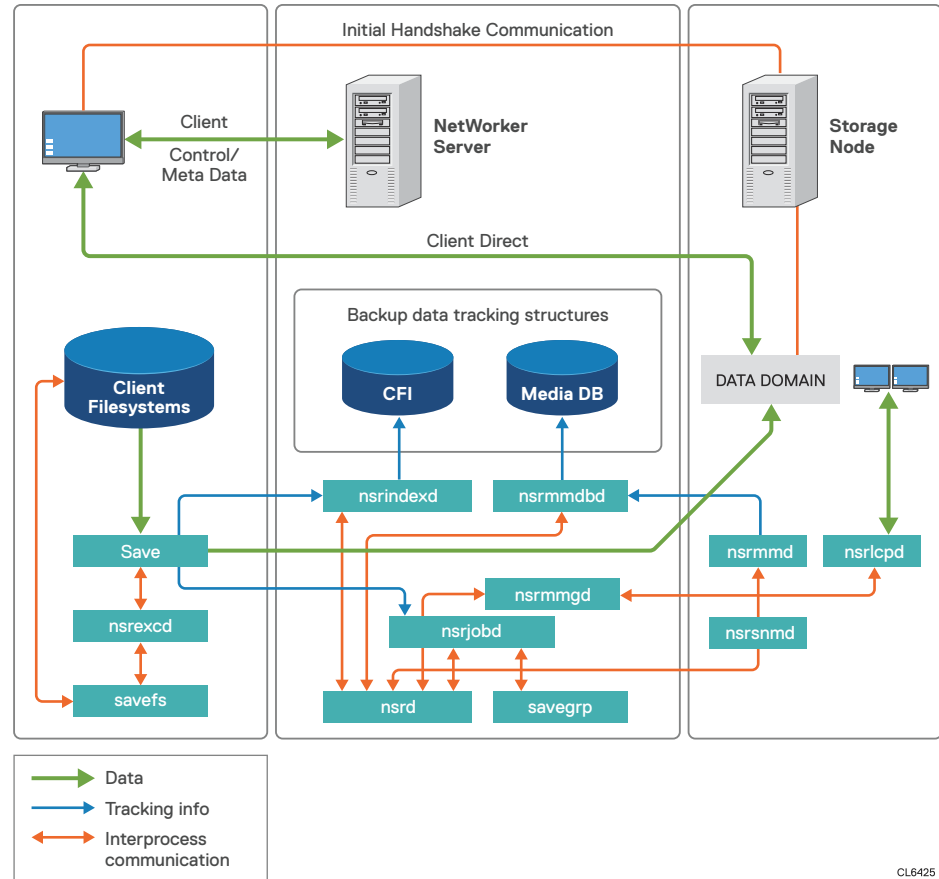
## NetWorker data flow

The following figures illustrate the backup and recover data flow for components in a NetWorker datazone.

The following figures are simplified diagrams, and not all interprocess communication is shown. There are many other possible backups and recover data flow configurations.



Figure 1 NetWorker backup data flow





# CHAPTER 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 are often attributed to hardware or environmental issues. An understanding of the entire backup data flow is important to determine the optimal performance expected from the NetWorker software.

- [Expectations](#)..... 20
- [System components](#)..... 21
- [Storage considerations](#)..... 28
- [Backup operation requirements](#).....32
- [Components of a NetWorker environment](#)..... 46
- [Recovery performance factors](#)..... 53
- [Connectivity and bottlenecks](#).....54

## Expectations

You can determine the backup performance expectations and required backup configurations for your environment based on the Recovery Time Objective (RTO) for each client.

### Determine backup environment performance expectations

It is important to determine performance expectations, while keeping in mind the environment and the devices used.

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.
  - Determine client browse and retention policy requirements.
- 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

[Connectivity and bottlenecks](#) on page 54 provides examples of possible bottlenecks in the NetWorker environment.

### Determining the backup window

It is very important to know how much down time is acceptable for each NetWorker client. This dictates the recovery time objective (RTO). Review and document the RTO for each NetWorker client to determine the backup window for each client.

#### Procedure

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

### Determining the required backup expectations

Often it is not possible to construct a backup image from a full backup and multiple incremental backups if the acceptable down time is limited. Full backups might be required more frequently which results in a longer backup window. This also increases network bandwidth requirements.

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 the information collected.
- Determine the organization of the separate NetWorker client groups based on these parameters:
  - Backup window
  - Business criticality
  - Physical location
  - Retention policy
- Ensure that RTO can be met with the backup created for each client. Backups become increasingly expensive as the acceptable downtime/backup window decreases.

## 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

Several system configuration components impact performance:


- 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 1 GHz 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.

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

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

- 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.
- 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 percent. The same backup server in `/nsr` on a disk array with low utilization, results in CPU use of less than 15 percent.
  - On UNIX, and Windows if much CPU time is spent in privileged mode or if a percentage of CPU load is higher in system time than user time, it often indicates that the NetWorker processes are waiting for I/O completion. If the NetWorker processes are waiting for I/O, the bottleneck is not the CPU, but the storage that is used to host NetWorker server.
  - On Windows, if much time is spent on Deferred Procedure Calls it often indicates a problem with device drivers.
- Hardware component interrupts cause high system CPU use resulting poor performance. If the number of device interrupts exceed 10,000 per second, check the device.

Monitor CPU use according to the following classifications:

- User mode
- System mode

## Memory requirements for the NetWorker server and NetWorker Management Console

The NetWorker software can consume a large amount of memory for the NetWorker server and NetWorker Management Console (NMC).

Also, the following services can be memory-intensive since these services use Java and Apache tomcat:

- Web-based authentication service
- Message Queue adapter
- Hyper-V FLR in NMM

NetWorker 9.1.x requires an additional 2 GB, 4 GB and 16 GB memory for small, medium, and large scale configurations respectively. Also, as a best practice it is recommended that Java heap memory should typically consume no more than 25% of physical memory.

**Note:** It is recommended that you avoid installing the NMC server and using the NMC UI client on the NetWorker server. If you install NMC on the NetWorker server, then the memory requirements for the NetWorker server that is identified in the following tables are in addition to the minimum NMC memory requirements. Because the NMC UI uses more memory when processing messages from RabbitMQ service, it is recommended that you change the default Heap memory from 4 GB to 12 GB for small, medium, and large scale environments.

### Sizing information for NetWorker 18.1 and later on physical and virtual hosts

**Table 3** Sizing information

Configuration	Physical NetWorker server		Virtual NetWorker server	
	Minimum CPU required	Minimum memory required	Minimum CPU required	Minimum memory required
Small configuration (maximum 500 clients) Up to 10,000 jobs per day	4 CPUs	16 GB	4 vCPUs Reservation: 50%	32 GB Reservation: 50%
Medium configuration (maximum 1000 clients) Up to 50,000 jobs per day	4 CPUs	16 GB	8 vCPUs Reservation: 50%	32 GB Reservation: 50%
Large configuration (maximum 2000 clients) Up to 100,000 jobs per day	8 CPUs	32 GB	16 vCPUs Reservation: 50%	64 GB Reservation: 50%

**Note:**

- For virtual machines running as NetWorker server, ensure that you reserve memory and vCPU.
- Ensure that the swap space is equal to or double the RAM size. For more information on swap tuning, see [https://www.centos.org/docs/5/html/Deployment\\_Guide-en-US/ch-swapspace.html](https://www.centos.org/docs/5/html/Deployment_Guide-en-US/ch-swapspace.html).
- In the case of cloning, if RPS is enabled (`nsrrecovery` spawns per process), the server requires additional memory of around 1.5 GB for each `nsrrecovery` process to run smoothly. For example, if five `nsrrecovery` processes are running on a local or remote storage node, then additionally 7.5 GB of memory is required for clone to complete in a large scale environment.
- Media database related operations using `mminfo` queries with different switch options (`-avot`, `-avVS`, `-aS`, and so on) can consume reasonable amount of memory to process the `mminfo` query request. For example, On a scaled media database of around 5 million records, processing of certain `mminfo` query request requires an additional memory of around 7 GB.

## Sizing information for NMC on physical and virtual hosts

**Table 4** NMC sizing information

NetWorker Management Console (NMC)	Physical server		Virtual server	
	Minimum CPU required	Minimum memory required	Minimum CPU required <sup>a</sup>	Minimum memory required <sup>b</sup>
NMC server (managing small configuration NetWorker servers)	4 CPUs	8 GB	8 vCPUs Reservation: 50%	16 GB Reservation: 50%
NMC UI client (managing small configuration NetWorker servers)	4 CPUs	8 GB	8 vCPUs Reservation: 50%	16 GB Reservation: 50%
NMC server (managing medium or large configuration NetWorker servers)	8 CPUs	16 GB	16 vCPUs Reservation: 50%	32 GB Reservation: 50%
NMC UI client (managing medium or large configuration NetWorker servers)	8 CPUs	16 GB	16 vCPUs Reservation: 50%	32 GB Reservation: 50%

a. For example, if 8 vCPUs are configured on a virtual server, then a minimum of 4 vCPUs must be reserved, which is 50% of 8vCPUs.

b. For example, if 16 GB of RAM is configured on a virtual server, then a minimum of 8 GB must be reserved, which is 50% of 16 GB RAM.

### Note:

- For better performance and scalability of NMC, Dell EMC recommends that you have a separate NMC server and a separate NMC UI client. Ensure that the NMC server and the NetWorker server are running inside the same subnet or vLAN to avoid latency impact when communicating with the NetWorker server.
- Dell EMC recommends that you configure 2000 jobs per workflow and a maximum of 100 workflows running concurrently with a maximum limit of 100K jobs per day. Exceeding these limits will significantly increase the load on the NetWorker server and on the user interface (UI) response time, and will impact the reliability of the system. NetWorker can process 1024 jobs at a time and rest of the jobs are queued. Dell EMC also recommends that you do not exceed more than 6000 jobs in a queue at any fixed point in time. To prevent overloading the server, stagger the workflow start time.



## NetWorker reliability events

The following table describes the NetWorker reliability events along with recommendations.

**Table 5** Reliability events

Event message	Recommendation
NetWorker Recommended Threshold Limit Exceeded: Unique Client Recommendation is 2000, Current value is 2002.	Redistribute the clients to a separate data zone, if there are more than 2000 unique clients in a single data zone. The section <a href="#">Memory requirements for the NetWorker server and NetWorker Management Console</a> provides more information on the sizing guidelines.
NetWorker Recommended Threshold Limit Exceeded: Number of save sets per clone action Recommendation is 2000, Current value is 2003 for Policy: POLICY_CLONE_TEST1, Workflow: WF01, Action: clone.	Configure 2000 save sets per clone action to avoid device contention for multiple workflows or failure of cloning action. <b>Note:</b> In the case of sequential and concurrent clone actions, Dell EMC recommends that you configure 2000 jobs per backup action, which is passed to the clone action as the input from the <code>savegrp</code> process through the job interface. The output of the backup action job is the input of the clone action. If more than 2000 save sets are passed to the clone action, there might be some inconsistencies because of high network port usage, high CPU, or memory consumption, and the results of the clone action might not be reliable. The 2000 jobs limitation is not applicable to scheduled clones or volume clones because the input is processed using the media database, which does not require high network port usage.
NetWorker Recommended Threshold Limit Exceeded: Concurrent Running Workflows Recommendation is 100, Current value is 106.	Schedule workflows in a manner that does not involve running 100 workflows concurrently. The section <a href="#">Distribution of workflows and jobs</a> provides more information.

## Monitor the pagefile or swap use

Memory paging should not occur on a dedicated backup server as it will have a negative impact on performance in the backup environment.

## Client Direct attribute for direct file access (DFA)

There are many conditions to consider when enabling DFA by using the Client Direct attribute.

The following are the considerations for enabling DFA by using the Client Direct attribute:

- Ensure there is enough CPU power on the client to take advantage of DFA-DD increased performance capability. In most cases, Client Direct significantly improves backup performance. The DFA-DD backup requires approximately 2-10% more CPU load for each concurrent session.
- Each save session using DFA-DD requires up to 70 MB of memory. If there are 10 DFA streams running, then the memory required on a client for all DFA sessions is 700 MB.
- Save sessions to DFA-AFTD use less memory and CPU cycles as compared to backup running to DFA-DD using Boost. Save sessions using DFA-AFTD use only slightly more memory and CPU cycles as compared to traditional saves with mmd.

## 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

Bus performance depends on several factors:

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


### System bus considerations

There are considerations to note that concern the bus performance:

- 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.

### System bus recommendations

It is recommended to use PCIeExpress for both servers and storage nodes to reduce the chance for I/O bottlenecks.

 **NOTICE** Avoid using old bus types or high speed components optimized for old bus type as they generate too many interrupts causing CPU spikes during data transfers.

### PCI-X and PCIeExpress considerations

There are considerations that specifically concern the PCI-X and PCIeExpress buses:

- 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.
- PCIeExpress is full-duplex bi-directional serial bus using 8/10 encoding.
- PCIeExpress 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 cannot be met.
- Hardware that connects fast storage to a slower HBA/NIC will slow overall performance.

The [component 70 percent rule](#) provides details on the ideal component performance levels.

## Bus speed requirements

Required bus speeds are based on the Fibre Channel size:

- 4 GB Fibre Channel requires 425 MB/s
- 8 GB Fibre Channel requires 850 MB/s
- 10 GB Fibre Channel requires 1,250 MB/s

## Bus specifications

Bus specifications are based on bus type, MHz, and MB per second.

Bus specifications for specific buses are listed in the following table.

**Table 6** Bus specifications

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
PCI-X 2.0	266	2,134
PCI-X 2.0	533	4,268
PCIeExpress 1.0 x 1		250
PCIeExpress 1.0 x 2		500
PCIeExpress 1.0 x 4		1,000
PCIeExpress 1.0 x 8		2,000
PCIeExpress 1.0 x 16		4,000
PCIeExpress 1.0 x 32		8,000
PCIeExpress 2.0 x 8		4,000

**Table 6** Bus specifications (continued)

Bus type	MHz	MB/second
PCIeXpress 2.0 x 16		8,000
PCIeXpress 2.0 x 32		16,000

## Storage considerations

There are components that impact the performance of storage configurations. They are as follows:

- Storage connectivity:
  - Local versus SAN attached versus NAS attached.
  - Use of storage snapshots.  
The type of snapshot technology that is used determines the read performance.
- Some storage replication technologies add significant latency to write access which 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 that is primarily used for storage networking.
  - Flash is a non-volatile computer storage that is used for general storage and the transfer of data between computers and other digital products.
- 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.
- 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.
- 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.

## Storage IOPS requirements

The file system that is used to host the NetWorker data (`/nsr`) must be a native file system that is supported by the operating system vendor for the underlying operating system and must be fully Posix compliant.

If the storage performance requirements measured in I/O operations per second (IOPS) documented in this section are not met, NetWorker server performance is degraded and can be unresponsive for short periods of time.

If storage performance falls below 50% of the preferred IOPS requirements:

- NetWorker server performance can become unreliable
  - NetWorker server can experience prolonged unresponsive periods
  - Backup jobs can fail
- NetWorker server requirements, with respect to storage performance are determined by the following:
- NetWorker datazone monitoring
  - Backup jobs
  - Maintenance tasks
  - Reporting tasks
  - Manual tasks

## NetWorker server and storage node disk write latency

It is important to determine the requirements for the NetWorker server and the storage node write latency. Write latency for `/nsr` on NetWorker servers, and storage nodes is more critical for the storage hosting `/nsr` than is the overall bandwidth. This is because NetWorker uses a very large number of small random I/O for internal database access.

The following table lists the effects on performance for disk write latency during NetWorker backup operations.

**Table 7** Disk write latency results and recommendations

Disk write latency in milliseconds (ms)	Effect on performance	Recommended
25 ms and below	<ul style="list-style-type: none"> <li>• Stable backup performance</li> <li>• Optimal backup speeds</li> </ul>	Yes
50 ms	<ul style="list-style-type: none"> <li>• Slow backup performance (the NetWorker server is forced to throttle database updates)</li> <li>• Delayed and failed NMC updates</li> </ul>	No
100 ms	Failed savegroups and sessions	No
150–200 ms	<ul style="list-style-type: none"> <li>• Delayed NetWorker daemon launch</li> <li>• Unstable backup performance</li> <li>• Unprepared volumes for write operations</li> <li>• Unstable process communication</li> </ul>	No

**NOTICE** Avoid using synchronous replication technologies or any other technology that adversely impacts latency.

## Recommended server and storage node disk settings

It is important to consider recommendations for optimizing NetWorker server and storage node disk performance:

- For NetWorker servers under increased load (number of parallel sessions occurring during a backup exceeds 100 sessions), dedicate a fast disk device to host NetWorker databases.
- For disk storage configured for the NetWorker server, use RAID 10.
- For large NetWorker servers with server parallelism higher than 400 parallel sessions, split the file systems that are used by the NetWorker server. For example, split the `/nsr` folder from a single mount to multiple mount points for:
  - `/nsr`
  - `/nsr/res`
  - `/nsr/index`
  - `/nsr/mm`
- For NDMP backups, configure a separate location on the NetWorker server for the `/nsr/tmp` folder to accommodate large temporary file processing.
- Use the operating system to handle parallel file system I/O even if all mount points are on the same physical location. The operating system handles parallel file system I/O more efficiently than the NetWorker software.
- Use RAID 3 for disk storage for Advanced File Type Device (AFTD).
- For antivirus software, disable scanning of the NetWorker databases. If the antivirus software scans the `/nsr` folder, performance degradation, time-outs, or NetWorker database corruption can occur because of frequent file open/close requests. The antivirus exclude list should also include NetWorker storage node locations that are used for AFTD.
 

**Note:** Disabled antivirus scanning of specific locations might not be effective if it includes all locations during file access, despite the exclude list if it skips scanning previously accessed files. Contact the specific vendor to obtain an updated version of the antivirus software.
- For file caching, aggressive file system caching can cause commit issues for:
  - The NetWorker server: All NetWorker databases can be impacted (`nsr\res`, `nsr\index`, `nsr\mm`).
  - The NetWorker storage node: When configured to use Advanced File Type Device (AFTD).  
Be sure to disable delayed write operations, and use driver Flush and Write-Through commands instead.
- Disk latency considerations for the NetWorker server are higher than for typical server applications as NetWorker uses committed I/O: Each write to the NetWorker internal database must be acknowledged and flushed before next write is tried. This setting avoids any potential data loss in internal databases. Where storage is replicated or mirrored for `/nsr`, consider the following:
  - Do not use software based replication as it adds an additional layer to I/O throughput and causes unexpected NetWorker behavior.
  - With hardware based replication, the preferred method is asynchronous replication as it does not add latency on write operations.

- Do not use synchronous replication over long distance links, or links with non-guaranteed latency.
- SANs limit local replication to 12 km and longer distances require special handling.
- Do not use TCP networks for synchronous replication as they do not guarantee latency.
- Consider the number of hops as each hardware component adds latency.

## Storage performance recommendations

The same physical storage sub-system can perform differently depending on the configuration. For example, splitting a single NetWorker mount point (`/nsr`) into multiple mount points can significantly increase performance due to the parallelism of the file system handler in the operating system.

The NetWorker software does not use direct I/O, but issues a sync request for each write operation. This setting ensures that data is flushed on the disk and avoids data loss if a system failure (committed I/O writes) occurs. Therefore write caching on the operating system has minimal, or no impact. However, hardware-based write-back cache can significantly improve NetWorker server performance.

Processes can be single threaded or multi-threaded, depending on process itself and whether it is configurable. Blocking-I/O used by the media database and resource database provides the best data protection. The exception is the index database where each client has its own I/O stream.

General recommendations for NetWorker server metadata storage are grouped depending on the NetWorker database type:

- The resource database (`/nsr/res`) is file based with full file read operations with an average I/O of 1 KB up to 100 KB. NetWorker 9.x introduced the Policy feature, which included the JSON string within a RAP resource. The size of the JSON attribute might vary based on the number of workflows and actions per workflow. The RAP query involving large JSON strings within a Policy resource can perform read operations up to 20 MB.
- The jobs database (`/nsr/res/jobsdb`) tracks recent jobs such as backups, restores, and clones. By default, the job records of the last 72 hours is stored on the NetWorker server. The overall number of job records might reach up to millions in an enterprise environment. The regular purge operation in a large-scale environment with a very large jobs database is one of the primary performance bottlenecks.
- Starting with NetWorker 9.0, the media database (`/nsr/mm`) uses the SQLite relational database. The NetWorker media management database daemon (`nsrmmdbd`) on the NetWorker server does some level of caching for save set and client queries. Because of this caching effect, the `nsrmmdbd` process running on the NetWorker server consumes more physical memory as compared to previous NetWorker versions.
- The index database (`/nsr/index`) is primarily based on sequential write operations with no fixed block size and few read operations. This directory is much larger than the other NetWorker database directories.
- The temporary NetWorker directory (`/nsr/tmp`) is extensively used during index merge operations for NDMP backups. The temporary NetWorker directory should reside on a higher tier storage with faster IOPS. Dell EMC recommends that you size the `/nsr/tmp` folder based on the recommendations provided in the *Network Data Management Protocol User Guide*.

- For NetWorker servers with over 100 simultaneous sessions occurring during backups, dedicate a fast disk device to host the NetWorker databases. Flash or SSD storage is recommended.
- For NetWorker servers with over 400 simultaneous sessions occurring during backups, consider splitting the `/nsr` folder from a single mount into separate mount points for each of the following:
  - `/nsr`
  - `/nsr/res`
  - `/nsr/index`
  - `/nsr/mm`

## I/O pattern considerations

The NetWorker I/O pattern for access to configuration and metadata databases varies depending on the database and its use. However, it generally includes certain elements:

- Normal backup operations: 80% write and 20% read
- Cross-check operations: 20% write and 80% read
- Reporting operations: 100% read
- Synthetic operations: 20% write and 80% read

Based on these patterns, it is recommended that you avoid manual running of NetWorker maintenance operations such as cross check. Also, external solutions that provide reporting information should be configured to avoid creating excessive loads on the NetWorker metadata databases during the production backup window. I/O block size also varies depending on database and use-case, but generally it is rounded to 8 KB requests.

## NetWorker datazone monitoring recommendations

Storage must provide a minimum of 30 IOPS to the NetWorker server. This number increases as the NetWorker server load increases.

# Backup operation requirements

Requirements for starting and running backup operations is the largest portion of the NetWorker software workload:

- Depending on the load, add to the IOPS requirements the maximum concurrent sessions on the NetWorker server, and divide this number by three. The maximum NetWorker server parallelism is 1024, therefore the highest possible load is  $1024/3=340$  IOPS.
- IOPS requirements increase if the NetWorker software must perform both index and bootstrap backups simultaneously. In this case, add:
  - 50 IOPS for small servers
  - 150 IOPS for medium servers
  - 400 IOPS for large servers[Manual NetWorker server task requirements](#) provides guidelines for small, medium, and large NetWorker servers.



**Note:** Add the additional IOPS only if the bootstrap backup runs concurrently with the normal backup operations. If the bootstrap backup is configured to run when the NetWorker server is idle, the IOPS requirements do not increase.

In NetWorker 9.0 and later, the Bootstrap backup runs as part of server protection policy. However the IOPS requirement remains almost same as mentioned in this section.

- IOPS requirements increase if the NetWorker software is configured to start many jobs simultaneously.  
To accommodate load spikes, add one IOPS for each parallel session that is started.

It is recommended not to start more than 40 clients per group with the default client parallelism of four. The result is 160 IOPS during group startup.

Starting many clients simultaneously can lead to I/O system starvation.

- Each volume request results in a short I/O burst of approximately 200 IOPS for a few seconds.  
For environments running a small number of volumes the effect is minimal. However, for environments with frequent mount requests, a significant load is added to the NetWorker server. In this case, add 100 IOPS for high activity (more than 50 mount requests per hour). To avoid the excessive load, use a smaller number of large volumes.
- NDMP backups add additional load due to index post-processing.  
For large NDMP environment backups with more than 10 million files, add an additional 120 IOPS.

## NetWorker kernel parameter requirements

Create a separate startup script for the NetWorker servers with heavy loads by enabling the following environment variable before the NetWorker services start:

*Open file descriptors:* Change the open file descriptors parameter to a minimum of:

- 8192 (small NetWorker environment)
- 16384 (medium NetWorker environment)
- 32768 (large NetWorker environment)

On a Linux NetWorker server, add `ulimit -n 8192` in the `.bash_profile` file and restart the current session.

On a Windows NetWorker server, set the following registry entries:

```
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Services for Unix\MaxOpenFiles
Data type: REG_DWORD
Base: Decimal
Enter the value data (ex. 8192 for ulimit -n 8192)
```

Add the following TCP parameters when the NetWorker server runs with a heavy load (concurrent runs with a large number of socket requests being made on the server application ports):

- On a Linux NetWorker server, add the following TCP parameters in the `/etc/sysctl.conf` file and run the `sysctl --system` command:

```
net.ipv4.tcp_fin_timeout = 30
net.ipv4.ip_local_port_range = 15000 65535
net.core.somaxconn = 1024
```

- On a Linux NMC server, update the `file-max` value to 65536 to ensure Postgres database connectivity when the NetWorker server runs with heavy loads:

```
echo 65536 > /proc/sys/fs/file-max
```

- On a Windows NetWorker server, set the following registry entries:

```
HKEY_LOCAL_MACHINE\System\CurrentControlSet\Services\Tcpip
\Parameters
Value Name: TcpTimedWaitDelay
Data type: REG_DWORD
Base: Decimal
Value: 30

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip
\Parameters
Value Name: MaxUserPort
Data Type: REG_DWORD
Base: Decimal
Value: 65535

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip
\Parameters
Value Name: TcpNumConnections
Data Type: REG_DWORD
Base: Decimal
Value: 1024
```

- Note:** Use the default startup script on the NetWorker storage nodes and clients. The *open file descriptor* parameter is not required on storage nodes and clients.

## Parallel save stream considerations

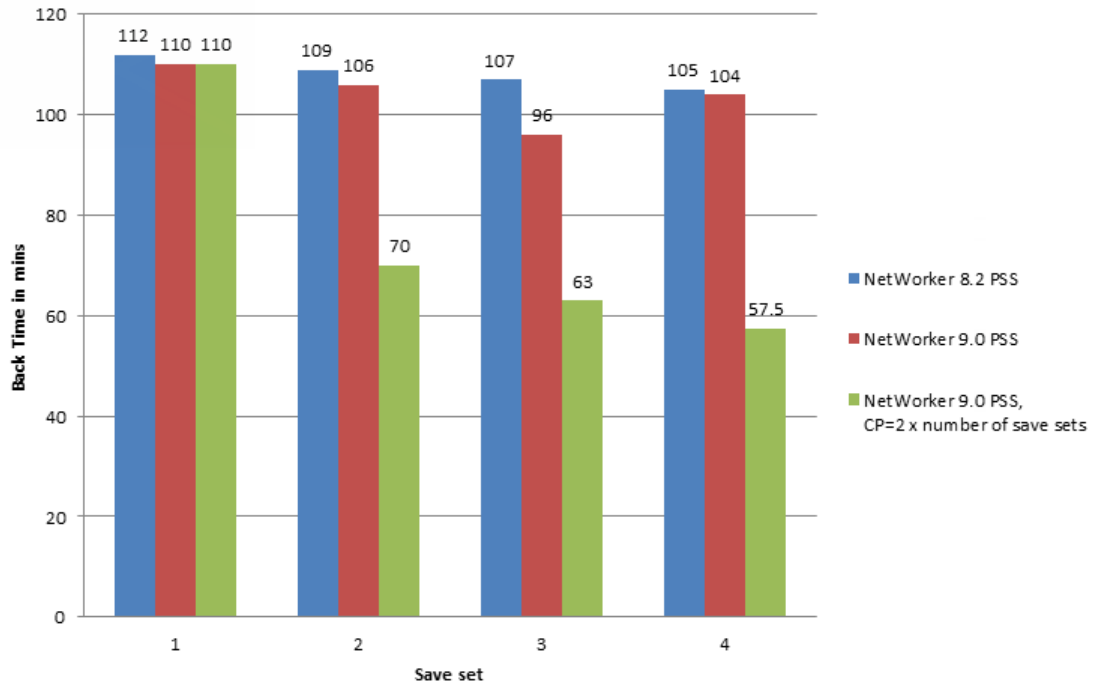
Enabling the parallel save streams (PSS) feature for a Client resource allows you to back up each save set for the client by using multiple parallel save streams to one or more destination backup devices. The save set entry is also called a save point, which is often a UNIX file system mount directory or a Windows volume drive letter. PSS is used for the scheduled, file-based backup of file systems. Significant parallel performance gains are possible during PSS backups and subsequent recoveries.

In NetWorker 8.1 and 8.2 releases, PSS does static division of the client parallelism (CP) up-front among the client's save points, also known as save sets, and starts all simultaneously. A sufficiently high client parallelism is therefore required.

In NetWorker 9.0.x, PSS schedules the save points at four parallel save streams each by default, and handles in batches according to the client parallelism value. A high CP value is therefore not required.

The following graph shows the potential performance gains between NetWorker 8.2 and NetWorker 9.0.x releases due to the PSS enhancements. In this example, the NetWorker backup contains a total 2 TB of data that is divided among four save sets of different sizes.

**Figure 3** PSS performance gains between NetWorker 8.2 and NetWorker 9.0.x releases



Subsequent sections in this chapter break down the behavior of PSS in each release.

### Parallel save streams considerations (previous to NetWorker 9.0.1)

The parallel save streams (PSS) feature provides the ability for each Client resource save set entry to be backed up by multiple parallel save streams to one or more destination backup devices.

The following table lists the items that are supported or not supported for PSS in NetWorker 8.2 and later.

**Table 8** PSS support by NetWorker release

NetWorker release	Operating systems	Supported save sets	Supported backup types	Virtual and non-virtual synthetic full	Checkpoint restart
8.1 releases	UNIX, Linux	ALL, individual save points	Scheduled	No	No
8.2 and later	UNIX, Linux, Windows	ALL, individual save points including DISASTER RECOVERY: \', deduplicated, and CSV volumes	Scheduled	Yes	No

**Table 8** PSS support by NetWorker release (continued)

NetWorker release	Operating systems	Supported save sets	Supported backup types	Virtual and non-virtual synthetic full	Checkpoint restart
		(Windows only)			

When a PSS enabled UNIX Client resource's parallelism value is greater than the resource's number of save points, the scheduled backup savegroup process divides the parallelism among the save points and starts PSS save processes for all the save points at approximately the same time. However, this is done within the limits of the following:

- The NetWorker server
- Group parallelism controls
- Media device session availability

It is recommended that you set the Client resource PSS parallelism value to two times or more the number of save points.

The number of streams for each PSS save point is determined before the backup from its client parallelism value and it remains fixed throughout the backup. It is a value 1–4 (maximum), where one indicates a single stream with a separate PSS process that traverses the save point's file system to determine the files to back up. The separation of processes for streaming data and traversing the file system can improve performance. Also, the number of save processes that run during a PSS save point backup is equal to the number of save stream processes that are assigned with two additional save processes for both the director and file system traversal processes.

When the client parallelism is less than its number of save points, some save point backups are run in PSS mode, with only a single stream. Other save points are run in the default mode (non-PSS). Therefore, for consistent use of PSS, set the client parallelism to two times or more the number of save points. This ensures multiple streams for each save point.

It is recommended that large, fast file systems that should benefit from PSS be put in a new separate PSS-enabled Client resource that is scheduled separately from the client's other save points. Separate scheduling is achieved by using two different save groups with different runtimes, but the same savegroup can be used if you avoid client disk parallel read contention. Also, use caution when enabling PSS on a single Client resource with the keyword `all`. `all` typically expands to include multiple small operating file systems that reside on the same installation disk. These file systems usually do not benefit from PSS but instead might waste valuable PSS multi-streaming resources.

Based on the second example, the `/sp1` save set record is referred to as the master and its save set time is used in browsing and time-based recover operations. It references the two related records (dependents) through the `*mbs dependents` attribute. This attribute lists the portable long-format save set IDs of the dependents. Each dependent indirectly references its master through save set name and save time associations. Its master is the save set record with the next highest save time and save set name with no prefix. Also, each master record has an `*mbs anchor save set time` attribute, which references its dependent with the earliest save set time.

PSS improves on manually dividing save point `/sp1`, into multiple sub-directories, `/sp1/subdirA`, `/sp1/subdirB...` and typing each subdirectory separately in the Client resource. PSS eliminates the need to do this and automatically

performs better load balancing optimization at the file-level, rather than at the directory level that is used in the manual approach. PSS creates pseudo sub-directories corresponding to the media save set record names, for example, /sp1, <1>/sp1, and <2>/sp1.

Both time-based recovery and savegroup cloning automatically aggregate the multiple physical save sets of a save point PSS backup. The multiple physical dependent save sets remain hidden. However, there is no automatic aggregation in save set based recovery, scanner, nsrmm, or nsrclone -S manual command line usage. The -S option requires the PSS save set IDs of both master and dependents to be specified at the command line. However, the -S option should rarely be required with PSS.

When the following PSS client configuration settings are changed, the number of save streams can change for the next save point incremental backup:

- The number of save points
- The parallelism value

NetWorker automatically detects differences in the number of save streams and resets the backup to a level Full accordingly. This starts a new <full, incr, incr, ...> sequence of backups with the same number of media database save sets for each PSS save point backup.

This applies to non-full level numbers 1–9 in addition to incremental, which is also known as level 10.

**i** **NOTICE** The PSS incremental backup of a save point with zero to few files changed since its prior backup results in one or more empty media databases save sets (actual size of 4 bytes), which is to be expected.

### Example 1

The following provides performance configuration alternatives for a PSS enabled client with the following backup requirements and constraints:

- Two savepoints: /sp200GB and /sp2000GB
- Save streams able to back up at 100 GB/hr
- Client parallelism is set to four (No more than four concurrent streams to avoid disk IO contention)

Based on these requirements and constraints, the following are specific configuration alternatives with the overall backup time in hours:

- A non-PSS Client resource with both savepoints at one stream each: 20 hours
- A single PSS Client resource with both /sp200GB at two streams and /sp2000GB at two streams for the same save group: 10 hours
- A non-PSS Client resource with /sp200GB at one stream and a PSS Client resource with /sp2000GB at three streams for the same client host and same save group: 6.7 hours
- A PSS Client resource with /sp200GB at four streams and another PSS Client resource with /sp2000GB at four streams for the same client but different sequentially scheduled save groups: 5.5 hours aggregate

### Example 2

With client parallelism set to eight and three save points /sp1, /sp2, and /sp3 explicitly listed or expanded by the keyword ALL for UNIX, the number of PSS streams for each savepoint backup is three, three, and two respectively. The number of mminfo media database save set records is also three, three, and two respectively.

For a particular save point, `/sp1`, `mminfo`, and NMC save set query results shows three save set records each named `/sp1`, `<1>/sp1`, and `<2>/sp1`. These related records have unique save times that are close to one another. The `/sp1` record always has the latest save time, that is, maximum save time, as it starts last. This makes time-based recovery aggregation for the entire save point `/sp1` work automatically.

### Example 3

For a PSS Windows save point backup, the number of streams per save point is estimated in the following two scenarios:

- The client parallelism per save point, where client parallelism=5, and the number of save points=2, the number of PSS streams is three for the first save point, and two streams for the second.  
For the save set `ALL`, with two volumes and client parallelism=5, each volume (save point) gets two streams.
- Using client parallelism=4, every save point is given two save streams. Both `DISASTER_RECOVERY:\` volumes, `C:\`, and `D:\` are given two streams also.  
For the save set `ALL`, the `DISASTER_RECOVERY:\` save set is considered to be a single save point. For this example, the system has `C:\`, `D:\`, and `E:\`, where `C:\`, and `D:\` are the critical volumes that make up the `DISASTER_RECOVERY:\` save set.

The save operation controls how the save points are started, and the total number of streams never exceeds the client parallelism value of 4.

## Parallel save stream considerations in NetWorker 19.1

NetWorker 19.1 PSS provides potentially greater performance gains over earlier NetWorker releases due to the new save set aggregation approach.

Save set aggregation is where the NetWorker server starts a single save process per PSS-enabled client, with all client save sets passed to the single process for various processing optimizations, such as minimal Windows VSS snapshots and support for the following:

- Four parallel streams started per save set, subject to any client parallelism limitations that might prevent all save sets from starting at the same time.
- The ability to modify the number of parallel streams per save set by defining the new `PSS:streams_per_ss` option in the selected client resource's `save operations` attribute.
- Automatic stream reclaiming, which dynamically increases the number of active streams for an already running save set backup to maximize utilization of limited client parallelism conditions, also known as Dynamic PSS.

PSS is for clients with supported UNIX, Linux, and Windows operating systems. Supported save sets for PSS include `ALL`, and individual save points including `DISASTER_RECOVERY:\`, `deduplicated`, and `CSV` volumes (Windows only). Checkpoint restart is not supported when you use PSS.

Unlike NetWorker releases previous to NetWorker 19.1, where PSS requires a sufficiently high CP value due to the upfront static division of CP among the client's save points which all get started at the same time, NetWorker 19.1 PSS schedules the save points at four parallel save streams each by default, and handles in batches according to the client parallelism value. Therefore, you do not require a high value for CP.

The default four parallel save streams per save point should be sufficient for most save points, however you can change the default value by setting the `PSS:streams_per_ss` environment variable in the client's save operations attribute.

On UNIX for example, launch NMC and the **NetWorker Administration** window, and then go to **View > Diagnostic Mode > Protection > Clients > Client Properties > Apps & Modules > Save operations** and set the following:

```
PSS:streams_per_ss=1,* , 2,/data[1-3] , 8,/data[4-5]
```

This setting will use one stream per client save set entry by default, with the exception of two streams for each of /data1, /data2 and /data3, and eight streams for each of /data4 and /data5. Client-supported wildcard characters can be used. After setting the environment variable, restart the NetWorker services for the changes to take effect. Increasing the default maximum value can improve the performance for clients with very fast disks.

On Windows, launch NMC and the **NetWorker Administration** window, and then go to **View > Diagnostic Mode > Protection > Clients > Client Properties > Apps & Modules > Save operations** and set the following:

```
PSS:streams_per_ss=2,C:\ , D:\ , 8 , E:\ , F:\HR
```

This Windows PSS client setting will continue to use the default four streams for each save point not explicitly listed here, but two streams each for the C:\ and D:\ drives, and eight streams each for the E:\ drive and F:\HR folder.

**Note:** Note PSS backups currently ignore the policy workflow action's parallelism, previously known as the savegrp parallelism.

When you set the client parallelism to a value less than the number of save points, some save point backups run in PSS mode, with only a single stream, and other save points will run in the default mode (non-PSS). Therefore, for consistent use of PSS, maintain the default setting or set the client parallelism to the number of save points. This ensures multiple streams for each save point.

**NOTICE** The PSS incremental backup of a save point with zero to few files changed since its prior backup will result in one or more empty media database save sets (actual size of 4 bytes), which is to be expected.

**Example 1** PSS enabled, CP=6 with 3 client save points

In NetWorker releases previous to NetWorker 19.1, if you set CP=6 and have three client save points, PSS will start all save points together at two streams each, and each save point will remain at two streams, with each stream actively backing up files from the start.

NetWorker 19.1, however, would start save point one with four active backup streams, and simultaneously start save point two with two active streams and two idle streams. If save point one finishes first, then save point two could end up with four active streams, and save point three would then start with two active streams and two idle streams. Depending on the time it takes the save point to complete, save point two could remain as it started and save point three may start similar to how save point one started, with four active streams. An idle stream is one that has not yet started saving data and will only become active when CP allows. The total number of active streams from all save sets at any one point in time will not exceed CP. It is recommended that you specify a value of 4 or a multiple of four to avoid idle streams.

## Command line examples

Consider the command line examples for after a PSS backup for the example UNIX save point /sp1 (Windows is similar):

- To view the consolidated job log file information following a scheduled backup of /sp1, type the following commands:
  - For NetWorker releases previous to NetWorker 19.1, type:
 

```
# tail /nsr/logs/sg/<save group name>/<job#>
```
  - For NetWorker 19.1, type:
 

```
# tail /nsr/logs/policy/<policy name>/<workflow name>/<action name>_<sequence#>_logs/<job#>
```

An output similar to the following appears:

```
...
parallel save streams partial completed savetime=1374016342
parallel save streams partial completed savetime=1374016339
parallel save streams partial completed savetime=1374016345
parallel save streams summary test.xyx.com: /sp1 level=full,
311 MB
00:00:08 455 files
parallel save streams summary savetime=1374016345
```

- To list only the master save sets for all /sp1 full and incremental backups, type the following command:
 

```
# mminfo -ocntR -N "/sp1"-r
"client,name,level,nsavetime,savetime(25),ssid,ssid(53),totalsize,n
files,attrs"
```
- To automatically aggregate <i>/sp1 with /sp1 save sets for browse time-based save point recovery, type the following command:
 

```
# recover [-t <now or earlier_master_ss_time>] [-d reloc_dir] [-a] /sp1
```

## Recommendations to enhance PSS performance

Observe the following recommendations to benefit from PSS performance enhancements:

- The PSS feature boosts backup performance by splitting the save point for PSS into multiple streams that are based on client parallelism. The fairly equal distribution of directory and file sizes in save sets adds additional performance benefit from PSS.
- Large save sets residing on storage with sufficiently high aggregate throughput from concurrent read streams perform significantly better with PSS. Avoid using slow storage with high disk read latency with PSS.
- Ensure that the target devices are fast enough to avoid write contentions or target device queuing since PSS splits a single save point into multiple save streams.
- If the target device is Data Domain, ensure PSS does not saturate the max sessions allowable limit on the DDR. Each Boost device allows a maximum of 60 NetWorker concurrent sessions.



- Ensure the total number of available device **max sessions** value is greater than or equal to the total CP values across all concurrently active PSS clients. In NetWorker 9.1, for each client whose CP value is not a multiple of four, round up the CP value to the nearest multiple of four when totaling the CP values. Otherwise, some PSS client backups may timeout or be unnecessarily delayed.
- PSS simulates the manual division of a client resource save set entry, or save point, into multiple smaller entries. For example, /sp into /sp, <1>/sp, <2>/sp, and <3>/sp. Once backup completes for save point /sp, its smaller save sets are inherently independent of each other, although they form a logical group. Therefore, manually deleting some but not all of these smaller save sets before expiry leads to subsequent incomplete or failed recovery operations. Avoid manually deleting PSS save sets. If manual deletion is necessary, then always delete the save sets as a complete group.

## NetWorker resource considerations

When you create NetWorker workflow and action resources, consider the following recommendations:

- The parallelism value for the action resource should not exceed 25.
- The total number of clients in a single workflow should not exceed 100.

## Internal maintenance task requirements

Requirements for completing maintenance tasks can add significant load to the NetWorker software:

- Daily index and media database consistency checks adds 40 IOPS for small environments, and up to 200 IOPS for large environments with more than 1,000 configured clients.
- Environments with very long backup and retention times (1 year or more) experience large internal database growth resulting in additional requirements of up to 100 to 200 IOPS.
- Purge operations can take 30 IOPS for small environments with up to 1000 backup jobs per day, 100 IOPS for mid-size environments and up to 200 IOPS for large environments with high loads of 50,000 jobs per day.

## Reporting task requirements

Monitoring tools like the NMC server, DPA, custom reporting, or monitoring scripts contribute to additional load on the NetWorker server:

### Procedure

- For each NMC server, add an additional 100 IOPS.
- For DPA reporting, add an additional 250 IOPS.

### Results

Customer reporting or monitoring scripts can contribute significant load depending on the design. For example, continuous reporting on the NetWorker index and media databases can add up to 500 IOPS.

## Manual NetWorker server task requirements

Manual tasks on the NetWorker server can add additional load:

- Each recover session that must enumerate objects on the backup server adds additional load to the NetWorker server.

For example, to fully enumerate 10,000 backup jobs, the NetWorker server can require up to 500 IOPS.

- For spikes, and unrelated operating system workloads, the total number of calculated IOPS should be increased by 30%.
- Single disk performance is often insufficient for large NetWorker servers. The following table provides information on single disk performance. To achieve higher IOPS, combine multiple disks for parallel access. The best performance for standard disks is achieved with RAID 0+1. However, modern storage arrays are often optimized for RAID 5 access for random workloads on the NetWorker server. Hardware-based write-back cache can significantly improve NetWorker server performance. The following table provides guidelines on the NetWorker server IOPS requirements.

**Table 9** Required IOPS for NetWorker server operations

Type of operation	Small NetWorker environment (1)	Medium NetWorker environment (2)	Large NetWorker environment (3)
Concurrent backups	30	80	170
Bootstrap backups	50	150	400
Backup group startup	50	150	250
Volume management	0	0	100
Large NDMP backups	100	100	200
Standard daily maintenance tasks	40	75	100
Large internal database maintenance	0	100	200
Purge operations	50	150	300
NMC reporting	50	75	100
DPA reporting	50	100	250
Recovery	30	200	500

(1) A small NetWorker server environment is considered to have less than 500 clients, or 256 concurrent backup sessions.

(2) A medium NetWorker server environment is considered to have more than 500, and up to 1000 clients or 512 concurrent backup sessions.

(3) A large NetWorker server environment is considered to have more than 1000 clients, and up to 2000 clients or 1024 concurrent backup sessions.

### IOPS considerations

The following are considerations and recommendations for IOPS values:

- The NetWorker software does not limit the number of clients per datazone, but a maximum of 1000 clients is recommended due to the complexity of managing large datazones, and the increased hardware requirements on the NetWorker server.

**i** **NOTICE** As the I/O load on the NetWorker server increases, so does the storage layer service time. If service times exceed the required values there is a direct impact on NetWorker server performance and reliability. Information on the requirements for maximum service times are available in [NetWorker server and storage node disk write latency](#) on page 29.

- The NetWorker server performs the data movement itself. If the backup device resides on the server rather than the NetWorker storage node, the backup performance is directly impacted.  
Examples 2 and 3 are based on the preceding requirements that are listed in Table 7.

**Example 2** Small to medium NetWorker datazone

- Optimized: 200 clients running in parallel with the following characteristics:
  - 100 jobs with up to 1,000 backup jobs per day.
  - Backups spread over time.
  - No external reporting.
  - No overlapping maintenance tasks.
  - Minimum required IOPS: 200, recommended IOPS: 400.
- Non-optimized: the same workload, however:
  - Most backup jobs start simultaneously.
  - Production backups overlap bootstrap and maintenance jobs.
  - Additional reporting is present.
  - Minimum required IOPS: 800, recommended IOPS 1000.

**Example 3** Large NetWorker datazone

- Optimized: 1000 clients running in parallel with the following characteristics:
  - 500 jobs with up to 50,000 backup jobs per day.
  - Backups spread over time.
  - Backups using backup to disk, or large tape volumes.
  - No external reporting.
  - No overlapping maintenance tasks.
  - Minimum required IOPS: 800, recommended IOPS: 1000.
- Non-optimized: the same workload, however:
  - Most backup jobs start simultaneously.
  - Many small volumes are used.
  - Production backups overlap bootstrap and maintenance jobs.
  - Additional reporting is present.
  - Minimum required IOPS: 2000, recommended IOPS: 2500.

**i** **Note:** This example identifies that the difference in NetWorker configuration can result in up to a 250% additional load on the NetWorker server. Also, the

**Example 3** Large NetWorker datazone (continued)

impact on sizing is such that well-optimized large environments perform better than non-optimized medium environments.

## IOPS values for disk drive technologies

The disk drive type determines the IOPS values for random small blocks and sequential large blocks.

The following table lists disk drive types and their corresponding IOPS values.

**Table 10** Disk drive IOPS values

Disk drive type	Values per device
Enterprise Flash Drives (EFD)	2500 IO/s for random small block IOs or 100 MB/s sequential large blocks
Fibre Channel drives (FC drives (15k RPM))	180 IO/s for random small block IOs or 12 MB/s sequential large blocks
FC drives (10K RPM)	140 IO/s for random small block IOs or 10 MB/s sequential large blocks
SATA2 or LCFC (7200 RPM)	80 IO/s for random small block IOs or 8 MB/s sequential large blocks
SATA drives (7200 RPM)	60 IO/s for random small block IOs or 7 MB/s sequential large blocks
PATA drives (5400 RPM)	40 IO/s for random small block IOs or 7 MB/s sequential large blocks

## File history processing

File history is processed by NDMP at the end of the backup operation. Normally the temporary files are deleted after the backup. However, if you create the file `/nsr/debug/ndmp_savedbg`, the files remain in the system.

The actual file history processing time is linear despite the number of files in the dataset. However, the processing time depends on other storage system factors, such as:

- The RAID type
- The number of disks being configured
- The cache size
- The type of file system for hosting `/nsr/index` and `/nsr/tmp`

**NOTICE** The expected results are approximately 20 minutes per each 10 million files.

File history processing creates a significant I/O load on the backup server, and increases IOPS requirements by 100-120 I/O operations per second during processing. If minimum IOPS requirements are not met, file history processing can be significantly slower.

## Network

Several components impact network configuration performance:

- **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.
- **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

Storage type and connectivity have the types of components that impact performance in target device configurations. They are as follows:

- **Storage type:**
  - **Raw disk versus Disk Appliance:**
    - Raw disk: 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 versus virtual tape library (VTL):**
    - 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 percent 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 percent of the rated capacity of any component.

Components include:

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

Performance and response time significantly decrease when the 70 percent utilization threshold is exceeded.

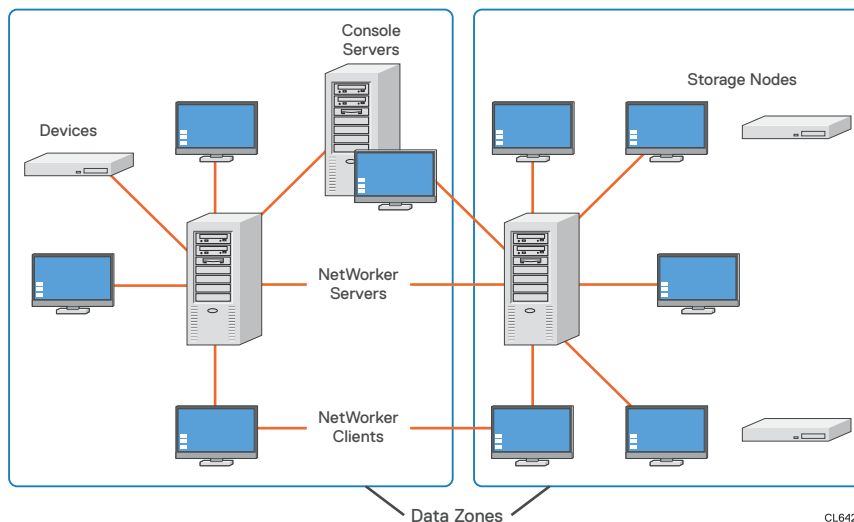
The physical tape drives, and solid state disks are the only exception to this rule, and should be used as close to 100 percent as possible. Neither the tape drives, nor the solid state disks suffer performance degradation during heavy use.

## Components of a NetWorker environment

A NetWorker datazone is constructed of several components.

The following figure illustrates the main components in a NetWorker environment. The components and technologies that make up a NetWorker environment are listed below.

**Figure 4** NetWorker datazone components



## Datazone

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

**NOTICE** It is recommended to have no more than 1500 clients or 3000 client instances per NetWorker datazone. This number reflects an average NetWorker server and is not a hard limit.

## 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

Some components determine the performance of NMC:

- 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, ensure that NMC server is equipped with sufficient memory.
- CPU: If the NMC server is used by multiple users, ensure that it has sufficient CPU power to ensure that each user is specified enough CPU time slices.
- #Jobs per day: The recommended number of jobs per day is 100,000. You should evaluate workload for any datazone with more than 100,000 jobs per day, and consider moving some jobs to other datazones. The Java heap plays a critical role in UI response time, it is recommended that you configure the Java heap setting according to recommendations that are made in the "Minimum system requirements for the NMC server" section.


### Minimum system requirements for the NMC server

Available disk space and JRE with Web Start must meet specific minimum requirements for the NMC server:

- Memory:
 

A bare minimum of 8GB with 2CPU processor is required for NMC server. If NMC server is handling a large scale NetWorker server with a large number of users, then size the NMC server with the following memory and CPU requirements:

  1. 32 GB RAM
  2. 8 core CPU (with  $\geq 1.5$  GHz)

 **Note:** The Java heap memory is a critical component for UI response. The default heap size on NMC server is 1GB. Change the memory to a minimum of 25% of overall physical RAM size. If the NMC server is running to handle a large scale NetWorker server, then it is recommended that you change the Java heap memory to at least 6GB.
- Available disk space:
 

Dual core 2 GHz and 2 GB of RAM with a buffer of disk space for a large Console database with multiple users.

### Java heap memory setting recommendations

If a workflow, backup, or clone action on NMC results in *Java Heap Space Out of Memory* error, do the following on Windows and Linux OS platforms:

1. Navigate to the NMC installation path.

- **On Windows:** C:\Program Files\EMC NetWorker\Management\GST\Web
- **On Linux:** /opt/lgtonmc/web

2. Modify the following line in the `gconsole.jnlp` file:

```
<j2se version="1.8+" java-vm-args="-
Djava.locale.providers=COMPAT -XX:+IgnoreUnrecognizedVMOptions
--add-modules=java.se.ee -Xms256m -Xmx2048m"/>
```

3. Increase the value of the `Xmx2048m` attribute to a value which is either 6 GB or 12 GB, based on the physical or virtual NetWorker server memory availability.

### Distribution of workflows and jobs

Dell EMC recommends that you configure 2000 jobs per workflow and a maximum of 100 workflows running concurrently with a maximum limit of 100K jobs per day. Exceeding these limits will significantly increase the load on the NetWorker server and on the user interface (UI) response time, and will impact the reliability of the system. NetWorker can process 1024 jobs at a time and rest of the jobs are queued. Dell EMC also recommends that you do not exceed more than 6000 jobs in a queue at any fixed point in time. To prevent overloading the server, stagger the workflow start time.

With the Message Bus Architecture between NetWorker Management Console (NMC) and the NetWorker server, the NMC can sustain 100K jobs per day. The following table describes how you can configure the jobs into one or more policies and schedule them with different time intervals.

**Table 11** Distribution of workflows and jobs

Number of workflows	Jobs per workflow	Jobs per day	Schedule
1	2000	50K	Every 1 hour
1	2000	100K	Every 30 minutes
2	4000 jobs with 2K per workflow	50K	Every 2 hours
2	4000	100K	Every 1 hour
10	10000	100K	Every 2 hour 30 minutes

Evaluate the workload for any datazone with more than a 100K jobs per day, and consider moving some of jobs to other datazones.

If the NetWorker server and NMC are migrated from a prior NetWorker 9.x installation to a NetWorker 9.1.x installation, then it is recommended to distribute the multiple workflows (previously configured as savegroups), among multiple policies with the above recommendations. For example, assuming a NetWorker 9.x datazone has 800 savegroups, if this gets migrated to NetWorker 9.1x, then all the savegroups are converted into workflows under a single backup policy. It is recommended to distribute these workflows among multiple policies and schedule them with interleaved time intervals. Adhere to the above recommendations when you are running multiple policies and workflows simultaneously.



NetWorker 18.1 and later has optimized Java heap memory within the UI so that large scale environments (100K jobs per day), can be handled with 6GB to 12 GB of Java heap memory.

## Console database

Use formulas to estimate the size and space requirements for the Console database.

### Formula for estimating the size of the NetWorker Management Console database

The Console server collects data from the NetWorker servers in the enterprise, and stores the data in its local Console database.

By default, the database is installed on the local file system that can provide the most available space. The Console integrates and processes this information to produce reports that facilitate trend analysis, capacity planning, and problem detection. The *NetWorker Administration Guide* provides information about reports.

To store the collected data, allocate sufficient disk space for the Console database. Several factors affect the amount of disk space required:

- The number of NetWorker servers that are monitored for the reports
- The number of policies that are run by each of those servers
- The frequency with which policies are run
- The length of time report data is saved (data retention policies)

**i** **NOTICE** Since the amount of required disk space is directly related to the amount of historical data that is stored, the requirements can vary greatly, on average between 0.5 GB and several GB. Allow space for this when planning hardware requirements.

### Formulas for estimating the space required for the Console database information

There are existing formulas used to estimate the space needed for different types of data and to estimate the total space required.

#### Save set media database

To estimate the space needed for the save set media database, multiply the weekly amount of save sets by the number of:

- NetWorker servers monitored by the Console
- Weeks in the Save Set Output policy

The result indicates the length of time that a save set took to run successfully. The results also identify the number of files that were backed up, and how much data was saved during the operation.

When we perform the compression on a SQLite media database, SQLite in the background creates a copy of the SQLite database in a temporary space. After the compression is complete, the copy in the temporary space gets deleted. You can configure the temporary space that the SQLite uses on the host machines. When you install NetWorker on your system, the following paths are set by default:

- `/nsr/tmp` on Linux
- `<nw_install_path>/nsr/tmp` on Windows

Use the formula (size of media database) + 20% to determine the required physical space for the default `/nsr/tmp` directory.

For example, if the media database is 8 GB, the physical space requirement for `/nsr/tmp` from SQLite's point of usage should be of the minimum.  $\text{Size} = 8 + 20\% \text{ of } 8 = 10 \text{ GB}$  approximately.

**i Note:** NDMP has its specific physical space requirement. Use the following formula to determine the required physical space for the default `/nsr/tmp` directory:

- $2 * (144 + \text{average file name length}) * \text{number of entries in the file system}$

Use this formula when you size the `nsr/tmp` directory so that both SQLite and NDMP operations run smooth.

### Save set output

To estimate the space needed for the save set media database, multiply the weekly amount of output messages by the number of:

- NetWorker servers monitored by the Console
- Save Set Output Retention policy

The result indicates how many groups and save sets were attempted and their success or failure.

### Policy, workflow, and action completion data

To estimate the space needed for the save set media database, multiply the weekly amount of policies by the number of:

- NetWorker servers monitored by the Console
- Weeks in the Completion Data Retention policy

The result can be used to troubleshoot backup problems.

## 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:
  - The volume name
  - The location of each save set fragment on the physical media (file number/file record)
  - The backup dates of the save sets on the volume
  - The 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.
- The NetWorker server schedules and queues all backup operations, tracks real-time backup and restore related activities, and all NMC communication. This information is stored for a limited amount of time in the `jobsdb` which for real-time operations has the most critical backup server performance impact.

**NOTICE** The data stored in this database is not required for restore operations.

## Components that determine backup server performance

The `nsrmmdbd` process uses a CPU intensive operation when thousands of save sets are processed in a single operation. Any NetWorker maintenance activities should be run outside of the primary backup window.

Some components that determine NetWorker server backup performance are:

- Use a 64-bit system for the NetWorker server.
- Use current hardware for the NetWorker server. For example, the current version of the NetWorker server software does not operate well on hardware built more than 10 years ago.
- From NetWorker 9.0 onwards, maintenance (such as `nsrim` and `nsrck`) and Bootstrap backup operations run as part of Server Protection Policy. Since both Bootstrap and Maintenance operations are IO intensive operations, it is recommended to schedule the Protection Policy outside the Backup, clone, and recovery operations window.
- The disk that is used to host the NetWorker server (`/nsr`):  
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 are the most common bottleneck of a backup server in larger environments.
- Avoid additional software layers as this adds to storage latency. For example, the antivirus software should be configured with the NetWorker databases (`/nsr`) in its exclusion list.
- 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.
- Use fewer CPUs, as systems with fewer high performance CPUs outperform systems with numerous lower performance CPUs.
- Do not attach a high number of high performance tape drives or AFTD devices directly to a backup server.
- Ensure that there is sufficient memory on the server to complete all internal database tasks.
- Offload backups to dedicated storage nodes when possible for clients that must act as a storage node by saving data directly to backup server.

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

## NetWorker storage node

A NetWorker storage node can be used to improve performance by offloading 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

Some components determine storage node performance:


- 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.
- Do not overlap staging and backup operations with a VTL or AFTD solution by using ATA or SATA drives. Despite the performance of the array, ATA technology has significant performance degradation on parallel read and write streams.

## 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.

 **Note:** Compared to traditional (non-DFA) backups, backups utilizing DDBoost require 2-40% of additional CPU, but for a much shorter period. Overall, the CPU load of a backup utilizing DDBoost is lower than a traditional backup.

## Components that determine NetWorker client performance

Some components determine NetWorker client performance:

- 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 a half million 200 KB files, although both result in a 100 GB save set.
  - For the same overall amount of changed data, an incremental/differential backup of one thousand 100 MB files with 50 modified files takes much less time than one hundred thousand 1 MB files with 50 modified files.
- Encryption and compression are resource intensive operations on the NetWorker client and can significantly affect backup performance.

 **Note:** BBB and DPSS must be used when millions of files are used on the clients as save sets.

- 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.

## NetWorker databases

Several factors determine the size of NetWorker databases.

These factors are available in [NetWorker database bottlenecks](#) on page 57.

## 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. The documentation for the applicable NetWorker module provides details.

## Virtual environments

NetWorker clients can be created for virtual machines for either traditional backup or VBA backup in the case of NetWorker 8.2.x or vProxy backups in the case of NetWorker 9.1.x or later.

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.

## Recovery performance factors

Recovery performance can be impeded by network traffic, bottlenecks, large files, and other factors.

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](#).
- The fastest method to recover data efficiently is to run multiple `recover` commands simultaneously by using `save set recover`. For example, three `save set recover` operations provide the maximum possible parallelism 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

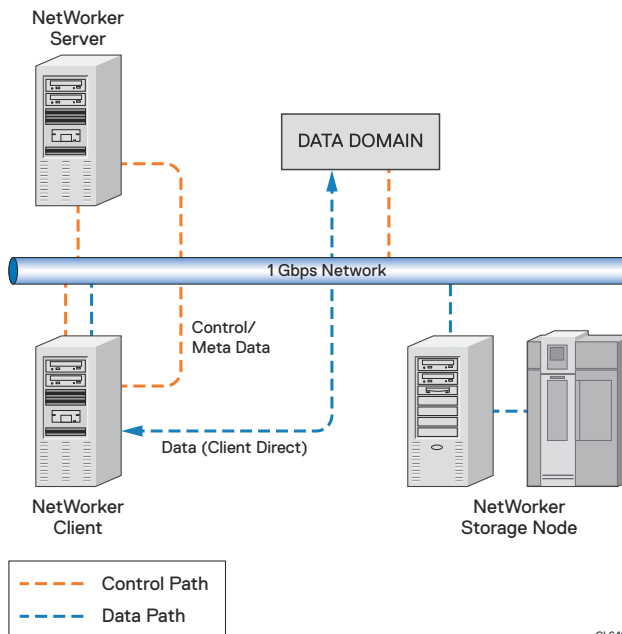
The backup environment consists of various devices from system, storage, network, and target device components, with hundreds of models from various vendors available for each of them.

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.

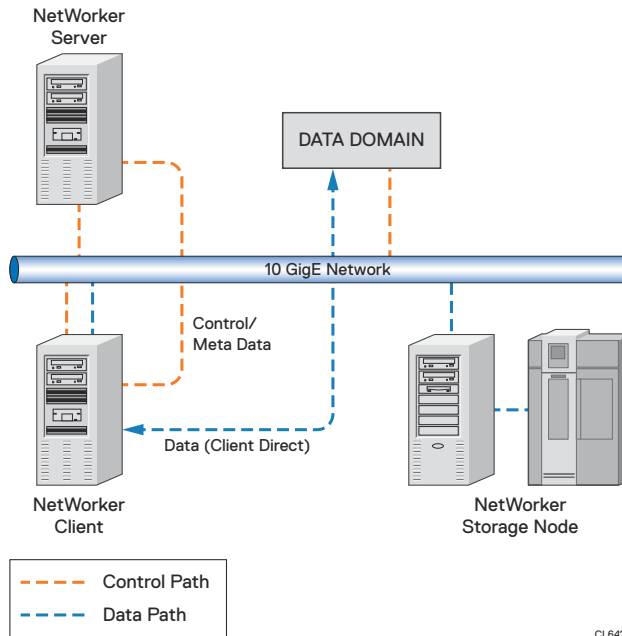
In the following figure, the network is unable to gather and send as much data as that of the components. Therefore, the network is the bottleneck, slowing down the entire backup process. Any single network device on the chain, such as a hub, switch, or a NIC, can be the bottleneck and slow down the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

**Figure 5** Network device bottleneck



As illustrated in the following figure, the network is upgraded from a 1 GigE network to a 10 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.

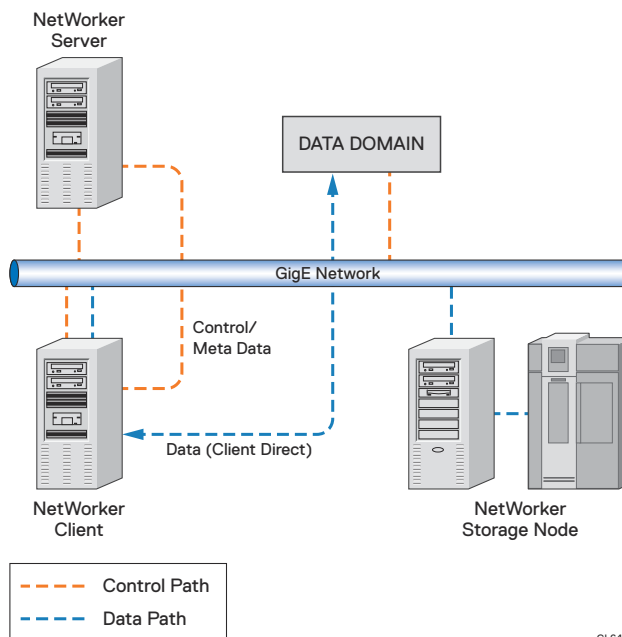
**Figure 6 Updated network**



CL6420

- 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.

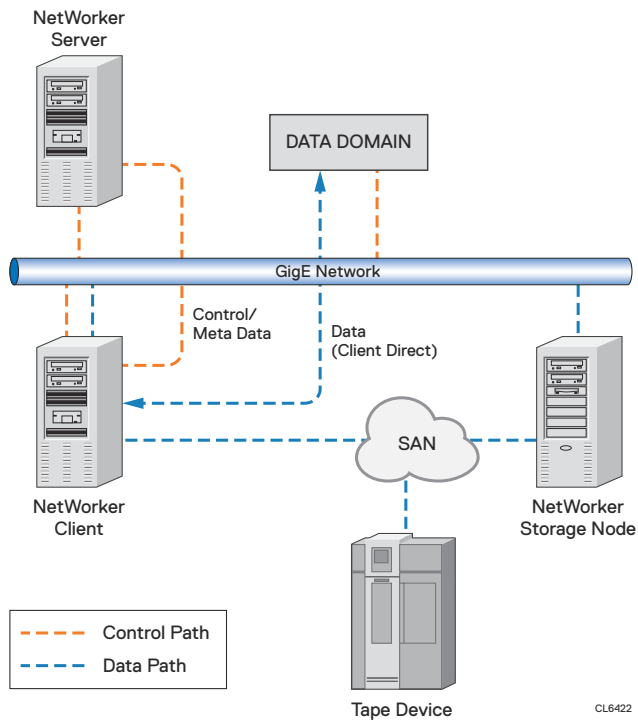
**Figure 7 Updated client**



CL6421

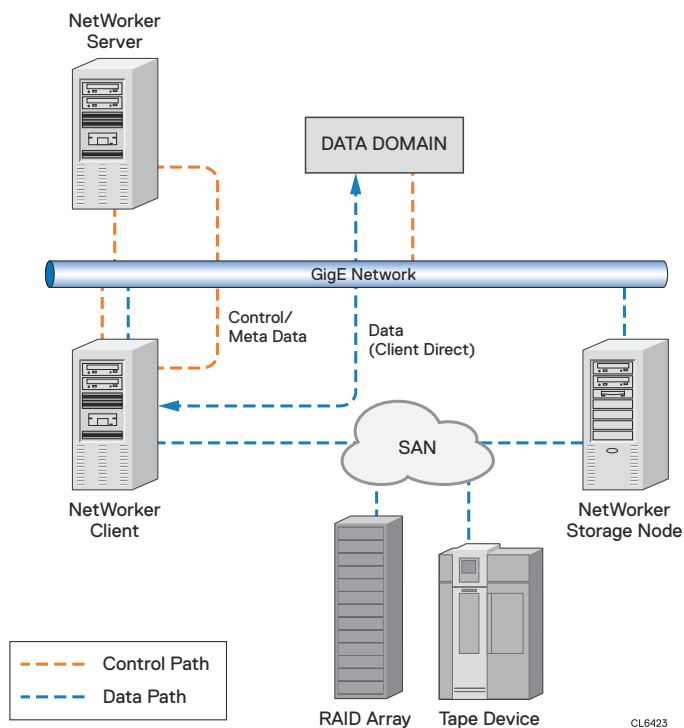
As illustrated in the following figure, higher performance tape devices on a SAN remove them as the bottleneck. The bottleneck device is now the storage devices. Although the local volumes are performing at optimal speeds, they are unable to use the available system, network, and target device resources.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

**Figure 8** Dedicated SAN



As illustrated in the following figure, 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 9** Raid array





## NetWorker database bottlenecks

There are several factors that determine the size of NetWorker databases:

- NetWorker resource database `/nsr/res` or `networker install dir/res`: The number of configured resources.
- NetWorker jobs database (`nsr/res/jobsdb`): The number of jobs such as backups, restores, clones multiplied by number of days set for retention. This can exceed 300,000 records in the largest environments and is one of the primary performance bottlenecks. The overall size is never significant.
- For the NetWorker media database (`nsr/mm`): The number of save sets in retention and the number of labeled volumes. In the largest environments this can reach several Gigabytes of data.
- For the NetWorker client file index database (`nsr/index`): The number of files indexed and in the browse policy. This is normally the largest of the NetWorker databases. For storage sizing, use this formula:  
Index catalog size =  $\{[(F+1)*N] + [(I+1) * (DFCR*N)]\} * [(1+G)*C]$

where:

F = 4 (Full Browse Period set to 4 weeks)

N = 1,000,000 (one million files for this example)

I = 24 (A four week browse period for incremental backups - minus the full backups)

DFCR = 3% (Daily file change rate for standard user file data)

G = 25% (estimated annual growth rate %)

C = 160 bytes (Constant number of bytes per file)

For example:

$$\{[(4+1)*1,000,000] + [(24+1) * (3%*1,000,000)]\} * [(1+.25)*160]$$

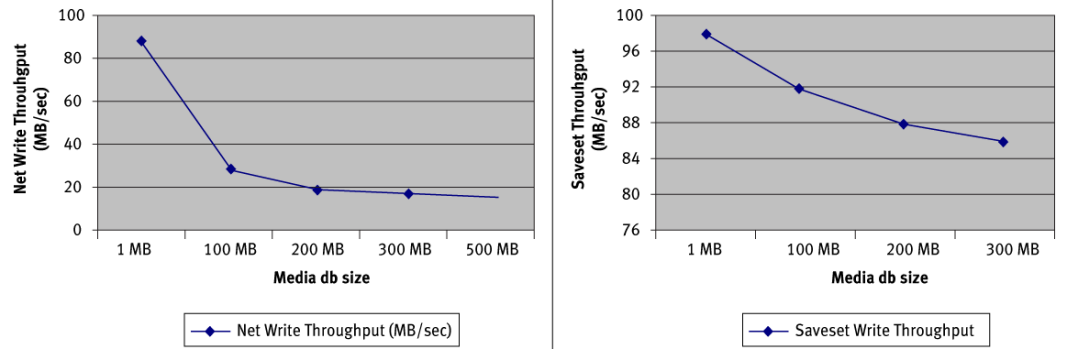
$$\{5,000,000 + [25 * 30,000]\} * [1.25 * 160]$$

$$5,750,000 * 200 \text{ bytes} = 1,150,000,000 \text{ bytes} = 1150 \text{ MB}$$

**i** **NOTICE** The index database can be split over multiple locations, and the location is determined on a per client basis.

The following figure illustrates the overall performance degradation when the disk performance on which NetWorker media database resides is a bottleneck. The chart on the right illustrates net data write throughput (save set + index + bootstrap) and the chart on the left is save set write throughput.

**Figure 10** NetWorker server write throughput degradation



# CHAPTER 3

## Tune Settings

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

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- [File system density](#) ..... 61
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## Optimize NetWorker parallelism

Follow the general best practices for server, group, and client parallelism to ensure optimal performance.

### 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. The default Server parallelism is 32 you can configure the parallelism up to 1024.

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.

### Server's client parallelism

Proper client parallelism values are important because backup delays often occur when client parallelism is set too low for the NetWorker server.

The best approach for client parallelism values is:

- For regular clients, use the default parallelism settings to best balance between the number of save sets and throughput.
- For the backup server, set the default client parallelism to ensure that the Server Protection Policy is not delayed.

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

The client parallelism values for the client that represents the NetWorker server are:

- Never set parallelism to 1
- For small environments (up to 500 clients), set parallelism to at least 8
- For medium environments (up to 1000 clients), set parallelism to at least 12
- For larger environments (up to 2000 clients), set parallelism to at least 16

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

### Action parallelism

Action parallelism defines the maximum number of simultaneous data streams that can occur on all clients in a group that is associated with the workflow that contains action.

Data streams include back data streams, `savefs` processes, and probe jobs. For a Backup action, the default parallelism value is 100. For all other action types, the default value is 0, or unlimited.

### 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.

[AFTD device target and max sessions](#) provides additional information on device Target Sessions.

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](#).
- Find the backup rate of each disk on the client. Use the uasm test described in [The uasm directive](#).

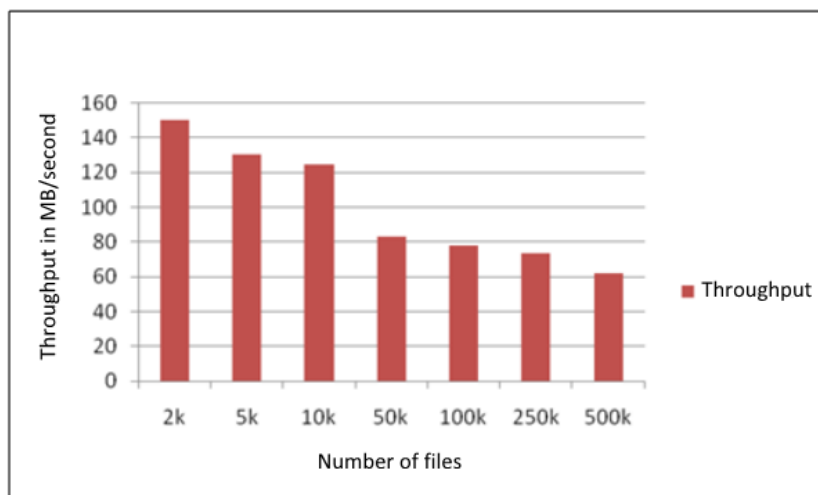
If the sum of the backup rates from all disks in a backup is greater than the maximum rate of the device, do not increase server parallelism. If more save groups are multiplexed in this case, backup performance will not improve, and recovery performance might slow down.

## File system density

File system density has a direct impact on backup throughput.

The NetWorker save operation spends significant time based on file system density specifically when there are many small files. NetWorker performance for high density file systems depends on disk latency, file system type, and number of files in the save set. The following figure illustrates the level of impact file system density has on backup throughput.


**Figure 11** Files versus throughput



## Disk optimization

NetWorker uses an intelligent algorithm when reading files from a client to choose an optimal block size value in the range of 64 KB and 8 MB based on the current read performance of the client system.

This block size selection occurs during the actual data transfer and does not add any overhead to the backup process, and potentially significantly increases disk read performance.

 **NOTICE** Read block size is not related to device block size used for backup, which remains unchanged.

This feature is transparent to the rest of the backup process and does not require any additional configuration.

You can override the dynamic block size by setting the `NSR_READ_SIZE` environment variable to a desired value in the NetWorker client. For example, `NSR_READ_SIZE=65536` forces the NetWorker software to use 64 KB block size during the read process.

## Device performance tuning methods

Specific device-related areas can improve performance.

### Input/output transfer rate

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 200 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 device to enable 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 target and max 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. More information on device target and max sessions is available at [AFTD device target and max sessions](#).

 **Note:** The maximum number of Data Domain devices recommended per storage node is 60.

## Fragmenting a disk drive

A fragmented file system on Windows clients can cause substantial performance degradation that is based on the amount of fragmentation. Defragment disks to avoid performance degradation.

### Procedure

1. To determine if disk fragmentation might be the problem, check the file system performance on the client by using a copy or ftp operation without NetWorker.
2. To consolidate data so the disk can perform more efficiently, run the **Disk Defragmenter** tool on the client:
  - a. Click to open **Disk Defragmenter**.
  - b. Under **Current status**, select the disk to defragment.
  - c. To verify that fragmentation is a problem, click **Analyze disk**. If prompted for an administrator password or confirmation, type the password or provide confirmation.
  - d. When Windows is finished analyzing the disk, check the percentage of fragmentation on the disk in the Last Run column. If the number is above 10%, defragment the disk.
  - e. Click **Defragment disk**. If prompted for an administrator password or confirmation, type the password or provide confirmation.

**Note:** The defragmentation might take from several minutes to a few hours to complete, depending on the size and degree of fragmentation of the hard disk. You can still use the computer during the defragmentation process.

## Network devices

Data that is backed up from remote clients, the routers, network cables, and network interface cards can 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.
- **NOTICE** 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 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 1 GB 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.
- The `nsrmmdbd` process uses a high CPU intensive operation when thousands of save sets are processed in a single operation. Therefore, cloning operations with huge save sets and NetWorker maintenance activities should run outside of the primary backup window.

## Fibre Channel latency

To reduce the impact of link latency, increase the NetWorker volume block size.

The result of increased volume block size is that data streams to devices without a frequent need for round-trip acknowledgment.

For low-latency links, increased block size does not have any effect.

For high-latency links, the impact can be significant and will *not* reach the same level of performance as local links.

**i** **NOTICE** High bandwidth does not directly increase performance if latency is the cause of slow data.

The following table is an example of different block sizes on a physical LTO-4 tape drive connected locally over a 15 KM 8 GB DWDM link.

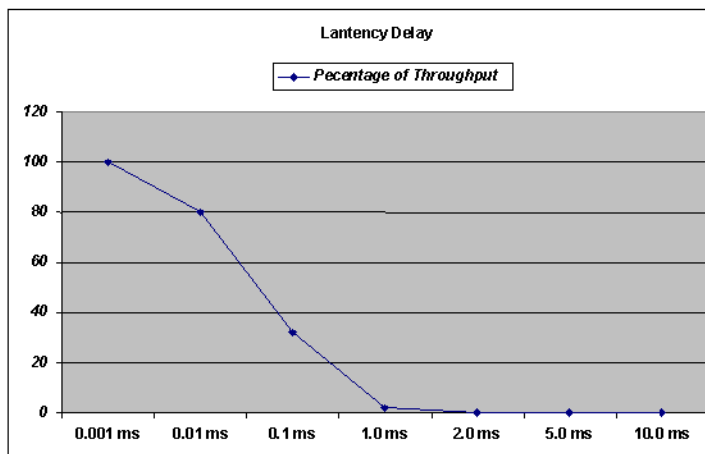
**Table 12** The effect of blocksize on an LTO-4 tape drive

Blocksize	Local backup performance	Remote backup performance
64 KB	173 MB/second	60 MB/second
128 KB	173 MB/second	95 MB/second
256 KB	173 MB/second	125 MB/second
512 KB	173 MB/second	130 MB/second
1024 KB	173 MB/second	130 MB/second

The following figure illustrates that the NetWorker backup throughput drops from 100 percent to 0 percent when the delay is set from 0.001 ms to 2.0 ms.



**Figure 12** Fibre Channel latency impact on data throughput



## Data Domain

Backup to Data Domain storage can be configured by using multiple technologies:

- NetWorker 8.1 and later supports DD Boost over Fibre Channel. This feature leverages the advantage of the boost protocol in a SAN infrastructure. It provides the following benefits:
  - DD Boost over Fibre Channel (DFC) backup with Client Direct is 20–25% faster when compared to backup with DD VTL.
  - The next subsequent full backup is three times faster than the first full backup.
  - Recovery over DFC is 2.5 times faster than recovery using DD VTL.
- Backup to VTL:
  - NetWorker devices are configured as tape devices and data transfer occurs over Fibre Channel.
  - Information on VTL optimization is available in [Number of virtual device drives versus physical device drives](#).
- Backup to AFTD over CIFS or NFS:
  - Overall network throughput depends on the CIFS and NFS performance which depends on network configuration. [Network optimization](#) provides best practices on backup to AFTD over CIFS or NFS.
  - Inefficiencies in the underlying transport limits backup performance to 70–80% of the link speed.
- The Client Direct attribute to enable direct file access (DFA):
  - Client Direct to Data Domain (DD) using Boost provides much better performance than DFA-AFTD using CIFS/NFS.
  - Backup performance with client direct enabled (DFA-DD/DFA-AFTD) is 20–60% faster than traditional backup using `nsrmmmd`.

- With an increasing number of streams to single device, DFA handles the backup streams much better than `nsrmmmd`.
- The minimum required memory for a NetWorker Data Domain Boost device with each device total streams set to 10 is approximately 250 MB. Each OST stream for BOOST takes an additional 25 MB of memory.
- Compared to traditional (non-DFA) backups, backups utilizing DDBoost require 2-40% of additional CPU, but for a much shorter period. Overall, the CPU load of a backup utilizing DDBoost is lower than traditional backup.

## CloudBoost

The CloudBoost device leverages the CloudBoost appliance and creates the NetWorker device on the cloud object store that is hosted on a CloudBoost appliance.

The following are CloudBoost benefits:

- Leverages the sending of a NetWorker client backup to the cloud for long term retention capabilities.
- Data can be sent directly to the Cloud from Linux x64 clients. For other client types, data is written to the cloud via a CloudBoost Storage Node.
- Data can be restored directly from the Cloud for Linux x64 clients. For other client types, the restore is performed via a CloudBoost Storage Node.
- NetWorker 18.1 allows Windows x64 clients to perform backup and recovery directly to and from the Cloud.
- The default target sessions for a CloudBoost device type are 10 for NetWorker 9.1, and 4 for NetWorker 9.0.1. The default maximum sessions are 80 for NetWorker 9.1, and 60 for NetWorker 9.0.1. For better performance, it is recommended that you keep the default values for Target and Maximum sessions.
- CloudBoost performs native deduplication, similar to the Data Domain device, the consecutive backups can be 2–3 time faster, based on the rate of change in data.

The *NetWorker with CloudBoost Integration Guide* provides details on configuring the Cloud appliance and device.

### CloudBoost observations and recommendations

- The recovery speed depends on the number of objects in the S3 storage. If the number of objects increase in the S3 bucket, the time to recover also increases. The recovery speed decreased in the case of an S3 bucket with fewer objects when compared to an S3 bucket with millions of objects in it.
- A NetWorker client with SSD performs backups faster when compared to the normal SAS or SATA disks. A test comparison between Azure and AWS for the same set of clients with Azure having SSD and AWS with non-SSD disks showed that SSD can improve backup performance by 1.5 times.
- The 8X deduplication data provides the best backup performance. In general, NetWorker and Cloud Boost solution can provide you with more deduplication data set by reducing the data foot-print and bandwidth on the S3 object store.
- On an average, the client direct backup is 5 times faster than non-client direct backups for mixed density save sets. With more deduplication data, the client direct backups are 10 to 15 times faster than the non-client direct backups.
- For better backup performance to a CloudBoost appliance, NetWorker clients must have 2 vCPU and 4GB memory.

- CloudBoost uses an average chunk size of 256 KB. If the chunk size increases from 256 to 1024 KB, the number of overall chunks being transferred to the S3 bucket reduces by 3.8 times. However, this does not impact the deduplication ratio.

## AFTD device target and max sessions

Each supported operating system has a specific optimal Advanced File Type Device (AFTD) device target, and max sessions settings for the NetWorker software.

### NetWorker 8.0 and later software

The dynamic `nsrmmmd` attribute in the NSR storage node attribute is off by default for the dynamic provisioning of `nsrmmmd` processes. Turning on the dynamic `nsrmmmd` attribute enables dynamic `nsrmmmd` provisioning.

**NOTICE** The dynamic `nsrmmmd` feature for AFTD and DD Boost devices in NetWorker 8.1 is enabled by default. In previous NetWorker versions, this attribute was disabled by default.

When the dynamic `nsrmmmd` attribute is enabled and the number of sessions to a device exceeds the number of target sessions, the visible change in behavior is multiple `nsrmmmd` processes on the same device. This continues until the max `nsrmmmd` count, or max sessions values are reached, whichever is lower.

To turn on backup to disk, select the **Configuration** tab to set these attributes as required:

- **Target Sessions** is the number of sessions the device handles before for another available device is used. For best performance, this should be set to a low value. The default values are four (FTD/AFTD) and six (DD Boost devices) and it may not be set to a value greater than 60.
- **Max Sessions** has a default value of 32 (FTD/AFTD) and 60 (DD Boost devices), which usually provides best performance. It cannot be set to a value greater than 60.
- **Max `nsrmmmd` count** is an advanced setting that can be used to increase data throughput by restricting the number of backup processes that the storage node can simultaneously run. When the target or max sessions are changed, the max `nsrmmmd` count is automatically adjusted according to the formula  $MS/TS$  plus four. The default values are 12 (FTD/AFTD) and 4 (DD Boost devices).

**NOTICE** It is not recommended to modify both session attributes and max `nsrmmmd` count simultaneously. If you must modify all these values, adjust the sessions attributes first, apply the changes, and then update max `nsrmmmd` count.

### Recommendations for the static `nsrmmmds` option

If the dynamic `mmds` option is enabled on the NetWorker storage node, NetWorker spawns a single `mmd` at a time based on the device target sessions. A firewall port must be calculated and opened based on the number of dynamic `mmds` that gets spawned. However, if there are firewall restrictions in the environment because of security reasons that demand all ports be open upfront, Dell EMC recommends that you disable the dynamic `mmds` option.

If you disable the dynamic `nsrmmmds` option under Storage Node properties, consider the following:

- Dell EMC recommends that you restrict the maximum `nsrmmmd` count based on the number of devices configured. For example, for AFTD devices, the max and target sessions are 4 and 32 respectively, and for Data Domain devices, the max and target sessions are 20 and 60 respectively.
- The number of `nsrmmmd` processes spawned is equal to the value set under **Max nsrmmmd count** under **Device properties**. Because the **Max nsrmmmd count** is calculated based on the target and max sessions, the **Max nsrmmmd count** value can increase with lower target sessions. Therefore, Dell EMC recommends that you keep the **Max nsrmmmd count** as 4 under the Static mmd configuration setting.
- A reduced **Max nsrmmmd count** helps in managing the mmds load on the NetWorker storage node, which might be idle most of the time.
- Maintaining optimal values for the number of mmds per device helps NetWorker to load balance the streams by saturating these mmds during backup or clone operations. For example, if there are 10 Data Domain devices with target and max sessions of 6 and 60 with static mmd setting, there are 140 (that is, 14 nsrmmmds per device X 10 devices) nsrmmmds. Dell EMC recommends that you use the default target or max sessions and the **Max nsrmmmd count** as 4 when dynamic mmd is disabled.
- The advantage of using the Static mmd setting is that even if a single device has to handle 60 streams, NetWorker will load balance these 60 streams across 4 nsrmmmds. Also, a lesser **Max nsrmmmd count** setting helps reduce the number of RPC and TCP connections during backup, clone, or server protection policy operations.

## Number of virtual device drives versus physical device drives

The acceptable number of virtual devices that are stored on an LTO depends on the type of LTO and the number of planned physical devices.

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

- For LTO-3: three virtual devices for every two physical devices planned.
- For LTO-4: three virtual devices for each physical device planned.  
The performance of each of these tape drives on the same port degrades with the number of attached devices.

For example:

- If the first virtual drive reaches the 150 MB per second limit.
- The second virtual drive will not exceed 100 MB per second.
- The third virtual drive will not exceed 70 MB per second.

## Network optimization

Adjust the following components of the network to ensure optimal performance.

### Advanced configuration optimization

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

The *NetWorker Security Configuration Guide* provides instructions on advanced configuration options.


## Operating system TCP stack optimization

There are general and environmental capability rules to ensure 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 PCIeExpress for 10 GB NICs. Other I/O architectures do not have enough bandwidth.  
More information on PCIeExpress is available in [PCI-X and PCIeExpress considerations](#) on page 26.

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. Information on jumbo frames is available in [Jumbo frames](#) on page 71.  
 **NOTICE** It is required that all network components in the data path can handle jumbo frames. Do not enable jumbo frames if this is not the case.
- TCP hardware offloading is beneficial if it works correctly. However, it can cause CRC mismatches. 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 NIC throughput values

High speed NICs are significantly more efficient than common NICs.

Common NIC throughput values are in the following ranges:

- 100 MB link: 6–8 MB/s
- 1 GB link: 45–65 MB/s
- 10 GB link: 150–350 MB/s

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

- 100 MB link: 12 MB/s
- 1 GB link: 110 MB/s
- 10 GB link: 1100 MB/s

The theoretical maximum throughput for a 10 GB Ethernet link is 1.164 GB/s per direction calculated by converting bits to bytes and removing the minimum Ethernet, IP and TCP overheads.

## Network latency

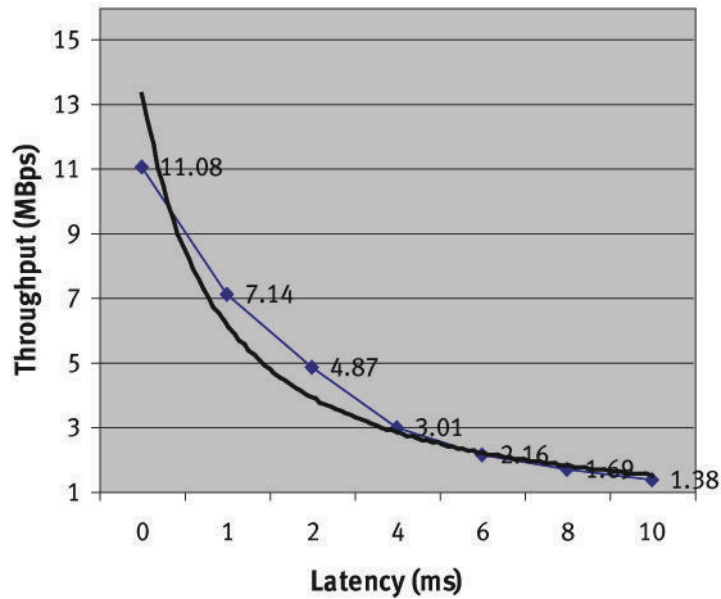
Increased network TCP latency has a negative impact on overall throughput, despite the amount of available link bandwidth. Longer distances or more hops between network hosts can result in lower overall throughput.

Network latency has a high impact on the efficiency of bandwidth use.

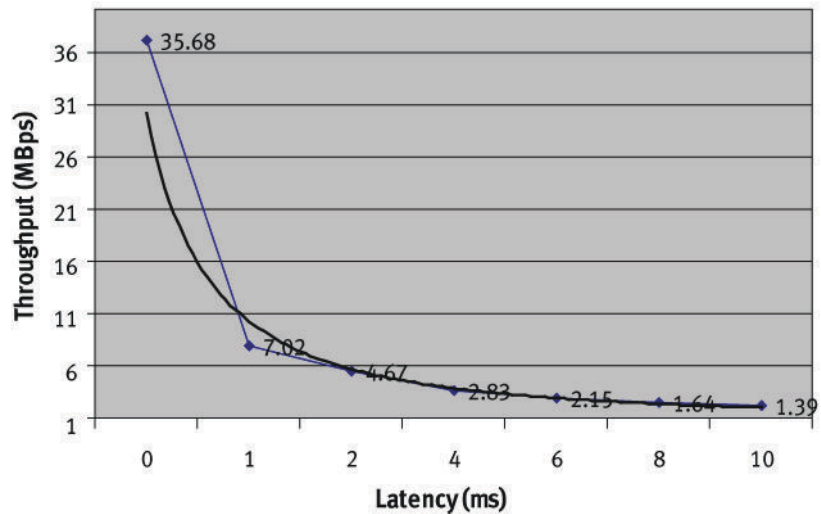
For example, The following figures illustrate backup throughput on the same network link, with varying latency.

For these examples, non-optimized TCP settings were used.

**Figure 13** Network latency on 10/100 MB per second



**Figure 14** Network latency on 1 GB



## Ethernet duplexing

Network links that perform in half-duplex mode cause decreased NetWorker traffic flow performance.

For example, a 100 MB half-duplex link results in backup performance of less than 1 MB per second.

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

- Proper cabling
- Compatible NIC adapter
- Compatible switch

Automatic 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 automatic negotiation on the other side of the link.

## Firewalls

The additional layer on the I/O path in a hardware firewall increases network latency, and reduces the overall bandwidth use.

Use software firewalls on the backup server as it processes many packets that result in significant overhead.

Details on firewall configuration and impact are available in the *NetWorker Administration Guide*.

## Jumbo frames

Use jumbo frames in environments capable of handling them. If both the source, the computers, and all equipment in the data path can handle jumbo frames, increase the MTU to 9 KB.

These examples are for Linux and Solaris operating systems:

- On Linux, type the following command to configure jumbo frames:

```
ifconfig eth0 mtu 9000 up
```

- On Solaris, type the following command to configure jumbo frames for a `nxge` device:

```
ndd -set /dev/nxge<#> accept-jumbo 1
```

where `<#>` is replaced with the driver instance number.

To determine the instance number of a following device, type the following command:

```
nxge /etc /path_to_inst
```

## Congestion notification

Methods to disable congestion notification algorithms vary based on the operating system.

### About this task

On Windows Server 2008 R2, 2012, and 2012 R2:

- Disable optional congestion notification algorithms by typing the following command:

```
C:\> netsh interface tcp set global ecncapability=disabled
```

- Compound TCP is an advanced TCP algorithm that provides the best results on Windows via the TCP Global parameter *Add-On Congestion Control Provider*. The value for this parameter is *none* if Compound TCP is disabled, or *ctcp* if Compound TCP is enabled.

If both sides of the network connection are not capable of the negotiation, you can disable *Add-On Congestion Control Provider* by typing the following command:

```
C:\> netsh interface tcp set global congestionprovider=none
```

**Note:** A reboot of the system is required if you enable *Add-On Congestion Control Provider* by typing the command `C:\> netsh int tcp set global congestionprovider=ctcp`.

On Linux systems:

- Check for non-standard algorithms by typing the following command:

```
cat /proc/sys/net/ipv4/tcp_available_congestion_control
```

- To disable ECN type the following command:

```
echo 0 >/proc/sys/net/ipv4/tcp_ecn
```

On Solaris systems:

- To disable TCP Fusion, if present, type the following command:

```
set ip:do_tcp_fusion = 0x0
```

## TCP buffers

When the rate of inbound TCP packets is higher than the system can process, the operating system drops some of the packets. This scenario can lead to an undetermined NetWorker state and unreliable backup operations. For NetWorker server or storage node systems that are equipped with high-speed interfaces, it is critical to monitor the system TCP statistics for dropped TCP packets, commonly done by using the `netstat -s` command. To avoid dropped TCP packets, increase the TCP buffer size. Depending on the operating system, this parameter is referred to as buffer size, queue size, hash size, backlog, or connection depth.

### About this task

For high-speed network interfaces, increase size of TCP send/receive buffers.

#### NetWorker server

- Linux:  
To modify the TCP buffer settings on Linux:
  1. Add the following parameters to the `/etc/sysctl.conf` file:



```
net.core.rmem_default = 262144
net.core.wmem_default = 262144
net.core.rmem_max = 16777216
net.core.wmem_max = 16777216
net.ipv4.tcp_rmem = 8192 524288 16777216
net.ipv4.tcp_wmem = 8192 524288 16777216
net.ipv4.tcp_fin_timeout: 120
```

2. Type the following command:

```
/sbin/sysctl -p
```

3. Set the recommended RPC value:

```
sunrpc.tcp_slot_table_entries = 64
```

4. Enable dynamic TCP window scaling which requires compatible equipment in the data path:

```
sysctl -w net.ipv4.tcp_window_scaling=1
```

- Solaris:

To modify the TCP buffer settings on Solaris, type the following command:

```
tcp_max_buf 10485760
tcp_cwnd_max 10485760
tcp_recv_hiwat 65536
tcp_xmit_hiwat 65536
```

- Windows:

The default Windows buffer sizes are sufficient. To modify the TCP buffer settings on Windows:

- Set the registry entry:

```
AdditionalCriticalWorkerThreads: DWORD=10
```

- If the NIC drivers can create multiple buffers or queues at the driver-level, enable it at the driver level. For example, Intel 10 GB NIC drivers by default have RSS Queues set to two, and the recommended value for best performance is 16.
- Increase the recycle time of ports in TIME\_WAIT as observed in `netstat` commands:

On Windows, set the following registry entries:

```
HKLM\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters
\TcpTimedWaitDelay
Data type REG_DWORD
Range 0x1E 0x12C ( 30-300 seconds )
Default value 0xF0 ( 240 seconds = 4 minutes )
```

### NetWorker storage node

- Linux:

- Increase the TIME\_WAIT seconds:

```
net.ipv4.tcp_fin_timeout: 120
```

- Solaris:

To modify the TCP buffer settings on Solaris, type the following command:

```
tcp_max_buf 10485760
tcp_cwnd_max 10485760
```

```
tcp_recv_hiwat 65536
tcp_xmit_hiwat 65536
```

- AIX:
  - To modify the TCP buffer settings on AIX, modify the values for the parameters in `/etc/rc.net` if the values are lower than the recommended. Consider the following:
    - The number of bytes a system can buffer in the kernel on the receiving sockets queue:
 

```
no -o tcp_recvspace=524288
```
    - The number of bytes an application can buffer in the kernel before the application is blocked on a send call:
 

```
no -o tcp_sendspace=524288
```
- Windows:
  - The default Windows buffer sizes are sufficient. To modify the TCP buffer settings on Windows:
    - Set the registry entry:
 

```
AdditionalCriticalWorkerThreads: DWORD=10
```
    - If the NIC drivers can create multiple buffers or queues at the driver-level, enable it at the driver level. For example, Intel 10 GB NIC drivers by default have RSS Queues set to two, and the recommended value for best performance is 16.
    - Increase the recycle time of ports in TIME\_WAIT as observed in `netstat` commands:
 

On Windows, set the following registry entries:

```
HKLM\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters
\TcpTimedWaitDelay
Data type REG_DWORD
Range 0x1E 0x12C ( 30-300 seconds )
Default value 0xF0 ( 240 seconds = 4 minutes )
```

## Increase TCP backlog buffer size

To increase TCP backlog buffer size, set the connection backlog queue to the maximum value allowed in the NetWorker server host:

```
net.ipv4.tcp_max_syn_backlog = 8192
net.core.netdev_max_backlog = 8192
```

The `net.core.somaxconn` value default is 128. Raise the value substantially to support bursts of requests. For example, to support a burst of 1024 requests, set `net.core.somaxconn` to 1024:

```
net.core.somaxconn = 1024
```

To make a temporary change to the variable:

```
sysctl -w variable=value
```

Do the following to make the values persistent across system reboot:

1. Open the `/etc/sysctl.conf` file and enter:

```
# vi /etc/sysctl.conf
```

2. Add value:

```
variable=value
```

3. Save the changes and load `sysctl` settings from the `/etc/sysctl.conf` file:

```
# sysctl -p
```

## IRQ balancing and CPU affinity

A high-speed network interface that uses either multiple 1 GB interfaces or one 10 GB interface benefits from disabled IRQ balancing and binding to specific CPU core processing.

**NOTICE** The general rule is that only one core per physical CPU should handle NIC interrupts. Use multiple cores per CPU only if there are more NICs than CPUs. Handle transmitting and receiving with the same CPU without exception.

These examples are for Linux and Solaris operating systems:

- Linux:

1. Disable IRQ balancing and set CPU affinity manually:

```
service irqbalance stop
chkconfig irqbalance off
```

2. Tune the CPU affinity for the eth0 interface:

```
grep eth0 /proc/interrupts
```

3. Tune the affinity for the highest to the lowest. For example:

```
echo 80 > /proc/irq/177/smp_affinity
echo 40 > /proc/irq/166/smp_affinity
```

SMP affinity works only for IO-APIC enabled device drivers. Check for the IO-APIC capability of a device by using `cat /proc/interrupts`, or by referencing the device documentation.

- Solaris:

Interrupt only one core per CPU. For example, for a system with 4 CPUs and four cores per CPU, use this command:

```
psradm -i 1-3 5-7 9-11 13-15
```

Additional tuning depends on the system architecture.

Successful settings on a Solaris system with a T1/T2 CPU include the following:

```
ddi_msix_alloc_limit 8
tcp_queue_wput 1
ip_soft_rings_cnt 64
ip_queue_fanout 1
```

Some NIC drivers artificially limit interrupt rates to reduce peak CPU use which limits the maximum achievable throughput. If a NIC driver is set for “Interrupt moderation,” disable it for optimal network throughput.

## Interrupt moderation

On Windows, for a 10 GB network, it is recommended to disable interrupt moderation for the network adapter to improve network performance.

## TCP chimney offloading

For systems with NICs capable of handling TCP packets at a lower level, enable TCP chimney offloading on the operating system to increase overall bandwidth utilization, and decrease the CPU load on the system.

Not all NICs that market offloading capabilities are fully compliant with the standard.

- For Windows 2008 R2, 2012, and 2012 R2, type the following command to enable TCP chimney offloading:

```
C:\> netsh interface tcp set global chimney=enabled
```


- For Windows 2008 R2, type these commands with additional properties to enable TCP offloading:

```
C:\> netsh interface tcp set global dca=enabled
```

```
C:\> netsh interface tcp set global netdma=enabled
```


- For Windows Server 2012 and 2012 R2, type the following command with additional properties to enable TCP offloading:

```
C:\> netsh interface tcp set global dca=enabled
```

 **Note:** Windows Server 2012 and 2012 R2 do not support NetDMA.

- Disable TCP offloading for older generation NIC cards that exhibit problems such as backup sessions that stop responding, failures due to RPC errors, or connection reset (CRC) errors similar to the following:

```
Connection reset by peer
```

 **Note:** TCP chimney offloading can cause CRC mismatches. Ensure that you consistently monitor for errors when you enable TCP chimney offloading.

## Name resolution

The NetWorker server relies heavily on the name resolution capabilities of the operating system.

For a DNS server, set low-latency access to the DNS server to avoid performance issues by configuring, either of the following:

- Local DNS cache  
or
- Local non-authoritative DNS server with zone transfers from the main DNS server

Ensure that the server name and the hostnames that are assigned to each IP address on the system are defined in the hosts file to avoid DNS lookups for local hostname checks.

## Operating system specific settings for SLES SP2

For SLES 12 SP2 and later, by default, the systemd framework blocks the creation of threads or processes to 512 per service.

### About this task

This restricts NetWorker from creating more than 512 threads or processes, and might lead to a shutdown of the `nsrd` or `authc` processes. To avoid this, update the `TasksMax` value in the systemd framework:

### Procedure

1. Shutdown NetWorker services.
2. Check if the `/usr/lib/systemd/system/networker.service` file is present or not.
  - a. If the `/usr/lib/systemd/system/networker.service` file is present, edit it to add the `TasksMax=infinity` line in the "[Service]" section.
  - b. If the `/usr/lib/systemd/system/networker.service` file is not present, edit the `/opt/nsr/admin/networker.service` file to add the `TasksMax=infinity` line in the "[Service]" section.
3. Type the `systemctl daemon-reload` command to reload the daemons.
4. Type the following command to determine the `TaskMax` value.
 

```
systemctl show networker.service | grep TasksMax
```
5. Restart NetWorker services.



# CHAPTER 4

## Test Performance

This chapter describes how to test and understand bottlenecks by using available tools including NetWorker programs such as `bigasm` and `uasm`.

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- [Monitor performance](#)..... 80
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- [Clone performance](#)..... 88
- [Limit memory usage on the host during clone operations](#)..... 88

## Determine symptoms

There are many considerations for determining the reason for poor backup performance.

Ask the following questions to determine the cause for poor performance:

- 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

You can monitor the I/O, disk, CPU, and network performance by using native performance monitoring tools.

The monitoring tools available for performance monitoring include the following:

- Windows: `perfmon` program
- 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, resources that are 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.

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 versus user space.

On Windows, if much time is spent on Deferred Procedure Calls, it often indicates a problem with device drivers.



## Determining bottlenecks by using a generic FTP test

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

### Procedure

1. On the NetWorker client, create a large datafile, and then use FTP to send it to the storage node.
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:
  - a. If the FTP performs much faster than the backups, the bottleneck might be with the tape devices.
  - b. If the FTP performs at a similar rate, the bottleneck might be in the network.
4. Compare results by using active FTP versus passive FTP transfer. NetWorker backup performance is greatly impacted by the capabilities of the underlying network and the network packets that are used by the NetWorker software.

### Results

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.

## Testing setup performance using the dd test

Without using NetWorker components, you can use the generic `dd` test to compare device throughput to the manufacturer's suggested throughput.

### Procedure

1. Create a large data file on the storage node, and then use `dd` to send it to the target device. Type the following command:
 

```
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 then 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.

## TCP window size and network latency considerations

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 can result in lower overall throughput. Since the propagation delay of the TCP packet depends on the distance between the two locations, increased bandwidth will not help if high latency exists between the two sites.

Throughput also depends on the TCP window size and the amount of latency between links. A high TCP window size generally results in better performance, however, with a high latency link, increasing the TCP window may significantly impact the backup window due to packet loss. Every unsuccessful packet that is sent must be kept in memory and must be re-transmitted in case of packet loss. Therefore, for TCP windows with a high latency link, it is recommended that you maintain the default TCP window size.

The network latency impact on NetWorker backup, clone, and recovery performance depends on the control path and data path:

- Latency between clients and NetWorker server (control path)—The latency impact on the NetWorker control path (metadata update) can vary based on the type of data you process during NetWorker backup and recovery operations. For example, if NetWorker clients and the server are separated by a high latency link, and clients back up a high density file system dataset, the large amount of metadata (file indexes) being sent over the wire impacts the index commit.
- Latency between client and target device (DD) (data path)—Latency between the NetWorker client and the target device significantly impacts throughput. Any packet loss will further impact throughput. The high latency link in the data path affects throughput irrespective of the type of data being processed.

The following section provides best practices and recommendations when using high latency networks such as WAN for NetWorker application data and control paths for backup, clone, and recovery operations.

These examples show the results from using high density datasets (many files but with a low overall size) and large density datasets (a small number of files but with a large overall size) during backup, clone, and restore workflows.

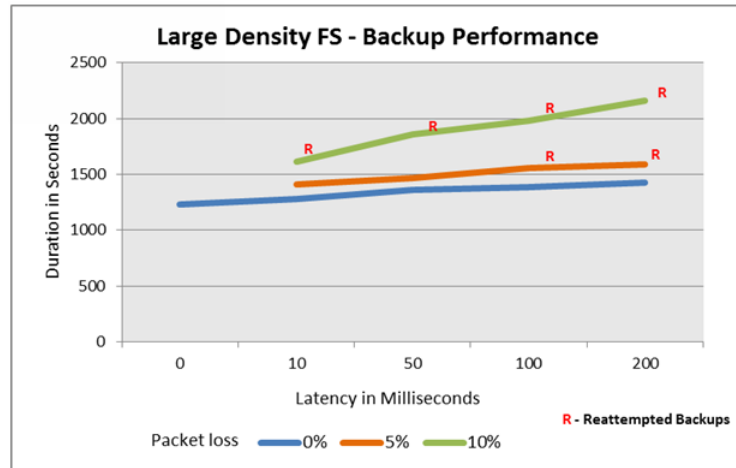
The data layout is as follows:

- High density file system (FS): 1 million files with approximately 4000 MB overall size
- Large density file system: <1000 files with approximately 390 GB overall size

**Note:** These tests were conducted using the WANem simulation tool by inducing latency and packet loss between the NetWorker control and data path. Allow for a 10–20% error margin in the results due to the simulation technique.

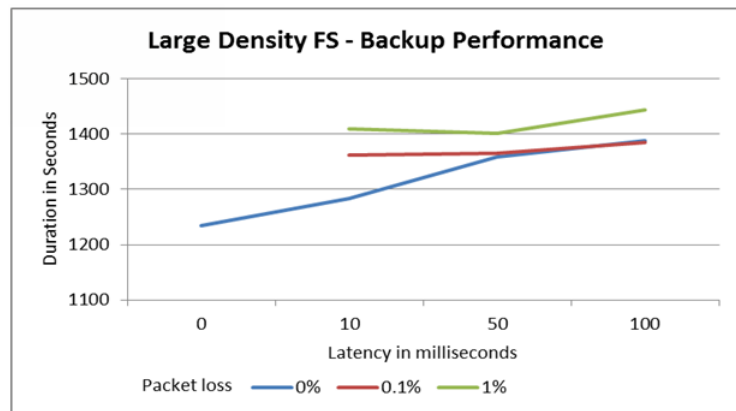
**WAN Latency impact in control path (NetWorker server and clients separated by high latency) for backup**

**Figure 15** Large Density FS Backup - WAN between NetWorker Clients and Server (High Packet Loss)

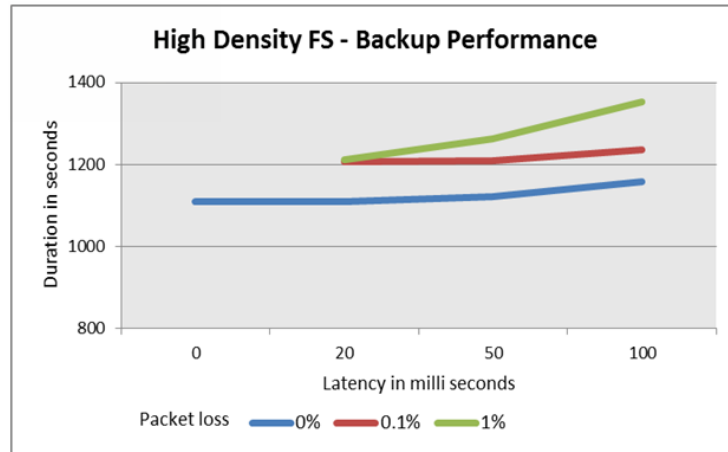


**Note:** The items that are marked in RED are reattempted backups with client retries >0 and <=5

**Figure 16** Large Density FS Backup - WAN between NetWorker Clients and Server (Low Packet Loss)



**Figure 17** High Density FS Backup Performance - WAN between NetWorker Clients and Server

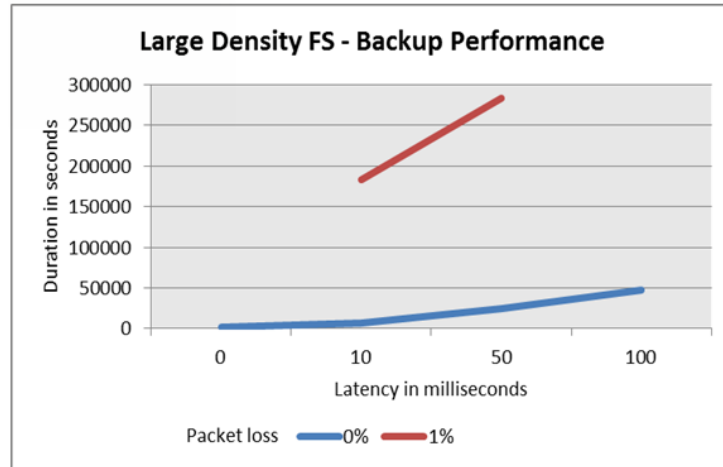


**Observations and recommendations:**

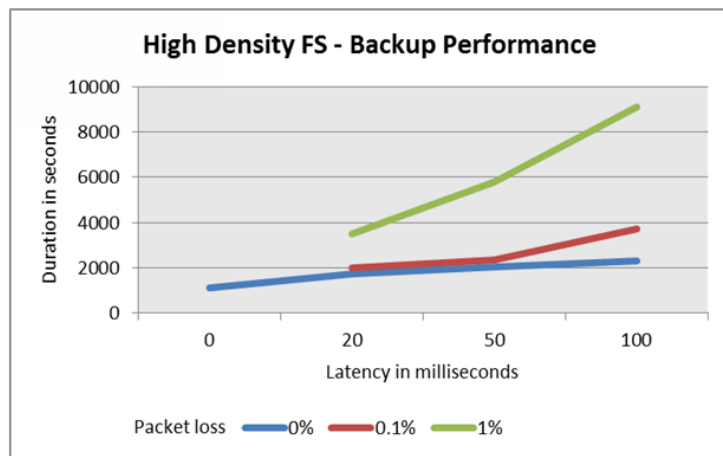
- NetWorker can sustain up to 200 ms latency with 0% packet loss between the NetWorker client and NetWorker server for metadata transfer of low density file systems.
- With a high density file system dataset (client backing up dataset with millions of files), the maximum latency between the NetWorker client and NetWorker server is 100 ms with 0% packet loss.
- NetWorker guarantees a 100% backup success rate with high latency on control path but any packet loss will significantly impact the backup success rate.
- If there is high latency link with packet loss between the NetWorker server and NetWorker client, it is recommended that you set higher client retry values in order for the backup to succeed. It was observed that with default client retries a backup with 200 ms and up to 5% packet loss succeeded.
- You will observe a 5–10% impact on the backup window when there is a high latency link between the NetWorker server and NetWorker clients.
- High packet loss (>5%) and high latency (>200 ms) results in a significant impact on the backup success rate and produce intermittent failures.

### WAN Latency impact in data path (NetWorker clients and target device such as Data Domain separated by high latency) for backup

**Figure 18** Large Density FS Backup Performance - WAN between NetWorker Clients and Data Domain



**Figure 19** High Density FS Backup Performance - WAN between NetWorker Clients and Data Domain

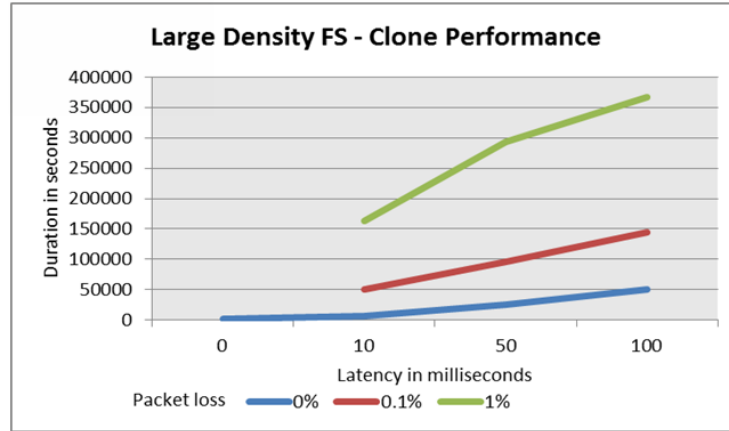


#### Observations and recommendations:

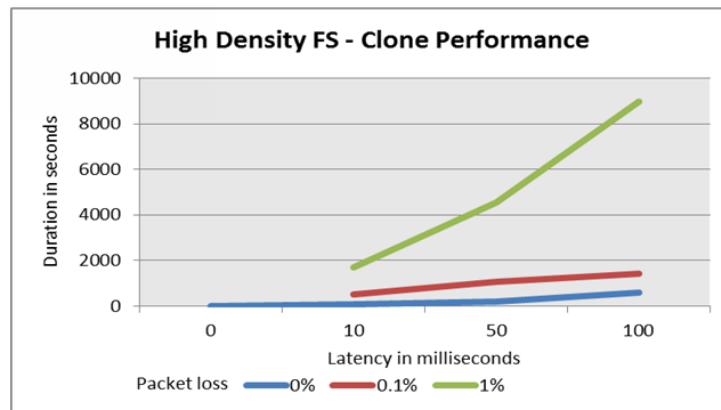
- There is huge impact on throughput when there is high latency between the NetWorker client and Data Domain over WAN with client direct enabled.
- Every increase of 5 ms latency will slow the backup throughput by 2-2.5 times for the initial full backup to Data Domain over Boost. Higher latency link results significant slowness during backup.
- The consecutive backups (full or incremental) with very minimal change rate over high latency link impacts around 5-10% on backup throughput.
- It is not recommended that you exceed the max latency of 50 ms between NetWorker client and remote Data Domain with very minimal (recommended 0%) packet loss.
- Packet loss in the data path has the most impact on the backup window and throughput. Even 1% of packet loss can reduce the backup throughput by 5-25 times, which significantly impacts the backup window.

### WAN latency impact in data path (Latency between source and target DDR) for cloning

**Figure 20** Large Density FS Clone Performance - WAN between NetWorker Clients and Data Domain



**Figure 21** High Density FS Clone Performance - WAN between NetWorker Clients and Data Domain



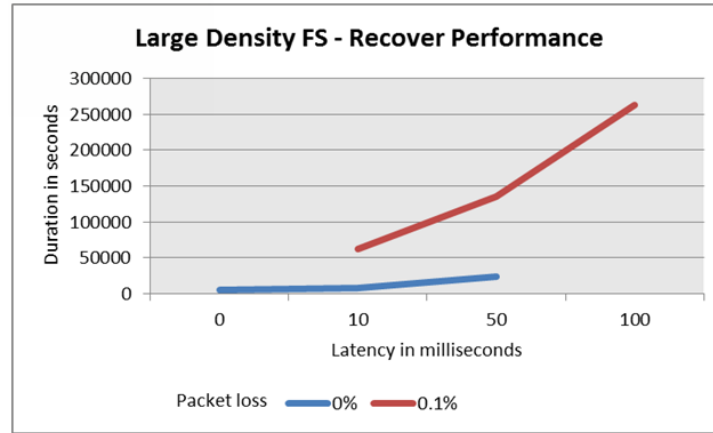
**Note:** Clone-controlled replication (CCR) performance completely depends on the Data Domain model, the existing load on DDRs and the latency between two different Data Domain systems that are separated by WAN. The preceding results show the WAN latency impact on a Large Density File System and High Density File System.

**Observations and recommendations:**

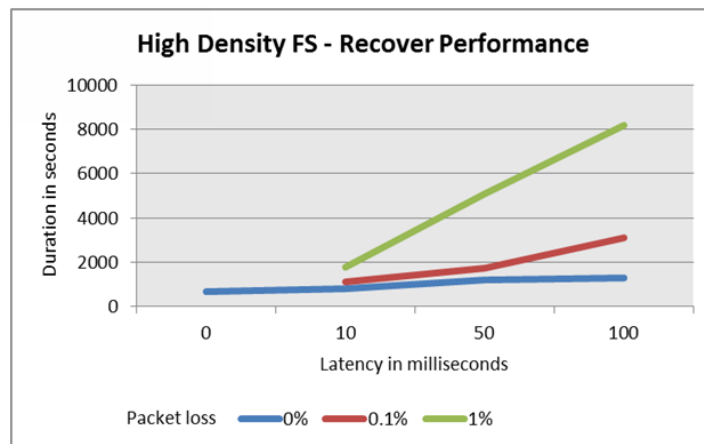
- If there is high latency link between the source and target DDR, then there is significant impact in clone throughput.
- Every 10 ms increase in latency reduces the clone throughput by 4-45 times.
- The packet loss in the WAN link further reduces the clone throughput by 4-300 times for a large density dataset and by 4-500 times for high density datasets.
- It is not recommended that you exceed the 50 ms latency for large size datasets and 20 ms latency for high density dataset cloning.

## WAN latency impact in data path (Latency between source and target DDR) for recovery

**Figure 22** Large Density FS Recovery Performance - WAN between NetWorker Clients and Data Domain



**Figure 23** High Density FS Recovery Performance - WAN between NetWorker Clients and Data Domain



**Note:** For large density file system and high density file system dataset restore, time indicates the time that is taken to perform 10 simultaneous restores.

### Observations and recommendations:

- Latency impacts recovery performance similar to the backup and clone workflows.
- If a high latency link exists between the NetWorker client and DDR during recovery, then the performance slows down drastically.
- Every 10 ms increase in latency reduces the recover throughput by 1-2 times for a high density dataset with multiple client restore. For a large density dataset with multiple client restore, throughput decreases by 2-10 times with increase in latency.
- The packet loss in the WAN link further reduces the restore throughput by 2-12 times.
- It is not recommended that you exceed the 50 ms latency (with multiple restores) for a high dataset and 20 ms latency (with multiple restores) for a large dataset during recovery.

## Summary

**Table 13** Tolerable Range for Low Density file system

WAN path	Latency	Packet loss
Client - NetWorker server	0-100ms	0-1%
Client - Data Domain (DFA)	0-50ms	0-0.1%

**Table 14** Tolerable Range for High Density file system

WAN path	Latency	Packet loss
Client - NetWorker server	0-100ms	0-0.1%
Client - Data Domain (DFA)	0-50ms	0-0.1%

**Note:** Higher latency and packet loss between the data path impacts throughput significantly. You can still use the high latency link for data path but the NetWorker server might re-attempt the failed backups due to packet loss. It is recommended that you apply the preceding recommendations to avoid the failures with high latency WAN links.

## Clone performance

For small sized save set (KB files), a Recover Pipe to Save (RPS) clone takes 30 seconds more than a non-RPS clone. When a dataset size is more than 2 GB, an RPS clone performs better than a non-RPS clone.

## Limit memory usage on the host during clone operations

During cloning operations, the `nsrrecovery.exe` program allocates the pool of buffers for data read and write processes. One `nsrrecovery.exe` program is spawned for each target volume. If multiple `nsrrecovery.exe` instances run at the same time, the `nsrrecovery.exe` instances might consume all of the host memory and might cause the system to stop responding or fail.

### Procedure

1. Create the following file:

```
/nsr/debug/nsrcloneconfig
```

2. To limit the number of pools, create an entry similar to the following:

```
Pool Size=500
```

The Pool Size value should be between 100 to 2000. The default is 1000.

3. To limit the buffer size, create an entry similar to the following:

```
Buffer Size=128
```

The Buffer Size value should be between 64 to 2048 and be a multiple of 64. The default is 256.