# INTRODUCTION TO CASSANDRA

## UNIT -2

### Chapter 7

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# Learning Objectives and Learning Outcomes

| Learning Objectives | Learning Outcomes |
|---|---|
| Introduction to Cassandra<br><br>1. To study the features of Cassandra.<br><br>2. To learn how to perform CRUD(Create, Read, Update and Delete) operations.<br><br>3. To learn about collections in Cassandra.<br><br>4. To import from and export to CSV format. | a) To comprehend the reasons behind the popularity of NoSQL database.<br><br>b) To be able to perform CRUD operations.<br><br>c) To distinguish between collections types such as SET, LIST and MAP.<br><br>d) To be able to successfully import from CSV.<br><br>e) To be able to successfully export to CSV. |

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# Agenda

- Apache Cassandra – An Introduction
- Features of Cassandra
  - Peer-to-Peer Network
  - Writes in Cassandra
  - Hinted Handoffs
  - Tunable Consistency: Read Consistency and Write Consistency
- CQL Data Types
- CQLSH
- CRUD : Insert, Update, Delete and Select
- Collections : Set, List and Map
- Time To Live (TTL)
- Import and Export


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# NoSQL Database

- A NoSQL database (sometimes called as Not Only SQL) is a database that provides a mechanism to store and retrieve data
- These databases are schema-free
  - support easy replication,
  - have simple API,
  - eventually consistent,
  - and can handle huge amounts of data.
- The primary objective of a NoSQL database is to have
  - simplicity of design,
  - horizontal scaling, and
  - finer control over availability.

# NoSQL vs. Relational Database

| Relational Database | NoSql Database |
|---|---|
| Supports powerful query language. | Supports very simple query language. |
| It has a fixed schema. | No fixed schema. |
| Follows ACID (Atomicity, Consistency, Isolation, and Durability). | It is only “eventually consistent”. |
| Supports transactions. | Does not support transactions. |

# Apache Cassandra – An Introduction

- Cassandra was born at Facebook for inbox search.
- It was open-sourced by Facebook in July 2008.
- Cassandra became an Apache Incubator project in March 2009.
- It was made an Apache top-level project since February 2010.

- It is built on Amazon's dynamo and Google's BigTable.
- Its highly scalable, high performance distributed database.
- It is a column-oriented database designed to support peer-to-peer symmetric nodes instead of the master-slave architecture.


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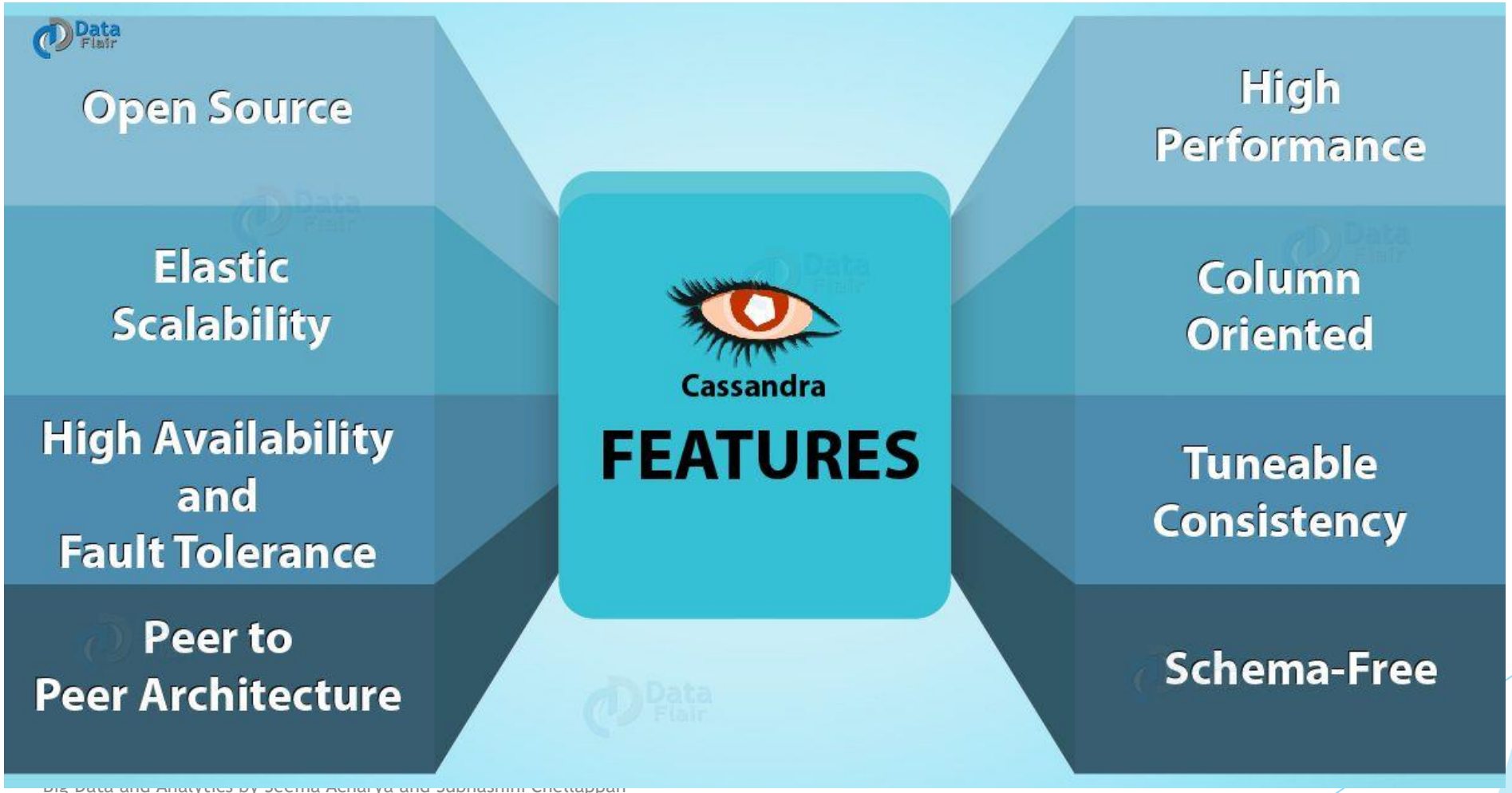
# What is Apache Cassandra?

- Apache Cassandra is an open source, distributed and decentralized/distributed storage system (database), for managing very large amounts of structured data spread out across the world.

- It provides highly available service with no single point of failure.

# Features of Cassandra

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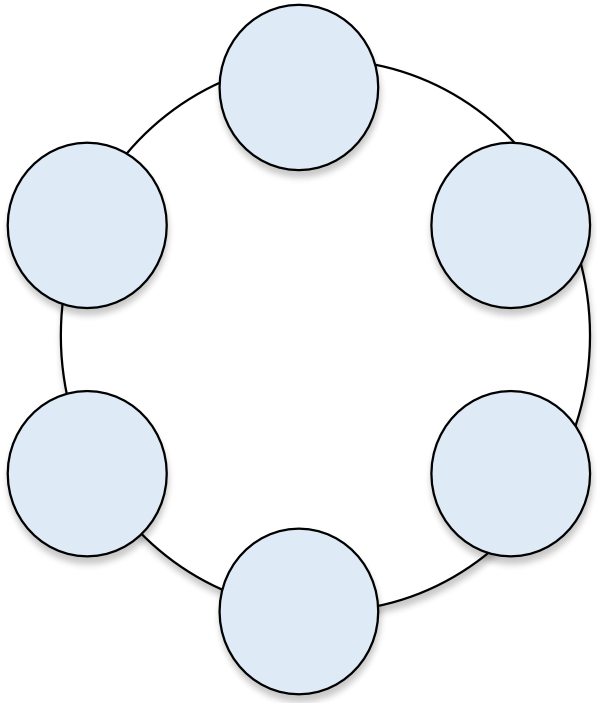
# Peer to Peer Network

- The aim of Cassandra's design is overall system availability and ease of scaling
- Does NOT have a Master Slave Architecture
- This design also makes it easier to scale Cassandra by adding new nodes

**Sample Cassandra Cluster**



# Gossip and Failure Detection

- Cassandra uses a gossip protocol for intra-ring communication so that each node can have state information about other nodes
- The gossiper runs every second on a timer
- Because Cassandra gossip is used for failure detection, the Gossiper class maintains a list of nodes that are alive and dead.

- Failure detection is implemented in Cassandra by the org.apache.cassandra.gms
- For repairing unread data, Cassandra uses anti-entropy version of gossip protocol.
- Anti-entropy, compares all replicas of each piece of data and update each replica to the newest version.

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# Partitioner

- Distribution of data on various nodes in cluster
- Partitioner is a Hash function which computes tokens.
- Partition key helps to identify a row uniquely

# Replication Factor

- Determines number of copies of data that will be stored across nodes in a cluster
- Two Strategies
  - Simple Strategy
  - Network Topology Strategy

# Writes in Cassandra

- A client that initiates a write request.
- It is first written to the commit log. A write is taken as successful only if it is written to the commit log.
- The next step is to push the write to a memory resident data structure called Memtable. A threshold value is defined in the Memtable.
- When the number of objects stored in the Memtable reaches a threshold, the contents of Memtable are flushed to the disk in a file called SSTable (Stored string Table). Flushing is a non-blocking operation.
- It is possible to have multiple Memtables for a single column family. One out of them is current and the rest are waiting to be flushed.


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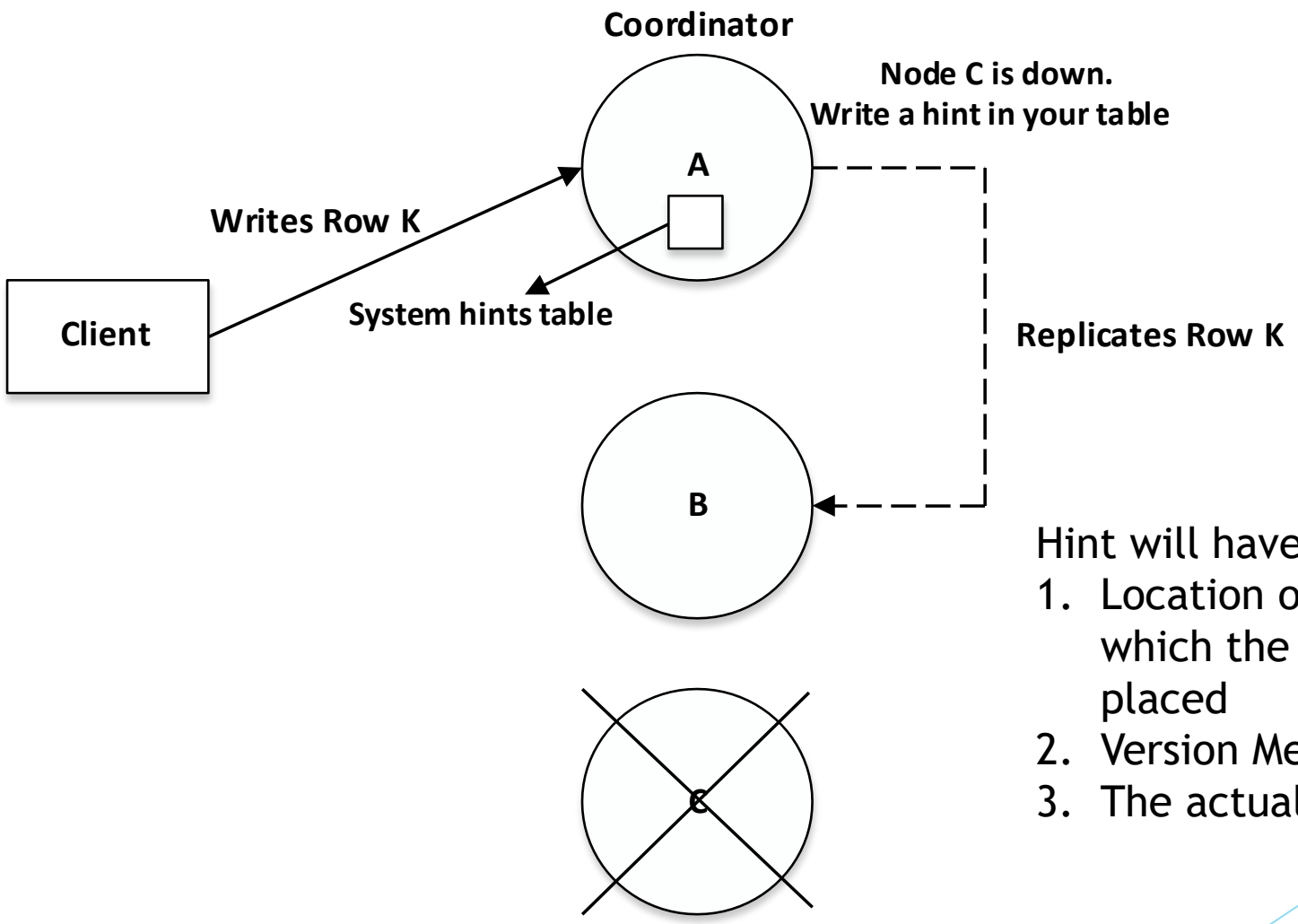
# Hinted Handoffs

Why Cassandra is all for availability?




Hint will have:

1. Location of the node on which the replica is to be placed
2. Version Metadata
3. The actual data

# Tunable Consistency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# Read Consistency

| | |
|---|---|
| ONE | Returns a response from the closest node (replica) holding the data. |
| QUORUM | Returns a result from a quorum of servers with the most recent timestamp for the data. |
| LOCAL_QUORUM | Returns a result from a quorum of servers with the most recent timestamp for the data in the same data center as the coordinator node. |
| EACH_QUORUM | Returns a result from a quorum of servers with the most recent timestamp in all data centers. |
| ALL | This provides the highest level of consistency of all levels and the lowest level of availability of all levels. It responds to a read request from a client after all the replica nodes have responded. |


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# Write Consistency

| | |
|---|---|
| ALL | This is the highest level of consistency of all levels as it necessitates that a write must be written to the commit log and Memtable on all replica nodes in the cluster. |
| EACH_QUORUM | A write must be written to the commit log and Memtable on a quorum of replica nodes in all data centers. |
| QUORUM | A write must be written to the commit log and Memtable on a quorum of replica nodes. |
| LOCAL_QUORUM | A write must be written to the commit log and Memtable on a quorum of replica nodes in the same data center as the coordinator node. This is to avoid latency of inter-data center communication. |
| ONE | A write must be written to the commit log and Memtable of at least one replica node. |
| TWO | A write must be written to the commit log and Memtable of at least two replica nodes. |
| THREE | A write must be written to the commit log and Memtable of at least three replica nodes. |
| LOCAL_ONE | A write must be sent to, and successfully acknowledged by, at least one replica node in the local data center. |

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# CQL Data types


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# CQL Data types

| Int | 32 bit signed integer |
|---|---|
| Bigint | 64 bit signed long |
| Double | 64-bit IEEE-754 floating point |
| Float | 32-bit IEEE-754 floating point |
| Boolean | True or false |
| Blob | Arbitrary bytes, expressed in hexadecimal |
| Counter | Distributed counter value |
| Decimal | Variable – precision integer |
| List | A collection of one or more ordered elements |
| Map | A JSON style array of elements |
| Set | A collection of one or more elements |
| Timestamp | Date plus time |
| Varchar | UTF 8 encoded string |
| Varint | Arbitrary-precision integers |
| Text | UTF 8 encoded string |


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# CQLSH

## Logging to cqlsh

| | |
|---|---|
| ***Objective:*** | What is it that we are trying to achieve here? |
| ***Input (optional):*** | What is the input that has been given to us to act upon? |
| ***Act:*** | The actual statement /command to accomplish the task at hand. |
| ***Outcome:*** | The result/output as a consequence of executing the statement. |

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# Example:

**Objective:** To get help with CQL.

**Act:**

**Help**

**Outcome:**

```
C:\windows\system32\cmd.exe - Python cqlsh

d:\apache-cassandra-2.0.0\apache-cassandra-2.0.0\apache-cassandra-2.0.0\bin>Python cqlsh
Connected to Test Cluster at localhost:9160.
[cqlsh 4.0.0 | Cassandra 2.0.0 | CQL spec 3.1.0 | Thrift protocol 19.37.0]
Use HELP for help.
cqlsh> help

Documented shell commands:
==========================
CAPTURE       COPY  DESCRIBE  EXPAND  SHOW    TRACING
CONSISTENCY   DESC  EXIT      HELP    SOURCE

CQL help topics:
================
ALTER                          CREATE_TABLE_OPTIONS   REVOKE
ALTER_ADD                      CREATE_TABLE_TYPES     SELECT
ALTER_ALTER                    CREATE_USER            SELECT_COLUMNFAMILY
ALTER_DROP                     DELETE                 SELECT_EXPR
ALTER_RENAME                   DELETE_COLUMNS         SELECT_LIMIT
ALTER_USER                     DELETE_USING           SELECT_TABLE
ALTER_WITH                     DELETE_WHERE           SELECT_WHERE
APPLY                          DROP                   TEXT_OUTPUT
ASCII_OUTPUT                   DROP_COLUMNFAMILY      TIMESTAMP_INPUT
BEGIN                          DROP_INDEX             TIMESTAMP_OUTPUT
BLOB_INPUT                     DROP_KEYSPACE          TRUNCATE
BOOLEAN_INPUT                  DROP_TABLE             TYPES
CREATE                         DROP_USER              UPDATE
CREATE_COLUMNFAMILY            GRANT                  UPDATE_COUNTERS
CREATE_COLUMNFAMILY_OPTIONS    INSERT                 UPDATE_SET
CREATE_COLUMNFAMILY_TYPES      LIST                   UPDATE_USING
CREATE_INDEX                   LIST_PERMISSIONS       UPDATE_WHERE
CREATE_KEYSPACE                LIST_USERS             USE
CREATE_TABLE                   PERMISSIONS            UUID_INPUT

cqlsh>
```

# A Simple Introduction


- *Figure - A list of values*

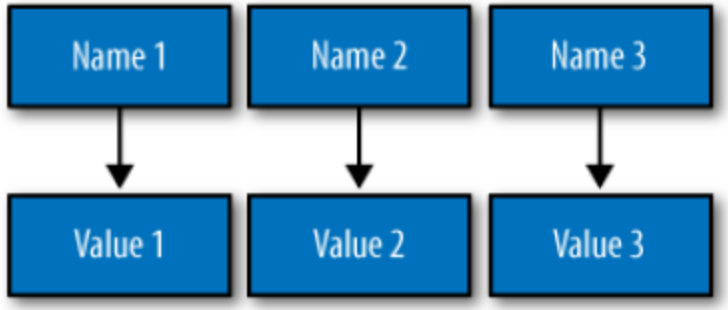


*Figure - A map of name/value pairs*

Example: Column names maybe firstName, lastName, phone, email, and so on

# Data Model

- Columns are grouped into Column Families(CF):
  - CFs have to be defined in advance → structured storage system
  - The number of CFs is not limited per table
- Types of Column Families:
  - Simple
  - Super (nested Column Families)
- Column
  - Has (Name, Value, Timestamp) and Can be ordered by timestamps or name
- Row
  - Can have  a different number of columns

# Column Family

Cassandra defines a *column family* to be a logical division that associates similar data. For example, we might have a User column family, a Hotel column family, an AddressBook column family, and so on

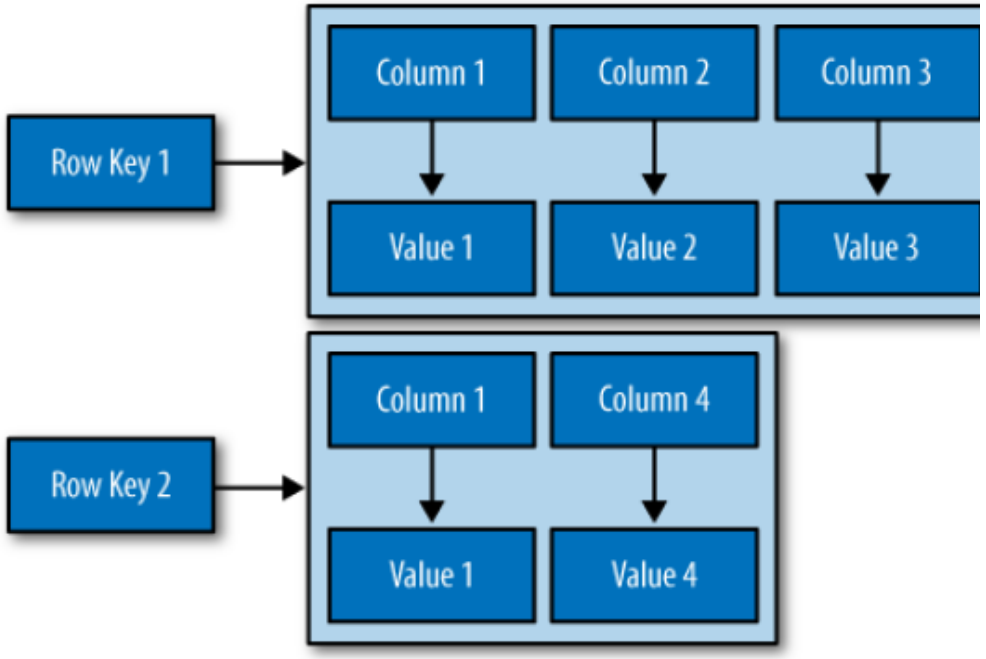


*Figure - A column family*

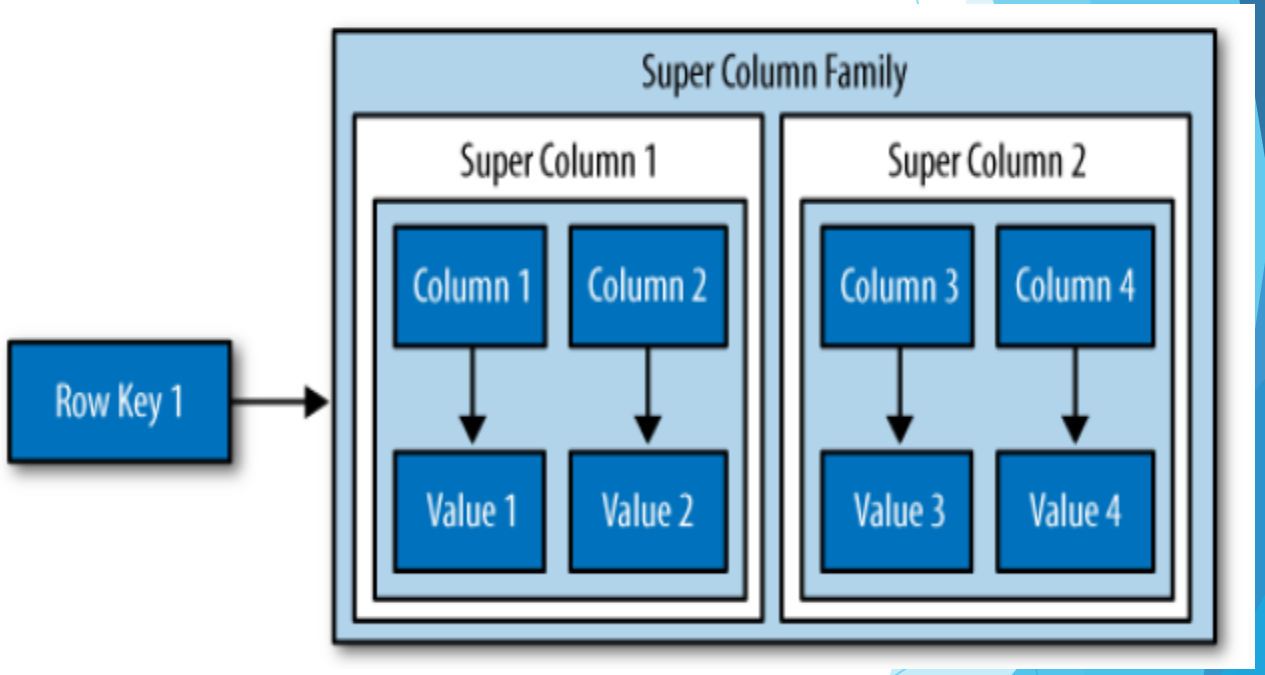


*Figure - A super column family*

# Cluster

- Cassandra database is distributed over several machines that operate together.
- Outermost container is known as the Cluster.
- Cassandra arranges the nodes in a cluster, in a ring format, and assigns data to them.

# Keyspace

- A cluster is a container for keyspaces
- A *keyspace* is the outermost container for data in Cassandra
- A keyspace has a name and a set of attributes that define keyspace-wide behaviour.
- For example, if your application is called Twitter, you would probably have a cluster called Twitter-Cluster and a keyspace called Twitter.

# CRUD (CREATE, READ, UPDATE, AND DELETE) OPERATIONS

Objective: To create a keyspace by the name “Students”

Act:

```
CREATE KEYSPACE Students WITH REPLICATION = {
        'class':'SimpleStrategy', 'replication_factor':1
 };
```

**Outcome:**

```
C:\windows\system32\cmd.exe - Python cqlsh
cqlsh> CREATE KEYSPACE Students WITH REPLICATION = {
   ...                 'class':'$impleStrategy',
   ...                 'replication_factor':1
   ...   };
cqlsh>
```

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**Objective:** To describe all the existing keyspaces.

**Act:**

**DESCRIBE KEYSPACES;**

**Outcome:**

```
C:\windows\system32\cmd.exe - python cqlsh

d:\apache-cassandra-2.0.0\apache-cassandra-2.0.0\apache-cassandra-2.0.0\bin>python cq
Connected to Test Cluster at localhost:9160.
[cqlsh 4.0.0 | Cassandra 2.0.0 | CQL spec 3.1.0 | Thrift protocol 19.37.0]
Use HELP for help.
cqlsh> describe keyspaces;

system  students  system_traces

cqlsh>
```

**Objective:** To get more details on the existing keyspaces such as keyspace name, durable writes, strategy class, strategy options, etc.

**Act:**

```
SELECT *
        FROM system.schema_keyspaces;
```

**Outcome:**

```
cqlsh> SELECT * FROM system.schema_keyspaces;

 keyspace_name | durable_writes | strategy_class                                    | strategy_options
---------------+----------------+---------------------------------------------------+----------------------------
       demo_con |           True | org.apache.cassandra.locator.SimpleStrategy       | {"replication_factor":"3"}
         system |           True |  org.apache.cassandra.locator.LocalStrategy       |                         {}
 system_traces |           True | org.apache.cassandra.locator.SimpleStrategy       | {"replication_factor":"1"}
       students |           True | org.apache.cassandra.locator.SimpleStrategy       | {"replication_factor":"1"}

(4 rows)
```

***Note:*** Cassandra converted the Students keyspace to lowercase as quotation marks were not used.

**Objective:** To use the keyspace "Students", use the following command:

Use keyspace_name

Use connects the client session to the specified keyspace.

**Act:**

**USE Students;**

**Outcome:**

```
C:\windows\system32\cmd.exe - python cqlsh
cqlsh> use Students;
cqlsh:students>
```

# CRUD – Create Table

To create a column family or table by the name “student_info”.

```
CREATE TABLE Student_Info (
  RollNo int PRIMARY KEY,
  StudName text, DateofJoining
  timestamp, LastExamPercent
  double
  );
```

**Outcome:**

```
cqlsh> use Students;
cqlsh:students> CREATE TABLE Student_Info (
            ...   RollNo int PRIMARY Key,
            ...   StudName text,
            ...   DateofJoining timestamp,
            ...   LastExamPercent double
            ...   );
```

The table “student_info” gets created in the keyspace “students”.

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**Objective:** To lookup the names of all tables in the current keyspace, or in all the keyspaces if there is no current keyspace.

**Act:**

**DESCRIBE TABLES;**

**Outcome:**

```
cqlsh:students> describe tables;

student_info

cqlsh:students>
```

**Objective:** To describe the table "student_info" use the below command.

**Act:**

**DESCRIBE TABLE student_info;**

**Outcome:**

C:\windows\system32\cmd.exe - python cqlsh

```
cqlsh:students> describe table student_info;

CREATE TABLE student_info (
  rollno int,
  dateofjoining timestamp,
  lastexampercent double,
  studname text,
  PRIMARY KEY (rollno)
) WITH
  bloom_filter_fp_chance=0.010000 AND
  caching='KEYS_ONLY' AND
  comment='' AND
  dclocal_read_repair_chance=0.000000 AND
  gc_grace_seconds=864000 AND
  index_interval=128 AND
  read_repair_chance=0.100000 AND
  replicate_on_write='true' AND
  populate_io_cache_on_flush='false' AND
  default_time_to_live=0 AND
  speculative_retry='NONE' AND
  memtable_flush_period_in_ms=0 AND
  compaction={'class': 'SizeTieredCompactionStrategy'} AND
  compression={'sstable_compression': 'LZ4Compressor'};
```

# CRUD - Insert

```
BEGIN BATCH
INSERT INTO student_info (RollNo,StudName,DateofJoining,LastExamPercent)
VALUES (1,'Michael Storm','2012-03-29', 69.6)
INSERT INTO student_info (RollNo,StudName,DateofJoining,LastExamPercent)
VALUES (2,'Stephen Fox','2013-02-27', 72.5)
INSERT INTO student_info (RollNo,StudName,DateofJoining,LastExamPercent)
VALUES (3,'David Flemming','2014-04-12', 81.7)
INSERT INTO student_info (RollNo,StudName,DateofJoining,LastExamPercent)
VALUES (4,'Ian String','2012-05-11', 73.4)
APPLY BATCH;
```

## Outcome:

```
cqlsh:students> BEGIN BATCH
           ...   INSERT INTO student_info (RollNo,StudName,DateofJoining,LastExamPercent)
           ... VALUES (1,'Michael Storm','2012-03-29',69.6)
           ...     INSERT INTO student_info (RollNo,StudName,DateofJoining,LastExamPercent)
           ... VALUES (2,'Stephen Fox','2013-02-27',72.5)
           ...   INSERT INTO student_info (RollNo,StudName,DateofJoining,LastExamPercent)
           ...  VALUES (3,'David Flemming ','2014-04-12',81.7)
           ...   INSERT INTO student_info (RollNo,StudName,DateofJoining,LastExamPercent)
           ...  VALUES (4,'Ian String','2012-05-11',73.4)
           ... APPLY BATCH;
cqlsh:students>
```

# CRUD - Select

To view the data from the table “student_info”.

```
SELECT *
        FROM student_info;
```

The above select statement retrieves data from the “student_info” table.

**Outcome:**

```
cqlsh:students> select * from student_info;

 rollno | dateofjoining                          | lastexampercent | studname
--------+----------------------------------------+-----------------+-----------------
      1 | 2012-03-29 00:00:00India Standard Time |            69.6 |   Michael Storm
      2 | 2013-02-27 00:00:00India Standard Time |            72.5 |     Stephen Fox
      4 | 2012-05-11 00:00:00India Standard Time |            73.4 |      Ian String
      3 | 2014-04-12 00:00:00India Standard Time |            81.7 | David Flemming

(4 rows)

cqlsh:students>
```

**Objective:** To view only those records where the RollNo column either has a value 1 or 2 or 3.

**Act:**

```
SELECT *
        FROM student_info
                WHERE RollNo IN(1,2,3);
```

## Outcome:

```
cqlsh:students> Select * from student_info where RollNo IN(1,2,3);

 rollno | dateofjoining                          | lastexampercent | studname
--------+----------------------------------------+-----------------+-----------------
      1 | 2012-03-29 00:00:00India Standard Time |            69.6 |   Michael Storm
      2 | 2013-02-27 00:00:00India Standard Time |            72.5 |     Stephen Fox
      3 | 2014-04-12 00:00:00India Standard Time |            81.7 | David Flemming

(3 rows)

cqlsh:students>
```


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# CRUD – Create Index

To create an index on the “studname” column of the “student_info” column family use the following statement

**CREATE INDEX ON student_info(studname);**

To execute the query using the index defined on “studname” column use

```
SELECT *
        FROM student_info
                WHERE studname='Stephen Fox' ;
```

**Outcome:**

```
cqlsh:students> create index on student_info(studname);
cqlsh:students> select * from student_info where studname='Stephen Fox' ;

 rollno | dateofjoining                          | lastexampercent | studname
--------+----------------------------------------+-----------------+----------
      2 | 2013-02-27 00:00:00India Standard Time |            72.5 | Stephen Fox

(1 rows)

cqlsh:students>
```

**Objective:** Let us create another index on the "LastExamPercent" column of the "student_info" column family.

## Act:

```
CREATE INDEX ON student_info(LastExamPercent);
```

## Outcome:

```
cqlsh:students> create index on student_info(Last
cqlsh:students> select * from student_info where LastExamPercent = 81.7;

 rollno | dateofjoining                          | lastexampercent | studname
--------+----------------------------------------+-----------------+-----------------
      3 | 2014-04-12 00:00:00India Standard Time |            81.7 | David Flemming

(1 rows)
```

**Objective:** To specify the number of rows returned in the output using limit.

**Act:**

```
SELECT rollno, hobbies, language, lastexampercent
        FROM student_info LIMIT 2;
```

**Outcome:**

```
cqlsh:students> select rollno, hobbies, language, lastexampercent from student_info limit 2;

 rollno | hobbies                                | language           | lastexampercent
--------+----------------------------------------+--------------------+-----------------
      1 |                 {'Chess, Table Tennis'} | ['Hindi, English'] |            69.6
      4 | {'Lawn Tennis, Table Tennis, Golf'} | ['Hindi, English'] |            73.4

(2 rows)
```

**Objective:** To use column alias for the column "language" in the "student_info" table. We would like the column heading to be "knows language".

## Act:

```
SELECT rollno, language AS "knows language"
        FROM student_info;
```

## Outcome:

```
cqlsh:students> select rollno, language as "knows language" from student_info;

 rollno | knows language
--------+----------------------------
      1 |          ['Hindi, English']
      4 |          ['Hindi, English']
      3 | ['Hindi,English,French']

(3 rows)
```

# CRUD – Update

Objective: To update the value held in the “StudName” column of the “student_info” column family to “David Sheen” for the record where the RollNo column has value = 2.

***Note:*** An update updates one or more column values for a given row to the Cassandra table. It does not return anything.

**UPDATE student_info  SET StudName = 'David Sheen'  WHERE RollNo = 2;**

**Outcome:**

```
cqlsh:students> UPDATE student_info  SET StudName = 'David Sheen'  WHERE RollNo = 2;
cqlsh:students> select * from student_info where rollno = 2;

 rollno | dateofjoining                          | lastexampercent | studname
--------+----------------------------------------+-----------------+-----------
      2 | 2013-02-27 00:00:00India Standard Time |            72.5 | David Sheen

(1 rows)

cqlsh:students>
```

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**Objective:** Let us try updating the value of a primary key column.

**Act:**

**UPDATE student_info SET rollno=6 WHERE rollno=3;**

**Outcome:**

```
cqlsh:students> update student_info set rollno=6 where rollno=3;
Bad Request: PRIMARY KEY part rollno found in SET part
cqlsh:students>
```

***Note:*** It does not allow update to a primary key column.

**Objective:** Updating more than one column of a row of Cassandra table.

**Step 1**: Before the update

```
cqlsh:students> select rollno, studname, lastexampercent from student_info where rollno=3;

 rollno | studname        | lastexampercent
--------+-----------------+-----------------
      3 | David Flemming  |            81.7
```

**Step 2:** Applying the update

```
cqlsh:students> select rollno, studname, lastexampercent from student_info where rollno=3;

 rollno | studname | lastexampercent
--------+----------+-----------------
      3 |  Samaira |              85
```

**Step 3:** After the update

```
cqlsh:students> DELETE LastExamPercent FROM student_info where RollNo=2;
cqlsh:students> select * from student_info where rollno = 2;

 rollno | dateofjoining                          | lastexampercent | studname
--------+----------------------------------------+-----------------+-----------
      2 | 2013-02-27 00:00:00India Standard Time |            null | David Sheen

(1 rows)

cqlsh:students>
```

# CRUD – Delete

To delete the column “LastExamPercent” from the “student_info” table for the record where the RollNo = 2.

***Note:*** Delete statement removes one or more columns from one or more rows of a Cassandra table or removes entire rows if no columns are specified.

**DELETE LastExamPercent FROM student_info WHERE RollNo=2;**

**Outcome:**

```
cqlsh:students> DELETE LastExamPercent FROM student_info where RollNo=2;
cqlsh:students> select * from student_info where rollno = 2;

 rollno | dateofjoining                          | lastexampercent | studname
--------+----------------------------------------+-----------------+-------------
      2 | 2013-02-27 00:00:00India Standard Time |            null | David Sheen

(1 rows)

cqlsh:students>
```

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**Objective:** To delete a row (where RollNo = 2) from the table "student_info".

**Act:**

**DELETE FROM student_info WHERE RollNo=2;**

**Outcome:**

```
cqlsh:students> DELETE  FROM student_info where RollNo=2;
cqlsh:students> select * from student_info where rollno=2;

(0 rows)

cqlsh:students>
```

# Assignment

- Create a table “Project_details” with primary key as (project_id, project_name)
- Perform CRUD operations.