LNET Router Resiliency and Tuning

John Fragalla
HPC Principal Engineer
Seagate Technology

Agenda

- Configuration Goal
- Benchmark Setup
- LNET Router Configuration/Testing
  - Fine Tuning and testing 4MB I/O
- Summary
- References
Configuration Goal

- Extend Data Access to Ethernet connected clients from an InfiniBand based Lustre System
  - 1 IB Lustre File System, IB Clients for performance, Ethernet Routed Clients for additional data access
- Resiliency and Performance of IB Clients were higher priority than optimizing performance of Routed Clients
Benchmark Setup

■ Lustre Storage System based on ClusterStor 9000 – IB System
  – Lustre MGS NID: 172.18.54.79@o2ib0
  – Lustre MDS NID: 172.18.54.80@o2ib0
  – 4 OSS Nodes with 4 GridRaid OSTs, 2 HA Pairs
■ InfiniBand Clients (16 Clients)
■ Ethernet Routed Clients (4 Clients), 10GigE Interface
  – 172.19.62.[170,172,174,178]@tcp0
■ LNET Routers (4 Configured)
  – InfiniBand ib0 / Ethernet eth20 Interface (10GigE)
    – 172.18.62.162@o2ib / 172.19.62.162@tcp
    – 172.18.62.164@o2ib / 172.19.62.164@tcp
    – 172.18.62.166@o2ib / 172.19.62.166@tcp
    – 172.18.62.168@o2ib / 172.19.62.168@tcp
Lustre Software and Kernel Versions

- **Server Side, tested two Lustre Versions**
  - Seagate Lustre 2.1.0.x5-148 on Kernel 2.6.32-220.7.1.el6.lustre.4226.x86_64
  - Seagate Lustre 2.5.1.x6-107 on Kernel 2.6.32-431.17.1.x2.0.43.x86_64

- **Clients (LNET Router, Ethernet, and InfiniBand Clients)**
  - Kernel: 2.6.32-431.23.3.el6.x86_64
  - Client version:
    1.8.9, 2.1, 2.4.3 (with Server version 2.1)
    2.4.3 and 2.5.1 (with Server version 2.5.1)
Client Mount Options

- checksum=0
- max_rpc_in_flight = 256
- max_dirty_mb=256
- max_pages_per_rpc=256 (1MB I/O)
- Mount Command

```
mount -t lustre 172.18.54.79@o2ib0:172.18.54.80@os2ib0:/lustre /mnt/lustre
```
Initial LNET Router Configuration and Results
Initial LNET Router Configuration – Server

Using Reference Materials

■ /etc/modprobe.d/lnet.conf
  options lnet dead_router_check_interval=60
  options lnet routes="/etc/lustre/routes.dat"
  options lnet networks="o2ib0(ib0)"
  options lnet avoid_asym_router_failure=1
  options ko2iblnd timeout=100 peer_timeout=130
  options ko2iblnd credits=2048 ntx=2048
  options ko2iblnd peer_credits=126 concurrent_sends=63
  peer_buffer_credits=128
  options lnet check_routers_before_use=1
  options lnet live_router_check_interval=60
  options lnet router_ping_timeout=50
  options lnet large_router_buffers=1025 small_router_buffers=16384

■ /etc/lustre/routes.conf
  tcp0 172.18.62.[162,164,166,168]@o2ib0
Initial LNET Router Configuration – LNET Router

Using Reference Material

/etc/modprobe.d/lnet.conf

options lnet dead_router_check_interval=60
options lnet avoid_asym_router_failure=1

options ko2iblnd timeout=100 peer_timeout=130
options ko2iblnd credits=2048 ntx=2048
options ko2iblnd peer_credits=126 concurrent_sends=63
peer_buffer_credits=128

options lnet check_routers_before_use=1
options lnet live_router_check_interval=60
options lnet router_ping_timeout=50
options lnet large_router_buffers=1025 small_router_buffers=16384
options lnet ip2nets="tcp0(eth20) 172.19.62.*;o2ib0(ib0) 172.18.62.*;o2ib0(ib0) 172.18.62.[162,164,166,168]"
options lnet routes="o2ib0 172.19.62.[162,164,166,164]@tcp0"
Initial LNET Router Configuration – Routed Ethernet Clients

Using Reference Material

```
/etc/modprobe.d/lnet.conf
options lnet dead_router_check_interval=60
options lnet networks="tcp(eth20)"
options lnet avoid_asym_router_failure=1
options lnet check_routers_before_use=1
options lnet live_router_check_interval=60
options lnet router_ping_timeout=50
options lnet large_router_buffers=1025 small_router_buffers=16384
options lnet routes="o2ib0 172.19.62.[162,164,166,164]@tcp0"
```

```
/etc/modprobe.d/ko2iblnd.conf
options ko2iblnd timeout=100 peer_timeout=130
options ko2iblnd credits=2048 ntx=2048
options ko2iblnd peer_credits=126 concurrent_sends=63
peer_buffer_credits=128
```
Initial LNET Router Configuration – IB Clients

Using Reference Material

■/etc/modprobe.d/lnet.conf
options lnet networks="o2ib0(ib0)"

■/etc/modprobe.d/ko2iblnd.conf
options ko2iblnd timeout=100 peer_timeout=130
options ko2iblnd credits=2048 ntx=2048
options ko2iblnd peer_credits=126 concurrent_sends=63
peer_buffer_credits=128
Initial Results

Using
options ko2iblnd timeout=100 peer_timeout=130
options ko2iblnd credits=2048 ntx=2048
options ko2iblnd peer_credits=126 concurrent_sends=63
peer_buffer_credits=128

Configuration is a bit more complex using these options
- On Client, saw a performance drop including these options in Inet.conf compared using a separate “.conf file” for the parameters.

Routed and Non-Routed Clients: Inconsistent Inet.conf parameters
- Simulating a router failure, and I/O is only occurring on Ethernet Routed Clients
- Writes Complete, but did not start the Read Phase, IOR was in a hung state

Outcome
- Remove the ko2iblnd parameters and configure all clients to have consistent Inet.conf parameters, regardless if the Client is IB or Routed Ethernet
Observation on Writes during Router Failure
- When 1 Router Fails, leaving 3 Up, I/O pauses from 2 to 4 minutes, then resumes.
- Reasons for the range of 2 to 4 minutes pause is the timing from the LNET parameters:
  - options lnet dead_router_check_interval=60
  - options lnet live_router_check_interval=60
  - options lnet router_ping_timeout=50

Observation on Reads during Router Recovery
- When the failed Router from Write Phase is recovered during Read Phase, Read never pauses, and throughput increases within 1 minute after the Router is recovered

Observation of Reads during Router Failure
- Failing 1 out of 4 routers during Read phase, I/O paused for approximately 60 seconds, then I/O resumes

Tested multiple Failures with I/O on IB Clients and Routed Ethernet Clients,
- MDT Failover, OST Failover, Multiple Router Failure/Recovery
- No impact on I/O and job completes
Phase 2 LNET Router
Configuration: Weighted versus Round Robin
LNET Router Configuration – Routed Clients

/etc/modprobe.d/lnet.conf

options lnet dead_router_check_interval=60
options lnet networks="tcp(eth20)"
options lnet avoid_asym_router_failure=1
options lnet check_routers_before_use=1
options lnet live_router_check_interval=60
options lnet router_ping_timeout=50
options lnet large_router_buffers=1025 small_router_buffers=16384

Client 1 -> options lnet routes="o2ib0 1 172.19.62.162@tcp0;o2ib0 2 172.19.62.164@tcp0;o2ib0 3 172.19.62.166@tcp0;o2ib0 4 172.19.62.168@tcp0"

Client 2 -> options lnet routes="o2ib0 1 172.19.62.164@tcp0;o2ib0 2 172.19.62.166@tcp0;o2ib0 3 172.19.62.168@tcp0;o2ib0 4 172.19.62.162@tcp0"

Client 3 -> options lnet routes="o2ib0 1 172.19.62.166@tcp0;o2ib0 2 172.19.62.168@tcp0;o2ib0 3 172.19.62.162@tcp0;o2ib0 4 172.19.62.164@tcp0"

Client 4 -> options lnet routes="o2ib0 1 172.19.62.168@tcp0;o2ib0 2 172.19.62.162@tcp0;o2ib0 3 172.19.62.164@tcp0;o2ib0 4 172.19.62.166@tcp0"
Results using Weighted Routing

Peak Performance

Max Write: 1081.74 MiB/sec (1134.29 MB/sec)
Max Read: 3056.69 MiB/sec (3205.17 MB/sec)
### Results using Round Robin Routing

#### Peak Performance

<table>
<thead>
<tr>
<th>Host</th>
<th>IP Address</th>
<th>State</th>
<th>_refs</th>
<th>_max</th>
<th>_rtr</th>
<th>_min</th>
<th>_tx</th>
<th>_queue</th>
</tr>
</thead>
<tbody>
<tr>
<td>sjsc-73</td>
<td>172.19.62.162</td>
<td>tcp</td>
<td>45</td>
<td>32</td>
<td>32</td>
<td>14</td>
<td>-24</td>
<td>18875664</td>
</tr>
<tr>
<td>sjsc-73</td>
<td>172.19.62.164</td>
<td>tcp</td>
<td>39</td>
<td>32</td>
<td>32</td>
<td>13</td>
<td>-26</td>
<td>19924312</td>
</tr>
<tr>
<td>sjsc-73</td>
<td>172.19.62.166</td>
<td>tcp</td>
<td>44</td>
<td>32</td>
<td>32</td>
<td>13</td>
<td>-18</td>
<td>19924312</td>
</tr>
<tr>
<td>sjsc-73</td>
<td>172.19.62.168</td>
<td>tcp</td>
<td>38</td>
<td>32</td>
<td>32</td>
<td>13</td>
<td>-37</td>
<td>19924312</td>
</tr>
<tr>
<td>sjsc-74</td>
<td>172.19.62.162</td>
<td>tcp</td>
<td>68</td>
<td>32</td>
<td>32</td>
<td>5</td>
<td>-16</td>
<td>28313496</td>
</tr>
<tr>
<td>sjsc-74</td>
<td>172.19.62.164</td>
<td>tcp</td>
<td>48</td>
<td>32</td>
<td>32</td>
<td>6</td>
<td>-14</td>
<td>27264848</td>
</tr>
<tr>
<td>sjsc-74</td>
<td>172.19.62.166</td>
<td>tcp</td>
<td>53</td>
<td>32</td>
<td>32</td>
<td>6</td>
<td>-23</td>
<td>27264848</td>
</tr>
<tr>
<td>sjsc-74</td>
<td>172.19.62.168</td>
<td>tcp</td>
<td>57</td>
<td>32</td>
<td>32</td>
<td>6</td>
<td>-134</td>
<td>27264848</td>
</tr>
<tr>
<td>sjsc-75</td>
<td>172.19.62.162</td>
<td>tcp</td>
<td>58</td>
<td>32</td>
<td>32</td>
<td>6</td>
<td>-16</td>
<td>27264848</td>
</tr>
<tr>
<td>sjsc-75</td>
<td>172.19.62.164</td>
<td>tcp</td>
<td>53</td>
<td>32</td>
<td>32</td>
<td>6</td>
<td>-15</td>
<td>27264848</td>
</tr>
<tr>
<td>sjsc-75</td>
<td>172.19.62.166</td>
<td>tcp</td>
<td>56</td>
<td>32</td>
<td>32</td>
<td>6</td>
<td>-15</td>
<td>27264848</td>
</tr>
<tr>
<td>sjsc-75</td>
<td>172.19.62.168</td>
<td>tcp</td>
<td>57</td>
<td>32</td>
<td>32</td>
<td>6</td>
<td>-134</td>
<td>27264848</td>
</tr>
<tr>
<td>sjsc-76</td>
<td>172.19.62.162</td>
<td>tcp</td>
<td>50</td>
<td>32</td>
<td>32</td>
<td>9</td>
<td>-24</td>
<td>24118904</td>
</tr>
<tr>
<td>sjsc-76</td>
<td>172.19.62.164</td>
<td>tcp</td>
<td>52</td>
<td>32</td>
<td>32</td>
<td>9</td>
<td>-36</td>
<td>24118904</td>
</tr>
<tr>
<td>sjsc-76</td>
<td>172.19.62.166</td>
<td>tcp</td>
<td>43</td>
<td>32</td>
<td>32</td>
<td>10</td>
<td>-28</td>
<td>23070256</td>
</tr>
<tr>
<td>sjsc-76</td>
<td>172.19.62.168</td>
<td>tcp</td>
<td>55</td>
<td>32</td>
<td>32</td>
<td>8</td>
<td>-80</td>
<td>25167552</td>
</tr>
</tbody>
</table>

Max Write: 3434.50 MiB/sec (3601.33 MB/sec)  
Max Read: 3048.00 MiB/sec (3196.06 MB/sec)
Comparison in Resiliency Testing

Weighted versus Round Robin

■ When simulating Router Failure using weighted routes during IOR Write phase, I/O halts on average of only 60 seconds, and resumes on the healthy routers.
■ 2-4 minutes is the average time to resume Write I/O on the client using the failed router as primary before resuming I/O on the backup Router
■ Weighted Routing is more deterministic in failure and less impact on all I/O being effected during Router Failure, compared to Round Robin
■ Round Robin has a 3x higher Write performance over Weighted Routing, on average
■ Weighted Routes can be useful grouping set a of clients to a subset of Routers, doing a combination of Weighted and Round Robin
Phase 3 LNET Router Configuration
Using ksockInd
ksocklnd LNET Routing Configuration

- ksocklnd module is used to fine tune TCP connections
- /etc/modprobe.d/ksocklnd.conf Clients and Router Side
  
  ```
  options ksocklnd peer_credits=16
  options ksocklnd tx_buffer_size=0
  options ksocklnd rx_buffer_size=65536
  ```

- /etc/modprobe.d/ksocklnd.conf Server Side

  ```
  options ksocklnd peer_credits=32
  ```
Using ksocklnrd

Benefits

- Minor performance improvement on writes and reads for Routed Clients
  Max Write: 3547.06 MiB/sec (3719.36 MB/sec)
  Max Read: 3104.70 MiB/sec (3255.51 MB/sec)
- No impact on performance for IB Clients
- Better Router Failover time during Resiliency testing, approximately 60 to 120 seconds to resume I/O
Phase 4 LNET Router Configuration and Results testing 4MB I/O
Client Mount Options

- `checksum=0`
- `max_rpc_in_flight = 256`
- `max_dirty_mb=256`
- `max_pages_per_rpc=1024 (4MB I/O)`
- Mount Command
  
  ```bash
  mount -t lustre 172.18.54.79@o2ib0:172.18.54.80@os2ib0:/lustre /mnt/lustre
  ```
LNET Routing Results testing 4MB I/Os

- Using 4MB I/O had interesting results during simulated Router Failures in this specific system setup
- No Router Failure, performance had a positive impact for IB clients and I/O completes for Ethernet Routed and IB Clients

- Using 4MB I/O on all clients, Simulating Router Failure during Write Phase during IOR, I/O is hung, never resumed
- IB Clients set to use 4MB I/O, but Ethernet Clients set to use 1MB I/O, Simulating router failure during Write Phase, I/O hung and never resumed (same state)
  - MTU size, enabling or disabling small/large buffer credits, enabling or disabling ksocklnd had no improvement on 4MB I/O resiliency simulating router failure

  - Changing back max_pages_per_rpc to 256 for all clients (1MB I/O) demonstrated no issue for I/O under failed Router test cases (write or read)
New Development: Solution Identified using 4MB I/O with Routers under Failed Condition

- A Server side Patch developed fixes the 4MB I/O hung threads (multi Bulk I/O in general) under Failed Router conditions
- This patch is newly developed and will be pushed back to the community soon (in process)
- Test Case that demonstrates the patch resolved the issue
  - Started IOR and failed routed 1 minute into the test
  - Partial Writes resume after 1 minute, full writes resume after 3 minutes
  - Before Read Phase, recovered Router
  - During Read Phase, failed Router, Read pause for 1 minute, then resumes
  - Recovered Router and full Read bandwidth increased within 1 minute
When configured correctly, using LNET routers to extend data access from an IB Lustre system to Ethernet clients works reliably.
- Consistent LNET configuration is required across all clients.
- ksockInd settings improves I/O during Router failure for Ethernet Clients.
- Multi-Bulk I/O patch addresses the hung I/O issue during Router Failures.
- Round Robin gives better performance during normal operation, but Weighted Routing provides significant benefits during router failures.
References

- **Seagate Acknowledgement**
  - Lustre Development Team
  - Bill Loewe, Rob Roy, Scott Milk, Karl Merritts, Nathan Rutman, Chris Walker, Torben Kling Petersen, Carlos Thomaz, Rex Tanakit

- **Online Materials**
  - http://docs.cray.com/cgi-bin/craydoc.cgi?mode=View;id=S-2483-22;idx=books_search;this_sort=release_date%20desc;q=Inet;type=books;title=OpenFabrics%20Interconnect%20Drivers%20for%20Cray%20XT%20Systems
Thank You

john.fragalla@seagate.com