CSE 512: Distributed and Parallel Data Systems

Lecture 4

Instructor: Mohamed Sarwat

Resilient Distributed Dataset (RDD)

What is an RDD?

•A RDD is a read-only, partitioned collection of records.
•RDDs can only be created through operations on either (1) data in stable storage or (2) other RDDs.
•It is a restricted Distributed shared – Memory System.

RDD Contains:

•A set of partitions: Atomic pieces of the dataset
•A set of dependencies on parent RDDs (For fault tolerance)
•A function for computing the dataset based on its parents (For fault Tolerance)
Metadata about its partitioning scheme and data placement

Resilient Distributed Dataset (RDD) – cont.

Two important features:

- Fault tolerance:
  - That is achieved through lineage retrieval
- Lazy Evaluation:
  - A RDD will not be created until a reduce-like job or persist job called.

- *Zaharia, Matei, et al. "Spark: cluster computing with working sets." in Proceedings of the 2nd USENIX conference on Hot topics in cloud computing. 2010.*
- *Zaharia, Matei, et al. "Resilient distributed datasets: A fault-tolerant abstraction for in-memory cluster computing." in Proceedings of the 9th USENIX conference on Networked Systems Design and Implementation. USENIX Association, 2012.*

Data Management in Apache Spark: RDD Abstraction

- Resilient distributed datasets
- Partitioned collection of records
- Spread across the cluster
- read-only
- Caching dataset in memory

RDD Operations

- ***Transformations* to build RDDs through deterministic operations on other RDDs**
  - transformations include *map*, *filter*, *join*
  - lazy operation
- ***actions* to return value or export data**
  - actions include *count*, *collect*, *save*
  - triggers execution

Job Example

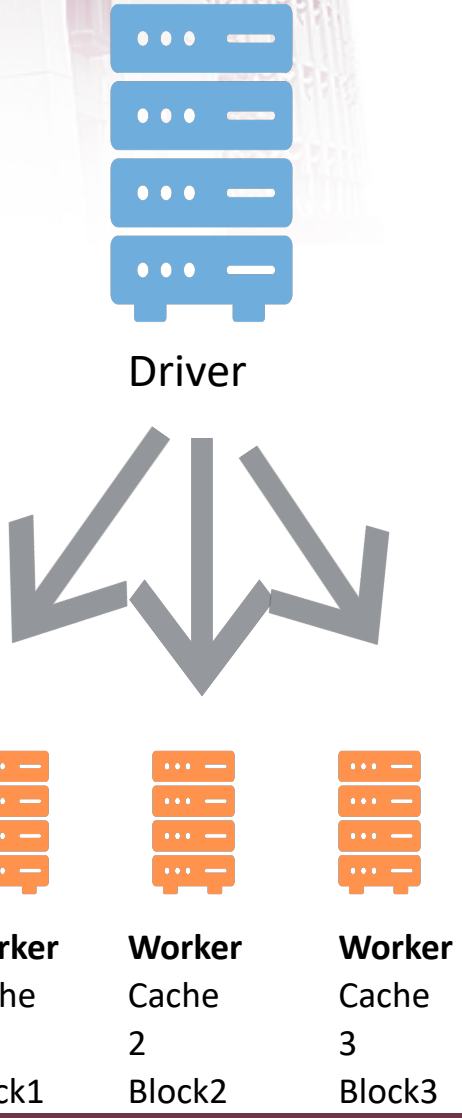
```
val log =
sc.textFile("hdfs://...")

val errors =
file.filter(_.contains("ER
ROR"))

errors.cache()

errors.filter(_.contains("
I/O")).count()

errors.filter(_.contains("
timeout")).count()
```



RDD Partition-Level View

Log:

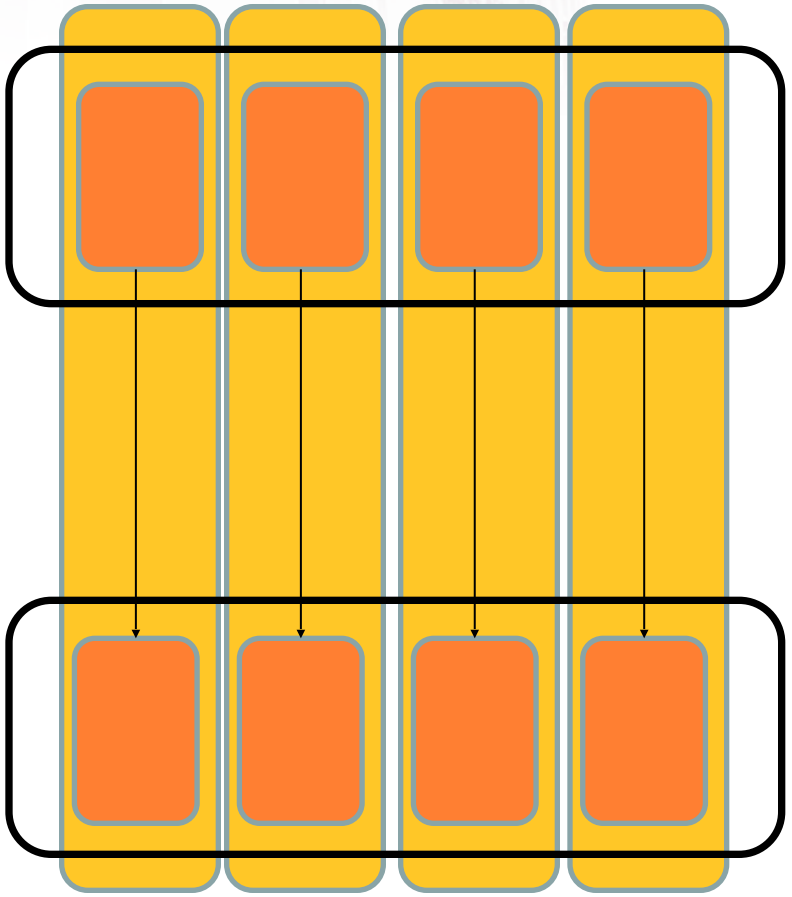
HadoopRDD
`path = hdfs://...`

Errors:

FilteredRDD
`func = _.contains(…)`
`shouldCache = true`

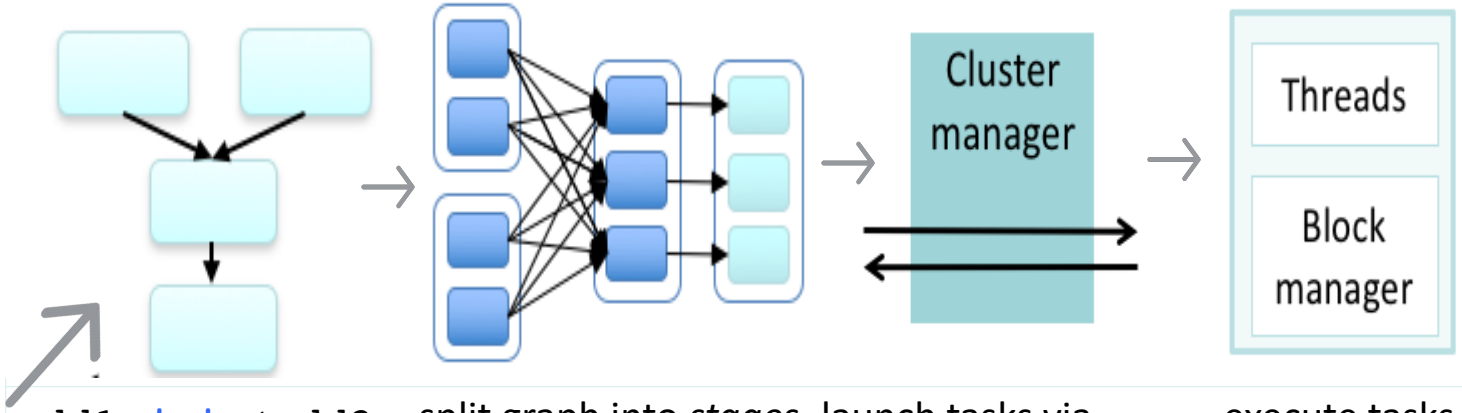
Dataset-level view

Task 1,
Task 2…



Partition-level view

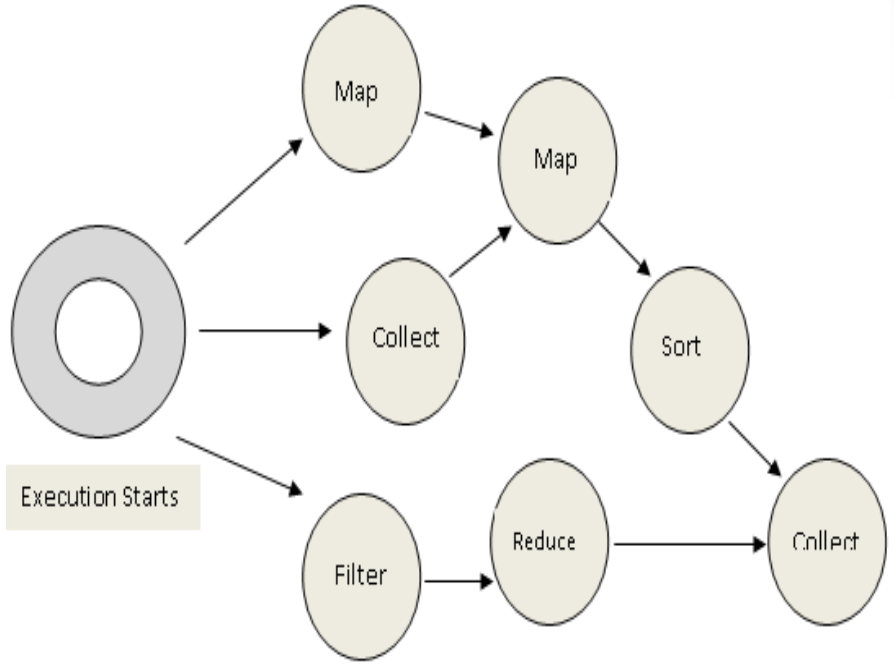
Job Scheduling

RDD Objects	DAGScheduler	TaskScheduler	Worker
			

`rdd1.join(rdd2)`
`.groupBy(…)`
`.filter(…)`
	split graph into *stages* of tasks	launch tasks via cluster manager	execute tasks

build operator DAG	submit each stage as ready	retry failed or straggling tasks	store and serve blocks

Directed Acyclic Graph (DAG) in Spark



DAG(Directed Acyclic Graph)

Data processing Operations are sorted in a directed acyclic graph

Job Scheduling

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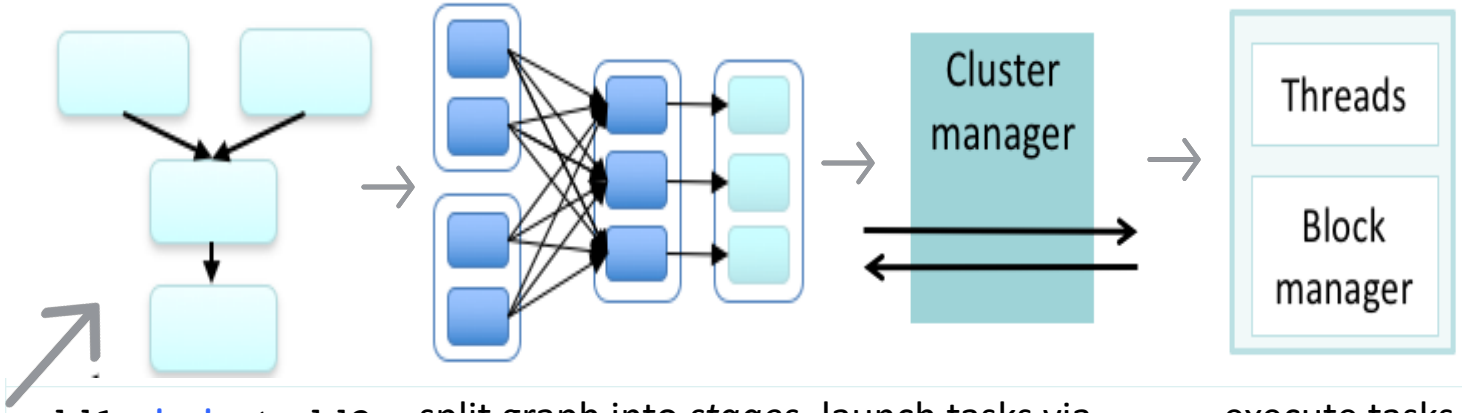			

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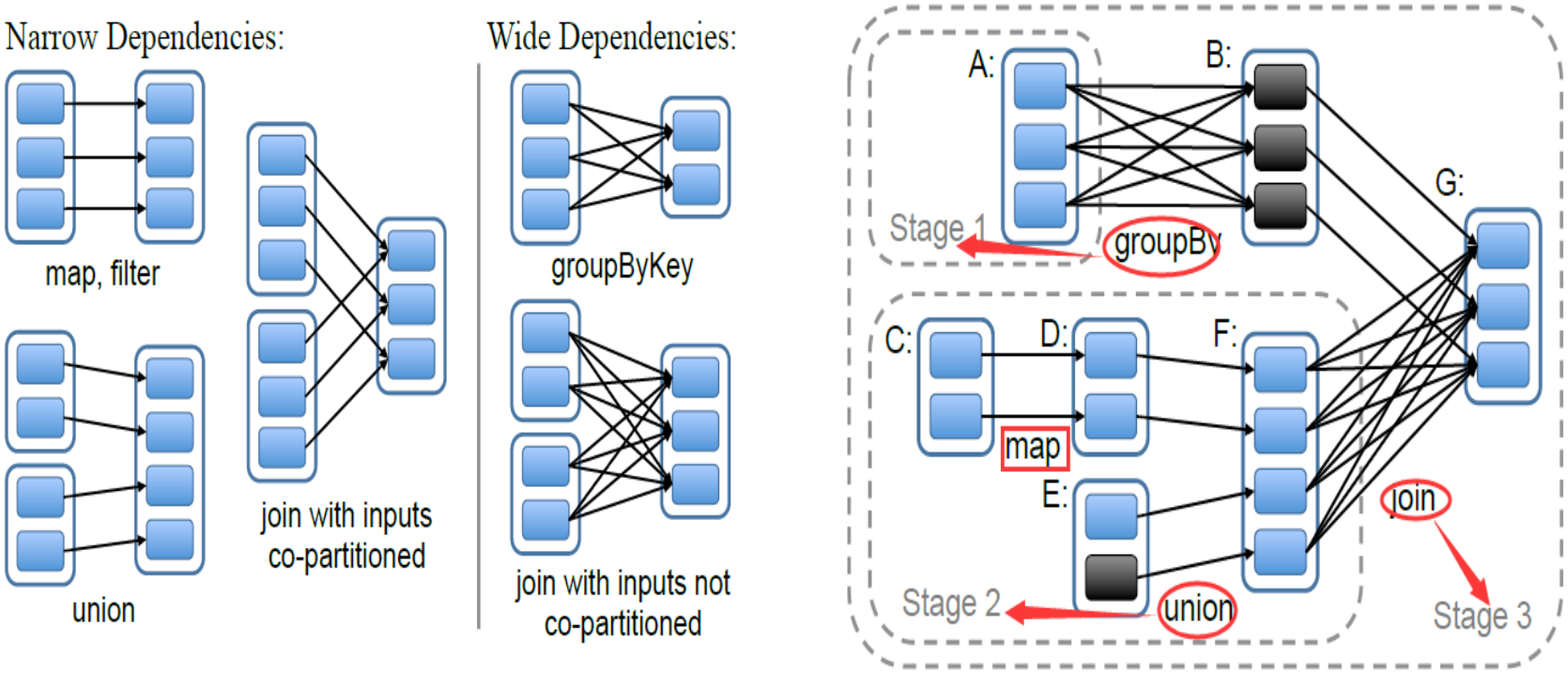
DAG Scheduler in Spark



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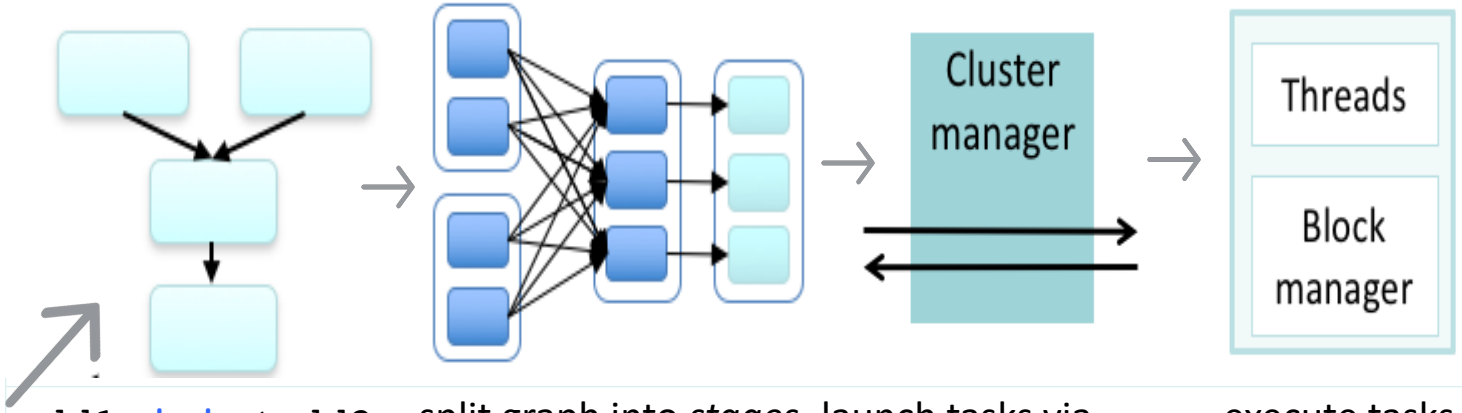			

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Comparing Spark and Hadoop

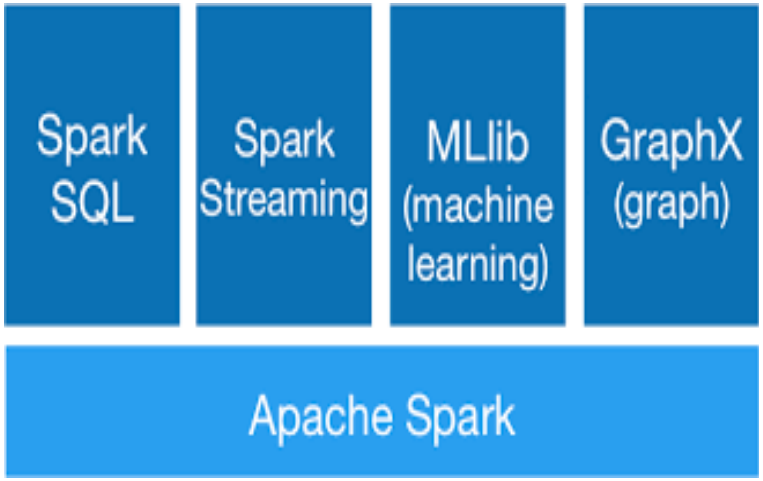
Spark

- Spark has an advanced DAG(Directed Acyclic Graph) execution engine
- Spark supports in-memory cluster computing – Thanks to RDD
- Rich Data Processing API (map, filter, reduce, join…)
- Runs on myriad storage engines (HDFS, Cassandra, HBase, S3…)

Hadoop

- Only supports two Runtime phases: Map / Reduce (and hidden data shuffling pahse)
- Intermediate data has to be on disk.
- Everything is programmed using Map/Reduce
- Loads data from HDFS

Spark Ecosystem

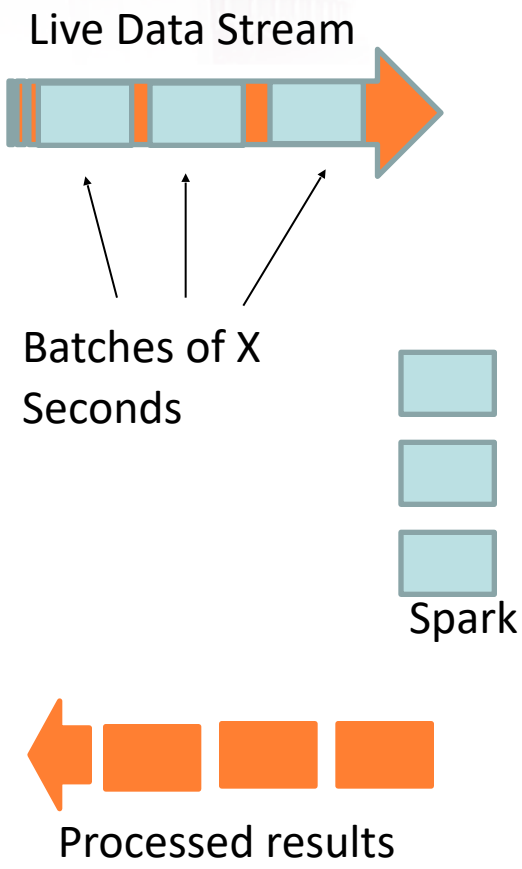


https://spark.apache.org

Spark Streaming: Discretized Stream Processing

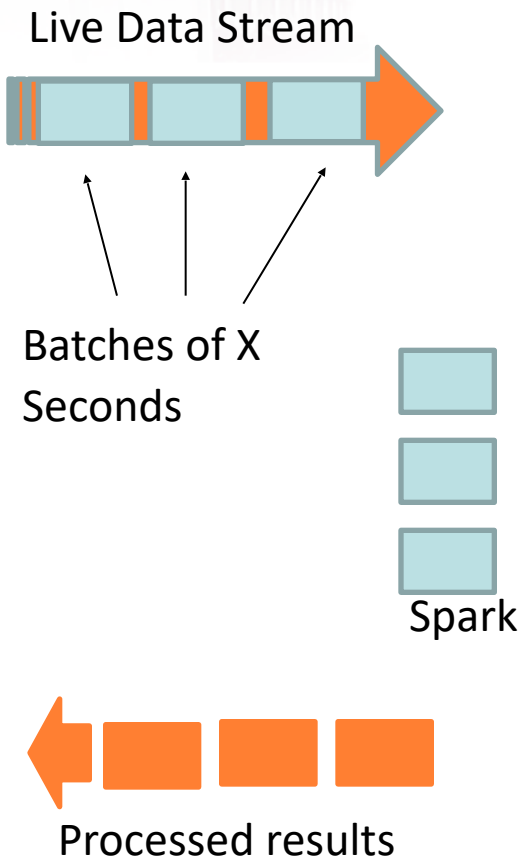
Run a streaming computation as a series of very small, deterministic batch jobs

- Chop up the live stream into batches of X seconds
- Spark treats each batch of data as RDDs and processes them using RDD operations
- Finally, the processed results of the RDD operations are returned in batches



Spark Streaming: Discretized Stream Processing

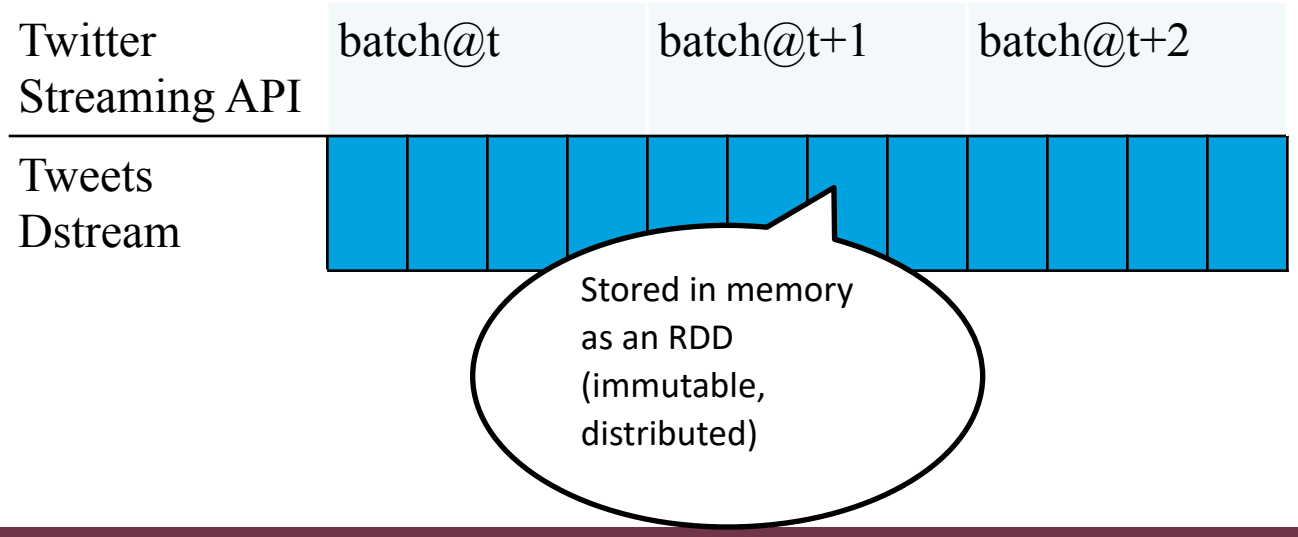
- Batch sizes as low as ½ second, latency ~ 1 second
- Potential for combining batch processing and streaming processing in the same system



Example 1 – Get hashtags from Twitter

- **Dstream: A sequence of RDD representing a stream of data**

```
val tweets =
ssc.twitterStream(<Twitter
username>, <Twitter password>)
```



Example 1 – Get hashtags from Twitter

```
val tweets =
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ream(<Twitter
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val hashTags
=
tweets.flatMa
p (status =>
getTags(statu
s))
```

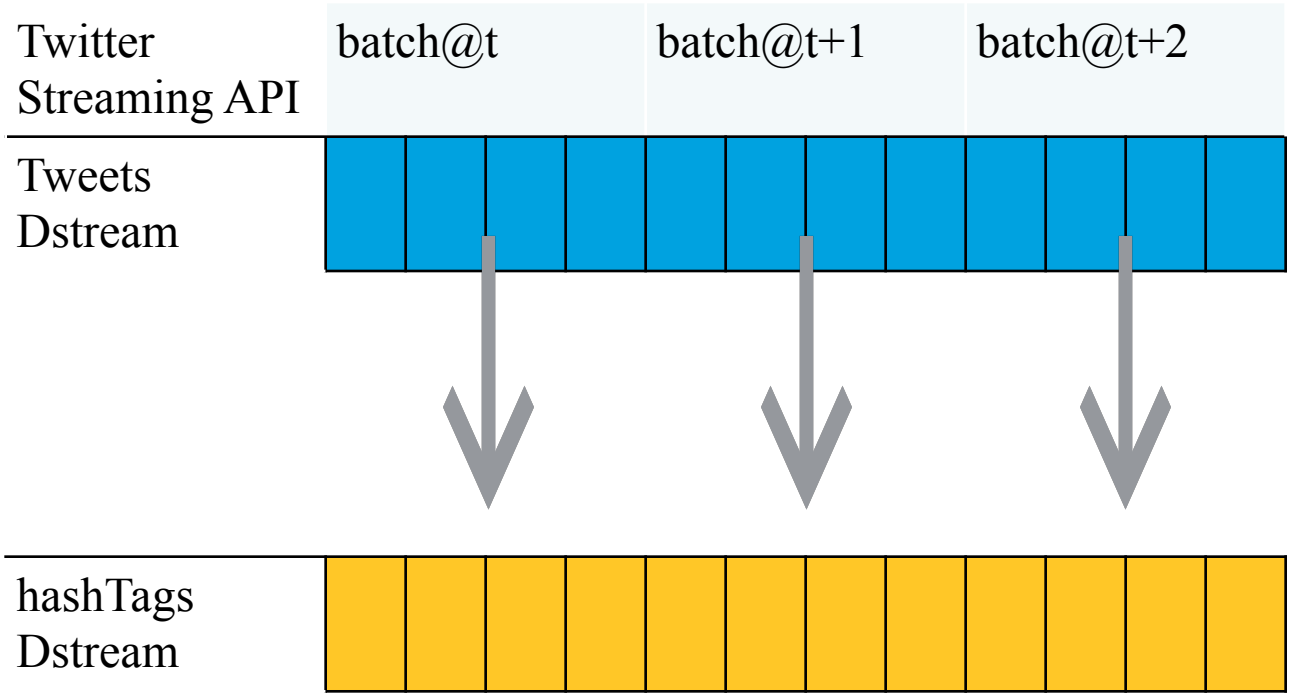

Example 1 – Get hashtags from Twitter

```
val tweets =
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m(<Twitter
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val hashTags =
tweets.flatMap
(status =>
getTags(status))

          .saveAsH
adoopFiles("hdfs
://...")
```
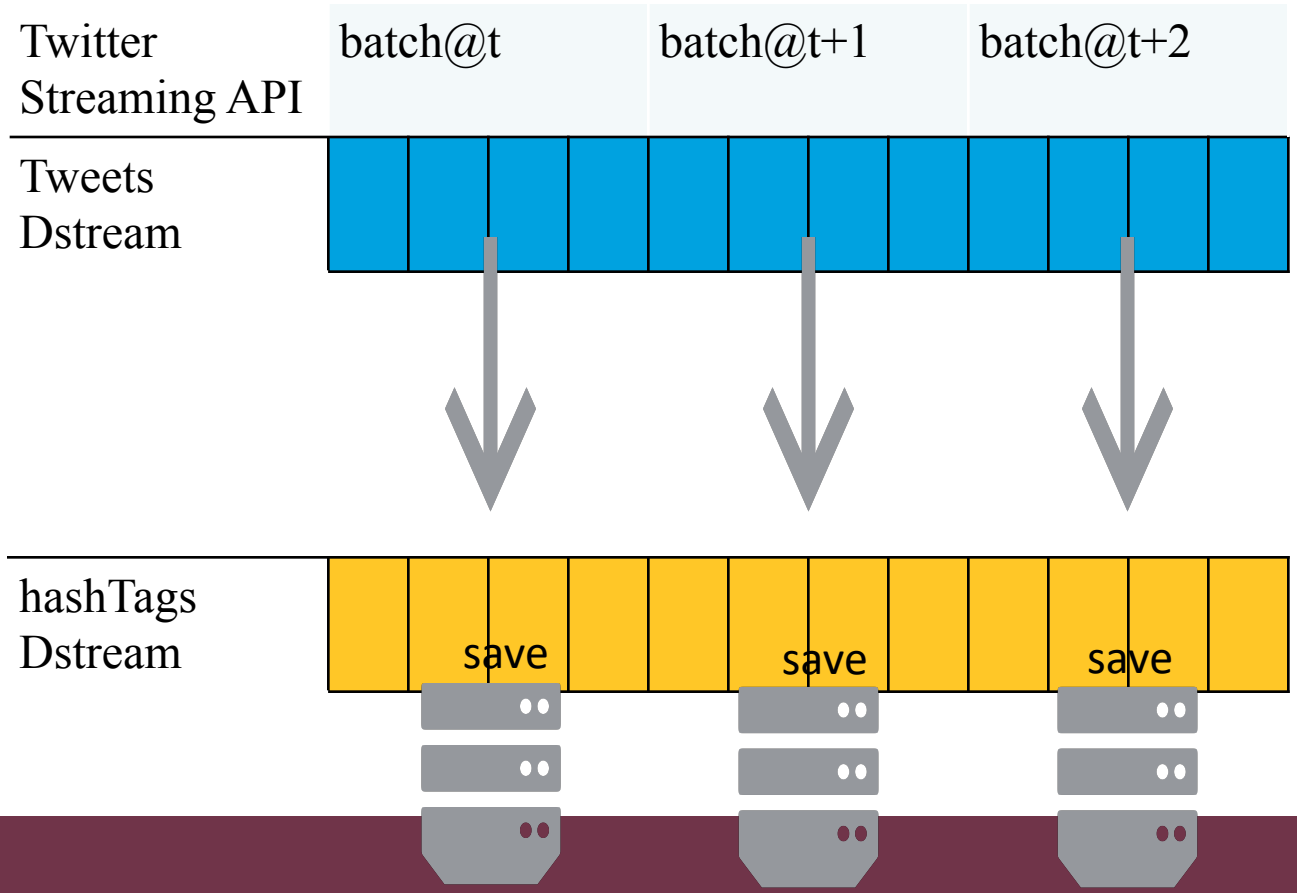



Java Example

Scala

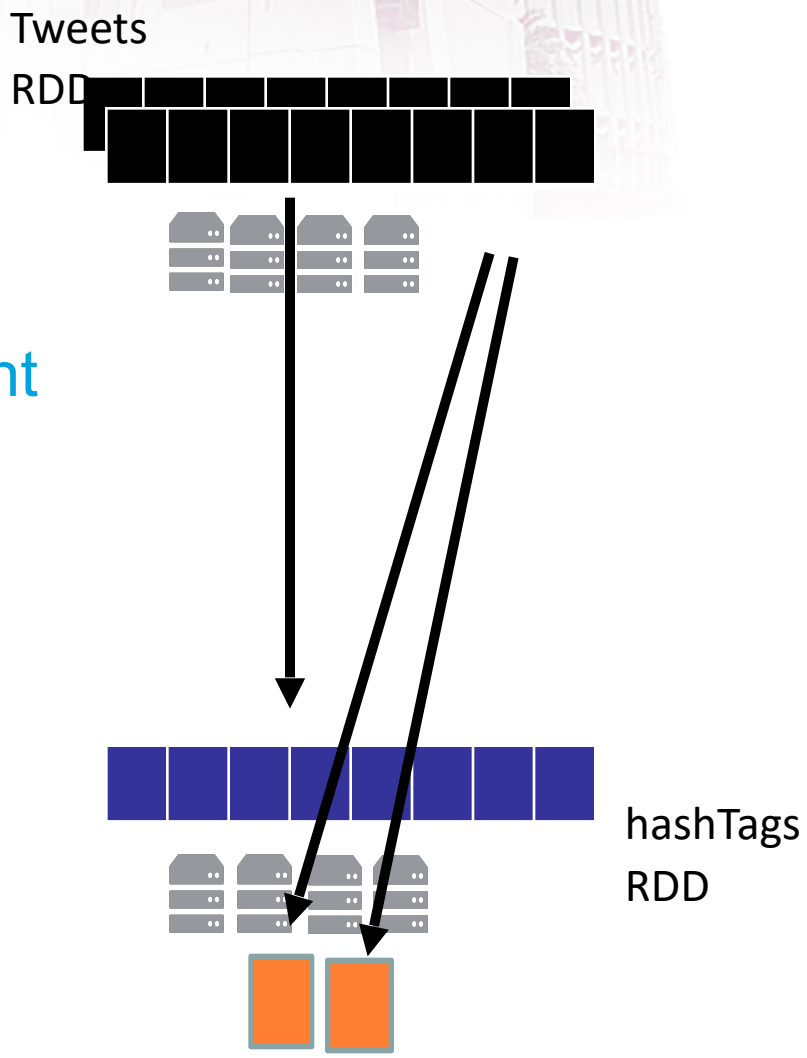
```
val tweets =
ssc.twitterStream(<Twitte
r username>, <Twitter
password>)

val hashTags =
tweets.flatMap (status =>
getTags(status))

          .saveAsHadoopFile
s("hdfs://...")
```

Java

```
JavaDStream<Status>
=
ssc.twitterStream(<Twitter
username>, <Twitter
password>)

JavaDstream<String>
hashTags =
tweets.flatMap(new
Function<...> {  })

          .saveAsHadoopFiles(
"hdfs://...")
```

Fault-tolerance

- RDDs are
  - remember the sequence of operations that created it from the original fault-tolerant input data
  - Batches of input data are replicated in memory of multiple worker nodes, therefore fault-tolerant
  - Data lost due to worker failure, can be recomputed from input data



Key Concepts

DStream

- Sequence of RDDs representing a stream of data
- Twitter, HDFS, Kafka, Flume, ZeroMQ, Akka Actor, TCP sockets

Transformations

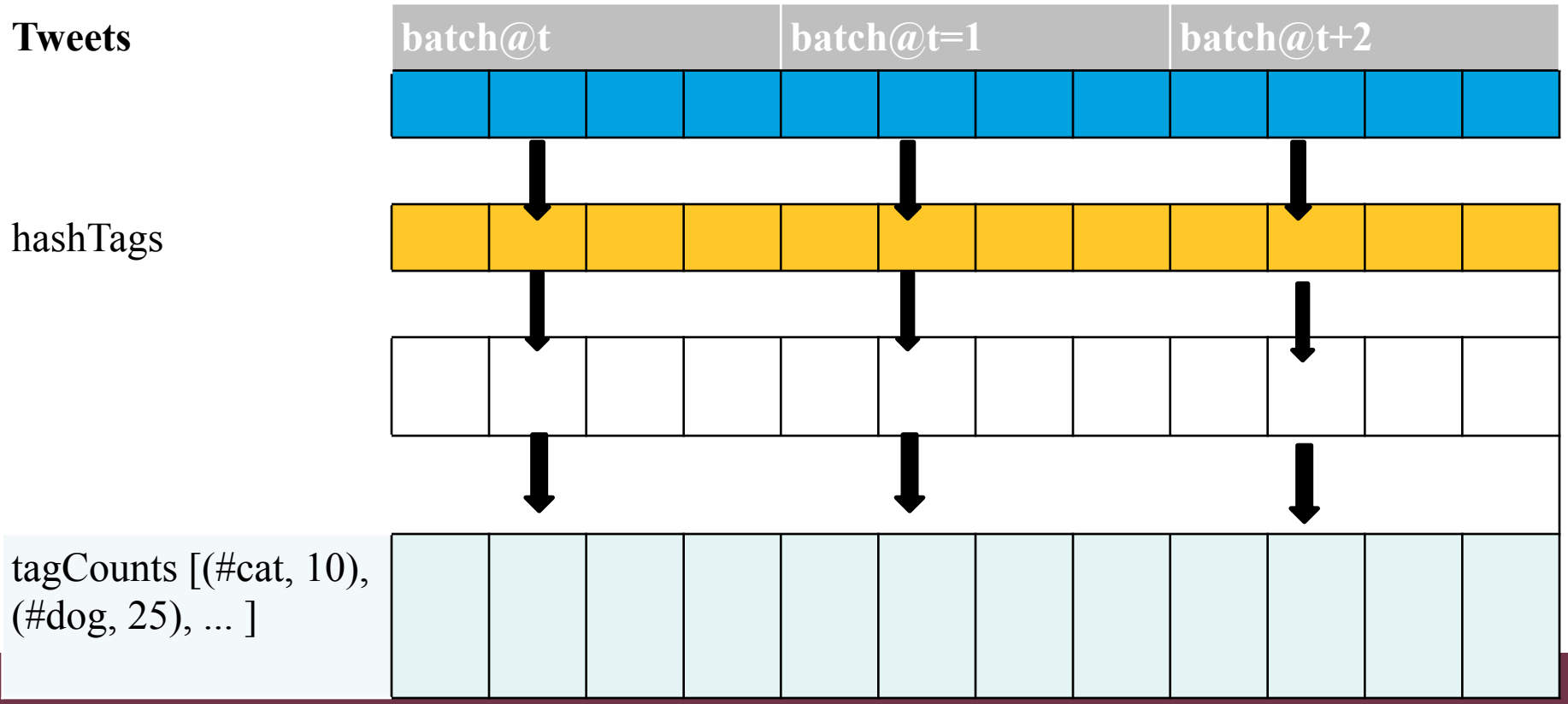
- Modify data from on DStream to another
- Standard RDD operations – map, countByValue, reduce, join, …
- Stateful operations – window, countByValueAndWindow, …

Output Operations – send data to external entity

- saveAsHadoopFiles – saves to HDFS
- foreach – do anything with each batch of results

Example: Count the hastags

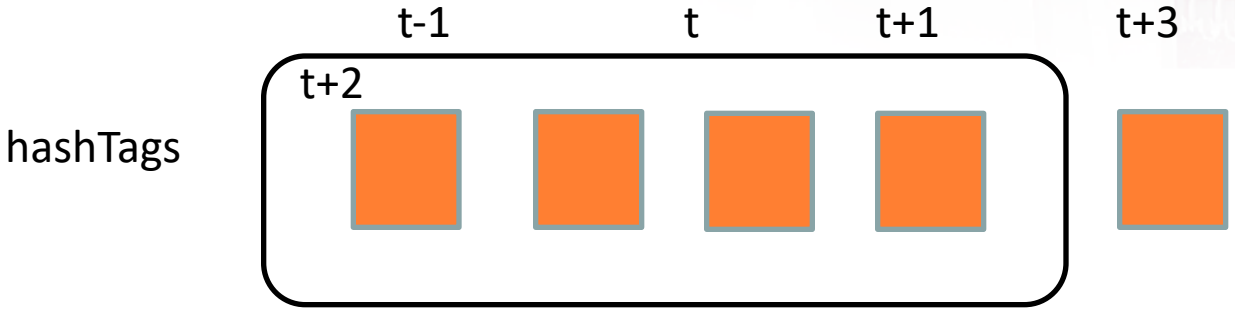
```
val tweets = ssc.twitterStream(<Twitter username>, <Twitter password>)
val hashTags = tweets.flatMap (status => getTags(status))
val           = hashTags.countByValue()
```



Example: Count the hashtags over last 10 mins

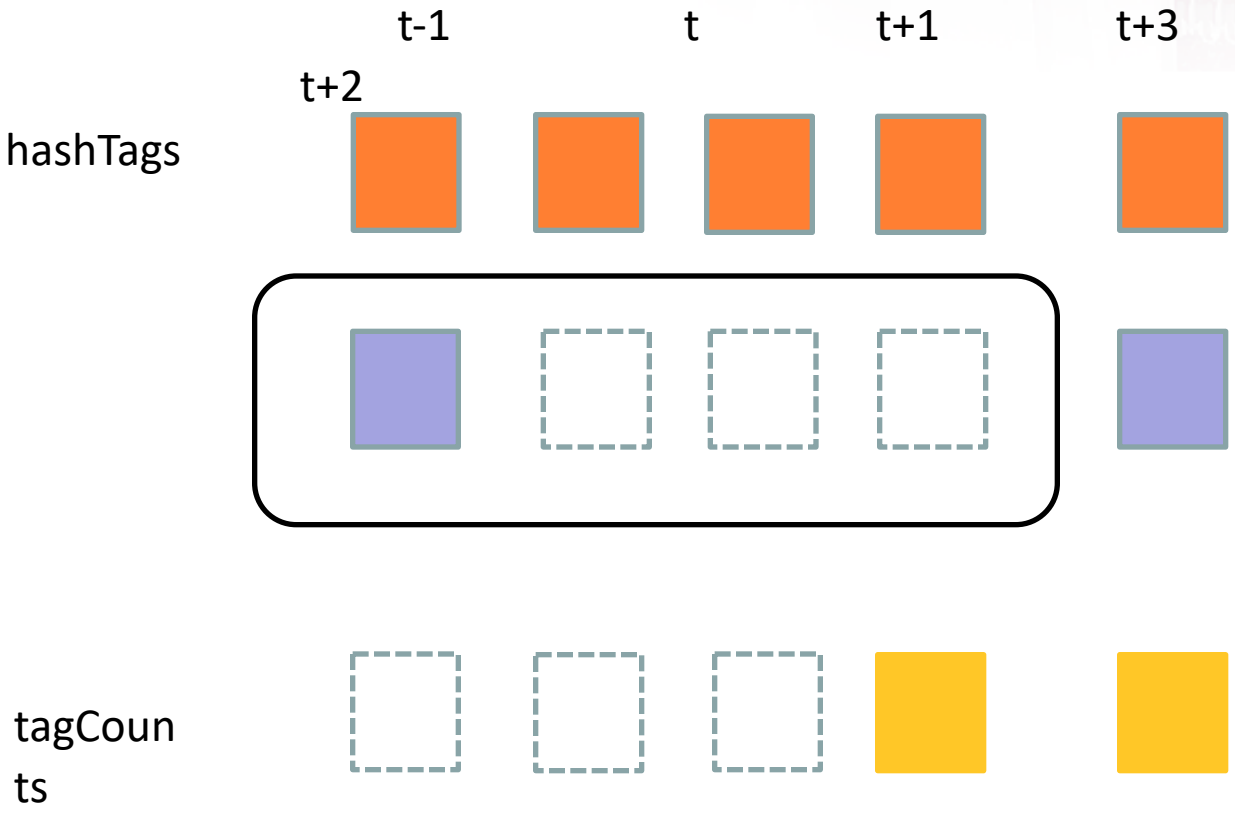
```
val tweets = ssc.twitterStream(<Twitter
username>, <Twitter password>)
val hashTags = tweets.flatMap (status =>
getTags(status))
val              = hashTags.window(Minutes(10),
Seconds(1)).countByValue()
```

```
Val  = hashTags.window(Minutes(10),
Seconds(1)).countByValue()
```



Example: Count the hashtags over last 10 mins

```
val tagCounts =
hashtags.countByValueAndWindow(Minutes(10),Seconds(1))
```



Smart window-based *reduce*

- Technique to incrementally compute count generalizes to many reduce operations
  - Need a function to "inverse reduce" ("subtract" for counting)

- Could have implemented counting as:

```
hashTags.reduceByKeyAndWindow(_ + _, _ - _,
Minutes(1), …)
```