Spark Streaming

Real-time big-data processing

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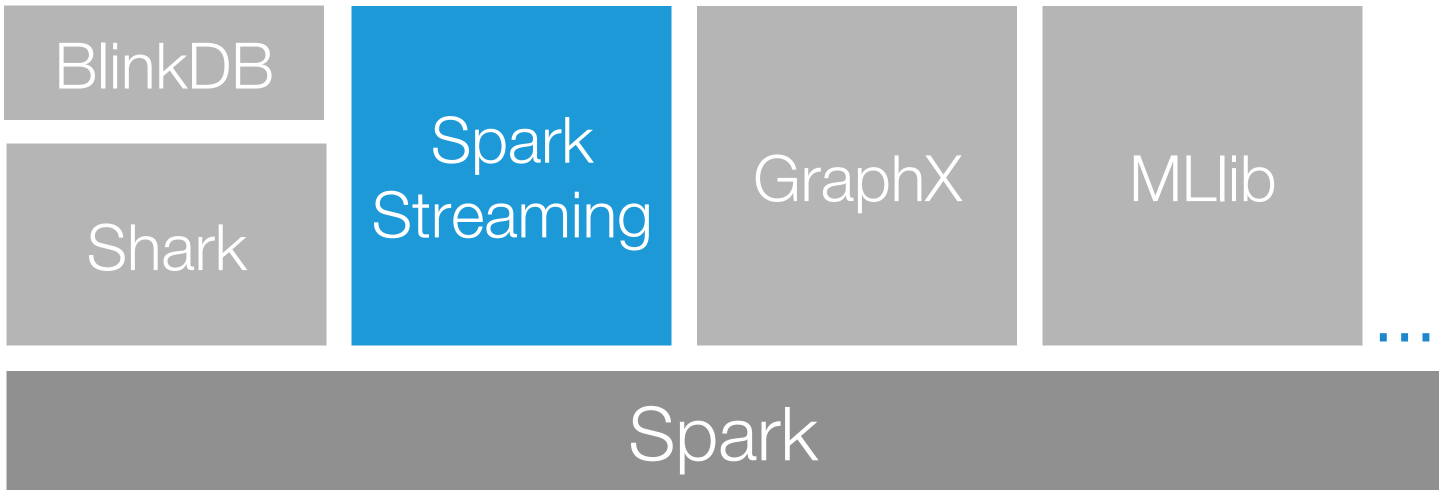
What is Spark Streaming?



- Extends Spark for doing big data stream processing
- Project started in early 2012, alpha released in Spring 2013 with Spark 0.7
- Moving out of alpha in Spark 0.9

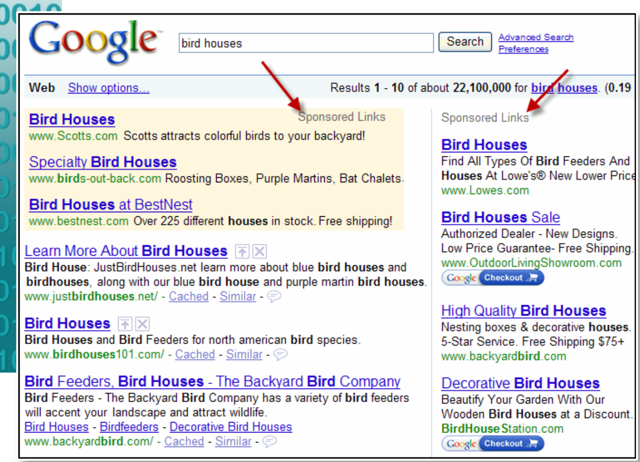
Why Spark Streaming?

Many big-data applications need to process large data streams in realtime

Website monitoring

Fraud detection

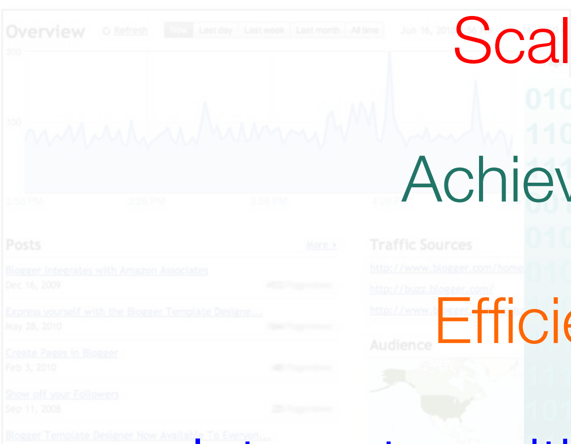
Ad monetization



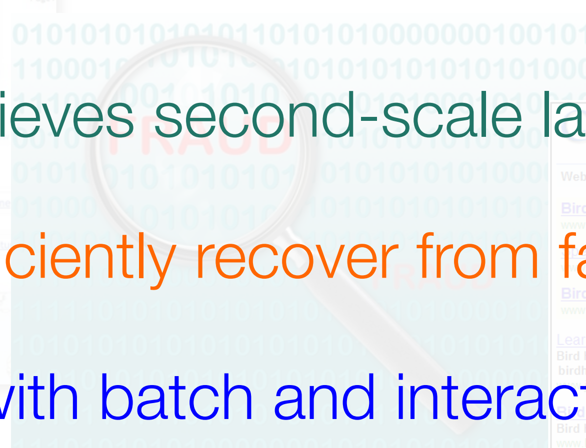
Why Spark Streaming?

Need a framework for big data
stream processing that

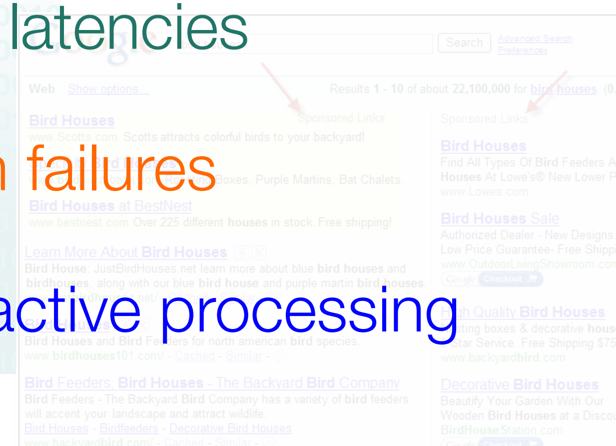
Website monitoring



Fraud detection



Ad monetization



Scales to hundreds of nodes

Achieves second-scale latencies

Efficiently recover from failures

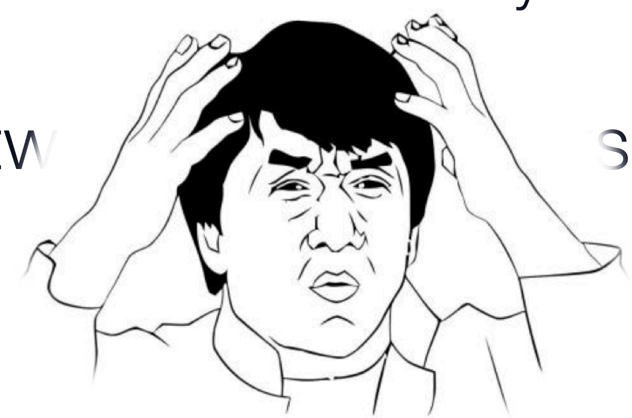
Integrates with batch and interactive processing

Integration with Batch Processing

- Many environments require processing same data in live streaming as well as batch post-processing

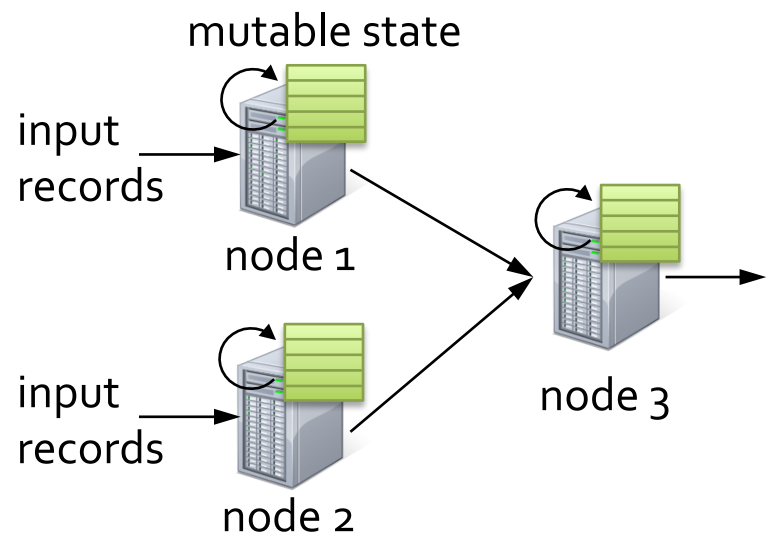
- Existing frameworks cannot do both
  - Either, stream processing of 100s of MB/s with low latency
  - Or, batch processing of TBs of data with high latency

- Extremely painful to maintain tw s
  - Different programming models
  - Double implementation effort



Stateful Stream Processing

- Traditional model
  - Processing pipeline of nodes
  - Each node maintains mutable state
  - Each input record updates the state and new records are sent out



- Mutable state is lost if node fails

- Making stateful stream processing fault tolerant is challenging!

Existing Streaming Systems

- Storm
  - Replays record if not processed by a node
  - Processes each record *at least once*
  - May update mutable state twice!
  - Mutable state can be lost due to failure!

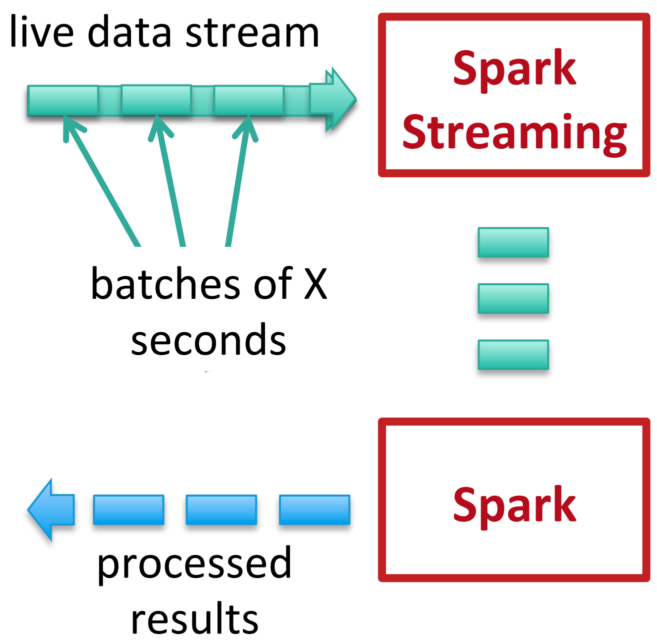
- Trident – Use transactions to update state
  - Processes each record *exactly once*
  - Per-state transaction to external database is slow

Spark Streaming

Spark Streaming

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

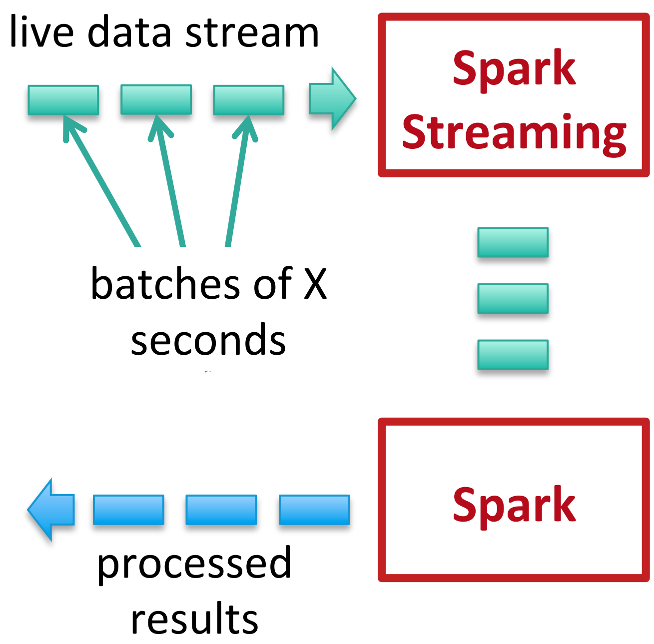
- Chop up the live stream into batches of X seconds
- Spark treats each batch of data as RDDs and processes them using RDD operations
- Finally, the processed results of the RDD operations are returned in batches



Spark Streaming

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

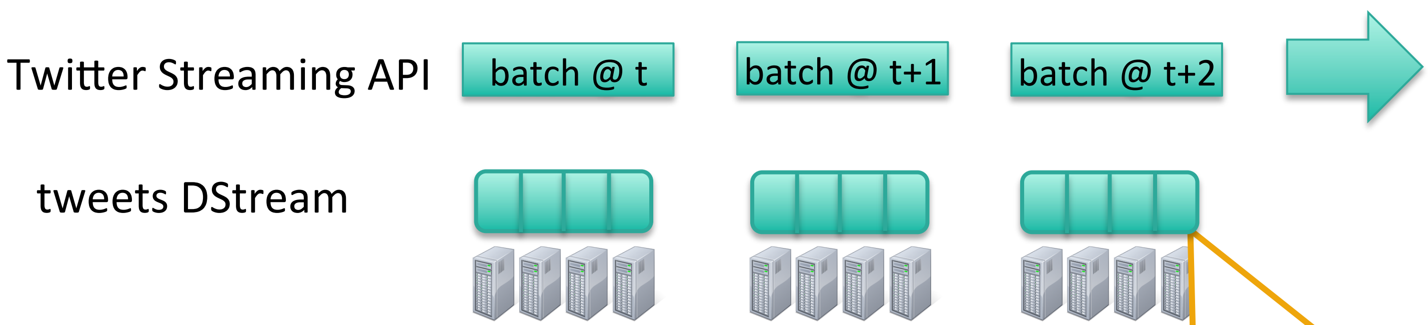
- Batch sizes as low as ½ second, latency of about 1 second
- Potential for combining batch processing and streaming processing in the same system



Example – Get hashtags from Twitter

```
val tweets = ssc.twitterStream()
```

DStream: a sequence of RDDs representing a stream of data



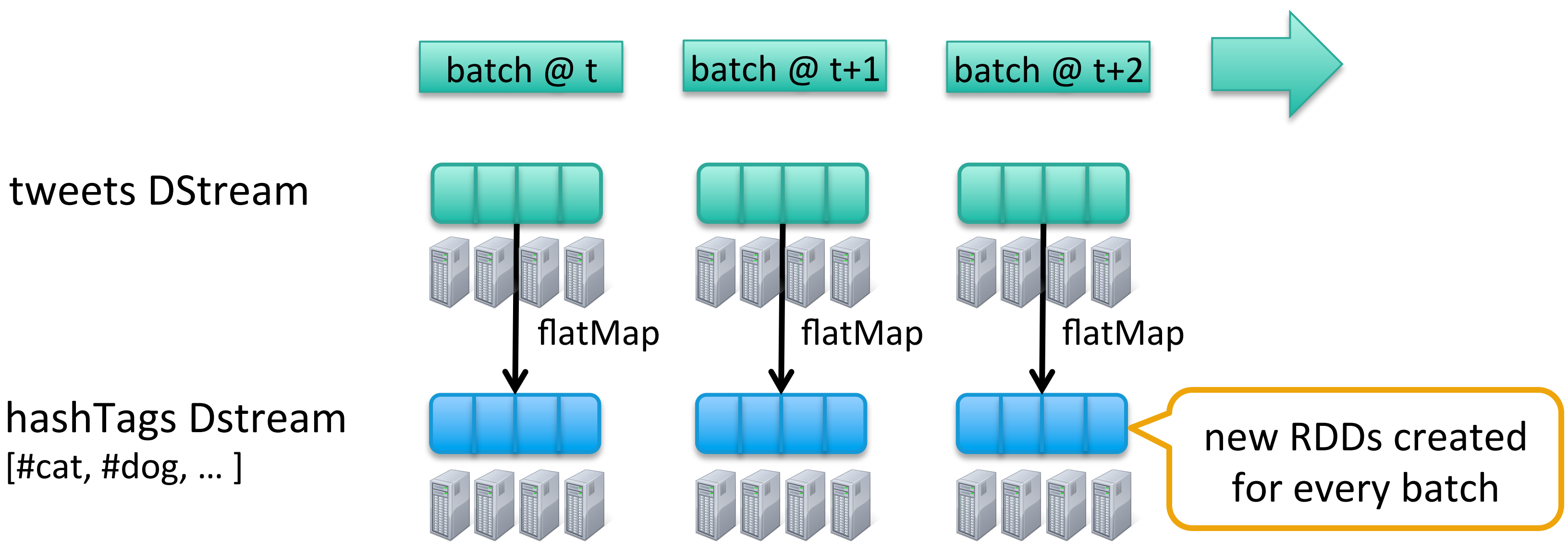
stored in memory as an RDD
(immutable, distributed)

Example – Get hashtags from Twitter

```
val tweets = ssc.twitterStream()
val hashTags = tweets.flatMap(status => getTags(status))
```

new DStream

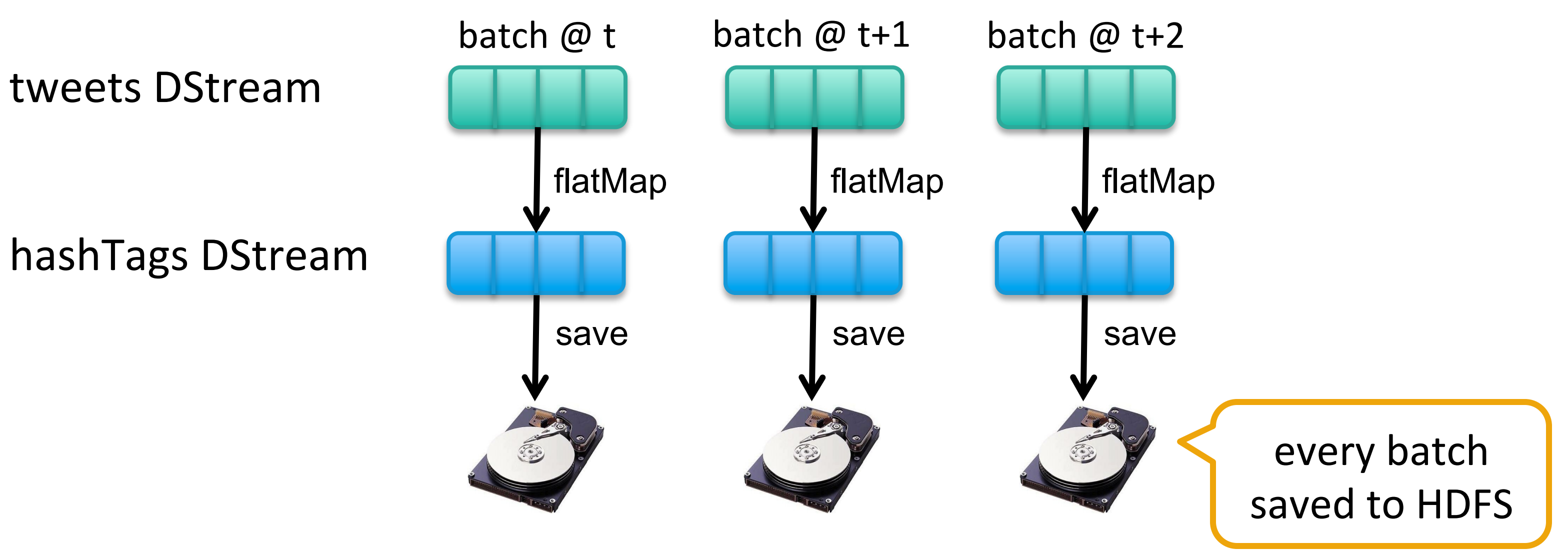
transformation: modify data in one DStream to create another DStream



Example – Get hashtags from Twitter

```
val tweets = ssc.twitterStream()
val hashTags = tweets.flatMap(status => getTags(status))
hashTags.saveAsHadoopFiles("hdfs://...")
```

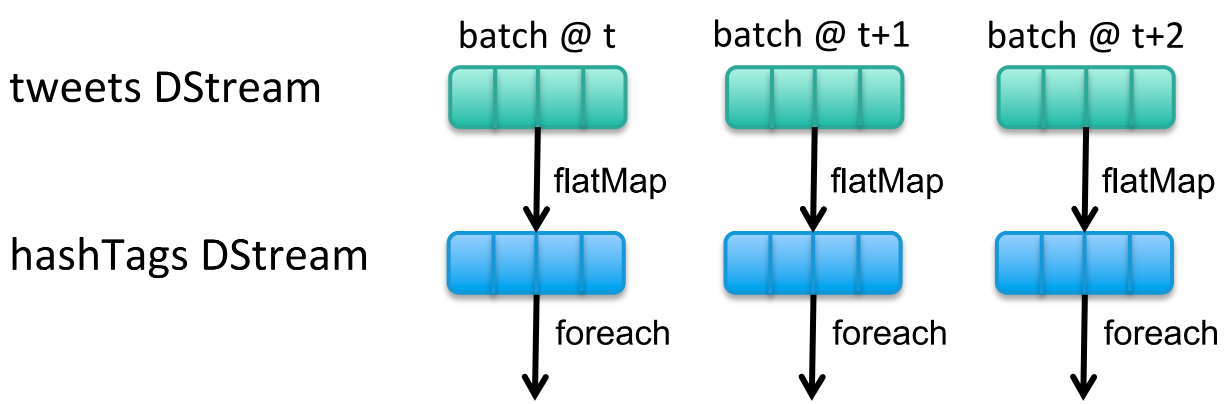
output operation: to push data to external storage



Example – Get hashtags from Twitter

```
val tweets = ssc.twitterStream()
val hashTags = tweets.flatMap(status => getTags(status))
hashTags.foreach(hashTagRDD => { ... })
```

foreach: do whatever you want with the processed data



Write to a database, update analytics
UI, do whatever you want

Demo

Java Example

Scala

```
val tweets = ssc.twitterStream()
val hashTags = tweets.flatMap(status => getTags(status))
hashTags.saveAsHadoopFiles("hdfs://...")
```

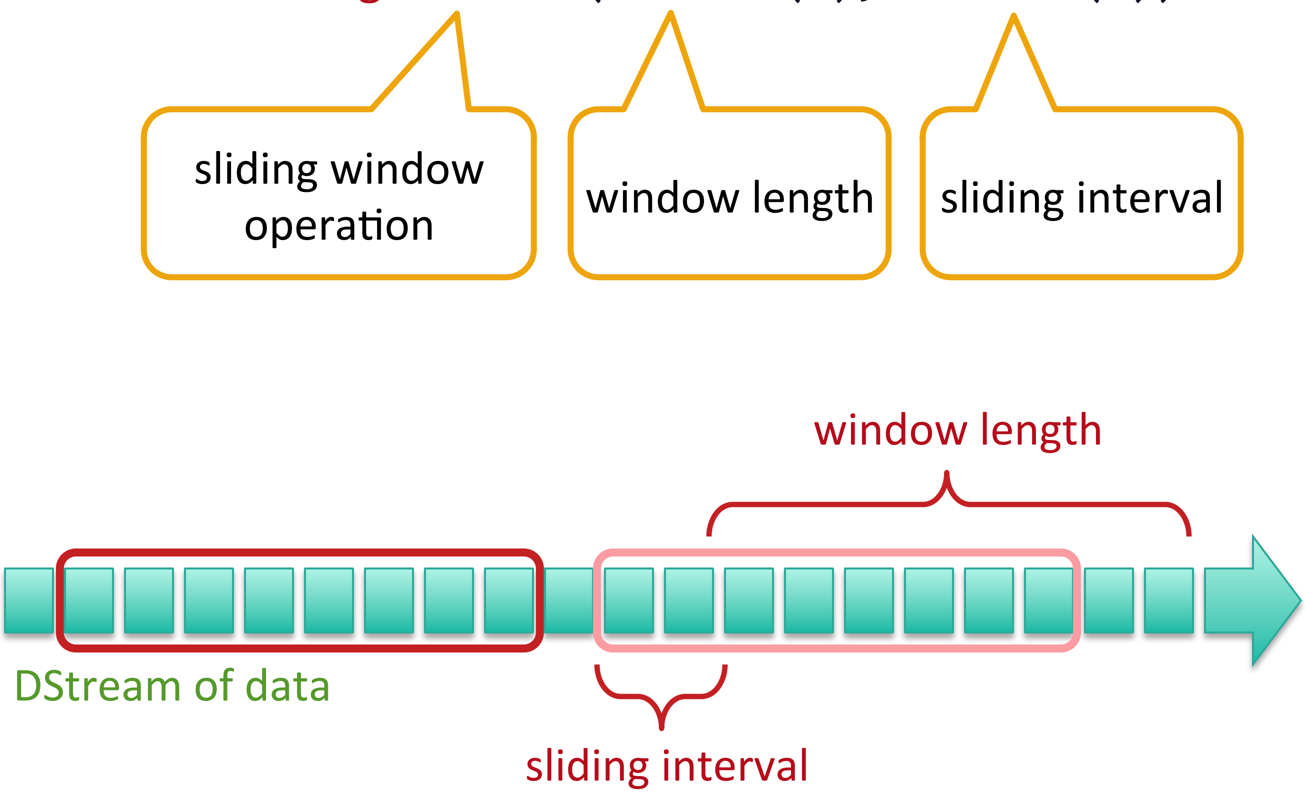
Java

```
JavaDStream<Status> tweets = ssc.twitterStream()
JavaDstream<String> hashTags = tweets.flatMap(new Function<...> {  })
hashTags.saveAsHadoopFiles("hdfs://...")
```

Function object

Window-based Transformations

```
val tweets = ssc.twitterStream()
val hashTags = tweets.flatMap(status => getTags(status))
val tagCounts = hashTags.window(Minutes(1), Seconds(5)).countByValue()
```



Arbitrary Stateful Computations

Specify function to generate new state based on previous state and new data

- Example: Maintain per-user mood as state, and update it with their tweets

```
def updateMood(newTweets, lastMood) => newMood

moods = tweetsByUser.updateStateByKey(updateMood _)
```

Arbitrary Combinations of Batch and Streaming Computations

Inter-mix RDD and DStream operations!

- Example: Join incoming tweets with a spam HDFS file to filter out bad tweets

```
tweets.transform(tweetsRDD => {
    tweetsRDD.join(spamHDFSFile).filter(...)
})
```

DStreams + RDDs = Power

- Online machine learning
  - Continuously learn and update data models (*updateStateByKey* and *transform*)
- Combine live data streams with historical data
  - Generate historical data models with Spark, etc.
  - Use data models to process live data stream (*transform*)
- CEP-style processing
  - window-based operations (reduceByWindow, etc.)

Input Sources

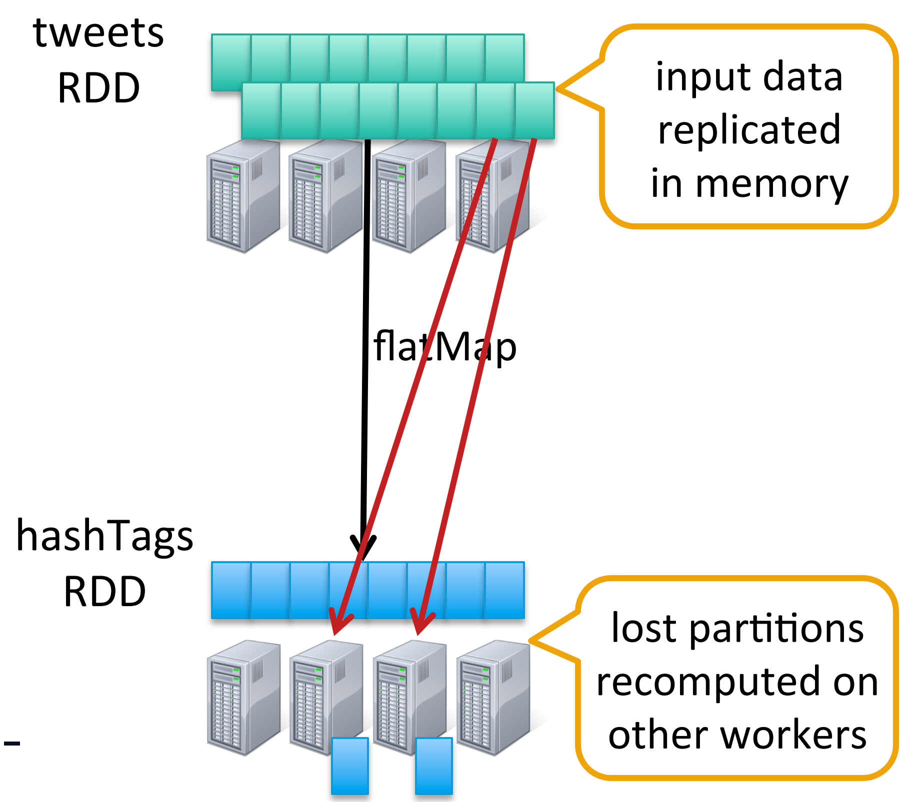
- Out of the box, we provide
  - Kafka, HDFS, Flume, Akka Actors, Raw TCP sockets, etc.

- Very easy to write a *receiver* for your own data source

- Also, generate your own RDDs from Spark, etc. and push them in as a “stream”

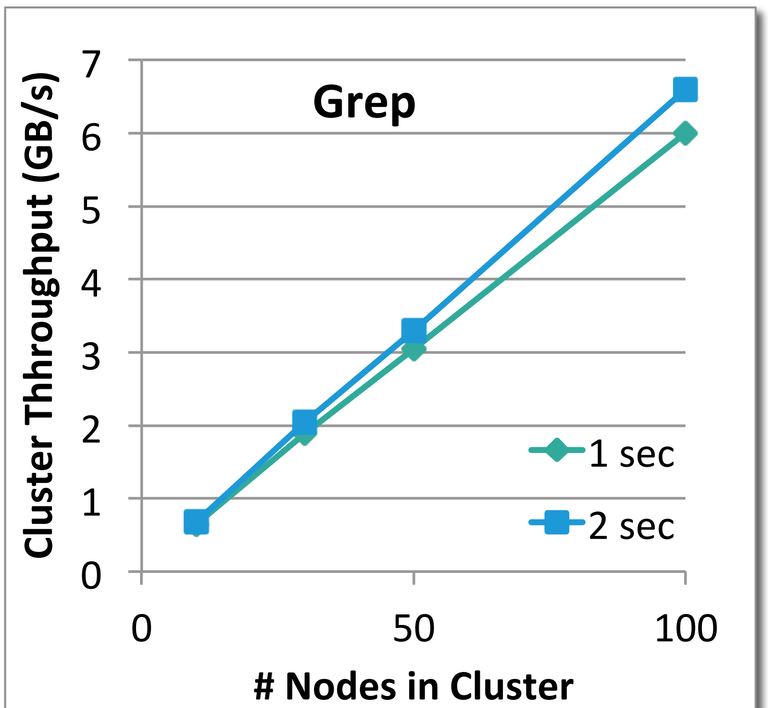
Fault-tolerance

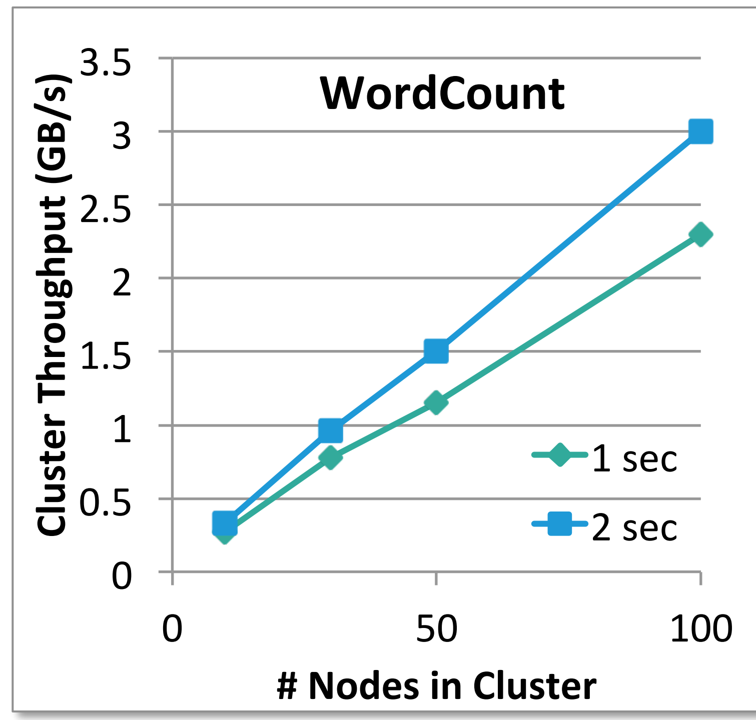
- Batches of input data are replicated in memory for fault-tolerance
- Data lost due to worker failure, can be recomputed from replicated input data
- All transformations are fault-tolerant, and *exactly-once* transformations



Performance

Can process **60M records/sec (6 GB/sec)** on **100 nodes** at **sub-second** latency

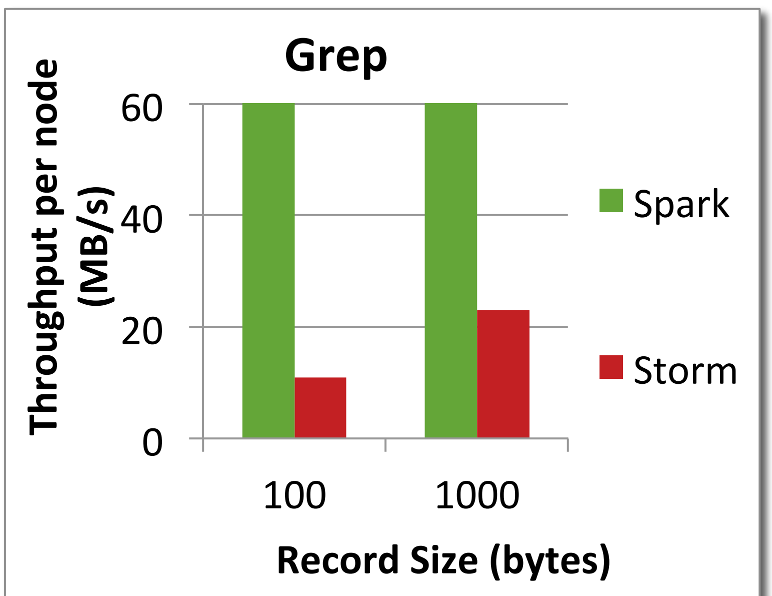


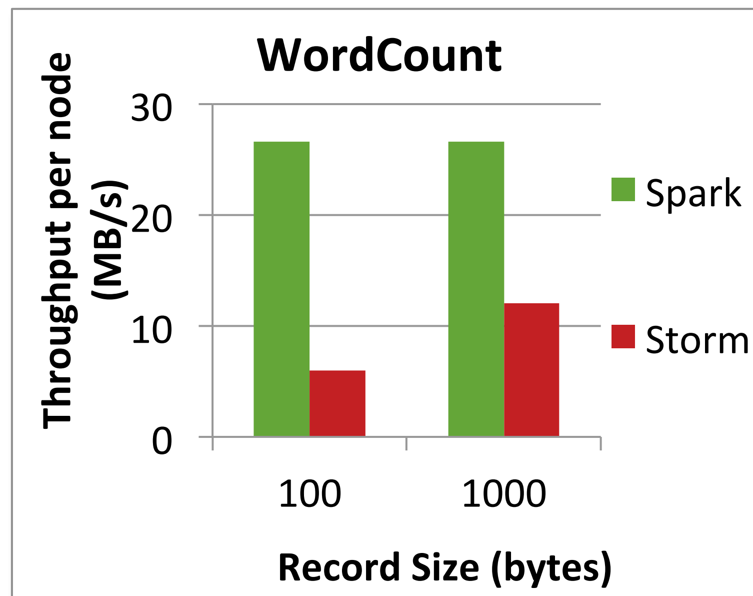


Comparison with other systems

Higher throughput than Storm

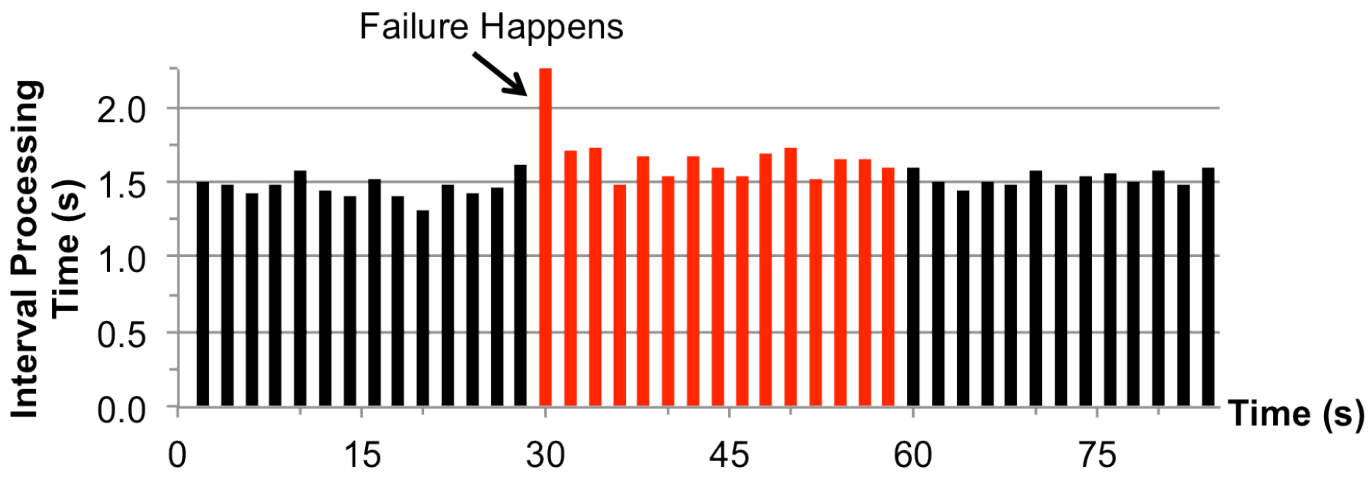
- Spark Streaming: **670k** records/sec/node
- Storm: **115k** records/sec/node
- Commercial systems: **100-500k** records/sec/node





Fast Fault Recovery

Recovers from faults/stragglers within **1 sec**

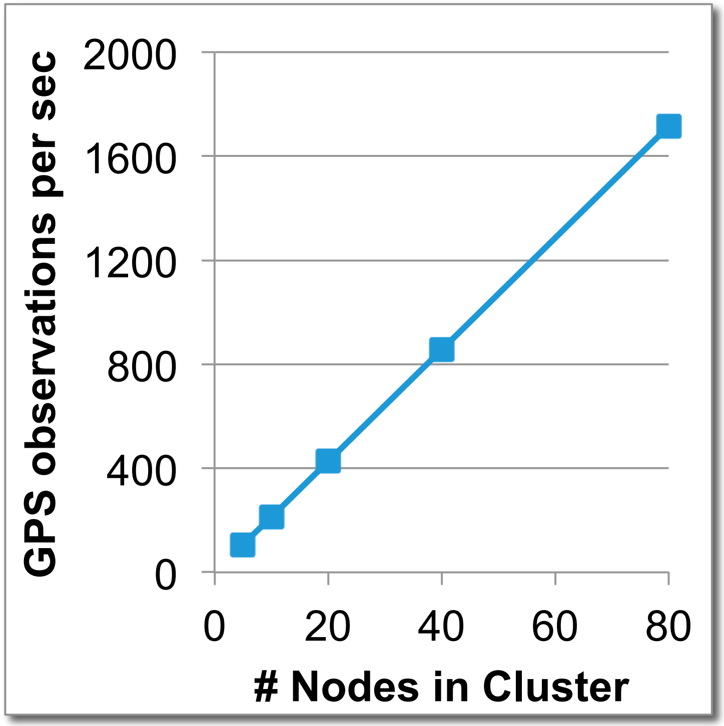


Sliding WordCount on 10 nodes with 30s checkpoint interval

Mobile Millennium Project

Traffic transit time estimation using online machine learning on GPS observations

- Markov-chain Monte Carlo simulations on GPS observations
- Very CPU intensive, requires dozens of machines for useful computation
- Scales linearly with cluster size



Advantage of an unified stack

- Explore data interactively to identify problems
- Use same code in Spark for processing large logs
- Use similar code in Spark Streaming for realtime processing

```
$ ./spark-shell
scala> val file = sc.hadoopFile("smallLogs")
...
scala> val filtered = file.filter(_.contains("ERROR"))
...
scala> val mapped = filtered.map(...)
...
```

```
object ProcessProductionData {
  def main(args: Array[String]) {
    val sc = new SparkContext(...)
    val file = sc.hadoopFile("productionLogs")
    val filtered = file.filter(_.contains("ERROR"))
    val mapped = filtered.map(...)
    ...
  }
}
```

```
object ProcessLiveStream {
  def main(args: Array[String]) {
    val sc = new StreamingContext(...)
    val stream = sc.kafkaStream(...)
    val filtered = stream.filter(_.contains("ERROR"))
    val mapped = filtered.map(...)
    ...
  }
}
```

Roadmap

- Spark 0.8.1
  - Marked alpha, but has been quite stable
  - Master fault tolerance – manual recovery
    - Restart computation from a checkpoint file saved to HDFS

- Spark 0.9 in Jan 2014 – out of alpha!
  - Automated master fault recovery
  - Performance optimizations
  - Web UI, and better monitoring capabilities

Roadmap

- Long term goals
  - Python API
  - MLlib for Spark Streaming
  - Shark Streaming

- Community feedback is crucial!
  - Helps us prioritize the goals

- Contributions are more than welcome!!

Today's Tutorial

- Process Twitter data stream to find most popular hashtags over a window

- Requires a Twitter account
  - Need to setup Twitter OAuth keys to access tweets
  - All the instructions are in the tutorial

- Your account will be safe!
  - No need to enter your password anywhere, only the keys
  - Destroy the keys after the tutorial is done

Conclusion

- Streaming programming guide – spark.incubator.apache.org/docs/latest/streaming-programming-guide.html

- Research Paper – tinyurl.com/dstreams