Toronto Apache Spark

Spark & Scala vs The Rest

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AGENDA

- Review of the challenge: Air Pollution in Canada
- Review of various implementations:
  Relational, Java MR, Pig, Hive, R, Spark
- Live Demo of the Spark Solution
  - Standalone Scala app
  - Interactive scala script
- Why Spark? Why Scala?
- Code & Presentation: https://github.com/NeuroNex/UG/tree/master/HadoopLab

ABOUT ME

- Big Data Engineer
- Data Science Certified
  (completed Coursera Data Science Specialization with Distinction)
- Hadoop Lead Dev (contract) @ Major Canadian Bank
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- LinkedIn: http://ca.linkedin.com/in/princecharmant

THE CHALLENGE

QUESTION

- Rank Canadian cities by air pollution level

HOW?

- Get public dataset from National Air Pollution Surveillance (NAPS)
- Use Ozone measures to judge general air pollution level
  (more Ozone = more Pollution)

THE DATASET

NAPS Data Products: http://maps-cartes.ec.gc.ca/rnspa-naps/data.aspx?lang=en

NAPS Stations (100K, 709 records)

```
StationID,STATION_NAME,Type,Status,TOXIC,Designated,PROVINCE,ADDRESS,CITY,COUNTRY,FSA, etc...
20101,56 FITZROY ST.,C,0,,P,PRINCE EDWARD ISLAND,56 FITZROY ST.,CHARLOTTETOWN,CANADA, etc...
30116,HALIFAX CITY HALL,C,0,,P,NOVA SCOTIA,BARRINGTON & DUKE,HALIFAX,CANADA, etc...
50102,JARDIN BOTANIQUE,R,0,,P,QUEBEC,BOUL. ROSEMONT,MONTREAL,CANADA,H1X,H1X, etc...
60419,CN TOWER,C,0,,N,ONTARIO,CN TOWER,TORONTO,CANADA,M5H,,-5,43.65,-79.38333, etc...
```

Ozone measurements (10MB, 74064 records for 2012)

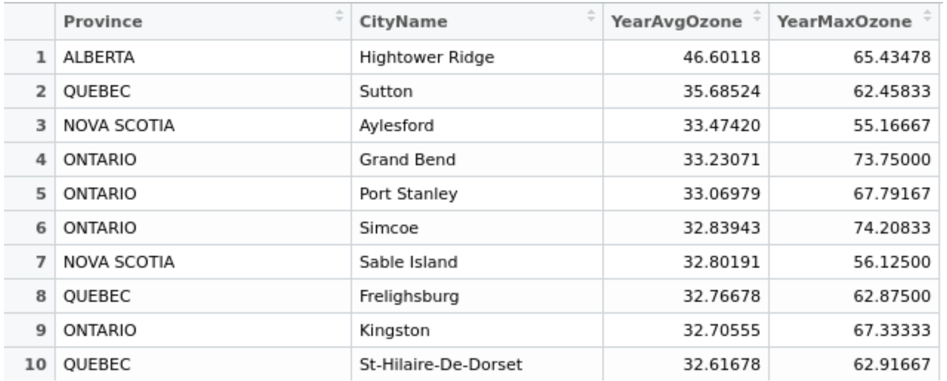
```
PC Stat  YYYYMMDD AVG MIN MAX H01 H02 H03 H04 H05 H06 H07 H08  ...  H20 H21 H22 H23 H24
00701010220120101  27  17  36  17  21  22  29  28  30  31  32  ...   29  33  33  34  33
00701010220120102  30  25  37  33  33  32  31  27  29  29  29  ...   33  34  35  37  36
00706440120120207-999  28  32  32  31  29  28  28  28  31  30  ... -999-999-999-999-999
00706410120120925   9   3  19  11  11  10   7   7   6   3   4  ...   10  11  10   9   8
```

SOLUTION DESIGN

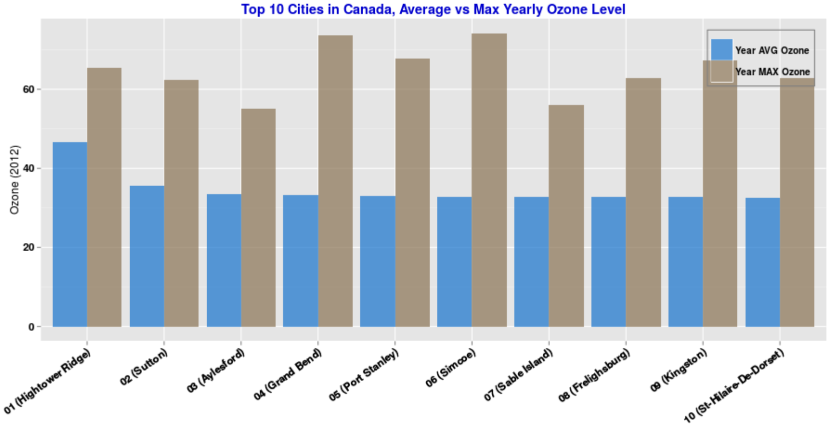
- Per StationID, Per day: Calculate Average, Min, Max (row-wise aggregate)
- JOIN: Ozone Measures, Station on StationID
- GROUP BY Province, City: Calculate AverageOzone, MaxOzone (entire year)
- ORDER BY AverageOzone DESC, MaxOzone DESC
- Save results to CSV

```
PC Stat  YYYYMMDD AVG MIN MAX H01 H02 H03 H04 H05 H06 H07 H08  ...  H20 H21 H22 H23 H24
00701010220120101  27  17  36  17  21  22  29  28  30  31  32  ...   29  33  33  34  33
00701010220120102  30  25  37  33  33  32  31  27  29  29  29  ...   33  34  35  37  36
00706440120120207-999  28  32  32  31  29  28  28  28  31  30  ... -999-999-999-999-999
00706410120120925   9   3  19  11  11  10   7   7   6   3   4  ...   10  11  10   9   8
```

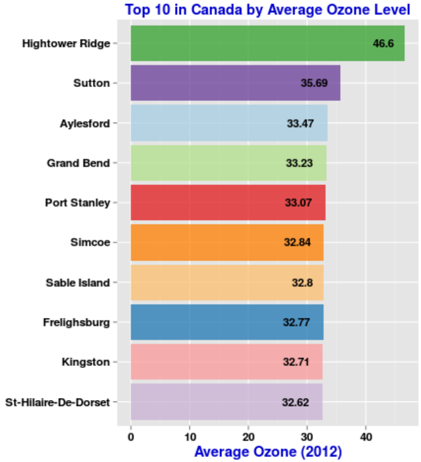
EXAMPLE OF RESULTS (by R)



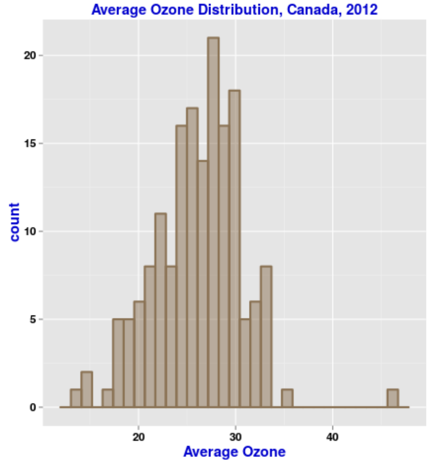
	Province	CityName	YearAvgOzone	YearMaxOzone
1	ALBERTA	Hightower Ridge	46.60118	65.43478
2	QUEBEC	Sutton	35.68524	62.45833
3	NOVA SCOTIA	Aylesford	33.47420	55.16667
4	ONTARIO	Grand Bend	33.23071	73.75000
5	ONTARIO	Port Stanley	33.06979	67.79167
6	ONTARIO	Simcoe	32.83943	74.20833
7	NOVA SCOTIA	Sable Island	32.80191	56.12500
8	QUEBEC	Frelighsburg	32.76678	62.87500
9	ONTARIO	Kingston	32.70555	67.33333
10	QUEBEC	St-Hilaire-De-Dorset	32.61678	62.91667



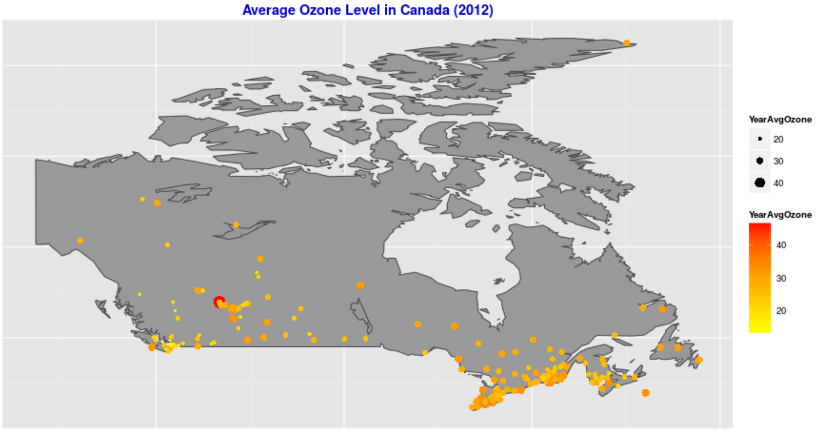
Top 10 Cities in Canada, Average vs Max Yearly Ozone Level



Top 10 in Canada by Average Ozone Level



Average Ozone Distribution, Canada, 2012



Average Ozone Level in Canada (2012)

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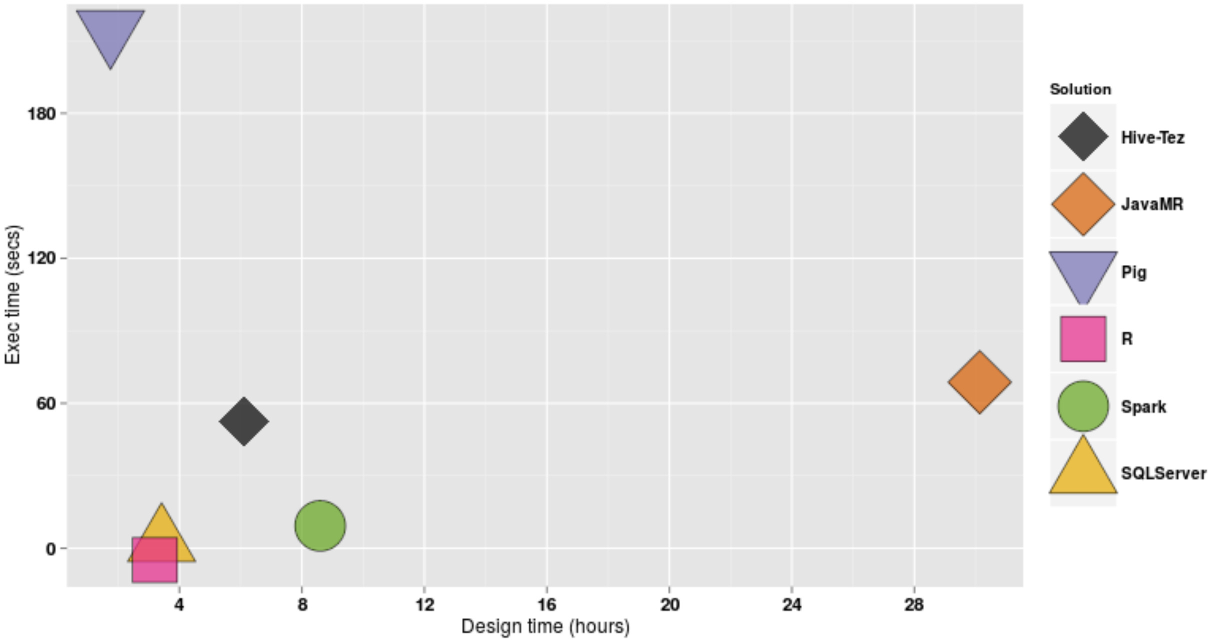
DESIGN COMPARISON

	SQLServer	Pig	Hive (TEZ)	Java MapRed	R	Spark
Exec Time	6 s	3 min 21 secs	60 s	70 s	**2 s**	9 s
Design Time	4 h	2 h	6 h	30 h	4 h	8 h



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WHY SPARK?

	Relational DB	Pig	Hive	Java MR	R	Spark
Programming API (fulfill custom Business Logic)	✓	✗	✗	✓	✓	✓
Big Data	✗	✓	✓	✓	✗	✓
DEV (Design, Maintenance)		💣		💣		
Computation Models: **Iterative**, **Graph**	✗	✗	✗	✗	✓	✓
Feature Extension	?	✗	✗	?(★)	∞	SparkSQL Streaming ML

(★) “*spark is already replacing mapreduce for most new applications. but mapreduce won't die*”
Doug Cutting, Cloudera Webinar Uniting Spark and Hadoop: The One Platform Initiative (2015-09-24)

NON-BIG DATA SOLUTIONS

- **SQLServer**, **R** are well adapted for single machine scenario
- When the data can fit in memory, **R** (and certainly **Python**) is very versatile and has many practical built-in features. The data analysis is done in 2 seconds with graphical reports. Before the Hive query finishes (60 seconds), R can geocode the locations in realtime and display the results on a map.
- **Relational**: extremely well integrated and supported in non-big data scenarios
- **Relational**: feature extensions are proprietary (vendor locked in). Sometimes designed for a niche usage (e.g. Data Quality Service in SQLServer). Lack the flexibility of NoSQL (e.g. handle JSON objects, schema on read, etc.)

BIG DATA SOLUTIONS

- **Spark** is the most attractive solution. It is generic and can accommodate almost any kind of infrastructure and application, from ETL to very advanced analysis. Spark is steadily evolving and becoming an ecosystem by itself.

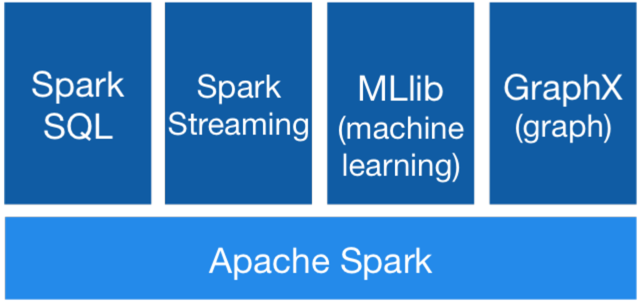
- **Java MapReduce** is limited in functionalities and very costly in design and maintenance. New Hadoop applications are transitioning to using Spark instead of MR as execution engine.
  (Pig, Hive on Spark are in beta as of 2015)

- **Pig** and **Hive** don't have a programming API. OK for batch reporting on immutable data. But would have difficulties to accommodate custom business rules. Example: invoke a web service, geocode the location, then rank pollution by latitude (instead of by City).

WHAT IS SPARK?

- Fast and General engine for large-scale data processing
  - Combine SQL, streaming, and complex analytics
  - Multiples computing models: MR, Iterative, Graph
- Java, Scala, Python, R
- Access data on: HDFS, S3, Tachyon, HBase, Cassandra, JDBC, etc.
- Run on: Hadoop, Mesos, Standalone, Cloud

[Apache Spark Web Site]



Spark SQL

Spark Streaming

MLlib (machine learning)

GraphX (graph)

Apache Spark

WHAT IS SCALA?

- Quick Intro (scala-lang.org)
- More developed intro (Wikipedia)
- Scalable (**SCA**le **LA**nguage)
- Address shortcomings of Java while still 100% compatible Java bytecode
- Full interoperability with Java
- Expressive syntax (more concise, less verbose)
- Object Oriented
- Functional
- Adoption: Spark, Twitter (Kafka, Samza), Apache Ignite

IS SCALA SIMPLE OR COMPLEX?

- Minimal Syntax != Simple
  - lots of simplifications done behind the scene to simplify developer task:
    implicit class, type inference
  - Need to be aware of too much automation Scala compiler cannot always guess what you want.
- Support both OO & Functional paradigms == ++Complexity
- High Learning curve but worth the investment
- IDE support for Scala is not (yet) as convenient as for other languages

WHY SCALA?

- Scala vs Java: How-to: Run a Simple Apache Spark App in CDH 5
  - Scala: 25 lines
  - Java : 75 lines
- Why Should I Learn Scala?
- What do you think about the Scala programming language?

LEARNING

- Book: Learning Spark
- Scala Documentation (scala-lang.org): Docs, FAQ, Tutorials, Tour
- Apache: Scala API, Spark API, Spark Programming Guides
- Communities: StackOverflow, Databricks forum

ONLINE COURSES

- Udemy: Introduction to **Apache Spark** for Developers and Engineers (Scala)
- edX: Introduction to Big Data with **Apache Spark** (Python)
- UC Berkeley: AMPCamp Big Data Bootcamp

REVISION HISTORY

- 2015-09-30: initial release, Toronto Apache Spark Meetup
- 2015-10-04: add comments on the benchmark comparing solution designs.
  (highlight Strength/Weakness of each solution)