facebook

# Storage Infrastructure Behind Facebook Messages

HBase/HDFS/ZK/MapReduce

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Big Data Experiences & Scars, HPTS 2011
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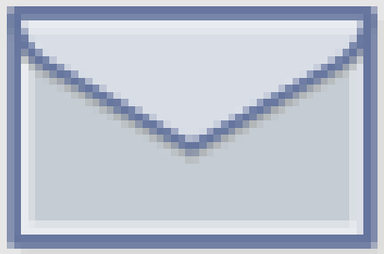
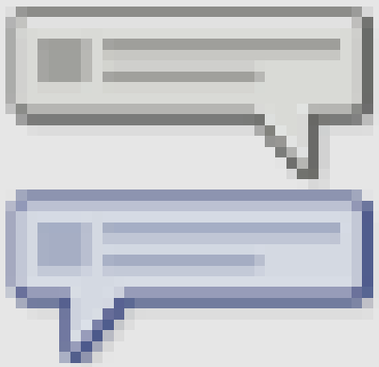
# The New Facebook Messages

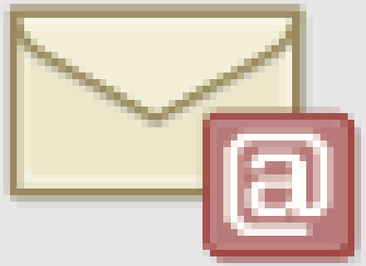
## Messages



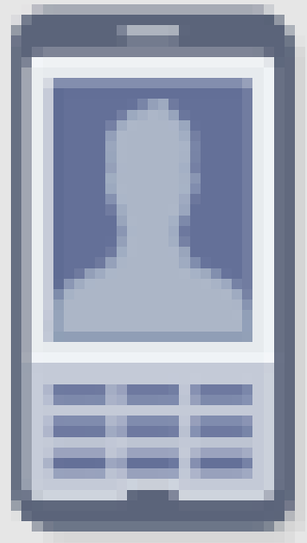
## Chats



## Emails



## SMS



# Why we chose HBase

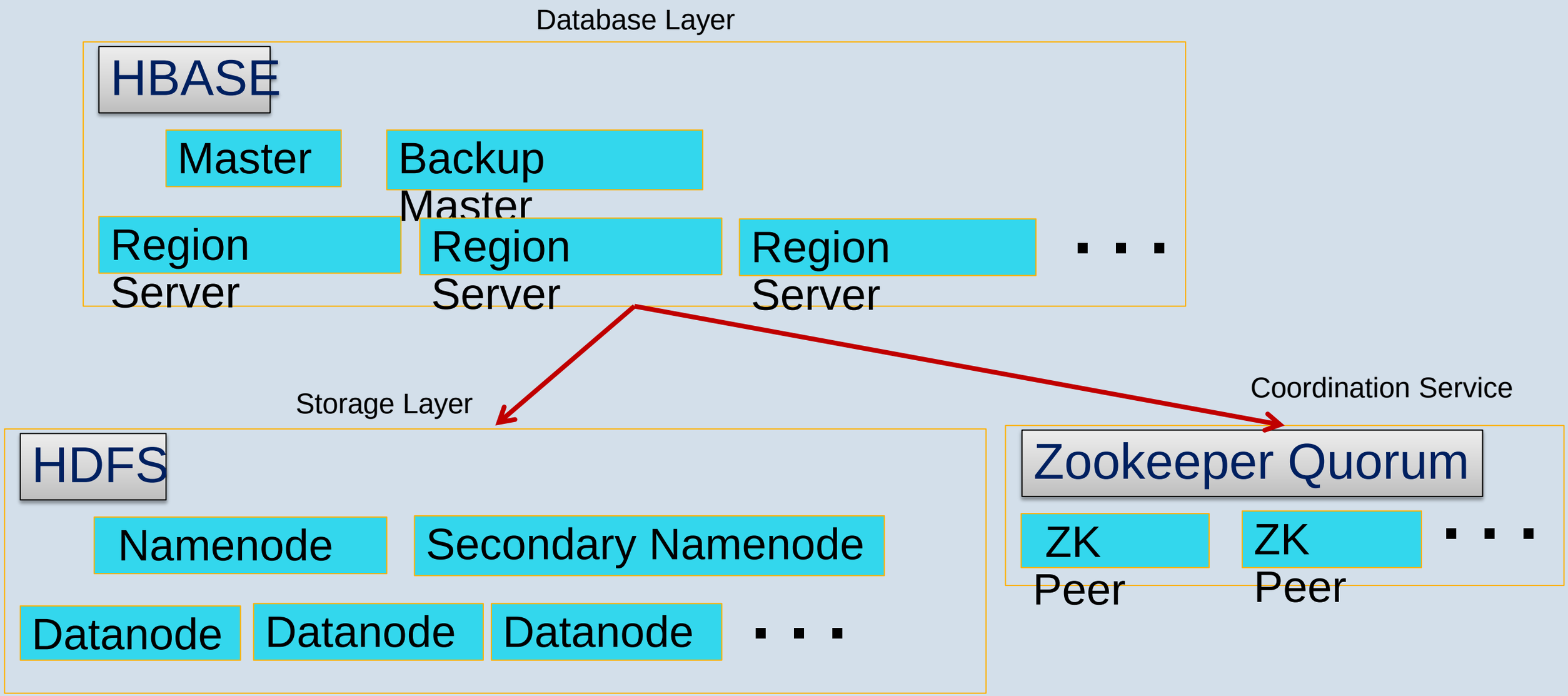
- High write throughput
- Good random read performance
- Horizontal scalability
- Automatic Failover
- Strong consistency
- *Benefits of HDFS*
  - *Fault tolerant, scalable, checksums, MapReduce*
  - *internal dev & ops expertise*

# What do we store in HBase

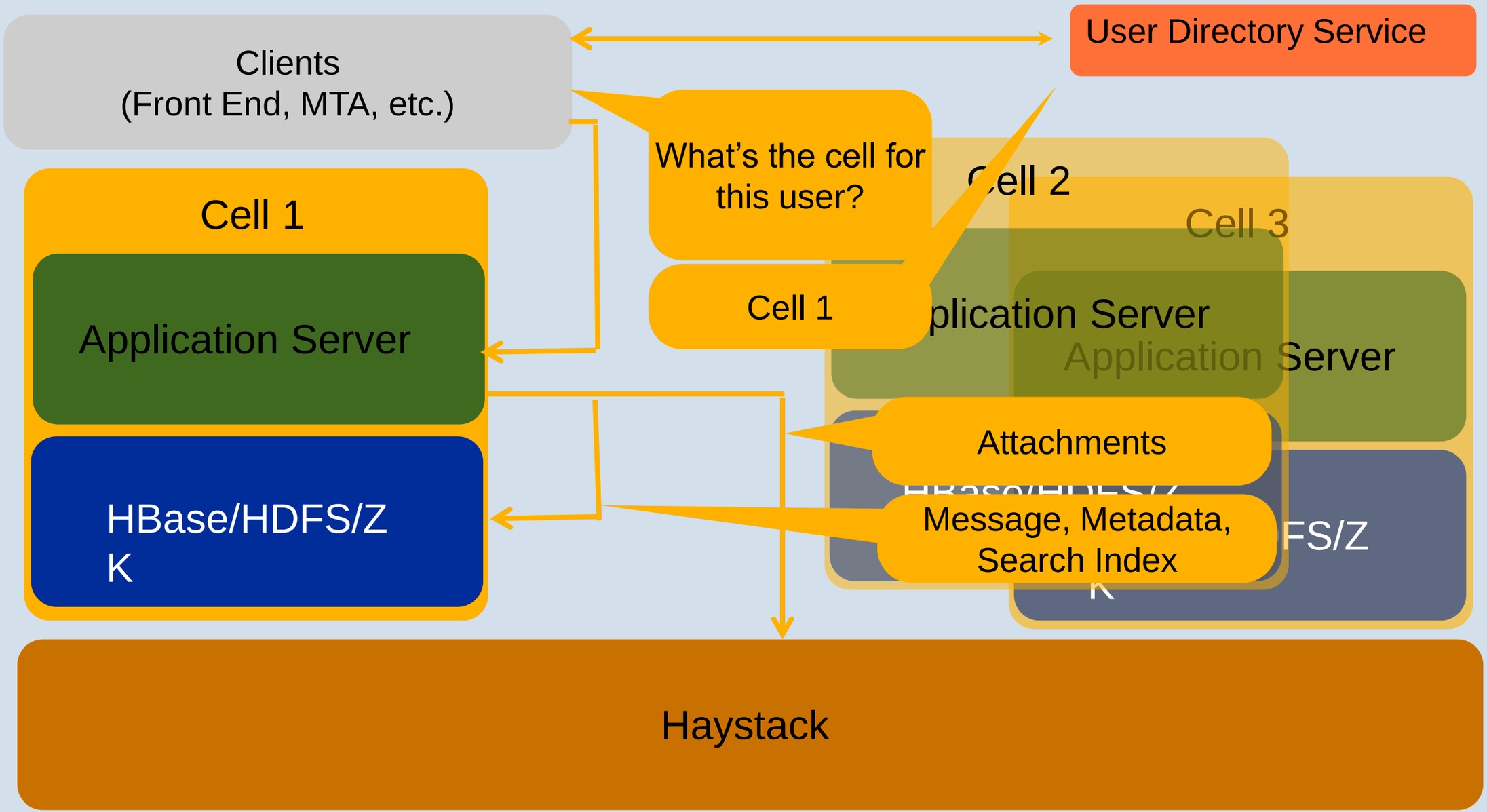
- HBase
  - Small messages
  - Message metadata (thread/message indices)
  - Search index

- Haystack (our photo store)
  - Attachments
  - Large messages

# HBase-HDFS System Overview

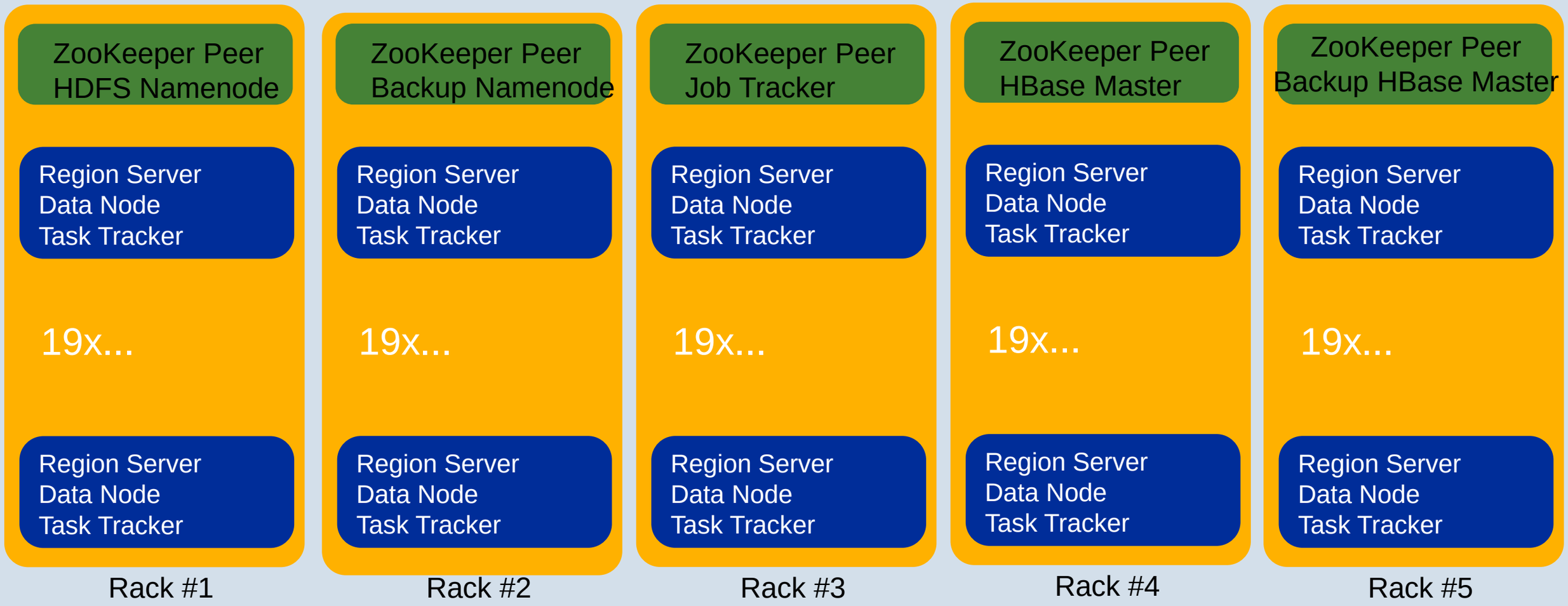


# Facebook Messages Architecture



# Typical Cluster Layout

- Multiple clusters/cells for messaging
  - 20 servers/rack; 5 or more racks per cluster
- Controllers (master/Zookeeper) spread across racks



# Facebook Messages: Quick Stats

- 6B+ messages/day

- Traffic to HBase
  - 75+ Billion  R+W ops/day
  - At peak: 1.5M ops/sec
  - ~ 55% Read vs. 45% Write ops
  - Avg write op inserts ~16 records across multiple column families.

# Facebook Messages: Quick Stats (contd.)

- 2PB+ of online data in HBase (6PB+ with replication; excludes backups)
  - message data, metadata, search index
- All data LZO compressed
- Growing at 250TB/month

# Facebook Messages: Quick Stats (contd.)

Timeline:

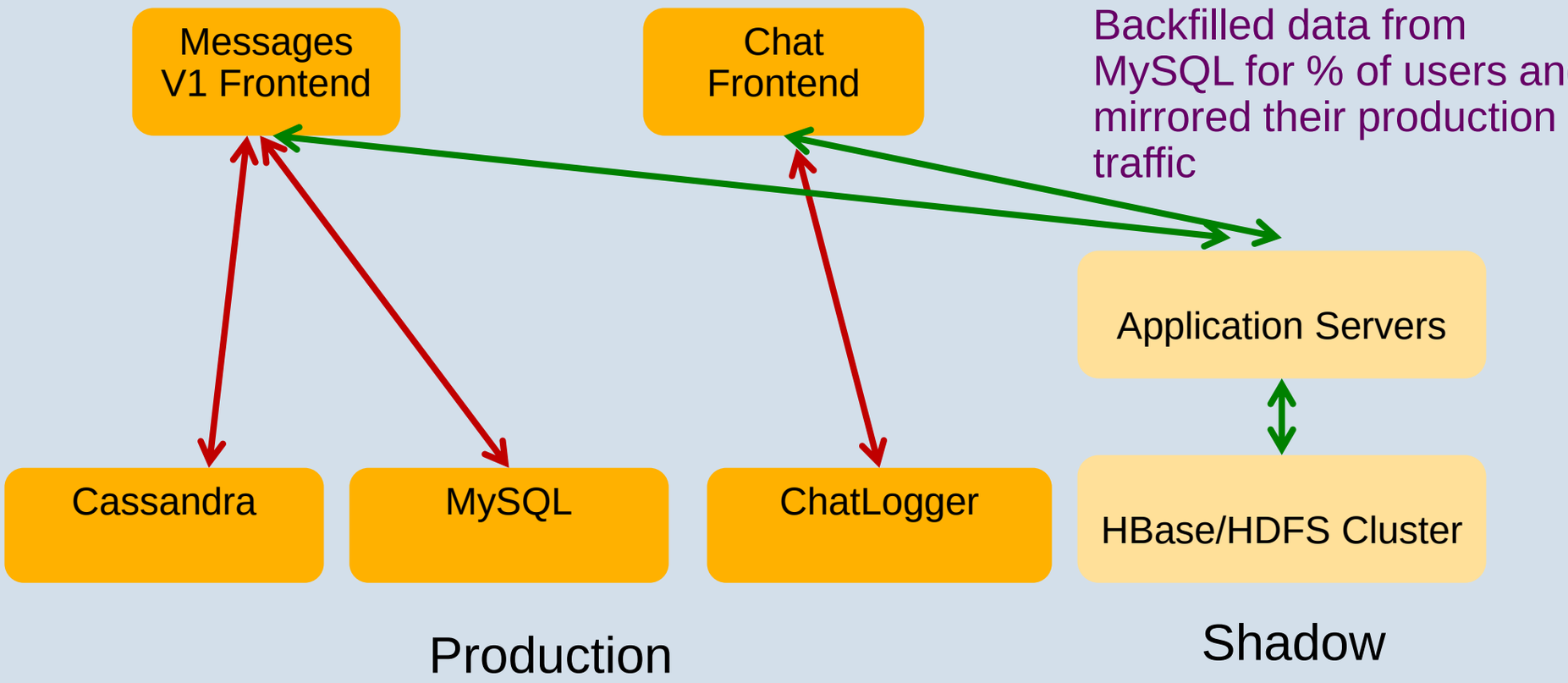
- Started in Dec 2009
- Roll out started in Nov 2010
- Fully rolled out by July 2011 (migrated 1B+ accounts from legacy messages!)

While in production:

- Schema changes: not once, but twice!
- Implemented & rolled out HFile V2 and numerous other optimizations in an upward compatible manner!

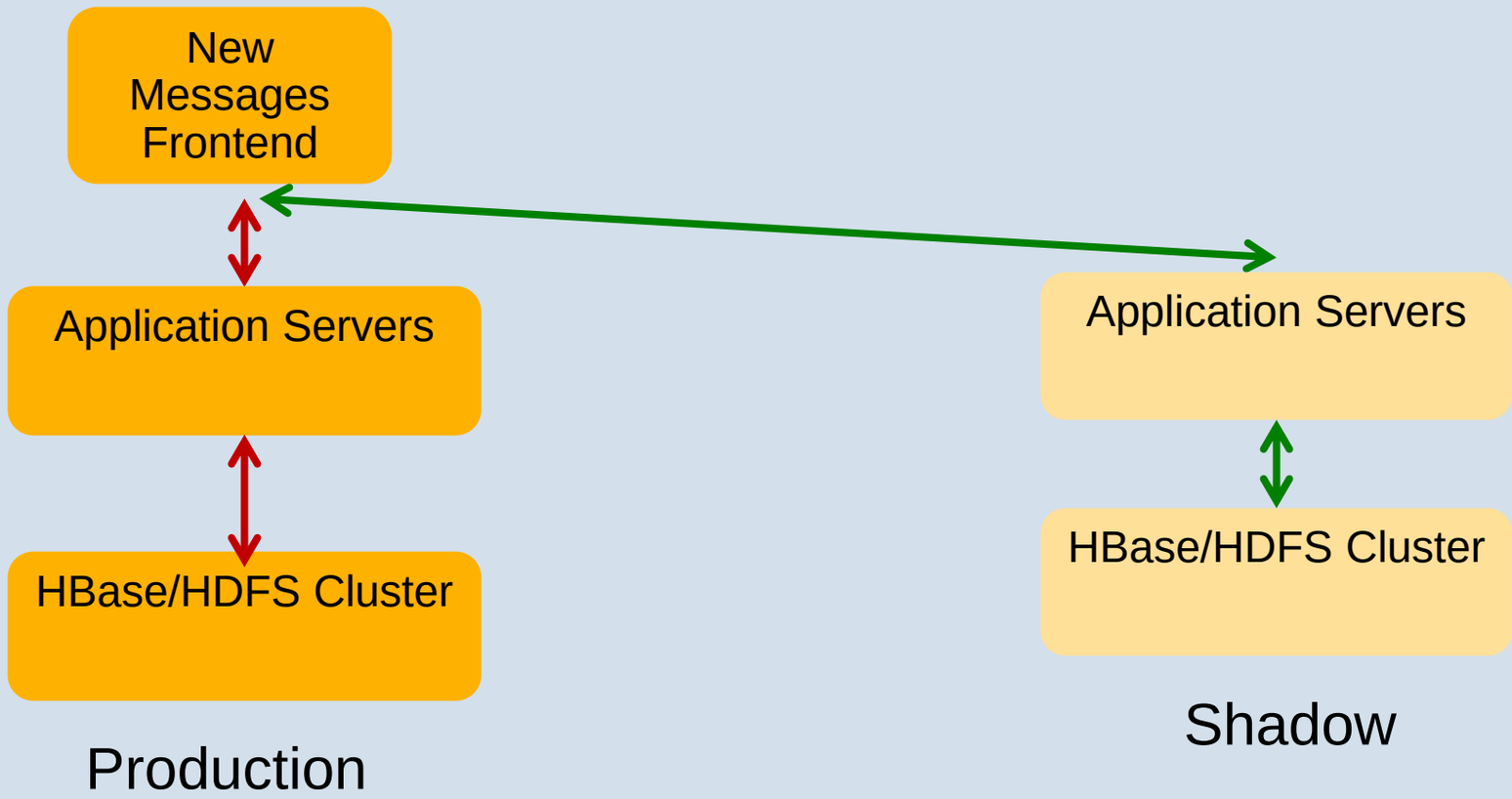
# Shadow Testing: Before Rollout

- Both product and infrastructure were changing.
- Shadows the old messages product + chat while the new one was under development



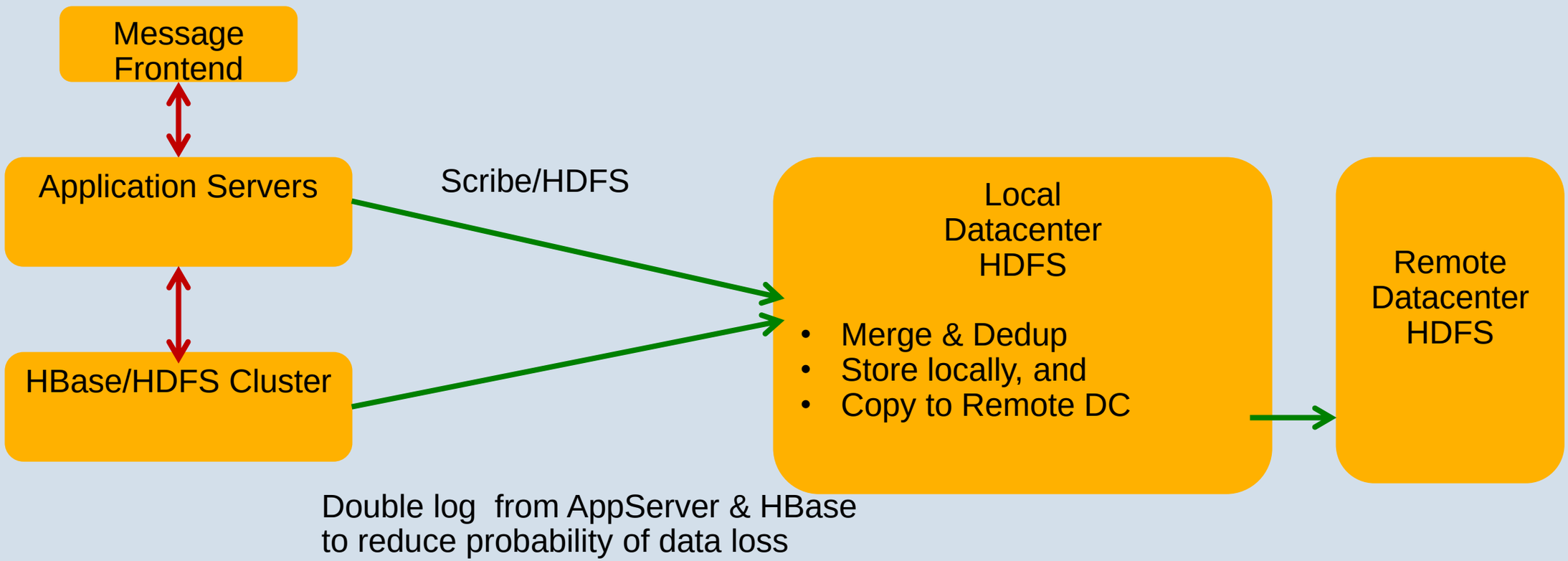
# Shadow Testing: After Rollout

- *Shadows new version of the Messages product.*
- *All backend changes go through shadow cluster before prod push*



# Backup/Recovery (V1)

- During early phase, concerned about potential bugs in HBase.
- Off-line backups: written to HDFS via Scribe
- Recovery tools; testing of recovery tools



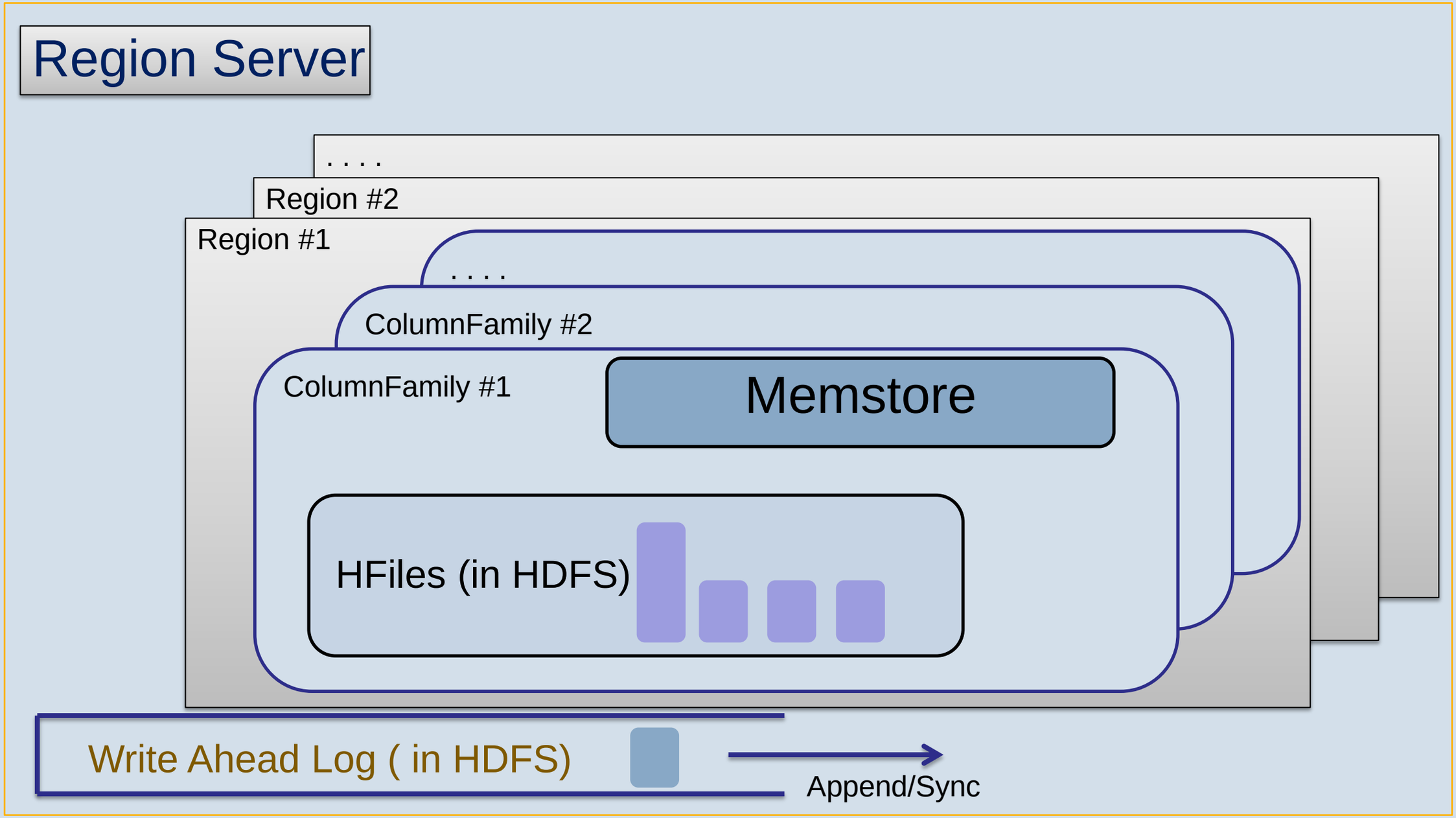
# Backups (V2)

- Now, does periodic HFile level backups.
- Working on:
  - Moving to HFile + Commit Log based backups to be able to recover to finer grained points in time
    - Avoid need to log data to Scribe.
  - Zero copy (hard link based) fast backups

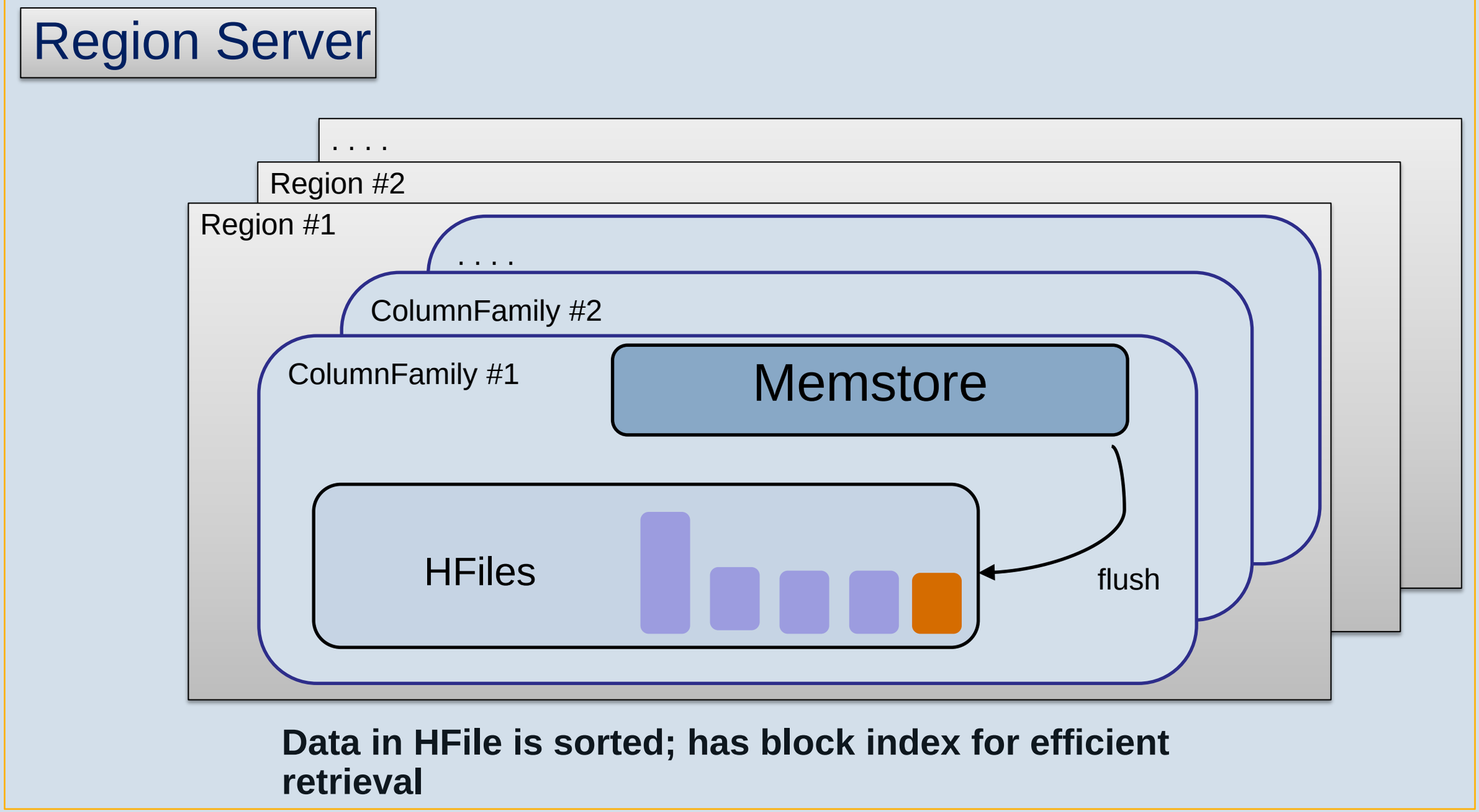
# Messages Schema & Evolution

- “Actions” (data) Column Family the source of truth
  - Log of all user actions (addMessage, markAsRead, etc.)
- Metadata (thread index, message index, search index) etc. in other column families
- Metadata portion of schema underwent 3 changes:
  - Coarse grained snapshots (early development; rollout up to 1M users)
  - Hybrid (up to full rollout – 1B+ accounts; 800M+ active)
  - Fine-grained metadata (after rollout)
- MapReduce jobs against production clusters!
  - Ran in throttled way
  - Heavy use of HBase bulk import features

# Write Path Overview

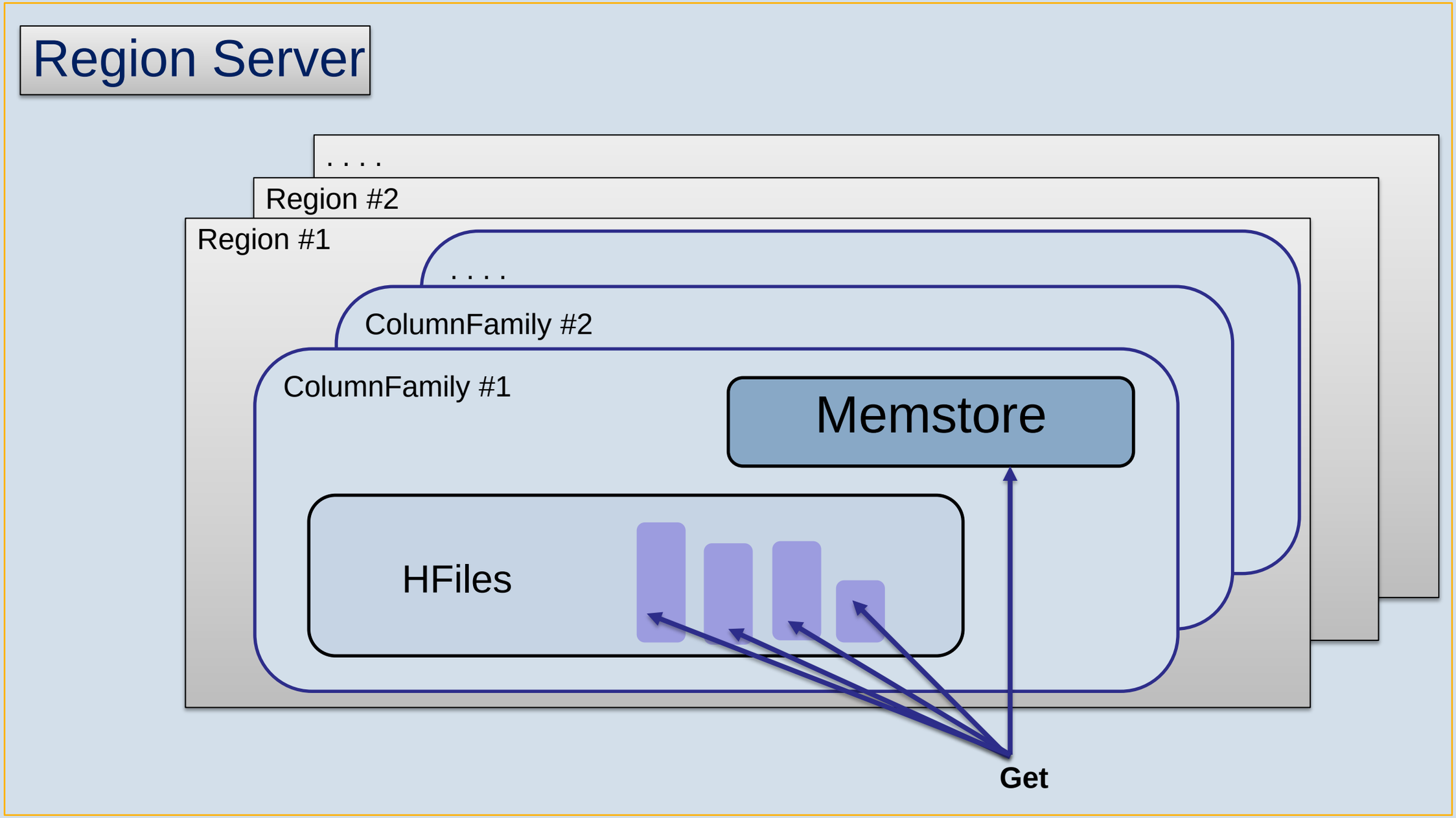


# Flushes: Memstore -> HFile

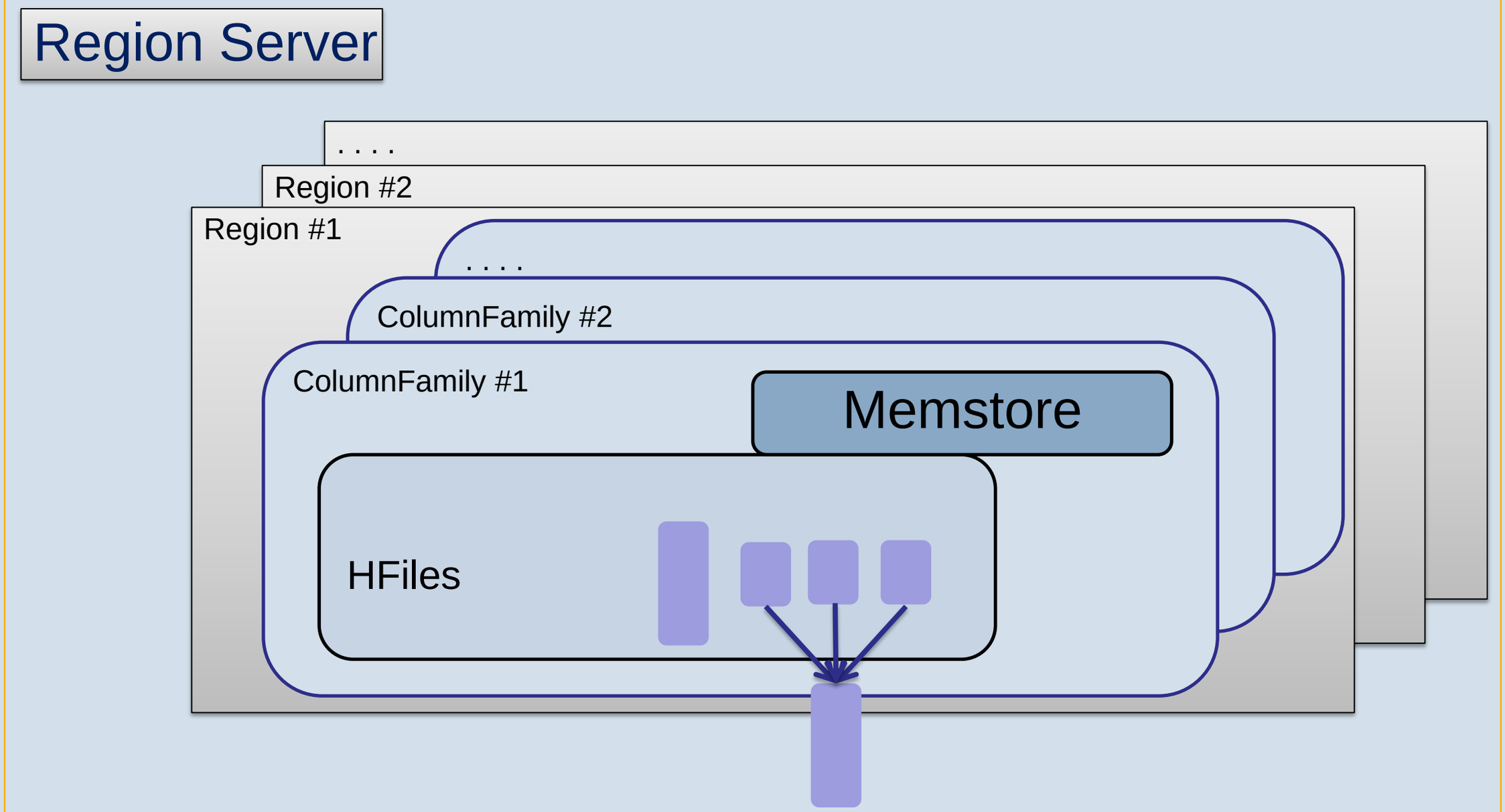



**Data in HFile is sorted; has block index for efficient retrieval**

# Read Path Overview



# Compactions



# Reliability: Early work

- HDFS sync support for durability of transactions
- Multi-CF transaction atomicity
- Several bug fixes in log recovery
- New block placement policy in HDFS
  - To reduce probability of data loss

# Availability: Early Work

- Common reasons for unavailability:
  - S/W upgrades
    - *Solution: rolling upgrades*
  - Schema Changes
    - Applications needs new Column Families
    - Need to change settings for a CF
    - *Solution: online “alter table”*
  - Load balancing or cluster restarts took forever
    - Upon investigation: stuck waiting for compactions to finish
    - *Solution: Interruptible Compactions!*

# Performance: Early Work

- Read optimizations:
  - Seek optimizations for rows with large number of cells
  - Bloom Filters
    - minimize HFile lookups
  - Timerange hints on HFiles (great for temporal data)
  - Multigets
  - Improved handling of compressed HFiles

# Performance: Compactions

- Critical for read performance
- Old Algorithm:

#1. Start from newest file (file 0); include next file if:

- size[i] < size[i-1] * C  (good!)

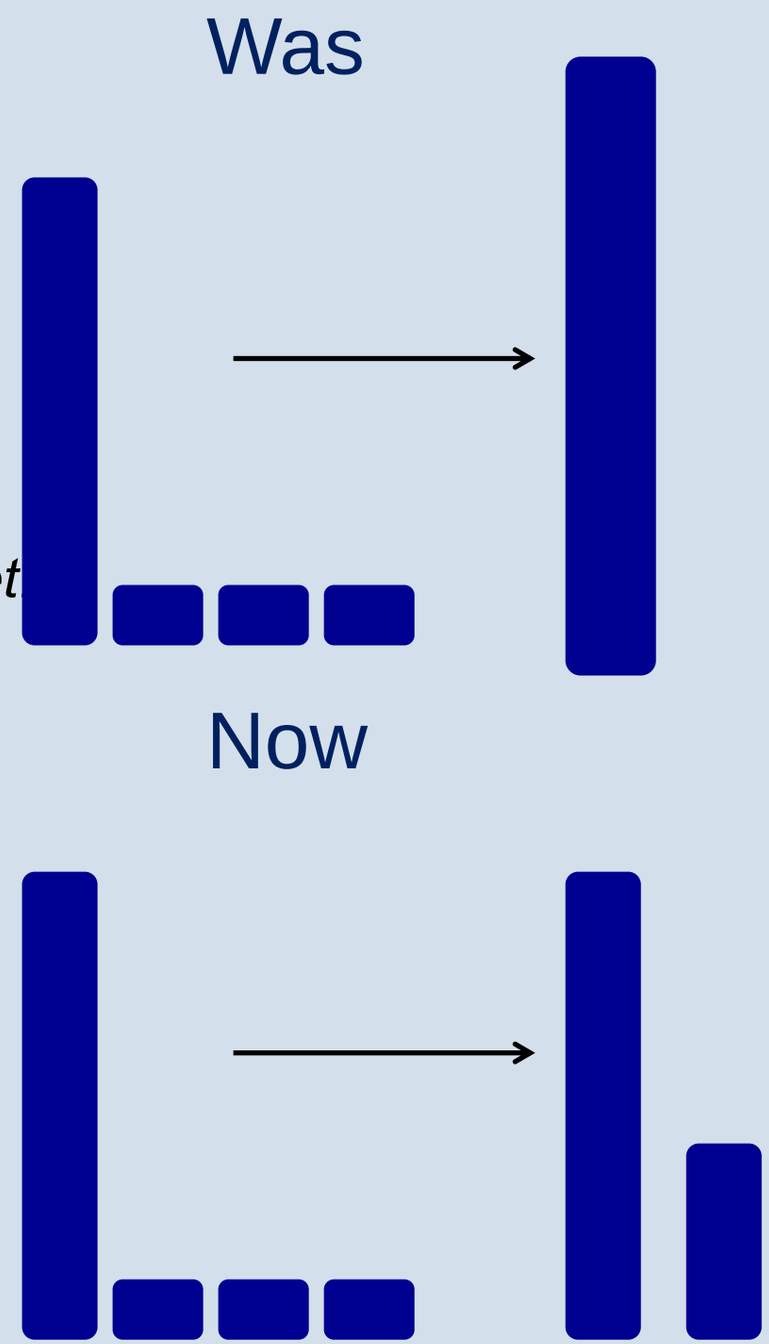
*#2. Always compact at least 4 files, even if rule #1 isn't met*

Solution:

#1. Compact at least 4 files, *but only if eligible files found*.

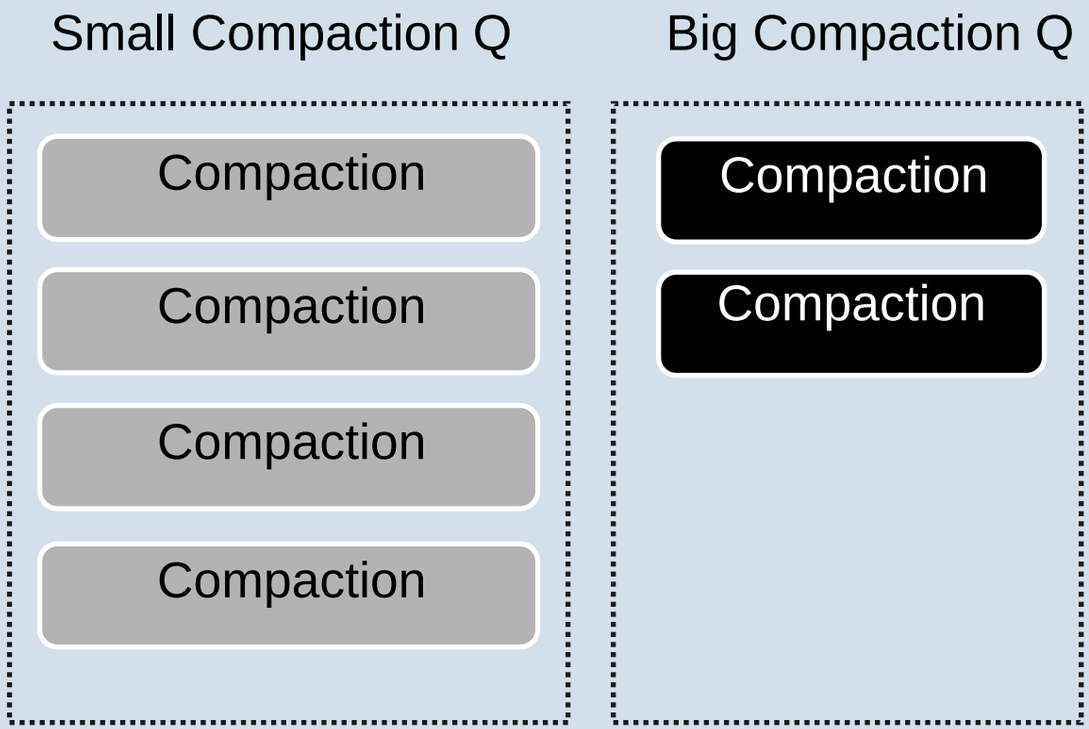
#2. Also, new file selection based on summation of sizes.

size[i] < (size[0] + size[1] + …size[i-1]) * C



# Performance: Compactions

- More problems!
  - Read performance dips during peak
  - Major compaction storms
  - Large compactions bottleneck
- Enhancements/fixes:
  - Staggered major compactions
  - Multi-thread compactions; separate queues for small & big compactions
  - Aggressive off-peak compactions



# Metrics, metrics, metrics…

- Initially, only had coarse level overall metrics (get/put latency/ops; block cache counters).
- Slow query logging
- Added per Column Family stats for:
  - ops counts, latency
  - block cache usage & hit ratio
  - memstore usage
  - on-disk file sizes
  - file counts
  - bytes returned, bytes flushed, compaction statistics
  - stats by block type (data block vs. index blocks vs. bloom blocks, etc.)
  - bloom filter stats

# Metrics (contd.)

- HBase Master Statistics:
  - Number of region servers alive
  - Number of regions
  - Load balancing statistics
  - ..
- All stats stored in Facebook's Operational Data Store (ODS).
- Lots of ODS dashboards for debugging issues
  - Side note: ODS planning to use HBase for storage pretty soon!

# Need to keep up as data grows on you!

- Rapidly iterated on several new features while in production:
  - Block indexes upto 6GB per server! Cluster starts taking longer and longer. Block cache hit ratio on the decline.
    - Solution: HFile V2
      - Multi-level block index, Sharded Bloom Filters
  - Network pegged after restarts
    - Solution: Locality on full & rolling restart
  - High disk utilization during peak
    - Solution: Several “seek” optimizations to reduce disk IOPS
      - Lazy Seeks (use time hints to avoid seeking into older HFiles)
      - Special bloom filter for deletes to avoid additional seek
      - Utilize off-peak IOPS to do more aggressive compactions during

# Scares & Scars!

- Not without our share of scares and incidents:
  - s/w bugs. (e.g., deadlocks, incompatible LZO used for bulk imported data, etc.)
    - found a edge case bug in log recovery as recently as last week!
  - performance spikes every 6 hours (even off-peak)!
    - cleanup of HDFS's Recycle bin was sub-optimal! Needed code and config fix.
  - transient rack switch failures
  - Zookeeper leader election took than 10 minutes when one member of the quorum died. Fixed in more recent version of ZK.
  - HDFS Namenode – SPOF
  - flapping servers (repeated failures)

# Scares & Scars! (contd.)

- Sometimes, tried things which hadn’t been tested in dark launch!
  - Added a rack of servers to help with performance issue
    - Pegged top of the rack network bandwidth!
      - Had to add the servers at much slower pace. Very manual ☹.
      - Intelligent load balancing needed to make this more automated.
- A high % of issues caught in shadow/stress testing
- Lots of alerting mechanisms in place to detect failures cases
  - Automate recovery for a lots of common ones
  - Treat alerts on shadow cluster as hi-pri too!
- Sharding service across multiple HBase cells also paid off

# Future Work

- Reliability, Availability, Scalability!
- Lot of new use cases on top of HBase in the works.

  - HDFS  Namenode HA
  - Recovering gracefully from transient issues
  - Fast hot-backups
  - Delta-encoding in block cache
  - Replication
  - Performance (HBase and HDFS)
  - HBase as a service Multi-tenancy
  - Features- coprocessors, secondary indices

# Acknowledgements

Work of lot of people spanning HBase, HDFS, Migrations, Backup/Recovery pipeline, and Ops!

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# Thanks! Questions?

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