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Apache Cassandra

From POC to PROD: Twelve sprints of Cassandra

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Agenda

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- Sprint 1 Data modeling
- Sprint 2 Cluster sizing
- Sprint 3 Stress test
- Sprint 4 Data modeling (revisit)
- Sprint 5 Analytics
- Sprint 6 Security
- **Sprint 7 Go Live**
- Sprint 8 Monitoring
- Sprint 9 Hello Compaction and Repair
- Sprint 10 Large partition and tombstone
- Sprint 11 Cluster expansion

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Sprint 0: Choosing Cassandra

Why people choose Cassandra?

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High availability

Linear scalability

Low latency

When is Cassandra a good choice?

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Schema relatively stable

Access pattern predictable

Update / delete infrequent

IOT / Timeseries / Transactions are good example

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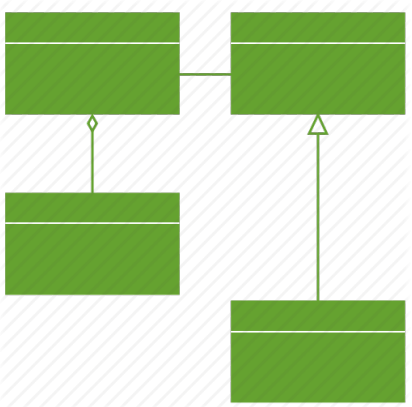
Sprint 1: Data Modeling



Quick introduction to Cassandra

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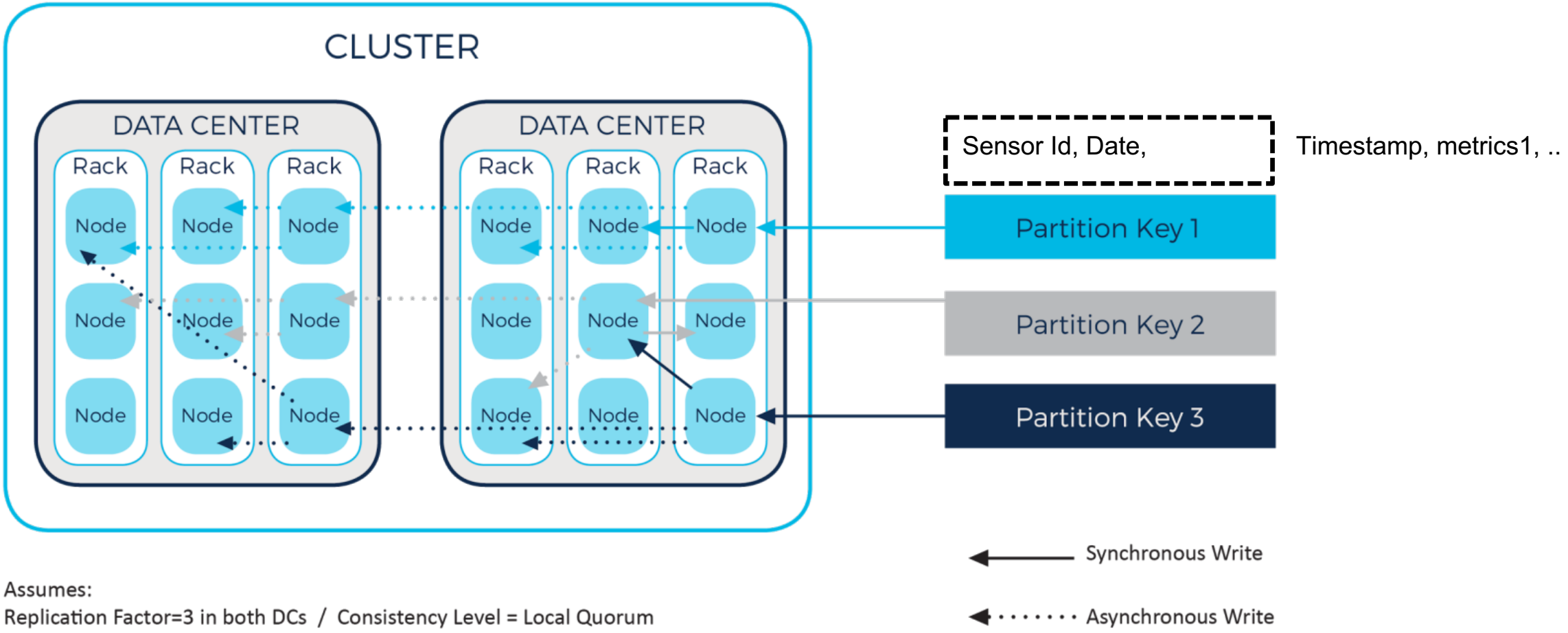

Partitioning

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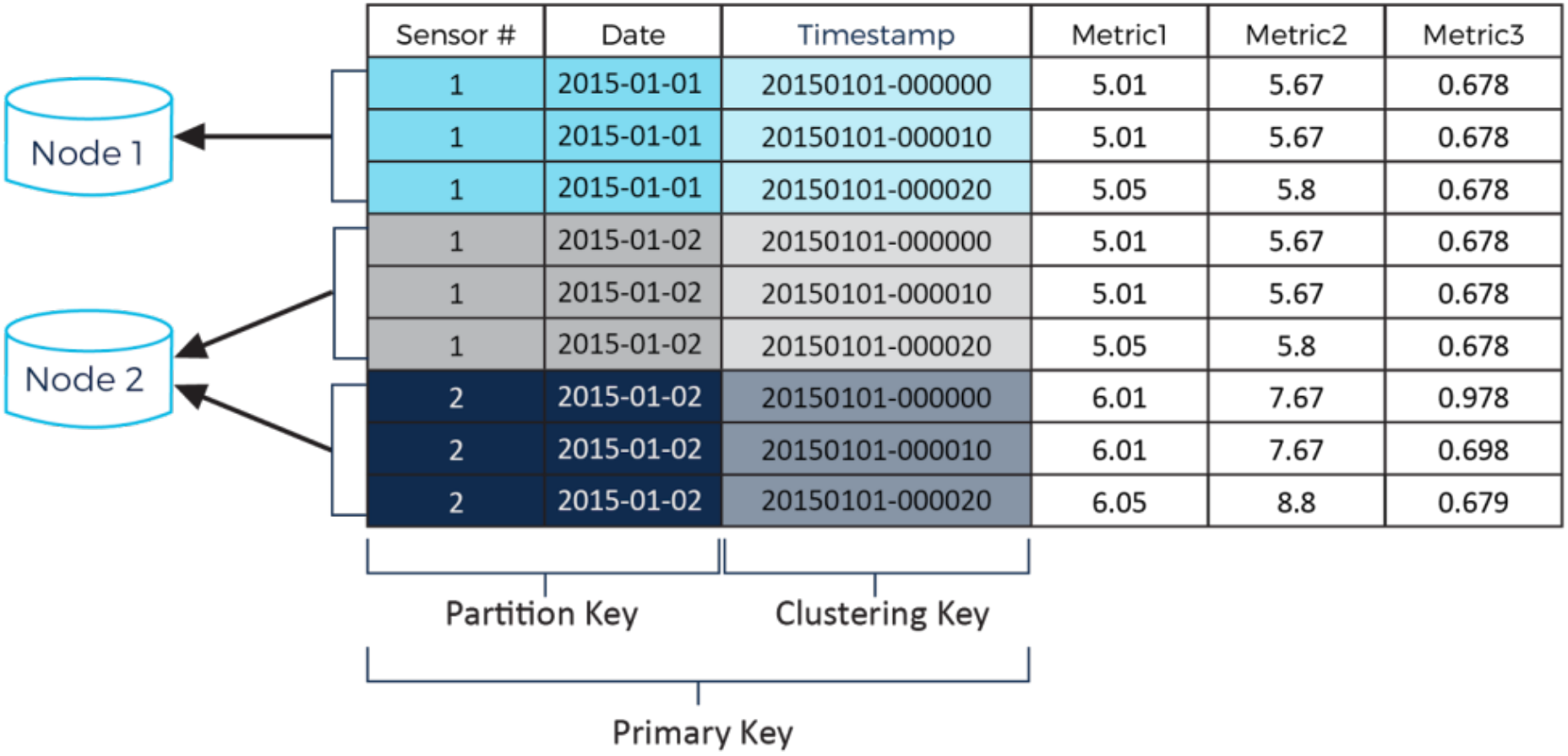

Sensor #	Date	Timestamp	Metric1	Metric2	Metric3
1	2015-01-01	20150101-000000	5.01	5.67	0.678
1	2015-01-01	20150101-000010	5.01	5.67	0.678
1	2015-01-01	20150101-000020	5.05	5.8	0.678
1	2015-01-02	20150101-000000	5.01	5.67	0.678
1	2015-01-02	20150101-000010	5.01	5.67	0.678
1	2015-01-02	20150101-000020	5.05	5.8	0.678
2	2015-01-02	20150101-000000	6.01	7.67	0.978
2	2015-01-02	20150101-000010	6.01	7.67	0.698
2	2015-01-02	20150101-000020	6.05	8.8	0.679

PRIMARY KEY ((Sensor,Date),Timestamp)

Design Approach

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- Phase 1: Understand the data
  - Define the data domain: E-R logical model
  - Define the required access patterns: how will you select an update data?
- Phase 2: Denormalize based on access patterns
  - Identify primary access entities: driven by the access keys
  - Allocate secondary entities: denormalize by pushing up or down to the primary entities
- Phase 3: Review & tune
  - Review partition keys and clusters
    - Do partition keys have sufficient cardinality?
    - Is the number of records in each partition bounded?
    - Does the design consider delete and update impact?
  - Test & tune: check updates, review compaction strategy

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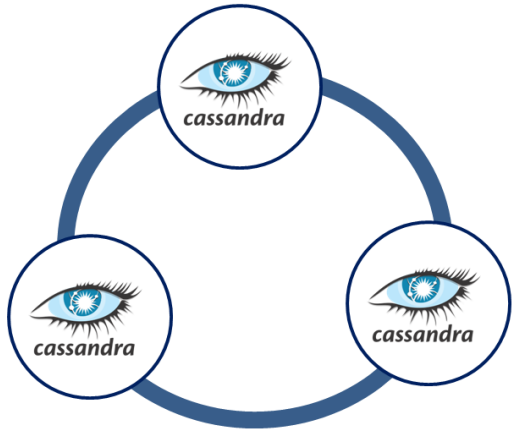
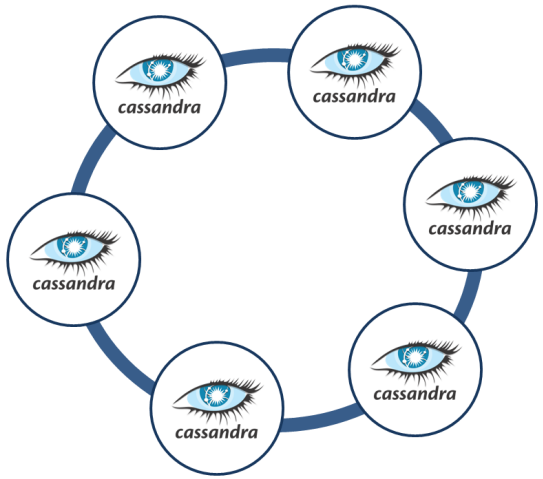
Sprint 2: Cluster Sizing





Cluster sizing: consideration

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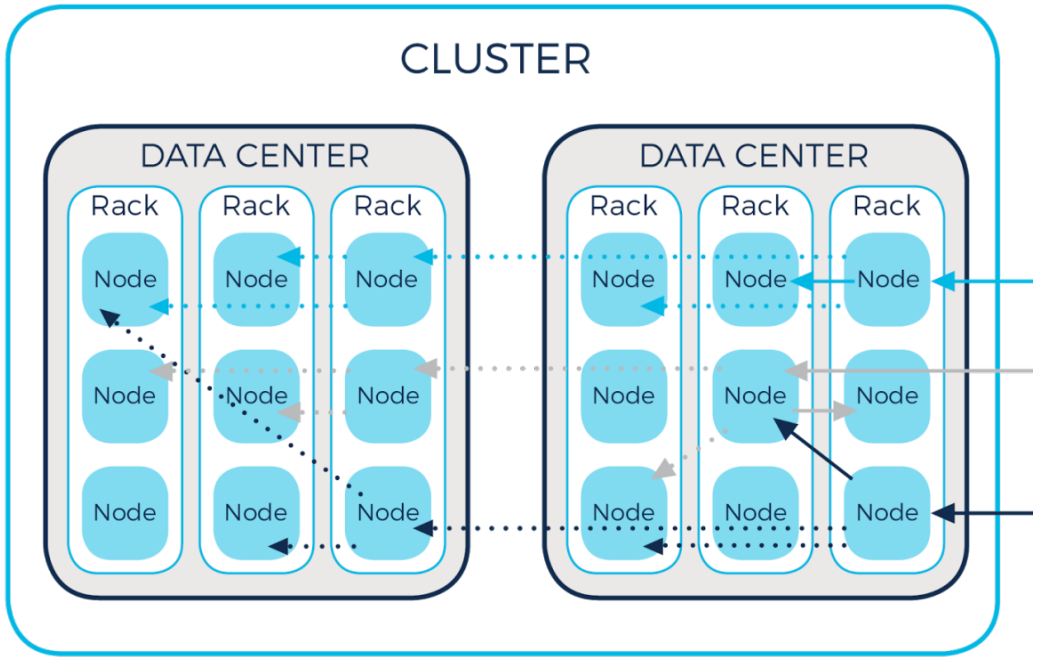
- Disk usage (RF / MV)
- Read / Write throughput driven
- Availability / Consistency desired



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Sprint 3: Stress test

Testing Cassandra applications

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- Long running tests with background load are vital
  - Can run extremely high write loads for an hour or two but might take days to catch up on compactions
  - Don’t forget repairs
- Make sure your data volumes on disk are representative as well as read/write ops - cache hit rates can make a big difference to performance
- Mirror production data demographics as closely as possible (eg partition size)
- Don’t forget to include update/delete workload if applicable
- For core cassandra features, can test on reduce size and rely on scale-up but beware:
  - Secondary indexes
  - MVs
  - LWTs

Testing in practice

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- Cassandra-test for synthetic testing
  - https://www.instaclustr.com/deep-diving-into-cassandra-stress-part-1

- JMeter for application level testing.
- JMeter / Cassandra plugin

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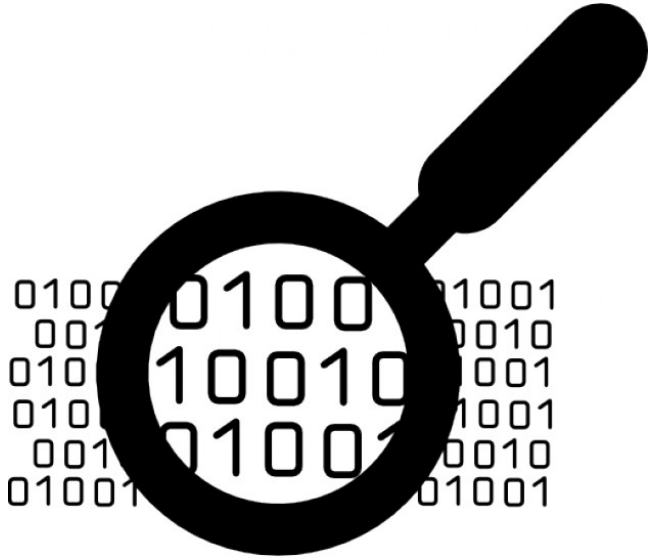
Sprint 4: Data modeling - revisit



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I want to query by a, or b, or c

-> Materialized view

```
CREATE TABLE my_ks.my_tb (a int PRIMARY KEY, b int, c int, d int);

CREATE MATERIALIZED VIEW my_ks.my_tb_by_b AS
   SELECT a, b, c, d
   FROM my_ks.my_tb
   WHERE a IS NOT NULL AND b IS NOT NULL
   PRIMARY KEY (b, a);
```

I want to query by a, b, c, d, e, f, a+c, d+e …..

-> Stratio Lucene

-> DSE search (Solr)

-> Elassandra (Cassandra + Elasticsearch)

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Sprint 5: Analytics (and data migration)

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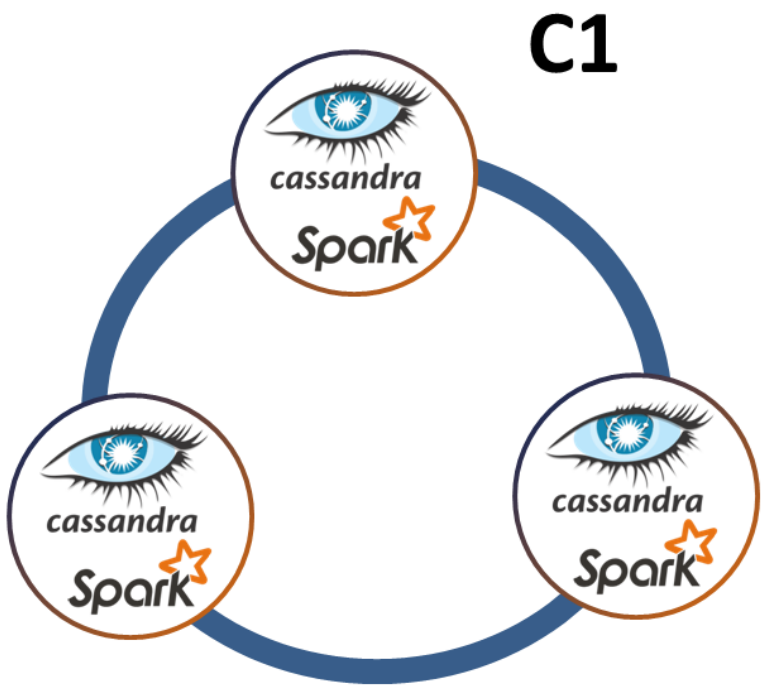
Cassandra => fast => no join.

Spark on Cassandra



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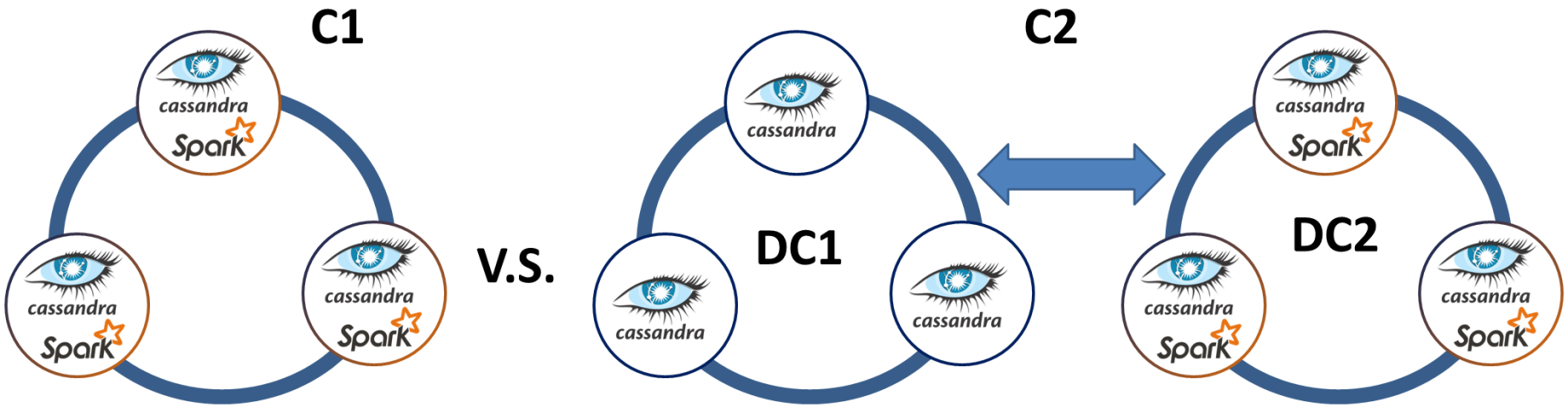
https://www.instaclustr.com/multi-data-center-apache-spark-and-apache-cassandra-benchmark/



output.throughput_mb_per_sec
input.fetch.size_in_rows
input.reads_per_sec

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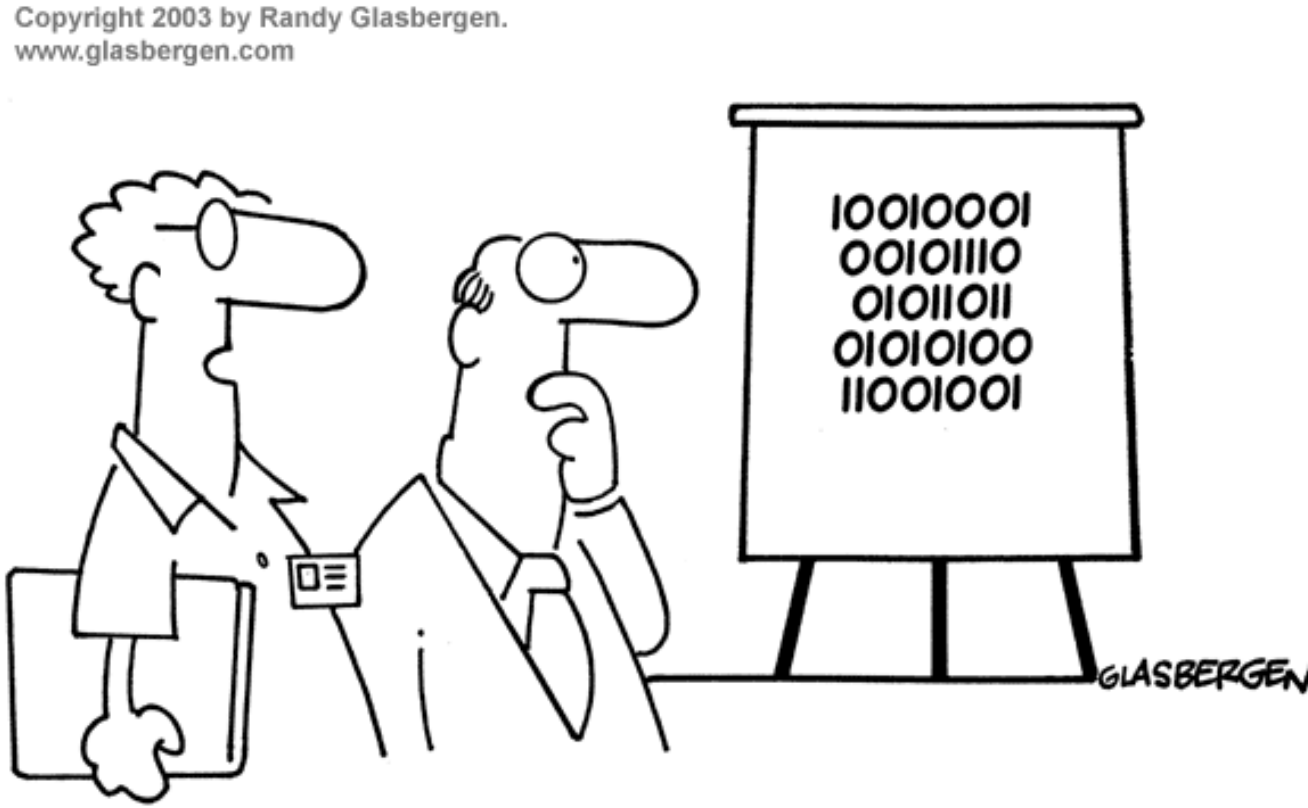
Sprint 6: Security



"We've devised a new security encryption code. Each digit is printed upside down."

Security

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- At a minimum
  - Enable password auth
  - Enable client->server encryption (particularly if using public IPs to connect)
  - Enable internode encryption
  - Don’t use the default Cassandra user
  - Set up some read only user
- Best practice
  - Encrypt sensitive data at the client
    - Works well with typical C* access patterns where PK values are hashed anyway
    - Dates are the most common case of range selects and typically are not sensitive if other identifying data is encrypted

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Sprint 7: Go Live!

Everything works!

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Sprint 8: Monitoring and Alerting

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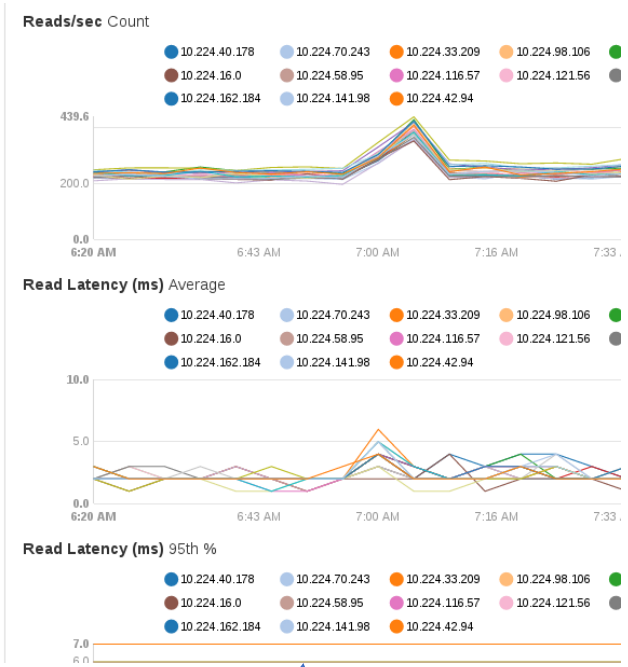
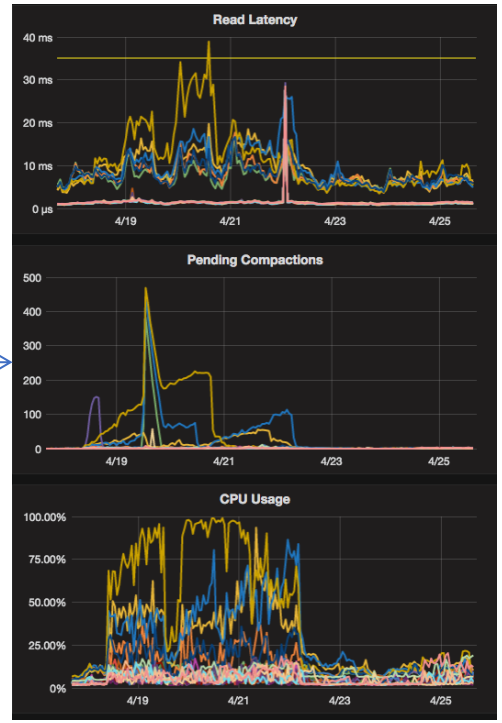


Instaclustr console

JMX_exporter + prometheus + Grafana



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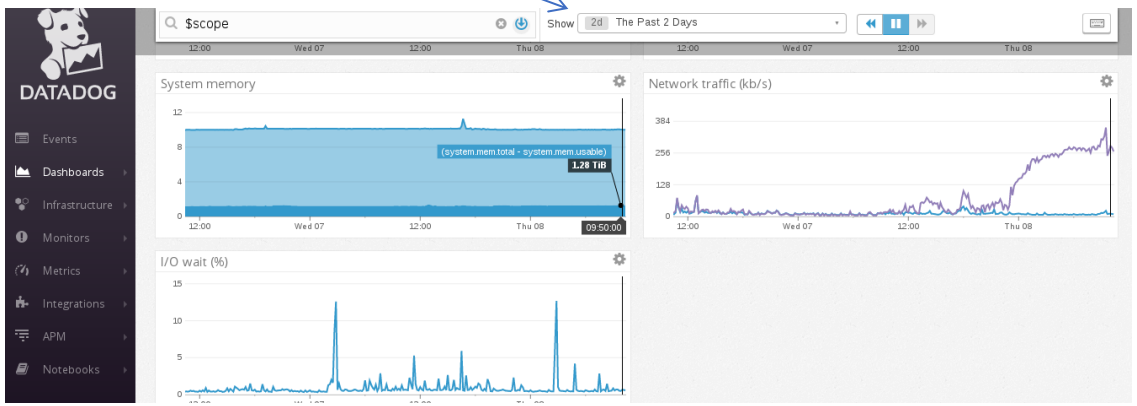

Monitoring Cassandra (Metrics + Alerting)

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Metric	Description	Frequency
**Node Status	Nodes DOWN should be investigated immediately. `org.apache.cassandra.net:type=FailureDetector`	*Continuous, with alerting*
**Client read latency	Latency per read query over your threshold `org.apache.cassandra.metrics:type=ClientRequest,scope=Read`	*Continuous, with alerting*
**Client write latency	Latency per write query over your threshold `org.apache.cassandra.metrics:type=ClientRequest,scope=Write`	*Continuous, with alerting*
CF read latency	Local CF read latency per read, useful if some CF are particularly latency sensitive.	*Continuous if required*
Tombstones per read	A large number of tombstones per read indicates possible performance problems, and compactions not keeping up or may require tuning	*Weekly checks*
SSTables per read	High number (>5) indicates data is spread across too many SSTables	*Weekly checks*
**Pending compactions	Sustained pending compactions (>20) indicates compactions are not keeping up. This will have a performance impact. `org.apache.cassandra.metrics:type=Compaction,name=PendingTasks`	*Continuous, with alerting*

*Items marked ** give an overall indication of cluster performance and availability*

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Sprint 9: Compaction and Repair

Compaction Intro

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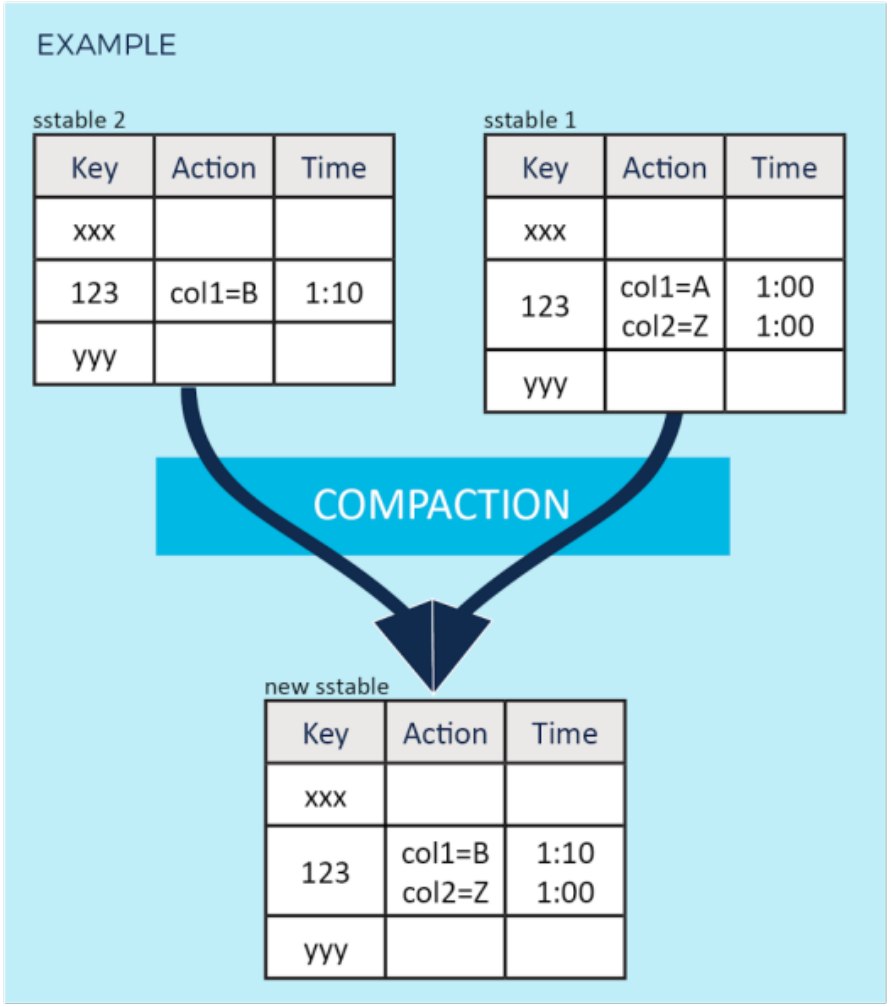
- Cassandra never updates sstable files once written to disk
- Instead all inserts and updates are essentially (logically) written as transaction logs that are reconstituted when read
- Compaction is the process of consolidating transaction logs to simplify reads
- It's an ongoing background process in Cassandra
- Compaction ≠ Compression



Repair Intro

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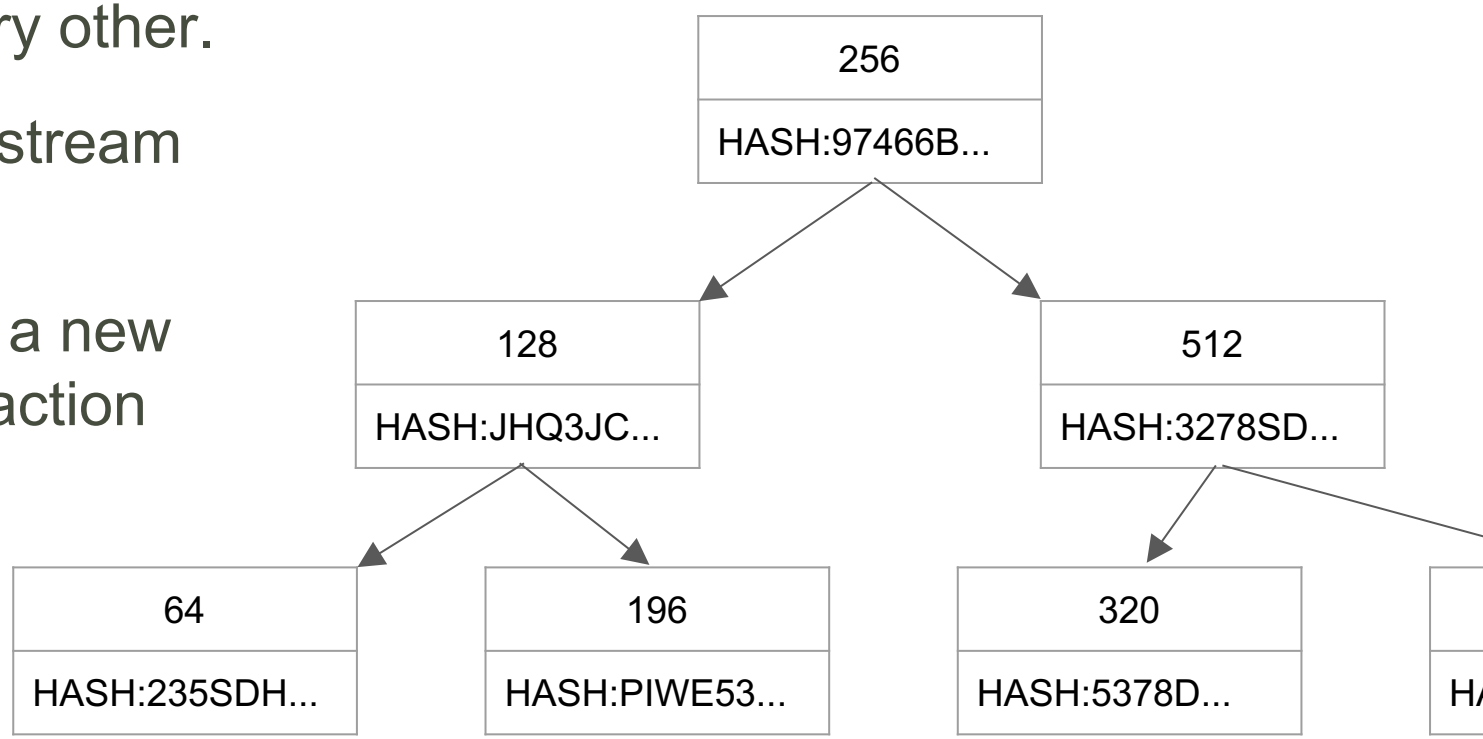
- Reads every SSTable to be repaired
- Generates a merkle tree of data read.
- Send merkle tree to replicas, each replica compares each tree against every other.
- Any differences, Cassandra will stream the missing data
- Streamed data will be written as a new SSTable generating more compaction



Compaction and Repair

- Regular compactions are an integral part of any healthy Cassandra cluster.
- Repairs need to be run to ensure data consistency every gc_grace period.
- Can have a significant **disk**, **memory** (GC), **cpu**, IO overhead.
- Are often the cause of “unexplained” **latency** or IO issues in the cluster.
- Repair has a number of different strategies (sequential, parallel, incremental, sub range).
- Choose one that works best for you (likely to be either sub range or incremental).

Monitoring Compactions/Repair

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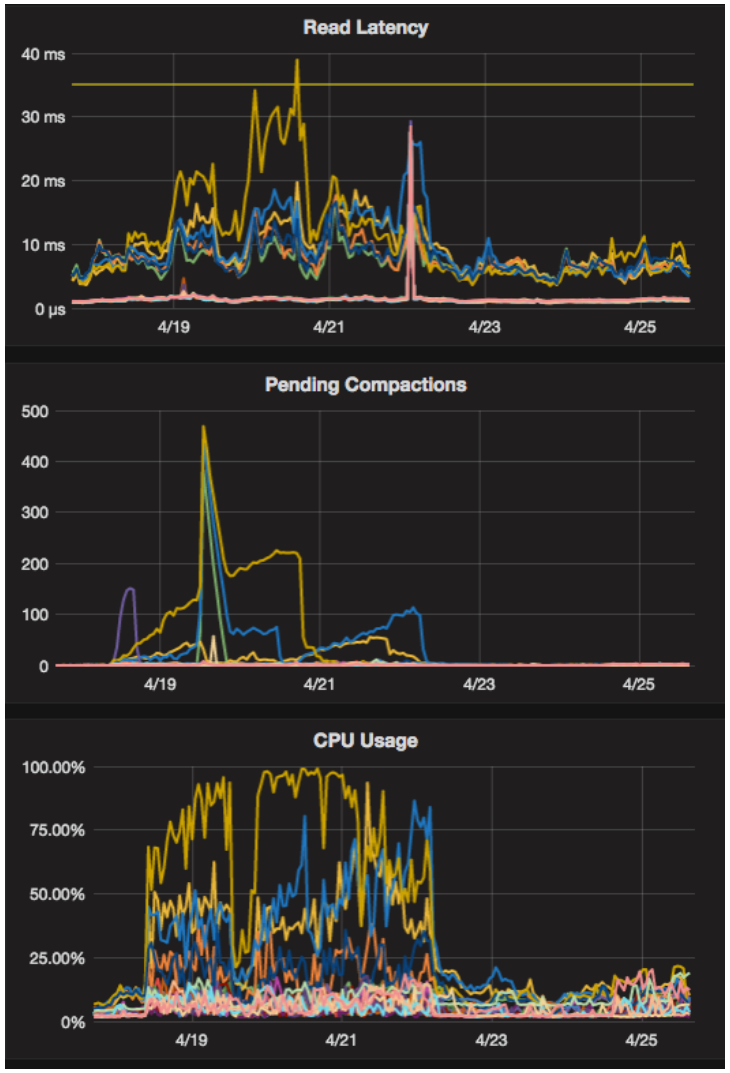
- Monitor with nodetool compactionstats, tpstats & netstats

```
~ $ nodetool compactionstats -H
pending tasks: 518
   compaction type   keyspace   table   completed       total    unit
progress
        Compaction       data      cf    18.71 MB   111.16 MB   bytes
16.83%
Active compaction remaining time :   0h00m05s
```

- A single node doing compactions can cause latency issues **<u>across the whole cluster</u>**, as it will become slow to respond to queries.
- Repair can often be the cause a large spike in compactions



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Sprint 10: Large partition and tombstone

Otherwise known as chasing 9's

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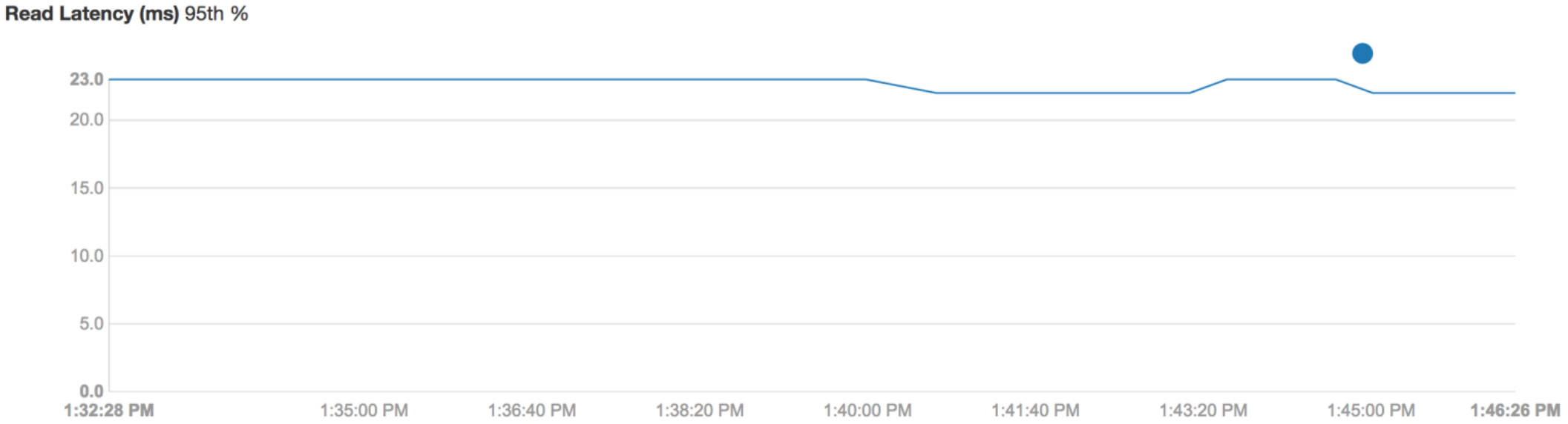

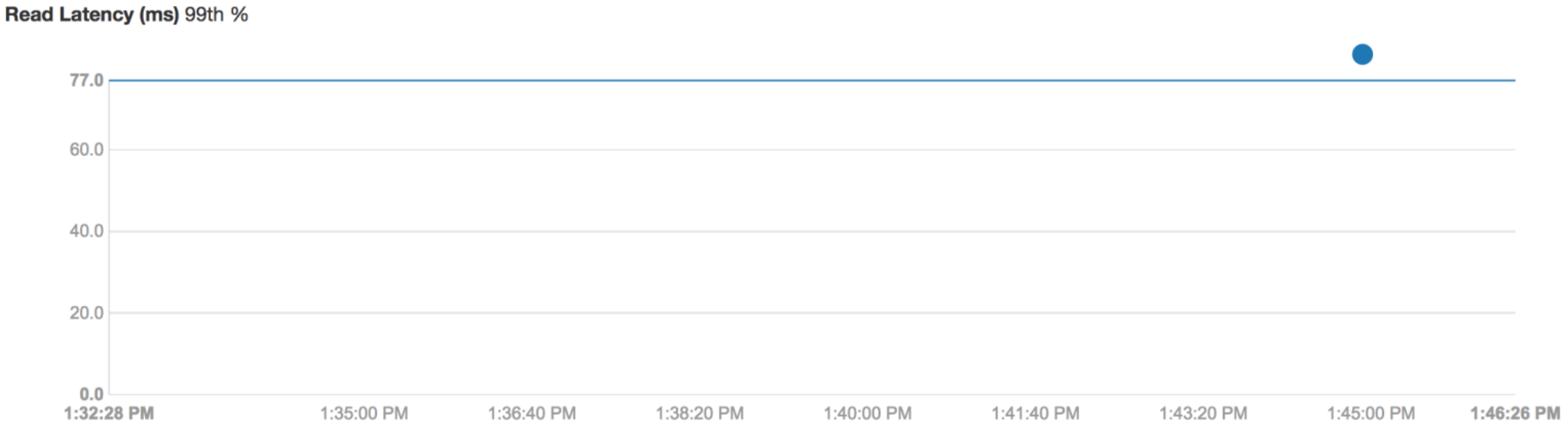

Partitioning: Diagnosing & Correcting

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- Diagnosing
  - Overlarge partitions will also show up through long GC pauses and difficulty streaming data to new nodes
  - nodetool cfstats and nodetool cfhistograms provide partition size info. <10MB green, <100MB amber
  - Log file warnings - compacting large partition
  - Many issues can be identified from data model review
- Correcting
  - Correcting generally requires data model change although depending on the application, application level change may be possible

Examples of Large partitions

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```
~ $ nodetool cfstats -H keyspace.columnfamily
  …
  Compacted partition minimum bytes: 125 bytes
  Compacted partition maximum bytes: 11.51 GB
  Compacted partition mean bytes: 844 bytes
$ nodetool cfhistograms keyspace columnfamily
```

Percentile	SSTables	Write Latency (micros)	Read Latency (micros)	Partition Size (bytes)	Cell Count
50%	1.00	14.00	124.00	372	2
75%	1.00	14.00	1916.00	372	2
95%	3.00	24.00	17084.00	1597	12
98%	4.00	35.00	17084.00	3311	24
99%	**5.00**	**50.00**	**20501.00**	**4768**	**42**
Min	0.00	4.00	51.00	125	0
Max	**5.00**	**446.00**	**20501.00**	**12359319162**	**129557750**

Tombstones

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- When a row is **deleted** in C* it is marked with a tombstone (virtual delete). Tombstones remain in the sstables for at least 10 days by default.
- A high ratio of tombstones to live data can have significant negative performance impacts (**latency**)
- Be wary of tombstones when: deleting data, updating with nulls or updating collection data types.
- **Diagnosing**
  - nodetool cfstats/cfhistograms and log file warnings
  - slow read queries, sudden performance issues after a bulk delete
- **Correcting**
  - tune compaction strategy - LCS or TWCS can help in the right circumstances
  - reduce GC grace period & force compaction for emergencies
  - review data model/application design to reduce tombstones

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Sprint 11: Cluster expansion

Cluster Changes

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Including:

- Adding and removing nodes
- Replacing dead nodes
- Adding a Data Center

Cluster Changes

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Ensure the cluster is 100% healthy and stable before making ANY changes.

Adding Nodes

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- **How do you know when to add nodes?**
  - When disks are becoming >70% full.
  - When CPU/OS load is consistently high during peak times.
- **Tips for adding new nodes:**
  - If using logical racks, add one node to every rack (keep distribution even)
  - Add one node at a time.
  - During the joining process, the new node will stream data from the existing node.
  - A joining node will accept writes but not reads.
  - Unthrottle compactions on the JOINING node “nodetool setcompactionthroughput 0”
    - *But throttle again once node is joined.*
  - Monitor joining status with “nodetool netstats”
  - After the node has streamed and joined it will have a backlog of compactions to get through.

Replacing Nodes

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- Replacing a dead node is similar to adding a new one, but add this line in the cassandra-env.sh *before* bootstrapping:

```
-Dcassandra.replace_address_first_boot=<dead_node_ip>
```

- This tells Cassandra to stream data from the other replicas.
  - *Note this can take quite a long time depending on data size*
  - *Monitor with nodetool netstats*
- If on >2.2.8 and replacing with a different IP address, the node will receive all the writes while joining.
- Otherwise, you should run repair.
  - If the replacement process takes longer than `max_hint_window_in_ms` you **should** run repair to make the replaced node consistent again, since it missed ongoing writes during bootstrapping (streaming).

Adding DC

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Why?

- Distribute workload across data center or regions
- Major topology change
- Cluster migration

Adding DC: tips

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- Ensure all keyspaces are using **NetworkTopologyStrategy**
- All queries using LOCAL_* consistency. This ensures queries will not check for replicas in the new DC that will be empty until this process is complete.
- All client connections are restricted to connecting only to nodes in the original DC. Use a data center aware load balancing policy such as DCAwareRoundRobinPolicy.
- Bring up the new DC as a stand alone cluster.
  - Provision nodes and configure Cassandra:
  - **cluster_name** in yaml must be the SAME as the original DC.
  - **DC name** in cassandra-rackdc.properties must be UNIQUE in the cluster.
  - Include **seed nodes** from the other DC.
- Join the new DC to the old one:
  - Start cassandra
  - Change replication on keyspaces
  - Execute nodetool rebuild <from existing dc> on 1-3 nodes at a time.

```
ALTER KEYSPACE my_ks  WITH replication = { 'class':
'NetworkTopologyStrategy', ‘DC1': 1, ‘DC2': 1, ‘DC3': 1};
```

<sales_pitch>

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Consulting

Cluster review

Kickstarter package

Managed service

Entreprise support

Cluster migration

</sales_pitch>

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- Managed service
- Consulting service
- Enterprise support contract

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