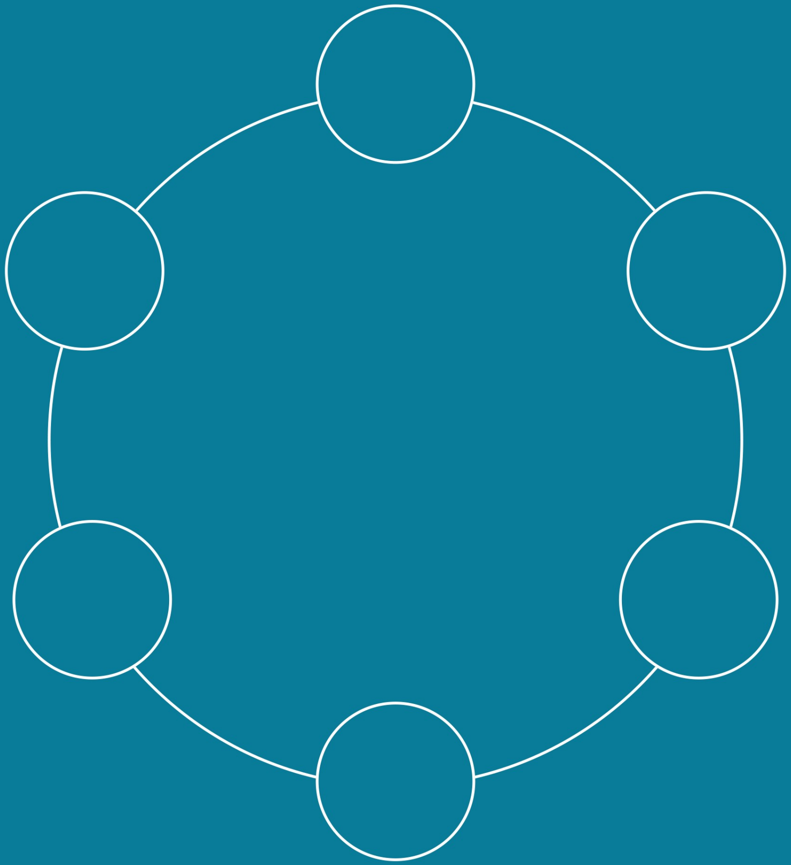
Volume 2

DBA's Guide to NoSQL
DataStax Enterprise



By: The Enlightened DBA

DBA'S GUIDE TO NOSQL

DataStax Enterprise

THE ENLIGHTENED DBA

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INTRODUCTION

As a database administrator (DBA), your job is to help develop, manage and guard your company's single most important asset - its information.

The meteoric rise of modern cloud applications – applications that create and leverage real-time value and run at epic scale - has brought about a change in data management with an unprecedented transformation to the decades-old way that databases have been designed and operated. Requirements from cloud applications have pushed beyond the boundaries of the relational database management system (RDBMS) and have introduced a new type of database into the DBA's domain - NoSQL.

As a DBA, you may naturally be skeptical of new database systems, having seen database engines such as object-oriented and OLAP databases come and go. Why should NoSQL be any different? Further, perhaps you've heard (and maybe even repeated) assertions about NoSQL databases like,

NoSQL is not secure...
NoSQL is not reliable...
NoSQL is not scalable...
NoSQL is not really being used by anyone in meaningful ways...

Perhaps you've also asked yourself the following questions about NoSQL:

Are NoSQL databases real and ready for serious applications?

What kinds of administration and management work does NoSQL entail?

How are security, backup and recovery, database monitoring and tuning handled?

How do I create databases, objects, and read/write data without SQL?

This guide was created to help answer all these questions and more. In the following pages, you'll learn exactly what NoSQL is, why it's needed, how it works, what it should be used for, and (just as importantly) when it shouldn't be used.

You'll also learn how all the key areas of database administration work - database design, creation, security, object management, backup/recovery, monitoring and tuning, data migrations, and more - are carried out in a NoSQL database like Apache Cassandra™.

When you're finished, you'll find that the negative rumors you've heard about NoSQL aren't actually true, and how being a DBA for NoSQL platforms like Cassandra isn’t hard. You'll also understand why having NoSQL database skills makes you even more valuable as a DBA today.

In fact, you may be interested to know that DBA salaries for administrators who possess NoSQL and other big data skills are significantly higher than the average RDBMS DBA's salary, with Cassandra currently leading the way for the NoSQL jobs according to a 2016 survey by Dice.

Now, let's get started.

WHY NOSQL?

The RDBMS has been the de-facto standard for managing data since it first appeared from IBM in the mid-1980s. The RDBMS really exploded in the 1990s with Oracle, Sybase, Microsoft SQL Server, and other similar databases appearing in the data centers of nearly every enterprise - databases you likely use today.

With the first wave of Web applications, open source relational database management systems (RDBMS) such as MySQL and Postgres emerged and became a standard at many companies that desired alternatives to expensive proprietary databases sold by vendors such as Oracle.

However, it wasn't long before things began to change, and the application and data center requirements of key Internet players like Amazon, Facebook, and Google began to outgrow the RDBMS for certain types of applications. The need for more flexible data models that supported agile development methodologies and the requirements to consume large amounts of fast-incoming data from millions of cloud applications users around the globe - while maintaining extreme amounts of performance and uptime - necessitated the introduction of a new data management platform.

Enter NoSQL.

Today, with every company utilizing modern cloud applications, the data problems originally encountered by the Internet giants have become common issues for every company, including yours. This means that you and your team of database administrators must realize that it is no longer a question of if you will be deploying and managing NoSQL database systems, but when, and how much of your company's data will eventually be stored on NoSQL platforms.

NOSQL 101

This chapter introduces the basics of NoSQL and then dives into a DBA's perspective on the most scalable and performant NoSQL database in the market today, Apache Cassandra.

Types of NoSQL Databases

There are different types of NoSQL databases, with the primary difference characterized by their underlying data model and method for storing data. The main categories of NoSQL databases are:

- **Tabular** - Also known as wide-column or wide-row stores, these databases store data in rows and users are able to perform some query operations via column-based access. A wide-row store offers very high performance and a highly scalable architecture. Examples include: Cassandra, HBase, and Google BigTable.
- **Key/Value** - These NoSQL databases are some of the least complex as all of the data within consists of an indexed key and a value. Examples include Amazon DynamoDB, Riak, and Oracle NoSQL database. Some tabular NoSQL databases, like Cassandra, can also service key/value needs.
- **Document** - Expands on the basic idea of key-value stores where "documents" are more complex, in that they contain data and each document is assigned a unique key, which is used to retrieve the document. These are designed for storing, retrieving, and managing document-oriented information, oftentimes stored as JSON. Examples include MongoDB and CouchDB. Note that some RDBMS and NoSQL databases outside of pure document stores are able to store and query JSON documents.
- **Graph** - Designed for highly complex and connected data, which outpaces the relationship and JOIN capabilities of an RDBMS. Graph databases are often exceptionally good at finding commonalities and anomalies among large datasets. Examples include: DataStax Enterprise Graph and Neo4J.

One trend that is starting to emerge in both the NoSQL and RDBMS markets is the “multi-model” database. Most database management systems are organized around a single data model that determines how data can be organized, stored, and manipulated. By contrast, a multi-model database is designed to support multiple data models against a single, integrated backend.

The value supplied by multi-model databases is that an enterprise doesn’t have to utilize multiple data management providers for applications that need to store parts of the system’s data in different data models, and thus the requirement to shard the application across different database platforms is removed.

What are the Advantages of NoSQL Over an RDBMS?

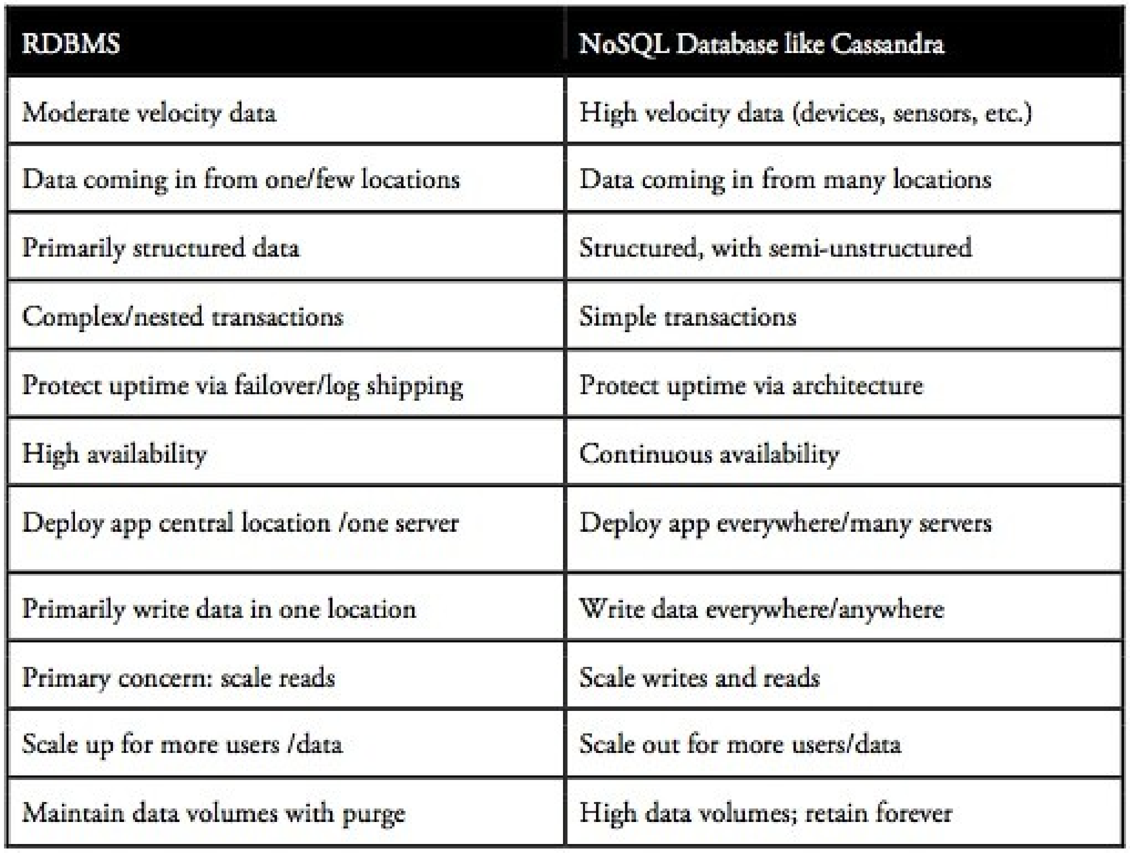
While there are hundreds of different "Not Only SQL" (NoSQL) databases offered today, each with its own particular features and benefits, what you should know from a DBA perspective is that a NoSQL database generally differs from a traditional RDBMS in the following ways:

- **Data model** - while an RDBMS primarily handles structured data in a rigid data model, a NoSQL database typically provides a more flexible and fluid data model and can be more adept at serving the agile development methodologies used for modern cloud applications. Note that one misconception about NoSQL data models is that they do not handle structured data, which is untrue. Lastly, as noted above, some NoSQL engines are supporting multiple data models against a single backend.
- **Architecture** - whereas an RDBMS is normally architected in a centralized, scale-up, master-slave fashion, NoSQL systems such as Cassandra operate in a distributed, scale-out, "masterless" manner (i.e. there is no 'master' node). However, some NoSQL databases (e.g. MongoDB, HBase) are master-slave in design.
- **Data distribution model** - because of their master-slave architectures, an RDBMS distributes data to slave machines that can act as read-only copies of the data and/or failover for the primary machine. By contrast, a NoSQL database like Cassandra distributes data evenly to all nodes making up a database cluster and enables both reads and writes on all machines. Furthermore, the replication model of an RDBMS (including master-to-master) is not designed well for wide-scale, multi-geographical replication and synchronization of data between different locales and cloud availability zones, whereas Cassandra's replication was built from the ground up to handle such things.
- **Availability model** - an RDBMS typically uses a failover design where a master fails over to a slave machine, whereas a NoSQL system like Cassandra is masterless and provides redundancy of both data and function on each node so that it offers continuous availability with no downtime versus simple high availability in the way an RDBMS does.
- **Scaling and Performance model** - an RDBMS typically scales vertically by adding extra CPU, RAM, etc., to a centralized machine, whereas a NoSQL database like Cassandra scales horizontally by adding extra nodes that deliver increased scale and performance in a linear manner.

There's little doubt that relational database management systems (RDBMS) will be around for a long time and are exactly the right kind of database for handling centralized applications that require sophisticated transaction handling. But it's also true that NoSQL databases are likely to better support widely distributed cloud applications and their specific use cases.

Deciding Between an RDBMS and NoSQL

How do you decide when to use an RDBMS and when to use a specific type of NoSQL database? In short, an RDBMS is great for centralized applications that need ACID transactions and whose data fits well within the relational data model. The following chart provides a general comparison between the characteristics that point towards an RDBMS vs. those that signal a NoSQL database may be a better choice:



RDBMS	NoSQL Database like Cassandra
Moderate velocity data	High velocity data (devices, sensors, etc.)
Data coming in from one/few locations	Data coming in from many locations
Primarily structured data	Structured, with semi-unstructured
Complex/nested transactions	Simple transactions
Protect uptime via failover/log shipping	Protect uptime via architecture
High availability	Continuous availability
Deploy app central location /one server	Deploy app everywhere/many servers
Primarily write data in one location	Write data everywhere/anywhere
Primary concern: scale reads	Scale writes and reads
Scale up for more users /data	Scale out for more users/data
Maintain data volumes with purge	High data volumes; retain forever

Figure 1 – RDBMS and NoSQL Comparison

Looking at the data model requirements is another tactic to use when evaluating an RDBMS vs. NoSQL. Certain NoSQL databases require the denormalization of data and aren’t concerned with the relationships between data entities whereas others are built to handle complex and very intense data relationship scenarios:

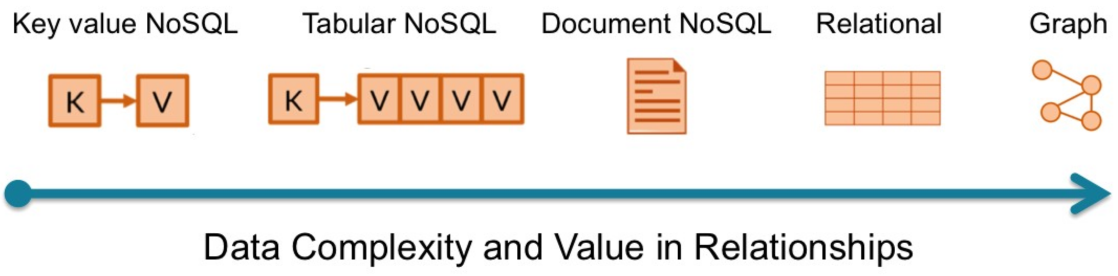
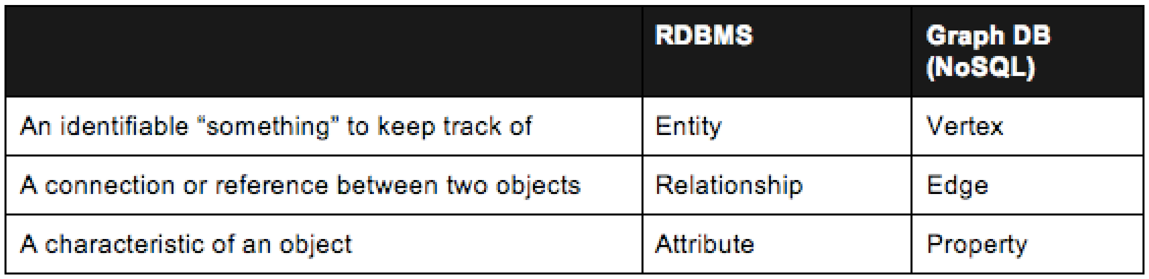


Figure 2 – The data model continuum by data complexity and connectedness

RDBMS and Graph (NoSQL) databases are at the high end of the data model continuum where the relationships between data are concerned and are somewhat similar in their base characteristics:

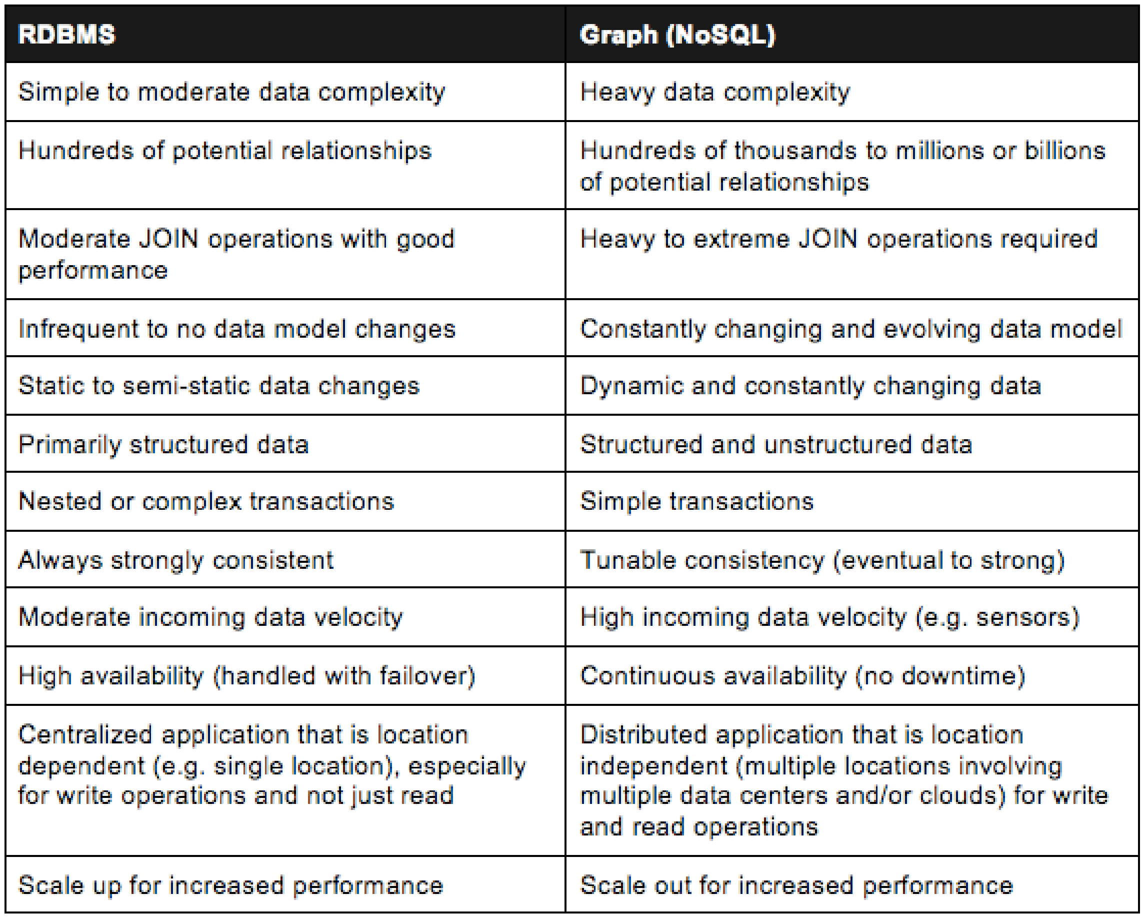


	RDBMS	Graph DB (NoSQL)
An identifiable “something” to keep track of	Entity	Vertex
A connection or reference between two objects	Relationship	Edge
A characteristic of an object	Attribute	Property

One of the key differences between a graph database (NoSQL) and an RDBMS is how relationships between entities/vertexes are prioritized and managed. While an RDBMS uses mechanisms like foreign keys to connect entities in a secondary fashion, edges in a graph database are of first order importance. As such, a graph database is more scalable and performant than an RDBMS when it comes to complex data that is highly connected (e.g. millions or billions of relationships).

Unlike most other ways of displaying data, graphs are foundationally designed to express relatedness. Graph databases can uncover patterns that are difficult to detect when using traditional representations, such as RDBMS tables.

Suggestions for when to use a graph database vs. an RDBMS is the following:



RDBMS	Graph (NoSQL)
Simple to moderate data complexity	Heavy data complexity
Hundreds of potential relationships	Hundreds of thousands to millions or billions of potential relationships
Moderate JOIN operations with good performance	Heavy to extreme JOIN operations required
Infrequent to no data model changes	Constantly changing and evolving data model
Static to semi-static data changes	Dynamic and constantly changing data
Primarily structured data	Structured and unstructured data
Nested or complex transactions	Simple transactions
Always strongly consistent	Tunable consistency (eventual to strong)
Moderate incoming data velocity	High incoming data velocity (e.g. sensors)
High availability (handled with failover)	Continuous availability (no downtime)
Centralized application that is location dependent (e.g. single location), especially for write operations and not just read	Distributed application that is location independent (multiple locations involving multiple data centers and/or clouds) for write and read operations
Scale up for increased performance	Scale out for increased performance

A NoSQL Example - Apache Cassandra

Now that you have a background on how NoSQL differs from an RDBMS, let's look a little more closely from a DBA's point of view at how a NoSQL database like Cassandra functions and discuss the above characteristics in detail.

Apache Cassandra is a massively scalable open source NoSQL database. It delivers continuous availability, linear scale performance, operational simplicity and easy data distribution across multiple data centers and cloud availability zones. Cassandra was originally developed at Facebook and sports a design combining capabilities from Amazon's Dynamo and Google's Bigtable architectures. It was open sourced in 2008.

What Makes Cassandra Ideal for Modern Cloud Applications

Cassandra provides a number of key features and benefits to facilitate the development and management of cloud applications:

- **Massively scalable architecture** - Cassandra has a masterless design where all nodes are the same, providing operational simplicity and easy scale out capabilities.
- **Active everywhere design** - all Cassandra nodes may be written to and read from

no matter where they are located.

- **Linear scale performance** - online node additions produce predictable increases in performance. For example, if two nodes produce 200K transactions/sec, four nodes will deliver 400K transactions/sec, and eight nodes, 800K transactions/sec.
- **Continuous availability** - Cassandra offers redundancy of both data and function, which supply no single point of failure and constant uptime.
- **Transparent fault detection and recovery** - nodes that fail can easily be restored or replaced.
- **Flexible and dynamic data models** - primarily supports the tabular data model, but also accommodates JSON well.
- **Strong data protection** - a commit log design ensures no data loss for incoming transactions. Also, built-in security with easy backup/restore keeps data protected.
- **Basic transaction support with tunable data consistency** - Cassandra supports the atomicity, isolation and durability of transactions (including batch) with strong or eventual data consistency supplied across a widely distributed cluster.
- **Multi-data center replication** - Cassandra provides strong cross data center (in multiple geographies) and multi-cloud availability zone support for writes/reads.
- **Data compression** - data compressed up to 80% without performance overhead helps save on storage costs.
- **CQL (Cassandra Query Language)** - a SQL-like language that makes moving from an RDBMS easy.

Top Use Cases

While Cassandra is a general purpose NoSQL database used for a variety of different applications in all industries, there are a number of use cases where the database excels over most any other option. These include:

- **Cloud Applications** – Applications that require the wide distribution of data, no downtime, predictable performance no matter the location of the user, and easy scale make good targets for Cassandra.
- **Internet of Things (IOT)** - Cassandra is good for consuming and analyzing lots of fast-incoming data from devices, sensors and similar mechanisms that exist in many different locations.
- **Product catalogs and retail apps** - For retailers that need durable shopping cart protection, fast product catalog input and lookups, and similar retail application support, Cassandra is a good choice.
- **User activity tracking and monitoring** - Media, gaming and entertainment companies use Cassandra to track and monitor the activity of users' interactions with their movies, music, games, website and online applications.
- **Messaging** - Cassandra serves as the database backbone for numerous mobile

phone, telecommunication, cable/wireless, and messaging providers' applications.

- **Social media analytics and recommendation engines** - Online companies, websites, and social media providers use Cassandra to ingest, analyze, and provide analysis and recommendations to their customers.
- **Other time series based applications** - because of Cassandra's fast write capabilities and wide-row design, it is well suited for most any time series based application.

Architecture Overview

The architecture of Cassandra allows the database to scale and perform with no downtime. Rather than using a legacy RDBMS master-slave or a manual and difficult-to-maintain sharded design, Cassandra has a masterless "ring" distributed architecture that is elegant, and easy to set up and maintain.

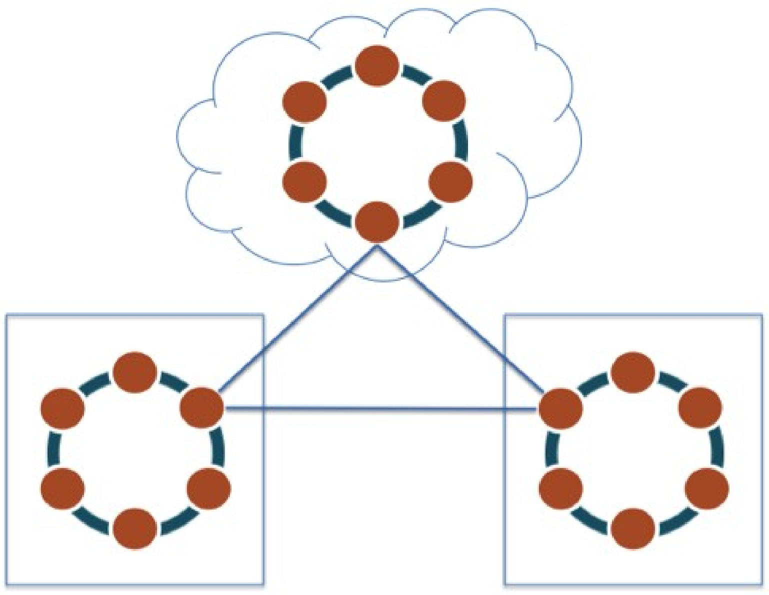


Figure 3 - Cassandra sports a masterless "ring" architecture.

In Cassandra, all nodes are the same; there is no concept of a master node, with all nodes communicating with each other via a gossip protocol.

Cassandra's built-for-scale architecture allows it to handle large amounts of data and thousands of concurrent users/operations per second, across multiple data centers, as easily as it can manage much smaller amounts of data and user traffic. To add more capacity, you simply add new nodes in an online fashion to an existing cluster.

Cassandra's architecture also means that, unlike other master-slave or sharded systems, it has no single point of failure and therefore offers true continuous availability and uptime.

Writing and Reading Data

One of Cassandra's hallmarks is its fast I/O operation capability for both writing and reading data.

Data is written to Cassandra in a way that provides both full data durability and high performance. From a high level perspective, data written to a Cassandra node is first recorded in a commit log and then written to a memory-based structure called a *memtable.* When a *memtable's* size exceeds a configurable threshold, the data is flushed to disk and written to an *SStable* (sorted strings table), which is immutable.

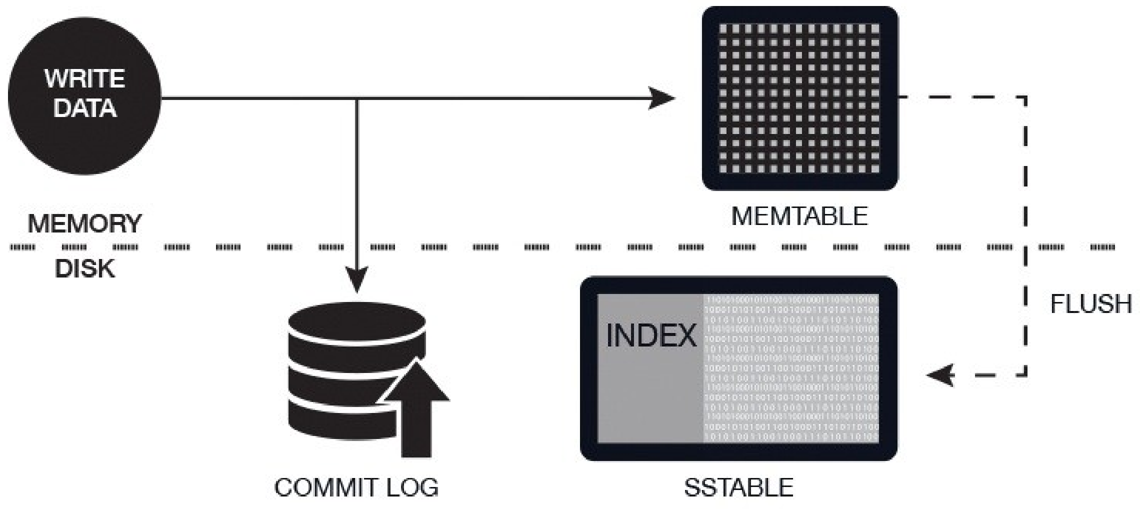


Figure 4 - The Cassandra write path.

Because of the way Cassandra writes data, many SStables can exist for a single Cassandra table/column family. A process called *compaction* for a node occurs on a periodic basis that coalesces multiple SStables into one for faster read access.

Reading data from Cassandra involves a number of processes that can include various memory caches and other mechanisms designed to produce fast read response times.

For a read request, Cassandra consults a *bloom filter* that checks the probability of a table having the needed data. If the probability is good, Cassandra checks a memory cache that contains row keys and either finds the needed key in the cache and fetches the compressed data on disk, or locates the needed key and data on disk and then returns the required result set.

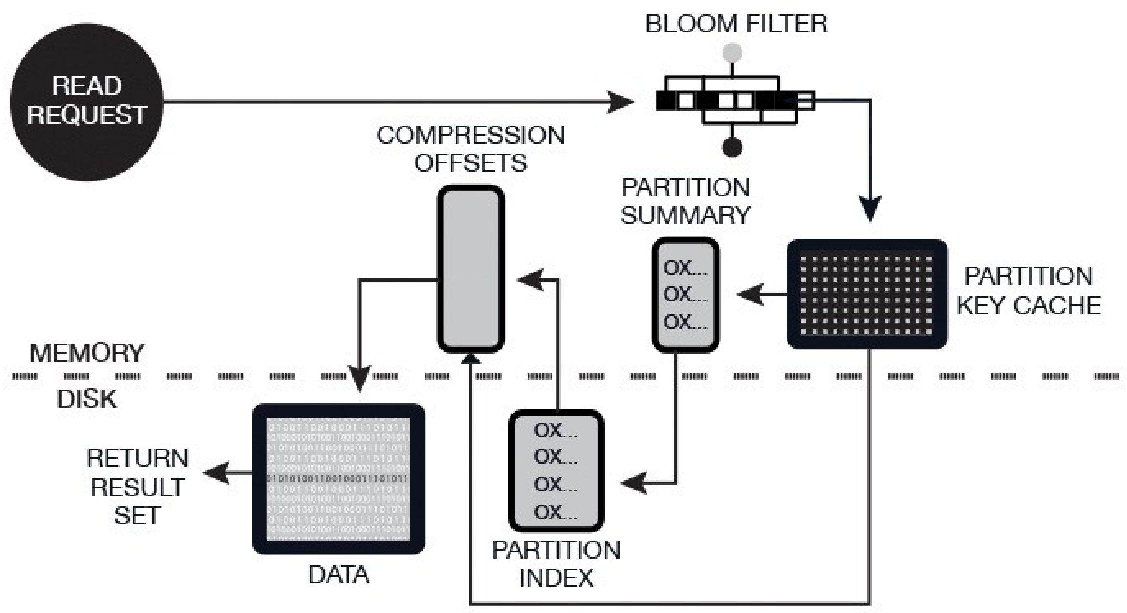


Figure 5 - The Cassandra read path.

Data Distribution and Replication

While the prior section provides a general overview of read and write operations in Cassandra, the actual I/O activity that occurs is somewhat more sophisticated, due to the database's masterless architecture. Two concepts that impact read and write activity are the chosen data distribution and replication models.

Automatic Data Distribution

While an RDBMS and some NoSQL databases necessitate manual and developer-driven methods for distributing data across multiple machines that make up a database (i.e. *sharding*), Cassandra automatically distributes and maintains data across a cluster so you as a DBA don't have to.

Cassandra uses a *partitioner* to determine how data is distributed across the nodes that make up a database cluster. A partitioner is a hashing mechanism that takes a table row's primary key, computes a numerical token for it, and then assigns it to one of the nodes in a cluster.

While Cassandra has multiple partitioners that can be chosen, the default partitioner is one that randomizes data across a cluster and ensures an even distribution of all data. Cassandra also automatically maintains the balance of data across a cluster even when existing nodes are removed or new nodes are added to a system.

Replication Basics

Unlike many other database management systems, replication in Cassandra is very straightforward and simple to configure and maintain. Most Cassandra users agree that the replication model is one of the features that help the database stand out from other RDBMS or NoSQL options.

A running Cassandra database cluster can have one or more *keyspaces,* which are analogous to a Microsoft SQL Server or MySQL database. It is at the keyspace level that replication is configured, allowing different keyspaces to have different replication models.

Cassandra is able to replicate data to multiple nodes in a cluster, which helps ensure reliability, continuous availability and fast I/O operations. The total number of data copies that are replicated is referred to as the *replication factor.* For example, a replication factor (RF) of 1 means that there is only one copy of each row in a cluster, whereas a replication factor of 3 means three copies of the data are stored across the cluster.

Once a keyspace and its replication have been created, Cassandra automatically maintains that replication even when nodes are removed, added or go down and become unavailable for receiving data requests. This equates to there being no replication babysitting you need to do as a DBA.

Cassandra's replication is both simple to configure and powerful in that it supports a wide range of replication capabilities such as replicating data to different hardware racks (reducing database downtime due to hardware failures) and multiple data centers in different geographic locations as well as the cloud.

Multi-Data Center and Cloud Support

A very popular aspect of Cassandra's replication is its support for multiple data centers and cloud availability zones. Many users deploy Cassandra in a multi-data center and cloud availability zone manner to ensure constant uptime for their applications and to supply fast read/write data access in localized regions.

You can easily set up replication so that data is replicated across many data centers with users being able to read and write to any data center they choose and the data being automatically synchronized across all centers.

You can also choose how many copies of your data exist in each data center (e.g. 2 copies in data center 1; 3 copies in data center 2) Hybrid deployments of part on-premise data centers and part cloud are also supported.

Using Cassandra in Production Environments

As a DBA, you have a responsibility to ensure that the database software you use will work and perform as expected in production environments. To provide that type of guarantee, most NoSQL databases have a commercial software vendor that offers a production-certified version of the database, which often times possess various enterprise features that the open source version does not.

For Cassandra, DataStax provides DataStax Enterprise as the commercial software offering. As a DBA, you should be aware that DataStax Enterprise (DSE) provides the following benefits over the open source version of Cassandra that help you manage, secure, and optimize your database systems:

- A production-certified version of Cassandra that is heavily tested and ready for enterprise environments.

- Multi-model database capabilities with support for the key value, tabular, JSON / Document, and graph data models, all of which inherit the capabilities of Cassandra and additional commercial functionality that follows.
- Advanced security with external security software support, encryption and data auditing.
- Integrated analytics, including integration with external Hadoop and Spark platforms.
- Integrated enterprise search on stored data.
- Workload isolation and data replication that ensures OLTP, analytics, and search workloads do not compete with each other for data or compute resources.
- In-memory database option for both OLTP and analytic workloads.
- Advanced replication that handles data distribution among different clusters in a hub-and-spoke fashion.
- Tiered storage that provides automatic movement of data between different storage media (e.g. SSD's, spinning disks).
- Multi-instance functionality that assists with running multiple instances of the software on single, large servers.
- Automatic management services that transparently automate numerous database maintenance and performance monitoring/management tasks.
- Visual management and monitoring tools that work from any device (laptop, tablet, smart phone).
- Around-the-clock expert support.
- Certified software updates.

NoSQL and Hadoop: A Comparison

You've no doubt heard about Hadoop and perhaps your company is already using it to handle various new data warehousing projects. Perhaps you're wondering how Hadoop differs from NoSQL.

Apache Hadoop^{TM} is an open source software project that enables the distributed processing of large data sets, and uses a scale-out architecture that stores and processes data across many machines. Hadoop is an ecosystem umbrella term that encompasses many different software components.

In general, Hadoop is not a database, but is instead a framework primarily devoted to handling modern data warehousing and analytics "data lake" use cases. Hadoop does offer a NoSQL database as part of its framework (HBase), but it is used mostly for data warehousing situations.

By contrast, a NoSQL database like Cassandra is an operational / transactional database used for cloud applications.

DATA AND OBJECT MANAGEMENT

This section takes a look at the core Cassandra's data model, what data objects are used for managing data, CQL (Cassandra Query Language), and how transactions are handled in the database.

Data Model Overview

Achieving success with Cassandra almost always comes down to getting two things right:

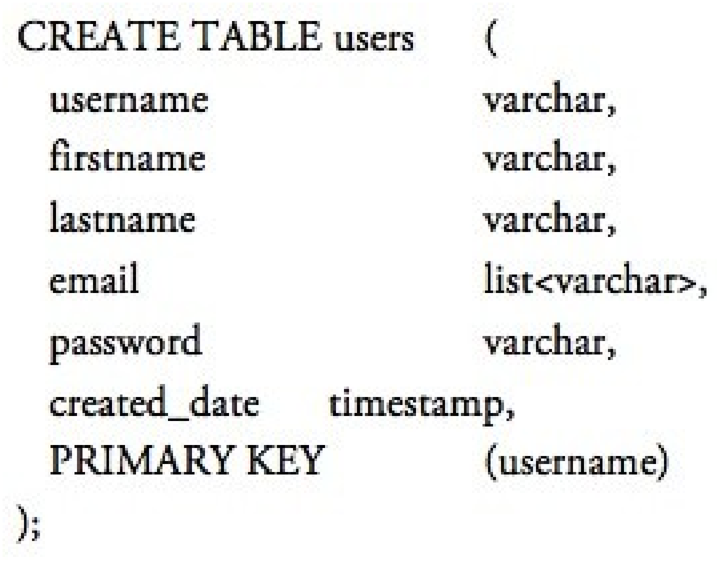
1. *The data model*
2. *The selected hardware, especially the storage subsystem*

Cassandra is a wide row / tabular database that uses a highly denormalized model designed to quickly capture and query data. There are no concepts of foreign keys, referential integrity, or joins in Cassandra (note that using Spark with Cassandra provides join capability through SparkSQL).

Although Cassandra has objects that resemble an RDBMS (e.g. tables, primary keys, indexes), data should not be modeled in a legacy entity-relationship-attribute fashion as is done with a relational database. Modeling data in Cassandra is done by understanding what questions you will need to ask the database up front, whereas in an RDBMS, you are likely not used to addressing such things until after all entities, relationships, and attributes are documented.

Unlike an RDBMS that penalizes the use of many columns in a table, Cassandra is highly performant with tables that have hundreds of columns. As a DBA, you may be used to highly normalized, third normal form models that you translate into a set of physical tables and their accompanying indexes and such. With Cassandra, you will oftentimes instead have wide row tables with some data duplication between tables.

Creating your physical objects, however, still looks very much like what you carry out in an RDBMS. For example, a new table defining users for an application might look like the following:



```
CREATE TABLE users      (
  username              varchar,
  firstname             varchar,
  lastname              varchar,
  email                 list<varchar>,
  password              varchar,
  created_date    timestamp,
  PRIMARY KEY           (username)
);
```

Cassandra Objects

The basic objects you will use in Cassandra include:

- **Keyspace** - a container for data tables and indexes; analogous to a database in many relational database management systems (RDBMS). It is also the level at which replication is defined.
- **Table** - somewhat like an RDBMS table only much more flexible and capable of handling all modern data types.
- **Primary key** - used to uniquely identify a row in a table and also distribute a table's rows across multiple nodes in a cluster.
- **Index** - similar to an RDBMS index in that it speeds read operations.
- **User** - a login account used to access data objects.

Cassandra Query Language

Earlier versions of Cassandra solely used an interface called Thrift to create database objects and manipulate data. Today, the Cassandra Query Language (CQL) has become the primary interface used for interacting with a Cassandra database cluster.

CQL very closely resembles SQL (Structured Query Language) used by all relational database management systems (RDBMS). Because of this similarity, your learning curve will be greatly reduced.

DDL (e.g. CREATE, ALTER, DROP), DML (INSERT, UPDATE, DELETE, TRUNCATE), and query (SELECT) operations are all supported in the manner to which you are accustomed.

CQL datatypes also reflect RDBMS syntax with numerical (int, bigint, decimal, etc.), character (ascii, varchar, etc.), date (timestamp, etc.), unstructured (blob, etc.), and specialized datatypes (JSON, etc.) being supported.

Learn more about CQL on the documentation page at www.DataStax.com.

Transaction Management

While Cassandra does not offer complex/nested transactions in the same way that your legacy RDBMS offer ACID transactions, it does offer the "AID" portion of ACID, in that data written is atomic, isolated, and durable. The "C" of ACID does not apply to Cassandra, as there is no concept of referential integrity or foreign keys.

With respect to data consistency, Cassandra offers *tunable data* consistency across a database cluster. This means you can decide exactly how strong (e.g., all nodes must respond) or eventual (e.g., just one node responds, with others being updated eventually) you want data consistency to be for a particular transaction, including transactions that are batched together. This tunable data consistency is supported across single or multiple data centers, and you have a number of different consistency options from which to choose.

Moreover, consistency can be handled on a *per operation* basis, meaning you can decide how strong or eventually consistent it should be per the SELECT, INSERT, UPDATE, and DELETE operation. For example, if you need a particular transaction available on all nodes throughout the world, you can specify that all nodes must respond before a transaction is marked complete. On the other hand, a less critical piece of data (e.g., a social media update) may only need to be propagated eventually, so in that case, the consistency requirement can be greatly relaxed.

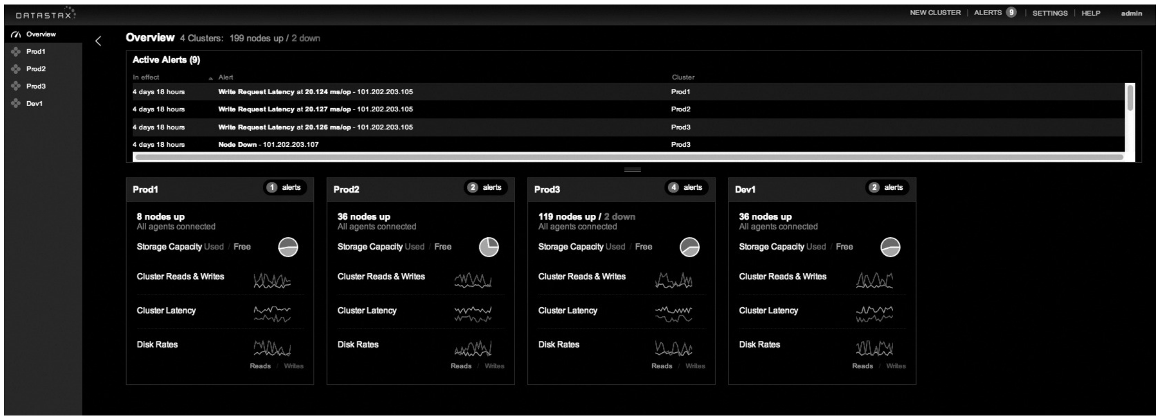
Cassandra also supplies "lightweight transactions" (or compare and set). Using and extending the Paxos consensus protocol (which allows a distributed system to agree on proposed data modifications without the need for any one 'master' database or two-phase commit), Cassandra offers a way to ensure a transaction isolation level similar to the serializable level offered by an RDBMS for situations that need it.

DBA Query and Management Tools

As a DBA coming from the RDBMS world, you likely use many command line and visual tools for interacting with the databases you manage. The same kind of tools are available to you with Cassandra.

Various command line utilities are provided for handling administration functions (e.g. the *nodetool* utility), loading data, and using CQL to create and query database objects (the CQL shell, which is much like Oracle's SQL*Plus or the MySQL shell).

In addition, graphical tools are provided for running CQL commands against database clusters (e.g. DataStax DevCenter, DataStax Studio) and visually creating/managing/monitoring your clusters (DataStax OpsCenter).



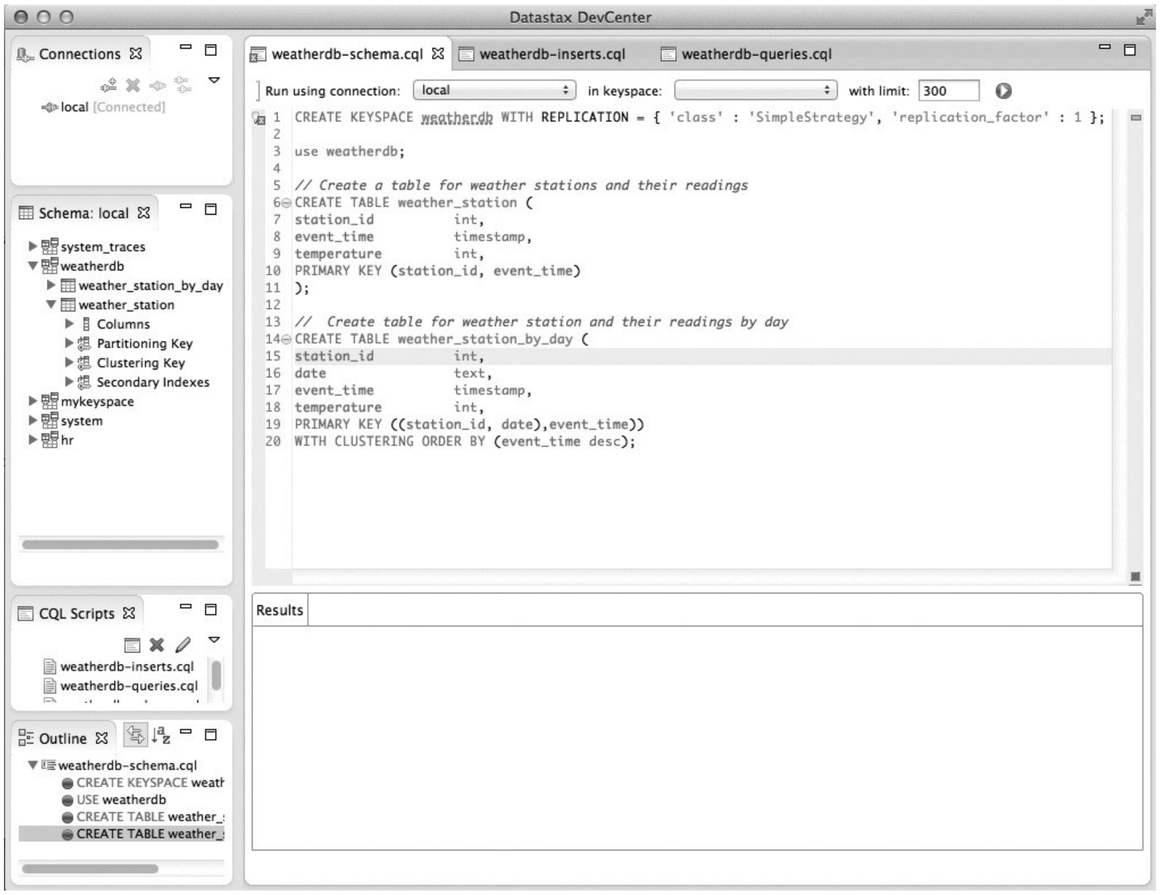
Overview 4 Clusters: 199 nodes up / 2 down

Active Alerts (9)

In effect	Alert	Cluster
4 days 18 hours	Write Request Latency at 20.124 ms/op - 101.202.203.105	Prod1
4 days 18 hours	Write Request Latency at 20.127 ms/op - 101.202.203.105	Prod2
4 days 18 hours	Write Request Latency at 20.126 ms/op - 101.202.203.105	Prod3
4 days 18 hours	Node Down - 101.202.203.107	Prod3

Prod1 (1 alerts)	Prod2 (2 alerts)	Prod3 (4 alerts)	Dev1 (2 alerts)
8 nodes up	36 nodes up	119 nodes up / 2 down	36 nodes up
All agents connected	All agents connected	All agents connected	All agents connected

Figure 6 - DataStax OpsCenter, used for visual database administration.



Run using connection: local in keyspace: with limit: 300

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

use weatherdb;

// Create a table for weather stations and their readings
CREATE TABLE weather_station (
station_id          int,
event_time          timestamp,
temperature         int,
PRIMARY KEY (station_id, event_time)
);

//  Create table for weather station and their readings by day
CREATE TABLE weather_station_by_day (
station_id          int,
date                text,
event_time          timestamp,
temperature         int,
PRIMARY KEY ((station_id, date),event_time))
WITH CLUSTERING ORDER BY (event_time desc);
```

Figure 7 - DataStax DevCenter, used for visually querying databases.

SECURITY MANAGEMENT

As a DBA, data security is one of your top priorities. One of the myths of NoSQL databases like Cassandra is that they don't offer the security needed in enterprise production environments. In this section, we'll review Cassandra's security capabilities.

Authentication

Cassandra supports internal-based authentication that allows you to easily create users who can be authenticated to Cassandra database clusters. You'll find the authentication framework extremely familiar - it uses the RDBMS-style CREATE/ALTER/DROP USER commands to create/manage with passwords that will then be internally handled by Cassandra. A default superuser, 'cassandra', is supplied by default to initially enable the security authentication definition process.

You can also use external, 3rd party security packages like Kerberos, LDAP, and Active Directory to manage security in DataStax Enterprise.

Permission Management

Object permission/authorization capabilities for Cassandra utilize the very familiar GRANT/REVOKE security paradigm - something you should have no problem using as a DBA. Control over DDL, DML, and SELECT operations are all handled via the granting and revoking of user privileges.

Note that a GRANT may be done with or without the GRANT OPTION, which allows the user receiving the grant to provide the same privileges on that object to other users just as how it occurs in the RDBMS world.

Encryption

There are multiple levels of encryption offered in both Cassandra and DataStax Enterprise that you can use to protect data. First, Cassandra includes an optional encrypted form of communication from a client machine to a database cluster. Client to server SSL ensures data in flight is not compromised and is securely transferred back/forth from client machines.

Next, node-to-node encryption can be used as well to ensure data is protected as it is transferred between nodes in a database cluster.

Lastly, transparent data encryption (TDE) in DataStax Enterprise protects data at rest from being stolen and used in an unauthorized manner. You can encrypt tables with AES 128 being the default, although other encryption algorithms can be used.

Encryption is transparent to all end user activities; data may be read, inserted, updated, etc., with nothing having to change on the application end.

Data Auditing

If needed, you can configure data auditing so you can understand what user activities took place on a particular node or entire cluster. Data auditing allows for a "who looked at what/when, who changed what/when" type of documentation that many large-scale enterprises need to have in order to comply with various internal or external security policies.

The granularity of activities that can be audited include:

- All activity (DDL, DML, queries, errors)
- DML only
- DDL only
- Security changes (e.g. assigning/revoking privileges, dropping users)
- Queries only
- Errors only (e.g. login failures)

You can also omit certain keyspaces from being audited if you choose and only focus on keyspaces in production or those that are of particular interest. Audit data can be written to log files or Cassandra tables and queried via CQL.

MANAGING AVAILABILITY AND MULTIPLE DATA CENTERS

Another key aspect of your job as a DBA is to ensure the databases you manage are always available for the applications that use them. One thing you will like about Cassandra is that ensuring constant uptime is easy. There is no need for specialized, add-on log shipping software such as Oracle Dataguard.

Further, distributing data to multiple geographies and across various cloud providers is simple and straightforward with Cassandra.

How to Ensure Constant Uptime

As previously discussed, Cassandra sports a masterless architecture where all nodes are the same; and it has been built from the ground up with the understanding that outages and hardware failures will occur. To overcome those and similar issues, Cassandra delivers redundancy in both data and function to a database cluster with all nodes being the same.

Where data operations are concerned, any node in a cluster may be the target for both reads and writes. Should a particular node go down, there is no hiccup in the cluster at all, as any other node may be written to, with reads served from other nodes holding copies of the downed node's data.

To ensure constant access to data, you should configure Cassandra's replication to keep multiple copies of data on the nodes that comprise a database cluster. The number of data copies is completely up to you, with three being the most commonly used in production Cassandra environments.

Should a node go down, new or updated information is simply written to another node that keeps a copy of that data. When the downed node is brought back online, it automatically syncs with other nodes holding its data so that it is brought back up to date in a transparent fashion.

Multi-Data Center and Cloud Options

Cassandra is the leading distributed database for multi-data center and cloud support. Many production Cassandra systems consist of a database cluster that spans multiple physical data centers, cloud availability zones, or a combination of both. Should a large outage occur in a particular geographical region, the database cluster continues to operate as normal with the other data centers assuming the operations previously directed at the now downed data center or cloud zone. Once the downed data center comes back online, it syncs with the other data centers and makes itself current.

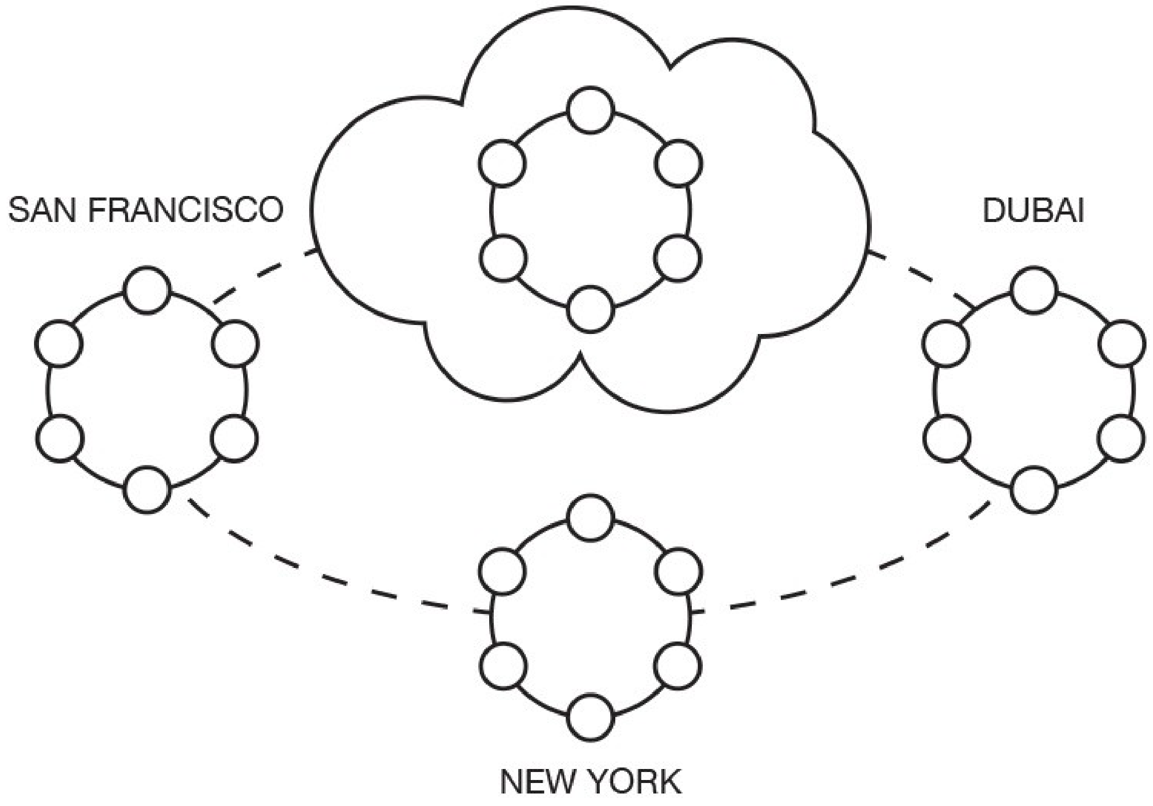


Figure 8 - A single Cassandra database cluster can span multiple data centers and the cloud.

An additional benefit of having a single cluster that spans multiple data centers and geographies is that data can be read and written to incredibly quickly in each location, thus keeping performance very high for the customers it serves in those locations.

ANALYZING AND SEARCHING DATA

Many applications have requirements that their underlying transactional database easily service analytic and search operations. As a DBA, you are likely familiar with analytic capabilities that can be run via SQL and full-text search options in an RDBMS, and might wonder how the same things are handled in Cassandra.

Real Time and Batch Analytics

Because Cassandra has a distributed, shared-nothing architecture, the framework for running analytics on it compared to a centralized RDBMS will be different.

There are two options in DataStax Enterprise that allow you to run analytic operations easily on Cassandra data. You can run both real-time and batch (i.e. longer running) analytics on data via the platform's built-in components that utilize Apache Spark for analytics work.

The analytics capability in the platform provides you with a number of the SQL functions and abilities that you are used to in the RDBMS world (e.g. joins, aggregate functions). In addition, analytics can be run across multiple data centers and cloud availability zones. Built-in continuous availability options are also included.

External Hadoop and Spark Support

You also have the ability to connect the data in DataStax Enterprise to an external Hadoop and/or Spark cluster and run analytic queries on data that combines both the operational data in Cassandra with historical data stored in a Hadoop deployment such as Cloudera or Hortonworks (e.g. a single query can join a Cassandra table with a Hadoop object). If you have used RDBMS connection options such as Oracle's database links or Microsoft SQL Server's linked servers to integrate external database systems, the concept is somewhat similar.

Searching Data

Some architects still shard their systems and use something like Cassandra for operational data management and a separate system and set of software for search operations. As a DBA, you'd likely prefer to have everything under one roof.

DataStax Enterprise supplies DSE Search, which uses Apache Solr™ as its foundation to manage search tasks. With DSE Search, you don't have to shard your application and you have the typical search bases covered including full-text search, hit highlighting, faceted search, rich document (e.g., PDF, Microsoft Word) handling and geospatial search.

Search operations can scale out across multiple nodes so you can add more nodes dedicated to search tasks when the need arises. Multi-data center and cloud support is built in, as is redundancy for continuous availability.

Workload Management for Analytics and Search

When enabling analytics and search on a database cluster, you have a number of configuration options available. If you choose, you can run transactional (OLTP), analytics and search operations on all nodes in a database cluster.

Another deployment methodology includes separating OLTP, analytics, and search workloads so that each runs on its own series of nodes. This strategy ensures that differing workloads do not compete with each other for either compute or data resources. Replication can be set up between all nodes so that data is transparently replicated to each set of nodes without manual intervention.

This translates into you not having to worry about complex ETL jobs that transfer data between different systems, as you might be used to doing with an RDBMS.

This also holds true if you are running graph database operations in a cluster – operational, analytical and search tasks can either be combined or separated across different nodes.

BACKUP AND RECOVERY

One of your key responsibilities as a DBA is to ensure that proper backup and recovery procedures are in place should a database become corrupted or a large data loss occurs. This section describes how backup and recovery processes work on a NoSQL database like Cassandra.

Using Replication and Multi-Data Center for Backup and Recovery

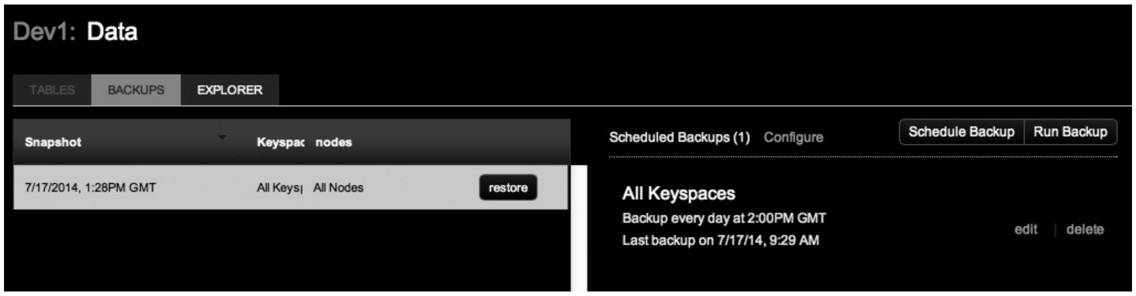
Some administrators simply use Cassandra's built-in replication and multi-data center capabilities for backup. Because the functionality is native to Cassandra, there is no need for add-on software (e.g. Oracle Dataguard). Since replication is so easy to use, some DBA's just create one or more physical or virtual data centers for a cluster and utilize them for disaster recovery purposes.

While such a strategy can be satisfactory for some situations, it is important to note that it will not protect you in cases where large amounts of data are deleted, tables are dropped, and other similar unintended actions are carried out - such activities will be replicated and applied to the other data centers.

Backing up Cassandra

Cassandra allows you easily backup all keyspaces in a cluster, certain selected keyspaces, or only desired tables in a keyspace. A backup is called a *snapshot* in Cassandra.

You can takes snapshots of your cluster via either a command line utility or visually through DataStax OpsCenter. While you can script your own backups via command line utilities, OpsCenter provides an easy way to design and schedule your backups.



Snapshot	Keyspac	nodes
7/17/2014, 1:28PM GMT	All Keys|	All Nodes

All Keyspaces
Backup every day at 2:00PM GMT
Last backup on 7/17/14, 9:29 AM

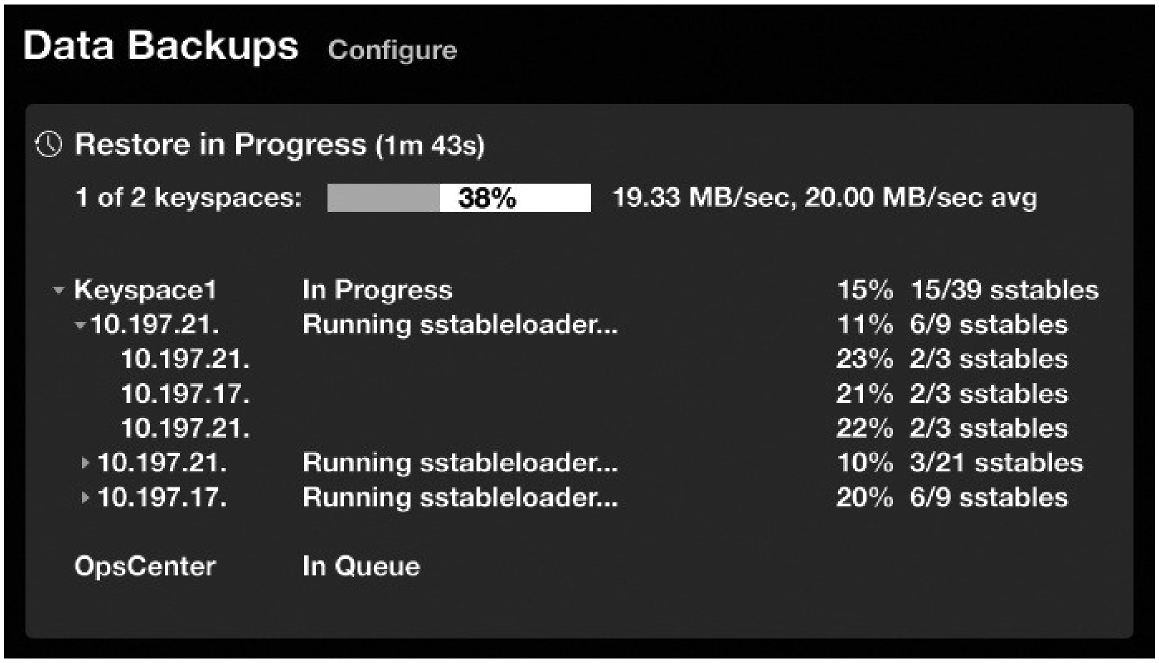
Figure 9 - DataStax OpsCenter's backup interface.

Note that you can also customize backups in OpsCenter by writing and including scripts that run both before and after a backup.

Lastly, incremental (only new or changed data versus full) backups are also supported for Cassandra, although it's not exactly the same as with an RDBMS. An incremental backup will backup only changed SStables vs. change rows as in an RDBMS.

Restoring Data

Database recovery operations can be carried out with either command line utilities or visually through DataStax OpsCenter. Restores can be full, utilize incremental backups, and also be object-level if needed (e.g. you can only restore one backed up table versus all tables).



```
Data Backups   Configure

Restore in Progress (1m 43s)
  1 of 2 keyspaces:  38%   19.33 MB/sec, 20.00 MB/sec avg

  Keyspace1        In Progress                    15%  15/39 sstables
   10.197.21.      Running sstableloader...       11%  6/9 sstables
      10.197.21.                                  23%  2/3 sstables
      10.197.17.                                  21%  2/3 sstables
      10.197.21.                                  22%  2/3 sstables
   10.197.21.      Running sstableloader...       10%  3/21 sstables
   10.197.17.      Running sstableloader...       20%  6/9 sstables

  OpsCenter        In Queue
```

Figure 10 - Restoring a keyspace with OpsCenter.

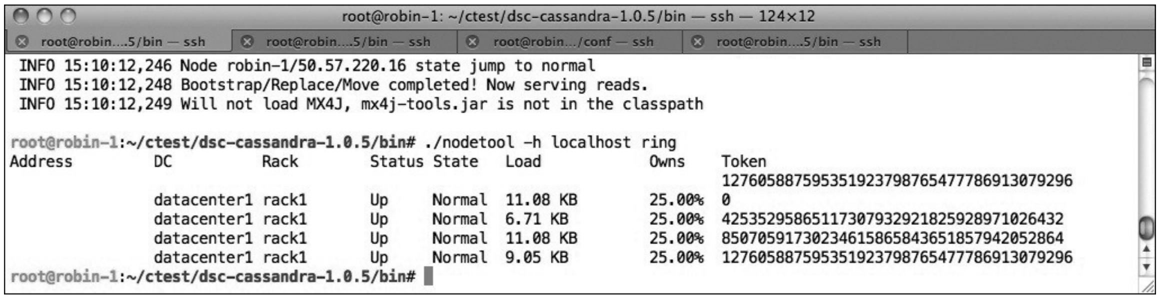
OpsCenter simplifies restore operations and handles restore tasks on all affected nodes.

PERFORMANCE MANAGEMENT

Monitoring, troubleshooting, and tuning databases are a top priority for you as a DBA. This section details how you can carry out your performance management tasks on a NoSQL database like Cassandra.

Monitoring Basics

There are a number of command line utilities that enable you to get a status of your database clusters as well as general metrics for the network, objects and I/O operations both at a high level and low level (e.g. table) fashion. For example, the Cassandra *nodetool* utility lets you quickly determine the up/down status and current data distribution of a cluster:


root@robin-1: ~/ctest/dsc-cassandra-1.0.5/bin — ssh — 124×12
root@robin....5/bin — ssh
root@robin....5/bin — ssh
root@robin.../conf — ssh
root@robin....5/bin — ssh

```
 INFO 15:10:12,246 Node robin-1/50.57.220.16 state jump to normal
 INFO 15:10:12,248 Bootstrap/Replace/Move completed! Now serving reads.
 INFO 15:10:12,249 Will not load MX4J, mx4j-tools.jar is not in the classpath

root@robin-1:~/ctest/dsc-cassandra-1.0.5/bin# ./nodetool -h localhost ring
Address         DC          Rack        Status State   Load            Owns    Token
                                                                               127605887595351923798765477786913079296
                datacenter1 rack1       Up     Normal  11.08 KB        25.00%  0
                datacenter1 rack1       Up     Normal  6.71 KB         25.00%  42535295865117307932921825928971026432
                datacenter1 rack1       Up     Normal  11.08 KB        25.00%  85070591730234615865843651857942052864
                datacenter1 rack1       Up     Normal  9.05 KB         25.00%  127605887595351923798765477786913079296
root@robin-1:~/ctest/dsc-cassandra-1.0.5/bin# 
```

Figure 11 - Checking a cluster's status with the nodetool utility.

Advanced Command Line Performance Monitoring Tools

From a performance metrics standpoint, Cassandra delivers many different statistics that can be accessed in various ways. If you are coming from an RDBMS like Oracle or Microsoft SQL Server and are used to performance data dictionaries like Oracle's V$ views or SQL Server' dynamic management tables, the most familiar interface for you is the one supplied by DataStax Enterprise's Performance Service.

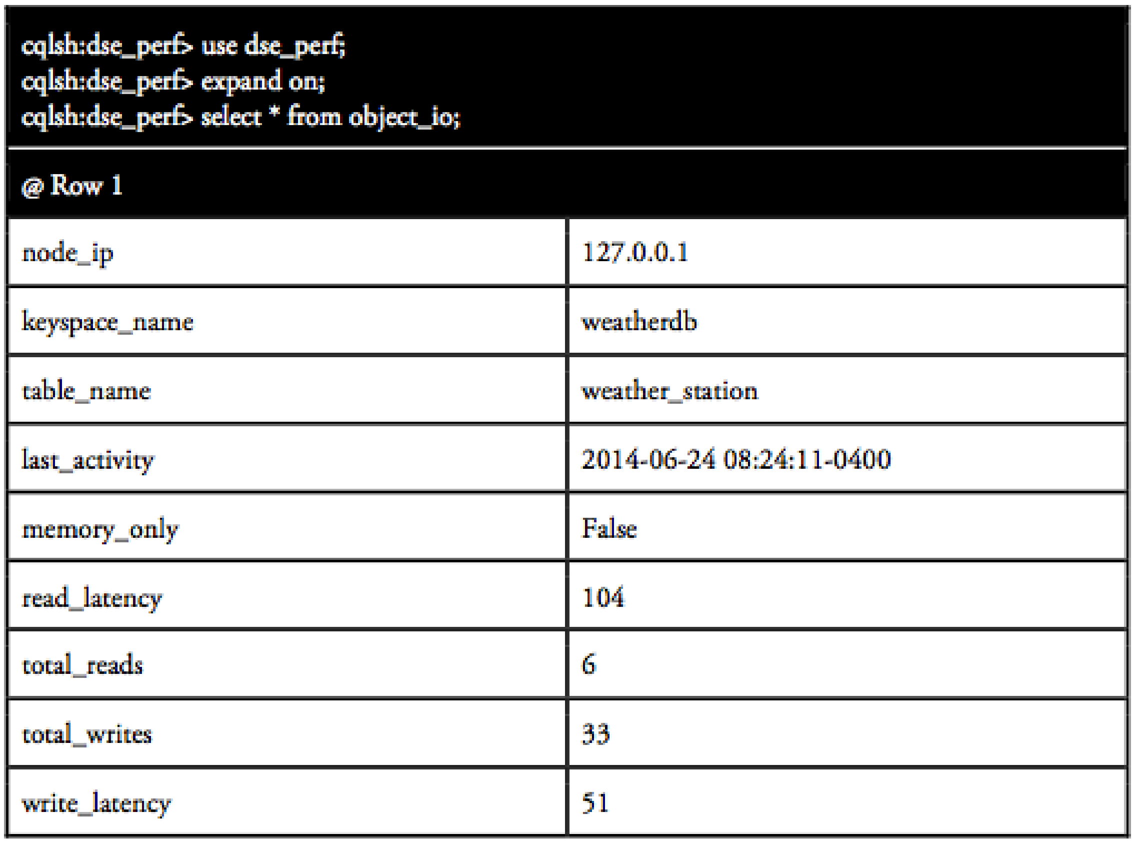
The Performance Service collects, organizes, and maintains an in-depth diagnostic data dictionary for each cluster. It consists of various tables that can be accessed via any CQL utility (e.g. the CQL shell utility, DataStax DevCenter) and gives you both high-level and detailed performance views of how well a cluster is running.

The Performance Service maintains the following levels of performance information:

- **System level** - supplies general memory, network and thread pool statistics.
- **Cluster level** - provides metrics at the cluster, data center and node level.
- **Database level** - provides drill down metrics at the keyspace, table and table-per-node level.
- **Table histogram level** - delivers histogram metrics for tables being accessed.
- **Object I/O level** - supplies metrics concerning 'hot objects' and data on what objects are being accessed the most.

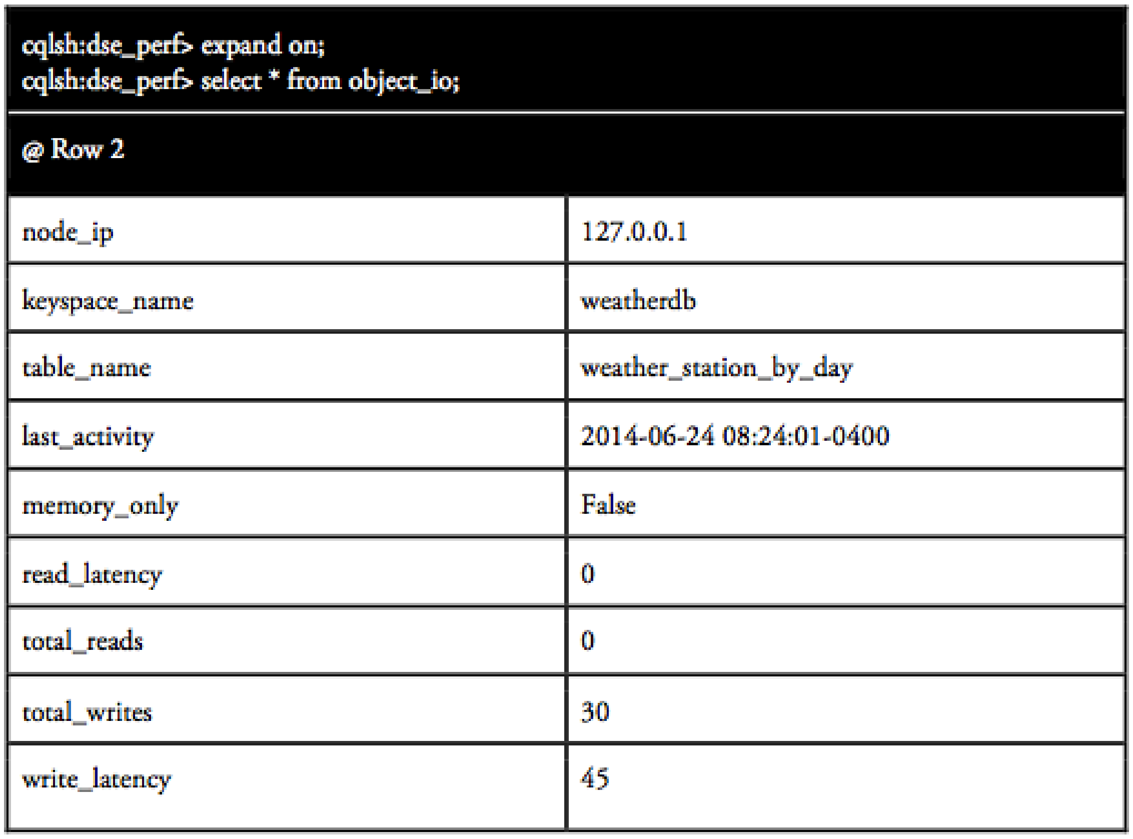
- **User level** - provides metrics concerning user activity, top users (those consuming the most resources on the cluster) and more.
- **Statement level** - captures queries that exceed a certain response time threshold along with all their relevant metrics.

You can configure the service to collect nothing, all, or selected performance metrics for the above categories. Once the service has been configured and is running, statistics are populated in their associated tables and stored in a special keyspace (dse_perf). You can then query the various performance tables to get statistics such as the I/O metrics for certain objects:



```
cqlsh:dse_perf> use dse_perf;
cqlsh:dse_perf> expand on;
cqlsh:dse_perf> select * from object_io;
```

@ Row 1	
node_ip	127.0.0.1
keyspace_name	weatherdb
table_name	weather_station
last_activity	2014-06-24 08:24:11-0400
memory_only	False
read_latency	104
total_reads	6
total_writes	33
write_latency	51



```
cqlsh:dse_perf> expand on;
cqlsh:dse_perf> select * from object_io;
```

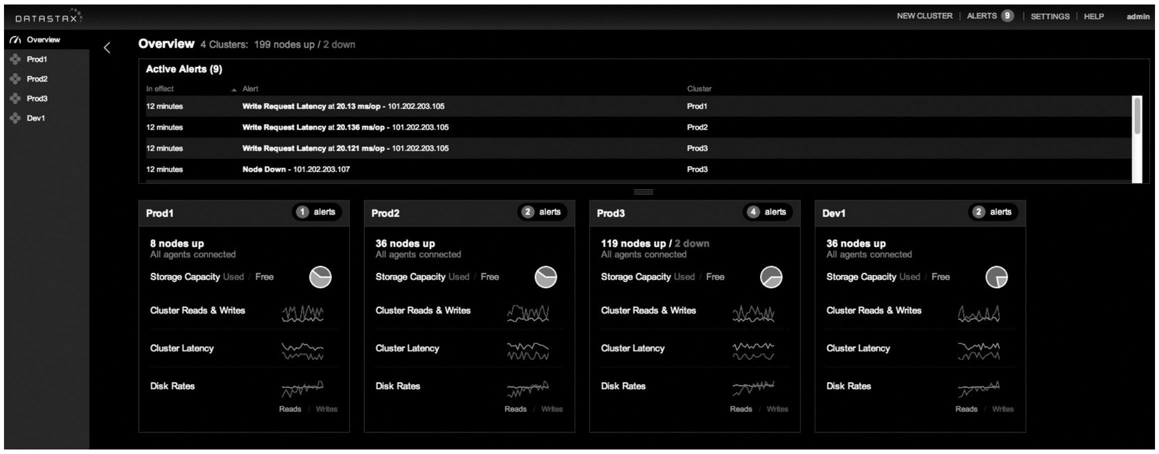
@ Row 2	
node_ip	127.0.0.1
keyspace_name	weatherdb
table_name	weather_station_by_day
last_activity	2014-06-24 08:24:01-0400
memory_only	False
read_latency	0
total_reads	0
total_writes	30
write_latency	45

(2rows)

Visual Database Monitoring

In addition to monitoring your database clusters from the command line, you can also easily check the health of all clusters you're managing visually by using DataStax OpsCenter. OpsCenter gives you both global, at-a-glance dashboards that help you understand how all clusters under your control are doing, as well as drill down capabilities into each cluster and its individual nodes.

A global dashboard helps you understand how well all clusters are running and if there are any alerts or issues for one or more clusters that need your attention:



Overview 4 Clusters: 199 nodes up / 2 down

Active Alerts (9)

In effect	Alert	Cluster
12 minutes	**Write Request Latency** at **20.13 ms/op** - 101.202.203.105	Prod1
12 minutes	**Write Request Latency** at **20.136 ms/op** - 101.202.203.105	Prod2
12 minutes	**Write Request Latency** at **20.121 ms/op** - 101.202.203.105	Prod3
12 minutes	**Node Down** - 101.202.203.107	Prod3

Prod1 (1 alerts)	Prod2 (2 alerts)	Prod3 (4 alerts)	Dev1 (2 alerts)
8 nodes up All agents connected	36 nodes up All agents connected	119 nodes up / 2 down All agents connected	36 nodes up All agents connected
Storage Capacity Used / Free	Storage Capacity Used / Free	Storage Capacity Used / Free	Storage Capacity Used / Free
Cluster Reads & Writes	Cluster Reads & Writes	Cluster Reads & Writes	Cluster Reads & Writes
Cluster Latency	Cluster Latency	Cluster Latency	Cluster Latency
Disk Rates Reads / Writes	Disk Rates Reads / Writes	Disk Rates Reads / Writes	Disk Rates Reads / Writes

Figure 12 - Checking OpsCenter's global cluster dashboard.

From the global dashboard, you can drill down into each individual cluster and create customized monitoring dashboards for the performance metrics you care about the most:

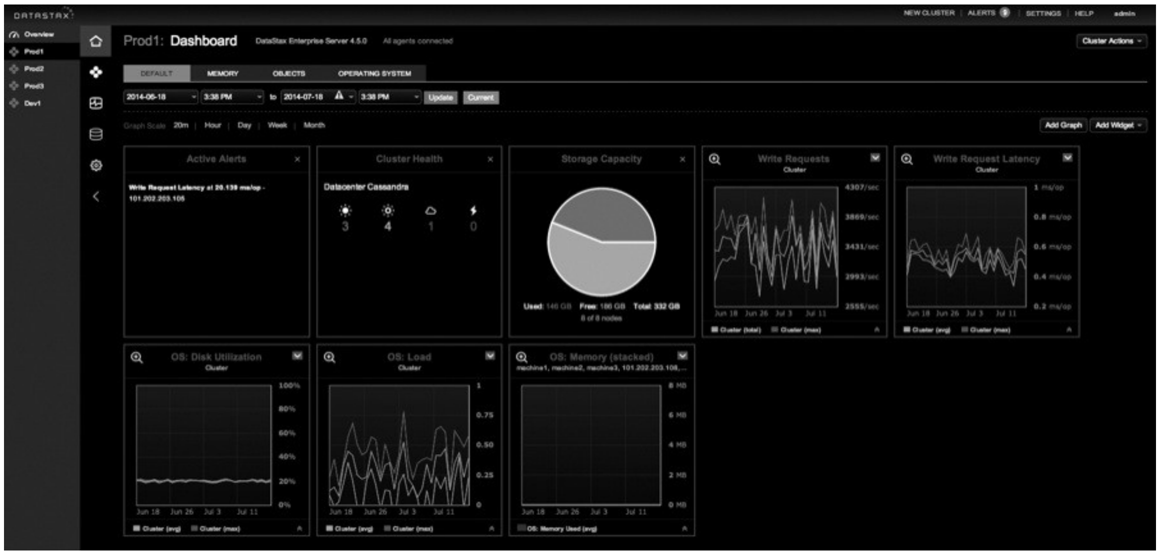


Figure 13 - Examining performance metrics for a single database cluster.

You can also create proactive alerts that notify you far in advance of a problem actually occurring in one of your clusters:

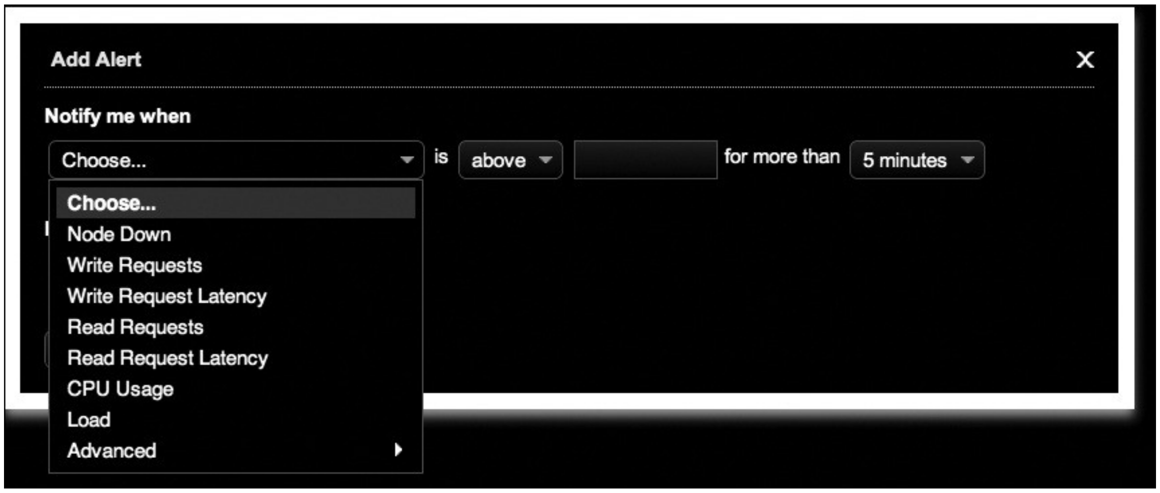
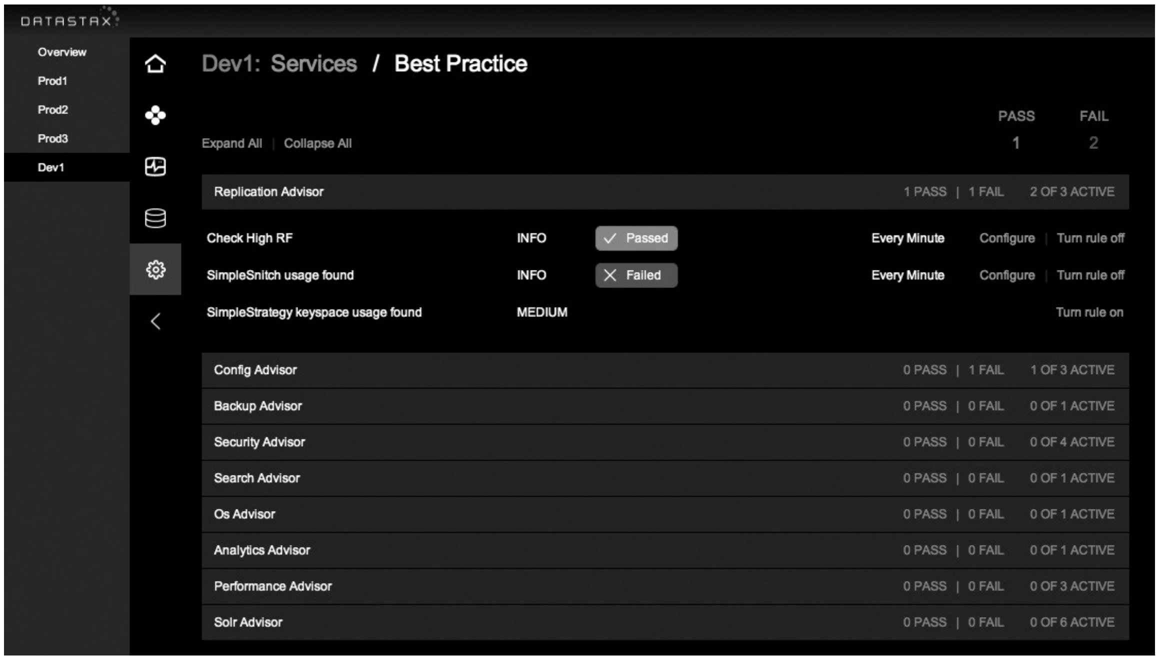


Figure 14 - Creating an alert in OpsCenter.

In addition, you can utilize built-in expert services like the Best Practice service that will scan your clusters and provide expert advice on how to configure and tune things for better uptime and performance:



Dev1: Services / Best Practice

PASS	FAIL
1	2

Replication Advisor			1 PASS | 1 FAIL	2 OF 3 ACTIVE
Check High RF	INFO	✓ Passed	Every Minute	Configure | Turn rule off
SimpleSnitch usage found	INFO	✗ Failed	Every Minute	Configure | Turn rule off
SimpleStrategy keyspace usage found	MEDIUM			Turn rule on
Config Advisor			0 PASS | 1 FAIL	1 OF 3 ACTIVE
Backup Advisor			0 PASS | 0 FAIL	0 OF 1 ACTIVE
Security Advisor			0 PASS | 0 FAIL	0 OF 4 ACTIVE
Search Advisor			0 PASS | 0 FAIL	0 OF 1 ACTIVE
Os Advisor			0 PASS | 0 FAIL	0 OF 1 ACTIVE
Analytics Advisor			0 PASS | 0 FAIL	0 OF 1 ACTIVE
Performance Advisor			0 PASS | 0 FAIL	0 OF 3 ACTIVE
Solr Advisor			0 PASS | 0 FAIL	0 OF 6 ACTIVE

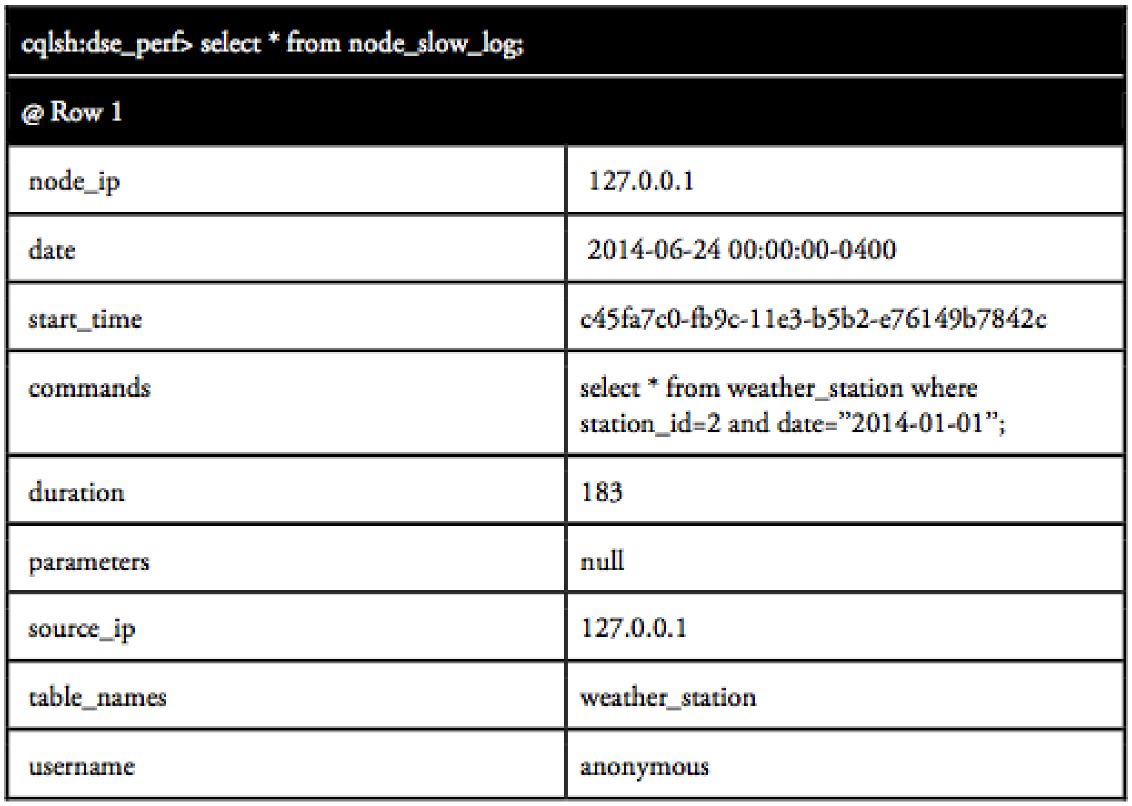
Figure 15 - OpsCenter's Best Practice service.

These and other capabilities in OpsCenter help monitor and tune database clusters via any Web browser (laptop, tablet, smart phone) no matter if they are in your own data center or are running on one of the cloud providers.

Finding and Troubleshooting Problem Queries

As a DBA, you're sometimes called upon to locate a database's worst running queries that slow the performance of the system as a whole. You'll find this isn't hard to do with Cassandra.

First, you can use the DataStax Enterprise Performance Service to automatically capture long-running queries (based on response time thresholds you specify) and then query a performance table that holds those statements:



```
cqlsh:dse_perf> select * from node_slow_log;
```

@ Row 1

node_ip	127.0.0.1
date	2014-06-24 00:00:00-0400
start_time	c45fa7c0-fb9c-11e3-b5b2-e76149b7842c
commands	select * from weather_station where station_id=2 and date=”2014-01-01”;
duration	183
parameters	null
source_ip	127.0.0.1
table_names	weather_station
username	anonymous

In addition, there is a background query tracing utility available that you can use on an ad-hoc basis. You can choose to trace all statements coming into a database cluster or only a percentage of them, and then look at the results. The trace information is stored in the systems_traces keyspace that holds two tables: sessions and events, which can be easily queried to answer questions such as what the most time-consuming query has been since a trace was started, and much more.

You can also use the tracing utility much in the same way you do an EXPLAIN PLAN on an RDBMS query. For example, to understand how a Cassandra cluster will satisfy a single CQL INSERT statement, you would enable the trace utility from the CQL command shell, issue your query, and review the diagnostic information provided:

```
cqlsh> tracing on;
Now tracing requests.
cqlsh:foo> INSERT INTO test (a, b) VALUES (1, 'example');
Tracing session: 4ad36250-1eb4-11e2-0000-fe8ebeead9f9
```

Activity	Time Stamp	Source	Source_Elapsed
execute_cql3_query	00:02:37, 015	127.0.0.1	0
Parsing statement	00:02:37, 015	127.0.0.1	81
Preparing statement	00:02:37, 015	127.0.0.1	273
Determining replicas for mutation	00:02:37, 015	127.0.0.1	540
Sending message to /127.0.0.2	00:02:37, 015	127.0.0.1	779
Messsage received from /127.0.0.1	00:02:37, 016	127.0.0.2	63
Applying mutation	00:02:37, 016	127.0.0.2	220
Acquiring switchLock	00:02:37, 016	127.0.0.2	250
Appending to commitlog	00:02:37, 016	127.0.0.2	277
Adding to memtable	00:02:37, 016	127.0.0.2	378
Enqueuing response to /127.0.0.1	00:02:37, 016	127.0.0.2	710
Sending message to /127.0.0.1	00:02:37, 016	127.0.0.2	888
Messsage received from /127.0.0.2	00:02:37, 017	127.0.0.1	2334
Processing response from /127.0.0.2	00:02:37, 017	127.0.0.1	2550
Request complete	00:02:37, 017	127.0.0.1	2581

With Cassandra's tracing capabilities, OpsCenter's visual monitoring, DataStax Enterprise's Performance service and general command line monitoring tools, you will have most, if not all, of the typical performance tools at your disposal with Cassandra as you do today with your favorite RDBMS.

MIGRATING DATA

Moving data from an RDBMS or other database to Cassandra is generally quite easy. The following options exist for migrating data to Cassandra:

- **COPY command** - CQL provides a copy command (very similar to Postgres) that is able to load data from an operating system file into a Cassandra table.
- **Bulk loader** - this utility is designed for more quickly loading a Cassandra table with a file that is delimited in some way (e.g. comma, tab, etc.) Note: there is a separate bulk loader available for DSE Graph.
- **ETL tools** - there are a variety of ETL tools (e.g. Informatica) that support Cassandra as both a source and target data platform. Many of these tools not only extract and load data but also provide transformation routines that can manipulate the incoming data in many ways. A number of these tools are also free to use (e.g. Pentaho, Jaspersoft, Talend).

DBA STRATEGIES FOR IMPLEMENTING NOSQL

This section provides basic checklists to use when evaluating a NoSQL database for production environments, guidelines for deciding when NoSQL should be deployed versus an RDBMS and what deployment scenarios are most common.

Evaluating NoSQL for Your Enterprise

Although not exhaustive, below are technical and business considerations designed to ask the right questions when evaluating whether a particular NoSQL database is suited for your production environment:

Technical Considerations

- Can the NoSQL database serve as the primary data source for the intended online application?
- How safe is the NoSQL database where the possibility of losing critical data is concerned? Are writes durable in nature by default so that data is safe?
- Is the NoSQL database fault tolerant (i.e., has no single point of failure) and is it capable of providing not just high availability, but continuous availability?
- Can the NoSQL database easily replicate data between the same and multiple data centers, as well as different cloud availability zones?
- Does the NoSQL database offer read/write anywhere capabilities (i.e. can any node in the cluster be written to and read from)?
- Does the NoSQL database provide a robust security feature set?
- Does it support easy-to-create and manage backup and recover procedures?
- Does the NoSQL database require or remove the need for special caching layers?
- Is the NoSQL database capable of managing "big data" and delivering high performance results regardless of data size?
- Does the NoSQL database offer linear scalability where adding new nodes is concerned?
- Can new nodes be added and removed online (i.e. without business impact)?
- Does the NoSQL database support key platforms/developer languages?
- Does the NoSQL database provide an SQL-like query language?
- Can the NoSQL database run on commodity hardware with no special hardware requirements?
- Is the NoSQL database easy to implement and maintain for large deployments?
- Does the NoSQL database provide data compression that supplies real storage savings?
- Can analytic operations be run easily on the NoSQL database?
- Can the NoSQL database easily interface with and support modern data warehouses or lakes that utilize Hadoop?
- Can search operations and functions be easily and directly carried out on the NoSQL database?
- Can the NoSQL database provide workload isolation between online, analytic, and search operations in a single application?
- Does the database have solid command-line and visual tools for development, administration, and performance management?

Business Requirements

- Is the NoSQL solution backed by a commercial entity?
- Does the commercial entity provide enterprise 24x7 support and services?
- Does the NoSQL solution have professional online documentation?
- Does the NoSQL solution have referenceable customers across a wide range of industries that use the product in critical production environments?
- Does the NoSQL database have an attractive cost/pricing structure?
- If open source, does the NoSQL database have a thriving open source community?

Practical Guidelines for Selecting NoSQL vs. an RDBMS

How do you determine whether a NoSQL database like Cassandra or DSE Graph should be used for all or part of an application versus an RDBMS? Some basic questions to ask include:

- Do you need a more flexible data model to manage data that goes beyond the RDBMS table/row data structure and instead includes a combination of structured, semi-structured and unstructured data?
- Do you find that complex JOIN operations are overwhelming your RDBMS and response times are slow because of them?
- Do you care more about the value derived from the relationships that form between the tables vs. the tables themselves?
- Do you need continuous availability with redundancy in both data and function across one or more locations versus simple failover for the database?
- Do you need a database that runs over multiple data centers / cloud availability zones?
- Do you need to handle high velocity data coming in via sensors, mobile devices, and the like, and have extreme write speed and low latency query speed?
- Do you need to go beyond single machine limits for scale-up and instead go to a scale-out architecture to support the easy addition of more processing power and storage capacity?
- Do you need to run different workloads (e.g. online, analytics, search) on the same data without needing to manually ETL the data to separate systems/machines?
- Do you need to manage a widely distributed system with minimal staff?

Deployment Considerations

From a practical perspective, as a DBA, how do you go about actually moving to NoSQL and implementing your first application? In general, there are three ways to deploy a NoSQL database like Cassandra:

1. **New applications:** many begin with NoSQL by choosing a new application and starting from the ground up. Such an approach mitigates the issues of application rewrites, data migrations, etc.
2. **Augmentation:** some choose to augment an existing system by adding a NoSQL component to it. This oftentimes happens with applications that have outgrown an RDBMS due to scale problems, the need for better availability, or other issues. Parts of the existing system continue to use the existing RDBMS whereas other components of the application are modified to utilize the NoSQL database.
3. **Full Rip-Replace:** for systems that simply are proving too costly from an RDBMS perspective to keep, or are breaking in major ways due to increases of user concurrency, data velocity, or data volume from cloud applications, a full replacement is done with a NoSQL database.

CONCLUSION

This guide has been designed to provide you with a preliminary understanding from a DBA perspective on the basics of NoSQL, and how a NoSQL database like Apache Cassandra differs from an RDBMS like Oracle, SQL Server, and MySQL. It has been written to supply you with an overview of how you will go about designing, managing, deploying, and monitoring Cassandra or multi-model database systems.

To find out more about Apache Cassandra and DataStax, and to obtain downloads of Apache Cassandra and DataStax Enterprise software, visit www.datastax.com or send an email to info@datastax.com.

DataStax Enterprise Edition is completely free to use in non-production environments, while production deployments require a software subscription be purchased.

ABOUT DATASTAX

DataStax, the leading provider of database software for cloud applications, accelerates the ability of enterprises, government agencies, and systems integrators to power the exploding number of cloud applications that require data distribution across datacenters and clouds, by using our secure, operationally simple platform built on Apache Cassandra™.

With more than 500 customers in over 50 countries, DataStax is the database technology of choice for the world's most innovative companies, such as Netflix, Safeway, ING, Adobe, Intuit, Target and eBay. Based in Santa Clara, Calif., DataStax is backed by industry-leading investors including Comcast Ventures, Crosslink Capital, Lightspeed Venture Partners, Kleiner Perkins Caufield & Byers, Meritech Capital, Premji Invest and Scale Venture Partners. For more information, visit DataStax.com or follow us @DataStax. 06.18.16