IBM Spectrum Scale Network Related Flows and Troubleshooting

V 1.3

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Spectrum Scale Expels – Why do We Need Them and What is Their Impact?

What is an expel?

An expel refers the case in which a node is temporarily suspended from accessing a Spectrum Scale cluster's file systems. An expelled node is sometimes referred to as having "lost cluster membership" or "lost quorum" (note this is different use of the term "quorum" than that used in "cluster **node quorum**" or "**file system descriptor quorum**").

Impact

After a node is expelled from a cluster, the expelled node may no longer submit I/O requests, its tokens and locks are released, and its Spectrum Scale file system(s) are unmounted. Applications executing on the expelled node may fail after receiving an EIO (input/output error) or ENOENT (no such file or directory) response to an I/O request made to an unmounted file system. After an unmount occurs, an application may receive a terminating SIGBUS signal if its binary is stored on the file system that gets unmounted.

Why Does Spectrum Scale Need to Expel Nodes?

To ensure data integrity and good performance, while preventing hangs and deadlocks, Spectrum Scale requires reliable communication between all nodes using a file system.

Recovery From Expels and Known Causes of Expels

Recovery from Expels

After a node is expelled from a Spectrum Scale cluster and all recovery protocols are run, the cluster manager will allow the expelled node to rejoin the cluster, provided the expelled node tries to rejoin the cluster by issuing a probe request to the quorum nodes (who respond by pointing the expelled probing node to the current cluster manager), and the expelled node has not been explicitly disabled via the mmexpelnode command. (The mmexpelnode command is one way of expelling a node that is in a bad state, e.g. if memory is over-committed on the affected node but there's a desire avoid rebooting the node).

Some Known Causes of Expels:

-Network connectivity problems (these are not always a hardware layer issue, e.g. sysctl tuning, such as preloading of the ARP tables, should be done on big IB clusters, such as clusters of 1000+ nodes)

-Resources issues on the cluster (Memory over-commitment on the failing/expelled node is the most common resource issue).

-Issues in Spectrum Scale code (of these issues, the most significant one was addressed in 4.2.2.3 (via IV93134– note that all V5 code has this fix) via an RPC prioritization change but a second RPC prioritization change has been added in 4.2.3.11 (via IJ08518– also in the base of the 5.0.2 code)

-Other software causing Spectrum Scale threads to be blocked (check for this by looking in the console log from the time a failure and look for 'stuck CPU' warnings/threads blocked for more than 120 seconds)

Types of Expels

There are three types of Expels in Spectrum Scale
(details on each of these expels are provided later in this presentation):

1. Disk lease timeout related expels.
These are expels initiated by the cluster manager some time after a node fails to renew its disk lease back to the cluster manager.

2. RPC timeout related node requested expel.
When a node makes an RPC request to another node, the source of the request may later ask the target to acknowledge that the RPC message is still pending. If the target does not acknowledge back to the source that the request is pending, the source will ask the cluster manager to expel the target node, and then the cluster manager will expel either the source or the target node.

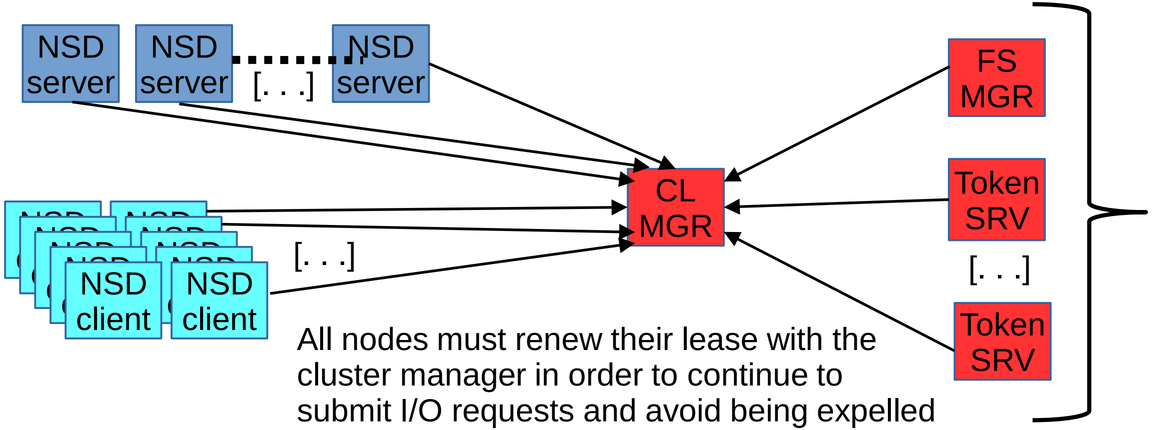
3. Expels requested by running the mmexpelnode command.
A Spectrum Scale admin may cause a node to be expelled by running the mmexpelnode command. This command has been used in some solutions to automate recovery, e.g., some DB2 configurations that use RSCT to determine when nodes become unavailable.

Details on Disk lease Timeout Related Expels (Expel Type 1)

- In each cluster, the cluster manager (CM) manages ‘disk leases’, and disk leases are needed to submit I/O requests to a given GPFS cluster

- Each node (regardless of its role) needs to renew its lease with the cluster manager (CM) node at regular intervals (leases are 35 seconds by default) or the node will no longer be able to submit I/O requests to the cluster and

- Shortly after lease expiration occurs, the CM may end up expelling the node that has an expired lease. So failure to renew leases in a timely manner will also result in expels.



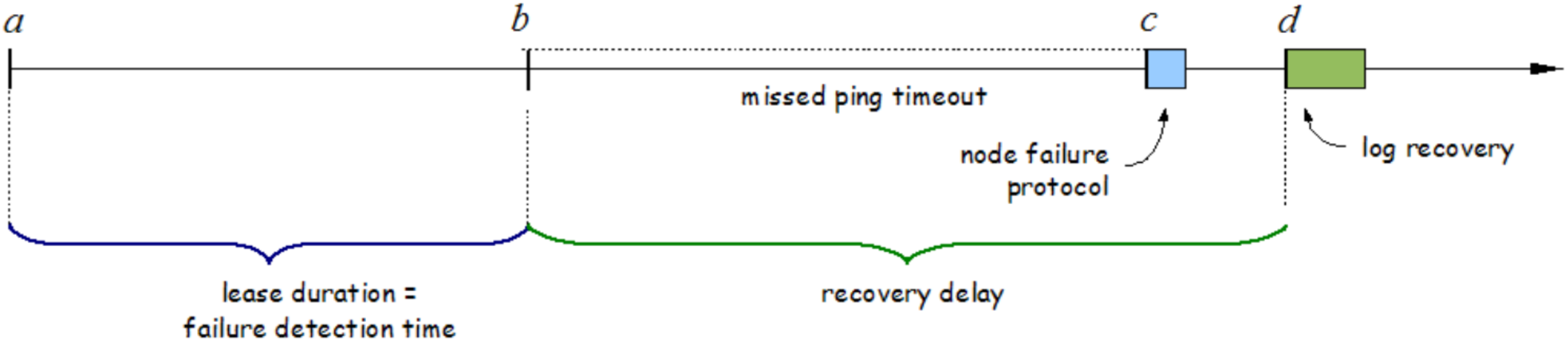
All nodes must renew their lease with the cluster manager in order to continue to submit I/O requests and avoid being expelled

Note that manager nodes and token servers can be classified as clients or servers – they are shown separately here from other clients and servers to emphasize that ALL nodes must renew their lease with the cluster manager

Details on the Flow (and Tuning) of Disk Lease Timeout Related Expels (1/2)

The following, from the developer Frank S., is the iconic diagram explaining the lease timeout flow when disk leasing is in effect. We'll focus on the disk leasing case and review the impact of configuration parameter tuning:

With disk leasing



The length of a non-quorum node's lease (in seconds) is defined by the configuration options **leaseDuration** and **failureDetectionTime**. Based on IBM test experience, we recommend always tuning **failureDetectionTime** and never **leaseDuration** (setting **failureDetectionTime** will also change **leaseDuration).**

A node is not really expelled until after its lease expires (lease duration=failure detection time in seconds) and then the 'missed ping timeout' window completes. In the 'missed ping timeout' window, the cluster manager (CM) will send ICMP datagrams (pings) to the node with the expired lease. The length of the 'missed ping timeout' window is dependent the node's response to the CM's pings as per the details on the next chart.

Details on the Flow (and Tuning) of Disk Lease Timeout Related Expels (2/2)

If a node **fails** to respond to pings from the cluster manager, the length of the ‘missed ping timeout’ window is defined by the mmfsd computed value **missedPingTimeout**, which defaults to 30 seconds. GPFS sets the value of **missedPingTimeout** based on the value of GPFS configuration parameters, taking the maximum of **minMissedPingTimeout** and **leaseRecoveryWait** (but never exceeding **maxMissedPingTimeout).**

If a node responds to pings from the cluster manager, the length of the ‘ping timeout’ window is defined by the GPFS configuration parameter **totalPingTimeout**, which defaults to 120 seconds.

For details on the meaning of the lease tuning parameters and how they are derived, see the Backup section of this presentation for slides on “**Lease Configuration Parameters As they Apply to Disk Leasing Described”**

When trying to run Spectrum Scale on a network that is less resilient (e.g. has a packet loss problem), some customers choose to increase the length of the ’missedPingTimeout’ window to allow nodes to be given more time before they are expelled (after their lease expires). Here’s one such set of configurations options that’s been tested in the field to try to ride over short windows in which network connectivity may break (these parameters require a restart of Spectrum Scale to take effect):

```
mmchconfig minMissedPingTimeout=60 #increase missedPingTimeout=60 and potentially
                               #ride over longer network outages without an expel

mmchconfig failureDetectionTime=60 #to increase the lease duration from 35 to 60s
```

Checking Spectrum Scale Lease Related Configuration Values

Details on how the Spectrum Scale Lease Configuration Parameters can be found in the backup section.

Here’s how to dump out the relevant lease tuning (mmchconfig) configuration values using mmdiag (mmlsconfig can also be run to query each of these values).

```
# mmdiag --config | egrep \

"failureDetectionTime|leaseDMSTimeout|leaseDuration|leaseRecoveryWait|PingTimeout"
```

```
failureDetectionTime -1

leaseDMSTimeout -1

leaseDuration -1

leaseRecoveryWait 35

maxMissedPingTimeout 60

minMissedPingTimeout 3
```

Example of Disk Lease Timeout Expel As Reported on the Cluster Manager

One of the best ways to determine if a network layer problem is root cause for an expel is to look at the low-level socket details dumped in the ‘internaldump’ log data (mmfs dump all) saved as part of automatic data collection on Linux GPFS nodes (not on AIX or Windows)

Some of this socket level data will also be printed to the logs in later code levels, when GPFS detects an issue with a socket that has outstanding messages associated with it.

The logs also show results of pings that are sent from the cluster manager to the failing node, before the expel, but we can’t always trust the correct underlying interface will be pinged in the case of an 802.3ad xmit layer 3+4 bonded configuration, and in the case that the subnets configuration option is used (this subnets issue is fixed in Spectrum Scale 5.0.2). If the pings don’t go through (if “Replies received: 0”) this may indicate a node failure, a reboot, or a network connectivity issue.

```
2018-04-01_18:45:54.994-0400: [E] The TCP connection to IP address 10.3.2.3 c933f02x03
    <c0n0> (socket 67) state is unexpected: ca_state=4 unacked=1 rto=4000000

2018-04-01_18:45:54.994-0400: [I] tscCheckTcpConn: Sending debug data collection request to
    node 10.3.2.3 c933f02x03

2018-04-01_18:46:00.420-0400: [E] Node 10.3.2.7 (c933f02x07) is being expelled because of an
    expired lease. Pings sent: 60. Replies received: 60.

2018-04-01_18:46:04.302-0400: [E] Node 10.3.2.5 (c933f02x05) is being expelled because of an
    expired lease. Pings sent: 60. Replies received: 60.
```

A Disk Lease Related Process - DMS Timeouts

Nodes in a Spectrum Scale cluster have a requirement for all I/Os to complete within a threshold of time after disk lease expiration. In order to preserve the integrity of the file system, Spectrum Scale must ensure there are no delayed/unexpected I/Os issued to the disks while log recovery is occuring.

If there are pending I/Os which have not completed after a server node's lease expires, this can trigger Spectrum Scale to panic (crash) the impacted server node. This panic is to prevent file system corruption.

When a server node renews its lease, it will schedule a timer event **leaseDMSTimeout** seconds after the point at which a lease timeout will occur. When the timer event occurs, if there are still pending local I/Os to the Spectrum Scale cluster file system, and the node in question has still not renewed its lease, the Spectrum Scale kernel extension will initiate a panic event that crashes the node. (In this context, 'local I/Os' are defined as I/Os to the storage that is managed/owned by the server, but the server no longer has a valid disk lease for this storage. So the typical case we'd expect this timer to pop is when an NSD server has an outstanding I/O to a GPFS NSD device, but this could also occur in SNC/FPO clusters or SAN configurations.)

This panic mechanism is referred to as the Dead Man Switch (DMS) timeout.

Another Disk Lease Related Process - Cluster Manager Takeover

The cluster manager can never be expelled from a GPFS cluster, but the cluster manager may decide not to renew its own lease and the quorum nodes can elect a new cluster manager. So the net effect of cluster manager takeover has the same effect as an expel, but it should not be called an expel.

If a majority of the quorum nodes do not renew their lease back to the cluster manager, then the cluster manager will not renew its own lease. This failure scenario will result in the quorum nodes not being able to renew their leases. After they timeout trying to contact the cluster manager, the quorum nodes will try to talk to each other, and this process may potentially result in the election of one of the candidate manager nodes as a new cluster manager.

Note that the quorum nodes use a shorter disk lease so they can efficiently validate the existence of a ‘good’ cluster manager and, if needed, initiate the process of cluster manager takeover. This shorter lease interval employed on the quorum nodes allows for a cluster manager failure to be detected in the same time frame as regular client node failures.

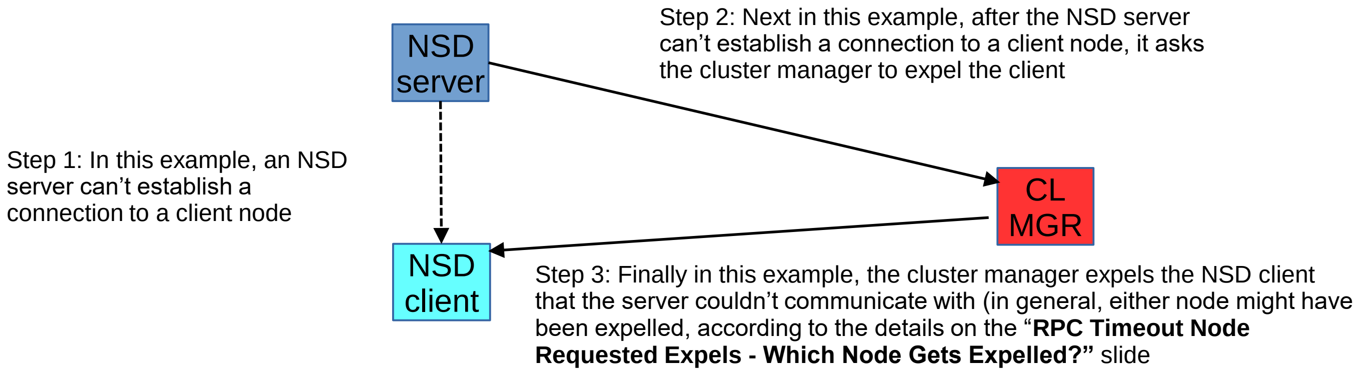
Details on RPC Timeout Related Node Requested Expels (Expel Type 2) (1/3)

- Any node may make an RPC request to any other node in the cluster; there are two cases in which such requests may timeout, leading to an expel:

  a) If the node that needs to make a request cannot establish a connection in a timely manner to the node that is the target of the request, the requesting node will ask the CM to expel the target node.

  b) If a connection is established from the requesting node to the target of the request, but the request is not handled in a timely manner, the node making the request will ask the target of the request to acknowledge that the request is pending. If that acknowledgement is not sent back in a timely manner, the requester will ask the CM to expel the target node.

- If the node making the RPC request hits one of these two cases ((a) or (b), it will ask the cluster manager (CM) to expel the target, and then the CM will expel either requester node, or the target of the request (details are on the “**RPC Timeout Node Requested Expels - Which Node Gets Expelled?” slide.**



Step 2: Next in this example, after the NSD server can’t establish a connection to a client node, it asks the cluster manager to expel the client

Step 1: In this example, an NSD server can’t establish a connection to a client node

Step 3: Finally in this example, the cluster manager expels the NSD client that the server couldn’t communicate with (in general, either node might have been expelled, according to the details on the “**RPC Timeout Node Requested Expels - Which Node Gets Expelled?”** slide

Details on RPC Timeout Related Node Requested Expels (Expel Type 2) (2/3)

Every 90 seconds the EEWatchDogThread in the GPFS daemon will look for pending messages outstanding to all destinations.

For every destination that has pending messages, the GPFS daemon will send a commMsgCheckMessages message that attempts to verify the destination is aware of all pending messages and can acknowledge that these messages are being worked.

The timeout on the commMsgCheckMessages is calculated to be the minimum of (10 * **leaseDuration)** and (300). As the default value for **leaseDuration** is 35, the timeout typically ends up being 300 seconds on a non quorum node (quorum nodes use 2/3rd the typical lease length).

The timeout on commMsgCheckMessages includes sending a single retry of the message to allow for timing holes in how the pending messages are viewed on the source and target nodes.

If the target of a given message has not acknowledged the commMsgCheckMessage for a message that has reached the commMsgCheckMessage timeout value (again, by default this is 300 seconds) then the source node will request the cluster manager to expel the target node. The cluster manager, then, needs to decide whether it should expel the source or destination node (more on that process on the later "**RPC Timeout Node Requested Expels - Which Node Gets Expelled?"** chart).

Details on RPC Timeout Related Node Requested Expels (Expel Type 2) (3/3)

Note that there are potentially shorter timeouts that can lead to RPC timeout node requested expels, in addition to the default timeout of 300 seconds that occurs when communicating with destinations that have connections already established.

If a node needs to make an RPC call to another node which there it has no established connection to, a shorter timeout can be hit in the code paths that establish new connections. Two examples of these shorter timeout cases, for TCP connections, are as follows:

1) When a new TCP connection must be established to another host, if ARP resolution is not working and a valid ARP entry is not present for the destination IP, a ”NO ROUTE TO HOST” error will occur establishing the connection, by default after 3 seconds of ARP retries (controlled by the applicable sysctl ucast_solicit parameter). GPFS will retry the connection but the RPC could timeout in as little as 6 seconds if ARP is not working and the default tuning is in effect.

2) If ARP is working but TCP connections cannot be established, an RPC timeout can, with default TCP tuning, occur in about two minutes (GPFS will retry the TCP connection if it times out on connect).

RPC Timeout Node Requested Expels - Which Node Gets Expelled?

The default policy when deciding which node should be expelled by the cluster manager, in the case of a node requested expel, is controlled by a default set of priority choices made by the cluster manager.

In terms of which nodes are favored (preferred) to keep active in the cluster, the defaults are:
1. quorum nodes are favored over non-quorum nodes
2. local (home/owning file system) cluster nodes are preferred over nodes accessing a remote file system
3. nodes having a management role are favored over non-manager nodes
4. nodes managing more file systems are preferred over nodes managing fewer file systems
5. NSD servers are favored over non-NSD server nodes
6. nodes that have been active longer in the cluster are preferred over nodes that have been part of the cluster for shorter periods of time.

GPFS provides a callback mechanism to allow changing these defaults, to provide more precise control over which node is expelled on an RPC timeout related node requested expel (see /**usr/lpp/mmfs/samples/expelnode.sample** for details on how to use this callback).

The callback script, which will run on the cluster manager on an RPC timeout related expel, can also be used to take action on such an expel, such as calling-out an admin, shutting down services, generating an alert, etc.

Details on Expels caused by the mmexpelnode Command (Expel Type 3)

What is the mmexpelnode Command?

A system administrator may cause a node to be expelled by running the mmexpelnode command. Expels that are forced in this manner have the same impact as an expel that results from the more common lease timeout or RPC timeout node requested expel flows. Running the mmexpelnode command can be useful when it's desired to remove a node from the GPFS cluster, without shutting the node down (for example, it may be desirable to temporarily expel a node that has a resource issue, such as over-committed memory). **Warning**: do **not** use the -f (--is-fenced). option to mmexpelnode, unless you are sure that the node is down/fenced (as this option avoids the typical log recovery delay associated with an expel). (It's generally recommended to avoid this --is-fenced option.)

To expel a node in this manner, run mmexpelnode with the –N flag to specify the target node(s) for the expel, e.g.:

```
/usr/lpp/mmfs/bin/mmexpelnode –N c933f02x27
```

To bring a node back into the cluster, after it's been expelled in this manner, use the –r' flag, e.g.:

```
/usr/lpp/mmfs/bin/mmexpelnode -r -N c933f02x27
```

Debugging Expels (1/2)

As per the previous chart, one of the best places to start debugging an expel is to look at any “internaldump” data collected from the time of the expel. (Note this approach is only valid on Linux.) TCP/IP socket level statistics provide a view of how the network is working at a low level (TCP acknowledgements are turned around by the kernel, typically in interrupt context). Using that internaldump data, look for the socket statistics in the “dump tscomm” section of the data, and focus on values such as:

rto: typically it starts out at around 204000 on a low latency network, and, if it goes higher, this may indicate that TCP is retransmitting and backing off the retransmission time

retransmits, backoff, lost: if any of these are non-zero, then the socket is retransmitting

ca_state: if this is anything other than ‘open’, there has been either packet loss or a out of order packet delivery issue

Here’s an example of a socket connection that is showing a clear problem:

```
192.168.1.13/1
    state 1 established snd_wscale 7 rcv_wscale 9 rto 120000000 ato 40000
    retransmits 0 probes 0 backoff 11 options: WSCALE
    rtt 3711 rttvar 123 snd_ssthresh 2 snd_cwnd 2 unacked 122
    snd_mss 1460 rcv_mss 973 pmtu 2044 advmss 2004 rcv_ssthresh 31074
    sacked 0 lost 120 retrans 0 fackets 0 reordering 3 ca_state 'loss’
```

As per the previous chart, some of this socket level data will also be printed to the logs in later code levels, when GPFS detects an issue with a socket that has outstanding messages associated with it.

Debugging Expels (2/2)

If there's no level socket data available (e.g. on AIX, Windows, or older Linux code levels), lease timeout related expels may offer some clue on the state of the network by looking at the cluster manager logs and checking if the pings from the cluster manager (done before an expel in the case of a lease timeout) are going through. If all the packets go through, as in this example, it may mean there's a resource, tuning, or code issue causing the expel, or it might still be a network layer problem. Here's an example:

```
2018-04-01_18:46:00.420-0400: [E] Node 10.3.2.7 (c933f02x07) is being expelled
   because of an expired lease. Pings sent: 60. Replies received: 60.
```

In such cases, where's there's no evidence of a network problem, traces may be needed, but other things to check include:

1) /var/log/messages for evidence of resource issues (e.g. memory being over-committed)
2) Verify if bonding is in use (GPFS may ping the wrong underlying physical interface in the case of 802.3ad bonding with xmit mode 3+4).
3) Also check if the customer is running GPFS level 4.2.2.3 (or any higher level) to make sure they have the fix for IV93134 (Prioritization of critical RPCs)

If ”Replies received” had been 0, this might point more at a network connectivity problem. In such cases, check gpfs.snap data for:

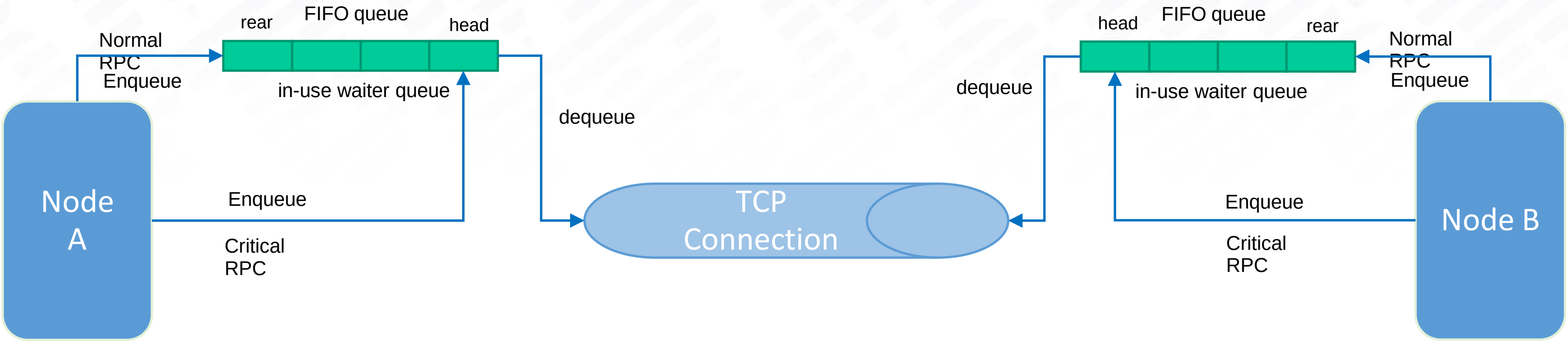
1) evidence of packet loss (e.g. high packet loss reported in 'ifconfig' data – we commonly see that a high “RX dropped” count may be an indication that additional receive ring buffers need to be configured
2) high retransmission levels reported in the netstat tcp statistics (also check /var/log/messages for signs of switch flow control– or pause frames– which may lead to retransmission)

Improvements in 5.0.2 + 5.0.3
For Avoiding and Debugging Expels

Network Resiliency Enhancement - Prioritize the commMsgCheckMessages RPC to avoid RPC Time-out Node Requested Expels

- If the sending of the commMsgCheckMessages RPC and/or reply is blocked because of exclusive use of the TCP connection by other threads (which we’ve seen happen when lots of NSD read and write RPCs are using the TCP connection) this may cause a long wait time for the commMsgCheckMessages RPC, possibly leading to an RPC timeout related expel, even if the network is good.

- In 5.0.2. we now prioritize the commMsgCheckMessages as critical RPC, enqueueing it to the front of the in-use waiter queue, which can eliminate such expels



Network PD improvement - Dump the TCP_INFO When Disk Lease Overdue Happens

- TCP_INFO of the connection is dumped when disk lease overdue happens

- To better determine if this is a GPFS problem or network problem according to the important fields of TCP_INFO

- Only available on Linux

TCP connection congestion state

- ca_state

TCP connection slow start and congestion avoidance

- snd_cwnd
- snd_ssthresh
- unacked

TCP connection retransmission

- backoff
- retransmits
- rto

TCP connection statistics

- retrans
- reordering
- lost

TCP connection RTT

- rtt
- rttvar

TCP connection receiver window

- rcv_ssthresh

Network PD improvement - dump the TCP_INFO when disk lease overdue happens – Example #1

Disk lease overdue due to TCP layer error (using tc & netem to inject TCP layer error)

clusterMgr: ps7n21

```
2018-08-14_04:43:42.031-0400: [N] Node 192.168.80.164 (c80f4m5n04) lease renewal is overdue. Pinging to check if it is alive
2018-08-14_04:43:42.031-0400: [I] The TCP connection to IP address 10.0.80.164 c80f4m5n04 <c0n2> (socket 59) state: state=1 ca_state=0 snd_cwnd=10 snd_ssthresh=2147483647
unacked=0 probes=0 backoff=0 retransmits=0 rto=210000 rcv_ssthresh=240272 rtt=6805 rttvar=11296 sacked=0 retrans=0 reordering=3 lost=0
2018-08-14_04:45:23.658-0400: [N] sdrServ: Received expel data collection request from 192.168.80.164
2018-08-14_04:45:23.658-0400: [N] GPFS will attempt to collect debug data on this node.
2018-08-14_04:45:42.027-0400: [E] Node 192.168.80.164 (c80f4m5n04) is being expelled because of an expired lease. Pings sent: 60. Replies received: 60.
2018-08-14_04:45:42.027-0400: [I] The TCP connection to IP address 10.0.80.164 c80f4m5n04 <c0n2> (socket 59) state: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=7 unacked=1
probes=0 backoff=8 retransmits=8 rto=53760000 rcv_ssthresh=240272 rtt=6805 rttvar=11296 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_04:45:42.027-0400: Sending request to collect expel debug data to c80f4m5n04 localNode
```

quorum: c80f4m5n04

```
2018-08-14_04:43:23.524-0400: [N] Node 192.168.116.71 (ps7n21) lease renewal is overdue. Pinging to check if it is alive
2018-08-14_04:43:23.524-0400: [I] The TCP connection to IP address 10.0.116.71 ps7n21 <c0n1> (socket 62) state: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=7 unacked=1 probes=0
backoff=4 retransmits=4 rto=3328000 rcv_ssthresh=55502 rtt=6286 rttvar=10161 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_04:43:43.526-0400: [N] Disk lease period expired 1.550 seconds ago in cluster c80f4m5n03.gpfs.net. Attempting to reacquire the lease.
2018-08-14_04:43:43.526-0400: [I] The TCP connection to IP address 10.0.116.71 ps7n21 <c0n1> (socket 62) state: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=7 unacked=1 probes=0
backoff=6 retransmits=6 rto=13312000 rcv_ssthresh=55502 rtt=6286 rttvar=10161 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_04:45:23.524-0400: [I] Node 192.168.116.71 (ps7n21): ping timed out. Pings sent: 60. Replies received: 60.
2018-08-14_04:45:23.524-0400: [I] The TCP connection to IP address 10.0.116.71 ps7n21 <c0n1> (socket 62) state: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=7 unacked=1 probes=0
backoff=9 retransmits=9 rto=106496000 rcv_ssthresh=55502 rtt=6286 rttvar=10161 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_04:45:23.524-0400: Sending request to collect expel debug data to ps7n21 localNode
2018-08-14_04:45:23.524-0400: [I] Quorum node: Ping timed out to cluster manager. Probing cluster c80f4m5n03.gpfs.net
```

Note: Bad ca_state, higher backoff and rto, packet loss on quorum node. In this case note that replies *are* received to cluster manager's ping attempts

Network PD improvement - dump the TCP_INFO when disk lease overdue happens – Example #2

Disk lease overdue due to IP layer error (using tc & netem to inject IP layer error)

clusterMgr: ps7n21

```
2018-08-14_05:07:42.168-0400: [N] Node 192.168.80.163 (c80f4m5n03) lease renewal is overdue. Pinging to check if it is alive
2018-08-14_05:07:42.168-0400: [I] The TCP connection to IP address 10.0.80.163 c80f4m5n03 <c0n0> (socket 78) state: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=5 unacked=1
probes=0 backoff=7 retransmits=7 rto=26880000 rcv_ssthresh=297216 rtt=2087 rttvar=3478 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_05:07:57.666-0400: [W] The TCP connection to IP address 10.0.80.163 c80f4m5n03 <c0n0> (socket 78) state is unexpected: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=5
unacked=1 probes=0 backoff=7 retransmits=7 rto=26880000 rcv_ssthresh=297216 rtt=2087 rttvar=3478 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_05:07:57.666-0400: [I] tscCheckTcpConn: Sending debug data collection request to node 192.168.80.163 c80f4m5n03
2018-08-14_05:07:57.666-0400: Sending request to collect TCP debug data to c80f4m5n03 localNode
2018-08-14_05:07:57.666-0400: [I] Calling user exit script gpfsSendRequestToNodes: event sendRequestToNodes, Async command /usr/lpp/mmfs/bin/mmcommon.
2018-08-14_05:08:12.170-0400: [E] Node 192.168.80.163 (c80f4m5n03) is being expelled because of an expired lease. Pings sent: 15. Replies received: 0.
2018-08-14_05:08:12.170-0400: [I] The TCP connection to IP address 10.0.80.163 c80f4m5n03 <c0n0> (socket 78) state: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=5 unacked=1
probes=0 backoff=8 retransmits=8 rto=53760000 rcv_ssthresh=297216 rtt=2087 rttvar=3478 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_05:08:12.172-0400: [I] Recovering nodes: 192.168.80.163
```

quorum: c80f4m5n03

```
2018-08-14_05:07:21.533-0400: GPFS: 6027-2725 [N] Node 192.168.116.71 (ps7n21) lease renewal is overdue. Pinging to check if it is alive
2018-08-14_05:07:21.533-0400: GPFS: 6027-1759 [I] The TCP connection to IP address 10.0.116.71 ps7n21 <c0n1> (socket 59) state: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=7
unacked=1 probes=0 backoff=4 retransmits=4 rto=3328000 rcv_ssthresh=124062 rtt=6100 rttvar=9717 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_05:07:41.524-0400: GPFS: 6027-3918 [N] Disk lease period expired 0.860 seconds ago in cluster c80f4m5n03.gpfs.net. Attempting to reacquire the lease.
2018-08-14_05:07:41.524-0400: GPFS: 6027-1759 [I] The TCP connection to IP address 10.0.116.71 ps7n21 <c0n1> (socket 59) state: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=7
unacked=1 probes=0 backoff=6 retransmits=6 rto=13312000 rcv_ssthresh=124062 rtt=6100 rttvar=9717 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_05:07:51.525-0400: GPFS: 6027-2778 [I] Node 192.168.116.71 (ps7n21): ping timed out. Pings sent: 15. Replies received: 0.
2018-08-14_05:07:51.525-0400: GPFS: 6027-1759 [I] The TCP connection to IP address 10.0.116.71 ps7n21 <c0n1> (socket 59) state: state=1 ca_state=4 snd_cwnd=1 snd_ssthresh=7
unacked=1 probes=0 backoff=7 retransmits=7 rto=26624000 rcv_ssthresh=124062 rtt=6100 rttvar=9717 sacked=0 retrans=1 reordering=3 lost=1
2018-08-14_05:07:51.525-0400: GPFS: 6027-2724 [I] Quorum node: Ping timed out to cluster manager. Probing cluster c80f4m5n03.gpfs.net
```

Note: Bad ca_state, higher backoff and rto, packet loss on quorum node, all the cluster manager’s ping attempts don’t get a reply back

Network PD improvement - add (undocumented) skipFastHandler config variable, avoid the use of (tscMFFastHandler) fast path handler RPCs in case they stall receive socket buffer processing

- Normally, the receiver thread(TcpConnTabReceiveThread) process receiving data from GPFS sockets, they will hand over the work to the receiver worker threads for handling. However, when RPCs have tscMFFastHandler flag, these RPCs will be handled directly by the receiver thread, such as nsdMsgReadExt and nsdMsgWriteExt

- Sometimes, bad design of RPC handler with tscMFFastHandler could cause the receiver thread to be stuck, or too many RPCs with tscMFFastHandler flag coming in a very short period could cause the receiver thread to become too busy, these scenarios could cause the receiver thread to be unable to handle the data from other sockets in a timely manner, for example, disk lease renewal request is not handled in time, which could case disk lease overdue to happen

- This undocumented config variable skipFastHandler is mainly for debug purpose so far, if you suspect some issues are because the receiver thread is stuck, such as disk lease overdue, you should enable this config

- skipFastHandler can be enabled dynamically, once enabled, even RPCs with tscMFFastHandler flag would be handed over to the receiver worker threads for handling, RPC replies are exceptions.

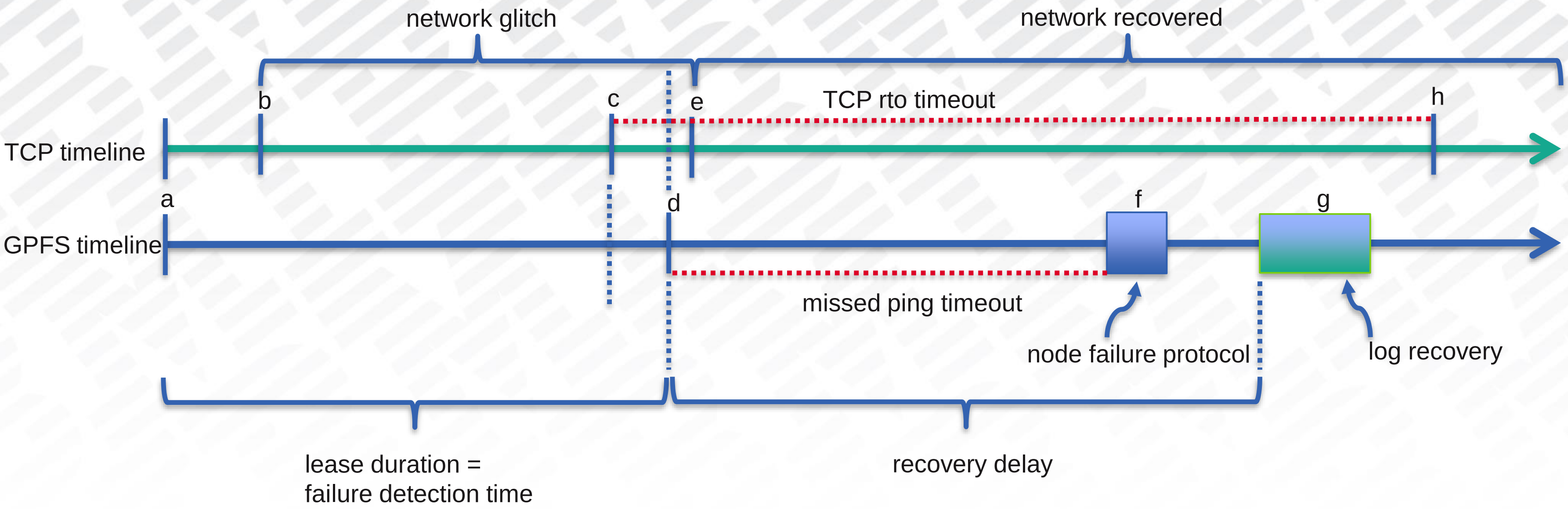
Enable:

```
# echo 999 | mmchconfig skipFastHandler=yes –i
```

Disable:

```
# echo 999 | mmchconfig skipFastHandler=no –i
```

Likely To Be Enabled In the Future – New Pro-active Reconnect Feature
Now documented in 5.0.3
Here’s why Pro-active Reconnect Should be Helpful



a) The last time the failed node renewed its lease
b) Network glitch happened
c) The client node should send a disk renew request at this time, but because network glitch, the TCP rto is bigger now, such as 64 seconds, then the request was lost, TCP would wait for rto timeout, then re-transmit
d) The cluster manager detects that the lease has expired, and starts pinging the node
e) Just around the time d, the network was recovered
f) The cluster manager decides that the node is dead and runs the node failure protocol
g) The file system manager starts log recovery
h) RTO timer pops but the node has already been expelled before retransmission can happen

To Enable:

```
# mmchconfig proactiveReconnect=yes –i
```

To Disable:

```
# mmchconfig proactiveReconnect=no -i
```

Performance Problems and the Network (1/2)

Good GPFS performance typically requires both good network and disk I/O subsystem performance. When possible, isolating the performance of the network from the disks is a good performance debug approach.

In general, the network should always be considered as a potential limiting factor for performance* (for SAN configurations, we can view fibre channel connections as the network used to get to the disks).

When looking at network issues there are two important considerations related to how Spectrum Scale currently uses the network:

1) Currently (as of Nov. 2018) Spectrum Scale will only establish one TCP/IP socket between each pair of nodes (this connection is on demand, and established for a number of seconds equal to the idleSocketTimeout tunable
2) When using bonded interfaces, the balance of physical interface usage is dependent on the configuration of bonding (GPFS does not try to balance usage)

*some exceptions exist, such as FPO workloads and also cases in which very good client side page pool caching can be achieved.

Performance Problems and the Network (2/2)

Regarding the balance of physical interface usage with mode=4 (802.3ad) bonding, we can only ensure that send side interface usage will be well balanced for any given node (sending to all destinations) if we ensure that both the MAC addresses and IP addresses yield a balance hash mapping.   Looking at the options, the most common one (layer 2+3) includes the **source port:**

With xmit_hash_policy=0 (layer 0):

source_MAC_address XOR destination_MAC) MODULO slave_count)

With xmit_hash_policy=1 (layer 3+4:

((source_port XOR dest_port) XOR ((source_IP XOR dest_IP) AND 0xffff) MODULO slave_count

With xmit_hash_policy=2 (layer 2+3:

(((source_IP XOR dest_IP) AND 0xffff) XOR (source_MAC XOR destination_MAC)) MODULO slave_count

It’s not enough to measure single pairs of node to assess performance of the network. IBM Spectrum Scale can put a heavy concurrent load on the nodes, so a performance test that measures the network component should be representative of Spectrum Scale’s use of the network. . . which is typically where nsdperf comes in.

*some exceptions exist, such as FPO workloads and also cases in which very good client side page pool caching can be achieved.

NSDPERF (1/3)

A good starting point set of instructions for running nsdperf is here:

https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/General%20Parallel%20File%20System%20(GPFS)/page/Testing%20network%20performance%20with%20nsdperf

The above page describes some wrapper scripts (which we may update in the future) to control nsdperf:

Script: control (two versions, one of which includes use of mmdsh)
Script: gencommand

These provided scripts can be copied from the wiki and then one of the example run procedures can be followed.

NSDPERF (2/3)

Example run procedure from the wiki:

1. Input files

testnodes - This file contains a list of all the nodes under test. One node on each line.

servers - This file contains a list of all the nodes you want to use as "servers" for the nsdperf test. One node on each line. This is a subset of the list in testnodes.

clients - This file contains a list of all the nodes you want to use as "clients" for the nsdperf test. One node on each line. This is a subset of the list in testnodes.

2. Generate the command input file

The gencommand script generates the command file used as input to the nsdperf command when executing the test. The output file is called commands. The gencommand script assumes that the servers and clients file are in the same directory as the gencommand script.

3. Edit the control script

Edit the rootdir path in control script. This path needs to be the path to the nsdperf executable on all of the nodes. Typically it is easiest to use the GPFS file system to place the binary.

```
rootdir="/scratch/nsdperf"
```

4. Start the process

Use the control script to start the nsdperf process on the nodes.

```
control start
```

5. Start the test

Use the nsdperf command to start the test run. You can start the test from any node.

```
nsdperf -i commands
```

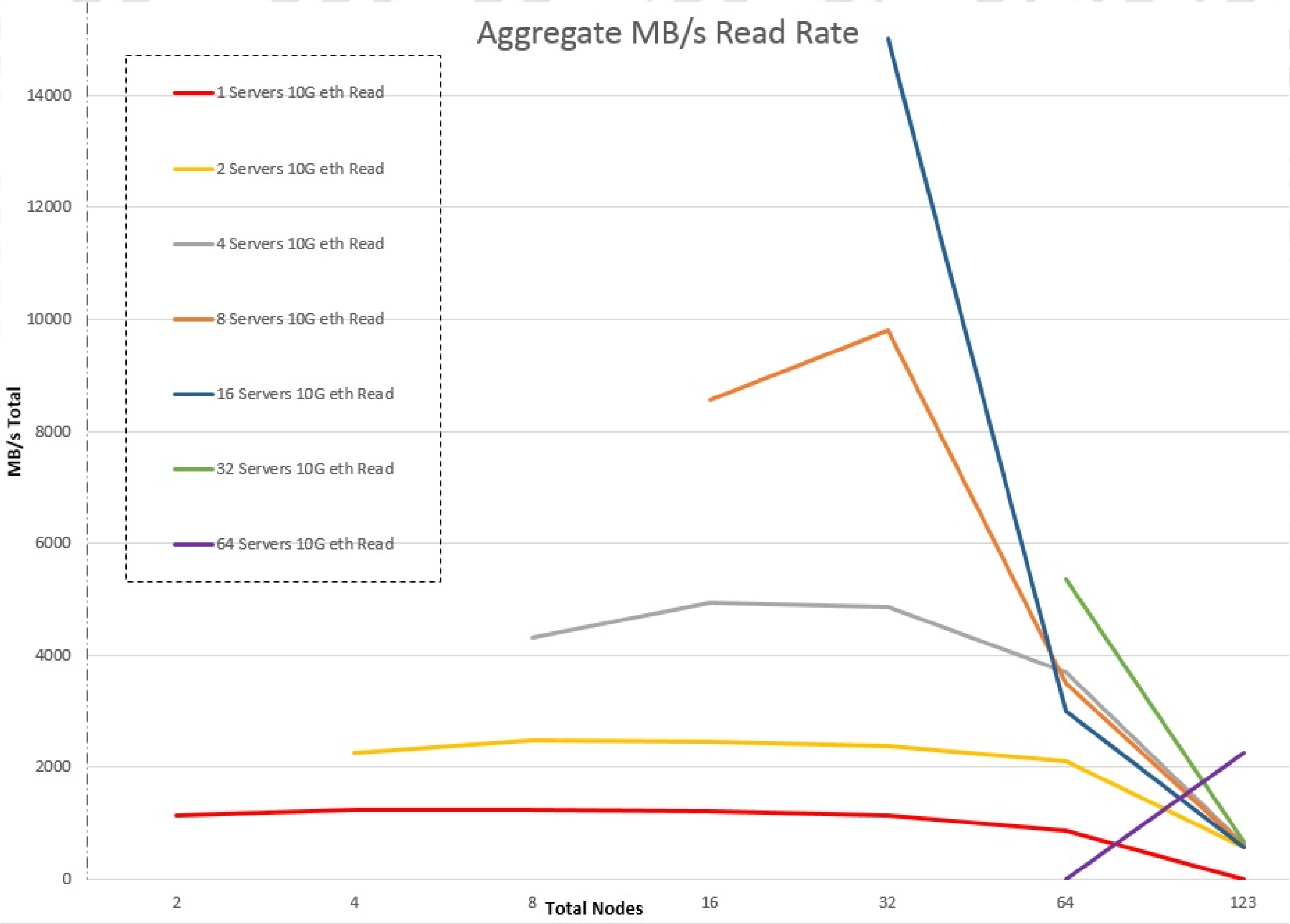
Where commands is the name of the file generated by the gencommand script.

6. Stop the process

When you are done running tests you should stop the nsdperf process on all of the nodes.

```
control stop
```

NSDPERF (3/3) – Example Data Graphed



Backup

Network Related FAQ Ideas (1/3)

(This is meant to be interactive but sample questions
that have come up in the past are listed below)

1) I have many waiters that are waiting for "Exclusive use of connection" what does that mean?

A: Spectrum Scale maintains, via locking, an ordered queue of threads that wait to enqueue data to each socket. When the queue grows long, it may indicate that Spectrum Scale is trying to send more data than the network can handle in a timely manner. Note that Spectrum Scale uses the value of the tunable maxMBpS to define a number of prefetch threads that is appropriate to the network and I/O subsystem bandwidth, so tuning this value incorrectly may cause more threads to wait on socket access. Possible other causes of many such waiters could be: excessive packet loss, or additional RPC traffic between Spectrum Scale mmfsd processes.

Network Related FAQ Ideas (2/3)

Looking for additions for Webinar planned:

2) I have had failure, such an expel, that IBM has diagnosed to likely be "network related" but my network seems just fine. How do I determine what's going on?
A: See the slides on **Debugging** Expels (starting with slide 18)

3) What should I expect, in terms of latency and bandwidth requirements, from the network on which I run Spectrum Scale?
A: The latency and bandwidth of the network will define the minimum latency of all I/O operations, as well as the maximum bandwidth of all such operations (of course the I/O subsystem also needs consideration). Size the network according to your performance requirements for GPFS and consider other usage (non-GPFS) of the network as well.

Network Related FAQ Ideas (3/3)

4) Why should I move to latest 4.2.3 PTF? What will that buy me with respect to expels, etc?
A: Some examples of important changes:
The change previously described to prioritize the commMsgCheckMessages RPC is delivered 4.2.3.11 (via IJ08518).
Also, automatic data collection on any expel event is another example of an enhancement to enable debugging expels.

5) Why should I move to latest 5.0.X PTF? What will that buy me with respect to expels, etc?
A: See the slides on “Improvements in 5.0.2 for Avoiding and Debugging Expels” (starting with slide 20)

Other resources

Other resources

- Spectrum Scale Wiki – Network Section Communication: https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/General%20Parallel%20File%20System%20(GPFS)/page/Spectrum%20Scale%20Network%20Communication%20Overview

- List of ports being used by IBM Spectrum Scale components https://ibm.biz/BdixM4

Details on Spectrum Scale
Lease configuration parameters

The “Real” Lease Related Variables Used by mmfsd and How to Display Them

Here’s how to dump out the related lease variables in use by the GPFS daemon, displaying the parameters reported by ‘cfgmgr data’ dump
Note there’s a

Note: Try to avoid running ‘mmfsadm dump’ in production, as there is a timing hole exposure that may cause a daemon failure (even with ‘saferdump’). The mmdiag command provides much, but not all, of the ‘mmfsadm dump’ data that might be needed in production.

```
# mmfsadm saferdump cfgmgr | grep -A 3 "^lease"

failureDetectionTime 35

no recoveryWait 35

dmsTimeout 23

leaseDuration 35.0/23.3

renewalInterval 30.0/11.7

renewalTimeout 5

fuzz 3.00/1.17

missedPingTimeout 15x2.0=30.0

totalPingTimeout 60x2.0=120.0
```

Lease Configuration Parameters As they Apply to Disk Leasing Described (1/6)

failureDetectionTime: The default value used in the GPFS daemon is 35 seconds (mmdiag will report the default as '-1').

This variable controls how long it takes GPFS to react to a node failure (how quickly the cluster manager may detect a failed node, expel it, and recover the cluster). When disk fencing (Persistent Reserve) is enabled, GPFS is capable of initiating faster recovery times, but Persistent Reserve is not a typical configuration so we will instead describe the more common 'disk leasing' mechanism used to manage disk leases.

When disk leasing is enabled, **failureDetectionTime** can be changed via mmchconfig to set the length of the lease (**leaseDuration**, can be also be set directly via mmchconfig but large clusters have typically tuned **failureDetectionTime** instead, allowing **leaseDuration** to be derived from **failureDetectionTime**, so only this approach will be considered here).

leaseDMSTimeout: The default value is 23 seconds (mmdiag will report the default as -1 and mmlsconfig will report the default as "2/3 leaseDuration").

When a GPFS server node acquires a disk lease, it will schedule a timeout interrupt to occur **leaseDMSTimeout** seconds after the new lease is set to expire. When that timer pops, if the lease associated with the timer had not been renewed, then GPFS will cause a kernel panic if there is any local I/O pending to a cluster file system for which the server's lease has expired.

Lease Configuration Parameters As they Apply to Disk Leasing (continued, 2/6)

leaseDuration: The default value for the duration of a GPFS disk lease is 35 seconds (mmdiag will report the default as -1).

It’s highly recommend this never be directly tuned (use **failureDetectionTime** instead).

The ‘mmfsadm saferdump’ command (which should be avoided on production systems) displays two values for this configuration option, first the length of non-quorum node leases, and second the length of quorum node leases. Quorum nodes need to renew their disk leases more frequently (2/3rd of the non quorum node lease values) because the quorum nodes’ renewal mechanism also verifies the existence of a valid cluster manager, and this shorter lease facilitates the quorum nodes’ election of a replacement cluster manager when required.

Lease Configuration Parameters As they Apply to Disk Leasing (continued, 3/6)

leaseRecoveryWait: The default value is 35 seconds.

To maintain the integrity of the file system, tuning this value below 35 seconds is discouraged unless it can be ensured that I/Os will never be delayed.

The **leaseRecoveryWait** configuration option is used in two ways by the Spectrum Scale code when disk leasing is enabled (as opposed to Persistent Reserve which is not covered here).

First, the default value of **leaseDMSTimeout** is calculated to be two thirds of **leaseRecoveryWait**.

Second, the value of **leaseRecoveryWait** is used by the GPFS daemon to determine how long to wait before running recovery protocols (also called log recovery) after an expel event occurs. As recovery must always wait at least **leaseRecoveryWait** seconds after a node is expelled, GPFS ensures that **missedPingTimeout** (discussed later) can never be smaller than **leaseRecoveryWait**.

Lease Configuration Parameters As they Apply to Disk Leasing (continued, 4/6)

renewalInterval: The default value is 30 seconds; **renewalInterval** is derived by subtracting **renewalTimeout** (which is by default 5 seconds) from **leaseDuration** (which defaults to 35 seconds).

This tunable defines the maximum number of seconds a node will wait, after it obtains a valid lease, before it attempts to renew that lease. On each new lease renewal, a random ‘fuzz factor’ (described below under the **fuzz** configuration option description) is subtracted from this **renewalInterval** value, in an attempt to stagger lease renewal times across the nodes.

renewalTimeout: The default value is 5 seconds, and always set to 5, unless the value of **leaseDuration** is set to less than 10 seconds. In the case that **leaseDuration** is set to less than 10 seconds, renewalTimeout is set to one half of **leaseDuration**.

This value is used in calculating the interval in which the lease is renewed as described above.

fuzz: The default value set to 3 seconds (derived from 1/10th of the **renewalInterval**, which defaults to 30).

As per the **renewalInterval** description, after each new lease renewal, the number of seconds a node will wait before initiating a new lease renewal is calculated to be **renewalInterval** seconds, minus a random ‘fuzz factor’, which is defined to be a random number of seconds between zero and this **fuzz** configuration option. So, with the default tuning, a node will attempt to renew its lease on an interval between (**renewalInterval** – **fuzz** = 30-3) 27 and (**renewalInterval**) 30 seconds.

Lease Configuration Parameters As they Apply to Disk Leasing (continued, 5/6)

maxMissedPingTimeout: The default value is 60 seconds.

When a node fails to renew its lease within the allotted **leaseDuration** window, the cluster manager will begin to ping (send ICMP datagrams to) the node (this is sometimes called the ping timeout window). One of the goals of these pings is to determine if a node still has a good connection back to the cluster manager, and therefore may be given more time to renew its lease before an expel. The **maxMissedPingTimeout** is used to define a maximum value for GPFS daemon's **missedPingTimeout** variable, which defines the length of time the cluster manager will ping before expelling a node, if the pings fail. The value of the internal **missedPingTimeout** variable is calculated as per the details described under **minMissedPingTimeout**

minMissedPingTimeout: The default value of the tunable is 3 seconds.

The value of **minMissedPingTimeout** defines a minimum value for GPFS daemon's **missedPingTimeout** variable. The actual value of the internal **missedPingTimeout** variable is taken to be the maximum of **minMissedPingTimeout** and **leaseRecoveryWait** (but it's limited to a maximum value according to **maxMissedPingTimeout).** GPFS uses the daemon **missedPingTimeout** value to define the amount of time the cluster manager will wait before expelling a node with an overdue lease in the case that the node does not respond to the cluster manager's pings. Note that, with the default tuning, missedPingTimeout will be defined by **leaseRecoveryWait .**

Lease Configuration Parameters As they Apply to Disk Leasing (continued, 6/6)

totalPingTimeout, The default value is 120 seconds.

This tunable is used by the GPFS daemon to define the total amount of time the cluster manager will wait before expelling a node with an overdue lease, in the case that the node responds to the pings sent my the cluster manager. As this tunable is already set to 120 seconds by default, it is generally left at the default (IBM has little experience tuning this value on large systems).

The intent of having separate values for **totalPingTimeout** and **missedPingTimeout** (defined according to the values of **minMissedPingTimeout, maxMissedPingTimeout,** and **leaseRecoveryWait)** is to allow for tuning such that nodes that still have good network connectivity back to the cluster manager are given more tolerance in terms of slow lease responses back to the cluster manager.

Thank You!