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

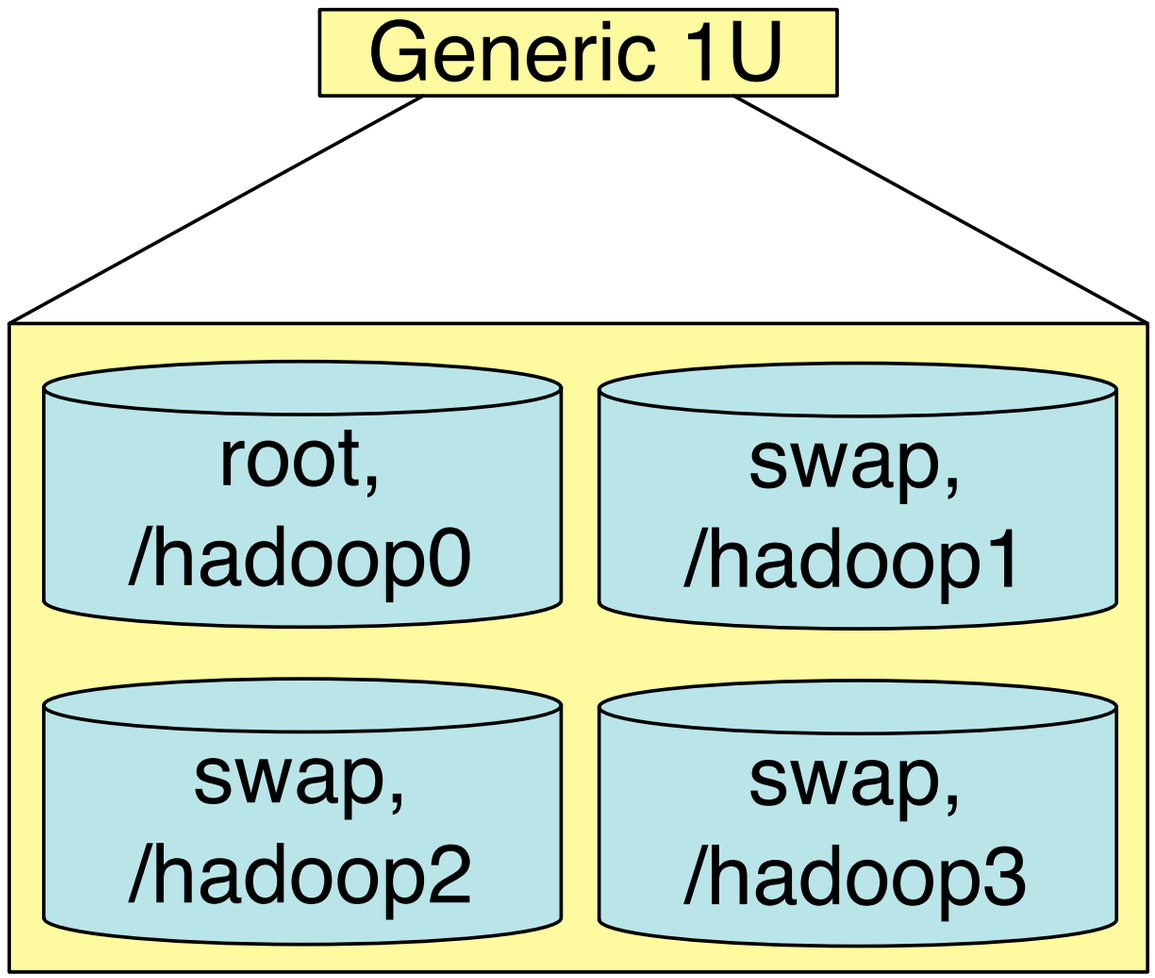
Install some nodes with Hadoop...

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

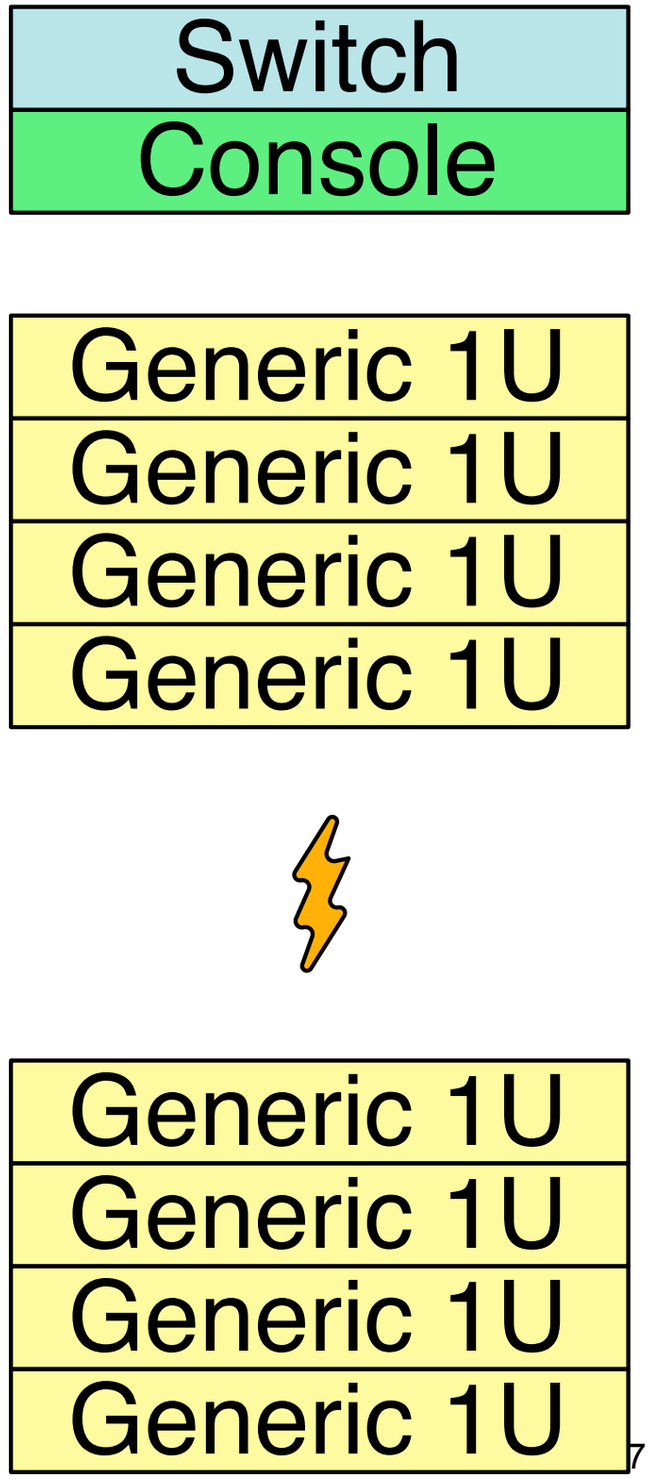
- slaves
  - used by start-*.sh/stop-*.sh
- dfs.include
  - IPs or FQDNs of hosts allowed in the HDFS
- dfs.exclude
  - IPs or FQDNs of hosts to ignore
- active datanode list=include list-exclude list
  - Dead list in NameNode Status

Adding/Removing DataNodes Dynamically

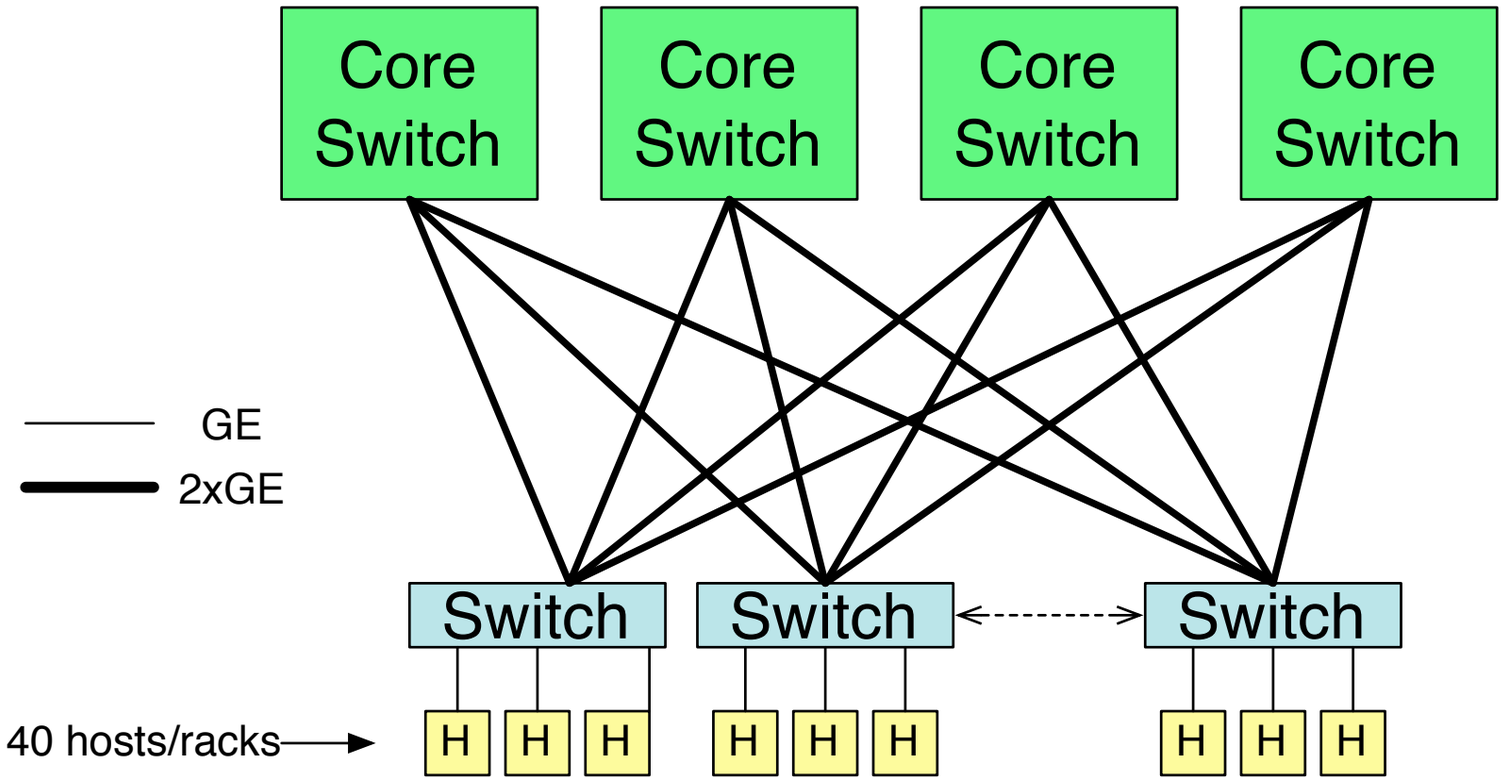
- Add nodes
  - Add new nodes to dfs.include
- (Temporarily) Remove Nodes
  - Add nodes to dfs.exclude
- Update Node Lists and Decommission
  - hadoop dfsadmin -refreshNodes
    - Replicates blocks from any live nodes in the exclude list
  - Hint: Do not decommission too many nodes (200+) at once! Very 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)

Rack Awareness (HADOOP-692)

- Hadoop needs node layout (really network) information
  - Speed:
    - read/write prioriti[sz]ation (*)
      - 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,
  - 192.168.1.129-191, 192.168.1.193-254

- 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

Host to lookup	Topology Input	Topology Output
sleepy	192.168.1.20	/192.168.1.0
frodo	192.168.1.145	/192.168.1.128
mars	192.168.1.73	/192.168.1.64
athena	192.168.1.243	/192.168.1.192

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: 2415919104 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

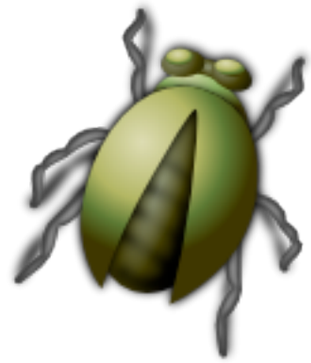
dfsadmin -report Example

- hadoop dfsadmin -report

```
Total raw bytes: 2338785117544448 (2.08 PB)
Remaining raw bytes: 2377132300316700 (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

Node	Last Contact	Admin State	Size (TB)	Used (%)	Used (%)	Remaining (TB)	Blocks
sleepy	2	In Service	1.42	67.19		0.11	25705
dopey	0	In Service	1.43	66.83		0.12	26399
grumpy	0	In Service	1.42	67.46		0.11	25789

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:

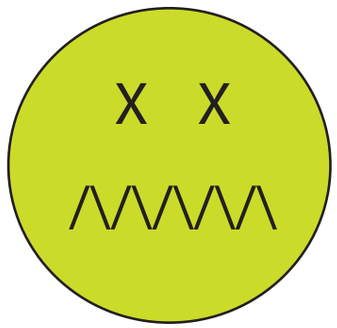
```
<property>
  <name>dfs.name.dir</name>
  <value>/hadoop/var/hdfs/name</value>
</property>
```

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

Trash, The Silent Killer That Users Love

- 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

```
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

```
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
- hadoop distcp hdfs://nn1:8020/full/path hdfs://nn2:8020/another/path
  - 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

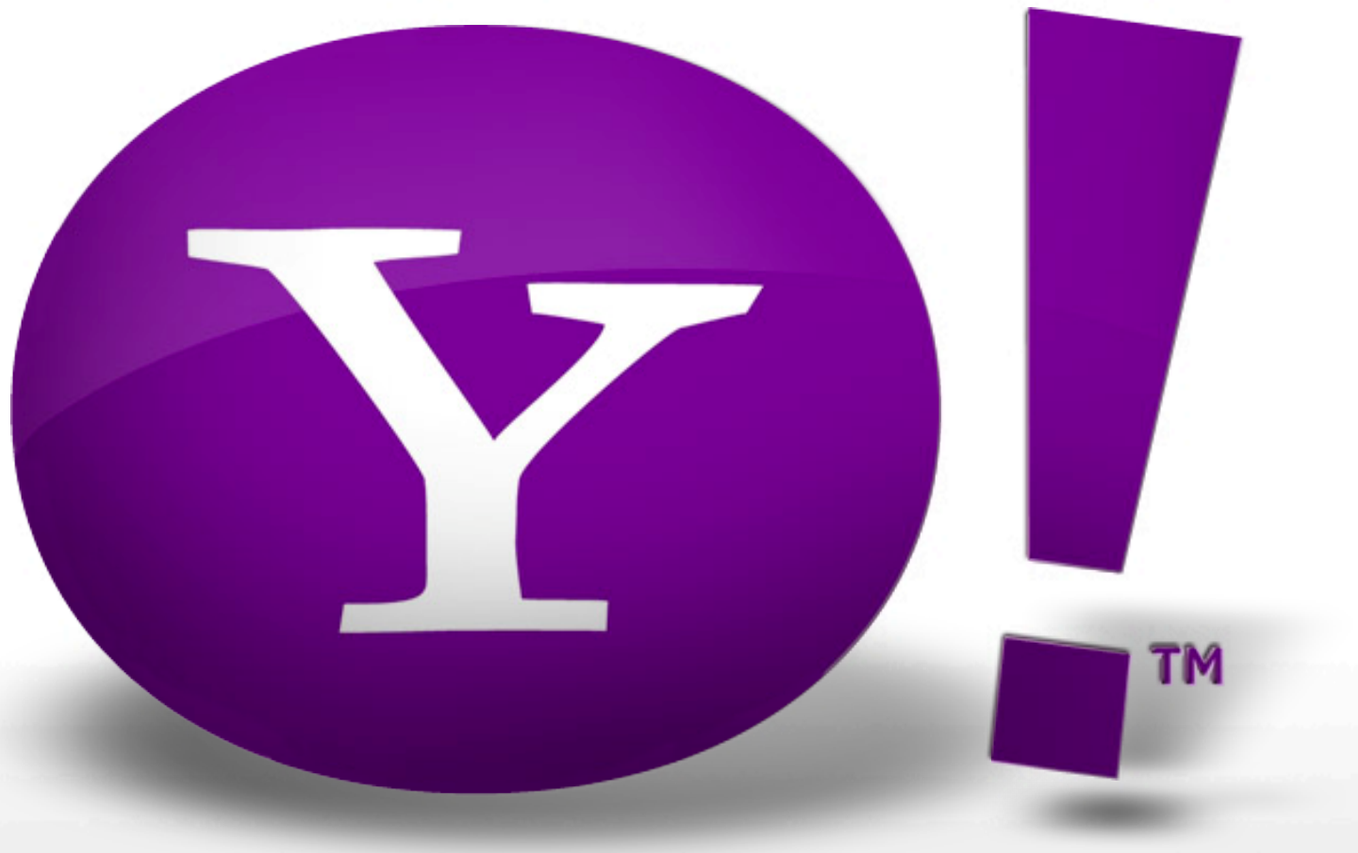
Copying Data Between Hadoop Versions

- 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

Q & A



YAHOO!