facebook

HBase @ Facebook

The Technology Behind Messages (and more…)

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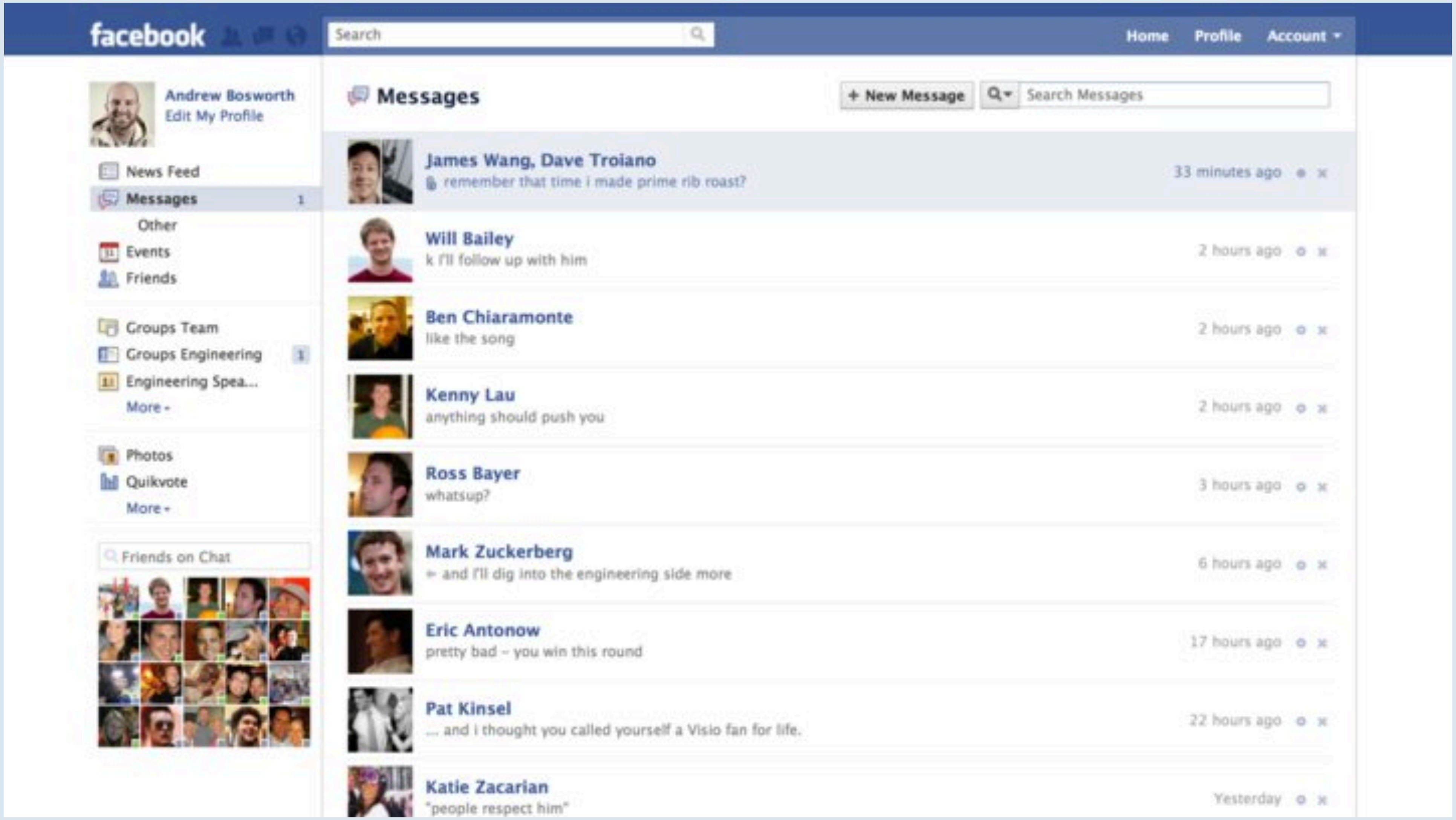
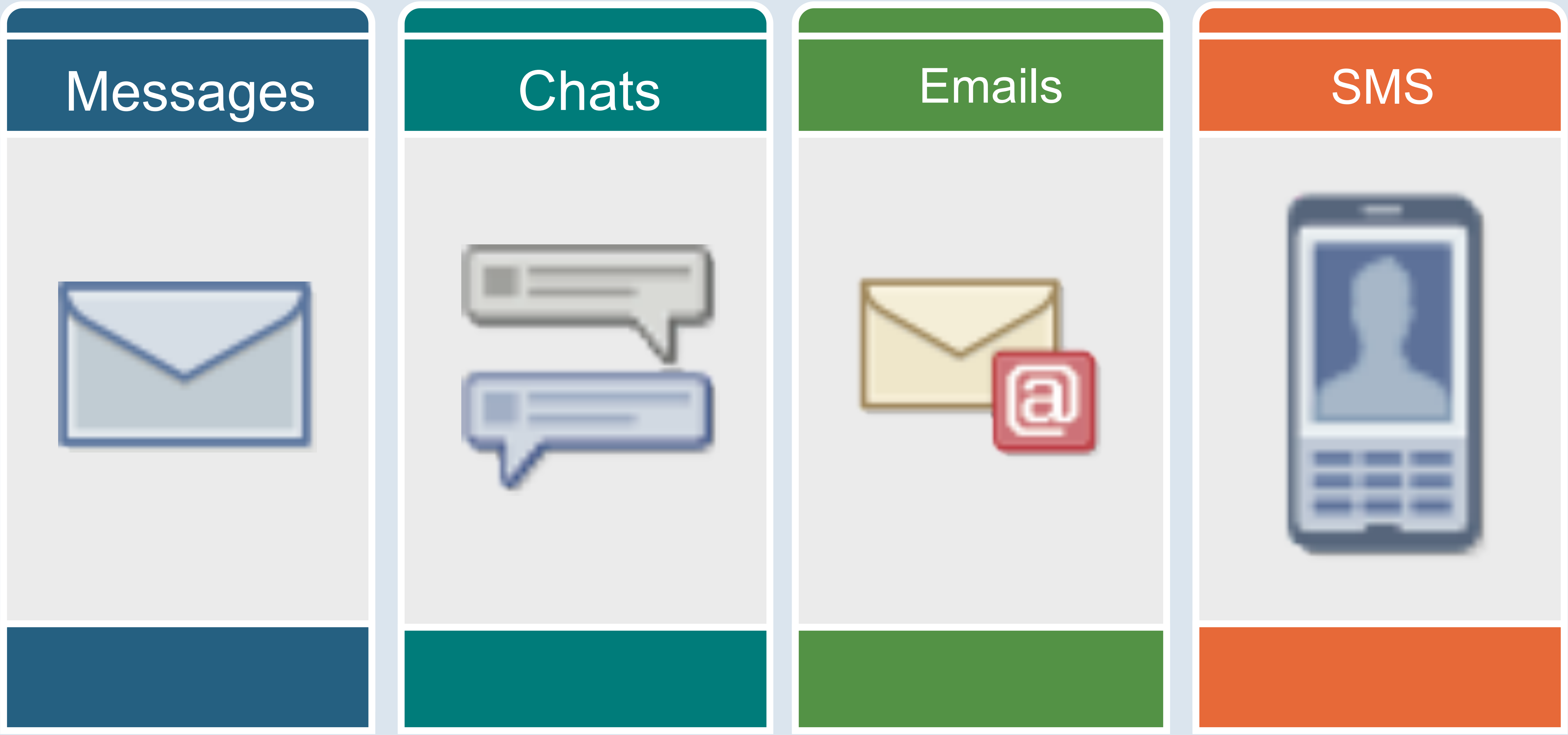
Talk Outline

- the new Facebook Messages, and how we got started with HBase
- quick overview of HBase
- why we picked HBase
- our work with and contributions to HBase
- a few other/emerging use cases within Facebook
- future plans
- Q&A



James Wang, Dave Troiano	remember that time i made prime rib roast?	33 minutes ago
Will Bailey	k I'll follow up with him	2 hours ago
Ben Chiaramonte	like the song	2 hours ago
Kenny Lau	anything should push you	2 hours ago
Ross Bayer	whatsup?	3 hours ago
Mark Zuckerberg	and I'll dig into the engineering side more	6 hours ago
Eric Antonow	pretty bad – you win this round	17 hours ago
Pat Kinsel	... and i thought you called yourself a Visio fan for life.	22 hours ago
Katie Zacarian	"people respect him"	Yesterday

The New Facebook Messages



Messages

Chats

Emails

SMS

Storage

Monthly data volume prior to launch

✉ **15B** x 1,024 bytes = 14TB

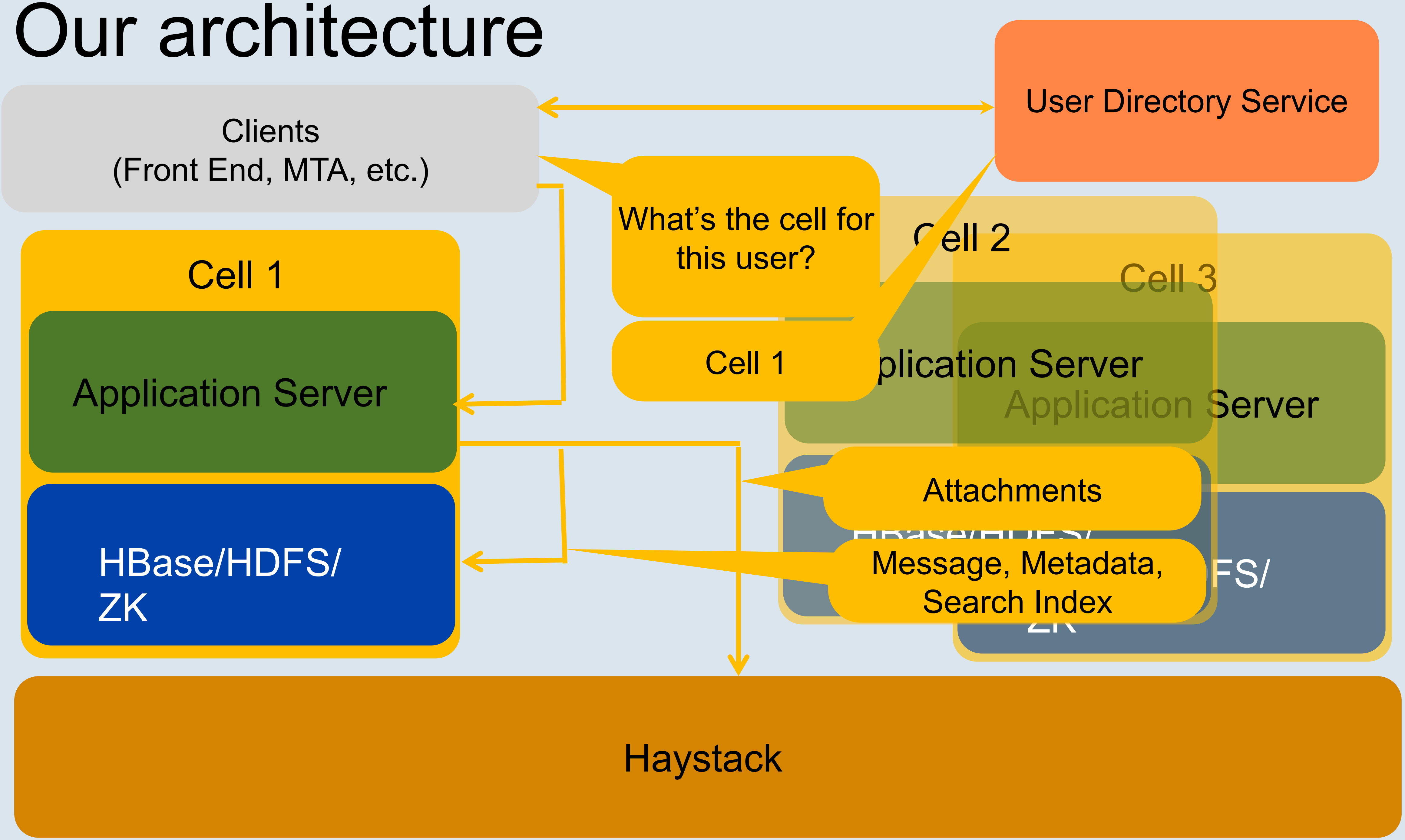
💬 120B x 100 bytes = 11TB

Messaging Data

- Small/medium sized data and indices in HBase
  - Message metadata & indices
  - Search index
  - Small message bodies

- Attachments and large messages in Haystack (our photo store)

Our architecture



About HBase

HBase in a nutshell

- distributed, large-scale data store
- efficient at random reads/writes
- open source project modeled after Google’s BigTable

When to use HBase?

- storing large amounts of data (100s of TBs)
- need high write throughput
- need efficient random access (key lookups) within large data sets
- need to scale gracefully with data
- for structured and semi-structured data
- don’t need full RDMS capabilities (cross row/cross table transactions, joins, etc.)

HBase Data Model

- An HBase table is:
  - a sparse , three-dimensional array of cells, indexed by:

    RowKey, ColumnKey, Timestamp/Version
  - sharded into *regions* along an ordered RowKey space

- Within each region:
  - Data is grouped into column families
  - Sort order within each column family:

    Row Key (asc), Column Key (asc), Timestamp (desc)

Example: Inbox Search

- Schema
  - Key: RowKey: userid, Column: word, Version: MessageID
  - Value: Auxillary info (like offset of word in message)

- Data is stored sorted by <userid, word, messageID>:

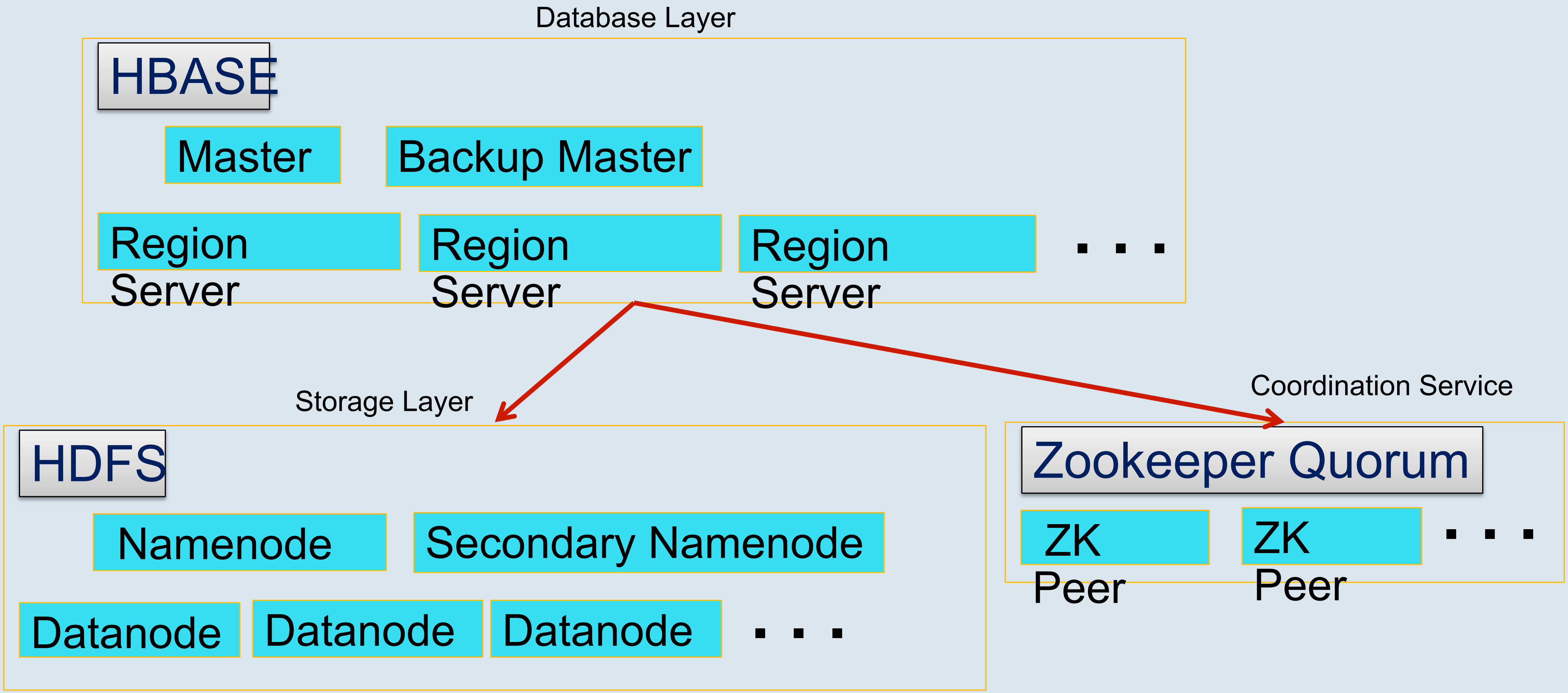
```
User1:hi:17->offset1
User1:hi:16->offset2
User1:hello:16->offset3
User1:hello:2->offset4
...
User2:....
User2:...
...
```

Can efficiently handle queries like:

- Get top N messageIDs for a specific user & word

- Typeahead query: for a given user, get words that match a prefix

HBase System Overview



Database Layer

HBASE

Master

Backup Master

Region Server

Region Server

Region Server

. . .

Storage Layer

HDFS

Namenode

Secondary Namenode

Datanode

Datanode

Datanode

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Coordination Service

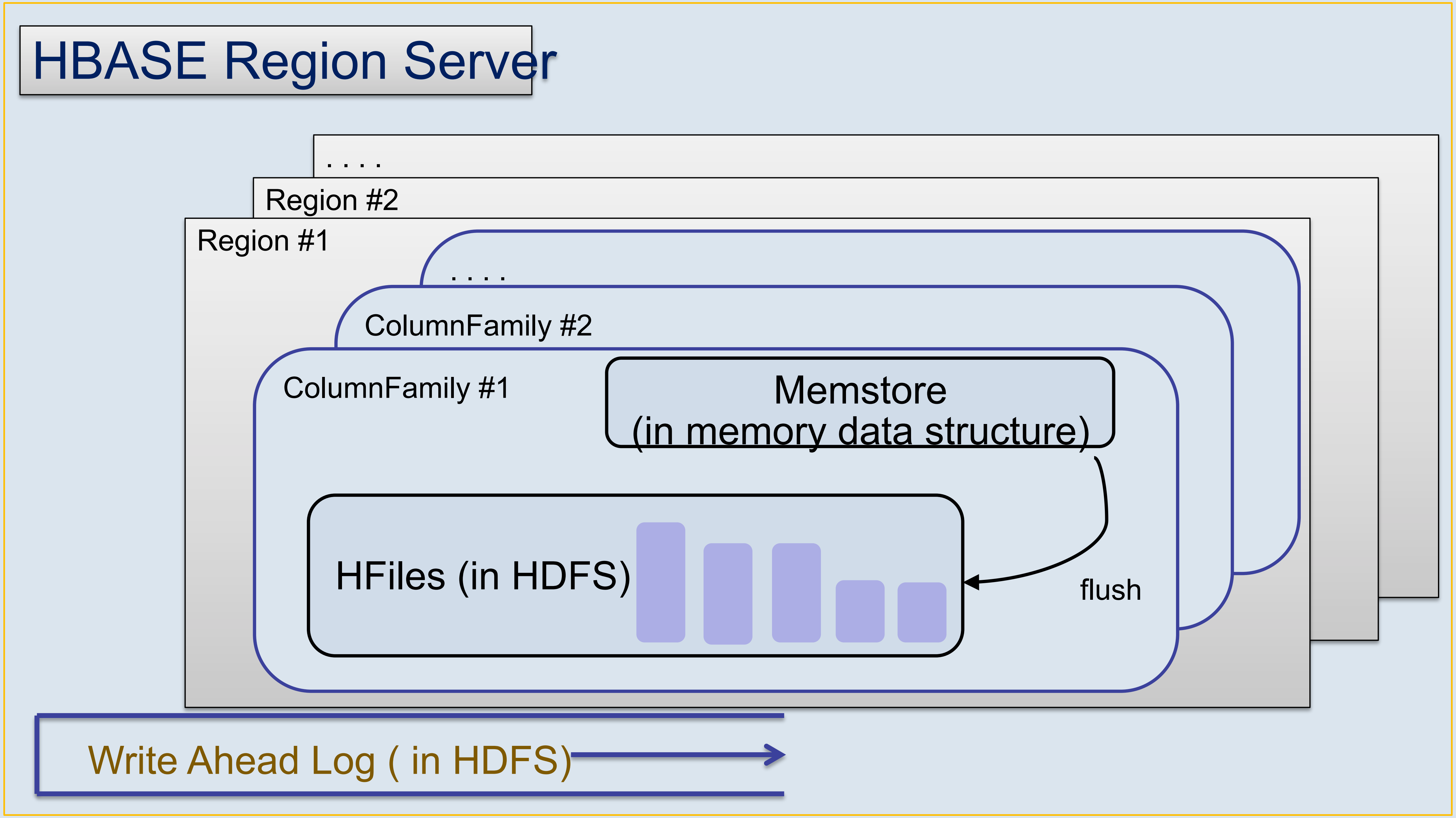
Zookeeper Quorum

ZK Peer

ZK Peer

. . .

HBase Overview



HBase Overview

- Very good at random reads/writes

- Write path
  - Sequential write/sync to commit log
  - update memstore

- Read path
  - Lookup memstore & persistent HFiles
  - HFile data is sorted and has a block index for efficient retrieval

- Background chores
  - Flushes (memstore -> HFile)
  - Compactions (group of HFiles merged into one)

Why HBase?

Performance is great, but what else…

Horizontal scalability

- HBase & HDFS are elastic by design
- Multiple table shards (regions) per physical server
- On node additions
  - Load balancer automatically reassigns shards from overloaded nodes to new nodes
  - Because filesystem underneath is itself distributed, data for reassigned regions is instantly servable from the new nodes.
- Regions can be *dynamically* split into smaller regions.
  - Pre-sharding is not necessary
  - Splits are near instantaneous!

Automatic Failover

- Node failures automatically detected by HBase Master
- Regions on failed node are distributed evenly among surviving nodes.
    - Multiple regions/server model avoids need for *substantial* overprovisioning
- HBase Master failover
    - 1 active, rest standby
    - When active master fails, a standby automatically takes over

HBase uses HDFS

We get the benefits of HDFS as a storage system for free

- Fault tolerance (block level replication for redundancy)
- Scalability
- End-to-end checksums to detect and recover from corruptions
- Map Reduce for large scale data processing
- HDFS already battle tested inside Facebook
  - running petabyte scale clusters
  - lot of in-house development and operational experience

Simpler Consistency Model

- HBase’s strong consistency model
    - simpler for a wide variety of applications to deal with
    - client gets same answer no matter which replica data is read from

- Eventual consistency: tricky for applications fronted by a cache
    - replicas may heal *eventually* during failures
    - but stale data could remain stuck in cache

Other Goodies

- Block Level Compression
  - save disk space
  - network bandwidth
- Block cache
- Read-modify-write operation support, like counter increment
- Bulk import capabilities

HBase Enhancements

Goal of Zero Data Loss/Correctness

- *sync* support added to hadoop-20 branch
  - for keeping transaction log (WAL) in HDFS
  - to guarantee durability of transactions
- *atomicity* of transactions involving multiple column families
- Fixed several critical bugs, e.g.:
  - Race conditions causing regions to be assigned to multiple servers
  - region name collisions on disk (due to crc32 encoded names)
  - Errors during log-recovery that could cause:
    - transactions to be incorrectly skipped during log replay
    - deleted items to be resurrected

Zero data loss (contd.)

- Enhanced HDFS’s Block Placement Policy:
  - Default Policy: rack aware, but minimally constrained
    - non-local block replicas can be on any other rack, and any nodes within the rack
  - New: Placement of replicas constrained to configurable node groups
  - Result: Data loss probability reduced by orders of magnitude

Availability/Stability improvements

- HBase master rewrite- region assignments using ZK
- Rolling Restarts – doing software upgrades without a downtime
- Interruptible compactions
  - Being able to restart cluster, making schema changes, load-balance regions quickly without waiting on compactions
- Timeouts on client-server RPCs
- Staggered major compaction to avoid compaction storms

Performance Improvements

- Compactions
  - critical for read performance
  - Improved compaction algo
  - delete/TTL/overwrite processing in minor compactions
- Read optimizations:
  - Seek optimizations for rows with large number of cells
  - Bloom filters to minimize HFile lookups
  - Timerange hints on HFiles (great for temporal data)
  - Improved handling of compressed HFiles

Performance Improvements (contd.)

- Improvements for large objects
    - threshold size after which a file is no longer compacted
        - rely on bloom filters instead for efficiently looking up object
    - safety mechanism to never compact more than a certain number of files in a single pass
        - To fix potential Out-of-Memory errors
    - minimize number of data copies on RPC response

Working within the Apache community

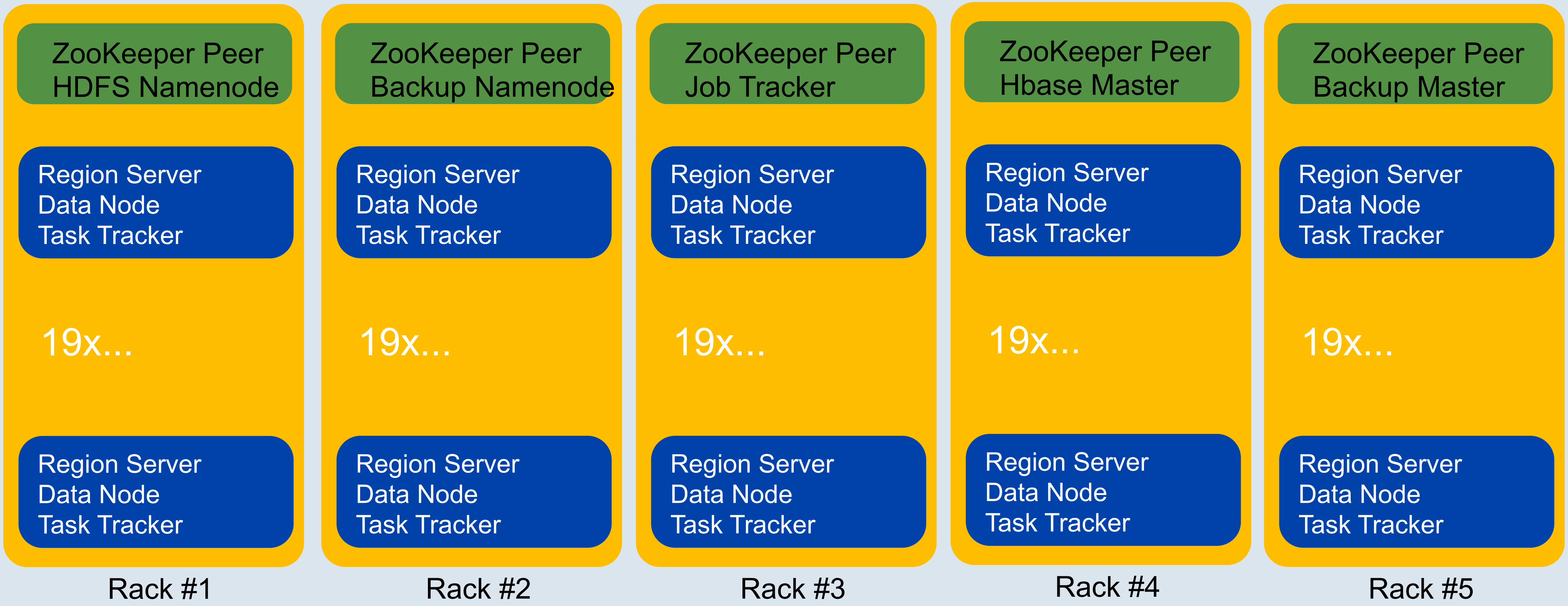
- Growing with the community
  - Started with a stable, healthy project
  - In house expertise in both HDFS and HBase
  - Increasing community involvement
- Undertook massive feature improvements with community help
  - HDFS 0.20-append branch
  - HBase Master rewrite
- Continually interacting with the community to identify and fix issues
  - e.g., large responses (2GB RPC)

Operational Experiences

- Darklaunch:
  - shadow traffic on test clusters for continuous, at scale testing
  - experiment/tweak knobs
  - simulate failures, test rolling upgrades
- Constant (pre-sharding) region count & controlled rolling splits
- Administrative tools and monitoring
  - Alerts (HBCK, memory alerts, perf alerts, health alerts)
  - auto detecting/decommissioning misbehaving machines
  - Dashboards
- Application level backup/recovery pipeline

Typical Cluster Layout

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



ZooKeeper Peer
HDFS Namenode

Region Server
Data Node
Task Tracker

19x...

Region Server
Data Node
Task Tracker

Rack #1

ZooKeeper Peer
Backup Namenode

Region Server
Data Node
Task Tracker

19x...

Region Server
Data Node
Task Tracker

Rack #2

ZooKeeper Peer
Job Tracker

Region Server
Data Node
Task Tracker

19x...

Region Server
Data Node
Task Tracker

Rack #3

ZooKeeper Peer
Hbase Master

Region Server
Data Node
Task Tracker

19x...

Region Server
Data Node
Task Tracker

Rack #4

ZooKeeper Peer
Backup Master

Region Server
Data Node
Task Tracker

19x...

Region Server
Data Node
Task Tracker

Rack #5

Data migration

Another place we used HBase heavily…

Move messaging data from MySQL to HBase

- In MySQL, inbox data was kept normalized
  - user’s messages are stored across many different machines
- Migrating a user is basically one big join across tables spread over many different machines
- Multiple terabytes of data (for over 500M users)
- Cannot pound 1000s of production UDBs to migrate users

How we migrated

- Periodically, get a full export of all the users' inbox data in MySQL
- And, use bulk loader to import the above into a *migration* HBase cluster
- To migrate users:
  - Since users may continue to receive messages during migration:
    - double-write (to old and new system) during the migration period
  - Get a list of all recent messages (since last MySQL export) for the user
    - Load new messages into the *migration* HBase cluster
    - Perform the join operations to generate the new data
    - Export it and upload into the final cluster

Facebook Insights

Real-time Analytics using HBase

Facebook Insights Goes Real-Time

- Recently launched real-time analytics for social plugins on top of HBase
- Publishers get real-time distribution/engagement metrics:
    - # of impressions, likes
    - analytics by
        - Domain, URL, demographics
        - Over various time periods (the last hour, day, all-time)
- Makes use of HBase capabilities like:
    - Efficient counters (read-modify-write increment operations)
    - TTL for purging old data

Future Work

It is still early days…!

- Namenode HA (AvatarNode)
- Fast hot-backups (Export/Import)
- Online schema & config changes
- Running HBase as a service (multi-tenancy)
- Features (like secondary indices, batching hybrid mutations)
- Cross-DC replication
- Lot more performance/availability improvements

Thanks! Questions?

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