- (Section: TDG) - RDBMS history
- (Section: TDG) - RDBMS Pros and cons
- (Section: TDG) - Why RDBMS is successful?
- (Section: TDG) - How RDBMS is tuned
- (Section: TDG) - Two-phase commit vs Compensation
- (Section: TDG) - Sharding (Share nothing)
- (Section: TDG) - List of NoSQL databases
- (Section: TDG) - Apache Cassandra - Official definition
- (Section: TDG) - Cassandra Features
- (Section: TDG) - What are all Consistency Forms?
- (Section: TDG) - Strong consistency in Cassandra
- (Section: TDG) - Row-Oriented data store
- (Section: TDG) - Always writeable
- (Section: TDG) - Notable tools
- (Section: TDG) - Few use cases
- (Section: TDG) - Updated CAP - Brewer's Theorem
- (Section: TDG) - What is the alternative for Two-phase commit
- (Section: TDG) - How to horizontally scale RDBMS (shard)
- (Section: TDG) - There are three basic strategies for determining shard structure:
- (Section: TDG) - Shared nothing
- (Section: TDG) - New SQL (Scalable ACID transactions)
- (Section: TDG) - Cassandra features
- (Section: TDG) - Cap Theorem (Brewer's theorem)
- (Section: TDG) - Cassandra Lightweight transaction (LWT) - Linearizable consistency
- (Section: TDG) - Row-Oriented (Wide column store)
- (Section: TDG) - Cassandra - schema free?
- (Section: TDG) - Cassandra - use-cases?
- (Section: TDG) - Cassandra directories
- (Section: TDG) - Cassandra directories and files
- (Section: TDG) - Cassandra run-time properties

- (Section: TDG) - Cassandra cqlsh
- (Section: TDG) - How to run apache Cassandra using docker
- (Section: TDG) - Datamodel quick checklist
- (Section: TDG) - THE WIDE PARTITION PATTERN
- (Section: TDG) - Cassandra Architecture - logical components (2+4+3+4+1)
- (Section: TDG) - Cassandra token ring
- (Section: TDG) - Hinted Handoff
- (Section: TDG) - Conflict-free replicated data type
- (Section: TDG) - What is anti-entropy repair?
- (Section: TDG) - MERKLE TREE usage in Cassandra?
- (Section: TDG) - Commit Log
- (Section: TDG) - Comapaction stragies in Cassandra
- (Section: TDG) - Cassandra under the hood
- (Section: TDG) - Deletion and Tombstones
- (Section: TDG) - Bloom Filter
- (Section: TDG) - cluster topology of Cassandra
- (Section: TDG) - CQL - Primary key and Clustering key
- (Section: TDG) - CQLSH - useful
- (Section: TDG) - How to remove node using nodetool
- (Section: TDG) - Cassandra linux limits
- (Section: TDG) - Cassandra troubleshoot linux commands
- (Section: TDG) - How does cassandra-topolgoy.properties look alike
- (Section: TDG) - Cassandra Client - features (Datastax Driver 4.9.0)
- (Section: TDG) - Cassandra Client - Retry Failied Queries (if node failed)
- (Section: TDG) - Cassandra Client side - SPECULATIVE EXECUTION
- (Section: TDG) - Cassandra Client side - CONNECTION POOLING
- (Section: TDG) - Cassandra Client side driver configuration
- (Section: TDG) - How to connect to Cassandra using Java API
- (Section: TDG) - How to connect to Cassandra using Python API

- (Section: TDG) - Cassandra Client (Datastax Driver 4.9.0) - Java API
- (Section: TDG) - Cassandra Client Mapper/Entity Annotations
- (Section: TDG) - Cassandra Client (Datastax Driver 5.0) - Query-Builder API API
- (Section: TDG) - Cassandra Client (Datastax Driver 5.0) - Async API
- (Section: TDG) - JDK 9 - Reactive style API
- (Section: TDG) - Cassandra write path
- (Section: TDG) - Cassandra write path - Materialized view
- (Section: TDG) - Cassandra write/read - consistency CQLS
- (Section: TDG) - Cassandra failures and solutions
- (Section: TDG) - Scaling Quotes
- (Section: TDG) - Performance Quotes
- (Section: TDG) - Nodetool
- (Section: TDG) - Building Cassandra
- (Section: TDG) - Resources
- (Section: TDG) - Follow-up questions for Cassandra
- (Section: TDG) - Definitive Guide References
- (Section: TDG) - Code
- (Section: TDG) - How to create anki from this markdown file
- (Section: Installation) - Pre-requisite for this tutorial is docker
- (Section: Installation) - Use Os-boxes as virtual machine to install cassandra
    - To start Cassandra
- (Section: Installation) - Cassandra cluster using apache cassandra (Wait at-least 1 minute between successive container spin-off)
- (Section: Installation) - Connect to cassandra docker cluster
- (Section: Installation) - Run commands into cassandra docker node
- (Section: Installation) - Via docker for DSE server
- (Section: Installation) - Setting up application using DSE image -Running Cassandra in Docker
- (Section: Installation) - Copy files into and out-of containers
- (Section: Installation) - Some Cassandra commands

- (Section: Installation) - Cassandra directory (Apache Cassandra)
- (Section: Installation) - Cassandra stress-tool
- (Section: Installation) - To start CQLSH
- (Section: Installation) - References
- (Section: Architecture) - nodetool
- (Section: Architecture) - Ring
- (Section: Architecture) - When a new node joins the ring
- (Section: Architecture) - Driver
- (Section: Architecture) - Peer-to-Peer
- (Section: Architecture) - VNode
- (Section: Architecture) - Why Vnode?
- (Section: Architecture) - Gossip protocol
- (Section: Architecture) - What is gossiped?
- (Section: Architecture) - Snitch
- (Section: Architecture) - Property File Snitch
- (Section: Architecture) - Gossiping Property File Snitch
- (Section: Architecture) - Cassandra replication
- (Section: Architecture) - Consistency Level
- (Section: Architecture) - Consistency level in Cassandra
- (Section: Architecture) - Hinted hand-off
- (Section: Architecture) - Read repair (Assume RF=3)
- (Section: Architecture) - Read Repair Chance
- (Section: Architecture) - Node-repai
- (Section: Architecture) - Nodetool has a repair tool that can repair entire cluster - Quite expensive operation
- (Section: Architecture) - Datastax Node-sync
- (Section: Architecture) - Write path
- (Section: Architecture) - Read path
- (Section: Architecture) - Data-stax
- (Section: Architecture) - Compaction
- (Section: Architecture) - Compacting partition
- (Section: Architecture) - Compacting SSTables

- (Section: Architecture) - Types of compaction
- (Section: Architecture) - Datastax ES6
- (Section: Architecture) - Under what circumstances is the use of lightweight transactions justified?
- (Section: Architecture) - Reference
- (Section: Partition) - Partition
- (Section: Partition) - Clustering Columns
- (Section: Partition) - Primary Key
- (Section: Partition) - Impact of partition key on query (CQL)
- (Section: Partition) - Querying
- (Section: Partition) - CQL
- (Section: Partition) - Datastax slides
- What is Each_Quorum
- (Section: Performance) - Performance could be degraded for many reasons
- (Section: Performance) - Dropped Mutataions
- (Section: Performance) - Configuration that affects dropped mutations
- (Section: Performance) - When does Cassandra end up having useless data
- (Section: Performance) - How to find the largest SSTable (or largest partition) in the cluster
- (Section: Performance) - Usage statistics of thread-pool - output
- (Section: DS210) - What is D210 Course about
- (Section: DS210) - What are basic parameter required for Cassandra quickstart
- (Section: DS210) - What is the location of default Cassandra.yaml?
- (Section: DS210) - What are two file-systedm that should be separated
- (Section: DS210) - Cluster Sizing
- (Section: DS210) - Cluster Sizing - Writethrough put example
- (Section: DS210) - Cluster Sizing - Read throughput example

- (Section: DS210) - Cluster-sizing - Monthly calculate
- (Section: DS210) - Cluster-sizing - Latency calculate
- (Section: DS210) - Cluster Sizing - Probing Questions
- (Section: DS210) - Cassandra stress tool
- (Section: DS210) - Linux top command
- (Section: DS210) - Linux top command - Cassandra
- (Section: DS210) - Linux dstat command (alternative to top)
- (Section: DS210) - Nodetool (Performance Analysis inside cluster node)
- (Section: DS210) - Nodetool compaction-history - what are all the fields and output?
- (Section: DS210) - To figure out the name of a node's datacenter and rack, which nodetool sub-command should you use?
- (Section: DS210) - Nodetool gcstats
- (Section: DS210) - Nodetool Gossipinfo
- (Section: DS210) - Nodetool Ring command
- (Section: DS210) - Nodetool Tableinfo (tablestats) - Quite useful for data-modelling information
- (Section: DS210) - How to find large partition?
- (Section: DS210) - Nodetool Threadpoolinfo (tpstats)
- (Section: DS210) - Cassandra logging
- (Section: DS210) - Cassandra JVM GC logging
- (Section: DS210) - How Cassandra JVM GC logging can be configured
- (Section: DS210) - How to read GC.log?
- (Section: DS210) - Adding a node
- (Section: DS210) - Bootstrapping (Adding a note)
- (Section: DS210) - What are the steps followed by a boostrapping node when joining?
- (Section: DS210) - What are the help rendered by a existing node to a joining?
- (Section: DS210) - Issues during bootstrap

- (Section: DS210) - If Bootstrap fails
- (Section: DS210) - After Boostrap (Cleanup)
- (Section: DS210) - Removing node
- (Section: DS210) - Where is the data coming from when a node is removed?
- (Section: DS210) - How to replace a down-node
- (Section: DS210) - Why replace a node than removing-and-adding?
- (Section: DS210) - STCS - Size Tieres Compaction Strategy
- (Section: DS210) - STCS Pros and Disadvantage
- (Section: DS210) - What triggers a STCS Compaction
- (Section: DS210) - STCS - Tombstones
- (Section: DS210) - LCS - Leveled Compaction Strategy
- (Section: DS210) - LCS Pros and Cons
- (Section: DS210) - LCS - Lagging behind
- (Section: DS210) - LeveledCompactionStrategy
- (Section: DS210) - TWCS - Time-window compaction strategies
- (Section: DS210) - Nodesync (Datastax Enterprise 6.0)
- (Section: DS210) - What are all the possible reason for large SSTable
- (Section: DS210) - Multi-Datacenter
- (Section: DS210) - Multi-Datacenter Consistency Level
- (Section: DS210) - What if one datacenter goes down?
- (Section: DS210) - Why we need additional DC?
- (Section: DS210) - SSTableDump
- (Section: DS210) - SSTableloader
- (Section: DS210) - Loading different formats of data into Cassandra
- (Section: DS210) - Datstax - DSE Bulk (configuration should be in HOCON format)
- (Section: DS210) - Backup and Snapshots
- (Section: DS210) - What is Cassandra snapshots?
- (Section: DS210) - How do incrementa backup works
- (Section: DS210) - Where to store snapshots?
- (Section: DS210) - How Truncate works?

- (Section: DS210) - How to snapshot?
- (Section: DS210) - Restore (We get 1 point for backup, 99 point for restore)
- (Section: DS210) - Steps to restore from snapshots
- (Section: DS210) - JVM settings
- (Section: DS210) - Garbage Collections (Apache Cassandra)
- (Section: DS210) - Why does full GC runs?
- (Section: DS210) - How to troubleshoot OutOfMemoryError issues in Casssandra?
- (Section: DS210) - What is TSC?
- (Section: DS210) - Tuning the Linux Kernel
- (Section: DS210) - What should be removed/disabled from Linux for Cassandra to work? How to remove
- (Section: DS210) - Hardware resources to consider
- (Section: DS210) - Datastax on Cloud
- (Section: DS210) - Cassandra on Cloud Challenges
- (Section: DS210) - Cassandra on cloud security
- (Section: DS210) - Cassandra Security Considerations
- (Section: DS210) - What is the default security configuration
- (Section: DS210) - Where is roles are stored in internal-scheme? (in default scheme)
- (Section: DS210) - Cassandra Authentication table (system_auth.roles - in default scheme)
- (Section: DS210) - What are best practices for Cassandra security
- (Section: DS210) - Cassandra Role/Authorization management
- (Section: DS210) - Cassandra encryption SSL
- (Section: DS210) - What are two artifacts required for Cassandra to enable SSL
- (Section: DS210) - 8 Steps for SSL setup (node-to-node)
- (Section: DS210) - How to harden Cassandra security
- (Section: DS210) - Datastax OpsCenter
- (Section: DS210) - Datastax OpsCenter (Cluster Monitoring/Alert)

- (Section: DS210) - Datastax OpsCenter (Management Service)
- (Section: DS210) - Datastax OpsCenter (Backup and restore Service)
- (Section: DS210) - Datastax OpsCenter LifeCycle Manager (Provisioning)
- (Section: DS210) - Datastax OpsCenter NodeSync
- (Section: DS210) - Datastax OpsCenter other features
- (Section: DS210) - Follow-up course
- (Section: DS210) - Lab notes
- (Section: DS210) - Cassandra people
- Cassandra production error
- (Server side) - com.datastax.oss.driver.api.core.connection.ConnectionIntiException.. ssl should be configured
- (Client side) - [SSLL SSLV3_ALERT_HANDSHAKE_FAILURE]
- (Client side) - Since you provided explicit contact points, the local DC must be explicitly set (see basic.load-balancing-policy.local-datacenter)
- Cluster level monitoring
- Top worst performing
- List monitoring elements
- List table level
- Node Status
- (Section: Nodetool) - Nodetool usage
- (Section: Nodetool) - Nodetool commands
- (Section: Repair) - Repair Service (on OpsCenter)
- (Section: Repair) - Repair command
- (Section: Repair) - Why repairs are necessary?
- (Section: Repair) - Repair guideline
- (Section: Repair) - What is Primary Range Repair?
- (Section: Repair) - How does repair work?
- (Section: Repair) - Events that trigger Repair
- (Section: Repair) - Dropped Mutation vs Repair
- (Section: Repair) - If 10 nodes equally sharing data with RF=3, if we

try to repair ‘nodetool repair on node-3’, How many node will be involved in repair?

- (Section: Repair) - How to specifically use only one node to repair itself
- (Section: Repair) - If we run full repair on a ‘n’ node cluster with RF=3, How many times we are repairing the data?
- (Section: Repair) - Developer who maintains/presented about Reaper
- (Section: Repair) - Repair documentation
- (Section: Repair) - Repair and some number related to time
- (Section: Repair) - What are Reaper settings
- (Section: Repair) - Reaper is predominantly used for repair tasks
- (Section: Repair) - Repair related commands
- (Section: Repair) - Reference
- (Section: Repair) - How to create anki from this markdown file
- (Section: Cqls) - Create KeySpace (and use it)
- (Section: Cqls) - Partition Key vs Primary Key
- (Section: Cqls) - Create TABLE and load/export data in and out-of-tables
- (Section: Cqls) - How to select token values of primary-key
- (Section: Cqls) - What is Conditional Insert?
- (Section: Cqls) - IS CQL Case-sensitive
- (Section: Cqls) - Create Keyspace/Table Syntax
- (Section: Cqls) - CQL Copy and rules
- (Section: Cqls) - CQL Copy options
- (Section: Cqls) - How to list partition_key (or the actual token) along with other columns
- (Section: Cqls) - Gosspinfo
- (Section: Cqls) - nodetool getendpoints killrvideo videos_by_tag cassandra
- (Section: Cqls) - What are all the System Schema
- (Section: Cqls) - See how many rows have been written into this table (Warning - row scans are expensive operations on large tables)

- (Section: Cqls) - Write a couple of rows, populate different columns for each, and view the results
- (Section: Cqls) - View the timestamps generated for previous writes
- (Section: Cqls) - Note that we're not allowed to ask for the timestamp on primary key columns
- (Section: Cqls) - Set the timestamp on a write
- (Section: Cqls) - Verify the timestamp used
- (Section: Cqls) - View the time to live value for a column
- (Section: Cqls) - Set the TTL on the last name column to one hour
- (Section: Cqls) - View the TTL of the last_name - (counting down)
- (Section: Cqls) - Find the token
- (Section: Cqls) - Clear the screen of output from previous commands
- (Section: Cqls) - Cassandra Dual equivalent table and SQL
- (Section: Cqls) - How to find avg, sum, min, max within Partition (use ratings_by_movie) as example??
- (Section: Cqls) - Sample function to find days between two date?
- (Section: Cqls) - How to add/delete column to a table?
- (Section: Cqls) - Exit cqlsh
- (Section: Cqls) - What would happen if we use Clustering Column where STATIC columns are updated
- (Section: Cqls) - Reference
- (Section: Advanced Type) - What are all the basic data-types?
- (Section: Advanced Type) - What are all the current-time-date functions?
- (Section: Advanced Type) - What are all the timestamp functions?
- (Section: Advanced Type) - What are all the timeuuid functions?
- (Section: Advanced Type) - How to add SET AND UPDATE its columns values?
- (Section: Advanced Type) - How to add LIST AND UPDATE its columns values?
- (Section: Advanced Type) - How to add MAP<TEXT, TEXT> AND UPDATE its columns values?

- (Section: Advanced Type) - How to UDT ADDRESS<street, city, state, postal_code> AND UPDATE ADDRESS columns values?
- (Section: Advanced Type) - Single vs Multiple batch?
- (Section: Advanced Type) - Batch restrictions?
- (Section: Advanced Type) - Batch cost and performance?
- (Section: Advanced Type) - Batch - System tables involved?
- (Section: SSTable) - SStable - settings in cassandra.yaml
- (Section: SSTable) - What are the files part of SSTable
- (Section: SSTable) - What is the role of index file
- (Section: SSTable) - What is the role of statitics file
- (Section: SSTable) - Why SQLite4 didn't use LSM?
- (Section: SSTable) - LSM Pros and Cons
- (Section: SSTable) - SSTable references
- (Section: Administration) - Course DSE installation
- (Section: Administration) - Nodetool vs DSEtool
- (Section: Administration) - Nodetool Gauge the server performance
- (Section: Administration) - Find all the material view of a keyspace
- (Section: Administration) - How to find number of partitions/node-of partition in a table
- (Section: Administration) - Cassandra Node (Server/VM/H/W)
- (Section: Administration) - Cassandra Ring (The cluster)
- (Section: Administration) - How new nodes join the ring
- (Section: Administration) - Peer-to-Peer
- (Section: Administration) - Why do we need VNode?
- (Section: Administration) - How to enable VNode?
- (Section: Administration) - Gossip protocol (nodemeta data is the subject)
- (Section: Administration) - What do nodes Gossip about?
- (Section: Administration) - What is Gossip data structure look like?
- (Section: Administration) - What is Gossip protocol?
- (Section: Administration) - How to find more details about Gossip
- (Section: Administration) - Sample Gossipinfo

- (Section: Administration) - Node failure detector
- (Section: Administration) - Snitch (meaning informer)
- (Section: Administration) - What is the role of DynamicSnitch
- (Section: Administration) - Mandatory operational practice
- (Section: Administration) - Replication with RF=1
- (Section: Administration) - Replication with RF>=2
- (Section: Administration) - Replication with RF>=2 and Cross Data-Center
- (Section: Administration) - Consistency in CQL
- (Section: Administration) - Reference
- (Section: Tools) - How to load json/csv in fastest way into Cassandra:
- (Section: Tools) - What are all DSBulk commands
- (Section: Tools) - Load CSV data into Cassandra (using name-to-name mapping):
- Time-series presentations
- (Section: Tombstone) - What are all the majore issues due to Tomb-stones
- (Section: Tombstone) - How to agressively collect tombstones (to re-solve few of the query timeout tactical solution)
- (Section: Tombstone) - Where is Tombstones are handled?
- (Section: WriteRead) - Sample data directory wiht WITH bloom_fil-ter_fp_chance = 0.1;
- (Section: WriteRead) - Sample data directory wiht WITH bloom_fil-ter_fp_chance = 0.0001;
- (Section: WriteRead) - Sample data directory wiht WITH bloom_fil-ter_fp_chance = 1.0; (100% false positive allowed… No filter file)
- (Section: WriteRead) - Nodetool CFStats
- (Section: WriteRead) - Followup questions
- What is compaction in Cassandra?
- Pre-requisite for Compaction
- We have problem with two nodes with large number of compaction pending, how to speed up?

- Reference
- (Section: Experimental) - MV - Limitations?
- (Section: Experimental) - How to mitigate the risk of base-view inconsistency?
- (Section: Experimental) - Example of MVs.
- (Section: Experimental) - What are all types of secondary index.
- (Section: Experimental) - Use cases for indexes in Cassandra production (specific cases):
- (Section: Experimental) - Limitations of indexes in Cassandra:
- (Section: Experimental) - Secondary index limitations
- Anti-patterns in the Cassandra
- What is the URL of hands-on workshop?
- Important Spring Java project
- JIRA based on labels
- JIRA Features in Cassandra
- Cassandra index
- Famous Cassandra articles
- Analyze Cassandra code
- K8ssandra

(Section: TDG) - RDBMS history

- IBM DB1 - IMS Hierarchical dbms - DBI/DB1 - Released in 1968
- IBM DB2 - 1970 - “A Relational Model of Data for Large Shared Data Banks - Dr. Edgar F. Codd”
- 1979-DB2 (E.F Cod 1970s), RDBMS relational model (not working system, just theoratical model)
- Traditionally RDBMS supports locks, locks helps to maintain consistency but reduces access/availability to others
- Journal or WAL log files are used for rollback or atomic-commit in RDBMS, journal sometime switched of to increase performance

- Codd provided a list of 12 rules (0-12, actually 13 :-)) in Computer-World Magazine in 1985 (15 years later from original paper)
- ANSI SQL - 1986

(Section: TDG) - RDBMS Pros and cons

- Pros : It works for most of the cases
    - SQL - Support
    - ACID - Transaction (A Transformation of State - Jim Gray)
        - Atomic (State A to State B - no in-between)
        - Consistency
        - Isolated - Force transactions to be serially executed. (If it doesn't require consistency and atomic, it is possible to have isolated and parallel txns)
        - Durable - Never lost
- Cons : Won't work for massively web scale db

(Section: TDG) - Why RDBMS is successful?

- SQL
- Atomic Transaction with ACID properties
- Two-phase commit was marketted well (Co-ordinated txn)
- Rich schema

(Section: TDG) - How RDBMS is tuned

- Introduce Index
- Master(write), Slave (many times only used for read)

        - Introduces replication and transaction issues
        - Introduces consistency issues
- Add more CPU, RAM - Vertical scaling
- Partitioning/Sharding
- Disable journaling

(Section: TDG) - Two-phase commit vs Compensation

- Compensation
    - Writing off the transaction if it fails, deciding to discard erroneous transactions and reconciling later.
    - Retry failed operations later on notification.
- In a reservation system or a stock sales ticker, these are not likely to meet your requirements.
- For other kinds of applications, such as billing or ticketing applications, this can be acceptable.
- Starbucks Does Not Use Two-Phase Commit
    - https://www.enterpriseintegrationpatterns.com/ramblings/18_starbucks.html

(Section: TDG) - Sharding (Share nothing)

- Rather keeping all customer in one table, divide up that single customer table so that each database has only some of the records, with their order preserved? Then, when clients execute queries, they put load only on the machine that has the record they're looking for, with no load on the other machines.
- How to shard?
    - Name-wise sharding issues like customer names that

starts with “Q,J” will have less, whereas customer name starts with J, M and S may be busy
        - Shard by DOB, SSN, HASH
- Three basic strategies for determining shard structure
    - Feature-based shard or functional segmentation
    - Key-based sharding - one-way hash on a key data element and distribute data across machines according to the hash.
    - Lookup Table

(Section: TDG) - List of NoSQL databases

- Key-Value stores - Oracle Coherence, Redis, and MemcacheD, Amazon’s Dynamo DB, Riak, and Voldemort.
- Column stores - Cassandra, Hypertable, and Apache Hadoop’s HBase.
- Document stores - MongoDB and CouchDB.
- Graph databases - Blazegraph, FlockDB, Neo4J, and Polyglot
- Object databases - db4o and InterSystems Caché
- XML databases - Tamino from Software AG and eXist.

(Section: TDG) - Apache Cassandra - Official definition

- “Apache Cassandra is an open source, distributed, decentralized, elastically scalable, highly available, fault-tolerant, tuneably consistent, row-oriented database. Cassandra bases its distribution design on Amazon’s Dynamo and its data model on Google’s Bigtable, with a query language similar to SQL”
- Tuneably consistent (not Eventual Consisten as majority believes)

(Section: TDG) - Cassandra Features

- CQL (Thrift API is completely removed in 3.x)
    - CQL also known as native-transport
- Secondary indexes
- Materialized views
- Lightweight transactions
- Consistency = Replication factor + consistency level (delegated to clients)
    - Consistency level <= replication factor
- Cassandra is not column-oriented (it is row oriented)
- Column values are stored according to a consistent sort order, omitting columns that are not populated

(Section: TDG) - What are all Consistency Forms?

- Strict (or Serial) Consistency or Strong (sequential consistency)
    - Works on Single CPU
    - “Rather than dealing with the uncertainty of the correctness of an answer, the data is made unavailable until it is absolutely certain that it is correct.”
- Casual Consistency (like Casuation)
    - Happens before
    - The cause of events to create some consistency in their order.
    - Writes that are potentially related must be read in sequence.
    - If two different, unrelated operations suddenly write to the same field, then those writes are inferred not to be

causally related.

- Weak (or) Eventual Consistency
    - Rather than dealing with the uncertainty of the correctness of an answer, the data is made unavailable until it is absolutely certain that it is correct
    - Eventual consisteny (matter of milli-seconds)

(Section: TDG) - Strong consistency in Cassandra

- R + W > RF = Strong consistency
- In this equation, R, W, and RF are the read replica count, the write replica count, and the replication factor, respectively;

(Section: TDG) - Row-Oriented data store

- Cassandra's data model can be described as a partitioned row store, in which data is stored in sparse multidimensional hashtables.
- "Sparse" means that for any given row you can have one or more columns, but each row doesn't need to have all the same columns as other rows like it (as in a relational model).
- "Partitioned" means that each row has a unique key which makes its data accessible, and the keys are used to distribute the rows across multiple data stores.

(Section: TDG) - Always writeable

- A design approach must decide whether to resolve these conflicts at one of two possible times: during reads or during writes. That is, a

distributed database designer must choose to make the system either always readable or always writable. Dynamo and Cassandra choose to be always writable, opting to defer the complexity of reconciliation to read operations, and realize tremendous performance gains. The alternative is to reject updates amidst network and server failures.

- CAP Theorem
    - Choose any two (of threee)
    - Cassandra assumes that network partitioning is unavoidable, hence it lets us deal only with availability and consistency.
    - CAP placement is independent of the orientation of the data storage mechanism
    - CAP theorem database mapping
        - AP - ?
            - To primarily support availability and partition tolerance, your system may return inaccurate data, but the system will always be available, even in the face of network partitioning. DNS is perhaps the most popular example of a system that is massively scalable, highly available, and partition tolerant.
        - CP - ?
            - To primarily support consistency and partition tolerance, you may try to advance your architecture by setting up data shards in order to scale. Your data will be consistent, but you still run the risk of some data becoming unavailable if nodes fail.

- CA - ?
    - To primarily support consistency and availability means that you're likely using two-phase commit for distributed transactions. It means that the system will block when a network partition occurs, so it may be that your system is limited to a single data center cluster in an attempt to mitigate this. If your application needs only this level of scale, this is easy to manage and allows you to rely on familiar, simple structures.

(Section: TDG) - Notable tools

- Sstableloader - Bulk loader
- Leveled compaction strategy - for faster reads
- Atomic batches
- Lightweight transactions were added using the Paxos consensus protocol
- User-defined functions
- Materialized views (sometimes also called global indexes)

(Section: TDG) - Few use cases

- Cassandra has been used to create a variety of applications, including a windowed time-series store, an inverted index for document searching, and a distributed job priority queue.

(Section: TDG) - Updated CAP - Brewer's Theorem

- Brewer now describes the "2 out of 3" axiom as somewhat misleading.
- He notes that designers only need sacrifice consistency or availability in the presence of partitions. And that advances in partition recovery techniques have made it possible for designers to achieve high levels of both consistency and availability.

(Section: TDG) - What is the alternative for Two-phase commit

- Compensation or compensatory action
- Writing off the tranaction if it fails, deciding to discard erroneous transactions and reconciling later
    - Won't work on trading or reservation system
- Retry failed operation later on notification
- "Starbucks does not use Two-phase commit" - Gregor Hohpe

(Section: TDG) - How to horizontally scale RDBMS (shard)

- Shard the database, (key for sharding is important)
- Split the customer based on name (few letter has less load) or according to phone-number or dob
- Host all the data that begins with certain letter in different database
- Shard users in one database, items in another database

(Section: TDG) - There are three basic strategies for determining shard structure:

- Feature-based shard or functional segmentation
    - Shard users in one database, items in another database
- Key-based sharding
    - Hash based sharding
    - time-based on numeri-ckeys to hash on
- Lookup table
    - Make one of the node as “Yellow-pages”, look-up for information about where the data stored

(Section: TDG) - Shared nothing

- Sharding could be termed a kind of shared-nothing architecture that’s specific to databases
- Shared-nothing - no primary or no-secondary
- Every node is independent
- No centralized shared state
- Cassandra (key-based sharding) and MongoDB - Autn o sharding database

(Section: TDG) - New SQL (Scalable ACID transactions)

- Calvin transaction protocol vs Google’s Spanner paper
- FaunaDB is an example of a database that implements the approach on the Calvin paper

(Section: TDG) - Cassandra features

- It uses gossip protcol (feature of peer-to-peer architecture) to maintain details of other nodes.
- It allows tunable cosistency and client can decide for each write/read (how many RF?)
- It is possible to remove one column value alone in Cassandra

(Section: TDG) - Cap Theorem (Brewer's theorem)

- CAP - Choose two (as of 2000)
- Network issue would certainly happens, hence network partition failures is un-avoidable, And should be handled. Hence choose between compromise on A or C (Availablity or consistency)
- CA - MySQL, Postgres, SQL
- CP - Neo4j, MongoDB, HBase, BigTable
- AP - DNS, Cassandra, Amazon Dynamo

(Section: TDG) - Cassandra Lightweight transaction (LWT) - Linearizable consistency

- Ensure there are not operation between read and write
- Example: Check if user exist, if not create user (don't overwrite in between)
- Example: Update the value if and only if the value is X (Check-and-set)
- LWT is based on Paxos algorithm (and it is better than two-phase

commit)

(Section: TDG) - Row-Oriented (Wide column store)

- Partitioned row store - sparse multidimensional hash tables
- Partitioned - means that each row has a unique partition key used to distribute the rows across multiple data stores.
- Sparse - not all rows has same number of columns
- Cassandra stores data in a multidimensional, sorted hash table.
- As data is stored in each column, it is stored as a separate entry in the hash table.
- Column values are stored according to a consistent sort order, omitting columns that are not populated.

(Section: TDG) - Cassandra - schema free?

- Started as schema free using Thrift API, later CQL was introduced
- No! Till 2.0 CQL and Thrit API co-exist, It was known as “Schema Optional”
- From 3.0, Thrift API is deprecated, and from 4.0 Thrif API is removed
- Additional values for columns can be added using List, Sets and Maps
    - Now-a-days it is considered flexible-schema
- Schema free -> “Optional Schema” -> “Flexible Schema”

(Section: TDG) - Cassandra - use-cases?

- Storing user activity updates

- Social network usage, recommendations/reviews,
- Application statistics
- Inverted index for document searching
- ~~Distributed job priority queue~~ (queues are not recommended anymore)
- Ability to handle application workloads that require high performance at significant write volumes with many concurrent client threads is one of the primary features of Cassandra.

(Section: TDG) - Cassandra directories

- /opt/cassadra/bin
- /opt/cassadra/bin/cassandra -f –run the process in foreground for debug print and learning..
- /opt/cassadra/conf/cassandra.yaml
- /var/lib/cassandra/hints/
- /var/lib/cassandra/saved_caches/
- /var/lib/cassandra/data/
- /var/lib/cassandra/commitlog/
- /var/log/cassandra/system.log
- /var/log/cassandra/debug.log

(Section: TDG) - Cassandra directories and files

- $CASSANDRA_HOME/data/commitlog
    - CommitLog-.log
    - CommitLog-7-1566780133999.log
- 1-SSTable has multiple files
    - SSTable stored under - $CASSANDRA_HOME/data/data

(Section: TDG) - Cassandra run-time properties

- -Dcassandra-foreground=yes
- -Dcassandra.jmx.local.port=7199
- -Dcassandra.libjemalloc=/usr/local/lib/libjemalloc.so
- -Dcassandra.logdir=/opt/cassandra/logs
- -Dcassandra.storagedir=/opt/cassandra/data
- -Dcom.sun.management.jmxremote.authenticate=false
- -Dcom.sun.management.jmxremote.password.file=/etc/cassandra/jmxremote.password
- -Djava.library.path=/opt/cassandra/lib/sigar-bin
- -Djava.net.preferIPv4Stack=true
- -Dlogback.configurationFile=logback.xml
- -XX:GCLogFileSize=10M
- -XX:OnOutOfMemoryError=kill
- -XX:StringTableSize=1000003
- /opt/java/openjdk/bin/java

(Section: TDG) - Cassandra cqlsh

- Object names are in snake_case. Cassandra converts into lower_case by default, double quote to override
- bin/cqlsh localhost 9042
- `sql show version; describe cluster; create keyspace sample_ks with replication = {'class': 'SimpleStrategy', 'replication_factor': 1}; use sample_ks; DESCRIBE KEYSPACES; describe keyspace`

```
sample_ks;       describe keyspace system;       create
table user ( first_name text, last_name text, title text,
PRIMARY KEY(last_name, first_name) );       describe table
user;       insert into user(first_name, last_name, title)
values  ('Mohan', 'Narayanaswamy', 'Developer');       se-
lect * from user where first_name='Mohan' and last_name =
'Narayanaswamy';       select * from user where
first_name='Mohan';       --* InvalidRequest: Error from
server: code=2200 [Invalid query] message="Cannot execute
this query as it might involve data filtering and hus may
have unpredictable performance. If you want to execute this
query despite the performance unpredictability, use ALLOW
FILTERING"       select count(*) from user; --Aggregation
query used without partition key       delete title from
user where last_name='Narayanaswamy' and first_name='Mo-
han';  --one column alone       delete from user where
last_name='Narayanaswamy' and first_name='Mohan';  --entire
row deletion
```

(Section: TDG) - How to run apache Cassandra using docker

```
docker pull cassandra
docker network create cass-network
docker run -d --name apc1 --network cass-network cassandra
docker run -d --name apc2 --network cass-network cassandra
#docker run --name  my-cassandra -p 9042:9042 -p 7000:7000 --network
        host -d cassandra:latest
docker exec -it apc2 cqlsh
docker stop apc2
```

(Section: TDG) - Datamodel quick checklist

- All the possible important query that needs to satisfied should be considered before design
- Minimize the number of partitions that must be searched to satisfy a given query
- Growing number of tombstones begins to degrade read performance. Data-model should account to minmize it
- Partition-size = Nv=Nr(Nc–Npk–Ns)+Ns (hard-limit 2 billion, in-general 100K)
- in Cassandra - everything is distributed hashmap despite they look like relational-model
- Joins are not supported and should be discouraged in Cassandra
- NO REFERENTIAL INTEGRITY - supported in Cassandra (or any nosql)

(Section: TDG) - THE WIDE PARTITION PATTERN

- group multiple related rows in a partition in order to support fast access to multiple rows within the partition in a single query.
- Cassandra can put tremendous pressure on the java heap and garbage collector, impact read latencies, and can cause issues ranging from load shedding and dropped messages to crashed and downed nodes.

(Section: TDG) - Cassandra Architecture - logical components (2+4+3+4+1)

- Network topology, Peer-to-peer
- Gossip, repair, hinted handoff, and lightweight transactions
- Reading, writing, and deleting data
- Data-structures of memtable, commit-logs, caches and SSTables
- LWW-Element-Set (Last-Write-Wins-Element-Set) and no-reconciliation

(Section: TDG) - Cassandra token ring

- Tokens range from -2^63 to 2^63 - 1
- Every node owns multiple token (and it's token ranges)
- TR - Token range of token t is - x > TR < t
    - x and t are two successive tokens
    - Range of values less than or equal to each token and greater than the last token of the previous node
- The node with the lowest token owns the range less than or equal to its token and the range greater than the highest token, which is also known as the wrapping range
- Early version of Cassandra node has only one token (one TR), nowadays it has 256 token for each node (256 virutal nodes)
- Larger machine can have more than 256 by modifying num_tokens@cassandra.yaml
- Partitioner :: partition_key -> token (clustering key is not used by partitioner)
- Partitioner can't be changed after initializing a cluster. Cassandra uses MurMurPartitioner since 1.2

(Section: TDG) - Hinted Handoff

- Acts like JMS MQ, till message is delivered
- But message is deleted after 3 hours (should be consumed within that)

(Section: TDG) - Conflict-free replicated data type

- To resolve conflicts, system can use the Last-Writer-Wins Register
- Which keeps only the last updated value when merging diverged data sets.
- Cassandra uses this strategy to resolve conflicts.
- We need to be very cautious when using this strategy because it drops changes that occurred in the meantime.

(Section: TDG) - What is anti-entropy repair?

- Replica synchronization mechanism for ensuring that data on different nodes is updated to the newest version.
- Replica synchronization as well as hinted handoff.
- Project Voldemort also uses read-repair similar to Cassandra (not anti-entropy repair)

(Section: TDG) - MERKLE TREE usage in Cassandra?

- The advantage MERKLE TREE usage is that it reduces network I/O.

- Used to ensure that the peer-to-peer network of nodes receives data blocks unaltered and unharmed.
- Each table has its own Merkle tree; the tree is created as a snapshot during a validation compaction,
- MerkleTree is kept only as long as is required to send it to the neighboring nodes on the ring.

(Section: TDG) - Commit Log

- Only one commit log for entire server
- Commit log shares across multiple table
- All writes to all tables will go into the same commit log
- Ther is a bit for flush_bit for each table in commit log (1 - flush_required, 0 - flush-not-required)
- Throw more memory to reduce false-positives

(Section: TDG) - Comapaction stragies in Cassandra

- SizeTieredCompactionStrategy (STCS) is the default compaction strategy and is recommended for write-intensive tables.
- LeveledCompactionStrategy (LCS) is recommended for read-intensive tables.
- TimeWindowCompactionStrategy (TWCS) is intended for time series or otherwise date-based data.
- Anticompaction - Split SSTable with one containing repaied data and other containing unrepaired data

(Section: TDG) - Cassandra under the hood

- Refactor and modernize the storage engine
- Materialized Views (was: Global Indexes)
- Cassandra pluggable storage engine

(Section: TDG) - Deletion and Tombstones

- Nodes that was down when records deleted should have mechanism, hence tombstones
- Tombstones can be configured using gc_grace_seconds (garbage collection grace seconds)
- gc_grace_seconds = 864000 seconds (10 days)

(Section: TDG) - Bloom Filter

- SSTable is not good when key that is not available in a table is queried
- Without bloomfilter, Cassandra read-path would query multiple files (sgements) to confirm a key is absent. It queries latest to oldest before confirming lack of key.
- Used to reduce disk access
- Used in Hadoop, Bigtable, Squid Proxy Cache (and many big-data systems)
- False-negative is not possible, but falst-positive is possible
- if bloom-filter conveys data is not available, if it is not avialble. But it might return ‘may be available’, it may not be available.

(Section: TDG) - cluster topology of Cassandra

- Cassandra cluster topology is the arrangement of the nodes (dcs, racs, etc.) and communication network between them.
- Snitch teaches Cassandra enough about your network topology
- cassandra-topology.properties can be used to configure topology details

(Section: TDG) - CQL - Primary key and Clustering key

```
PRIMARY KEY (("k1", "k2"), "c1", "c2"), ) WITH CLUSTERING ORDER BY ("c1" DESC, "c2" DESC);
```

(Section: TDG) - CQLSH - useful

- CQL would use Murmur3 partitioner
- Minimum token is -9223372036854775808 (and maximum token is 9223372036854775808).
- `sql cassandra@cqlsh:system_schema> DESCRIBE CLUSTER; DESCRIBE KEYSPACES; DESCRIBE TABLES; SELECT * FROM system_schema.keyspaces; desc KEYSPACE Keyspace_Name; select token(key), key, my_column from mytable where token(key) >= %s limit 10000;`

(Section: TDG) - How to remove node using nodetool

- Decommission - Streams data from the leaving node (prefered and guaranteed consistency as if it started)
- Removenode - Streams data from any available node that owns the range
- assassinate - Forcefully remove a dead node without re-replicating any data. Use as a last resort if you cannot removenode

(Section: TDG) - Cassandra linux limits

- if cassandra has 30 sstables, it would use 30 * 6 - 180 file handles
- XX:MaxDirectMemorySize - we can set off-heap memory (outside JVM on OS)

(Section: TDG) - Cassandra troubleshoot linux commands

```
cat /proc/cass_proc_id/limits | grep files
```

(Section: TDG) - How does cassandra-topology.properties look alike

```
# datacenter One

175.56.12.105=DC1:RAC1
```

```
175.50.13.200=DC1:RAC1
175.54.35.197=DC1:RAC1

120.53.24.101=DC1:RAC2
120.55.16.200=DC1:RAC2
120.57.102.103=DC1:RAC2

# datacenter Two

110.56.12.120=DC2:RAC1
110.50.13.201=DC2:RAC1
110.54.35.184=DC2:RAC1

50.33.23.120=DC2:RAC2
50.45.14.220=DC2:RAC2
50.17.10.203=DC2:RAC2

# Analytics Replication Group

172.106.12.120=DC3:RAC1
172.106.12.121=DC3:RAC1
172.106.12.122=DC3:RAC1

# default for unknown nodes
default=DC3:RAC1
```

(Section: TDG) - Cassandra Client - features (Datastax Driver 4.9.0)

- xml `<groupId>com.datastax.oss</groupId>` `<artifactId>java-driver-query-builder</artifactId>`

```
<artifactId>java-driver-core</artifactId>        <artifac-
tId>java-driver-mapper-processor</artifactId>        <arti-
factId>java-driver-mapper-runtime</artifactId>
```

- CqlSession maintains TCP connections to multiple nodes, it is a heavyweight object. Reuse it
- Prefer file based client side driver configuration
- PreparedStatements also improve security by separating the query logic of CQL from the data.
- Prepared statements were stored in a cache, but beginning with the 3.10 release, each Cassandra node stores prepared statements in a local table so that they are present if the node goes down and comes back up.
- Client side loadbalancing can be configured
    - RoundRobin/Token awareness/Data center awareness
- Driver should deal with node failures, hence we can also configure retry mechnism
- CQL native protocol is asynchronous
- Compression can be enabled between client and server
- Security can be configured between client and server
- Deifferent profiles can be configured between invocation by the same client

(Section: TDG) - Cassandra Client - Retry Failied Queries (if node failed)

- ExponentialReconnectionPolicy vs ConstantReconnectionPolicy
- onReadTimeout(), onWriteTimeout(), and onUnavailable()
- The RetryPolicy operations return a RetryDecision

(Section: TDG) - Cassandra Client side - SPECULATIVE EXECUTION

- The driver can preemptively start an additional execution of the query against a different coordinator node.
- When one of the queries returns, the driver provides that response and cancels any other outstanding queries.
- ConstantSpeculativeExecutionPolicy

(Section: TDG) - Cassandra Client side - CONNECTION POOLING

- Default single connection per node
- 128 simultaneous requests in protocol - v2
- 32768 simultaneous requests in protocol - v3
- 1024 - Default maximum number of simultaneous requests per connection.

(Section: TDG) - Cassandra Client side driver configuration

```
datastax-java-driver {
  basic {
    contact-points = [ "127.0.0.1:9042", "127.0.0.2:9042" ]
    session-keyspace = reservation
  }
}
```

(Section: TDG) - How to connect to Cassandra using Java API

1. Create Cluster object
2. Create Session object
3. Execute Query using session and retrieve the result
4.

```
Cluster cluster = Cluster.builder().addContact-
        Point("127.0.0.1").build()


Session session = cluster.connect("KillrVideo")
ResultSet result = session.execute("select * from
        videos_by_tag where tag='cassandra'");


boolean columnExists = result.getColumnDefini-
        tions().asList().stream().anyMatch(cl -> cl.get-
        Name().equals("publisher"));



List<Book> books = new ArrayList<Book>();
result.forEach(r -> {
  books.add(new Book(
      r.getUUID("id"),
      r.getString("title"),
      r.getString("subject"))));
});
return books;
```

(Section: TDG) - How to connect to Cassandra using Python API

```
python -m pip install --upgrade pip
pip install cassandra-driver
``


```python
from cassandra.cluster import Cluster
cluster = Cluster(protocol_version = 3)
session = cluster.connect('Killrvideo')
result = session.execute("select * from videos_by_tag where tag='cas-
        sandra'")[0];
print('{0:12} {1:40} {2:5}'.format('Tag', 'ID', 'Title'))
for val in session.execute("select * from videos_by_tag"):
   print('{0:12} {1:40} {2:5}'.format(val[0], val[2], val[3]))
```

(Section: TDG) - Cassandra Client (Datastax Driver 4.9.0) - Java API

```
CqlSession cqlSession = CqlSession.builder()
    .addContactPoint(new InetSocketAddress("127.0.0.1", 9042))
    .withKeyspace("reservation")
    .withLocalDatacenter("<data center name>")
    .build()
```
```

(Section: TDG) - Cassandra Client Mapper/Entity Annotations

- @Mapper
- @Select
- @Insert
- @Delete
- @Query

(Section: TDG) - Cassandra Client (Datastax Driver 5.0) - QueryBuilder API API

```
Select reservationSelect =  selectFrom("reservation", "reserva-
        tions_by_confirmation")
  .all()
  .whereColumn("confirm_number").isEqualTo("RS2G0Z");


SimpleStatement reseravationSelectStatement = reservationSe-
        lect.build()
```

(Section: TDG) - Cassandra Client (Datastax Driver 5.0) - Async API

- CQL native protocol is asynchronous
-

```
CompletionStage<AsyncResultSet> resultStage =  cqlSession.exe-
  cuteAsync(statement);
```

```
// Load the reservation by confirmation number
CompletionStage<AsyncResultSet> selectStage = session.executeA-
  sync("SELECT * FROM reservations_by_confirmation WHERE con-
  firm_number=RS2G0Z");


// Use fields of the reservation to delete from other table
CompletionStage<AsyncResultSet> deleteStage =
  selectStage.thenCompose(
    resultSet -> {
      Row reservationRow = resultSet.one();
      return session.executeAsync(SimpleStatement.newInstance(
        "DELETE FROM reservations_by_hotel_date WHERE hotel_id
  = ? AND
          start_date = ? AND room_number = ?",
        reservationRow.getString("confirm_number"),
        reservationRow.getLocalDate("start_date"),
        reservationRow.getInt("room_number"));
    });


// Check results for success
deleteStage.whenComplete(
    (resultSet, error) -> {
      if (error != null) {
        System.out.printf("Failed to delete: %s\n", er-
  ror.getMessage());
      } else {
        System.out.println("Delete successful");
      }
```

(Section: TDG) - JDK 9 - Reactive style API

- The CqlSession interface extends a new ReactiveSession interface. Which adds methods such as executeReactive() to process queries expressed as reactive streams.

- ```
  try (CqlSession session = ...) {
        Flux.from(session.executeReactive("SELECT ..."))
            .doOnNext(System.out::println)
            .blockLast();
  } catch (DriverException e) {
    e.printStackTrace();
  }

  try (CqlSession session = ...) {
    Flux.just("INSERT ...", "INSERT ...", "INSERT ...", ...)
        .doOnNext(System.out::println)
        .flatMap(session::executeReactive)
        .blockLast();
  } catch (DriverException e) {
    e.printStackTrace();
  }
  ```

(Section: TDG) - Cassandra write path

- Performance optimzied for write using append only
- Database commit log and hinted handoff design, the database is always writable, and within a row, writes are always atomic.
- Consistency Level - ANY/ONE/TWO/THREE/LOCAL_ONE/QUO-
  ```

RUM/LOCAL_QUORUM/EACH_QUORUM/ALL
    - ANY - Hinted hand-off is counted
    - ONE (Atleast one commit-log + sstable) is counted as one
- Write-Path
    - Client > Cassandra Cordinator Node > Nodes (replicas)
    - If client uses token-aware cordinator itself replica, if not key is used by partitioner to find node
    - Co-ordinator selects remote co-ordinator for X-DC replications
- Node that was down will have data using one of the following
    - hinted handoff
    - read repair
    - Anti-entropy repair.
- Existing Row-Cache is invalidated during write
- Flush and Compaction might be peformed if necessary
- Memtables are stored as SS-Table to disk

(Section: TDG) - Cassandra write path - Materialized view

- Partition must be locked while consensus negotiated between replicas
- Logged batches are used to maintain materialized views
- The Cassandra database performs an additional read-before-write operation to update each materialized view
- If a delete on the source table affects two or more contiguous rows, this delete is tagged with one tombstone.
- But one delete in a source table might create multiple tombstones in the materialized view

(Section: TDG) - Cassandra write/read - consistency CQLS

- bash cqlsh> CONSISTENCY; ## Current consistency level is ONE. cqlsh> CONSISTENCY LOCAL_ONE; ## Consistency level set to LOCAL_ONE. ## statement.setConsistencyLevel(ConsistencyLevel.LOCAL_QUORUM);

(Section: TDG) - Cassandra failures and solutions

- java.lang.OutOfMemoryError: Map failed` - Almost always incorrect user limits - check ulimit -a
    - Check the values of max memory size and virtual memory

(Section: TDG) - Scaling Quotes

- If you can't split it, you can't scale it. "Randy Shoup, Distinguished Architect, eBay"
- "The Case for Shared Nothing" - Michael Stonebreaker
- No sane pilot would take off in an airplane without the ability to land, and no sane engineer would roll code that they could not pull back off in an emergency
- Management means measurement, and a failure to measure is a failure to manage.

(Section: TDG) - Performance Quotes

1. “The recommendation for speeding up …. is to add cache and more cache. And after that add a little more cache just in case.”
2. “When something becomes slow it’s a candidate for caching.”
3. “LRU policy is perhaps the most popular due to its simplicity, good runtime performance, and a decent hit rate in common workloads.”
4. “Rather than dealing with the uncertainty of the correctness of an answer, the data is made unavailable until it is absolutely certain that it is correct.” (pitfall of strong consistency)

(Section: TDG) - Nodetool

- Adminstration tool uses JMX to interact with Cassandra
- TPstats (threadpoolstatus) and Tablestats are subcommands in nodetool
- nodetool help tpstats
- nodetool tpstats –

(Section: TDG) - Building Cassandra

- Cassandra is built using Ant & Maven (Ant in-turn uses Maven)
- Apache Builds
- Apache Cassandra Build
- Cassandra source
- ‘jdk8; ant -f build.xml clean generate-idea-files’
- ‘jdk8; ant -f build.xml test cqltest’
- To test one class in intelli-idea
    - java -Dcassandra.config=file:\:.yaml -Dlogback.configu-

rationFile=file:\:-test.xml -Dcassandra.logdir=D:/git/cassandra4/build/test/logs -Djava.library.path=D:/git/cassandra4/lib/sigar-bin -ea org.apache.cassandra.db.compaction.LeveledCompactionStrategyTest

- Ant default target would produce apache-cassandra-x.x.x.jar

(Section: TDG) - Resources

- https://community.datastax.com/
- user@cassandra.apache.org - provides a general discussion list for users and is frequently used by new users or those needing assistance.
- dev@cassandra.apache.org - is used by developers to discuss changes, prioritize work, and approve releases.
- client-dev@cassandra.apache.org - is used for discussion specific to development of Cassandra clients for various programming languages.
- commits@cassandra.apache.org - tracks Cassandra code commits. This is a fairly high-volume list and is primarily of interest to committers.
- cassandra and cassandra-dev slack channels
- Cassandra blogs
    - https://thelastpickle.com/blog/
    - https://cassandra.apache.org/blog/
    - https://www.instaclustr.com/category/technical/cassandra/
    - https://www.datastax.com/blog

(Section: TDG) - Follow-up questions for Cassandra

- What are the other peer-to-peer databases?
    - How clients are connecting to them?
- Does mongo-db/kafka supports Cassandra-toplogy/cross-dc kind of configurations?
- How to find node using token in Cassandra?
- Where else “PHI THRESHOLD AND ACCRUAL FAILURE DETECTORS” being used?
- MerkleTree (surprise usage in Cassandra)
- PHI THRESHOLD AND ACCRUAL FAILURE DETECTORS (Surprise)

(Section: TDG) - Definitive Guide References

- Cassandra Guide
- Cassandra Paper
- AWS re:Invent 2018: Amazon DynamoDB Deep Dive: Advanced Design Patterns for DynamoDB (DAT401)
- amazon-dynamodb-deep-dive-advanced-design-patterns-for-dynamodb
- Best Practices NOSql
- E.F Codd paper
- The Case for Shared Nothing - Michael Stonebraker
- CAP Theorem
- CAP Twelve Years Later: How the “Rules” Have Changed
- Cassandra - A Decentralized Structured Storage System
- Cassandra - A Decentralized Structured Storage System-Updated-Commentry by Johnathan Ellis

- Awesome Cassandra
- Cassandra pay-2015
- Cassandra pay-2019
- Dice pay 2020
- CQLSH Introduction
- Wide Partitions in Apache Cassandra 3.11
- Paxos made simple
- Datastax driver reference
- Incremental Repair Improvements in Cassandra 4
- CassandraSummit

(Section: TDG) - Code

- jeffreyscarpenter/reservation-service
- Datastax KillrVideo sample java application
- Datastax spring pet-clinic

(Section: TDG) - How to create anki from this markdown file

```
mdanki Cassandra_Definitive_Guide_Anki.md Cassandra_Defini-
tive_Guide.apkg --deck "Mohan::Cassandra::DefinitiveGuide"
```

(Section: Installation) - Pre-requisite for this tutorial is docker

- Docker cheatsheet
- Dockerfile-3.11.10

(Section: Installation) - Use Os-boxes as virtual machine to install cassandra

- Base installation location - /home/osboxes/node
- Base location for lab - /home/osboxes/Downloads/labwork/data-files
- /home/osboxes/Downloads/labwork/data-files/videos-by-tag.csv

To start Cassandra

```
cd /home/osboxes/node/
nohup ./bin/dse cassandra
### Find status Cassandra
osboxes@osboxes:~/node/bin$ ./dsetool status

C: Cassandra       Workload: Cassandra       Graph: no
=====================================================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
--   Address          Load             Effective-Ownership  To-
ken                                        Rack         Health [0,1]
UN   127.0.0.1        180.95 KiB       100.00%
0                                            rack1
0.70
```

(Section: Installation) - Cassandra cluster using apache cassandra (Wait at-least 1 minute between successive container spin-off)

```
docker pull cassandra:3.11.10
docker network create cassnet
docker run --name cass1 --network cassnet -d cassandra:3.11.10
docker run --name cass2 --network cassnet -e CASSANDRA_SEEDS=cass1
        -d cassandra:3.11.10
docker run --name cass3 --network cassnet -e CASSAN-
        DRA_SEEDS=cass1,cass2 -d cassandra:3.11.10
#docker run --name  my-cassandra -p 9042:9042 -p 7000:7000 --network
        host -d cassandra:latest
## (Section: Installation) -  Check log
docker logs -f cass1
## (Section: Installation) -  Loging using CQLSH
docker exec -it cass2 cqlsh
docker exec -it cass2 nodetool ring
docker exec -it cass2 nodetool stopdaemon
```

(Section: Installation) - Connect to cassandra docker cluster

```
docker inspect cass2 | grep IPAddress
docker exec -it cass2 bash
cqlsh 172.18.0.3 9042
use cycling;
```

(Section: Installation) - Run commands into cassandra docker node

```
docker exec -it cass2 nodetool tpstats
docker exec -it cass2 nodetool repair
```

(Section: Installation) - Via docker for DSE server

```
## (Section: Installation) -  Find Cassandra tag to practice --
        choose ops-center and later dse server -- 6.0.16-1
docker pull datastax/dse-server:6.0.16-1
docker network create cassnet # docker network create --dri-
        ver=bridge cassnet
## (Section: Installation) -  OPS Center can manage cluser, it
        should run first
docker run -e DS_LICENSE=accept -d -p 8888:8888 -p 61620:61620 --
        name my-opscenter --network cassnet datastax/dse-opscen-
        ter:6.1.10
docker run -e DS_LICENSE=accept -p 9042:9042 -p 7000:7000 -d --name
        my-cassandra --network cassnet datastax/dse-server:6.0.16-1
docker run -e DS_LICENSE=accept -p 9042:9042 -p 7000:7000 -d --name
        my-cassandra-2 --network -e CASSANDRA_SEEDS=my-cassandra
        cassnet datastax/dse-server:6.0.16-1
## (Section: Installation) -  Running dse-studio
docker run -e DS_LICENSE=accept --network cassnet  --link some-cas-
        sandra --name my-studio -d datastax/dse-studio
docker exec -it my-cassandra cqlsh
docker exec -it my-cassandra nodetool status


## (Section: Installation) -  #172.19.0.2 #172.19.0.3


docker exec -it my-studio cqlsh ip_address
```

```
docker exec -it my-cassandra sh -c "/opt/dse/bin/cqlsh.sh"
"within container" >> cd /opt/dse/bin/cqlsh.sh

docker cp  D:/git/cassandra_playground/labwork/data-files/videos.csv
        some-cassandra:/videos.csv
```

(Section: Installation) - Setting up application using DSE image -Running Cassandra in Docker

- bash docker pull cassandra docker run -d --name nodeA --network cassnet cassandra docker logs -f nodeA docker pull datastaxdevs/petclinic-backend docker run -d \ --name backend \ --network cass-cluster-network \ -p 9966:9966 \ -e CASSANDRA_USE_ASTRA=false \ -e CASSANDRA_USER=cassandra \ -e CASSANDRA_PASSWORD=cassandra \ -e CASSANDRA_LOCAL_DC=datacenter1 \ -e CASSANDRA_CONTACT_POINTS=nodeA:9042 \ -e CASSANDRA_KEYSPACE_CQL="CREATE KEYSPACE spring_petclinic WITH REPLICATION = {'class':'SimpleStrategy','replication_factor':1};" \ datastaxdevs/petclinic-backend curl -X GET "http://localhost:9966/petclinic/api/pettypes" -H "accept: application/json" | jq curl -X POST \ "http://localhost:9966/petclinic/api/pettypes" \ -H "accept: application/json" \ -H "Content-Type: application/json" \ -d "{ \"id\": \"unicorn\", \"name\": \"unicorn\"}" | jq docker exec -it nodeA cqlsh; USE spring_petclinic; SELECT * FROM petclinic_reference_lists WHERE list_name='pet_type'; QUIT; docker pull datastaxdevs/petclinic-frontend-nodejs docker run -d --name

```
frontend -p 8080:8080 -e URL=https://2886795274-9966-ja-
go04.environments.katacoda.com datastaxdevs/petclinic-fron-
tend-nodejs     clear     docker ps --format
'{{.ID}}\t{{.Names}}\t{{.Image}}'     docker stop $(docker
ps -aq)     docker rm $(docker ps -aq)     docker ps --for-
mat '{{.ID}}\t{{.Names}}\t{{.Image}}'     ## Via docker com-
pose     docker-compose up --scale db=3
```

- Swagger-API

(Section: Installation) - Copy files into and out-of containers

```
docker cp cass1:/etc/cassandra/cassandra.yaml /tmp
docker cp cass1:/var/log/cassandra/* D:/git/cassandra_playground/log
docker cp cass1:/var/log/cassandra/system.log D:/git/cassandra_play-
        ground/log
docker cp cass1:/var/log/cassandra/debug.log D:/git/cassandra_play-
        ground/log
```

(Section: Installation) - Some Cassandra commands

```
nodetool status
nodetool info
nodetool describecluster
nodetool getloggginglevels
nodetool setloggginglevel org.apache.cassandra TRACE
nodetool settraceprobability 0.1
nodetool drain
nodetool stopdaemon
```

```
nodtool flush
cassandra-stress write n=50000 no-warmup -rate threads=1
```

(Section: Installation) - Cassandra directory (Apache Cassandra)

- /etc/cassandra
- -Dcom.sun.management.jmxremote.password.file=/etc/cassandra/jmxremote.password
- -Dcassandra.logdir=/var/log/cassandra
- -Dcassandra.storagedir=/var/lib/cassandra
- /usr/share/cassandra/lib/HdrHistogram-2.1.9.jar

(Section: Installation) - Cassandra stress-tool

- Creates keyspace1
- Reports maximum possible io-ops, partition-rate and latency mean

(Section: Installation) - To start CQLSH

```
set PATH=D:\Apps\Python\Python27;%PATH%;
#via Docker
docker exec -it my-cassandra cqlsh

CREATE KEYSPACE "KillrVideo" WITH REPLICATION = {
 'class' : 'SimpleStrategy',
 'replication_factor' : 1
};

USE KillrVideo;
```

```
create table KillrVideo.videos(
    video_id timeuuid PRIMARY KEY,
    added_date timestamp,
    Title Text
);

insert into videos (video_id, added_date, Title) values
        (1645ea59-14bd-11e5-a993-8138354b7e31, '2014-01-29', 'Cassan-
        dra History');
select * from videos where
        video_id=1645ea59-14bd-11e5-a993-8138354b7e31;
insert into videos (video_id, added_date, Title) values
        (245e8024-14bd-11e5-9743-8238356b7e32, '2012-04-03', 'Cassan-
        dra & SSDs');
select * from videos;
TRUNCATE videos;
COPY videos(video_id, added_date, title) FROM '/home/osboxes/Down-
        loads/labwork/data-files/videos.csv' WITH HEADER=TRUE;
```

(Section: Installation) - References

- Dockerfile-3.11.10
- Docker DSE
- Docker Setup
- DSE Docker setup on windows
- Cassandra Acadamy
- Datastax VM
- Assets for course

- C: ## Cassandra node
- Cassandra designed for JBOD (just a bunch of disk) setup
- If disk is attached to ethernet, it is wrong choice, hence Cassandra not tuned to work with SAN/NAS
- A node can work with
    - 6K to 12K transaction
    - 2-4TB of data on ssd
- Cassandra can lineraly scale with new nodes
-

(Section: Architecture) - nodetool

- help - help
- info - jvm statistics
- status - all the nodes status (how this node see other nodes in cluster)

(Section: Architecture) - Ring

- Apache cassandra cluster - Collection of nodes
- Node that we connect is co-ordinator node
- Each node is responsible for range of data
    - Token range
- Every node can deduce which node owns the range of token (range of data)
- Co-ordinate sends to acknowledge to client
    - co-ordinator-node !12== data-node
- Range

        - (2^63)-1 to -(2^63)
- Partitioner - Decides how to distribute data within nodes
- Right partitioner would place the data widely
    - Murmur3 as a partitioner
    - MD5 partitioner (random and even)

(Section: Architecture) - When a new node joins the ring

- Gossips out to seed-node (seed-nodes are configured in cassandra.yaml)
- Other node finds where could new node could fit (could be manual or automatic)
- Seed nodes communicate cluster topology to the joining new-node
- State of the nodes
    - Joining, Leaving, UP and Down

(Section: Architecture) - Driver

- Client could intelligently use node status and clutser
- Client would use different policies
    - TokenAwarePolicy
    - RoundRobinPolicy
    - DCAwareRoundRobinPolicy
- Driver knowing token range would make it intelligent, It would directly talk to data node when data is required
- Driver can use the TokenAwarePolicy and directly deal with the node that is responsbile for the data, internally it would avoid one more hop (co-ordinator-node === data-node)

(Section: Architecture) - Peer-to-Peer

- We should understand the reason by behind peer-to-peer
- Relation databases scales in one of the following way
    - Leader-follower
        - Data is not replicated realtime (hence not consistent)
    - Sharding
        - We need routing if we shard the data
        - No Aggregation support
        - No-joins or group-by
- In peer-to-peer
    - No node is special
    - Everyone is peer
    - Any node can act as co-ordinator (router)
    - No-split-brain Problem
        - Any node that is visible to client might accept the write request
        - Last write wins

(Section: Architecture) - VNode

- If token is distributed in contiguous-range to a physical node, it won't help when new-node joins
    - Hence every node will not get contiguous token range for its capcity
- Bootstraping new node is complex in peer-to-peer without vnodes
- Adding/Removing nodes in distributed system is complex, it can't just rely on the number of physical node
- Vnodes eases the use of heterogeneous machines in a cluster. Better

machine can have more vnodes than older.

- We can't move all the data of one-physical node to other node when new-node joins
    - It put strain on the node that transfers the data
    - It won't happen in parallel way
- Each node has 128 VNode (default)
- Vnode automate token range assignment
- num_tokens@cassandra.yaml > 1, enables the vnode (1 means disable vnode)
- If all nodes have equal hardware capability, each node should have the same num_tokens value.

(Section: Architecture) - Why Vnode?

- If we have 30 node (with RF=3), effectively we have 10 nodes of original data, 20 nodes of replicated. If every node holds data for 3 ranges of token, and when a node goes down, logically we have RF=2 for set of data, and we can stream from 6 nodes of data
- If you started your older machines with 64 vnodes per node and the new machines are twice as powerful, simply give them 128 vnodes each and the cluster remains balanced even during transition.
- When using vnodes, Cassandra automatically assigns the token ranges for you. Without vnode, manual assignment is required.

(Section: Architecture) - Gossip protocol

- Gossip is a peer-to-peer communication protocol in which nodes periodically exchange state information about themselves and about other nodes they know about.
- if a first gossips with second node, and later 1st node gossips with 3

other nodes and second nodes gossips with 3 other node, and each node successively gossips with randomly with other node.. information is quickly spread
        - Node information spreads out in polynomial fashion

1. Each node initiates a gossip round every second
2. Picks one to three nodes to gossip with
3. Nodes can gossip with ANY other node in the cluster
4. Probabilistically (slightly favor) seed and downed nodes
5. Nodes do not track which nodes they gossiped with prior
6. Reliably and efficiently spreads node metadata through the cluster
7. Fault tolerant—continues to spread when nodes fail

(Section: Architecture) - What is gossiped?

- SYN, ACK, ACK2
    - SYN - sender node details
    - ACK - reciever node details + packs additional details that receiver knows extra than sender (not just digest)
    - ACK2 - packs additional details that initiator knows extra then receiver (not just digest)
- Gossip message is tiny, won't cause significant impact to network bandwidth (network spikes won't be caused)
- JSON is only for analogy

```
## (Section: Architecture) -  Json analogy
{
  "endPointState": {
    "endPoint": "192.168.0.1",
    "heartBeatState": 515,
    "version": 28
  },
```

```
  "applicationState": {
    "STATUS": "NORMAL",
    "DC": "west",
    "RACK": "rack1",
    "SCHEMA": "c2b9ksc",
    "LOAD": 100.0,
    "SEVERITY": 0.75
  }
}
```


(Section: Architecture) - Snitch

- Snitch - means informer (with criminal background or approver)
- Rerports DC, Rack information to each other
- Types of snitch
    - SimpleSnitch hardcodes DC1, RACK1 (useless)
    - PropertyFileSnitch - Every node has to keep, and manualy maintenance
    - GossipingPropertyFileSnitch
    - RackInferingSnitch - Infers from IP address - unreliable (not recommended to use)
    - Cassandra.yaml
        - endpoint_snitch : {“SmpleSnitch” | “Property-FileSnitch” | “GossipingPropertyFileSnitch” | “DynamicSnitch” }
        - Ec2Snitch, GoogleCloudSnitch, CloudStack-Snitch
    - DynamicSnitch - can work on top of snitch that was con-figured, and in addition knows the high performing node. When node needs to replicate, it can find high-peforming node using DynamicSnitch

- If we need to change the snitch
    - After changing, need to restart all the nodes and run the sequential repair and clean-up on each node.
- All node must use same snitch

(Section: Architecture) - Property File Snitch

- Reads datacenter and rack information for all nodes from a file You must keep files in sync with all nodes in the cluster

```
cassandra-topology.properties file
175.56.12.105=DC1:RAC1
175.50.13.200=DC1:RAC1
175.54.35.197=DC1:RAC2
175.54.35.152=DC1:RAC2

120.53.24.101=DC2:RAC1
120.55.16.200=DC2:RAC1
120.57.18.103=DC2:RAC2
120.57.18.177=DC2:RAC2
```

(Section: Architecture) - Gossiping Property File Snitch

- Relieves the pain of the property file snitch
- Declare the current node's DC/rack information in a file
- You must set each individual node's settings
- But you don't have to copy settings as with property file snitch
- Gossip spreads the setting through the cluster

```
cassandra-rackdc.properties file
```

```
dc=DC1
rack=RAC
```

(Section: Architecture) - Cassandra replication

- When co-ordinator responsible for token range 15-25 receives data to save, it finds its token range and copies data to target node
- Co-ordinator needs to write data to the node where hash-range belongs
    - if RF=2, every node has its data, and it also gets data from its prior node as part of replication
    - if RF=3, every node has its data, and it also gets replicated copies of data from prior node-range (as part of replication)
- We can configure multi-datacenter replication for each keyspace
    - Replication factor could be different for each datacenter
    - When Co-ordinator needs to write data to target-node + 2 other node, where one-of-them belongs to other data-center
    - Data recieved in that target-node of the different data-center takes responsibility to replicate in its data-center
- A replication factor greater than one…
    - Widens the range of token values a single node is responsible for.
    - Causes overlap in the token ranges amongst nodes.
    - Requires more storage in your cluster.

(Section: Architecture) - Consistency Level

- **Request-Coordinator to Client** Defines how many replicas that are writing or reading data must respond to a **request coordinator** before the coordinator responds to the client.
- Cassandra fits into AP system (CAP), Csonsistency is tunable parameter in Cassandra.
- Cassandra by default optimized for Availablity and Partiton, But can be tuned little to accomadate consistency
- Client writes data into Cassandra, it can choose any of the below
    - CL = ONE === Fastest
    - CL = Quorum
    - CL = ALL (every replica has to write and acknowledge the read) === Slowest
- Client read data into Cassandra, it can choose any of the below
    - CL = ONE (Write CF = All)
    - CL = Quorum (Recommeneded if data was written using CF = Quorum)
    - CL = ALL (Write CF = Quorum)
- Read (CF=ONE) and Write (CF=ONE), When is it useful
    - IOT
    - Log-data
    - IOT Timeseries data (where consistency is not that important)
- Consistency across data-center
    - Replica to remote DC could be part of quorum, but it makes write/read slower
    - Choose for local-quorum
- Higher consistency === higher latency (higher latency – poor)

(Section: Architecture) - Consistency level in Cassandra

Consistency Settings In order of weakest to strongest 1. ANY - Storing a hint at minimum is satisfactory 1. ALL - Every node must participate 1. ONE,TWO,THREE - Checks closest node(s) to coordinator 1. QUORUM - Majority vote, (sum_of_replication_factors / 2) + 1 1. LOCAL_ONE - Closest node to coordinator in same data center 1. LOCAL_QUORUM - Closest quorum of nodes in same data center 1. EACH_QUORUM - Quorum of nodes in each data center, applies to writes only

With a replication factor of three, which of the following options guarantee strong consistency?

- [x] - write all, read one
- [x] - write all, read quorum
- [x] - write quorum, read all
- [x] - write quorum, read quorum
- [-] - ~~write one, read all~~

(Section: Architecture) - Hinted hand-off

- Write request can be served, even when nodes are down. Co-ordinator caches using hints file, later handoever the data to target node
- Hints file will be deleted after expiry (default 3 hours), hence data write is not guarantee to the node it was down
- If actual node comes while co-ordinator was down, data won't reach the target node
- When node comes back-online, it receives copy from co-ordinator (not from other 2-replicas when RF=3)

- Hinted-hand-off + Consistency-level-Any means potential data-loss.
    - Even when RF=3 and if three targe nodes for data is down, CONSISTENCY_LEVEL_ANY would successfully return to client
- Consistency-level-Any is not practical due to hinted-hand-off
- We can disable hinted-hand-off

(Section: Architecture) - Read repair (Assume RF=3)

- Nodes goes out-of-sync for many reasons
    - Network partition, node failures, storage failure
- Co-ordinator sometime can answer best available anster (instead of correct answer)
- for read request of CL=ALL, Co-ordinator asks data from fastest node (finds using snitch), and checksum-digest from other two nodes, if they are all consistent, it would reply to client-read
- if checksum-digest doesn't matches
    1. Co-ordinator requests replicated data from other two nodes
    2. Compares the timestamp for the 3 copies
    3. Sends the latest data to client
    4. Replicates the latest data to the nodes that has stale copy

(Section: Architecture) - Read Repair Chance

- Performed when read is at a consistency level less than ALL
- Request reads only a subset of the replicas
- We can't be sure replicas are in sync
- Generally you are safe, but no guarantees

- Response sent immediately when consistency level is met
- Read repair done asynchronously in the background
- 10% by default

(Section: Architecture) - Node-repai

(Section: Architecture) - Nodetool has a repair tool that can repair entire cluster - Quite expensive operation

- nodetool repair –full
- Extra load on the network, IO also might spike

(Section: Architecture) - Datastax Node-sync

- It uses the same mechnism what read-repair mechnism does
- Datastax Node-sync (should be enabled on per-table-basis)
- Datastax Node-sync - runs in background, continously repairing data
    - Should be enabled per table
    - Create table myTable(…) WITH nodesync = {‘enabled’: ‘true’ };
    - Local token ranges as segments, and every segrment progress is saved in data-structure save-points
    - gc_grace_seconds for node-sync is 10 days, it tries to achieve this target.
    - Each segment is about 200MB, can be configured using segment_size_target_bytes
    - Segment is automic, system_distributed.nodesync_status table has segment status

        - Segment outcomes
            - full_in_sync - All replicas were in sync
            - full_repaired - Some repair necessary
            - partial_in_sync
            - partial_repaired
            - uncompleted
            - failed

(Section: Architecture) - Write path

1. Data reaches to node to write
2. Cassandra writes data to mem-table & commit-log
    - In mem-table, it is sorted under partion-key (used for read operation)
    - Commit-log is append-only log (it is like WAL - write ahead log) (used for recovery operation to reconstruct the mem-table)
3. Upon mem-table is full, Cassandra stores the mem-table to disk as SS-Table
    - Disk format is called ss-table (strig sorted table)
    - SS-Table is of similar format to the mem-table
4. Cassandra drops the commit-log (upon successful SS_TABLE) and destroys old mem-table
5. New mem-table (and commit log) is created
6. Read-path would take care to read data between mem-table and SS-Table
7. **Always ensure commit-log and ss-table are stored in different drive for performance reason**
    - If they are stored in same disk, append only log and read (seek operation), both would slow-down

- When does a client acknowledge a write?
    - Ans: After the commit log and MemTable are written
- SSTable and MemTable are stored sorted by clustering columns

(Section: Architecture) - Read path

- Data could be spread across multiple SS-Table (and in-memory), Hence read is bit more complex than write
- Data is partioned and partion-token is found, if partion-token is available in mem-table then data is returned (Simple)
- SS-Table is sorted and stored based on partion-token
- SS-Table partion-index is stored in a separate file called partition-index
- Partition-index (itself might grow big)
    - Example : If partition index file has 100 partition keys in it: pk001 to pk100. The partition keys are stored in sorted order, so we know that pk027 comes after pk025.
    - pk001: 0 (index offset)
    - pk002: 1170
    - pk...: 999999
    - pk099: 3431170
- Partition-summary (index about partition-index)
    - Incomplete partition index data-structure in-memory
    - Increases the speed to scan the partition-index-file
        - pk001-pk020: 0 (index offset of parition-index)
        - pk021-pk055: 45
        - pk056-pk700: 160
- Key-cache
    - If data was already read, then it directly stores the partition-token-offset of SS-Table in key-cache (cache)

- Bloom-filter
    - Key - possibly there (possible falst positive)
    - It is definitely not there
- Read > Bloom-Filter > Key-Cache > Partition Summary > Partition Index > SSTable

(Section: Architecture) - Data-stax

- No partition-index, instead trie based data-structure used as index
    - SS-Table lookup is much faster than OSS version
- Data-stax can read OSS-Cassandra and migrate to latest format of SS-Table
    - If we know pk0020 location inside the partition-index, it is easier to find the parition-index offset for pk0024 (https://stackoverflow.com/questions/26244456/internals-of-partition-summary-in-cassandra)

(Section: Architecture) - Compaction

(Section: Architecture) - Compacting partition

- Two SS-Table paritions can be merged using merge-sort
    - If keys are matching, take one with latest timestamp
    - Mostly latest paritions will have latest records
    - If two keys are matching, but if there is tombstone, and gc-grace-seconds are elapsed deleted records evicted, not written to new SS-TABLE
    - Despite there could be tombstore, but if gc_grace_seconds not breached, tombstone stored in new partition (for data-resurrection during repair)

- Not all tombstones are discarded during compaction.
- A new partition on disk be larger than either of its input partition segments after a compaction, if later partition segments are made up of mostly INSERT operations.
- Benefits from compactions are
    - More optimal disk usage
    - Faster reads
    - Less memory pressure

(Section: Architecture) - Compacting SSTables

- Two SS-Table merged using merge-sorted
- Merge might reduce the partition as all the stale values inside the parition are evicted
- Once new SS-Table is created, old SS-Table is dropped

(Section: Architecture) - Types of compaction

- SizeTiered Compaction (default for write heavy-load)
- Leveled Compaction (read optimized compaction)
- TimeWindow Compaction (for timeseries data)
- Alter table ks.myTable WITH compaction = { ‘class’: ‘LeveledCompactionStrategy’}

(Section: Architecture) - Datastax ES6

- Only one core per CPU and Non-blocking-IO
    - Claims to be more performant than OSS version

        - These threads are never block
        - Writes and Reads, both are asynchronous
        - Each thread has its own mem-table
        - Separate management thread for Mem-table-flush, Compaction, Hints, Streaming
- OSS - Executor thread-pool

(Section: Architecture) - Under what circumstances is the use of lightweight transactions justified?

- Race conditions and low data contention

(Section: Architecture) - Reference

- Vnodes

(Section: Partition) - Partition

- The most important concept in Cassandra is patition.
- Primary Key (state, (id))
    - First part of the primary is always partition keys, in the above primary key state is used as partition key
    - In 1000 node ring, state is used to find the ring-number using consistent hashing algorithm
    - It's complexity is - o(1)
- Partition key should be analogus to "GROUP BY" related column in typical rdbms table, Here we pre-compute whereas in RDBMS it might do full-table-scan

- Group rows physically together on disk based on the partition key.
- It hashes the partition key values to create a partition token.
- We can choose partition after table were constructed and data inserted

(Section: Partition) - Clustering Columns

- This constitutes part of Primary Key along with partition key
- We can have one or more clustering column
- Rows are sorted within the partition based on clustering column
- PRIMARY KEY ((state), city, name)
    - By default they are sorted in Ascending order
- A table always has a partition key, and that if the table has no clustering columns
    - Every partition of that table is only comprised of a single row
- Example
    - (PRIMARY KEY((state), city, name, id) WITH CLUSTERING ORDER BY (city DESC, name ASC))
    - “CREATE TABLE videos_by_tag (tag text, video_id uuid, added_date timestamp, title text, PRIMARY KEY(tag, added_date)) WITH CLUSTERING ORDER BY (added_date DESC);”

(Section: Partition) - Primary Key

- Primary Key = Partition Key + Clustering Column
- Decides uniqueness and date order (sorted and stored)
- Some example of primary key definition are:
    - PRIMARY KEY (a): a is the partition key and there is no

clustering columns.
    - PRIMARY KEY (a, b, c) : a is the partition key and b and c are the clustering columns.
    - PRIMARY KEY ((a, b), c) : a and b compose the partition key (this is often called a composite partition key) and c is the clustering column.

(Section: Partition) - Impact of partition key on query (CQL)

- All equality comparision comes before inequality (<, >)
- Inequality comparision or range queries on clustering columns are allowed (provided partition-key precedes)
- Since data is already sorted on disk
    - Range queries are binary search and followed by a linear read
- If we use datetime or timeuuid and stored them in descending order, later record always contains most recent one.
- ALLOW FILTERING
    - *Scans all partitions in the table*
    - Relaxes querying on parition key constraint
    - allows query on just clustering columns without knowing partition key
    - Don’t use it

(Section: Partition) - Querying

- Always provide partition key
- Follow the equality similar to the way it is defined
    - Remember that the storage order is based on Clustering

key within partition
    - If CQL has more than one equality within clustering column, follow the order of table definition
-

(Section: Partition) - CQL

```
cqlsh:killrvideo> desc table video;

CREATE TABLE killrvideo.videos (
    video_id timeuuid PRIMARY KEY,
    added_date timestamp,
    title text
) WITH bloom_filter_fp_chance = 0.01
    AND caching = {'keys': 'ALL', 'rows_per_partition': 'NONE'}
    AND comment = ''
    AND compaction = {'class': 'org.apache.cassandra.db.com-
        paction.SizeTieredCompactionStrategy', 'max_threshold': '32',
        'min_threshold': '4'}

    AND compression = {'chunk_length_in_kb': '64', 'class':
        'org.apache.cassandra.io.compress.LZ4Compressor'}
    AND crc_check_chance = 1.0
    AND default_time_to_live = 0
    AND gc_grace_seconds = 864000
    AND max_index_interval = 2048
    AND memtable_flush_period_in_ms = 0
    AND min_index_interval = 128
    AND speculative_retry = '99PERCENTILE';

COPY video(video_id, added_date, title) TO '/home/osboxes/node/lab-
        work/video.csv' WITH HEADER=TRUE;
```

```
cqlsh:killrvideo> COPY video(video_id, added_date, title) TO '/home/
        osboxes/node/labwork/video.csv' WITH HEADER=TRUE;
Using 1 child processes

Starting copy of killrvideo.video with columns [video_id,
        added_date, title].
Processed: 5 rows; Rate:      21 rows/s; Avg. rate:      21 rows/s
5 rows exported to 1 files in 0.234 seconds.

create table KillrVideo.videos(
    video_id timeuuid PRIMARY KEY,
    added_date timestamp,
    Title Text
);
COPY videos(video_id, added_date, title) FROM '/home/osboxes/node/
        labwork/video.csv' WITH HEADER=TRUE;
drop table video;

create table KillrVideo.videos_by_tag(
    tag Text,
    video_id timeuuid,
    added_date timestamp,
    Title Text,
    PRIMARY KEY (tag, video_id)
);
COPY videos_by_tag(tag, video_id, added_date, title) FROM '/home/os-
        boxes/Downloads/labwork/data-files/videos-by-tag.csv' WITH
        HEADER=TRUE;
select token(video_id), video_id from videos_by_tag where tag='cas-
        sandra';
select token(video_id), video_id from videos_by_tag where title='Cas-
        sandra Intro' allow FILTERING;
select * from videos_by_tag where tag='cassandra' and added_date >
        '2013-03-17';
drop table videos_by_tag;
```

```
CREATE TABLE videos_by_tag (
     tag text,
     video_id uuid,
     added_date timestamp,
     title text,
     PRIMARY KEY(tag, added_date)
 ) WITH CLUSTERING ORDER BY (added_date DESC);

COPY videos_by_tag(tag, video_id, added_date, title) FROM '/home/
        videos-by-tag.csv' WITH HEADER = TRUE;
select * from videos_by_tag where tag='cassandra' and added_date >
        '2013-03-17';
```

(Section: Partition) - Datastax slides

- (https://www.slideshare.net/planetcassandra/datastax-a-deep-look-at-the-cql-where-clause)[DataStax: A deep look at the CQL WHERE clause] ## (Section: Partition) - Reference
- Primary Key, Partition Key and Data Definition
- Cassandra Acadamy ## CAP Theorem (Consistency)
- CAP Theory and Consistency
- Cassandra fits into AP system, doesn't promise Consistency
    - Cassandra supports partition tolerance and availability
    - Cassandra promises tunable Consistency
    - Consistency can be controlled for each and every read/request independently
- Consistency is harder in distributed systems

- CL = Consistency-Number (Number of replication count for current transaction)
    - CL=1 = A node that stored data in commit-log and memtable
    - CL=ANY = Data is note is not stored in any node, but just handed over to co-ordinator node.
    - CL=Quorum = 51% of the nodes acknowledged that it wrote
    - CL=ALL, Highest consistency and reduce the availability
- CL=Quorum (both read and write) - is considered strongly consistent
- CL=ANY, used only for write (not for read)
- CL=ONE (Quite useful)
    - Log-data
    - TimeSeries data
    - IOT
- CL=ALL
    - Most useless (Entire cluster might stop… should use only after quite thoughtful conversation)
- Cross DC Consistency
    - Strong replication with consistency
    - Remote Coordinator
    - Quorum is heavy (for Cross-DC), It has to consider all the nodes across all the DC's
    - Local-Quorum (Remote coordinator would not consider for remote Quorum)
        - Not considered remote DC Quorum in Local

- Any < One/Two/Three < Quorum < Local_One < Local_Quorum < Each_Quorum < ALL (from weak to strong consistency)
- Each_Quorum - Quorum of nodes in each data-center, applies to write only

What is Each_Quorum

- Quorum of nodes in each data-center, applies to write only
- Not many application uses it

```
# nodetool status
Datacenter: datacenter1
=======================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
--  Address     Load       Tokens       Owns (effective)  Host
        ID                                Rack
UN  172.19.0.3  5.85 MiB   256          46.7%
        2b3576cd-3f5d-4b9c-80bf-9c5a5fce7dc5  rack1
UN  172.19.0.2  6.65 MiB   256          53.3%
        4936c442-00c7-4242-87cb-4cf265c5ae78  rack1


# nodetool ring | grep "172.19.0.3" | wc -l
256


# nodetool ring


Datacenter: datacenter1
==========
Address     Rack        Status State   Load
        Owns                Token
```

```
        9126432156340756354

172.19.0.2  rack1       Up     Normal  6.65 MiB
        53.31%              -9163250791483814686
172.19.0.3  rack1       Up     Normal  5.85 MiB
        46.69%              -9137673090615533091
172.19.0.2  rack1       Up     Normal  6.65 MiB
        53.31%              -9083337207055421835
172.19.0.2  rack1       Up     Normal  6.65 MiB
        53.31%              -8994933303427082675
172.19.0.3  rack1       Up     Normal  5.85 MiB
        46.69%              -8931107877434468662
172.19.0.3  rack1       Up     Normal  5.85 MiB
        46.69%              -8862098302720005632
172.19.0.2  rack1       Up     Normal  6.65 MiB
        53.31%              -8835701033996281573
172.19.0.3  rack1       Up     Normal  5.85 MiB
        46.69%              -8779311204712756082

# nodetool gossipinfo
/172.19.0.3
  generation:1573517338
  heartbeat:1729
  STATUS:15:NORMAL,-104443974761627325
  LOAD:1694:6131589.0
  SCHEMA:11:3e2505d7-5286-3090-bc68-d01d101c68db
  DC:7:datacenter1
  RACK:9:rack1
  RELEASE_VERSION:5:3.11.5
  RPC_ADDRESS:4:172.19.0.3
  NET_VERSION:2:11
  HOST_ID:3:2b3576cd-3f5d-4b9c-80bf-9c5a5fce7dc5
  RPC_READY:27:true
  TOKENS:14:<hidden>
/172.19.0.2
```

```
  generation:1573517338
  heartbeat:1728
  STATUS:15:NORMAL,-103897790007775916
  LOAD:1694:6974127.0
  SCHEMA:11:3e2505d7-5286-3090-bc68-d01d101c68db
  DC:7:datacenter1
  RACK:9:rack1
  RELEASE_VERSION:5:3.11.5
  RPC_ADDRESS:4:172.19.0.2
  NET_VERSION:2:11
  HOST_ID:3:4936c442-00c7-4242-87cb-4cf265c5ae78
  RPC_READY:27:true
  TOKENS:14:<hidden>

#  nodetool gossipinfo
/172.19.0.3
  generation:1573519222
  heartbeat:17
  STATUS:15:NORMAL,-104443974761627325
  LOAD:19:6396507.0
  SCHEMA:11:3e2505d7-5286-3090-bc68-d01d101c68db
  DC:7:datacenter1
  RACK:9:rack1
  RELEASE_VERSION:5:3.11.5
  RPC_ADDRESS:4:172.19.0.3
  NET_VERSION:2:11
  HOST_ID:3:2b3576cd-3f5d-4b9c-80bf-9c5a5fce7dc5
  TOKENS:14:<hidden>
/172.19.0.2
  generation:1573517338
  heartbeat:1971
  STATUS:15:NORMAL,-103897790007775916
```

```
  LOAD:1946:6974127.0
  SCHEMA:11:3e2505d7-5286-3090-bc68-d01d101c68db
  DC:7:datacenter1
  RACK:9:rack1
  RELEASE_VERSION:5:3.11.5
  RPC_ADDRESS:4:172.19.0.2
  NET_VERSION:2:11
  HOST_ID:3:4936c442-00c7-4242-87cb-4cf265c5ae78
  RPC_READY:27:true
  TOKENS:14:<hidden>

#  nodetool gossipinfo
/172.19.0.3
  generation:1573519222
  heartbeat:32
  STATUS:15:NORMAL,-104443974761627325
  LOAD:19:6396507.0
  SCHEMA:11:3e2505d7-5286-3090-bc68-d01d101c68db
  DC:7:datacenter1
  RACK:9:rack1
  RELEASE_VERSION:5:3.11.5
  RPC_ADDRESS:4:172.19.0.3
  NET_VERSION:2:11
  HOST_ID:3:2b3576cd-3f5d-4b9c-80bf-9c5a5fce7dc5
  RPC_READY:27:true
  TOKENS:14:<hidden>
/172.19.0.2
  generation:1573517338
  heartbeat:1982
  STATUS:15:NORMAL,-103897790007775916
  LOAD:1946:6974127.0
  SCHEMA:11:3e2505d7-5286-3090-bc68-d01d101c68db
```

```
DC:7:datacenter1
RACK:9:rack1
RELEASE_VERSION:5:3.11.5
RPC_ADDRESS:4:172.19.0.2
NET_VERSION:2:11
HOST_ID:3:4936c442-00c7-4242-87cb-4cf265c5ae78
RPC_READY:27:true
TOKENS:14:<hidden>

#
```

(Section: Performance) - Performance could be degraded for many reasons

- nodetool status - check all nodes are up
- nodetool tpstats - for dropped messages
    - Usage statistics of thread-pool

(Section: Performance) - Dropped Mutataions

- Cassandra uses SEDA architecture
    - If messages inside the are not processed with certain timeout under heavy load, they are dropped
    - If cross node is slow, it doesn't receive message fast enough, would be another cause for dropping of messages.
- High number of dropped mutation would cause query timeout
    - This indicates data writes may be lost
- Dropped mutations are automatically recovered by repair/read_repair

- Mutation Drop could happen within same node or cross nodes.
    - INFO [ScheduledTasks:1] 2019-07-21 11:44:46,150 MessagingService.java:1281 - MUTATION messages were dropped in last 5000 ms: 0 internal and 65 cross node. Mean internal dropped latency: 0 ms and Mean cross-node dropped latency: 4966 ms
-

(Section: Performance) - Configuration that affects dropped mutations

- write_request_timeout_in_ms - How long the coordinator waits for write requests to complete with at least one node in the local datacenter. Lowest acceptable value is 10 ms.
- it is milli-seconds, hence every 1000 ms - should be considered as 1 second
- cross_dc_rtt_in_ms - How much to increase the cross-datacenter timeout (write_request_timeout_in_ms + cross_dc_rtt_in_ms) for requests that involve only nodes in a remote datacenter. This setting is intended to reduce hint pressure.

(Section: Performance) - When does Cassandra end up having useless data

- If we reduce the replication factor, additional un-necessary data may be sitting till the actual compaction happens
- Once we add new node to reduce the token range, Cassandray may contain data from portions of token ranges it no longer owns

(Section: Performance) - How to find the largest SSTable (or largest partition) in the cluster

- nodetool tablehistograms keyspaces.table
- find the max value

(Section: Performance) - Usage statistics of thread-pool - output

```
root@15a092649e23:/# nodetool tpstats
Pool Name                         Active   Pending      Completed
        Blocked  All time blocked
ReadStage                              0         0
        3         0                 0
MiscStage                              0         0
        0         0                 0
CompactionExecutor                     0         0
        44         0                 0
MutationStage                          0         0
        1         0                 0
MemtableReclaimMemory                  0         0
        20         0                 0
PendingRangeCalculator                 0         0
        1         0                 0
GossipStage                            0         0
        0         0                 0
SecondaryIndexManagement               0         0
        0         0                 0
HintsDispatcher                        0         0
        0         0                 0
RequestResponseStage                   0         0
        0         0                 0
```

```
ReadRepairStage                         0         0
        0         0                 0
CounterMutationStage                    0         0
        0         0                 0
MigrationStage                          0         0
        1         0                 0
MemtablePostFlush                       0         0
        20         0                 0
PerDiskMemtableFlushWriter_0            0         0
        20         0                 0
ValidationExecutor                      0         0
        0         0                 0
Sampler                                 0         0
        0         0                 0
MemtableFlushWriter                     0         0
        20         0                 0
InternalResponseStage                   0         0
        0         0                 0
ViewMutationStage                       0         0
        0         0                 0
AntiEntropyStage                        0         0
        0         0                 0
CacheCleanupExecutor                    0         0
        0         0                 0

Message type           Dropped
READ                         0
RANGE_SLICE                  0
_TRACE                       0
HINT                         0
MUTATION                     0
COUNTER_MUTATION             0
BATCH_STORE                  0
BATCH_REMOVE                 0
REQUEST_RESPONSE             0
PAGED_RANGE                  0
READ_REPAIR                  0
```

(Section: DS210) - What is D210 Course about

- Operations for Apache Cassandra™ and DataStax Enterprise
- Installation
    - echo “deb https://debian.datastax.com/enterprise stable main” | sudo tee -a /etc/apt/sources.list.d/datastax.sources.list
    - curl -L https://debian.datastax.com/debian/repo_key | sudo apt-key add -
    - sudo apt-get update
    - sudo apt-get install dse-full

(Section: DS210) - What are basic parameter required for Cassandra quickstart

- Four parameters
    - cluster-name
    - listen-address (for peer Cassandra nodes to connect to)
    - native-transport-address (for clients)
    - seeds
        - Seeds should be comma seperated inside double quote - “ip1,ip2,ip3”

(Section: DS210) - What is the location of default Cassandra.yaml?

- /etc/dse/cassandra.yaml (package installer)
- /cassandra-home/resources/cassandra/conf/cassandra.yaml

(Section: DS210) - What are directories related settings, and level-2

settings (right after quickstart)

- initial_token: <128>
- commitlog_directory
    - /var/lib/cassandra/commitlog
- data_file_directories
    - /var/lib/cassandra/data
- hints_directory
    - /var/lib/cassandra/hints
- saved_caches_directory
- endpoint_snitch

(Section: DS210) - What are two file-systedm that should be separated

- /var/lib/cassandra/data and /var/lib/cassandra/commitlog

(Section: DS210) - Cluster Sizing

- Figure out cluster size parameters
    1. (Write)-Throughput - How much data per second?
    2. Growth Rate - How fast does capacity increase?
    3. Latency (Read) - How quickly must the cluster respond?

(Section: DS210) - Cluster Sizing - Writethrough put example

- 2m user commenting 5 comments a day, where a comment is 1000 byte

- **comments per second = (2m * 5)/(246060) = 10m/86400 = 100 comments per second**

- 100 * 1000 bytes = 100KB per-second (multiply into number of replication-factor)

(Section: DS210) - Cluster Sizing - Read throughput example

- 2m user viewing 10 video summaries a day, where a video has 4 comments

- **comments per second = (2m * 10 * 4)/(246060) = 80m/**

86400 = 925 comments per second

- 925 * 1000 bytes = 1MB per-second (should multiply into number of replication-factor?)

(Section: DS210) - Cluster-sizing - Monthly calculate

- Data should cover only 50% of disk space at any-time to allow repair and compaction to work
- Few they estimate just by doubling the need for 60-seconds and ex-tra-polate to 30 days
- per-second-data-volume * 30*86400
- 1MB per second into monthly need
    - 1MB * 86400 * 30 = 2.531 TB (here 1MB inclusive of anti-entropy)

(Section: DS210) - Cluster-sizing - Latency cal-culate

- Relevant Factors
    - IO Rate
    - Workload shape
    - Access Patterns
    - Table width

    - Node profile (memory/cpu/network)
- What is required SLA
- Do the benchmarking initially before launching

(Section: DS210) - Cluster Sizing - Probing Questions

1. What is the new/update ratio?
2. What is the replication factor?
3. Additional headroom for operations - Anti-entropy repair?

(Section: DS210) - Cassandra stress tool

- Define your shcema, and schema performance
- Understand how your database scales
- It could generate graphical output
- Specify any compaction strategy
- Optmize your datamodel and setttings
- Determine production capacity
- Yaml for Schema, Column, Batch and Query descriptions
- columnspec:

```
- name: name
  size: uniform(5..10) # The names of the staff members are be-
      tween 5-10 characters
  population: uniform(1..10) # 10 possible staff members to pick
      from
- name: when
  cluster: uniform(20..500) # Staff members do between 20 and 500
      events
- name: what
  size: normal(10..100,50)
```

- Distribution can be any among fom, EXTREME, EXP, GAUSS, UNIFORM, FIXED
- cassandra-stress user profile=/home/cassandra/TestProfile.yaml ops(insert=10000, user_by_email=100000) -node node-ds210-node1
- cassandra-stress user profile=TestProfile.yml ops(insert=2,user_by_email=2) no-warmup -rate threads<=54
- cassandra-stress user profile=TestProfile.yml ops(insert=2000,user_by_email=2) no-warmup -rate threads'<=32'

ubuntu@ds210-node1:~/labwork$ cassandra-stress user profile=TestProfile.yaml ops(insert=100000,user_by_email=100000) -node ds210-node1 There was a problem parsing the table cql: line 0:-1 mismatched input '' expecting ')'

(Section: DS210) - Linux top command

- Comes with every linux distribution - (How much Cassandra is using)
- Brief summary of Linux system resources + Per process details
- Summary
    - CPU Average
        - 1,5,15 (minute) average
        - Spike - will show up in 5 or 15
        - CPU - Wait
            - Too much of wait is problem for Cassandra (should be zero)
            - si/hi (sofwatre/hardware - interrupt) might give clue about waiting
- Memory
    - Res - Physical Memory
    - SHR - Shared Memory
    - VIRT - Virtual memory

        - Buffers are important
            - High read might cause SSTable in buffer
- Process State
        - Zombie, Sleeping, Running

(Section: DS210) - Linux top command - Cassandra

- Swap should be zero (Cassandra discourages swap)
        - Disable the swap, zero should be allocated
- Zombie should be zero

(Section: DS210) - Linux dstat command (alternative to top)

- dstat = cpustat + iostat + vmstat + ifstat (cpy/io/network)
- cpu-core specific information can be listed
- dstate - by defult won't include memory (dstate -am to add memory details output)
- print stat for every 2 seconds, and measure 7 iteration

```
ubuntu@ds210-node1:~$ dstat -am 2 7
--total-cpu-usage-- -dsk/total- -net/total- ---paging-- ---
system-- ------memory-usage-----
usr sys idl wai stl| read  writ| recv  send|  in   out |
int   csw | used  free  buff  cach
  3   6  89   2   0|3412k  112k|   0     0 |   0     0 |
505  1443 | 587M 6286M  100M  935M
```

```
  1   1  98   0   0|   0     0 |  66B  722B|   0     0 |
506  1261 | 587M 6286M  100M  935M
  0   0 100   0   0|   0     0 |  66B  418B|   0     0 |
147   403 | 587M 6286M  100M  935M
  0   0 100   0   0|   0     0 |  66B  418B|   0     0 |
161   376 | 587M 6286M  100M  935M
  0   1  99   0   0|   0     0 |  66B  418B|   0     0 |
596  1900 | 587M 6286M  100M  935M
  0   1  98   0   0|   0     0 |  66B  418B|   0     0 |
760  2137 | 587M 6286M  100M  935M
  0   0 100   0   0|   0  8192B|  66B  418B|   0     0 |
111   366 | 587M 6286M  100M  935M
ubuntu@ds210-node1:~$
```

- sys is higher - something costly happenning in system space (above 0 is not good)
- disk is weakest link in most system. if wait numbers are higher in user/system space, check disk
- hiq/siq = h/w and s/w interrupt
- HDD can transfer 10s of MBS, while SSDs can transfer hundreds of MBS
- Gigabit is 100MBS usually
- Paging should be usually be near zero (lots of paging is bad to performance)
- System stats can be an indication of process contention (CSW - context switch)

(Section: DS210) - Nodetool (Performance Analysis inside cluster node)

- dstat, top - can investigate inside linux
- nodetool - can investigate inside Cassandra JVM
- Every Cache size hit ratio should be higher (should be above 80%)
- Load - How much data is stored inside node

```
cqlsh:killr_video> exit
root@c1bf4c2d5378:/# nodetool info
ID                     : 020b9ef3-ae33-4c9f-902a-33eb7f9a753d
Gossip active          : true
Thrift active          : false
Native Transport active: true
Load                   : 571.88 KiB
Generation No          : 1625291106
Uptime (seconds)       : 35986
Heap Memory (MB)       : 209.83 / 998.44
Off Heap Memory (MB)   : 0.01
Data Center            : datacenter1
Rack                   : rack1
Exceptions             : 0
Key Cache              : entries 3721, size 323.3 KiB, capacity 49
MiB, 6138479 hits, 6142208 requests, 0.999 recent hit rate, 14400
save period in seconds
Row Cache              : entries 0, size 0 bytes, capacity 0 bytes,
0 hits, 0 requests, NaN recent hit rate, 0 save period in seconds
Counter Cache          : entries 0, size 0 bytes, capacity 24 MiB, 0
hits, 0 requests, NaN recent hit rate, 7200 save period in seconds
Chunk Cache            : entries 27, size 1.69 MiB, capacity 217
MiB, 120 misses, 6150101 requests, 1.000 recent hit rate, NaN mi-
```

```
croseconds miss latency
Percent Repaired       : 100.0%
Token                  : (invoke with -T/--tokens to see all 256 to-
kens)
```

(Section: DS210) - Nodetool compaction-history - what are all the fields and output?

```
root@c1bf4c2d5378:/# nodetool compactionhistory
Compaction History:
id                                     keyspace_name columnfamily_name
compacted_at            bytes_in bytes_out rows_merged
e01933a0-dc04-11eb-bef5-537733e6a124 system        size_estimates
2021-07-03T13:45:06.266 169066   41854     {4:4}
e0175ee0-dc04-11eb-bef5-537733e6a124 system        sstable_activity
2021-07-03T13:45:06.254 1102     224       {1:12, 4:4}
bacb1140-dbeb-11eb-bef5-537733e6a124 system        size_estimates
2021-07-03T10:45:06.260 169604   41922     {4:4}
bac8ee60-dbeb-11eb-bef5-537733e6a124 system        sstable_activity
2021-07-03T10:45:06.246 968      224       {1:8, 3:1, 4:3}
```

(Section: DS210) - To figure out the name of a node's datacenter and rack, which nodetool sub-command should you use?

- Nodetool info

(Section: DS210) - Nodetool gcstats

- Higher the GC Elapsed time is worst performance of the cluster
- Higher StdDev, cluster performance would be erratic

```
root@c1bf4c2d5378:/# nodetool gcstats
       Interval (ms) Max GC Elapsed (ms)Total GC Elapsed (ms)Stdev
        GC Elapsed (ms)   GC Reclaimed (MB)         Collections
        Direct Memory Bytes
                 334                   0
        0                NaN                    0
        0                      -1
root@c1bf4c2d5378:/# nodetool gcstats
       Interval (ms) Max GC Elapsed (ms)Total GC Elapsed (ms)Stdev
        GC Elapsed (ms)   GC Reclaimed (MB)         Collections
        Direct Memory Bytes
                2057                   0
        0                NaN                    0
        0                      -1
root@c1bf4c2d5378:/# nodetool gcstats
       Interval (ms) Max GC Elapsed (ms)Total GC Elapsed (ms)Stdev
        GC Elapsed (ms)   GC Reclaimed (MB)         Collections
        Direct Memory Bytes
                1307                   0
        0                NaN                    0
        0                      -1
```

(Section: DS210) - Nodetool Gossipinfo

- What is the status of the node according its peer node
- Peer node knows the detaila about another node using ‘gossipe-info’
- Schema-Version mismatch can be noted from this output. Rare but crucial information.

(Section: DS210) - Nodetool Ring command

- “nodetool ring” is used to output all the tokens of a node.
- nodetool ring – ks_killr_vide – for specific keyspace
- `root@c1bf4c2d5378:/# nodetool ring -- killr_video | head`

```
Datacenter: datacenter1
==========
Address     Rack        Status State   Load
        Owns                Token

        9187745666723249887

172.19.0.3  rack1       Up     Normal  624.25 KiB
        100.00%             -9143401694522716388
172.19.0.3  rack1       Up     Normal  624.25 KiB
        100.00%             -9002139349711660790
172.19.0.3  rack1       Up     Normal  624.25 KiB
        100.00%             -8851720287326751527
172.19.0.3  rack1       Up     Normal  624.25 KiB
        100.00%             -8617136159627124213
172.19.0.3  rack1       Up     Normal  624.25 KiB
        100.00%             -8578864381590385349
```

-

(Section: DS210) - Nodetool Tableinfo (tablestats) - Quite useful for data-modelling information

- nodetool tablestats – ks_killr_video
- nodetool tablestats – ks_killr_video user_by_email

- bash root@c1bf4c2d5378:/# nodetool tablestats -- killr_video Total number of tables: 37 ---------- Keyspace : killr_video Read Count: 3952653 Read Latency: 2.332187202873614 ms Write Count: 12577242 Write Latency: 0.026214161419490855 ms Pending Flushes: 0 Table: user_by_email SSTable count: 3 Space used (live): 321599 Space used (total): 321599 Space used by snapshots (total): 0 Off heap memory used (total): 5745 SSTable Compression Ratio: 0.6803828095486517 Number of partitions (estimate): 2468 Memtable cell count: 1809586 Memtable data size: 103656 Memtable off heap memory used: 0 Memtable switch count: 3 Local read count: 3952653 Local read latency: 0.030 ms Local write count: 12577242 Local write latency: 0.003 ms Pending flushes: 0 Percent repaired: 0.0 Bloom filter false positives: 0 Bloom filter false ratio: 0.00000 Bloom filter space used: 4680 Bloom filter off heap memory used: 4656 Index summary off heap memory used: 1041 Compression metadata off heap memory used: 48 Compacted parti- tion minimum bytes: 61 Compacted parti-

```
tion maximum bytes: 86                    Compacted parti-
tion mean bytes: 84                    Average live cells
per slice (last five minutes): 1.0                    Maxi-
mum live cells per slice (last five minutes):
1                    Average tombstones per slice (last
five minutes): 1.0                    Maximum tombstones
per slice (last five minutes): 1
Dropped Mutations: 6
```

- Table histogram helps to find how much time taken for read/vs/write

```
killr_video/user_by_email histograms
Percentile  SSTables     Write Latency      Read Latency    Parti-
        tion Size        Cell Count
                              (micros)          (micros)
        (bytes)
50%             0.00              0.00
        0.00                86                   2
75%             0.00              0.00
        0.00                86                   2
95%             0.00              0.00
        0.00                86                   2
98%             0.00              0.00
        0.00                86                   2
99%             0.00              0.00
        0.00                86                   2
Min             0.00              0.00
        0.00                61                   2
Max             0.00              0.00
        0.00                86                   2
```

(Section: DS210) - How to find large partition?

- nodetool tablehistograms ks_killr_video table – would give multi-millions cell-count

- nodetool tablehistograms ks_killr_video table – would give large partition-size

(Section: DS210) - Nodetool Threadpoolinfo (tpstats)

- Early versions of Cassandra were designed using SEDA architectures (now it actually moved away from it)
- If queue is blocked, the request is blocked
- if MemtableFlushWriter is blocked, Cassandra unable to write to disk
    - If blocked, lots of data is sitting in memory, sooner Long-GC might kick-in

(Section: DS210) - Cassandra logging

- It is ususally known as system.log (and debug.log only if enabled in logback.xml or using nodetool setlogginglevel)
- java gc.log is also available to investigate gc (garbage collection)
- /var/log/cassandra/system.log
- syste.log (INFO and above)
- logging location can be changed in /etc/dse/cassandra/jvm.options or -DCassandra.logdir=
- default configurations are in /etc/cassandra/logback.xml
- Change logging level for live systems
    - nodetool setlogginglevel org.apache.cassandra.service.StorageProxy DEBUG
    - nodetool getlogginglevel

(Section: DS210) - Cassandra JVM GC logging

- GC logging answeres 3 questions
    - When GC occured
    - How much memory reclaimed
    - What is the heap memory before an after reclaim (on the heap)
- GC logging details are configured /etc/cassandra/jvm.options
- Cassandra doesn't use G1 garbage collection

(Section: DS210) - How Cassandra JVM GC logging can be configured

- How it was turn it on
    - -Xloggc:/var/log/cassandra/gc.log (in the cassandra start script)
- -XX:+PrintGC (refer jvm.options for mroe documentation and options)
- Dynamically alter JVM process GC.log
    - info -flag +PrintGC

(Section: DS210) - How to read GC.log?

- GC pause in a second or two is big trouble, it should have been in sub-milli-seconds
- Ensure after GC, heap consumption is reduced (number should reduce)

(Section: DS210) - Adding a node

- Why to add node?
    - To increase capacity for operational head-room
    - Reached maxmum h/w capcity
    - Reached maxmum traffic capcity
        - To decrease latency of the application
- How to add nodes for single-token nodes?
    - Always double to capcity of your cluster
    - Token ranges has to bisect each of the existing clutser ranges
- How to add nodes for Vnodes cluster?
    - Add single node in incremental fashion
- Can we add multiple node at the same time?
    - Not recommended, but possible
- What is the impact of adding single node?
    - Lots of data movement into the new-node
    - We may need to remove excess copy for old nodes
    - Will have gradual impact on performance of the cluster
    - Will take longer to grow the cluster
- VNodes make it simple to add node
- Seed - nodes, Any node that is running while adding other nodes. They are not special in any way

(Section: DS210) - Bootstrapping (Adding a note)

- We need any existing running nodes as seed-nodes (they are not special nodes)
- (Adding cluster) Topology changes (adding/removing nodes) are not

recommended when there is a repair process alive in your cluster
- Cluster-name has to match to join existing cluster

(Section: DS210) - What are the steps followed by a boostrapping node when joining?

1. Contact the seed nodes to learn about gossip state.
2. Transition to Up and Joining state (to indicate it is joining the cluster; represented by UJ in the nodetool status).
3. Contact the seed nodes to ensure schema agreement.
4. Calculate the tokens that it will become responsible for.
5. Stream replica data associated with the tokens it is responsible for from the former owners.
6. Transition to Up and Normal state once streaming is complete (to indicate it is now part of the cluster; represented by UN in the nodetool status).

(Section: DS210) - What are the help rendered by a existing node to a joining?

- Cluster nodes has to prepare to stream necessary SSTables
- Existing Cluster nodes continue to satisfy read and write, but also forward write to joining node
- Monitor the bootstrap process using ‘nodetool netstas’

(Section: DS210) - Issues during bootstrap

- New node will certainly have a lot of compactions to deal with(especially if it is LCS).

- New node should compact as much as before accepting read requests
    - nodetool disablebinary && nodetool disablethrift && nodetooldisablegossip*
        - Above will disconnect Cassandra from the cluster, but not stop Cassandra itself. At this point you can unthrottle compactions and let it compact away.
- We should unthrottle during bootstrap as the node won't receive read queries until it finishes streaming and joins the cluster.

(Section: DS210) - If Bootstrap fails

- Read the log and find the reason
- If it Up and failed with 50% data, try to restart.. mostly it would fix it-self
- if it further doesn't work, investigate further

(Section: DS210) - After Boostrap (Cleanup)

- Nodetool cleanup should be peformed to the other cluster nodes (not to the node that joined)
- Cleans up keyspaces and partition keys no longer belonging to a node. (bootstrapped node would have taken some keys and reduced burden on this node)
- Cleanup just reads all ss-table and throws-away all the keys not be-long to the node, worst-case it just copies the sstable as is
- It is almost like Compaction
- nodetool [options] cleanup – keyspace `{=html}` `<table>`

(Section: DS210) - Removing node

- Why to remove a node?
    - For some event, we ramped-up, need to scale down for legitimate reason
    - Replacing h/w, or faulty node
- We can't just shutdown and leave
- 3 ways to remove the node
    1. Inform the leaving node that, this node would be taken away, so it would redistribute its data to the rest of the cluster
        - nodetool decommission
            - It was properly redistributed
            - Shutting down the port and shutting down process
            - Data still on the disk, but should be deleted if we plan to bring the node back
    2. Inform to the rest of the cluster nodes, that a node was removed/lost
        - nodetool removenode
    3. Inform the node to just leave immediately without replicating any of its data
        - nodetool assasinate (like kill -9) && nodetool repair (on the rest of the ndoes to fix)
        - Try when it is not trying to go away

(Section: DS210) - Where is the data coming from when a node is removed?

- Decommision - Data comes from the node leaving
- RemoveNode - Data comes from the rest of the cluster nodes

(Section: DS210) - How to replace a down-node

- Replace vs Remove-and-Add
- Backup for a node will work a replaced node, because same tokens are used to bring replaced node into cluster
- Best option is replace instead of remove-and-add
- -Dcassandra.replace_address= // has to change in JVM.options
    - Above line informs cluster that node will have same range of tokens as existing dead node
- Once replaced, we should remove -Dcassandra.replace_address=
- We should update seed-node (remove old node, and update with latest IP), to fix GossipInfo

(Section: DS210) - Why replace a node than removing-and-adding?

1. Don’t need to move data twice
2. Backup would work for th replaced node (if the token range is same)
3. It is faster and lesser impact on the cluster

(Section: DS210) - STCS - Size Tieres Compaction Strategy

- STCS Organizes SSTables into Tiers based on sizes
    - On an exponential scale
- Multiple SSTables would become (larger or smaller)
    - Smaller - when plenty of deltes
    - Largers - Sum of size of smaller SSTables (when there is no delete in smaller sstable)
- Lower-tier means smaller SStables
- Higher-tier means larger SStables
- min_threshold and max_thrshold (number of files within the tier)

(Section: DS210) - STCS Pros and Disadvantage

- STCS doesn't compact 1 GB and 1MB file together
    - Avoids write amplification
    - Handles write heavy system very well
- STCS requires of at least twice the data size (Space amplification)
- How do we combine 4 * 128MB file, we require 512MB additional space to combine them (at-least 50%)
- Stale records in Larger SSTables take unnecessary space (old file would take time to catchup)
- Concurrent_Compactors - Failed more often than helping.

- STCS - Major compaction was not recommended for producton (one big large compacted file) - Never do ‘nodetool compact’ ## (Section: DS210) - STCS Hotness
- STCS compaction chooses hottest tier first to compact
- SSTable hotness determined by number of reads per second per partition key ## (Section: DS210) - Wht STCS is slower for read
- If new write is in lower tier, and old values are in higher tier, they can’t be compacted together (immediately)

(Section: DS210) - What triggers a STCS Compaction

- More write –> More Compaction
- Compaction starts every time a memtable flushes to an SSTable
- MemTable too large, commit log too large or manual flush (Triggering events)
- When the cluster streams SSTable segments to the node
    - Bootstrap, rebuild, repair
- Compaction continues until there are no more tiers with at least min_threshold tables in it

(Section: DS210) - STCS - Tombstones

- If no eligible buckets, STCS compacts a single SSTable
- tombstone_compaction_interval - At-least one day old before considered for Tombstone compaction
- Compaction ensures that tombstones donot overlap old records in other SSTables

- The number of expired tombstones must be above 20%

(Section: DS210) - LCS - Leveled Compaction Strategy

- sstable_size_in_mb - Max size of SSTable
    - ‘Max SSTable Size’ - would be considered like unit size for compaction to trigger
- When there are more than 10 SSTables, they are combined and level is promoted
- Every higher level would be 10times bigger than their lower levels
- LCS - limits space amplification, but it ends in higher write amplification
- L0 - is landing place

(Section: DS210) - LCS Pros and Cons

- LCS is best for reads
    - 90% of the data resides in the lowest level
    - Each partition resides in only one table
- LCS is not suitable for more writes than reads, but suits occasional writes but high reads
- Reads are handled only by few SSTable make it faster
- LCS - doesn’t require 50% space, it wastes less disk space

(Section: DS210) - LCS - Lagging behind

- If lower levels are two big, LCS falls back to STCS for L0 compaction
- Falling to STCS would helps to create larger SSTable, and compacting

two larger SSTable is optimum

(Section: DS210) - LeveledCompactionStrategy

- LCS Cassandra

(Section: DS210) - TWCS - Time-window compaction strategies

- Best suited for Time-series data
- Windowf of time can be chosen while creating Table
- STCS is used within the timewindow
- Any SSTable that spans two window will be considered for next window
- Not suited for data that is being updated

(Section: DS210) - Nodesync (Datastax Enterprise 6.0)

- Continuous background repair
    - only for DSE-6.0 and above
    - Repair - doesn't mean something broken, rather preventing anti-entropy
- Low overhead, Consistency performance, Doesn't use Merkel tree
- Predicatable synchronization overhead, and easier than repair

- `sql create table mytable (k int primary key) with nodesync = {'enabled': 'true', 'deadline_target_sec: 'true'}; nodetool nodesyncservice setrate <val–ue_in_kb_per_sec> nodetool nodesyncservice getrate`
- Parameters
    - Rate – how much bandwidth could be used (between rate and target — rate always wins)
    - Target – (lesser than gc_grace_seconds)
- nodetool nodesync vs dse/bin/nodesync (second binary is cluster-wide tool)

(Section: DS210) - What are all the possible reason for large SSTable

- nodetool compact (somebody run it)
    - Major compaction using STCS would create large SSTable
- LCS (over period of time created large SSTable)
- We need to split the file sometime (anti-compaction)
- Warning before using SSTablesplit (don't run on live system)
- `bash sudo service cassandra stop sstablesplit –s 40 /user/share/data/cssandra/killr_video/users/*`

(Section: DS210) - Multi-Datacenter

- We can add datacenter using `alter keyspace` even before datacenter is available
- Cassandra allows to add datacenter to live system
- conf/cassandra-rackdc.properties
- Snitch is control where the data is.
- NetworkTopologyStrategy - is the one that achieves the distribution (among DC, controlled by Snitch)
- Replication values can be per-datacenter
- DC level information are per keyspace level (not table level)
- ```
  sql       alter keyspace killr_video with replication = {'class': 'NetworkTopologyStrategy', 'DC1': 2, 'DC2': 2}
  ```
- nodetool reubuild – name-of-existing-datacenter
- Run ‘nodetool rebuild’ specifying the existing datacenter on all the nodes in the new DC
- Without above, request with LOCAL_ONE or ONE consistency level may fail if the existing DC are not completely in sync

(Section: DS210) - Multi-Datacenter Consistency Level

- Local_Quorum - TO reduce latency
  ```

- Each - Very heavy operation
- Snitch should be specified

(Section: DS210) - What if one datacenter goes down?

- Gossip will find that DC is down
- Reocvery can be accomplished with a rolling repair to all nodes in failed datacenter
- Hints would be piling up in other datacenters (that is receiving updates)
- We should run-repair if we go beyond GC_Grace_seconds

(Section: DS210) - Why we need additional DC?

- Live Backup
- Improved Performance
- Analytics vs Transaction workload

(Section: DS210) - SSTableDump

1. Old tool, quite useful
2. Only way to dump SSTable into json (for investigation purpose)
3. Useful to diagnose SSTable ttl and tombostone
4. Usage
    1. tools/bin/sstable data/ks/table/sstable-data.db
    2. -d to view as key-value (withtout JSON)

(Section: DS210) - SSTableloader

1. sstableloader -d co-ordinator-ip /var/lib/cassandra/data/killrvideo/users/
2. Load existing data in SSTable format into another cluster (production to test)
3. Useful to upgrade data from one enviroment to another environment (migrating to new DC)
4. It adheres to replication factor of target cluster
5. Tables are repaired in target cluster after being loaded
6. Fastest way to load the data
7. Source should be a running node with proper Cassandra.yaml file
8. Atleast one node in the cluster is configured as SEED
9. sample dump

```
json      [       {         "partition" :
{           "key" : [
"36111c91-4744-47ad-9874-79c2ecb36ea7" ],          "posi-
tion" : 0         },         "rows" : [
{             "type" : "row",             "position" :
30,             "liveness_info" : { "tstamp" :
"2021-07-06T03:38:20.642757Z" },             "cells" :
[               { "name" : "v", "value" : 1 }
]           }         ]       },       {         "parti-
tion" : {           "key" : [
"ec07b617-1348-42b8-afb1-913ff531a24c" ],          "posi-
tion" : 43         },         "rows" : [
{             "type" : "row",             "position" :
73,             "cells" : [               { "name" : "v",
"value" : 2, "tstamp" : "2021-07-06T03:39:12.173004Z"
}             ]           }         ]       },
{         "partition" : {           "key" : [
"91d7d620-de0b-11eb-ad2f-537733e6a124" ],          "posi-
```

```
tion" : 86         },         "rows" : [
{             "type" : "row",             "position" :
116,             "liveness_info" : { "tstamp" :
"2021-07-06T03:38:03.777666Z" },             "cells" :
[               { "name" : "v", "deletion_info" : { "lo-
cal_delete_time" : "2021-07-06T09:06:57Z"
},                 "tstamp" :
"2021-07-06T09:06:57.504609Z"               }
]           }         ]       },       {         "parti-
tion" : {           "key" : [
"7164f397-f1cb-4341-bc83-ac10088d5bfd" ],           "posi-
tion" : 128         },         "rows" : [
{             "type" : "row",             "position" :
158,             "cells" : [               { "name" : "v",
"value" : 2, "tstamp" : "2021-07-06T03:38:56.888661Z"
}             ]           }         ]       }     ]
```

(Section: DS210) - Loading different formats of data into Cassandra

1. Apache Spark for Dataloading

2. ```
   from pyspark import SparkConf
   import pyspark_cassandra
   from pyspark_cassandra import CassandraSparkContext

   conf = SparkConf().set("spark.cassandra.connection.host",
           <IP1>).set("spark.cassandra.connection.native.port",<IP2>)



   sparkContext = CassandraSparkContext(conf = conf)
   ```
   ```

```
        rdd = sparkContext.parallelize([{"validated":False, "sam-
                pleId":"323112121",
                "id":"121224235-11e5-9023-23789786ess" }])
        rdd.saveToCassandra("ks", "test", {"validated", "sam-
                ple_id", "id"} )
```

3. Loading a CSV file into a Cassandra table with validation:

```
import com.datastax.spark.connector._
import com.datastax.spark.connector.cql._
import org.apache.spark.SparkContext


//Preparing SparkContext to work with Cassandra
val conf = new SparkConf(true).set("spark.cassandra.connec-
        tion.host", "192.168.123.10")
        .set("spark.cassandra.auth.username", "cassan-
        dra")
        .set("spark.cassandra.auth.password", "cassandra")
val sc = new SparkContext("spark://192.168.123.10:7077", "test",
        conf)
val beforeCount = sc.cassandraTable("killrvideo", "users").count
val users = sc.textFile("file:///home/student/users.csv").reparti-
        tion(2 * sc.defaultParallelism).cache // The RDD is used in
        two actions
val loadCount = users.count
users.map(line => line.split(",") match {
      case Array(id, firstname, lastname, email, created_date)    =>
        User(java.util.UUID.fromString(id), firstname, lastname,
        email, new java.text.SimpleDateFormat("yyyy-mm-
        dd").parse(created_date))
  }
).saveToCassandra("killrvideo", "users")
val afterCount = sc.cassandraTable("killrvideo", "users").count
if (loadCount - (afterCount - beforeCount) > 0)
  println ("Errors or upserts - further validation required")
```

(Section: DS210) - Datstax - DSE Bulk (configuration should be in HOCON format)

1. CLI import tool (from csv or json)
2. Can move to and from files in the file-system
3. Why DSE Bulk?
4. Casandra-loader is not formally supported, SSTableLoader data should be in SSTable format
5. CQLSH Copy is not performant
6. Can be used as format for backup
7. Unload and reformat as different data-model
8. Usage: dsbulk -f dsbulk.conf -c csv/json -k keyspace -t tablename

(Section: DS210) - Backup and Snapshots

1. Why do we need your backup for distributed data?
2. Human error caused data wipe
3. Somebody thought they are dropping data in UAT, but it was production
4. Programmatic accidental deletion or overwriting data
5. Wrong procedure followed and lost data
6. SSTables are immutable, we can just copy them for backup purpose
7. usage - nodetool -h localhost -p 7199 snapshot mykeyspace

(Section: DS210) - What is Cassandra snapshots?

1. The DDL to create the table is stored as well.

2. A snapshot is a copy of a table's SSTable files at a given time, created via hard links.
3. Hardlink snapshots are acting as Point-in-Time backup ## (Section: DS210) - Why Snapshots are fast in Cassandra? How to snapshot at the same time?

- It just creates hard-links to underlying SSTable (immutable files)
- Actual files are not copied, hence less (zero) data-movement
- A parallel SSH tool can be used to snapshot at the same time.

(Section: DS210) - How do incrementa backup works

- Every flush to disk should be added to snapshots
    - incremental_backup: true –##cassandra.yaml
- Snapshot is required (before incremental backups) in-order for incremental backup to work (pre-requisite)
- Snapshot informations are stored under "snapshots/directory"
- incremental backups are stored under "backups/directory"
- incremental backups - are not automatically removed (warning would pile-up)
    - These should be manually removed before creating new snapshot

(Section: DS210) - Where to store snapshots?

- Snapshots and incremental backups are stored on each cassandra-node
- Files should be copied to remote place (not on node)
    - tablesnap can store to AWS S3

(Section: DS210) - How Truncate works?

- auto_snapshot is critical, don't disable it
- Helps to take Snapshots, just before table truncation.

(Section: DS210) - How to snapshot?

- bin/nodetool snapshot -cf table - t – keyspace keyspace2
- How to snapshot and restore

(Section: DS210) - Restore (We get 1 point for backup, 99 point for restore)

- Backup that doesn't help to restore is useless
- Restore should be tested many times and documented properly

(Section: DS210) - Steps to restore from snapshots

1. Delete the current data files
2. Copy the snapshot and incremental files to the appropriate data directories
3. The table schema must already be present in order to use this method
4. If using incremental backups
    1. Copy the contents of the backups/ directory to each table directory
5. Restart and repair the node after the file copying is done Honorable mention – tablesnap and tablerestore • Used when backing up Cas-

sandra to AWS S3 ## (Section: DS210) - How to remove snapshots?

- nodetool clearsnapshot
    - Not specifying a snapshot name removes all snapshots
- Remember to remove old snapshots before taking new ones, not automatic

(Section: DS210) - JVM settings

1. jvm.options can be used to modify jvm settings
2. cassandra-env.sh is a shell that launches cassandra server, that uses jvm.options
3. MAX_HEAP_SIZE : -Xmx8G
4. HEAP_NEW_SIZE : -XX:NewSize=100m
5. Java 9 by default uses G1 Collector

(Section: DS210) - Garbage Collections (Apache Cassandra)

- Cassandra on JDK-8 was using CMS
- Decrease Pause-Time, But increase Through-Put
- Eden, S-1, S-2 space
- GC Process - Eden -> Survivor -> S2/S1 (Always one of the survivor space is empty)
- GC Process - Step2 - Eden + Survivor -> S2/S1 (Always one of the survivor space is empty)
- After many young gc, S1/S2 -> Old GC
- CMS kicks in when OldGen is 75% full

(Section: DS210) - Why does full GC runs?

- If the old gen fills up before the CMS collector can finish
- Full GC, stop the world collctor checks new-gen, old-gen and perm-gen

(Section: DS210) - How to troubleshoot Out-OfMemoryError issues in Casssandra?

- -XX:+HeapDumpOnOutOfMemoryError - would dump the entire memory
- Use Eclipse Memory Analyzer tool to analyze the content of memory
- Cassandra puts the file in a subdirectory of the working, root directory when running as a service
- Ensure Cassandra has access to the directory where dump directory was configured, disk should have space to hold this file

(Section: DS210) - What is TSC?

- It is a register inside CPU
- Time Stamp Counter (counts the number of cycles), but won't match between processors

(Section: DS210) - Tuning the Linux Kernel

- NTP should be in place for Cassandra to agree time within the clusters
    - NTP would adjust from hierarchy of time servers every

1-20 minutes

- Cassandra service requires unfettered access to all resources
- ulimit -a would display all the limits or limits.conf file
- What are all the limits
    1. -t: cpu time (seconds) unlimited
    2. -f: file size (blocks) unlimited
    3. -d: data seg size (kbytes) unlimited
    4. -s: stack size (kbytes) 8176
    5. -c: core file size (blocks) 0
    6. -v: address space (kbytes) unlimited
    7. -l: locked-in-memory size (kbytes) unlimited
    8. -u: processes 2666
    9. -n: file descriptors 256
    10. -msgqueue unlimited
    11. -sigpending unlimited

(Section: DS210) - What should be removed/ disabled from Linux for Cassandra to work? How to remove

- swapping should be removed in linux from two places
- swapoff -a (not permanently)
- /etc/fstab should be edited to disable swapping
- edit /etc/sysctl.conf and set vm.swappines=0
    - sysctl -p should reload /etc/sysctl.conf
- Refer datastax for other recommended linux settings

(Section: DS210) - Hardware resources to consider

1. Parameters

- Peristent type
- Memory (16GB to 32GB)
- CPU (16 Core is best for value)
- Network (OS should use separate NIC, shouldn't share with Cassandra)
    - Cassandra.yaml supports different NIC for CQL and internode
- Number of nodes

1. Don't allow

- SAN/NAS/NFS

1. SSDs are prefered

- 0.50 USD/GB vs 0.05 USD/GB
- TWCS - can use HDD
- HDD should be backed with more memory

(Section: DS210) - Datastax on Cloud

- Templates and scripts to install DSE on cloud
- OPSCenter LCM 6.0+ (Lifecycle manager)
    1. Provisioning (installation and config)
    2. Configuration management
    3. Chef, Ansible, Recipes playbook out there for DSE OPS-

Center

- Always prefer locally attached SSD
- If Elastic storage is the only option (on cloud)
    1. When ephemeral volume fails, terminate and get a fresh box
- AWS
    1. GP2 or IO2 EBS (if you can't affort ephemerals)
    2. Get big ones, IO latencies are better for larger disk volumes
- Google
    1. Elastic volume always have the same tight latencies
    2. pd-ssd seems faster than local-ssd

(Section: DS210) - Cassandra on Cloud Challenges

- Hyeperthreads - you don't get a real CPU
- Noisy neighbors - if you see CPU steal, terminate your box and get a new one
- Networking
    - AWS VPN - Setup cross region network
        - Prefer Enhanced networking, supported only for few instance
    - Azure - Do not use VPN gateways, use public IPs, Vnet2Vnet is slow but works for small workloads
    - Google - Flat network - No config, it's great

(Section: DS210) - Cassandra on cloud security

- AWS - volume encryption for EBS
- Google - largely secure by default. Should go through multifactor auth

(Section: DS210) - Cassandra Security Considerations

- Authentication and Authorization (Covered in DS410)
- Authentication in disabled by default
    - Enable the authentication in dse.yaml
    - DSEAuthenticator (supports 3 schemes)
        - Kerberos
        - Ldap
        - Internal
    - Default superuser comes with datastax - user-id and password (cassandra/cassandra)
    - ALTER change cassandra WITH PASSWORD ‘newpassword’
- Cassandra stores all the credentials in the sys_auth keyspace

(Section: DS210) - What is the default security configuration

```
authentication_options:
  enabled: false
```

```
default_scheme: internal
allow_digest_with_krb: true
plain_text_without_ssl: warn
```

(Section: DS210) - Where is roles are stored in internal-scheme? (in default scheme)

- ALTER keyspace system_auth with replication {‘class’ : ‘Network-TopologyStrategy’, ‘dc’: 1 , ‘dc’: 3}
- All the roles are stored in system_auth.roles table

(Section: DS210) - Cassandra Authentication table (system_auth.roles - in default scheme)

- `sql CREATE table system_auth.roles (role text primary key, can_login boolean, is_superuser boolean, number_of set<text>, salted_hash text) CREATE ROLE fred with PASSWORD = 'Yababdadfdfd' and LOGIN = true; if LOGIN=TRUE --- user if LOGIN=FALSE --- role LIST roles; DROP role fred;`
- salted_hash is password

(Section: DS210) - What are best practices for Cassandra security

1. Create one more superuer_role and delete the default cassandra super-user
2. At least change the password for default super-user ‘cassandra’

3. ALTER USER cassandra WITH password ‘newpassword’
4. Ensure system_auth keyspace should be replicated to multiple data-center

(Section: DS210) - Cassandra Role/Authorization management

```
Grant Select ON killr_video.user_by_email TO user/role;
Grant Select ON killr_video.user_by_email TO fred;
Create Role DB_Accessors;
Grant Select ON killr_video.user_by_email to db_accessors;
Grant db_accessors to fred;
REVOKE SELECT FROM db_accessors;
Permissions
* Create Keyspace, Create Table,
* DDROP – Drop..
* MODIFY –
* Alter –
* Authorize –
```

(Section: DS210) - Cassandra encryption SSL

- node-to-node
- client-to-node
- SSL
    - client-symmeteric key would be used to communicate, client-key is encrypted by server public key (typical SSL)
    - Keystore - signed key-pair (private/public key pair)
    - Truststore - RCA (root certificate authority) for signed certificate validation

- Inter node communiation
    - Nodes present their certificate from keystore to other nodes
    - Other nodes validate the certicate using their trust-store RCA details

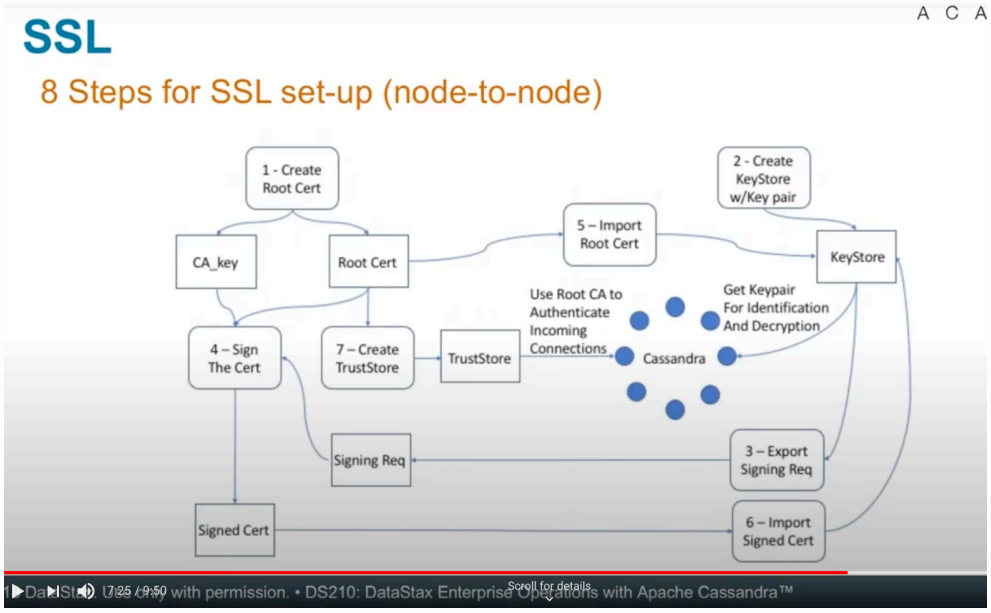
(Section: DS210) - What are two artifacts required for Cassandra to enable SSL

1. TrustStore (all the trusted certificate- ROOT CA)
    1. This is common among all the Cassandra nodes
2. Keystore (key-pair, its own signed certificate)

(Section: DS210) - 8 Steps for SSL setup (node-to-node)

1. Create Root Cert (Root of entire SSL communication)
    1. Root Cert = “CA_KEY” + “Root Cert”
2. Create keyStore w/Key pair (for each node)
    1. KeyStore
3. Export Signing Req (Each nodes certificate sign request)
4. Sign the certificate using Root-CA
    1. To Sign new certificate using root-CA, we need both CA-KEY + Root-Cert
5. Import RootCert into keyStore
6. Import Singed Certificate into keyStore
7. Create Turst Store
    1. Use RootCA to authenticate incoming Connections.

- Credit-Datastax



"Credit-Datastax-SSL"

- Cassandra Security Configuration
    1. Credit: SSL Configuration

(Section: DS210) - How to harden Cassandra security

1. Secure the keystore - since this contains private key
2. Setup firewasll so that only nodes can talk to each other on the listen_port
3. Protect the root CA private key - this Not be disbuted to the nodes
4. Enable require_client_auth, otherwise program could spoof being a node

(Section: DS210) - Datastax OpsCenter

1. Two Products

2. Configure and deploy cluster
3. Configure Security
4. Perform software upgrades
5. Load Certificate

(Section: DS210) - Datastax OpsCenter (Cluster Monitoring/Alert)

1. Monitoring and management (Operation)
2. Broswer -> OpsCenter Service -> Agent running inside DataStax Cassandra JVM (exposed via JMX)
3. UI features
    1. Dashboard
    2. Metrics
    3. Alerts
    4. Trend/Capacity analysis
    5. Performance service
4. Comprehensive Grafana like dashboard

(Section: DS210) - Datastax OpsCenter (Management Service)

1. Backup & Restore Service
2. NodeSync Service
3. Repair Service
4. Best Practices Service
5. Capacity Service

(Section: DS210) - Datastax OpsCenter (Back-up and restore Service)

1. Visual backup management
2. Backup & Restore on distributed system is hard
3. Support for multi-cloud backup and restore option
4. Enterprise-class visual backup service guards against data loss on managed database clusters
5. Backup Destination
    1. Local server
    2. Amazon S3
    3. Custom Location
6. Compresses data
7. Configurable retention polcies
8. Includes alerts and reporting

(Section: DS210) - Datastax OpsCenter LifeCycle Manager (Provisioning)

1. Configuration and deployment (Onboarding)
2. UI Menu has option for
3. SSH Credentials
4. Repositories (download software from datastax)
5. Config Profiles
6. Add DC/Nodes/Clusters
7. Point in time backup & restore

(Section: DS210) - Datastax OpsCenter Node-Sync

1. Prefered over repair service
2. Low intensity continuous repair

(Section: DS210) - Datastax OpsCenter other features

1. Best Practice service - periodically audits, alerts and suggests solution
2. Capacity service - Used to forecast metrics, configurable for multiple parameters
3. Performance Service - Diagnose table performance, query performance, ThreadPool stats
4. Datastax DSE uses one thread per core (and tries to avoid ThreadPools)
5. Alerts - Integreated into Enterprise Monitoriing system
    1. Post request
    2. Mail
    3. SNMP - to an enterprise monitoring system

(Section: DS210) - Follow-up course

1. DS-220 - Practical application modelling with Apache Casssandra
2. DS-310 - DataStax Enterprise Search
3. DS-320 - DataStax Enterprise Apache Sparx
4. DS-330 - DataStax Enterprise Graph

(Section: DS210) - Lab notes

- 172.18.0.2
- /usr/share/dse/data
- /var/lib/cassandra/data
- DS-220

(Section: DS210) - Cassandra people

- Jamie King
- Jonathan Ellis
- Patrick McFadin

(Section: DS210) - How to create anki from this markdown file

```
mdanki Cassandra_Datastax_210_Anki.md Cassandra_Datastax_210_Anki.apkg --deck "Mohan::Cassandra::DS210::Operations"
```

Cassandra production error

- RANGE SLICE Messages were dropped
- StorageProxy.readRegular(group, consistencyLevel, queryStartNanoTime);
- SinglePartitionCommand.java[1176]/StorageProxy.read(this, consistency, clientState, queryStartNanoTime);

(Server side) - com.datastax.oss.driver.api.core.connection.ConnectionIntiException.. ssl should be configured

- Client side should enable ssl ; true (in spring-boot application.yaml)
    - spring.data.cassandra.ssl: true

(Client side) - [SSLL SSLV3_ALERT_HANDSHAKE_FAILURE]

- Ensure you configured SSL on cient side

(Client side) - Since you provided explicit contact points, the local DC must be explicitly set (see basic.load-balancing-policy.local-datacenter)

- spring.data.cassandra.local-datacenter: asiapac

Cluster level monitoring

- Current cluster availability
- Current Storage Load
- Average Cluster Availablity for Period
- For Each datacenter

- # of client requests

Top worst performing

- Top 5 worst performing nodes by client latency

List monitoring elements

1. Node status
2. Disk Usage
3. Read Requests
4. Write Requests
5. Read Latency
6. Write Latency
7. Clients
8. Native Transport Requests
9. Compactions Pending
10. Dropped Mutations
11. Full GC Duration
12. Full GC Count
13. Heap memory usage
14. Off-Heap Memory Usage

List table level

1. Read Latency
2. Write Latency
3. SSTable Count

4. SSTable Per Read
5. Table Disk Used
6. Table Row Size

Node Status

(Section: Nodetool) - Nodetool usage

-

```
usage: nodetool [(-pwf <passwordFilePath> | --password-file
    <passwordFilePath>)]
      [(-u <username> | --username <username>)]
      [(-pw <password> | --password <password>)] [(-h <host> | --
    host <host>)]
      [(-p <port> | --port <port>)] <command> [<args>]
```

(Section: Nodetool) - Nodetool commands

```
The most commonly used nodetool commands are:
assassinate                 Forcefully remove a dead node with-
    out re-replicating any data.  Use as a last resort if you
    cannot removenode
bootstrap                   Monitor/manage node-s bootstrap
    process
cleanup                     Triggers the immediate cleanup of
    keys no longer belonging to a node. By default, clean all
    keyspaces
clearsnapshot               Remove the snapshot with the given
    name from the given keyspaces. If no snapshotName is speci-
    fied we will remove all snapshots
compact                     Force a (major) compaction on one
    or more tables or user-defined compaction on given SSTables
compactionhistory           Print history of compaction
```

```
compactionstats              Print statistics on compactions
decommission                 Decommission the *node I am con-
   necting to*
describecluster              Print the name, snitch, partition-
   er and schema version of a cluster
describering                 Shows the token ranges info of a
   given keyspace
disableautocompaction        Disable autocompaction for the giv-
   en keyspace and table
disablebackup                Disable incremental backup
disablebinary                Disable native transport (binary
   protocol)
disablegossip                Disable gossip (effectively mark-
   ing the node down)
disablehandoff               Disable storing hinted handoffs
disablehintsfordc            Disable hints for a data center
disablethrift                Disable thrift server
drain                        Drain the node (stop accepting
   writes and flush all tables)
enableautocompaction         Enable autocompaction for the giv-
   en keyspace and table
enablebackup                 Enable incremental backup
enablebinary                 Reenable native transport (binary
   protocol)
enablegossip                 Reenable gossip
enablehandoff                Reenable future hints storing on
   the current node
enablehintsfordc             Enable hints for a data center
   that was previsouly disabled
enablethrift                 Reenable thrift server
failuredetector              Shows the failure detector informa-
   tion for the cluster
flush                        Flush one or more tables
garbagecollect               Remove deleted data from one or
   more tables
gcstats                      Print GC Statistics
getcompactionthreshold       Print min and max compaction
   thresholds for a given table
```

```
getcompactionthroughput      Print the MB/s throughput cap for
    compaction in the system
getconcurrentcompactors      Get the number of concurrent com-
    pactors in the system.
getendpoints                 Print the end points that owns the
    key
getinterdcstreamthroughput   Print the Mb/s throughput cap for
    inter-datacenter streaming in the system
getlogginglevels             Get the runtime logging levels
getsstables                  Print the sstable filenames that
    own the key
getstreamthroughput          Print the Mb/s throughput cap for
    streaming in the system
gettimeout                   Print the timeout of the given
    type in ms
gettraceprobability          Print the current trace probabili-
    ty value
gossipinfo                   Shows the gossip information for
    the cluster
help                         Display help information
info                         Print node information (uptime,
    load, ...)
invalidatecountercache       Invalidate the counter cache
invalidatekeycache           Invalidate the key cache
invalidaterowcache           Invalidate the row cache
join                         Join the ring
listsnapshots                Lists all the snapshots along with
    the size on disk and true size.
move                         Move node on the token ring to a
    new token
netstats                     Print network information on pro-
    vided host (connecting node by default)
pausehandoff                 Pause hints delivery process
proxyhistograms              Print statistic histograms for net-
    work operations
rangekeysample               Shows the sampled keys held across
    all keyspaces
rebuild                      Rebuild data by streaming from oth-
    er nodes (similarly to bootstrap)
```

```
rebuild_index                Rebuild native secondary indexes for a given table
refresh                      Load newly placed SSTables to the system without restart
refreshsizeestimates         Refresh system.size_estimates
reloadlocalschema            Reload local node schema from system tables
reloadtriggers               Reload trigger classes
relocatesstables             Relocates sstables to the correct disk
removenode                   Show status of current node removal, force completion of pending removal or remove provided ID
repair                       Repair one or more tables
replaybatchlog               Kick off batchlog replay and wait for finish
resetlocalschema             Reset node=s local schema and resync
resumehandoff                Resume hints delivery process
ring                         Print information about the token ring
scrub                        Scrub (rebuild sstables for) one or more tables
setcachecapacity             Set global key, row, and counter cache capacities (in MB units)
setcachekeystosave           Set number of keys saved by each cache for faster post-restart warmup. 0 to disable
setcompactionthreshold       Set min and max compaction thresholds for a given table
setcompactionthroughput      Set the MB/s throughput cap for compaction in the system, or 0 to disable throttling
setconcurrentcompactors      Set number of concurrent compactors in the system.
sethintedhandoffthrottlekb   Set hinted handoff throttle in kb per second, per delivery thread.
setinterdcstreamthroughput   Set the Mb/s throughput cap for inter-datacenter streaming in the system, or 0 to disable throttling
```

```
setlogginglevel             Set the log level threshold for a
   given class. If both class and level are empty/null, it will
   reset to the initial configuration
setstreamthroughput         Set the Mb/s throughput cap for
   streaming in the system, or 0 to disable throttling
settimeout                  Set the specified timeout in ms,
   or 0 to disable timeout
settraceprobability         Sets the probability for tracing
   any given request to value. 0 disables, 1 enables for all re-
   quests, 0 is the default
snapshot                    Take a snapshot of specified key-
   spaces or a snapshot of the specified table
status                      Print cluster information (state,
   load, IDs, ...)
statusbackup                Status of incremental backup
statusbinary                Status of native transport (binary
   protocol)
statusgossip                Status of gossip
statushandoff               Status of storing future hints on
   the current node
statusthrift                Status of thrift server
stop                        Stop compaction
stopdaemon                  Stop cassandra daemon
tablehistograms             Print statistic histograms for a
   given table
tablestats                  Print statistics on tables
toppartitions               Sample and print the most active
   partitions for a given column family
tpstats                     Print usage statistics of thread
   pools
truncatehints               Truncate all hints on the local
   node, or truncate hints for the endpoint(s) specified.
upgradesstables             Rewrite sstables (for the request-
   ed tables) that are not on the current version (thus upgrad-
   ing them to said current version)
verify                      Verify (check data checksum for)
   one or more tables
version                     Print cassandra version
```

```
viewbuildstatus             Show progress of a materialized
    view build

See "nodetool help <command>" for more information on a specif-
    ic command.
```

- WORKSHOP: Opensource Tools for Apache Cassandra 24 Nov 20. Adam Zegelin SVP Engineering, Instaclustr
- Best Practices of Cassandra in Production ## (Section: Repair) - What is repair?
- Repair ensures that all replicas have identical copies of a given partition
- Data won't be in sync due to eventual consistency pattern, Merkel-Tree based reconciliation would help to fix the data.
- It is also called anti-entropy repair.
- Cassandra reaper is famous tool for scheduling repair
- Reaper and nodetool repair works slightly different
- Reaper repair mode
    - sequential
    - requiresParallelism (Building merkle-tree or validation compaction would be parallel)
    - datacenter_aware
        - It is like sequential but one node per each DC

(Section: Repair) - Repair Service (on Ops-Center)

1. Runs in the background
2. Works on small chunks to limit performance impact
3. Continuously cycles within a specified time period
4. Can run in parallel
5. Can work on sub-ranges or incremental

(Section: Repair) - Repair command

- `bash nodetool <options> repair --dc <dc_name> identify data centers --pr <partitioner-range> repair only primary range --st <start_token> used when repairing a subrange --et <end_token> used when repairing a subrange`

(Section: Repair) - Why repairs are necessary?

- Nodes may go down for a period of time and miss writes
    - Especially if down for more than max_hint_window_in_ms
- If nodes become overloaded and drop writes
- if dropped mutation is high repair was missing in its place

(Section: Repair) - Repair guideline

- Make sure repair completes within gc_grace_seconds window

- Repair should be scheduled once before every gc_grace_seconds

(Section: Repair) - What is Primary Range Repair?

- The primary range is the set of tokens the node is assigned
- Repairing only the node's primary range will make sure that data is synchronized for that range
- Repairing only the node's primary range will eliminate reduandant repairs

(Section: Repair) - How does repair work?

1. Nodes build merkel-trees from partitions to represent how current data values are
2. Nodes exchange merkel trees
3. Nodes compare the merkel trees to identify specific values that need synchronization
4. Nodes exchange data values and update their data

(Section: Repair) - Events that trigger Repair

- 'CL=Quorum' - Read would trigger the repair
- Random repair (even for non-quorum read)
    - read_repair_chance
    - dclocal_read-repair_chance
- Nodetool repair - externally triggered

(Section: Repair) - Dropped Mutation vs Repair

(Section: Repair) - If 10 nodes equally sharing data with RF=3, if we try to repair 'nodetool repair on node-3', How many node will be involved in repair?

- 5 nodes.
- Node-3 will replicate its data to 2 other nodes (N3 (primary) + N4 (copy-1) + N5 (copy-2))
- Node-1 would use N3 for copy-2
- Node-2 would use N3 for copy-1

(Section: Repair) - How to specifically use only one node to repair itself

- nodetool -pr node-3 –But we have to run in all the nodes immediately
- runing nodetool -pr on only one node is **not-recommended**

(Section: Repair) - If we run full repair on a ‘n’ node cluster with RF=3, How many times we are repairing the data?

- We repair thrice.

(Section: Repair) - Developer who maintains/ presented about Reaper

- Alexander Dejanovski
- Real World Tales of Repair (Alexander Dejanovski, The Last Pickle) | Cassandra Summit 2016

(Section: Repair) - Repair documentation

- All the options of nodetool-repair
- Cassandra documentation
- Datastax documentation

(Section: Repair) - Repair and some number related to time

- First scheduled repair would always take more time
- Repair scheduled often generally completes faster, since there are less data to repair
- Few reported - it took 308+ hours to complete repair on 2.1.12 version

- With 3 DC with 12 nodes, 4 tb of a keyspace took around 22 hours to repair it.

(Section: Repair) - What are Reaper settings

- Segments per node
- Tables
- Blacklist
- Nodes
- Datacenters
- Threads
- Repair intensity

(Section: Repair) - Reaper is predominantly used for repair tasks

- Reaper uses concept called segments (despite in Cassandra world Segment means CommitLog)
- As per Reaper, you need to use a segment for every 50mb, 20K Segment for every 1 TB
- Smaller the segement, let reaper to repair it faster

(Section: Repair) - Repair related commands

```
nodetool repair -dc DC ## is the command to repair using nodetool
nodetool -h 1.1.1.1 status
```

(Section: Repair) - Reference

- Repair Improvements in Apache Cassandra 4.0 | DataStax
- Apache Cassandra Maintenance and Repair
- DSE 6.8 Architecture Guide, About Repair
- Real World Tales of Repair (Alexander Dejanovski, The Last Pickle) | Cassandra Summit 2016
- Repair

(Section: Repair) - How to create anki from this markdown file

```
mdanki cassandra_repair_anki.md cassandra_repair_anki.apkg --deck
"Mohan::Cassandra::Repair::doc"
```

(Section: Cqls) - Create KeySpace (and use it)

```
## (Section: Cqls) - Only when cluster replication exercise
CREATE KEYSPACE killrvideo WITH replication = {'class': 'Network-
        TopologyStrategy','east-side': 1,'west-side': 1};

CREATE KEYSPACE killrvideo WITH replication = {'class': 'SimpleStrat-
        egy', 'replication_factor': 1 };
USE killrvideo;
```

(Section: Cqls) - Partition Key vs Primary Key

- Partition key uniquiely identifies partition inside a table
- Primary key uniquely identifies row inside partition

- PartitionKey == Primary-Key, every partition has single-row
- PrimaryKey = Partition_Key + Clustering Key
    - Partition has multiple rows

(Section: Cqls) - Create TABLE and load/export data in and out-of-tables

```
CREATE TABLE videos (video_id uuid,added_date timestamp,title
        text,PRIMARY KEY ((video_id)));
insert into videos (video_id, added_date, title) values
        (5645f8bd-14bd-11e5-af1a-8638355b8e3a, '2014-02-28','Cass-
        ndra History')


-- docker cp  D:/git/cassandra_playground/labwork/data-files/
        videos.csv some-cassandra:/vidoes.csv
-- COPY videos(video_id, added_date, title) FROM '~/labwork/data-
        files/videos.csv' WITH HEADER=TRUE;
COPY videos(video_id, added_date, title) FROM '/videos.csv' WITH
        HEADER=TRUE;


CREATE TABLE videos_by_tag (tag text,video_id uuid,added_date time-
        stamp,title text,PRIMARY KEY ((tag), added_date, video_id))
        WITH CLUSTERING ORDER BY(added_date DESC);
-- docker cp  D:/git/cassandra_playground/labwork/data-files/videos-
        by-tag.csv some-cassandra:/videos-by-tag.csv
-- COPY videos_by_tag(tag, video_id, added_date, title) FROM '~/lab-
        work/data-files/videos-by-tag.csv' WITH HEADER=TRUE;
COPY videos_by_tag(tag, video_id, added_date, title) FROM '/videos-
        by-tag.csv' WITH HEADER=TRUE;
INSERT INTO killrvideo.videos_by_tag (tag, added_date, video_id, ti-
        tle) VALUES ('cassandra', '2016-2-8', uuid(), 'Me Lava Cas-
        sandra');
UPDATE killrvideo.videos_by_tag SET title = 'Me LovEEEEEEEE Cassan-
        dra' WHERE tag = 'cassandra' AND added_date = '2016-02-08'
        AND video_id = paste_your_video_id;


--Export data
```

```
COPY vidoes(video_id, added_date, title) TO '/tmp/videos.csv' WITH
        HEADER=TRUE;
```

(Section: Cqls) - How to select token values of primary-key

```
SELECT token(tag), tag FROM killrvideo.videos_by_tag;
--output of gossip-info
system.token(tag)    | tag
----------------------+-----------
 -1651127669401031945 |  datastax
 -1651127669401031945 |  datastax
   356242581507269238 | cassandra
   356242581507269238 | cassandra
   356242581507269238 | cassandra
```

(Section: Cqls) - What is Conditional Insert?

1. A conditional INSERT can be used to prevent an upsert when it matters, such as when two users try to register using the same email. Only the first INSERT should succeed:

```
INSERT INTO users (email, name, age, date_joined) VALUES
        ('art@datastax.com', 'Art', 33, '2020-05-04') IF
        NOT EXISTS;
INSERT INTO users (email, name, age, date_joined) VALUES
        ('art@datastax.com', 'Arthur', 44, '2020-05-04')
        IF NOT EXISTS;


SELECT * FROM users WHERE email = 'art@datastax.com';
```

```
UPDATE users SET name = 'Arthur' WHERE email = 'art@datas-
        tax.com' IF name = 'Art';
```

(Section: Cqls) - IS CQL Case-sensitive

- By default, names are case-insensitive, but case sensitivity can be forced by using double quotation marks around a name.

(Section: Cqls) - Create Keyspace/Table Syntax

```
CREATE KEYSPACE [ IF NOT EXISTS ] keyspace_name  WITH REPLICATION =
        { replication_map };

CREATE TABLE [ IF NOT EXISTS ] [keyspace_name.]table_name
(
  column_name data_type [ , ... ]
  PRIMARY KEY (
   ( partition_key_column_name  [ , ... ] )
   [ clustering_key_column_name [ , ... ] ]
  )
)
[ WITH CLUSTERING ORDER BY
   ( clustering_key_column_name ASC|DESC [ , ... ] )
];
```

(Section: Cqls) - CQL Copy and rules

- Cassandra expects same number of columns in every row (in delimited file)

- Number of columns should match the table
- Empty data in column is assumed by default as NULL value
- COPY from should not be used to dump entire data (could be in TB or PB)
- For importing larger datasets, use DSBulk
- Can be piped with standar-input and standrd-outpu

(Section: Cqls) - CQL Copy options

1. DELIMITER
2. HEADER
3. CHUNKSIZE - 1000 (default)
4. SKIPROW - number of rows to skip (for testing)

(Section: Cqls) - How to list partition_key (or the actual token) along with other columns

- USe token fucntion and pass all the parameter of the partition_key
- select tag, title, video_added_date, token(tag) from videos_by_tag;
- “InvalidRequest: code=2200 [Invalid query] message=”Invalid number of arguments in call to function token: 1 required but 2 provided”
    - When you pass clustering column that are not part of partition_key, CQL throws this error

(Section: Cqls) - Gosspinfo

```
SELECT peer, data_center, host_id, preferred_ip, rach, release_ver-
      sion, rpc_address, schema_version FROM system.peers;
```

(Section: Cqls) - nodetool getendpoints killrvideo videos_by_tag cassandra

172.19.0.2

(Section: Cqls) - What are all the System Schema

```
system
system_auth
system_distributed
system_schema
system_traces
```

(Section: Cqls) - See how many rows have been written into this table (Warning - row scans are expensive operations on large tables)

- SELECT COUNT (*) FROM user;

(Section: Cqls) - Write a couple of rows, populate different columns for each, and view the results

1. INSERT INTO user (first_name, last_name, title) VALUES ('Bill', 'Nguyen', 'Mr.');
2. INSERT INTO user (first_name, last_name) VALUES ('Mary', 'Rodriguez');
3. SELECT * FROM user;

(Section: Cqls) - View the timestamps generated for previous writes

- SELECT first_name, last_name, writetime(last_name) FROM user;

(Section: Cqls) - Note that we're not allowed to ask for the timestamp on primary key columns

- SELECT WRITETIME(first_name) FROM user;

(Section: Cqls) - Set the timestamp on a write

- UPDATE user USING TIMESTAMP 1434373756626000 SET last_name = 'Boateng' WHERE first_name = 'Mary' ;

(Section: Cqls) - Verify the timestamp used

- SELECT first_name, last_name, WRITETIME(last_name) FROM user WHERE first_name = ‘Mary’;

(Section: Cqls) - View the time to live value for a column

- SELECT first_name, last_name, TTL(last_name) FROM user WHERE first_name = ‘Mary’;

(Section: Cqls) - Set the TTL on the last name column to one hour

- UPDATE user USING TTL 3600 SET last_name = ‘McDonald’ WHERE first_name = ‘Mary’ ;

(Section: Cqls) - View the TTL of the last_name - (counting down)

- SELECT first_name, last_name, TTL(last_name) FROM user WHERE first_name = ‘Mary’;

(Section: Cqls) - Find the token

- SELECT last_name, first_name, token(last_name) FROM user;

(Section: Cqls) - Clear the screen of output from previous commands

- CLEAR

(Section: Cqls) - Cassandra Dual equivalent table and SQL

```
1. select now() from system.local;
```

(Section: Cqls) - How to find avg, sum, min, max within Partition (use ratings_by_movie) as example??

```
How to analize ratings for the movie:

SELECT COUNT(rating) AS count,
       SUM(rating) AS sum,
       AVG(CAST(rating AS FLOAT)) AS avg,
       MIN(rating) AS min,
       MAX(rating) AS max
FROM   ratings_by_movie
WHERE  title = 'Alice in Wonderland'
  AND  year  = 2010;
```

(Section: Cqls) - Sample function to find days between two date?

```
CREATE FUNCTION IF NOT EXISTS DAYS_BETWEEN_DATES(date1 TEXT, date2
      TEXT)
  RETURNS NULL ON NULL INPUT
  RETURNS BIGINT
  LANGUAGE Java AS
      'return java.lang.Math.abs(
        java.time.temporal.ChronoUnit.DAYS.between(
          java.time.LocalDate.parse(date1),
          java.time.LocalDate.parse(date2)
        )
      );';

      SELECT name,
            DAYS_BETWEEN_DATES(
              CAST(date_joined   AS TEXT),
              CAST(TODATE(NOW()) AS TEXT) ) AS days
      FROM   users
      WHERE  email = 'joe@datastax.com';
```

(Section: Cqls) - How to add/delete column to a table?

- ALTER TABLE movies ADD country TEXT;
- ALTER TABLE movies drop country;

(Section: Cqls) - Exit cqls

- EXIT
- Quit

(Section: Cqls) - What would happen if we use Clustering Column where STATIC columns are updated

```
cqlsh:killr_video> update rating_by_user set name='bkj' where
        email='akj@je.com' and year=2021;
InvalidRequest: Error from server:
code=2200 [Invalid query]
message="Invalid restrictions on clustering columns since the UPDATE
        statement modifies only static columns"
```

(Section: Cqls) - Reference

- A deep look at the CQL WHERE clause

(Section: Advanced Type) - What are all the basic data-types?

- TEXT, INT, FLOAT, and DATE
- TIMESTAMP – we can use in query like added_date > '2013-03-17';

(Section: Advanced Type) - What are all the current-time-date functions?

- uuid() function takes no parameters and generates a random Type 4 UUID
- select toTimestamp(now()) from system.local; - Find current time
- select toDate(now()) from system.local; - Find current date

(Section: Advanced Type) - What are all the timestamp functions?

- toDate(timestamp) - Converts timestamp to date in YYYY-MM-DD format.
- toUnixTimestamp(timestamp) - Converts timestamp to UNIX timestamp format.
- toTimestamp(date) - Converts date to timestamp format.
- toUnixTimestamp(date) - Converts date to UNIX timestamp format.
- system.totimestamp(system.now())

(Section: Advanced Type) - What are all the timeuuid functions?

- now() - Generates a new unique timeuuid in milliseconds when the statement is executed.
- toDate(timeuuid) - Converts timeuuid to date in YYYY-MM-DD format.
- toTimestamp(timeuuid) - Converts timeuuid to timestamp format.
- toUnixTimestamp(timeuuid) - Converts timeuuid to UNIX time-

stamp format.

- minTimeuuid() and maxTimeuuid() - The values returned by minTimeuuid and maxTimeuuid functions are not true UUIDs in that the values do not conform to the Time-Based UUID generation process specified by the RFC 4122. The results of these functions are deterministic, unlike the now() function.
- select mintimeuuid(toTimestamp(now())) from system.local;

(Section: Advanced Type) - How to add SET AND UPDATE its columns values?

```
ALTER TABLE movies ADD production SET<TEXT>;
SELECT title, year, production FROM movies;
Add three production companies for one of the movies:

UPDATE movies SET production = { 'Walt Disney Pictures', 'Roth
        Films' } WHERE id = 5069cc15-4300-4595-ae77-381c3af5dc5e;
UPDATE movies SET production = production + { 'Team Todd' } WHERE id
        = 5069cc15-4300-4595-ae77-381c3af5dc5e;
SELECT title, year, production FROM movies;
```

(Section: Advanced Type) - How to add LIST AND UPDATE its columns values?

```
ALTER TABLE users ADD emails LIST<TEXT>;
UPDATE users SET emails = [ 'joe@datastax.com', 'joseph@datas-
        tax.com' ] WHERE id = 7902a572-e7dc-4428-b056-0571af415df3;
SELECT id, name, emails FROM users;
```

(Section: Advanced Type) - How to add MAP<TEXT, TEXT> AND UPDATE its columns values?

```
ALTER TABLE users ADD preferences MAP<TEXT,TEXT>;
UPDATE users SET preferences['color-scheme'] = 'dark' WHERE id =
        7902a572-e7dc-4428-b056-0571af415df3;
UPDATE users SET preferences['quality'] = 'auto' WHERE id =
        7902a572-e7dc-4428-b056-0571af415df3;
SELECT name, preferences FROM users;
```

(Section: Advanced Type) - How to UDT ADDRESS<street, city, state, postal_code> AND UPDATE ADDRESS columns values?

```
CREATE TYPE ADDRESS (
    street TEXT,
    city TEXT,
    state TEXT,
    postal_code TEXT
);
Alter table users to add column address of type ADDRESS:

ALTER TABLE users ADD address ADDRESS;
SELECT name, address FROM users;
Add an address for one of the users:

UPDATE users
SET address = { street: '1100 Congress Ave',
```

```
                city: 'Austin',
                state: 'Texas',
                postal_code: '78701' }
WHERE id = 7902a572-e7dc-4428-b056-0571af415df3;
SELECT name, address FROM users WHERE id =
        7902a572-e7dc-4428-b056-0571af415df3;
```

(Section: Advanced Type) - Single vs Multiple batch?

- A single-partition batch is an atomic batch where all operations work on the same partition and that, under the hood, can be executed as a single write operation. As a result, single-partition batches guarantee both all-or-nothing atomicity and isolation. The main use case for single-partition batches is updating related data that may become corrupt unless atomicity is enforced.

- A multi-partition batch is an atomic batch where operations work on different partitions that belong to the same table or different tables. Multi-partition batches only guarantee atomicity. Their main use case is updating the same data duplicated across multiple partitions due to denormalization. Atomicity ensures that all duplicates are consistent

(Section: Advanced Type) - Batch restrictions?

1. A batch starts with BEGIN BATCH and ends with APPLY BATCH.
2. Single-partition batches can even contain lightweight transactions, but multi-partition batches cannot.
3. The order of statements in a batch is not important as they can be executed in arbitrary order.

4. Unlogged and Counter - should never be used as they have no useful applications or there exist better alternatives.
5. Unlogged batches break the atomicity guarantee and counter batches are not safe to replay automatically as counter updates are not idempotent.
6. Do not use batches to group operations just for the sake of grouping. This example is an anti-pattern:
7. A counter update (inside batch) is not an idempotent operation.

(Section: Advanced Type) - Batch cost and performance?

1. Single-partition batches are quite efficient and can performance better than individual statements because batches save on client-coordinator and coordinator-replicas communication.
2. Sending a large batch with hundreds of statements to one coordinator node can also negatively affect workload balancing.
3. Multi-partition batches are substantially more expensive as they require maintaining a batchlog in a separate Cassandra table.
4. Use multi-partition batches only when atomicity is truly important for your application.

(Section: Advanced Type) - Batch - System tables involved?

1. batches - id, mutations, version
2. batchlog - id, data, version, written_at ## (Section: SSTable) - Storage Architecture

- Only one commit log per cluster

- Commit-logs are flused to (via MemTable) sstables
- When memtables are flushed to disk, they are written as SSTables (fast compression used by default)
- Memtable and SSTable is sorted by primary-key and clustering-key
    - A partition-key would be exist within SSTable only one page
- SSTable very poor to find absence of key (hence we need bloom-filter)

(Section: SSTable) - SStable - settings in cassandra.yaml

1. flush_compression: fast
2. file_cache_enabled: false
    - The chunk cache will store recently accessed sections of the sstable in-memory as uncompressed buffers. - 32MB
3. Memtable
    1. memtable_heap_space_in_mb: 2048
    2. memtable_offheap_space_in_mb: 2048
4. index_summary_capacity_in_mb (SSTable index summary)
5. index_summary_resize_interval_in_minutes
    - How frequently index summaries should be resampled
6. compaction_throughput_mb_per_sec: 64
7. stream_entire_sstables: true
8. max_value_size_in_mb: 256

(Section: SSTable) - What are the files part of SSTable

- mb-1-big-Summary.db
- mb-1-big-Index.db
- mb-1-big-Filter.db
- mb-1-big-Data.db
- SSTable metata files
    - mb-1-big-Digest.crc32
    - mb-1-big-Statistics.db
    - mb-1-big-CRC.db
    - mb-1-big-Toc.txt – list of the above files

(Section: SSTable) - What is the role of index file

- It lists the partition-keys/cluster-keys that are available inside the SSTable with offset information. Disk seek can directly locate few keys

(Section: SSTable) - What is the role of statitics file

- It has the column definition
- It has almost all the details about DDL of a table

(Section: SSTable) - Why SQLite4 didn't use LSM?

- Every insert needs to check constraint, and it requires reads. In simple, every write operation also ends up with read operation.
- LSM is great for blind writes, but doesn't work work as well when constraints must be checked prior to each write

(Section: SSTable) - LSM Pros and Cons

- Pros
    - Faster writes
    - Reduced write amplification
    - Linear Writes
    - Less SSD Wear
- Cons
    - Slower Reads
    - Background Merge process
    - More space on disk
    - Greater Complexity

(Section: SSTable) - SSTable references

- What is in All of Those SSTable Files Not Just the Data One but All the Rest Too! (John Schulz, The Pythian Group) | Cassandra Summit 2016
- So you have a broken Cassandra SSTable file?
- C23: Lessons from SQLite4 by SQLite.org - Richard Hipp ## (Section: Administration) - DSE Cassandra Course topics

1. Install and Start Apache Cassandra™
2. CQL
3. Partitions
4. Clustering Columns
5. Application Connectivity and Drivers
6. Node
7. Ring
8. VNodes
9. Gossip
10. Snitches
11. Replication
12. Consistency Levels
13. Hinted Handoff
14. Read Repair
15. Node Sync
16. Write Path
17. Read Path
18. Compaction
19. Advanced Performance

(Section: Administration) - Course DSE installation

```
ubuntu@ds201-node1:~$ tar -xf dse-6.0.0-bin.tar.gz
mv dse-6.0.0 node
. labwork/config_node
cd node/bin
./dse cassandra
./dsetool status
```

(Section: Administration) - Nodetool vs DSE-tool

- nodetool – only Apache Cassandra
- dsetool – Apache Cassandra™, Apache Spark™, Apache Solr™, Graph

(Section: Administration) - Nodetool Gauge the server performance

```
./nodetool describecluster
./nodetool getlogginglevels
./nodetool setlogginglevels org.apache.cassandra TRACE
## (Section: Administration) -  Create and populate garbage to
        stress the cluster
/home/ubuntu/node/resources/cassandra/tools/bin/cassandra-stress write
        n=50000 no-warmup -rate threads=2


./nodetool flush
./nodetool status
```

(Section: Administration) - Find all the material view of a keyspace

```
SELECT view_name FROM system_schema.views where keyspace_name='myKey-
        space';
```

(Section: Administration) - How to find number of partitions/node-of partition in a table

- ./nodetool tablestats -H keyspace.tablename;
- select token(tag) from killrvideo.videos_by_tag;
    - ./nodetool getendpoints killrvideo videos_by_tag -1651127669401031945
    - ./nodetool getendpoints keyspace table_name #token_number;
    - ./nodetool ring
    - ./nodetool getendpoints killrvideo videos_by_tag 'cassandra'
    - ./nodetool getendpoints killrvideo videos_by_tag 'datastax'

(Section: Administration) - Cassandra Node (Server/VM/H/W)

- Runs a java process (JVM)
- Only supported on local storage or direct attached storage
- If your disk has ethernet cable, It is wrong choice
    - Don't run it on SAN (not supported)
- Typically 6000-12000 TXN per second / core
- How much data a single Cassandra node can handle?
    - 2 -to- 4 TB
- How do you manage node?
    - Use nodetool utilitiy

(Section: Administration) - Cassandra Ring (The cluster)

- Any node can act as a co-ordinator to incoming data
- How does co-ordinator knows the node that handles the data?
    - Co-ordinator has token-range, Token range is all about paritition key range and node
    - (2^^63)-1 –> (-2^^63) - ranges of tokents are available
    - 20 digit number - 18,446,744,073,709,551,616

(Section: Administration) - How new nodes join the ring

- Uses seed-nodes configured in new-nodes Cassandra.yaml
    - SeedNode provider could be rest-api
- Node joins by communicating with any seed-nodes
- Seed nodes communicate cluster topology to the joining node
- Once the new-node joins the cluster, all the nodes are peers
    - Node status could be - Leaving/Joining/Up/Running - UN (Up and Normal)

(Section: Administration) - Peer-to-Peer

- Leader-Follower fails when we do sharding
    - Leader-Follower model is just client-server model on the service side
- Leader follower would fail other leaders are read-replicas, and also supports sharding

- If Leader and follower can't each other due to network glitch, It becomes even more error prone.
- In Cassandra, It is peer-to-peer
    - No node is superior than other
    - Everyone is peer

(Section: Administration) - Why do we need VNode?

- When adding a new physical node, how to equally distribute data from existing nodes into new node?
- If overloaded node, is distributing data to new node, it would become additional burden for existing overloaded node
- VNode also help distributing data consistently acorss nodes
    - Without vnode, Cluster has to store continuous sequential ranges of data into node
    - VNode automate token range assignment
- It helps making easier to bootstrap new node
- Adding/removing nodes with vnodes helps keep the cluster balanced
- By default each node has 128 vnodes

(Section: Administration) - How to enable VNode?

- num_tokens value should greather than 1 in Cassandra.yaml
- num_tokens = 1 ## Disable vnode

(Section: Administration) - Gossip protocol (nodemeta data is the subject)

- No centralized service to spread the information - How do we share information?
- Gossip protocol helps to spread information (despite peer-to-peer)
- Every second a node pick one-to-three other nodes to gossip with
    - It might pick same node successive time, they don't keep track of the node that they gossped with

(Section: Administration) - What do nodes Gossip about?

- They gossip about node-meta-data
    - Heartbeat, generation, version and load
- What is the difference between generation and version?
    - Generation - timestamp of when the node-bootstraps
    - version - counter incremented every-second

(Section: Administration) - What is Gossip data structure look like?

- EP: 127.0.0.1, HB:100:20, LOAD:86
- Endpoint, HeartBeat:generation:version, Load

- `json EndPointState { HeartBeatState: { Generation: 5, Version: 22 }, ApplicationState: { Status: Normal/Leaving/Left/Joining/Removing, DC: CDC1, RACK: sg-2a, SCHEMA: c2acbn, Severity=0.75, } }`

(Section: Administration) - What is Gossip protocol?

- Initiator - Sends SYN
- Receiver - Receives SYN and Constructs and replies with ACK message
- Initiator - Gets ACK reponse from receiver
- Initiator - ACKs the ACK (from receiver) using ACK2 reponse

(Section: Administration) - How to find more details about Gossip

- project = CASSANDRA AND component = “Cluster/Gossip”
- https://issues.apache.org/jira/browse/CASSANDRA-16588?jql=project%20%3D%20CASSANDRA%20AND%20component%20%3D%20%22Cluster%2FGossip%22

(Section: Administration) - Sample Gossipinfo

```
ubuntu@ds201-node1:~/node1/bin$ ./nodetool gossipinfo
/127.0.0.1
  generation:1623251077
  heartbeat:732
```

```
  STATUS:32:NORMAL,-117951217631614635
  LOAD:717:6930897.0
  SCHEMA:322:08e0aca4-d15e-3357-8876-0e7cc6cc60ba
  DC:50:Cassandra
  RACK:18:rack1
  RELEASE_VERSION:4:4.0.0.2284
  NATIVE_TRANSPORT_ADDRESS:3:127.0.0.1
  X_11_PADDING:677:{"dse_version":"6.0.0","workloads":"Cassandra","workload":"Cassand
        DD","graph":false,"health":0.1}

  NET_VERSION:1:256
  HOST_ID:2:d8e387df-71c3-4584-b911-bb8867f66b8b
  NATIVE_TRANSPORT_READY:86:true
  NATIVE_TRANSPORT_PORT:6:9041
  NATIVE_TRANSPORT_PORT_SSL:7:9041
  STORAGE_PORT:8:7000
  STORAGE_PORT_SSL:9:7001
  JMX_PORT:10:7199
  TOKENS:31:<hidden>
/127.0.0.2
  generation:1623251055
  heartbeat:736
  STATUS:61:NORMAL,-1182052107726675062
  LOAD:699:7303102.0
  SCHEMA:328:08e0aca4-d15e-3357-8876-0e7cc6cc60ba
  DC:65:Cassandra
  RACK:18:rack1
  RELEASE_VERSION:4:4.0.0.2284
  NATIVE_TRANSPORT_ADDRESS:3:127.0.0.1
  X_11_PADDING:680:{"dse_version":"6.0.0","workloads":"Cassandra","workload":"Cassand
        DD","graph":false,"health":0.1}

  NET_VERSION:1:256
```

```
HOST_ID:2:55c76577-e187-4948-807f-a95026a7c4dd
NATIVE_TRANSPORT_READY:95:true
NATIVE_TRANSPORT_PORT:6:9042
NATIVE_TRANSPORT_PORT_SSL:7:9042
STORAGE_PORT:8:7000
STORAGE_PORT_SSL:9:7001
JMX_PORT:10:7299
TOKENS:60:<hidden>
```

(Section: Administration) - Node failure detector

- Every node declares their own status.
- Every node detects failure of peer-node
- They don't send their assumptions/evaluations during gossip (nodes don't send their judgement about other nodes)

(Section: Administration) - Snitch (meaning informer)

- Snitch - toplogy of cluster
- Informs each IP and its physical location
    - DC and Rack
- HttpPropertyFileSnitch
- SimpleSnitch
- Cloud-Based snitches
    - EC2Snitch
    - EC2MultiRegionSnitch
    - RackInferrringSnitch

        - GoogleCloudSnitch
        - CloudStackSnitch
- PropertyFileSnitch
- RackInferingSnitch (don't rely on it)
    - ip=DC1:RACK2
    - ip2=DC2:RACK2
    - 110:100:200:105
        - 110 - Country (ignored by snitcher)
        - 100 - DC octet (second ip octet)
        - 200 - rack octet
        - 105 - node octet
    - cassandra-rackdc.properties can contain the data

(Section: Administration) - What is the role of DynamicSnitch

- It uses underlying snitch
- Maintains pulse of each nodes performance
- Determines which node to query based on performance
- Turned on by default for all snitches

(Section: Administration) - Mandatory operational practice

- All nodes should use same snitch
- Changing network topology requires restarting all the nodes with latest snitch
- Run sequential repair and cleanup on each node

(Section: Administration) - Replication with RF=1

- Every node is responsible for certain token range
- Partitioner finds the token from the data (MurMurPartitioner)
- RF=1 - Only one copy of the data (source alone)
- Let us say we have token range or 0, 13, 25, 38, 50, 63, 75, 88, 100
- If we try to insert data with token value of 59.
    - Node that owns token higher than 59 is (here 63 is choosen)
    - Node that owns 50 and above.. but below 63 would store the data

(Section: Administration) - Replication with RF>=2

- Data would be stored in node that supposed to own token range
- For every RF>1, Node who is neighbour (token range higher) also gets copy of the data
- Let us say if we try to store token()==59 and RF=2
    - Node that owns 50-63 would get a copy
    - Node that owns 63-75 would also get a copy

(Section: Administration) - Replication with RF>=2 and Cross DataCenter

- Cross DC replication is hard
- We can have different RF for each DC

- Country specific replication can be controlled at the keyspace level
- Remote Co-ordinator would act as a local-cordinator to replicate data within remote DC

(Section: Administration) - Consistency in CQL

```
consistency ANY;
##Consistency level set to ANY.


select * from videos_by_tag;
##InvalidRequest: Error from server: code=2200 [Invalid query] mes-
        sage="ANY ConsistencyLevel is only supported for writes"


INSERT INTO videos_by_tag(tag, added_date, video_id, title)  VALUES
        ('cassandra', '2016-2-11', uuid(), 'Cassandra, Take Me
        Home');


select * from videos_by_tag;InvalidRequest: Error from server:
        code=2200 [Invalid query] message="ANY ConsistencyLevel is
        only supported for writes"
```

(Section: Administration) - Reference

- Datastax videos
- Datastax Virtual-box VM

(Section: Tools) - How to load json/csv in fastest way into Cassandra:

1. DSKBulk or Apache Spark (faster works for json and CSV)

2. CQL-Copy (slow and only for CSV)

(Section: Tools) - What are all DSBulk commands

1. load
2. unload
3. count - statistics

(Section: Tools) - Load CSV data into Cassandra (using name-to-name mapping):

```
dsbulk load -url users.csv       \
            -k killr_video       \
            -t users             \
            -header true         \
            -m "user_id=id,      \
                gender=gender,   \
                age=age"         \
            -logDir /tmp/logs
```

Time-series presentations

1. (https://www.youtube.com/watch?v=nHes8XW1VHw)
2. (https://www.youtube.com/watch?v=YewOx6En7WM)
3. (https://www.youtube.com/watch?v=3yhd073ad5w)
4. (https://www.youtube.com/watch?v=jSRBCoOaz6I)
5. (https://www.youtube.com/watch?v=QwYH2EyKwNk)
6. (https://www.youtube.com/watch?v=4VBh6UQd6z8)

7. (https://www.youtube.com/watch?v=xVwo9lsrxfg)
8. (https://www.youtube.com/watch?v=AZB5DX9m7Hc)
9. (https://www.youtube.com/watch?v=3pPser3MYEE)
10. (https://www.youtube.com/watch?v=ovMo5pIMj8M)
11. (https://www.youtube.com/watch?v=iQBtkhvaOBM) ## (Section: Tombstone) - What are Tombstones?

- Dead cells (columns/rows) are kept it memory and disk, for other other nodes to aware about dead cells for 10-days.
- When rows are queried, query has to scan over multiple expired cells/rows to get to the live cells

(Section: Tombstone) - What are all the majore issues due to Tombstones

- Often query read ends up in timesout
- Memory is occupied by dead-cells
- Rarely TombstoneOverwhelmException happens

(Section: Tombstone) - How to agressively collect tombstones (to resolve few of the query timeout tactical solution)

1. tombstone_threshold ratio to 0.1
2. unchecked_tombstone_compaction: true
3. min_threshold: 2 (Compaction would be triggered for just 2 similar sized SSTables)

(Section: Tombstone) - Where is Tombstones are handled?

- Tombstones are handled part of Compaction
- AbstractCompactionStrategy
    - protected boolean worthDroppingTombstones(SSTableReader sstable, int gcBefore)
    - java System.currentTimeMillis() > sstable.getCreationTimeFor(Component.DATA) + tombstoneCompactionInterval * 1000 AND double droppableRatio = sstable.getEstimatedDroppableTombstoneRatio(gcBefore); if (droppableRatio > tombstoneThreshold=0.2f) ```bash wget http://archive.apache.org/dist/cassandra/4.0-alpha4/apache-cassandra-4.0-alpha4-bin.tar.gz wget http://archive.apache.org/dist/cassandra/4.0-rc2/apache-cassandra-4.0-rc2-bin.tar.gz

tar xvfz http://archive.apache.org/dist/cassandra/4.0-rc2/apache-cassandra-4.0-rc2-bin.tar.gz cd apache-cassandra-4.0-rc2 bin/cassandra -R bin/stopserver $>user=whoami;pkill -u $user -f cassandra

```
# How to find the Cassandra and CQL (Native protocol supported versions) version?
1. grep -m 1 -A 2 "Cassandra version" logs/system.log
1.
    ```pre
        $ grep -m 1 -C 1 "Cassandra version" logs/system.log
        INFO  [main] 2021-07-16 09:53:21,299 QueryProcessor.java:150
- Preloaded 0 prepared statements
```
```

```
        INFO  [main] 2021-07-16 09:53:21,301 StorageService.java:615
- Cassandra version: 4.0-alpha4
        INFO  [main] 2021-07-16 09:53:21,302 StorageService.java:616
- CQL version: 3.4.5
    ```

How to find where Cassandra is initializing internal data struc-
tures, such as caches:
1. grep -m 4 "CacheService.java" logs/system.log

How to search for terms like JMX, gossip, and listening:

*
    ```bash
        grep -m 1 "JMX" logs/system.log
        grep -m 1 "gossip" logs/system.log
        grep -m 1 "listening" logs/system.log
    ```
How to confirm Cassandra is running normally?
*
    ```bash
        grep -m 1 -C 1 "state jump" logs/system.log
        INFO  [main] 2021-07-16 09:53:22,619 StorageService.ja-
va:2486 - Node 127.0.0.1:7000 state jump to NORMAL
    ```
Howt Classify CQL

1. CQL-Shell commands
    1. CAPTURE CLS   COPY DESCRIBE EXPAND LOGIN   SERIAL
SOURCE   UNICODE
    1. CLEAR   CONSISTENCY DESC EXIT   HELP   PAGING SHOW
TRACING

1. CQL topics
(Section: WriteRead) - Hinted Handoff

* Simple sticky note on co-ordinator
* Once actual node is available, Co-ordinator would deliver the message
* Previous version used to store hinted-handoff in the table (not nowadays)
* Cassandra is not good fit to design *Queue*, Hence hinted handoff is not stored in table
* There after timeout exceeds hinted-handoff itself dropped
  * By default 2 hours
* How co-ordinator knows node came online?
  * Gossip protocol helps to trigger
* COnsistency level of ANY - Hinted handoff is considered as valid transaction

(Section: WriteRead) - How read works?

* Co-ordinator reads data from fastest machine
* Co-ordinator reads checksum form other two machine
* if 1 and 2, matches, then we co-ordinator responds to client queries

(Section: WriteRead) - Read Repair (Happens only when CL=All)

* Over-time nodes goes out-of-sync
* Every write chooses between availablity and consistency
* When we choose availablity over consistency
  * We also agree that some inconsistency between server, data becomes out-of-sync

* When Co-ordinator observes data between 3 cluster is not valid, it does the following sequence
    1. Request all nodes to return latest copies of data
    1. Every cell (column) has latest timestamp, Finds the latest timestamp data and latest copy is chosen as valid
    1. It sends latest copies to two other nodes for them to udpate (their obsolete data is repaired)
    1. Responds to client with latest result

(Section: WriteRead) - Read Repair Chance (when CL < ALL) (less than ALL consistency read)

* Cassandra does read-repair even for request less than ALL, But not 100% but probablistically
  * Probability is configurable
  * dclocal_read_repair_chance - (0.1 -- 10%)
  * read_repair_chance
* Client can't be sure if data is latest or replicas are in sync
* Read repair done asynchronously in the background

(Section: WriteRead) - Nodetool repair

* It is the last line of defence for us to improve consistency with-in stored data
* Syncs all data in the cluster
* Expensive
  * Grows with amount of data in cluster
* Use with clusters servicing high writes/deletes
* Must run to synchronize a failed node coming back online
* Run on nodes not read from very often

(Section: WriteRead) - Nodetool Sync (only datastax)

* Peforming full-repair is costly
* Full-repair should be run before gc_grace_seconds
* It is default and automatically enabled in datastax
* Repairs in small chunks as we go rather than full repair
  * Create table myTable (...) WITH nodesync = {'enabled': 'true'};

(Section: WriteRead) - Nodetool Sync Save points (only datastax)

* Each node splits its local range into segments
  * Small token range of a table
* Each segment makes a save point
  * NodeSync repairs a segment
  * Then NodeSync saves its progress
  * Repeat
  * Save-point is the place where progress is stored
* NodeSync priorities segments to meet deadline target

(Section: WriteRead) - Nodetool Sync - Segments Sizes

* Eache segment is less than 200MB
* If a partition is great than 200MB win over segments less than 200MB
* Each segment cannot be less than its partition size, hence if segments are larger .. it means partition was larger

(Section: WriteRead) - Nodetool Sync - Segments failures

* Node fails during segment validation, node drops all work for that segment and starts over
* A segment repair is automic operation
* system_distributed.nodesync_status table - has the information and

progress
* segment_outcomes
  * full_in_sync : All replicas were in sync
  * full_repaired : Some repair necessary
  * partial_in_sync : all respondent were in sync, but not all replicas responded
  * partial_repaired
  * uncompleted : one node availabled/responded; no validation occurred
  * failed: unexpected error happened; check logs.

(Section: WriteRead) - Nodetool Sync - Segments Validation

* NodeSync - simply performs a read repair on the segment
* read-data from all replicas
* Check for inconsistencies
* Repair stale nodes

(Section: WriteRead) - Cassandra Write Path (inside the node, and for *a* partition)

* Two atomic operation makes a write successfull (Both commit-log + mem-table)
  * HDD - Commit Log
  * Memory - MemTable
* Commit log
  * It is append only commit log
  * Only retrieved during server restart (for replay)
   * Mem-Table: ![alt text][mem_table]
* Ensure Commit-log and ss-tables are stored in different drive
  * Commit log is append only for peformance

  * When we share same disk, disk seek operation for MM-Table would cause performance degradation
* Once Mem-Table is full, it is written as SS-Table (SSTable is immutable)
* No inplace update performed on SS-Table

(Section: WriteRead) - Cassandra Read Path (inside the node, and for particular a partition)

* Read is easy if records are in mem-table
  * Based on token, just to binary-search on mem-table and return the data to client
* Read is bit more complex than write
  * Write path created plenty of SS-Table in disk for a partition
* SSTable has token:byte_off_set index
  * 7:0,13:1120,18:3528,21:4392
  * 7 partition token starts at 0th byte-offset
  * 13 partition token starts at 1120th byte-offset
* Read_Token_58_From_SS_Table: ![alt text][read_token_58]
* There is a file named "partition_index" that has details about token vs file-byte-offset index. It is used before reading ss-table
* Partition-summary is an another index used by Cassandra
  * Partition-summary resides in memory

(Section: WriteRead) - Cassandra Read Path workflow

* ReadRequest --> Bloomfilter --> Key Cache --> Partition Summary --> Partition Index --> SS-Table
* Checks in key-cache (if succseeds, data returned directly reading ss-table)
* Checks in partition-index (partition-summary-table)

  * Finds the byte-offset of ss-table from partition-index
  * Reads byte-offset from ss-table for actual data of the primary-key
  * Updates key-cache
    * key-cache contains byte-offsets of the most recently accessed records
    * key-cache is cache for partition-index (it avoids searcing in partition-index about ss-table byte-offset)
* Finally... bloom filter can optimize all the above

(Section: WriteRead) - Bloom filter

* It might stop the entire process if the data is not present
* It might produce false positives, but never ends in false negative
* If Bloom-filter says "no-data", there is no such partition data in that node
* If Bloom-filter says "possible-data", there may or may not present data in that node

(Section: WriteRead) - Datastax

* Trie based partition-summary is being used
* SSTable lookups are extreemly fast
* When migrating from OSS to Datastax
  * Datastax can work with both kinds of ss_table-partition-index
  * It will gradually compact oss version into Trie-based partition-index
  * Tried based partition index is extreemly faster

(Section: WriteRead) - Compaction (merging ss-tables)

* Compaction

  * Removes old un-necessary immutable data
  * Deleted data (columns) are removed after gc_grace_seconds
  * Lesser number of ss-table, but during compaction it requires both old and new ss-table
* It merges two set-of partitions into one
  * Common partition data values are merged
  * Last write wins selected
  * Tombstone is marker for deleted record, that won't move into new ss-table (if record passed gc_grace_seconds=10-days)
  * nodetool compact <keyspace> <table>, There is no real offline compaction
* Not all tombstones are discarded
*
* We never modify ss-table
  * Merge creates new ss-table
  * Stale data removed and compacted (reduced and combined into fewer ss-tables)

(Section: WriteRead) - Compaction Strategies (based on use-case)

* Choose proper strategy based on use-case
  * SizeTieredCompaction - For write heavy
  * LeveledCompaction - For read heavy
  * TimeWindowCompaction - For timeseries
* We can change compaction strategy

(Section: WriteRead) - Advanced Peformance Gains in (DSE)

* OSS uses thread-pools, might cause thread contention
* DSE - uses only one thread per core
* DSE - Uses asynchronous a lot and non-blocking

(Section: WriteRead) - Before and after flush

Total number of tables: 47	**Total number of tables: 47**
Keyspace : keyspace1	Keyspace : keyspace1
Read Count: 0	Read Count: 0
Read Latency: NaN ms	Read Latency: NaN ms
Write Count: 574408	Write Count: 574408
Write Latency: 0.009942241403323074	ms Write Latency: 0.009942241403323074 ms
Pending Flushes: 0	Pending Flushes: 0
Table: standard1	Table: standard1
SSTable count: 3	| SSTable count: 4
Space used (live): 92.67 MiB	| Space used (live): 97.73 MiB
Space used (total): 92.67 MiB	| Space used (total): 97.73 MiB
Space used by snapshots (total):	0 bytes Space used by snapshots (total): 0 bytes
Off heap memory used (total): 49	7.8 KiB | Off heap memory used (total): 525.04 KiB
SSTable Compression Ratio: -1.0	SSTable Compression Ratio: -1.0
Number of partitions (estimate):	426808 | Number of partitions (estimate): 427070
Memtable cell count: 22313	| Memtable cell count: 0
Memtable data size: 5.94 MiB	| Memtable data size: 0 bytes
Memtable off heap memory used: 0	bytes Memtable off heap memory used: 0 bytes

Total number of tables: 47	**Total number of tables: 47**
Memtable switch count: 18	| Memtable switch count: 19
Local read count: 0	Local read count: 0
Local read latency: NaN ms	Local read latency: NaN ms
Local write count: 574408	Local write count: 574408
Local write latency: 0.009 ms	Local write latency: 0.009 ms
Pending flushes: 0	Pending flushes: 0
Percent repaired: 0.0	Percent repaired: 0.0
Bytes repaired: 0.000KiB	Bytes repaired: 0.000KiB
Bytes unrepaired: 88.575MiB	| Bytes unrepaired: 93.424MiB
Bytes pending repair: 0.000KiB	Bytes pending repair: 0.000KiB
Bloom filter false positives: 0	Bloom filter false positives: 0
Bloom filter false ratio: 0.0000	0 Bloom filter false ratio: 0.00000
Bloom filter space used: 497.82	KiB | Bloom filter space used: 525.07 KiB
Bloom filter off heap memory use	d: 497.8 KiB | Bloom filter off heap memory used: 525.04 KiB
Index summary off heap memory us	ed: 0 bytes Index summary off heap memory used: 0 bytes
Compression metadata off heap me	mory used: 0 Compression metadata off heap memory used: 0
Compacted partition mini-mum byte	s: 180 Compacted partition minimum bytes: 180
Compacted partition maxi-	s: 258 Compacted partition maximum bytes:

Total number of tables: 47	**Total number of tables: 47**
mum byte	258
Compacted partition mean bytes:	258 Compacted partition mean bytes: 258
Average live cells per slice (la	st five minut Average live cells per slice (last five minut
Maximum live cells per slice (la	st five minut Maximum live cells per slice (last five minut
Average tombstones per slice (la	st five minut Average tombstones per slice (last five minut
Maximum tombstones per slice (la	st five minut Maximum tombstones per slice (last five minut
Dropped Mutations: 0 bytes	Dropped Mutations: 0 bytes
Failed Replication Count: null ```	Failed Replication Count: null

(Section: WriteRead) - Sample data directory wiht WITH bloom_filter_fp_chance = 0.1;

```
ubuntu@ds201-node1:~/node1/data/data/keyspace1/stan-
dard1-000692d1cb3811eb8b932752b509e266$ ls -ltar
total 36296
drwxrwxr-x 2 ubuntu ubuntu     4096 Jun 12 04:38 backups
drwxrwxr-x 4 ubuntu ubuntu     4096 Jun 12 04:38 ..
-rw-rw-r-- 1 ubuntu ubuntu        0 Jun 12 04:41 aa-9-bti-Rows.db
-rw-rw-r-- 1 ubuntu ubuntu 35457984 Jun 12 04:41 aa-9-bti-Data.db
```

```
-rw-rw-r-- 1 ubuntu ubuntu  1472810 Jun 12 04:41 aa-9-bti-Parti-
tions.db
-rw-rw-r-- 1 ubuntu ubuntu   194656 Jun 12 04:41 aa-9-bti-Filter.db
-rw-rw-r-- 1 ubuntu ubuntu    10271 Jun 12 04:41 aa-9-bti-Statis-
tics.db
-rw-rw-r-- 1 ubuntu ubuntu       10 Jun 12 04:41 aa-9-bti-Di-
gest.crc32
-rw-rw-r-- 1 ubuntu ubuntu     2176 Jun 12 04:41 aa-9-bti-CRC.db
-rw-rw-r-- 1 ubuntu ubuntu       82 Jun 12 04:41 aa-9-bti-TOC.txt
drwxrwxr-x 3 ubuntu ubuntu     4096 Jun 12 04:41 .
```

(Section: WriteRead) - Sample data directory wiht WITH bloom_filter_fp_chance = 0.0001;

```
ubuntu@ds201-node1:~/node1/data/data/keyspace1/stan-
dard1-000692d1cb3811eb8b932752b509e266$ ls -ltar
total 36488
drwxrwxr-x 2 ubuntu ubuntu     4096 Jun 12 04:38 backups
drwxrwxr-x 4 ubuntu ubuntu     4096 Jun 12 04:38 ..
-rw-rw-r-- 1 ubuntu ubuntu        0 Jun 12 04:47 aa-10-bti-Rows.db
-rw-rw-r-- 1 ubuntu ubuntu 35457984 Jun 12 04:47 aa-10-bti-Data.db
-rw-rw-r-- 1 ubuntu ubuntu  1472810 Jun 12 04:47 aa-10-bti-Parti-
tions.db
-rw-rw-r-- 1 ubuntu ubuntu   389304 Jun 12 04:47 aa-10-bti-Filter.db
-rw-rw-r-- 1 ubuntu ubuntu       10 Jun 12 04:47 aa-10-bti-Di-
gest.crc32
-rw-rw-r-- 1 ubuntu ubuntu     2176 Jun 12 04:47 aa-10-bti-CRC.db
-rw-rw-r-- 1 ubuntu ubuntu       82 Jun 12 04:47 aa-10-bti-TOC.txt
-rw-rw-r-- 1 ubuntu ubuntu    10271 Jun 12 04:47 aa-10-bti-Statis-
tics.db
drwxrwxr-x 3 ubuntu ubuntu     4096 Jun 12 04:47 .
```

(Section: WriteRead) - Sample data directory wiht WITH bloom_filter_fp_chance = 1.0; (100% false positive allowed... No filter file)

```
ubuntu@ds201-node1:~/node1/data/data/keyspace1/stan-
dard1-000692d1cb3811eb8b932752b509e266$ ls -ltar
total 36104
drwxrwxr-x 2 ubuntu ubuntu     4096 Jun 12 04:38 backups
drwxrwxr-x 4 ubuntu ubuntu     4096 Jun 12 04:38 ..
-rw-rw-r-- 1 ubuntu ubuntu        0 Jun 12 04:53 aa-12-bti-Rows.db
-rw-rw-r-- 1 ubuntu ubuntu 35457984 Jun 12 04:53 aa-12-bti-Data.db
-rw-rw-r-- 1 ubuntu ubuntu  1472810 Jun 12 04:53 aa-12-bti-Parti-
tions.db
-rw-rw-r-- 1 ubuntu ubuntu       10 Jun 12 04:53 aa-12-bti-Di-
gest.crc32
-rw-rw-r-- 1 ubuntu ubuntu     2176 Jun 12 04:53 aa-12-bti-CRC.db
-rw-rw-r-- 1 ubuntu ubuntu    10271 Jun 12 04:53 aa-12-bti-Statis-
tics.db
-rw-rw-r-- 1 ubuntu ubuntu       72 Jun 12 04:53 aa-12-bti-TOC.txt
drwxrwxr-x 3 ubuntu ubuntu     4096 Jun 12 04:53 .
ubuntu@ds201-node1:~/node1/data/data/keyspace1/standard1-0
```

(Section: WriteRead) - Nodetool CFStats

```
ubuntu@ds201-node1:~/node/bin$ ./nodetool cfstats keyspace1
Total number of tables: 47
----------------
Keyspace : keyspace1
    Read Count: 0
```

```
Read Latency: NaN ms
Write Count: 154846
Write Latency: 0.011354216447308938 ms
Pending Flushes: 0
    Table: counter1
    SSTable count: 0
    Space used (live): 0
    Space used (total): 0
    Space used by snapshots (total): 0
    Off heap memory used (total): 0
    SSTable Compression Ratio: -1.0
    Number of partitions (estimate): 0
    Memtable cell count: 0
    Memtable data size: 0
    Memtable off heap memory used: 0
    Memtable switch count: 0
    Local read count: 0
    Local read latency: NaN ms
    Local write count: 0
    Local write latency: NaN ms
    Pending flushes: 0
    Percent repaired: 100.0
    Bytes repaired: 0.000KiB
    Bytes unrepaired: 0.000KiB
    Bytes pending repair: 0.000KiB
    Bloom filter false positives: 0
    Bloom filter false ratio: 0.00000
    Bloom filter space used: 0
    Bloom filter off heap memory used: 0
    Index summary off heap memory used: 0
    Compression metadata off heap memory used: 0
    Compacted partition minimum bytes: 0
```

```
Compacted partition maximum bytes: 0
Compacted partition mean bytes: 0
Average live cells per slice (last five minutes): NaN
Maximum live cells per slice (last five minutes): 0
Average tombstones per slice (last five minutes): NaN
Maximum tombstones per slice (last five minutes): 0
Dropped Mutations: 0
Failed Replication Count: null

Table: standard1
SSTable count: 1
Space used (live): 36943323
Space used (total): 36943323
Space used by snapshots (total): 0
Off heap memory used (total): 0
SSTable Compression Ratio: -1.0
Number of partitions (estimate): 155716
Memtable cell count: 0
Memtable data size: 0
Memtable off heap memory used: 0
Memtable switch count: 9
Local read count: 0
Local read latency: NaN ms
Local write count: 154846
Local write latency: 0.010 ms
Pending flushes: 0
Percent repaired: 0.0
Bytes repaired: 0.000KiB
Bytes unrepaired: 33.815MiB
Bytes pending repair: 0.000KiB
Bloom filter false positives: 0
Bloom filter false ratio: 0.00000
```

```
        Bloom filter space used: 0
        Bloom filter off heap memory used: 0
        Index summary off heap memory used: 0
        Compression metadata off heap memory used: 0
        Compacted partition minimum bytes: 180
        Compacted partition maximum bytes: 258
        Compacted partition mean bytes: 258
        Average live cells per slice (last five minutes): NaN
        Maximum live cells per slice (last five minutes): 0
        Average tombstones per slice (last five minutes): NaN
        Maximum tombstones per slice (last five minutes): 0
        Dropped Mutations: 0
        Failed Replication Count: null

----------------
ubuntu@ds201-node1:~/node/bin$

./cassandra-stress read CL=ONE no-warmup n=1000000 -rate threads=1
./nodetool cfstats
```

(Section: WriteRead) - Followup questions

- we could not find /var/log/system.log
    - During single-node check console output or nohup.out or terminal output
- What is the difference between partition-summary and partition-index?

What is compaction in Cassandra?

- It is similar to comapaction of file-system
- Multiple SS-Tables are merged (like merge-sort), and deleted removed, tombstones removed, updated records retained.
    - It leads to lean SS-Table

Pre-requisite for Compaction

- Find table statistics
    - nodetool cfstats
    - nodetool tpstats

We have problem with two nodes with large number of compaction pending, how to speed up?

- Disable the node act as a co-ordinator? (it can spend its io/cpu in compaction)
    - nodetool disablebinary
- Disable the node accepting write (should be lesser than hinted-hand-off period) ?
    - nodetool disablegossip (marking node as down)
    - nodetool disablehandoff (marking node as down)
- Disable the node accepting write (should be lesser than hinted-hand-off period) ?
    - nodetool disablegossip
- Increase the compaction througput (there would be consequences for

read)

- nodetool setconcurrentcompactors 2

Reference

Understanding the Nuance of Compaction in Apache Cassandra TWCS part 1 - how does it work and when should you use it ?

(Section: Experimental) - MV - Limitations?

1. A view and a base table must belong to the same keyspace;
2. No base table static column can be included in a view;
3. All base table primary key columns must become materialized view primary key columns;
4. At most one base table non-primary key column can become a materialized view primary key column;
5. All view primary key columns must be restricted to not allow nulls.
6. It is possible that a materialized view and a base table become out-of-sync. Cassandra does not provide a way to automatically detect and fix such inconsistencies
    1. Applications can drop and recreate the materialized view, which is not an ideal solution in production
7. Even though writes to base tables and views are asynchronous
    1. Each materialized view slows down writes to its base table by approximately 10%. 1, Cassandra community recommends to not create more than two materialized views per table.
8. sql cqlsh:killr_video> CREATE MATERIALIZED VIEW IF NOT EXISTS users_by_name_age AS SELECT * FROM users WHERE name IS NOT NULL AND email IS

```
NOT NULL AND age  IS NOT NULL                    PRIMARY KEY
((name, age), email);     InvalidRequest: Error from serv-
er: code=2200 [Invalid query] message="Cannot include more
than one non-primary key column in materialized view prima-
ry key (got name, age)"
```

(Section: Experimental) - How to mitigate the risk of base-view inconsistency?

1. Use consistency levels LOCAL_QUORUM and higher for base table writes.
2. Standard recommended repair procedures should be performed on both tables and views regularly or whenever a node is removed, replaced or started back up.

(Section: Experimental) - Example of MVs.

1.
```
CREATE TABLE users (
    email TEXT, name TEXT,
    age INT,date_joined DATE,
    PRIMARY KEY ((email))
);

CREATE MATERIALIZED VIEW IF NOT EXISTS users_by_name AS
    SELECT * FROM users    WHERE name IS NOT NULL AND
    email IS NOT NULL PRIMARY KEY ((name), email);
CREATE MATERIALIZED VIEW IF NOT EXISTS
    users_by_date_joined AS SELECT * FROM users WHERE
    date_joined IS NOT NULL AND email IS NOT NULL PRI-
    MARY KEY ((date_joined), email);
```

(Section: Experimental) - What are all types of secondary index.

1. Regular secondary index (2i): a secondary index that uses hash tables to index data and supports equality (=) predicates.
2. SSTable-attached secondary index (SASI): an experimental and more efficient secondary index that uses B+ trees to index data and can support equality (=), inequality (<, <=, >, >=) and even text pattern matching (LIKE).

(Section: Experimental) - Use cases for indexes in Cassandra production (specific cases):

1. Real-time transactional query: retrieving rows from a large multi-row partition, when both a partition key and an indexed column are used in a query.

2. Expensive analytical query: retrieving a large number of rows from potentially all partitions, when only an indexed low-cardinality column is used in a query.

    1. A low-cardinality column is characterized by a large number of duplicates stored in it and a limited data range for its possible values.

3. Retrieve rows based on a rating value:

```
-- Real-time transactional query
SELECT * FROM ratings_by_movie WHERE title  = 'Alice in Wonderland' AND year = 2010 AND rating = 9;
-- Expensive analytical query
SELECT * FROM ratings_by_movie WHERE rating = 9;
```

```
--Create the SASI:
CREATE CUSTOM INDEX IF NOT EXISTS rating_rat-
        ings_by_movie_sasi ON ratings_by_movie (rating)US-
        ING 'org.apache.cassandra.index.sasi.SASIIndex';
--Retrieve rows based on a rating range:
-- Real-time transactional query
SELECT * FROM ratings_by_movie    WHERE title  = 'Alice in
        Wonderland'    AND year   = 2010    AND rating >=
        8 AND rating <= 10;
-- Expensive analytical query
SELECT * FROM ratings_by_movie    WHERE rating >= 8 AND rat-
        ing <= 10;
```

(Section: Experimental) - What is the main real-time transactional use case for a secondary index?

4. Retrieving rows from a large multi-row partition

(Section: Experimental) - Limitations of indexes in Cassandra:

1. For all other use cases, which usually involve high-cardinality columns, you should always prefer **tables and materialized views** to secondary indexes.
2. The general recommendation is to have at most one secondary index per table.

(Section: Experimental) - Secondary index limitations

1. To understand secondary index limitations, let's take a closer look at how they work in comparison to Cassandra tables and materialized views.
2. Tables and materialized views are examples of distributed indexing. A table or view data structure is distributed across all nodes in a cluster based on a partition key. When retrieving data using a partition key, Cassandra knows exactly which replica nodes may contain the result. For example, given a 100-node cluster with the replication factor of 5, at most 5 replica nodes and 1 coordinator node need to participate in a query.
3. In contrast, secondary indexes are examples of local indexing. A secondary index is represented by many independent data structures that index data stored on each node. When retrieving data using only an indexed column, Cassandra has no way to determine which nodes may have necessary data and has to query all nodes in a cluster. For example, given a 100-node cluster with any replication factor, all 100 nodes have to search their local index data structures. This does not scale well.
4. Therefore, for real-time transactional queries, you should only use a secondary index when a partition key is also known, such that your query retrieves rows from a known partition based on an indexed column. In this case, Cassandra takes advantage of both distributed and local indexing.
5. Secondary indexes can also be beneficial to distribute processing across all nodes in a cluster for expensive analytical queries that retrieve a large subset of table rows based on a low-cardinality column. Such queries are generally run via Spark-Cassandra Connector,

where retrieved data is further processed using Apache Spark™. Note, however, that Apache Solr™-based search indexes can do substantially better than secondary indexes in this use case. ## Queue anti-pattern

- Cassandra is not suited for Queue

Anti-patterns in the Cassandra

- Anti-patterns in Cassandra - 2.2
- Anti-patterns-Planning and testing DataStax Enterprise deployments
- Anti-patterns which all Cassandra users must know
- Anti-patterns which all Cassandra users must know
- Cassandra nice use cases and worst anti patterns
- Apache Cassandra Anti Patterns-2012
- Cassandra anti-patterns: Queues and queue-like datasets
- Cassandra Anti-Patterns
- Building a queue, Frequently updated data, Query flexibility, Incorrect use of BATCH, Querying an entire table
- ```
  Using Apache Cassandra as a backend for a queue or queue-like structure is never going to end well. We have discussed at length that, due to Cassandra's log-based storage engine, inserts, updates, and deletes are all treated as writes. Well, what does a queue do? It does the following:
  ```
  ```

Data gets written to a queue.

Data gets updated while it's in the queue (example: status). Sometimes several times.

When the data is no longer required, it gets deleted.

Given what we have covered about how Cassandra handles things, such as in-place updates (obsoleted data) and deletes (tombstones), it should be obvious that this is not a good idea. Remember, a data model built to accommodate a small amount of in-place updates or deletes is fine. A data model that relies on in-place updates and deletes isn’t going to make anyone happy in the end.

What is the URL of hands-on workshop?

- Cassandra Fundamental
- Scenarios
- Trunk Cassandra.yaml

Important Spring Java project

- Cassandra Datastax PetClinic
- Cassandra Datastax Reactive PetClinic # Important Cassandra links
- JIRA
- Cassandra Cwiki
- GIT Cassandra

- CI-Cassandra-Build
- CI Console log

JIRA based on labels

- Consistency/Coordination
- Materialized View
- Sasi

JIRA Features in Cassandra

- All the Components
- Local/SSTable
- Local/Compaction/LCS
- Feature/Lightweight Transactions
- Consistency/Repair, Observability/Logging
- Test/unit
- Cluster/Schema
- Tool/sstable ## Cassandra usages in famous producs
- Pega - decision management data ## Cassandra Course Videos
- DS-201 vidoes

Cassandra index

- Architecture
- README
- cassandra_commands_output
- cassandra_definitive_guide_anki
- cassandra_docker
- cqls_anki
- data_types
- partition
- setup
- todo
- Debug log
- System Log

Famous Cassandra articles

- The things I hate about Apache Cassandra - John Schulz ## How to generate conf/cassandra_simple.yaml
- grep -v "^#" conf/cassandra.yaml | sed '/^$/d' > conf/cassandra_simple.yaml

Analyze Cassandra code

```
`cat test/unit/org/apache/cassandra/db/compaction/LeveledCompactionStrategyTest.java | tr ' ' '\r\n' | tr A-Z a-z | sort| tr -d '[\\}\\{}]' | sort
```

K8ssandra

- Workshop
- Workshop slides
- Workshop Steps