Hadoop 24/7

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Dear SysAdmin,

Please set up Hadoop using these machines. Let us know when they are ready for use.

Thanks,
The Users
Install some nodes with Hadoop...
Individual Node Configuration

• MapReduce slots tied to # of cores vs. memory

• DataNode reads/writes spread (statistically) even across drives

• hadoop-site.xml dfs.data.dir:
  
  `<property>
  <name>dfs.data.dir</name>
  <value>/hadoop0,/hadoop1,/hadoop2,/hadoop3</value>
  </property>`

• RAID
  – If any, mirror NameNode only
  – Slows DataNode in most configurations
NameNode’s Lists of Nodes

- **slaves**
  - used by start-*.sh/stop-*.sh

- **dfs.include**
  - IPs or FQDNs of hosts allowed in the HDFS

- **dfs.exclude**
  - IPs or FQDNs of hosts to ignore

- **active datanode list=include list-exclude list**
  - Dead list in NameNode Status
Adding/Removing DataNodes Dynamically

• Add nodes
  – Add new nodes to dfs.include

• (Temporarily) Remove Nodes
  – Add nodes to dfs.exclude

• Update Node Lists and Decommission
  – hadoop dfsadmin -refreshNodes
    • Replicates blocks from any live nodes in the exclude list
  – Hint: Do not decommission too many nodes (200+) at once! Very easy to saturate namenode!
Racks Of Nodes

• Each node
  – 1 connection to network switch
  – 1 connection to console server

• Dedicated
  – Name Nodes
  – Job Tackers
  – Data Loaders
  – ...

• More and More Racks...
Networks of Racks, the Yahoo! Way

- Each switch connected to a bigger switch
- Physically, one big network
- Loss of one core covered by redundant connections
- Logically, lots of small networks (netmask /26)

 Yahoo! @ ApacheCon
Rack Awareness (HADOOP-692)

• Hadoop needs node layout (really network) information
  – Speed:
    • read/write prioritization (*)
      – local node
      – local rack
      – rest of system
  – Data integrity:
    • 3 replicas: write local -> write off-rack -> write on-the-other-rack -> return

• Default: flat network == all nodes of cluster are in one rack

• Topology program (provided by you) gives network information
  – hadoop-site.xml parameter: topology.script.file.name
  – Input: IP address   Output: /rack information

* or perhaps gettext("prioritization") ?
Rack Awareness Example

- Four racks of /26 networks:
  - 192.168.1.1-63, 192.168.1.65-127,

- Four hosts on those racks:
  - sleepy 192.168.1.20  mars 192.168.1.73
  - frodo 192.168.1.145  athena 192.168.1.243

<table>
<thead>
<tr>
<th>Host to lookup</th>
<th>Topology Input</th>
<th>Topology Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>sleepy</td>
<td>192.168.1.20</td>
<td>/192.168.1.0</td>
</tr>
<tr>
<td>frodo</td>
<td>192.168.1.145</td>
<td>/192.168.1.128</td>
</tr>
<tr>
<td>mars</td>
<td>192.168.1.73</td>
<td>/192.168.1.64</td>
</tr>
<tr>
<td>athena</td>
<td>192.168.1.243</td>
<td>/192.168.1.192</td>
</tr>
</tbody>
</table>
Rebalancing Your HDFS (HADOOP-1652)

• Time passes
  – Blocks Added/Deleted
  – New Racks/Nodes

• Rebalancing places blocks uniformly across nodes
  – throttled so not to saturate network or name node
  – live operation; does not block normal work

• hadoop balancer [ -t <threshold> ]
  – (see also bin/start-balancer.sh)
  – threshold is % of over/under average utilization
    • 0 = perfect balance = balancer will likely not ever finish
  – Bandwidth Limited: 5 MB/s default, dfs.balance.bandwidthPerSec
    • per datanode setting, need to bounce datanode proc after changing!

• When to rebalance?
HDFS Reporting

• “What nodes are in what racks?”
• “How balanced is the data across the nodes?”
• “How much space is really used?”

• The big question is really:

“What is the health of my HDFS?”

• Primary tools
  – hadoop dfsadmin -fsck
  – hadoop dfsadmin -report
  – namenode status web page
hadoop fsck /

• Checks status of blocks, files and directories on the file system
  – Hint: Partial checks ok; provide path other than /
  – Hint: Run this nightly to watch for corruption

• Common Output:
  – A bunch of dots
    • Good blocks
  – Under replicated blk_XXXX. Target Replication is X but found Y replica(s)
    • Block is under replicated and will be re-replicated by namenode automatically
  – Replica placement policy is violated for blk_XXXX.
    • Block violates topology; need to fix this manually
  – MISSING X blocks of total size Y B
    • Block from the file is completely missing
“Good” fsck Summary

Total size: 506115379265905 B (Total open files size: 4165942598 B)
Total dirs: 358015
Total files: 10488573 (Files currently being written: 246)
Total blocks (validated): 12823618 (avg. block size 39467440 B) (Total open file blocks (not validated): 51)
Minimally replicated blocks: 12823618 (100.00001 %)
Over-replicated blocks: 25197 (0.196489 %)
Under-replicated blocks: 9 (7.0183E-5 %)
**Mis-replicated blocks:** 1260 (0.00982562 %)
Default replication factor: 3
Average block replication: 3.005072
Corrupt blocks: 0
Missing replicas: 10 (2.5949832E-5 %)
Number of data-nodes: 1507
Number of racks: 42

The filesystem under path '/' is HEALTHY
Bad fsck Summary

**Status:** CORRUPT

**Total size:** 505307372371599 B (Total open files size: 241591904 B)
**Total dirs:** 356465
**Total files:** 10416773 (Files currently being written: 478)
**Total blocks (validated):** 12763719 (avg. block size 39589352 B) (Total open file blocks (not validated): 288)

************************************************
**CORRUPT FILES:** 1
**MISSING BLOCKS:** 1
**MISSING SIZE:** 91227974 B
**CORRUPT BLOCKS:** 1
************************************************

Minimally replicated blocks: 12763718 (99.99999 %)
Over-replicated blocks: 970560 (7.6040535 %)
Under-replicated blocks: 4 (3.133883E-5 %)
Mis-replicated blocks: 1299 (0.0101772845 %)
Default replication factor: 3
Average block replication: 3.0837624
Corrupt blocks: 1
Missing replicas: 5 (1.2703163E-5 %)
Number of data-nodes: 1509
Number of racks: 42

The filesystem under path '/' is CORRUPT
hadoop dfsadmin -report

Total raw bytes: 233878511754448 (2.08 PB)
Remaining raw bytes: 237713230031670 (216.2 TB)
Used raw bytes: 1538976032374394 (1.37 PB)
% used: 65.8%

Total effective bytes: 0 (0 KB)
Effective replication multiplier: Infinity

Datanodes available: 1618

Name: 192.168.1.153:50010
Rack: /192.168.1.128
State: In Service
Total raw bytes: 1959385432064 (1.78 TB)
Remaining raw bytes: 234818330641 (218.69 GB)
Used raw bytes: 1313761392777 (1.19 TB)
% used: 67.05%
Last contact: Thu Feb 19 21:57:01 UTC 2009
NameNode Status

NameNode 'mynamenode.example.com:8020'

Started: Wed Feb 04 16:18:50 UTC 2009
Version: 0.18.3-2486615, r
Compiled: Thu Jan 29 16:43:04 UTC 2009 by hadoopqa
Upgrades: There are no upgrades in progress.

Browse the filesystem

Cluster Summary

10877074 files and directories, 12860721 blocks = 23737795 total. Heap Size is 13.57 GB / 13.57 GB (100%)
Capacity : 2.08 PB
DFS Remaining : 216.08 TB
DFS Used : 1.37 PB
DFS Used% : 65.81 %
Live Nodes : 1403
Dead Nodes : 215

Live Datanodes : 1403

<table>
<thead>
<tr>
<th>Node</th>
<th>Last Contact</th>
<th>Admin State</th>
<th>Size (TB)</th>
<th>Used (%)</th>
<th>Used (%)</th>
<th>Remaining (TB)</th>
<th>Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>sleepy</td>
<td>2</td>
<td>In Service</td>
<td>1.42</td>
<td>67.19</td>
<td></td>
<td>0.11</td>
<td>25705</td>
</tr>
<tr>
<td>dopey</td>
<td>0</td>
<td>In Service</td>
<td>1.43</td>
<td>66.83</td>
<td></td>
<td>0.12</td>
<td>26399</td>
</tr>
<tr>
<td>grumpy</td>
<td>0</td>
<td>In Service</td>
<td>1.42</td>
<td>67.46</td>
<td></td>
<td>0.11</td>
<td>25789</td>
</tr>
</tbody>
</table>
The Not So Secret Life of the NameNode

- Manages HDFS Metadata
  - in-memory (Java heap determines size of HDFS!)
  - on-disk

- Image file
  - static version that gets re-read on startup

- Edits file
  - log of changes to the static version since startup
  - Restarting namenode applies edits to the image file

- hadoop-site.xml:

```xml
<property>
    <name>dfs.name.dir</name>
    <value>/hadoop/var/hdfs/name</value>
</property>
```
NameNode: Your Single Point of Failure

• When NameNode dies, so does HDFS

• In practice, does not happen very often

• Multiple directories can be used for the on-disk image
  – <value>/hadoop0/var/hdfs/name,/hadoop1/var/hdfs/name</value>
  – sequentially written
  – 2nd directory on NFS means always having a copy

• Hint: Watch the disk space!
  – Namenode logs
  – image and edits file
  – audit logs (more on that later)
Why NameNodes Fail

• Usually not a crash; brownout
  – Hint: Monitoring
    • Checking for dead process is a fail
    • Must check for service!

• Bugs
  – No, really.

• Hardware
  – Chances are low

• Misconfiguration
  – Not enough Java heap
  – Not enough physical RAM
    • swap=death

• As HDFS approaches full DataNodes cannot write add’l blocks
  – inability to replicate can send NameNode into death spiral

• Users doing bad things
**HDFS NameNode Recovery**

- When NN dies, bring up namenode on another machine
  - mount image file from NFS
  - create local directory path
  - change config to point to new name node
  - restart HDFS
  - NameNode process will populate local dir path with copy of NFS version

- Hint: Use an A/CNAME with small TTL for namenode in hadoop-site.xml
  - Move the A/CNAME to the new namenode
    - No config changes required on individual nodes
  - For CNAMEs, restart the DataNodes to pick up changes
    - See HADOOP-3988 for details

- But what about the secondary?
Secondary NameNode: Enabling Fast Restarts

- **NOT** High Availability

- Merge the edits file and image file without namenode restart
  - Service is **down** until merge is finished when run on the primary
  - Secondary does this live with no downtime

- Optional, but for sizable grids, this should run
  - 40g edits file will take ~6hrs to process
    - Weeks worth of changes from 800 users on a 5PB HDFS

- Requires the same hardware config as namenode
  - due to some issues with forking, may require more memory
    - swap is fine here..
    - HADOOP-4998 and HADOOP-5059 have some discussion of the issues
Herding Cats... err.. Users

- Major user-created problems
  - Too many metadata operations
  - Too many files
  - Too many blocks

- Namespace quotas (0.18 HADOOP-3187)
  - Limit the number of files per directory
  - hadoop dfsadmin -setQuota # dir1 [dir2 ... dirn]
  - hadoop dfsadmin -clrQuota dir1 [dir2 ... dirn]

- Size quotas (0.19 HADOOP-3938, 0.18 HADOOP-5158)
  - Limit the total space used in a directory
  - hadoop dfsadmin -setspaceQuota # dir1 [dir2 ... dirn]
    - defaults to bytes, but can use abbreviations (e.g., 200g)
  - hadoop dfsadmin -clrspaceQuota dir1 [dir2 ... dirn]
More on Quotas

• Reminder: Directory-based, not User-based
  – /some/directory/path has a limit
  – user allen does not

• No defaults
  – User creation scripts need to set “default” quota

• No config file
  – Store as part of the metadata
  – HDFS must be up; no offline quota management

• Quota Reporting
  – hadoop fs -count -q dir1 [dir2 ...]
  – There is no “give me all quotas on the system” command
    • HADOOP-5290
• Recovery of multi-TB files is hard

• hadoop fs -rm / client-side only feature
  – MR, Java API will not use .Trash

• Deleted files sent to HOMEDIR/.Trash/Current
  – “poor man’s snapshot”
  – hadoop-site.xml: fs.trash.interval
    • Number of minutes between cleanings

• Typical scenario:
  – Running out of space
  – Users delete massive amounts of files
  – Still out of space
  – Need to remove files out of trash to reclaim
Hadoop Permission System

• “Inspired” by POSIX and AFS
  – users, groups, world
  – read/write/execute
  – Group inheritance

• User and Group
  – Retrieved from client
  – Output of whoami, id, groups

• hadoop-site.xml: dfs.umask
  – umask used when creating files/dirs
  – **Decimal**, not octal
    • 63 not 077
HADOOP IS NOT SECURE! RUN FOR YOUR LIVES!

- Server never checks client info

- Permission checking is easily circumvented
  - App asks namenode for block #’s that make up file (regardless of read perms)
  - App asks datanode for those blocks

- Strategy 1: Who cares?

- Strategy 2: User/Data Separation
  - Firewall around Hadoop
  - Provision users only on grids with data they can use
  - Trust your users not to break the rules
Audit Logs (HADOOP-3336)

• **When, Who, Where, How, What**

```plaintext
2009-02-27 00:00:00,299 INFO org.apache.hadoop.fs.FSNamesystem.audit:
ugi=allenw,users ip=/192.168.1.100 cmd=create src=/project/cool/data/file1 dst=null perm=allenw:users:rw--------
```

• **log4j.properties**

```plaintext
log4j.logger.org.apache.hadoop.fs.FSNamesystem.audit=INFO,DRFAAUDIT
log4j.additivity.org.apache.hadoop.fs.FSNamesystem.audit=false
log4j.appender.DRFAAUDIT=org.apache.log4j.DailyRollingFileAppender
log4j.appender.DRFAAUDIT.File=/var/log/hadoop-audit.log
log4j.appender.DRFAAUDIT.DatePattern=yyyy-MM-dd
log4j.appender.DRFAAUDIT.layout=org.apache.log4j.PatternLayout
log4j.appender.DRFAAUDIT.layout.ConversionPattern=%d{ISO8601} %p %c: %m%n
```
Multiple Grids

• Needed for
  – Security
  – Data redundancy

• How separate should they be?
  – Separate user for namenode, datanode, etc, processes?
  – Separate ssh keys?
  – Separate home directories for users?

• Data redundancy
  – Dedicated loading machines
  – Copying data between grids
distcp - distributed copy

- hadoop distcp [flags] URL [URL ...] URL
  - submits a map/reduce job to copy directories/files

  - copies block by block using Hadoop RPC
  - very fast

- Important flags
  - p = preserve various attributes, except modification time
  - i = ignore failures
  - log = write to a log file
  - m = number of copies (maps)
    - very easy to flood network if too many maps are used!
  - filelimit / sizelimit = limits the quantity of data to be copied
    - Another safety check against eating all bandwidth
• hdfs method uses Hadoop RPC
  – versions of Hadoop must match!

• hadoop distcp hftp://nn1:50070/path/to/a/file hdfs://nn2:8020/another/path
  – file-level copy
  – slow
  – fairly version independent
  – must run on destination cluster
  – cannot write via hftp

• Uses a single port for copying