This tutorial outlines the high-level requirements to plan out a cluster configuration with a checklist approach and then proceeds with the deployment instructions through the new cluster command-line interface (CLI). The steps outlined are for illustration purposes and can be easily modified to deploy more-complex configurations. Note that beyond these instructions, there are alternative paths using the smitty sysmirror and IBM Systems Director interface, which are well documented in IBM Redbooks and online documentation. The CLI examples shown were primarily tested using the 7.1.2 cluster release and show options and flags that might not have been retrofitted in the earlier version 7 releases.

Introduction

The IBM PowerHA® SystemMirror V7 cluster software is the next evolution of IBM AIX® clustering. In an effort to provide tighter integration with the AIX operating system, a new kernel level layer called Cluster Aware AIX (CAA) was developed. The cluster software leverages this new foundation for its heartbeat and message communication. Running at the kernel level ensures that the cluster communication receives top priority and is not affected in the event of a memory leak or rogue application consuming the system's resources. This redesign enables health monitoring across all of the network interfaces along with the ability to react to the loss of root volume group (rootvg) when booting from an external storage area network (SAN) storage enclosure. In addition, new target mode capabilities in Fibre Channel (FC) adapters allow for a new storage framework communication for health monitoring over the SAN. The following instructions are intended to assist in the rapid deployment of a PowerHA SystemMirror V7 cluster leveraging the new clmgr CLI. They also provide examples of common administrative tasks, sample configuration files, and useful logs.

Minimum prerequisites

<table>
<thead>
<tr>
<th>PowerHA SystemMirror release</th>
<th>Generally available</th>
<th>Minimum AIX level</th>
</tr>
</thead>
</table>
• The packages required for CAA functionality include:
  • bos.cluster.rte
  • bos.ahafs
  • bos.cluster.solid (No longer required beyond HA 7.1.0)
• All shared volume groups (VGs) in a version 7 cluster must be Enterprise Concurrent Mode (ECM) VGs:
  • bos.clvm.enh

Cluster resource checklist

• IP address planning
  • Request IPs (number of boot/base, persistent, and service IPs).
  • Register Domain Name Server (DNS) names.
  • Update configuration files: /etc/hosts /etc/cluster/rhosts.
  • Hard set IPs on interfaces.
• Shared storage planning
  • Determine space requirements [number of data logical unit numbers (LUNs) and cluster repository disk]
  • Identify driver and multipath requirements
  • Define LUN mappings
  • Create SAN zones
  • Create or import the shared volume group, logical volume, and file system information
  • Use unique names for resources imported across cluster members
• Highly available applications planning
  • Identify the installation location and space requirements.
  • Identify user and permission settings.
  • Test and deploy application start and stop scripts.
  • Optionally, test and deploy application monitoring scripts.
• PowerHA SystemMirror cluster deployment:
  • Identify and install AIX level requirements [including CAA and Reliable Scalable Cluster Technology (RSCT) packages] on all nodes.
  • Identify and install the required PowerHA SystemMirror code level on all nodes.
  • Restart logical partitions (LPARs) to pick up kernel bos updates
• From Node 1:
  • Define cluster name
  • Define cluster repository disk
  • Define multicast address (automatic or manual)
  • Define node names
- Define networks
- Define interfaces
- Define application controllers
- Define service IPs
- Define resource groups
- Define resources to resource groups
- Verify and synchronize the cluster.
- Start cluster services on all nodes.

After the configuration is completed and synchronized, you can proceed with the following tasks:

- Fallover testing: Graceful stop with takeover and resource group moves (soft) compared to reboot –q (hard).
- Monitor the environment.

Configuration files:
- `/etc/hosts`: The contents of this file should include all of the cluster IP addresses and their corresponding IP labels as it is preferred to have the cluster resolve locally and then revert to DNS, if necessary.
- `/etc/cluster/rhosts`: Populate the file on both nodes and refresh the cluster communication daemon. (refresh –s clcomd). Explicitly defined cluster IPs in each line helps in avoiding name resolution issues. Ensure that only valid, accessible cluster IPs are defined in this file.
- `/usr/es/sbin/cluster/netmon.cf`: This file is used by the cluster in single adapter networks to attempt to determine the adapter status in the event of a failure. Virtualized environments should deploy this file to point to default gateways or IPs residing outside the physical frame to validate outside connectivity.

IP addresses:
- Multicast address (automatically or manually assigned): Cluster heartbeat on version 7 clusters uses IP multicasting and by default, assigns a multicast address during the cluster creation process. It attempts to avoid duplication across clusters by defining an address based on the first IP that it detects on your network interfaces (for example, en0 – 9.10.10.1 base IP might result in a 228.10.10.1 multicast address). If you wish to define your own multicast address, you can also do so during that portion of the cluster configuration. This default changes back to unicast communication in Version 7.1.3, but IP multicasting will still be an available option.
- Base IP addresses: Every adapter in AIX will typically have an IP address on it stored in the ODM and set to come online during the system boot sequence. These adapters can be defined within the cluster definitions as base / boot adapters if they are to be within a PowerHA network. Note that CAA attempts to use all interfaces within the LPAR anyway unless the administrator has explicitly defined them in a PowerHA private network. Virtual local area networks (VLANs) that have interfaces that will host a potential service IP must have IP multicasting enabled. Otherwise, CAA considers those interfaces down and never attempts to acquire the service IP alias onto them.
- Persistent IPs: This is a cluster node specific alias that will be available on system boot whether HA services are running or not. These can be used as administrative IPs for
each node or as IPs to hold the route for the routable subnet in the event of a cluster failover. For some time now, PowerHA has allowed single adapter networks to define the base/boot IP and service IPs on the same routable subnet. Therefore, the need for a persistent IP is not as prevalent as in earlier releases, and thus, these are not typically required.

- Service IPs: Any defined service IP address aliases will be managed by the cluster as long as they are defined within a resource group. Based on where the resource group and its corresponding resources are being hosted will determine the location of the service IP aliases.

- Shared disks:
  - CAA repository disk (size requirement: minimum 512 MB and maximum 460 GB): This is a new CAA requirement that must be visible to all cluster members. The common practice is for this LUN to be defined as standard LUN size in the environment as long as it is within the minimum and maximum size requirements. At the time of the first verify and synchronize operation, the cluster creates a private volume group on the device.
  - Shared data volumes: All cluster-managed shared volume groups must be created or converted to enhanced concurrent mode and mapped and then imported onto all cluster nodes. The corresponding LUNs should be defined to have no reservations set in their backend multipath drivers. During cluster processing, the cluster manages the devices with its own disk fence registers and only allows file systems to mount on the node hosting the resource group.

- Cluster resource group policies:
  - A resource group in the cluster configuration is a container for the different highly available resources. The different resource group startup, fallover, and fallback policies should be established during the planning phase and should be fully understood.

<table>
<thead>
<tr>
<th>Resource group policy</th>
<th>Available options</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Startup policy</strong></td>
<td>• Online on Home Node Only&lt;br&gt;• Online on First Available Node&lt;br&gt;• Online Using Distribution Policy&lt;br&gt;• Online on All Available Nodes</td>
</tr>
<tr>
<td><strong>Fallover policy</strong></td>
<td>• Fallover to Next Node in the List&lt;br&gt;• Fallover Using Dynamic Node Priority&lt;br&gt;• Bring Offline</td>
</tr>
<tr>
<td><strong>Fallback policy</strong></td>
<td>• Fallback to Higher Priority Node in the List&lt;br&gt;• Bring Offline</td>
</tr>
</tbody>
</table>

- Clustered applications (application controller definitions)
  - Start / Stop scripts: The application controller scripts must reside in a common path in all participating cluster members. They must also be executable by the root user. The content of the scripts does not need to match between all cluster members. However, if the contents need to match based on application requirements, the PowerHA file collection function can be used to ensure that changes are replicated automatically every 10 minutes.
• (Optional) Application monitoring scripts: The cluster software delivers an optional application monitoring framework that can be used in any deployment. The cluster runs a `clappmon` process for every monitor defined on the node hosting its resource group and corresponding application controller. Any monitor script should be executable by root, be thoroughly tested, have proper script termination, and reside in a common location on all cluster members.

### CAA Heartbeat Communication

- Repository disk version 7 cluster communication requires the use of a shared LUN (repository disk) for heartbeating and to store cluster configuration information. The size requirement for the 7.1.1 and 7.1.2 releases are a minimum size of 512 MB and a maximum of 460 GB. It is common for clients to use their standard LUN size rather than designating a volume smaller than their current data LUNs.
- IP interfaces: The new communication protocol used by version 7 clusters requires the enablement of IP multicasting on the layer 2 devices backing the network interfaces. CAA uses all the interfaces on the system by default unless they are defined to a highly available private network. IP network definitions are required for the cluster to perform IP address takeover between the cluster members. The cluster will not bring a service IP alias online on an interface if multicast communication is not working because the interface will be considered unavailable.
- (Optional) Storage framework communication [ SANCOMM ]: SAN-based communication is an additional heartbeating option in version 7 clusters. If properly enabled, the storage framework communication will pass heartbeats between the Fibre Channel adapters within the shared SAN environment to provide an additional heartbeat communication path. This configuration is only supported over SAS, or 4 GB and 8 GB Fibre Channel adapters and will work in dedicated host bus adapters (HBAs) or virtualized ones using virtual Small Computer System Interface (VSCSI) or N-Port ID Virtualization (NPIV). On the supported HBAs, you must enable target mode on the LPARs that own the cards and ensure that the SAN zoning provides visibility between all applicable adapters on all cluster members.

```bash
chdev -l fscsi# -a dyntrk=yes -a fc_err_recov=fast_fail -P
chdev -l fcs# -a tme=yes -P (reboot is required)
```

**Note:** The `-P` is used to only update the AIX ODM when there are existing child devices on the HBAs, hence why a reboot is required for the setting to take effect.

Virtualized environments require the use of a reserved Ethernet VLAN (3358) between the client LPARs and the corresponding Virtual I/O Server (VIOS) instances. A virtual Ethernet adapter must be defined on the client LPAR and on the VIOS in order to create a bridge that allows SAN heartbeat communication to reach the physical HBAs on the VIOS instances. The virtual Ethernet adapters are not required to have an IP address defined on them. For the storage packets to pass between cluster members defined across physical server frames, the SAN zoning must include all corresponding HBA worldwide port numbers (WWPNs). In a virtualized environment, the physical WWPN for the HBAs in each VIOS (not the client virtual WWPNs) need to be defined within the same SAN zone. Review the current online documentation or recent Redbooks publications for examples using this feature.
CLI rapid deployment instructions

PowerHA SystemMirror V7 clusters can be created entirely from the new CLI. In this example, IPs have already been appended to the /etc/hosts file. The volume group is already imported onto all cluster members and the application scripts have already been written and propagated to the common /usr/local/hascripts directory in each of the cluster nodes. The following instructions create a basic two-node cluster:

Cluster topology configuration

<table>
<thead>
<tr>
<th>Network</th>
<th>Label</th>
<th>Function</th>
<th>Interface</th>
<th>Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>net_ether_01</td>
<td>Nodeb_base1</td>
<td>boot</td>
<td>en0</td>
<td>nodeA</td>
</tr>
<tr>
<td>net_ether_01</td>
<td>Nodeb_base1</td>
<td>boot</td>
<td>en0</td>
<td>nodeB</td>
</tr>
<tr>
<td>net_ether_01</td>
<td>sharedIP</td>
<td>service</td>
<td>alias</td>
<td>shared</td>
</tr>
</tbody>
</table>

Resource group configuration

<table>
<thead>
<tr>
<th>Resource group name</th>
<th>DB_app1_rg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Startup Policy</td>
<td>Online on Home Node Only</td>
</tr>
<tr>
<td>Fallover Policy</td>
<td>Fallover to Next Priority Node</td>
</tr>
<tr>
<td>Fallback Policy</td>
<td>Never Fallback</td>
</tr>
<tr>
<td>Participating Nodes</td>
<td>NodeA NodeB</td>
</tr>
<tr>
<td>Service IP Label</td>
<td>sharedIP</td>
</tr>
<tr>
<td>Volume Group</td>
<td>sharedvg</td>
</tr>
<tr>
<td>Application Controller</td>
<td>DB_App1</td>
</tr>
</tbody>
</table>

Note: Resource Group policies in this example are set to the most commonly used policies of Online on Home Node Only (default in the command and its input is not required), Fallover to the Next Available Node and Never Fallback.

The following tasks with the different `clmgr` commands are required to create the cluster topology and resource group configuration outlined in the tables above:

- Create a cluster.
  ```
  clmgr add cluster SampleCluster repository=hdisk10 nodes=nodea.dfw.ibm.com, nodeb.dfw.ibm.com
  ```
- Add service IP.
  ```
  clmgr add service_ip sharedIP network=net_ether_01
  ```
- Define application controller:
  ```
  clmgr add application_controller DB_app1 startscript="/usr/local/hascripts/DB_app_start.sh" stopscript="/usr/local/hascripts/DB_app_stop.sh"
  ```
- Create resource group:
  ```
  clmgr add rg DB_app1_rg nodes=nodea.dfw.ibm.com, nodeb.dfw.ibm.com startup=ohn fallback=nfb service_label=sharedIP volume_group=sharedvg application=DB_app1
  ```
- Verify and synchronize cluster:
Note: The CAA private volume group created on the repository disk shows up only after the first
time the cluster definitions are synchronized. This is a hands-off volume group and should not be
modified, mirrored, or extended through AIX LVM. Also note that the syntax options in our example
can be modified to include additional cluster features.

Common administrative tasks

This section outlines the different operations or commands that will effectively accomplish the
same thing but may use the clmgr or the older legacy commands.

- Access PowerHA SystemMirror SMIT menus:
  - smitty sysmirror
  - smitty cl_admin
- Start cluster services: (different choices)
  - clmgr start cluster
  - clmgr online node nodeA
  - clmgr start node node A
  - smitty clstart
- Stop cluster services: (different choices)
  - clmgr stop cluster
  - clmgr offline node nodeA
  - clmgr stop node nodeA
  - smitty clstop
- Verify / Synchronize cluster:
  - clmgr verify cluster
  - clmgr sync cluster
- Move resource group: (different choices)
  - clmgr move rg rgA, rgB node=nodeA (with multiple RGs move is performed serially)
  - clRGmove -g RGname -n nodeA -m
- Add an application monitor:
  - clmgr add mon appA_mon TYPE=Custom APPLICATION=appA MONITORINTERVAL=60
    FAILUREACTION=fallover STABILIZATION=300 RESTARTINTERVAL=1200 CLEANUPMETHOD=/
    usr/local/hascripts/appA_cleanup.sh RESTARTMETHOD=/usr/local/hascripts/
    appA_restart.sh RESTARTCOUNT=3 MONITORMETHOD=/usr/local/hascripts/
    appA_monitor.sh
- Suspend / Resume application monitoring:
  - clmgr manage application_controller suspend test_app1
  - clmgr resume application_controller resume test_app1

Note: The clmgr operation will automatically mount the file system and update the ODM and /etc/
filesystems file in the other cluster nodes. If the volume group is already defined to a resource
group, the cluster will automatically manage the file system.

- Validate IP multicast traffic: (must be run on each node)
• `mping -v -r -a 228.10.10.1 (nodeA – receive flag)`
• `mping -v -s -a 228.10.10.1 (nodeB – send flag)`

- Display / Modify tunables:
  - `clctrl – tune –L display default and set tunable values`

### Sample output:

```
root@mhoracle1 /> clctrl -tune -L

NAME                      DEF    MIN    MAX    UNIT           SCOPE     CUR
ENTITY_NAME(UUID)                                                
config_timeout            240    0      2G-1   seconds        c n         240
deadman_mode              a               c n         
                        sapdemo71_cluster(1de50be8-6ab0-11e2-ace9-46a6ba546402) a
hb_src_disk               1      -1     3                     c           1
                        sapdemo71_cluster(1de50be8-6ab0-11e2-ace9-46a6ba546402) c
hb_src_lan                1      -1     3                     c           1
                        sapdemo71_cluster(1de50be8-6ab0-11e2-ace9-46a6ba546402) c
hb_src_san                2      -1     3                     c           2
                        sapdemo71_cluster(1de50be8-6ab0-11e2-ace9-46a6ba546402) c
link_timeout              30000  0      1171K  milliseconds   c n         30000
node_down_delay           10000  5000   600000 milliseconds c n         10000
node_timeout              20000  10000  600000 milliseconds c n         20000
packet_ttl                32     1      64                    c n         32
remote_hb_factor          10     1      100                   c           10
repos_mode                e               c n         
                        sapdemo71_cluster(1de50be8-6ab0-11e2-ace9-46a6ba546402) e
site_merge_policy         p               c           p
                        sapdemo71_cluster(1de50be8-6ab0-11e2-ace9-46a6ba546402) p

n/a means parameter not supported by the current platform or kernel

Scope codes:
c = clusterwide: applies to the entire cluster
s = per site: may be applied to one or more sites
n = per node: may be applied to one or more nodes
i = per interface: may be applied to one or more communication interfaces

Value conventions:
K = Kilo: 2^10          G = Giga: 2^30          P = Peta: 2^50
M = Mega: 2^20          T = Tera: 2^40          E = Exa: 2^60

**Note:** In AIX 61 TL9 and AIX 71 TL3, usability has been enhanced to allow users to specify the IP address of the interface they want to mping on [ –b address ]. Note that in previous versions, the commands might report back as successful as long as it could mping down one of the interfaces on the server.
• CAA enhanced usability:
The bos.cluster.rte CAA package introduced the clcmd command. It allows administrators
to precede their commands and collection information from all cluster nodes from a single
window.
  • clcmd netstat -in displays all interfaces and IPs from all cluster nodes
  • clcmd lspv displays all Physical Volume Identifiers (PVIDs) and VG information from all
cluster nodes

Sample output:

root@mhoracle1 /> clcmd netstat -in
-------------------------------
NODE mhoracle2.dfw.ibm.com
-------------------------------
<table>
<thead>
<tr>
<th>Name</th>
<th>Mtu</th>
<th>Network</th>
<th>Address</th>
<th>Ipkts</th>
<th>Ierrs</th>
<th>Opkts</th>
<th>Oerrs</th>
<th>Coll</th>
</tr>
</thead>
<tbody>
<tr>
<td>en0</td>
<td>1500</td>
<td>link#2</td>
<td>32.43.2b.33.8a.2</td>
<td>3256281</td>
<td>0</td>
<td>267653</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>en0</td>
<td>1500</td>
<td>9.19.51</td>
<td>9.19.51.212</td>
<td>3256281</td>
<td>0</td>
<td>267653</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>lo0</td>
<td>16896</td>
<td>link#1</td>
<td></td>
<td>378442</td>
<td>0</td>
<td>378442</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>lo0</td>
<td>16896</td>
<td>127</td>
<td>127.0.0.1</td>
<td>378442</td>
<td>0</td>
<td>378442</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>lo0</td>
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<td>::1%1</td>
<td></td>
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</thead>
<tbody>
<tr>
<td>en0</td>
<td>1500</td>
<td>link#2</td>
<td>46.a6.ba.54.64.2</td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>en0</td>
<td>1500</td>
<td>9.19.51</td>
<td>9.19.51.239</td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>en0</td>
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<td>9.19.51</td>
<td>9.19.51.211</td>
<td>3318895</td>
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<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>lo0</td>
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<td>link#1</td>
<td>283853</td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
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<td>127</td>
<td>127.0.0.1</td>
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<td>::1%1</td>
<td></td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Sample output:

root@mhoracle1 /> clcmd lspv
-------------------------------
NODE mhoracle2.dfw.ibm.com
-------------------------------
| hdisk0 | 00f604142514b8f | rootvg | active |
| hdisk1 | 00f604142514b8f | sapvg  | concurrent |
| hdisk2 | 00f604142514b8f | oravg  | concurrent |
| hdisk3 | 00f604142514b8f | None   |          |
| hdisk4 | 00f604142514b8f | None   |          |
| hdisk5 | 00f604142514b8f | None   |          |
| hdisk6 | 00f604142514b8f | None   |          |
| hdisk7 | 00f604142514b8f | caavg_private | active |
| hdisk8 | 00f604142514b8f | sapersvg | concurrent |

-------------------------------
NODE mhoracle1.dfw.ibm.com
-------------------------------
| hdisk0 | 00f604142514b8f | rootvg | active |
| hdisk1 | 00f604142514b8f | sapvg  | concurrent |
| hdisk2 | 00f604142514b8f | oravg  | concurrent |
| hdisk3 | 00f604142514b8f | None   |          |
| hdisk4 | 00f604142514b8f | None   |          |
| hdisk5 | 00f604142514b8f | None   |          |
| hdisk6 | 00f604142514b8f | None   |          |
| hdisk7 | 00f604142514b8f | caavg_private | active |
| hdisk8 | 00f604142514b8f | sapersvg | concurrent |

Sample output:

root@mhoracle1 /> clcmd netstat -in
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<td>46.a6.ba.54.64.2</td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>en0</td>
<td>1500</td>
<td>9.19.51</td>
<td>9.19.51.239</td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>en0</td>
<td>1500</td>
<td>9.19.51</td>
<td>9.19.51.211</td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>lo0</td>
<td>16896</td>
<td>link#1</td>
<td>283853</td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>lo0</td>
<td>16896</td>
<td>127</td>
<td>127.0.0.1</td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>lo0</td>
<td>16896</td>
<td>::1%1</td>
<td></td>
<td>3318895</td>
<td>0</td>
<td>251392</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Sample output:

root@mhoracle1 /> clcmd lspv
-------------------------------
NODE mhoracle2.dfw.ibm.com
-------------------------------
| hdisk0 | 00f604142514b8f | rootvg | active |
| hdisk1 | 00f604142514b8f | sapvg  | concurrent |
| hdisk2 | 00f604142514b8f | oravg  | concurrent |
| hdisk3 | 00f604142514b8f | None   |          |
| hdisk4 | 00f604142514b8f | None   |          |
| hdisk5 | 00f604142514b8f | None   |          |
| hdisk6 | 00f604142514b8f | None   |          |
| hdisk7 | 00f604142514b8f | caavg_private | active |
| hdisk8 | 00f604142514b8f | sapersvg | concurrent |

-------------------------------
NODE mhoracle1.dfw.ibm.com
-------------------------------
| hdisk0 | 00f604142514b8f | rootvg | active |
| hdisk1 | 00f604142514b8f | sapvg  | concurrent |
| hdisk2 | 00f604142514b8f | oravg  | concurrent |
| hdisk3 | 00f604142514b8f | None   |          |
| hdisk4 | 00f604142514b8f | None   |          |
| hdisk5 | 00f604142514b8f | None   |          |
| hdisk6 | 00f604142514b8f | None   |          |
| hdisk7 | 00f604142514b8f | caavg_private | active |
| hdisk8 | 00f604142514b8f | sapersvg | concurrent |
• Replace repository disk:
  • `clmgr replace repository new_disk`

**Cluster status monitoring**

This section outlines a number of commands to check the levels of code being used and the status of the corresponding cluster daemons and services. Sample outputs have been provided but you may want to experiment in your own environment to see which ones are the most useful to you.

• Product version
  • `halevel -s`
  • `lslpp -l cluster.es.server.rte`
  • `lssrc -ls clstrmgrES | grep fix`
  • `clmgr query version`

**Sample output:**

```
root@mhoracle1 /> halevel -s
7.1.2 SP3

root@mhoracle1 /> lslpp -l cluster.es.server.rte
Fileset                     Level  State      Description
Path: /usr/lib/objrepos
cluster.es.server.rte      7.1.2.3  COMMITTED  Base Server Runtime
Path: /etc/objrepos
cluster.es.server.rte      7.1.2.3  COMMITTED  Base Server Runtime

root@mhoracle1 /> lssrc -ls clstrmgrES | grep fix
cluster fix level is "3"

root@mhoracle1 /> clmgr query version
SystemMirror Information:
=========================
Version:            7.1.2 SP3
Build Level:        1323C_hacmp712 (Jul 12 2013, 14:21:00)
Cluster Type:       Multi Site Cluster Deployment (Stretched Cluster)

CAA Information:
================
Oct 30 2012
14:30:59
h2012_44A1
@(#) _kdb_buildinfo unix_64 Oct 30 2012 14:30:59 h2012_44A1
Cluster Configured:  Yes.

Host Information:
=================
HOSTNAME:       mhoracle1.dfw.ibm.com
IPADDRESS:      9.19.51.211
LOCALHOST:      true
HAVERSION:      7.1.2.3
VERSION_NUMBER: 14
HAEDITION:      STANDARD
AIX_LEVEL:      7100-02-01-1245

Director Information:
=====================
```
DIRECTOR_AGENT_STATUS:            ACTIVE
DIRECTOR_AGENT_PLUGIN_STATUS:     ACTIVE
DIRECTOR_AGENT_PLUGIN_VERSION:    7.1.2.0
DIRECTOR_AGENT_PLUGIN_INST_DATE:  Tue Jan 29 13:39:55 CST6CDT 2013
DIRECTOR_AGENT_PLUGIN_BUILD_DATE: Monday October 08, 2012 at 10:09:01
DIRECTOR_AGENT_FILE_SYSTEM:       96%
DIRECTOR_AGENT_TRACE_LEVEL:       NORMAL
DIRECTOR_AGENT_MANAGER:
DIRECTOR_AGENT_EVENT_STATUS:      ERROR

• Query cluster settings / status:
  • clmgr query cluster
  • clmgr -v -a name,state,raw_state query node
  • lssrc -ls clstrmgrES | grep state
  • clshowsrv -v

Sample output:

cluster
root@mhoracle1 /> clmgr query cluster
CLUSTER_NAME="sapdemo71_cluster"
CLUSTER_ID="1120652512"
STATE="STABLE"
TYPE="SC"
VERSION="7.1.2.3"
VERSION_NUMBER="14"
EDITION="STANDARD"
CLUSTER_IP="228.19.51.211"
UNSYNCED_CHANGES="false"
SECURITY="Standard"
FC_SYNC_INTERVAL="10"
RG_SETTLING_TIME="0"
RG_DIST_POLICY="node"
MAX_EVENT_TIME="180"
MAX_RG_PROCESSING_TIME="180"
DAILY_VERIFICATION="Enabled"
VERIFICATION_NODE="Default"
VERIFICATION_HOUR="0"
VERIFICATION_DEBUGGING="Enabled"
LEVEL="DISABLED"
ALGORITHM=""
GRACE_PERIOD_SEC=""
REFRESH=""
MECHANISM=""
CERTIFICATE=""
PRIVATE_KEY=""
HEARTBEAT_FREQUENCY="20"
GRACE_PERIOD="10"
SITE_POLICY_FAILURE_ACTION="fallover"
SITE_POLICY_NOTIFY_METHOD=""
SITE_HEARTBEAT_CYCLE="0"
SITE_GRACE_PERIOD="0"

root@mhoracle1 /> clmgr -v -a name,state,raw_state query node
NAME="mhoracle1"
STATE="NORMAL"
RAW_STATE="ST_STABLE"

NAME="mhoracle2"
STATE="NORMAL"
RAW_STATE="ST_STABLE"

root@mhoracle1 /> lssrc -ls clstrmgrES | grep state
Current state: ST_STABLE
root@mhoracle1 /> clshowsrv -v
Status of the RSCT subsystems used by HACMP:

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Group</th>
<th>PID</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>cthags</td>
<td>cthags</td>
<td>5243000</td>
<td>active</td>
</tr>
<tr>
<td>ctrmc</td>
<td>rsct</td>
<td>5439656</td>
<td>active</td>
</tr>
</tbody>
</table>

Status of the HACMP subsystems:

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Group</th>
<th>PID</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>clstrmgrES</td>
<td>cluster</td>
<td>5505208</td>
<td>active</td>
</tr>
<tr>
<td>clcomd</td>
<td>caa</td>
<td>7405578</td>
<td>active</td>
</tr>
</tbody>
</table>

Status of the optional HACMP subsystems:

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Group</th>
<th>PID</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>clinfoES</td>
<td>cluster</td>
<td></td>
<td>inoperative</td>
</tr>
</tbody>
</table>

- Display cluster configuration:
  - cltopinfo
  - clmgr( View report basic )
  - cllsif (Cluster Topology view)
  - clshowres(Resource Group configuration view)

Sample output:

root@mhoracle1 /> cltopinfo
Cluster Name: sapdemo71_cluster
Cluster Connection Authentication Mode: Standard
Cluster Message Authentication Mode: None
Cluster Message Encryption: None
Use Persistent Labels for Communication: No
Repository Disk: hdisk9
Cluster IP Address: 228.19.51.211
There are 2 node(s) and 1 network(s) defined
NODE mhoracle1:
  Network net_ether_01
    sharesvc1 9.19.51.239
    mhoracle1 9.19.51.211
NODE mhoracle2:
  Network net_ether_01
    sharesvc1 9.19.51.239
    mhoracle2 9.19.51.212

Resource Group SAP_rg
  Startup Policy  Online On Home Node Only
  Failover Policy Failover To Next Priority Node In The List
  Fallback Policy Never Fallback
  Participating Nodes mhoracle1 mhoracle2
  Service IP Label sharesvc1

root@mhoracle1 /> clmgr view report basic
Cluster Name: sapdemo71_cluster
Cluster Connection Authentication Mode: Standard
Cluster Message Authentication Mode: None
Cluster Message Encryption: None
Use Persistent Labels for Communication: No
Repository Disk: hdisk9
Cluster IP Address: 228.19.51.211
There are 2 node(s) and 1 network(s) defined
NODE mhoracle1:
  Network net_ether_01
    sharesvc1 9.19.51.239
    mhoracle1 9.19.51.211
NODE mhoracle2:
  Network net_ether_01
sharesvc1  9.19.51.239  
mhoracle2  9.19.51.212  

Resource Group SAP_rg
  Startup Policy   Online On Home Node Only
  Fallover Policy  Fallover To Next Priority Node In The List
  Fallback Policy  Never Fallback
  Participating Nodes  mhoracle1 mhoracle2
  Service IP Label  sharesvc1

root@mhoracle1 /> cllsif
Adapter  Type  Network  Net Type  Attribute  Node  
IP Address  Hardware Address  Interface Name  Global Name  
Netmask  Alias for HB Prefix Length  
mhoracle1  boot  net_ether_01  ether  public
  9.19.51.211  en0  255.255.255.0  24
sharesvc1  service  net_ether_01  ether  public
  9.19.51.239  en0  255.255.255.0  24
mhoracle2  boot  net_ether_01  ether  public
  9.19.51.212  en0  255.255.255.0  24
sharesvc1  service  net_ether_01  ether  public
  9.19.51.239  en0  255.255.255.0  24

root@mhoracle1 /> clshowres
Resource Group Name  SAP_rg
  Participating Node Name(s)  mhoracle1 mhoracle2
  Startup Policy  Online On Home Node Only
  Fallover Policy  Fallover To Next Priority Node In The List
  Fallback Policy  Never Fallback
  Site Relationship  ignore
  Node Priority  
  Service IP Label  sharesvc1
  Filesystems  ALL
  Filesystems Consistency Check  fsck
  Filesystems Recovery Method  parallel
  Filesystems/Directories to be exported (NFSv3)  /asap /sapmnt/TST /usr/sap/trans
  Filesystems/Directories to be exported (NFSv4)  
  Filesystems to be NFS mounted  
  Network For NFS Mount  
  Filesystem/Directory for NFSv4 Stable Storage  
  Volume Groups  sapvg oravg sapersvg sapsgfvg
  Concurrent Volume Groups  
  Use forced varyon for volume groups, if necessary false
  Disks  
  Raw Disks  
  Disk Error Management?  no
  GMVG Replicated Resources  
  GMD Replicated Resources  
  PPRC Replicated Resources  
  SVC PPRC Replicated Resources  
  EMC SRDF® Replicated Resources  
  Hitachi TrueCopy® Replicated Resources  
  Generic XD Replicated Resources  
  AIX Connections Services  
  AIX Fast Connect Services  
  Shared Tape Resources  
  Application Servers  sap
  Highly Available Communication Links  
  Primary Workload Manager Class  
  Secondary Workload Manager Class  
  Delayed Fallback Timer  
  Miscellaneous Data  
  Automatically Import Volume Groups  false
  Inactive Takeover  
  SSA Disk Fencing  false
  Filesystems mounted before IP configured  true
WPihanna Name

Run Time Parameters:

<table>
<thead>
<tr>
<th>Node Name</th>
<th>Debug Level</th>
<th>Format for hacmp.out</th>
</tr>
</thead>
<tbody>
<tr>
<td>mhoracle1</td>
<td>high</td>
<td>Standard</td>
</tr>
<tr>
<td>mhoracle2</td>
<td>high</td>
<td>Standard</td>
</tr>
</tbody>
</table>

- Location of resources:
  - clRGinfo -p

Sample output:

root@mhoracle1 /> clRGinfo -p

Cluster Name: sapdemo71_cluster
Resource Group Name: SAP_rg

<table>
<thead>
<tr>
<th>Node</th>
<th>Group State</th>
</tr>
</thead>
<tbody>
<tr>
<td>mhoracle1</td>
<td>ONLINE</td>
</tr>
<tr>
<td>mhoracle2</td>
<td>OFFLINE</td>
</tr>
</tbody>
</table>

- CAA commands:
  - lscluster -c (Cluster configuration, multicast address)
  - lscluster -i (Status of cluster interfaces)
  - lscluster -d (Cluster storage interfaces)
  - lcluster -m (Cluster node configuration information)

Sample output:

root@mhoracle1 /> lscluster -c

Cluster Name: sapdemo71_cluster
Cluster UUID: 1de50be8-6ab0-11e2-ace9-46a6ba546402
Number of nodes in cluster = 2
  Cluster ID for node mhoracle1.dfw.ibm.com: 1
  Primary IP address for node mhoracle1.dfw.ibm.com: 9.19.51.211
  Cluster ID for node mhoracle2.dfw.ibm.com: 2
  Primary IP address for node mhoracle2.dfw.ibm.com: 9.19.51.212
Number of disks in cluster = 1
  Disk = hdisk9 UUID = d3ce4fd5-3083-ac21-9789-6d9a598242fd
  cluster_major = 0 cluster_minor = 1
Multicast for site LOCAL: IPv4 228.19.51.211 IPv6 ff05::e413:33d3

root@mhoracle1 /> lscluster -i

Network/Storage Interface Query

Cluster Name: sapdemo71_cluster
Cluster UUID: 1de50be8-6ab0-11e2-ace9-46a6ba546402
Number of nodes reporting = 2
Number of nodes stale = 0
Number of nodes expected = 2

Node mhoracle1.dfw.ibm.com
Node UUID = 1dfc2d5a-6ab0-11e2-ace9-46a6ba546402
Number of interfaces discovered = 3
  Interface number 1, en0
    IFNET type = 6 (IFT_ETHER)
    NDD type = 7 (NDD_ISO88023)
MAC address length = 6
MAC address = 46:A6:BA:54:64:02
Smoothed RTT across interface = 7
Mean deviation in network RTT across interface = 3
Probe interval for interface = 100 ms
IFNET flags for interface = 0x1E080863
NDD flags for interface = 0x0021081B
Interface state = UP
Number of regular addresses configured on interface = 2
IPv4 ADDRESS: 9.19.51.211 broadcast 9.19.51.255 netmask 255.255.255.0
IPv4 ADDRESS: 9.19.51.239 broadcast 9.19.51.255 netmask 255.255.255.0
Number of cluster multicast addresses configured on interface = 1
IPv4 MULTICAST ADDRESS: 228.19.51.211

Interface number 2, sfwcom
IFNET type = 0 (none)
NDD type = 304 (NDD_SANCOMM)
Smoothed RTT across interface = 7
Mean deviation in network RTT across interface = 3
Probe interval for interface = 100 ms
IFNET flags for interface = 0x00000000
NDD flags for interface = 0x00000000
Interface state = UP

Interface number 3, dpcom
IFNET type = 0 (none)
NDD type = 305 (NDD_PINGCOMM)
Smoothed RTT across interface = 750
Mean deviation in network RTT across interface = 1500
Probe interval for interface = 22500 ms
IFNET flags for interface = 0x00000000
NDD flags for interface = 0x00000000
Interface state = UP
Interface state = UP
Number of regular addresses configured on interface = 2
IPv4 MULTICAST ADDRESS: 228.19.51.211
Number of cluster multicast addresses configured on interface = 1

Node mhoracle2.dfw.ibm.com
Node UUID = 1e1476a8-6ab0-11e2-ace9-46a6ba546402
Number of interfaces discovered = 3

Interface number 1, en0
IFNET type = 6 (IFT_ETHER)
NDD type = 7 (NDD_ISO88023)
MAC address length = 6
MAC address = 32:43:2B:33:8A:02
Smoothed RTT across interface = 7
Mean deviation in network RTT across interface = 3
Probe interval for interface = 100 ms
IFNET flags for interface = 0x1E080863
NDD flags for interface = 0x0021081B
Interface state = UP
Number of regular addresses configured on interface = 1
IPv4 MULTICAST ADDRESS: 228.19.51.211

Interface number 2, sfwcom
IFNET type = 0 (none)
NDD type = 304 (NDD_SANCOMM)
Smoothed RTT across interface = 7
Mean deviation in network RTT across interface = 3
Probe interval for interface = 100 ms
IFNET flags for interface = 0x00000000
NDD flags for interface = 0x00000000
Interface state = UP

Interface number 3, dpcom
IFNET type = 0 (none)
NDD type = 305 (NDD_PINGCOMM)
Smoothed RTT across interface = 750
Mean deviation in network RTT across interface = 1500
Probe interval for interface = 22500 ms
IFNET flags for interface = 0x00000000
NDD flags for interface = 0x00000000
root@mhoracle1 /> lscluster -d
Storage Interface Query

Cluster Name: sapdemo71_cluster
Cluster UUID: 1de50be8-6ab0-11e2-ace9-46a6ba546482
Number of nodes reporting = 2
Number of nodes expected = 2

Node mhoracle1.dfw.ibm.com
Node UUID = 1dfc2d5a-6ab0-11e2-ace9-46a6ba546402
Number of disks discovered = 1
  hdisk9:
    State : UP
    udid : 3E213600A0B00002B020202D3850960F1815     FASTT03IBMfc
    uuuid : d3ce4fd5-3003-ac21-7989-69a590242fd
    site uuuid : 51735173-5173-5173-5173-517351735173
    Type : REPDISK

Node mhoracle2.dfw.ibm.com
Node UUID = 1e1476a8-6ab0-11e2-ace9-46a6ba546402
Number of disks discovered = 1
  hdisk9:
    State : UP
    udid : 3E213600A0B00002B020202D3850960F1815     FASTT03IBMfc
    uuuid : d3ce4fd5-3003-ac21-7989-69a590242fd
    site uuuid : 51735173-5173-5173-5173-517351735173
    Type : REPDISK

root@mhoracle1 /> lscluster -m
Calling node query for all nodes...
Node query number of nodes examined: 2

Node name: mhoracle1.dfw.ibm.com
Cluster shorthand id for node: 1
UUID for node: 1de50be8-6ab0-11e2-ace9-46a6ba546402
State of node: UP  NODE_LOCAL
Smoothed rtt to node: 0
Mean Deviation in network rtt to node: 0
Number of clusters node is a member in: 1
  CLUSTER NAME       SHID         UUID
  sapdemo71_cluster  0            1de50be8-6ab0-11e2-ace9-46a6ba546402
  SITE NAME          SHID         UUID
  LOCAL              1            51735173-5173-5173-5173-517351735173

Points of contact for node: 0

------------------------------------------------------------------------

Node name: mhoracle2.dfw.ibm.com
Cluster shorthand id for node: 2
UUID for node: 1e1476a8-6ab0-11e2-ace9-46a6ba546402
State of node: UP
Smoothed rtt to node: 7
Mean Deviation in network rtt to node: 3
Number of clusters node is a member in: 1
  CLUSTER NAME       SHID         UUID
  sapdemo71_cluster  0            1de50be8-6ab0-11e2-ace9-46a6ba546402
Points of contact for node: 3

<table>
<thead>
<tr>
<th>Interface</th>
<th>State</th>
<th>Protocol</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>dpcom</td>
<td>DOWN</td>
<td>none</td>
<td>RESTRICTED</td>
</tr>
<tr>
<td>en0</td>
<td>UP</td>
<td>IPv4</td>
<td>none</td>
</tr>
<tr>
<td>sfwcom</td>
<td>UP</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

SANCOMM is working only if sfwcom is visible in the `lscluster -m` output:

<table>
<thead>
<tr>
<th>Interface</th>
<th>State</th>
<th>Protocol</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>dpcom</td>
<td>DOWN</td>
<td>none</td>
<td>RESTRICTED</td>
</tr>
<tr>
<td>en0</td>
<td>UP</td>
<td>IPv4</td>
<td>none</td>
</tr>
<tr>
<td>sfwcom</td>
<td>UP</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

Iscluster –s cluster statistics

You can also check the sent and received storage packet counts in

```
lscluster -s:
storage pkts sent: 168493709 storage pkts recv: 82575360
```

```
# clras sancomm_status
NAME                        UUID                          STATUS
nodeA.dfw.ibm.com | e9b4d6a4-5e71-11-e2-af42-00145ee726e1 | UP |
```

Iscluster –s full sample output

```
root@mhoracle1 /> lscluster -s
Cluster Network Statistics:
pkts seen: 15627136 passed: 3335048
IP pkts: 12873577 UDP pkts: 12344880
gossip pkts sent: 2470583 gossip pkts recv: 4032115
cluster address pkts: 0 CP pkts: 12292272
bad transmits: 0 bad posts: 33
Bad transmit (overflow): 0
Bad transmit (host unreachable): 0
Bad transmit (net unreachable): 0
Bad transmit (network down): 0
Bad transmit (no connection): 0
short pkts: 0 multicast pkts: 11664024
cluster wide errors: 0 bad pkts: 0
dup pkts: 398159 pkt fragments: 10964
fragments queued: 0 fragments freed: 0
pkts pulled: 0 no memory: 0
rxmit requests recv: 619 requests found: 511
requests missed: 157 ooo pkts: 76
requests reset sent: 157 reset recv: 90
remote tcpsock send: 0 tcpsock recv: 0
rxmit requests sent: 696
alive pkts sent: 0 alive pkts recv: 0
ahafs pkts sent: 14 ahaFs pkts recv: 4
nodedown pkts sent: 0 nodedown pkts recv: 0
socket pkts sent: 24859 socket pkts recv: 24910
cwide pkts sent: 990856 cwide pkts recv: 992280
socket pkts no space: 0 pkts recv notforhere: 0
```
Sample configuration files

/etc/cluster/rhosts

9.10.10.1
9.10.10.2

/etc/hosts

127.0.0.1 loopback
# PowerHA SystemMirror Cluster IP Addresses
9.10.10.1 nodea.dfw.ibm.com nodeA # node A base address
9.10.10.2 nodeb.dfw.ibm.com nodeB # node B base address
9.10.10.10 shared_ip.dfw.ibm.com shared_ip # Shared SVC IP address

/etc/netsvc.conf

hosts=local,bind

/etc/resolv.conf

nameserver 9.0.1.1
domain dfw.ibm.com

/usr/es/sbin/cluster/netmon.cf

9.10.10.6
!REQD owner target
!IBQPORT owner
!IBQPORTONLY owner

Reference /usr/sbin/rsct/samples/hats/netmon.cf

Documentation APARs: IZ01332 IZ01332

Application controller scripts

/usr/local/hascripts/appA_start.sh (basic SAP example)

#!/bin/ksh
su - orastst -c "lsnrctl start"
su - tstadm -c "startsap"
exit 0
/usr/local/hascripts/appA_stop.sh (basic SAP example)

```sh
#!/bin/ksh
su – tstadm –c "stopsap"
su – oratst –c "lsnrctl stop"
exit 0
```

/usr/local/hascripts/appA_monitor.sh

```sh
#!/bin/ksh
_user provided logic ... 
exit 0
```

Useful cluster log files

/var/hacmp/log/hacmp.out (detailed event processing)

```
Aug 14 16:34:49 EVENT START: node_up nodea
:node_up [165] [[ high==high ]] :node_up [165] version=1.10.11.32
:node_up [167] node_up_vg_fence_init...
```

/var/hacmp/adm/cluster.log (high-level cluster events)

```
Aug 14 16:34:49 nodea user:notice PowerHA SystemMirror for AIX: EVENT START: node_up nodea
Aug 14 16:34:51 nodea user:notice PowerHA SystemMirror for AIX: EVENT COMPLETED: node_up nodea
```

/var/hacmp/log/clutils.log (generated by cluster utilities)

```
CLMGR STARTED (9153:10254698:5177392) : Thu Aug 14 16:34:49 CET 2013
CLMGR USER (9153:10254698:5177392) : ::root:system
CLMGR COMMAND (9153:10254698:5177392) : clmgr online node nodea
CLMGR ACTUAL (9153:10254698:5177392) : start_node nodea
```

/var/adm/ras/syslog.caa (CAA logging and troubleshooting)

```
Aug 14 16:34:28 nodea caa:info syslog: caa_query.c cl_get_capability 2594
There are 2 more capabilities defined at level 131072
Aug 14 16:34:49 nodea caa:info syslog: caa_query.c cl_get_capability 2594
There are 2 more capabilities defined at level 131072
```

- Also useful to check:
  - /var/hacmp/clverify/clverify.log (for detailed verification check output)
  - /var/hacmp/clcmdl/clcmdl.log (for troubleshooting communication issues)
  - /var/hacmp/log/cspoc.log.long (for detailed information from CSPOC)
  - /var/hacmp/log/clstrmgr.debug (generated by clstrmgr daemon)
• /var/hacmp/log/autoverify.log (generated by nightly verification)

Useful references

• IBM Redbooks
  • SG24-8106 PowerHA SM 7.1.2 Enterprise Edition for AIX
  • SG24-8030 PowerHA SM Standard Edition for AIX 7.1.1 Update
  • SG24-7841 PowerHA SM 6.1.0 Enterprise Edition for AIX
• PowerHA SystemMirror External Site (FAQs, Documentation, References)
• IBM Systems Magazine "clmgr" A Technical Reference
• YouTube Videos (some of the many)
  • Offline Migration from PowerHA SystemMirror 6.1.to v7.1.2
  • Rolling Migration to PowerHA SystemMirror v7
  • Configuring a PowerHA SystemMirror V7.1 for AIX Cluster – IBM Training
  • Configuring PowerHA v7.1.2 using IBM Systems Director Demo
• IBM DeveloperWorks PowerHA (HACMP) Forum
About the author

Michael Herrera

Michael Herrera has been working with IBM HACMP™ and the PowerHA SystemMirror cluster software on AIX for over 14 years. He has held roles in the AIX Software Support Center supporting PowerHA and SAN solutions and has published a number of Redbooks and technical papers. He is currently part of the Advanced Technical Sales Support organization and is responsible for the effective deployment of high availability and disaster recovery solutions in the field. He is based out of Dallas, TX and can be reached at mherrera@us.ibm.com.

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