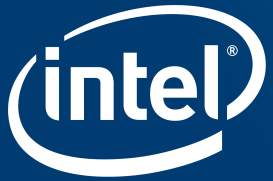

New Resource Agents for Pacemaker available to the Lustre community

Gabriele Paciucci, HPC Solution Architect

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Agenda

- High availability and Lustre
- (Quick) Basic cluster setup
- Resource Agent for Lustre
- Constraints
- Improving monitor capabilities
- Conclusions

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High Availability and Failover in Lustre

- Service continuity is implemented in Lustre by a mechanism called “failover”
- Failover service runs in one location at a time, but can choose where
- Lustre services are tightly coupled to the data storage (targets)
- There are no user-space daemons: only *mount* or *u(n)mount*
- We need to guarantee no data corruption
- Lustre uses external HA framework

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High Availability and Failover

- Storage targets must be configured with the NIDs of the Lustre servers hosting the Lustre service
- These are specified using *--failnode* or *--servicenode* options to mkfs.lustre:
  - failnode: older method primary/secondary
  - servicenode: **recommended** option, all hosts are equally able to run a given service, with no defined preferred primary

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Pacemaker and Corosync

- The most commonly used HA cluster framework for Linux comprises two software applications used in combination:
  - Pacemaker – resource management
  - Corosync – cluster communications and low-level management
- Pacemaker is coming from Linux HA project (Heartbeat)
- Corosync is derived from the OpenAIS project
- In RHEL/CentOS 7, the high-availability framework has been rationalized around Pacemaker and Corosync version 2
- Red Hat also provides a command line tool called PCS (Pacemaker and Corosync Shell) that is available for both RHEL version 6 and version 7

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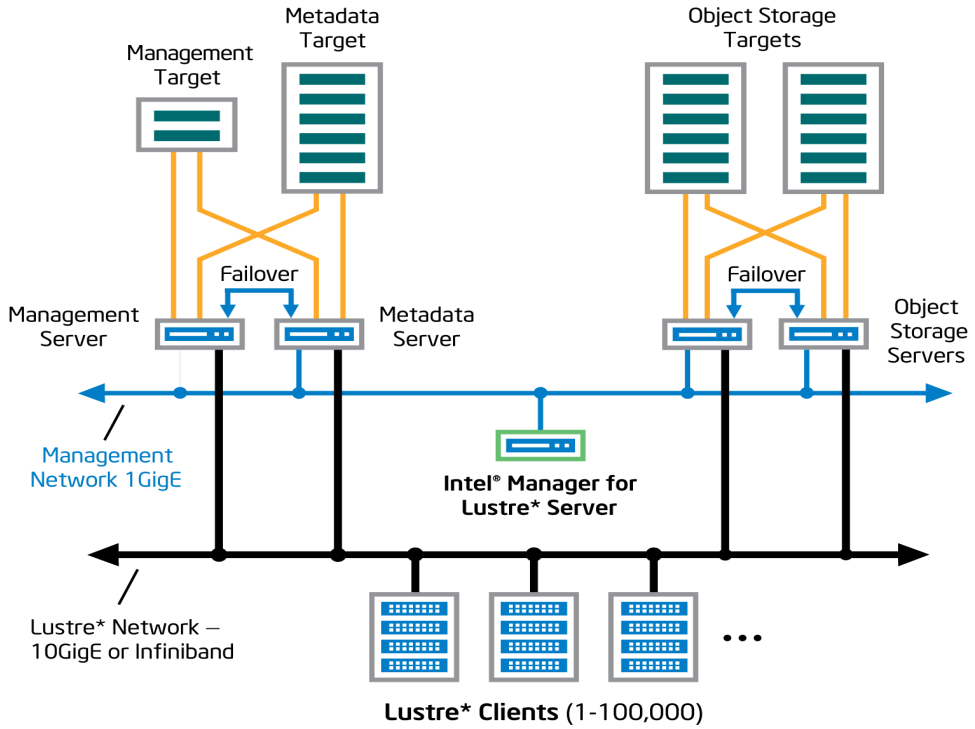
Configuration for Two- Node Cluster



- Is the 2-way cluster the most common choice ?
- Each server requires several network interfaces:
  - A *management network* or public interface connection
  - A dedicated *cluster communication network* between paired servers
  - Routed network to fencing devices
  - *High performance data network*

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Basic cluster setup

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Configure the Basic HA Framework

- HA framework software to install (extra subscriptions for RHEL):

```
yum -y install pcs pacemaker corosync fence-agents
```

- To manage the cluster add an user account to the *haclient* group (*hacluster*)
- Set a password for the *hacluster* account
- Start the Pacemaker configuration daemon (pcsd) on all servers:

```
systemctl start pcsd.service
```

- Set up PCS authentication:

```
pcs cluster auth serverA serverB -u hacluster
```

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Setup the cluster

- Configuration of the cluster:

```
pcs cluster setup --name Cluster01 serverA,serverA-HA
serverB,serverB-HA --transport udp --rrpmode passive --
token 17000
```

  - ServerA and ServerB (output from *uname -n)*
  - ServerA-HA and ServerB-HA (Ips on the cluster communication network)
  - Transport types: *udpu* (UDP unicast) and *udp* (used for multicast)
  - The redundant ring protocol (RRP) mode is specified by the *--rrpmode* flag
  - The *--token* timeout before a node is declared dead: **on a Lustre server we want to increase this value**
    - Pacemaker user space threads vs Lustre kernel space threads under heavy load

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Status of the cluster

```
# pcs status
Cluster name: kapollo_oss
WARNING: no stonith devices and stonith-enabled is not false
Last updated: Thu Jun  2 05:19:48 2016          Last change: Thu Jun  2 05:20:20 2016 by hacluster via
crmd on kapollo02
Stack: corosync
Current DC: kapollo02 (version 1.1.13-10.el7_2.2-44eb2dd) - partition with quorum
2 nodes and 0 resources configured

Online: [ kapollo01 kapollo02 ]

Full list of resources:


PCSD Status:
  kapollo01: Online
  kapollo02: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/disabled
```

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Status of the corosync rings

```
# corosync-cfgtool -s
Printing ring status.
Local node ID 1
RING ID 0
  id = 10.70.227.11
  status = ring 0 active with no faults
RING ID 1
  id = 192.168.227.11
  status = ring 1 active with no faults
```

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Fencing mechanism

- In a high-availability environment, it is essential to isolate a failed component and remove it from production to avoid any corruption: fencing mechanism
- Pacemaker is using STONITH (Shoot the Other Node in the Head) as fencing mechanism
- Pacemaker has a set of software components called fencing agents that are used for this purpose

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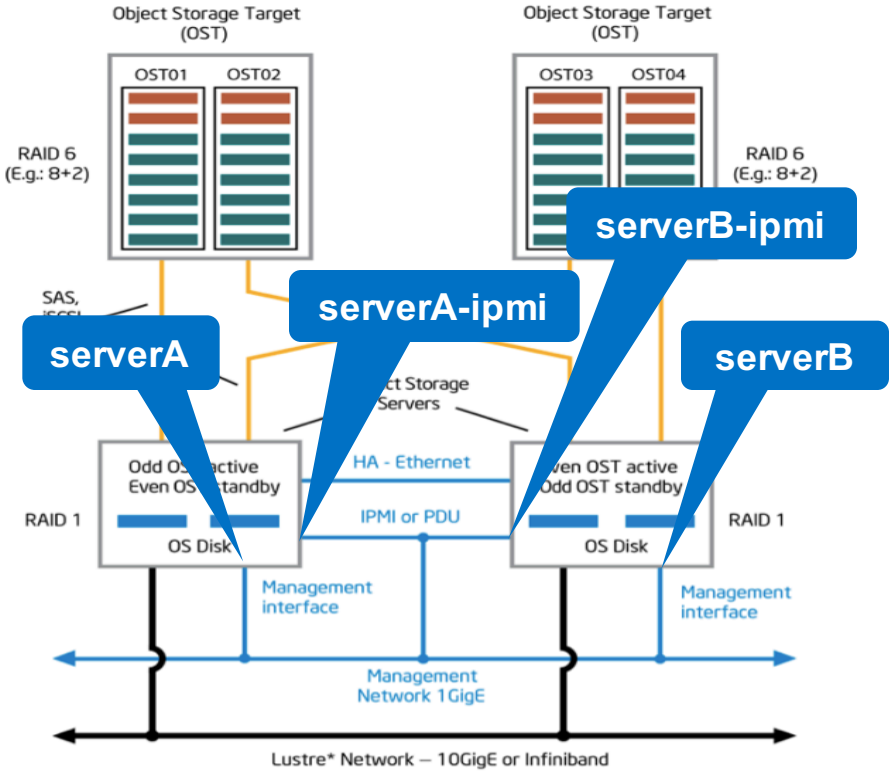
Fencing configuration

```
pcs  stonith create serverA-fence fence_ipmilan
ipaddr=serverA-ipmi passwd=XXX lanplus=yes login=XXX
pcmk_host_list=serverA

pcs stonith create serverB-fence fence_ipmilan
ipaddr=serverB-ipmi passwd=XXX lanplus=yes login=XXX
pcmk_host_list=serverB
```



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Status of the cluster

```
# pcs status
Cluster name: kapollo_oss
Last updated: Thu Jun  2 05:22:57 2016          Last change: Thu Jun  2 05:21:03 2016 by root via
cibadmin on kapollo01
Stack: corosync
Current DC: kapollo02 (version 1.1.13-10.el7_2.2-44eb2dd) - partition with quorum
2 nodes and 2 resources configured

Online: [ kapollo01 kapollo02 ]

Full list of resources:

 kapollo01-ipmi (stonith:fence_ipmilan):        Started kapollo01
 kapollo02-ipmi (stonith:fence_ipmilan):        Started kapollo02

PCSD Status:
  kapollo01: Online
  kapollo02: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

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Resource Agent for Lustre

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Pacemaker and Lustre

- The Lustre community provided some scripts for the (old) Heartbeat framework
- Pacemaker provides a generic Filesystem RA that give a basic support for Lustre on LDISKFS only
- Intel is providing 3 new RAs to:
  - support for ZFS* based Lustre file system: LU-8455
  - increase monitor capabilities for LNet: LU-8457
  - increase monitor capabilities for Lustre Services: LU-8458

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Target's resource for ZFS (LU-8455)

```
pcs resource create ost00 ocf:heartbeat:LustreZFS pool=<pool name> volume=<volume name> mountpoint=<mount point> [OCF_CHEK_LEVEL=10]
```

- The script mount/umount MGT, MDT and OST targets and export/import of pools
- `pool` (pool name used during zpool create). The script is able to manage 1 target per pool
- `volume` (volume name defined during the Lustre formatting).
- `OCF_CHEK_LEVEL=10`. This option enable testing the health of the pool using the `zpool get health` command. DEGRADED mode is reported only. FAULTY pool is causing a failover
- **hostid protection must be configured**

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ZFS RA assumptions and limitations

- ZFS RA script (LU-8455)
  - Pool import protection using the ZFS's hostid
    - ZFS pools cannot be imported on multiple nodes at one time
    - hostid blocks accidental pool import, but STONITH needed during failover
    - Multi-Mount Protection under development to prevent multiple imports
  - At the moment designed for 2 way cluster only
  - Single script for ZFS's pools import and Lustre mount
  - 1:1 pool/target

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Status of the cluster

```
# pcs status

Online: [ kapollo01 kapollo02 ]

Full list of resources:

 kapollo01-ipmi (stonith:fence_ipmilan):        Started kapollo02
 kapollo02-ipmi (stonith:fence_ipmilan):        Started kapollo01
 ost00  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost01  (ocf::heartbeat:LustreZFS):     Started kapollo01
 ost02  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost03  (ocf::heartbeat:LustreZFS):     Started kapollo01
 ost04  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost05  (ocf::heartbeat:LustreZFS):     Started kapollo01
 ost06  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost07  (ocf::heartbeat:LustreZFS):     Started kapollo01
 ost08  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost09  (ocf::heartbeat:LustreZFS):     Started kapollo01
```

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Constraints

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Pacemaker's constraints and score

- The behavior of a resource in a cluster is determined by constraints:
  - location constraints
  - order constraints
  - colocation constraints
- When defining resource constraints, you specify a score for each constraint
- Scores are calculated on a per-resource basis and any node with a negative score for a resource cannot run that resource
- After calculating the scores for a resource, the cluster then chooses the node with the highest score

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Suggested constraints for Lustre

- Preference constraint to enable manual balancing:
  - pcs constraint location ost00 prefers kapollo01=20
  - pcs constraint location ost00 prefers kapollo02=10
    - pcs resource relocate run
- Stickiness to prevent auto-failback:
  - pcs resource update ost00 meta resource-stickiness=1000

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Status of the cluster

```
# pcs constraint show
Location Constraints:
  Resource: ost00
    Enabled on: kapollo01 (score:20) (id:location-ost00-kapollo01-20)
    Enabled on: kapollo02 (score:10) (id:location-ost00-kapollo02-10)

 # pcs resource  show ost00
  Resource: ost00 (class=ocf provider=heartbeat type=LustreZFS)
   Attributes: pool=zost00 volume=ost00 mountpoint=/mnt/ost00
   Meta Attrs: resource-stickiness=1000
   Operations: start interval=0s timeout=300s (ost00-start-interval-0s)
               stop interval=0s timeout=300s (ost00-stop-interval-0s)
               monitor interval=20s timeout=300s (ost00-monitor-interval-20s)
```

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Improving monitor capabilities

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Increasing the monitor capabilities

- Monitor capabilities are limited to:
  - Operating System crashes
  - Hardware failures
  - Split brain
  - Targets not mounted
  - Ring 0 / Ring 1 failures
- We developed additional scripts to monitor:
  - LNet outages - healthLNET
  - Lustre servers status – healthLUSTRE
  - Lustre targets status - healthLUSTRE

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Clone RA

- These agents are **not** ZFS specific
- Pacemaker's resource **clone** technique provides active/active monitoring
- The cloned monitor resource is actively monitoring LNet outages or Lustre services outages and update a specific variables in the pacemaker CIB database
- If the variables is below a specific threshold, a pacemakers' constraint is triggered and all the resources available on the faulted node are moved on the healthy node

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LNet monitor RA (LU-8457)

- Creation and options:

```
pcs resource create healthLNET ocf:pacemaker:healthLNET
dampen=5s multiplier=1000 lctl=true device=ib0
host_list="192.168.211.215@o2ib0 192.168.211.216@o2ib0" –
clone
```

  - `dampen` The time to wait (dampening) further changes occur OCF_RESKEY_dampen=5s
  - `lctl` Option to enable lctl ping. The default is true OCF_RESKEY_lctl=true
  - `device` Device used for the LNET network. We assume the same device accross the cluster
  - `host_list` NIDs (if lctl is selected) or IPs associated to the device selected

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LNet monitor RA

- Constraints:

  ```
  pcs constraint location <Resource Name> rule score=-
  INFINITY pingd lt 1 or not_defined pingd
  ```

  – `pingd` This is the variable the clone RA is updating in the CIB database

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Lustre monitor RA (LU-8458)

- Creation and options:

```
pcs resource create healthLUSTRE
ocf:pacemaker:healthLUSTRE dampen=5s  --clone
```

  - `dampen` The time to wait (dampening) further changes occur OCF_RESKEY_dampen=5s
  - Testing: `lctl get_param health_check`
    - LBUG are reported
    - I/O errors are also triggered
  - By default Lustre enable `panic_on_lbug`

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Lustre monitor RA

- Constraints:

  `pcs constraint location <Resource Name> rule score=-INFINITY lustred lt 1 or not_defined lustred`

  - `lustred` This is the variable the clone RA is updating in the CIB database

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Status of the cluster

```
# pcs status


Online: [ kapollo01 kapollo02 ]

Full list of resources:

 kapollo01-ipmi (stonith:fence_ipmilan):        Started kapollo02
 kapollo02-ipmi (stonith:fence_ipmilan):        Started kapollo01
 ost00  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost01  (ocf::heartbeat:LustreZFS):     Started kapollo01
 ost02  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost03  (ocf::heartbeat:LustreZFS):     Started kapollo01
 ost04  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost05  (ocf::heartbeat:LustreZFS):     Started kapollo01
 ost06  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost07  (ocf::heartbeat:LustreZFS):     Started kapollo01
 ost08  (ocf::heartbeat:LustreZFS):     Started kapollo02
 ost09  (ocf::heartbeat:LustreZFS):     Started kapollo01
 Clone Set: healthLNET-clone [healthLNET]
     Started: [ kapollo01 kapollo02 ]
 Clone Set: healthLUSTRE-clone [healthLUSTRE]
     Started: [ kapollo01 kapollo02 ]
```

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Status of the cluster

```
# pcs constraint show --full
Location Constraints:
  Resource: ost00
    Enabled on: kapollo01 (score:20) (id:location-ost00-kapollo01-20)
    Enabled on: kapollo02 (score:10) (id:location-ost00-kapollo02-10)
    Constraint: location-ost00
      Rule: score=-INFINITY boolean-op=or  (id:location-ost00-rule)
        Expression: pingd lt 1  (id:location-ost00-rule-expr)
        Expression: not_defined pingd  (id:location-ost00-rule-expr-1)
    Constraint: location-ost00-1
      Rule: score=-INFINITY boolean-op=or  (id:location-ost00-1-rule)
        Expression: lustred lt 1  (id:location-ost00-1-rule-expr)
        Expression: not_defined lustred  (id:location-ost00-1-rule-expr-1)
```

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Conclusion

- HA implementation and tuning in Lustre is a complex topic
- RAs scripts are in production and heavily tested, but a wider adoption can improve robustness and add new functionalities like:
  - Support cluster with >2 nodes
  - Split ZFS import and Lustre mount scripts
  - Improve low level monitor capabilities (integration with ZED ?)

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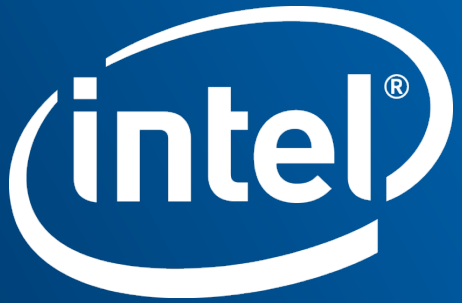
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LDISKFS configuration for HA

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Creation of the target's resource for LDISKFS

- Filesystem default script:

```
pcs resource create <Reource Name> ocf:heartbeat:Filesystem device="/dev/mapper/mpatha"
fstype="lustre" directory="/lustrefs/mgs"
```

  - `ocf:heartbeat:Filesystem.` The script must be located in /usr/lib/ocf/resource.d/heartbeat with permission 755 on all the lustre server nodes.
  - `device` (required): The name of block device for the filesystem, or -U, -L options for mount, or NFS mount specification.
  - `directory` (required): The mount point for the filesystem.
  - `fstype` (required): The type of filesystem to be mounted.

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