Performance Improvements in Apache Spark 2.0

Whole-stage code generation and vectorization

Markus Dale, Databricks
(http://tinyurl.com/markus-spark-2-0)

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What's in Apache Spark 2.0.0?

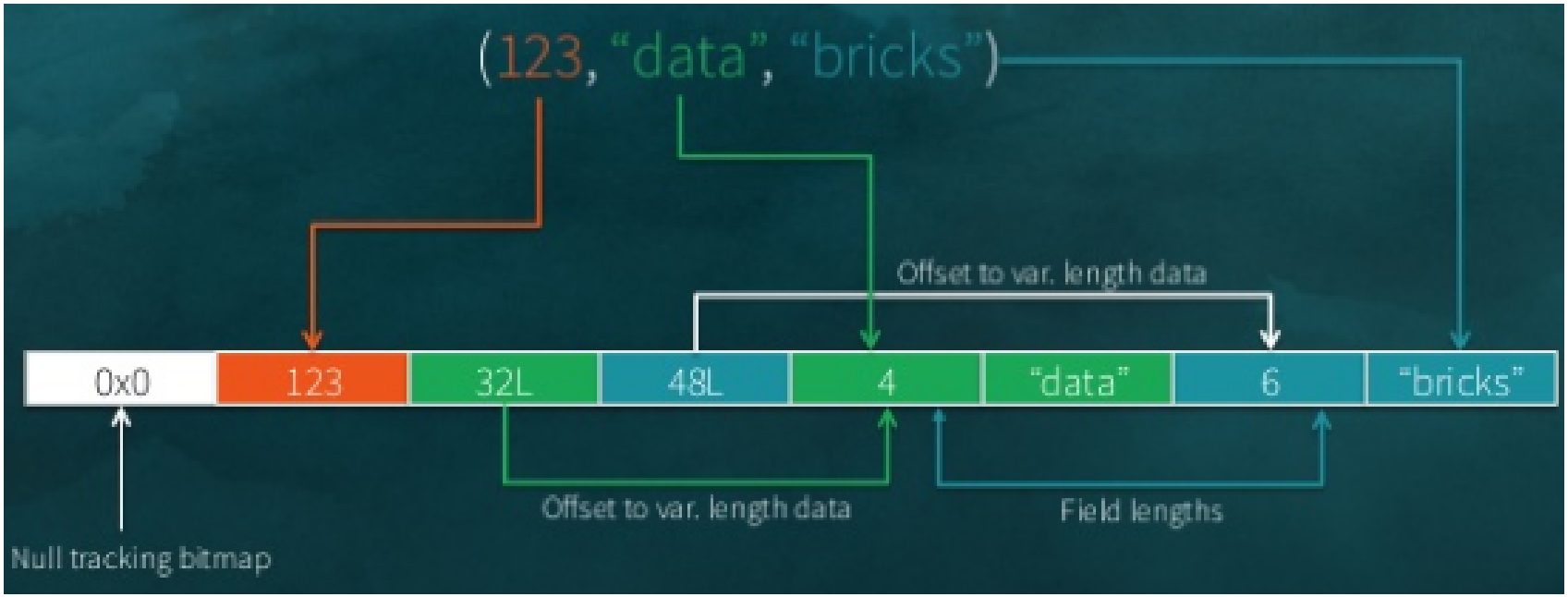
- Over 2,000 JIRA tickets
- Some ticket titles:
  - (Dataset-oriented) API evolution in Spark 2.0
  - Create a full-fledged built-in SQL parser
  - Add support for off-heap caching
  - Model export/import for Pipeline API
  - Whole stage codegen
  - Vectorize parquet decoding using ColumnarBatch

Project Tungsten - Closer to bare metal

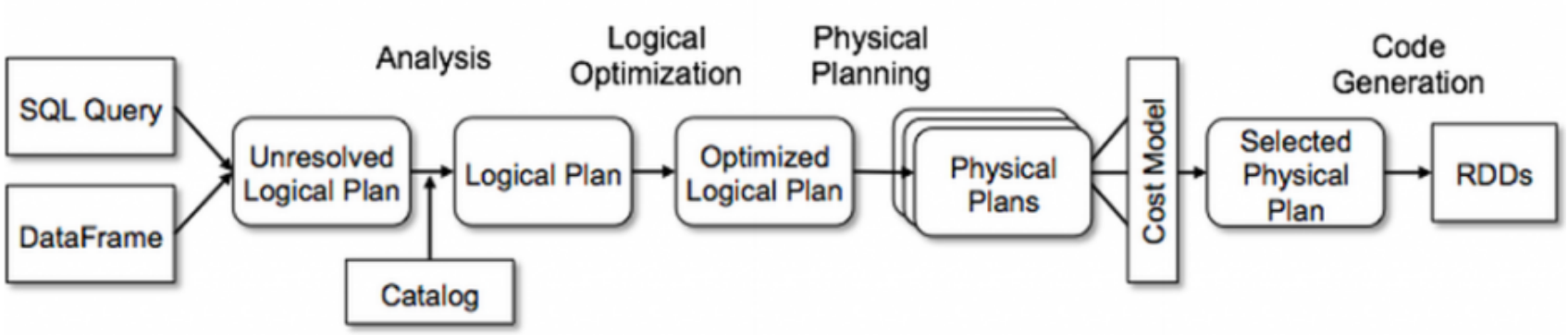
- Apache Spark 1.3 introduced DataFrames/Catalyst Optimizer
- Tungsten 1.0:
  - Memory management and binary processing
  - Code generation for expression evaluation
  - See Project Tungsten: Bringing Apache Spark Closer to Bare Metal, Xin and Rosen (2015)

Tungsten Binary Format

- Spark 1.5



Catalyst Optimizer



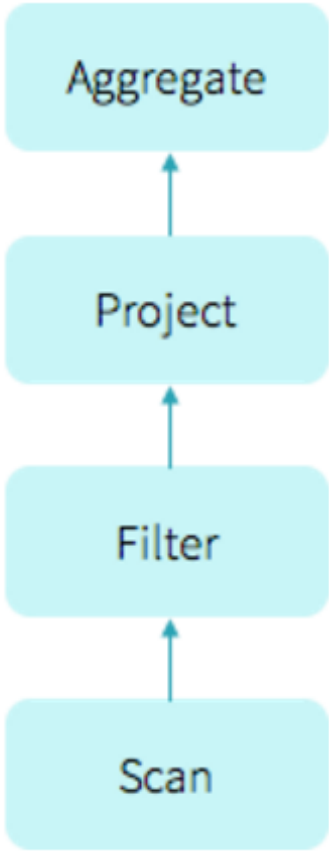
See Databricks Catalyst Optimizer blog entry, Armbrust et al. (2015)

Project Tungsten 2.0 - reduce CPU bottlenecks

- virtual function calls
- reading or writing intermediate data to CPU cache or memory

Simple aggregate query with filter

```
select count(*) from store_sales
where ss_item_sk = 1000
```



Pre-2.0 Apache Spark: Volcano Iterator Model

```
class Filter(child: Operator, predicate: (Row => Boolean))
  extends Operator {
  def next(): Row = {
    var current = child.next()
    while (current == null || predicate(current)) {
      current = child.next()
    }
    return current
  }
}
```

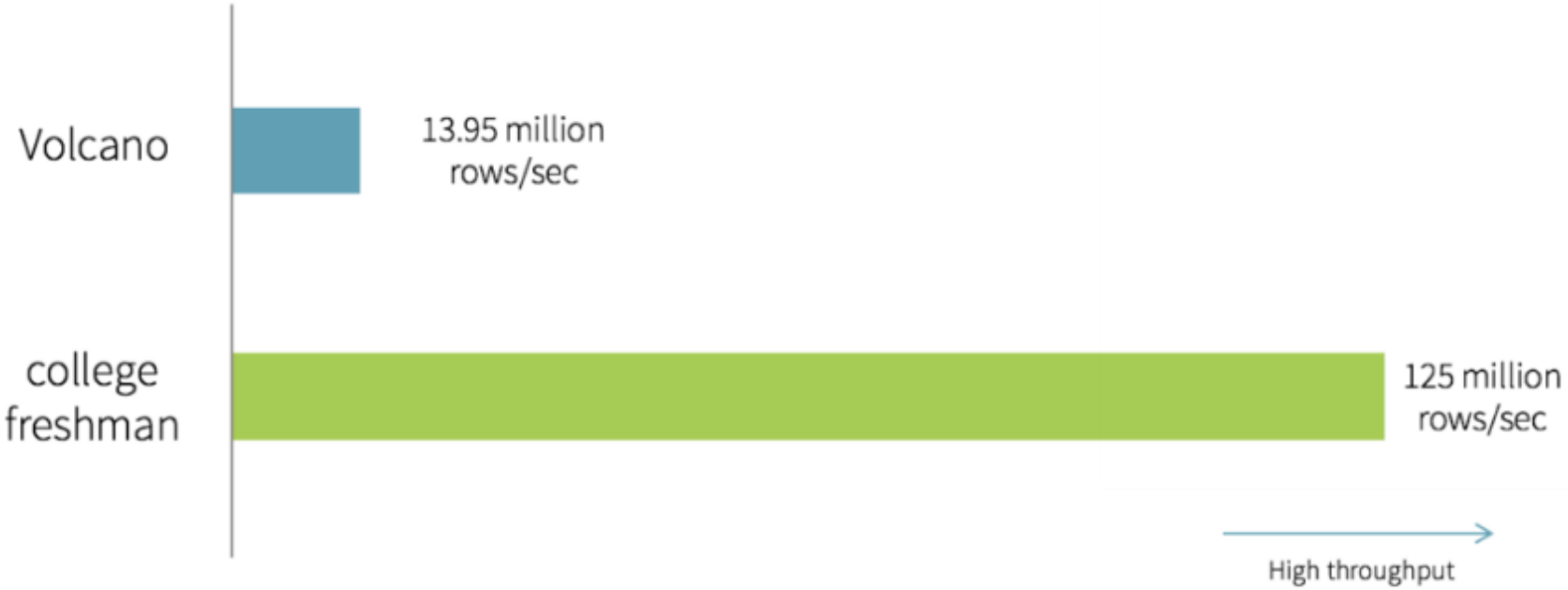
See Graefe (1994)

Handwritten Code

```
var count = 0
for (ss_item_sk in store_sales) {
    if (ss_item_sk == 1000) {
        count += 1
    }
}
```

Handwritten vs. Volcano

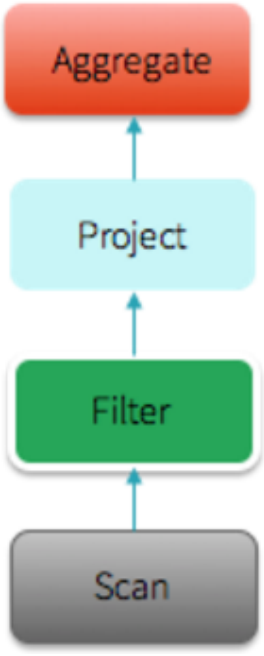
- Single threaded data from Parquet on disk



Whole-Stage Code Generation Benefits

- No virtual function dispatches
- Intermediate data in CPU registers
- Loop unrolling and SIMD

Whole-Stage Code Generation Example



```
long count = 0;
for (ss_item_sk in store_sales) {
  if (ss_item_sk == 1000) {
    count += 1;
  }
}
```

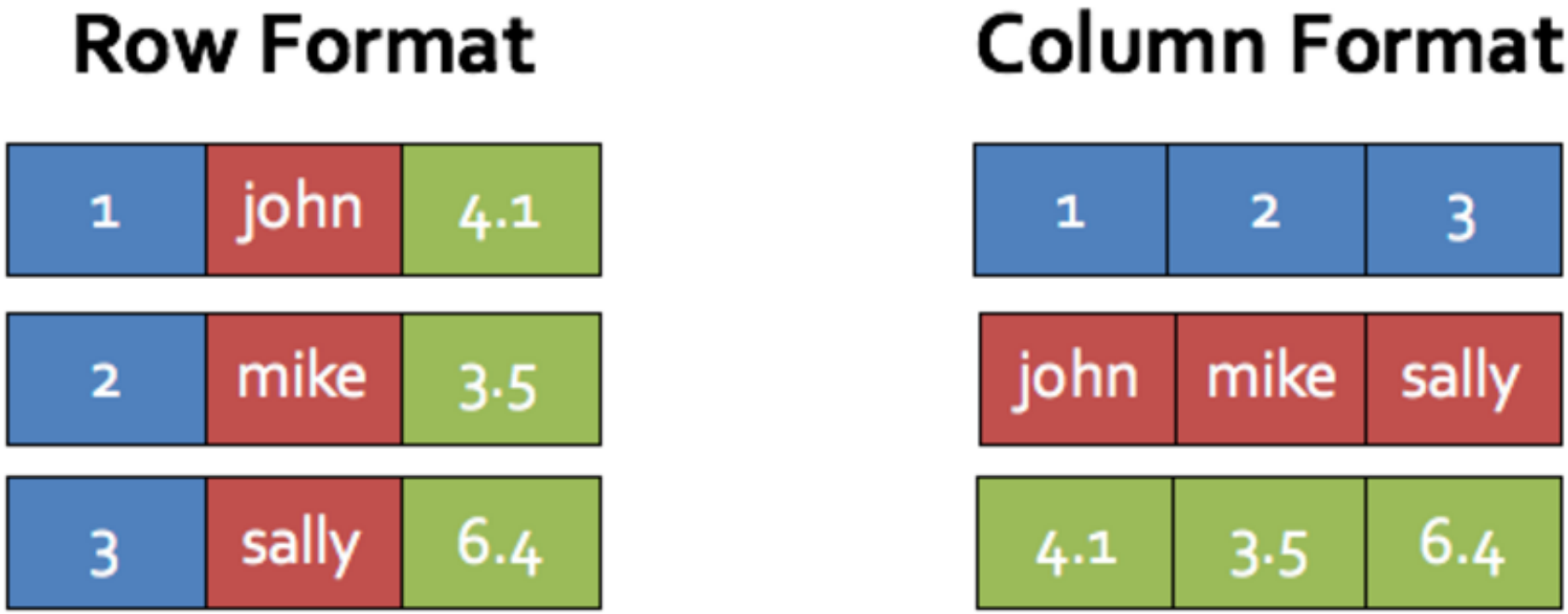
See Whole-Stage Code Generation with explain()

```
spark.range(1000).
   filter("id > 100").
   selectExpr("sum(id)").explain()

== Physical Plan ==
*Aggregate(functions=[sum(id#201L)])
+- Exchange SinglePartition, None
   +- *Aggregate(functions=[sum(id#201L)])
      +- *Filter (id#201L > 100)
         +- *Range 0, 1, 3, 1000, [id#201L]
```

Vectorization

- Use if unable to do whole-stage codegen
- Each "next" call runs operator on batched column value



Demo

- SparkSession
- 1.6 vs. 2.0 TSV file
- ETL to Parquet
- 1.6 vs. 2.0 on Parquet file
- See `http://tinyurl.com/markus-spark-2-0` and then src (or https://github.com/medale/presentations/tree/master/spark-performance-2.0-2016-06/src) for notebooks
- `https://databricks.com/try-databricks` - Databricks Community Edition

References I

Armbrust, Michael, Yin Huai, Cheng Liang, Reynold S. Xin, and Matei Zaharia. 2015. "Deep Dive into Spark SQL's Catalyst Optimizer." `https://databricks.com/blog/2015/04/13/deep-dive-into-spark-sqls-catalyst-optimizer.html`.

Graefe, G. 1994. "Volcano-an Extensible and Parallel Query Evaluation System." *IEEE Transactions on Knowledge and Data Engineering* 6 (1) (February): 120–135. doi:10.1109/69.273032.

Xin, Reynold S., and Josh Rosen. 2015. "Project Tungsten - Bringing Apache Spark Closer to Bare Metal." `https://databricks.com/blog/2015/04/28/project-tungsten-bringing-spark-closer-to-bare-metal.html`.