Migrating to Cassandra in the Cloud, the Netflix Way

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Tech History, 1998-2008

- In the beginning, there was the webapp
  - and a single database
  - in a single datacenter
- Then Netflix grew, and grew, and grew
  - More databases, all linked
  - Database links, PL/SQL, materialized views
  - Multi-Master Replication (MMR)

History, 2008

- Then it melted down (Aug 2008)
  - Hardware driver
  - “one in a billion chance”
- Couldn’t ship DVDs for ~5 days

History, 2009

- Time to rethink everything
  - Abandon our datacenter
  - Ditch the monolithic webapp
  - Migrate SPOF database
- On-demand streaming was becoming the thing!

History, 2010

- SimpleDB
  - Managed by Amazon
  - Got us started with NoSQL in the cloud
  - Problems:
    - High latency, rate limiting (throttling)
    - (no) auto-sharding, no backups
    - We were running at 10x the intended capacity

History, 2011-now

- Cassandra
  - Similar to SImpleDB, but with limits removed
  - Dynamo-style, master-less system
  - Great multi-datacenter support
  - Written in Java

Cassandra in 3 minutes

- Dynamo and Big Table papers
- CAP Theorem: AP
  - Eventually consistent

- Distributed hash table
  - Each node takes range on ring
- Replication
  - RF = how many copies to keep
  - Within datacenter (shard across nodes)
  - Across datacenters (full data set)
- Peer-to-peer
  - Gossip
  - Failure detection

- Anti-Entropy protocols
  - Hinted handoff
  - Read repair
  - Node repair

- Writes
  - mmap'd commit log files
  - Mutations buffered in memtable
  - Flushed to immutable files (sstable)
- Reads
  - Check all sstables for key
  - Bloom filter used for IO optimization

- Compactions
  - Several styles, but basically reduce the number of sstables by merging data
  - Eliminate expired/deleted data
  - I/O & CPU intensive

- Tunable Consistency
  - 1, 2, Quorum (local, each), All
- Columnar, Key-Value storage
  - Schema-less
  - Denormalization (wide rows)
- Cassandra Query Language (CQL)

Cassandra at Netflix

By the numbers…

Production clusters	> 65
Production nodes	> 2000
Multi-region clusters	> 40
Most regions used	4 (three clusters)
Total data	300 TB
Largest cluster size	144 nodes (three clusters)
Max reads/writes	300k rps, 1.2m wps

Example 1

- Subscriber data
- Wide row implementation
  - Row key = customer id
  - Column for each attribute about a subscriber
    - id, name, subscription plan details, holds, …

Example 2

- Movie Ratings
- New ratings initially stored flat (per subscriber)
- Recurring job to aggregate into JSON blob
- Reads grab JSON blob + new writes

Example 3

- Edge Services scripts
  - Versioned, executable Groovy scripts
  - Inefficient query read _entire_ table
  - Created inverted index to get IDs
    - Roll-your-own indices in Cassandra

Life in the cloud

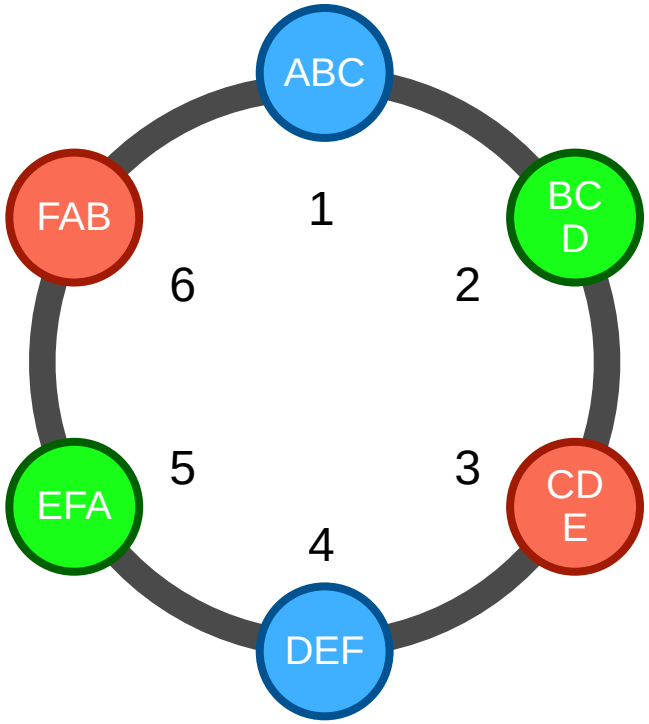
Cloud life

- AWS is our home
  - Availability Zones (AZ)
  - Regions
- All Cassandra clusters run in multiple AZs within each region
- Some clusters on multiple regions

Resiliency

- We use Cassandra replication factor = 3 / region
  - Stripe data across AZs

Availability Zone 1	1 4
Availability Zone 2	2 5
Availability Zone 3	3 6



Priam

- Co-process that runs next to Cassandra on every node
- Manages
  - Backup/restore
  - Cassandra bootstrap / token assignment
  - Centralized configuration management
- github.com/netflix/priam

Priam – AWS Cluster Management

- Assigns tokens to nodes at instance launch
- Stores token->node assignments in external datastore
  - Reference implementation uses SimpleDB
  - Netflix uses another Cassandra cluster
- Stripes neighbor node token in different availability zones
- Supports multi-region Cassandra deployments

Priam, Backup and Restore

- Automate Cassandra snapshots
  - Nightly backups
- Copy all Cassandra artifacts to S3
  - Snappy compression
  - Throttled, multi-part upload
  - Data imported to our BI system (Aegisthus)
- Restore (full or partial)
  - Common for prod -> test refresh

Secondary backup

- Stand alone app for disaster recovery
- Copies all previous day's artifacts:
  - Secondary Amazon account
  - Secondary cloud provider
- Longer TTL than primary backup

Java client libraries

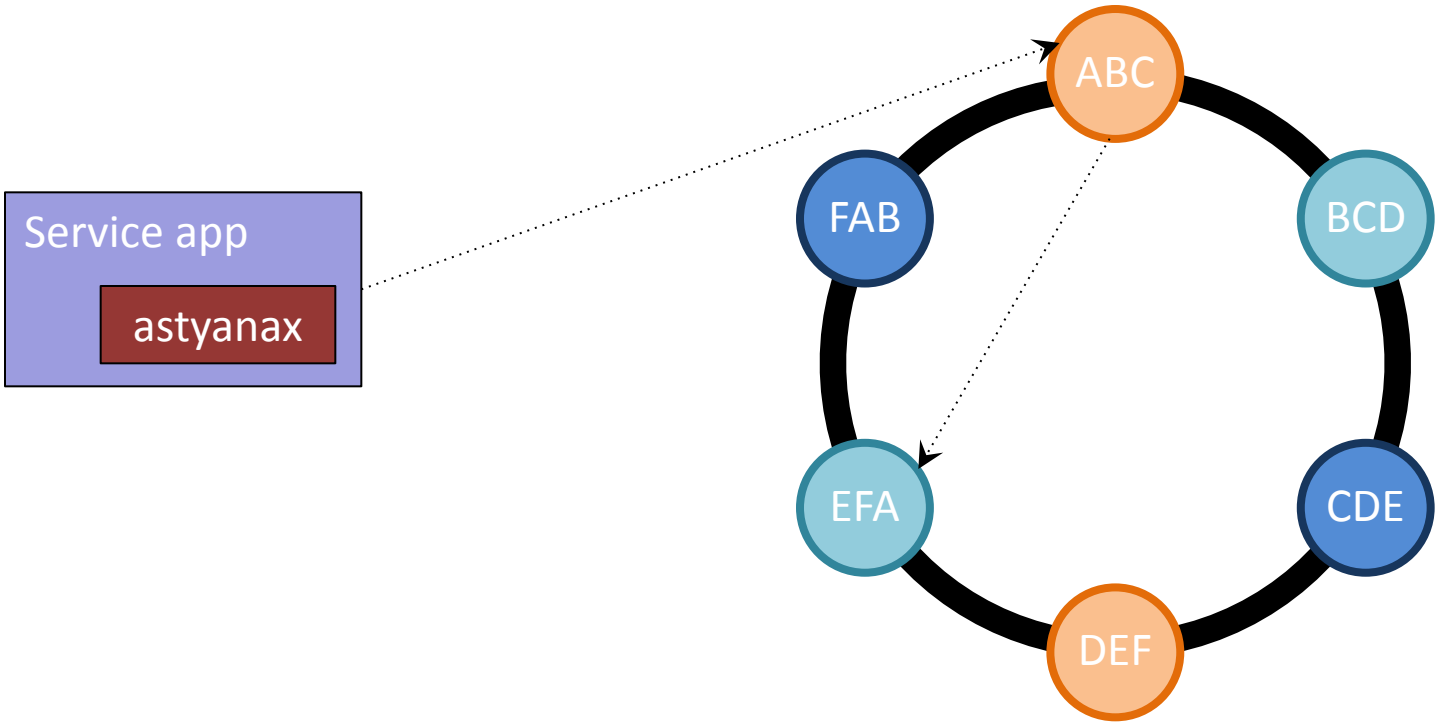
- Hector
  - https://github.com/hector-client/hector
- Astyanax
  - Developed by Netflix
  - https://github.com/netflix/astyanax
- Cassandra Java Driver
  - Developed by DataStax
  - https://github.com/datastax/java-driver

Astyanax

- Clean object model
- Cassandra node discovery
- Node quarantine
- Request failover/retry
- JMX monitoring
- Connection pooling
- Futures execution for timing out long-running queries

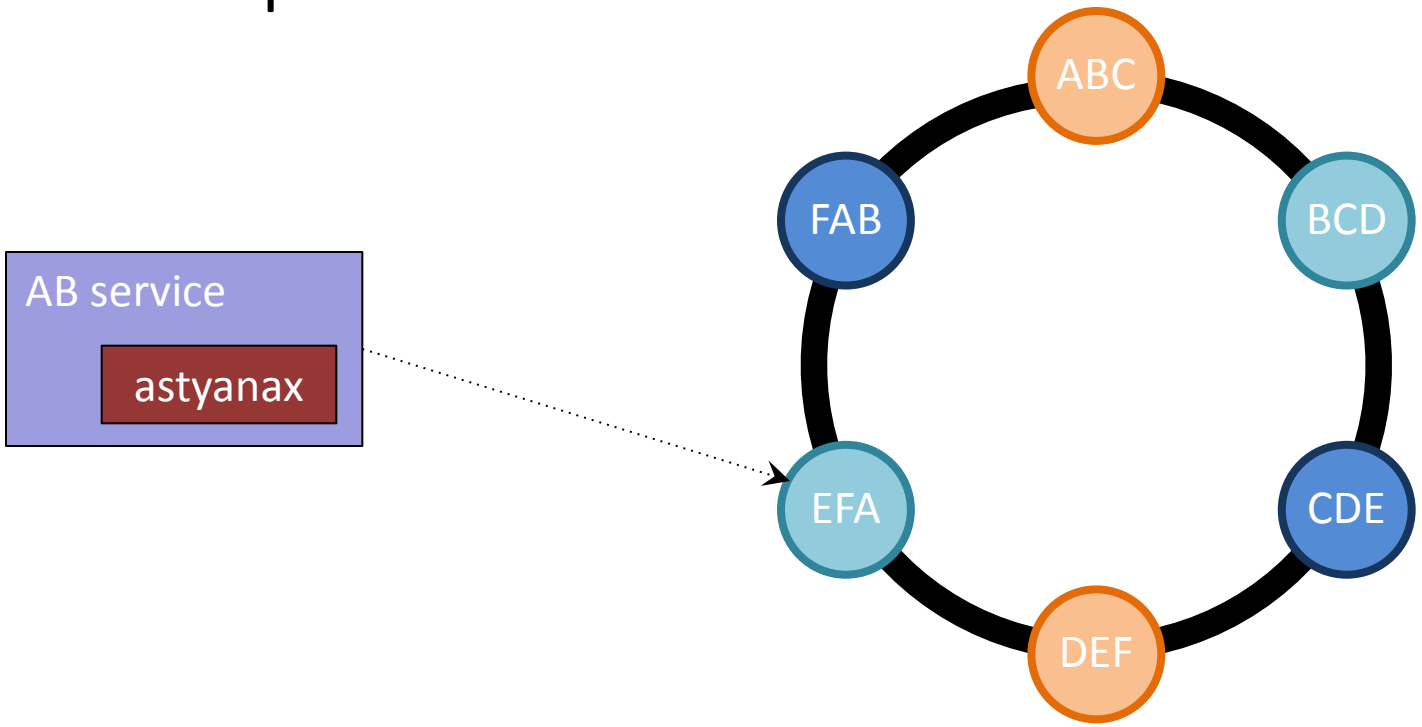
Astyanax, Round Robin pool

- Round Robin uses coordinator node to determine a node with data



Astyanax, Token-Aware pool

- Token aware knows where the data resides
- Great for point reads



Challenges of running Cassandra in the cloud

Building for/Deploying in AWS

- Every application change is a new:
  - Build artifact (war, tar, library)
  - AMI (Amazon Machine Image)
  - Auto Scale Group
  - Instance Launch
- No hand-modified configurations in production

… but Cassandra is different

- We can't drop/launch new instances endlessly
  - We have state!
- Updates are done in place on existing instances
  - Bootstrapping new nodes not free
- We turn over instances at a slow rate

Misbehaving nodes

- Node death happens
  - Just ‘disappears’
  - Disk failure
- EBS wonkiness
  - Currently, root mount is EBS-mounted

Networking

- Network flapping causes Cassandra to see peers as UP, DOWN, UP, DOWN, UP ….
- Causes
  - Weird latency statistics
  - request failure if partitioning is really bad
  - Anti-entropy (hints)
  - This is good – system as a whole did not fail

hi1.4xlarge

- SSDs in the cloud!
- Welp, not sooo fast
  - Higher IOPs, better latencies
  - Not quite like SSD on bare metal

BI integration

- Didn't want BI to run monster distributed queries on prod clusters
- Instead, they:
  - grab the nightly backups
  - Export to JSON
  - Import to Hadoop
  - Find new data
  - Import to Hive, Teradata, etc.

Developer education

- Data model re-think
  - Denormalization
  - Client query tuning is different
  - Eventual consistency

Takeaways

- Netflix is making all of our components distributed and fault tolerant as we grow domestically and internationally.
- Cassandra is a core piece of our cloud infrastructure.
- Netflix is open sourcing it's cloud platform, including Cassandra support (Astyanax, Priam, more to come).

Thank you!