Streaming Report

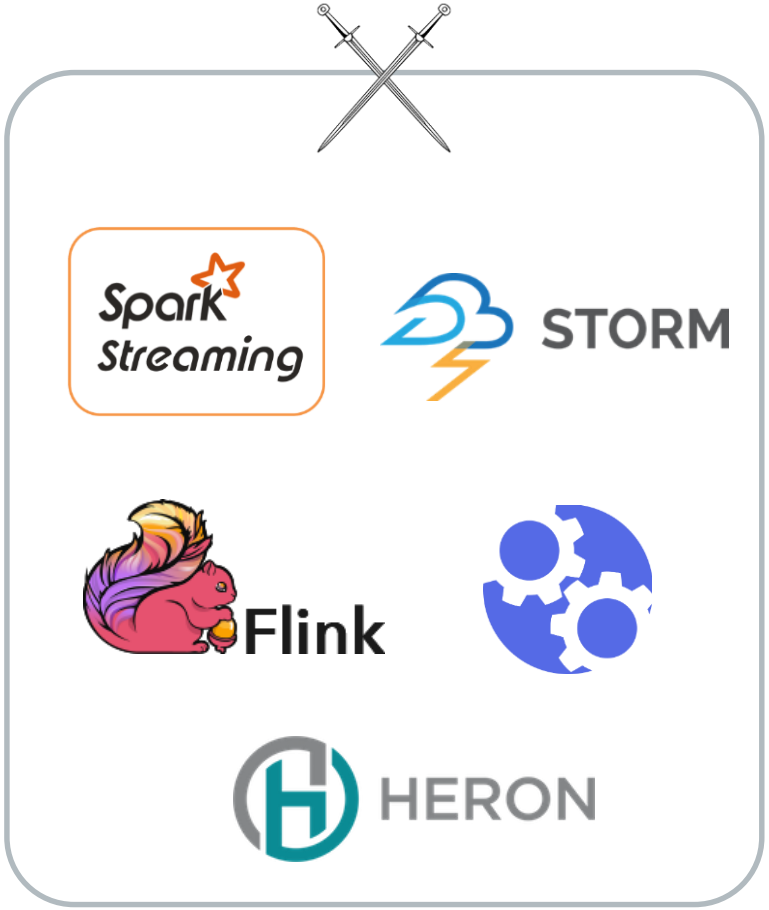
Functional Comparison and Performance Evaluation

Mao Wei
Wang, Huafeng
Zhang, Tianlun

Overview

- Streaming Core
- MISC
- Performance Benchmark

Choose your weapon !

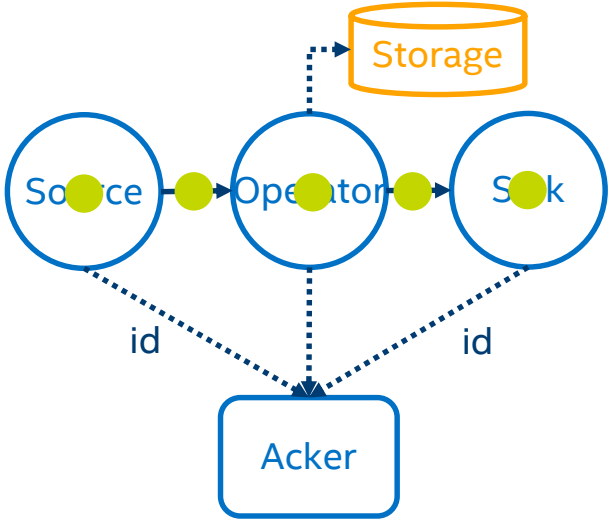


Execution Model + Fault Tolerance Mechanism

Continuous Streaming

Ack per Record

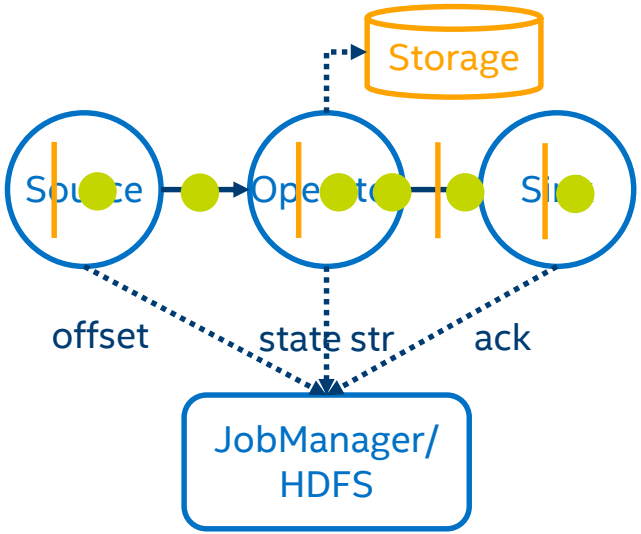
Storm | Heron



Continuous Streaming

Checkpoint "per Batch"

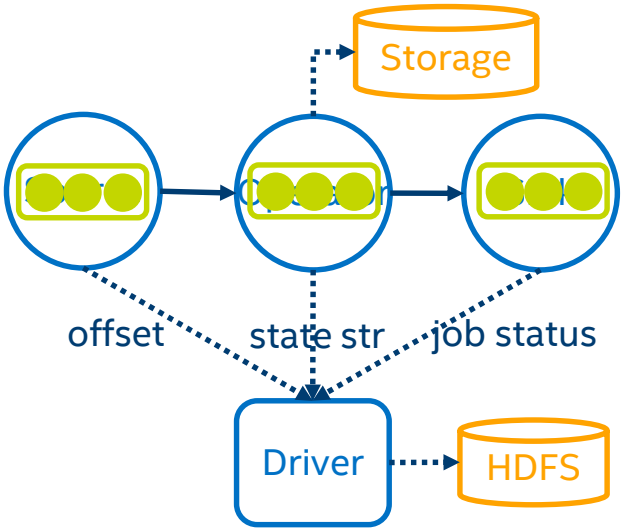
Flink | Gearpump



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 Throughput

Low Overhead

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

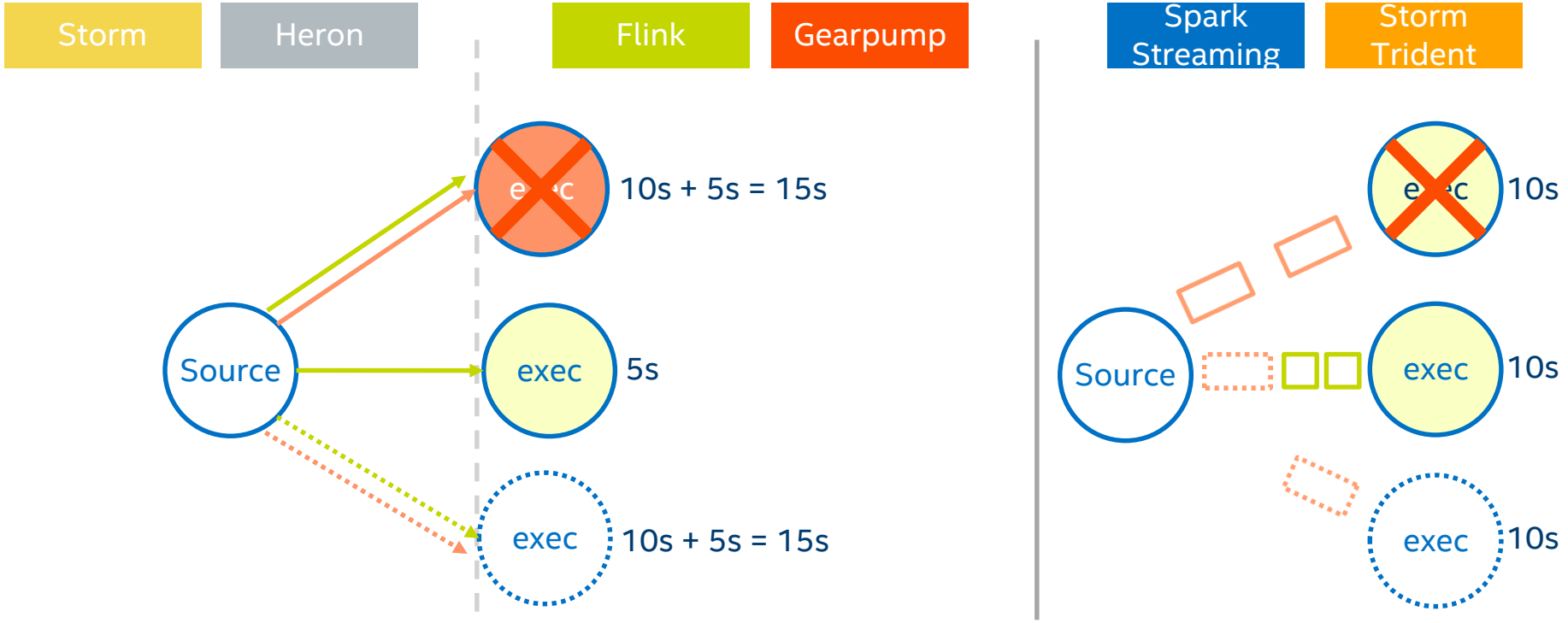
- Flink Java API:
  - ✓ ValueState
  - ✓ ListState
  - ✓ ReduceState
- Flink Scala API:
  - ✓ mapWithState
- Gearpump
  - ✓ persistState

Spark Streaming | Storm Trident

Yes

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

Dynamic Load Balance & Recovery Speed

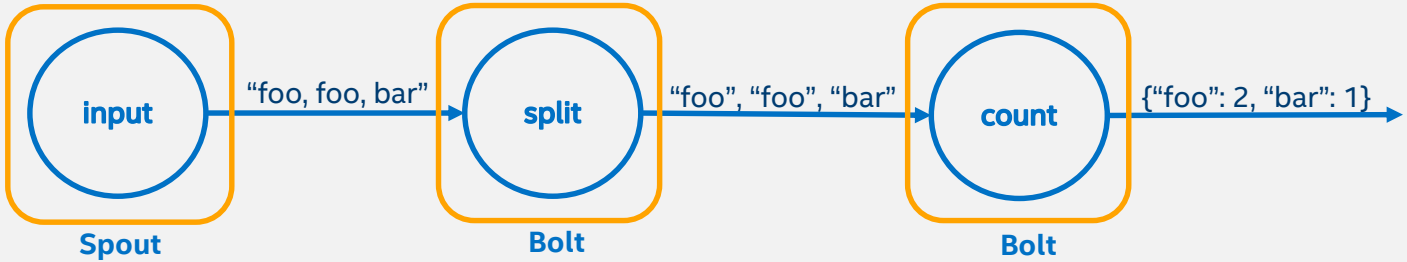


API

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"));
```

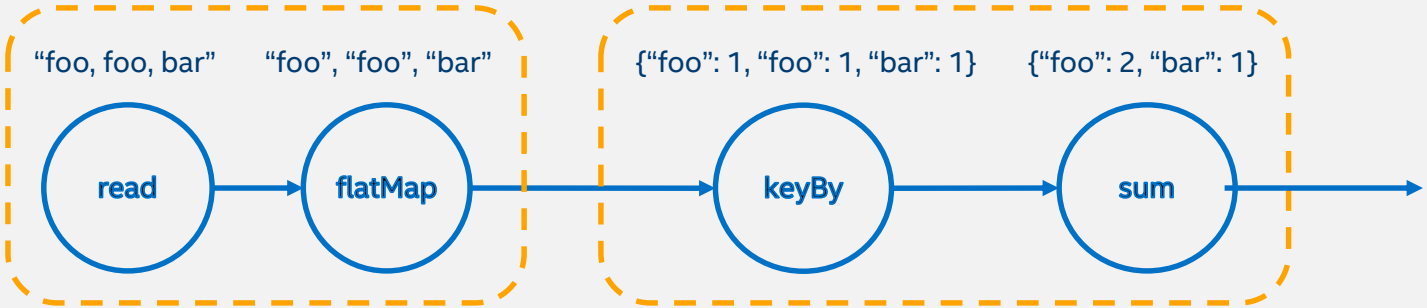


Declarative

Spark Streaming
Storm Trident
Flink
Gearpump

- Higher order function as operators (map, 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

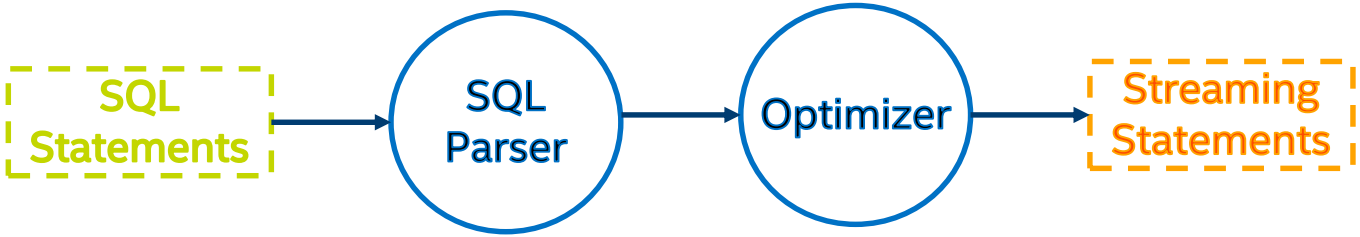
```
lines = ssc.textFileStream(params.get("input"))
words = lines.flatMap(lambda line: line.split(“,"))
pairs = words.map(lambda word: (word, 1))
counts = pairs.reduceByKey(lambda x, y: x + y)
counts.saveAsTextFiles(params.get("output"))
```

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

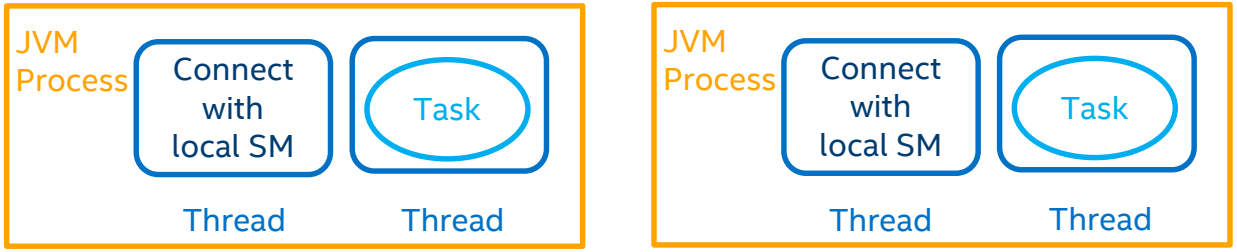
Summary

	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

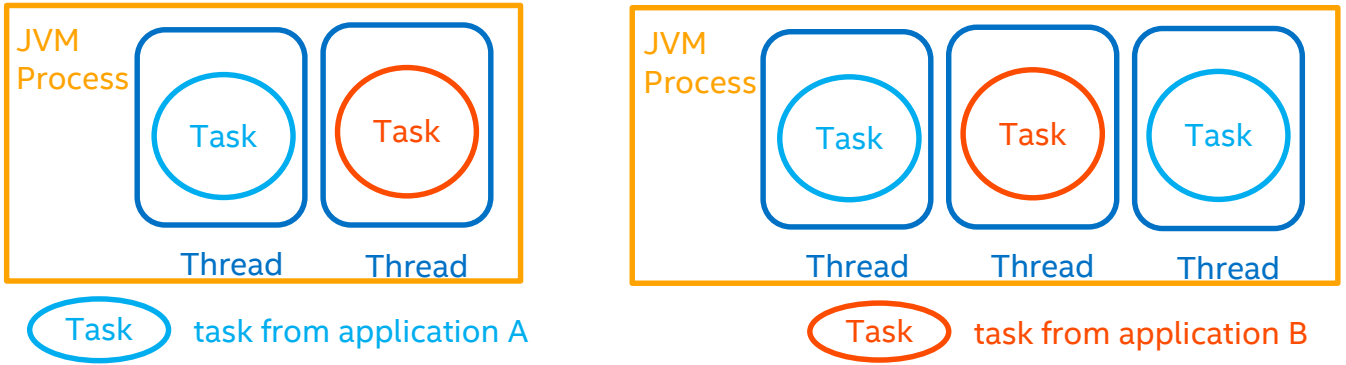
- Single Task on Single Process

Heron



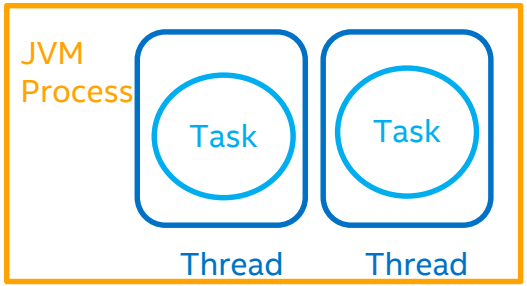
- Multi Tasks of Multi Applications on Single Process

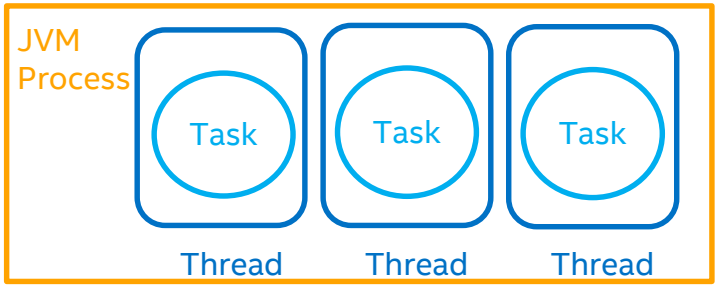
Flink



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

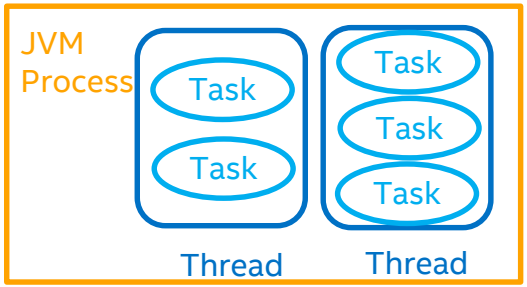
Spark Streaming

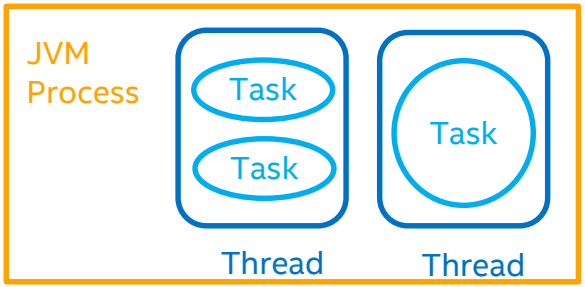




  - Multi tasks on single thread

Gearpump | Storm | Storm Trident



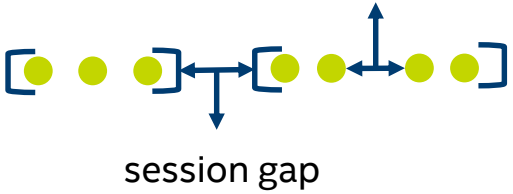


MISC

- 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

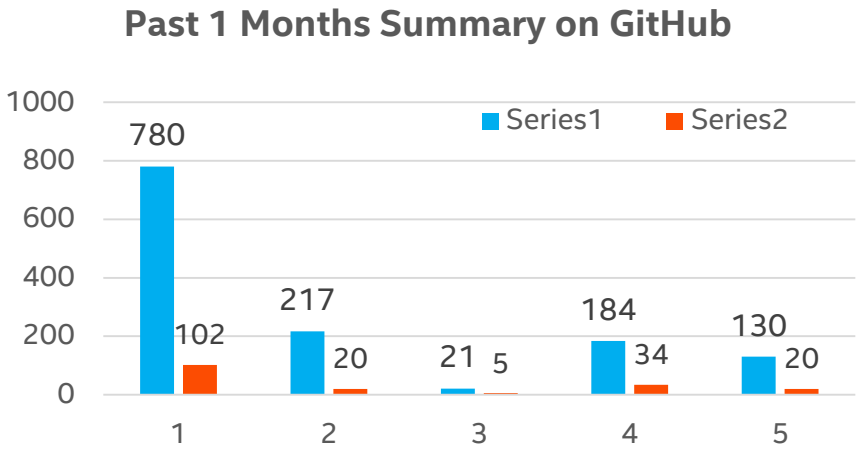
	Standalone	YARN	Mesos
Spark Streaming	√	√	√
Storm	√	√	√
Storm Trident	√	√	√
Gearpump	√	√	X
Flink	√	√	X
Heron	√	√	√

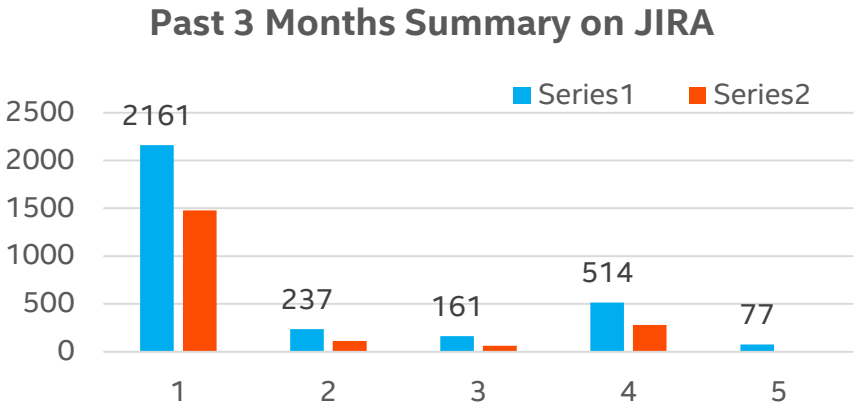
Web UI

	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





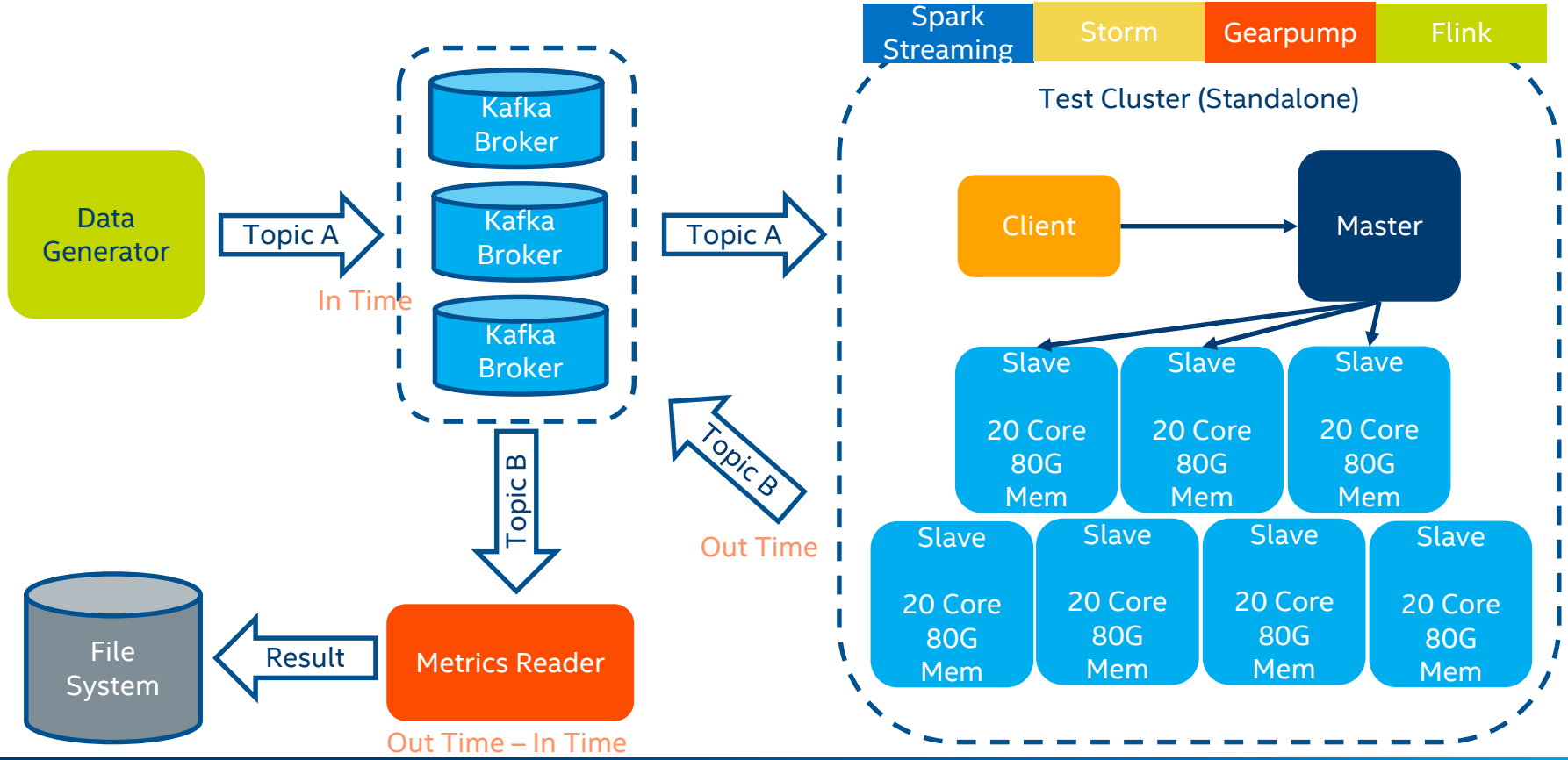
Performance Benchmark

HiBench 6.0

Test Philosophical

- “Lazy Benchmarking”
- Simple test case infer practical use case

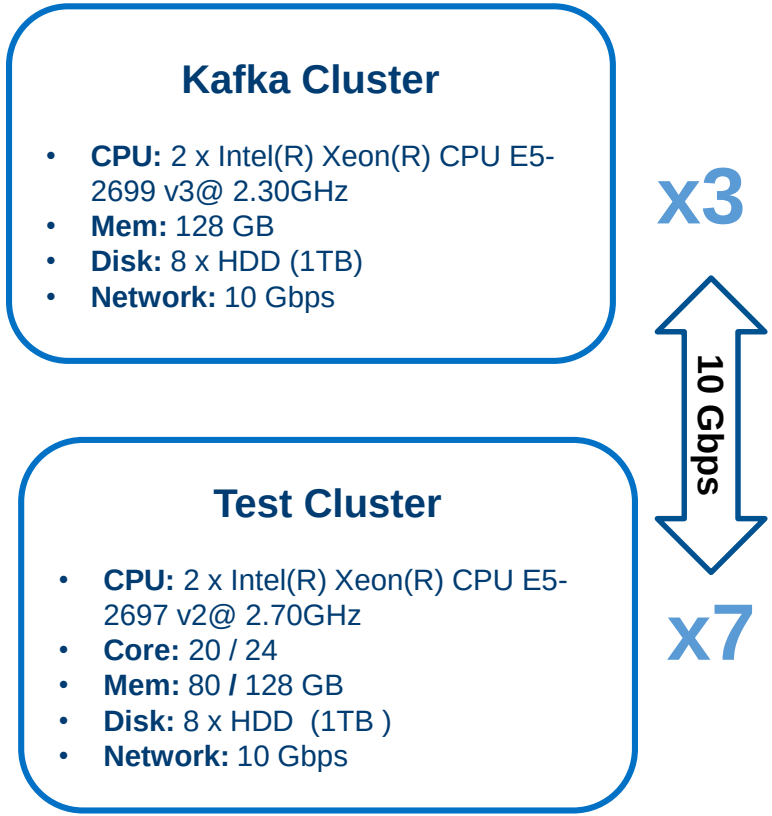
Architecture



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)



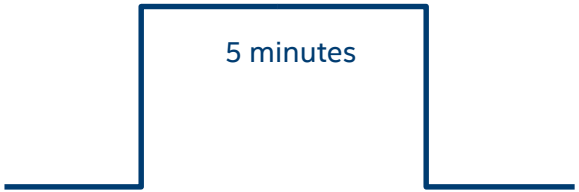
Raw Input Data

- 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,YEM-AR,snowdrops,1"

- Strong Type: class UserVisit (ip, sessionId, browser)

- Keep feeding data at specific rate for 5 minutes



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

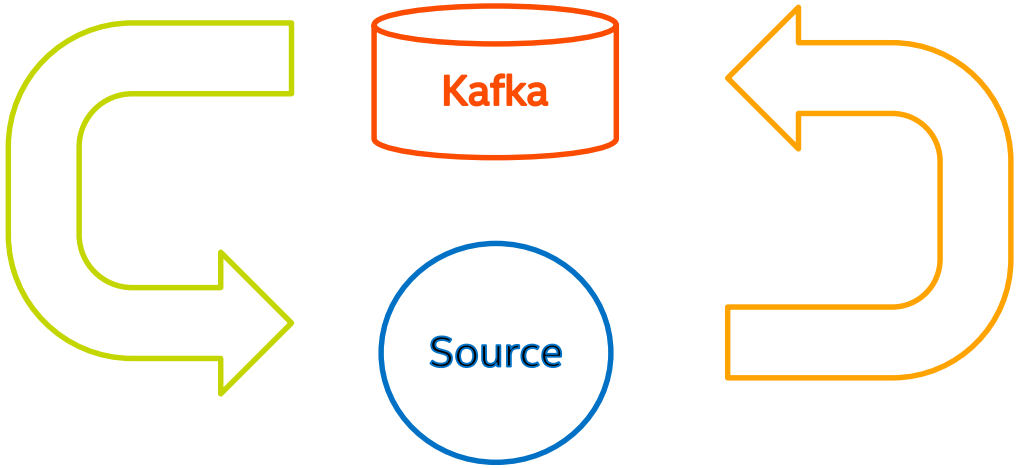
Data Input Rate

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

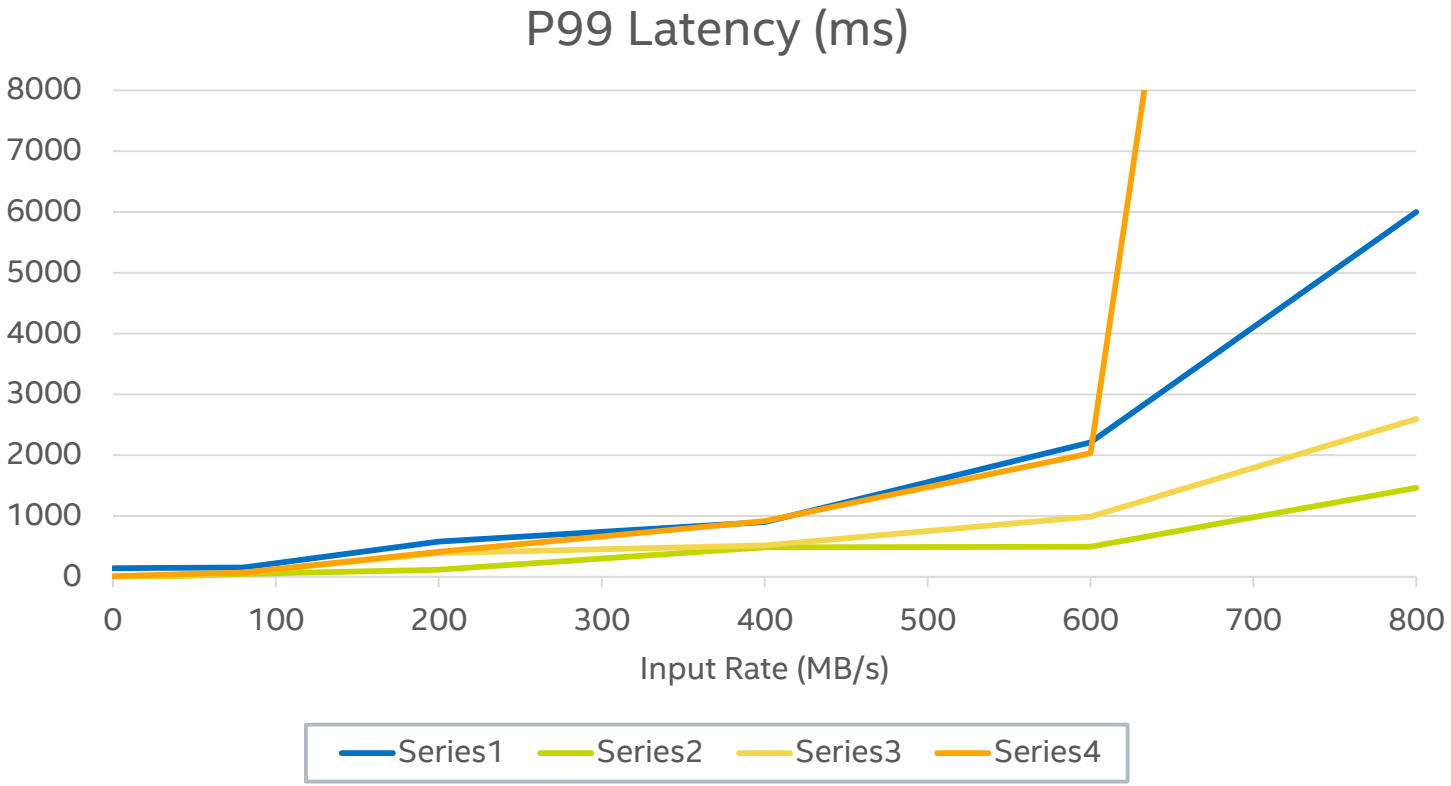
Let’s start with the simplest case

Test Case: Identity

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



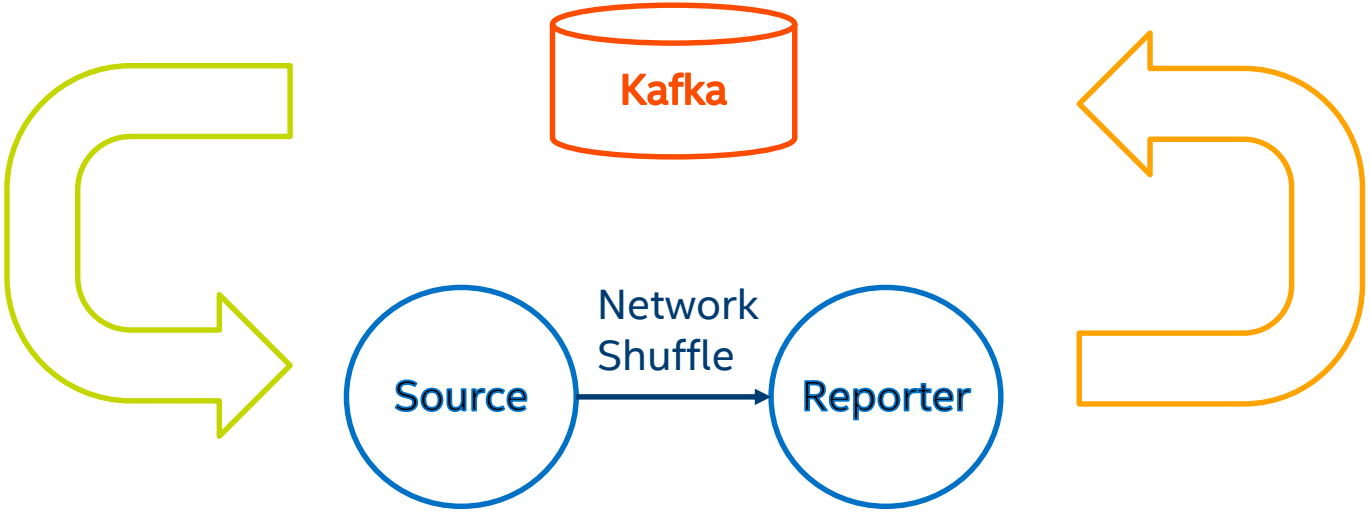
Result


P99 Latency (ms)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
100
200
300
400
500
600
700
800
Input Rate (MB/s)
Series1
Series2
Series3
Series4

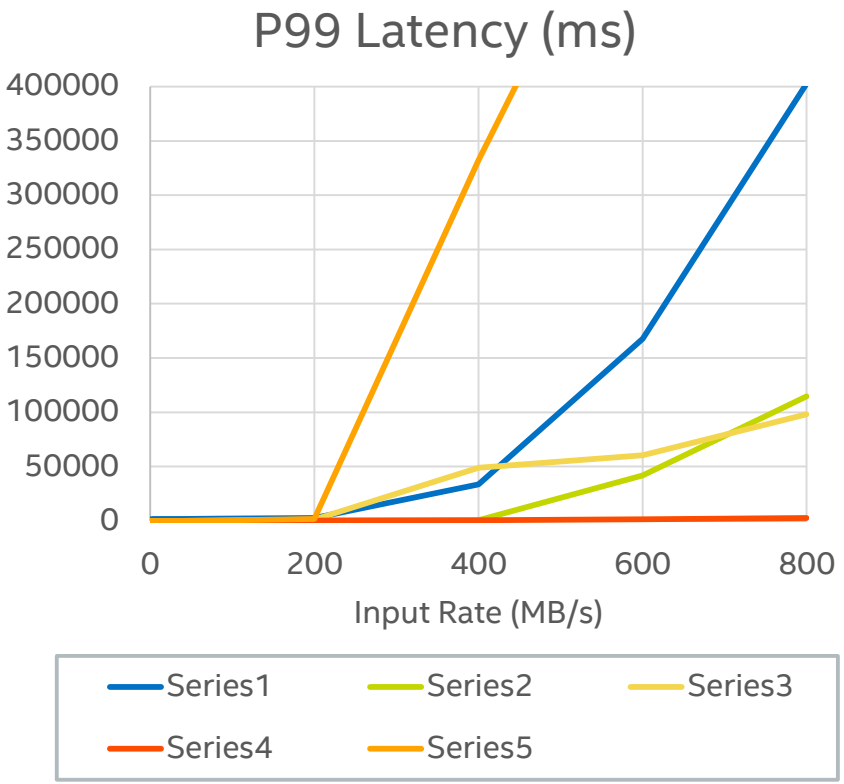
Q: What if source data are skew or even packed?

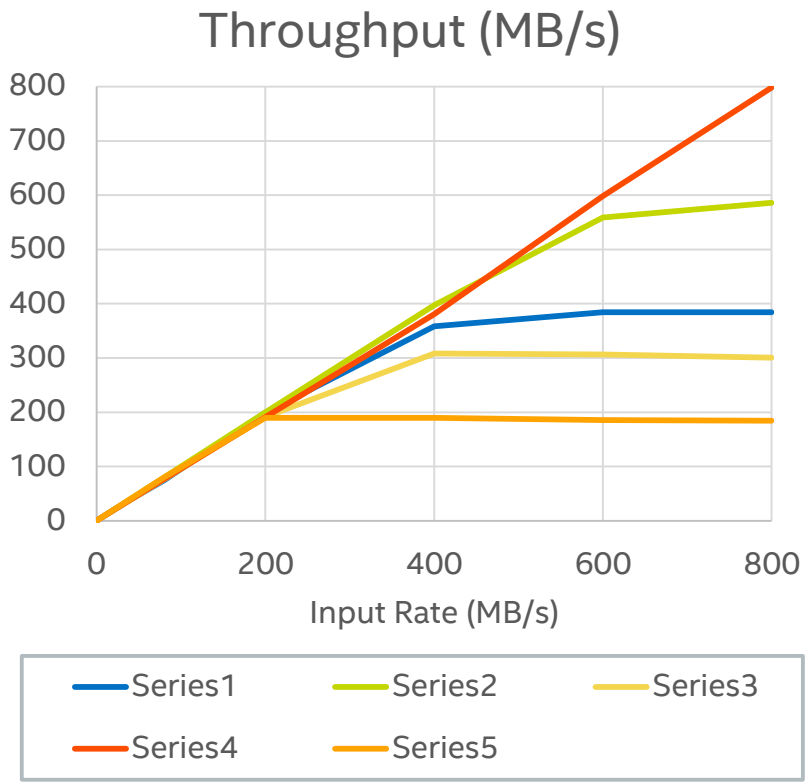
Test Case: Repartition

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



Result


P99 Latency (ms)
400000
350000
300000
250000
200000
150000
100000
50000
0
0
200
400
600
800
Input Rate (MB/s)
Series1
Series2
Series3
Series4
Series5


Throughput (MB/s)
800
700
600
500
400
300
200
100
0
0
200
400
600
800
Input Rate (MB/s)
Series1
Series2
Series3
Series4
Series5

Observation

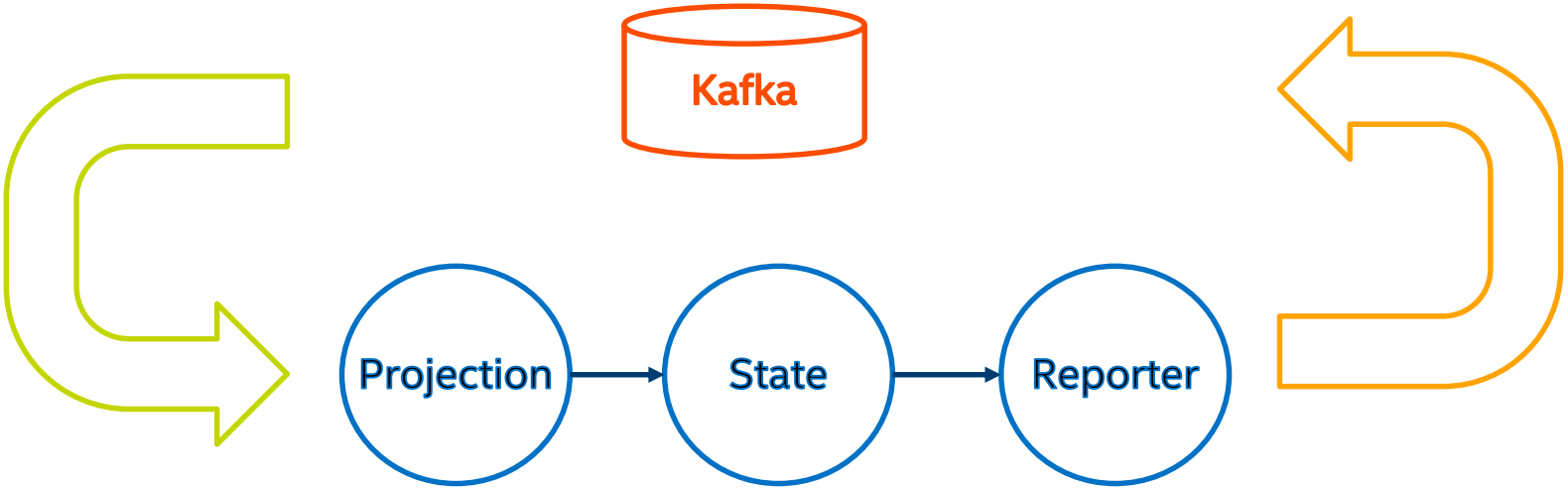
- Flink and Storm has close performance and are better choices to meet **sub-second SLA** requirement if no repartition happened.
- Spark Streaming need to schedule task with additional context. Under tiny batch interval case, the overhead could be dramatic worse compared to other frameworks.
- According 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?

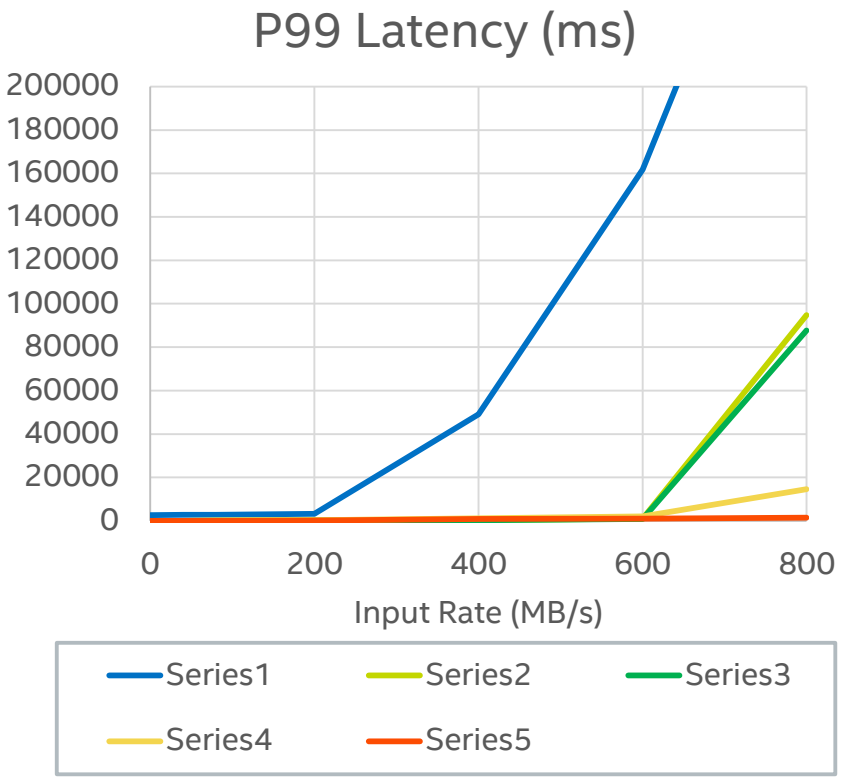
Test Case: Stateful WordCount

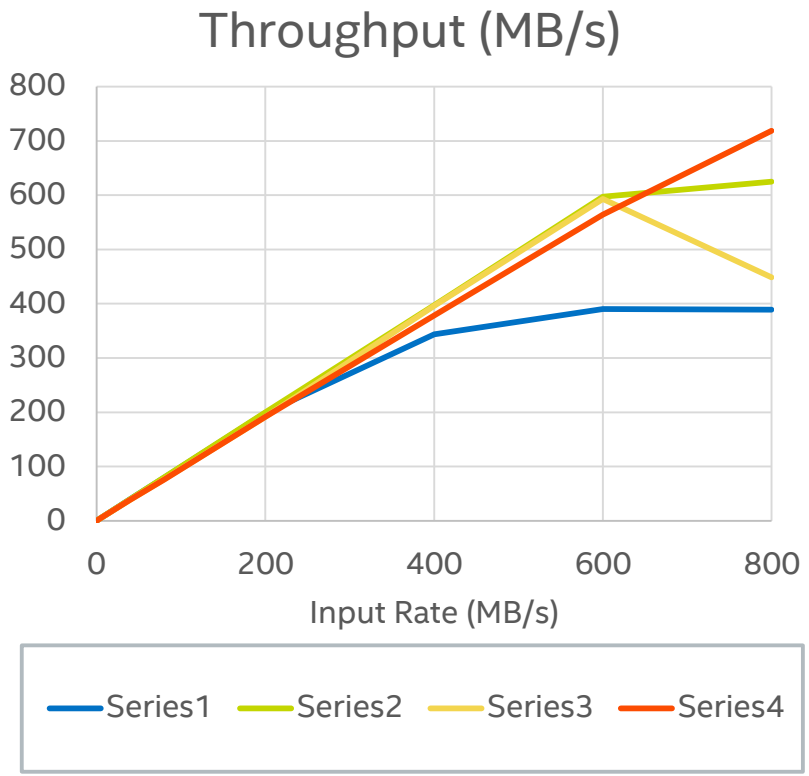
Native state operator is supported by all frameworks we evaluated

Stateful operator performance + Checkpoint/Acker cost



Result


P99 Latency (ms)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0
200
400
600
800
Input Rate (MB/s)
Series1
Series2
Series3
Series4
Series5


Throughput (MB/s)
800
700
600
500
400
300
200
100
0
0
200
400
600
800
Input Rate (MB/s)
Series1
Series2
Series3
Series4

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.

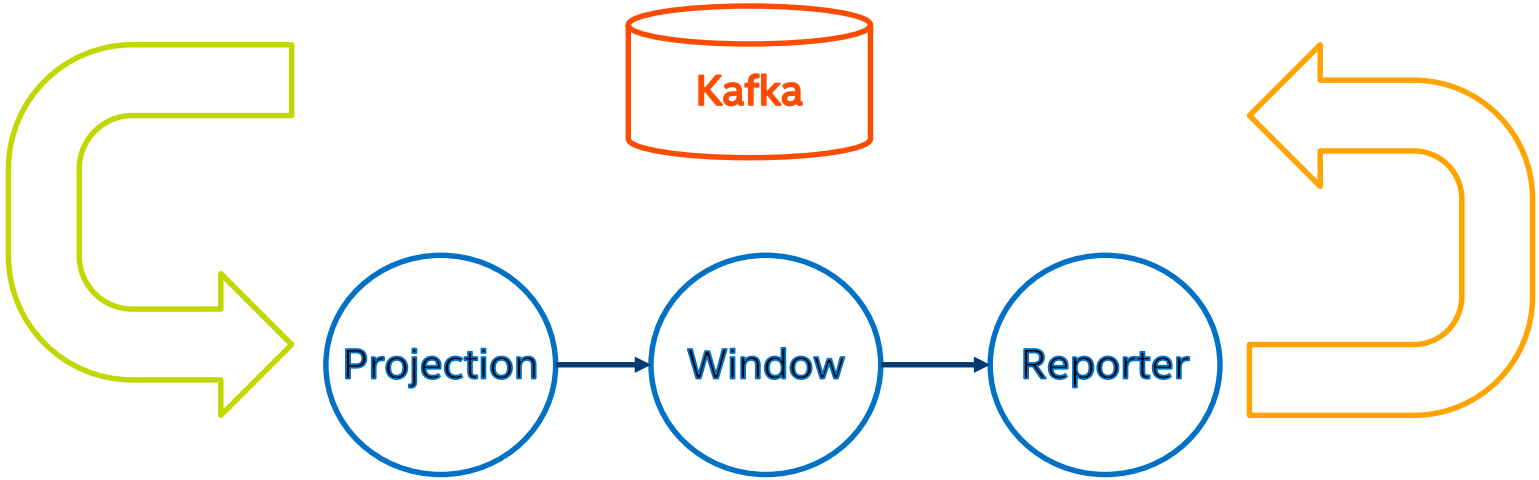
- Checkpoint mechanisms and storages play a critical role here.

Q: How about Window Operation?

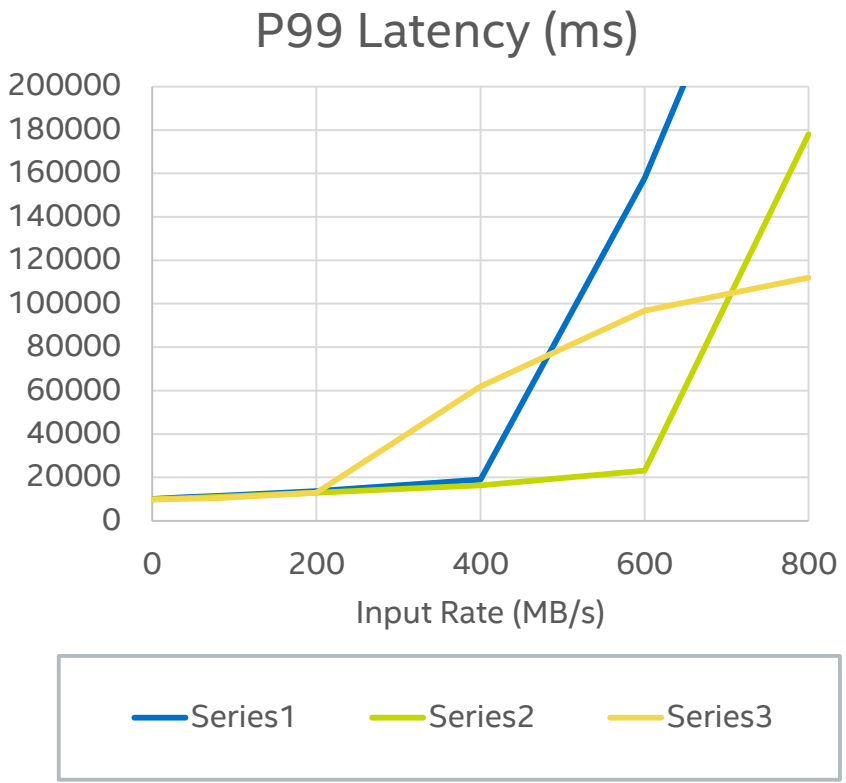
Test Case: Window Based Aggregation

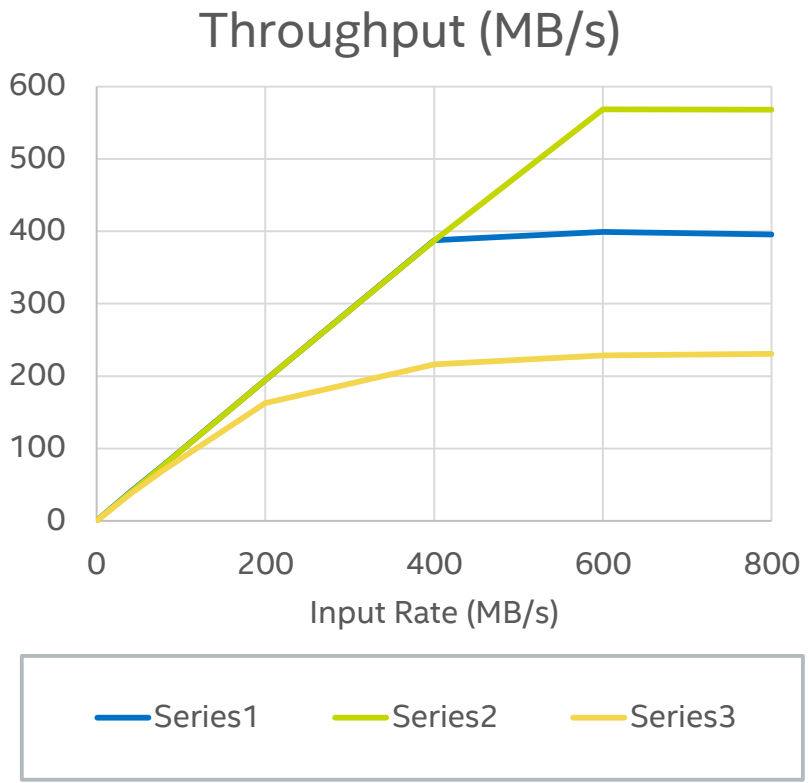
This test case manages a 10-seconds sliding window.

Latency = End2End – window.duration



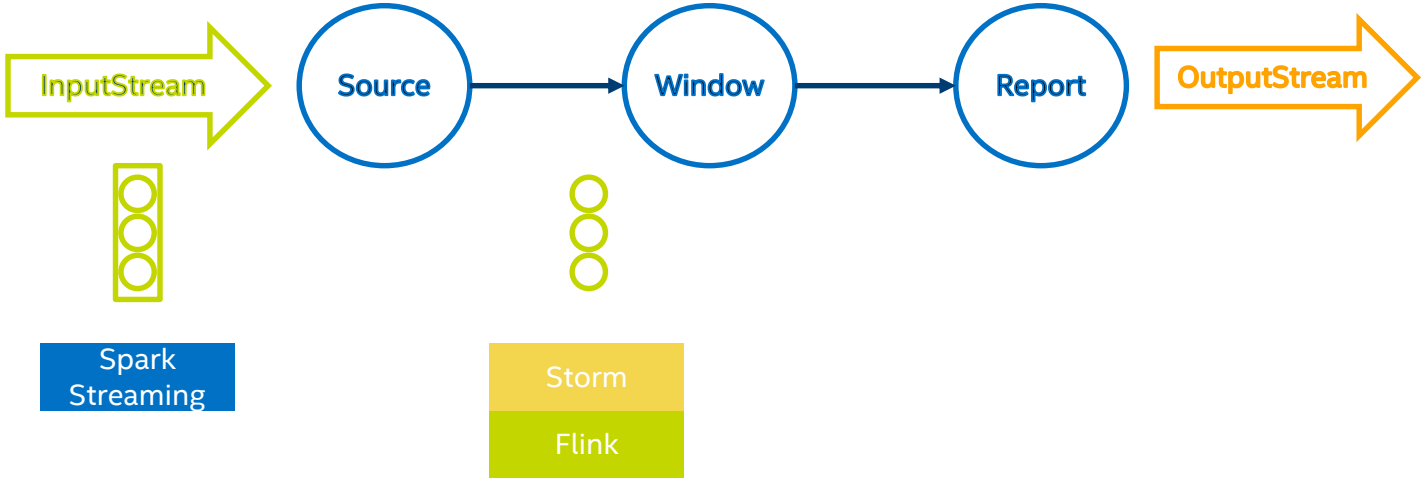
Result


P99 Latency (ms)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0
200
400
600
800
Input Rate (MB/s)
Series1
Series2
Series3


Throughput (MB/s)
600
500
400
300
200
100
0
0
200
400
600
800
Input Rate (MB/s)
Series1
Series2
Series3

Observation

The native streaming execution model helps here



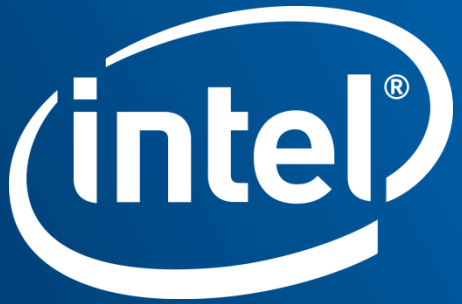
So which streaming framework should I use?

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]


intel®

Legal Disclaimer

No license (express or implied, by estoppel or otherwise) to any intellectual property rights is granted by this document.

Intel does not control or audit third-party benchmark data or the web sites referenced in this document. You should visit the referenced web site and confirm whether referenced data are accurate.

Intel and the Intel logo are trademarks of Intel Corporation in the U.S. and/or other countries.

*Other names and brands may be claimed as the property of others.