Using HDFS as a WLCG SE

Brian Bockelman

Introducing Hadoop

- Hadoop is a data processing system that follows the MapReduce paradigm for scalable data analysis.
  - Largest install is at Yahoo, a major contributor.
  - 14PB of online disk.
  - Larger clusters are planned

Hadoop and HDFS

- To do large-scale data processing, you need an underlying file system.
- But to do this affordably, you need a distributed FS designed for commodity hardware.
  - I.e., stuff all your worker nodes full of disks.

HDFS

- HDFS is a scalable file system with two major components:
  - Namenode: central metadata server.
  - Datanode: file servers for data.
- Lots of design decisions in HDFS will look familiar to WLCG sites.

HDFS Design

- Big subject! See the Hadoop whitepapers
- The filesystem keeps all namespace information persisted in a journal and merges the journal once every hr or 64MB.
  - All operations that do not alter namespace are guaranteed to be RAM-only.
  - Benchmarked at 50k ops / sec for reads, 5k ops / sec for writes.

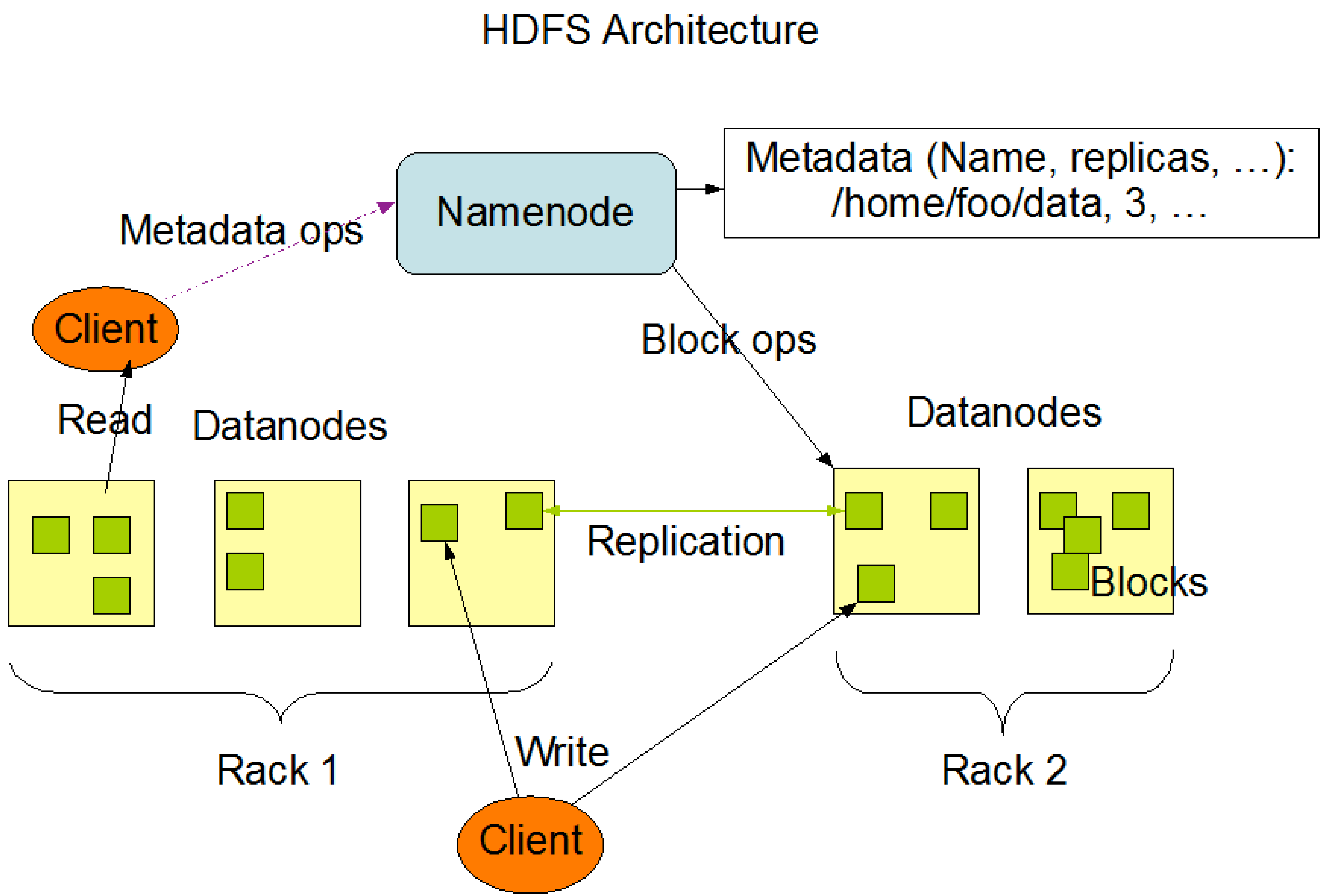


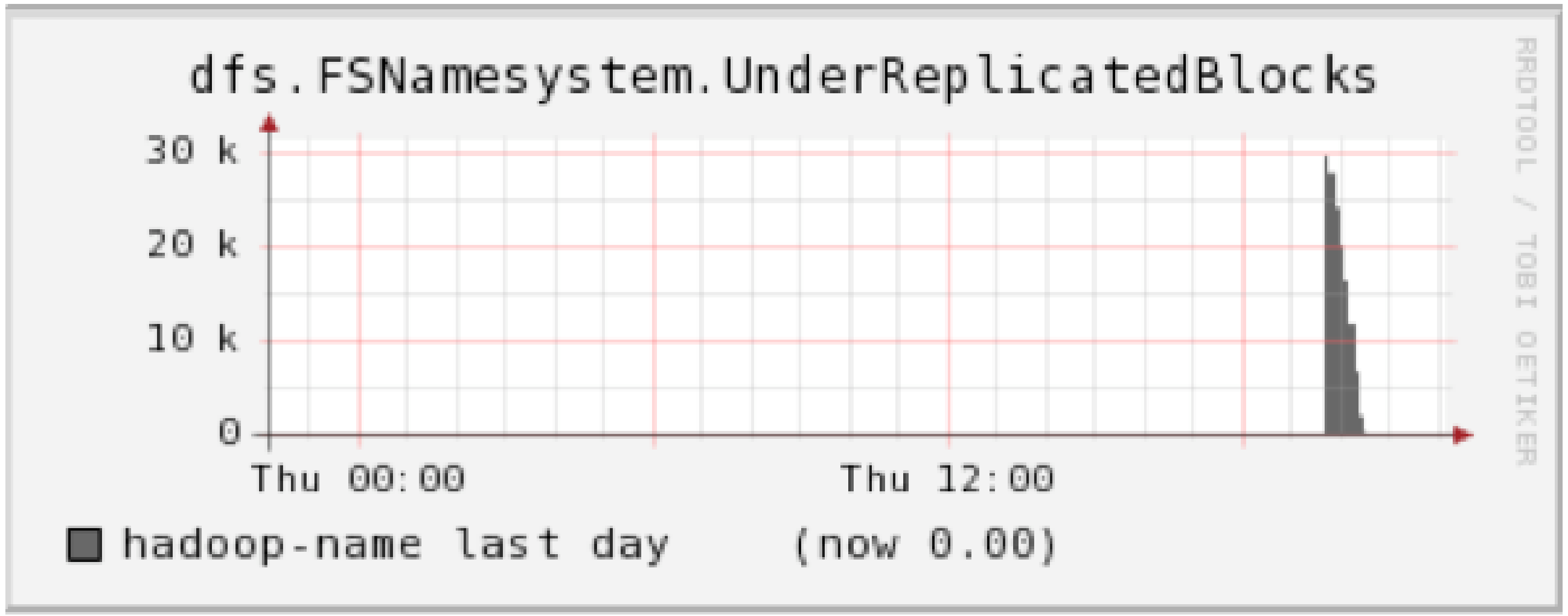
Image courtesy of Hadoop website

HDFS Replication

- Replication built into core of system.
- Default replication policy:
  - First replica to local datanode
  - Second replica to a node on a different rack
  - Third replica to yet another rack.

Replication Example

- Our current policy is that any node that does not have a heartbeat in 10 minutes is declared dead.
- At that point, namenode will start creating new replicas, assuming the node is dead.
- Example below: 1.5TB HDD failed; "danger zone" passed in ~ 1 hr.



Replication

- At no point when a HDD fails does a client fail!

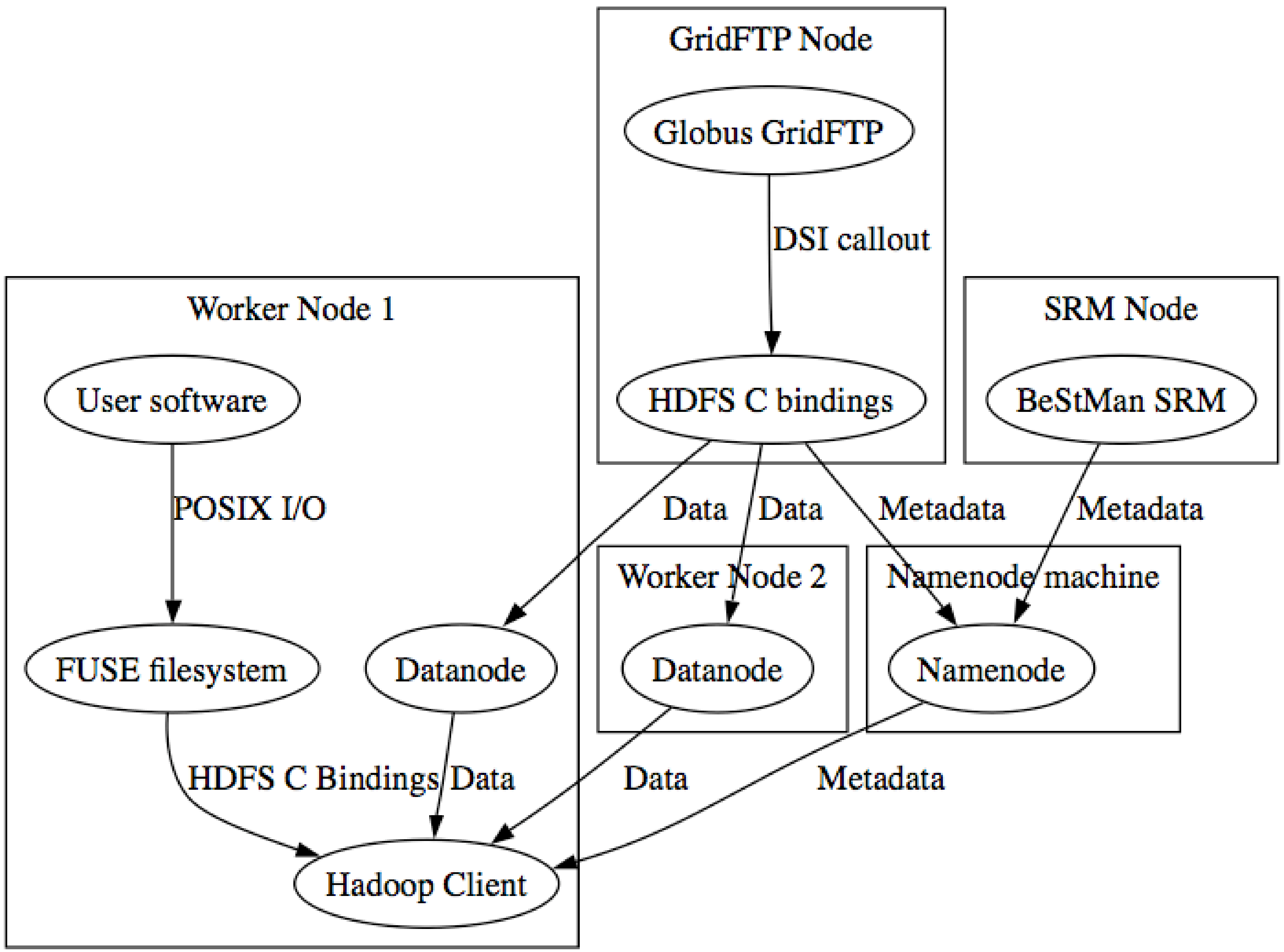
HDFS Replication

- HDFS replication allows client's reads to survive:
  - Death of datanode currently reading from.
  - Death of namenode.

Grid-Enabling HDFS

- We combine HDFS with two grid components:
  - BestMan SRM server
  - Globus Gridftp
  - Both are well maintained & modular.
- And then we mount it on our WN for local file access.

HDFS SE Diagram



HDFS Grid Site

Advantages of HDFS

- In order, these are the primary drivers of our use of HDFS:
  - Manageability
  - Reliability
  - Usability
  - Scalability

Manageability

- The following tasks are trivial:
  - Integration of statistics with **Ganglia**.
  - **Decommissioning** hardware.
  - **Recovery** from hardware failure.
  - **Fsck**!
    - Checks the current knowledge of the filesystem and counts how many block replicas there are per file, and highlights any which are under-replicated.
  - RPM and Pacman-based install for the whole kit.
  - Many of our “well-known” problems are not possible.
    - **Don’t need a separate admin toolkit**!
  - Setting quotas.

FSCK example

root@hadoop-name:~ — ssh — 107×33

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....................................................................................................
................................................................Status: HEALTHY
 Total size:    72767054047268 B
 Total dirs:    2271
 Total files:   59765 (Files currently being written: 1)
 Total blocks (validated):      1053128 (avg. block size 69096115 B)
 Minimally replicated blocks:   1053128 (100.0 %)
 Over-replicated blocks:        3778 (0.3587408 %)
 Under-replicated blocks:       0 (0.0 %)
 Mis-replicated blocks:         0 (0.0 %)
 Default replication factor:    3
 Average block replication:     2.0923886
 Corrupt blocks:                0
 Missing replicas:              0 (0.0 %)
 Number of data-nodes:          113
 Number of racks:               1


The filesystem under path '/' is HEALTHY

real    0m7.753s
user    0m0.835s
sys     0m0.159s
[root@hadoop-name ~]#
```

Ganglia Graphs

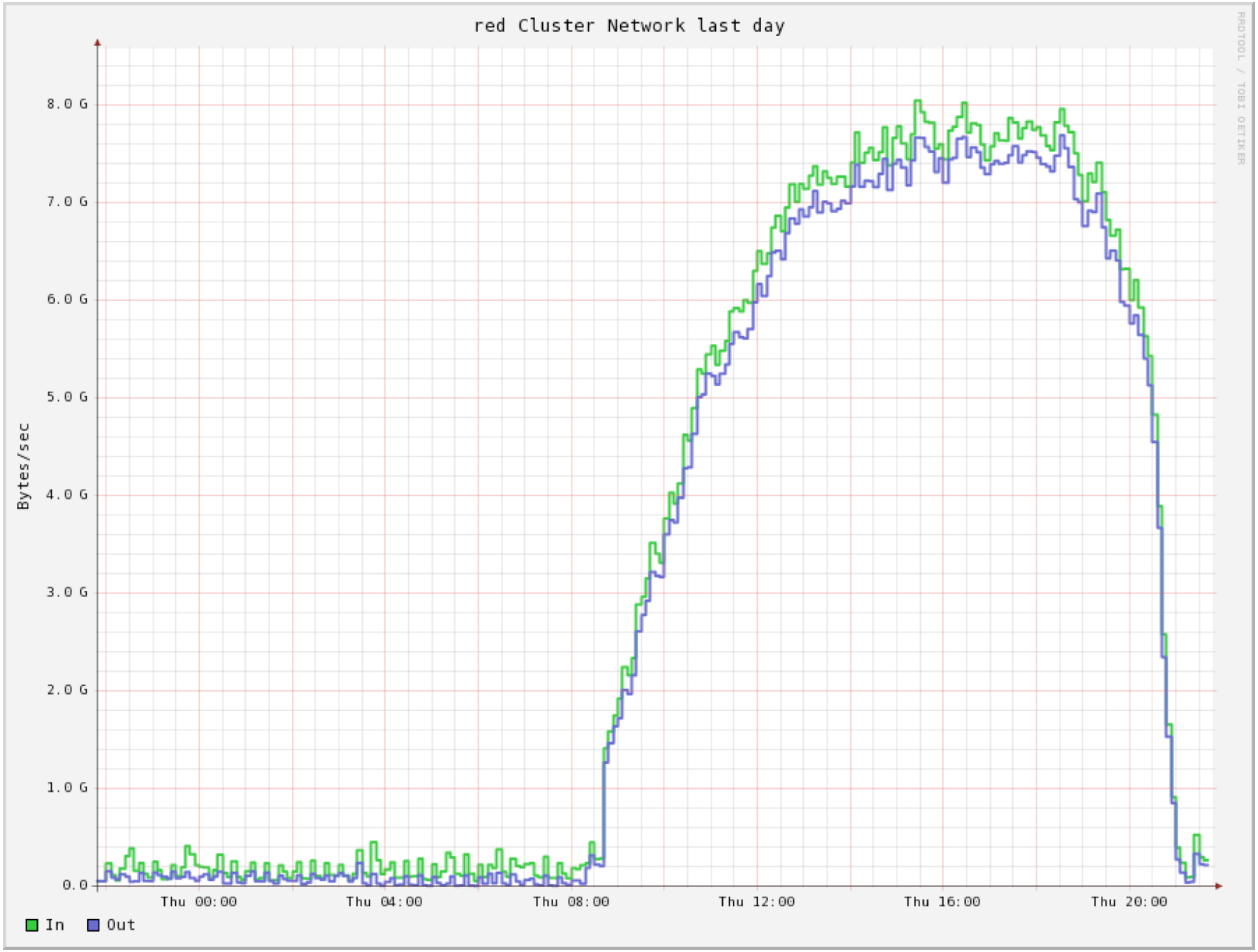
Reliability

- Replication works incredibly well.
- Client (CMSSW) reads live through restarts of any piece of HDFS.
- Writes are pipelined; guaranteed to have N copies on cluster when close() returns.
- Each datanode does a constant

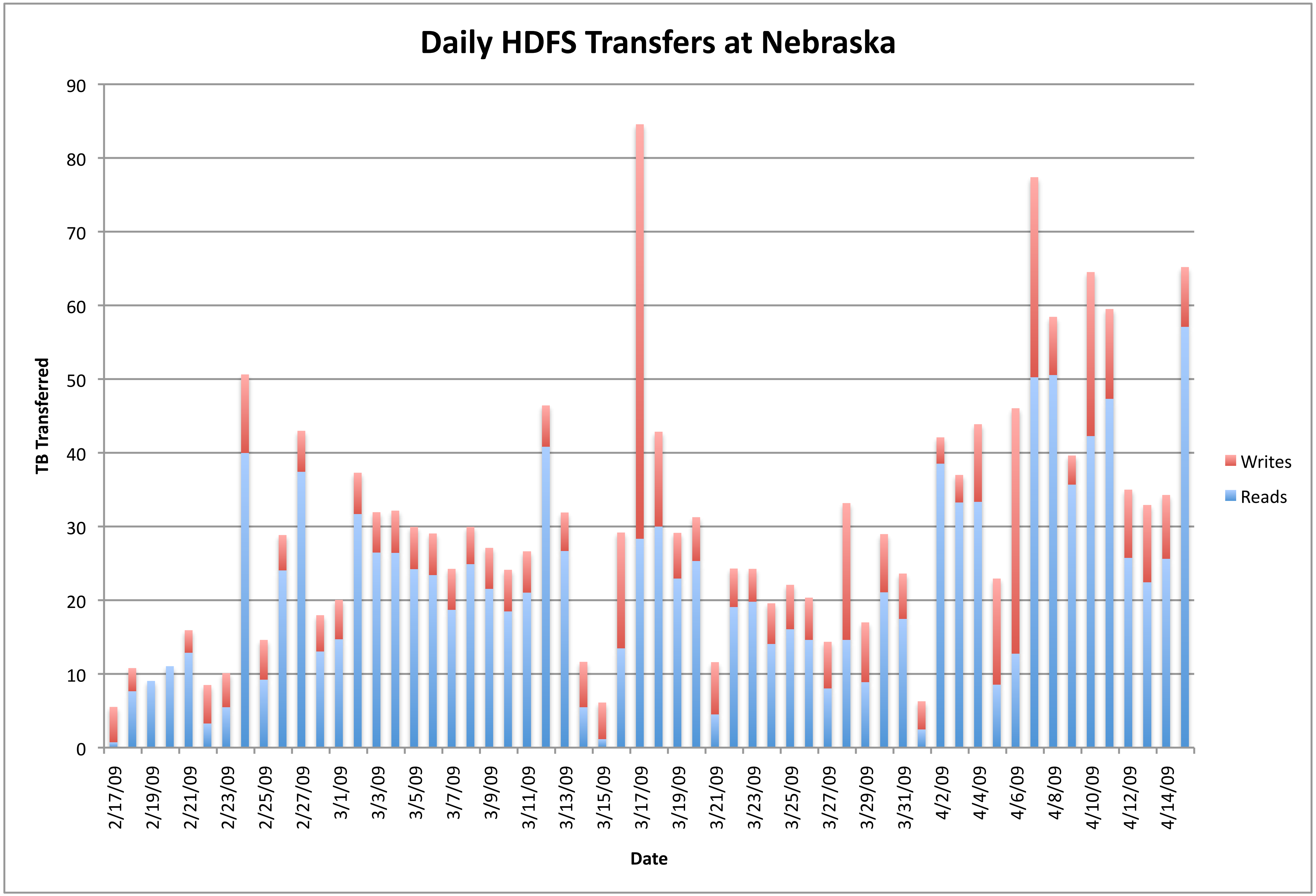
Usability

- POSIX works*; this opens a lot of doors to communities who are put off by recompiling their software.
  - * = writes are append-only
- Users no longer have to know about your FS-specific tools.
  - Although there are some nifty additions the tools provide.

(CMSSW) Performance



TB moved / day



Daily HDFS Transfers at Nebraska
TB Transferred
90
80
70
60
50
40
30
20
10
0
2/17/09
2/19/09
2/21/09
2/23/09
2/25/09
2/27/09
3/1/09
3/3/09
3/5/09
3/7/09
3/9/09
3/11/09
3/13/09
3/15/09
3/17/09
3/19/09
3/21/09
3/23/09
3/25/09
3/27/09
3/29/09
3/31/09
4/2/09
4/4/09
4/6/09
4/8/09
4/10/09
4/12/09
4/14/09
Date
Writes
Reads

Performance Stats

- We've clocked:
  - The filesystem at 80Gbps.
  - 23 Gbps for 300 CMSSW processes analyzing a *single file* @ 2 replicas (we picked a fake workflow to pump up the per-job rate).
  - SRM endpoints at 37Hz (these SRMs are stateless; load-balancing is trivial). Done using GUMS auth.
  - fsck takes <10s.
  - Decommissioning a pool <1hr.
  - Namenode restart in about 60s.
  - WAN transfers peak at 9Gbps, sustain 5Gbps.
  - 18,400 metadata ops / sec from the namenode.

Conclusions

- Hadoop gives us significant improvements in manageability of storage => lowers cost of maintenance.
- Performance scalability benefits by co-locating storage and WNs
  - Reliability during disk failures => less failures seen by users.
- Allows us to use commodity hardware => lowers cost of hardware.