BlueRunner: Building an Email Service in the Cloud

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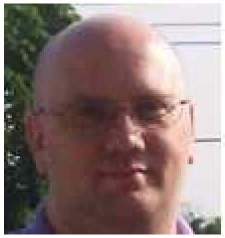
Apache Cassandra Committer

The Team

User Systems and Experience Research



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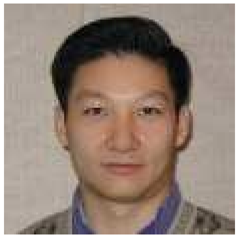


Jun Rao

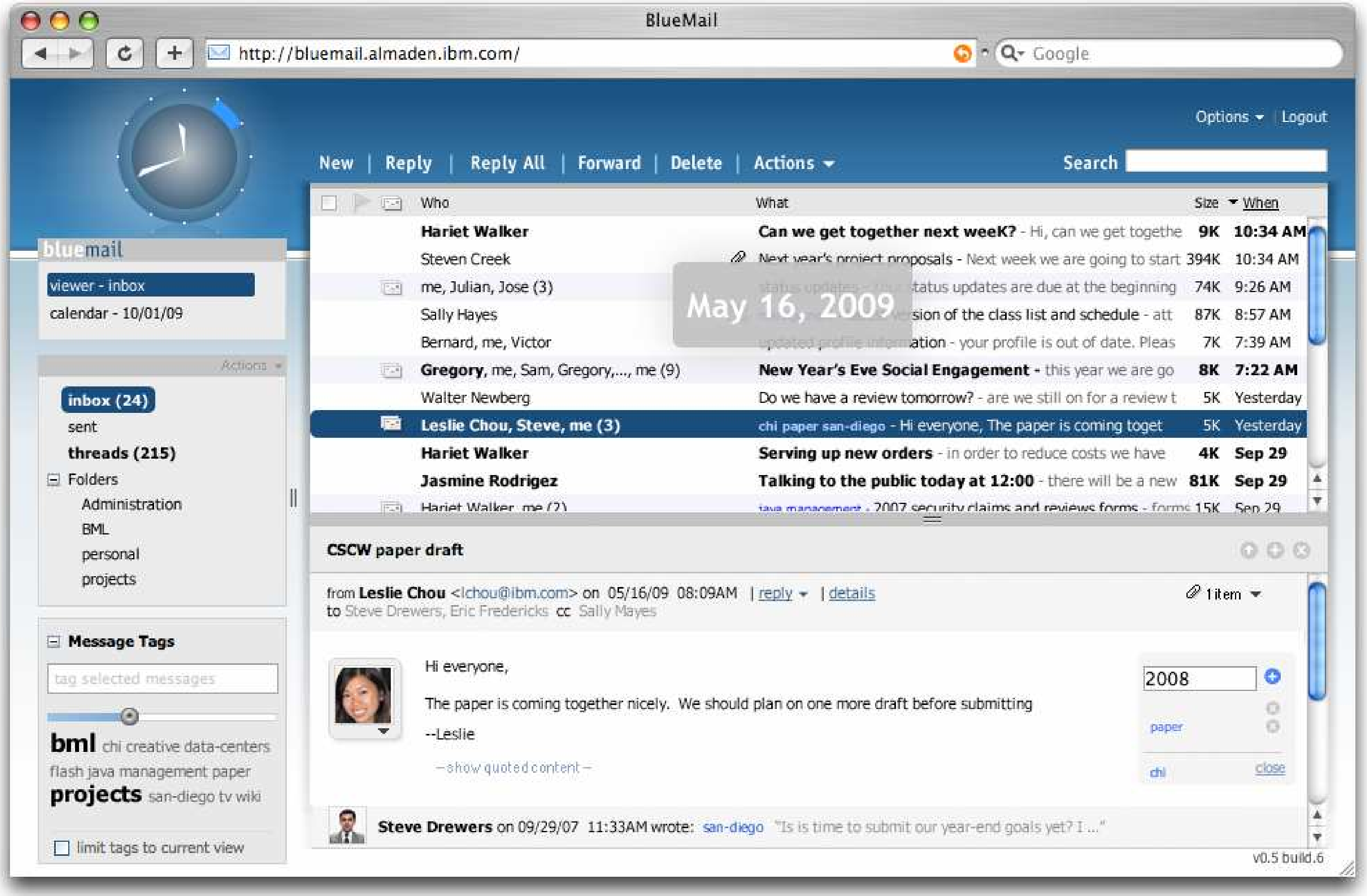
Outline

- BlueRunner overview
- Scalable Row Stores
- BlueRunner design in Cassandra
- Preliminary performance results
- Summary

What’s BlueRunner

- Research prototype for hosted emails at IBM ARC
- Browser-based email client + Cassandra backend
  - 3+ years on the client
  - ~1 year on the Cassandra backend
- Many advanced features in client
  - Scrolling
  - Foldering/Tagging
  - Sorting/Pivoting
  - Threading
  - Orienteering and Usability Improvements
- Backend
  - Thin client; most operations pushed to the backend
  - Designed for large-scale hosted environment
    - 100K mailboxes, each with 100K messages

How does the client look?



Who	What	Size	When
Hariet Walker	**Can we get together next weeK?** - Hi, can we get togethe	**9K**	**10:34 AM**
Steven Creek	Next year's project proposals - Next week we are going to start	394K	10:34 AM
me, Julian, Jose (3)	status updates - your status updates are due at the beginning	74K	9:26 AM
Sally Hayes	[illegible] version of the class list and schedule - att	87K	8:57 AM
Bernard, me, Victor	updated profile information - your profile is out of date. Pleas	7K	7:39 AM
Gregory, me, Sam, Gregory,..., me (9)	**New Year's Eve Social Engagement -** this year we are go	**8K**	**7:22 AM**
Walter Newberg	Do we have a review tomorrow? - are we still on for a review t	5K	Yesterday
Leslie Chou, Steve, me (3)	chi paper san-diego - Hi everyone, The paper is coming toget	5K	Yesterday
Hariet Walker	**Serving up new orders** - in order to reduce costs we have	**4K**	**Sep 29**
Jasmine Rodrigez	**Talking to the public today at 12:00** - there will be a new	**81K**	**Sep 29**
Hariet Walker, me (2)	java management - 2007 security claims and reviews forms - forms	15K	Sep 29

CSCW paper draft

from **Leslie Chou** <lchou@ibm.com> on 05/16/09 08:09AM | reply | details
to Steve Drewers, Eric Fredericks cc Sally Mayes

Hi everyone,

The paper is coming together nicely. We should plan on one more draft before submitting

--Leslie

– show quoted content –

Steve Drewers on 09/29/07 11:33AM wrote: san-diego "Is is time to submit our year-end goals yet? I ..."

Why a new backend?

Limitations in Traditional DBs	
Fault-tolerance relies on expensive reliable storage	limiting scalability
Weak elasticity--- hard to grow a cluster incrementally	
No automatic load-balancing	
Rigid relational schema	mismatch for many apps
No versioning support	

The Cloud Landscape for Scalable Backend

LinkedIn
Google App Engine
apache CouchDB relax
facebook
Y!
PNUTS
amazon web services™
Amazon SimpleDB™ BETA
Sun
APACHE
mongoDB
{name: "mongo", type: "db"}

Voldemort

BigTable

Cassandra

Drizzle

HBase

- **Flurry of activity in this space motivated by**
  - RDBMS too rigid/heavy for some apps
  - Existing RDBMS engines missing many key cloud requirements

What is a Scalable Row Store?

- Middle ground btw a DBMS and a file system
  - Much simpler API then SQL
  - Designed to scale

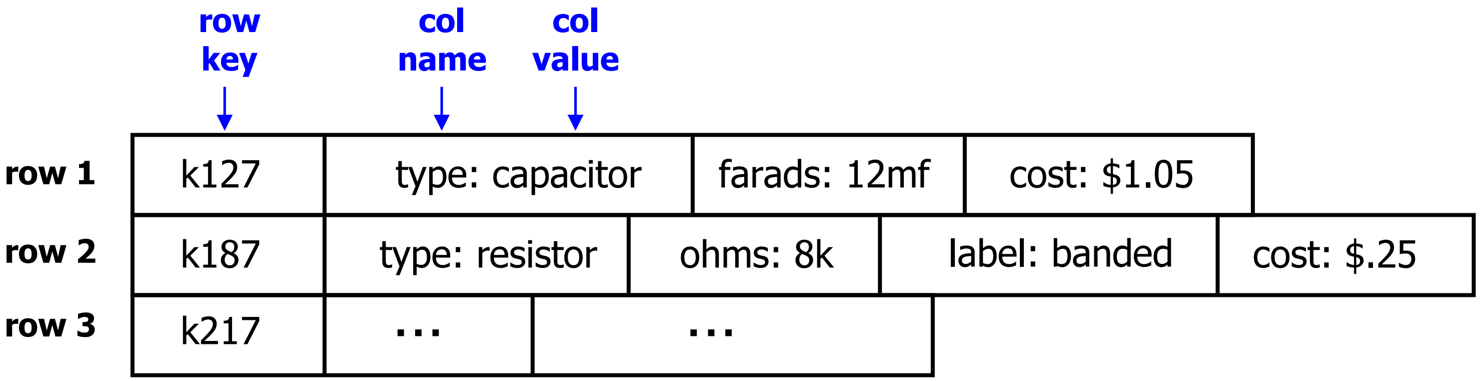
Limitations in Traditional DBs	**Scalable Row Stores**
Fault-tolerance relies on expensive reliable storage	Fault-tolerance done in software; replication on commodity disks
Weak elasticity--- hard to grow a cluster incrementally	Can grow a cluster incrementally and online
No automatic load-balancing	Built-in automatic load-balancing
Rigid relational schema	No strong schema required
No versioning support	Built-in versioning

Cassandra

- Google’s Bigtable data model + Amazon’s Dynamo scalable architecture
- Developed by Facebook in 2007
  - Used in production for a few apps (e.g., inbox search for 200M users)
- Became an Apache Incubator project early 2009
  - active community
  - additional committers from Rackspace and IBM
  - contributors from Digg, Twitter, etc

Cassandra Data Model

- Familiar relational tables, rows, and columns, but more flexible
  - No upfront schema required
  - New columns can be added any time and columns can vary from row to row



row key

col name

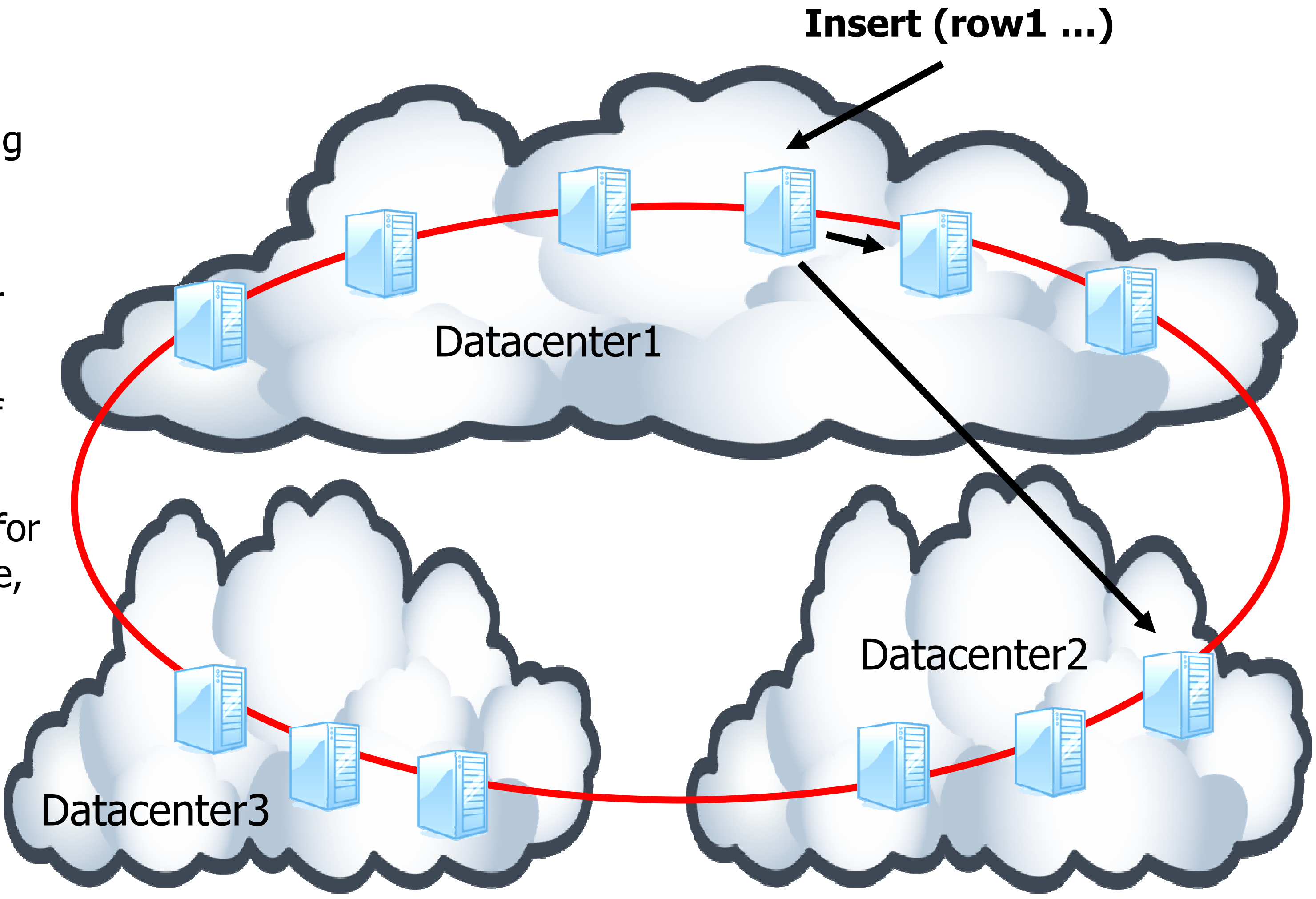
col value

row 1	k127	type: capacitor	farads: 12mf	cost: $1.05	
row 2	k187	type: resistor	ohms: 8k	label: banded	cost: $.25
row 3	k217	...	...		

- Columns grouped into Column Families
  - Column families are stored separately (like vertical partitioning)

Cassandra Distributed Architecture

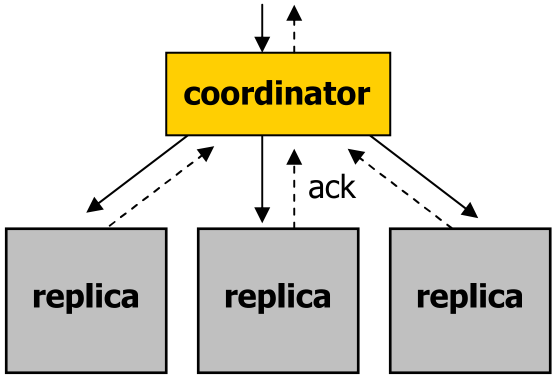
- Based on DHT ring
- Replication cross-rack and cross-datacenter (sync or async)
- No single point of failure
- Gossip protocols for membership, failure, DHT map, etc



Scale, Fault-tolerance, Elasticity, Low-cost

Eventual Consistency

- **CAP Theorem** [Brewer00]
  - Can only get 2 of **C**onsistency, **A**vailability, or **P**artition tolerance
- Cassandra relaxes **C** to eventual consistency
  - Emphasis is on performance and availability
  - Allow concurrent read/write to any replica – latest write wins on conflict
- **Knobs to tradeoff consistency and performance**
  - Writes are sent to all N replicas in parallel
  - Can choose to read from **R** replicas and wait for **W** acks for writes
  - Tune R and W to 1,2,3…,N for latency requirements



coordinator acts as a
simple state machine

Email Schema in Cassandra

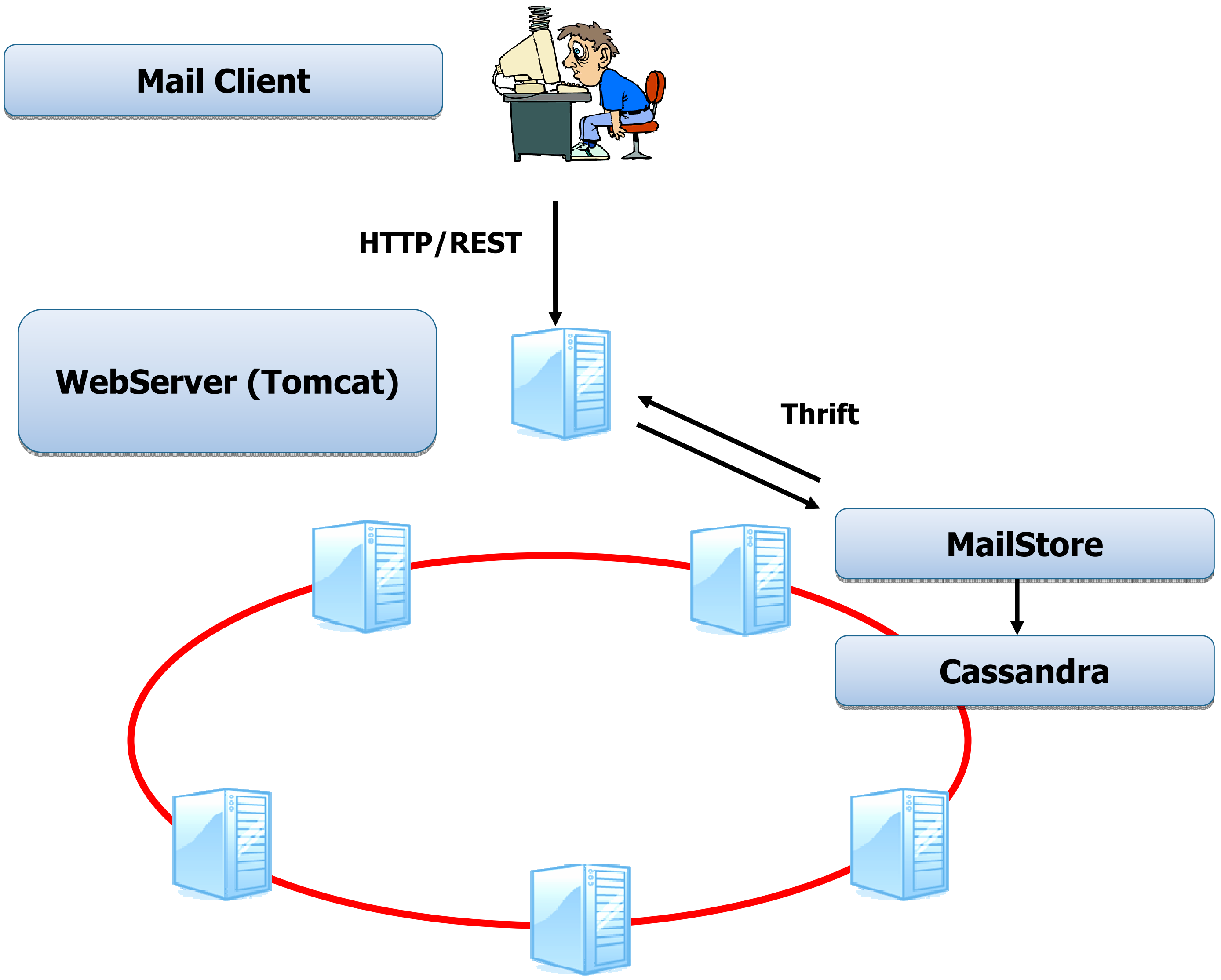
- Row key - User id
  - All data for one user is on a single node
  - Currently no sharing of messages across users
- Column Families
  - MailList - Message id : full message
  - HeaderList - Message id : message headers + metadata
  - CollectionIndex - Collection id + sort key : message id

    e.g., Inbox/Date/2009-07-10-14:20:56 : message1000
    Inbox/Sender/Mike Brown : message1000
  - Others
    - CollectionMetadata, ThreadList, ThreadIndex
- Full message stored separately from index and metadata
- Data format - JSON

Typical Operations

- Cassandra APIs used
  - get_column(row, CF, column)
  - get_columns(row, CF, columns[])
  - get_slice(row, CF, startColumn, asc/desc, count)
  - Efficient with row/column index support in Cassandra
- ListMessages
  - get_slice(Jun, CollectionIndex, Inbox/Date/current_date/, desc, 50) to obtain the first 50 messageIDs in Inbox
  - get_columns(Jun, HeaderList, messageID[])
- GetMessage
  - get_column(Jun, MailList, messageID)
- SortMessages by Sender
  - get_slice(Jun, CollectionIndex, Inbox/Sender//, asc, 50)
  - get_columns(Jun, HeaderList, messageID[])

BlueRunner Deployment



Mail Client

HTTP/REST

WebServer (Tomcat)

Thrift

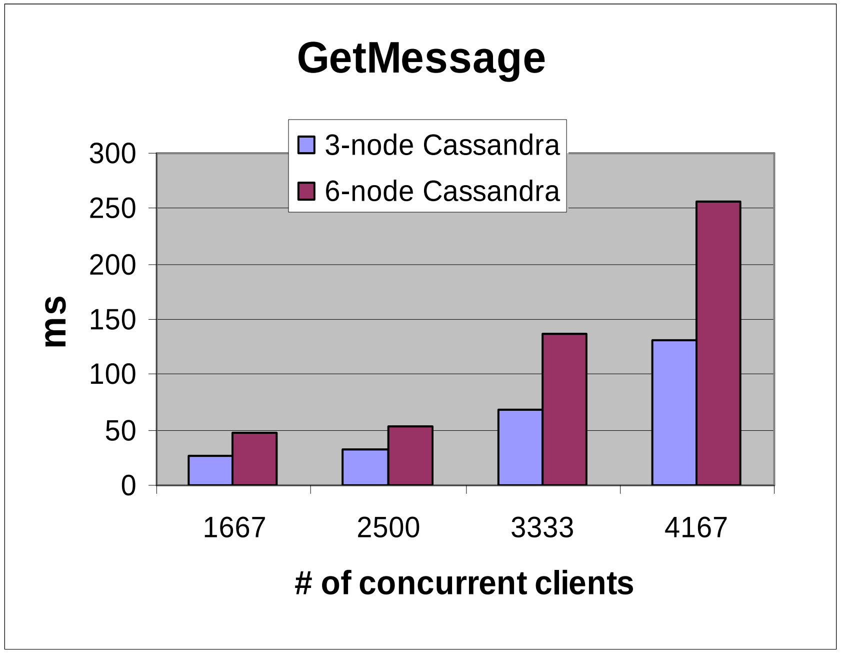
MailStore

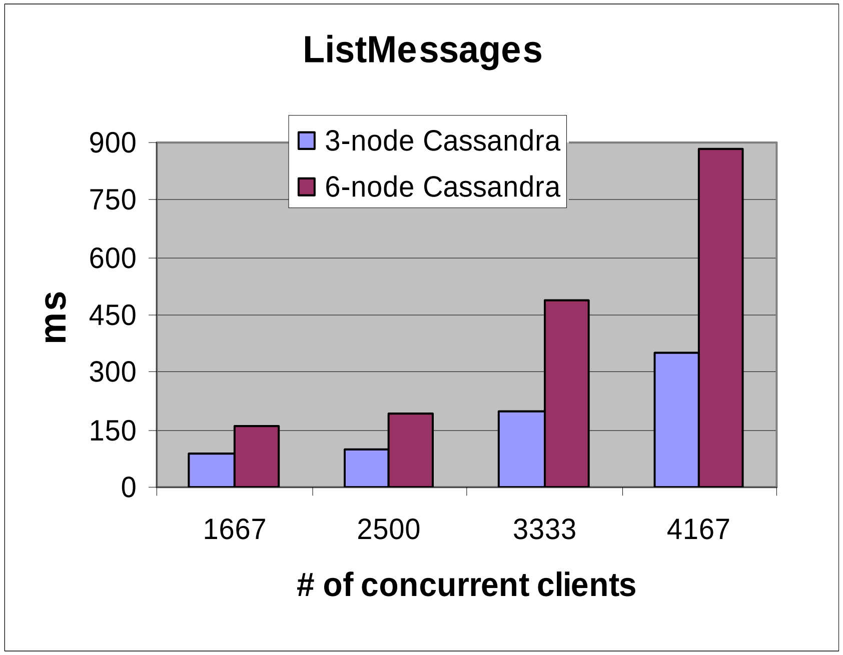
Cassandra

Experimental Setup

- 6-node cluster and each node with
  - 2 quad-core CPUs
  - 16 GB memory
  - 5 SATA disks (1 for Cassandra commit log and 4 for data)
- Data
  - generated 1800 mailboxes per node
    - 250-16K messages per mailbox
    - ~50GB w/o replication
  - Cassandra replication set to 2
- Workload
  - Varying # of concurrent clients from 1600 to 4100 per node
  - Each client repeatedly
    - opens up an inbox
    - looks at a few message
    - go to sleep for a while

Preliminary Result (median response time in ms)





- Able to sustain 2500 concurrent clients per node with reasonable response time
  - average: ~100 requests per sec per node

Summary

- Cassandra-based backend very promising
  - Enabling scalability, availability, and elasticity
  - Flexible data model a good fit
- Future work
  - Many places can be improved
    - Alternative schema design
    - Secondary index/full-text index support
    - Enabling MapReduce-based analytics on the backend
  - Other potential collaborative apps on Cassandra
  - Research on better reasoning btw consistency and availability