

IBM Spectrum Scale Container Native Storage  
Access  
5.1.6

*IBM Spectrum Scale  
Container Native Storage Access Guide*



**Note**

Before using this information and the product it supports, read the information in [“Notices” on page 99.](#)

This edition applies to Version 5 release 1 modification 6 of the following products, and to all subsequent releases and modifications until otherwise indicated in new editions:

- IBM Spectrum Scale Data Management Edition ordered through Passport Advantage® (product number 5737-F34)
- IBM Spectrum Scale Data Access Edition ordered through Passport Advantage (product number 5737-I39)
- IBM Spectrum Scale Erasure Code Edition ordered through Passport Advantage (product number 5737-J34)
- IBM Spectrum Scale Data Management Edition ordered through AAS (product numbers 5641-DM1, DM3, DM5)
- IBM Spectrum Scale Data Access Edition ordered through AAS (product numbers 5641-DA1, DA3, DA5)
- IBM Spectrum Scale Data Management Edition for IBM® ESS (product number 5765-DME)
- IBM Spectrum Scale Data Access Edition for IBM ESS (product number 5765-DAE)

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## About this information

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This edition applies to IBM Spectrum Scale version 5.1.6 for AIX®, Linux®, and Windows.

IBM Spectrum Scale is a file management infrastructure, based on IBM General Parallel File System (GPFS) technology, which provides unmatched performance and reliability with scalable access to critical file data.

To find out which version of IBM Spectrum Scale is running on a particular AIX node, enter:

```
lslpp -l gpfs\*
```

To find out which version of IBM Spectrum Scale is running on a particular Linux node, enter:

```
rpm -qa | grep gpfs      (for SLES and Red Hat Enterprise Linux)
```

```
dpkg -l | grep gpfs     (for Ubuntu Linux)
```

To find out which version of IBM Spectrum Scale is running on a particular Windows node, open **Programs and Features** in the control panel. The IBM Spectrum Scale installed program name includes the version number.

### Which IBM Spectrum Scale information unit provides the information you need?

The IBM Spectrum Scale library consists of the information units listed in [Table 1 on page x](#).

To use these information units effectively, you must be familiar with IBM Spectrum Scale and the AIX, Linux, or Windows operating system, or all of them, depending on which operating systems are in use at your installation. Where necessary, these information units provide some background information relating to AIX, Linux, or Windows. However, more commonly they refer to the appropriate operating system documentation.

**Note:** Throughout this documentation, the term "Linux" refers to all supported distributions of Linux, unless otherwise specified.

Table 1. IBM Spectrum Scale library information units

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Concepts, Planning, and Installation Guide</i></p>	<p>This guide provides the following information:</p> <p><b>Product overview</b></p> <ul style="list-style-type: none"> <li>• Overview of IBM Spectrum Scale</li> <li>• GPFS architecture</li> <li>• Protocols support overview: Integration of protocol access methods with GPFS</li> <li>• Active File Management</li> <li>• AFM-based Asynchronous Disaster Recovery (AFM DR)</li> <li>• Introduction to AFM to cloud object storage</li> <li>• Introduction to system health and troubleshooting</li> <li>• Introduction to performance monitoring</li> <li>• Data protection and disaster recovery in IBM Spectrum Scale</li> <li>• Introduction to IBM Spectrum Scale GUI</li> <li>• IBM Spectrum Scale management API</li> <li>• Introduction to Cloud services</li> <li>• Introduction to file audit logging</li> <li>• Introduction to clustered watch folder</li> <li>• Understanding call home</li> <li>• IBM Spectrum Scale in an OpenStack cloud deployment</li> <li>• IBM Spectrum Scale product editions</li> <li>• IBM Spectrum Scale license designation</li> <li>• Capacity-based licensing</li> </ul>	<p>System administrators, analysts, installers, planners, and programmers of IBM Spectrum Scale clusters who are very experienced with the operating systems on which each IBM Spectrum Scale cluster is based</p>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<i>IBM Spectrum Scale: Concepts, Planning, and Installation Guide</i>	<b>Planning</b> <ul style="list-style-type: none"> <li>• Planning for GPFS</li> <li>• Planning for protocols</li> <li>• Planning for Cloud services</li> <li>• Planning for AFM</li> <li>• Planning for AFM DR</li> <li>• Planning for AFM to cloud object storage</li> <li>• Planning for performance monitoring tool</li> </ul>	
<i>IBM Spectrum Scale: Concepts, Planning, and Installation Guide</i>	<ul style="list-style-type: none"> <li>• Firewall recommendations</li> <li>• Considerations for GPFS applications</li> <li>• Security-Enhanced Linux support</li> <li>• Space requirements for call home data upload</li> </ul>	

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Concepts, Planning, and Installation Guide</i></p>	<p><b>Installing</b></p> <ul style="list-style-type: none"> <li>• Steps for establishing and starting your IBM Spectrum Scale cluster</li> <li>• Installing IBM Spectrum Scale on Linux nodes and deploying protocols</li> <li>• Installing IBM Spectrum Scale on AIX nodes</li> <li>• Installing IBM Spectrum Scale on Windows nodes</li> <li>• Installing Cloud services on IBM Spectrum Scale nodes</li> <li>• Installing and configuring IBM Spectrum Scale management API</li> <li>• Installing GPUDirect Storage for IBM Spectrum Scale</li> <li>• Installation of Active File Management (AFM)</li> <li>• Installing AFM Disaster Recovery</li> <li>• Installing call home</li> <li>• Installing file audit logging</li> <li>• Installing clustered watch folder</li> <li>• Steps to permanently uninstall IBM Spectrum Scale</li> </ul> <p><b>Upgrading</b></p> <ul style="list-style-type: none"> <li>• IBM Spectrum Scale supported upgrade paths</li> <li>• Online upgrade support for protocols and performance monitoring</li> <li>• Upgrading IBM Spectrum Scale nodes</li> </ul>	<p>System administrators, analysts, installers, planners, and programmers of IBM Spectrum Scale clusters who are very experienced with the operating systems on which each IBM Spectrum Scale cluster is based</p>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Concepts, Planning, and Installation Guide</i></p>	<ul style="list-style-type: none"> <li>• Upgrading IBM Spectrum® Scale non-protocol Linux nodes</li> <li>• Upgrading IBM Spectrum Scale protocol nodes</li> <li>• Upgrading GPUDirect Storage</li> <li>• Upgrading AFM and AFM DR</li> <li>• Upgrading object packages</li> <li>• Upgrading SMB packages</li> <li>• Upgrading NFS packages</li> <li>• Upgrading call home</li> <li>• Manually upgrading the performance monitoring tool</li> <li>• Manually upgrading pmswift</li> <li>• Manually upgrading the IBM Spectrum Scale management GUI</li> <li>• Upgrading Cloud services</li> <li>• Upgrading to IBM Cloud Object Storage software level 3.7.2 and above</li> <li>• Upgrade paths and commands for file audit logging and clustered watch folder</li> <li>• Upgrading IBM Spectrum Scale components with the installation toolkit</li> <li>• Protocol authentication configuration changes during upgrade</li> <li>• Changing the IBM Spectrum Scale product edition</li> <li>• Completing the upgrade to a new level of IBM Spectrum Scale</li> <li>• Reverting to the previous level of IBM Spectrum Scale</li> </ul>	<p>System administrators, analysts, installers, planners, and programmers of IBM Spectrum Scale clusters who are very experienced with the operating systems on which each IBM Spectrum Scale cluster is based</p>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Concepts, Planning, and Installation Guide</i></p>	<ul style="list-style-type: none"> <li>• Coexistence considerations</li> <li>• Compatibility considerations</li> <li>• Considerations for IBM Spectrum Protect for Space Management</li> <li>• Applying maintenance to your IBM Spectrum Scale system</li> <li>• Guidance for upgrading the operating system on IBM Spectrum Scale nodes</li> <li>• Considerations for upgrading from an operating system not supported in IBM Spectrum Scale 5.1.x.x</li> <li>• Servicing IBM Spectrum Scale protocol nodes</li> <li>• Offline upgrade with complete cluster shutdown</li> </ul>	

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Administration Guide</i></p>	<p>This guide provides the following information:</p> <p><b>Configuring</b></p> <ul style="list-style-type: none"> <li>• Configuring the GPFS cluster</li> <li>• Configuring GPUDirect Storage for IBM Spectrum Scale</li> <li>• Configuring the CES and protocol configuration</li> <li>• Configuring and tuning your system for GPFS</li> <li>• Parameters for performance tuning and optimization</li> <li>• Ensuring high availability of the GUI service</li> <li>• Configuring and tuning your system for Cloud services</li> <li>• Configuring IBM Power Systems for IBM Spectrum Scale</li> <li>• Configuring file audit logging</li> <li>• Configuring clustered watch folder</li> <li>• Configuring Active File Management</li> <li>• Configuring AFM-based DR</li> <li>• Configuring AFM to cloud object storage</li> <li>• Tuning for Kernel NFS backend on AFM and AFM DR</li> <li>• Configuring call home</li> <li>• Integrating IBM Spectrum Scale Cinder driver with Red Hat OpenStack Platform 16.1</li> <li>• Configuring Multi-Rail over TCP (MROT)</li> </ul>	<p>System administrators or programmers of IBM Spectrum Scale systems</p>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Administration Guide</i></p>	<p><b>Administering</b></p> <ul style="list-style-type: none"> <li>• Performing GPFS administration tasks</li> <li>• Performing parallel copy with mmxcp command</li> <li>• Protecting file data: IBM Spectrum Scale safeguarded copy</li> <li>• Verifying network operation with the mmnetverify command</li> <li>• Managing file systems</li> <li>• File system format changes between versions of IBM Spectrum Scale</li> <li>• Managing disks</li> </ul>	<p>System administrators or programmers of IBM Spectrum Scale systems</p>



Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Administration Guide</i></p>	<ul style="list-style-type: none"> <li>• Managing protocol services</li> <li>• Managing protocol user authentication</li> <li>• Managing protocol data exports</li> <li>• Managing object storage</li> <li>• Managing GPFS quotas</li> <li>• Managing GUI users</li> <li>• Managing GPFS access control lists</li> <li>• Native NFS and GPFS</li> <li>• Accessing a remote GPFS file system</li> <li>• Information lifecycle management for IBM Spectrum Scale</li> <li>• Creating and maintaining snapshots of file systems</li> <li>• Creating and managing file clones</li> <li>• Scale Out Backup and Restore (SOBAR)</li> <li>• Data Mirroring and Replication</li> <li>• Implementing a clustered NFS environment on Linux</li> <li>• Implementing Cluster Export Services</li> <li>• Identity management on Windows / RFC 2307 Attributes</li> <li>• Protocols cluster disaster recovery</li> <li>• File Placement Optimizer</li> <li>• Encryption</li> <li>• Managing certificates to secure communications between GUI web server and web browsers</li> <li>• Securing protocol data</li> <li>• Cloud services: Transparent cloud tiering and Cloud data sharing</li> <li>• Managing file audit logging</li> <li>• RDMA tuning</li> <li>• Configuring Mellanox Memory Translation Table (MTT) for GPFS RDMA VERBS Operation</li> <li>• Administering AFM</li> <li>• Administering AFM DR</li> </ul>	<p>System administrators or programmers of IBM Spectrum Scale systems</p>

Table 1. IBM Spectrum Scale library information units (continued)

<b>Information unit</b>	<b>Type of information</b>	<b>Intended users</b>
<i>IBM Spectrum Scale: Administration Guide</i>	<ul style="list-style-type: none"><li>• Administering AFM to cloud object storage</li><li>• Highly available write cache (HAWC)</li><li>• Local read-only cache</li><li>• Miscellaneous advanced administration topics</li><li>• GUI limitations</li></ul>	System administrators or programmers of IBM Spectrum Scale systems

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Problem Determination Guide</i></p>	<p>This guide provides the following information:</p> <p><b>Monitoring</b></p> <ul style="list-style-type: none"> <li>• Monitoring system health by using IBM Spectrum Scale GUI</li> <li>• Monitoring system health by using the mmhealth command</li> <li>• Performance monitoring</li> <li>• Monitoring GPUDirect storage</li> <li>• Monitoring events through callbacks</li> <li>• Monitoring capacity through GUI</li> <li>• Monitoring AFM and AFM DR</li> <li>• Monitoring AFM to cloud object storage</li> <li>• GPFS SNMP support</li> <li>• Monitoring the IBM Spectrum Scale system by using call home</li> <li>• Monitoring remote cluster through GUI</li> <li>• Monitoring file audit logging</li> <li>• Monitoring clustered watch folder</li> <li>• Monitoring local read-only cache</li> </ul> <p><b>Troubleshooting</b></p> <ul style="list-style-type: none"> <li>• Best practices for troubleshooting</li> <li>• Understanding the system limitations</li> <li>• Collecting details of the issues</li> <li>• Managing deadlocks</li> <li>• Installation and configuration issues</li> <li>• Upgrade issues</li> <li>• CCR issues</li> <li>• Network issues</li> <li>• File system issues</li> <li>• Disk issues</li> <li>• GPUDirect Storage troubleshooting</li> <li>• Security issues</li> <li>• Protocol issues</li> <li>• Disaster recovery issues</li> <li>• Performance issues</li> </ul>	<p>System administrators of GPFS systems who are experienced with the subsystems used to manage disks and who are familiar with the concepts presented in the <i>IBM Spectrum Scale: Concepts, Planning, and Installation Guide</i></p>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<i>IBM Spectrum Scale: Problem Determination Guide</i>	<ul style="list-style-type: none"> <li>• GUI and monitoring issues</li> <li>• AFM issues</li> <li>• AFM DR issues</li> <li>• AFM to cloud object storage issues</li> <li>• Transparent cloud tiering issues</li> <li>• File audit logging issues</li> <li>• Troubleshooting mmwatch</li> <li>• Maintenance procedures</li> <li>• Recovery procedures</li> <li>• Support for troubleshooting</li> <li>• References</li> </ul>	

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Command and Programming Reference</i></p>	<p>This guide provides the following information:</p> <p><b>Command reference</b></p> <ul style="list-style-type: none"> <li>• gpfs.snap command</li> <li>• mmaddcallback command</li> <li>• mmadddisk command</li> <li>• mmaddnode command</li> <li>• mmadquery command</li> <li>• mmafmconfig command</li> <li>• mmafmcosaccess command</li> <li>• mmafmcosconfig command</li> <li>• mmafmcosctl command</li> <li>• mmafmcoskeys command</li> <li>• mmafmctl command</li> <li>• mmafmlocal command</li> <li>• mmapplypolicy command</li> <li>• mmaudit command</li> <li>• mmauth command</li> <li>• mmbackup command</li> <li>• mmbackupconfig command</li> <li>• mmbuildgpl command</li> <li>• mmcachectl command</li> <li>• mmcallhome command</li> <li>• mmces command</li> <li>• mmchattr command</li> <li>• mmchcluster command</li> <li>• mmchconfig command</li> <li>• mmchdisk command</li> <li>• mmcheckquota command</li> <li>• mmchfileset command</li> <li>• mmchfs command</li> <li>• mmchlicense command</li> <li>• mmchmgr command</li> <li>• mmchnode command</li> <li>• mmchnodeclass command</li> <li>• mmchnsd command</li> <li>• mmchpolicy command</li> <li>• mmchpool command</li> <li>• mmchqos command</li> <li>• mmclidecode command</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDSM standard</li> </ul>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Command and Programming Reference</i></p>	<ul style="list-style-type: none"> <li>• mmclone command</li> <li>• mmcloudgateway command</li> <li>• mmcrcluster command</li> <li>• mmcrfileset command</li> <li>• mmcrfs command</li> <li>• mmcrnodeclass command</li> <li>• mmcrnsd command</li> <li>• mmcrsnapshot command</li> <li>• mmdefedquota command</li> <li>• mmdefquotaoff command</li> <li>• mmdefquotaon command</li> <li>• mmdefragfs command</li> <li>• mmdelacl command</li> <li>• mmdelcallback command</li> <li>• mmdeldisk command</li> <li>• mmdelfileset command</li> <li>• mmdelfs command</li> <li>• mmdelnode command</li> <li>• mmdelnodeclass command</li> <li>• mmdelnsd command</li> <li>• mmdelsnapshot command</li> <li>• mmdf command</li> <li>• mmdiag command</li> <li>• mmdsh command</li> <li>• mmeditacl command</li> <li>• mmedquota command</li> <li>• mmexportfs command</li> <li>• mmfsck command</li> <li>• mmfsckx command</li> <li>• mmfsctl command</li> <li>• mmgetacl command</li> <li>• mmgetstate command</li> <li>• mmhadoopctl command</li> <li>• mmhdfs command</li> <li>• mmhealth command</li> <li>• mmimgbackup command</li> <li>• mmimgrestore command</li> <li>• mmimportfs command</li> <li>• mmkeyserv command</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDSM standard</li> </ul>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Command and Programming Reference</i></p>	<ul style="list-style-type: none"> <li>• mmlinkfileset command</li> <li>• mmlsattr command</li> <li>• mmlscallback command</li> <li>• mmlscluster command</li> <li>• mmlsconfig command</li> <li>• mmlsdisk command</li> <li>• mmlsfileset command</li> <li>• mmlsfs command</li> <li>• mmlslicense command</li> <li>• mmlsmgr command</li> <li>• mmlsmount command</li> <li>• mmlsnodeclass command</li> <li>• mmlsnsd command</li> <li>• mmlspolicy command</li> <li>• mmlspool command</li> <li>• mmlsqos command</li> <li>• mmlsquota command</li> <li>• mmlsnapshot command</li> <li>• mmmigratefs command</li> <li>• mmmount command</li> <li>• mmnetverify command</li> <li>• mmnfs command</li> <li>• mmnsddiscover command</li> <li>• mmobj command</li> <li>• mmperfmon command</li> <li>• mmpmon command</li> <li>• mmprotocoltrace command</li> <li>• mmpsnap command</li> <li>• mmputacl command</li> <li>• mmqos command</li> <li>• mmquotaoff command</li> <li>• mmquotaon command</li> <li>• mmreclaimspace command</li> <li>• mmremotefilesystem command</li> <li>• mmremotefs command</li> <li>• mmrepquota command</li> <li>• mmrestoreconfig command</li> <li>• mmrestorefs command</li> <li>• mmrestripefile command</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDSM standard</li> </ul>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Command and Programming Reference</i></p>	<ul style="list-style-type: none"> <li>• mmrestripefs command</li> <li>• mmrpldisk command</li> <li>• mmsdrrestore command</li> <li>• mmsetquota command</li> <li>• mmshutdown command</li> <li>• mmsmb command</li> <li>• mmsnapdir command</li> <li>• mmstartup command</li> <li>• mmtracectl command</li> <li>• mmumount command</li> <li>• mmunlinkfileset command</li> <li>• mmuserauth command</li> <li>• mmwatch command</li> <li>• mmwinservctl command</li> <li>• mmxcp command</li> <li>• spectrumscale command</li> </ul> <p><b>Programming reference</b></p> <ul style="list-style-type: none"> <li>• IBM Spectrum Scale Data Management API for GPFS information</li> <li>• GPFS programming interfaces</li> <li>• GPFS user exits</li> <li>• IBM Spectrum Scale management API endpoints</li> <li>• Considerations for GPFS applications</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDSM standard</li> </ul>



Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale: Big Data and Analytics Guide</i></p>	<p>This guide provides the following information:</p> <p>Summary of changes</p> <p>Big data and analytics support</p> <p>Hadoop Scale Storage Architecture</p> <ul style="list-style-type: none"> <li>• Elastic Storage Server</li> <li>• Erasure Code Edition</li> <li>• Share Storage (SAN-based storage)</li> <li>• File Placement Optimizer (FPO)</li> <li>• Deployment model</li> <li>• Additional supported storage features</li> </ul> <p>IBM Spectrum Scale support for Hadoop</p> <ul style="list-style-type: none"> <li>• HDFS transparency overview</li> <li>• Supported IBM Spectrum Scale storage modes</li> <li>• Hadoop cluster planning</li> <li>• CES HDFS</li> <li>• Non-CES HDFS</li> <li>• Security</li> <li>• Advanced features</li> <li>• Hadoop distribution support</li> <li>• Limitations and differences from native HDFS</li> <li>• Problem determination</li> </ul> <p>IBM Spectrum Scale Hadoop performance tuning guide</p> <ul style="list-style-type: none"> <li>• Overview</li> <li>• Performance overview</li> <li>• Hadoop Performance Planning over IBM Spectrum Scale</li> <li>• Performance guide</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDMS standard</li> </ul>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<i>IBM Spectrum Scale: Big Data and Analytics Guide</i>	Cloudera Data Platform (CDP) Private Cloud Base <ul style="list-style-type: none"> <li>• Overview</li> <li>• Planning</li> <li>• Installing</li> <li>• Configuring</li> <li>• Administering</li> <li>• Monitoring</li> <li>• Upgrading</li> <li>• Limitations</li> <li>• Problem determination</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDSE standard</li> </ul>
<i>IBM Spectrum Scale: Big Data and Analytics Guide</i>	Cloudera HDP 3.X <ul style="list-style-type: none"> <li>• Planning</li> <li>• Installation</li> <li>• Upgrading and uninstallation</li> <li>• Configuration</li> <li>• Administration</li> <li>• Limitations</li> <li>• Problem determination</li> </ul> Open Source Apache Hadoop <ul style="list-style-type: none"> <li>• Open Source Apache Hadoop without CES HDFS</li> <li>• Open Source Apache Hadoop with CES HDFS</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDSE standard</li> </ul>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
<p><i>IBM Spectrum Scale Erasure Code Edition Guide</i></p>	<p>IBM Spectrum Scale Erasure Code Edition</p> <ul style="list-style-type: none"> <li>• Summary of changes</li> <li>• Introduction to IBM Spectrum Scale Erasure Code Edition</li> <li>• Planning for IBM Spectrum Scale Erasure Code Edition</li> <li>• Installing IBM Spectrum Scale Erasure Code Edition</li> <li>• Uninstalling IBM Spectrum Scale Erasure Code Edition</li> <li>• Incorporating IBM Spectrum Scale Erasure Code Edition in an Elastic Storage Server (ESS) cluster</li> <li>• Creating an IBM Spectrum Scale Erasure Code Edition storage environment</li> <li>• Using IBM Spectrum Scale Erasure Code Edition for data mirroring and replication</li> <li>• Upgrading IBM Spectrum Scale Erasure Code Edition</li> <li>• Administering IBM Spectrum Scale Erasure Code Edition</li> <li>• Troubleshooting</li> <li>• IBM Spectrum Scale RAID Administration</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDSM standard</li> </ul>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
IBM Spectrum Scale Container Native Storage Access	<p>This guide provides the following information:</p> <ul style="list-style-type: none"> <li>• Overview</li> <li>• Planning</li> <li>• Installation prerequisites</li> <li>• Installing the IBM Spectrum Scale container native operator and cluster</li> <li>• Upgrading</li> <li>• Configuring IBM Spectrum Scale Container Storage Interface (CSI) driver</li> <li>• Using IBM Spectrum Scale GUI</li> <li>• Maintenance of a deployed cluster</li> <li>• Cleaning up the container native cluster</li> <li>• Monitoring</li> <li>• Troubleshooting</li> <li>• References</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDSM standard</li> </ul>
IBM Spectrum Scale Data Access Service	<p>This guide provides the following information:</p> <ul style="list-style-type: none"> <li>• Overview</li> <li>• Architecture</li> <li>• Security</li> <li>• Planning</li> <li>• Installing and configuring</li> <li>• Upgrading</li> <li>• Administering</li> <li>• Monitoring</li> <li>• Collecting data for support</li> <li>• Troubleshooting</li> <li>• The <b>mmdas</b> command</li> <li>• REST APIs</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XDSM standard</li> </ul>

Table 1. IBM Spectrum Scale library information units (continued)

Information unit	Type of information	Intended users
IBM Spectrum Scale Container Storage Interface Driver Guide	<p>This guide provides the following information:</p> <ul style="list-style-type: none"> <li>• Summary of changes</li> <li>• Introduction</li> <li>• Planning</li> <li>• Installation</li> <li>• Upgrading</li> <li>• Configurations</li> <li>• Using IBM Spectrum Scale Container Storage Interface Driver</li> <li>• Managing IBM Spectrum Scale when used with IBM Spectrum Scale Container Storage Interface driver</li> <li>• Cleanup</li> <li>• Limitations</li> <li>• Troubleshooting</li> </ul>	<ul style="list-style-type: none"> <li>• System administrators of IBM Spectrum Scale systems</li> <li>• Application programmers who are experienced with IBM Spectrum Scale systems and familiar with the terminology and concepts in the XD SM standard</li> </ul>

## Prerequisite and related information

For updates to this information, see [IBM Spectrum Scale in IBM Documentation](#).

For the latest support information, see the [IBM Spectrum Scale FAQ in IBM Documentation](#).

## Conventions used in this information

Table 2 on page xxix describes the typographic conventions used in this information. UNIX file name conventions are used throughout this information.

**Note: Users of IBM Spectrum Scale for Windows** must be aware that on Windows, UNIX-style file names need to be converted appropriately. For example, the GPFS cluster configuration data is stored in the `/var/mmfs/gen/mmsdrfs` file. On Windows, the UNIX namespace starts under the `%SystemDrive%\cygwin64` directory, so the GPFS cluster configuration data is stored in the `C:\cygwin64\var\mmfs\gen\mmsdrfs` file.

Table 2. Conventions

Convention	Usage
<b>bold</b>	<p>Bold words or characters represent system elements that you must use literally, such as commands, flags, values, and selected menu options.</p> <p>Depending on the context, <b>bold</b> typeface sometimes represents path names, directories, or file names.</p>
<b>bold underlined</b>	<b>bold underlined</b> keywords are defaults. These take effect if you do not specify a different keyword.

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Table 2. Conventions (continued)

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Convention	Usage
<b>constant width</b>	Examples and information that the system displays appear in constant-width typeface.  Depending on the context, constant-width typeface sometimes represents path names, directories, or file names.
<i>italic</i>	<i>Italic</i> words or characters represent variable values that you must supply.  <i>Italics</i> are also used for information unit titles, for the first use of a glossary term, and for general emphasis in text.
<b>&lt;key&gt;</b>	Angle brackets (less-than and greater-than) enclose the name of a key on the keyboard. For example, <Enter> refers to the key on your terminal or workstation that is labeled with the word <i>Enter</i> .
<b>\</b>	In command examples, a backslash indicates that the command or coding example continues on the next line. For example: <pre>mkcondition -r IBM.FileSystem -e "PercentTotUsed &gt; 90" \ -E "PercentTotUsed &lt; 85" -m p "FileSystem space used"</pre>
<b>{item}</b>	Braces enclose a list from which you must choose an item in format and syntax descriptions.
<b>[item]</b>	Brackets enclose optional items in format and syntax descriptions.
<b>&lt;Ctrl-x&gt;</b>	The notation <Ctrl-x> indicates a control character sequence. For example, <Ctrl-c> means that you hold down the control key while pressing <c>.
<b>item...</b>	Ellipses indicate that you can repeat the preceding item one or more times.
<b> </b>	In <i>synopsis</i> statements, vertical lines separate a list of choices. In other words, a vertical line means <i>Or</i> .  In the left margin of the document, vertical lines indicate technical changes to the information.

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**Note:** CLI options that accept a list of option values delimit with a comma and no space between values. As an example, to display the state on three nodes use `mmgetstate -N NodeA,NodeB,NodeC`. Exceptions to this syntax are listed specifically within the command.

## How to send your comments

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Your feedback is important in helping us to produce accurate, high-quality information. If you have any comments about this information or any other IBM Spectrum Scale documentation, send your comments to the following e-mail address:

`mhvrcfs@us.ibm.com`

Include the publication title and order number, and, if applicable, the specific location of the information about which you have comments (for example, a page number or a table number).

To contact the IBM Spectrum Scale development organization, send your comments to the following e-mail address:

`scale@us.ibm.com`

# Chapter 1. Overview

The overview of IBM Spectrum Scale container native includes the following topics:

- [“Introduction”](#) on page 1
- [“What's new?”](#) on page 1
- [“Supported features”](#) on page 2
- [“Limitations”](#) on page 3

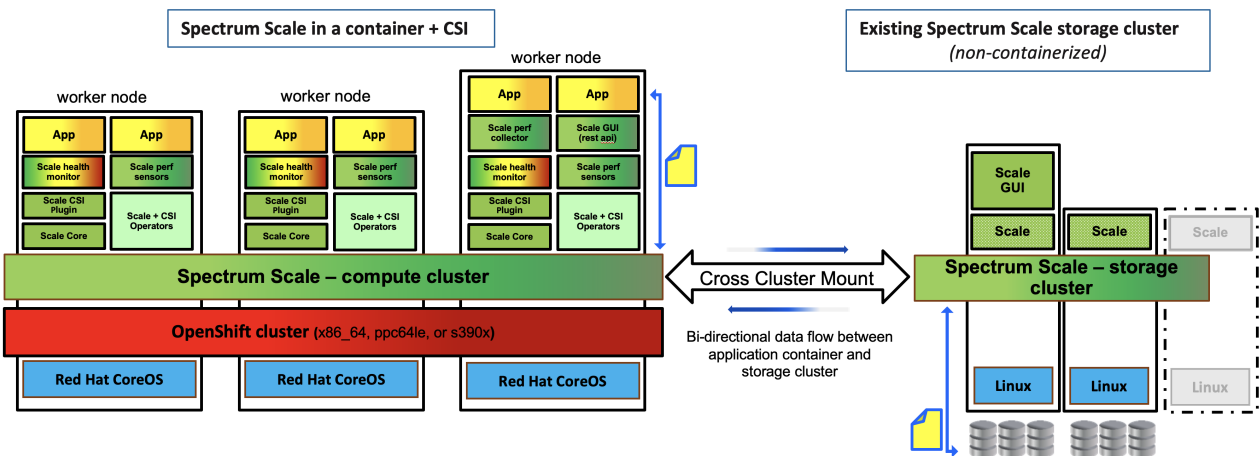
## Introduction

IBM Spectrum Scale container native is a containerized version of IBM Spectrum Scale.

IBM Spectrum Scale is a clustered file system that provides concurrent access to a single file system or set of file systems from multiple nodes. The nodes can be SAN attached, network attached, a mixture of SAN attached, and network attached, or in a shared-nothing cluster configuration. This enables high performance access to this common set of data to support a scale-out solution or to provide a high availability platform. For more information about IBM Spectrum Scale features, see [Product overview](#) in IBM Spectrum Scale documentation.

IBM Spectrum Scale container native allows the deployment of the cluster file system in a Red Hat OpenShift cluster. Using a remote mount attached file system, the container native deployment provides a persistent data store to be accessed by the applications through the IBM Spectrum Scale CSI driver by using Persistent Volumes (PVs). For more information, see [IBM Spectrum Scale Container Storage Interface Driver](#) in IBM Spectrum Scale CSI documentation.

Figure 1. Remote mount



For more information about direct storage attachment, see [“Deployment considerations”](#) on page 10.

## What's new?

The following enhancements are made in this release:

- Ability to upgrade IBM Spectrum Scale container native from 5.1.5.x to 5.1.6.0. For more information, see [Chapter 5, “Upgrading,”](#) on page 57.

**Note:** If upgrading from a version of IBM Spectrum Scale container native less than 5.1.5.0, it is required to first upgrade to IBM Spectrum Scale container native 5.1.5.0 before continuing to higher levels.

- Support for IBM Spectrum Scale Container Storage Interface (CSI) 2.8.0. For more information, see [What's New in IBM Spectrum Scale CSI documentation](#).
- Support for IBM Spectrum Scale Data Access Services (DAS) 5.1.6. For more information, see *Release Notes* in DAS documentation.
- Support for Red Hat OpenShift Infrastructure nodes. For more information, see [Infrastructure nodes](#).
- Ability to update quorum node assignments. For more information, see [“Manual” on page 32](#).

**Note:** If the storage cluster is running a GUI high availability configuration, for example, having 2 or more GUI nodes installed, ensure the storage cluster is running IBM Spectrum Scale 5.1.6.1 or higher prior to use with IBM Spectrum Scale container native and IBM Spectrum Scale CSI.

## Supported features

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IBM Spectrum Scale container native with Red Hat OpenShift Container Platform supports the following features:

- IBM Spectrum Scale node labels to establish node affinity
- Automated client-only cluster creation
- Automated remote file system mount for IBM Spectrum Scale Storage cluster
- Integrated IBM Spectrum Scale Container Storage Interface (CSI) driver for application persistent storage
- Automated deployment of IBM Spectrum Scale Container Storage Interface (CSI) driver
- IBM Spectrum Scale container native client cluster node expansion on Red Hat OpenShift Container Platform
- Cluster monitoring by using Red Hat OpenShift Container Platform Liveness and Readiness probe
- Call home
- Performance data collection
- Storage cluster encryption
- Rolling upgrade
- Automated IBM Spectrum Scale performance monitoring bridge for Grafana
- File audit logging (FAL)
- Compression
- Quotas on the storage cluster
- ACLs on the storage cluster
- ILM support on the storage cluster
- File clones on the storage cluster
- Snapshots on the storage cluster
- TCP/IP network connectivity among cluster nodes
- Direct storage attachment on s390x, x86, and power servers
- Automatic quorum selection is Kubernetes topology aware

IBM Spectrum Scale Data Access Services (DAS) supports the following features:

- S3 object access for Artificial Intelligence and analytics workloads
- Up to 10 TB single object size
- Up to 100 locally managed S3 accounts
- Up to 500 S3 buckets
- Up to 1,000,000 objects per S3 bucket



- Each IBM Spectrum Scale DAS cluster can be attached to one IBM Spectrum Scale storage cluster and to one IBM Spectrum Scale file system only.
- Each IBM Spectrum Scale storage cluster can be attached to one IBM Spectrum Scale DAS cluster only.

For more information, see *IBM Spectrum Scale Data Access Services*.

## Limitations

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- IBM Spectrum Scale container native currently supports only remote mount of the file system. It does not support local disks and NSD nodes.
- Deployment of IBM Spectrum Scale pods on master nodes is not supported with the exception of compact OpenShift clusters.
- Deployment of IBM Spectrum Scale pods on RHEL worker nodes is not supported.
- Deployment of IBM Spectrum Scale pods on nodes with ARM CPUs is not supported.
- Single node OpenShift clusters are not supported.

### Scalability constraints

<i>Table 3. Maximum Capacity Specification</i>	
<b>Description</b>	<b>Max Supported</b>
Number of worker nodes	128
Number of remote clusters	4
Number of remote file systems	16



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## Chapter 2. Planning

The planning for IBM Spectrum Scale container native includes the following topics:

- [Prerequisites](#)
- [Hardware requirements](#)
- [Software requirements](#)
- [Deployment considerations](#)
  - [“Container Network Interface \(CNI\) configuration” on page 13](#)
- [Container image list for IBM Spectrum Scale container native](#)
- [Roles and personas](#)

### Prerequisites

---

The planning process to install IBM Spectrum Scale on Red Hat OpenShift consists of many steps.

These steps are built on top of each other, so it is critical to follow the sequence defined in the following sections. Before you begin installation, there are several things that need to be considered. The list of questions provided helps you to be prepared for the procedure.

- What version of Red Hat OpenShift Container Platform do you need?
- What are the hardware requirements?
- Have the necessary ports been opened?
- Is the Red Hat OpenShift Container Platform cluster in a restricted network environment?
- What is the minimum level of IBM Spectrum Scale that is needed on the storage cluster?

### Preparations for deploying the IBM Spectrum Scale container native cluster

The following section summarizes the prerequisites required before deploying the IBM Spectrum Scale container native cluster:

- Validate that the OpenShift cluster, or the node from where you are managing the OpenShift cluster, has access to the manifest files in IBM Spectrum Scale container native repository of GitHub.

For more information, see [IBM Spectrum Scale container native repository](#) on GitHub.

**Note:** GitHub YAML manifests are inline with the Installation steps and are either accessed directly or pulled through `curl` through an existing internet connection. If an air gapped environment is running, the manifest files must be made locally available for use.

- Validate and apply the configuration to the Red Hat OpenShift installation settings.
- Obtain IBM Cloud Container Registry entitlement key to access the container images of IBM Spectrum Scale container native.
- If you are in a restricted network environment, then mirror the container images of IBM Spectrum Scale container native into a site-managed private image registry.
- Create an OpenShift global pull secret for the image registry that the cluster uses (either IBM Cloud Container Registry or private image registry).

### Deploying the IBM Spectrum Scale container native cluster

To deploy a cluster, complete the following steps:

1. Create the IBM Spectrum Scale container native and IBM Spectrum Scale CSI operators by deploying the operator installer file.

2. Download the sample YAML file from the [GitHub repository](#).  
**Note:** The `scale_v1beta1_cluster_cr.yaml` sample file is a collection of multiple custom resources and kinds.
  - a. Configure the Cluster custom resource that is used for deployment of the Operator.
    - i. Specify the IBM Spectrum Scale Edition in the license field.
    - ii. Configure appropriate node selectors for the IBM Spectrum Scale container native deployment.
    - iii. Configure host aliases or ensure that the proper DNS is configured for your environment to allow for communication to storage cluster.
    - iv. Configure Ephemeral Port Range, if necessary.
    - v. Enable the optional Grafana Bridge.
  - b. Configure the Callhome custom resource.
  - c. Configure the Filesystem custom resource.
    - i. Define the RemoteCluster resource.
    - ii. Define the file system on the RemoteCluster to mount.
  - d. Configure the RemoteCluster custom resource.
    - i. Populate the details of the storage cluster GUI.
3. Create an IBM Spectrum Scale container native cluster by deploying the configured `scale_v1beta1_cluster_cr.yaml` file.
4. If accessing encrypted data on the storage cluster, download and configure the `EncryptionConfig` custom resource YAML file from the [GitHub repository](#).
5. Complete the storage cluster configuration.
  - a. Create a GUI user on the storage cluster with the `ContainerOperator` role.
  - b. Create a GUI user on the storage cluster with the `CsiAdmin` role.
  - c. Configure CSI prerequisites on storage cluster.
6. Create a secret by using the storage cluster GUI user credentials for the `ContainerOperator` GUI user in the `ibm-spectrum-scale` namespace.
7. Create a secret by using the storage cluster GUI user credentials for `CsiAdmin` GUI user in the `ibm-spectrum-scale-csi` namespace.
8. Create a storage class to create volumes to use with your container native cluster.

## Hardware requirements

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**Note:** IBM Spectrum Scale container native 5.1.6 supports only on-premises environments (customer infrastructure) and does not support cloud environments.

### Network

- All nodes in a compute cluster must be able to communicate with all nodes in a storage cluster.
- A minimum of 10 Gb network is needed but 40 - 100 Gb is recommended.
- RDMA for InfiniBand or RoCE for Ethernet is not supported.

### Worker node requirements

IBM Spectrum Scale takes at least 2 GiB per node. Therefore, 8 GiB or more total memory is recommended for worker nodes.

IBM Spectrum Scale container native supports x86, ppc64le, and s390 CPU architectures. All nodes in the OpenShift cluster must have the same architecture. The ARM architecture is not supported.

IBM Spectrum Scale container native deploys several pods in the cluster. The following table shows the resource consumption of those pods.

*Table 4. Hardware requirements*

Pods	Where deployed	CPU request	Memory request	Storage	Description
core fs	Default all workers	>=1000mCPU, default 25%	>=2GiB, default 25%	Config in /var (~25GiB)	This is the pod that provides the filesystem service for the node. It is required to be deployed on all nodes where PVs are accessed from application pods. The CPU and memory requests can be customized in the cluster CR.
operator	Single node	100mCPU	40MiB	-	The controller runtime that manages all custom resources.
GUI	Two nodes	630mCPU	1.25GiB	Local PV for DB	The graphical user interface and ReST API.
pmcollector	Two nodes	120 mCPU	3-7GiB depending on cluster size	Local PV for DB	The performance collector database.
grafana-bridge	One node	100mCPU	1GiB	-	The bridge for accessing pmcollector from grafana.

**Note:** The shown values are requests. For more information, see [Kubernetes resource management](#) in Kubernetes documentation. The limits are higher. This means that for CPU the pods might have bursts with more CPU usage at times where the CPU has free cycles. For memory the pods should not exceed their request significantly.

By default the core fs pods take 25% of the worker node capacity. This might be oversized in many applications. For more information about configuring the requests for both CPU and memory, see [Cluster Custom Resource](#).

- Allocating more resources to IBM Spectrum Scale will result in better storage performance.
- Allocating less will allow more applications to be scheduled on a node.

For CPU, allocation can be reduced if the core fs pods consistently stay below the request. This can be monitored on the OpenShift console. When going too low, the filesystem daemon might starve on

CPU cycles which destabilizes the whole cluster and can result in outages. For memory there is no real monitoring, allocating more will result in more data being cached which can boost performance. But this will be only seen indirectly by observing application performance.

**Note:** The CPU request can be dialed down below the 1000mCPU minimum. Your system might run just fine with, for example, 100mCPU. But, if a service ticket is opened for an issue that might be in any way related to this setting you will be asked to go up to 1000mCPU. The ticket is accepted only if the problem keeps showing up. Examples for related issues are, node expells, lag on PV creation in CSI, slow policy runs, bad performance, long waiters, etc.

The OpenShift console will report all worker nodes as overcommitted. The reason is that the CPU and memory limits of the pods add up to more than the total capacity of the node. Pods are scheduled based on their requests and the scheduler ensures that nodes will not be overcommitted in this regard. Higher limits allow pods to use resources that are free at the moment, but only the requested resources are guaranteed to them by Kubernetes. For more information about pods scheduling, see [Kubernetes resource management](#).

This list does not include pods of the CSI driver which come on top of this. For more information, see [IBM Spectrum Scale CSI documentation](#).

## Software requirements

Use the following table to determine the software requirement levels for each release:

IBM Spectrum Scale container native	IBM Spectrum Scale Container Storage Interface	Architecture	IBM Spectrum Scale remote storage cluster level	File system version cannot be newer than	OpenShift Container Platform level	Red Hat CoreOS	UBI level
5.1.6.0	2.8.0	x86,ppc64le,x390x	5.1.3.0+	30.00	4.9, 4.10, 4.11	4.9, 4.10, 4.11	8.7
5.1.5.0	2.7.0	x86,ppc64le,x390x	5.1.3.0+	29.00	4.9, 4.10, 4.11	4.9, 4.10, 4.11	8.6
5.1.4.0	2.6.0	x86,ppc64le,x390x	5.1.3.0+	28.00	4.8, 4.9, 4.10	4.8, 4.9, 4.10	8.6
5.1.3.0	2.5.0	x86,ppc64le,x390x	5.1.3.0+	27.00	4.8, 4.9, 4.10	4.8, 4.9, 4.10	8.5
5.1.2.1	2.4.0	x86,ppc64le,x390x	5.1.2.1+	26.00	4.8, 4.9	4.8, 4.9	8.5
5.1.1.4	2.3.1	x86,ppc64le,s390x	5.1.1.4+	25.00	4.8	4.8	8.4

**Note:** For more information about the minimum levels required for specific CSI functions, see *Hardware and software requirements* in IBM Spectrum Scale CSI documentation.

**Note:**

The storage cluster is supported to be down-level from the IBM Spectrum Scale container native cluster, but it is ideal that the versions match. CSI functionality is highly dependent upon the IBM Spectrum Scale release, filesystem level, and version, installed on the storage cluster. If the storage cluster is running an earlier version, some functionality may not be available. For more information about CSI features and required levels, see *Table 1 in Hardware and Software Requirements* in IBM Spectrum Scale CSI documentation. For more information about compatibility and software matrix, see [Section 17.3](#) in IBM Spectrum Scale FAQ documentation.

## IBM Spectrum Scale Container Storage Interface (CSI)

- CSI 2.8.0 is installed in conjunction with IBM Spectrum Scale container native 5.1.6.0.

### Storage cluster

- The storage cluster must be at IBM Spectrum Scale 5.1.1.2 or later.
- To take advantage of all functions provided by IBM Spectrum Scale Container Storage Interface Driver (CSI) 2.8, the storage cluster must be at IBM Spectrum Scale 5.1.6.0 or later and the file system must be at file system format level 30.00. For earlier levels restrictions may apply. For more information, see *Hardware and software requirements* in IBM Spectrum Scale CSI documentation.

For more information, see [Upgrading multi-cluster environments](#) in IBM Spectrum Scale documentation.

- Determine if the storage cluster is running a GUI high availability configuration, for example, having 2 or more GUI nodes installed.

On the storage cluster, issue the following command. If two or more GUI nodes are displayed, then the storage cluster is running a GUI high availability configuration.

```
/usr/lpp/mmfs/gui/cli/lsnode
```

**Note:** If the storage cluster is running a GUI high availability configuration, ensure the storage cluster is running IBM Spectrum Scale 5.1.6.1 or higher prior to use with IBM Spectrum Scale container native and IBM Spectrum Scale CSI.

For more information, see [Ensuring high availability of the GUI service](#) in IBM Spectrum Scale documentation.

- Enable the `--auto-inode-limit` parameter on the remotely mounted file system.

For more information about `auto-inode-limit` parameter, see [mmchfs command](#) in IBM Spectrum Scale documentation.

**Note:** The `--auto-inode-limit` option is available only with file system format level 28.00 or later.

- Encrypted file systems are supported. Configure the EncryptionConfig custom resource with the necessary key client and key server information. For more information, see [EncryptionConfig](#).

### External container images

There are some external container images that are required to run IBM Spectrum Scale container native. If running in an air gap environment, these images are required for successful deployment. For more information, see [Container image list for IBM Spectrum Scale container native](#).

### Auxiliary helper applications

- `curl` is used to retrieve some files required for the IBM Spectrum Scale container native installation.
- `jq 1.5+` is used to help parse and format json output.

## Deployment considerations

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Before deployment, ensure that you are aware of the Red Hat OpenShift version, cluster network, persistent storage, and the IBM Spectrum Scale storage cluster considerations.

### Red Hat OpenShift cluster considerations

The following list includes the Red Hat OpenShift cluster considerations:

- A minimum configuration of three master nodes and three worker nodes, with a maximum of 128 worker nodes is required.
- Deploying IBM Spectrum Scale pods on master nodes is not supported. An exception is when deploying in a compact cluster configuration. For more information, see [Compact Cluster Support](#).
- Single node OpenShift clusters are not supported. The recommendation is to access data on a IBM Spectrum Scale storage cluster through NFS.
- Red Hat Enterprise Linux CoreOS (RHCOS) restricts new file system mounts to the /mnt subtree. IBM Spectrum Scale can mount any file system under /mnt on the Red Hat OpenShift cluster regardless of the default mount point that is defined on the storage cluster.

### Red Hat OpenShift cluster network considerations

IBM Spectrum Scale container native comes with a collection of different pods. A subset of these pods can be considered regular pods that behave like typical application pods. Those pods are the operator, the GUI pods, and the performance data collector pods. The exception is what we refer to as the core pods as they provide the actual filesystem services. The core pods are not controlled by the Kubernetes scheduler through a regular DaemonSet. Instead, the IBM Spectrum Scale container native operator handles the management of those pods.

- The filesystem daemon running inside the core pods requires a static IP address for communication between daemons on different nodes.
- All core pods must be able to communicate with each other through the chosen network.

There are two network configurations that can be employed: host network or Container Network Interface (CNI) network. Only one network configuration can be chosen.

### Host network

By default, the IBM Spectrum Scale pods use the host network. While this is the simplest configuration, it has some disadvantages:

- Using the host network breaks the network isolation that usually comes with containers. For example, any network port opened by IBM Spectrum Scale may conflict with a network port opened by another component on the host.
- Security features, like network policies, are not available for the host network.
- If the node has multiple network adapters, there is no way to select the adapter. Host network will always use the network adapter the worker node IP is assigned to.

### Container Network Interface (CNI) network

As an alternative to host network, IBM Spectrum Scale can use a CNI network. There is more configuration effort to set up the CNI:

- In this configuration, core pods will have an IP address on the usual OpenShift SDN and another one on the CNI network.
  - OpenShift SDN will be used for communication with other pods.
  - CNI network will be used for communication between filesystem daemons, both inter-cluster and with the storage cluster.



- If the node is equipped with high speed network, the CNI should be attached to that.
  - This will be the daemon network where the filesystem I/O runs on. High bandwidth and low latency are highly beneficial for performance.
- The CNI network will be used exclusively by IBM Spectrum Scale and eliminates the potential for port conflicts with other components.
- Security features like network policies work on MACVLAN CNIs.
- The DNS must be configured properly to allow the worker nodes the ability to resolve the storage cluster nodes.
  - For more information, see [Host aliases](#).

**Note:** Advanced features of SR-IOV type CNIs, such as RDMA and GPUdirect, are not yet supported.

For more information about configuring CNI with IBM Spectrum Scale container native, see [Container network interface \(CNI\) configuration](#).

## Red Hat OpenShift cluster persistent storage considerations

The following list includes the Red Hat OpenShift cluster persistent storage considerations:

- The IBM Spectrum Scale pods use host path mounts to store IBM Spectrum Scale cluster metadata and various logs.
- The IBM Spectrum Scale container native operator creates two local PersistentVolumes (PVs) on two eligible worker nodes. At least 25 GB free space must be available in the file system that contains the `/var` directory on all eligible worker nodes to avoid potential failures during the deployment. These PVs are created with the ReadWriteOnce (RWO) access mode.
- Both the host path mounts and local PVs are not automatically cleaned up when you delete the associated IBM Spectrum Scale container native cluster. You must manually clean these up. For more information about cleaning up the persistent storage, see [Cleaning up the worker nodes](#) and [Cleaning up IBM Spectrum Scale operator](#).
- IBM Spectrum Scale container native does not support the use of dynamically created or pre-created PVs.

## Enterprise grade image registry considerations

The following list includes the considerations for enterprise grade image registry:

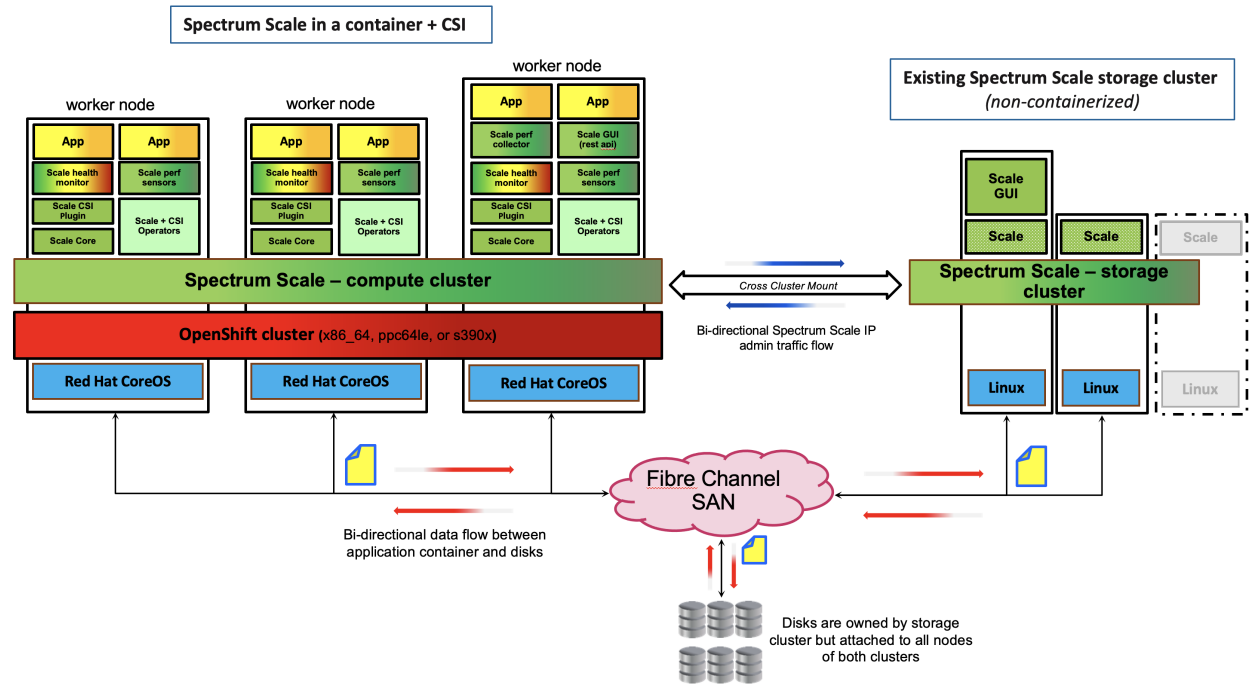
- In a restricted network environment where the Red Hat OpenShift Container Platform cluster cannot pull IBM Spectrum Scale images from the IBM Container Repository, images must be mirrored to a production grade enterprise image registry that the Red Hat OpenShift Container Platform cluster can access.
- In a restricted network environment, there must be a node that can communicate externally and also with the target Red Hat OpenShift Container Platform cluster.
- Any registry that is used for hosting the container images of IBM Spectrum Scale container native must not be accessible to external users. Also, it must be restricted to the service account used for IBM Spectrum Scale container native management. All users and machines that are accessing these container images must be authorized per IBM Spectrum Scale license agreement.

## Direct storage attachment considerations

The following list includes the considerations for direct storage attachment:

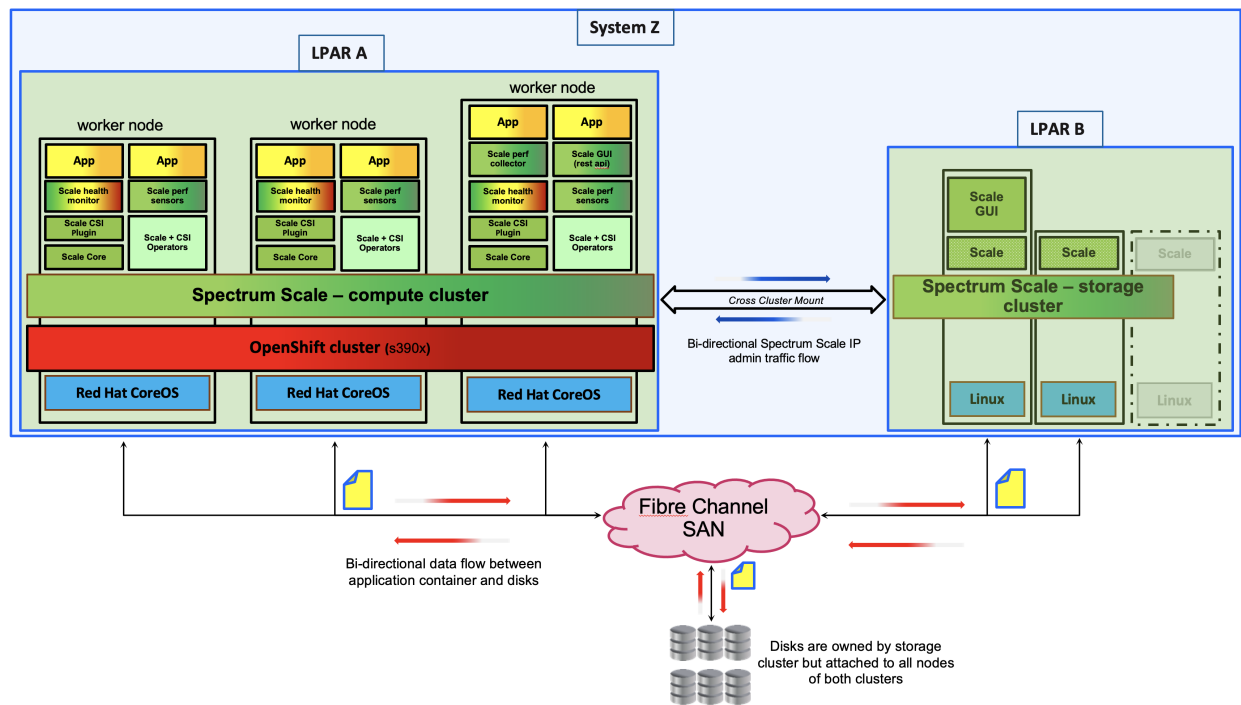
- Support for direct storage attachment on x86, power, and Z servers. In direct storage attachment configuration, the worker nodes use the SAN fabric instead of the IBM Spectrum Scale NSD protocol for I/O traffic.
- If using Power or x86 servers, it might be necessary to load multi-path drivers through Red Hat CoreOS before storage can be seen.

Figure 2. Direct attach config



- The virtualization layers of an IBM Z server allow the physical connection of the disks containing the IBM Spectrum Scale file system data to both the storage cluster and the IBM Spectrum Scale container native cluster.
- For more information about setting up a direct storage attachment, see [Attaching direct storage on IBM Z in IBM Spectrum Scale documentation](#).

Figure 3. Direct attach SystemZ



## Container Network Interface (CNI) configuration

This section describes the optional configuration of a Container Network Interface (CNI) for use with IBM Spectrum Scale container native.

### Networks - admin and daemon

IBM Spectrum Scale allows for the specification of two networks, `admin` and `daemon`. The `admin` network is used for monitoring and management while the `daemon` network is used for filesystem I/O. In the container native solution, the `admin` network uses the default pod network. The `daemon` network uses the CNI network.

### How to configure CNI

Complete the following steps:

1. To configure OpenShift for CNI, refer steps on Red Hat website.

For more information, see [Adding CNI networks](#) in Red Hat OpenShift documentation.

#### Considerations

- If the node has only a single physical network attachment, then the network adapter needs to be shared between networks. There are several CNI flavors that allow this: Bridge, IPVLAN, and MACVLAN.
  - The MACVLAN CNI supports also network policies and should be the default choice.
- If the node has multiple physical network attachments and you want to dedicate one of the physical networks to IBM Spectrum Scale, select `host-adapter` CNI. It will map a physical network adapter into a pod, making it inaccessible to the host and other pods.
- SR-IOV surpasses the capabilities of `host-adapter`. For more information, see [About Single Root I/O Virtualization \(SR-IOV\) hardware networks](#) in Red Hat OpenShift documentation. Advanced features like RDMA, GPUdirect, and bonding of network ports are accessible via SR-IOV hardware network.

**Note:** The features RDMA, GPUdirect, and bonding of network ports are not currently supported by IBM Spectrum Scale. Also SR-IOV allows to partition the hardware adapter and hand those partitions to different pods. Configuration is more complex compared to other CNIs and choice of supported network adapters is limited. As of today, IBM Spectrum Scale is not tested with SR-IOV.

- The IP address mapping is required to be static. This can be achieved by setting up static IPs or by configuring DHCP static mapping. For remote mount of a filesystem from a IBM Spectrum Scale storage cluster, this network must be routed to the storage cluster's daemon network.
2. Configure each of the OpenShift nodes that comprise the IBM Spectrum Scale CNSA cluster:
    - a. Create runtime configuration node annotation that has the CNI definition. The specific node annotations for IBM Spectrum Scale is `scale.spectrum.ibm.com/daemon-network`. The format of the CNI annotation value is formed in the same format of a single network as defined in the format specified by `k8s.v1.cni.cncf.io/networks`.

Example:

```
annotations:
scale.spectrum.ibm.com/daemon-network: |-
  {
    "name": "daemon-network",
    "mac": "22:22:0a:11:37:b2",
    "ips": [
      "10.17.99.63"
    ]
  }
```

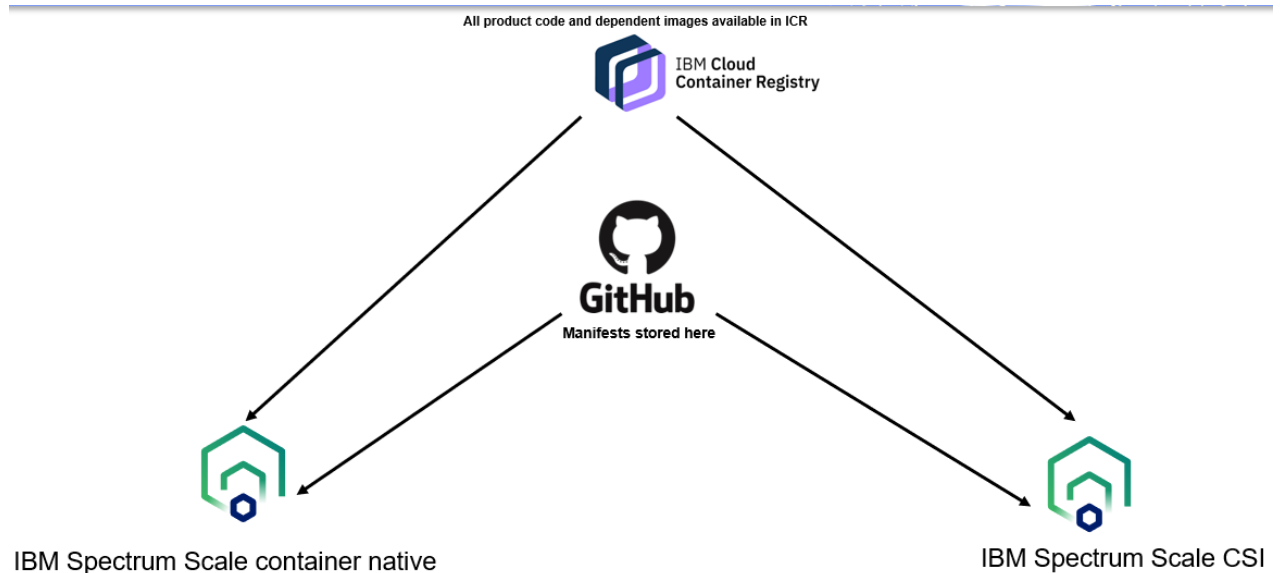
- b. `ips` field must be set as this is the static IP desired for this CNI network.

c. mac field may be set if you use DHCP ipam (backed by a statically mapped DHCP). ips still must be set in addition to mac.

**Note:** This might seem redundant, but IBM Spectrum Scale container native uses ips to set up its own name resolution. This process is asynchronous and independent of the pod actually being created. If ips was not set, then DHCP address would not be discovered until after pod creation.

## Container images

The container images are required for the successful deployment of IBM Spectrum Scale container native. All images required for the deployment of IBM Spectrum Scale container native cluster are sourced from the IBM Container Repository.



**Note:** It is recommended to use the latest fixpack release available.

Figure 4. Dependent images available in ICR

- [“Container image list for IBM Spectrum Scale container native 5.1.6.0” on page 14](#)

## Container image list for IBM Spectrum Scale container native 5.1.6.0

### IBM Spectrum Scale images acquired from non-entitled IBM Container Repository

The images listed in the following table are the container images that are obtained through the IBM Container Repository that do not require entitlement. These images can be anonymously pulled.

Table 6. Images acquired from non-entitled IBM Container Repository

Pod	Container	Repository	Image
ibm-spectrum-scale-controller-manager-XXXXXXXX-XXXXX	manager	icr.io/cpopen/	ibm-spectrum-scale-operator@sha256: fcc14fae885ca862b9ed8a61544dcea3c7b8f3a9d4d691539375bc6d20016370
ibm-spectrum-scale-csi-operator	operator	icr.io/cpopen/	ibm-spectrum-scale-csi-operator@sha256:355a4bfc89a96b81664ec915b63ed02d5a35d49a9c8386d9c09567f33765004e

Table 6. Images acquired from non-entitled IBM Container Repository (continued)

Pod	Container	Repository	Image
must-gather-XXXXX	must-gather	icr.io/cpopen/	ibm-spectrum-scale-must-gather@sha256: 8425d50ec11c21e26b66687640b4923885fbb13f98e2c0 a381e2687a92f1404b

### IBM Spectrum Scale images acquired from entitled IBM Container Repository

The images listed in the following table are the container images that are obtained through entitlement to the IBM Container Repository:

Table 7. Images acquired from entitled IBM Container Repository

Pod	Container	Repository	Image
<sup>1</sup> workerX/ masterX	mmbuildgpl	cp.icr.io/cp/ spectrum/scale	ibm-spectrum-scale-core-init@sha256: aa9ef7003fcf9de12d3992aa03bf8d5550a51efb3a8d a4ab4f765560dddae44f
<sup>1</sup> workerX/ masterX	config	cp.icr.io/cp/ spectrum/scale	ibm-spectrum-scale-core-init@sha256: aa9ef7003fcf9de12d3992aa03bf8d5550a51efb3a8d a4ab4f765560dddae44f
<sup>1</sup> workerX/ masterX	gpfs (if using Data Access Edition)	cp.icr.io/cp/ spectrum/scale/ data-access	ibm-spectrum-scale-daemon@sha256: 00e74a5bb47a45a1c10c79e707e4cc1a229714161b 9be5efd8dd7c1dfbdc5f2e
<sup>1</sup> workerX/ masterX	gpfs (if using Data Management Edition)	cp.icr.io/cp/ spectrum/scale/ data-management	ibm-spectrum-scale-daemon@sha256: 4d71421059336c1942ed2658979d4f247b0509ffd2 e78a84c8e598906e5f40f1
<sup>1</sup> workerX/ masterX	logs	cp.icr.io/cp/ spectrum/scale	ubi-minimal@sha256: 4ed971a5564d2cfedf750793da53ef6f1fdf295263f1c c31d703aa8acf6d02cf
ibm- spectrum- scale-gui-X	liberty	cp.icr.io/cp/ spectrum/scale	ibm-spectrum-scale-gui@sha256: 2326bda1c4fa4fc1bace680605adc3a4a2e27ecc0c6 975aea5c1159f9c757cb
ibm- spectrum- scale-gui-X	sysmon	cp.icr.io/cp/ spectrum/scale	ibm-spectrum-scale-monitor@sha256: cbf07926122956d71f98a76c9c43b3322504f46cc23 99c75c355c667d7035849
ibm- spectrum- scale-gui-X	postgres	cp.icr.io/cp/ spectrum/scale	postgres@sha256: 135c62a8134dcef829a1e4f5568bfae44bcfa2c75659 ff948f43c71964366aa4
ibm- spectrum- scale-gui-X	logs	cp.icr.io/cp/ spectrum/scale	ubi-minimal@sha256: 4ed971a5564d2cfedf750793da53ef6f1fdf295263f1c c31d703aa8acf6d02cf
ibm- spectrum- scale- pmcollector-X	pmcollector	cp.icr.io/cp/ spectrum/scale	ibm-spectrum-scale-pmcollector@sha256: 4ab246283998575bc7675cd0aab04dbd50feb15d3f 1937ea4c484b97a03dd960

Table 7. Images acquired from entitled IBM Container Repository (continued)

Pod	Container	Repository	Image
ibm-spectrum-scale-pmcollector-X	sysmon	cp.icr.io/cp/spectrum/scale	ibm-spectrum-scale-monitor@sha256: cbf07926122956d71f98a76c9c43b3322504f46cc23 99c75c355c667d7035849
ibm-spectrum-scale-csi-snapshotter	csi-snapshotter	cp.icr.io/cp/spectrum/scale/csi	csi-snapshotter@sha256: 291334908ddf71a4661fd7f6d9d97274de8a5378a2 b6dfdeb2ce73414a34f82f
ibm-spectrum-scale-csi-attacher	ibm-spectrum-scale-csi-attacher	cp.icr.io/cp/spectrum/scale/csi	csi-attacher@sha256: 9a685020911e2725ad019dbce6e4a5ab93d51e3d4 557f115e64343345e05781b
ibm-spectrum-scale-csi-provisioner	csi-provisioner	cp.icr.io/cp/spectrum/scale/csi	csi-provisioner@sha256: ee3b525d5b89db99da3b8eb521d9cd90cb6e9ef0fbb 651e98bb37be78d36b5b8
ibm-spectrum-scale-csi-driver-XXXXX	liveness-probe	cp.icr.io/cp/spectrum/scale/csi	livenessprobe@sha256: cacee2b5c36dd59d4c7e8469c05c9e4ef53ecb2df90 25fa8c10cdaf61bce62f0
ibm-spectrum-scale-csi-driver-XXXXX	driver-registrar	cp.icr.io/cp/spectrum/scale/csi	csi-node-driver-registrar@sha256: 0103eee7c35e3e0b5cd8cdca9850dc71c793cdeb66 69d8be7a89440da2d06ae4
ibm-spectrum-scale-csi-resizer-X	ibm-spectrum-scale-csi-resizer	cp.icr.io/cp/spectrum/scale/csi	csi-resizer@sha256: 425d8f1b769398127767b06ed97ce62578a3179bcb 99809ce93a1649e025ffe7
ibm-spectrum-scale-csi-driver-XXXXX	ibm-spectrum-scale-csi	cp.icr.io/cp/spectrum/scale/csi	ibm-spectrum-scale-csi-driver@sha256: 86e0138bec8189eefb1eb6cc90885e930a333444c1 077ca75df33266efc83f86
ibm-spectrum-scale-grafana-bridge-X	grafanabridge	cp.icr.io/cp/spectrum/scale	ibm-spectrum-scale-grafana-bridge@sha256: 18c60c34efb839d96b71804d9f2f537599cb3347c0b 3937301cbf4df40abc85a
coredns-XXXXX	coredns	cp.icr.io/cp/spectrum/scale	ibm-spectrum-scale-coredns@sha256: 3b082240155e5666c5414fb1f768442c89f5fe1ddcd 0a9157ccbe0ff94228031

<sup>1</sup> Pod names that contain the mmbuildgpl, config, and gpfs containers may vary. The pod name is based on the shortname of the node it was scheduled to.

**Note:**

No user action is required to obtain or define this list of images when in a non-airgapped environment. There are instructions to mirror the list of images in an air gap environment. For more information, see [Air gap setup for network restricted Red Hat OpenShift Container Platform clusters](#).

## Roles and personas

Different roles, cluster roles, and levels of access are needed to deploy a fully functioning IBM Spectrum Scale container native cluster.

### Persona

Red Hat OpenShift Cluster administrator must deploy the IBM Spectrum Scale container native cluster.

### Operator permissions

The IBM Spectrum Scale container native operator is a namespace-scoped operator. The operator watches the namespace that it is deployed into. As part of the operator installation, you can deploy various role-based access control (RBAC) related YAML files that control the operator's access to resources within the namespace it is watching. While the operator is running with a namespace scope, it requires access to cluster level resources to successfully deploy. Access to cluster level resources is handled through a cluster role that is deployed during the deployment of RBAC YAML files. The role and cluster role are bound to the custom `ibm-spectrum-scale-operator` ServiceAccount, which the operator uses to create the IBM Spectrum Scale container native cluster.

### ibm-spectrum-scale-operator role

Resources	Verbs	API Groups
pods, pods/exec, services, serviceaccounts, configmaps, secrets, services/finalizers	*	-
roles, rolebindings	*	rbac.authorization.k8s.io
leases	get, create, update	coordination.k8s.io
daemonsets, replicaset, statefulsets	*	apps
servicemonitors	get, create	monitoring.coreos.com
deployments, deployments/finalizers (resourceName=ibm-spectrum-scale-operator only)	get, update	apps
*	*	ibm.com
scaleclusters/status	get, patch, update	scale.ibm.com
scaleclusters, scaleclusters/finalizers	create, delete, get, list, patch, update, watch	scale.ibm.com

### ibm-spectrum-scale-operator cluster role

Resources	Verbs	API Groups
nodes, services, events	get, list, create, patch, watch	-
persistentvolumes, persistentvolumes/finalizers, persistentvolumeclaims	get, list, create, patch, delete	-

Table 9. *ibm-spectrum-scale-operator* cluster role (continued)

Resources	Verbs	API Groups
statefulsets	get	apps
securitycontextconstraints	get, list, watch, create, update, patch, delete	security.openshift.io
storageclasses	get, list, patch, create	storage.k8s.com
clusterroles, clusterrolebindings	get, list, watch, create, update, patch, delete	rbac.authorization.k8s.io

### Core pod permissions

You can collect a `gpfs.snap` from any running Spectrum Scale core pod for diagnostic log collection when seeking problem determination. The `gpfs.snap` contains both `gpfs` logs and captured output relevant to `kubernetes` and `OpenShift` resources. In order to successfully query `Kubernetes` and `OpenShift` resources, the `daemonset` must be given permission to access said resources. This permission is given by a role that is bound to the `ibm-spectrum-scale-core` service account, which is used exclusively by the `daemonset`.

Table 10. Core pod permissions

Resources	Verbs	API Groups
pods, services	get, list	-
deployments, statefulsets	get, list	apps



---

## Chapter 3. Installation prerequisites

Before the installation of IBM Spectrum Scale container native, the following are the prerequisites:

- [Red Hat OpenShift Container Platform configuration](#)
  - [Compact clusters support](#)
- [IBM Cloud container registry](#)
  - [IBM Cloud Container Registry \(ICR\) entitlement](#)
  - [Adding IBM Cloud container registry credentials](#)
  - [Air gap setup for network restricted Red Hat OpenShift Container Platform clusters](#)

---

### Red Hat OpenShift Container Platform configuration

You must modify the Red Hat OpenShift Container Platform installation for IBM Spectrum Scale container native to operate correctly.

For more information, see [Installing in Red Hat OpenShift documentation](#).

For the instructions that follow, it is assumed that the Red Hat OpenShift Container Platform is already installed.

#### Note:

The configuration tasks shown can also be handled during the Red Hat OpenShift Container Platform installation by adding day-1 kernel arguments. For more information, see [Installation Configuration](#) in Red Hat OpenShift documentation.

Applying the machine configuration provided drives a rolling update of the OpenShift nodes and could take several minutes to complete. For the new configuration to take effect, the nodes within the pool must be rebooted. On applying the supplied YAML files, you can complete the following tasks:

- **Pid Limits:** Ensure that the pid limits is at least 4096. Insufficient pid limits will cause the GPFS daemon to crash during I/O.
  - On OpenShift Container Platform < 4.11, increase this by using the provided MCO sample files below.
  - On OpenShift Container Platform >= 4.11, the KubeletConfig defaults podPidsLimit to 4096.
- **Kernel Devel/Header Packages:** Install the kernel related packages for IBM Spectrum Scale to successfully build its portability layer.
- **Increase vmalloc kernel parameter:** Modify the kernel parameters that are required to operate properly with Red Hat CoreOS. It applies only to the IBM Spectrum Scale running on Linux on Z.

#### Applying Machine Config Operator (MCO) Settings

Apply the following set of MCO settings depending on your OCP version and machine's architecture:

- If you are running x86\_64, enter the following command:

For 4.9:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.9/mco_x86_64.yaml
```

For 4.10:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.10/mco_x86_64.yaml
```

For 4.11:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.11/mco_x86_64.yaml
```

- If you are running ppc64le, enter the following command:

For 4.9:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.9/mco_ppc64le.yaml
```

For 4.10:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.10/mco_ppc64le.yaml
```

For 4.11:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.11/mco_ppc64le.yaml
```

- If you are running s390x, enter the following command:

For 4.9:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.9/mco_s390x.yaml
```

For 4.10:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.10/mco_s390x.yaml
```

For 4.11:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.11/mco_s390x.yaml
```

## Verifying Machine Config Operator (MCO) settings

Complete the following steps:

1. Check the status of the update has completed by entering the following command:

```
oc get MachineConfigPool
```

**Note:** The status might take a while to display after you enter the command.

2. Validate that the PID limits are correctly matching the intended configured value on the nodes which deploy core pods.

```
# using the node-role selector for "worker"
oc get nodes -lnode-role.kubernetes.io/worker= \
-ojsonpath="{range .items[*]}{.metadata.name}{'\n'}" |\
xargs -I{} oc debug node/{} -T -- chroot /host crio-status config | grep pids_limit
```

**Note:** This command creates a debug pod for all worker nodes. Use it with discretion if you have a large system.

### For OCP 4.11

Check the kubelet podPidsLimit value by running the following command:

```
oc get nodes -lnode-role.kubernetes.io/worker= \
-ojsonpath="{range .items[*]}{.metadata.name}{'\n'}" |\
```

```
xargs -I{} oc debug node/{} -T -- chroot /host grep podPidsLimit /etc/kubernetes/
kubelet.conf
```

If `podPidsLimit` is lower than `pids_limit` and `pids_limit` is not set to 0, then the effective container pids limit is defined by the value set in `podPidsLimit`. For more information about how to resolve this, see [pid\\_limits set higher than podPidLimits, but not being honored](#).

3. Validate that the `kernel-devel` package is successfully applied on the Red Hat OpenShift container worker nodes by entering the following command:

```
oc get nodes -lnode-role.kubernetes.io/worker= \
-ojsonpath="{range .items[*]}{{.metadata.name}}'\n'}" | \
xargs -I{} oc debug node/{} -T -- chroot /host sh -c "rpm -q kernel-devel"
```

**Note:** This command runs through all the worker nodes. Use it with discretion if you have a large system.

### s390x specific validation

Perform the extra validation steps if deployed on the s390x architecture:

1. Validate that the `vmalloc` kernel parameter is applied on the Red Hat OpenShift Container Platform worker nodes by entering the following command:

```
oc get nodes -lnode-role.kubernetes.io/worker= \
-ojsonpath="{range .items[*]}{{.metadata.name}}'\n'}" | \
xargs -I{} oc debug node/{} -T -- cat /proc/cmdline
```

The following shows an example where the value, `vmalloc=4096G` is seen in the output at the end:

```
# oc debug node/worker1.example.com -- cat /proc/cmdline
Starting pod/worker1examplecom-debug ...
To use host binaries, run `chroot /host`
rhcos.root=crypt_rootfs random.trust_cpu=on ignition.platform.id=metal
rd.luks.options=discard $ignition_firstboot ostree=/ostree/boot.1/rhcos/
51e4c768b7c3dcec3bb63b01b9de9e8741486bf0dd4ae4df2d1ff1f872efe2e/0 vmalloc=4096G
```

**Note:** This command runs through all the worker nodes. Use it with discretion if you have a large system.

## Compact clusters support

You can deploy compact-3-node clusters on resource constrained environments in Red Hat OpenShift Container Platform 4.5 and later.

For more information, see [Delivering a Three-node Architecture for Edge Deployments](#) in Red Hat Hybrid Cloud documentation.

In this configuration, ensure that the system is sized correctly to operate smoothly. In compact clusters, the Kubernetes control plane, IBM Spectrum Scale container native, and user applications will all compete for the same resources in the cluster (CPU, memory, network, local disk, etc). High application load can impact the control plane resources, causing the OpenShift cluster to become unusable or unstable. `etcd` is very sensitive to latency and could present as frequent leader elections, and other instabilities. IBM Spectrum Scale container native may also take down the filesystem if resources are constrained.

For more information, see [Recommended etcd practices](#) in Red Hat OpenShift documentation.

### Schedulable control plane nodes

To allow pod placement for master nodes also known as control plane nodes, ensure that they are configured as schedulable. By default, control plane nodes are not schedulable.

Verify that `mastersSchedulable` is set to `true` by entering the following command:

```
oc get schedulers.config.openshift.io cluster -ojson | jq -r ".spec.mastersSchedulable"
```

If this value is not `true`, patch the cluster by entering the following command:

```
oc patch schedulers.config.openshift.io cluster --type='json' \
-p='[{"op": "replace", "path": "/spec/mastersSchedulable", "value":true}]'
```

For more information, see [Configuring control plane nodes as schedulable](#) in Red Hat OpenShift documentation.

## Applying Machine Config Operator (MCO) settings

Similar to the configuration tasks that are required for the workers nodes, these MCO settings must also be applied to the master nodes in a compact-cluster environment. For more information, see [Red Hat OpenShift Container Platform configuration](#).

You can take the sample `mco.yaml` files as a base template that can be modified and applied to your cluster.

1. Download the correct sample file based on your OCP version and machine architecture and save it as `master_mco.yaml`.

- If you are running `x86_64`, enter the following commands for the relevant versions:

For 4.9:

```
curl https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/
generated/mco/ocp4.9/mco_x86_64.yaml > master_mco.yaml
```

For 4.10:

```
curl https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/
generated/mco/ocp4.10/mco_x86_64.yaml > master_mco.yaml
```

For 4.11:

```
curl https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/
generated/mco/ocp4.11/mco_x86_64.yaml > master_mco.yaml
```

- If you are running `ppc64le`, enter the following command:

For 4.9:

```
curl https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/
generated/mco/ocp4.9/mco_ppc64le.yaml > master_mco.yaml
```

For 4.10:

```
curl https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/
generated/mco/ocp4.10/mco_ppc64le.yaml > master_mco.yaml
```

For 4.11:

```
curl https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/
generated/mco/ocp4.11/mco_ppc64le.yaml > master_mco.yaml
```

- If you are running `s390x`, enter the following command:

For 4.9:

```
curl https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/
generated/mco/ocp4.9/mco_s390x.yaml > master_mco.yaml
```

For 4.10:

```
curl https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.10/mco_s390x.yaml > master_mco.yaml
```

For 4.11:

```
curl https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/mco/ocp4.11/mco_s390x.yaml > master_mco.yaml
```

2. Modify the sample file for the `master` role and apply to your cluster:

```
cat master_mco.yaml | sed 's/worker/master/g' | oc apply -f -
```

3. Validate the MCO settings against the `master` pool.

For more information, see [Verifying Machine Config Operator \(MCO\) Settings](#).

4. Remove the `node-role.kubernetes.io/worker: ""` selector from the default `Cluster CR` node selector.

Removing this selector enables the deployment of IBM Spectrum Scale **core** pods on master and worker nodes. For more information, see [Node Selectors](#).

## Obtaining a deployment image from IBM Cloud Container Registry

Starting with IBM Spectrum Scale container native 5.1.1.1, the container images have moved from Fix Central to the IBM Cloud Container Registry.

### Note:

If your cluster is already configured with IBM Cloud Container Registry, you do not need to create an entitlement key nor create the global pull secret since they already exist there.

- [IBM Cloud Container Registry \(ICR\) entitlement](#)
- [Adding IBM Cloud container registry credentials](#)
- [Air gap setup for network restricted Red Hat OpenShift Container Platform clusters](#)

## IBM Cloud Container Registry (ICR) entitlement

To obtain an entitlement key, complete the following steps:

1. Log in to the [IBM container software library](#) with an IBM id and a password that is associated with the entitled software.
2. Click `Get entitlement key` on the left navigation bar.
3. On the `Access your container software` page, click `Copy key` to copy the generated entitlement key.
4. Save the key to a secure location for future use.

**Note:** Entitlement keys determine whether the IBM Spectrum Scale operator can automatically pull the required IBM Spectrum Scale container native images. During installation, image pull failures may occur due to an invalid entitlement key or a key belonging to an account that does not have entitlement to either IBM Spectrum Scale Data Access Edition or IBM Spectrum Scale Data Management Edition. It is therefore important to generate a key from an account that already has entitlement to the desired edition of IBM Spectrum Scale software.

## Adding IBM Cloud container registry credentials

For images to be properly pulled at the pod level, the OpenShift global pull secrets must be modified to contain credentials to access the IBM Cloud Container Registry.

**Note:** The following steps are for users whose OpenShift cluster is accessing the IBM Cloud Container Registry. For more information, see [Air gap setup for network restricted Red Hat OpenShift Container Platform clusters](#).

1. Create a base64 encoded string of the credentials used to access the image registry.
  - For using IBM Cloud Container Registry, the credentials are the fixed cp user and the generated entitlement key.

For more information, see [IBM Cloud Container Registry \(ICR\) entitlement](#).

```
echo -n "cp:REPLACE_WITH_GENERATED_ENTITLEMENT_KEY" | base64 -w0
```

2. Create an `authority.json` to include the base64 encoded string of your credentials, the fixed username cp (used to access `cp.icr.io` repository), and generated entitlement key for the IBM Cloud Container Registry.

```
{
  "auth": "REPLACE_WITH_BASE64_ENCODED_KEY_FROM_PREVIOUS_STEP",
  "username": "cp",
  "password": "REPLACE_WITH_GENERATED_ENTITLEMENT_KEY"
}
```

3. Enter the following command to include the `authority.json` as a new authority in your `.dockerconfigjson` and store it as `temp_config.json`:

**Note:** Using the IBM Cloud Container Registry as the authority, use `cp.icr.io` as the input key for the contents of `authority.json`.

```
oc get secret/pull-secret -n openshift-config -ojson | \
jq -r '.data[".dockerconfigjson"]' | \
base64 -d - | \
jq '.[]."cp.icr.io" += input' - authority.json > temp_config.json
```

**Note:** This command is supported with jq 1.5.

- To verify that your authority credentials were created in the resulting file:

```
# cat temp_config.json
{
  "auths": {
    "quay.io": {
      "auth": "",
      "email": ""
    },
    "registry.connect.redhat.com": {
      "auth": "",
      "email": ""
    },
    "registry.redhat.io": {
      "auth": "",
      "email": ""
    },
    "cp.icr.io": {
      "auth": "REPLACE_WITH_BASE64_ENCODED_KEY_FROM_PREVIOUS_STEP",
      "username": "cp",
      "password": "REPLACE_WITH_GENERATED_ENTITLEMENT_KEY"
    }
  }
}
```

4. Use the contents of the `temp_config.json` file, and apply the updated config to the OpenShift cluster.

```
oc set data secret/pull-secret -n openshift-config --from-file=.dockerconfigjson=temp_config.json
```

To verify that your pull-secret is updated with your new authority, issue the following command and confirm that your authority is present:

```
oc get secret/pull-secret -n openshift-config -ojson | \
jq -r '.data[".dockerconfigjson"]' | \
base64 -d -
```

5. The updated config is now rolled out to all the nodes in the OpenShift cluster. Nodes are cycled through one at a time and are not schedulable before rebooting. Enter the `watch oc get nodes` command to observe nodes.

```
# oc get nodes
```

NAME	STATUS	ROLES	AGE	VERSION
master0.example.com	NotReady,SchedulingDisabled	master	99d	v1.19.0+43983cd
master1.example.com	Ready	master	99d	v1.19.0+43983cd
master2.example.com	Ready	master	99d	v1.19.0+43983cd
worker0.example.com	NotReady,SchedulingDisabled	worker	99d	v1.19.0+43983cd
worker1.example.com	Ready	worker	99d	v1.19.0+43983cd
worker2.example.com	Ready	worker	99d	v1.19.0+43983cd

**Note:** Red Hat OpenShift Container Platform 4.7 and above versions do not reboot the nodes. For more information, see [Updating the global cluster pull secret](#) in Red Hat OpenShift documentation.

6. When the global pull secret is updated, enter the following command to remove the temporary files that were created:

```
rm authority.json temp_config.json
```

## Air gap setup for network restricted Red Hat OpenShift Container Platform clusters

Specified instructions per fixpack for installing IBM Spectrum Scale container native in an air gap setup.

**Note:** It is recommended to use the latest fixpack release available.

- [“Air gap setup for network restricted Red Hat OpenShift Container Platform clusters \(optional\) 5.1.6.0” on page 25](#)

### Air gap setup for network restricted Red Hat OpenShift Container Platform clusters (optional) 5.1.6.0

Air gap setup is done for Red Hat OpenShift Container Platform clusters that are in a restricted network environment.

**Note:** You need to do the Air gap setup if the worker nodes are not able to access the repository due to network and firewall restrictions.

### Prerequisites

Following are the prerequisites before setting up the air gap environment:

- A production grade Docker V2 compatible registry, such as Quay Enterprise, JFrog Artifactory, or Docker Registry. The Red Hat OpenShift Internal Registry is not supported.
- An online node that can copy images from the source image registry to the production grade internal image registry.
- The online node must have skopeo installed.
- Access to the Red Hat OpenShift Container Platform cluster as a user with the `cluster-admin` role.

**Note:** For Red Hat OpenShift Container Platform clusters that are in a restricted network environment, the obtained files must be transferred to a bastion/infrastructure node that can communicate with the target cluster before applying the `yaml` files. This is likely the same node in your Red Hat OpenShift Container Platform cluster where the `oc` command is executed.

## Configuring the registry mirror

Create a new `ImageContentSourcePolicy` on your Red Hat OpenShift cluster to enable the redirection of requests to pull images from a repository on a mirrored image registry.

Complete the following steps from the `inf` node of your Red Hat OpenShift cluster:

1. Paste the following in a file (example: `registrymirror.yaml`) and replace your internal image registry repository with `example.io/subdir`:

```
apiVersion: operator.openshift.io/v1alpha1
kind: ImageContentSourcePolicy
metadata:
  name: icr-mirror
spec:
  repositoryDigestMirrors:
  - mirrors:
    - example.io/subdir
    source: cp.icr.io/cp/spectrum/scale
  - mirrors:
    - example.io/subdir
    source: icr.io/cpopen
```

**Note:** Do not prefix mirrors with `http://` or `https://` and ensure that they do not have trailing / characters as this causes an issue while resolving them correctly.

2. Create the `icr-mirror` `ImageContentSourcePolicy` by entering the following command:

```
oc apply -f registrymirror.yaml
```

The mirror gets rolled out to all nodes in the OpenShift cluster. Nodes are cycled one at a time and are made unschedulable before rebooting.

3. Enter the following command to observe the nodes:

```
watch oc get nodes
```

**Note:** Red Hat OpenShift Container Platform 4.7 and later do not reboot the nodes.

4. Once all nodes have finished updating and rebooting, verify that the `ImageContentSourcePolicy` is applied by entering the `oc debug` command to query the mirrors on the host nodes.

```
$ oc debug node/worker0.subdomain
Starting pod/worker0examplecom-debug ...
To use host binaries, run `chroot /host`
Pod IP: 12.34.56.789
If you don't see a command prompt, try pressing enter.

# chroot /host
# cat /etc/containers/registries.conf
unqualified-search-registries = ["registry.access.redhat.com", "docker.io"]

[[registry]]
  prefix = ""
  location = "cp.icr.io/cp/spectrum/scale"
  mirror-by-digest-only = true

[[registry.mirror]]
  location = "example.io/subdir"

[[registry]]
  prefix = ""
  location = "icr.io/cpopen"
  mirror-by-digest-only = true

[[registry.mirror]]
  location = "example.io/subdir"
```

**Note:** For more information, see [Configuring image registry repository mirroring in Red Hat OpenShift documentation](#).



## Copying images from source image registry to target internal image registry

The OpenShift cluster is configured to redirect external image registry requests to an internal registry through the ImageContentSourcePolicy. Now, the internal registry must be populated with the images from the source image registry.

Complete the following steps from the online node described in the prerequisites:

1. Log in to the IBM Entitled Container Registry with the credentials by entering the skopeo command.

```
skopeo login cp.icr.io
```

2. Log in to your internal production grade image registry with the credentials by entering the skopeo command.

```
skopeo login example.io
```

3. Use skopeo copy to copy the following images from the IBM Entitled Container Registry to your internal production grade image registry.

```
icr.io/cpopen/ibm-spectrum-scale-operator@sha256:
fcc14fae885ca862b9ed8a61544dcea3c7b8f3a9d4d691539375bc6d20016370
cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-core-init@sha256:
aa9ef7003fcf9de12d3992aa03bf8d5550a51efb3a8da4ab4f765560dddae44f
cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-pmcollector@sha256:
4ab246283998575bc7675cd0aab04dbd50feb15d3f1937ea4c484b97a03dd960
cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-monitor@sha256:
cbf07926122956d71f98a76c9c43b3322504f46cc2399c75c355c667d7035849
cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-gui@sha256:
2326bda1c4fa4fc1bace680605adc3a4a2e27ecc0c6975aea5c1159fcfc757cb
cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-grafana-bridge@sha256:
18c60c34efb839d96b71804d9f2f537599cb3347c0b3937301cbf4df40abc85a
icr.io/cpopen/ibm-spectrum-scale-must-gather@sha256:
8425d50ec11c21e26b66687640b4923885fbb13f98e2c0a381e2687a92f1404b
cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-coredns@sha256:
3b082240155e5666c5414fb1f768442c89f5fe1ddcd0a9157ccbe0ff94228031
cp.icr.io/cp/spectrum/scale/ubi-minimal@sha256:
4ed971a5564d2cfe7f50793da53ef6f1fd295263f1cc31d703aa8acfd02cf
cp.icr.io/cp/spectrum/scale/postgres@sha256:
135c62a8134dce829a1e4f5568bfae44bcfa2c75659ff948f43c71964366aa4
icr.io/cpopen/ibm-spectrum-scale-csi-
operator@sha256:355a4bfc89a96b81664ec915b63ed02d5a35d49a9c8386d9c09567f33765004e
cp.icr.io/cp/spectrum/scale/csi/ibm-spectrum-scale-csi-driver@sha256:
86e0138bec8189eeb1eb6cc90885e930a333444c1077ca75df33266efc83f86
cp.icr.io/cp/spectrum/scale/csi/csi-snapshotter@sha256:
291334908ddf71a4661fd7f6d9d97274de8a5378a2b6fdfeb2ce73414a34f82f
cp.icr.io/cp/spectrum/scale/csi/csi-provisioner@sha256:
ee3b525d5b89db99da3b8eb521d9cd90cb6e9ef0fbb651e98bb37be78d36b5b8
cp.icr.io/cp/spectrum/scale/csi/csi-node-driver-registry@sha256:
0103eee7c35e3e0b5cd8cdca9850dc71c793cdeb6669d8be7a89440da2d06ae4
cp.icr.io/cp/spectrum/scale/csi/csi-attacher@sha256:
9a685020911e2725ad019dbce6e4a5ab93d51e3d4557f115e6434345e05781b
cp.icr.io/cp/spectrum/scale/csi/livenessprobe@sha256:
cacee2b5c36dd59d4c7e8469c05c9e4ef53ecb2df9025fa8c10cdaf61bce62f0
cp.icr.io/cp/spectrum/scale/csi/csi-resizer@sha256:
425d8f1b769398127767b06ed97ce62578a3179bcb99809ce93a1649e025ffe7
```

To deploy a cluster using the Data Access edition of IBM Spectrum Scale container native, copy the following image:

```
cp.icr.io/cp/spectrum/scale/data-access/ibm-spectrum-scale-daemon@sha256:
00e74a5bb47a45a1c10c79e707e4cc1a229714161b9be5efd8dd7c1dfbdc5f2e
```

To deploy a cluster using the Data Management edition of IBM Spectrum Scale container native, copy the following image:

```
cp.icr.io/cp/spectrum/scale/data-management/ibm-spectrum-scale-daemon@sha256:
4d71421059336c1942ed2658979d4f247b0509ffd2e78a84c8e598906e5f40f1
```

**Note:** The destination is up to the user and depends on how the registry mirror was configured in the first section. Using the same example .io/subdir repository, a sample skopeo copy command is shown:

```
skopeo copy --all docker://cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-gui@sha256:2326bda1c4fa4fc1bace680605adc3a4a2e27ecc0c6975aea5c1159fcfc757cb docker://example.io/subdir/ibm-spectrum-scale-gui@sha256:2326bda1c4fa4fc1bace680605adc3a4a2e27ecc0c6975aea5c1159fcfc757cb
```

**Note:** The ibm-spectrum-scale-daemon image is edition specific. When copying it, you must put it in a folder that indicates its edition. The folder it resides in must be data-access or data-management depending on the image you are entitled to.

The sample command for copying the Data Access Edition ibm-spectrum-scale-daemon image is shown:

```
skopeo copy --all docker://cp.icr.io/cp/spectrum/scale/data-access/ibm-spectrum-scale-daemon@sha256:00e74a5bb47a45a1c10c79e707e4cc1a229714161b9be5efd8dd7c1dfbdc5f2e docker://example.io/subdir/data-access/ibm-spectrum-scale-daemon@sha256:00e74a5bb47a45a1c10c79e707e4cc1a229714161b9be5efd8dd7c1dfbdc5f2e
```

The sample command for copying the Data Management Edition ibm-spectrum-scale-daemon image is:

```
skopeo copy --all docker://cp.icr.io/cp/spectrum/scale/data-management/ibm-spectrum-scale-daemon@sha256:4d71421059336c1942ed2658979d4f247b0509ffd2e78a84c8e598906e5f40f1 docker://example.io/subdir/data-management/ibm-spectrum-scale-daemon@sha256:4d71421059336c1942ed2658979d4f247b0509ffd2e78a84c8e598906e5f40f1
```

A generic skopeo copy command is shown:

```
skopeo copy --all docker://<source image registry>/<image> docker://<internal image registry>/<image>
```

4. Log out of the IBM Entitled Container Registry by entering the skopeo command.

```
skopeo logout cp.icr.io
```

5. Log out of your internal production grade image registry by entering the skopeo command.

```
skopeo logout example.io
```

## Testing the pull of images from the mirrored registry

Complete the following steps from the inf node of your OpenShift cluster:

1. Pick a worker node from oc get nodes and start a node to debug it.

```
oc debug node/<worker node>
```

A command prompt must be presented.

2. Switch to host binaries by entering the chroot /host command.

```
# oc debug node/worker0.example.com
Starting pod/worker0examplecom-debug ...
To use host binaries, run `chroot /host`
Pod IP: 12.34.56.789
If you don't see a command prompt, try pressing enter.
# chroot /host
```

3. Enter the podman login command to authenticate your mirrored image registry.

```
# podman login example.io
Username: sampleemail@email.com
```

```
Password:
Login Succeeded!
```

4. Attempt to pull one of the images from the source image registry through podman. The OpenShift cluster must be able to redirect the request from the external image registry to the internal image registry and successfully pull the image.

```
# podman pull cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-gui@sha256:
2326bda1c4fa4fc1bace680605adc3a4a2e27ecc0c6975aea5c1159fcfc757cb
```

5. Verify that the image is pulled.

```
# podman images | grep cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-gui
cp.icr.io/cp/spectrum/scale/ibm-spectrum-scale-gui <none> 9c215ae62f37 22 hours
ago 851 MB
```

## Red Hat OpenShift Container Registry pull secret

For images to be properly pulled at the pod level, the OpenShift global pull secrets must be modified to contain credentials to access your internal container registry.

Complete the following steps:

1. Create a base64 encoded string of the credentials used to access your internal container registry.

**Note:** The following example uses `example.io/subdir` as the internal container registry.

- Use the credentials to access your `example.io/subdir` internal container registry.

```
echo -n "<username>:<password>" | base64 -w0
```

2. Create an `authority.json` to include the base64 encoded string of your credentials. Use your username and password to access internal container registry `example.io/subdir`.

```
{
  "auth": "<base64 encoded string from previous step>",
  "username": "<example.io username>",
  "password": "<example.io generated entitlement key>"
}
```

3. Enter the following command to include the `authority.json` as a new authority in your `.dockerconfigjson` and store it as `temp_config.json`:

**Note:** For the example internal container registry of `example.io/subdir`, use `example.io` as the input key for the contents of `authority.json`.

```
oc get secret/pull-secret -n openshift-config -ojson | \
jq -r '.data[".dockerconfigjson"]' | \
base64 -d - | \
jq '.[]."example.io" += input' - authority.json > temp_config.json
```

**Note:** This command is supported with `jq 1.5`.

- Enter the following command to verify that your authority credentials were created in the resulting file:

```
# cat temp_config.json
{
  "auths": {
    "quay.io": {
      "auth": "",
      "email": ""
    },
    "registry.connect.redhat.com": {
      "auth": "",
      "email": ""
    },
    "registry.redhat.io": {
      "auth": "",
      "email": ""
    }
  }
}
```

```

    "example.io": {
      "auth": "<base64 encoded string created in previous step>",
      "username": "<example.io username>",
      "password": "<example.io password>"
    }
  }
}

```

4. Use the contents of the `temp_config.json` file, and apply the updated configuration to the OpenShift cluster.

```
oc set data secret/pull-secret -n openshift-config --from-file=.dockerconfigjson=temp_config.json
```

- To verify that your pull-secret is updated with your new authority, enter the following command and confirm your authority is present:

```
oc get secret/pull-secret -n openshift-config -ojson | \
jq -r '.data[".dockerconfigjson"]' | \
base64 -d -
```

The updated configuration is now rolled out to all nodes in the OpenShift cluster. Nodes are cycled one at a time and are made unavailable for scheduling before rebooting.

5. Enter the `watch oc get nodes` command to observe the nodes.

```
# ocgetnodes
```

NAME	STATUS	ROLES	AGE	VERSION
master0.example.com	NotReady,SchedulingDisabled	master	99d	v1.19.0+43983cd
master1.example.com	Ready	master	99d	v1.19.0+43983cd
master2.example.com	Ready	master	99d	v1.19.0+43983cd
worker0.example.com	NotReady,SchedulingDisabled	worker	99d	v1.19.0+43983cd
worker1.example.com	Ready	worker	99d	v1.19.0+43983cd
worker2.example.com	Ready	worker	99d	v1.19.0+43983cd

**Note:** Red Hat OpenShift Container Platform 4.7 and above versions do not reboot the nodes. For more information, see [Updating the global cluster pull secret](#) in Red Hat OpenShift documentation.

6. When the global pull secret is updated, remove the temporary files that were created.

```
rm authority.json temp_config.json
```

---

## Chapter 4. Installing the IBM Spectrum Scale container native operator and cluster

The installation of the IBM Spectrum Scale container native operator and cluster includes several procedures.

- [Node labels and annotations](#)
- [Firewall recommendations](#)
- [IBM Spectrum Scale storage cluster configuration](#)
- [Deploy the operator](#)
- [Configuring the IBM Spectrum Scale container native cluster custom resources](#)
  - [Cluster](#)
  - [Callhome](#)
  - [Filesystems](#)
  - [Encryption](#)
- [Creating the IBM Spectrum Scale container native cluster](#)
- [Creating secrets for storage cluster GUI](#)
- [Configuring Certificate Authority \(CA\) certificates](#)
- [Verifying the IBM Spectrum Scale container native cluster](#)
- [Status and events](#)

---

### Labels and annotations

IBM Spectrum Scale container native assigns labels to worker nodes and allows to set memory and CPU limits on a per node basis by using a node annotation.

#### Designation labels

IBM Spectrum Scale container native automatically assigns designations to some worker nodes. You do not need to explicitly designate the worker nodes but if it is required then it can be done using node labels.

The following mechanisms are supported to designate IBM Spectrum Scale container native nodes:

- **Automatic** (*Recommended*) - Allows the Operator to designate the nodes automatically.
- **Manual** (*Optional*) - Allows administrators to have more control of the placement of IBM Spectrum Scale node designations (like the quorum designation) to pods on specific worker nodes.

**Note:** Manual labeling requires insight about IBM Spectrum Scale and should only be used by experienced administrators.

#### Automatic

If a user does not label any nodes as quorum nodes, the Operator automatically applies quorum annotations to a subset of the nodes in the cluster. The number of nodes to be annotated depends on the number of nodes in a cluster:

- If the number of nodes in the cluster definition is less than 4, all nodes are designated as quorum nodes.
- If the number of nodes in the cluster definition is between 4 and 9 inclusive, 3 nodes are designated as quorum nodes.

- If the number of nodes in the cluster definition is between 10 and 18 inclusive, 5 nodes are designated as quorum nodes.
- If the number of nodes in the cluster definition is greater than 18, 7 nodes are designated as quorum nodes.

Kubernetes zones are considered if they are configured in the OpenShift cluster. The operator selects quorum nodes across all zones. For example, if there are 3 zones and 3 quorum nodes are to be designated as quorum nodes, then one node of each zone is designated as quorum node. For more information, see [Kubernetes zones](#).

**Note:** The automatic node designation only works at initial cluster creation time. Once the cluster is created, the operator does not change node designations automatically, for example, if the nodes are added to the cluster. If node designations need to be changed on an existing cluster, the Manual steps can be performed, even if Automatic mode is used at cluster creation time. For more information, see [“Manual” on page 32](#) and [“Automatic” on page 31](#) sections.

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Supported designation label values are `quorum` and `manager`. The nodes designated as quorum nodes also automatically assume the role of `manager`. If nodes are left without a designation label and sufficient quorum nodes are designated, unlabeled nodes become client nodes within the cluster.

### IBM Spectrum Scale quorum designation

For more information about IBM Spectrum Scale quorum designation, see [Quorum](#) in IBM Spectrum Scale documentation. It is recommended to configure an odd number of nodes, with 3, 5, or 7 nodes being the typical numbers used.

### IBM Spectrum Scale manager designation

For more information about IBM Spectrum Scale manager designation, see [Manager](#) in IBM Spectrum Scale documentation.

## Node Labeling

To see the list of nodes in your cluster, enter the `oc get nodes` command:

```
# oc get nodes
NAME                STATUS    ROLES    AGE   VERSION
master0.example.com Ready    master   50d   v1.16.2
worker0.example.com Ready     worker   50d   v1.16.2
worker1.example.com Ready     worker   50d   v1.16.2
worker2.example.com Ready     worker   50d   v1.16.2
```

The following labels can be applied to nodes in the Red Hat OpenShift cluster to dictate how the pods deployed on those nodes are designated:

```
scale.spectrum.ibm.com/designation=quorum
scale.spectrum.ibm.com/designation=manager
```

To apply a label to a node, enter the `oc label node <node name> scale.spectrum.ibm.com/designation=<designation>` command as follows:

```
oc label node worker0.example.com scale.spectrum.ibm.com/designation=quorum
```

To verify that the label was applied to the node, enter the `oc describe node <node name>` command as follows:

```
# oc describe node worker0.example.com
Name:                worker0.example.com
...
Labels:              ...
```

```
...
scale.spectrum.ibm.com/designation=quorum
...
```

To remove a label from a node, enter the following command:

```
oc label node <node name> scale.spectrum.ibm.com/designation-
```

**Note:** Quorum node designations can be changed on the IBM Spectrum Scale container native cluster by manually applying or removing node labels. Manual labeling requires insight about IBM Spectrum Scale and should only be performed by experienced administrators.

## Firewall recommendations

Ensure that ports 12345, 1191, 443, ping, and the ephemeral port ranges are open on a storage cluster and on any network switches between a storage and container native cluster. Otherwise, the container native cluster cannot remotely mount a file system from the storage cluster.

Table 11. Recommended port numbers		
Port number	Protocol	Service name
12345	TCP	Config, GPFS
1191	TCP	Config, GPFS

For more information to set ephemeral port ranges, see [Ephemeral port range](#).

### Configure cluster profile with `tscCmdAllowRemoteConnections`

Starting with IBM Spectrum Scale 5.1.3.0 and IBM Spectrum Scale container native 5.1.3.0, the `tscCmdAllowRemoteConnections` configuration is recommended to be set to `no`. If the storage cluster and all client clusters (including IBM Spectrum Scale container native) are at versions  $\geq 5.1.3.0$ , it is recommended to set this value to `no`. However, if any version is  $< 5.1.3.0$ , `tscCmdAllowRemoteConnections` must be set to `yes` on the storage cluster and client clusters to successfully communicate between the clusters.

Use the following table as a reference:

Table 12. Configure <code>tscCmdAllowRemoteConnections</code>		
Storage cluster version	IBM Spectrum Scale container native version	<code>tscCmdAllowRemoteConnections</code>
$< 5.1.3$	$< 5.1.3.0$	yes
$\geq 5.1.3$	$< 5.1.3.0$	yes
$\geq 5.1.3$	$\geq 5.1.3.0$	no

- To change this value on the storage cluster, enter the following command:

```
mmchconfig
  tscCmdAllowRemoteConnections='yes|no'
```

- To change this value on the IBM Spectrum Scale container native cluster, set `tscCmdAllowRemoteConnections: yes|no` in the `clusterProfile` section of the cluster spec:

```
kind: Cluster
metadata:
  name: ibm-spectrum-scale
spec:
  ...
  daemon:
    ...
```

```
...
clusterProfile:
  tscCmdAllowRemoteConnections: "yes"
```

For more information to configure the **clusterProfile** section of the cluster spec, see [Cluster](#).

For more information about all IBM Spectrum Scale services, see [Securing the IBM Spectrum Scale system using firewall](#) in IBM Spectrum Scale documentation.

## IBM Spectrum Scale storage cluster configuration

Some additional tasks need to be performed on the IBM Spectrum Scale storage cluster. The operators of CNSA and CSI interact with the storage cluster through REST API (which is part of the GUI stack). To enable this, user IDs need to be created on the storage cluster GUI. There are tailored roles that grant those user IDs only the operations needed to provide their functionality. In addition, some settings on the cluster and the filesystem are required for interoperability with CSI.

**Note:** If the storage cluster is running a GUI high availability configuration, for example, having 2 or more GUI nodes installed, ensure the storage cluster is running IBM Spectrum Scale 5.1.6.1 or higher prior to use with IBM Spectrum Scale container native and IBM Spectrum Scale CSI.

### Creating Container Operator User and Group

Complete the following steps in the shell of the GUI node of the storage cluster:

1. To verify whether the IBM Spectrum Scale GUI user group ContainerOperator exists, enter the following command:

```
/usr/lpp/mmfs/gui/cli/lsusergrp ContainerOperator
```

2. To create the ContainerOperator GUI user group if it does not exist, enter the following command:

```
/usr/lpp/mmfs/gui/cli/mkusergrp ContainerOperator --role containeroperator
```

3. To verify whether an IBM Spectrum Scale GUI user exists within the ContainerOperator group, enter the following command:

```
/usr/lpp/mmfs/gui/cli/lsuser | grep ContainerOperator
```

4. To create a GUI user for the ContainerOperator group, enter the following command:

```
/usr/lpp/mmfs/gui/cli/mkuser cnsa_storage_gui_user -p cnsa_storage_gui_password -g ContainerOperator
```

By default, user passwords expire after 90 days. If the security policy of your organization permits it, then enter the following command to create the user with a password that never expires:

```
/usr/lpp/mmfs/gui/cli/mkuser cnsa_storage_gui_user -p cnsa_storage_gui_password -g ContainerOperator -e 1
```

**Note:** The `-e 1` parameter is only available for the IBM Spectrum Scale storage cluster 5.1.1.0 or later.

### Creating CSI Operator User and Group

Complete the following steps in the shell of the GUI node of the storage cluster:

1. To verify whether the IBM Spectrum Scale GUI user group CsiAdmin exists, enter the following command:

```
/usr/lpp/mmfs/gui/cli/lsusergrp CsiAdmin
```



- To create the CsiAdmin GUI user group if it does not exist, enter the following command:

```
/usr/lpp/mmfs/gui/cli/mkusergrp CsiAdmin --role csiadmin
```

- To verify whether an IBM Spectrum Scale GUI user exists within the CsiAdmin group, enter the following command:

```
/usr/lpp/mmfs/gui/cli/lsuser | grep CsiAdmin
```

- To create the GUI user for the CsiAdmin group, enter the following command:

```
/usr/lpp/mmfs/gui/cli/mkuser csi_storage_gui_user -p csi_storage_gui_password -g CsiAdmin
```

By default, user passwords expire after 90 days. If the security policy of your organization permits it, then enter the following command to create the user with a password that never expires:

```
/usr/lpp/mmfs/gui/cli/mkuser csi_storage_gui_user -p csi_storage_gui_password -g CsiAdmin -e 1
```

**Note:** The `-e 1` parameter is only available for IBM Spectrum Scale storage cluster 5.1.1.0 or later.

## Storage cluster configuration for Container Storage Interface (CSI)

Complete the following steps on the storage cluster to ensure the IBM Spectrum Scale CSI driver can operate successfully:

- Ensure that the perfilesset quota on the file systems used by IBM Spectrum Scale Container Storage Interface driver is set to No.

**Note:** The IBM Spectrum Scale Container Storage Interface driver will create a large number of filesets (one per PV). Tracking user and group quotas on a per-fileset basis will significantly increase the overhead of quota management. As a result, the file system performance may suffer.

```
$ mmfsfs fs1 --perfilesset-quota
flag          value          description
-----
--perfilesset-quota No          Per-fileset quota enforcement
```

- Enter the following command to enable the Quota in the file systems:

**Note:** The IBM Spectrum Scale Container Storage Interface driver translates capacity of persistent volumes to fileset quotas. For this to work, quotas are required to be enabled in the file system.

```
mmchfs fs1 -Q yes
```

- Enter the following command to verify that the quota is enabled:

```
$ mmfsfs fs1 -Q
flag          value          description
-----
-Q           user;group;fileset  Quotas accounting enabled
             user;group;fileset  Quotas enforced
             none             Default quotas enabled
```

- Enable the quota for the root user by entering the following command:

**Note:** On Kubernetes, the containers may run as root, so ensure that quotas are enforced for the root user as well.

```
mmchconfig enforceFilesetQuotaOnRoot=yes -i
```

- Ensure that the `controlSetxattrImmutableSELinux` parameter is set to yes by entering the following command:

**Note:** Kubernetes does not honor immutability of files/directories when setting SELinux labels. This creates issues, for example, with the immutable `.snapshot` directory.

```
mmchconfig controlSetxattrImmutableSELinux=yes -i
```

6. Enable `filesetdf` of the file system by entering the following command:

**Note:** IBM Spectrum Scale Container Storage Interface driver will only be able to report free space on persistent volumes if `filesetdf` is set correctly.

```
mmchfs fs1 --filesetdf
```

7. Enable `auto-inode-limit` of the file system by entering the following command:

**Note:** IBM Spectrum Scale Container Storage Interface driver has no information about the number of inodes a persistent volume will consume. Therefore, corresponding independent filesets are created with default values for `maxInodes`. The above setting enables automatic expansion of the inode space, so persistent volumes do not run out of inodes.

```
mmchfs fs1 --auto-inode-limit
```

**Note:** The `--auto-inode-limit` option is available only with filesystem format level 28.00 or later. Enable `auto-inode-limit` as soon as the filesystem format level is updated to 28.00 or later. On older filesystem levels the administrator of the storage cluster needs to manually increase the inode limit when warnings for low inodes are raised by the health monitoring.

For more information about `auto-inode-limit` parameter, see [mmchfs command](#) in IBM Spectrum Scale documentation.

## Deploy the operator

---

Deploy the IBM Spectrum Scale container native operator by entering the following command:

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/installer/ibm-spectrum-scale-operator.yaml
```

Validate that the operator pods are running in the following namespaces:

- `ibm-spectrum-scale-operator`

```
oc get pods -n ibm-spectrum-scale-operator
```

```
$ oc get pods -n ibm-spectrum-scale-operator
NAME                                                    READY   STATUS    RESTARTS   AGE
ibm-spectrum-scale-controller-manager-78df9cf866-jd89q  1/1     Running   0           78s
```

- `ibm-spectrum-scale-csi`

```
oc get pods -n ibm-spectrum-scale-csi
```

```
$ oc get pods -n ibm-spectrum-scale-csi
NAME                                                    READY   STATUS    RESTARTS   AGE
ibm-spectrum-scale-csi-operator-7f94bfd897-w88fr       1/1     Running   0           40s
```

## Configuring the IBM Spectrum Scale container native cluster custom resources

---

Before deploying a cluster, you need to make changes to the sample `scale_v1beta1_cluster_cr.yaml` file.

Save the sample YAML file from the [GitHub](#) by entering the following command:

```
curl -fs https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/scale_v1beta1_cluster_cr.yaml > scale_v1beta1_cluster_cr.yaml || echo "Failed to curl Cluster CR"
```

This file is used to set configuration. When deployed, it initiates the IBM Spectrum Scale cluster creation.

The following table describes the custom resource definitions (CRDs) managed by the IBM Spectrum Scale container native operator:

*Table 13. IBM Spectrum Scale container native cluster custom resources*

Resource	Short name	Description
cluster	gpfs	Set attributes for the IBM Spectrum Scale container native cluster.
callhome	none	Configures IBM Spectrum Scale callhome functionality.
filesystem	fs	Configures remote mounted filesystems for the container native cluster.
remoteclusters	remotegpfs	Provide configuration to the remote cluster and establishes the secure authorizations. For more information, see <a href="#">Filesystem</a> section.
encryptionconfig	ec	Allows users to configure encryption functionality.

The following sections guide you through this process:

- [Cluster](#)
- [Callhome](#)
- [Filesystems](#)
- [Encryption](#)

## Cluster

The sample `Cluster` custom resource can be found under `kind: Cluster` in the `scale_v1beta1_cluster_cr.yaml` file.

For more information, see [Configuring the IBM Spectrum Scale container native cluster custom resources](#). Once deployed, enter the `oc edit cluster` command to modify the properties.

### Cluster spec

The following table describes the properties for `Cluster`:

*Table 14. Cluster property and description*

Property	Required	Default	Description
license	Yes	None	The license must be accepted by the end user that provides a way to specify the IBM Spectrum ScaleEdition.
license.accept	Yes	None	It reads the license and specify <code>true</code> to accept or <code>false</code> to not accept.

Table 14. Cluster property and description (continued)

Property	Required	Default	Description
license.license	Yes	None	It specifies the IBM Spectrum Scale edition, data-access or data-management.
daemon	Internal CR	N/A	It specifies the configuration of the GPFS daemons.
grafanaBridge	Internal CR	Disabled	It specifies the configuration of the Grafana Bridge.
gui	Internal CR	N/A	It specifies the configuration of the GUIs.
pmcollector	Internal CR	N/A	It specifies the configuration of the pmcollectors.

## License

The license section allows you to accept and choose the IBM Spectrum Scale edition that needs to be deployed in the IBM Spectrum Scale container native cluster. You must complete the following activities:

- Review the appropriate license documentation through the URL in the CR.
- Accept the license by specifying `true` in the `license.accept` field.
- Supply the edition being used in the `license.license` field.

The sample CR defaults to `data-access` under the `license.license` field, indicating IBM Spectrum Scale Data Access Edition. If you need the IBM Spectrum Scale Data Management Edition, then change the value in `license.license` to `data-management`.

Specifying an edition without proper entitlement results in image pull failures during deployment.

```
apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
  ..
  license:
    accept: true
    license: data-access
```

Enter the `oc explain cluster.spec.license` command to view more details.

## Daemon

The daemon section in the cluster specification specifies configuration for the IBM Spectrum Scale core pods.

## Node selectors

The `daemon.nodeSelector` section allows you to configure a `nodeSelector` to determine where IBM Spectrum Scale pods can be deployed. The default location in the sample is to deploy core pods to Kubernetes worker roles:

```
apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
  ...
  daemon:
    nodeSelector:
      node-role.kubernetes.io/worker: ""
```

You may configure multiple node selector values by adding labels to the `nodeSelector` list. The Operator checks that a node has all defined labels present in order to deem a node eligible to deploy IBM Spectrum Scale pods. In the following example, the Operator deploys IBM Spectrum Scale pods on nodes with both the worker label and daemon selector label:

```
apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
  ...
  daemon:
    nodeSelector:
      node-role.kubernetes.io/worker: ""
      scale.spectrum.ibm.com/daemon-selector: ""
```

Enter the `oc explain cluster.spec.daemon.nodeSelector` command to view more details. For more information, see [Compact clusters support](#).

## Host aliases

It is highly recommended that a proper DNS is configured in your environment.

The `daemon.hostAliases` section allows for user defined entries to be added into the IBM Spectrum Scale CoreDNS service handling name resolution for the core pods.

For example, if the core pods are unable to resolve hostname of the servers in the storage cluster by DNS, their hostname and their IP addresses can be specified in the `hostAliases` as follows:

```
apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
  ...
  daemon:
    hostAliases:
      - hostname: node1.example.com
        ip: 10.0.0.1
      - hostname: node2.example.com
        ip: 10.0.0.2
```

The IBM Spectrum Scale CoreDNS service only handles name resolution for the core pods. For `RemoteCluster` CR, the hostname provided in the `remotecluster.spec.gui.host` field must be DNS resolvable and using host aliases is not a valid workaround.

Enter the `oc explain cluster.spec.daemon.hostAliases` command to view more details.

## Cluster profile

The `daemon.clusterProfile` allows the user to set default IBM Spectrum Scale configuration parameters for the cluster at cluster creation time.

```
apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
```

```

daemon:
  ...
  clusterProfile:
    controlSetxattrImmutableSELinux: "yes"
    enforceFilesetQuotaOnRoot: "yes"
    ignorePrefetchLUNCount: "yes"
    initPrefetchBuffers: "128"
    maxblocksize: 16M
    prefetchPct: "25"
    prefetchTimeout: "30"

```

**Note:** Changing the values in the `clusterProfile` is not supported and must be avoided unless advised by IBM Support.

There are two exceptions where changing values in the `clusterProfile` is supported. For more information, see [“Cluster profile - ephemeral port range”](#) on page 40 and [“Configure cluster profile with `tscCmdAllowRemoteConnections`”](#) on page 33.

Enter the `oc explain cluster.spec.daemon.clusterProfile` command to view more details.

## Cluster profile - ephemeral port range

If the storage cluster has the ephemeral port range configured, you need to set `tscCmdPortRange` on the container native cluster to match the range.

For example, if the storage cluster is configured to use port range, 60000-61000, set this value under the `clusterProfile` section in the Cluster CR.

```

apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
  ...
  daemon:
    clusterProfile:
      ...
      tscCmdPortRange: "60000-61000"

```

## Roles

The `daemon.roles` section under the Cluster spec allows the user to fine tune memory and CPU requests using the `resources` object on the nodes that are part of specific IBM Spectrum Scale roles. For more information on Request and Limits, see [Resource Management for Pods and Containers](#) in Kubernetes documentation.

- `client` role: For `client` role, the configuration recommendation is 2 CPU and 4GiB. On systems with a lot of CPU cores, big memory, and/or high speed network, the storage performance might increase with higher values. Encryption and compression of PVs result in higher CPU load, therefore, higher resource values can be beneficial. On smaller systems and/or applications with low I/O workload, 1 CPU and 2GiB can be set.

**Note:** Low resource configurations may yield poor performance.

The following describes the resource properties of the core pods:

- Limits are set to the capacity of the nodes
- Requests, if not specified in the cluster spec for the roles is set to 25% of the capacity of the nodes

For example, to set memory and CPU requests for the `client` role, specify the values under `spec.daemon.roles.resources`:

**Note:** These values must be set at cluster creation time. Changes made after the cluster is created will not take effect until the pods restart.

```

apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:

```

```

...
daemon:
  roles:
  - name: client
    resources:
      memory: "40G"
      cpu: "4"

```

**Note:** For s390x, the sample cluster CR ships with "4G" memory request and you may need to reduce the memory request to "2G" if your hardware does not have enough physical memory.

Enter the `oc explain cluster.spec.daemon.roles` command to view more details.

## Grafana bridge

The `grafanaBridge` section allows the user to enable the deployment of the IBM Spectrum Scale bridge for Grafana application. For more information, see [IBM Spectrum Scale bridge for Grafana repository](#) in Github.

Specify `grafanaBridge: {}` to enable Grafana Bridge:

```

apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
  ...
  grafanaBridge: {}

```

Enter the `oc explain grafanabridge.spec` command to view more details.

## Infrastructure nodes

The GUI pods, `pmcollector` pods, and Grafana bridge pods can be placed on OpenShift infrastructure nodes. At least two infrastructure nodes are required because two replicas of GUI and `pmcollector` pods have to run on different infrastructure nodes.

### GUI, pmcollector, and Grafana Bridge pods

The `gui`, `pmcollector`, and `grafanaBridge` sections allow to specify a [Kubernetes Node Selector](#) and [Kubernetes Taints and Tolerations](#).

If the OpenShift infrastructure nodes are labeled with `node-role.kubernetes.io/infra=""` and have `node-role.kubernetes.io/infra:NoSchedule` and `node-role.kubernetes.io/infra:NoExecute` taints, add the following lines to run the `gui`, `pmcollector`, and `grafanaBridge` sections:

```

apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
  ...
  gui:
    nodeSelector:
      node-role.kubernetes.io/infra: ""
    tolerations:
    - effect: NoSchedule
      key: node-role.kubernetes.io/infra
      operator: Exists
    - effect: NoExecute
      key: node-role.kubernetes.io/infra
      operator: Exists
  pmcollector:
    nodeSelector:
      node-role.kubernetes.io/infra: ""
    tolerations:
    - effect: NoSchedule
      key: node-role.kubernetes.io/infra
      operator: Exists
    - effect: NoExecute
      key: node-role.kubernetes.io/infra
      operator: Exists
  grafanaBridge:
    nodeSelector:

```

```

node-role.kubernetes.io/infra: ""
tolerations:
- effect: NoSchedule
  key: node-role.kubernetes.io/infra
  operator: Exists
- effect: NoExecute
  key: node-role.kubernetes.io/infra
  operator: Exists

```

The [Grafana Bridge](#) is optional.

### Spectrum Scale core pods

When using infrastructure pods as described above, it is required that Spectrum Scale core pods run on the infrastructure nodes as well. By default, the Spectrum Scale core pods are scheduled on worker nodes. For more information, see [Node Selectors](#).

```

apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
  ...
  daemon:
    nodeSelector:
      node-role.kubernetes.io/worker: ""

```

If the infrastructure nodes have the `node-role.kubernetes.io/worker` and `node-role.kubernetes.io/infra` role labels, core pods are scheduled on the infrastructure nodes as required and no further action is needed.

If the infrastructure nodes do not have the `node-role.kubernetes.io/worker` label, the following steps are performed:

1. Label all worker nodes and infrastructure nodes with a common label, for example, `scale.spectrum.ibm.com/daemon-selector: ""`

```

oc label nodes --selector node-role.kubernetes.io/worker scale.spectrum.ibm.com/daemon-selector=""

oc label nodes --selector node-role.kubernetes.io/infra scale.spectrum.ibm.com/daemon-selector=""

```

2. Update the Node Selector to select all worker and infrastructure nodes that are labeled in previous step.

```

apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Cluster
spec:
  ...
  daemon:
    nodeSelector:
      scale.spectrum.ibm.com/daemon-selector: ""

```

For more information, see [Node Selector](#).

**Note:** The Spectrum Scale core pods tolerate the NoExecute taint. Therefore, the core pods will run on infrastructure nodes even if these have a NoExecute taint (like `node-role.kubernetes.io/infra:NoExecute`).

### Cluster Status

Status Conditions can be viewed as a snapshot of the current and most up-to-date status of a Cluster.

- The Success condition is set to True if the Cluster is successfully configured.

## Callhome

The sample Callhome custom resource can be found under `kind: Callhome` in the `scale_v1beta1_cluster_cr.yaml` file.





Table 15. Callhome property and description (continued)

Property	Required	Default	Description
proxy	No	None	If specified, defines a proxy server configuration.
proxy.host	Yes, if proxy is specified	None	The host of proxy server as hostname or IP address.
proxy.port	Yes, if proxy is specified	None	The port of proxy server.
proxy.secretName	Yes, if proxy is specified	None	The secret name of a basic authentication secret, which contains username and password for proxy server.

### License agreement

To agree and accept the license, set `license.accept` property to `true`. If you do not accept the license, call home is not enabled.

```
apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Callhome
...
spec:
  license:
    accept: true
```

### Personal information

Under the `spec` for `Callhome`, enter your `companyName`, the `customerID` that IBM provided to you, the `companyEmail` and the `countryCode`.

**Note:** The `countryCode` is a two-letter upper case country codes as defined in ISO 3166-1 alpha-2. For example, US for the United States or DE for Germany.

### Type

Set the `spec.type` to reflect the type of cluster, `test` or `production`.

### Proxy (optional)

If you are using a proxy for communication, enter information about the proxy service in the `spec.proxy` field. Enter the `oc explain callhome.spec.proxy` command to view more details.

If your proxy requires authentication, you must create a `kubernetes` secret containing the credentials. For example, to create a secret `proxyServerSecret`, you can enter the following command:

```
oc create secret generic proxyServerSecret --from-literal=username='<proxy_username>' \
--from-literal=password='<proxy_password>' -n ibm-spectrum-scale
```

Then add your configuration into the CR:

```
apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Callhome
...
spec:
```

```

...
proxy:
  host: proxyserver.example.com
  port: 443
  secretName: proxyServerSecret

```

## Call home Status

Status Conditions can be viewed as a snapshot of the current and most up-to-date status of Callhome.

- The Enabled condition is set to True if Callhome functionality is enabled by accepting the license.
- The Success condition is set to True if Callhome configured successfully and is able to communicate with the IBM Callhome server.

## Filesystems

### Remote filesystem

To configure a remote mounted file system for a container native cluster, you must create a `Filesystem` custom resource and a `RemoteCluster` custom resource.

### Filesystem

#### Filesystem spec

**Note:** If you choose to configure an encrypted remote mounted filesystem for the IBM Spectrum Scale container native cluster you must create an `EncryptionConfig` custom resource. For more information, see [EncryptionConfig](#).

The following table describes the properties for `Filesystem`:

<i>Table 16. Filesystem property and description</i>			
Property	Required	Default	Description
remote	No	None	If specified, describes the file system to be remote mounted filesystem.
remote.fs	Yes, if `remote` is specified	None	It is the name of the filesystem on the remote cluster to mount.
remote.cluster	Yes, if `remote` is specified	None	It is the name of the Remote Cluster custom resource.

The sample `Filesystem` custom resource can be found under `kind: Filesystem` in `scale_v1beta1_cluster_cr.yaml` file. For more information, see [Configuring the IBM Spectrum Scale container native cluster custom resources](#).

The name that you set for the `Filesystem` CR under `metadata.name` is the name of the custom resource and also becomes the name of the remote file system mount point at `/mnt/<metadata.name>`. In the sample, the name of the local file system is `remote-sample` and is mounted at `/mnt/remote-sample`. You can define more than one `Filesystem` CR.

Set the details under the remote section to reflect the storage cluster file system being mounted as fs and the name of the RemoteCluster created as a cluster.

```

apiVersion: scale.spectrum.ibm.com/v1beta1
kind: Filesystem
metadata:
  ...
  name: remote-sample
spec:
  remote:
    cluster: remoteclasser-sample
    fs: fs1

```

### Limitations

Deleting a Filesystem custom resource does not un-mount or delete the file system configuration from an IBM Spectrum Scale cluster.

Enter the `oc explain filesystem.spec.remote` command to view more details.

### Filesystem Status

Status Conditions can be viewed as a snapshot of the current and most up-to-date status of a Filesystem instance.

- The Success condition is set to True if the Filesystem is created and mounted.

### RemoteCluster

The sample RemoteCluster custom resource can be found under kind: RemoteCluster in `scale_v1beta1_cluster_cr.yaml` file.

### RemoteCluster spec

The following table describes the properties for RemoteCluster:

<i>Table 17. RemoteCluster field and description</i>			
Field	Required	Default	Description
metadata.name	Yes	None	The name of the CR, that is used to identify the remote storage cluster in the filesystem CR.
contactNodes	No	None	This property is optional and provides a list of nodes from the storage cluster to be used as the remote cluster contact nodes. The names should be the daemon node names. If not specified, the operator uses any 3 nodes detected from the storage cluster.
gui	Yes	None	It specifies the details for the IBM Spectrum Scale Remote Cluster GUI.
gui.cacert	No	None	It specifies the name of the RootCA ConfigMap.

Table 17. RemoteCluster field and description (continued)

Field	Required	Default	Description
gui.csiSecretName	Yes	csi-remote-mount-storage-cluster-1	It references the secret that contains the username and password of the CSI admin user in the ibm-spectrum-scale-csi namespace.
gui.host	Yes	None	The hostname for the GUI endpoint on the storage cluster.
gui.insecureSkipVerify	No	None	The parameter controls whether a client verifies the storage cluster's GUI certificate chain and host name. If set to true, TLS is susceptible to machine-in-the-middle attacks. The default value is false.
gui.port	No	443	It specifies the port of the Remote Cluster.
gui.scheme	No	https	The default value is 'https'. No other value is supported.
gui.secretName	Yes	None	The name of the Kubernetes secret created during the storage cluster configuration.

The name that you set for the RemoteCluster CR under metadata.name identifies the remote storage cluster you want to create an authentication to. This name is used as a reference in the Filesystem CR remote.cluster to identify the remote storage cluster serving the file system. You can define more than one RemoteCluster.

To create RemoteCluster spec, complete the following steps:

1. Validate that a secret for the storage cluster is created.

For more information, see [Creating secrets for storage cluster GUI](#).

2. Set the GUI details to match your remote storage GUI in the gui section:

```

apiVersion: scale.spectrum.ibm.com/v1beta1
kind: RemoteCluster
...
metadata:
  name: remoteccluster-sample
spec:
  contactNodes:
  - storagecluster1node1
  - storagecluster1node2
  gui:
    cacert: cacert-storage-cluster-1
    host: guihost.example.com
    insecureSkipVerify: false
    secretName: cnsa-remote-mount-storage-cluster-1

```

### Limitations

Deleting a RemoteCluster custom resource definition does not delete the access permission of an IBM Spectrum Scale container native cluster to the file systems on a remote storage cluster.

Enter the `oc explain remoteclasser.spec` command to view more details.

## RemoteCluster Status

Status Conditions can be viewed as a snapshot of the current and most up-to-date status of a `Remoteclasser` instance.

- The `Ready` condition is set to `True` if the `Remoteclasser` credentials are established.

## Encryption

IBM Spectrum Scale container native supports remote mount of an encrypted filesystem.

Encryption is managed through use of encryption keys stored on key server.

The following key servers are supported:

- IBM Security Guardium Key Lifecycle Manager (SKLM)

## EncryptionConfig

To give IBM Spectrum Scale container native access to the encryption key server, an `EncryptionConfig` custom resource must be created. The configuration must add the same key server and tenant as configured on storage cluster hosting the filesystem. You can define more than one `EncryptionConfig` custom resource.

For more information, see [Encryption](#) in IBM Spectrum Scale documentation.

## EncryptionConfig spec

The following table describes the properties for `EncryptionConfig`:

Property	Required	Default	Description
<code>metadata.name</code>	Yes	None	The name of the CR.
<code>server</code>	Yes	None	The key server host name or IP in which encryption keys are stored.
<code>backupServers</code>	No	None	The backup key servers configured for high availability. This field is optional.
<code>port</code>	No	None	It can be used to override the default port for the key server.
<code>cacert</code>	No	None	The ConfigMap storing CA and endpoint certificates used while adding/renewing key server certificate chain.
<code>secret</code>	Yes	None	The name of the basic-auth secret containing the username and password to the key server.

Table 18. Encryption property and description (continued)

Property	Required	Default	Description
tenant	Yes	None	The tenant name on the key server that contains encryption keys. This has to be the same tenant name that is used to store the encryption keys of the remote storage file system.
client	Yes	None	The key client to communicate with the key Server.
remoteRKM	Yes	None	The RKM ID from the storage cluster corresponding to given key server and tenant.

### Limitations

Deleting an EncryptionConfig custom resource does not delete the encryption configuration from the IBM Spectrum Scale container native cluster.



**Warning:** Updating client and tenant is not recommended as it causes loss of master encryption keys for that tenant.

For more information, enter the `oc explain encryptionconfig.spec` command.

## Configure EncryptionConfig custom resource

### Prerequisites

- Create a secret containing the administrator username and password credentials to the key server.

```
oc create secret generic keyserver-credentials -n ibm-spectrum-scale \
--from-literal=username=<keyserver_admin_name> \
--from-literal=password=<keyserver_admin_password>
```

- If using CA certificates, create the ConfigMap holding the CA certificate chain.
  1. Obtain CA certificates and endpoint/server certificates. Separate the root certificate and the intermediate certificates into the following .crt files:
    - Root certificate :root.crt
    - Server or Endpoint certificate: endpoint.crt
    - Intermediate certificates: intermediate<numeric\_index>.crt
  2. Create the ConfigMap with the following command:

```
oc create ConfigMap sample-ca-cert \
--from-file=/path/to/root.crt \
--from-file=/path/to/intermediate1.crt \
--from-file=/path/to/intermediate2.crt \
--from-file=/path/to/intermediate3.crt \
--from-file=/path/to/endpoint.crt \
-n ibm-spectrum-scale
```

- Encryption details from storage cluster, specifically, tenant and RKMID.

**Note:** If the core pods are unable to resolve the IP address of the IBM SKLM server, you can add hostAliases entries in the Cluster custom resource. For more information, see [Cluster](#).

## Configure Encryption

Download and save a copy of the sample `scale_v1beta1_encryptionconfig_cr.yaml` from [GitHub](#) to make changes specific to your installation.

```
curl -fs https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/scale_v1beta1_encryptionconfig_cr.yaml > scale_v1beta1_encryptionconfig_cr.yaml || echo "Failed to curl EncryptionConfig CR"
```

Set the details in the EncryptionConfig custom resource:

- Replace `keyserver.example.com` with your keyserver hostname
- Replace `keyserver1.example.com`, `keyserver2.example.com`, etc with your backup keyserver hostnames
- Replace `sampleTenant` with your tenant name
- Replace `sampleClient` with your client name
- Replace `sampleRKM` with your RKMID
- If using self-signed certificates, comment out the `cacert` field in the spec

### Limitation

Deleting an EncryptionConfig custom resource does not delete the encryption configuration from the IBM Spectrum Scale container native cluster.

### EncryptionConfig status

Status Conditions can be viewed as a snapshot of the current and most up-to-date status of a EncryptionConfig instance.

- The Success condition is set to True if the EncryptionConfig is successfully configured.

## Creating an IBM Spectrum Scale container native cluster

---

Deploy a cluster by applying the custom resource modified in the *Configuring the IBM Spectrum Scale container native cluster custom resources* procedure.

For more information, see [Configuring the IBM Spectrum Scale container native cluster custom resources](#).

Once the custom resources file is applied, IBM Spectrum Scale Operator creates all the pods that make up an IBM Spectrum Scale container native cluster. Enter the following command to apply the YAML file:

```
oc apply -f ./scale_v1beta1_cluster_cr.yaml
```

If you are in a connected environment, create the `ibm-entitlement-key` pull secret so that deployed resources can gain permission to pull images from the IBM Cloud Container Registry.

```
oc create secret docker-registry ibm-entitlement-key \
--docker-server=cp.icr.io \
--docker-username cp \
--docker-password <REPLACE WITH ICR ENTITLEMENT KEY> -n ibm-spectrum-scale
```

## Creating secrets for the storage cluster GUI

---

Create a secret on the Red Hat OpenShift cluster to store a username and a password for an IBM Spectrum Scale Storage cluster GUI user and password.

This secret is used by the Operator to communicate with the storage cluster while configuring for a remote mount.

Two new secrets must be added for each storage cluster being configured for remote mount on the IBM Spectrum Scale container native cluster.



1. Create a secret for the storage cluster ContainerOperator GUI user.

The username and password specified in this topic must match the GUI user that was created on the storage cluster in the *Creating Operator User and Group* procedure. For more information, see [Creating Operator User and Group](#).

To create the storage cluster GUI user secret named `cnsa-remote-mount-storage-cluster-1` in the `ibm-spectrum-scale` namespace, enter the following command:

**Note:** The name of this secret must match the `secretName` field defined for the RemoteCluster CR. For more information, see [Filesystems](#).

```
oc create secret generic cnsa-remote-mount-storage-cluster-1 --from-
literal=username='cnsa_storage_gui_user' \
--from-literal=password='cnsa_storage_gui_password' -n ibm-spectrum-scale
```

2. Create a secret for the storage cluster CsiAdmin GUI user.

The username and password specified in this topic must match the GUI user that was created on the storage cluster of the *Container Storage Interface (CSI) configuration* procedure. For more information, see [Container Storage Interface \(CSI\) configuration](#).

**Note:** The name of this secret should match the `csiSecretName` field defined for the RemoteCluster CR. For more information, see [Filesystems](#).

3. To create the storage cluster GUI user secret named `csi-remote-mount-storage-cluster-1` in the `ibm-spectrum-scale-csi` namespace, enter the following command:

```
oc create secret generic csi-remote-mount-storage-cluster-1 --from-
literal=username='csi_storage_gui_user' \
--from-literal=password='csi_storage_gui_password' -n ibm-spectrum-scale-csi
```

4. To label the secret, enter the following command:

```
oc label secret csi-remote-mount-storage-cluster-1 -n ibm-spectrum-scale-csi product=ibm-
spectrum-scale-csi
```

## Configuring Certificate Authority (CA) certificates for storage cluster

---

IBM Spectrum Scale container native uses Transport Layer Security (TLS) verification to guarantee secure HTTPS communication with the storage cluster GUI. It verifies the server's certificate chain and host name.

### Configure a security protocol

A security protocol must be configured for use with IBM Spectrum Scale container native in one of three different ways.

#### Option 1 - CA Certificate ConfigMap

A ConfigMap containing the CA certificate of the storage cluster GUI must be created to allow the IBM Spectrum Scale container native operator to perform TLS verification. CA certificate data can exist in base64 encoded or decoded forms.

In the following example, we create a ConfigMap from `storage-cluster-1.crt` file. This file contains the storage cluster CA certificate data in decoded form. The decoded form must appear as shown:

```
# cat storage-cluster-1.crt
-----BEGIN CERTIFICATE-----
MIIDZDC.....
.....
.....n/J90JFdoXs=
-----END CERTIFICATE-----
```

Create the ConfigMap with one of the following two commands. The second command is provided to assist the users who wish to trust the self-signed certificate of the storage cluster GUI.

```
oc create configmap cacert-storage-cluster-1 --from-file=storage-cluster-1.crt=storage-cluster-1.crt -n ibm-spectrum-scale
```

**Note:** By default, the storage cluster GUI self-signs a certificate that can be used in lieu of a CA certificate. This certificate can be obtained and used to create the cacert ConfigMap by entering the following command. Replace the gui host with the hostname of the storage cluster GUI.

```
oc create configmap cacert-storage-cluster-1 --from-literal=storage-cluster-1.crt="$(openssl s_client -showcerts -connect <gui host>:443 </dev/null 2>/dev/null|openssl x509 -outform PEM)" -n ibm-spectrum-scale
```

### Option 2 - Storage Cluster uses the OpenShift Container Platform CA or a Red Hat Default CA

IBM Spectrum Scale container native automatically includes the OpenShift Container Platform CA and the default Red Hat CA bundle for storage cluster GUI communication. If the storage cluster uses the OpenShift Container Platform CA or a Red Hat trusted CA, a ConfigMap, as described in Option 1, does not need to be created for the CA certificate and the cacert field should be deleted from the Filesystem Custom Resource. For more information, see [Filesystems](#).

### Option 3 - Skip Verification

Storage cluster verification may be skipped if desired, however, TLS is susceptible to machine-in-the-middle attacks. To skip verification, the insecureSkipVerify option must be set to true, when configuring the Filesystem Custom Resource. For more information, see [Filesystems](#).

## Storage cluster verification

Events are posted onto the RemoteCluster resource if configuration is missing. For example, if secrets and ConfigMaps are missing, you may see events similar to the following sample:

```
$ oc describe remotecuster remotecuster-sample
...
Events:
  Type      Reason          Age          From          Message
  ----      -
  Warning   RemoteConnError 6m3s        RemoteCluster Secret "cnsa-remote-mount-storage-cluster-1" not found
  Warning   RemoteConnError 3s (x6 over 5m3s) RemoteCluster ConfigMap "cacert-storage-cluster-1" not found
```

## Verifying an IBM Spectrum Scale container native cluster

Verify whether the deployment of an IBM Spectrum Scale container native cluster is done correctly.

Complete the following steps:

**Note:** For more information, see [“Debugging IBM Spectrum Scale deployment”](#) on page 78.

1. Verify that the Operator has created a cluster by checking the pods.

```
oc get pods -n ibm-spectrum-scale
```

A sample output is shown:

```
# oc get pods -n ibm-spectrum-scale
NAME                                READY   STATUS    RESTARTS   AGE
ibm-spectrum-scale-gui-0            4/4     Running  0          5m45s
ibm-spectrum-scale-gui-1            4/4     Running  0          2m9s
ibm-spectrum-scale-pmcollector-0    2/2     Running  0          5m15s
ibm-spectrum-scale-pmcollector-1    2/2     Running  0          4m11s
worker0                              2/2     Running  0          5m43s
worker1                              2/2     Running  0          5m43s
worker3                              2/2     Running  0          5m45s
```

**Note:** The following list includes considerations about the IBM Spectrum Scale cluster creation and its pods:

- The cluster takes some time to create.
- One core pod per node gets created on nodes matching the `nodeSelector`.
- Core pods can take several minutes to move to Running status.
- GUI pods do not achieve the Running status until all the core pods are in a Running status.
- Two GUI pods are created, where the second is created after the first is moved to Running status.
- Two pmcollector pods are created, where the second is created after the first is moved to Running status.
- Resulting cluster should have one core pod per node as specified by the `nodeSelector`, two GUI pods, and two pmcollector pods.

2. Verify that the IBM Spectrum Scale cluster is created correctly:

a. Enter the `mmlscluster` command:

```
oc exec $(oc get pods -lapp.kubernetes.io/name=core \
-ojsonpath="{.items[0].metadata.name}" -n ibm-spectrum-scale) \
-c gpfs -n ibm-spectrum-scale -- mmlscluster
```

The output from the command should show that an IBM Spectrum Scale cluster is created, and all nodes as specified by the `nodeSelector` are present.

```
GPFS cluster information
=====
GPFS cluster name:      ibm-spectrum-scale.mycluster.example.com
GPFS cluster id:       835278197609441888
GPFS UID domain:       ibm-spectrum-scale.mycluster.example.com
Remote shell command:  /usr/bin/ssh
Remote file copy command: /usr/bin/scp
Repository type:       CCR

Node  Daemon node name  IP address      Admin node name  Designation
-----
1     worker2.daemon.ibm-spectrum-scale.stg.mycluster.example.com. 172.29.0.145
worker2.admin.ibm-spectrum-scale.stg.mycluster.example.com. quorum-manager-perfmon
2     worker1.daemon.ibm-spectrum-scale.stg.mycluster.example.com. 172.29.0.146
worker1.admin.ibm-spectrum-scale.stg.mycluster.example.com. quorum-manager-perfmon
3     worker3.daemon.ibm-spectrum-scale.stg.mycluster.example.com. 172.29.0.148
worker3.admin.ibm-spectrum-scale.stg.mycluster.example.com. quorum-manager-perfmon
```

b. Enter the `mmgetstate` command:

```
oc exec $(oc get pods -lapp.kubernetes.io/name=core \
-ojsonpath="{.items[0].metadata.name}" -n ibm-spectrum-scale) \
-c gpfs -n ibm-spectrum-scale -- mmgetstate -a
```

The output from the command should show that the `GPFS state` for all nodes are listed as `active`.

```
Node number  Node name      GPFS state
-----
1           worker0       active
2           worker1       active
3           worker3       active
```

3. Verify that the Remote Cluster authentication is successfully created.

a) Get a list of the remote clusters.

```
oc get remoteclusters -n ibm-spectrum-scale
```

b) Inspect the RemoteClusters and ensure that the value for `READY` is `True`.

Example:

```
# oc get remotecluster -n ibm-spectrum-scale
NAME                                HOST                                READY  AGE
remotecluster-sample                cnsa-storage.example.ibm.com      True   30h
```

4. Verify that the storage cluster file system is configured:

a) Get a list of the file systems:

```
oc get filesystems -n ibm-spectrum-scale
```

b) Inspect the Filesystems and ensure that the value for `ESTABLISHED` is `True`.

```
# oc get filesystems -n ibm-spectrum-scale
NAME                ESTABLISHED  AGE
remote-sample      True         30h
```

5. Manually verify that the file system is mounted by using the `mmlsmount` command.

```
oc exec $(oc get pods -lapp.kubernetes.io/name=core \
-ojsonpath="{.items[0].metadata.name}" -n ibm-spectrum-scale) \
-c gpfs -n ibm-spectrum-scale -- mmlsmount remote-sample -L
```

Example output:

```
File system remote-sample (gpfs1.local:fs1) is mounted on ...
...
172.29.0.148 worker3.daemon.ibm-spectrum-scale.stg.mycluster.example.com. ibm-spectrum-
scale.mycluster.example.com
172.29.0.146 worker1.daemon.ibm-spectrum-scale.stg.mycluster.example.com. ibm-spectrum-
scale.mycluster.example.com
172.29.0.145 worker2.daemon.ibm-spectrum-scale.stg.mycluster.example.com. ibm-spectrum-
scale.mycluster.example.com
```

6. Verify that there are no problems reported in the operator status and events. For more information, see [“Status and events” on page 54](#).

7. Verify that the CSI pods are up and running.

```
oc get pods -n ibm-spectrum-scale-csi
```

8. Verify that the Core DNS pods are up and running. There will be at least one Core DNS pod per core pod.

```
oc get pods -n ibm-spectrum-scale-dns
```

## Status and events

The custom resource (CR) objects contain helpful information which can be retrieved by entering the `oc describe` command.

For each object, a `Status` attribute provides the last observed state of the resource. In the retrieved information, a log of recent `Events` pertaining to the resource is also shown. This information can be helpful to check the desired state of the resource or when debugging with the IBM Spectrum Scale container native cluster. For more information, see [Application Introspection and Debugging](#) in Kubernetes documentation.

The `oc describe <CR> -n ibm-spectrum-scale` command is used to view the `status` and `events` of the custom resources, such as `cluster`, `daemon`, `filesystem`, `remotecluster`, `callhome`, and others.

The `Status` can be seen in the `Conditions` section:

```
$ oc describe callhome -n ibm-spectrum-scale
...
Status:
Conditions:
  Last Transition Time: 2021-08-31T12:54:05Z
```

```

Message:          Callhome is enabled.
Reason:          Enabled
Status:          True
Type:            Enabled
Last Transition Time: 2021-08-31T12:54:07Z
Message:          Successfully tested connection to the IBM Callhome Server.
Reason:          TestPassed
Status:          True
Type:            Success
Mode:            test
...

```

A *Condition* has the following fields:

- *Type*: Type of condition.
- *Status*: Status of the condition, one of True, False or Unknown.
- *Reason*: The reason contains a programmatic identifier indicating the reason for the condition's last transition.
- *Message*: Message is a human readable message indicating details about the transition.
- *Last Transition Time*: This is the last time the condition transitioned from one status to another (For example, from False to True).

The Events section of `oc describe` output lists the *Events*:

```

$ oc describe callhome -n ibm-spectrum-scale
...
Events:
  Type      Reason      Age   From      Message
  ----      -
  Normal    NodeUpdate  44m   Callhome  Callhome was enabled on 0 nodes before, but now it's
  enabled on all 5 nodes.
  Normal    Configured  44m   Callhome  Successfully updated callhome configuration.
  Customer=IBM, CustomerID=123456, Email=sroth@de.ibm.de, Country=DE, Type=test
  Normal    Enabled     44m   Callhome  Callhome has been enabled.

```

Enter the `oc get crd | grep ibm` command to see a full list of CRs that can be checked for status and events with the `oc describe` command.

**Note:**

- The *Events* disappear after they are created.
- The *Status* and *Events* listed above are examples and they look different on your system.



## Chapter 5. Upgrading

Refer to the following sections to upgrade IBM Spectrum Scale container native to the next version:

- “Supported upgrade paths” on page 57
- “Upgrading IBM Spectrum Scale container native” on page 57
- “Post upgrade tasks” on page 58

### Supported upgrade paths

Use this information to understand the supported upgrade paths for IBM Spectrum Scale container native.

The following table lists the supported upgrade paths for IBM Spectrum Scale container native:

*Table 19. Supported upgrade paths*

Upgrade from	Upgrade to 5.1.2.1	Upgrade to 5.1.3.x	Upgrade to 5.1.4.x	Upgrade to 5.1.5.x	Upgrade to 5.1.6.x
5.1.5.x	--	--	--	Yes	Yes
5.1.4.x	--	--	Yes	Yes	No
5.1.3.x	--	--	Yes	No	No
5.1.2.1	--	Yes	Yes	No	No
5.1.1.4	Yes	Yes	No	No	No

### Upgrading IBM Spectrum Scale container native

While an upgrade is in progress, do not perform the following:

- Do not make changes to the `Cluster` custom resource.
- Do not attempt to add a node to the cluster.

**Note:** If upgrading from a version of IBM Spectrum Scale container native less than 5.1.5.0, it is required to first upgrade to 5.1.5.0 before continuing to higher levels.

During an upgrade, the IBM Spectrum Scale operator orchestrates the upgrade procedure in a rolling node-by-node fashion. Each node will be:

- Cordoned (tainted unschedulable)
- Drained (its pods safely evicted and rescheduled to other available nodes)
- Rebooted, if necessary
- Uncordoned (returning it to normal service)

After the node is schedulable, IBM Spectrum Scale and IBM Spectrum Scale Container Storage Interface (CSI) pods will start. Applications may fail to attach storage until the system is started.

To upgrade IBM Spectrum Scale container native to 5.1.6.x, complete the following steps:

1. Stop the running operator pod by setting the `replicas` in the deployment to 0.

```
oc patch deployment ibm-spectrum-scale-controller-manager -n ibm-spectrum-scale-operator \
  --type='json' -p='[{"op": "replace", "path": "/spec/replicas", "value": 0}]'
```

2. Delete the old security context constraint.

```
oc delete scc ibm-spectrum-scale-privileged
```

3. Delete the old role binding for privilege.

```
oc delete rolebinding -nibm-spectrum-scale ibm-spectrum-scale-privileged
```

4. Create the new role binding for reduced privileges.

```
echo 'apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  labels:
    app.kubernetes.io/instance: ibm-spectrum-scale
    app.kubernetes.io/name: cluster
name: ibm-spectrum-scale-restricted
namespace: ibm-spectrum-scale
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: ibm-spectrum-scale-restricted
subjects:
  - kind: ServiceAccount
    name: ibm-spectrum-scale-pmcollector
    namespace: ibm-spectrum-scale
  - kind: ServiceAccount
    name: ibm-spectrum-scale-gui
    namespace: ibm-spectrum-scale
' | oc apply -f -
```

5. Apply the new manifests.

```
oc apply -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/
v5.1.6.0/generated/installer/ibm-spectrum-scale-operator.yaml
```

## Verification

When the new IBM Spectrum Scale container native operator is deployed, the upgrade process begins. It takes some time to complete as the new code is rolled out into the cluster.

You can check the progress of pod restarts and node reboots by looking at information provided in the Daemon CR under `.status.statusDetails`. Query the Daemon CR using the following command:

```
oc describe daemon -n ibm-spectrum-scale
```

## Code version updated

The version details will be listed under `.status.versions` in the Daemon CR and will be updated as the pods roll. The following command will show the versions that core pods currently have on them. Wait until all the pods are reporting the same new version.

```
oc get daemon -n ibm-spectrum-scale -ojson | jq -r .items[].status.versions
```

## Post upgrade tasks

---

It describes actions that should be performed on the cluster to complete the upgrade of IBM Spectrum Scale container native to the new code levels.

### Approve the new release level

It is recommended to first use the cluster with the new code of IBM Spectrum Scale installed, until you are sure to permanently upgrade the cluster to the new level. When you are ready to enable the new functionality of the installed release and lock in the new level, you need to approve an `UpgradeApproval` resource. An `UpgradeApproval` resource is automatically created by the operator if a release level change is detected after the upgrade.



For more information, see [File system format changes between versions of IBM Spectrum Scale in IBM Spectrum Scale documentation](#).

Complete the following steps:

1. Check to see if any cluster upgrade approvals are present that require action.

**Note:** An upgrade approval that shows nothing under the `COMPLETED` field are ones that require some action.

```
oc get upgradeapproval -n ibm-spectrum-scale
```

**Note:** If an upgrade approval does not appear, check the Daemon CR status to ensure that all pods are on the new version using `oc get daemon -n ibm-spectrum-scale -ojson | jq -r .items[].status.versions`

2. Check the `minReleaseLevel` of the cluster:

```
oc exec $(oc get pods -lapp.kubernetes.io/name=core -ojsonpath="{.items[0].metadata.name}" \
-n ibm-spectrum-scale) -c gpfs -n ibm-spectrum-scale -- mmlsconfig release
```

3. To approve the upgrade approval job, execute the following command:

```
oc patch upgradeapproval <upgradeapproval-name> -n ibm-spectrum-scale --type='json' \
-p='[{"op": "replace", "path": "/spec/approved", "value":true}]'
```

Full Example:

```
# Check for any upgrade approvals for TYPE=cluster
$ oc get upgradeapproval -n ibm-spectrum-scale
NAME          TYPE          FILESYSTEM    LAST SCHEDULE TIME    LAST SUCCESSFUL TIME    RUNNING
COMPLETED
upgrade-rlp4  cluster
upgrade-rlp4  cluster

# check the daemon status for the versions deployed on each core pod
$ oc get daemon -n ibm-spectrum-scale -ojson | jq .items[].status.versions
[
  {
    "count": "3",
    "version": "5.1.6.0"
  }
]

# check the current cluster release version
$ oc exec $(oc get pods -lapp.kubernetes.io/name=core -ojsonpath="{.items[0].metadata.name}"
-n ibm-spectrum-scale) -c gpfs -n ibm-spectrum-scale -- mmlsconfig release
minReleaseLevel 5.1.5.0

# patch the upgrade approval
$ oc patch upgradeapproval upgrade-rlp4 -n ibm-spectrum-scale \
> --type='json' -p='[{"op": "replace", "path": "/spec/approved", "value":true}]'
upgradeapproval.scale.spectrum.ibm.com/upgrade-rlp4 patched

# query the upgrade approval to see it running
$ oc get upgradeapproval -n ibm-spectrum-scale
NAME          TYPE          FILESYSTEM    LAST SCHEDULE TIME    LAST SUCCESSFUL TIME    RUNNING
COMPLETED
upgrade-rlp4  cluster      gpfs          23s                   6s                       ibm-
spectrum-scale/worker2/gpfs/upgradeCluster_p6Jhz9

# upgrade approval job completed
$ oc get upgradeapproval -n ibm-spectrum-scale
NAME          TYPE          FILESYSTEM    LAST SCHEDULE TIME    LAST SUCCESSFUL TIME    RUNNING
COMPLETED
upgrade-rlp4  cluster      gpfs          38s                   6s                       Successful

# verify that the cluster release level has been updated
$ oc exec $(oc get pods -lapp.kubernetes.io/name=core -ojsonpath="{.items[0].metadata.name}"
-n ibm-spectrum-scale) -c gpfs -n ibm-spectrum-scale -- mmlsconfig release
minReleaseLevel 5.1.6.0
```

For more information, see [Completing the upgrade to a new level of IBM Spectrum Scale in IBM Spectrum Scale documentation](#).

## Remote storage cluster considerations

The storage cluster is supported to be down-level from the IBM Spectrum Scale container native cluster, but it is strongly recommended that the versions match. CSI functionality is highly dependent upon the IBM Spectrum Scale release, filesystem level, and version, installed on the storage cluster. If the storage cluster is running an earlier version, some functionality may not be available. For more information about CSI features and required levels, see *Table 1 in Hardware and Software Requirements* in IBM Spectrum Scale CSI documentation. For more information about compatibility and software matrix, see [Section 17.3](#) in IBM Spectrum Scale FAQ documentation.

- Run the following step for each filesystem to upgrade to the latest metadata format:



**Warning:** If the storage cluster is being mounted by other GPFS client clusters that are running lower version of code, performing this step makes those client cluster unable to mount filesystems from this storage cluster.

```
mmchfs <Filesystem> -V full
```

**Note:** This step is optional but recommended for enabling the functionality provided at the latest levels of code.

- Enable `auto-inode-limit` of the file system.

```
mmchfs <Filesystem> --auto-inode-limit
```

**Note:** The `--auto-inode-limit` option is available only at filesystem format level of 28.00 or later. Enable this option as soon as the filesystem is updated to 28.00 or later.

---

# Chapter 6. Configuring IBM Spectrum Scale Container Storage Interface (CSI) driver

Use the following sections to help with deploying IBM Spectrum Scale CSI with IBM Spectrum Scale container native:

- [“Configuring storage class to use CSI driver” on page 61](#)
- [“Managed CSI fields” on page 62](#)
- [“Setting primary file set” on page 62](#)

---

## Configuring storage class to use CSI driver

Storage class is used for creating lightweight volumes and fileset based volumes.

### Lightweight (directory) based volumes

A storage class example for creating directory (lightweight) based volumes is provided.

**Note:** Adjust the parameters as per your environment.

```
# cat storageClass_Lightweight.yaml
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: ibm-spectrum-scale-csi-lt
provisioner: spectrumscale.csi.ibm.com
parameters:
  volBackendFs: "fs1"
  volDirBasePath: "pvfileset/lwdir" # relative path from filesystem mount point for creating
lightweight volume
reclaimPolicy: Delete
```

```
oc create -f storageClass_Lightweight.yaml
```

### Fileset based volumes

A storage class example for creating fileset based volumes is provided.

**Note:** Adjust the parameters as per your environment.

```
# cat storageClass_fileset.yaml
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: ibm-spectrum-scale-csi-fileset
provisioner: spectrumscale.csi.ibm.com
parameters:
  volBackendFs: fs1
  clusterId: "17797813605352210071" # cluster ID of storage cluster
reclaimPolicy: Delete
```

A sample fileset based storage class is created by using a primary file system as the volBackendFs. It can be used to create other storage classes with the remote cluster ID that is provided. Enter the **oc get storageclass -oyaml > storageClass\_fileset.yaml** command to create a copy of this storage class. Then configure parameters as desired and create the configured storage class using the command below:

```
oc create -f storageClass_fileset.yaml
```

**Note:** For more information, see [Storage Class](#) in IBM Spectrum Scale CSI documentation.

## Managed CSI fields

In the CSI Custom Resource (CR) that is created by the CSI Controller, there are some fields that are managed by the controller. If these fields are changed, they are overridden by the controller. If required, you can change any field that is not managed by the controller.

### Managed fields

**Note:** The following fields are populated with default values by the CSI Controller. Any new values are honored, however, any values that are manually removed are repopulated upon the next controller reconcile cycle.

*Table 20. Managed fields description*

Field	Default Value(s)
clusters	Two entries are created by default (local and remote clusters).
clusters.id	Local Cluster ID / Cluster ID of Remote cluster.
clusters.secrets	ibm-spectrum-scale-gui-csiadmin
clusters.secureSSLMode	false
clusters.primary.primaryFs	The name of the first file system created (only applicable in local. cluster entry).
clusters.restApi.guiHost	ibm-spectrum-scale.<container-native-namespace> for local cluster entry and the host specified in the remote cluster CR for the remote cluster entry.
tolerations	NoSchedule, NoExecute and CriticalAddonsOnly
attacherNodeSelector	scale=true
provisionerNodeSelector	scale=true
pluginNodeSelector	scale=true
snapshotterNodeSelector	scale=true

### Editing the CSI CR

To edit a CSI CR, enter this command and fill the desired field:

```
oc edit csiscaleoperator -n ibm-spectrum-scale-csi
```

## Setting primary file set

After the CSI CR is created by the CSI controller a primary file set needs to be set in order to avoid the naming conflict. Once this field is added the CSI driver pods are deleted and recreated one by one.

Enter the `oc edit csiscaleoperator -n ibm-spectrum-scale-csi` command and add the `primaryFset` field:

```
clusters:
  - id: "11171289193543683780"
    secrets: "secret-cnfsa"
    secureSslMode: false
    primary:
```

```
primaryFs: "fs5"
primaryFset: "cluster1-fset" #<---- example
remoteCluster: "2303539379337927879"
restApi:
  - guiHost: "ibm-spectrum-scale-gui.ibm-spectrum-scale"

- id: "2303539379337927879"
  secrets: "secret-storage"
  restApi:
    - guiHost: "koopa-gui-1.fyre.ibm.com"
```



# Chapter 7. Using IBM Spectrum Scale GUI

You can refer to the mapping of OpenShift users to IBM Spectrum Scale GUI user groups for accessing the IBM Spectrum Scale GUI.

- [“IBM Spectrum Scale container native GUI” on page 65](#)

## IBM Spectrum Scale container native GUI

You can manage and monitor cluster and node information through the IBM Spectrum Scale container native GUI.

### OpenShift Users

All OpenShift users are mapped to two IBM Spectrum Scale GUI user groups. Details are provided in the following table:

*Table 21. Roles and privileges*

Roles			Privileges		
OCP role	GUI role	View	<sup>1</sup> Download snap	<sup>2</sup> Manage events	Test connection for call home
Cluster admin	Maintenance	Yes	Yes	Yes	Yes
Kubeadmin	Maintenance	Yes	Yes	Yes	Yes
View	Monitor	Yes	Yes	No	Yes

<sup>1</sup> Ability to download master and non-master snaps.

<sup>2</sup> Ability to mark events as resolved, hiding resolved tips and notifications.

### Accessing the IBM Spectrum Scale GUI

Users created on the OpenShift Container Platform (OCP) can log in to the IBM Spectrum Scale container native GUI through single-sign-on (SSO) by using the OAuth implementation.

To access the IBM Spectrum Scale GUI, complete the following steps:

1. In a browser, navigate to `https://ibm-spectrum-scale-gui-ibm-spectrum-scale.apps.<ocp domain>/`, where `<ocp domain>` is the domain of your OpenShift cluster. You should see the IBM Spectrum Scale GUI login page.

If the domain is `ocp4.example.com`, the URL would be `https://ibm-spectrum-scale-gui-ibm-spectrum-scale.apps.ocp4.example.com`.

2. Click **Sign in**, which redirects to the Red Hat OpenShift Container Platform login page.
3. Authenticate by using your OCP user credentials.

On success, you are redirected back to the IBM Spectrum Scale GUI home page.





---

## Chapter 8. Maintenance of a deployed cluster

The maintenance of a deployed IBM Spectrum Scale container native cluster includes certain procedures.

---

### Shutting down a cluster

Before you begin the maintenance procedure, the IBM Spectrum Scale container native cluster must be shut down to avoid any issues.

**Note:** For more information, see [On the nodes running CSI sidecars in IBM Spectrum Scale CSI documentation](#).

Complete the following steps to shut down a cluster:

1. Enter the following command to scale the number of IBM Spectrum Scale container native operators to 0:

```
oc edit deploy -n ibm-spectrum-scale-operator
```

Set number of replicas to 0:

```
...
spec:
  progressDeadlineSeconds: 600
  replicas: 0
...
```

2. Enter the following command to remove a CSI label:

```
oc label node --all scale-
```

3. Enter the following command to delete the running core pods:

```
oc delete pods -lapp.kubernetes.io/name=core -n ibm-spectrum-scale
```

---

### IBM Spectrum Scale container native cluster and node maintenance

The following section provides information on changing the IBM Spectrum Scale cluster configuration.

#### Limitations

While a configuration change is in progress, do not perform the following:

- Do not upgrade IBM Spectrum Scale container native.
- Do not attempt to add a node to the cluster.
- Do not upgrade Red Hat OpenShift.

#### Updating existing cluster configuration

IBM Spectrum Scale cluster configuration is controlled by the Cluster resource.

To edit configuration for an existing cluster:

```
oc edit cluster.scale
```

When a core pod configuration requires an update, the IBM Spectrum Scale operator will cordon, drain, reboot (if necessary), and uncordon the node. This is performed one node at a time. Once the drain is complete, the core pod will be updated with the new configuration.

**Note:** If the node was previously cordoned before the update, the operator will not uncordon the node.

## Updating cluster configuration through upgrade

An upgrade of IBM Spectrum Scale container native is also considered an update of the cluster configuration, as this will likely introduce changes to pod specification, for example, update of container images.

For more information about how IBM Spectrum Scale Operator orchestrates an upgrade, see [IBM Spectrum Scale container native upgrade](#).

## Red Hat OpenShift maintenance

---

When a Red Hat OpenShift administrator needs to perform maintenance on a node that involves a drain, the IBM Spectrum Scale operator will intercept and handle the updates safely. If the operator is not running, the interception and drain fails.

### Limitations

While Red Hat OpenShift configuration or maintenance is in progress, do not perform the following:

- Do not update IBM Spectrum Scale container native configuration.
- Do not upgrade IBM Spectrum Scale container native.
- Do not attempt to add a node to the cluster.

In addition, deadlock is possible waiting for applications to safely evict from nodes undergoing maintenance. This can occur if too many nodes are undergoing maintenance concurrently, and application workload is disrupted if further action is taken. In these cases, the OpenShift administrator should safely evict and reschedule impacted applications.

For more information about troubleshooting cluster maintenance issues, see [Identifying applications preventing cluster maintenance](#)

### Red Hat OpenShift cluster configuration update

Red Hat OpenShift machine configuration is managed by the Machine Config Operator (MCO). When configuration changes impact node operation, MCO cordon and drain nodes to perform the maintenance action. Existing pods on the node will be evicted and rescheduled to another available node. The IBM Spectrum Scale operator intercepts requests from the Kubernetes scheduler to ensure that the applications running IBM Spectrum Scale storage workloads are removed before the IBM Spectrum Scalecore pod on the corresponding node. This allows the application to gracefully shutdown before storage access on the node is disrupted.

Once the core pod is safely removed, the MCO update continues and reboots the node, if necessary. After the MCO update is complete, the node gets uncordoned and schedulable.

### OpenShift node administrator maintenance

When an OpenShift administrator needs to perform manual maintenance on a node, it should be cordoned and safely drained of pods. The cordon will taint the node as unschedulable and safely evicts applications. This allows the application to reschedule to other available nodes, and notifies the IBM Spectrum Scale operator about the desired node maintenance.

1. Drain the node requiring maintenance. The drain command also cordons the node.

```
oc adm drain <node name>
```

2. Once drain completes without error, the node can then have maintenance performed, for example, powering it down.
3. When maintenance is complete, unordon the node to allow it to resume normal operation and scheduling.

```
oc adm unordon <node name>
```

## Starting the cluster after shutdown

If the IBM Spectrum Scale cluster was shut down, start the cluster by using the following steps:

**Note:** Ensure that the worker nodes are in the Ready state before restarting the IBM Spectrum Scale cluster by entering the `oc get nodes` command. If any of the worker nodes are in a state other than Ready, the IBM Spectrum Scale cluster fails to restore.

Scale the number of operator pods back to 1.

```
oc edit deploy -n ibm-spectrum-scale-operator
```

Set number of replicas to 1:

```
...
spec:
  progressDeadlineSeconds: 600
  replicas: 1
...
```

After the operator pod comes back up, the core pods are rescheduled and the default CSI label is re-applied.

## Adding a new node to an existing cluster

To add a new node:

- Ensure the new node belongs to the existing Machine Config Pool configured to include the kernel-level extensions. This was configured as a prerequisite to IBM Spectrum Scale container native installation, and defaults to Red Hat OpenShift `worker` nodes. For more information, see [Red Hat OpenShift Container Platform configuration](#).
- Ensure the new node has a node selector that matches the existing cluster's node selector. For more information, see [Cluster CR Node Selector for IBM Spectrum Scale pods](#).

When the node selector is recognized by the IBM Spectrum Scale Operator, a pod is created on the new node and it goes to running state within a few minutes.

Check the progress of the creation of the new pod by entering the following command:

```
oc get pods -n ibm-spectrum-scale
```

Ensure that the new pod is ready by entering the following command:

```
oc exec <scale-pod> -n ibm-spectrum-scale -- mmgetstate -a
```

The output appears as shown:

Node number	Node name	GPFS state
1	worker1	active
2	new node	arbitrating
3	worker0	active

Once the pod has finished arbitrating and enters the active state, CSI will automatically be configured for use by the pod by the IBM Spectrum Scale and CSI Operators. Once CSI has completed configuration, then the newly added node can be used for running applications.

**Note:** When adding nodes, it makes sense to select additional quorum nodes. For more information, see [“Labels and annotations” on page 31](#).

---

## Chapter 9. Cleaning up the container native cluster

To safely remove the pods or perform other maintenance actions, the IBM Spectrum Scale container native cluster must be manually shut down before performing these operations. The following procedures outline the steps to complete these actions and validate that it is safe to shut down the cluster.

- [“Deleting a cluster” on page 71](#)
- [“Removing applications” on page 71](#)
- [“Custom Resource” on page 71](#)
  - [“Filesystems” on page 71](#)
  - [“Remote Clusters” on page 72](#)
- [“Cleaning up IBM Spectrum Scale operator” on page 73](#)
- [“Cleaning up the worker nodes” on page 73](#)
- [“Cleaning up on a storage cluster” on page 74](#)

---

### Deleting a cluster

When deleting an entire cluster, all applications and the IBM Spectrum Scale Container Storage Interface driver must be unloaded before the unmount and shutdown steps.

---

### Removing applications

Complete the following steps:

**Note:** Ensure that you are in the project for IBM Spectrum Scale Container Storage Interface (CSI) driver.

1. Enter the following command to query the PVC to identify the applications that are active.

```
oc describe <csi pvc>
```

2. Enter the following command to remove all the applications. This requires the node to be drained of all data.

```
oc delete <application deployment or daemonSet from csi pvc describe output>
```

---

### Custom Resource

There can be situations when you need to change the custom resource definitions but not clean up the whole container native cluster. The following sections describe how to clean up the IBM Spectrum Scale artifacts when only deleting custom resource definitions.

- [“Filesystems” on page 71](#)
- [“Remote Clusters” on page 72](#)

### Filesystems

Deleting a Filesystem custom resource does not result in the operator un-mounting or deleting the remote mount file system configuration on the IBM Spectrum Scale container native cluster.

Before removing the configuration of the remote mounted file system, ensure that there are no applications actively writing to the file system.

In this example, the Filesystem to be removed is named as `remote-sample`:

```
kind: Filesystem
metadata:
  ...
  name: remote-sample
spec:
  remote:
    cluster: remoteclasser-sample
    fs: fs1
```

Complete the following steps:

1. Enter the following command to delete the file system from OpenShift.

```
oc delete filesystem remote-sample -n ibm-spectrum-scale
```

2. Log in to a core pod by using the following command to remove the file system from IBM Spectrum Scale.

```
oc rsh -n ibm-spectrum-scale worker0
```

- Unmount the file system on all the container native pods.

```
mmunmount remote-sample -a
```

- Delete the remote file system.

```
mmremotefs delete remote-sample
```

3. If the remote storage cluster is only configured to mount and serve the single `remote-sample` file system, you can delete the remote cluster definition. Otherwise, the other file system(s) must be deleted by using the same process mentioned in the above step.

- Find the remote clusters.

```
mmremoteclasser show all
```

- Delete the remote cluster that is serving the remote file system. For example, to delete a remote cluster named `gpfs.storage`.

```
mmremoteclasser delete gpfs.storage
```

## Remote Clusters

Deleting a `RemoteCluster` custom resource does not result in the operator deleting the access permission of an IBM Spectrum Scale container native cluster to the file systems on a remote storage cluster. The `RemoteCluster` controller only handles creating the access permissions.

Before removing the remote cluster credentials, ensure that no additional file systems are using this credential.

For this example, the sample `RemoteCluster` is used:

```
kind: RemoteCluster
metadata:
  name: remoteclasser-sample
spec:
  ...
```

Perform the following steps:

1. Delete the `RemoteCluster` definition from OpenShift by entering the following command:

```
oc delete remoteclasser remoteclasser-sample -n ibm-spectrum-scale
```

2. Delete the secure credentials on the storage cluster. For more information, see [“Cleaning up on a storage cluster”](#) on page 74.

## Cleaning up IBM Spectrum Scale operator

---

Complete the following steps:

1. Enter the following command to delete the IBM Spectrum Scale Custom Resources.

```
oc delete -f scale_v1beta1_cluster_cr.yaml -n ibm-spectrum-scale
```

2. Enter the following command to uninstall the Operator, related objects, and namespaces.

```
oc delete -f https://raw.githubusercontent.com/IBM/ibm-spectrum-scale-container-native/v5.1.6.0/generated/installer/ibm-spectrum-scale-operator.yaml
```

3. Enter the following command to clean up the performance monitoring and IBM Spectrum Scale CSI artifacts.

- a) Enter the following command to list the PVs with claim of `datadir-ibm-spectrum-scale-scale-pmcollector`. Two PVs are returned.

```
oc get pv -lapp.kubernetes.io/instance=ibm-spectrum-scale,app.kubernetes.io/name=pmcollector
oc delete pv -lapp.kubernetes.io/instance=ibm-spectrum-scale,app.kubernetes.io/name=pmcollector
```

- b) Enter the following command to delete the Storage Classes created by performance monitoring and IBM Spectrum Scale CSI artifacts:

```
oc delete sc -lapp.kubernetes.io/instance=ibm-spectrum-scale,app.kubernetes.io/name=pmcollector
oc delete sc ibm-spectrum-scale-sample
```

**Note:** If the current namespace was deleted in these steps (`ibm-spectrum-scale`, `ibm-spectrum-scale-operator`, `ibm-spectrum-scale-csi`), then the working namespace should be changed to an existing one.

```
oc project default
```

## Cleaning up the worker nodes

---

IBM Spectrum Scale requires host path volume mounts and creates directories on each worker node.

**Note:** At this point, the project is deleted. Ensure that you are in the default namespace by entering **oc project default** command.

Complete the following steps:

1. Enter the following command to list the nodes that have the `node-role.kubernetes.io/worker=` label.

```
oc get nodes -l 'node-role.kubernetes.io/worker=' -o jsonpath="{range .items[*]}{.metadata.name}{'\n'}"
```

2. For each of the listed worker nodes, enter the following command to create a debug pod that removes the kernel modules and the host path volume mounted directories used by IBM Spectrum Scale:

```
oc debug node/<openshift_worker_node> -T -- chroot /host sh -c "rm -rf /var/mmfs; rm -rf /var/adm/ras; immmod tracedev mmfs26 mmfslinux;"
```

Example:

```
oc debug node/worker0.example.com -T -- chroot /host sh -c "rm -rf /var/mmfs; rm -rf /var/adm/ras; immmod tracedev mmfs26 mmfslinux;"
```

```
Starting pod/worker0examplecom-debug ...
To use host binaries, run `chroot /host`
Removing debug pod ...
```

3. Ensure that none of the artifacts are left by entering the following command:

```
oc debug node/<openshift_worker_node> -T -- chroot /host sh -c "ls /var/mmfs; ls /var/adm/
ras; rmmmod tracedev mmfs26 mmfslinux;"
```

Example:

```
oc debug node/worker0.example.com -T -- chroot /host sh -c "ls /var/mmfs; ls /var/adm/ras;
rmmmod tracedev mmfs26 mmfslinux;"
Starting pod/worker0examplecom-debug ...
To use host binaries, run `chroot /host`
ls: cannot access '/var/mmfs': No such file or directory
ls: cannot access '/var/adm/ras': No such file or directory
rmmmod: ERROR: Module tracedev is not currently loaded
rmmmod: ERROR: Module mmfs26 is not currently loaded
rmmmod: ERROR: Module mmfslinux is not currently loaded
Removing debug pod ...
error: non-zero exit code from debug container
```

4. Remove node labels created by the IBM Spectrum Scale container native operator:

```
oc label node --all scale.spectrum.ibm.com/role-
oc label node --all scale.spectrum.ibm.com/designation-
oc label node --all scale-
```

## Cleaning up on a storage cluster

---

Delete the access permission that is granted to the IBM Spectrum Scale client cluster for mounting a remote file system.

Perform the following steps on the IBM Spectrum Scale storage cluster:

1. Enter the following command to query the name of the containerized client cluster:

```
$ mmauth show all | grep ibm-spectrum-scale
Cluster name: ibm-spectrum-scale.clustername.example.com
```

2. Enter the following command to remove the client cluster authorization:

```
$ mmauth delete ibm-spectrum-scale.clustername.example.com
mmauth: Propagating the cluster configuration data to all affected nodes.
mmauth: Command successfully completed
```



---

## Chapter 10. Monitoring

The IBM Spectrum Scale container native cluster is monitored by sending the health status and events between its pods.

- [“System monitor and Kubernetes readiness probe” on page 75](#)
- [“Viewing and analyzing the performance data with the IBM Spectrum Scale bridge for Grafana” on page 75](#)

---

### System monitor and Kubernetes readiness probe

The scale-monitor sidecar container has the following objectives:

- Runs the containermon service which is monitoring the service (GUI, pmcollector) in the same pod.
- Provides a readiness probe API (HTTPS).
- Sends the health status and events back to the core pod on the same worker node.
- Core pod is forwarding the events to GUI or mmhealth.
- Provides an API for call home data collection.
- Has several debug tools installed and can be used for problem determination.

**Note:**

For more information, see [Container probes](#) in Kubernetes documentation.

If the monitoring status is HEALTHY, the probe returns success 200. When the `unreadyOnFailed` option is enabled in `containermon.conf` (default=true), any FAILED state causes the probe to return 500. When a critical event occurred which has the `container_unready=True` flag, the probe returns 501. When the service faces an issue, for example, no service found, it returns 502.

---

### Viewing and analyzing the performance data with the IBM Spectrum Scale bridge for Grafana

IBM Spectrum Scale has built-in performance monitoring tool that collects metrics from various GPFS components.

These metrics can provide you with a status overview and trends of the key performance indicators. You can view and analyze the collected performance data with Grafana, a third-party visualization software.

For using Grafana, you need a running Grafana instance and the IBM Spectrum Scale performance monitoring bridge for Grafana deployed on your IBM Spectrum Scale container native cluster. For more information, see [IBM Spectrum Scale bridge for grafana repository](#) in GitHub.

The IBM Spectrum Scale bridge for Grafana is an open source tool, available for free usage on IBM Spectrum Scale devices. It translates the metadata and performance data collected by the IBM Spectrum Scale performance monitoring tool to query requests acceptable by the Grafana-integrated openTSDB plugin.

The IBM Spectrum Scale performance monitoring bridge for Grafana could be deployed automatically through the operator. For more information, see [“Configuring the IBM Spectrum Scale container native cluster custom resources” on page 36](#).

For more information about setting up a Grafana instance for monitoring the IBM Spectrum Scale container native cluster, see [Setup Grafana for monitoring a IBM Spectrum Scale container native cluster in a k8s OCP environment](#) in GitHub documentation.



---

# Chapter 11. Troubleshooting

Use the following sections to help troubleshoot and debug specific issues with the IBM Spectrum Scale container native deployment.

- [“Debugging PVC creation issue : PVC binding in pending state” on page 77](#)
- [“Debugging the IBM Spectrum Scale operator” on page 77](#)
- [“Debugging IBM Spectrum Scale deployment” on page 78](#)
- [“Debugging the IBM Spectrum Scale Container Storage Interface \(CSI\) deployment” on page 80](#)
- [“Debugging OCP upgrade” on page 81](#)
- [“Identifying applications preventing cluster maintenance” on page 82](#)
- [“Common issues” on page 83](#)
- [“Known issues” on page 86](#)
- [“Collecting data for support” on page 91](#)

---

## Debugging PVC creation issue : PVC binding in pending state

If there are PVC creation issues:

1. Check if multiple GUI's are installed at the remote storage cluster.
2. SSH to one of the GUI node and run the following command:

```
mmlsfileset <filesystem name>
```

3. Check if fileset is unlinked.

If multiple GUI's are installed then contact IBM support for further guidance.

---

## Debugging the IBM Spectrum Scale operator

### Problem: The operator pod is not successfully deployed

No operator pod appears when running `oc get pods -n ibm-spectrum-scale-operator`.

- Verify that all worker nodes in the Red Hat OpenShift Container Platform cluster are in a Ready state. If not, the operator pod may not have an eligible node to be deployed to.

```
# oc get nodes
NAME                STATUS    ROLES    AGE   VERSION
master0.example.com Ready     master   65d   v1.18.3+6c42de8
master1.example.com Ready     master   65d   v1.18.3+6c42de8
master2.example.com Ready     master   65d   v1.18.3+6c42de8
worker0.example.com NotReady  worker   65d   v1.18.3+6c42de8
worker1.example.com NotReady  worker   65d   v1.18.3+6c42de8
worker2.example.com NotReady  worker   65d   v1.18.3+6c42de8
```

- Inspect the operator namespace and look for details that may point to any problems.

```
oc get deployment -n ibm-spectrum-scale-operator
oc describe deployment ibm-spectrum-scale-controller-manager -n ibm-spectrum-scale-operator

oc get replicaset -n ibm-spectrum-scale-operator
oc describe replicaset <replicaset name> -n ibm-spectrum-scale-operator
```

## Problem: Operator pod shows container restarts

- Kubernetes keeps the logs of the current container and the previous container. Take a look at the previous container's logs for any clues by using the following command:

```
oc logs -p <operator pod> -n ibm-spectrum-scale-operator
```

## Debugging IBM Spectrum Scale deployment

### Problem: No endpoints available for service "ibm-spectrum-scale-webhook-service"

When applying the cluster CR or making changes to IBM Spectrum Scale container native Custom Resources, it is possible that validating or mutating webhooks can fail if the operator pod is unavailable. If you receive an error regarding `no endpoints for service "ibm-spectrum-scale-webhook-service"`, check the status of the operator pod.

Example error:

```
# oc apply -f scale_v1beta1_cluster_cr.yaml
namespace/ibm-spectrum-scale unchanged
serviceaccount/ibm-spectrum-scale-core configured
serviceaccount/ibm-spectrum-scale-default configured
serviceaccount/ibm-spectrum-scale-gui configured
serviceaccount/ibm-spectrum-scale-pmcollector configured
role.rbac.authorization.k8s.io/ibm-spectrum-scale-sysmon unchanged
rolebinding.rbac.authorization.k8s.io/ibm-spectrum-scale-privileged unchanged
rolebinding.rbac.authorization.k8s.io/ibm-spectrum-scale-sysmon unchanged
callhome.scale.spectrum.ibm.com/callhome unchanged
remotecluster.scale.spectrum.ibm.com/remotecluster-sample unchanged
Error from server (InternalError): error when creating "scale_v1beta1_cluster_cr.yaml":
Internal error occurred: failed calling webhook "mcluster.scale.spectrum.ibm.com":
failed to call webhook: Post "https://ibm-spectrum-scale-webhook-service.ibm-spectrum-
scale-operator.svc:443/mutate-scale-spectrum-ibm-com-v1beta1-cluster?timeout=10s": no endpoints
available for service "ibm-spectrum-scale-webhook-service"
Error from server (InternalError): error when creating "scale_v1beta1_cluster_cr.yaml":
Internal error occurred: failed calling webhook "vfilesystem.scale.spectrum.ibm.com":
Post "https://ibm-spectrum-scale-webhook-service.ibm-spectrum-scale-operator.svc:443/validate-
scale-spectrum-ibm-com-v1beta1-filesystem?timeout=10s": no endpoints available for service "ibm-
spectrum-scale-webhook-service"
```

Checking status of the operator pod:

```
# oc get pods -n ibm-spectrum-scale-operator
NAME                                READY   STATUS
RESTARTS      AGE
pod/ibm-spectrum-scale-controller-manager-64bb4798df-rrj4j  0/1     ImagePullBackOff  10
(4m14s ago)    34m
```

In the above example, it appears that there might be some issue with image pull credentials. As a remedy to the `no endpoints available` issue, the operator issue must be resolved first. Once it is resolved, perform the steps again that failed with `no endpoints available`.

### Problem: Core, GUI, or collector pods are in ErrImgPull or ImagePullBackOff state

When viewing `oc get pods -n ibm-spectrum-scale`, if any of the pods are in `ErrImgPull` or `ImagePullBackOff` state, use `oc describe pod <podname>` to get more details on the pod and look for any errors that may be happening.

```
oc describe pod <pod-name> -n ibm-spectrum-scale
```

## Problem: Core, GUI, or collector pods are not up

- If the pods are not deployed in the `ibm-spectrum-scale` namespace, or a cluster is not created, examine the operator pod logs:

```
oc logs $(oc get pods -n ibm-spectrum-scale-operator -ojson | jq -r
".items[0].metadata.name") -n ibm-spectrum-scale-operator
```

## Problem: Core, GUI, or collector pods show container restarts

- Kubernetes keeps the logs of the current container and the previous container. Check the previous container's logs for any clues by using the following command:

```
oc logs -p <scale pod> -n ibm-spectrum-scale
```

## Problem: Core pods are stuck in Init:1/2

If for some reason, an IBM Spectrum Scale container native cluster fails to create the core pods on the worker nodes get stuck in the Init container.

```
# oc get pods
NAME                                READY   STATUS    RESTARTS   AGE
...
worker0                             2/2    Init:1/2   0          2h
worker1                             2/2    Init:1/2   0          2h
worker2                             2/2    Init:1/2   0          2h
worker3                             2/2    Init:1/2   0          2h
```

There is no recovery from this. For more information about clean up, see [“Cleaning up IBM Spectrum Scale operator”](#) on page 73 and [“Cleaning up the worker nodes”](#) on page 73. For more information about redeploy, see [Chapter 4, “Installing the IBM Spectrum Scale container native operator and cluster,”](#) on page 31.

## Problem: All pods have been deployed but a GPFS cluster is stuck in the "arbitrating" state

If the cluster is stuck in the arbitrating state:

- Check the output of `mmlscluster`.

```
oc exec $(oc get pods -lapp.kubernetes.io/name=core -n ibm-spectrum-scale -o json | jq -r
".items[0].metadata.name") -- mmlscluster
```

- Check the GPFS logs.

```
oc logs $(oc get pods -lapp.kubernetes.io/name=core -n ibm-spectrum-scale -o json | jq -r
".items[0].metadata.name") -c logs | grep mmfs.log.latest
```

## Problem: A remote mount file system not getting configured or mounted

- Check the `RemoteCluster` objects and the `Filesystem` objects. The `Filesystem` controller waits until a `RemoteCluster` object is `Ready` before attempting to configure the remote mount file system. Describe the objects and check `Status` or `Events` for any reasons for failures.

– Remote Clusters

```
oc get remoteclusters -n ibm-spectrum-scale
oc describe remotecluster <name> -n ibm-spectrum-scale
```

– Filesystems

```
oc get filesystems -n ibm-spectrum-scale
oc describe filesystem <name> -n ibm-spectrum-scale
```

Check the Status and Events for any reason of failures.

If nothing, check the operator logs for any errors:

```
oc logs $(oc get pods -n ibm-spectrum-scale-operator -ojson | jq -r ".items[0].metadata.name") -n ibm-spectrum-scale-operator
```

- Enter the `mmnetverify` command to verify the network between the clusters. For more information, see [mmnetverify command](#) in IBM Spectrum Scale documentation.

## Debugging the IBM Spectrum Scale Container Storage Interface (CSI) deployment

### Problem: CSI pods stuck in CrashLoopBackOff (Unauthorized GET request)

```
# oc get pods
NAME                                READY   STATUS             RESTARTS   AGE
ibm-spectrum-scale-csi-95661        1/2    CrashLoopBackOff   9           26m
ibm-spectrum-scale-csi-attacher-0    1/1    Running            0           85m
ibm-spectrum-scale-csi-klr7x         1/2    CrashLoopBackOff   9           26m
ibm-spectrum-scale-csi-operator-56955949c4-mzn7g  1/1    Running            0           90m
ibm-spectrum-scale-csi-provisioner-0 1/1    Running            0           85m
ibm-spectrum-scale-csi-xlxk1         1/2    CrashLoopBackOff   9           26m
```

```
# oc logs ibm-spectrum-scale-csi-95661 -c ibm-spectrum-scale-csi
...
I1218 17:27:33.875884      1 http_utils.go:60] http_utils FormatURL. url: https://ibm-spectrum-scale-gui-ibm-spectrum-scale.apps.example.com:443/
I1218 17:27:33.875894      1 rest_v2.go:586] rest_v2 doHTTP. endpoint: https://ibm-spectrum-scale-gui-ibm-spectrum-scale.apps.example.com:443/scalemgmt/v2/cluster, method: GET, param: <nil>
I1218 17:27:33.875900      1 http_utils.go:74] http_utils HttpExecuteUserAuth. type: GET, url: https://ibm-spectrum-scale-gui-ibm-spectrum-scale.apps.example.com:443/scalemgmt/v2/cluster, user: csi-cnsa-gui-user
```

- Check that the `csi-cnsa-gui-user` role was created.

```
# oc exec ibm-spectrum-scale-gui-0 -n ibm-spectrum-scale -- /usr/lpp/mmfs/gui/cli/luser
Defaulting container name to liberty.
Use 'oc describe pod/ibm-spectrum-scale-gui-0 -n ibm-spectrum-scale' to see all of the
containers in this pod.
Name                Long name Password status Group names                Failed login attempts Target
Feedback Date
ContainerOperator   active                ContainerOperator 0
EFSSG1000I The command completed successfully.
```

In this case, the `csi-cnsa-gui-user` role was not created. To resolve the issue, enter the following command to create a GUI user:

```
# oc exec -c liberty ibm-spectrum-scale-gui-0 -n ibm-spectrum-scale -- /usr/lpp/mmfs/gui/cli/mkuser csi-cnsa-gui-user -p csi-cnsa-gui-password -g CsiAdmin
EFSSG0019I The user csi-cnsa-gui-user has been successfully created.
EFSSG1000I The command completed successfully.
```

- Check that the `csi-remote-mount-storage-cluster-1` secret was created with correct credentials.

```
# oc get secrets csi-remote-mount-storage-cluster-1 -n ibm-spectrum-scale-csi
-ojsonpath='{.data.username}' | base64 --decode
csi-cnsa-gui-user

# oc get secrets csi-remote-mount-storage-cluster-1 -n ibm-spectrum-scale-csi
-ojsonpath='{.data.password}' | base64 --decode
this-is-a-bad-password
```

In this case, the `csi-remote-mount-storage-cluster-1` secret was created without a correct password. To resolve the issue, enter the following command to delete the secret and recreate it with correct values:

```
# oc delete secrets csi-remote-mount-storage-cluster-1 -n ibm-spectrum-scale-csi
secret "csi-remote-mount-storage-cluster-1" deleted

# oc create secret generic csi-remote-mount-storage-cluster-1 --from-literal=username=csi-
cnsa-gui-user --from-literal=password=csi-cnsa-gui-password -n ibm-spectrum-scale-csi
secret/csi-remote-mount-storage-cluster-1 created

# oc label secret csi-remote-mount-storage-cluster-1 product=ibm-spectrum-scale-csi -n ibm-
spectrum-scale-csi
secret/csi-remote-mount-storage-cluster-1 labeled
```

## Problem: CSI CR is never created

If all the core pods are running and an IBM Spectrum Scale container native cluster appears to be in a good state, the CSI CR should be created automatically. In some error paths this does not happen and causes the driver pods to not be scheduled:

**Note:** Only the operator pod is listed and no results are found for `csiscaleoperators`.

```
# oc get po,csiscaleoperator -n ibm-spectrum-scale-csi
NAME                                READY   STATUS    RESTARTS   AGE
pod/ibm-spectrum-scale-csi-operator-79bd756d58-ht6hf  1/1     Running   0           47h
```

- Check that the GUI pod(s) are up and running.

```
# oc get pods -n ibm-spectrum-scale
NAME                                READY   STATUS    RESTARTS   AGE
ibm-spectrum-scale-gui-0            4/4     Running   0           3m58s
ibm-spectrum-scale-gui-1            4/4     Running   0           95s
ibm-spectrum-scale-pmcollector-0    2/2     Running   0           3m59s
worker0                              2/2     Running   0           3m59s
worker1                              2/2     Running   0           3m58s
worker2                              2/2     Running   0           3m58s
```

All GUI pods must be up and running before the CSI CR is created. Each pod can take a few minutes for all containers in the pod to enter the Running state.

- Check that the daemon status has a non-empty cluster ID.

```
# oc describe daemon -n ibm-spectrum-scale
```

Find the status section and ensure that the `Cluster ID` field exists and is not empty.

```
Status:
Cluster ID:    3004252500454687654
Cluster Name:  example.cluster.com
```

If those fields are missing then the IBM Spectrum Scale container native cluster is experiencing an issue. Check the operator logs for more information.

## Debugging OCP upgrade

### Problem: GUI mount not getting refreshed as multiple OCP clusters are remote mounted on the same FS

To resolve the issue, unmount the FS from another OCP cluster.

```
# /usr/lpp/mmfs/gui/cli/runtask FILESYSTEM_MOUNT
err: Batch entry 3 INSERT INTO FSCC.FILESYSTEM_MOUNTS
(CLUSTER_ID, DEVICENAME, HOST_NAME, MOUNT_MODE, LAST_UPDATE)
VALUES ('5228226002706731921','fs1','worker1.example.com','RW','2021-07-28
19:06:15.111000+00'::timestamp) was aborted: ERROR: duplicate key value violates unique
```

```
constraint "filesystem_mounts_pk"
Detail: Key (host_name, cluster_id, devicename)=(worker1.example.com, 5228226002706731921 ,
fs1) already exists. Call getNextException to see other errors in the batch.
EFSSG1150C Running specified task was unsuccessful.
# /usr/lpp/mmfs/gui/cli/runtask FILESYSTEM_MOUNT
EFSSG1000I The command completed successfully.
# exit
exit
```

## Identifying applications preventing cluster maintenance

---

Debug steps to determine when a cluster maintenance action is not being completed.

### When would we see this?

A drain occurs when a core pod is selected for deletion. There are a number of actions that prompt a core pod deletion:

- Pod evictions
  - Red Hat OpenShift Machine Config Operator
  - User-initiated drains
- Pod spec updates
  - Resource requests, i.e. changing core pod requests for CPU and/or memory
  - Image updates prompted by a new release

### What does this look like?

An update driven by pod spec updates will present as core pods awaiting deletion. An update driven by Red Hat OpenShift Machine Config Operator (MCO) ceases to update nodes. The signature will look similar between the two scenarios. Use the following steps to determine where to direct the support case.

### When to open a support case?

To determine if the MCO is stuck due to IBM Spectrum Scale container native, run the following command on the node that is failing to update:

```
oc adm drain <node> --force --ignore-daemonsets --delete-emptydir-data --pod-selector='app.kubernetes.io/instance notin(ibm-spectrum-scale)'
```

If this command completes without errors, then IBM Spectrum Scale container native is blocking the ongoing drain. To resolve it, raise a support ticket to IBM. For more information, see [Gather data to submit a support ticket to IBM](#).

If errors are presented from the `oc adm drain` command, raise a support ticket to Red Hat. For more information, see [Gather data to submit a support ticket to Red Hat OpenShift](#).

### Identifying signatures of an ongoing update

Complete the following steps:

1. Check the Daemon status to verify if any pods are awaiting deletion.

```
oc describe daemon -n ibm-spectrum-scale
```

Example output:

```
Status Details:
  Nodes Rebooting:
  Nodes Unreachable:
  Nodes Waiting For Reboot:
  Pods Starting:
```



```
Pods Terminating:
Pods Unknown:
Pods Waiting For Delete: worker0, worker1, worker2
Quorum Pods: worker0, worker1, worker2
```

2. Check if any nodes are cordoned.

```
oc get nodes
```

Example:

NAME	STATUS	ROLES	AGE	VERSION
master0.example.ibm.com	Ready	master	23d	v1.24.0+3882f8f
master1.example.ibm.com	Ready	master	23d	v1.24.0+3882f8f
master2.example.ibm.com	Ready	master	23d	v1.24.0+3882f8f
worker0.example.ibm.com	Ready,SchedulingDisabled	worker	23d	v1.24.0+3882f8f
worker1.example.ibm.com	Ready	worker	23d	v1.24.0+3882f8f
worker2.example.ibm.com	Ready	worker	23d	v1.24.0+3882f8f

3. Check events on the core pod of the failing node.

```
oc describe <pod> -n ibm-spectrum-scale
```

Example event:

```
error when evicting pods/"mypod-0" -n "myworkload" (will retry after 5s): Cannot evict pod as it would violate the pod's disruption budget.
```

## Common issues

### Error: daemon and kernel extension do not match

This error occurs when there is an unintentional upgrade of GPFS code.

The issue presents itself as the GPFS state is down and the above error is found in the GPFS logs.

To resolve the issue, follow proper upgrade procedures. The issue occurs because the kernel module cannot be unloaded when a file system is in use. Rebooting the node resolves the problem, or follow procedures to remove application workloads and then enter the following command on the node issue:

```
rmmod tracedev mmfs26 mmfslinux
```

**Note:** For more information, see [“Removing applications”](#) on page 71.

### RestError: Failed to get storage cluster information. errmsg: 401 Unauthorized GET

The `oc describe gpfs` command shows the following error:

```
Warning RestError 48s (x12 over 2m2s) RemoteMount <filesystem>: [storage cluster] Failed to get storage cluster information. errmsg: 401 Unauthorized GET request to https://<storage cluster GUI>:443/scalemgmt/v2/cluster
```

The IBM Spectrum Scale GUI REST credentials for storage clusters are stored in kubernetes secrets. For more information, see [“IBM Spectrum Scale storage cluster configuration”](#) on page 34. The `RestError` indicates that the GUI user in the kubernetes secret does not match the GUI user in the storage cluster.

There are different possible root causes:

- A GUI user was never created as described in the procedure for creating operator user and group. For more information, see [Creating Operator User and Group](#).
- The GUI user password has expired in the storage cluster and must be changed.
- The GUI user password is changed in the storage cluster.
- The GUI user is deleted in the storage cluster.

Complete the following steps to solve this problem:

1. Get the name of the secret by entering `oc describe remotecluster -n ibm-spectrum-scale` command and looking for Secret Name:

```
...
Spec:
  Contact Nodes:
    storagecluster1node1
    storagecluster1node2
  Gui:
    Cacert:          cacert-storage-cluster-1
    Csi Secret Name: csi-remote-mount-storage-cluster-1
    Host:            guihost.example.com
    Insecure Skip Verify: false
    Port:            443
    Secret Name:     cnsa-remote-mount-storage-cluster-1
...
```

2. Read the credentials from the kubernetes secret for accessing the storage cluster IBM Spectrum Scale GUI REST API.

```
oc get secret cnsa-remote-mount-storage-cluster-1 -n ibm-spectrum-scale
-ojsonpath='{.data.username}' | base64 -d -
oc get secret cnsa-remote-mount-storage-cluster-1 -n ibm-spectrum-scale
-ojsonpath='{.data.password}' | base64 -d -
```

**Note:** In some shells, the end of the line has a highlighted %. This denotes there is no new line and should not be included when updating the password.

3. If the password differs from the one that is set for a GUI user in the storage cluster, then delete and re-create the secret as configured during installation.
4. If a GUI user does not exist in a storage cluster, create an IBM Spectrum Scale GUI user in the ContainerOperator group by either using the GUI or by issuing the following command in the shell of the GUI node of the storage cluster:

```
/usr/lpp/mmfs/gui/cli/mkuser cnss_storage_gui_user -p cnss_storage_gui_password -g
ContainerOperator
```

## MountVolume.Setup failed for volume "ssh-keys"

```
Warning FailedMount 83m (x5 over 83m) kubelet, worker-0.example.ibm.com MountVolume.Setup
failed for volume "ssh-keys" : secret "ibm-spectrum-scale-ssh-key-secret" not found
```

The pod create times show that the ssh key secret was created after the deployment. This means that the deployment rightfully could not find the secret to mount, as it did not yet exist.

This message can be misleading as the pods should resolve themselves once the secret is created. If core pods are not in a Running state, and the secret is already created, deleting the `ibm-spectrum-scale-core` pods should resolve the issue. This restarts the pods and allow the mount to complete successfully for the already created SSH key.

## A pmcollector pod is in pending state during the OpenShift Container Platform upgrade or reboot

```
Events:
  Type    Reason             Age          From          Message
  ----    -
Warning  FailedScheduling  65s (x202 over 4h43m)  default-scheduler  0/6 nodes are available:
1 node(s) were unschedulable, 2 node(s) had volume node affinity conflict, 3 node(s) had taint
{node-role.kubernetes.io/master:}, that the pod didn't tolerate.
```

This issue is caused by a problem during the OpenShift Container Platform Upgrade or when a worker node has not been reset to schedulable after reboot. The pmcollector remains in a Pending state until the pod itself and its respective Persistent Volume can be bound to a worker node.

```
# oc get nodes
NAME                                STATUS    ROLES    AGE   VERSION
master0.example.com                Ready    master   5d18h v1.18.3+2fbd7c7
master1.example.com                Ready    master   5d18h v1.18.3+2fbd7c7
master2.example.com                Ready    master   5d18h v1.18.3+2fbd7c7
worker0.example.com                Ready    worker   5d18h v1.17.1+45f8ddb
worker1.example.com                Ready,SchedulingDisabled worker   5d18h v1.17.1+45f8ddb
worker2.example.com                Ready    worker   5d18h v1.17.1+45f8ddb
```

If the Persistent Volume has Node Affinity to the host that has SchedulingDisabled, the pmcollector pod remains in Pending state until the node associated with the PV becomes schedulable.

```
# oc describe pv worker1.example.com-pv
Name:          worker1.example.com-pv
Labels:        app=scale-pmcollector
Annotations:   pv.kubernetes.io/bound-by-controller: yes
Finalizers:    [kubernetes.io/pv-protection]
StorageClass:  ibm-spectrum-scale-internal
Status:        Bound
Claim:         example/datadir-ibm-spectrum-scale-pmcollector-1
Reclaim Policy: Delete
Access Modes:  RWO
VolumeMode:    Filesystem
Capacity:      25Gi
Node Affinity:
  Required Terms:
    Term 0:     kubernetes.io/hostname in [worker1.example.com]
Message:
Source:
  Type:        LocalVolume (a persistent volume backed by local storage on a node)
  Path:        /var/mmfs/pmcollector
```

If the issue was with OpenShift Container Platform Upgrade, fixing the upgrade issue should resolve the pending pod.

If the issue is due to worker node in SchedulingDisabled state and not due to a failed OpenShift Container Platform Upgrade, re-enable scheduling for the worker with the `oc adm uncordon` command.

## Failed to establish remote cluster connection when cacert ConfigMap does not exist

When describing the remote cluster objects, you may see an error: Error: ConfigMap "cacert-storage-cluster-1" not found.

This issue is caused by not configuring TLS verification of CA certificates for the remote storage GUI. For more information, see [“Configuring Certificate Authority \(CA\) certificates for storage cluster”](#) on page 51.

To resolve this issue, choose a configuration option from *Configuring certificate authority (CA) certificates for storage cluster* procedure and follow the instructions below for the corresponding option of choice.

For more information, see [“Configuring Certificate Authority \(CA\) certificates for storage cluster”](#) on page 51.

- Option 1

Create the `cacert-storage-cluster-1` ConfigMap.

For more information, see [“Configuring Certificate Authority \(CA\) certificates for storage cluster”](#) on page 51.

- Option 2

Ensure that the storage cluster GUI is using a default trusted CA certificate. If configured correctly, the storage cluster GUI should connect successfully.

- Option 3

Patch the Custom Resource to use `insecureSkipVerify: true`.

```
oc patch scaleclusters ibm-spectrum-scale --type='json' -n ibm-spectrum-scale \
  -p='[{"op": "replace", "path": "/spec/remoteClusters/0/gui/insecureSkipVerify", "value":
true}]'
```

## Known issues

### Adding a remote cluster to an existing IBM Spectrum Scale container native cluster taking long time to appear

When adding a RemoteCluster custom resource after initial installation of IBM Spectrum Scale container native, it can take some time for the IBM Spectrum Scale container native operator to propagate this information to the CSI custom resource.

To resolve this, manually trigger a reconcile of the operator by deleting the operator pod and allowing it to be recreated.

```
oc delete pod -nibm-spectrum-scale-operator -lapp.kubernetes.io/name=operator
```

Once the operator reconciles, it updates the CSI custom resource with the new RemoteCluster custom resource.

### pmsensors showing null after failure of pmcollector node

If a node that is running the pmcollector pod is drained, when the node is uncordoned, the pmcollector pods get new IPs assigned. This leads to the pmsensors process issue. It displays the following message:

```
Connection to scale-pmcollector-0.scale-pmcollector successfully established.
```

But an error is reported:

```
Error on socket to scale-pmcollector-0.scale-pmcollector: No route to host (113)
```

See `/var/log/zimon/ZIMonSensors.log`. This issue can also be seen on the pmcollector pod:

```
# echo "get metrics cpu_user bucket_size 5 last 10" | /opt/IBM/zimon/zc 0
1:      worker1
2:      worker2
Row Timestamp                cpu_user
1  2020-11-16 05:27:25      null
2  2020-11-16 05:27:30      null
3  2020-11-16 05:27:35      null
4  2020-11-16 05:27:40      null
5  2020-11-16 05:27:45      null
6  2020-11-16 05:27:50      null
7  2020-11-16 05:27:55      null
8  2020-11-16 05:28:00      null
9  2020-11-16 05:28:05      null
10 2020-11-16 05:28:10      null
```

If the scale-pmcollector pods get their IP addresses changed, the pmsensors process needs to be killed and restarted manually on all scale-core pods, to get the performance metrics collection resumed.

To kill the pmsensor process, run these commands on all the ibm-spectrum-scale-core pods. The PMSENSORPID variable holds the results of the `oc exec` command. If this variable is empty, there is no process running, and you do not need to enter the following command to kill the process.

```
PMSENSORPID=`oc exec <ibm-spectrum-scale-core> -n ibm-spectrum-scale -- pgrep
-fx '/opt/IBM/zimon/sbin/pmsensors -C /etc/scale-pmsensors-configuration/ZIMonSensors.cfg
-R /var/run/perfmon'`
echo $PMSENSORPID
oc exec <scale-pod> -n ibm-spectrum-scale -- kill $PMSENSORPID
```

To start the service again, enter this command on all the scale pods.

```
oc exec <scale-pod> -n ibm-spectrum-scale -- /opt/IBM/zimon/sbin/pmsensors -C /etc/scale-pmsensors-configuration/ZIMonSensors.cfg -R /var/run/perfmon
```

## Remote file systems are defined but not mounted on all nodes

If the RemoteMount controller shows that a target storage cluster file system is established, but the remote file system is not mounted on all the nodes in the `ibm-spectrum-scale-core` pods, execute the following command to mount the file system manually from one of the `scale-core` pods:

```
# Replace FILESYSTEM with the name of your filesystem
FILESYSTEM="fs1"
oc exec $(oc get pods -lapp=ibm-spectrum-scale-core -ojsonpath="{.items[0].metadata.name}") --
mmlsfs $FILESYSTEM -a
```

## Remote file systems unable to mount successfully

On the Filesystem CR, if you see events that indicate the filesystem is unable to mount, check in the pod to see if running `mmlsfs <filesystem>` results in 'Operation not permitted' error message.

Starting with IBM Spectrum Scale 5.1.3.0 and IBM Spectrum Scale container native 5.1.3.0, the `tscCmdAllowRemoteConnections` configuration is recommended to be set to `no`. If a storage cluster and all client clusters (including IBM Spectrum Scale container native) are at versions  $\geq 5.1.3.0$ , it is recommended to set this value to `no`. However, if any version is  $< 5.1.3.0$ , `tscCmdAllowRemoteConnections` needs to be set to `yes` on the storage cluster and client clusters to successfully communicate between the clusters.

Use the following table as a reference.

Storage Cluster version	IBM Spectrum Scale container native	tscCmdAllowRemoteConnections
$< 5.1.3.0$	$< 5.1.3.0$	yes
$\geq 5.1.3.0$	$< 5.1.3.0$	yes
$\geq 5.1.3.0$	$\geq 5.1.3.0$	no

To change this value on a storage cluster, run `mmchconfig tscCmdAllowRemoteConnections:yes|no`.

To change this value on an IBM Spectrum Scale container native cluster, set the `tscCmdAllowRemoteConnections:yes|no` in the `clusterProfile` section of the cluster spec by entering the following command:

```
kind: Cluster
metadata:
  name: ibm-spectrum-scale
spec:
  ...
  daemon:
    ...
  clusterProfile:
    tscCmdAllowRemoteConnections: "yes"
```

For more information to configure the `clusterProfile` section of the cluster spec, see [Cluster](#).

## File system fails to mount because it is already mounted on an IBM Spectrum Scale container native cluster

If a file system is failing to mount to the container native cluster ensure that this is not caused by the single cluster limitation:

The same remote file system cannot be mounted on multiple IBM Spectrum Scale container native clusters.

### pid\_limits set higher than podPidLimits, but not being honored

With OpenShift Container Platform 4.11, some CRI-O fields introduced before kubelet supported those values are being deprecated in favor of using the fields defined in kubelet. One of those deprecated fields is `pids\_limit` set by the `ContainerRuntimeConfig` CR. For more information, see [CRI-O should deprecate log size max and pids limit options](#) in RedHat JIRA dashboard.

If you had applied a custom MCO configuration with a `pids\_limit` value higher than 4096, the container limits is restricted by the default `podPidsLimit` value in `kubelet.conf`. This default is set to 4096 on OCP 4.11. To increase this value, perform the following:

#### Note:

It is highly recommended that you are at IBM Spectrum Scale container native 5.1.6.0 or higher before making changes to `MachineConfig` as the IBM Spectrum Scale container native operator will orchestrate the updates to `MachineConfig` as an attempt to keep the IBM Spectrum Scale cluster operational.

1. Define the `podPidsLimit` in the `KubeletConfig` custom resource.

```
yaml
---
apiVersion: machineconfiguration.openshift.io/v1
kind: KubeletConfig
metadata:
  name: 01-worker-ibm-spectrum-scale-increase-pid-limit
spec:
  machineConfigPoolSelector:
    matchLabels:
      pools.operator.machineconfiguration.openshift.io/worker: ''
  kubeletConfig:
    podPidsLimit: 8192
```

2. Delete the IBM Spectrum Scale container native ContainerRuntimeConfig CR to set the default back to 0 (unlimited):

```
oc delete ContainerRuntimeConfig 01-worker-ibm-spectrum-scale-increase-pid-limit
```

## Adding a node fails with "The node appears to already belong to a GPFS cluster"

When adding a worker node into OpenShift, and using the nodeSelector of `node-role.kubernetes.io/worker` in the Cluster CR, the IBM Spectrum Scale container native operator will deploy a core pod to the newly added node and attempt to add this node into the GPFS cluster. There may be a situation where the core pod will be in "Init:1/2" state with no sign of recovery.

The operator log will contain entries matching `ERROR Failed to add node and mmaddnode failing with the reason "The node appears to already belong to a GPFS cluster"`.

To recover from this scenario, perform the following steps:

1. Create a debug pod to the node where the pod is failing to start and delete the GPFS metadata.

```
oc debug node/<openshift_worker_node> -T -- chroot /host sh -c "rm -rf /var/mmfs; rm -rf /var/adm/ras"
```

Example:

```
oc debug node/worker0.example.com -T -- chroot /host sh -c "rm -rf /var/mmfs; rm
-rf /var/adm/ras"
Starting pod/worker0examplecom-debug ...
To use host binaries, run `chroot /host`
Removing debug pod ...
```

2. Delete the core pod. If the core pod is called worker3, run the following command:

```
oc delete pod worker3 -n ibm-spectrum-scale
```

3. The operator should reconcile and attempt to create the pod again and succeed.

## GUI or Grafana bridge pods fails to start, no data returned from pmcollector to frontend applications

There exists an issue where no data is returned to frontend applications that are actively consuming performance metrics from IBM Spectrum Scale pmcollector. This also has a signature of Grafana Bridge pod failing to start. If this is experienced, apply the following workaround.

1. Check NodeNetworkConfigurationPolicy's to determine which network interfaces are configured for a node network.

- List the NodeNetworkConfigurationPolicies

```
oc get nnce
```

Example:

```
# oc get nnce
NAME                                                    STATUS
compute-0.mycluster.example.com.bond1-ru5-policy      SuccessfullyConfigured
compute-1.mycluster.example.com.bond1-ru6-policy      SuccessfullyConfigured
compute-2.mycluster.example.com.bond1-ru7-policy      SuccessfullyConfigured
control-0.mycluster.example.com.bond1-ru2-policy      SuccessfullyConfigured
control-1.mycluster.example.com.bond1-ru3-policy      SuccessfullyConfigured
control-2.mycluster.example.com.bond1-ru4-policy      SuccessfullyConfigured
```

- Describe the NodeNetworkConfigurationPolicy to identify the network interface being used.

Example:

```
# oc describe nnce compute-0.mycluster.example.com.bond1-ru5-policy | grep Name
Name:          compute-0.mycluster.example.com.bond1-ru5-policy
Namespace:
  Name:        bond1-ru5-policy
  Name:        bond1
  Name:        bond1.3201
```

**Note:** In this particular example, the bond interfaces are configured for the node network traffic.

2. Change the Performance Data Collection rules to limit the discovery of the Network adapters to only the configured interfaces.

- Stop the sensors activities on all Core nodes

```
oc get pods -lapp.kubernetes.io/name=core -n ibm-spectrum-scale \
-ojsonpath="{range .items[*]}{.metadata.name}{'\n'}" | \
xargs -I{} oc exec {} -n ibm-spectrum-scale -c gpfs -- \
kill $(pgrep -fx '/opt/IBM/zimon/sbin/pmsensors -C /etc/scale-pmsensors-configuration/
ZIMonSensors.cfg -R /var/run/perfmon')
```

- Review the current filter settings for the Network sensor in the Performance Data Collection rules. These are stored in the `ibm-spectrum-scale-pmsensors-config` ConfigMap.

```
oc describe cm ibm-spectrum-scale-pmsensors-config -n ibm-spectrum-scale | grep filter |
grep netdev
```

Example output:

```
# oc describe cm ibm-spectrum-scale-pmsensors-config -n ibm-spectrum-scale | grep filter |
grep netdev
filter = "netdev_name=veth.*|docker.*|flannel.*|cali.*|cbr.*"
```

**Note:** The above filter is used for exclusion logic.

- Edit the `ibm-spectrum-scale-pmsensors-config` ConfigMap and replace the substring `netdev_name=veth.|docker.|flannel.|cali.|cbr.` with `netdev_name=^(?!bond).`

```
oc edit ibm-spectrum-scale-pmsensors-config -n ibm-spectrum-scale
```

**Note:** Bond interface is being used in this example, replace `bond` with the respective adapter name used by the customer's network interface.

- Verify that the `ibm-spectrum-scale-pmsensors-config` ConfigMap now reflects the desired adapter.

```
oc describe cm ibm-spectrum-scale-pmsensors-config -n ibm-spectrum-scale|grep filter |
grep netdev
```

3. Cleanup the metadata keys in the `pmcollector` database not related to the configured node network interfaces. Remote shell into each `pmcollector` pod and issue the following commands.

```
oc rsh -cpmcollector ibm-spectrum-scale-pmcollector-0
```

```
echo "delete key .*|Network|[a-f0-9]{15}|.*" | /opt/IBM/zimon/zc 0
```

```
echo "topo -c -d 6" | /opt/IBM/zimon/zc 0| grep Network | cut -d'|' -f2-3 | sort | uniq -c |
sort -n | tail -50
```

Then exit the container.

Example:

```
# oc rsh -cpmcollector ibm-spectrum-scale-pmcollector-0
sh-4.4$ echo "delete key .*|Network|[a-f0-9]{15}|.*" | /opt/IBM/zimon/zc 0
sh-4.4$ echo "topo -c -d 6" | /opt/IBM/zimon/zc 0| grep Network | cut -d'|' -f2-3 | sort |
uniq -c | sort -n | tail -50
   96 Network|bond0
   96 Network|bond1
   96 Network|bond1.3201
   96 Network|lo
sh-4.4$ exit
```

```
# oc rsh -cpmcollector ibm-spectrum-scale-pmcollector-1
sh-4.4$ echo "delete key .*|Network|[a-f0-9]{15}|.*" | /opt/IBM/zimon/zc 0
sh-4.4$ echo "topo -c -d 6" | /opt/IBM/zimon/zc 0| grep Network | cut -d'|' -f2-3 | sort |
uniq -c | sort -n | tail -50
   96 Network|bond0
   96 Network|bond1
   96 Network|bond1.3201
   96 Network|lo
sh-4.4$ exit
```

4. Start the sensors jobs on all Core nodes.

```
oc get pods -lapp.kubernetes.io/name=core -n ibm-spectrum-scale \
-ojsonpath="{range .items[*]}{.metadata.name}{'\n'}" | \
xargs -I{} oc exec {} -n ibm-spectrum-scale -c gpfs -- \
/opt/IBM/zimon/sbin/pmsensors -C /etc/scale-pmsensors-configuration/ZIMonSensors.cfg
-R /var/run/perfmon
```

5. Delete the `pmcollector` and `grafana` bridge pods to update the configuration changes.

```
oc delete pod -lapp.kubernetes.io/instance=ibm-spectrum-scale,app.kubernetes.io/
name=pmcollector
oc delete pod -lapp.kubernetes.io/instance=ibm-spectrum-scale,app.kubernetes.io/
name=grafanabridge
```



After some time, the pmcollector and grafana bridge pods are redeployed by the ibm-spectrum-scale-operator.

## Collecting data for support

---

You need to perform the following procedures to gather data for support:

- [“Generating GPFS trace reports” on page 91](#)
- [“Configuring GPFS trace reports from cluster creation” on page 92](#)
- [“Kernel crash dumps” on page 92](#)
- [“Gather data about the IBM Spectrum Scale container native cluster” on page 92](#)
- [“Gather data about a Red Hat OpenShift Container Platform cluster” on page 93](#)

### Generating GPFS trace reports

Some issues might require low-level system detail accessible only through the IBM Spectrum Scale daemon and the IBM Spectrum Scale Linux kernel trace facilities.

In such instances the IBM Support Center might request such GPFS trace reports to facilitate rapid problem determination of failures.

The level of detail that is gathered by the trace facility is controlled by setting the trace levels using the mmtracectl command. For more information, see [mmtracectl command](#) in IBM Spectrum Scale documentation.

**Note:** The following steps must be performed under the direction of the IBM Support Center.

1. Enter the following command to access a running ibm-spectrum-scale-core pod:

```
oc rsh -n ibm-spectrum-scale <ibm-spectrum-scale-core-pod>
```

**Note:** The pod must be in Running status to connect. It is best to pick a pod running on a node that is not exhibiting issues.

The remaining steps should be completed while connected to this shell running inside the gpfs container of this running core pod.

2. Enter the mmchconfig command to change the dataStructureDump field to point to /var/adm/ras. This changes the default location where trace data is stored to a directory that persists on the host machine:

```
mmchconfig dataStructureDump=/var/adm/ras/
```

3. Set desired trace classes and levels. This part of the process is identical to classic IBM Spectrum Scale installs. For more information, see [Generating GPFS trace reports](#) in IBM Spectrum Scale documentation.

```
mmtracectl --set --trace={io | all | def | "Class Level [Class Level ...]"}&
```

4. Start the trace facility on all nodes by entering the following command:

```
mmtracectl --start
```

5. Re-create the problem.

6. Stop the trace generation as soon as the problem to be captured occurs, by entering the following command:

```
mmtracectl --stop
```

7. Turn off trace generation by entering the following command:

```
mmtracectl --off
```

## Configuring GPFS trace reports from cluster creation

In some situations, it may be required to configure GPFS tracing from cluster creation. This can be accomplished using the cluster core profile and settings directed by IBM Support Center.

## Kernel crash dumps

Red Hat Enterprise Linux CoreOS (RHCOS) based machines do not support configuring kdump or generating kernel crash dumps for Red Hat OpenShift Container Platform 4.6 and earlier. For more information, see [How to configure kdump in Red Hat CoreOS](#) in Red Hat OpenShift documentation.

In some virtual machine installations, it may be possible to generate a vmcore crash dump from the hypervisor.

In lieu of kernel dumps, CoreOS currently recommends using pstore, even if only small snippets of diagnostic data can be collected. For more information, see [Using pstore](#) in CoreOS documentation on GitHub.

## Gather data about the IBM Spectrum Scale container native cluster

To gather logs and diagnostic data to assist IBM Support in debugging an issue, enter the `oc adm must-gather` CLI command with the supporting `must-gather` image specifically for IBM Spectrum Scale container native.

**Note:** `oc adm must-gather --image`` requires the `must-gather` image that is stored in a repository where it can be anonymously pulled (no credentials required). In an airgapped environment, the `must-gather` image must be pulled from the IBM Cloud Container Registry and then uploaded to an image registry allowing anonymous pull. For more information about air gap instructions, see [Air gap setup for network restricted Red Hat OpenShift Container Platform clusters](#).

The `ibm-spectrum-scale-must-gather` image collects the Kubernetes objects associated with its namespace and also retrieve a GPFS snap from the IBM Spectrum Scale container native cluster.

**Note:** Running `oc adm must-gather` requires the user to be logged in to an account on a Red Hat OpenShift Container Platform cluster that has sufficient privileges to query OpenShift and Kubernetes resources. Collaboration with the administrator may be needed to get necessary credentials for `oc login -u <username>` to successfully query OpenShift and Kubernetes resources.

1. In the directory where the `must-gather` contents need to be stored, enter the `must-gather` command by using the `ibm-spectrum-scale-must-gather` image:

```
oc adm must-gather --image=icr.io/cpopen/ibm-spectrum-scale-must-gather:v5.1.6.0
```

2. Once completed, a new directory with `must-gather` prefix is created in your working directory.

For example:

```
# ls -ltr
drwxr-xr-x 3 root root 229 Jun 14 09:11 must-gather.local.681612165636007567
```

3. Create a compressed file from the `must-gather` directory that was just created in your working directory.

```
tar cvaf must-gather.tar.gz must-gather.local.681612165636007567/
```

**Note:** Replace the directory name used in this command with your respective `must-gather` directory.

## Gather data about a Red Hat OpenShift Container Platform cluster

For issues with a Red Hat OpenShift Container Platform cluster where a ticket must be opened with Red Hat Support, provide the debugging information about the cluster for problem determination. For more information, see [Gathering data about your cluster](#) in Red Hat OpenShift documentation.

**Note:** Executing a default `must-gather` for OpenShift Container Platform debug does not collect information for IBM Spectrum Scale container native.



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## Chapter 12. References

- [“IBM Spectrum Scale” on page 95](#)
- [“Red Hat OpenShift or Kubernetes” on page 95](#)

### IBM Spectrum Scale

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- [Administration Guide](#)
- [For Linux on Z: Changing the kernel settings](#)
- [mmchconfig command](#)
- [mmnetverify command](#)
- [Accessing a remote GPFS file system](#)
- [Defining the cluster topology for the installation toolkit](#)
- [Node quorum](#)
- [Installing IBM Spectrum Scale Container Storage Interface driver using CLI](#)

### Red Hat OpenShift or Kubernetes

---

- [Display which Pods have the PVC in use](#)
- [Red Hat OpenShift Container Platform 4 now defaults to CRI-O as underlying container engine](#)
- [How to configure kdump in Red Hat CoreOS?](#)
- [Installing and configuring OpenShift Container Platform clusters](#)
- [Installation Configuration](#)
- [Configuring an HTPasswd identity provider](#)



## Accessibility features for IBM Spectrum Scale

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Accessibility features help users who have a disability, such as restricted mobility or limited vision, to use information technology products successfully.

### Accessibility features

---

The following list includes the major accessibility features in IBM Spectrum Scale:

- Keyboard-only operation
- Interfaces that are commonly used by screen readers
- Keys that are discernible by touch but do not activate just by touching them
- Industry-standard devices for ports and connectors
- The attachment of alternative input and output devices

IBM Documentation, and its related publications, are accessibility-enabled.

### Keyboard navigation

---

This product uses standard Microsoft Windows navigation keys.

### IBM and accessibility

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See the [IBM Human Ability and Accessibility Center \(www.ibm.com/able\)](http://www.ibm.com/able) for more information about the commitment that IBM has to accessibility.





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# Glossary

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This glossary provides terms and definitions for IBM Spectrum Scale.

The following cross-references are used in this glossary:

- *See* refers you from a nonpreferred term to the preferred term or from an abbreviation to the spelled-out form.
- *See also* refers you to a related or contrasting term.

For other terms and definitions, see the [IBM Terminology website \(www.ibm.com/software/globalization/terminology\)](http://www.ibm.com/software/globalization/terminology) (opens in new window).

## B

### **block utilization**

The measurement of the percentage of used subblocks per allocated blocks.

## C

### **cluster**

A loosely coupled collection of independent systems (nodes) organized into a network for the purpose of sharing resources and communicating with each other. See also *GPFS cluster*.

### **cluster configuration data**

The configuration data that is stored on the cluster configuration servers.

### **Cluster Export Services (CES) nodes**

A subset of nodes configured within a cluster to provide a solution for exporting GPFS file systems by using the Network File System (NFS), Server Message Block (SMB), and Object protocols.

### **cluster manager**

The node that monitors node status using disk leases, detects failures, drives recovery, and selects file system managers. The cluster manager must be a quorum node. The selection of the cluster manager node favors the quorum-manager node with the lowest node number among the nodes that are operating at that particular time.

**Note:** The cluster manager role is not moved to another node when a node with a lower node number becomes active.

### **clustered watch folder**

Provides a scalable and fault-tolerant method for file system activity within an IBM Spectrum Scale file system. A clustered watch folder can watch file system activity on a fileset, inode space, or an entire file system. Events are streamed to an external Kafka sink cluster in an easy-to-parse JSON format. For more information, see the *mmwatch command* in the *IBM Spectrum Scale: Command and Programming Reference*.

### **control data structures**

Data structures needed to manage file data and metadata cached in memory. Control data structures include hash tables and link pointers for finding cached data; lock states and tokens to implement distributed locking; and various flags and sequence numbers to keep track of updates to the cached data.

## D

### **Data Management Application Program Interface (DMAPI)**

The interface defined by the Open Group's XDSM standard as described in the publication *System Management: Data Storage Management (XDSM) API Common Application Environment (CAE) Specification C429*, The Open Group ISBN 1-85912-190-X.

**deadman switch timer**

A kernel timer that works on a node that has lost its disk lease and has outstanding I/O requests. This timer ensures that the node cannot complete the outstanding I/O requests (which would risk causing file system corruption), by causing a panic in the kernel.

**dependent fileset**

A fileset that shares the inode space of an existing independent fileset.

**disk descriptor**

A definition of the type of data that the disk contains and the failure group to which this disk belongs. See also *failure group*.

**disk leasing**

A method for controlling access to storage devices from multiple host systems. Any host that wants to access a storage device configured to use disk leasing registers for a lease; in the event of a perceived failure, a host system can deny access, preventing I/O operations with the storage device until the preempted system has reregistered.

**disposition**

The session to which a data management event is delivered. An individual disposition is set for each type of event from each file system.

**domain**

A logical grouping of resources in a network for the purpose of common management and administration.

**E****ECKD**

See *extended count key data (ECKD)*.

**ECKD device**

See *extended count key data device (ECKD device)*.

**encryption key**

A mathematical value that allows components to verify that they are in communication with the expected server. Encryption keys are based on a public or private key pair that is created during the installation process. See also *file encryption key, master encryption key*.

**extended count key data (ECKD)**

An extension of the count-key-data (CKD) architecture. It includes additional commands that can be used to improve performance.

**extended count key data device (ECKD device)**

A disk storage device that has a data transfer rate faster than some processors can utilize and that is connected to the processor through use of a speed matching buffer. A specialized channel program is needed to communicate with such a device. See also *fixed-block architecture disk device*.

**F****failback**

Cluster recovery from failover following repair. See also *failover*.

**failover**

(1) The assumption of file system duties by another node when a node fails. (2) The process of transferring all control of the ESS to a single cluster in the ESS when the other clusters in the ESS fails. See also *cluster*. (3) The routing of all transactions to a second controller when the first controller fails. See also *cluster*.

**failure group**

A collection of disks that share common access paths or adapter connections, and could all become unavailable through a single hardware failure.

**FEK**

See *file encryption key*.

**fileset**

A hierarchical grouping of files managed as a unit for balancing workload across a cluster. See also *dependent fileset*, *independent fileset*.

**fileset snapshot**

A snapshot of an independent fileset plus all dependent filesets.

**file audit logging**

Provides the ability to monitor user activity of IBM Spectrum Scale file systems and store events related to the user activity in a security-enhanced fileset. Events are stored in an easy-to-parse JSON format. For more information, see the *mmaudit* command in the *IBM Spectrum Scale: Command and Programming Reference*.

**file clone**

A writable snapshot of an individual file.

**file encryption key (FEK)**

A key used to encrypt sectors of an individual file. See also *encryption key*.

**file-management policy**

A set of rules defined in a policy file that GPFS uses to manage file migration and file deletion. See also *policy*.

**file-placement policy**

A set of rules defined in a policy file that GPFS uses to manage the initial placement of a newly created file. See also *policy*.

**file system descriptor**

A data structure containing key information about a file system. This information includes the disks assigned to the file system (*stripe group*), the current state of the file system, and pointers to key files such as quota files and log files.

**file system descriptor quorum**

The number of disks needed in order to write the file system descriptor correctly.

**file system manager**

The provider of services for all the nodes using a single file system. A file system manager processes changes to the state or description of the file system, controls the regions of disks that are allocated to each node, and controls token management and quota management.

**fixed-block architecture disk device (FBA disk device)**

A disk device that stores data in blocks of fixed size. These blocks are addressed by block number relative to the beginning of the file. See also *extended count key data device*.

**fragment**

The space allocated for an amount of data too small to require a full block. A fragment consists of one or more subblocks.

**G****GPUDirect Storage**

IBM Spectrum Scale's support for NVIDIA's GPUDirect Storage (GDS) enables a direct path between GPU memory and storage. File system storage is directly connected to the GPU buffers to reduce latency and load on CPU. Data is read directly from an NSD server's pagepool and it is sent to the GPU buffer of the IBM Spectrum Scale clients by using RDMA.

**global snapshot**

A snapshot of an entire GPFS file system.

**GPFS cluster**

A cluster of nodes defined as being available for use by GPFS file systems.

**GPFS portability layer**

The interface module that each installation must build for its specific hardware platform and Linux distribution.

## **GPFS recovery log**

A file that contains a record of metadata activity and exists for each node of a cluster. In the event of a node failure, the recovery log for the failed node is replayed, restoring the file system to a consistent state and allowing other nodes to continue working.

## **I**

### **ill-placed file**

A file assigned to one storage pool but having some or all of its data in a different storage pool.

### **ill-replicated file**

A file with contents that are not correctly replicated according to the desired setting for that file. This situation occurs in the interval between a change in the file's replication settings or suspending one of its disks, and the restripe of the file.

### **independent fileset**

A fileset that has its own inode space.

### **indirect block**

A block containing pointers to other blocks.

### **inode**

The internal structure that describes the individual files in the file system. There is one inode for each file.

### **inode space**

A collection of inode number ranges reserved for an independent fileset, which enables more efficient per-fileset functions.

## **ISKLM**

IBM Security Key Lifecycle Manager. For GPFS encryption, the ISKLM is used as an RKM server to store MEKs.

## **J**

### **journalized file system (JFS)**

A technology designed for high-throughput server environments, which are important for running intranet and other high-performance e-business file servers.

### **junction**

A special directory entry that connects a name in a directory of one fileset to the root directory of another fileset.

## **K**

### **kernel**

The part of an operating system that contains programs for such tasks as input/output, management and control of hardware, and the scheduling of user tasks.

## **M**

### **master encryption key (MEK)**

A key used to encrypt other keys. See also *encryption key*.

### **MEK**

See *master encryption key*.

### **metadata**

Data structures that contain information that is needed to access file data. Metadata includes inodes, indirect blocks, and directories. Metadata is not accessible to user applications.

### **metanode**

The one node per open file that is responsible for maintaining file metadata integrity. In most cases, the node that has had the file open for the longest period of continuous time is the metanode.



**mirroring**

The process of writing the same data to multiple disks at the same time. The mirroring of data protects it against data loss within the database or within the recovery log.

**Microsoft Management Console (MMC)**

A Windows tool that can be used to do basic configuration tasks on an SMB server. These tasks include administrative tasks such as listing or closing the connected users and open files, and creating and manipulating SMB shares.

**multi-tailed**

A disk connected to multiple nodes.

**N****namespace**

Space reserved by a file system to contain the names of its objects.

**Network File System (NFS)**

A protocol, developed by Sun Microsystems, Incorporated, that allows any host in a network to gain access to another host or netgroup and their file directories.

**Network Shared Disk (NSD)**

A component for cluster-wide disk naming and access.

**NSD volume ID**

A unique 16-digit hex number that is used to identify and access all NSDs.

**node**

An individual operating-system image within a cluster. Depending on the way in which the computer system is partitioned, it may contain one or more nodes.

**node descriptor**

A definition that indicates how GPFS uses a node. Possible functions include: manager node, client node, quorum node, and nonquorum node.

**node number**

A number that is generated and maintained by GPFS as the cluster is created, and as nodes are added to or deleted from the cluster.

**node quorum**

The minimum number of nodes that must be running in order for the daemon to start.

**node quorum with tiebreaker disks**

A form of quorum that allows GPFS to run with as little as one quorum node available, as long as there is access to a majority of the quorum disks.

**non-quorum node**

A node in a cluster that is not counted for the purposes of quorum determination.

**Non-Volatile Memory Express (NVMe)**

An interface specification that allows host software to communicate with non-volatile memory storage media.

**P****policy**

A list of file-placement, service-class, and encryption rules that define characteristics and placement of files. Several policies can be defined within the configuration, but only one policy set is active at one time.

**policy rule**

A programming statement within a policy that defines a specific action to be performed.

**pool**

A group of resources with similar characteristics and attributes.

**portability**

The ability of a programming language to compile successfully on different operating systems without requiring changes to the source code.

**primary GPFS cluster configuration server**

In a GPFS cluster, the node chosen to maintain the GPFS cluster configuration data.

**private IP address**

An IP address used to communicate on a private network.

**public IP address**

An IP address used to communicate on a public network.

**Q****quorum node**

A node in the cluster that is counted to determine whether a quorum exists.

**quota**

The amount of disk space and number of inodes assigned as upper limits for a specified user, group of users, or fileset.

**quota management**

The allocation of disk blocks to the other nodes writing to the file system, and comparison of the allocated space to quota limits at regular intervals.

**R****Redundant Array of Independent Disks (RAID)**

A collection of two or more disk physical drives that present to the host an image of one or more logical disk drives. In the event of a single physical device failure, the data can be read or regenerated from the other disk drives in the array due to data redundancy.

**recovery**

The process of restoring access to file system data when a failure has occurred. Recovery can involve reconstructing data or providing alternative routing through a different server.

**remote key management server (RKM server)**

A server that is used to store master encryption keys.

**replication**

The process of maintaining a defined set of data in more than one location. Replication consists of copying designated changes for one location (a source) to another (a target) and synchronizing the data in both locations.

**RKM server**

See *remote key management server*.

**rule**

A list of conditions and actions that are triggered when certain conditions are met. Conditions include attributes about an object (file name, type or extension, dates, owner, and groups), the requesting client, and the container name associated with the object.

**S****SAN-attached**

Disks that are physically attached to all nodes in the cluster using Serial Storage Architecture (SSA) connections or using Fibre Channel switches.

**Scale Out Backup and Restore (SOBAR)**

A specialized mechanism for data protection against disaster only for GPFS file systems that are managed by IBM Spectrum Protect for Space Management.

**secondary GPFS cluster configuration server**

In a GPFS cluster, the node chosen to maintain the GPFS cluster configuration data in the event that the primary GPFS cluster configuration server fails or becomes unavailable.

**Secure Hash Algorithm digest (SHA digest)**

A character string used to identify a GPFS security key.

**session failure**

The loss of all resources of a data management session due to the failure of the daemon on the session node.

**session node**

The node on which a data management session was created.

**Small Computer System Interface (SCSI)**

An ANSI-standard electronic interface that allows personal computers to communicate with peripheral hardware, such as disk drives, tape drives, CD-ROM drives, printers, and scanners faster and more flexibly than previous interfaces.

**snapshot**

An exact copy of changed data in the active files and directories of a file system or fileset at a single point in time. See also *fileset snapshot*, *global snapshot*.

**source node**

The node on which a data management event is generated.

**stand-alone client**

The node in a one-node cluster.

**storage area network (SAN)**

A dedicated storage network tailored to a specific environment, combining servers, storage products, networking products, software, and services.

**storage pool**

A grouping of storage space consisting of volumes, logical unit numbers (LUNs), or addresses that share a common set of administrative characteristics.

**stripe group**

The set of disks comprising the storage assigned to a file system.

**striping**

A storage process in which information is split into blocks (a fixed amount of data) and the blocks are written to (or read from) a series of disks in parallel.

**subblock**

The smallest unit of data accessible in an I/O operation, equal to one thirty-second of a data block.

**system storage pool**

A storage pool containing file system control structures, reserved files, directories, symbolic links, special devices, as well as the metadata associated with regular files, including indirect blocks and extended attributes. The `system storage pool` can also contain user data.

**T****token management**

A system for controlling file access in which each application performing a read or write operation is granted some form of access to a specific block of file data. Token management provides data consistency and controls conflicts. Token management has two components: the token management server, and the token management function.

**token management function**

A component of token management that requests tokens from the token management server. The token management function is located on each cluster node.

**token management server**

A component of token management that controls tokens relating to the operation of the file system. The token management server is located at the file system manager node.

**transparent cloud tiering (TCT)**

A separately installable add-on feature of IBM Spectrum Scale that provides a native cloud storage tier. It allows data center administrators to free up on-premise storage capacity, by moving out cooler data to the cloud storage, thereby reducing capital and operational expenditures.

**twin-tailed**

A disk connected to two nodes.

**U****user storage pool**

A storage pool containing the blocks of data that make up user files.

**V****VFS**

See *virtual file system*.

**virtual file system (VFS)**

A remote file system that has been mounted so that it is accessible to the local user.

**virtual node (vnode)**

The structure that contains information about a file system object in a virtual file system (VFS).

**W****watch folder API**

Provides a programming interface where a custom C program can be written that incorporates the ability to monitor inode spaces, filesets, or directories for specific user activity-related events within IBM Spectrum Scale file systems. For more information, a sample program is provided in the following directory on IBM Spectrum Scale nodes: `/usr/lpp/mmfs/samples/util` called `tswf` that can be modified according to the user's needs.

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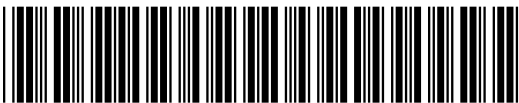
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