Linux Clusters Made Easy
with the SUSE® Linux Enterprise High Availability Extension

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Agenda

Introduction

Summary of cluster architecture

Common configuration issues

Gathering cluster-wide support information

Exploring effects of cluster events

Self-written resource agents

Understanding log files
Introduction
Overview
SUSE® Linux Enterprise High Availability Extension

• Most modern and complete open source solution for implementing high available Linux clusters

• A suite of robust open source technologies that is:
  – Affordable
  – Integrated
  – Virtualization agnostic

• Used with SUSE Linux Enterprise Server, it helps to:
  – Maintain business continuity
  – Protect data integrity
  – Reduce unplanned downtime for your mission-critical Linux workloads
Fighting Murphy's Law

- Service failover at any distance – from local to geo
- 99.9999% availability with the appropriate tuning
- Rolling updates for less *planned* downtime
- Easy setup, administration, management
- Virtualization agnostic
- Leading open source High Availability
- On par with proprietary products
Benefits
SUSE® Linux Enterprise High Availability

- Quickly and easily install, configure and manage clustered Linux servers
- Ensure continuous access to your mission-critical systems and data
- Transparent to Virtualization – nodes can be virtual or physical
- Meet your Service Level Agreements
- Increase service availability
Overview
SUSE® Linux Enterprise High Availability Extension

• Service availability 24/7
  - Policy driven clustering

• Shared and Scaled data-access
  - Cluster file system
  - Clustered Samba

• Geo Clustering
  - Cluster across unlimited distance

• Virtualization Agnostic
  - Platform independent setup

• Disaster tolerance
  - Data replication via IP
  - Node recovery

• Scale network services
  - IP load-balancing

• User friendly tools
  - Graphical user interface
  - Unified command line interface

• Free Resource Agents
Delivery
SUSE® Linux Enterprise High Availability Extension

- Extension to and with SUSE Linux Enterprise Server
- Releases synchronized with base server product
- Sold as annual support subscriptions
- Inherits the support level of the underlying SUSE Linux Enterprise Server subscription
- Included for free with Itanium, IBM Power, and IBM System z subscriptions
- Charged for x86 and AMD64&Intel64
- Free trial available
Key Use Cases
SUSE® Linux Enterprise High Availability Extension

• High availability for mission-critical services
• Active/active services
  ‒ OCFS2, Databases, Samba File Servers
• Active/passive service fail-over
  ‒ Traditional databases, SAP setups, regular services
• Private Cloud
  ‒ HA, automation and orchestration for managed VMs
• High availability across guests
  ‒ Fine granular monitoring and HA on top of virtualization
• Remote clustering
  ‒ Local, Metro, and Geographical area clusters
Key Use Cases
SUSE® Linux Enterprise High Availability Extension

Simple Stack HA
- Node A: Local Disk /sapmnt /SID
- Node B: Local Disk /sapmnt /SID
- NFS Mount Point before Switchover
- Equivalent setup for /usr/sap/trans /sapdb/programs /sapdb/data possible.

Enqueue Replication
- Resource failover active / active
- Lock table replication
- SAP system - database - SAP (A)SCS
- SAP system - SAP Enq-Repl

DRBD Data Replication
- DRBD data replication active / active
- Data Center 1
- Data Center 2

NFS and SAP in one Cluster
- Node A: Local Disk /import /export
- Node B: Local Disk /import /export
- SID global profile exe
- SID export /sapmnt /SID

HA in Virtualized Environments
- Cluster nodes on virtual systems
- Clustered Hyper Visor on physical systems
Service Pack 2 – **Added Features**
SUSE® Linux Enterprise High Availability Extension

- **Easy Installation and Set-Up**
  - Cluster Bootstrap & Join
  - Templates and Wizards
- **Improved Supportability**
  - History Explorer
  - Log File Query Tools
- **Efficient Management**
  - Access Control Lists
  - Enhanced Web Console
- **Improved Reliability**
  - Multiple SBD devices for storage-based fencing
- **Additional Capabilities**
  - Joining of Clustered SAMBA to Active Directory
  - Load Balancer Connection Tracking and Replication
  - ReaR support for SUSE boot media
Service Pack 3 – **Added Features**
SUSE® Linux Enterprise High Availability Extension

- **Managing remote resources**
  - Black Box / remote monitoring

- **Management**
  - Dashboard to manage multiple clusters
  - Display setup in a Cluster Diagram

- **Usability**
  - Improved web console

- **Supportability**
  - Cluster Simulator with configuration changes
  - Enhanced History Explorer

- **Administration**
  - Pacemaker, YaST2, & Resource Agents

- **Supportability**
  - Cluster Simulator with configuration changes
  - Enhanced History Explorer
Blackbox Monitoring

• Remote monitoring of resources
  – no High Availability components needed
  – re-use of Nagios plugins
• Improved handling of virtual guests
  – monitor virtual services from the hypervisor
  – improve protection of VMs as cluster workload
  – guests remain unaltered – monitoring is external
• Extends pacemaker to include the concept of “container” resources
Hawk – Cluster Dashboard & Diagram

Cluster Dashboard

- **test**
  - **Cluster has errors - click for details**

- **Tickets**
  - ✓ Granted: 1
  - ○ Revoked: 1

- **2 nodes configured**
  - ▶ Online: 1
  - ● Standby: 1

- **9 resources configured**
  - ▶ Started: 4
  - ■ Stopped: 5
Usability - Hawk

Cluster Status

Summary
- Cluster Configuration
  - STONITH Enabled: true
  - No Quorum Policy: ignore
  - Symmetric Cluster: true
  - Resource Stickiness: 0

Tickets
- Granted: 1
- Revoked: 1

2 nodes configured
- Online: 1
- Standby: 1

9 resources configured
- Started: 4
- Stopped: 5

Details
- xxx: Started: sles11sp3-1
- www: Started: sles11sp3-1
- dummy: Started: sles11sp3-1
- d2: Started: sles11sp3-1

www

Attributes
- target-role: Started
- sles11sp3-0
  - Fail Count: 0
- sles11sp3-1
  - Fail Count: 1
  - Last Failure: Mon Feb 11 2013 16:03:11 GMT+1100 (EST)
Cluster Architecture
3 Node Cluster Overview

Network Links

- Xen VM 1
- LAMP Apache IP ext3
- cLVM2+OCFS2
- DLM
- Pacemaker
- Corosync + openAIS
- Kernel

Client

- Storage

Xen VM 2
Detailed View of Components
Per Node: (WIP, a bit out-of-date!)
Why Is This Talk Necessary?

We heard comments:

- Can't you just make the software stack really easy to understand?
- Why is a multi-node setup more complicated than a single node?
- Gosh, this is awfully complicated! Why is this stuff so powerful? I don't need those other features!

This session addresses most of these questions.
Sample Customer Implementations
La Curacao

• Failover Database Environment
  – Core Database Required for Store Price Lookups
  – Shared SAN Storage
  – Redundant Switches
  – IPMI STONITH
  – Heavily Tuned Timeouts
  – Heavily Tested
  – 0 Unnecessary Failovers in 4 Years
Cutting Corners
Major Medical Testing Facility

- Failover Database Environment
  - Mixed Workload Cluster (Database and Application Layer)
  - ReaR for Remote DR
  - SBD STONITH
  - Complex Placement Rules
  - Started as SLES 10 Cluster
  - In Production for 6+ Years
Cluster Design
Recent Features That Make the Cluster Easier
Reducing CIB Duplication

- Resource templates
  - Define resources once, inherit often
  - Define a constraint just once, all inherited resources

```bash
rsc_template t_vm ocf:heartbeat:VirtualDomain \  
  op monitor interval="20s" timeout="60s" \  
  op migrate_to timeout="300s" interval="0" \  
  op migrate_from timeout="300s" interval="0" \  
  meta allow-migrate="false" target-role="Started" \  
  utilization cpu="2" memory="1024" \  
  params autoset_utilization_cpu="false"  
  migration_transport="ssh"  
  hypervisor="qemu:///system"  
  autoset_utilization_hv_memory="false"force_stop="true"  

primitive vm-01 @t_vm \  
  params config="/cluster/vmstore/vm-01.xml"  

primitive vm-02 @t_vm \  
  params config="/cluster/vmstore/vm-02.xml"  

...  

colocation colo-fs-vm inf: t_vm baseclone  
order order-fs-vm Mandatory: baseclone t_vm
Automate Resource Placement

- Define the capacity that nodes provide &
- Specify how much capacity resources consume
- Set “placement-strategy=balanced”
- Nodes will never over-commit, and make a reasonable attempt at load distribution
- Avoid lengthy & complex rsc_location constraints

```bash
node hex-1 \  
  utilization memory="8192" cpu="32"
primitive dummy1 ocf:heartbeat:Dummy \  
  utilization cpu="1" memory="512"
```
crm Shell Improvements

- Find out what resource agents are doing, exactly!
  - # crm resource (un)trace sap_DB start

- Test a resource before committing:
  - # crm configure rsctest sap_DB

- Interrogate the cluster history
  - # crm history help
Design and Architecture Considerations
General Considerations

• Consider the support level requirements of your mission-critical systems.

• Your staff is your key asset!
  – Invest in training, processes, knowledge sharing.
  – A good administrator will provide higher availability than a mediocre cluster setup.

• Get expert help for the initial setup, and

• Write concise operation manuals that make sense at 3am on a Saturday ;-)

• Thoroughly test the cluster regularly.
  – Use a staging system before deploying large changes!
Manage Expectations Properly

- Clustering improves reliability, but does not achieve 100%, ever.
- Fail-over clusters **reduce** service outage, but do not eliminate it.
- High Availability protects **data** before the **service**.
- Clusters are more complex than single nodes.
- Clustering broken applications will not fix them.
- Clusters do not replace backups, RAID, or good hardware.
Complexity Versus Reliability

• Every component has a failure probability.
  ‒ Good complexity: Redundant components.
  ‒ Undesirable complexity: chained components.
  ‒ Choke point → single point of failure
  ‒ Also consider: Administrative complexity.

• Use as few components (features) as feasible.
  ‒ Our extensive feature list is not a mandatory checklist for your deployment ;-)

• What is your fall-back in case the cluster breaks?
  ‒ Backups, non-clustered operation
  ‒ Architect your system so that this is feasible!
Cluster Size Considerations

• More nodes:
  - Increased absolute redundancy and capacity.
  - Decreased relative redundancy.
  - One cluster $\rightarrow$ one failure and security domain.
  - HA is not HPC.

• Does your work-load scale well to more nodes?

• Choose odd node counts
  - 4 and 3 node clusters both lose majority after 2 nodes.

• Question:
  - 5 cheaper servers, or
  - 3 higher quality servers with more capacity each?
Common Setup Issues
General Software Stack

• Please avoid chasing already solved problems!

• Please apply all available software updates:
  – SUSE® Linux Enterprise Server 11 SP3
  – SUSE Linux Enterprise High Availability Extension

• Consider migrating to SUSE Linux Enterprise High Availability Extension 11 SP3, if you have not already.
  – Usability, ease of setup, integration are all much improved.
  – SUSE Linux Enterprise Server 10 remains fully supported.
From One to Many Nodes

- **Error**: Configuration files not identical across nodes.
  - /etc/drbd.conf, /etc/corosync/corosync.conf, /etc/ais/openais.conf, resource-specific configurations ...

- **Symptoms**: Causes weird misbehavior, works one but not on other systems, interoperability issues, and possibly others.

- **Solution**: Make sure they are synchronized.
  - SUSE® Linux Enterprise High Availability Extension 11 SP2 provides “csync2” to do this automatically for you.
  - You can add your own files to this list as needed.
Networking

- Switches must support multicast properly.
- Bonding is preferable to using multiple rings:
  - Reduces complexity
  - Exposes redundancy to all cluster services and clients
- Firewall rules are not your friend.
- Keep firmware on switches uptodate!
- Make NIC names identical on all nodes
- Local hostname resolution versus DNS
- Setup NTP for time synchronization.
Fencing (STONITH)

• Error: Not configuring STONITH at all
  - It defaults to enabled, resource start-up will block and the cluster simply do nothing. This is for your own protection.

• Warning: Disabling STONITH
  - DLM/OCFS2 will block forever waiting for a fence that is never going to happen.

• Error: Using “external/ssh”, “ssh”, “null” in production
  - These plug-ins are for testing. They will not work in production!
  - Use a “real” fencing device or external/sbd

• Error: configuring several power switches in parallel.

• Error: Trying to use external/sbd on DRBD
CIB Configuration Issues

• 2 node clusters cannot have majority with 1 node failed
  - # crm configure property no-quorum-policy=ignore

• Resources are starting up in “random” order or on “wrong” nodes
  - Add required constraints!

• Resources move around when something “unrelated” changes
  - # crm configure property default-resource-stickiness=1000

• # crm_verify -L ; ptest -L -V V V V V
  - Will point out some basic issues

We'll get back to that ...
Configuring Cluster Resources

- **Symptom**: On start of one or more nodes, the cluster restarts resources!

- **Cause**: resources under cluster control are also started via the “init” sequence.
  - The cluster “probes” all resources on start-up on a node, and when it finds resources active where they should not be – possibly even more than once in the cluster –, the recovery protocol is to stop them all (including all dependencies) and start them cleanly again.

- **Solution**: Remove them from the “init” sequence.
Setting Resource Time-outs

- **Belief**: “Shorter time-outs make the cluster respond faster.”

- **Fact**: Too short time-outs cause resource operations to “fail” erroneously, making the cluster unstable and unpredictable.
  - A somewhat too long time-out will cause a fail-over delay;
  - a slightly too short time-out will cause an unnecessary service outage.

- Consider that a loaded cluster node may be slower than during deployment testing.
  - Check “crm_mon -t1” output for the actual run-times of resources.
OCFS2

- Using ocfs2-tools-o2cb (legacy mode)
  - O2CB only works with Oracle RAC; full features of SUSE® Linux Enterprise High Availability Extension are only available in combination with Pacemaker
  - # zyppermocfs2-tools-o2cb
  - Forget about /etc/ocfs2/cluster.conf, /etc/init.d/ocfs2, /etc/init.d/o2cb and /etc/sysconfig/ocfs2

- Nodes crash on shutdown
  - If you have active ocfs2 mounts, you need to umount before shutdown
  - If openais is part of the boot sequence
    - # insserv openais

- Consider: Do you really need OCFS2?
  - Can your application really run concurrently?
Distributed Replicated Block Device

• Myth: has no shared state, thus no STONITH needed.
  – **Fact:** DRBD still needs fencing!

• Active/Active:
  – Does not magically make ext3 or applications concurrency-safe, still can only be mounted once
  – With OCFS2, split-brain is still fatal, as data diverges!

• Active/Passive:
  – Ensures only one side can modify data, added protection.
  – Does not magically make applications crash-safe.

• Issue: Replication traffic during reads.
  – “noatime” mount option.
Storage in General

- Activating non-battery backed caches for performance
  - Causes data corruption.

- iSCSI over unreliable networks.

- Lack of multipath for storage.

- Believing that RAID replaces backups.
  - RAID and replication immediately propagate logical errors!

- Please ensure that device names are identical on all nodes.
Exploring the Effect of Events
What Are Events?

- All state changes to the cluster are **events**
  - They cause an update of the CIB
  - Configuration changes by the administrator
  - Nodes going up or going down
  - Resource monitoring failures

- Response to events is configured using the CIB policies and computed by the Policy Engine

- This can be simulated using `ptest`
  - Available comfortably through the “crm” shell
Simulating Node Failure

hex-0:~ # crm

crm(live)# cib new sandbox

INFO: sandbox shadow CIB created

crm(sandbox)# cib cibstatus node hex-0 unclean

crm(sandbox)# simulate
Simulating Node Failure
Simulating Resource Failure

crm(sandbox) # cib cibstatus load live

crm(sandbox) # cib cibstatus op

usage: op <operation> <resource> <exit_code> [<op_status>] [<node>]

crm(sandbox) # cib cibstatus op start
dummy1 not_running done hex-0

crm(sandbox) # cib cibstatus op start
dummy1 unknown timeout hex-0

crm(sandbox) # configure simulate

ptest[4918]: 2010/02/17_12:44:17 WARN: unpack_rsc_op:
Processing failed op dummy1_start_0 on hex-0: unknown error (1)
Simulating Resource Failure

dummy1_stop_0 hex-0

all_stopped
dummy1_start_0 hex-0
dummy1_monitor_5000 hex-0
Exploring Configuration Changes

```bash
crm(sandbox) # cib cibstatus load live

crm(sandbox) # configure primitive dummy42 ocf:heartbeat:Dummy

crm(sandbox) # simulate actions nograph

notice: LogActions: Start dummy42 (hex-2)
```
Configuration Changes - Woah!
Log Files and Their Meaning
hb_report Is The Silver Support Bullet

• Compiles
  – Cluster-wide log files,
  – Package state,
  – DLM/OCFS2 state,
  – System information,
  – CIB history,
  – parses core dump reports (install debuginfo packages!)
  – into a single tarball for all support needs.

• # hb_report -n “node1 node2 node3” -f 12:00 /	mp/hb_report_example1
Logging

• “The cluster generates too many log messages!”
  - Alas, customers are even more upset when asked to reproduce a problem on their production system ;-) 

• System-wide logs: /var/log/messages

• CIB history: /var/lib/pacemaker/pengine/*
  - All cluster events are logged here and can be analyzed with hindsight (python GUI, ptest, and the crm shell).

• Logging can be selectively bumped to “blackbox” logging at runtime for debugging
Where Is the Real Cause?

- The answer is **always** in the logs
- Even though the logs on the DC may print a reference to the error, the real cause may be on another node.
- Most errors are caused by resource agent misconfiguration.
Correlating Messages to Their Cause

- Feb 17 13:06:57 hex-8 pengine: [7717]: WARN: unpack_rsc_op: Processing failed op ocfs2-1:2_monitor_20000 on hex-0: not running (7)
  - This is **not** the failure, just the Policy Engine reporting on the CIB state! The real messages are on hex-0, grep for the operation key:

- Feb 17 13:06:57 hex-0 Filesystem[24825]: [24861]: INFO: /filer is unmounted (stopped)

- Feb 17 13:06:57 hex-0 crmd: [7334]: info: process_lrm_event: LRM operation ocfs 2-1:2_monitor_20000 (call=37, rc=7, cib-update=55, confirmed=false) not running
  - Look for the error messages from the **resource agent** before the lrmd/pengine lines!
History Info (loads the report)

```
xen-f:~ #crm history info
INFO: fetching new logs, please wait ...
Source: live
Created on: Thu Sep 12 12:58:41 CEST 2013
By: hb_report -Z -f Thu Sep 12 11:56:18 2013 /var/cache/crm/history/live
Nodes: xen-f xen-g
Groups: web-server nfs
Resources: s-libvirt drbd0-vg fs virtual-ip nfs-server web-ip apache p_drbd_nfs
         s-sbd
Transitions: 651 652 653
xen-f:~ #
```

```
Source: bug-825765_hb_report-Mon-13-May-2013.tar.bz2
Created on: --:--:--
By: unknown
Nodes: rad4-a rad4-b
Groups: network_grp
Resources: fence phmd snmp_mon service_ip default_gw RP mibreader dbrads pingnet
Transitions: 66 67 68 70 71 72 73 74 75 76 77 78 3 4 335 336 337 338 339
[0]hex-10:825765 >
```
Basic Transition Usage

crm(live)# resource start apache
crm(live)# history transition
INFO: fetching new logs, please wait ...
INFO: running ptest with /var/cache/crm/history/live/xen-f/pengine/pe-input-638.bz2
INFO: starting dotty to show transition graph
warning: unpack_nodes: Blind faith: not fencing unseen nodes
  total 4 actions: 4 Complete
Sep  5 15:18:17 xen-f crmd[12627]:  notice: te_rsc_command: Initiating action 28: start apache_start_0 on xen-f (local)
Sep  5 15:18:18 xen-f apache(apache)[29141]:  INFO: httpd2: Could not reliably determine the server's fully qualified domain name, using 10.2.13.56 for ServerName
Sep  5 15:18:18 xen-f crmd[12627]:  notice: process_lrm_event: LRM operation apache_start_0 (call=309, rc=0, cib-update=370, confirmed=true) ok

Resource Events

- Tue Sep 15 20:46:27 CEST 2010

Usage:

         limit [<from_time> [<to_time>]]

Examples:

         limit 10:15
         limit 15h22m 16h
         limit "Sun 5 20:46" "Sun 5 22:00"

crm(live)history# timeframe 15:17
crm(live)history# resource apache
INFO: 23: fetching new logs, please wait ...
Sep  5 15:18:17 xen-f crmd[12627]: notice: te_rsc_command: Initiating action 28: start apache_start_0 on xen-f (local)
Sep  5 15:18:18 xen-f apache(apache)[29141]: INFO: httpd2: Could not reliably dete
          mine the server's fully qualified domain name, using 10.2.13.56 for Serv
          e
Sep  5 15:18:18 xen-f crmd[12627]: notice: process_lrm_event: LRM operation ap
          ache_start_0 (call=309, rc=0, cib-update=370, confirmed=true) ok
crm(live)history#  

Node Events

```
crm(live)history#
crm(live)history#
crm(live)history#
crm(live)history#
crm(live)history#
crm(live)history# node xen-g
Sep 5 16:54:26 xen-f corosync[12617]: [pcmk ] info: pcmpk_peer_update: lost: xen-g 957153802
Sep 5 16:54:26 xen-f pengine[12626]: warning: pe_fence_node: Node xen-g will be fenced because the node is no longer part of the cluster
Sep 5 16:54:26 xen-f pengine[12626]: warning: stage6: Scheduling Node xen-g for STONITH
Sep 5 16:54:26 xen-f crmd[12627]: notice: te_fence_node: Executing reboot fencing operation (47) on xen-g (timeout=60000)
Sep 5 16:54:37 xen-f stonith-ng[12623]: notice: log_operation: Operation 'reboot' [10441] (call 3 from crmd.12627) for host 'xen-g' with device 's-sbd' returned: 0 (OK)
Sep 5 16:55:17 xen-g corosync[2766]: [MAIN ] Corosync Cluster Engine ('1.4.6') : started and ready to provide service.
crm(live)history#
crm(live)history#
crm(live)history#
crm(live)history#
crm(live)history#
crm(live)history#
```
Debugging Resource Agents
Common Resource Agent Issues

• Operations must succeed if the resource is already in the requested state.

• “monitor” must distinguish between at least “running/OK”, “running/failed”, and “stopped”
  - Probes deserve special attention

• Meta-data must conform to DTD.

• 3rd party resource agents do not belong under /usr/lib/ocf/resource.d/heartbeat – chose your own provider name!

• Use ocf-tester to validate your resource agent.
ocf-tester Example Output

hex-0:~ # ocf-tester -n Example
/usr/lib/ocf/resource.d/bs2010/Dummy

Beginning tests for /usr/lib/ocf/resource.d/bs2010/Dummy...

* Your agent does not support the notify action (optional)
* Your agent does not support the demote action (optional)
* Your agent does not support the promote action (optional)
* Your agent does not support master/slave (optional)

* rc=7: Stopping a stopped resource is required to succeed

Something Hangs and I Don’t Know Where ... 

```
hex-0:~  # export OCF_RESKEY_sid=MyDB
hex-0:~  # bash -x
/usr/lib/ocf/ocf/resource.d/heartbeat/oracle
monitor 2>&1 | \
while read L ; do echo "$(date) $L" ;
done
```
More about High Availability with SUSE Linux Enterprise

**CAS1417** A Xen cluster success story using the SLES HA Extension

**CAS1589** A carrier grade cloud phone system based on SUSE Linux Enterprise Server

**TT1395** How to Build an HA environment with Linux on IBM System z

**TT1449** How To Make Databases on SUSE Linux Enterprise Server Highly Available

Thank you.
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