What no one tells you about writing a streaming app

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tiny.cloudera.com/streaming-app

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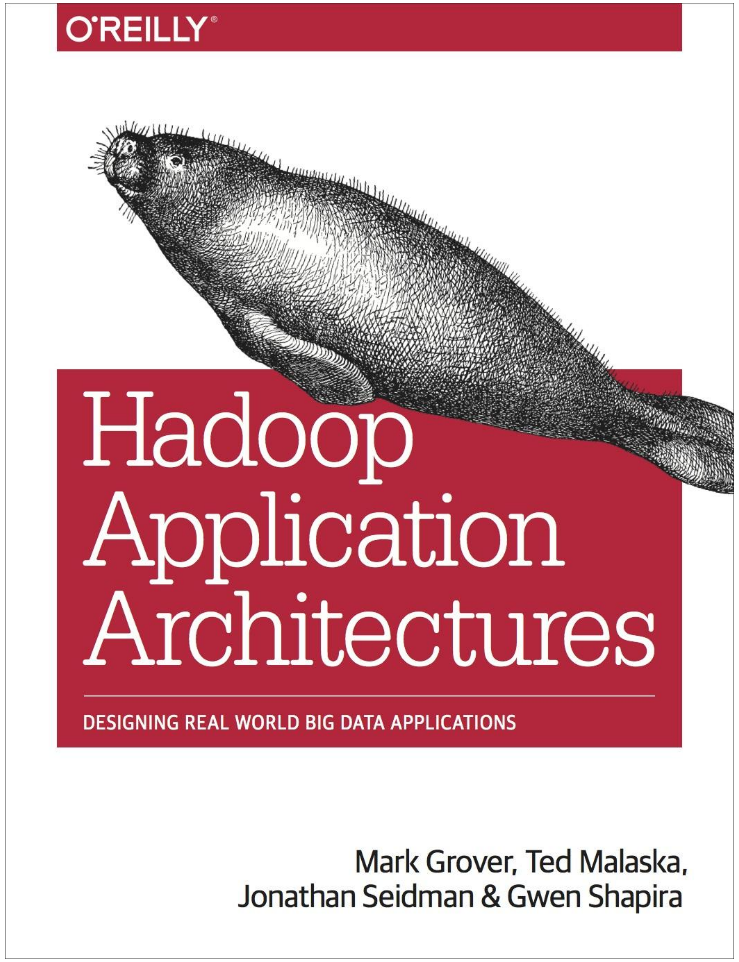
Book

- Book signing, 6:30pm
  - Cloudera booth
- hadooparchitecturebook.com
- @hadooparchbook
- github.com/hadooparchitecturebook
- slideshare.com/hadooparchbook


O'REILLY
Hadoop Application Architectures
DESIGNING REAL WORLD BIG DATA APPLICATIONS
Mark Grover, Ted Malaska, Jonathan Seidman & Gwen Shapira

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Agenda

- 5 things no one tells you about writing a streaming app

#5 - Monitoring and managing jobs

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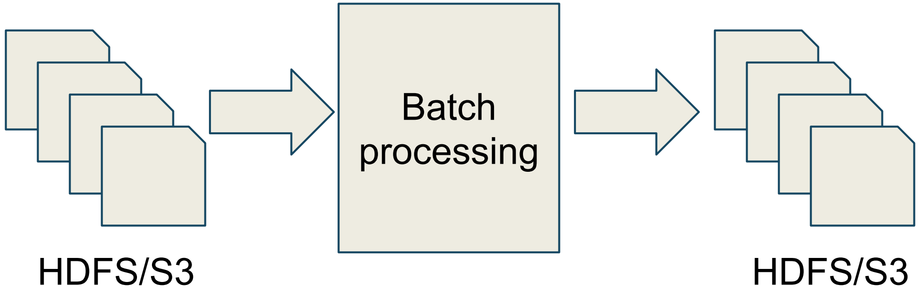
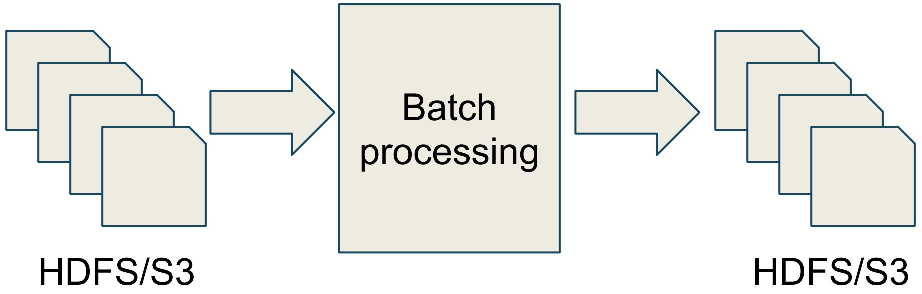
Batch systems

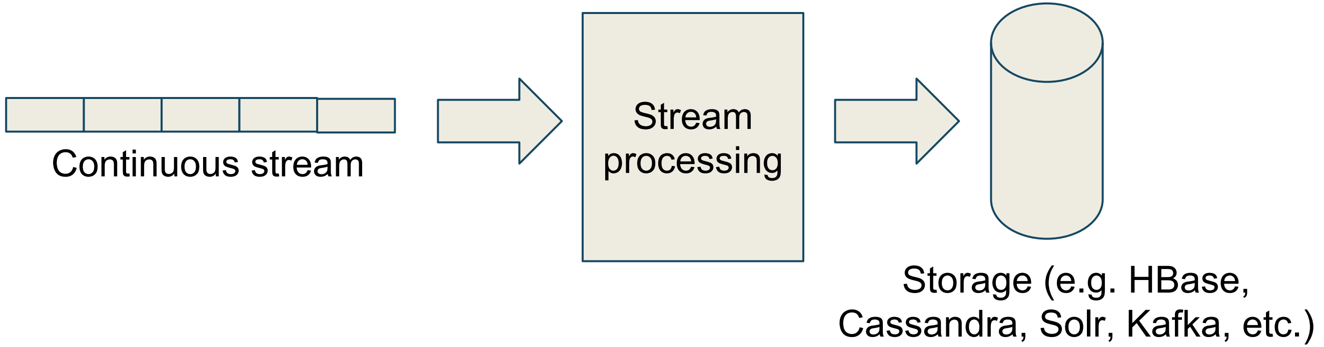


Managing and monitoring batch systems



- Use Cron/Oozie/Azkaban/Luigi for orchestration
- Validation logic in the job (e.g. if input dir is empty)
- Logs aggregated at end of the job
  - Track times against previous runs, etc.

Streaming systems systems



- “Automatic” orchestration (micro-batching)
- Long running driver process

Not originally built for streaming

- YARN
  - Doesn’t aggregate logs until job finishes
- Spark
  - Checkpoints can’t survive app or Spark upgrades
  - Need to clear checkpoint directory during upgrade

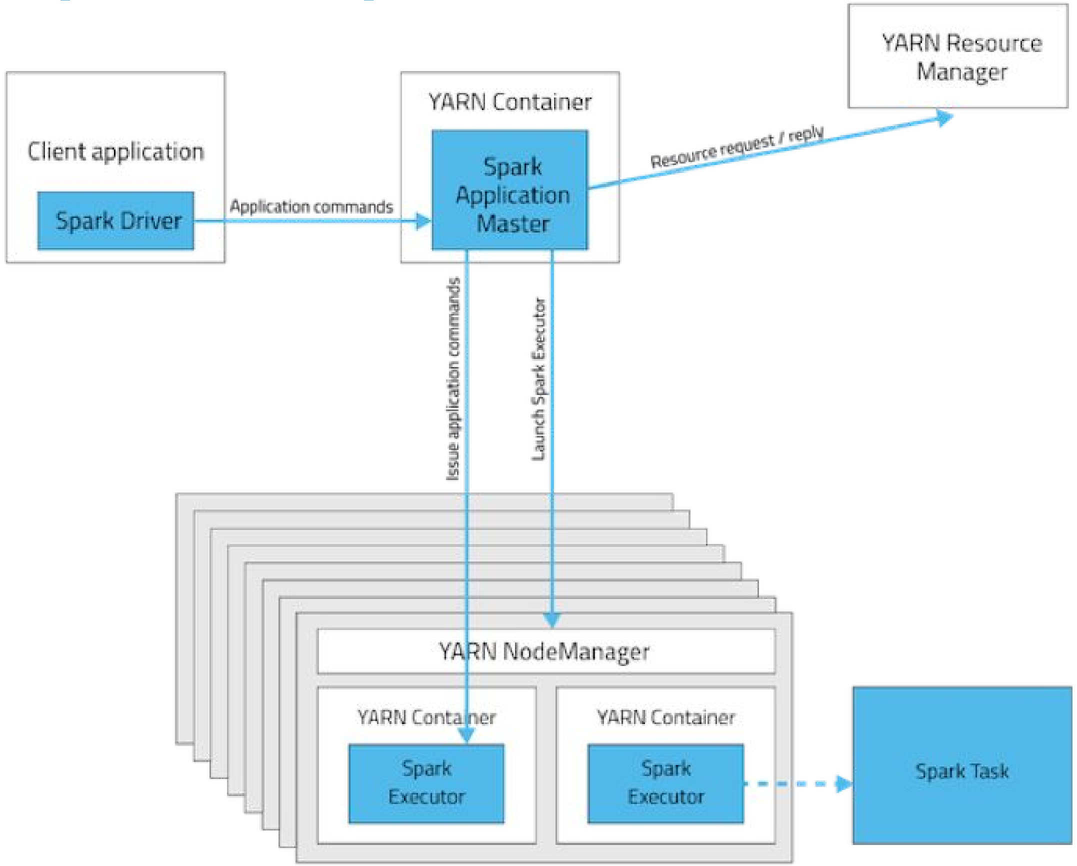
Big questions remain unanswered

1. Management
   a. Where to run the driver?
   b. How to restart the driver automatically if it fails?
   c. How to pause the job?
2. Monitoring
   a. How to prevent backlog i.e. make sure processing time < batch interval?
   b. How to keep tabs on health of the long running driver process, etc.?

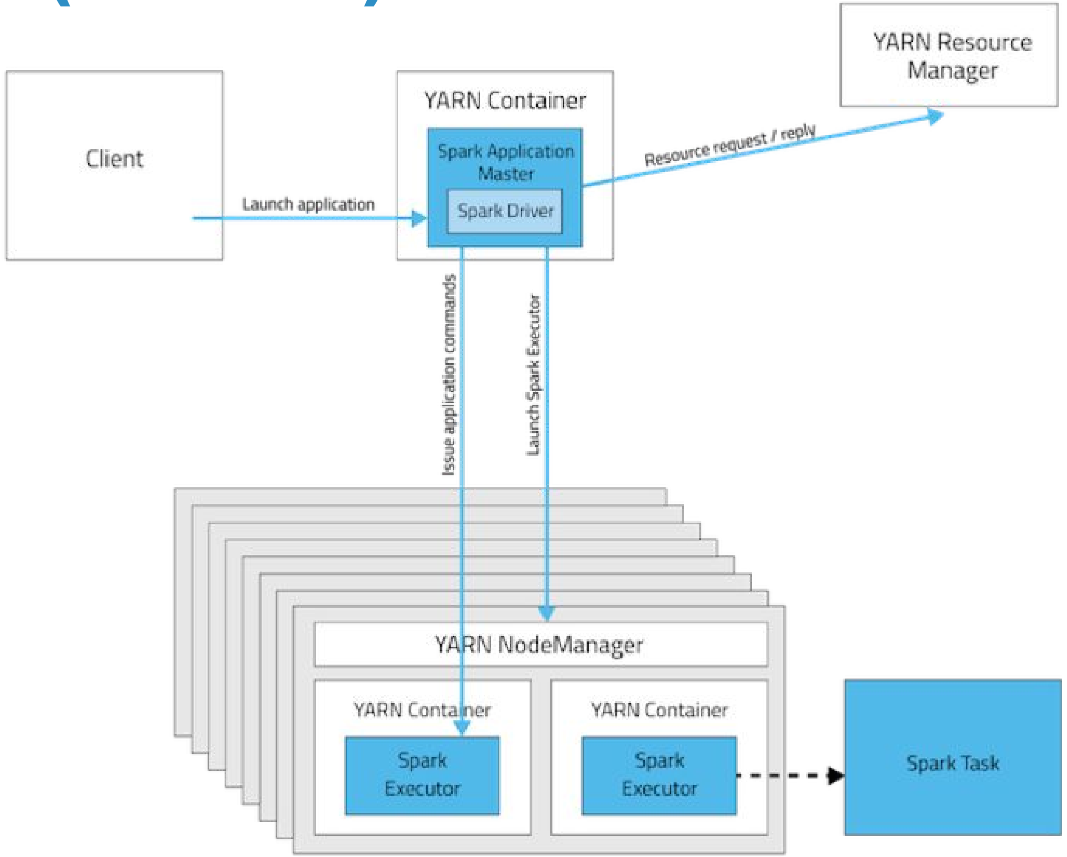
Disclaimer

- Most discussion that follows corresponds to YARN but can be applied to other cluster managers as well.

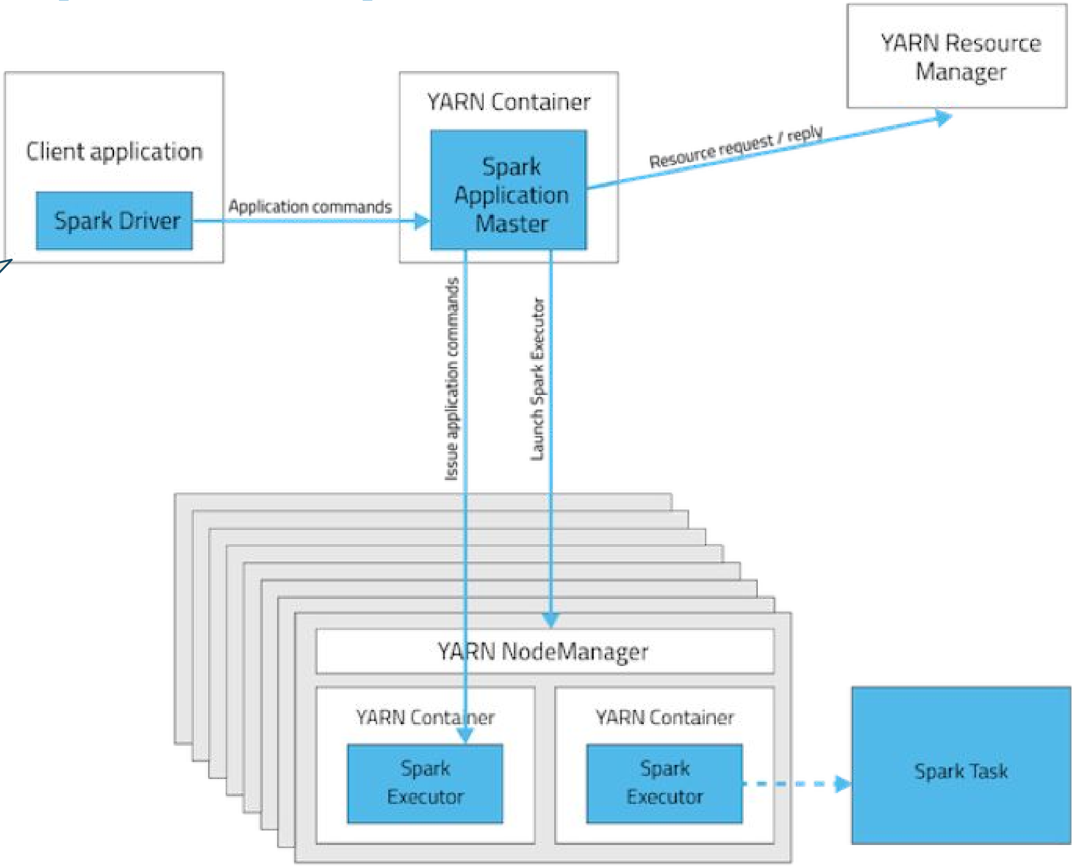
Recap: (YARN) Client mode



Recap: (YARN) Cluster mode

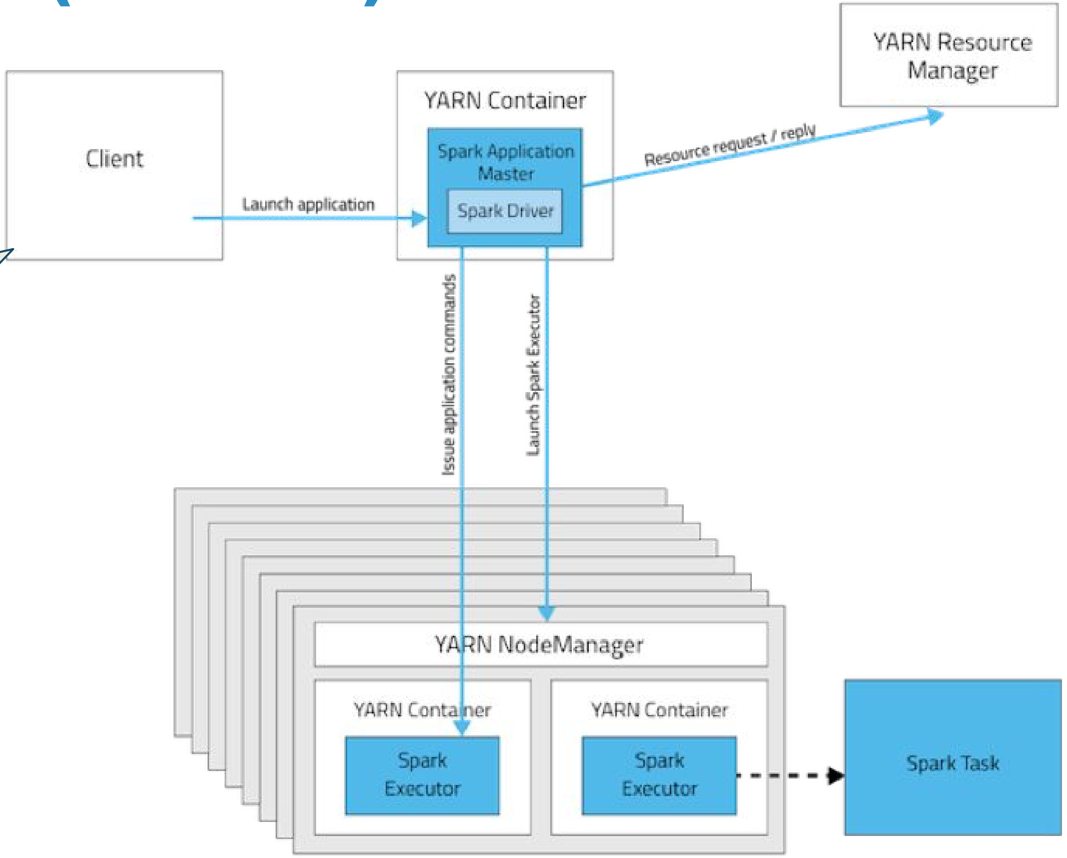


Recap: (YARN) Client mode



Client dies, driver dies i.e. job dies

Recap: (YARN) Cluster mode



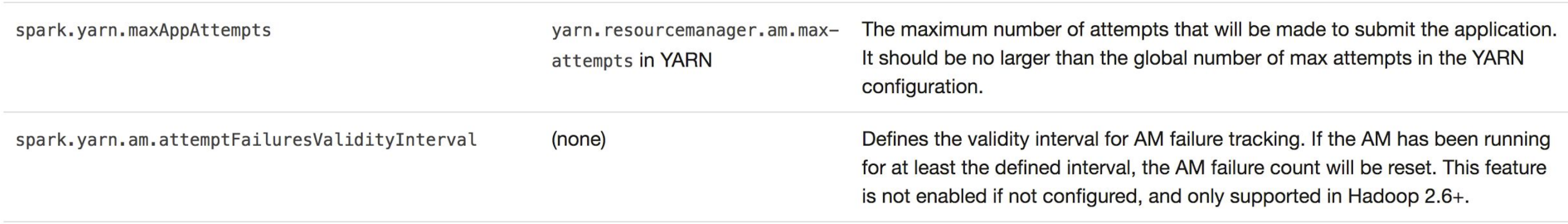
Still OK if the client dies.

1a. Where to run the driver?

- Run on YARN Cluster mode
  - Driver will continue running when the client machine goes down

1b. How to restart driver?

- Set up automatic restart



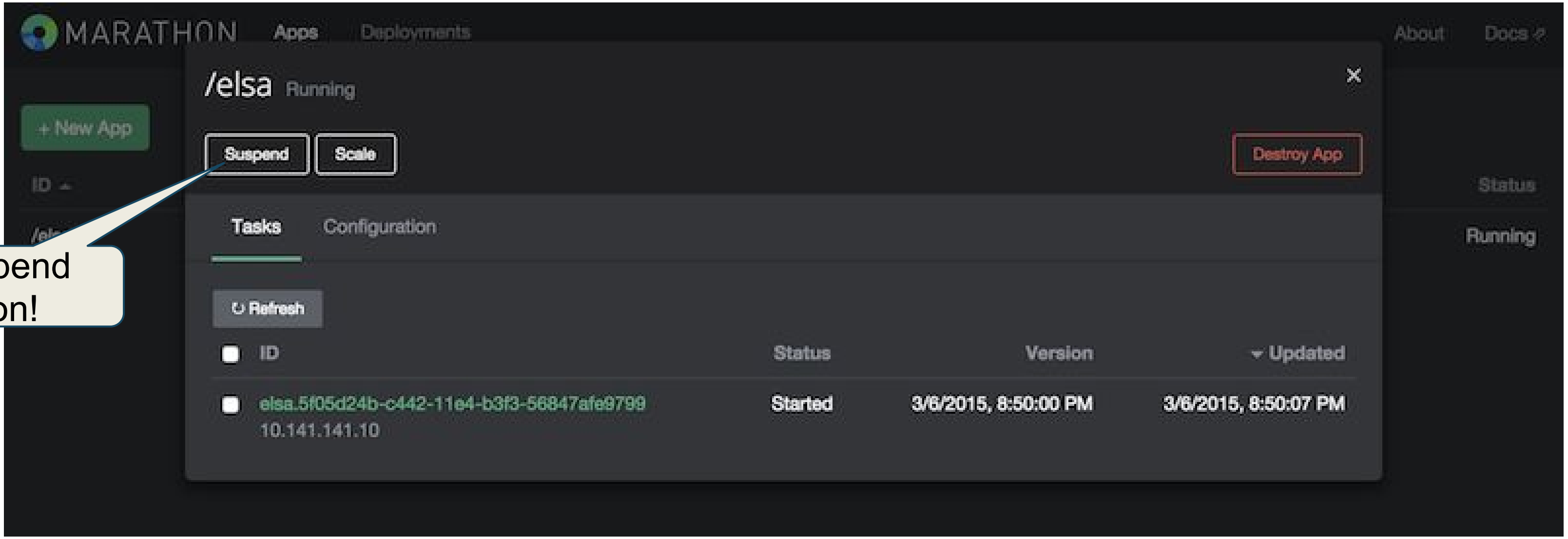
`spark.yarn.maxAppAttempts`	`yarn.resourcemanager.am.max-attempts` in YARN	The maximum number of attempts that will be made to submit the application. It should be no larger than the global number of max attempts in the YARN configuration.
`spark.yarn.am.attemptFailuresValidityInterval`	(none)	Defines the validity interval for AM failure tracking. If the AM has been running for at least the defined interval, the AM failure count will be reset. This feature is not enabled if not configured, and only supported in Hadoop 2.6+.

In spark configuration (e.g. `spark-defaults.conf`):

```
spark.yarn.maxAppAttempts=2
spark.yarn.am.attemptFailuresValidityInterval=1h
```

1c. How to pause a job?

- If running on Mesos, use Marathon:
- See "Graceful Shutdown" later for YARN, etc.



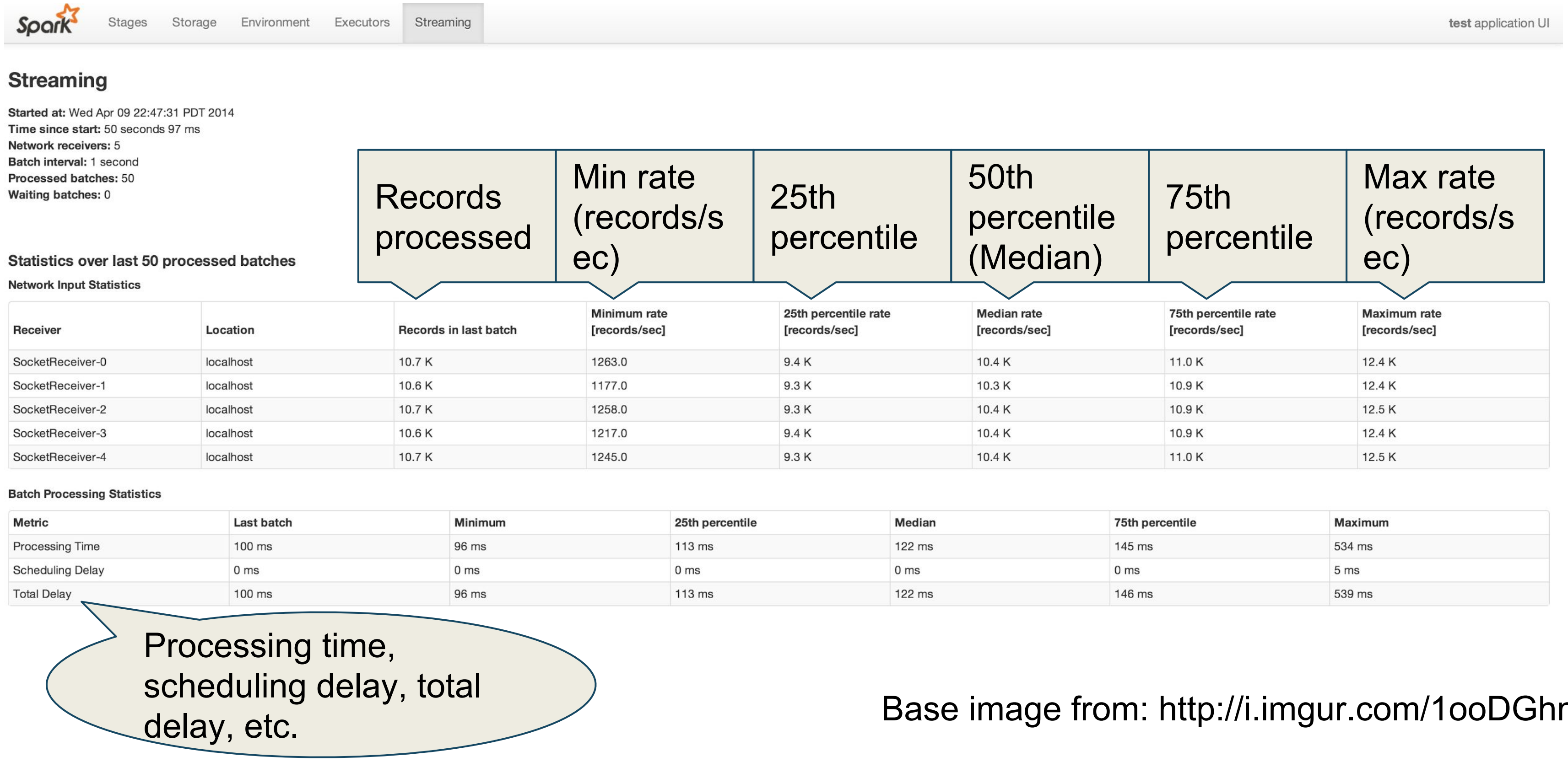
/elsa Running

ID	Status	Version	Updated
elsa.5f05d24b-c442-11e4-b3f3-56847afe9799 10.141.141.10	Started	3/6/2015, 8:50:00 PM	3/6/2015, 8:50:07 PM

Suspend button!

Image source: https://raw.githubusercontent.com/mhausenblas/elsa/master/doc/elsa-marathon-deploy.png

2. Monitoring - Spark Streaming UI



Streaming

Started at: Wed Apr 09 22:47:31 PDT 2014
Time since start: 50 seconds 97 ms
Network receivers: 5
Batch interval: 1 second
Processed batches: 50
Waiting batches: 0

Statistics over last 50 processed batches

Network Input Statistics

Receiver	Location	Records in last batch	Minimum rate [records/sec]	25th percentile rate [records/sec]	Median rate [records/sec]	75th percentile rate [records/sec]	Maximum rate [records/sec]
SocketReceiver-0	localhost	10.7 K	1263.0	9.4 K	10.4 K	11.0 K	12.4 K
SocketReceiver-1	localhost	10.6 K	1177.0	9.3 K	10.3 K	10.9 K	12.4 K
SocketReceiver-2	localhost	10.7 K	1258.0	9.3 K	10.4 K	10.9 K	12.5 K
SocketReceiver-3	localhost	10.6 K	1217.0	9.4 K	10.4 K	10.9 K	12.4 K
SocketReceiver-4	localhost	10.7 K	1245.0	9.3 K	10.4 K	11.0 K	12.5 K

Batch Processing Statistics

Metric	Last batch	Minimum	25th percentile	Median	75th percentile	Maximum
Processing Time	100 ms	96 ms	113 ms	122 ms	145 ms	534 ms
Scheduling Delay	0 ms	0 ms	0 ms	0 ms	0 ms	5 ms
Total Delay	100 ms	96 ms	113 ms	122 ms	146 ms	539 ms

Base image from: http://i.imgur.com/1ooDGhm.png

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2. Monitoring - But I want more!

- Spark has a configurable metrics system
  - Based on Dropwizard Metrics Library
- Use Graphite/Grafana to dashboard metrics like:
  - Number of records processed
  - Memory/GC usage on driver and executors
  - Total delay
  - Utilization of the cluster

Summary - Managing and monitoring

- Afterthought
- But it’s possible
- In Structured Streaming, use `StreamingQueryListener` (starting Apache Spark 2.1)

References

- Spark Streaming on YARN by Marcin Kuthan

http://mkuthan.github.io/blog/2016/09/30/spark-streaming-on-yarn/

- Marathon

https://mesosphere.github.io/marathon/

#4 - Prevent data loss

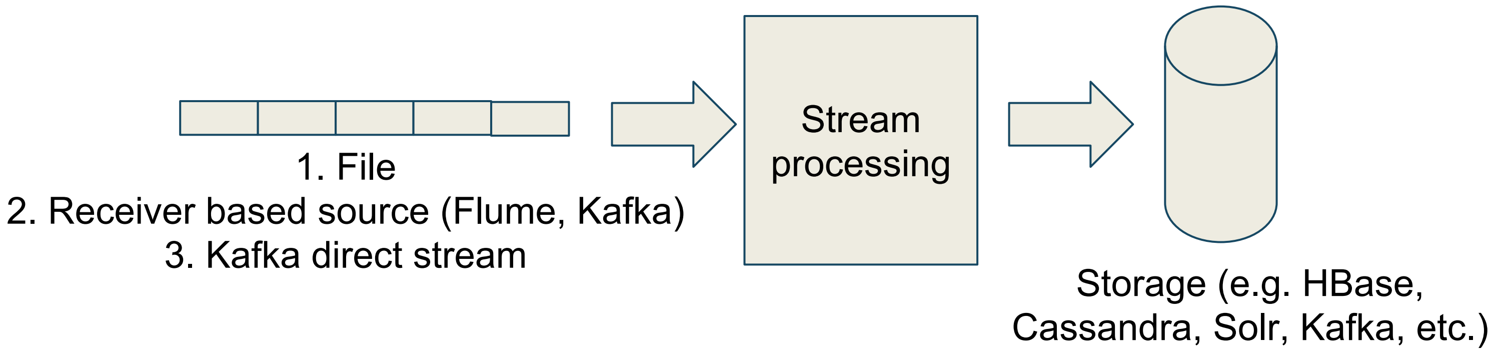
Prevent data loss

- Ok, my driver is automatically restarting
- Can I lose data in between driver restarts?

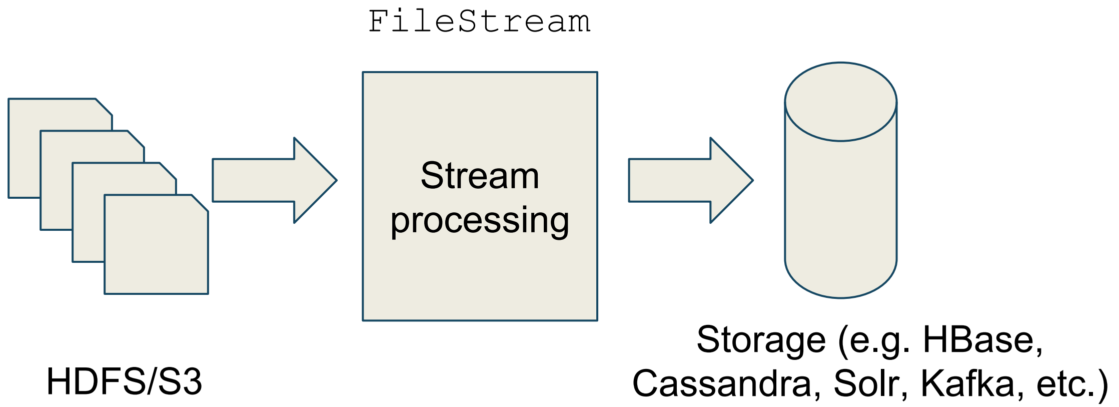
No data loss!

As long as you do things the right way

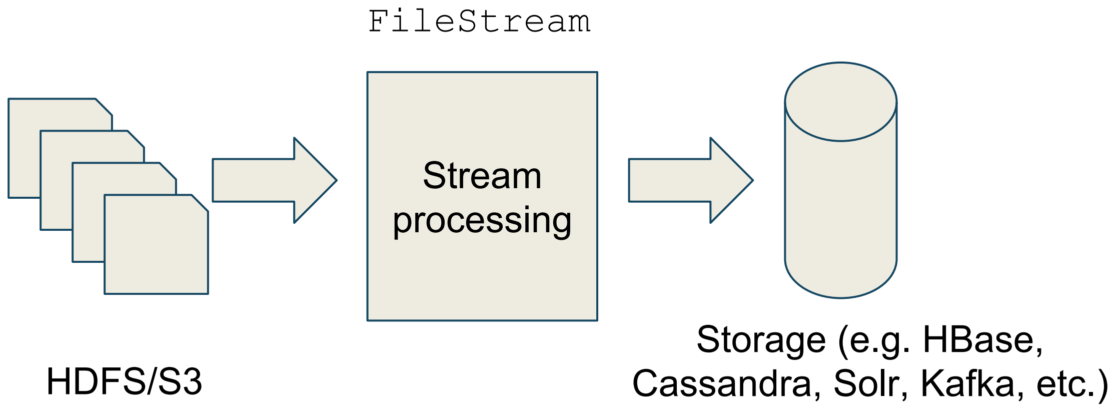
How to do things the right way


1. File
2. Receiver based source (Flume, Kafka)
3. Kafka direct stream
Stream processing
Storage (e.g. HBase, Cassandra, Solr, Kafka, etc.)

1. File sources



1. File sources



- Use checkpointing!

Checkpointing

```
// new context

val ssc = new StreamingContext(...)

...

// set checkpoint directory

ssc.checkpoint(checkpointDirectory)
```

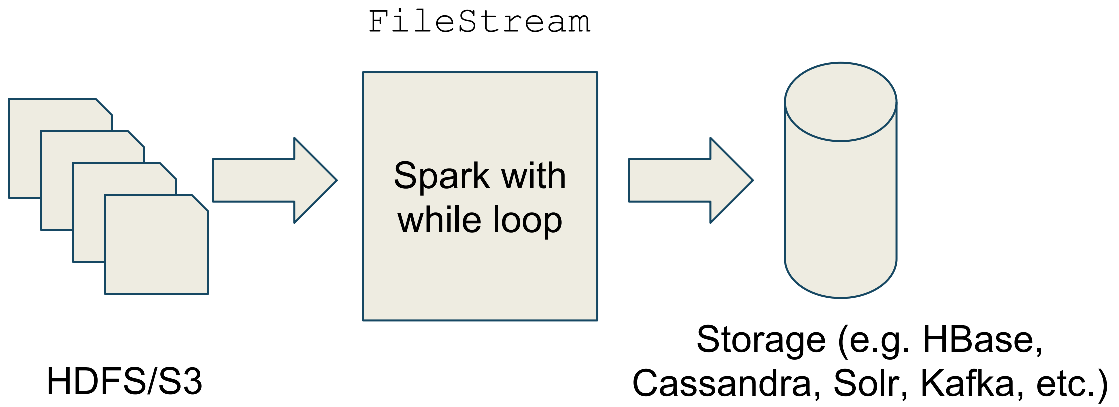
What is checkpointing

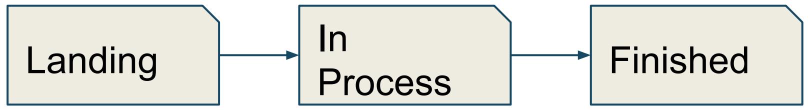
- Metadata checkpointing (Configuration, Incomplete batches, etc.)
  - Recover from driver failures
- Data checkpointing
  - Trim lineage when doing stateful transformations (e.g. updateStateByKey)
- Spark streaming checkpoints both data and metadata

Checkpointing gotchas

- Checkpoints don’t work across app or Spark upgrades
- Clear out (or change) checkpointing directory across upgrades

Ted's Rant





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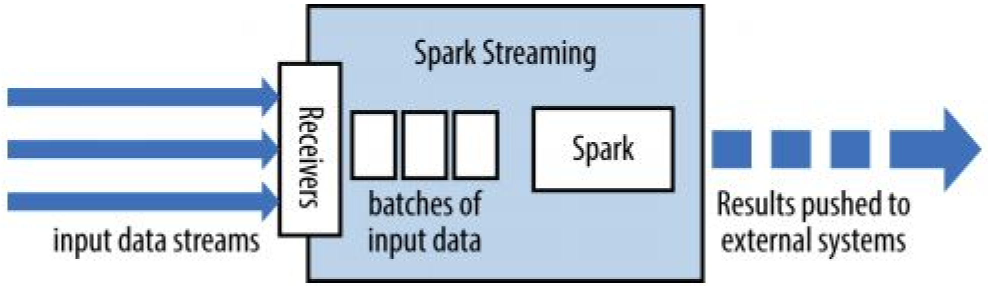
2. Receiver based sources

High-level architecture of Spark Streaming



DStream as a continuous series of RDDs

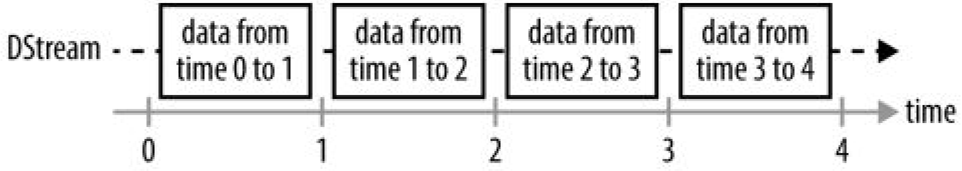


Image source: http://static.oschina.net/uploads/space/2015/0618/110032_9Fvp_1410765.png

Receiver based sources

- Enable checkpointing, AND
- Enable Write Ahead Log (WAL)
  - Set the following property to `true`

    `spark.streaming.receiver.writeAheadLog.enable`
  - Default is `false`!

Why do we need a WAL?

- Data on Receiver is stored in executor memory
- Without WAL, a failure in the middle of operation can lead to data loss
- With WAL, data is written to durable storage (e.g. HDFS, S3) before being acknowledged back to source.

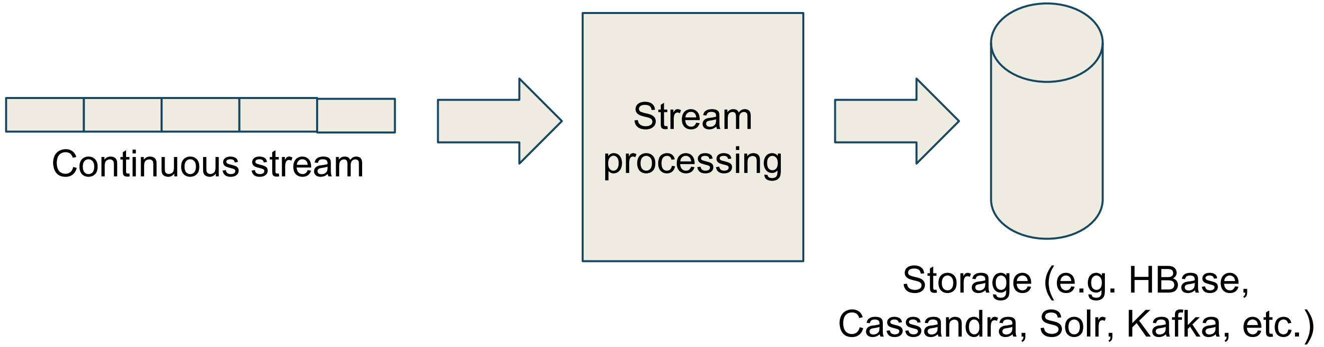
WAL gotchas!

- Makes a copy of all data on disk
- Use `StorageLevel.MEMORY_AND_DISK_SER` storage level for your `DStream`
  - No need to replicate the data in memory across Spark executors
- For S3 `spark.streaming.receiver.writeAheadLog.closeFileAfterWrite` to `true` (similar for driver)

But what about Kafka?

- Kafka already stores a copy of the data
- Why store another copy in WAL?

3. Spark Streaming with Kafka



- Use “direct” connector
- No need for a WAL with the direct connector!

Kafka with WAL

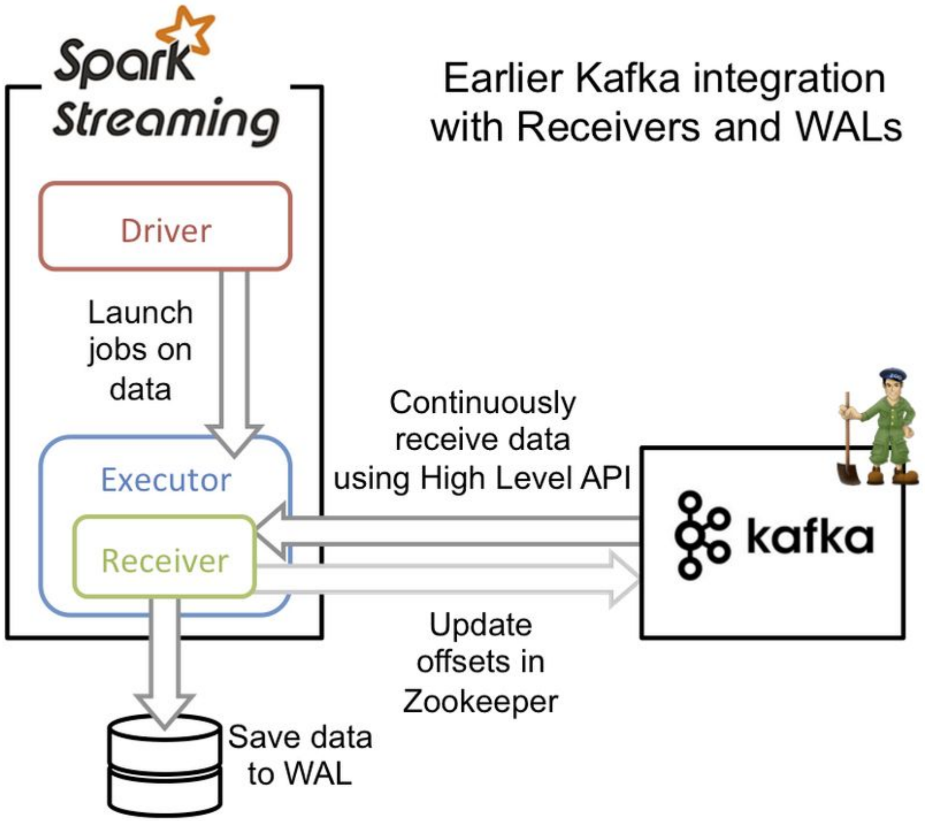

Spark Streaming
Earlier Kafka integration with Receivers and WALs
Driver
Launch jobs on data
Executor
Receiver
Continuously receive data using High Level API
kafka
Update offsets in Zookeeper
Save data to WAL

Image source:
https://databricks.com/wp-content/uploads/2015/03/Screen-Shot-2015-03-29-at-10.11.42-PM.png

Kafka direct connector (without WAL)

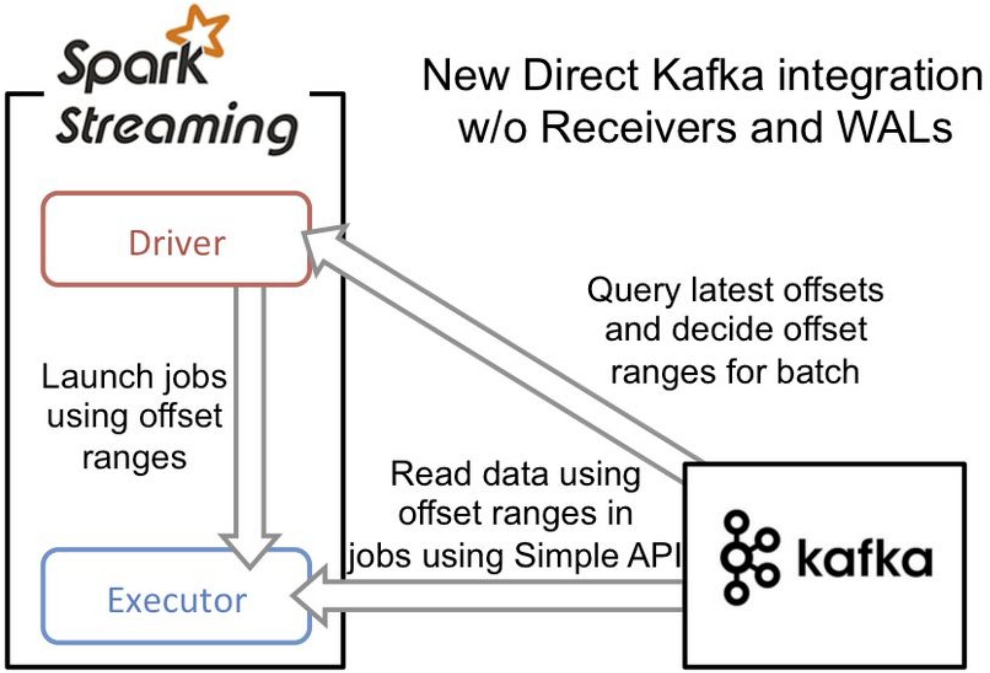

Spark Streaming
New Direct Kafka integration w/o Receivers and WALs
Driver
Launch jobs using offset ranges
Query latest offsets and decide offset ranges for batch
Read data using offset ranges in jobs using Simple API
Executor
kafka

Image source:
https://databricks.com/wp-content/uploads/2015/03/Screen-Shot-2015-03-29-at-10.14.11-PM.png

Why no WAL?

- No receiver process creating blocks
- Data is stored in Kafka, can be directly recovered from there

Direct connector gotchas

- Need to track offsets for driver recovery
- Checkpoints?
  - No! Not recoverable across upgrades
- Track them yourself
  - In ZooKeeper, HDFS, or a database
- For accuracy
  - Processing needs to be idempotent, OR
  - Update offsets in the same transaction when updating results

Summary - prevent data loss

- Different for different sources
- Preventable if done right
- In Structured Streaming, state is stored in memory (backed by HDFS/S3 WAL), starting Spark 2.1

References

- Improved fault-tolerance and zero data loss
https://databricks.com/blog/2015/01/15/improved-driver-fault-tolerance-and-zero-data-loss-in-spark-streaming.html
- Tracking offsets when using direct connector
http://blog.cloudera.com/blog/2015/03/exactly-once-spark-streaming-from-apache-kafka/

#3 - Do I really need to use Spark Streaming?

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When do you use streaming?

When do you use streaming?

ALWAYS!

Do I need to use Spark Streaming?

Think about your goals

Types of goals

- Atomic Enrichment
- Notifications
- Joining
- Partitioning
- Ingestion
- Counting
- Incremental machine learning
- Progressive Analysis

Types of goals

- Atomic enrichment
  - No cache/context needed

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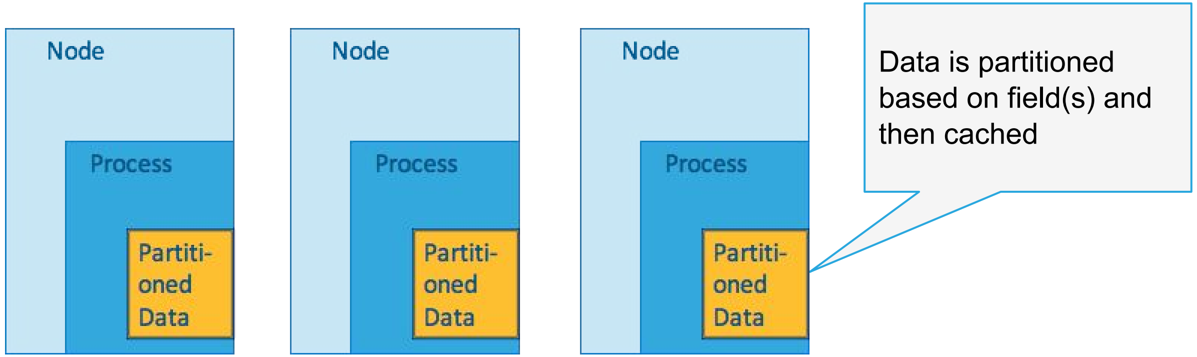
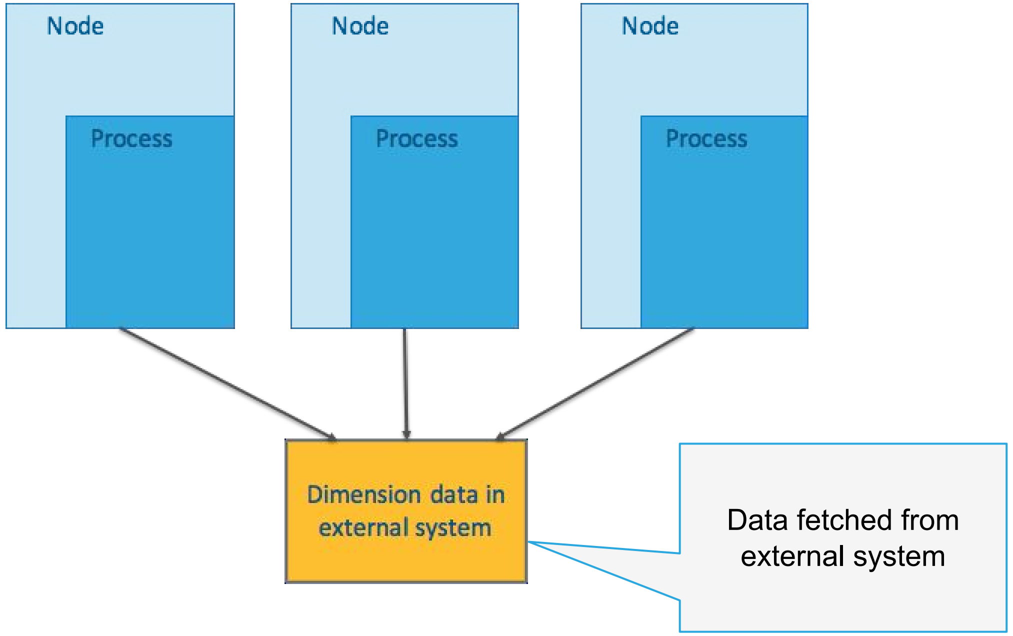
Types of goals

- Notifications
  - NRT
  - Atomic
  - With Context
  - With Global Summary

#2 - Partitioned cache data



#3 - External fetch


Node
Process
Node
Process
Node
Process
Dimension data in external system
Data fetched from external system

Types of goals

- Joining
  - Big Joins
  - Broadcast Joins
  - Streaming Joins

Types of goals

- !!Ted to add a diagram!!
- Partitioning
  - Fan out
  - Fan in
  - Shuffling for key isolation

Types of goals

- Ingestion
  - File Systems or Block Stores
  - No SQLs
  - Lucene
  - Kafka

Types of goals

- Counting
  - Streaming counting
  - Count on query
  - Aggregation on query

Types of goals

- Machine Learning

Types of goals

- Progressive Analysis
  - Reading the stream
  - SQL on the stream

Summary - Do I need to use streaming?

- Spark Streaming is great for
  - Accurate counts
  - Windowing aggregations
  - Progressive Analysis
  - Continuous Machine Learning

#2 - Exactly once semantics

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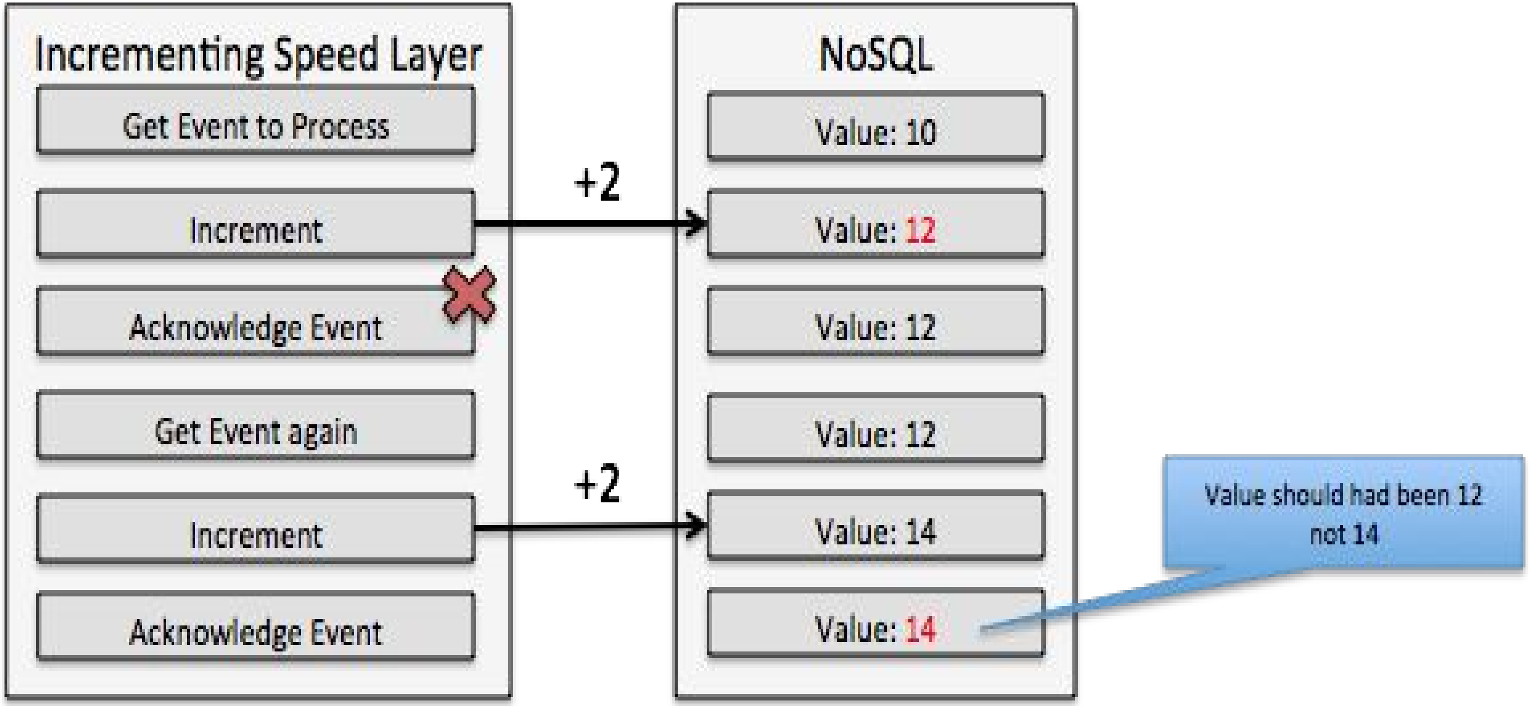
Exactly once semantics

- No duplicate records
- Perfect Counting

In the days of Lambda



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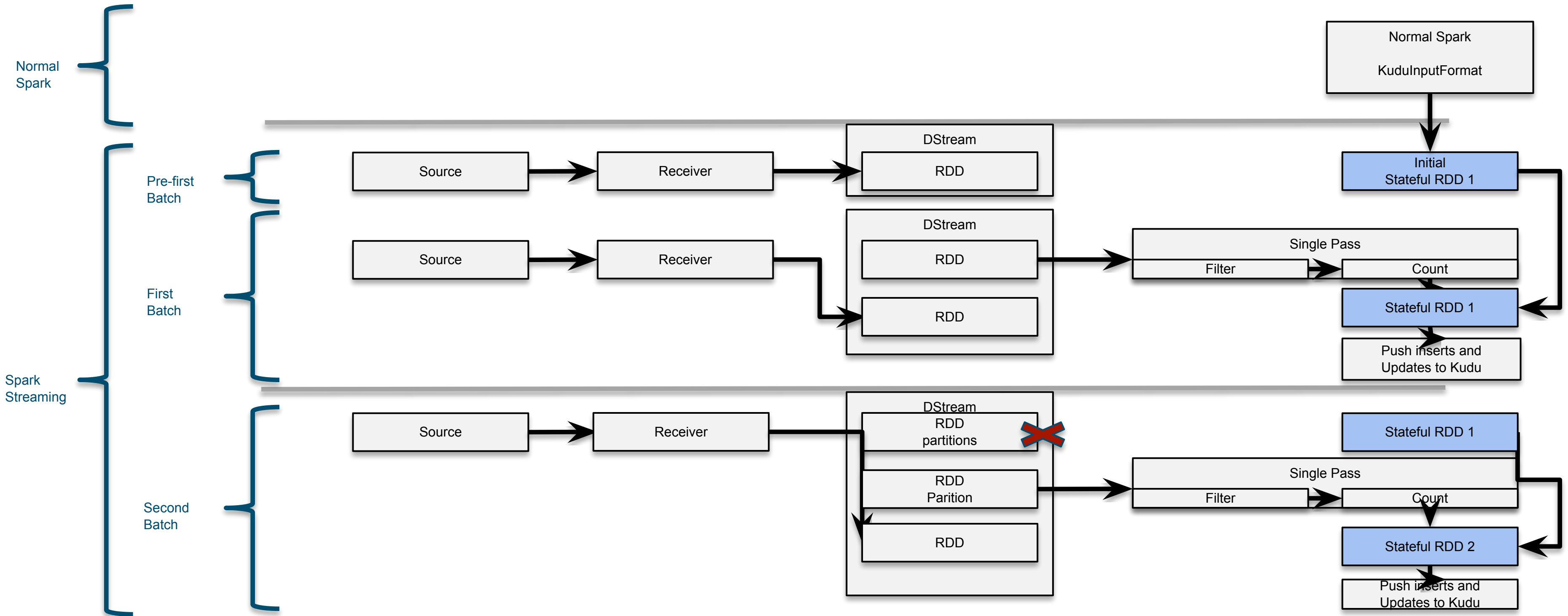
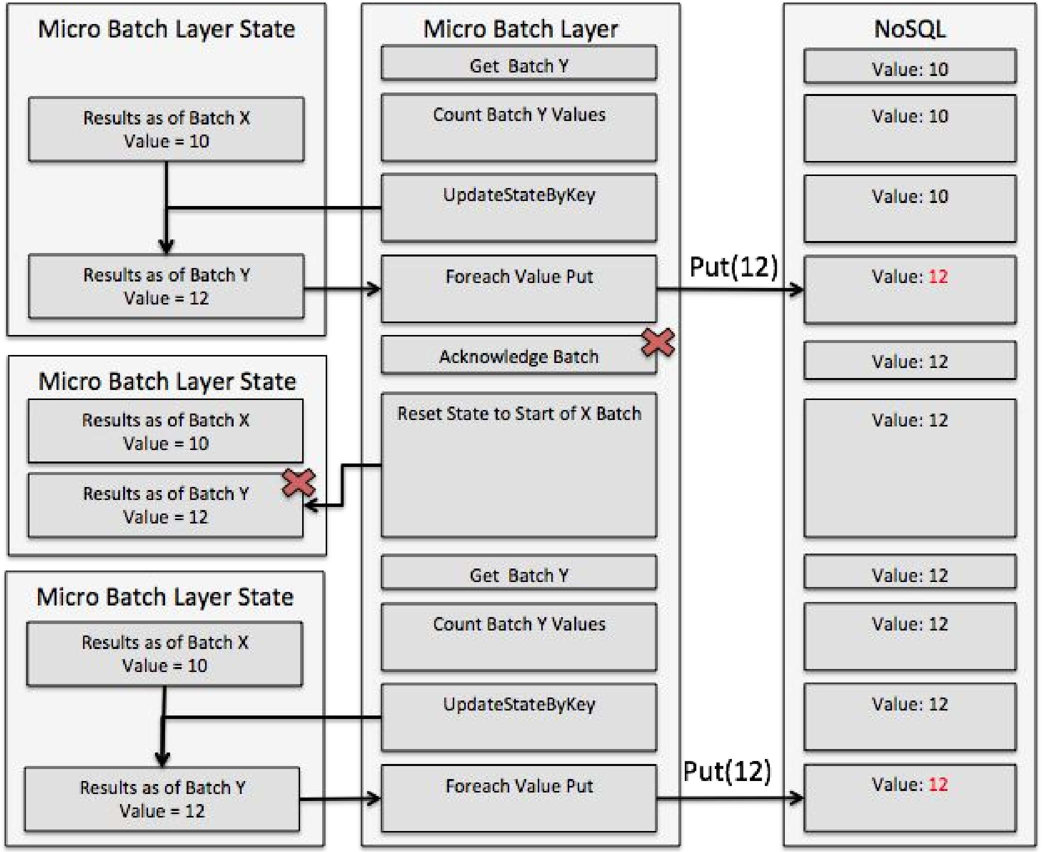
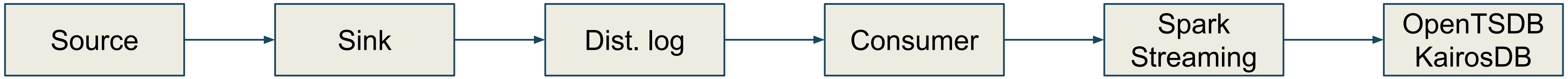
Spark Streaming State



State within



Things can go wrong in many places



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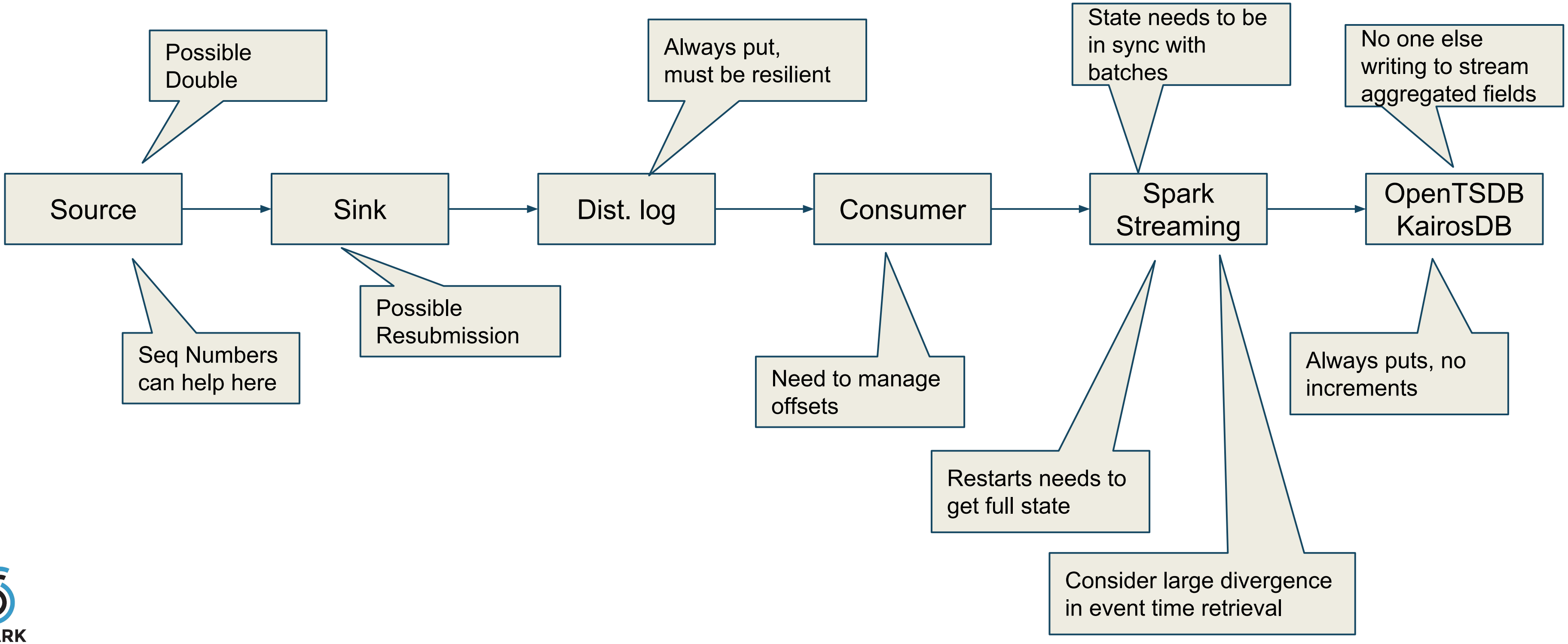
Things can go wrong in many places


Possible Double
Always put, must be resilient
State needs to be in sync with batches
No one else writing to stream aggregated fields
Source
Sink
Dist. log
Consumer
Spark Streaming
OpenTSDB KairosDB
Seq Numbers can help here
Possible Resubmission
Need to manage offsets
Restarts needs to get full state
Consider large divergence in event time retrieval
Always puts, no increments

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Summary - Exactly once semantics

- Seq number tied to sources
- Puts for external storage system
- Consider large divergence in event time retrieval
    - Increase divergence window
    - Retrieve state from external storage system *
    - Ignore
    - Process off line
    - Source aggregation (pre-distributed log)

#1 - Graceful shutting down your streaming app

Graceful shutdown

Can we define graceful?

- Offsets known
- State stored externally
- Stopping at the right place (i.e. batch finished)

How to be graceful?

- Thread hooks
  - Check for an external flag every N seconds

```
/**
   * Stop the execution of the streams, with option of ensuring all received data
   * has been processed.
   *
   * @param stopSparkContext if true, stops the associated SparkContext. The underlying SparkContext
   *                         will be stopped regardless of whether this StreamingContext has been
   *                         started.
   * @param stopGracefully if true, stops gracefully by waiting for the processing of all
   *                       received data to be completed
   */
  def stop(stopSparkContext: Boolean, stopGracefully: Boolean): Unit = {
```

Under the hood of grace

```
receiverTracker.stop(processAllReceivedData) //default is to wait 10 second, grace waits until done
jobGenerator.stop(processAllReceivedData) // Will use spark.streaming.gracefulStopTimeout
jobExecutor.shutdown()
val terminated = if (processAllReceivedData) {
    jobExecutor.awaitTermination(1, TimeUnit.HOURS)  // just a very large period of time
} else {
    jobExecutor.awaitTermination(2, TimeUnit.SECONDS)
}
if (!terminated) {
    jobExecutor.shutdownNow()
}
```

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How to be graceful?

- cmd line
  - $SPARK_HOME_DIR/bin/spark-submit --master $MASTER_REST_URL --kill $DRIVER_ID
  - spark.streaming.stopGracefullyOnShutdown=true

```
private def stopOnShutdown(): Unit = {
    val stopGracefully = conf.getBoolean("spark.streaming.stopGracefullyOnShutdown", false)
    logInfo(s"Invoking stop(stopGracefully=$stopGracefully) from shutdown hook")
    // Do not stop SparkContext, let its own shutdown hook stop it
    stop(stopSparkContext = false, stopGracefully = stopGracefully)
  }
```

How to be graceful?

- By marker file
  - Touch a file when starting the app on HDFS
  - Remove the file when you want to stop
  - Separate thread in Spark app, calls

```
streamingContext.stop(stopSparkContext =
true, stopGracefully = true)
```

Storing offsets

- Externally in ZK, HDFS, HBase, Database
- Recover on restart

Summary - Graceful shutdown

- Use provided command line, or
- Background thread with a marker file

Conclusion

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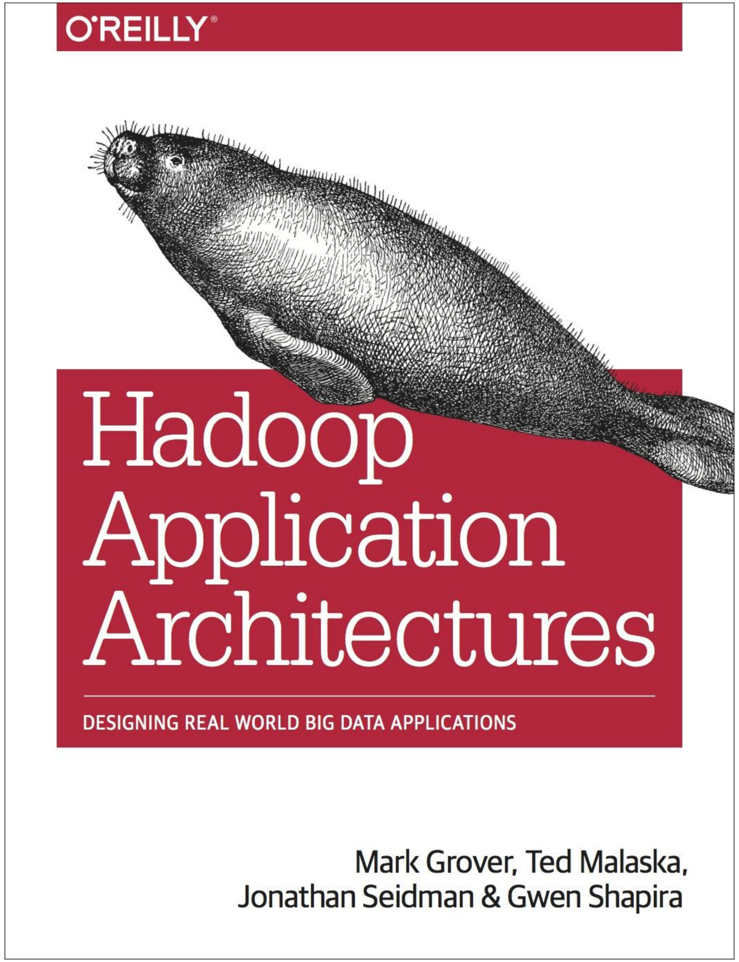
Conclusion

- #5 – How to monitor and manage jobs?
- #4 – How to prevent data loss?
- #3 – Do I need to use Spark Streaming?
- #2 – How to achieve exactly/effectively once semantics?
- #1 – How to gracefully shutdown your app?

Book signing

- Cloudera booth @ 6:30pm



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Hadoop Application Architectures

DESIGNING REAL WORLD BIG DATA APPLICATIONS

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Thank You.

tiny.cloudera.com/streaming-app

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