Big Data and Spatial Databases

A Comparative Analysis

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Table of Contents

Motivation

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  - Spatial crowd-sourcing movements/ Volunteer Geographic Information (VGI).

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- The increasing volume of spatial information, coupled with the computationally intensive nature of spatial queries demand scalable and efficient solutions.
  - fast query response, which requires a scalable architecture.
  - Support to clusters on a cost-effective architecture, such as commodity clusters or cloud environments.

Our Approach

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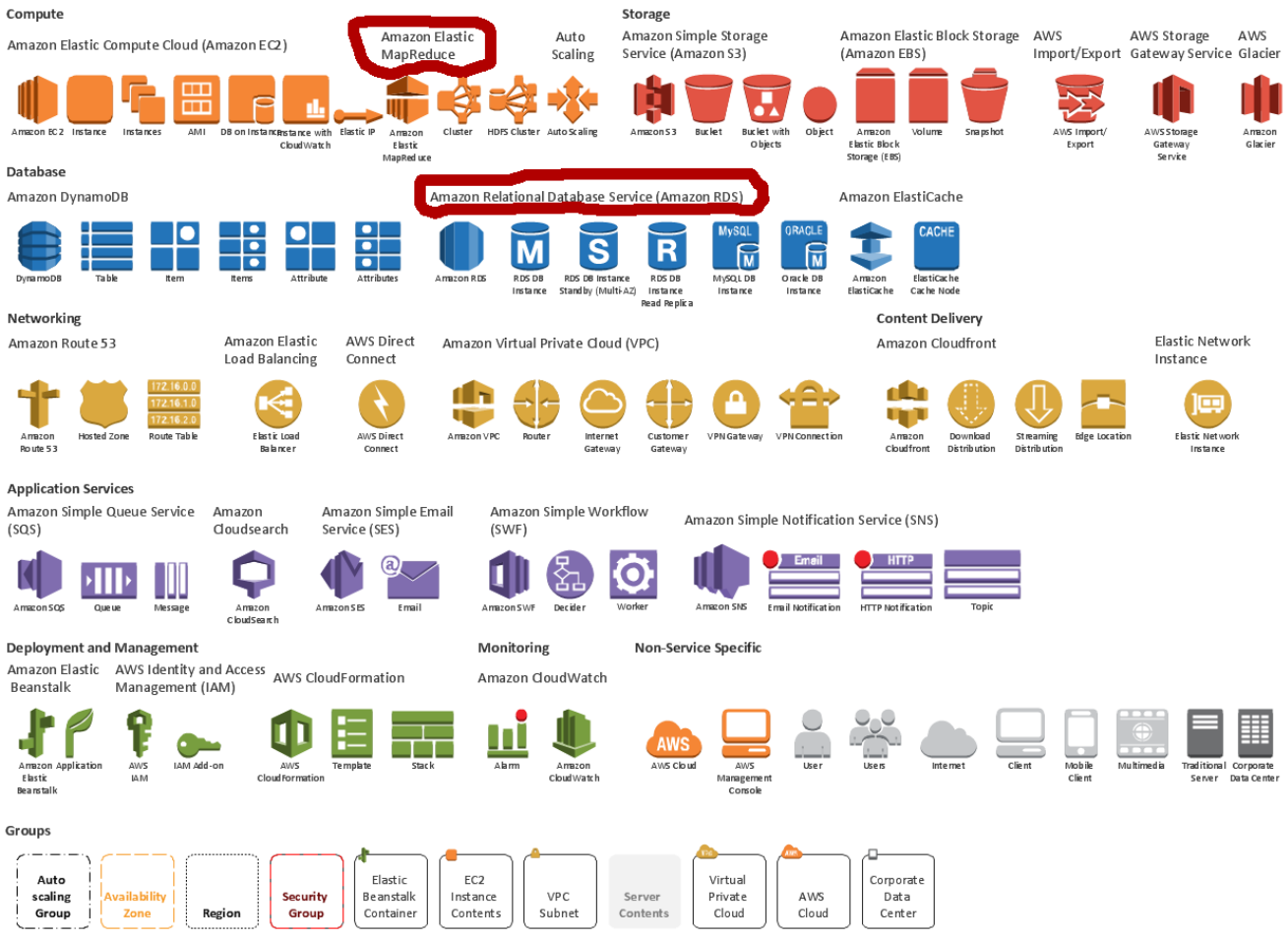
- To compare a relational database server running on a single-machine with different clusters.
- **Disclaimer:** we focused whithin the scope of our work environment.

The cloud


Compute
Amazon Elastic Compute Cloud (Amazon EC2)
Amazon Elastic MapReduce
Auto Scaling
Amazon EC2
Instance
Instances
AMI
DB on Instance
Instance with CloudWatch
Elastic IP
Amazon Elastic MapReduce
Cluster
HDFS Cluster
Auto Scaling
Storage
Amazon Simple Storage Service (Amazon S3)
Amazon Elastic Block Storage (Amazon EBS)
AWS Import/Export
AWS Storage Gateway Service
AWS Glacier
Amazon S3
Bucket
Bucket with Objects
Object
Amazon Elastic Block Storage (EBS)
Volume
Snapshot
AWS Import/ Export
AWS Storage Gateway Service
Amazon Glacier
Database
Amazon DynamoDB
Amazon Relational Database Service (Amazon RDS)
Amazon ElastiCache
DynamoDB
Table
Item
Items
Attribute
Attributes
Amazon RDS
RDS DB Instance
RDS DB Instance Standby (Multi-AZ)
RDS DB Instance Read Replica
MySQL DB Instance
Oracle DB Instance
Amazon ElastiCache
ElastiCache Cache Node
Networking
Amazon Route 53
Amazon Elastic Load Balancing
AWS Direct Connect
Amazon Virtual Private Cloud (VPC)
Content Delivery
Amazon Cloudfront
Elastic Network Instance
Amazon Route 53
Hosted Zone
Route Table
Elastic Load Balancer
AWS Direct Connect
Amazon VPC
Router
Internet Gateway
Customer Gateway
VPN Gateway
VPN Connection
Amazon Cloudfront
Download Distribution
Streaming Distribution
Edge Location
Elastic Network Instance
Application Services
Amazon Simple Queue Service (SQS)
Amazon Cloudsearch
Amazon Simple Email Service (SES)
Amazon Simple Workflow (SWF)
Amazon Simple Notification Service (SNS)
Amazon SQS
Queue
Message
Amazon CloudSearch
Amazon SES
Email
Amazon SWF
Decider
Worker
Amazon SNS
Email Notification
HTTP Notification
Topic
Deployment and Management
Amazon Elastic Beanstalk
AWS Identity and Access Management (IAM)
AWS CloudFormation
Monitoring
Amazon CloudWatch
Non-Service Specific
Amazon Elastic Beanstalk
Application
AWS IAM
IAM Add-on
AWS CloudFormation
Template
Stack
Alarm
Amazon CloudWatch
AWS Cloud
AWS Management Console
User
Users
Internet
Client
Mobile Client
Multimedia
Traditional Server
Corporate Data Center
Groups
Auto scaling Group
Availability Zone
Region
Security Group
Elastic Beanstalk Container
EC2 Instance Contents
VPC Subnet
Server Contents
Virtual Private Cloud
AWS Cloud
Corporate Data Center

RDS vs EMR

Relational Database Service (RDS)

Elastic Map Reduce (EMR)

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- RDBMS on a dedicated server, with an optimized configuration.

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- A Linux-based distributed system that uses Hadoop as framework.

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Relational Database Service (RDS)

- RDBMS on a dedicated server, with an optimized configuration.
- PostgreSQL v.9.3.3
- PostGIS 2.1

Elastic Map Reduce (EMR)

- A Linux-based distributed system that uses Hadoop as framework.
- Hadoop 2.4.0
- Hive 0.13.1
- **GIS tools for Hadoop 2.0**

Introducing GIS tools for Hadoop

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- FOS toolkit for "Big Spatial Data Analytics".
- Hosted on github.
- It consists in three libraries:
  - Esri Geometry API for Java.
  - Geoprocessing Tools for Hadoop.
  - **Spatial Framework for Hadoop (SFH):** extends Hive to to enable spatial queries and geometry types.

Hardware Description

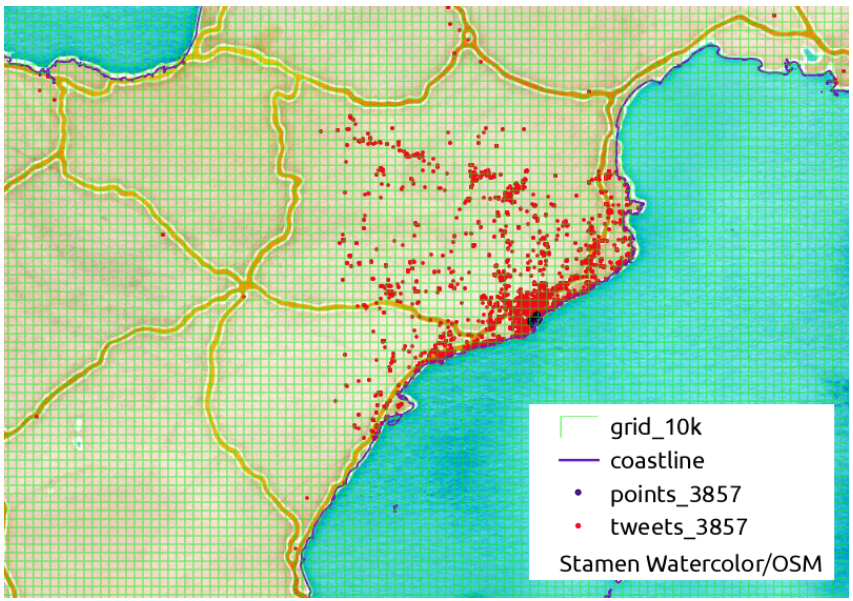
Designation	Description
RDS	db.m3.medium: 100 GB, 1 CPU, 3.75 GB RAM
EMRx3	master: m3.xlarge; cores: m1.medium (3)
EMRx6	master: m3.xlarge; cores: m1.medium (6)
EMRx9	master: m3.xlarge; cores: m1.medium (9)
EMRx3Large	master: m3.xlarge; cores: m3.xlarge (3)

m1.medium 410 GB, 3.75 GB RAM, 1 CPU:

m3.xlarge SSD 2x40 GB, 15 GB RAM, 4xCPU;

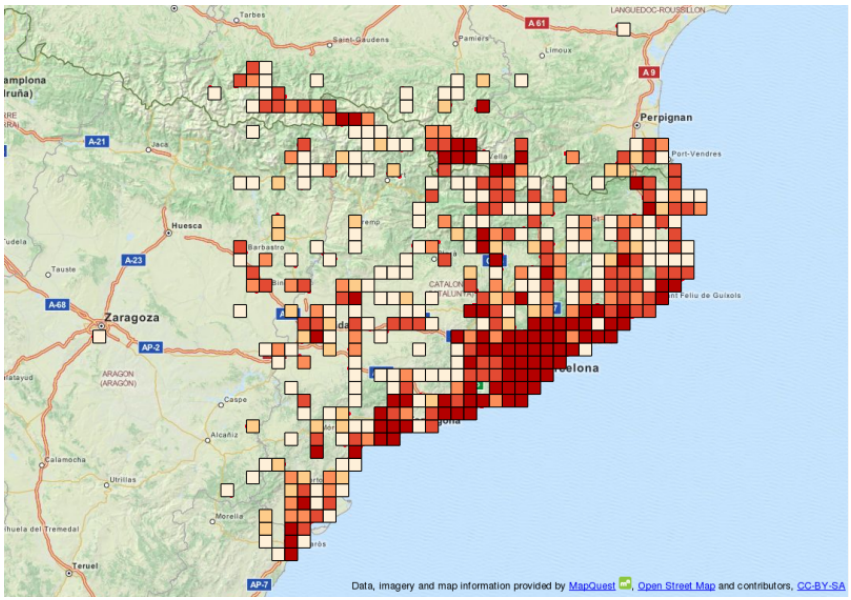
Introducing the Queries

- Four queries.
- Four Layers with different geometries (e.g: point, polygon, polyline).
- Same CRS: Google Mercator (EPSG:3857).
- Syntax may differ slightly on PostGIS and SFH.



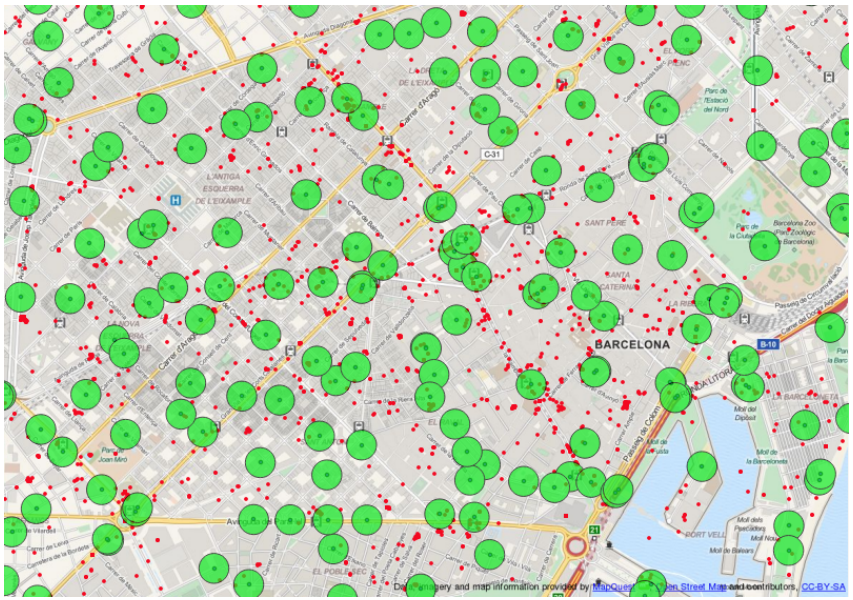
Create Density Grid

- Objective: transforming a point cloud in a density surface.
- Scenario: create a grid for displaying the density of tweets.
- Operations involved: create table, aggregation (GROUP BY), ST_CONTAINS.



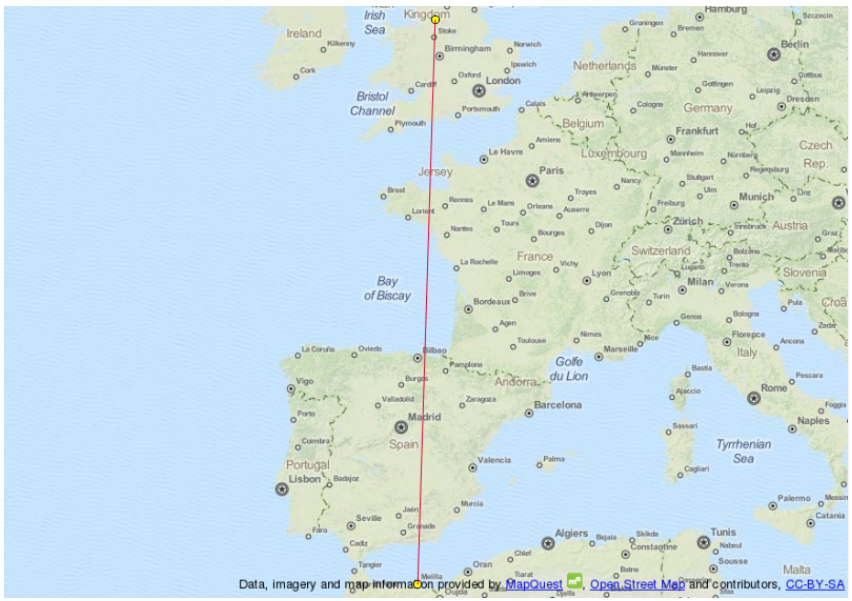
Buffers

- Objective: count how many points lie whithin a buffer.
- Scenario: how many tweets are sent within 100 m of a bicing station.
- Operations involved: ST_BUFFER, ST_CONTAINS.



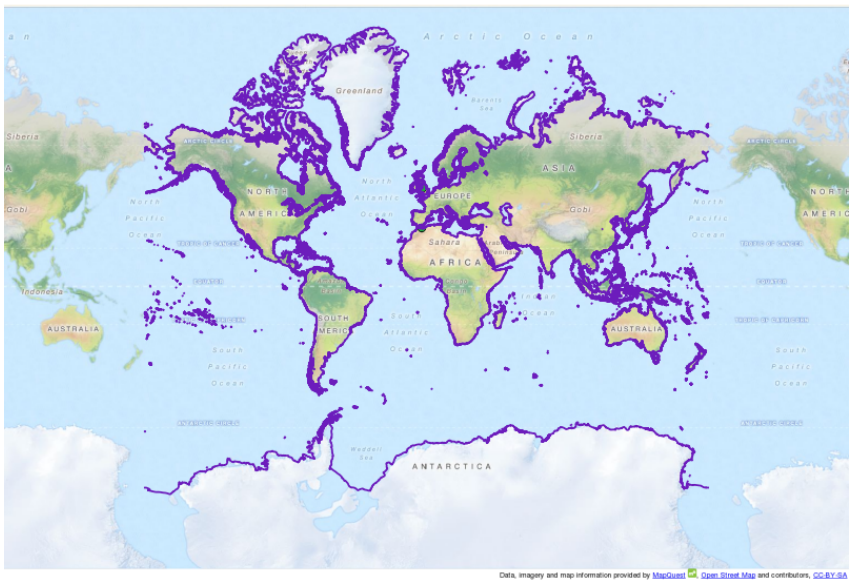
Select Maximum Distance

- Objective: measure distance between two points.
- Scenario: calculate the maximum distance between tweets mentioning New Years, on New Years Day (01/01/2015).
- Operations involved: MAX, ST_DISTANCE, filters (WHERE).



Import Layer

- Objective: importing a layer into the system.
- Scenario: instantiate geometry from a CSV file, with WKT definitions.
- Operations involved: create table, copy values, ST_GeomFromText.



Running the Queries

- Query times on clusters showed a large variability, so we used average values.

General Overview

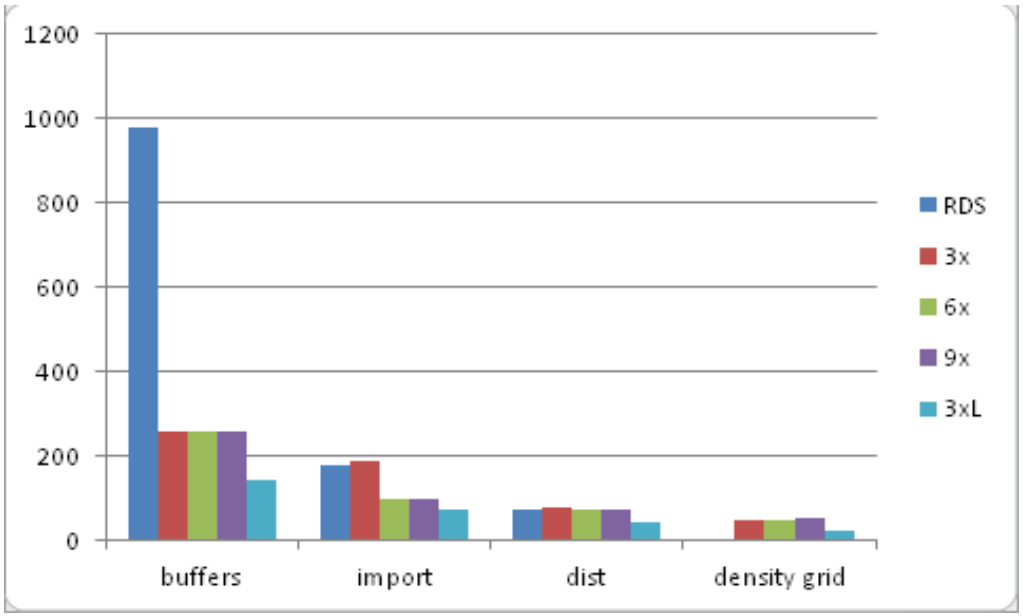
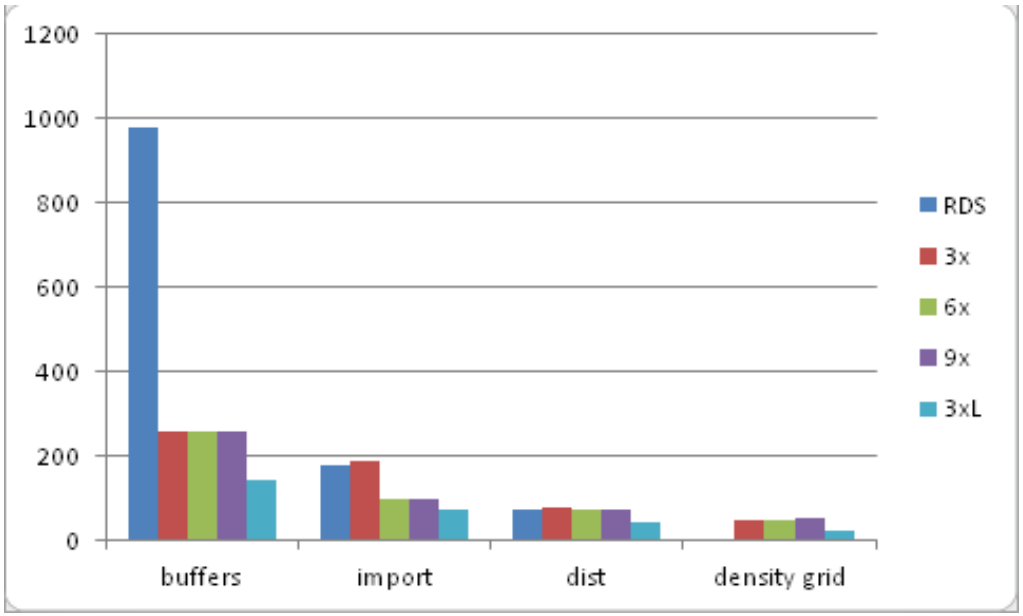


Figure : Results of the benchmarking of the different queries, on different setups on the cloud; query duration is shown in seconds.

General Overview

- The *buffers* query, is by far the most expensive one.



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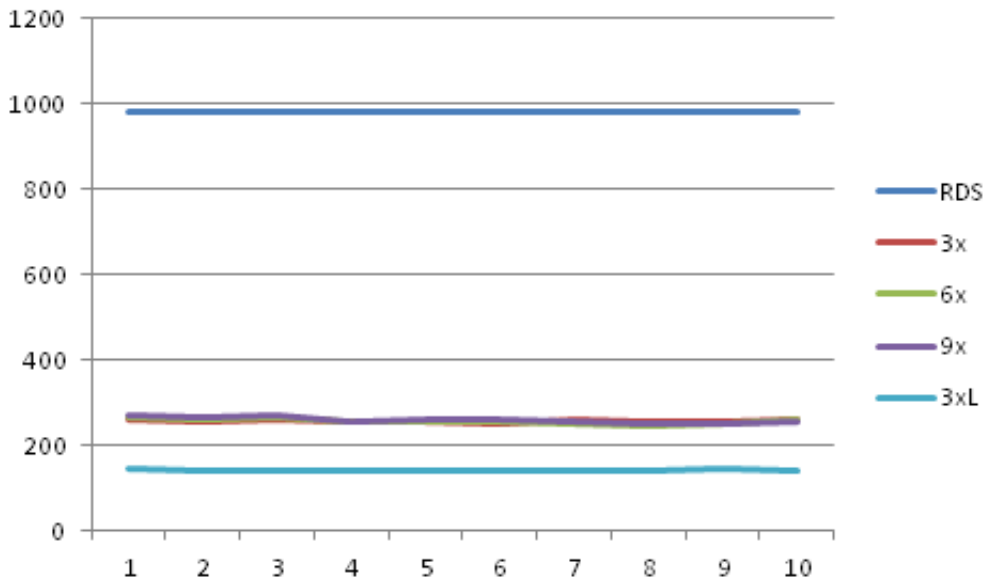
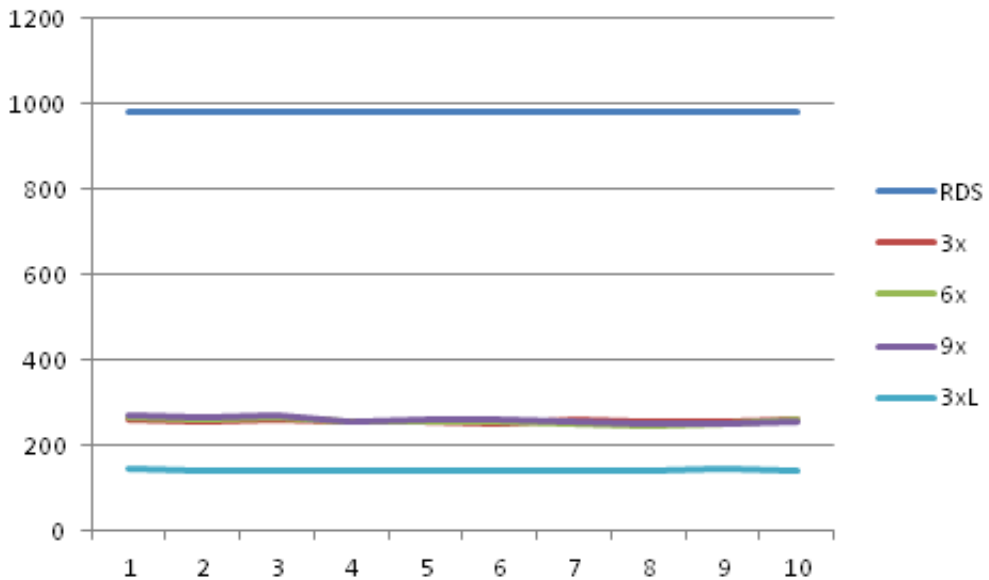


Figure : duration of the *buffers* query.

Buffers

- This is where RDS has its worst performance.



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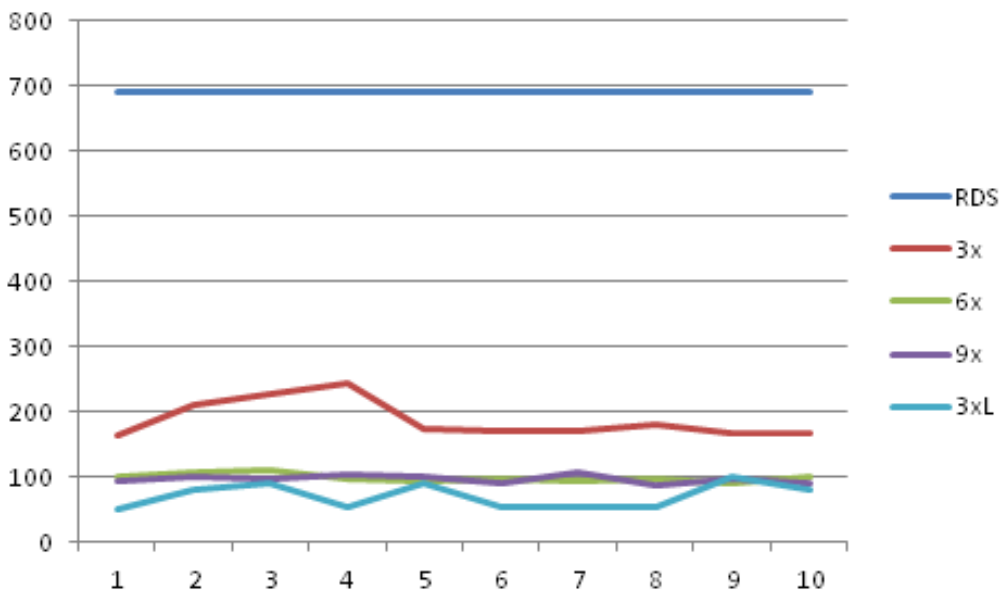


Figure : duration of the *import* query.

Import Layer

- On this query RDS also performs much worst than any of the clusters.

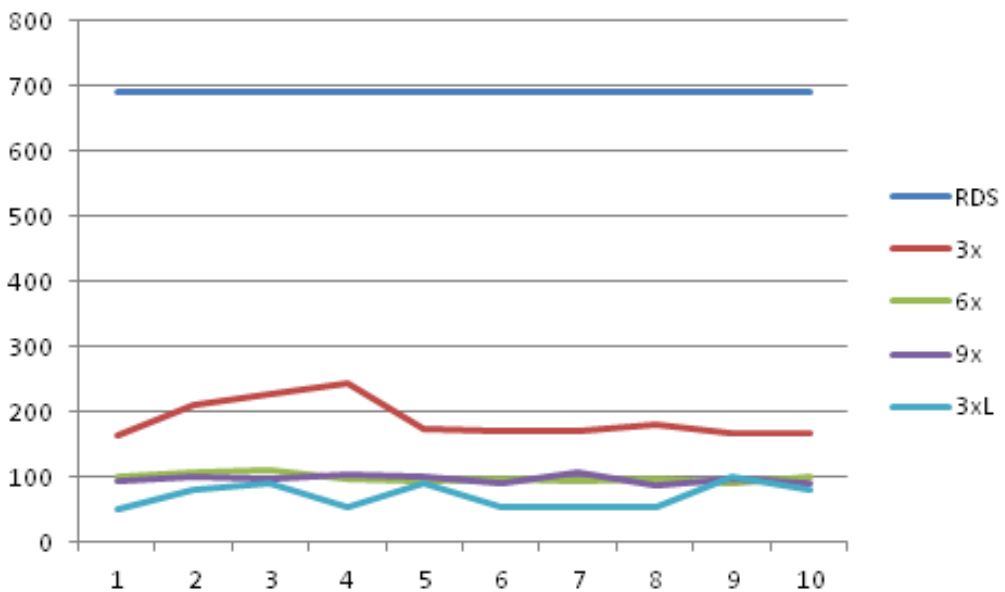


Figure : duration of the *import* query.

Import Layer

- On this query RDS also performs much worst than any of the clusters.
- Using an alternative method for importing (shp2pgsql) improves dramatically the import time for RDS.

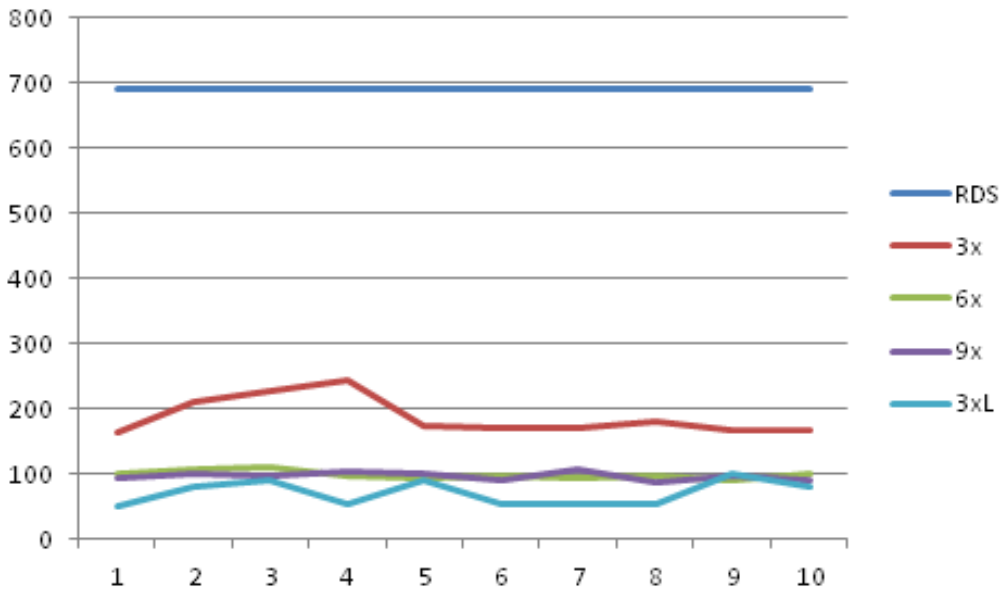


Figure : duration of the *import* query.

Create Density Grid

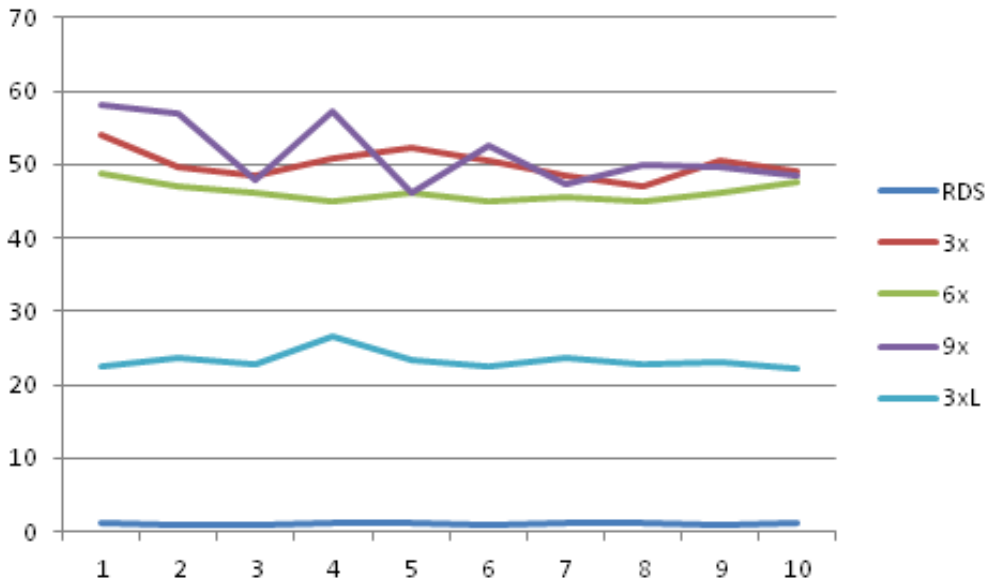
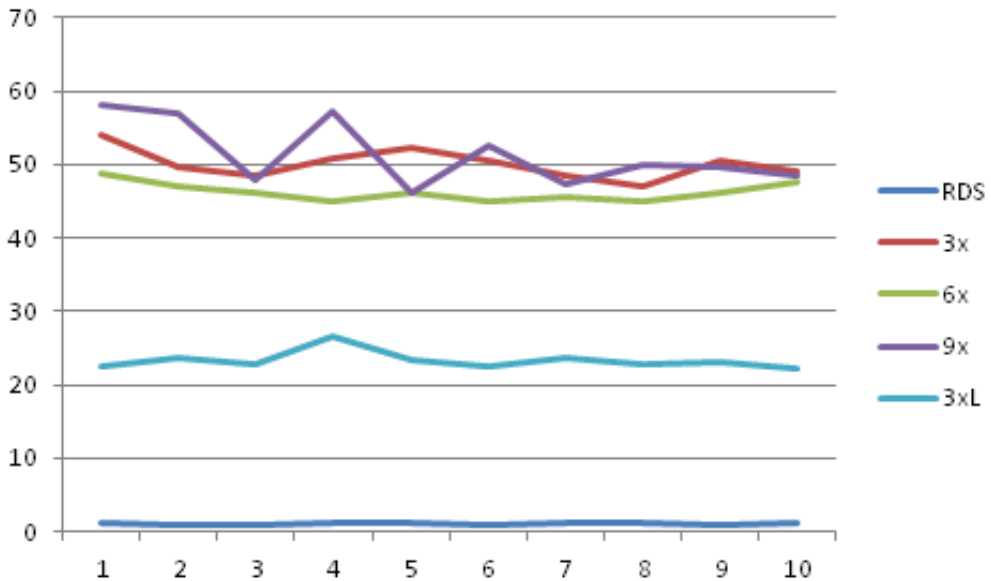


Figure : duration of the *grid* query.

Create Density Grid

- RDS is 20 to 50 times faster than the clusters.



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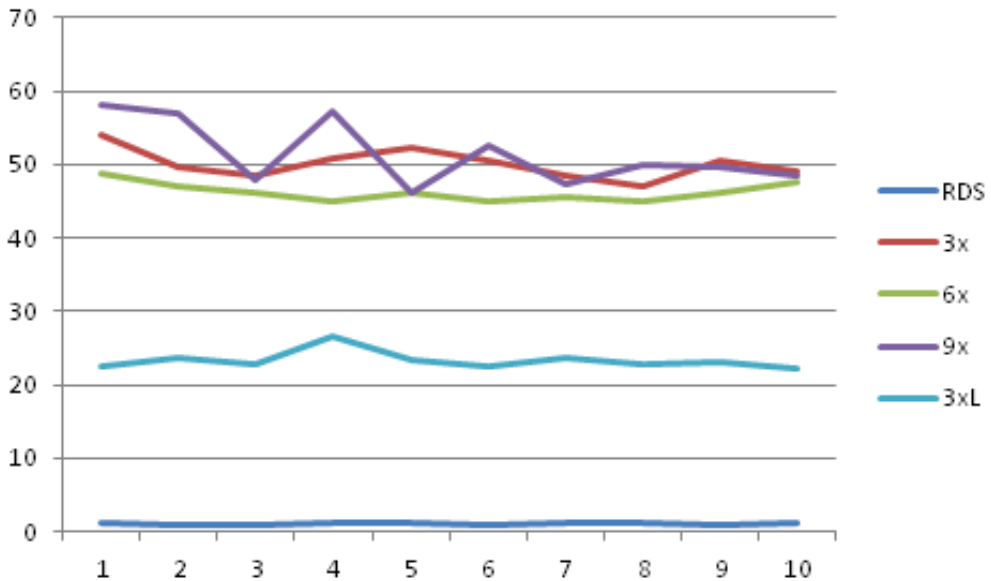
Create Density Grid

- RDS is 20 to 50 times faster than the clusters.
- Using more workers (9), actually results in longer response times.



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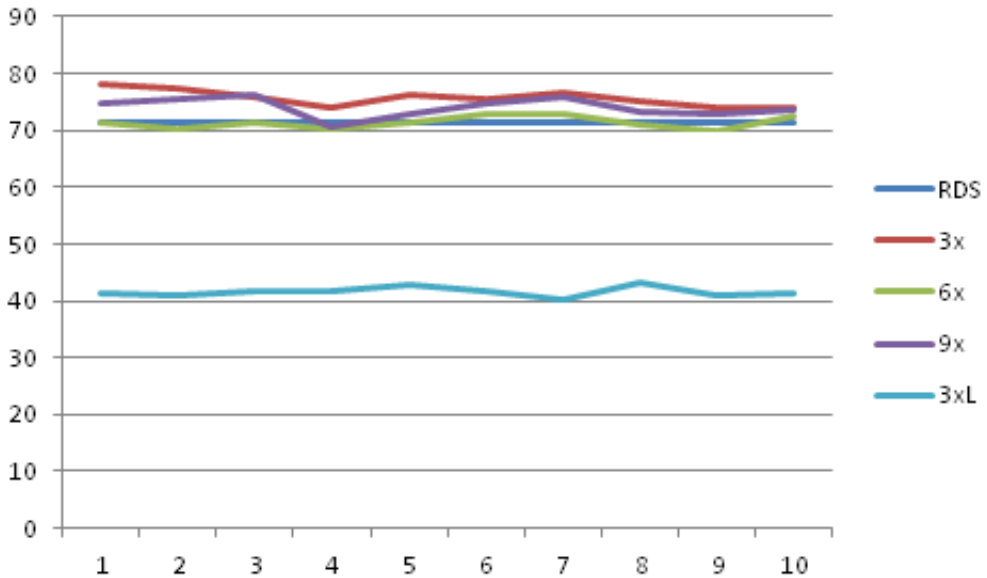


Figure : duration of the *distance* query.

Select Maximum Distance

- Second less expensive query.

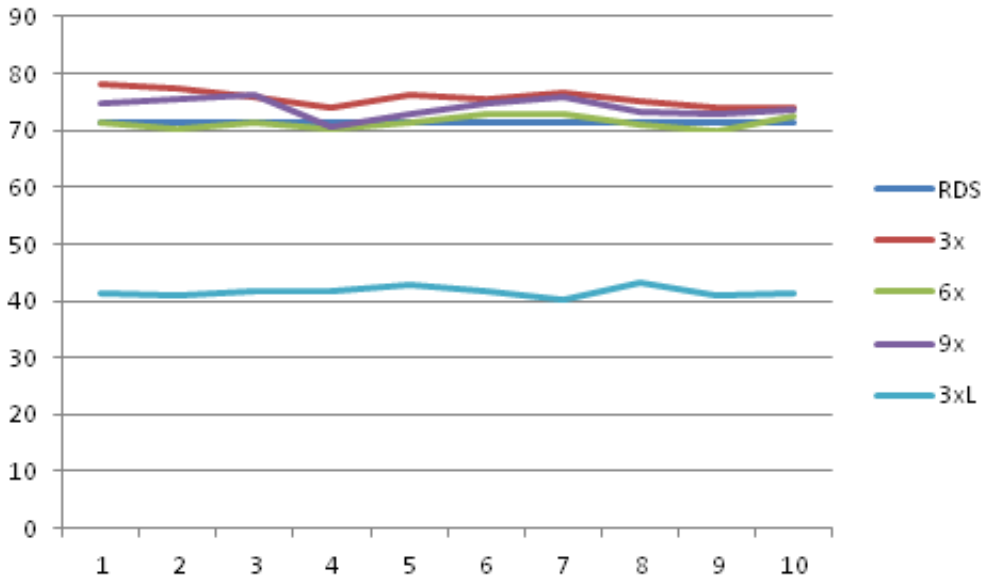
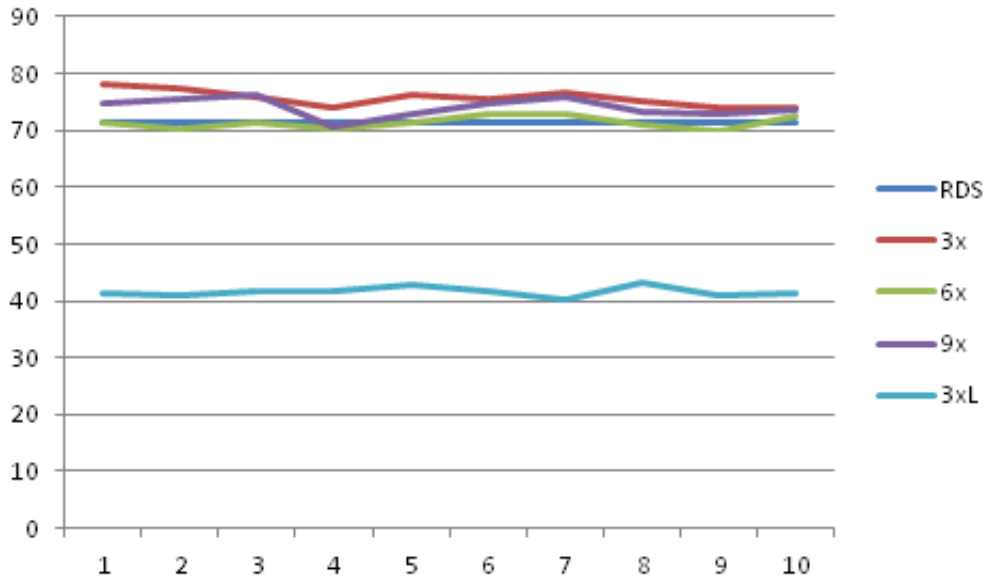


Figure : duration of the *distance* query.

Select Maximum Distance

- Second less expensive query.
- RDS performs better than the smaller cluster (EMRx3).



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Costs

- The costs bellow were calculated using the AWS calculator.
- Since all the queries were completed in less than 1 hour, we used the cost of 1h/mnth.

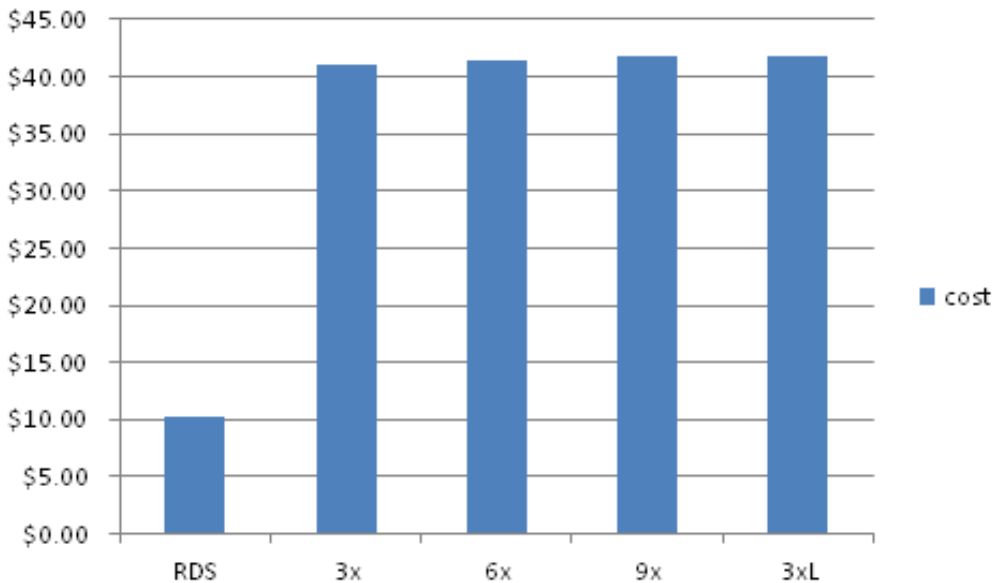
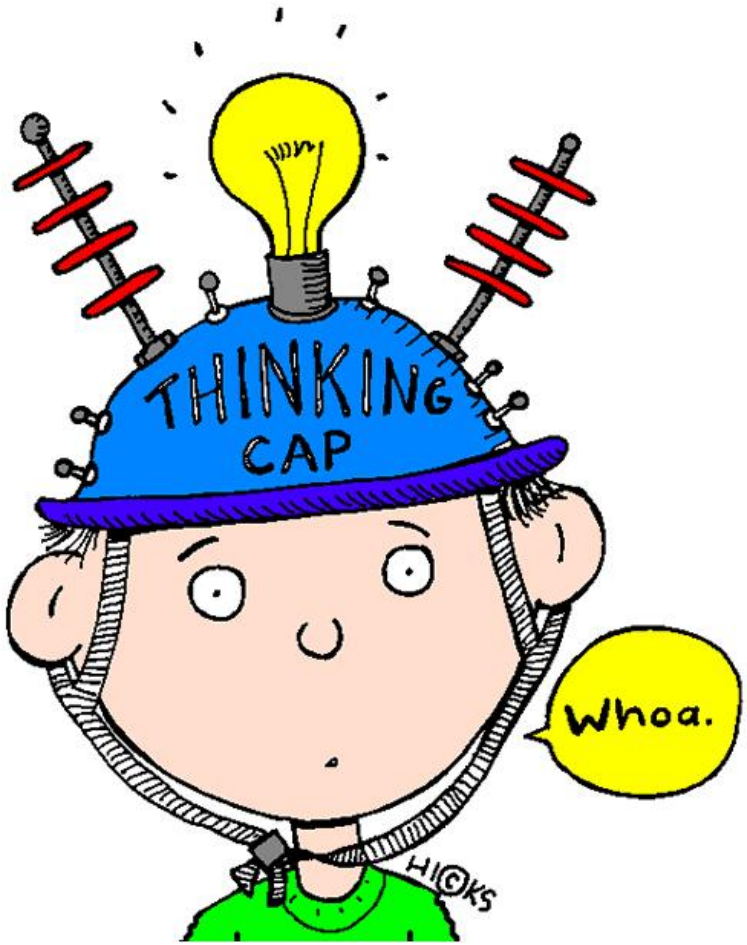


Figure : Cost in dollars, for deploying each benchmarking environment in AWS.

Time for Some Conclusions?



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- Price-wise, RDS and EMRx3Large are good deals.
- On the context of this benchmarking, the cluster with more nodes (EMRx9) seems like a waste of money.
- These disruptive results enforce the urge to do more benchmarkings, with larger sample sizes, and to review the code from SFH.

References

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