Simba: Efficient In-Memory Spatial Analytics.

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SIGMOD'16.

Andres Calderon

November 9, 2016

Agenda

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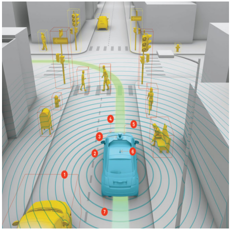
Introduction

- There has been an explosion in the amount of spatial data in recent years...



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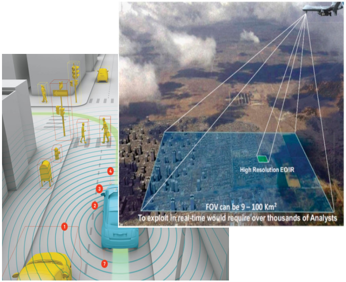

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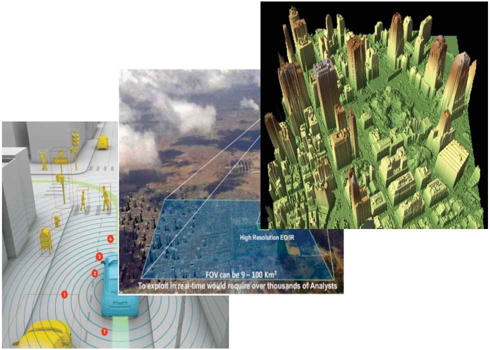

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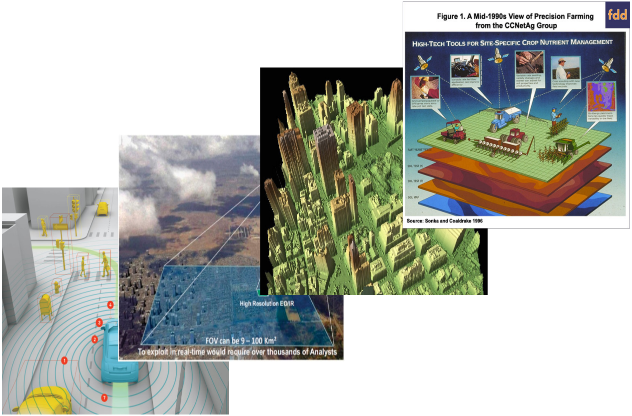

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- The applications and commercial interest is clear...

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- But remember that "Spatial is Special"...

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PostGIS
Spatial PostgreSQL
ORACLE SPATIAL
ArcGIS
ESRI
MySQL
Microsoft SQL Server

Hadoop-GIS
Spatial Big Data Solutions
MD-Hbase
Spatial Hadoop
I can play with your spatial data
SECONDO
geomesa

GeoSpark
GeoTrellis
Spark SQL
SpatialSpark
MEMSQL

Introduction

- Why do we need a new tool???

Introduction

- Problems of Existing Systems...
  - Single node database (low scalability)
    ArcGIS, PostGIS, Oracle Spatial.
  - Disk-oriented cluster computation (low performance)
    Hadoop-GIS, SpatialHadoop, GeoMesa.
  - No native support for spatial operators
    Spark SQL, MemSQL
  - No sophisticated query planner and optimizer
    SpatialSpark, GeoSpark

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- Simba: **S**patial **I**n **M**emory **B**ig data **A**nalytics.
  1. Extends Spark SQL to support spatial queries and offers simple APIs for both SQL and DataFrame.
  2. Support two-layer spatial indexing over RDDs (low latency).
  3. Designs a SQL context to run important spatial operations in parallel (high throughput).
  4. Introduces spatial-aware and cost-based optimizations to select good spatial plans.

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Core Features	Simba	GeoSpark	SpatialSpark	SpatialHadoop	Hadoop GIS
Data dimensions	multiple	$d \leq 2$	$d \leq 2$	$d \leq 2$	$d \leq 2$
SQL	✓	×	×	Pigeon	×
DataFrame API	✓	×	×	×	×
Spatial indexing	R-tree	R-/quad-tree	grid/kd-tree	grid/R-tree	SATO
In-memory	✓	✓	✓	×	×
Query planner	✓	×	×	✓	×
Query optimizer	✓	×	×	×	×
Concurrent query execution	thread pool in query engine	user-level process	user-level process	user-level process	user-level process
query operation support					
Box range query	✓	✓	✓	✓	✓
Circle range query	✓	✓	✓	×	×
k nearest neighbor	✓	✓	only 1NN	✓	×
Distance join	✓	✓	✓	via spatial join	✓
kNN join	✓	×	×	×	×
Geometric object	×[1]	✓	✓	✓	✓
Compound query	✓	×	×	✓	×

Table 1: Comparing Simba against other systems.

Agenda

1. Background
2. Simba Architecture Overview
   - Programming Interface
   - Indexing
   - Spatial Operations
   - Optimization
3. Experiments
4. Conclusions

Spark SQL Overview

Spark SQL is Apache Spark's module for working with structured data.

- Seamlessly mixes SQL queries with Spark programs.
- Connects to any data source the same way.
- Includes a highly extensible cost-based optimizer (*Catalyst*).
- Spark SQL is a full-fledged query engine based on the underlying Spark core.

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Spark SQL Overview

```
# Apply functions to results of SQL queries.
context = HiveContext(sc)
results = context.sql("""
                        SELECT
                                *
                        FROM
                                people""")
names = results.map(lambda p: p.name)
# Query and join different data sources.
context.jsonFile("s3n://...").registerTempTable("json")
results = context.sql("""
                        SELECT
                              *
                        FROM
                              people
                        JOIN
                              json ...""")
```

Simba Architecture

Simba is an extension of Spark SQL across the system stack.

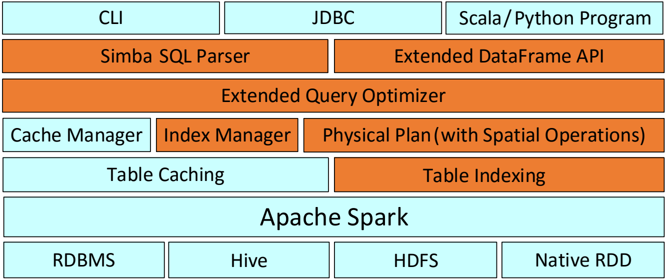

Figure 1: Simba architecture.

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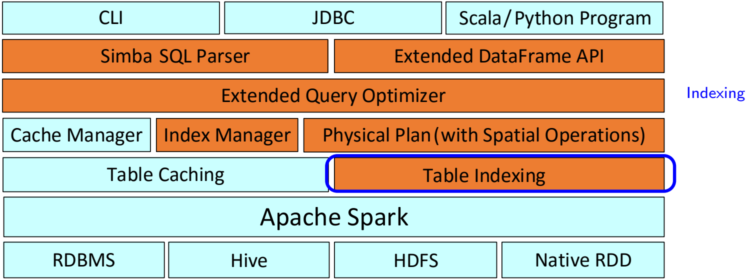

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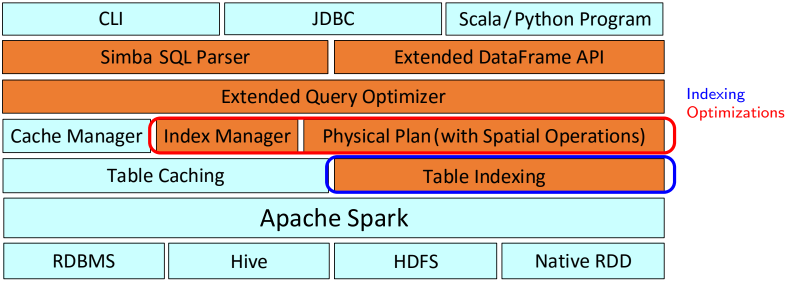

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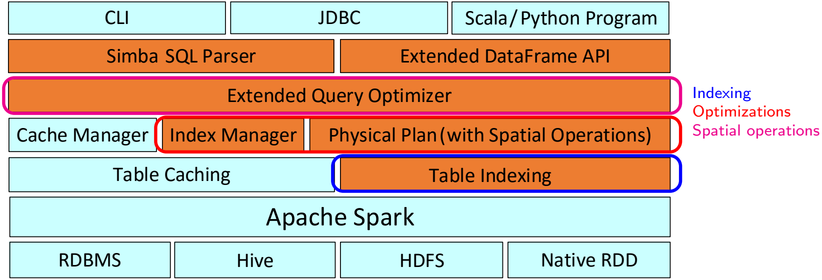

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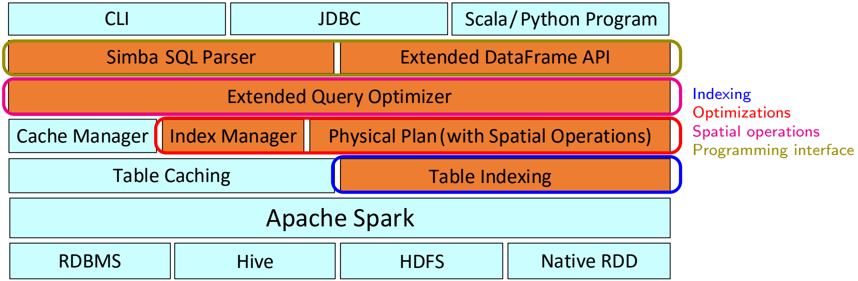

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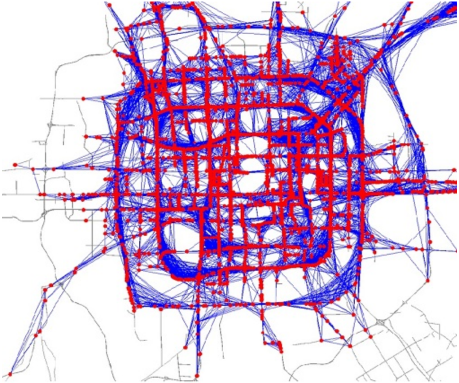
Setup

- Cluster of 25 nodes:
  - HDD from 50GB to 200GB.
  - RAM from 2GB to 8GB.
  - Processors 2.2GHz to 3GHz
- Single machine:
  - HDD 2TB.
  - RAM 16GB.
  - Processor 3.4GHz.

Datasets

- Real datasets (from OpenStreetMap):
  - OSM1: 164M polygons, 80GB.
  - OSM2: 1.7B points, 52GB.
- Synthetic dataset:
  - SYNTH: 3.8B points, 128GB.
  - Five different distributions.



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Conclusions

- This paper introduced CG_Hadoop as a scalable and efficient MapReduce library.
- Focused on 5 fundamental computational geometry problems...
  - Polygon union, Skyline, Convex hull, Farthest and Closest Pairs.
- Provided versions for Apache Hadoop and SpatialHadoop systems.
- Distributed approach speed up performance.
- Spatial partitioning allows early pruning which make it even more efficient.
- Achieve up to 29x and 260x better performance.

Future ideas

- Working on more complex operations, for example motion patterns.
- Explore ports to new distributed platforms such as Spark or Simba.

Thank you!!!

Do you have any question?