Hoodie

How (and Why) Uber built an Analytical datastore On Spark

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What’s our problem?

Queryable State for Analytics

Analytics == Big Scans

- Super fast scans on subset of columns
- Large time ranges - Lots of data

Queryable state == mutations

- Pure Dimension Table e.g. Users
- Fact Tables that can get super large and needs a materialized view e.g. Trips
- Late Arriving Data
  - Event time vs Processing time
- Delete records (Compliance)
- Data correction upstream

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Okay, so what did we want?

OLAP Database

- **Scale and complexity**
  - Scale horizontally [Petabytes]
  - Support Nested columns
  - Batch ingest and Analytical scans
- **Latency**
  - Ingest Latency ~ 10 minutes
  - Query Latency ~ upto 2 minutes
- **Multi tenant - High throughput**
- **Transactional - ACID**
- **Self Healing**
  - Less tunable knobs
  - Handle data skew
  - Auto scale with load
  - Failure Recovery
  - Rollback and Savepoints

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Okay, Could you do ...?

Solutions that did not work for us

- **OLAP RDBMS**
  - Petabyte scale
  - Elastic scaling of compute
- **No/New SQL (LSM)**
  - Scan performance
  - Operations involved - Compaction
- **Hack around it**
  - Dump LSM Snapshot
  - Rewrite partitions too costly
  - Watermark - Approximations
- **Hive Transactions**
  - Hive specific solution
  - Hash bucketing - tuning?
- **Apache Kudu**
  - Separate storage server
  - Eco system support

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Let's design what we want.
We have 20 minutes.

“Software Engineer engineers the illusion of simplicity”

Grady Booch, UML Creator

Pick the area in RUM triangle

Design choices

- **RUM Conjecture**
  - Optimize 2 at the expense of the third
- **Fast data - Write Optimized**
  - Control Read Amplification
  - Query execution cost
- **Fast Scans - Read Optimized**
  - Control Write Amplification
  - Ingestion cost
- **Choice per client/query**

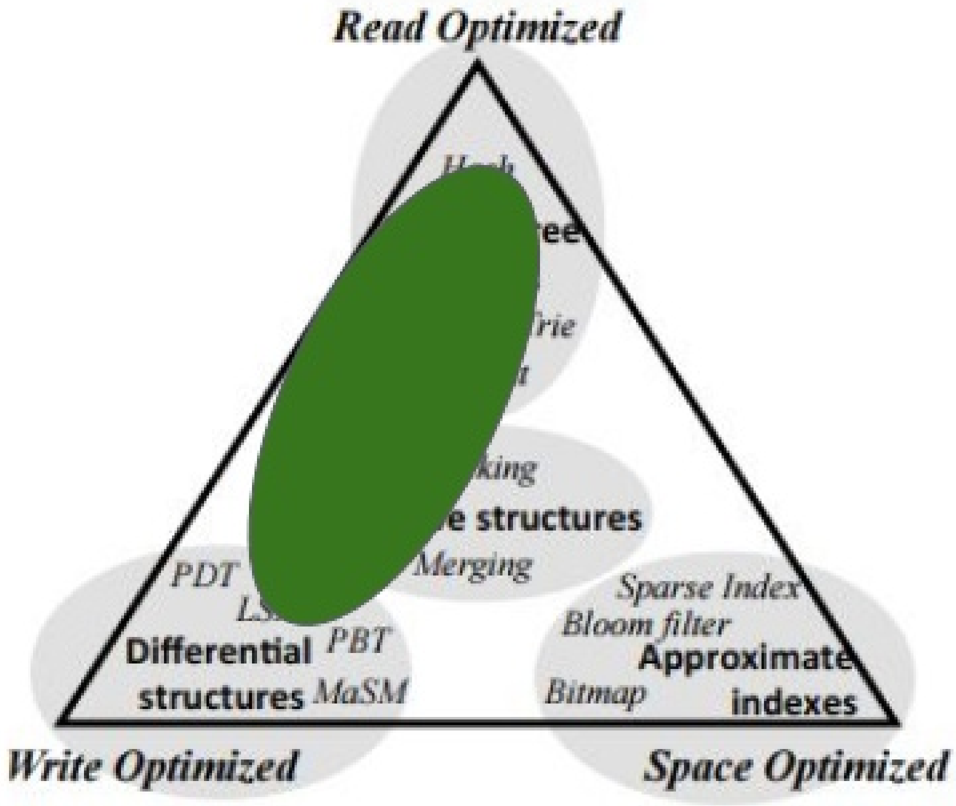

Figure 1: Popular data structures in the RUM space.

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Pick Framework

Leveraging Spark's Elasticity + Scalability + Speed

- **Spark + DFS vs Storage Server**
  - **Batch engine vs MPP engine**
    - Throughput vs Latency
    - Flexibility to go batch or streaming
    - Dynamic Resource Allocation
  - **Complexity**
    - Static Partitioning
    - Dedicated resources
    - Consensus
  - **Scaling**
    - Auto Scaling with load using Spark
  - **Resiliency and Recovery (RDD)**
    - Simplify Application Abstraction
    - Self Healing
  - **Simplified API Layer**

Correctness - ACID

Design choices

- **Atomic ingest of a batch**
  - Based on Processing time
  - Cross row atomicity
- **Strong consistency**
- **Single Writer | Multiple Reader**
- **High query concurrency**
  - Query Isolation using Snapshot
- **Time travel**
  - Temporal queries

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Storage

Design choices

- **Hybrid Storage**
  - Row based - Recent data
  - Column based - Cold data
- **Compactor**
- **Insert vs Update during Ingest**
  - Need for Index
- **Ingest parallelism vs Query parallelism**
  - Max file size

Partitioning

Implementation choices

- **DFS - Directory Partitioning**
  - Coarse grained
  - Need finer grained
    - Hash Bucket
    - Auto create partition on insert

Introducing **Hoodie**

Hadoop **U**psert an**D** **I**ncrementals

https://github.com/uber/hoodie

https://eng.uber.com/hoodie

How do I ingest?

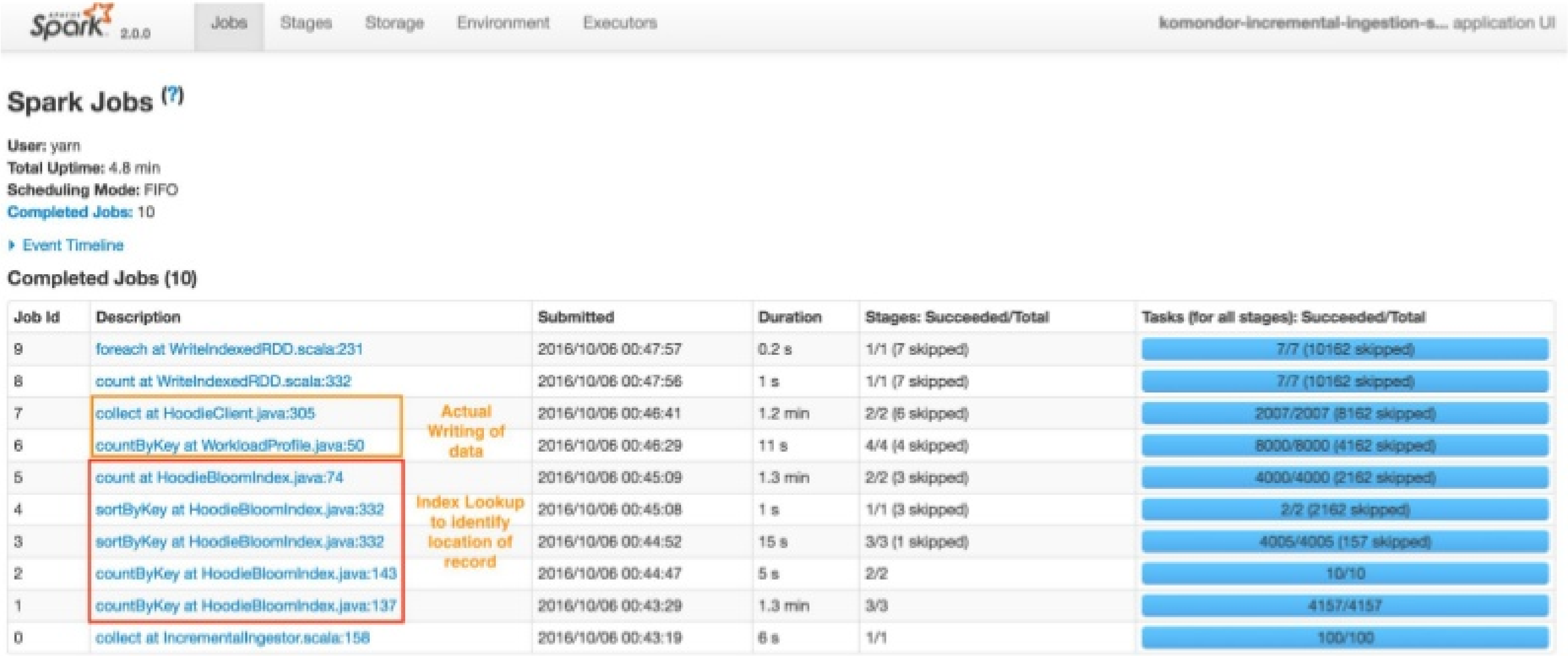
Show me the code !!!

```
HoodieWriteConfig cfg = HoodieWriteConfig.newBuilder()
             .withPath(path)
             .withSchema(schema)
             .withParallelism(500)
             .withIndexConfig(HoodieIndexConfig.newBuilder()
                   .withIndexType(HoodieIndex.IndexType.BLOOM).build())
             .withStorageConfig(HoodieStorageConfig.newBuilder()
                   .defaultStorage().build())
             .withCompactionConfig(HoodieCompactionConfig.newBuilder()
                   .withCompactionStrategy(new BoundedIOCompactionStrategy()).build())
             .build();

JavaRDD<HoodieRecord> inputRecords = … // input data
HoodieWriteClient client = new HoodieWriteClient(sc, cfg);
JavaRDD<WriteStatus> result = client. upsert(inputRecords, commitTime);
boolean toCommit = inspectResultFailures(result);
if(toCommit) {
      client.commit(commitTime, result);
} else {
      client.rollback(commitTime);
}
```

Spark DAG

How is that graph looking?



Spark Jobs (?)

User: yarn
Total Uptime: 4.8 min
Scheduling Mode: FIFO
Completed Jobs: 10

▸ Event Timeline

Completed Jobs (10)

Job Id	Description	Submitted	Duration	Stages: Succeeded/Total	Tasks (for all stages): Succeeded/Total
9	foreach at WriteIndexedRDD.scala:231	2016/10/06 00:47:57	0.2 s	1/1 (7 skipped)	7/7 (10162 skipped)
8	count at WriteIndexedRDD.scala:332	2016/10/06 00:47:56	1 s	1/1 (7 skipped)	7/7 (10162 skipped)
7	collect at HoodieClient.java:305	2016/10/06 00:46:41	1.2 min	2/2 (6 skipped)	2007/2007 (8162 skipped)
6	countByKey at WorkloadProfile.java:50	2016/10/06 00:46:29	11 s	4/4 (4 skipped)	8000/8000 (4162 skipped)
5	count at HoodieBloomIndex.java:74	2016/10/06 00:45:09	1.3 min	2/2 (3 skipped)	4000/4000 (2162 skipped)
4	sortByKey at HoodieBloomIndex.java:332	2016/10/06 00:45:08	1 s	1/1 (3 skipped)	2/2 (2162 skipped)
3	sortByKey at HoodieBloomIndex.java:332	2016/10/06 00:44:52	15 s	3/3 (1 skipped)	4005/4005 (157 skipped)
2	countByKey at HoodieBloomIndex.java:143	2016/10/06 00:44:47	5 s	2/2	10/10
1	countByKey at HoodieBloomIndex.java:137	2016/10/06 00:43:29	1.3 min	3/3	4157/4157
0	collect at IncrementalIngestor.scala:158	2016/10/06 00:43:19	6 s	1/1	100/100

Actual Writing of data

Index Lookup to identify location of record

Storage & Index

Implementation choices

Storage RDD

Every columnar file has one or more "redo" log

- **Row based Log Format - Apache Avro**
  - Append block
  - Rollback
- **Columnar Format - Apache Parquet**
  - Predicate pushdown
  - Columnar compression
  - Vectorized Reading

Index RDD - Insert vs Update during Ingest

- **Embedded**
  - Bloom Filter
- **External**
  - Key Value store

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Correctness

Implementation choices

- **Commit File on DFS**
  - Atomic rename to publish data
  - Consume from downstream Spark job
- **Query Isolation**
  - Multiple versions of data file
  - Query hook - InputFormat via SparkSQL

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Compaction

Implementation

- **Compaction**
  - Background Spark job
  - Lock log files
  - Minor
    - IO Bound Strategy
    - Improve Query Performance
  - Major
    - No log left behind

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How can I query?

Show me the code !!!

```
SparkSession spark = SparkSession.builder()
                  .appName("Hoodie SparkSQL")
                  .config("spark.sql.hive.convertMetastoreParquet", false)
                  . enableHiveSupport()
                  .getOrCreate();

// real time query
spark.sql("select fare, begin_lon, begin_lat, timestamp from  hoodie.trips_rt where fare
> 100.0").show();

// read optimized query
spark.sql("select fare, begin_lon, begin_lat, timestamp from  hoodie.trips_ro where fare
> 100.0").show();

// Spark Datasource (WIP)
Dataset<Row> dataset = sqlContext.read().format(HOODIE_SOURCE_NAME)
    .option("query", "SELECT driverUUID, riderUUID FROM trips").load();
```

Query

Design choices

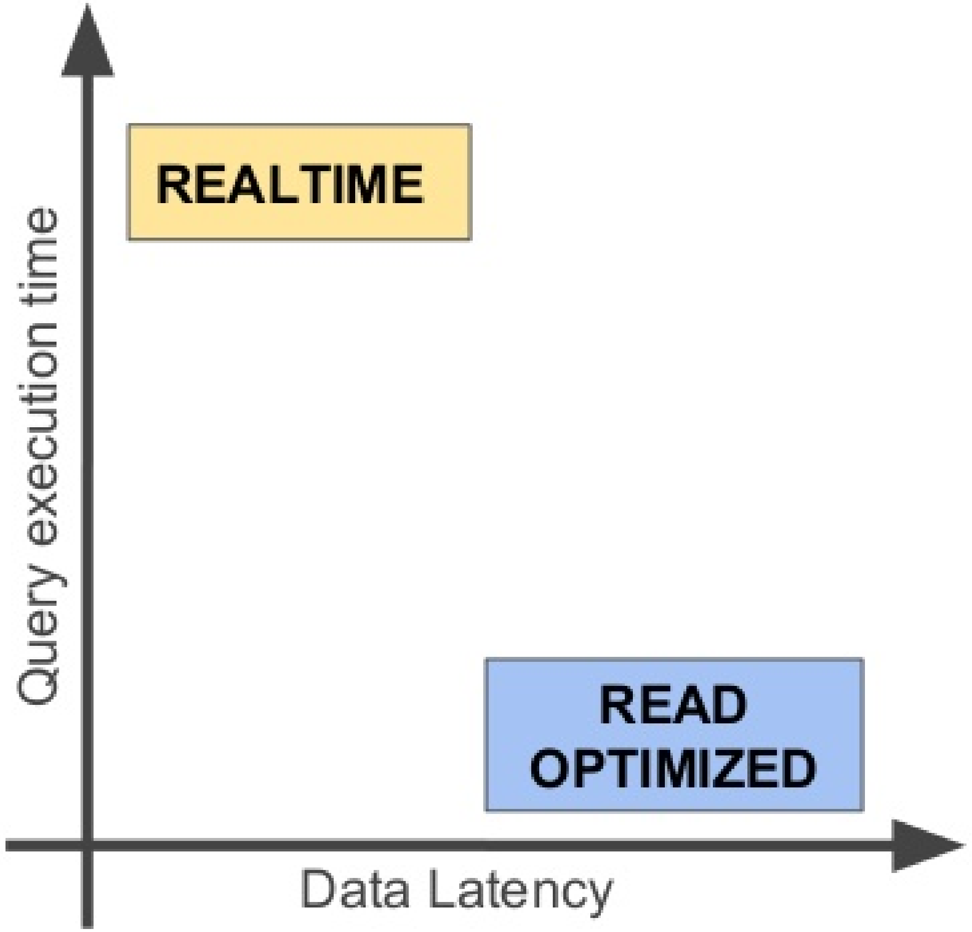
RUM Conjecture - Moving within the chosen area

Read Optimized View

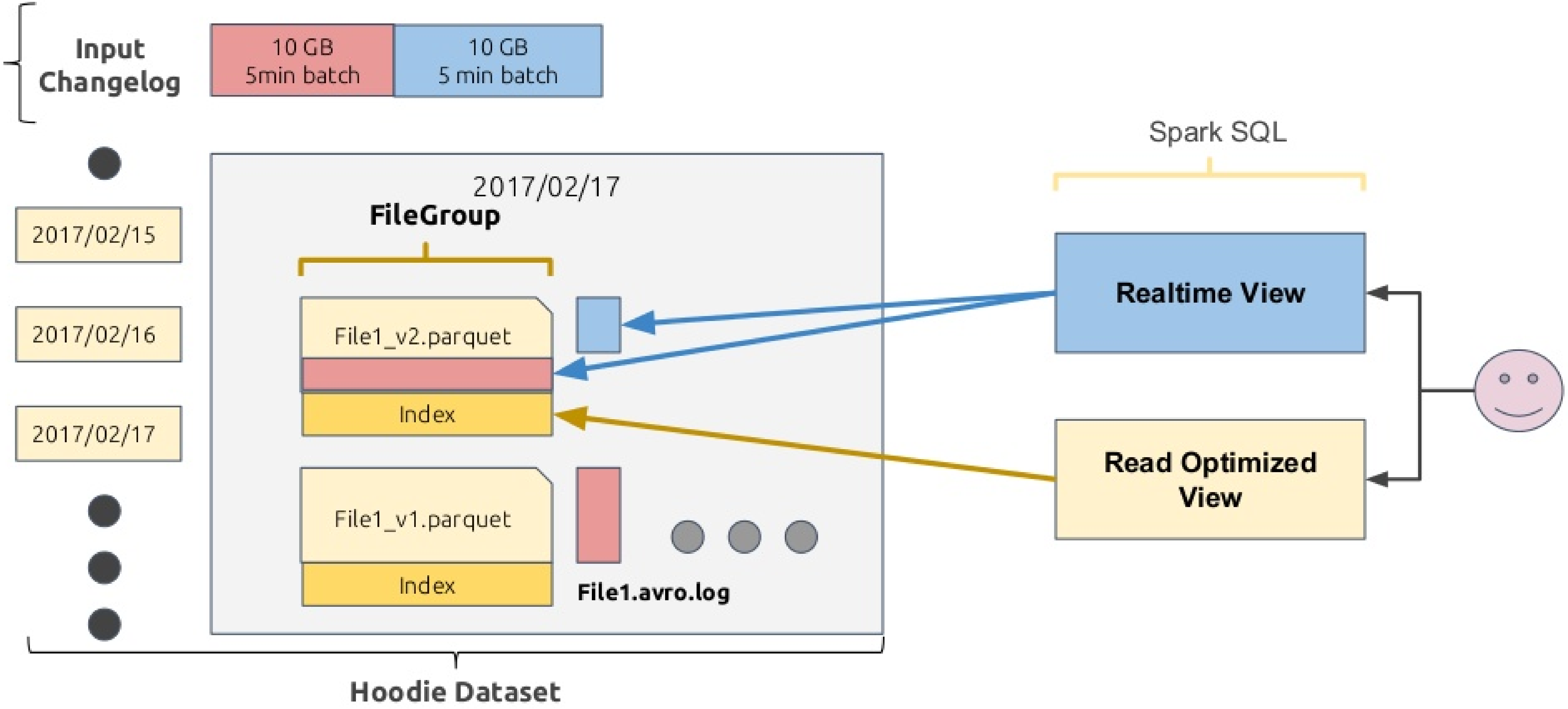
- Pick only columnar files for querying
- Raw Parquet Query Performance
- Freshness of Major Compaction

Real Time View

- Hybrid of row and columnar data
- Brings near-real time tables
- SparkSQL with convertMetaStore=false



Under The Hood



Community

Share love and code

Shopify evaluating for use

- Incremental DB ingestion onto GCS
- Early interest from multiple companies

Engage with us on Github (uber/hoodie)

- Look for “beginner-task” tagged issues
- Try out tools & utilities

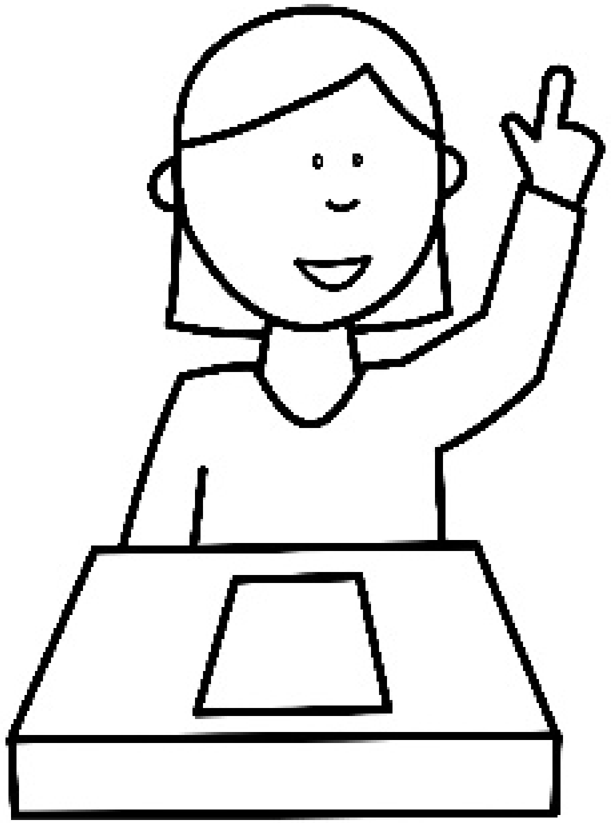
Uber is hiring for “Hoodie”

- Staff Engineer

Future Plans

Aim high

- Productionizing on AWS S3/EFS, GCP
- Spark Datasource
- Structured Streaming Sink
- Performance in Read Path
  - Presto plugin
  - Impala
- Spark Caching and integration with Apache Arrow
- Beam Runner



Questions?