分布式流处理框架

——功能对比和性能评估

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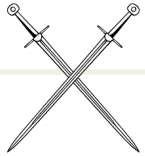
- Streaming Core
- MISC
- Performance Benchmark



Spark Streaming

STORM

Flink

Apache Gearpump

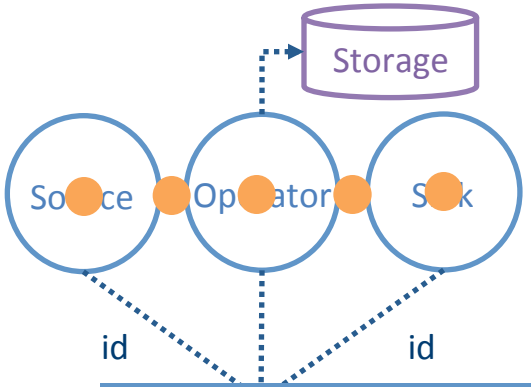
HERON

Execution Model + Fault Tolerance Mechanism

Continuous Streaming

Ack per Record

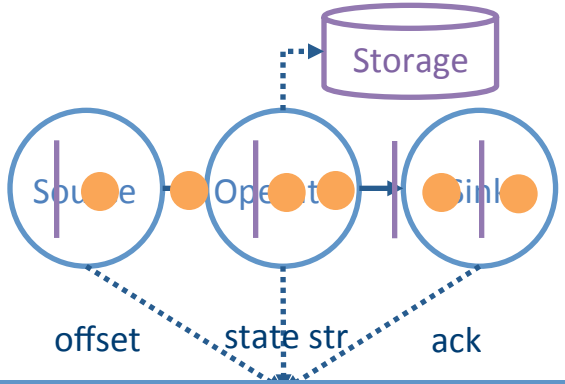
Storm | Heron



Continuous Streaming

Checkpoint "per Batch"

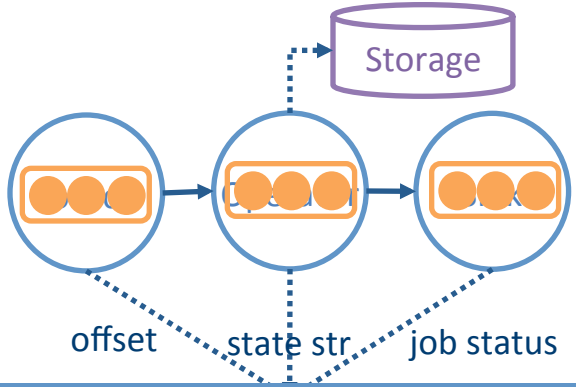
Flink | Gearpump



Micro-Batch

Checkpoint per Batch

Spark Streaming | Storm Trident



This is the **critical** part, as it affects many features

Continuous Streaming

Ack per Record

Storm | Heron

Continuous Streaming

Checkpoint "per Batch"

Flink | Gearpump

Micro-Batch

Checkpoint per Batch

Spark Streaming | Storm Trident

Low Latency

High Latency

High Overhead

Low Overhead

Low Throughput

High Throughput

Delivery Guarantee

Storm | Heron | Flink | Gearpump | Spark Streaming | Storm Trident

At least once

- Ackers know about if a record is processed successfully or not. If it failed, replay it.
- There is no state consistency guarantee.

Exactly once

- State is persisted in durable storage
- Checkpoint is linked with state storage per Batch

Native State Operator

Storm | Heron

Yes*

- Storm:
  - ✓ KeyValueState
- Heron:
  - X User Maintain

Flink | Gearpump

Yes

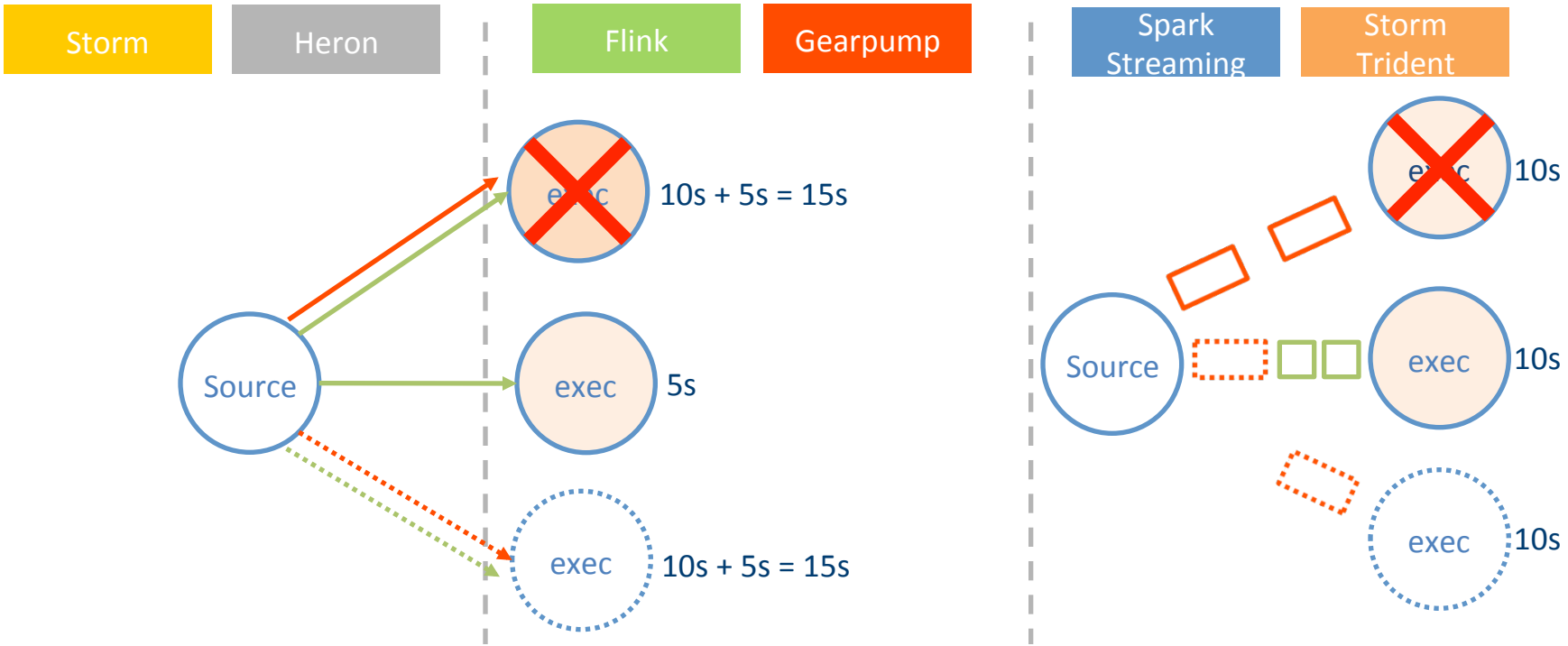
- Flink Java API:
  - ✓ ValueState
  - ✓ ListState
  - ✓ ReduceState
- Flink Scala API:
  - ✓ mapWithState
- Gearpump
  - ✓ persistState

Spark Streaming | Storm Trident

Yes

- Spark 1.5:
  - ✓ updateStateByKey
- Spark 1.6:
  - ✓ mapWithState
- Trident:
  - ✓ persistentAggregate
  - ✓ State

Dynamic Load Balance & Recovery Speed



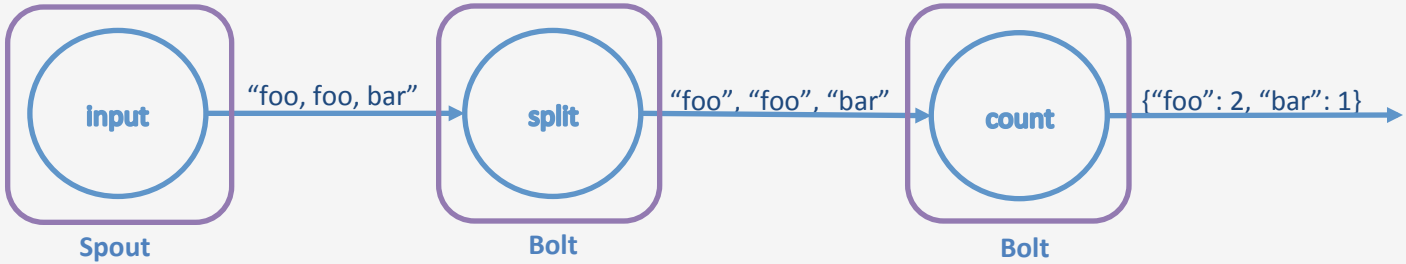
API

Storm
Gearpump
Heron

Compositional

- Highly customizable operator based on basic building blocks
- Manual topology definition and optimization

```
TopologyBuilder builder = new TopologyBuilder();
builder.setSpout("input", new RandomSentenceSpout(), 1);
builder.setBolt("split", new SplitSentence(), 3).shuffleGrouping("spout");
builder.setBolt("count", new WordCount(), 2).fieldsGrouping("split", new Fields("word"));
```

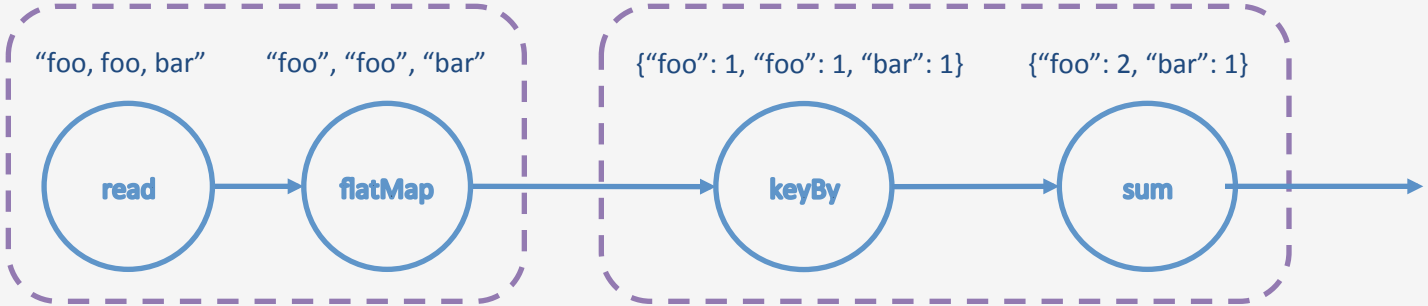


Spark Streaming
Storm Trident
Flink
Gearpump

Declarative

- Higher order function as operators (filter, mapWithState…)
- Logical plan optimization

```
DataStream<String> text = env.readTextFile(params.get("input"));
DataStream<Tuple2<String, Integer>> counts = text.flatMap(new Tokenizer()).keyBy(0).sum(1);
```



Statistical

- Data scientist friendly
- Dynamic type

Spark Streaming | Storm | Heron*

Python

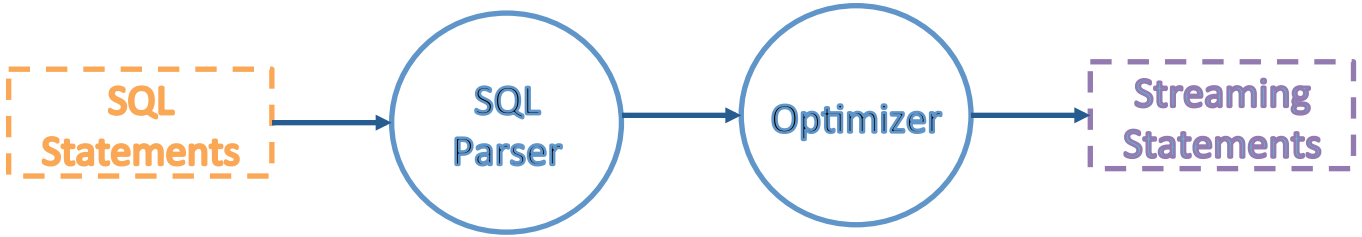
```
lines = ssc.textFileStream(params.get("input"))
words = lines.flatMap(lambda line: line.split(“,"))
pairs = words.map(lambda word: (word, 1))
counts = pairs.reduceByKey(lambda x, y: x + y)
counts.saveAsTextFiles(params.get("output"))
```

Structured Streaming* | Storm*

R

```
lines <- textFile(sc, “input”)
words <- flatMap(lines, function(line) {
            strsplit(line, “ ”)[[1]]
      })
wordCount <- lapply(words, function(word) {
            list(word, 1L)
      }
counts <- reduceByKey(wordCount, “+”, 2L)
```

SQL



Fusion Style

Spark Streaming
Flink

```
InputDStream.transform((rdd: RDD[Order], time: Time) => {
   import sqlContext.implicits._
   rdd.toDF.registAsTempTable
   val SQL = "SELECT ID, UNIT_PRICE * QUANTITY
      AS TOTAL FROM ORDERS WHERE UNIT_PRICE * QUANTITY >
50"
   val largeOrderDF = sqlContext.sql(SQL)
   largeOrderDF.toRDD
})
```

Pure Style

Structured Streaming*
Storm Trident

```
CREATE EXTERNAL TABLE
   ORDERS (ID INT PRIMARY KEY, UNIT_PRICE INT, QUANTITY INT)
   LOCATION 'kafka://localhost:2181/brokers?topic=orders'
   TBLPROPERTIES '{...}}‘

INSERT INTO LARGE_ORDERS SELECT ID, UNIT_PRICE * QUANTITY
   AS TOTAL FROM ORDERS WHERE UNIT_PRICE * QUANTITY > 50
```

bin/storm sql XXXX.sql

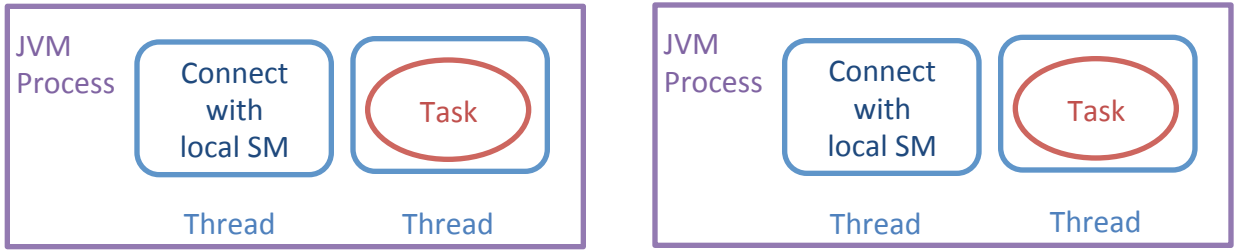
Summary

	Compositional	Declarative	Python/R	SQL
Spark Streaming	X	√	√	√
Storm	√	X	√	NOT support aggregation, windowing and joining
Storm Trident	X	√	X	
Gearpump	√	√	X	X
Flink	X	√	X	Support select, from, where, union
Heron	√	X	√*	X

Runtime Model

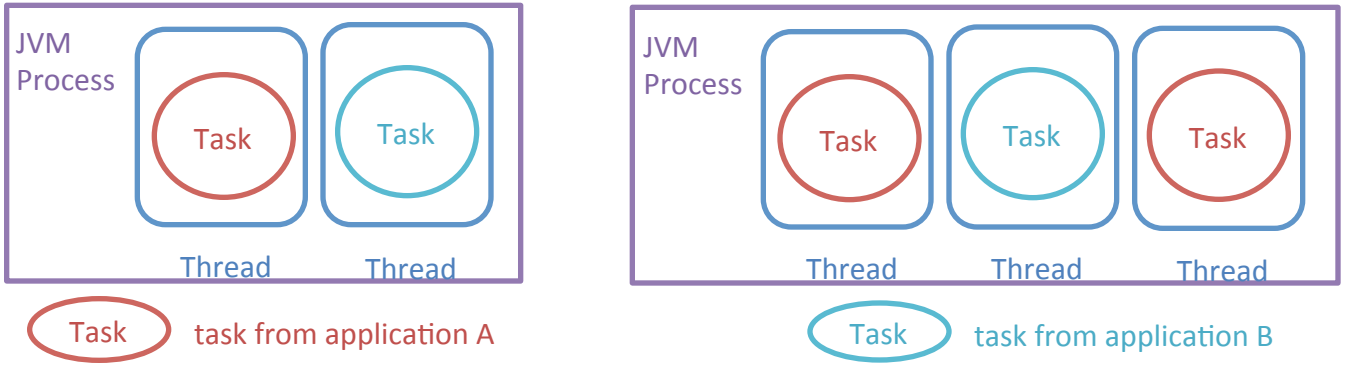
- Single Task on Single Process

Heron



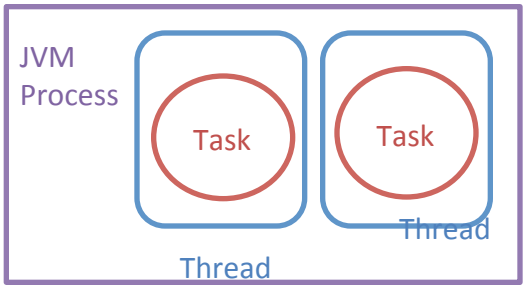
- Multi Tasks of Multi Applications on Single Process

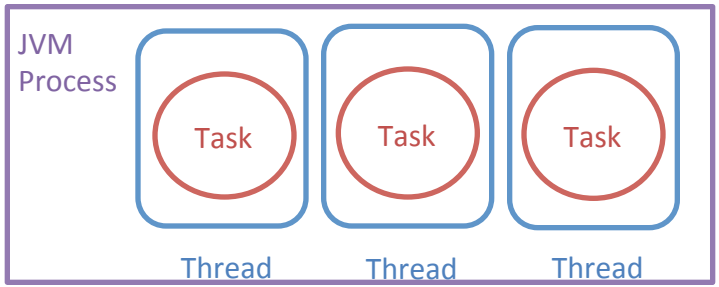
Flink



- Multi Tasks of Single application on Single Process
  - Single task on single thread

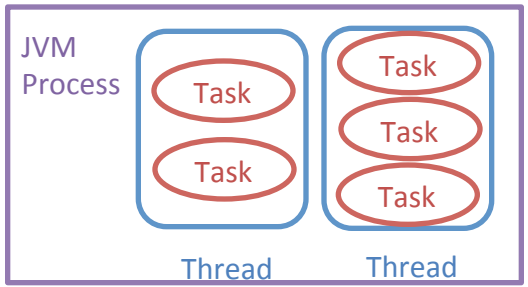
Spark Streaming

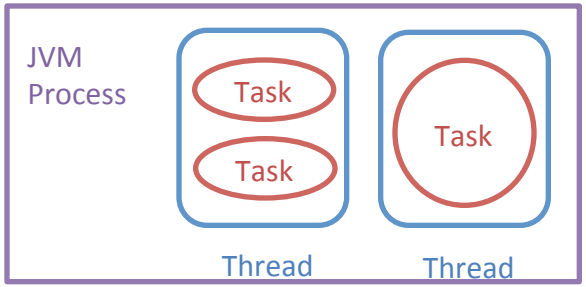




  - Multi tasks on single thread

Gearpump | Storm | Storm Trident



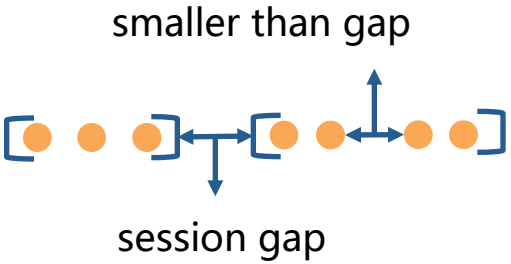


MISC

- Window Support
- Out-of-order Processing
- Memory Management
- Resource Management
- Web UI
- Community Maturity

Window Support

- Sliding Window 

- Count Window 
- Session Window 

	Sliding Window	Count Window	Session Window
Spark Streaming	√	X	X*
Storm	√	√	X
Storm Trident	√	√	X
Gearpump	√*	X	X
Flink	√	√	√
Heron	X	X	X

Out-of-order Processing

	Processing Time	Event Time	Watermark
Spark Streaming	√	√*	X*
Storm	√	√	√
Storm Trident	√	X	X
Gearpump	√	√	√
Flink	√	√	√
Heron	√	X	X

Memory Management

	JVM Manage	Self Manage on-heap	Self Manage off-heap
Spark Streaming	√	√*	√*
Flink	√	√	√
Storm	√	X	X
Gearpump	√	X	X
Heron	√	X	X

Resource Management

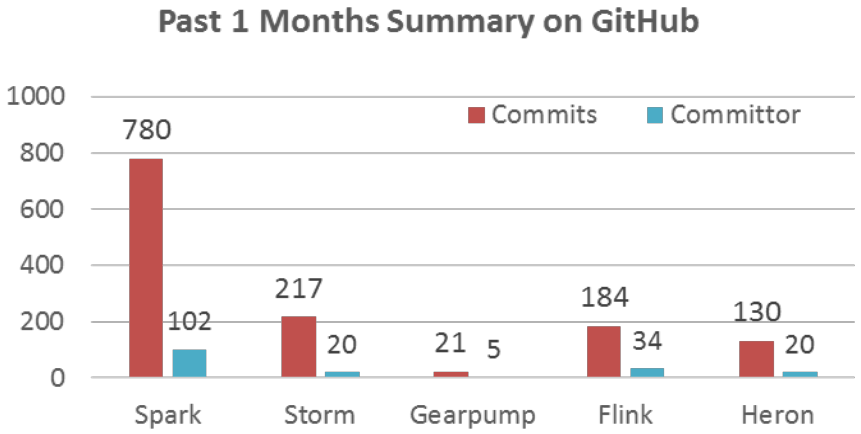
	Standalone	YARN	Mesos
Spark Streaming	√	√	√
Storm	√	√*	√*
Storm Trident	√	√*	√*
Gearpump	√	√	X
Flink	√	√	X
Heron	√	√	√

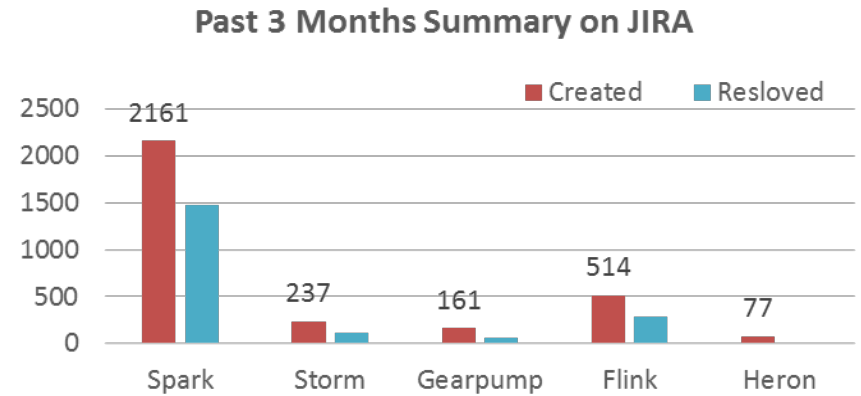
Web UI

	Submit Jobs	Cancel Jobs	Inspect Jobs	Show Statistics	Show Input Rate	Check Exceptions	Inspect Config	Alert
Spark Streaming	X	√	√	√	√	√	√	X
Storm	X	√	√	√	√*	√	√	X
Gearpump	√	√	√	√	√*	√	√	X
Flink	√	√	√	√	X	√	√	X
Heron	X	X	√	√	√*	√	√	X

Community Maturity

	Initiation Time	Apache Top Project	Contributors
Spark Streaming	2013	2014	926
Storm	2011	2014	219
Gearpump	2014	Incubator	21
Flink	2010	2015	208
Heron	2014	N/A	44





Performance Benchmark

HiBench 6.0

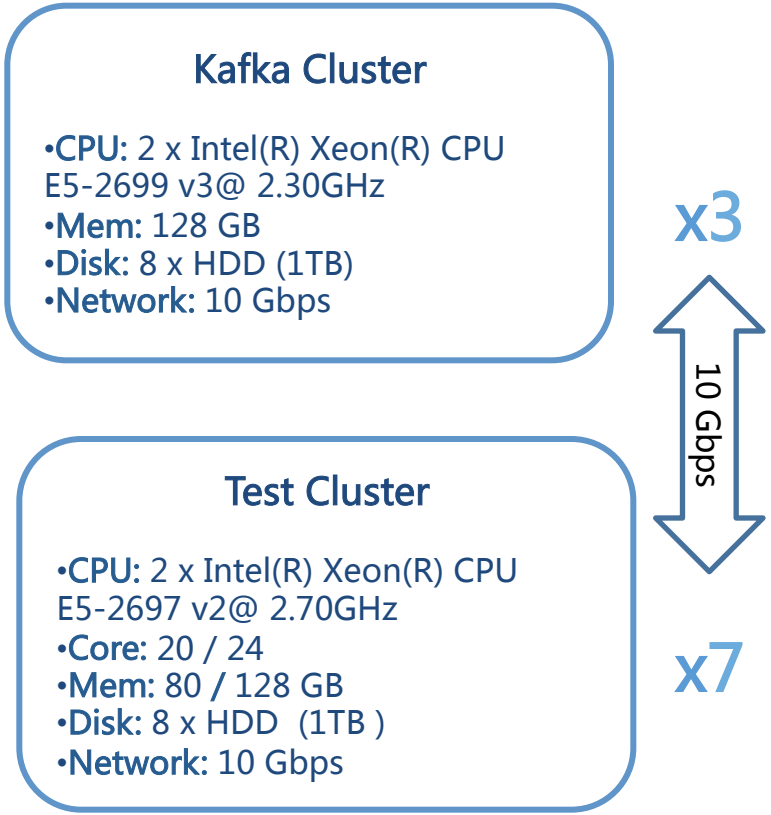
Test Philosophical

- Lazy Benchmarking
- Simple test case infer practical use case

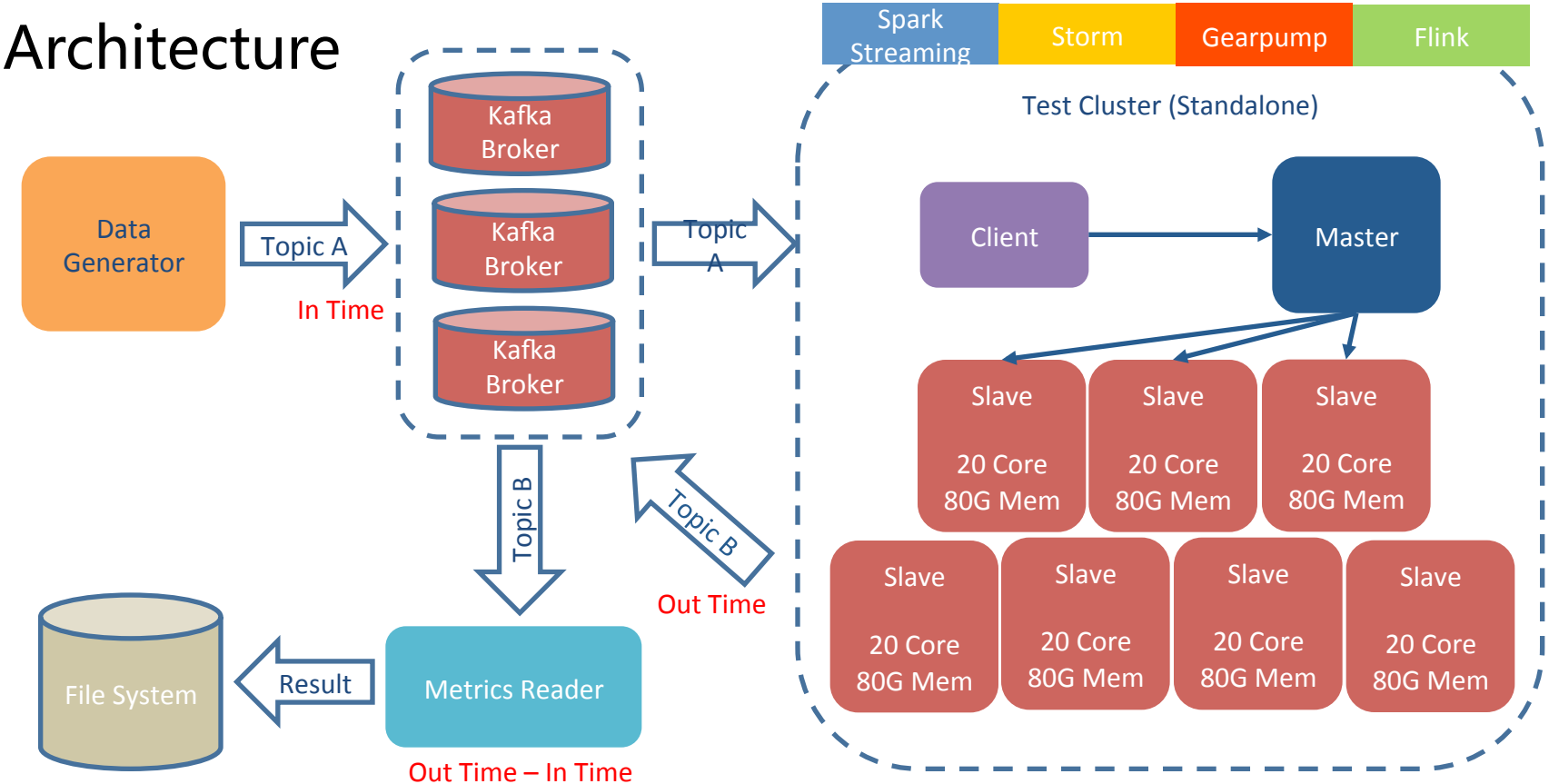
The Setup

Name	Version
Java	1.8
Scala	2.11.7
Hadoop	2.6.2
Zookeeper	3.4.8
Kafka	0.8.2.2
Spark	1.6.1
Storm	1.0.1
Flink	1.0.3
Gearpump	0.8.1

- Heron require specific Operation System (Ubuntu / CentOS / Mac OS)
- Structured Streaming doesn’ t support Kafka source yet (Spark 2. 0)



Architecture



Framework Configuration

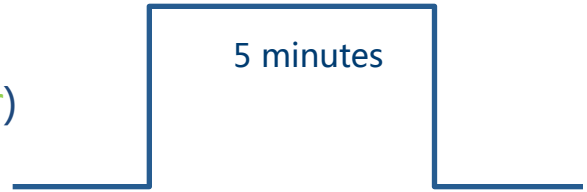
Framework	Related Configuration
Spark Streaming	7 Executor 140 Parallelism
Flink	7 TaskManager 140 Parallelism
Storm	28 Worker 140 KafkaSpout
Gearpump	28 Executors 140 KafkaSource

Raw Input Data

- Kafka Topic Partition: 140
- Size Per Message (configurable): 200 bytes
- Raw Input Message Example:

"0,227.209.164.46,nbizrgdziebsaecsecujfjcqtvnpcnxxwiopmddorcxnlijdizgoi,1991-06-10,0.115967035,Mozilla/5.0 (iPhone; U; CPU like Mac OS X)AppleWebKit/420.1 (KHTML like Gecko) Version/3.0 Mobile/4A93Safari/419.3,YEM,snowdrops,1"

- Strong Type: class UserVisit (ip, sessionId, browser)
- Keep feeding data at specific rate for 5 minutes



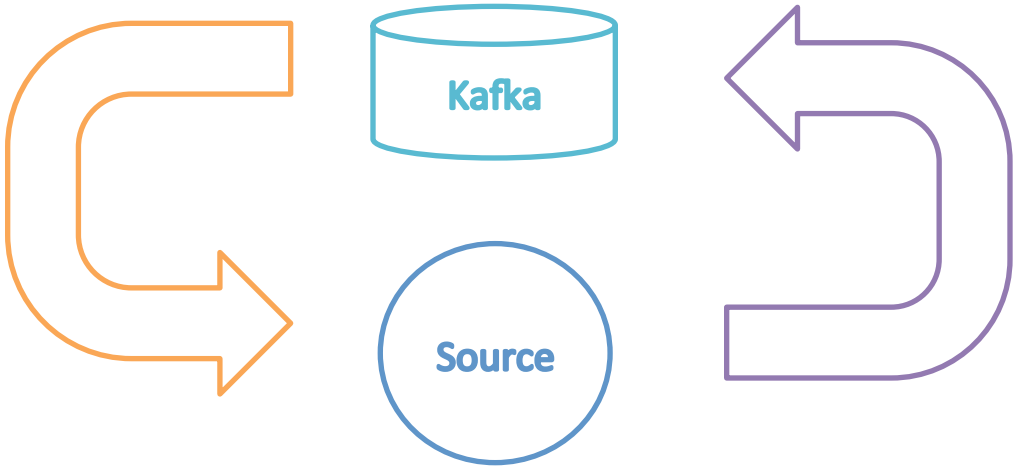
Data Input Rate

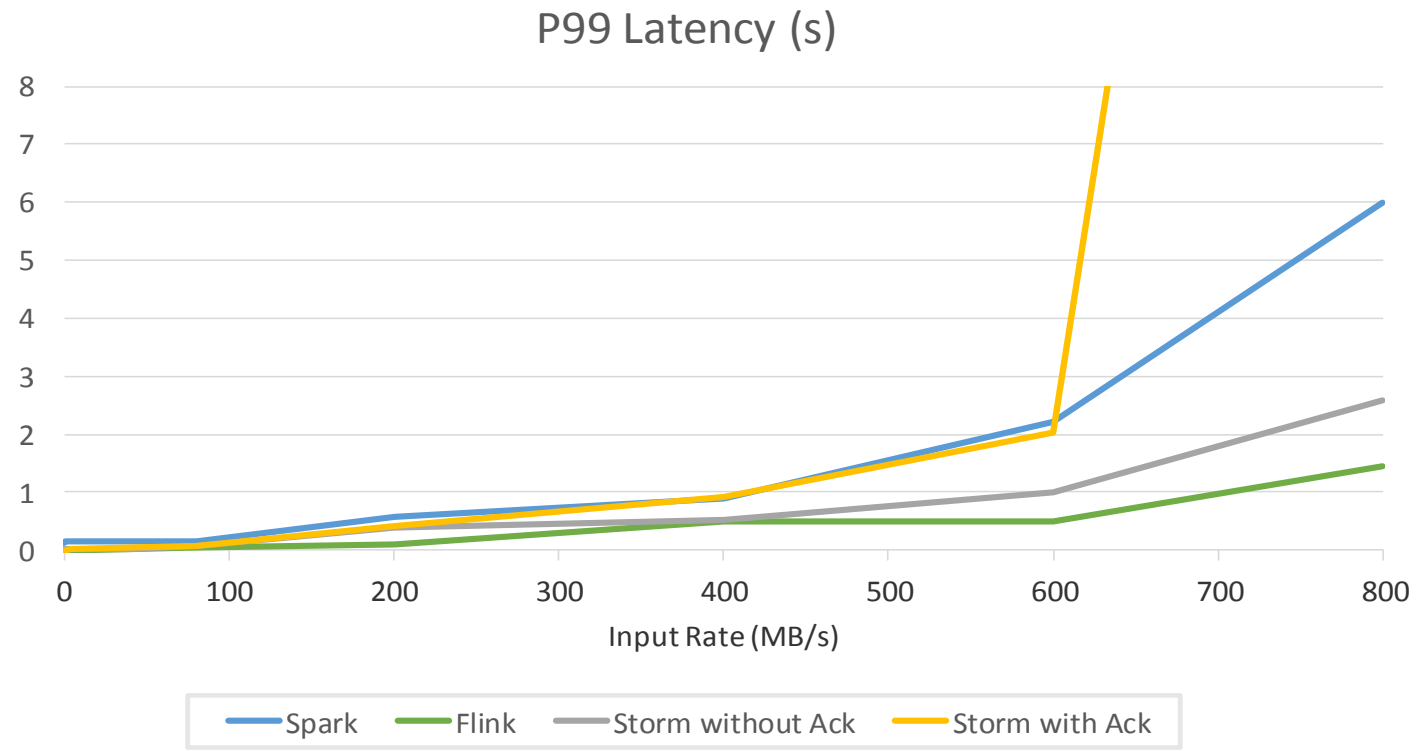
Throughput	Message/Second	Kafka Producer Num
40KB/s	0.2K	1
400KB/s	2K	1
4MB/s	20K	1
40MB/s	200K	1
80MB/s	400K	1
400MB/s	2M	10
600MB/s	3M	15
800MB/s	4M	20

Let’s start with the simplest case

Test Case: Identity

- The application reads input data from Kafka and then writes result to Kafka immediately, there is no complex business logic involved.

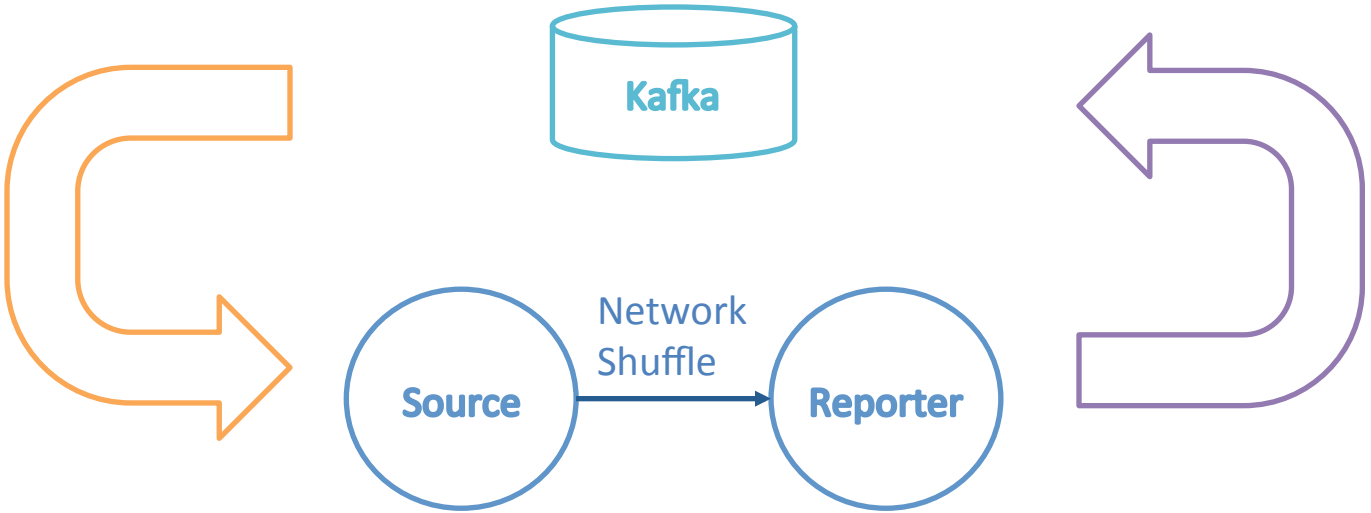


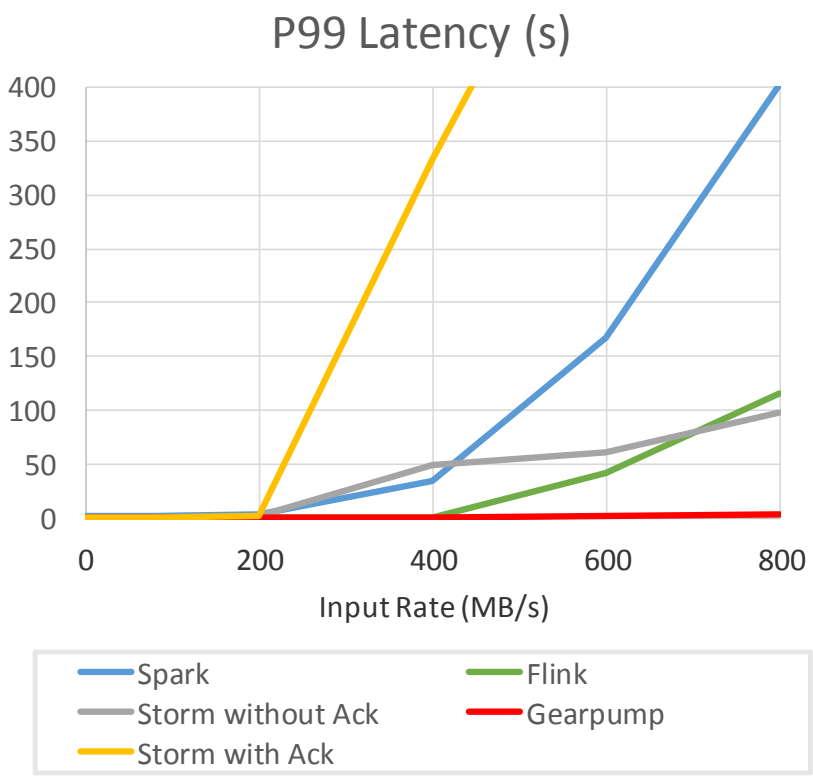

P99 Latency (s)
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
600
700
800
Input Rate (MB/s)
Spark
Flink
Storm without Ack
Storm with Ack

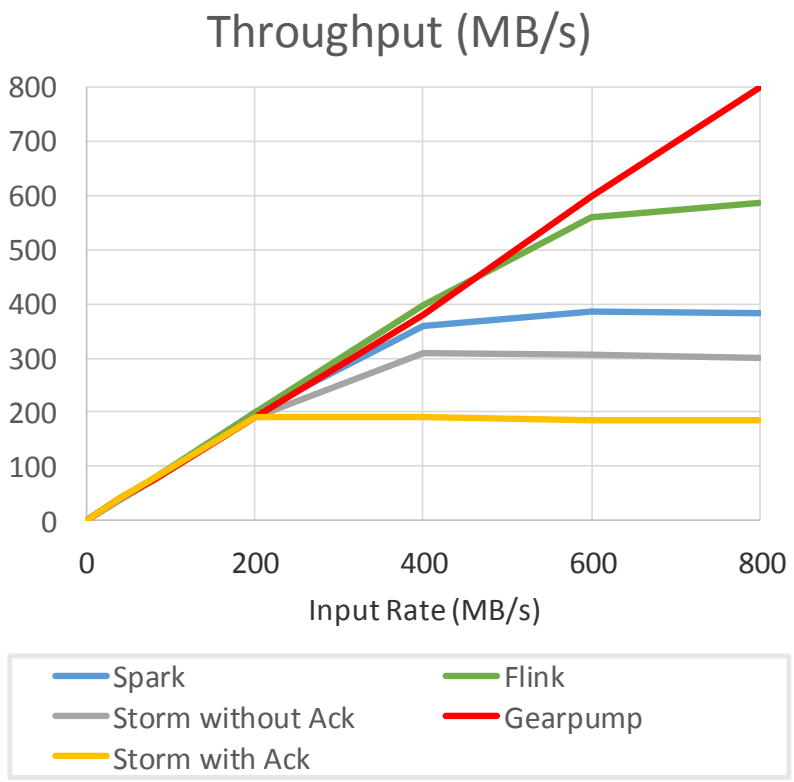
Q: What if source data are skew or even packed?

Test Case: Repartition

- Basically, this test case can stand for the efficiency of data shuffle.




P99 Latency (s)
400
350
300
250
200
150
100
50
0
0
200
400
600
800
Input Rate (MB/s)
Spark
Flink
Storm without Ack
Gearpump
Storm with Ack

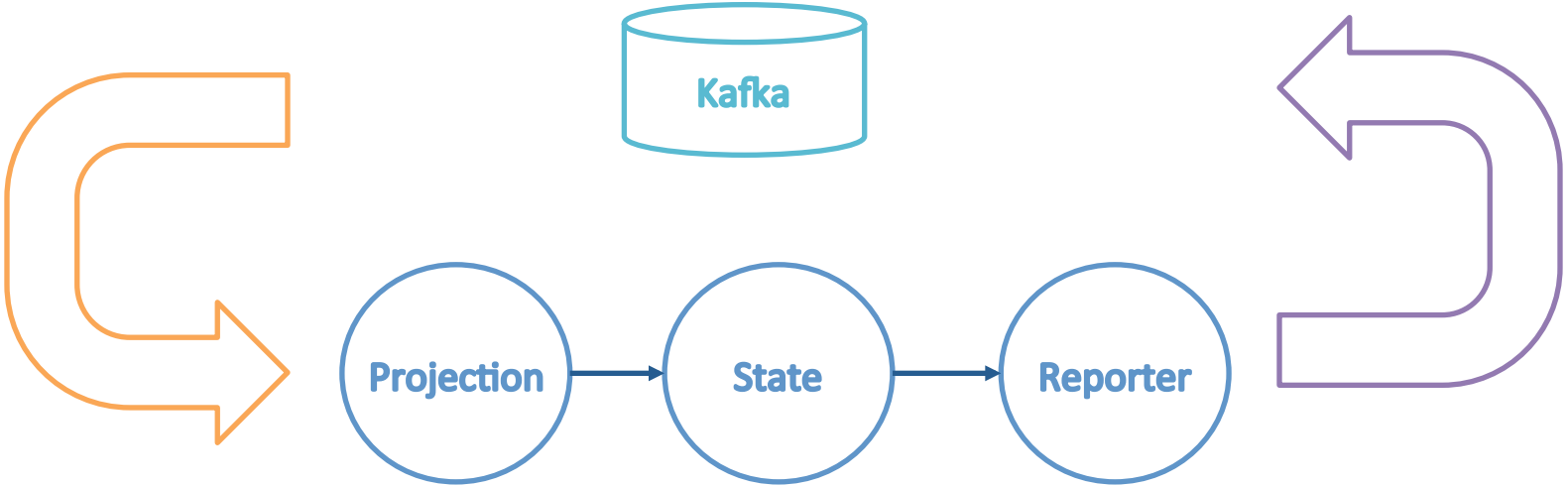

Throughput (MB/s)
800
700
600
500
400
300
200
100
0
0
200
400
600
800
Input Rate (MB/s)
Spark
Flink
Storm without Ack
Gearpump
Storm with Ack

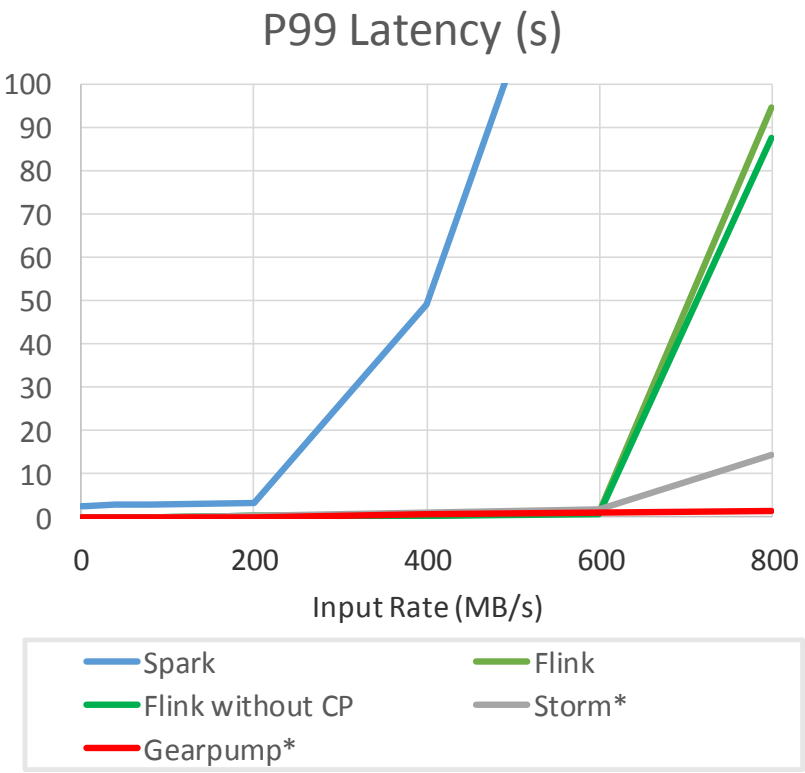
- Flink and Storm has close performance and are better choices to meet **sub-second SLA** requirement if no repartition happened.
- Spark Streaming need to schedule task with additional context. Under tiny batch interval case, the overhead could be dramatic worse compared to other frameworks.
- According to our test, minimum Batch Interval of Spark is about 80ms (140 tasks per batch), otherwise task schedule delay will keep increasing
- Repartition is heavy for every framework, but usually it’s unavoidable.
- Latency of Gearpump is still quite low even under 800MB/s input throughput.

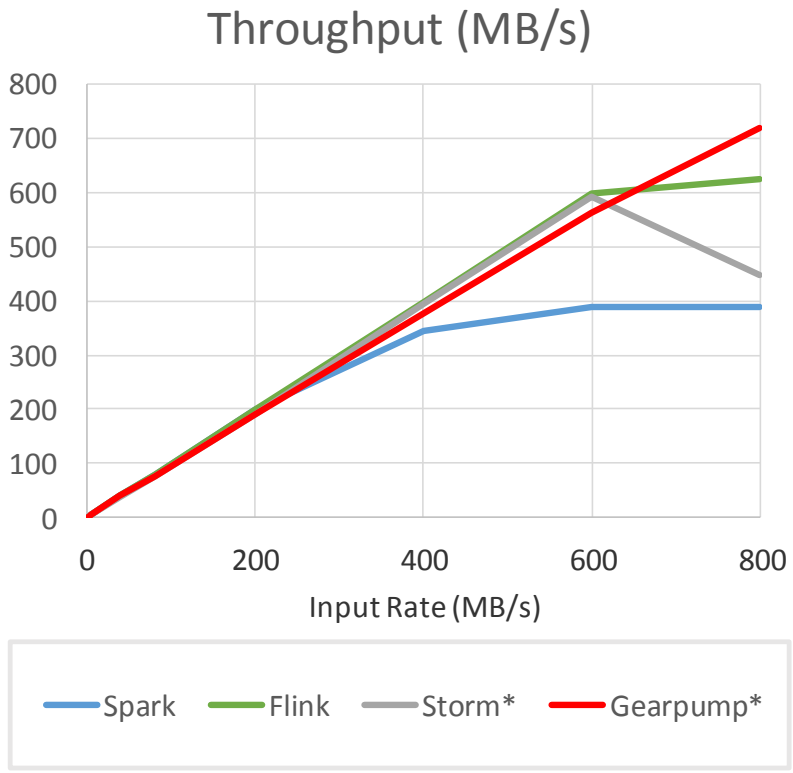
Q: What if I want to apply slightly complex logic which need to maintain entire state?

Test Case: Stateful WordCount

- Native state operator is supported by all frameworks we evaluated
- Stateful operator performance + Checkpoint/Acker cost




P99 Latency (s)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
Input Rate (MB/s)
Spark
Flink
Flink without CP
Storm*
Gearpump*


Throughput (MB/s)
800
700
600
500
400
300
200
100
0
0
200
400
600
800
Input Rate (MB/s)
Spark
Flink
Storm*
Gearpump*

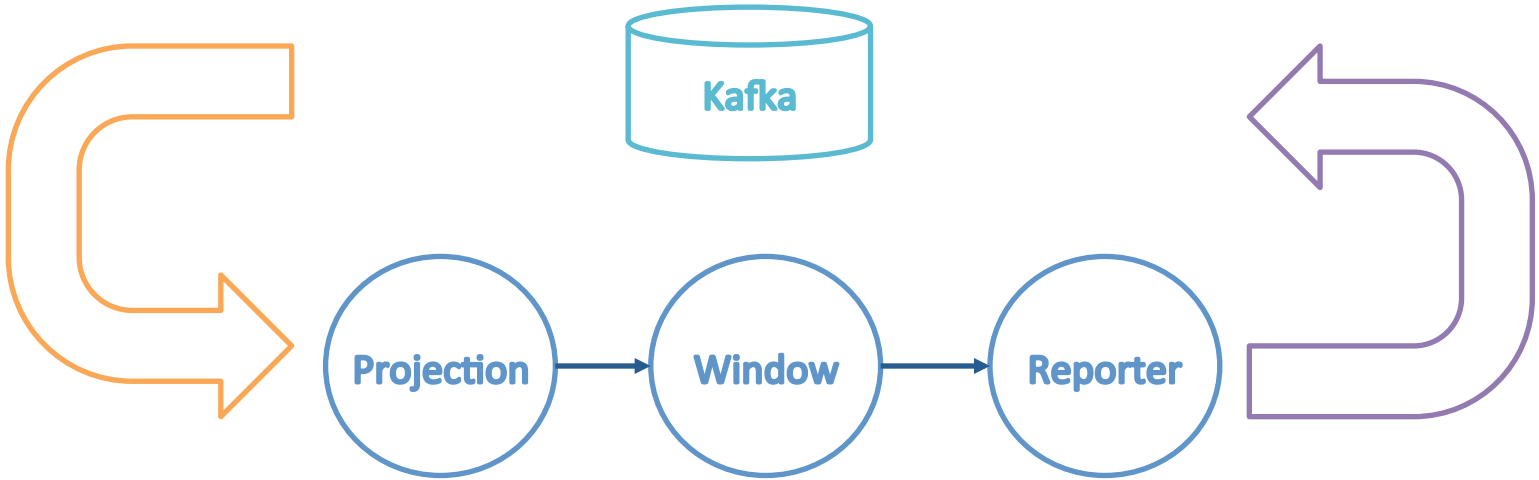
Observation

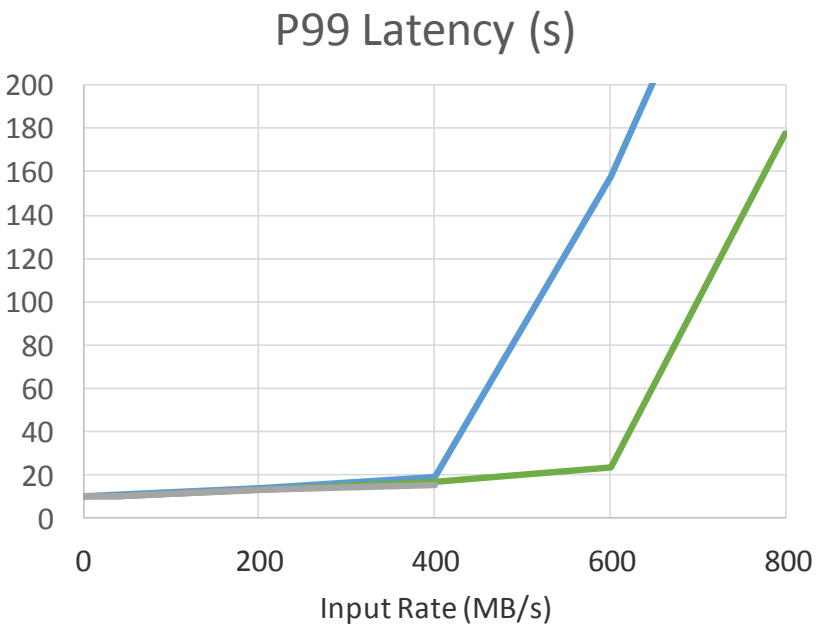
- Exactly-once semantics usually require state management and checkpoint. But better guarantees come at high cost.
- There is no obvious performance difference in Flink when switching fault tolerance on or off.
- Checkpoint mechanisms and storages play a critical role here.

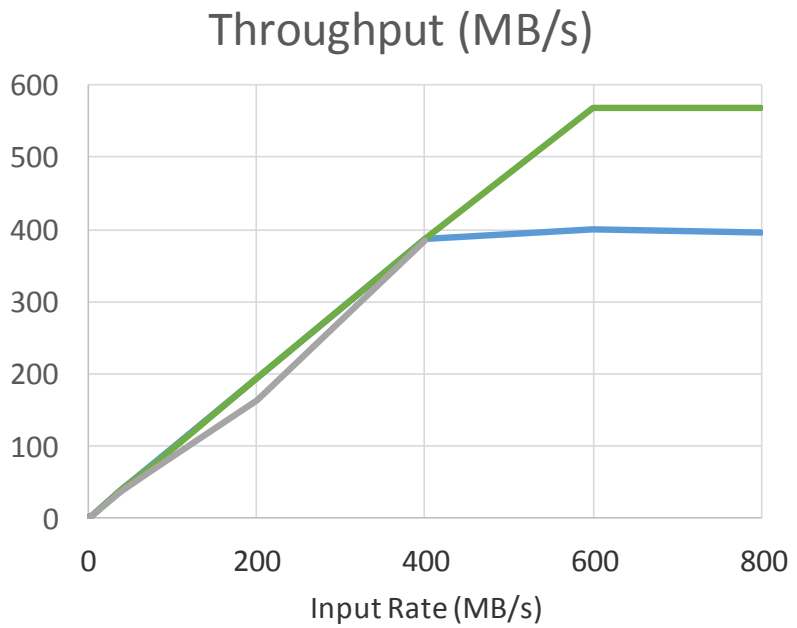
Q: How about Window Operation?

Test Case: Window Based Aggregation

- This test case manages a 10-seconds sliding window

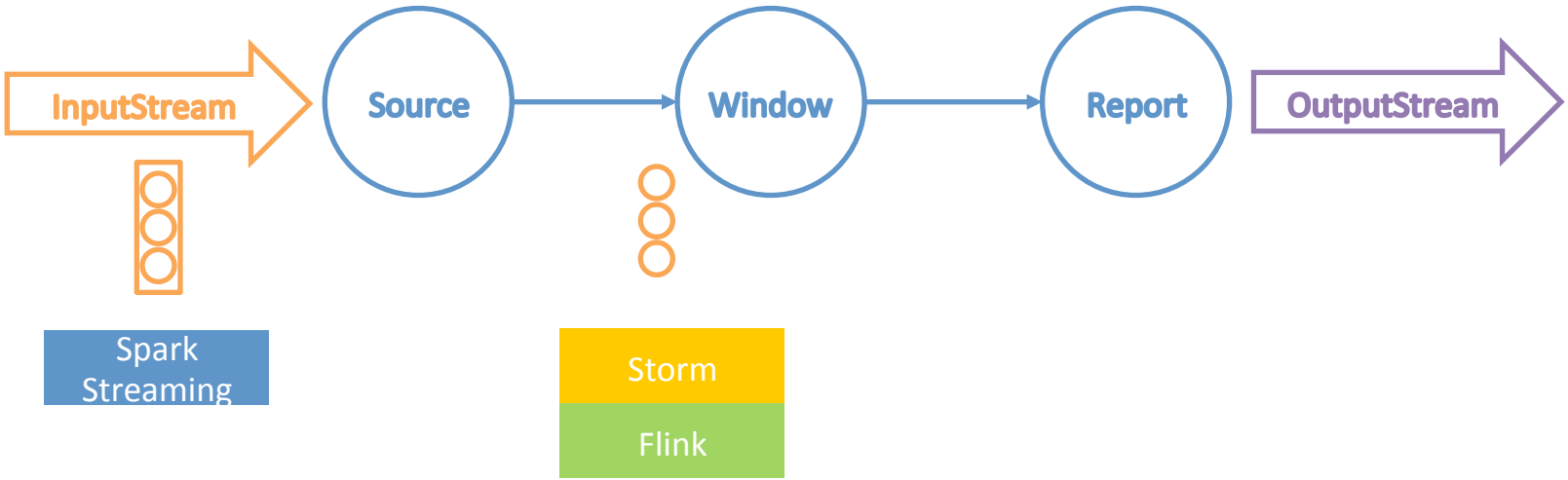



P99 Latency (s)
200
180
160
140
120
100
80
60
40
20
0
0
200
400
600
800
Input Rate (MB/s)
Spark
Flink
Storm*


Throughput (MB/s)
600
500
400
300
200
100
0
0
200
400
600
800
Input Rate (MB/s)
Spark
Flink
Storm*

Observation

- The native streaming execution model helps here



So which streaming framework should I use?

Do your own benchmark

- **HiBench**：a cross platforms micro-benchmark suite for big data (https://github.com/intel-hadoop/HiBench)

- Open Source since 2012

- Better streaming benchmark supporting will be included in next release [HiBench 6.0]

2016 The Computing Conference

THANKS

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