Hypertable Goes Realtime at Baidu

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Agenda

- Motivation
- Related Work
- Model Design
- Evaluation
- Conclusion

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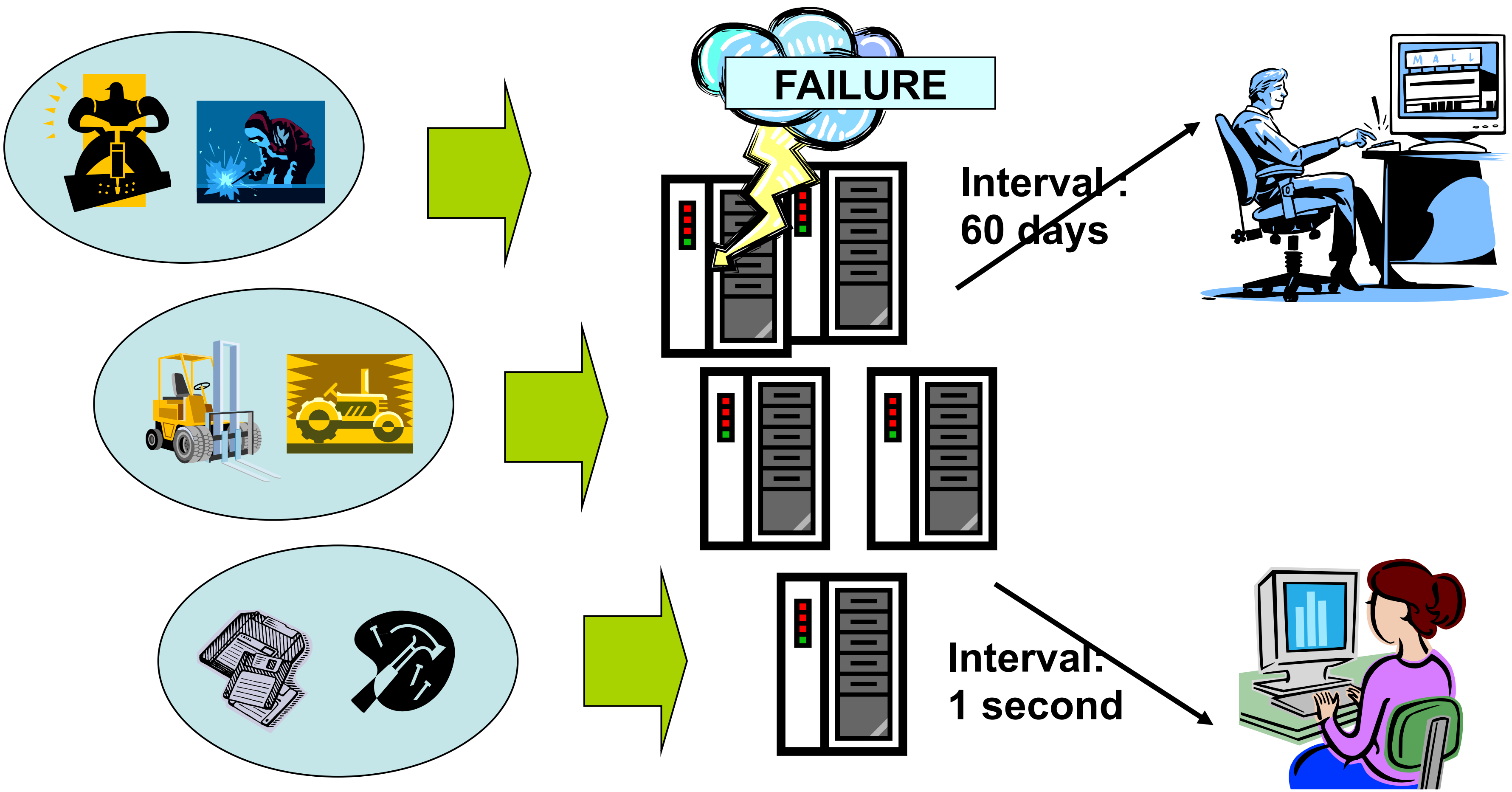
Motivation



What is Noah

- Noah System
  - Operational Data Store
    - System metrics (CPU, Memory, IO, Network)
    - Application metrics (Web, DB, Caches)
    - Baidu metrics (Usage, Revenue)
      - Easily visualize data over time
      - Supports complex aggregation, transformations, etc.
  - Component
    - **Monitoring sub-system**
    - Collection sub-system
    - ... ...

System Requirement

- Storage Capacity
  - 10TB~100TB
  - 100~1000 billion Records
- Automatic Sharding
  - Irregular data growth patterns
- Heavy Writes
  - 10000~30000 inserts/s
- Fast Reads of Recent Data
  - Recently written data should be available quickly
- Table Scans
  - e.g. The entire dataset will also be periodically scanned in order to perform time-based rollups

Problems of Existing Stack

- MySQL
  - Not inherently distributed
    - Difficult to scale
      - Irregular data growth patterns
      - Manually re-sharding data frequently
  - Table size limitation
  - Inflexible schema
- Hadoop
  - No support for random writes
  - Poor support for random reads

Hypertable Meets the Requirements

- Hypertable + Hadoop
  - Elasticity
  - High write throughput
  - High Availability and Disaster Recovery
  - Fault Isolation
  - Range Scans

Typical Applications of Hypertable

- Common Library
  - AsyncComm/Compression/HQL … in Hypertable
- Database (Query Engine)
  - Hypertable
- MapReduce (Batch Processing)
  - MapReduce + Hypertable
- OLAP (Online Analytical Processing)
  - MySQL + Hypertable

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Related Work

- **Apache Hadoop Goes Realtime at Facebook**
  - *Titan* (Facebook Messages)
  - *Puma* (Facebook Insights)
  - *ODS* (Facebook Internal Metrics)

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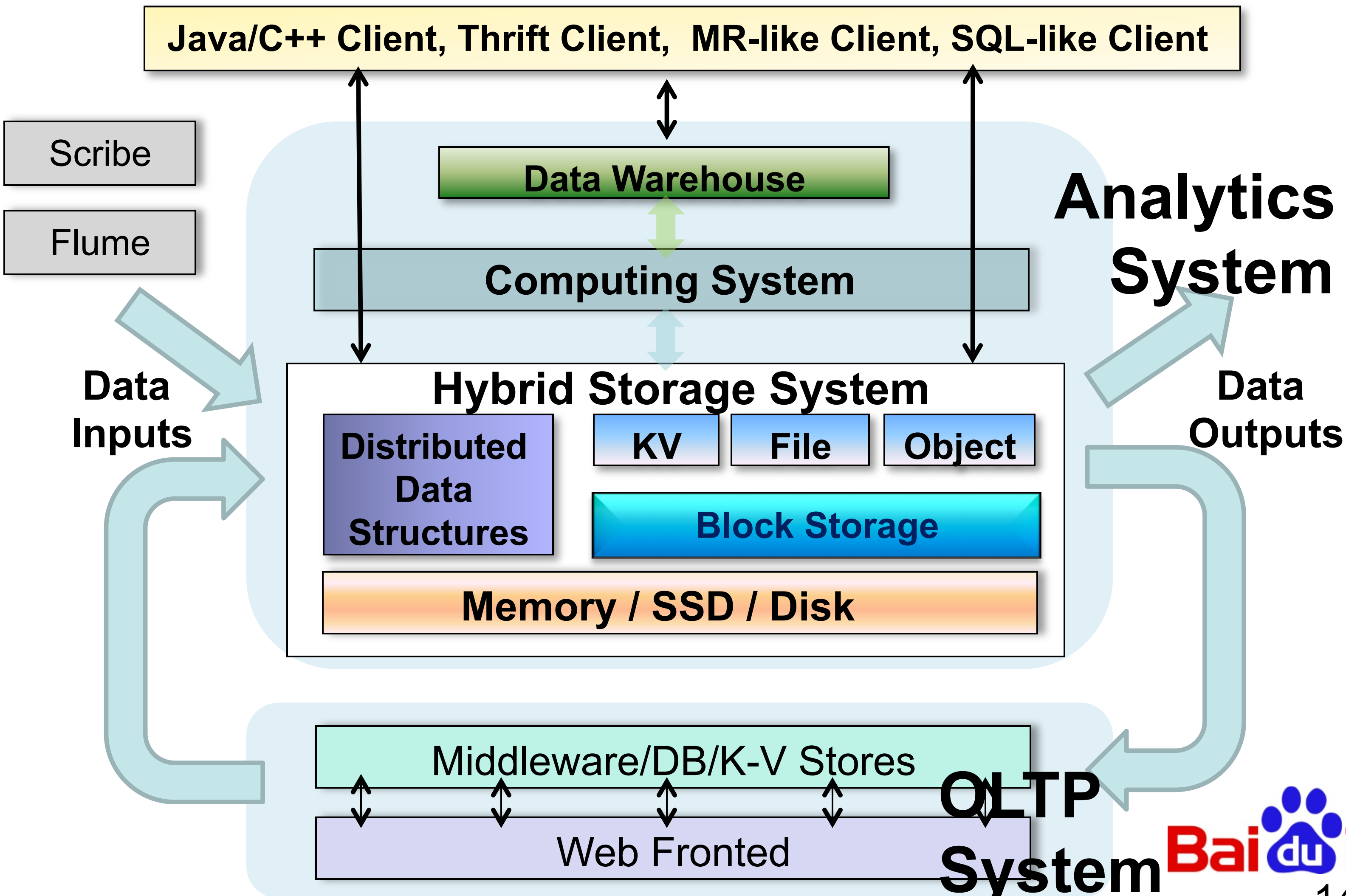
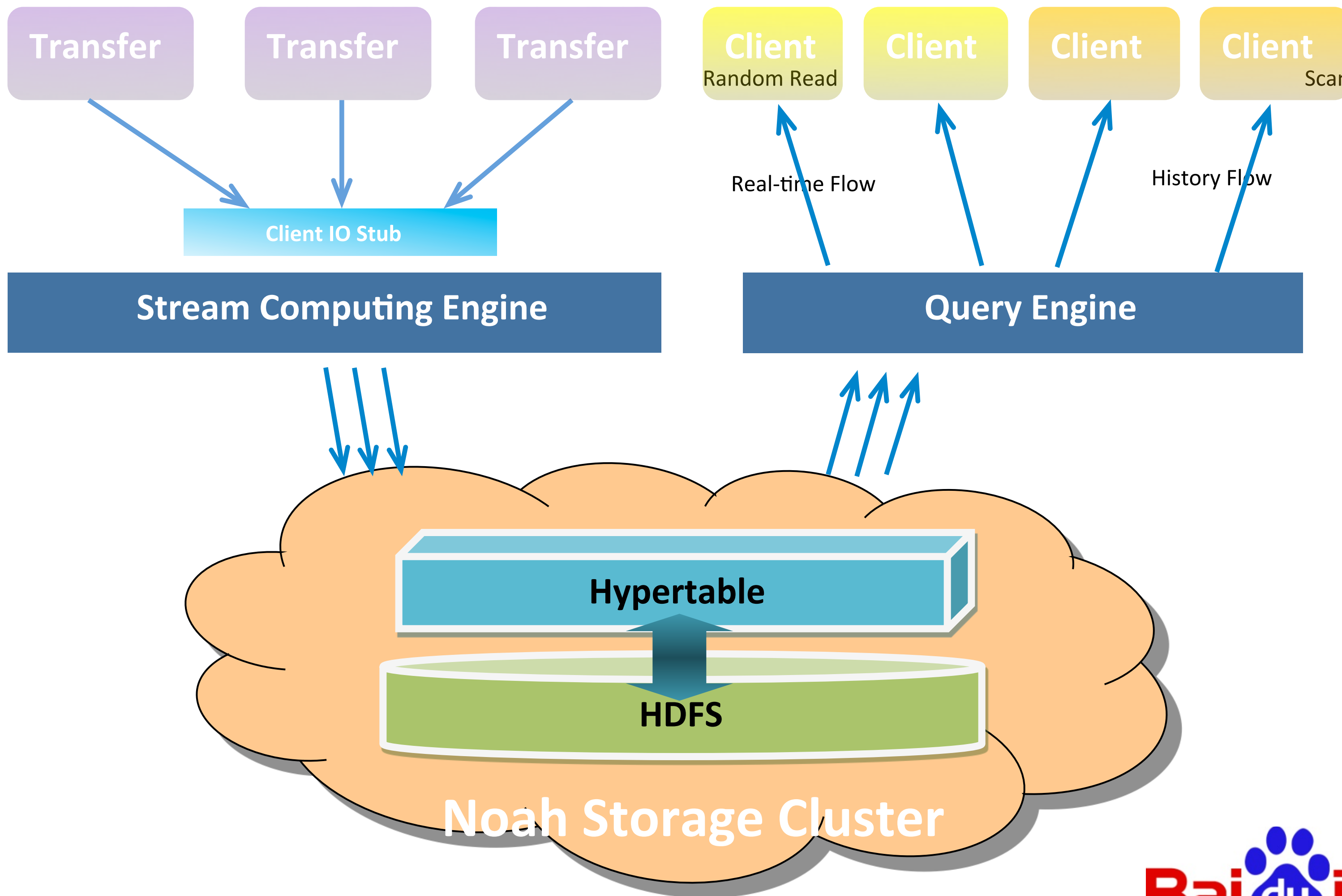
Model Design

- Storage System Architecture
- Functional Model
- Processing Model
- Data Model

Storage System Architecture



Functional Model



Processing Model

- Query Interface

  InfoQuery <table> <rowkey_range_start> <rowkey_range_end> <column_family> <to_file> <human|machine> [max_lines]

  - table: table name
  - rowkey_range_start & end: row key string range
  - column_family: monitor_data_status is ”value”, other tables are “value_pack”
  - to_file: file by result written into
  - human|machine: text or binary
  - max_lines: default < 2w

Processing Model

- Query Mode
  - Normal Query
    - Hostname + MonitorItemIDs + Interval -> Results Graph
    - Hostnames + MonitorItemIDs -> Sorted Latest Results
    - Hostnames -> Status Results
  - Special Query
    - Many Hosts + MonitorItemIDs + Interval: Multiple queries
    - Long Interval: default <= 2w Recods
    - Low Latency: No guarantee
    - Batch queries continuously: Influence to system

Data Model

- Tradeoff
  - Query efficiency
  - Record volume

Tables	Row Key	Column	Version	TTL
History Tables	Hostname + Timestamp	MonitorItem +MonitorItem*	1	0.5 ~ 24 months
Latest Table	Hostname + MonitorItemID	MonitorItem +MonitorItem*	1	
Status Table	Hostname	MonitorItem	10	24 months

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Evaluation

- High Availability
- Memory Usage
- Read/Write Performance

High Availability

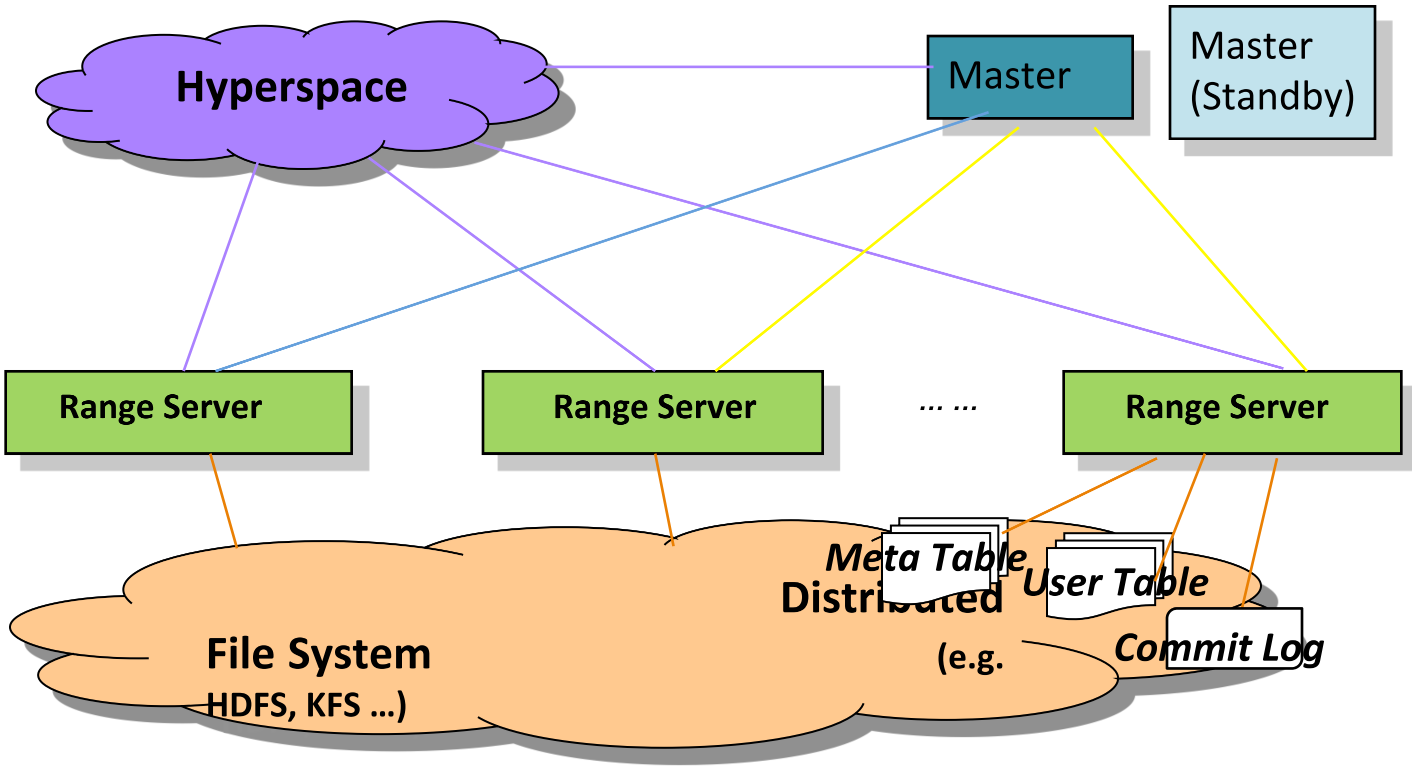
- Challenge
  - Recovery
    - No support sync for append operation in Hadoop-v2 (based on 0.18.2)
  - Load Balance
    - No implementation in Hypertable-B2 (based on 0.9.2.0)

High Availability

- Improvements
  - Recovery
    - Data in HDFS, Log in LocalFS
      - Local-Recovery
    - Centralized Meta Ranges
      - 2048PB User-Data index by 16TB Meta-Data
    - Master Standby
    - Application Remove-duplicates
  - Load Balance
    - Split-driven
    - Manual online and offline operations

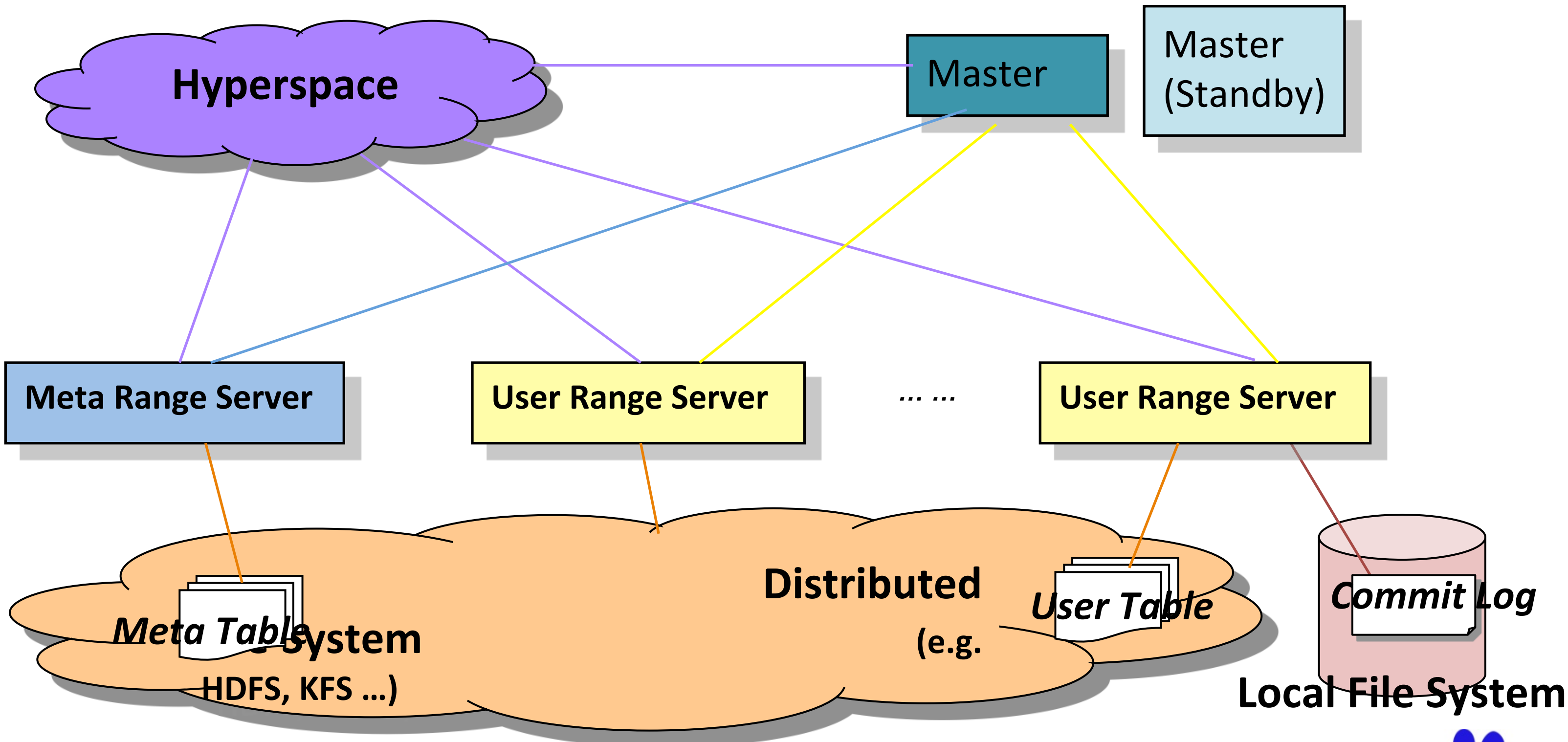
High Availability

- Deployment Model (before improvement)



High Availability

- Deployment Model (after improvement)



Weaknesses

- Range data managed by a single range server
  - Though no data loss, can cause periods of unavailability
  - Can be mitigated by client-side cache or memcached
  - Can minimize recovery time by active standby of cluster

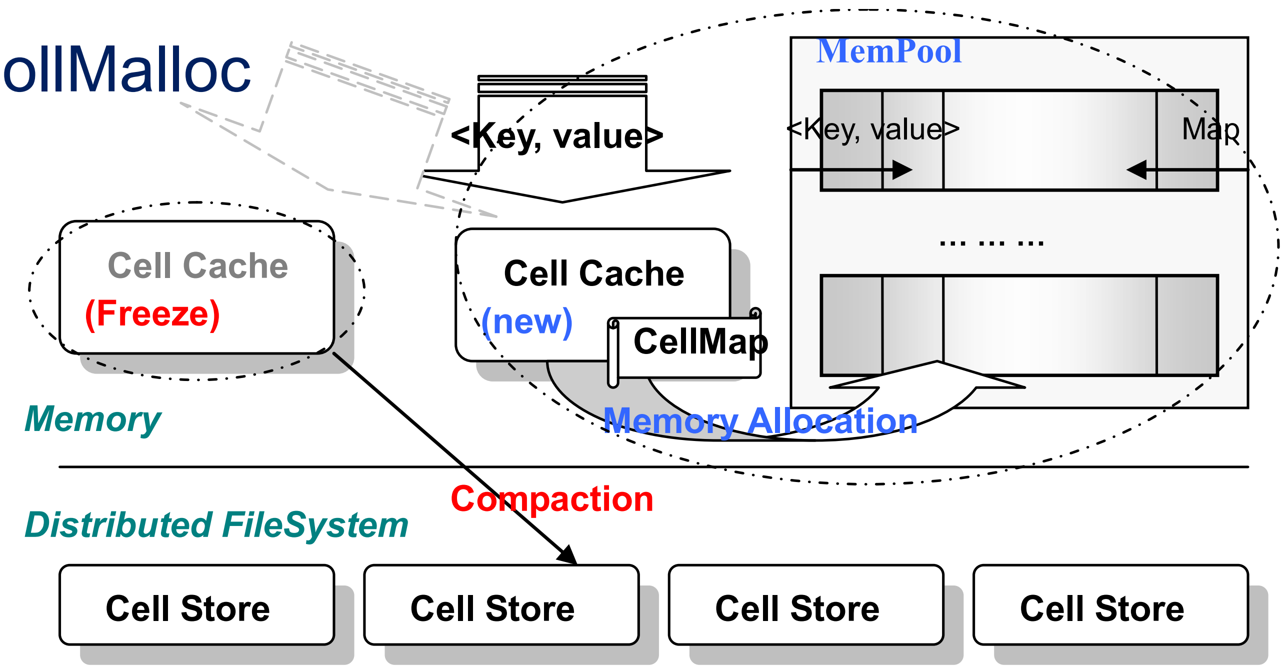
Memory Usage

- Challenge
  - Hypertable is memory intensive

Function (during execution)	Memory Usage
Hypertable::CellCache::add	75.6%
__gnu_cxx::new_allocator::allocate	18.8%
Hypertable::DynamicBuffer::grow	4.1%
Hypertable::IOHandlerData::handle_event	1.0%
Hypertable::BlockCompressionCodecLzo ::BlockCompressionCodecLzo	0.5%

Memory Usage

- Improvement
  - TCMalloc
  - SimplePollMalloc

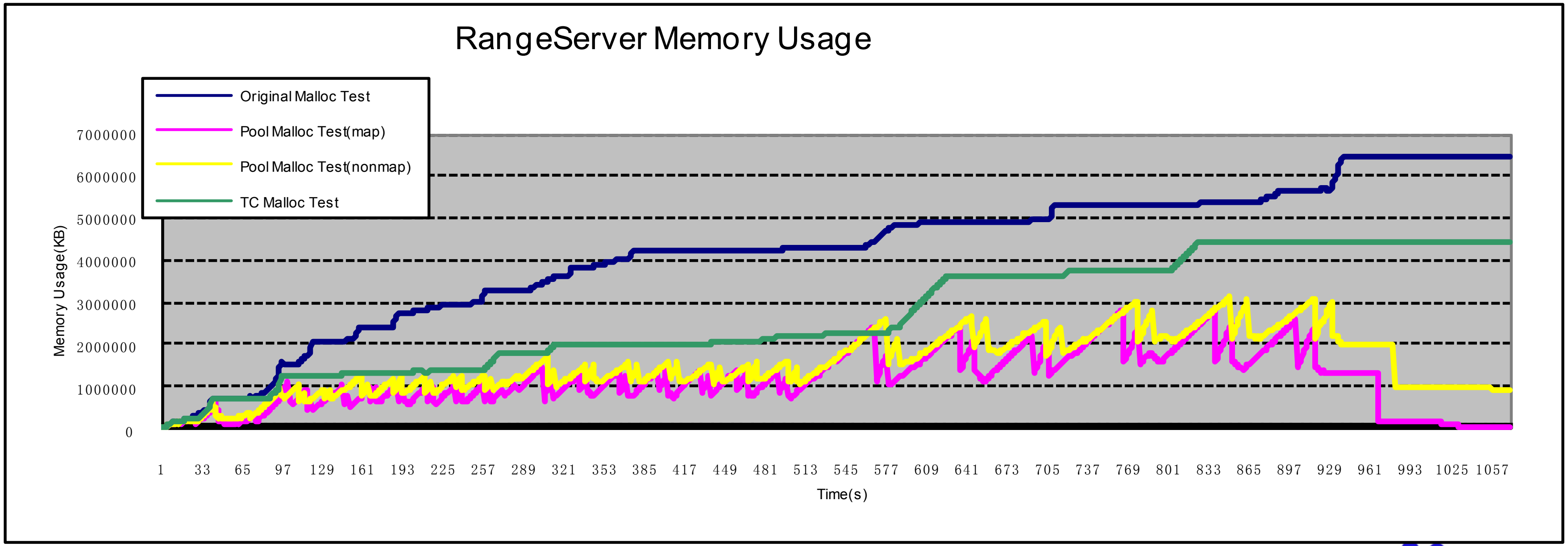


Memory Usage

Function (during execution)	Mem Usage	Mem Usage	Function (during execution)
CellCachePool::get_memory	**94.3%**	**75.6%**	Hypertable ::CellCache::add
		18.8%	__gnu_cxx ::new_allocator::allocate
Hypertable:: DynamicBuffer::grow	3.8%	4.1%	Hypertable ::DynamicBuffer::grow
Hypertable ::BlockCompressionCodecLzo ::BlockCompressionCodecLzo	1.1%	1.0%	Hypertable ::IOHandlerData ::handle_event
Hypertable ::IOHandlerData ::handle_event	0.5%	0.5%	Hypertable ::BlockCompressionCodecLzo ::BlockCompressionCodecLzo

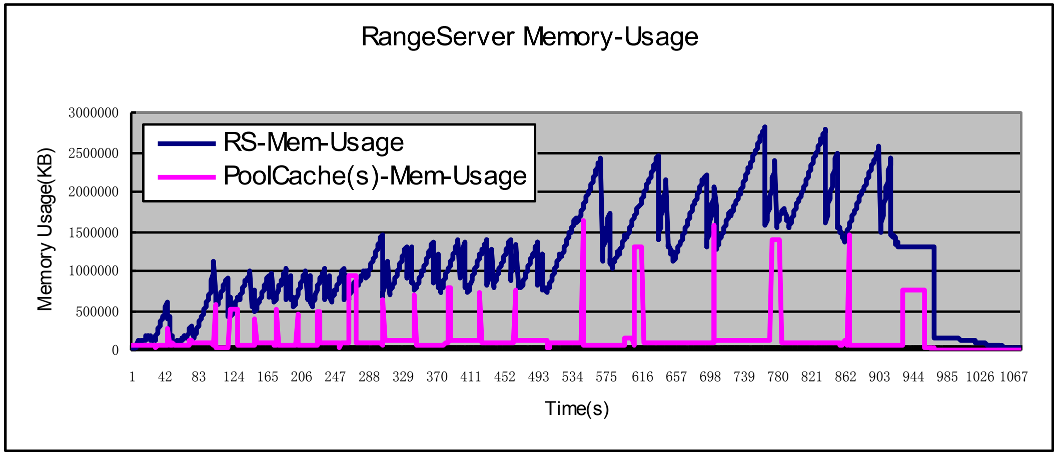
Memory Usage

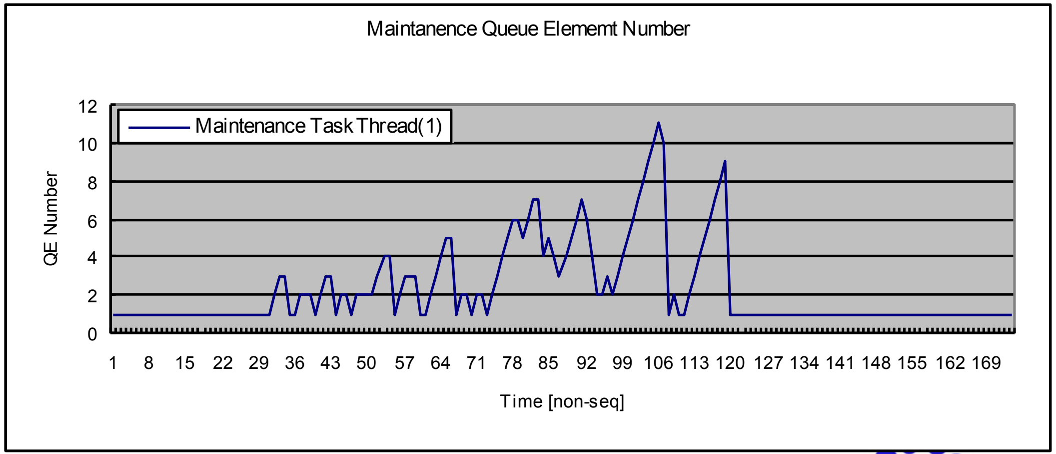
- New/Delete vs. TCMalloc vs. PollMalloc vs. PollMalloc (with map)



Memory Usage

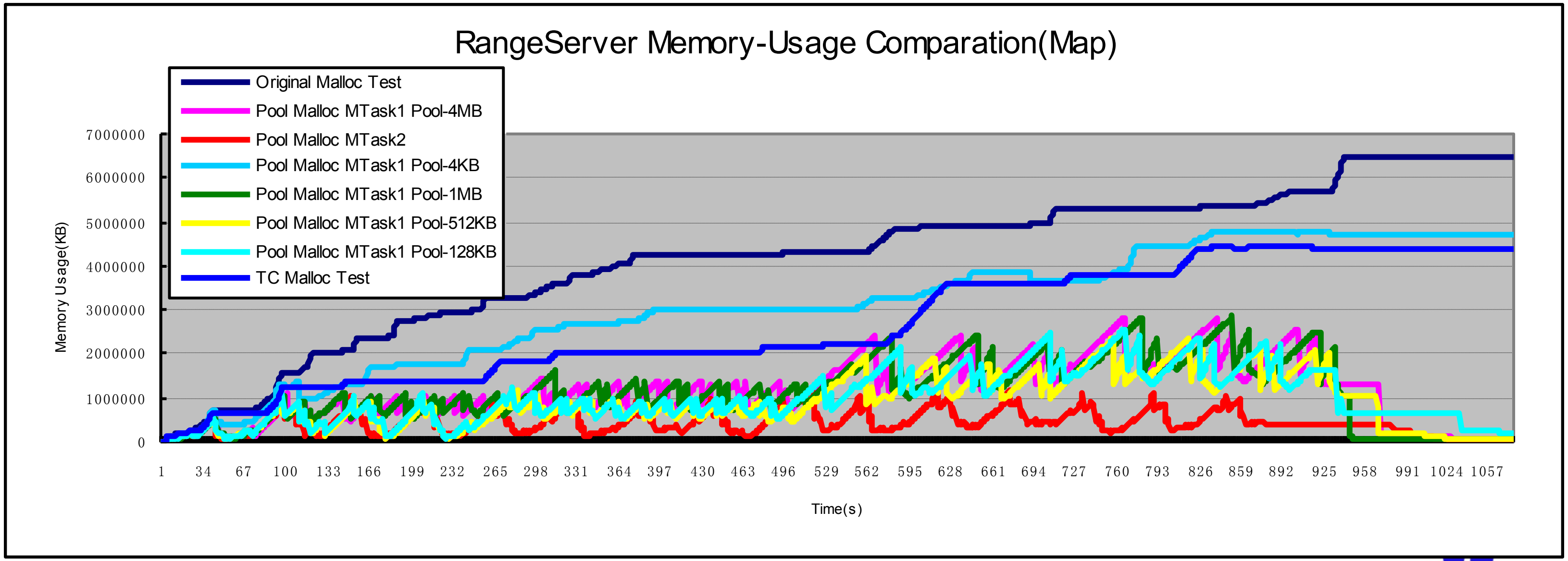
- Opportunity
  - Compaction Efficiency





Memory Usage

- Improvement
  - Compaction Optimization Factor
    - Cell Cache Buffer Size
    - Maintenance Thread Number



Read Performance

- Challenge
  - Noah generates lots of random read ops

Machine	Sequential Write (KB/s)	Random Read (KB/s)	Random Write (KB/s)
X1	**284191**	**1932**	**79834**
X2	165264	973	1627
X3	93919	863	7256
X4	63565	471	23149
X5	55598	424	18768
X6	60858	336	23188

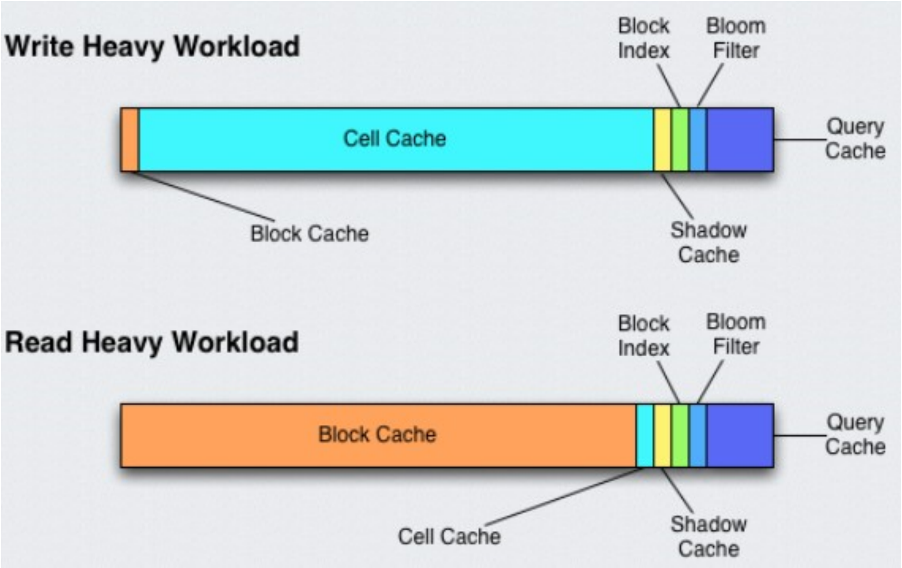
<./iozone -f t3 -s 10g -c -e -w -+n -i 0 ./iozone -f t3 -s 10g -c -e -w -+n -i 2 >

Read Performance

- Memory Read
  - Latency
    - ms level
  - Memory usage
    - Sparse Table: value + 40Bytes(keys + map)
    - MVCC: Old record is deleted when cell cache compaction

Read Performance

- Cache Read
  - Block Cache
    - Cellstore blocks
    - Uncompressed
  - Query Cache
    - Query results



Read Performance

- Disk Read
  - CellStore
    - 5 CSs/Range, 5*216=950 RR, 950*2=1900 RR; 500 iops, ioutil 100%
  - Bloomfilter

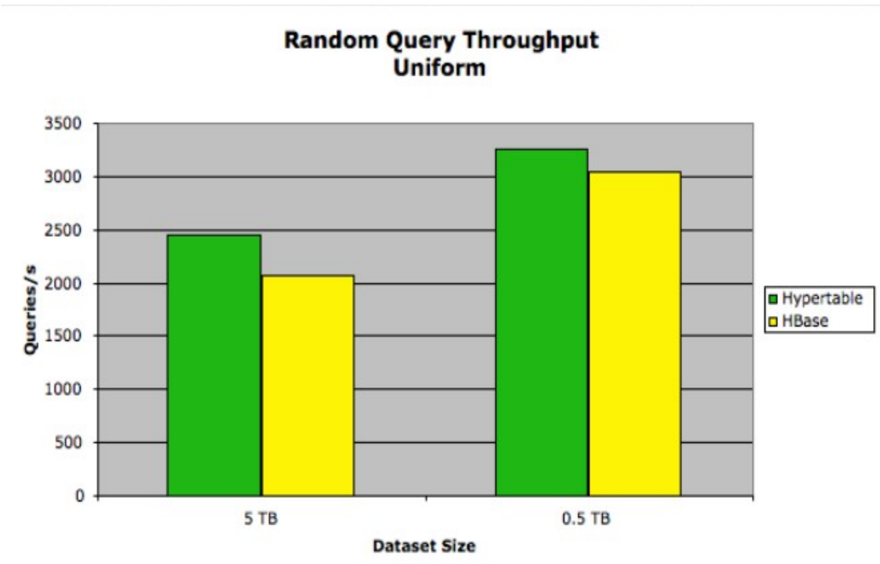
	CS 10			CS 5			CS 1		
Threads	1	16	32	1	16	32	1	16	32
Queries/s	3.8	3.8	2.4	9.8	13.5	5	23.1	52.6	25.6
Aggregate Queries/s	3.8	61	77	9.8	216	160	23.1	1684	1641
Average Latency(ms)	260	260	420	102	74	200	43	19	39

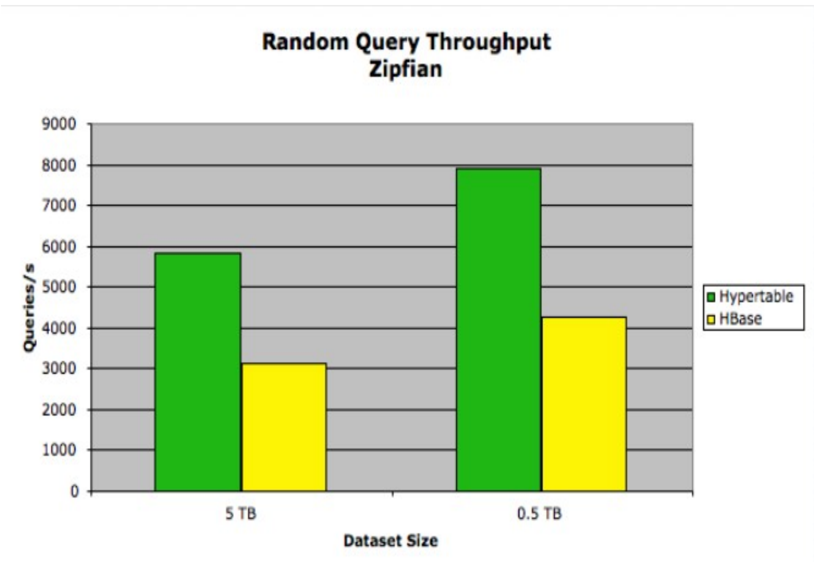
Read Performance

- Disk Read
  - Compression
    - Lzo/Quicklz/Gzip/Snappy
  - SSD/SATA/SAS
    - Read Access Time/Capacity/Price per GB/Idle or Full power/MTBF
  - Concurrent W/R
    - Resource isolation
    - Manual control

Read Performance

- Hypertable vs. Hbase





Write Performance

- Challenge
  - HDFS operation pressure
  - RangeServer writing pressure
- Improvement
  - Compaction frequency adjusting
  - Row key reversal

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Conclusion

- Application level
  - Table Design
  - Load-in Strategy
  - Duplicate Removing
- High Availability
  - Metadata Centralization
  - Master Standby
  - Log/Data Separation
  - Load Balance
  - System Active Standby
- Memory Usage
  - Memory Pool
  - Compaction Strategy
- Read/Write Performance
  - Mem/SSD/SAS/SATA
  - Block/Query Caching
  - Compression Strategy
  - Resource Isolation
  - Compaction Strategy

Hypertable versus HBase

versus	Hypertable	HBase
Community	Hypertable	Apache
Company	Hypertable Inc	Cloudera, HortonWorks
Implementation Language	Boost C++	Java
Memory Management	Explicit Memory Management	Garbage Collection
Cache Managemnt	Dynamic cache management	Java heap for caching
Performance	High	Normal
Compiler Optimization	Easy	Hard
Compression	Direct native compression	JNI-based compression

Thanks for your Attention!

Questions?

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