Serving Large-scale Batch Computed Data with Project Voldemort

Roshan Sumbaly, Jay Kreps, Lei Gao, Alex Feinberg, Chinmay Soman, and Sam Shah

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USENIX Conference on File and Storage Technologies

February, 2012

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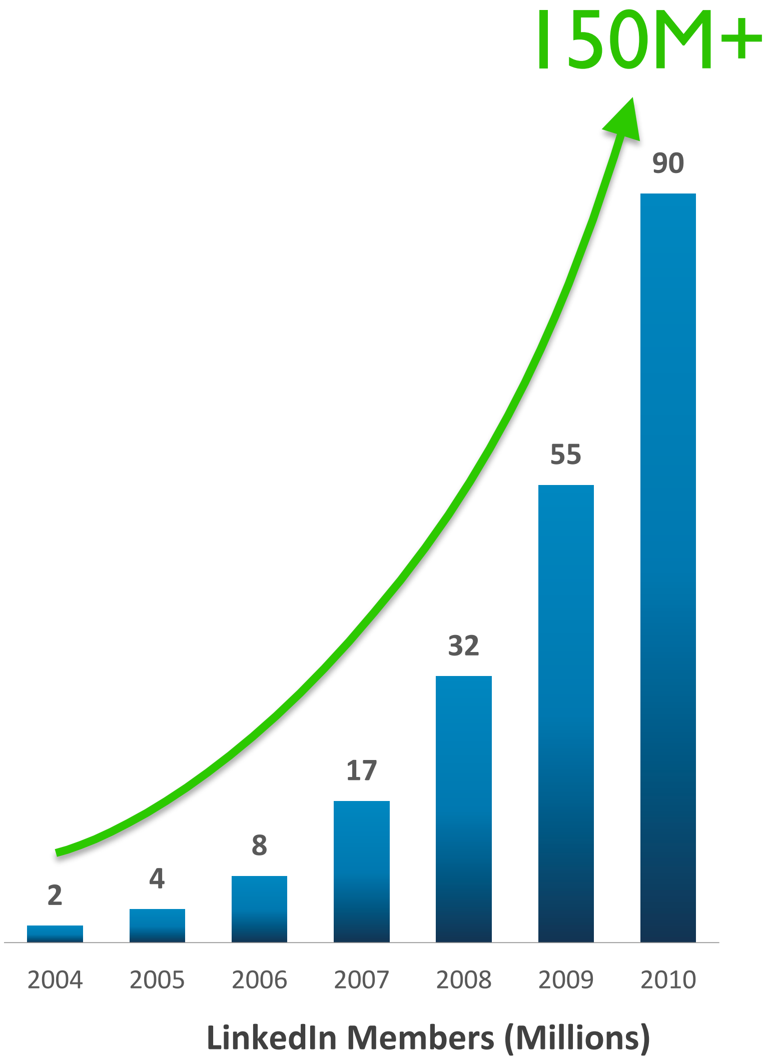

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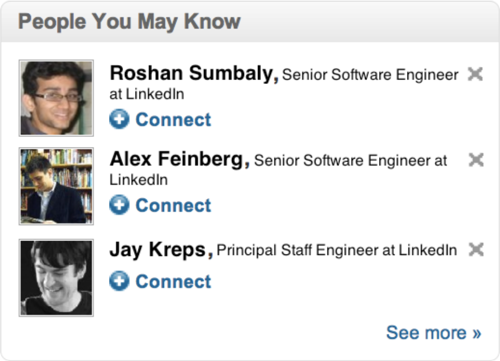

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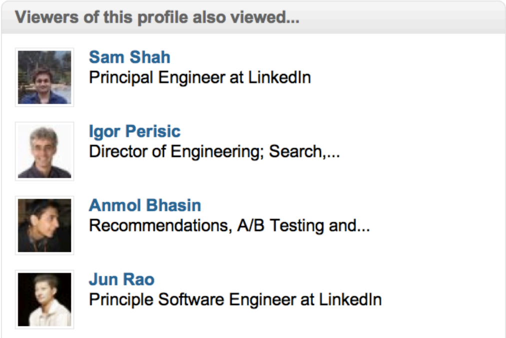

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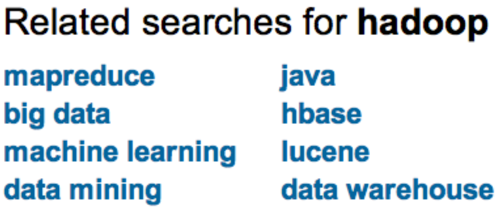

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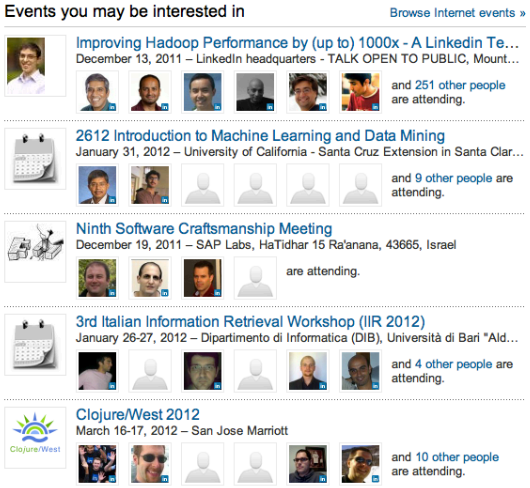

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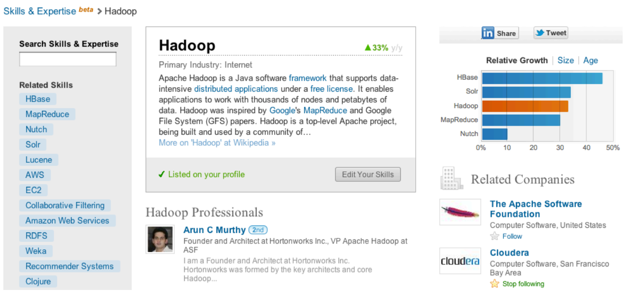

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Hadoop ▲33% y/y
Primary Industry: Internet
Apache Hadoop is a Java software framework that supports data-intensive distributed applications under a free license. It enables applications to work with thousands of nodes and petabytes of data. Hadoop was inspired by Google's MapReduce and Google File System (GFS) papers. Hadoop is a top-level Apache project, being built and used by a community of...
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I am a Founder and Architect at Hortonworks Inc. Hortonworks was formed by the key architects and core Hadoop...

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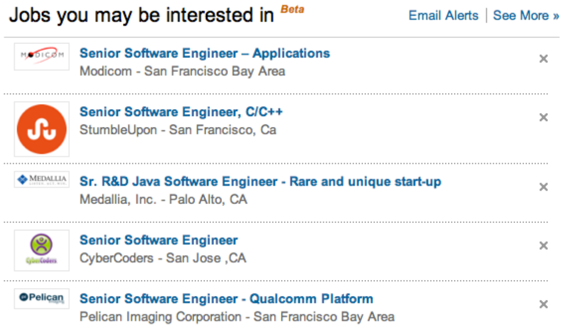

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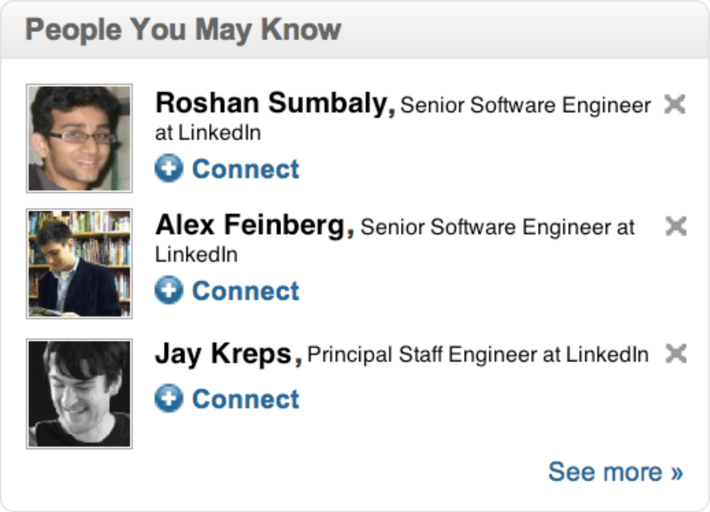

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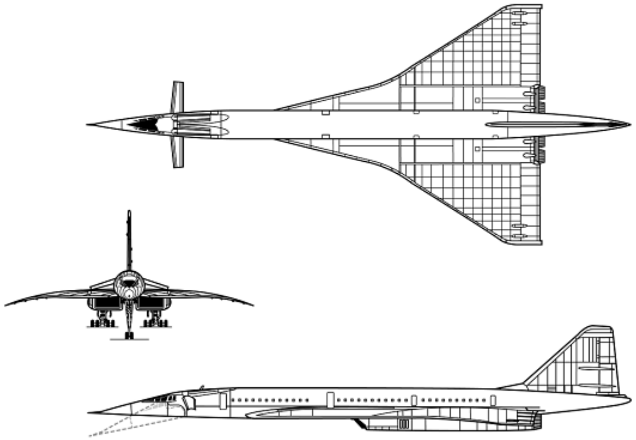
- Batch computed algorithms
  - MapReduce (Hadoop)
- Output
  - Large
  - Immutable
  - Key-value
  - Full refresh

Problem

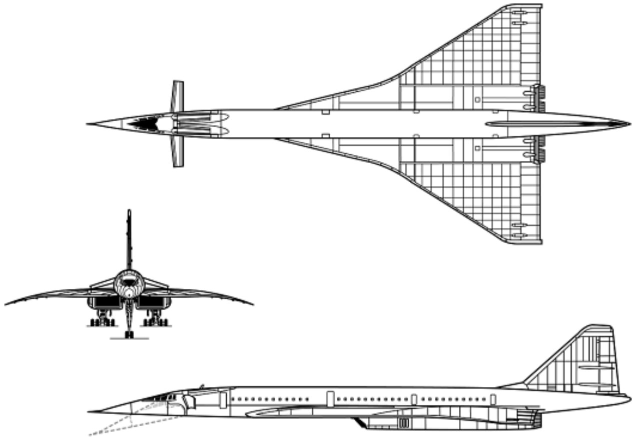
How do we serve these massive outputs to our 150 million members?

System features



- Fast, available and elastic
- Bulk load massive data-sets
- Minimum time in error
- Easy to use
- Open-source

System features



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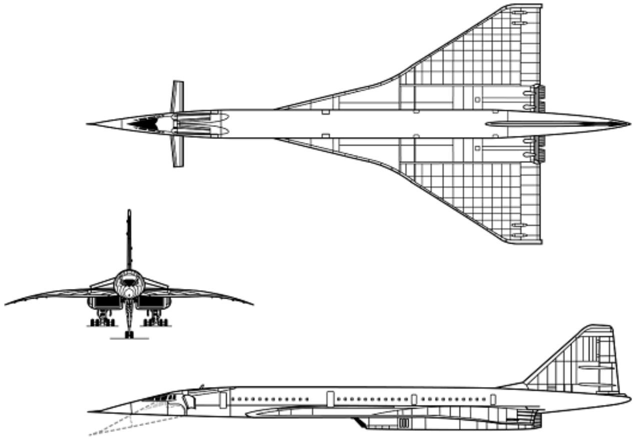
- Distributed key-value system

System features



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- Minimum time in error
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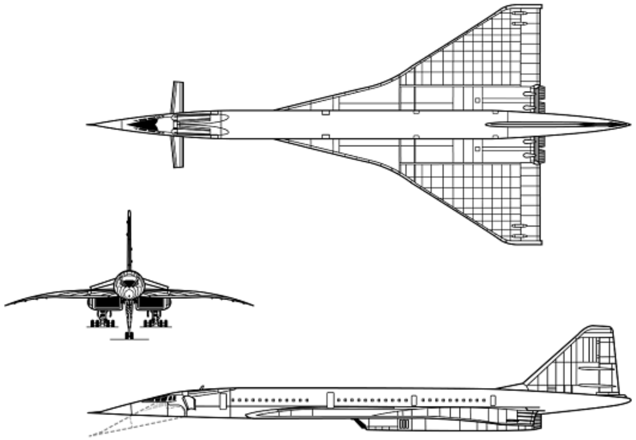
- Minimum performance impact during bulk loads
- Offload index construction to processing system

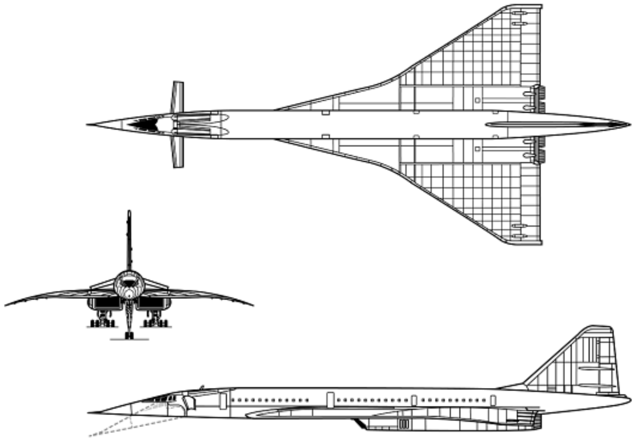
System features



- Fast, available and elastic
- Bulk load massive data-sets
- Minimum time in error
- Easy to use
- Open-source

- Error in algorithm → Bulk load bad data → Bad state till next push
- Quick rollback capability

System features



- Fast, available and elastic
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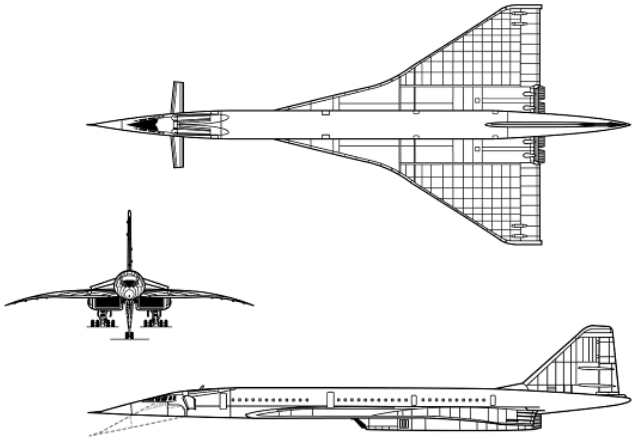
- Minimum time in error
- **Easy to use**
- Open-source

```
job.class=com.linkedin.jobs.BuildAndPushJob

build.input.path=/algorithm/output
push.store.name=people-you-may-know
push.cluster=tcp://testing-cluster-url:6666
build.replication.factor=1
```

System features



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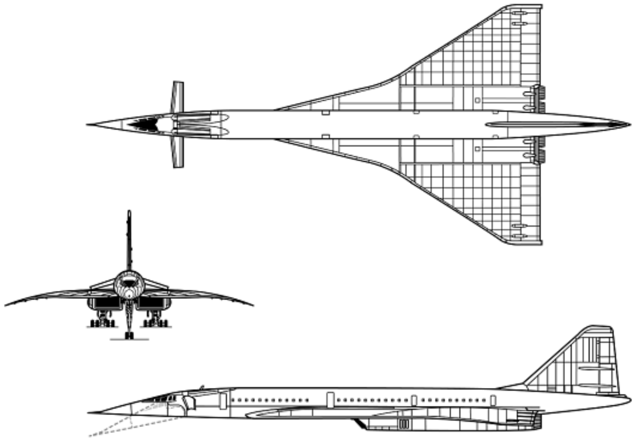
push.store.name=people-you-may-know
push.cluster=tcp://production-cluster-url:6666
build.replication.factor=2
```

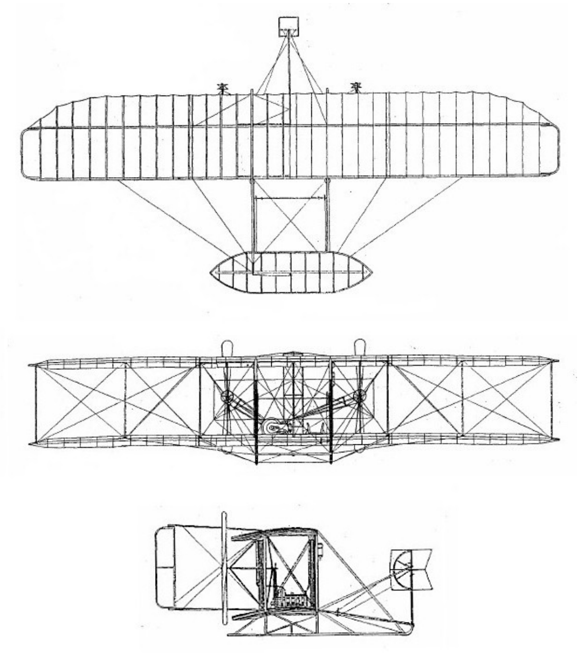
System features



- Fast, available and elastic
- Bulk load massive data-sets
- Minimum time in error
- Easy to use
- Open-source

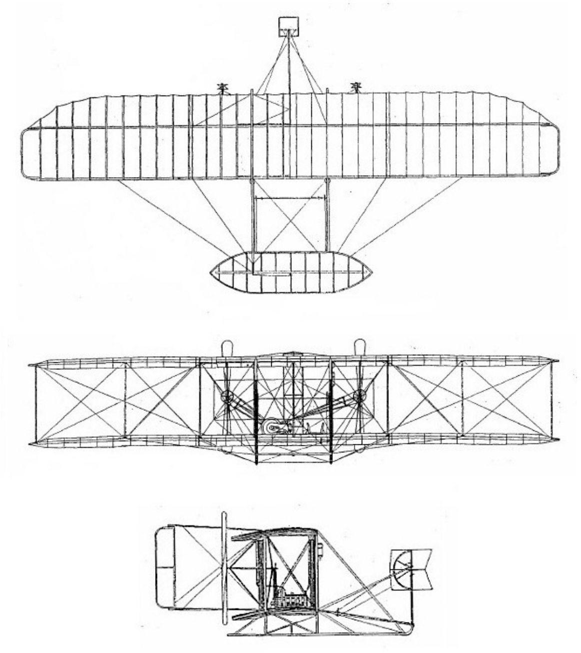
- Apache License v2.0
- Project Voldemort – http://project-voldemort.com

Roadmap



- Background – Voldemort architecture
- Custom Voldemort storage engine
    - Minimal impact on live system
    - Fast rollback
    - Fast lookups
    - Easy rebalancing
- Performance

Roadmap



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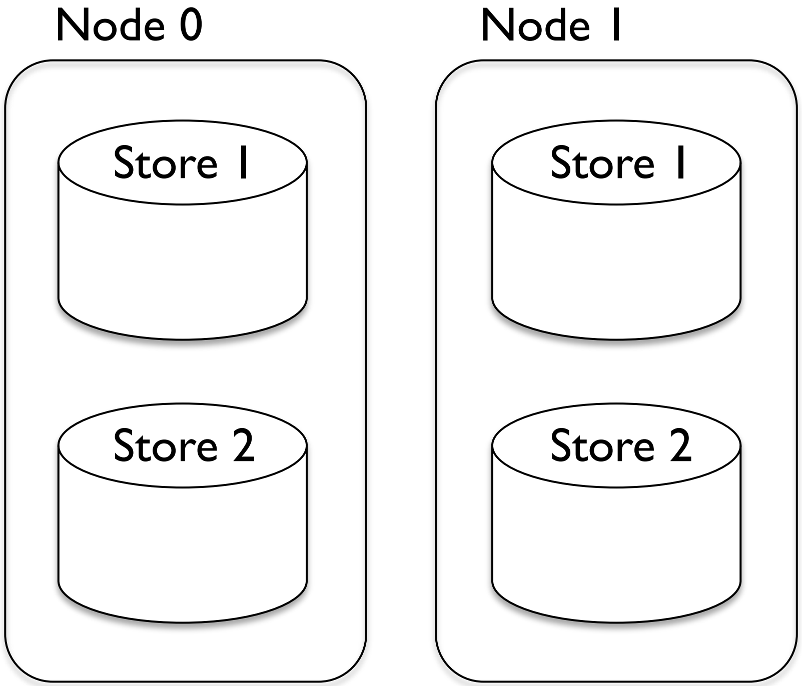
Project Voldemort

- Amazon’s Dynamo clone
    - Distributed key-value store
- Pluggable architecture
- Initially written for read-write storage engines
    - MySQL, BDB

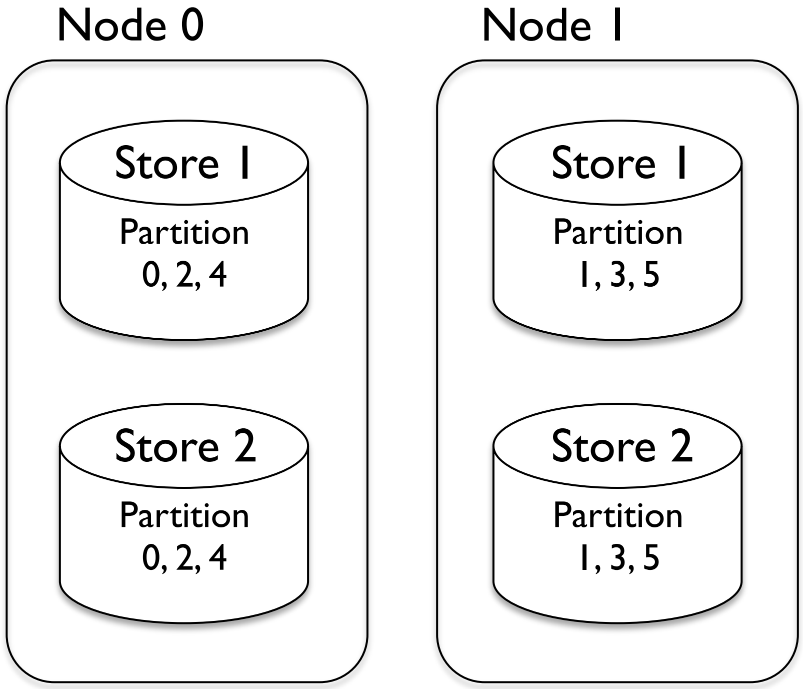
Project Voldemort

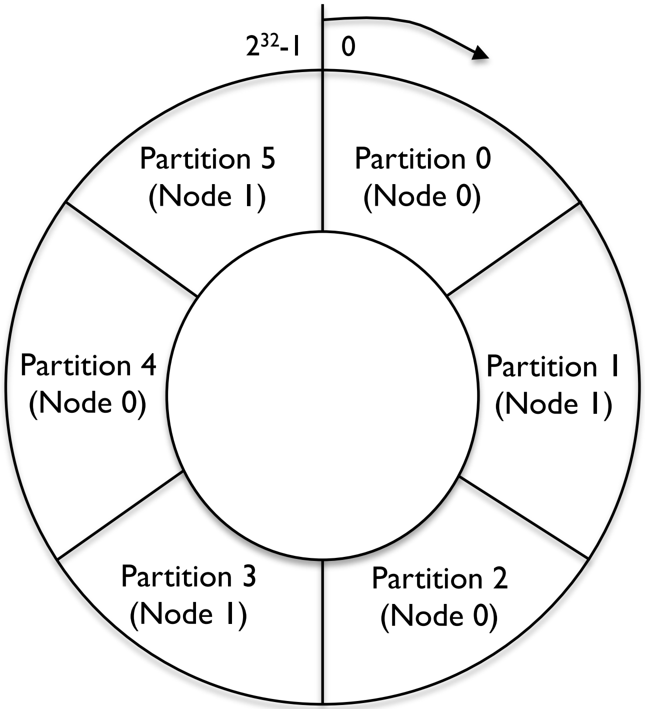


- Multiple peers
- Multiple stores (~ tables)
- Different replication factor per store

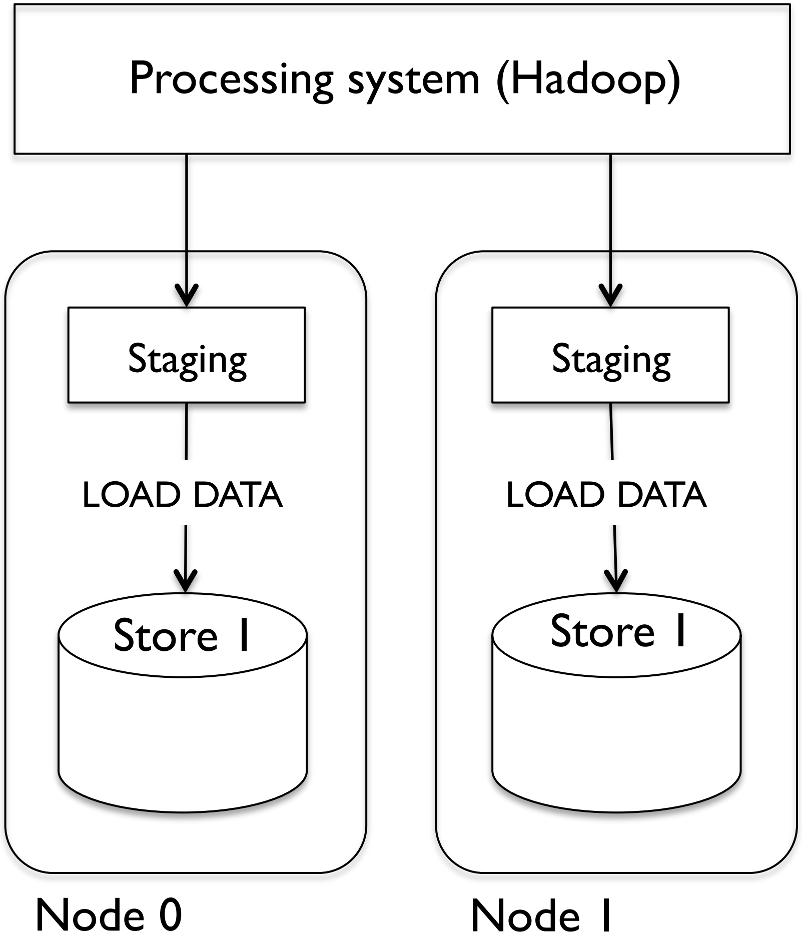
Project Voldemort

- Hash ring per store
- Ring split into partitions



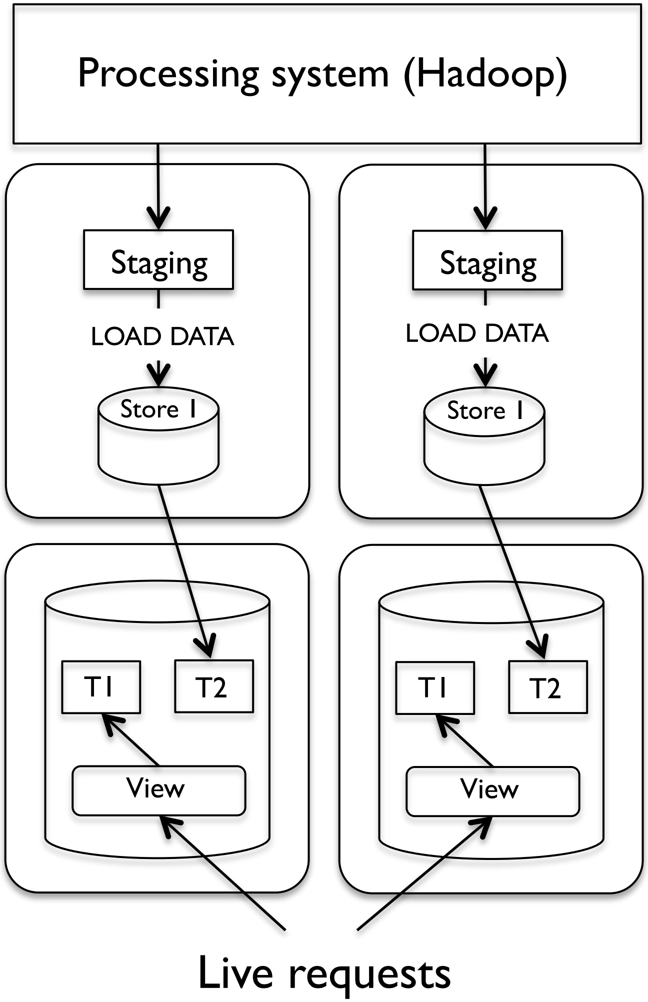


Existing approaches – Bulk load solution 1



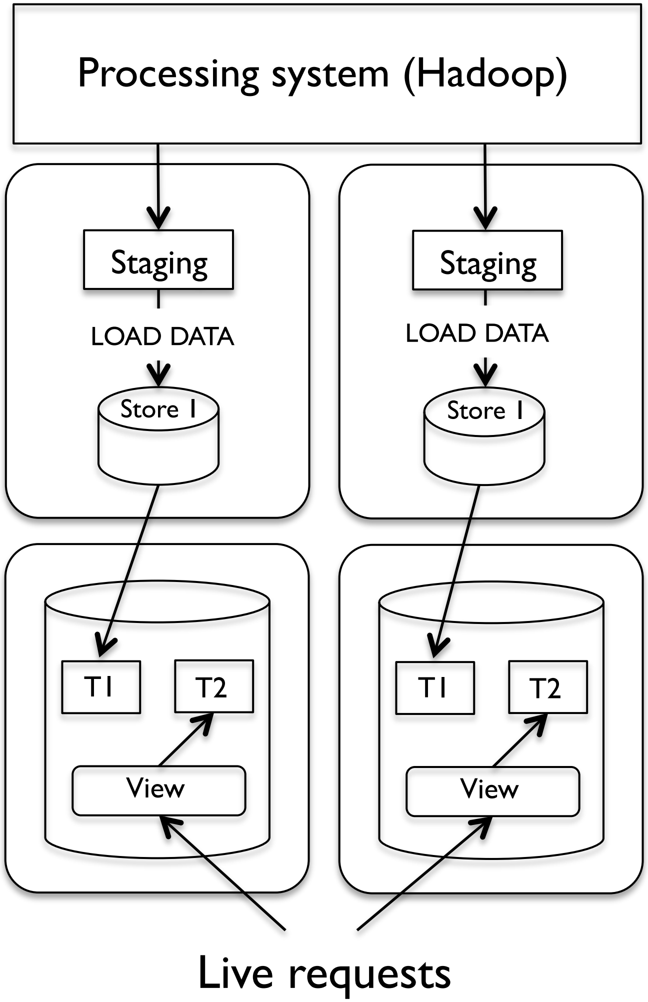
- Latency degradation during load

Existing approaches – Bulk load solution 2



- Maintaining extra cluster

Existing approaches – Bulk load solution 2



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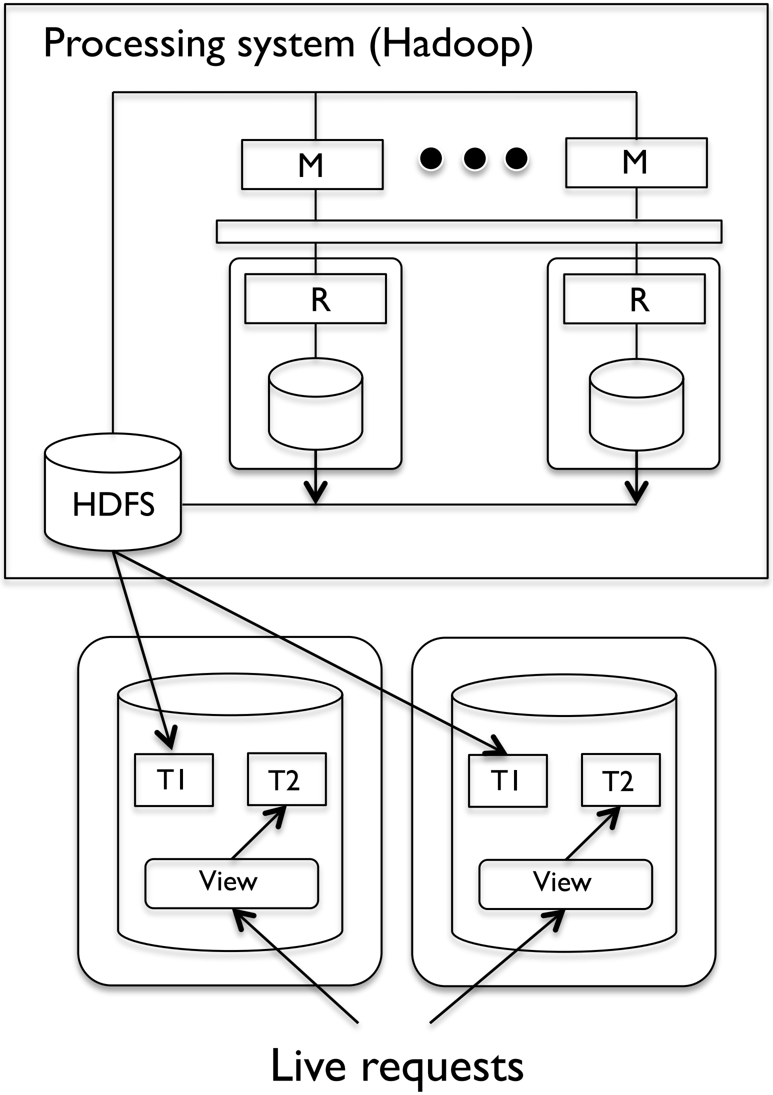
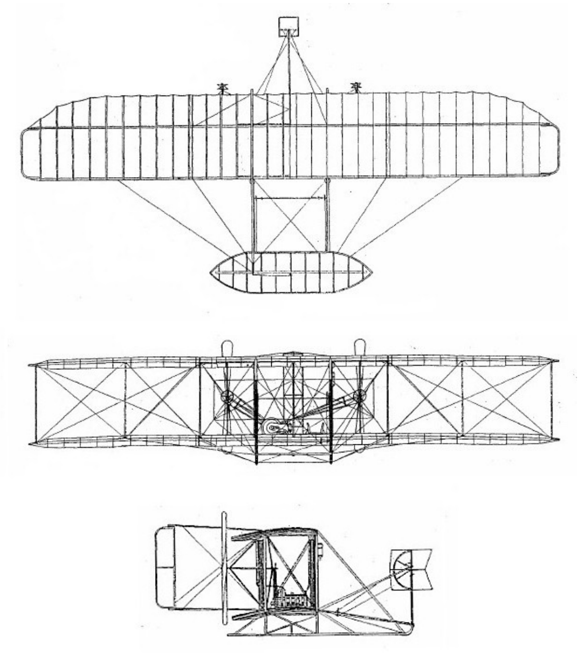
Existing approaches – Bulk load solution 3



- Multiple copy operations

Roadmap



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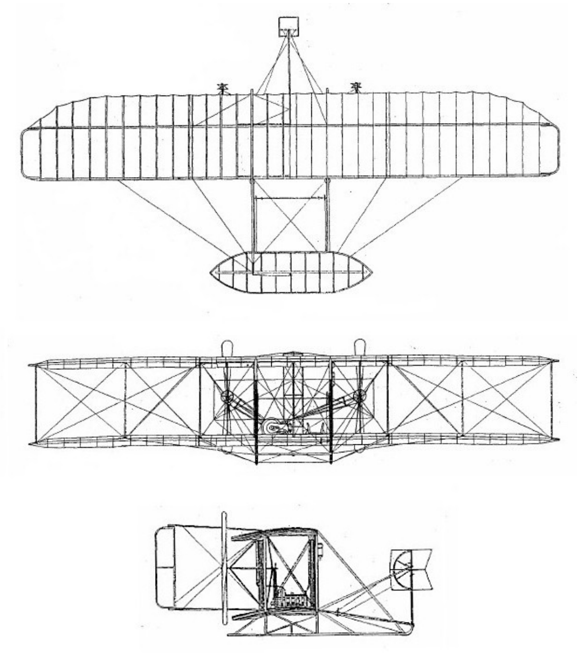

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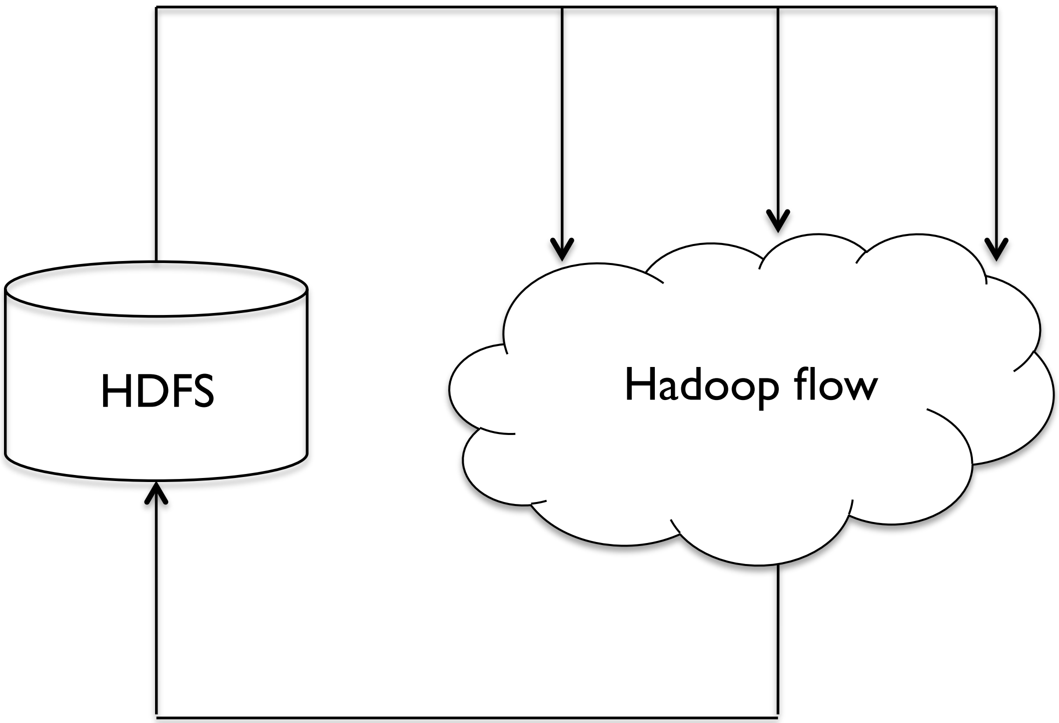
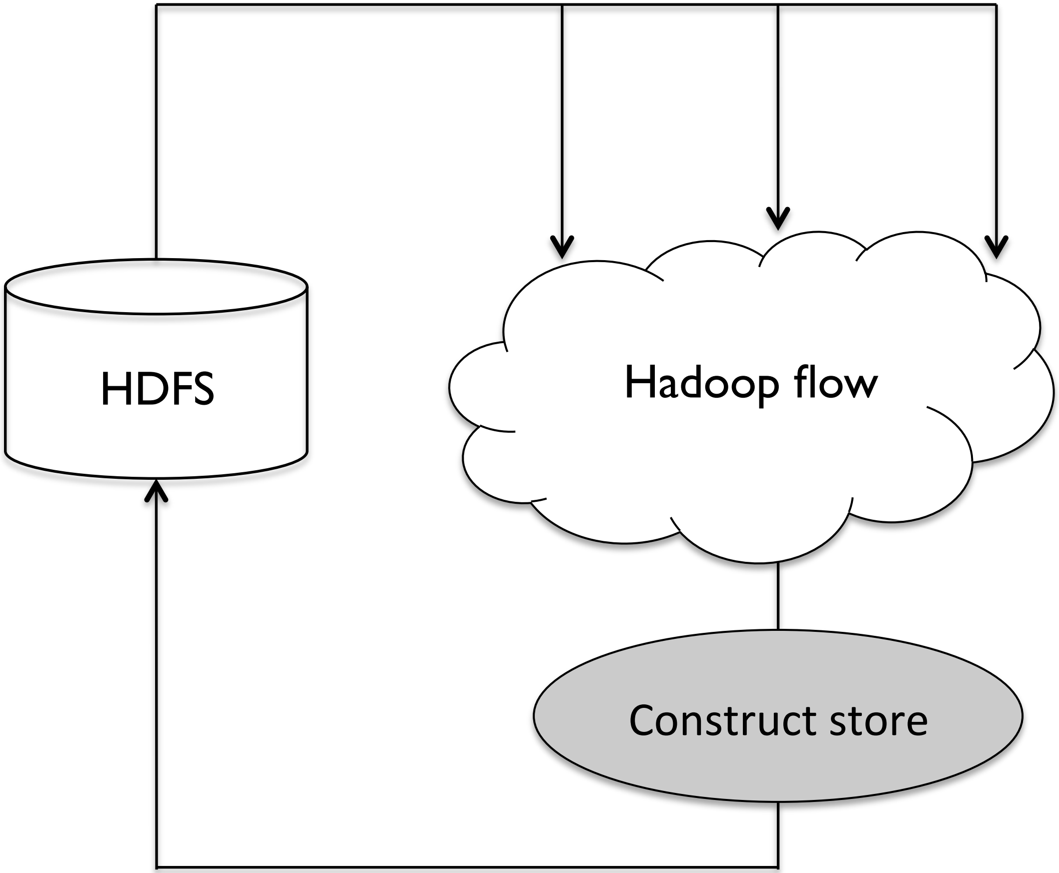
Bulk load extensions – Minimal impact on live system



Bulk load extensions – Minimal impact on live system

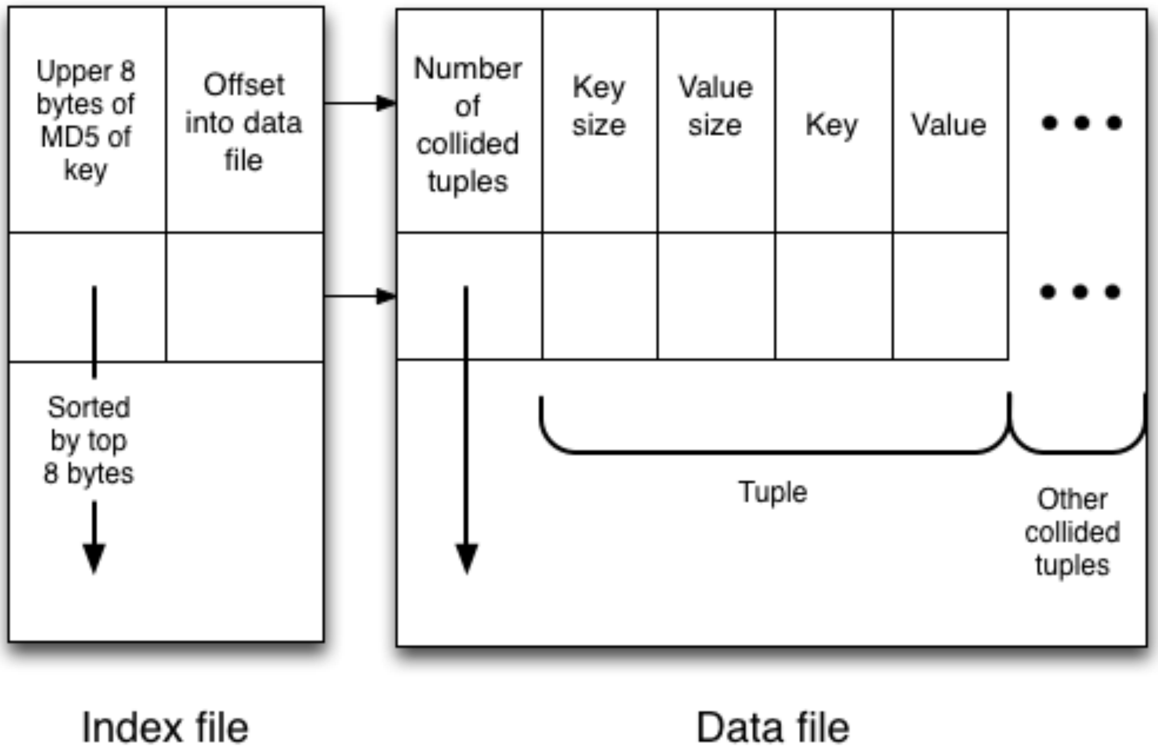


Bulk load extensions – Minimal impact on live system

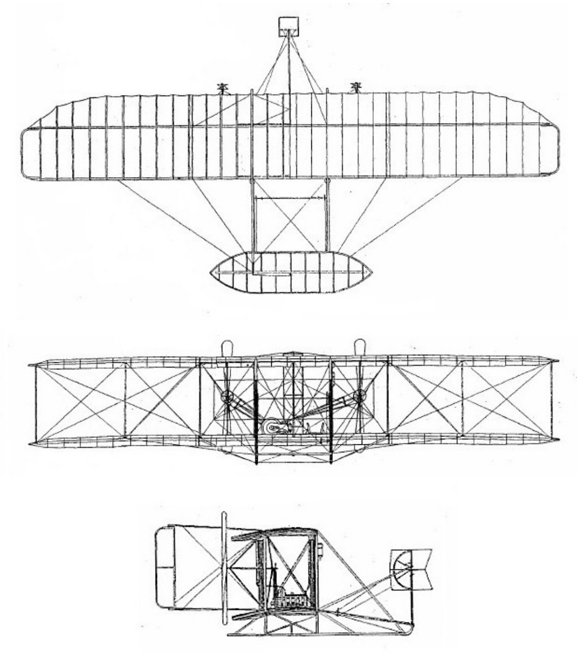
- “Construct Store” step
  - Single MapReduce job
  - Map
    - Input - Output of algorithm
    - Output – Emit replication factor number of times
  - Partitioner
    - Redirect to appropriate reducer
  - Reducer
    - Output to Voldemort node based folders

Bulk load extensions – Minimal impact on live system

- What is output in the reducer phase?
  - Store $\xrightarrow{\text{split into}}$ Partitions $\xrightarrow{\text{split into}}$ Chunk sets
  - One reducer = one chunk set
  - Chunk set = Index + data file



Roadmap



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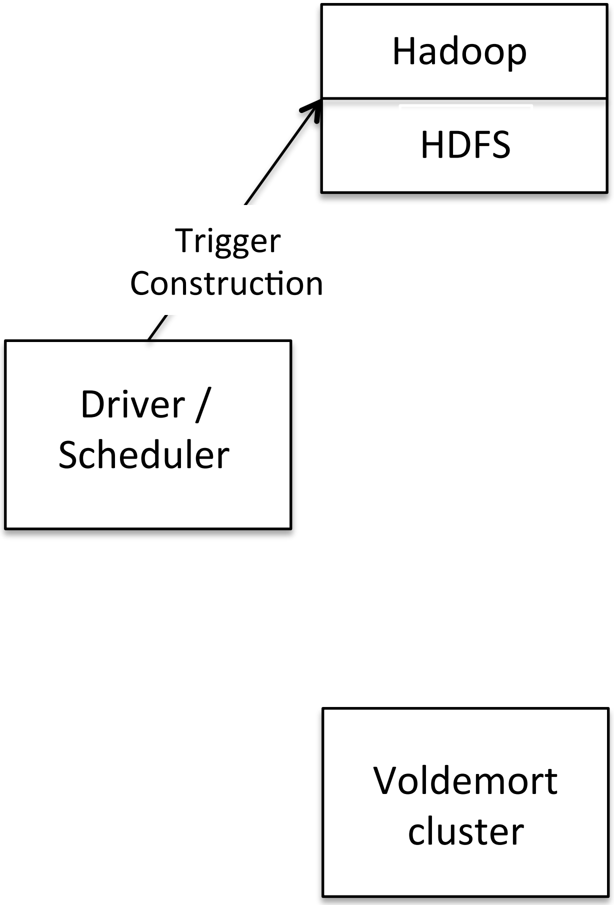
Bulk load extensions – Full pipeline

- Construction
  - MapReduce job
- Fetch
  - Pull chunk sets in parallel
  - Store into new version folder
- Swap
  - Close latest version's index files
  - Change latest version link
  - Memory map new version's index files
- Rollback
  - Close latest version's index file
  - Change latest version link
  - Memory map old version's index file



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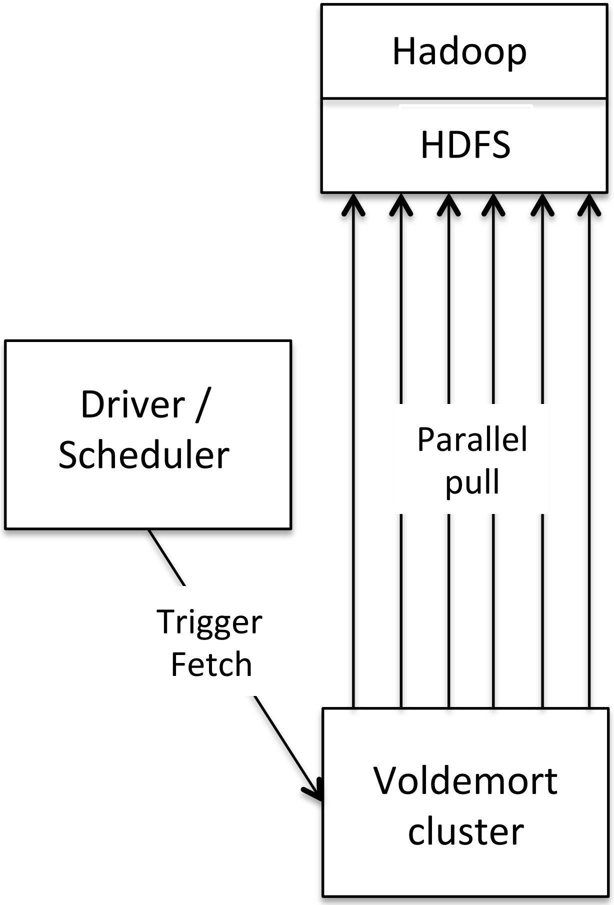
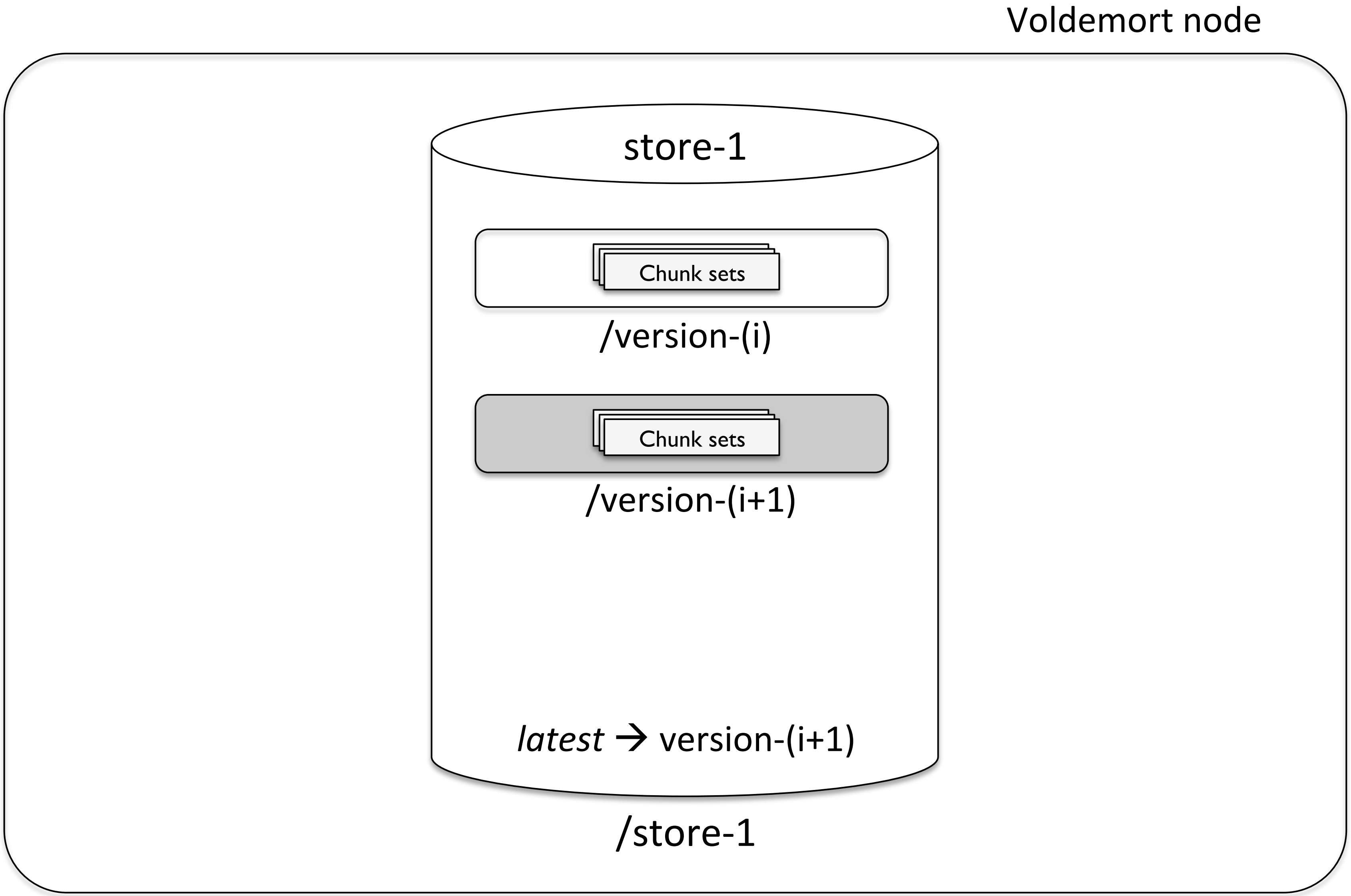


Bulk load extensions - Rollback



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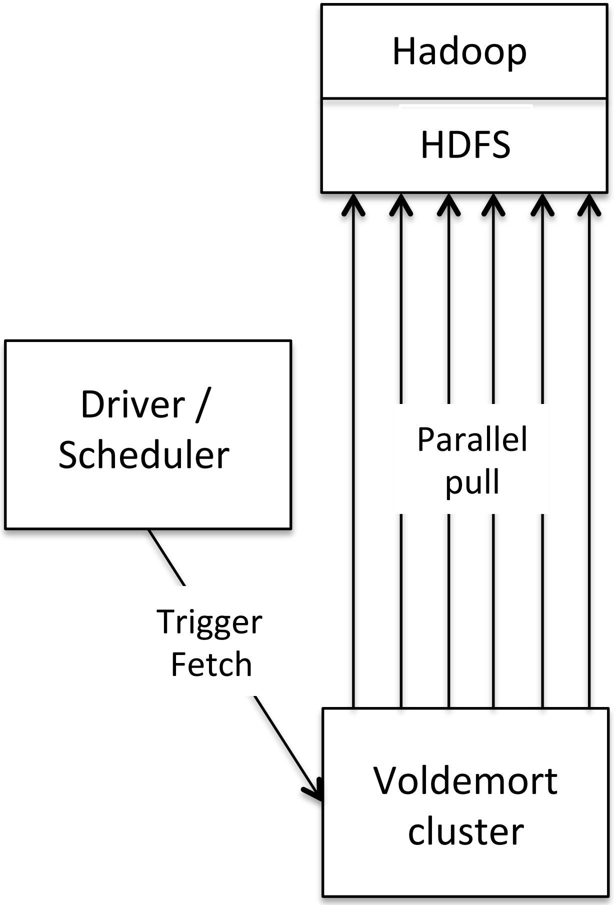

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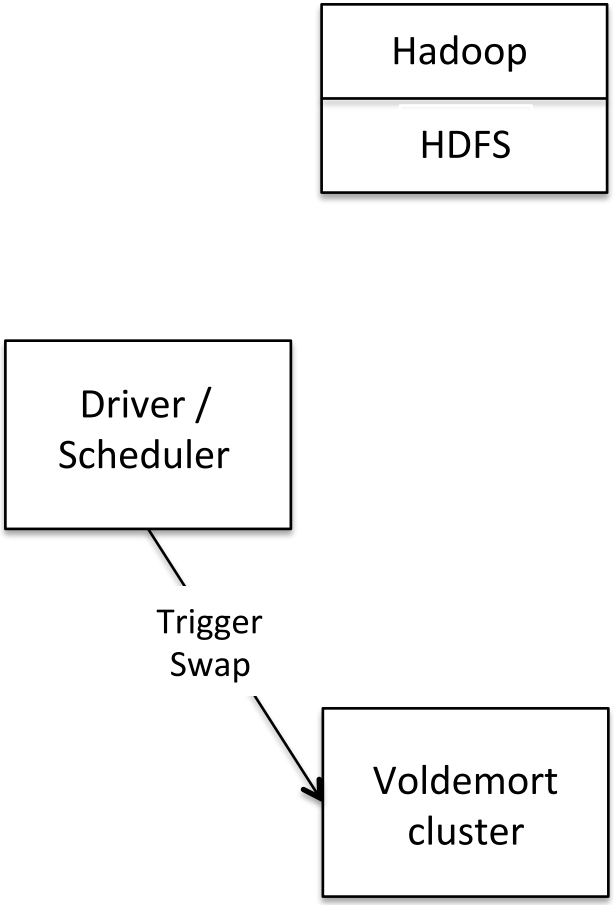

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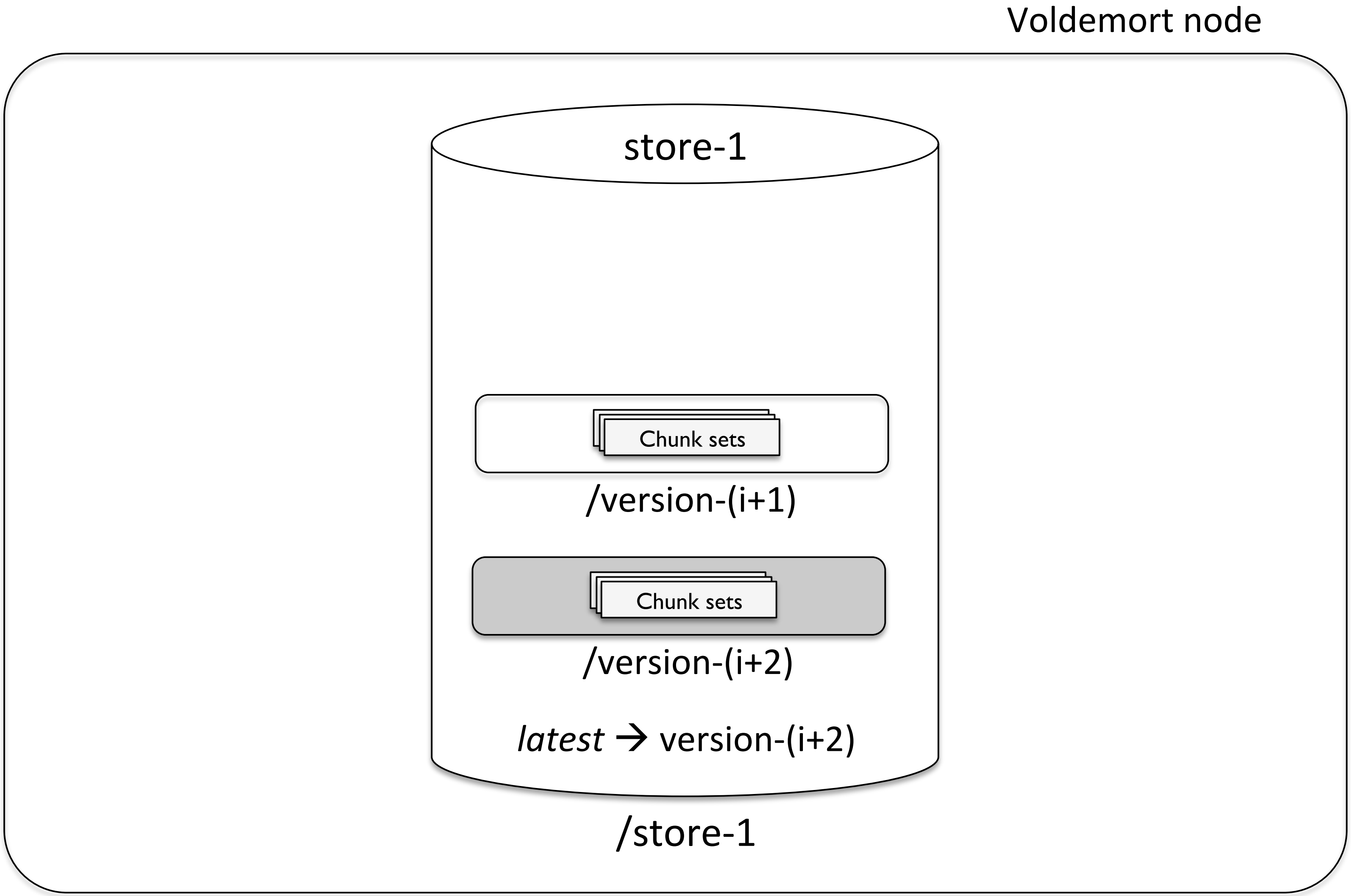

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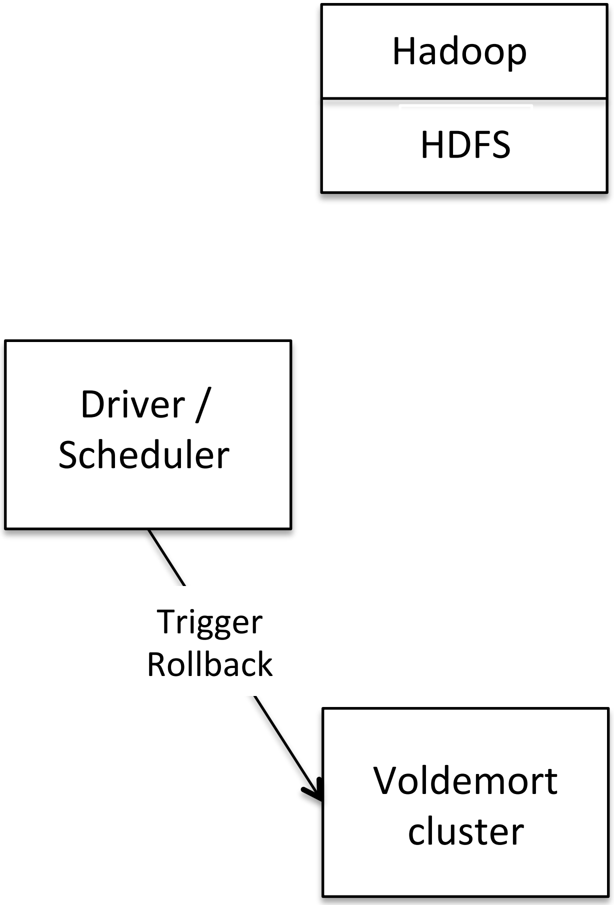
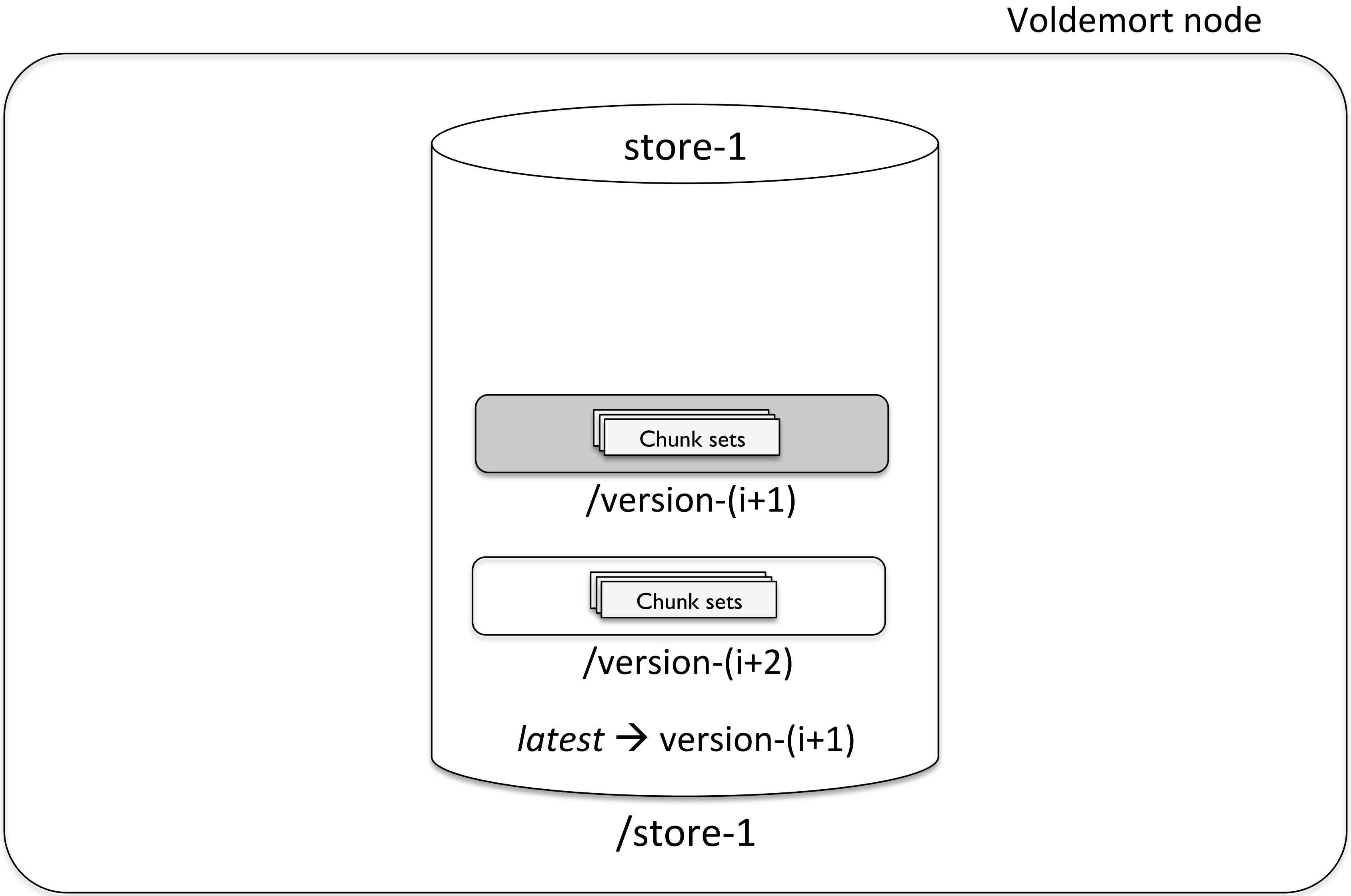
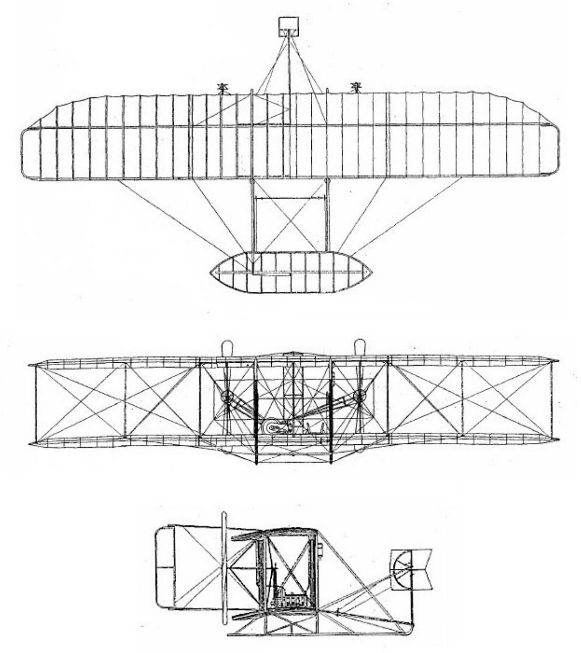


Bulk load extensions - Rollback



Roadmap



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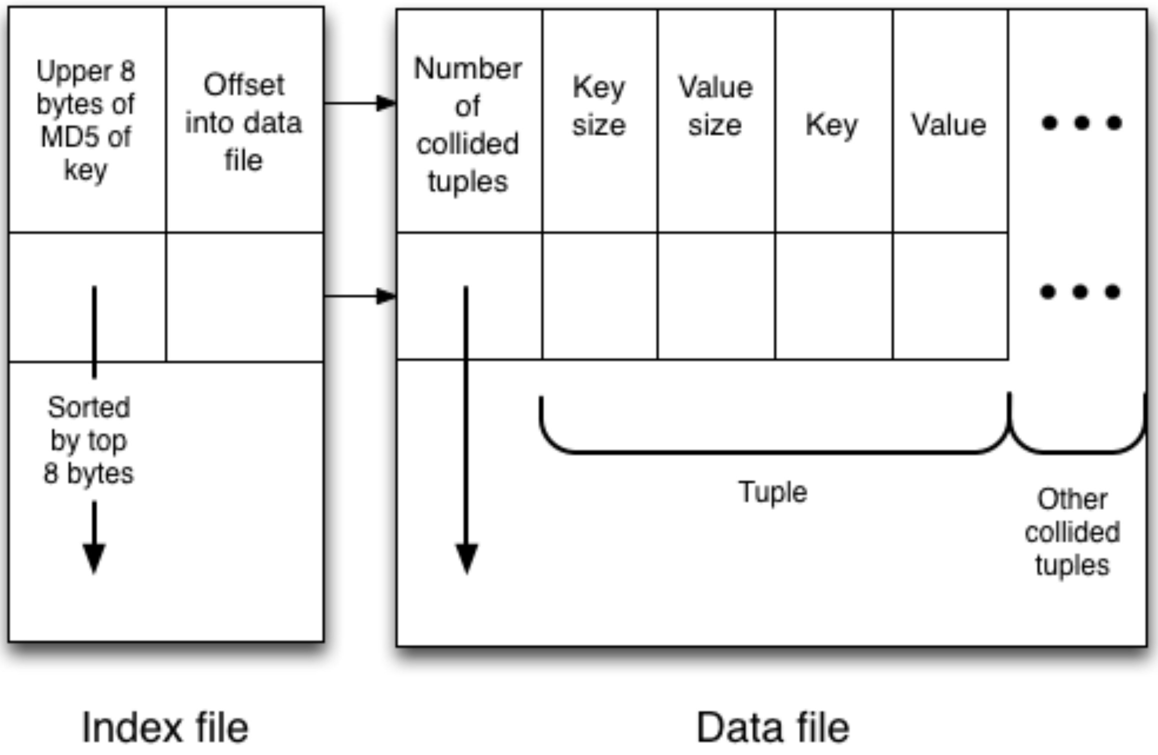
- Performance

Bulk load extensions – Lookup

- Find partition and chunk set to read
- Binary search in index file of chunk set
- Jump to offset in data file
- Go through all collided tuples



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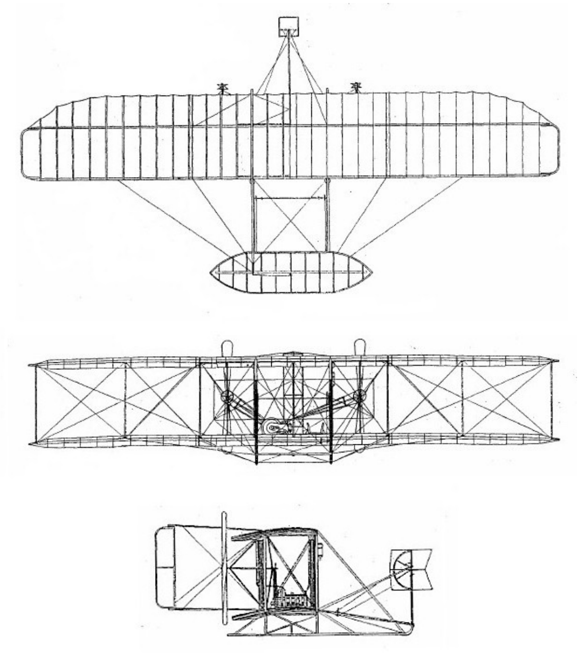

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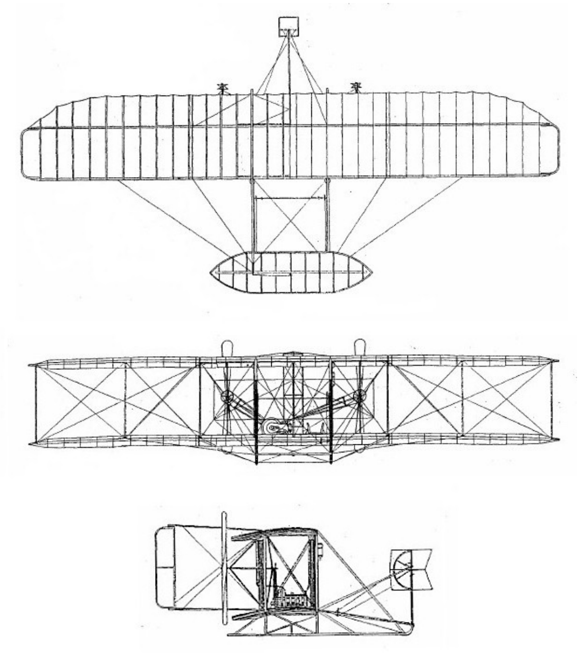
Bulk load extensions – Rebalancing

- Adding new nodes with no downtime
- Change ownership of partitions to new nodes
    - Simple move of corresponding chunk sets + swap

Roadmap



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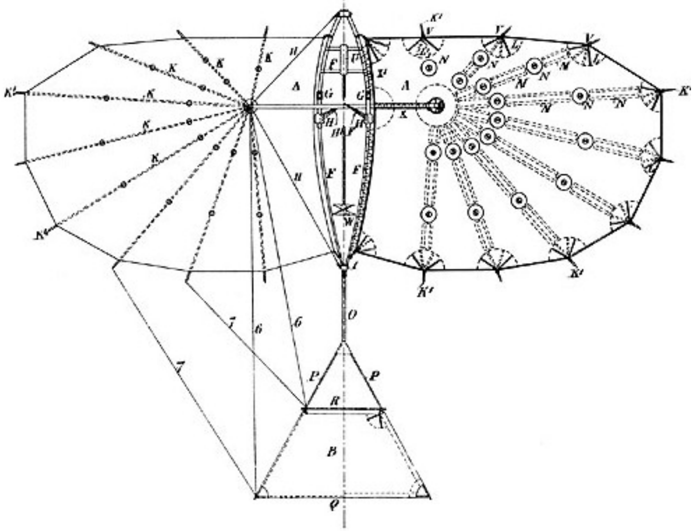
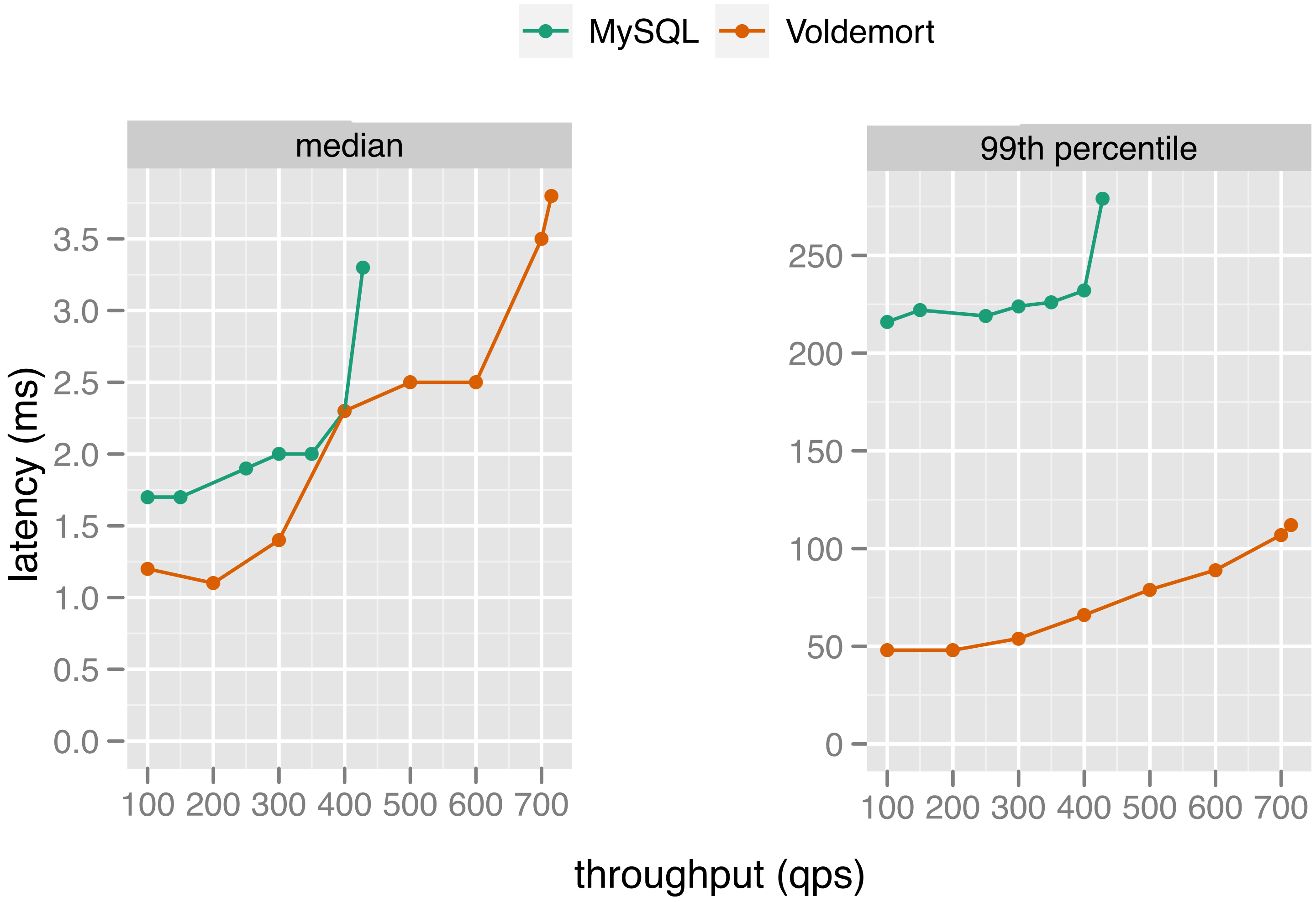
Performance

Fig. 4.



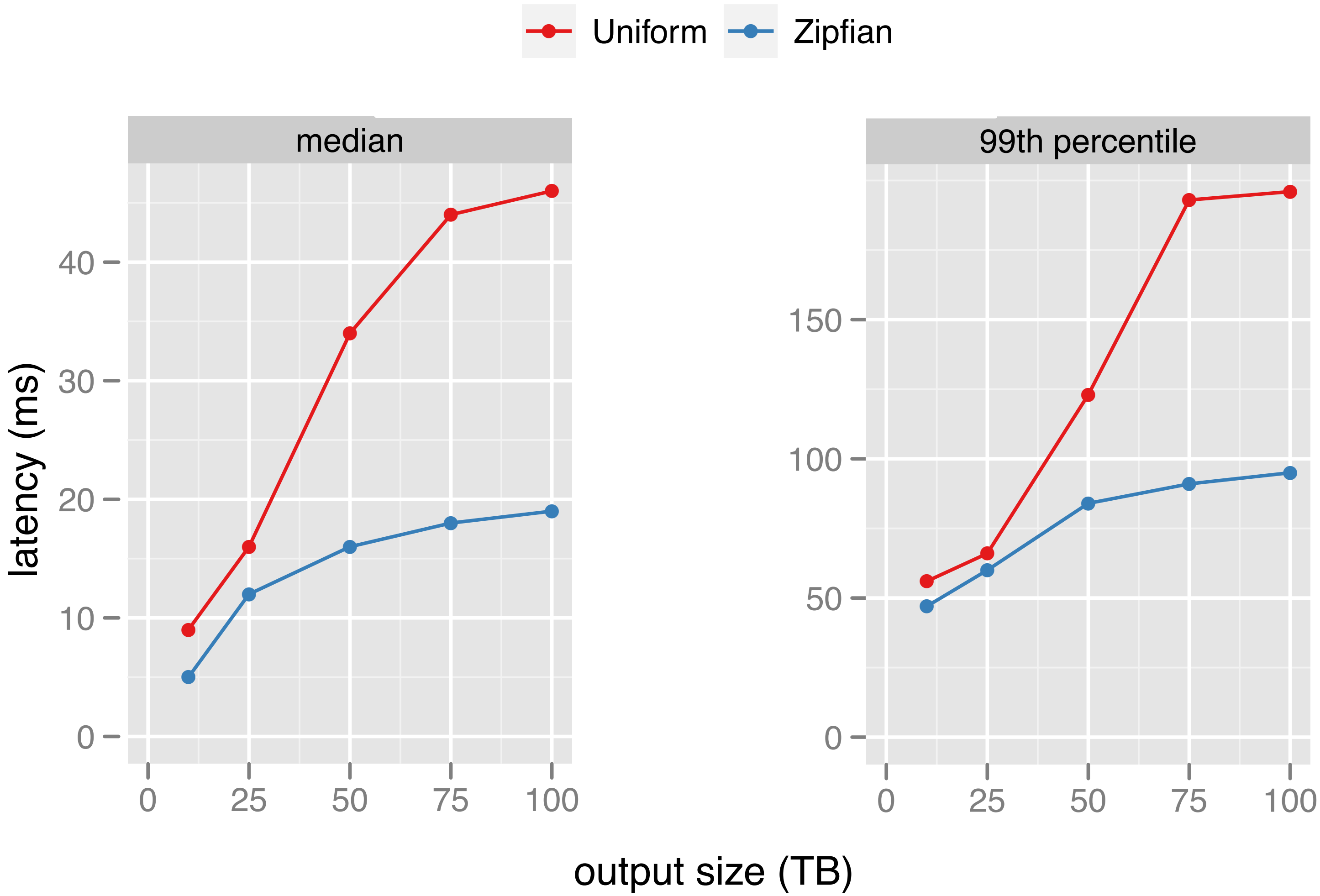
- Single node latency
- Multi-node latency
- Production

Performance – Single node latency



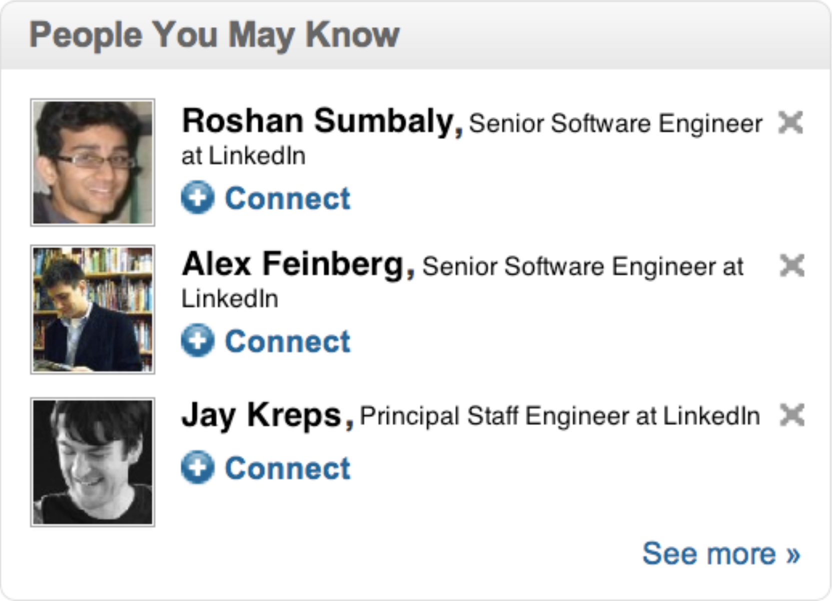
100 GB data, 24 GB RAM

Performance – Multi-node latency



32 nodes client side latency

Performance – Production



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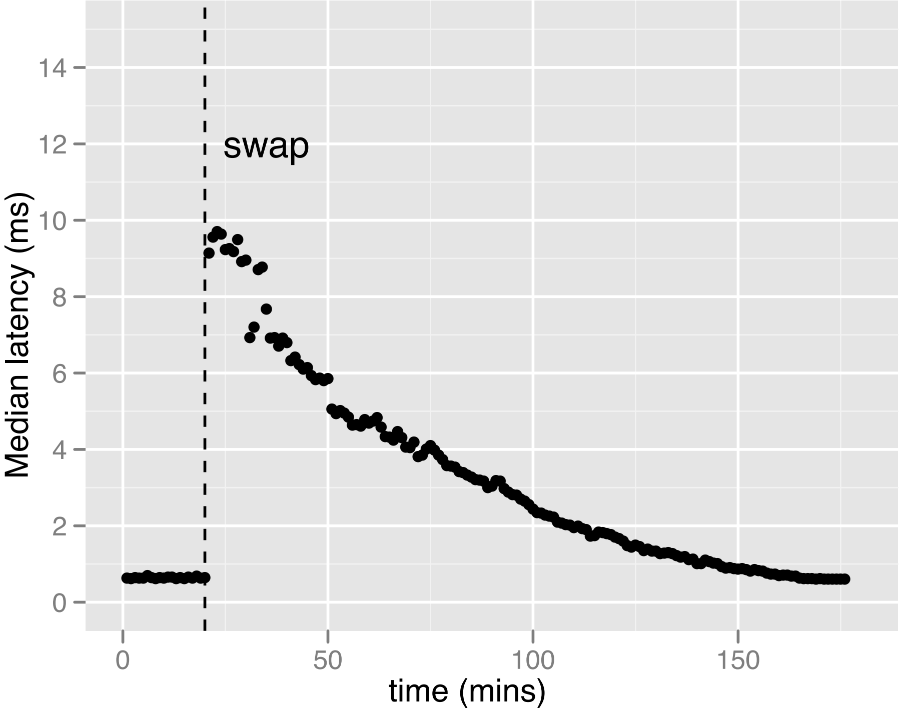

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Related Work

- Shared nothing databases
  - Yahoo’s PNUTS [Silberstein08]
    - Bulk load into range partitioned tables
    - Requires some compaction on serving system
  - HBase [Konstantinou11], Cassandra [Lebresne11]
    - Offline tablet construction
    - Expensive rollback
- Search systems
  - Build index offline and pull
    - MapReduce[Dean04] use-case

Conclusion

- LinkedIn
  - Serving ~120 stores in production for past 2 years
  - Fetching ~ 4 TB of data every day
  - 76 stores swapped every day
- Open-source
  - http://project-voldemort.com

Bibliography

Images

- Slide 6 - www.aviastar.org/air/inter/inter_concorde.php
- Slide 15 - www.wright-brothers.org/Information_Desk/Just_the_Facts/Airplanes/Flyer_II.htm
- Slide 17 - www.youtube.com/watch?v=oz-7wJJ9HZ0
- Slide 48 - www.wright-brothers.org/History_Wing/History_of_the_Airplane/Century_Before/Road_to_Kitty_Hawk/Road_to_Kitty_Hawk.htm

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