SACC 2016 第八届中国系统架构师大会
SYSTEM ARCHITECT CONFERENCE CHINA 2016
架构创新之路

Streaming Report

Functional Comparison and Performance Evaluation

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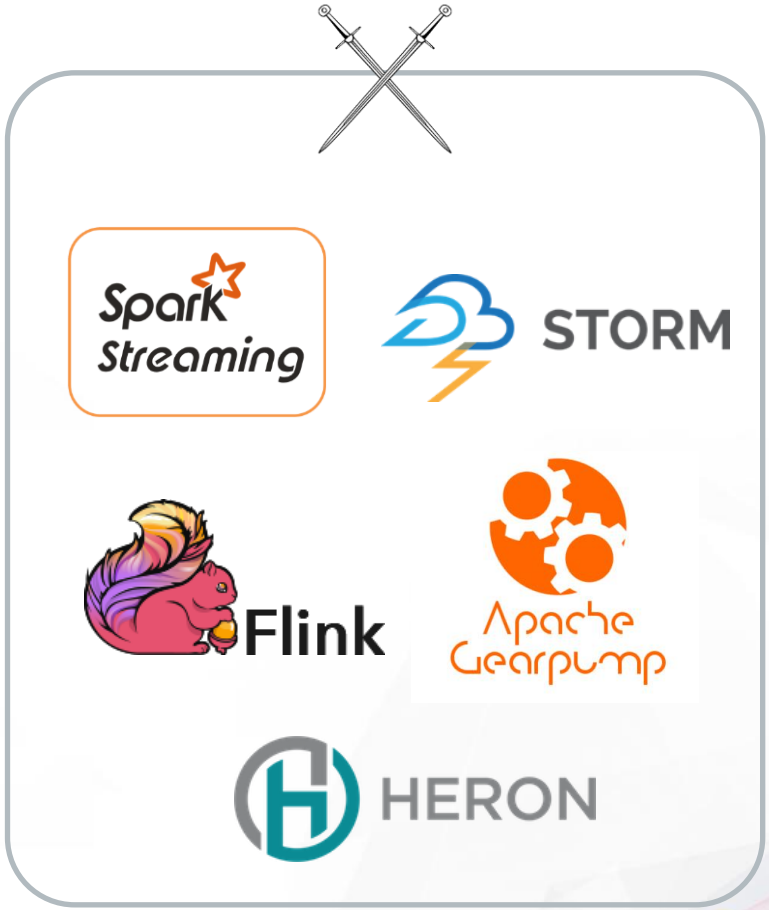
Big Data Technology Department

Overview

- Streaming Core
- MISC
- Performance Benchmark

Choose your weapon !



Execution Model + Fault Tolerance Mechanism

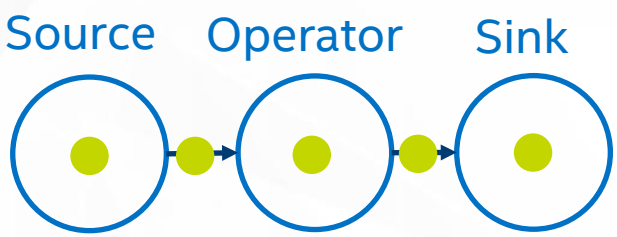
Continuous Streaming

Apache Storm*

Twitter Heron*

Aapche Flink*

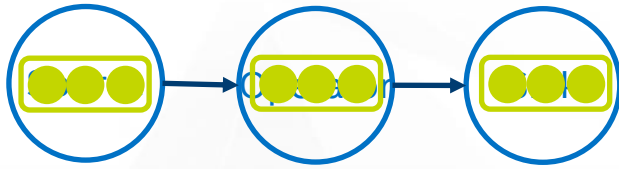
Apache Gearpump*



Micro-Batch

Apache Spark Streaming*

Apache Storm Trident*

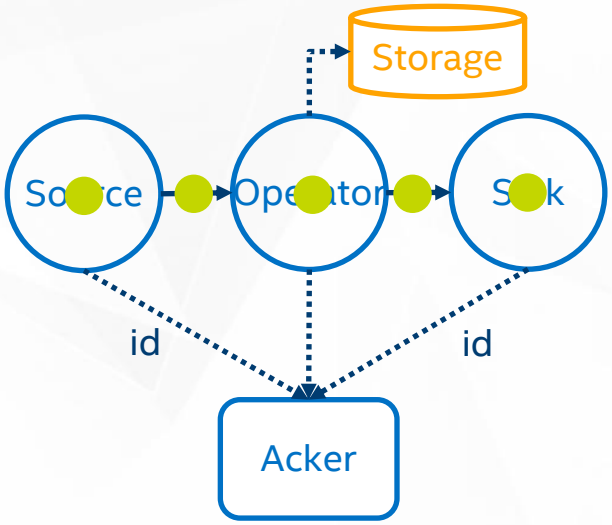


*Other names and brands may be claimed as the property of others.

Continuous Streaming

Ack per Record

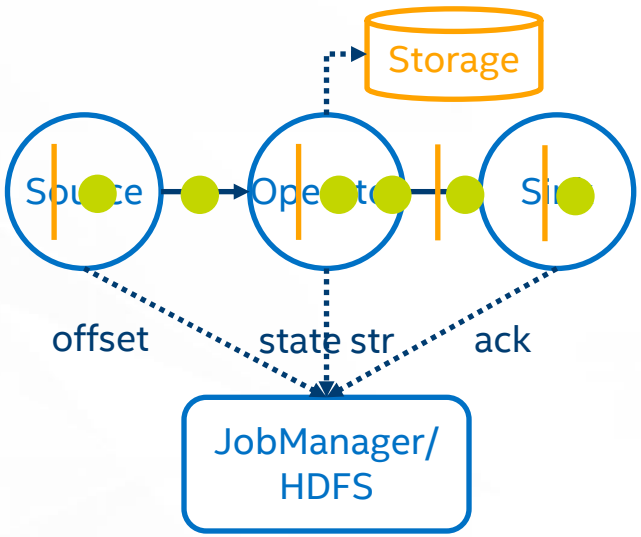
Apache Storm* | Twitter Heron*



Continuous Streaming

Checkpoint "per Batch"

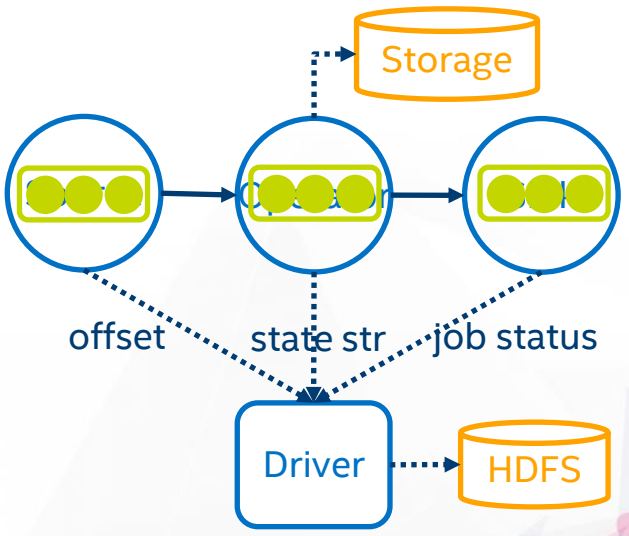
Aapche Flink* | Apache Gearpump*



Micro-Batch

Checkpoint per Batch

Apache Spark Streaming* | Apache Storm Trident*



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

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

Continuous Streaming

Ack per Record

Apache Storm*

Twitter Heron*

Continuous Streaming

Checkpoint “per Batch”

Aapche Flink*

Apache Gearpump*

Micro-Batch

Checkpoint per Batch

Apache Spark Streaming*

Apache Storm Trident*

Low Latency

High Latency

High Overhead

Low Throughput

Low Overhead

High Throughput

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

Delivery Guarantee

Apache Storm* | Twitter Heron* | Aapche Flink* | Apache Gearpump* | Apache Spark Streaming* | Apache 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

Apache Storm*	Twitter Heron*	Aapche Flink*	Apache Gearpump*	Apache Spark Streaming*	Apache Storm Trident*

Yes*

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

Yes

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

Yes

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

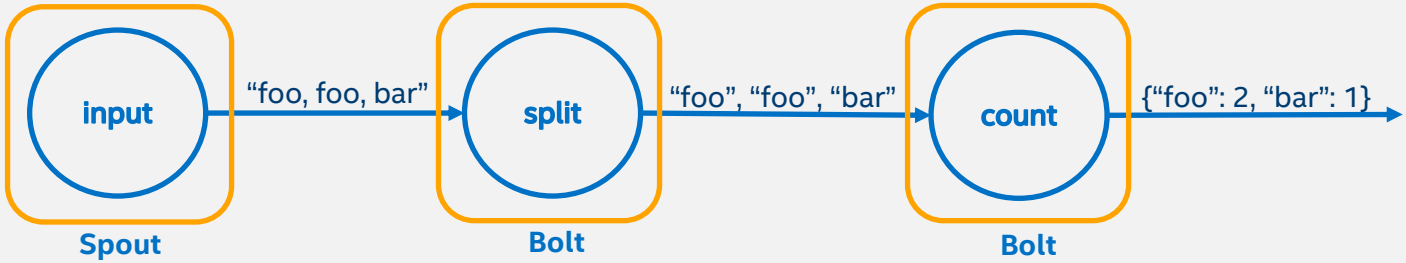
API

Compositional

Apache Storm*
Twitter Heron*
Apache Gearpump*

- 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"));
```



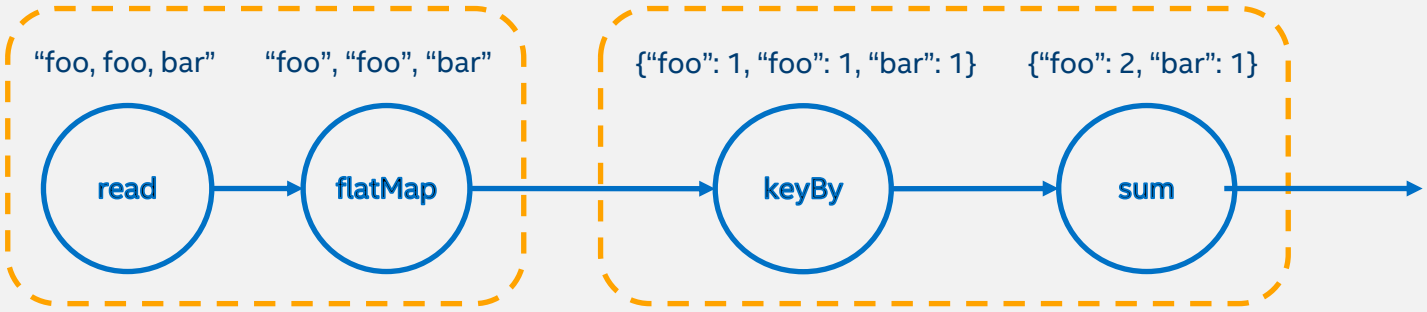
*Other names and brands may be claimed as the property of others.

Declarative

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

Apache Spark Streaming*
Apache Storm Trident*
Aapche Flink*
Apache Gearpump*

```
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

Apache Spark Streaming*	Apache Storm*	Twitter Heron*

Python

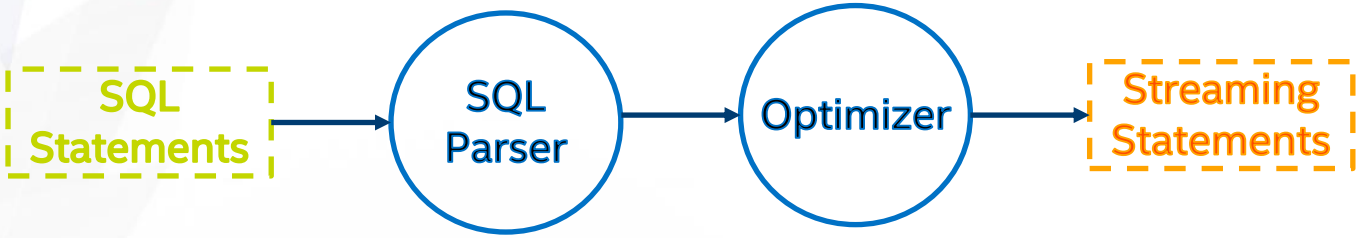
```
lines = ssc.textFileStream(params.get("input"))
words = lines.flatMap(lambda line: line.split(“,"))
pairs = words.map(lambda word: (word, 1))
counts = pairs.reduceByKey(lambda x, y: x + y)
counts.saveAsTextFiles(params.get("output"))
```

˚Structured Streaming*	˚Apache 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

Apache Spark Streaming*

Aapche 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

Apache 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

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

Summary

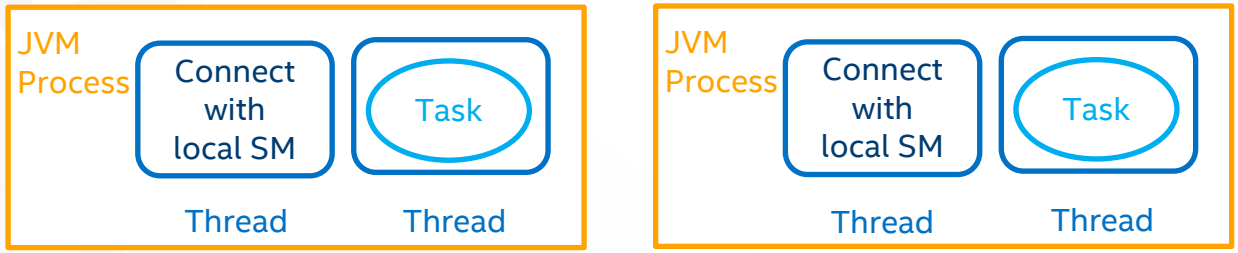
	Compositional	Declarative	Python/R	SQL
Apache Spark Streaming*	X	√	√	√
Apache Storm*	√	X	√	NOT support aggregation, windowing and joining
Apache Storm Trident*	X	√	X	
Apache Gearpump*	√	√	X	X
Aapche Flink*	X	√	X	Support select, from, where, union
Twitter Heron*	√	X	√˚	X

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

Runtime Model

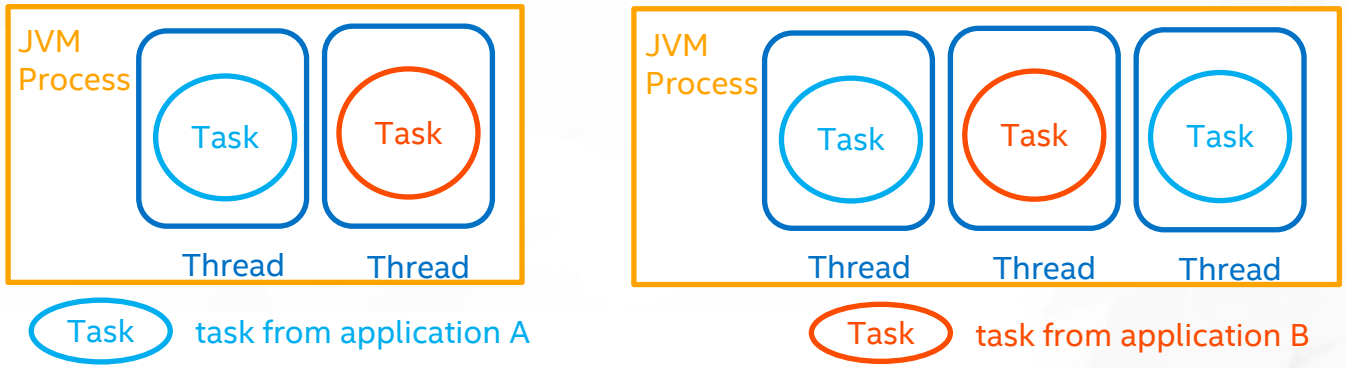
- Single Task on Single Process

Twitter Heron*



- Multi Tasks of Multi Applications on Single Process

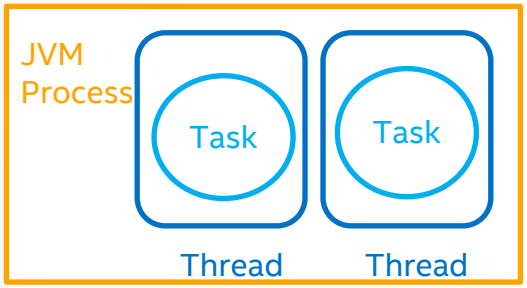
Aapche Flink*

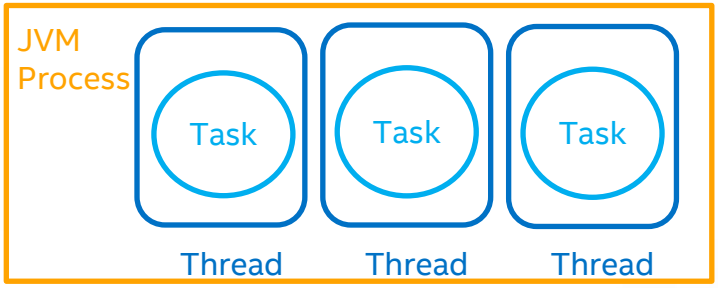


*Other names and brands may be claimed as the property of others.

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

Apache Spark Streaming*



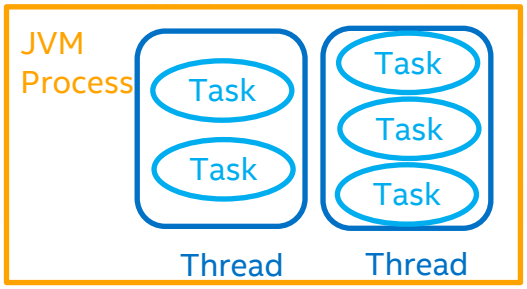


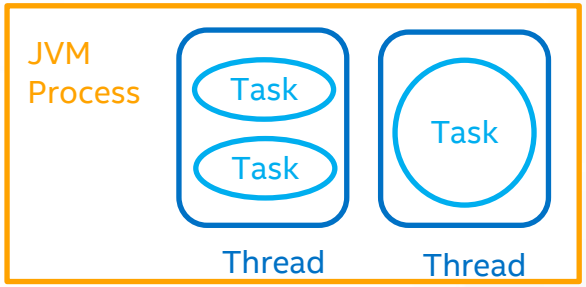
  - Multi tasks on single thread

Apache Storm*

Apache Storm Trident*

Apache Gearpump*





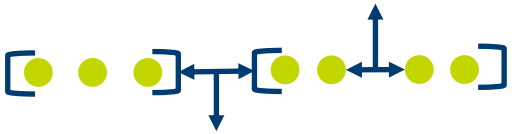
*Other names and brands may be claimed as the property of others.

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
Apache Spark Streaming*	√	X	X°
Apache Storm*	√	√	X
Apache Storm Trident*	√	√	X
Apache Gearpump*	√°	X	X
Apache Flink*	√	√	√
Apache Heron*	X	X	X

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

Out-of-order Processing

	Processing Time	Event Time	Watermark
Apache Spark Streaming*	√	√°	X°
Apache Storm*	√	√	√
Apache Storm Trident*	√	X	X
Apache Gearpump*	√	√	√
Aapche Flink*	√	√	√
Twitter Heron*	√	X	X

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

Memory Management

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

Resource Management

	Standalone	YARN	Mesos
Apache Spark Streaming*	√	√	√
Apache Storm*	√	√˚	√˚
Apache Storm Trident*	√	√˚	√˚
Apache Gearpump*	√	√	X
Aapche Flink*	√	√	X
Twitter Heron*	√	√	√

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

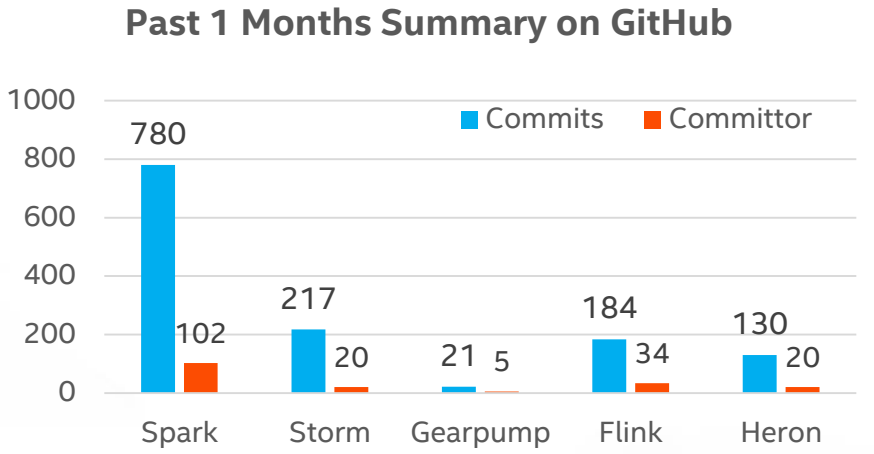
Web UI

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

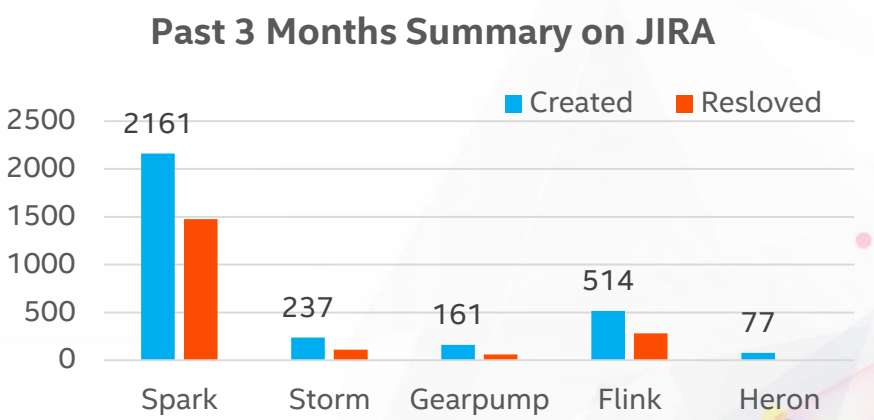
*Other names and brands may be claimed as the property of others.

Community Maturity

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



Source website: https://github.com/apache/spark/pulse/monthly



Source website: https://issues.apache.org/jira/secure/Dashboard.jspa

Performance Benchmark

HiBench 6.0

Test Philosophical

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

Cluster Setup

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

- Apache Heron* require specific Operation System (Ubuntu / CentOS / Mac OS)
- Structured Streaming doesn't support Kafka source yet (Spark 2.0)

Apache Kafka* Cluster

- **CPU:** 2 x Intel(R) Xeon(R) CPU E5-2699 v3@ 2.30GHz
- **Mem:** 128 GB
- **Disk:** 8 x HDD (1TB)
- **Network:** 10 Gbps

x3

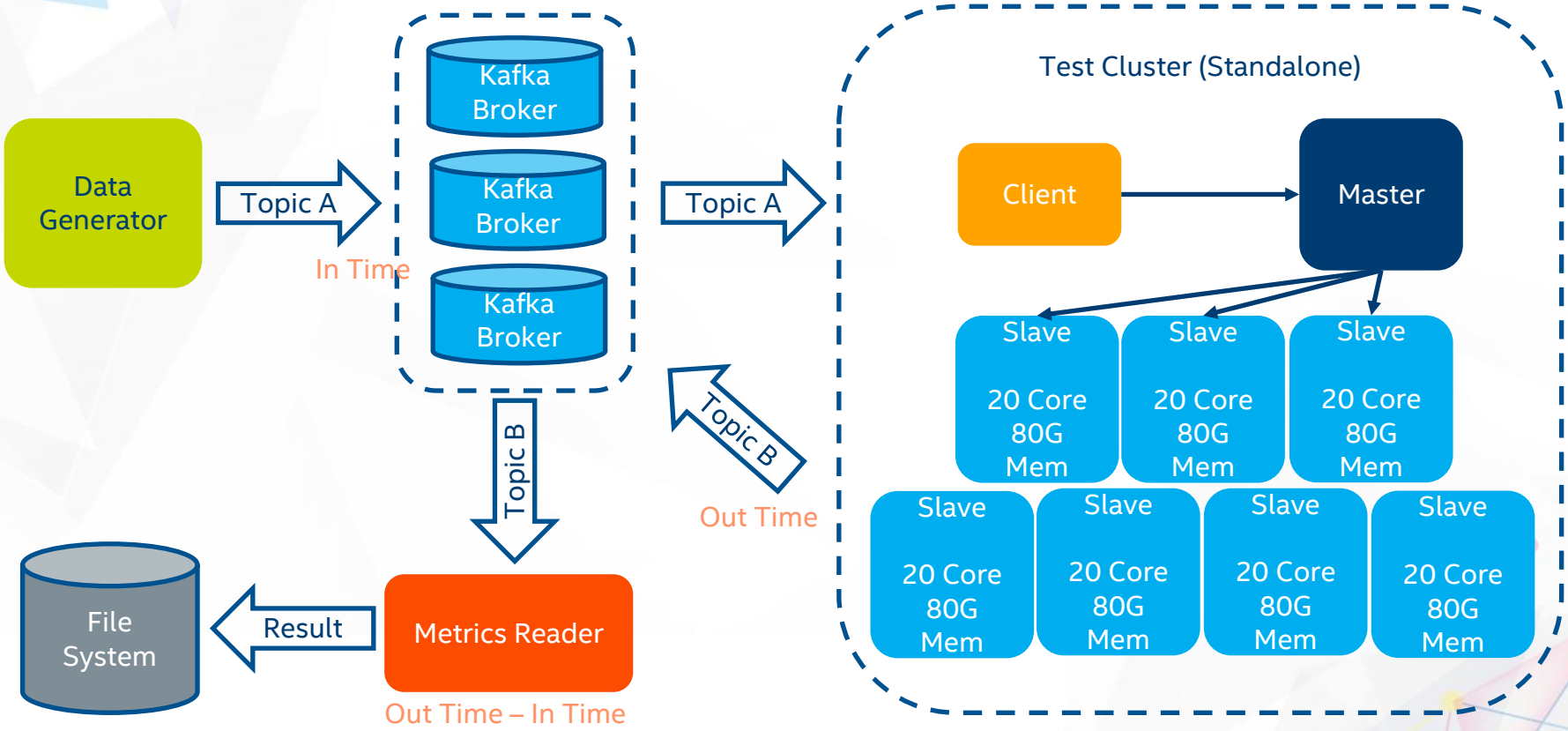
10 Gbps

Test Cluster

- **CPU:** 2 x Intel(R) Xeon(R) CPU E5-2697 v2@ 2.70GHz
- **Core:** 20 / 24
- **Mem:** 80 / 128 GB
- **Disk:** 8 x HDD (1TB)
- **Network:** 10 Gbps

x7

Architecture



Framework Configuration

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

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

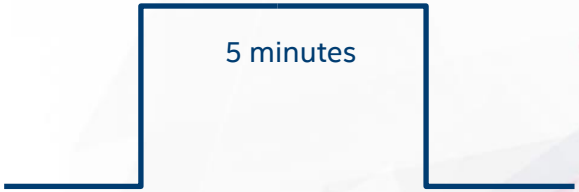
Raw Input Data

- 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



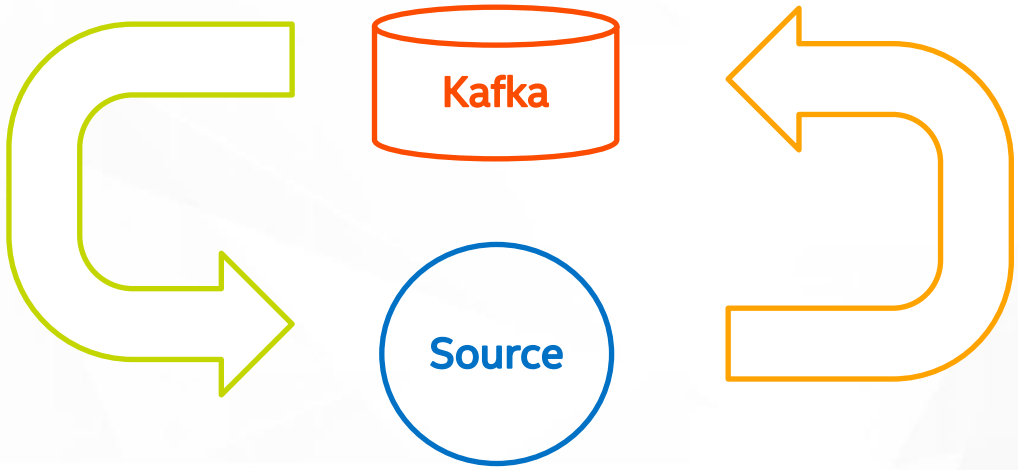
Data Input Rate

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

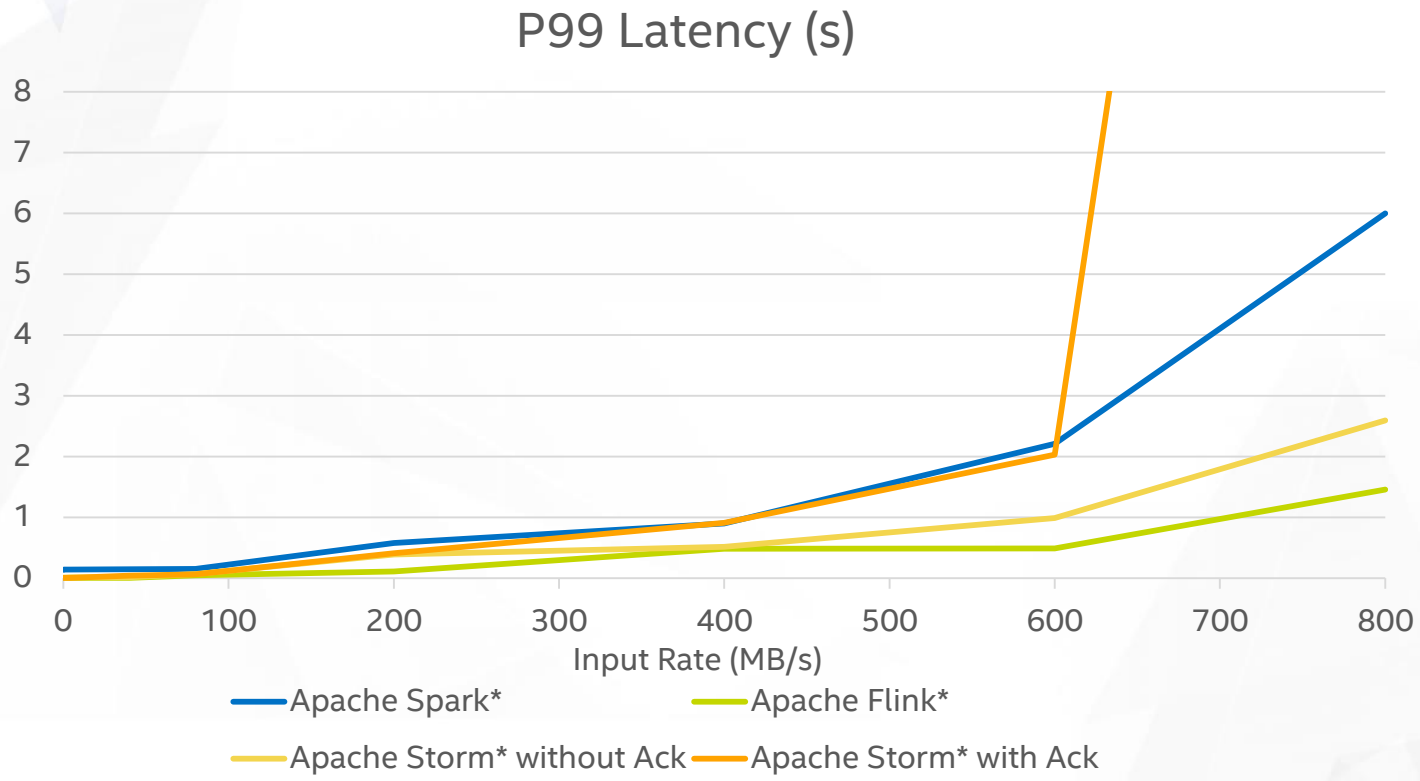
Let’s start with the simplest case

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



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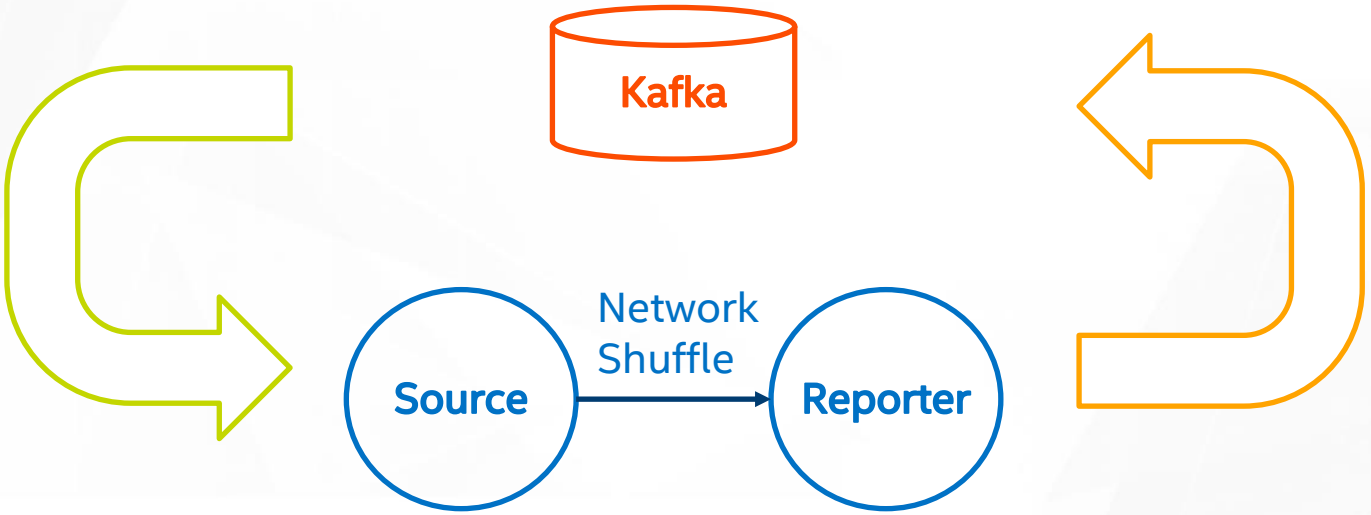
For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.
Results have been estimated or simulated using internal Intel analysis or architecture simulation or modeling, and provided to you for informational purposes. Any differences in your system hardware, software or configuration may affect your actual performance.

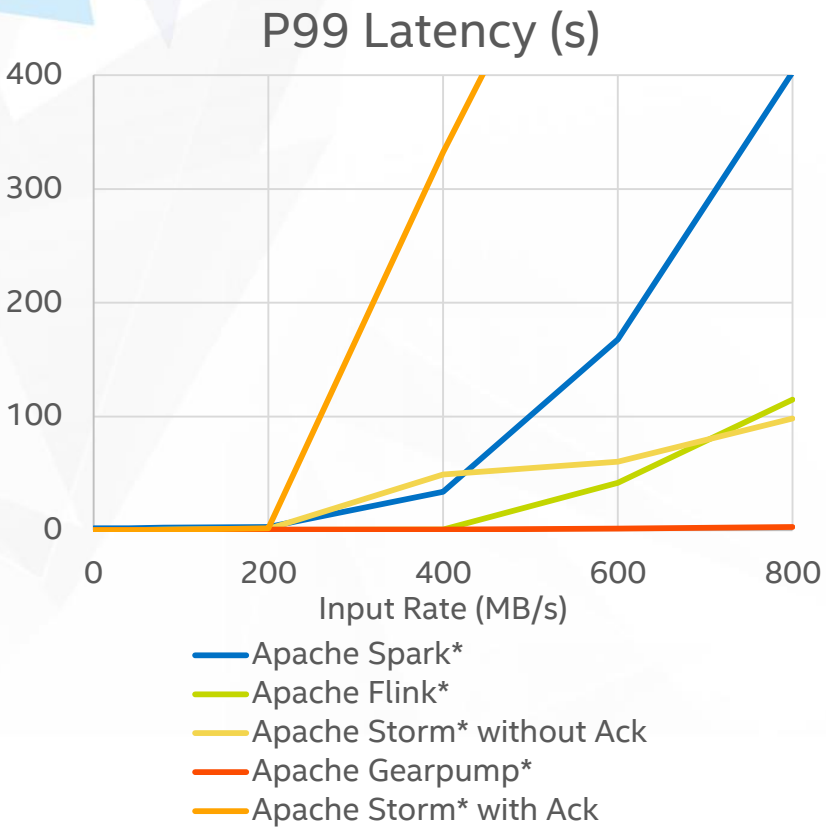
Q: What if source data are skew or even packed?

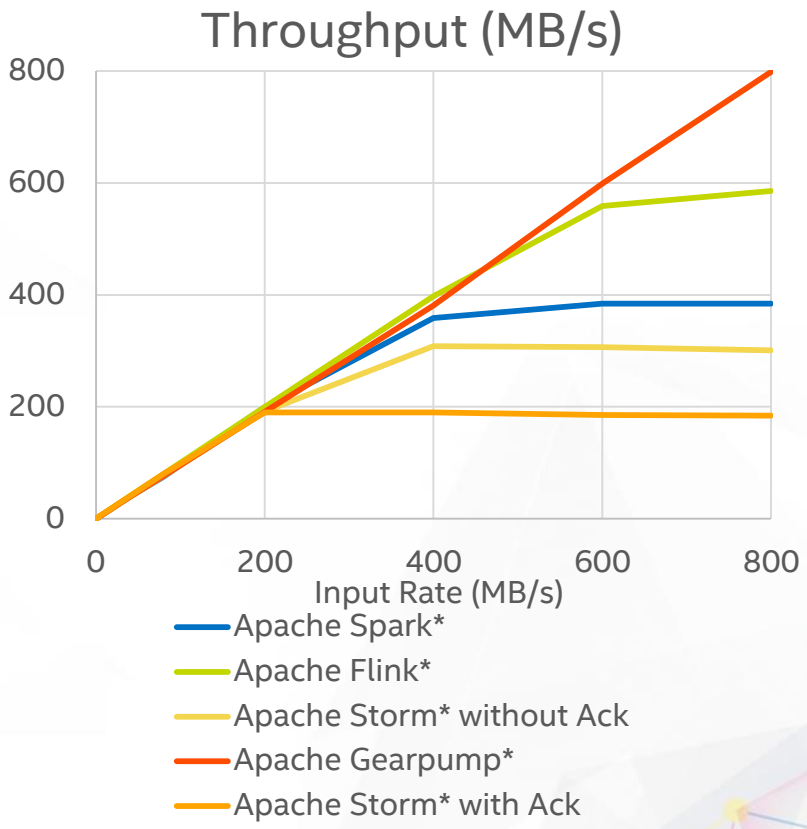
Test Case: Repartition

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



Result





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Observation

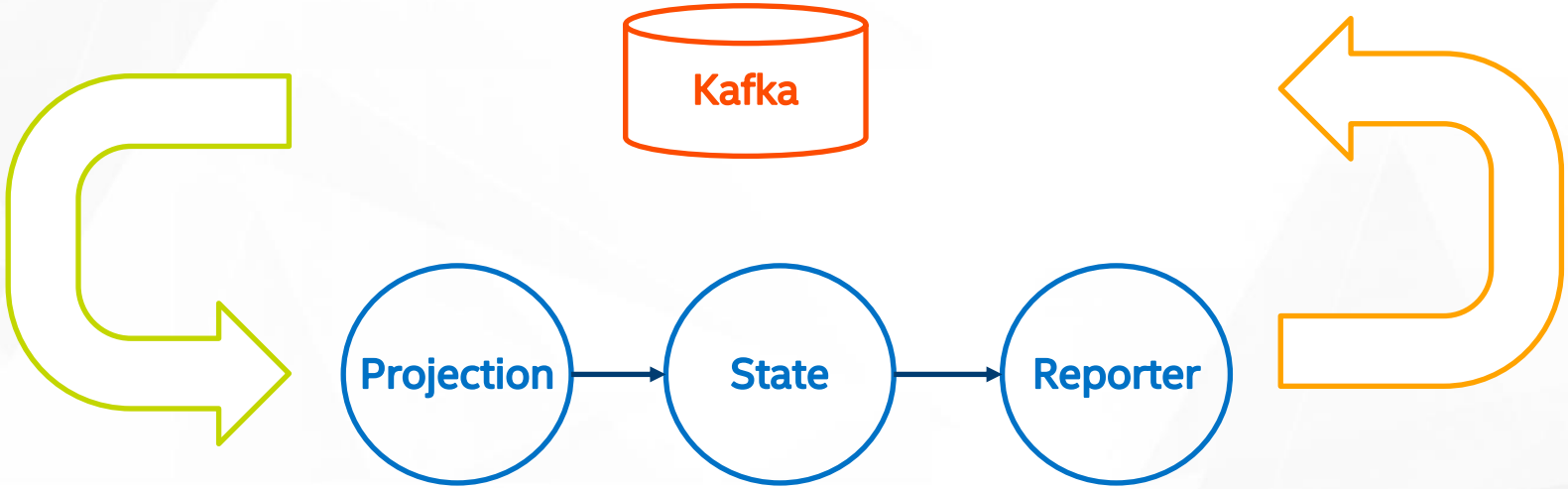
- Spark Streaming need to schedule task with additional context. Under tiny batch interval case, the overhead could be dramatic worse compared to other frameworks.
- According to our test, minimum Batch Interval of Spark is about 80ms (140 tasks per batch), otherwise task schedule delay will keep increasing
- 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?

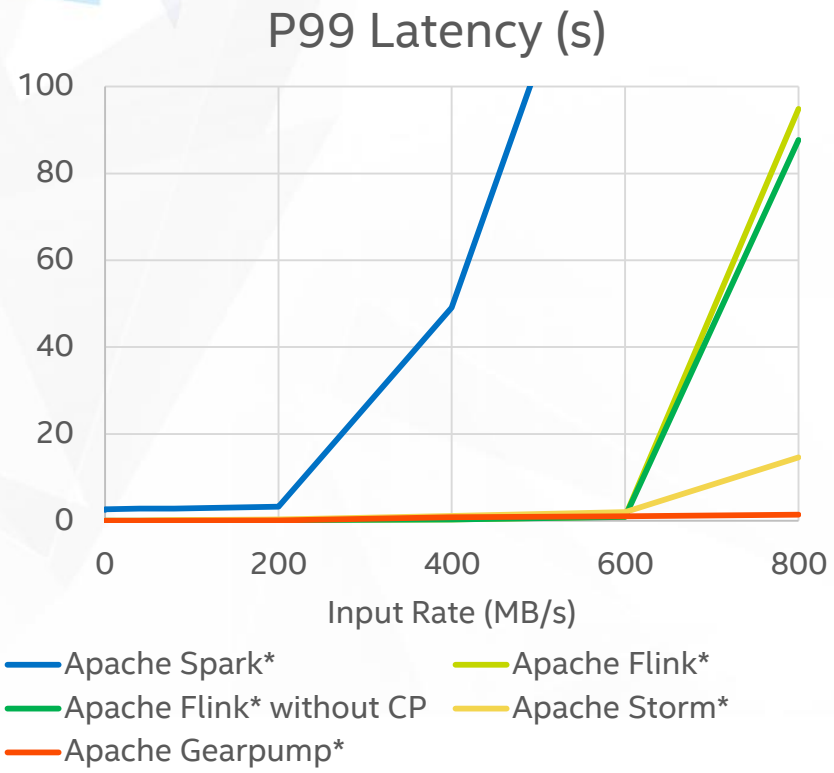
Test Case: Stateful WordCount

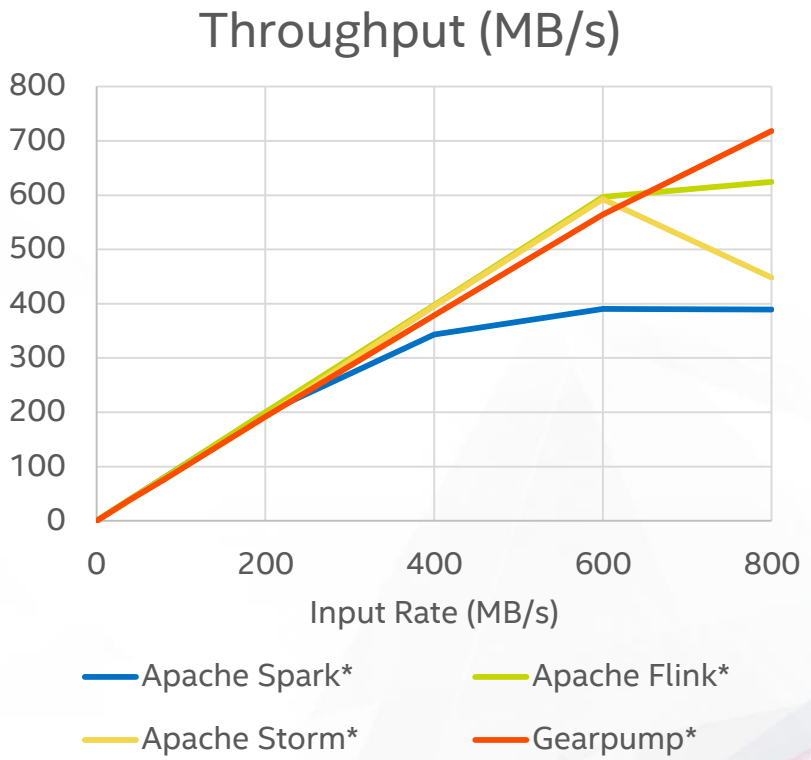
Native state operator is supported by all frameworks we evaluated

Stateful operator performance + Checkpoint/Acker cost



Result





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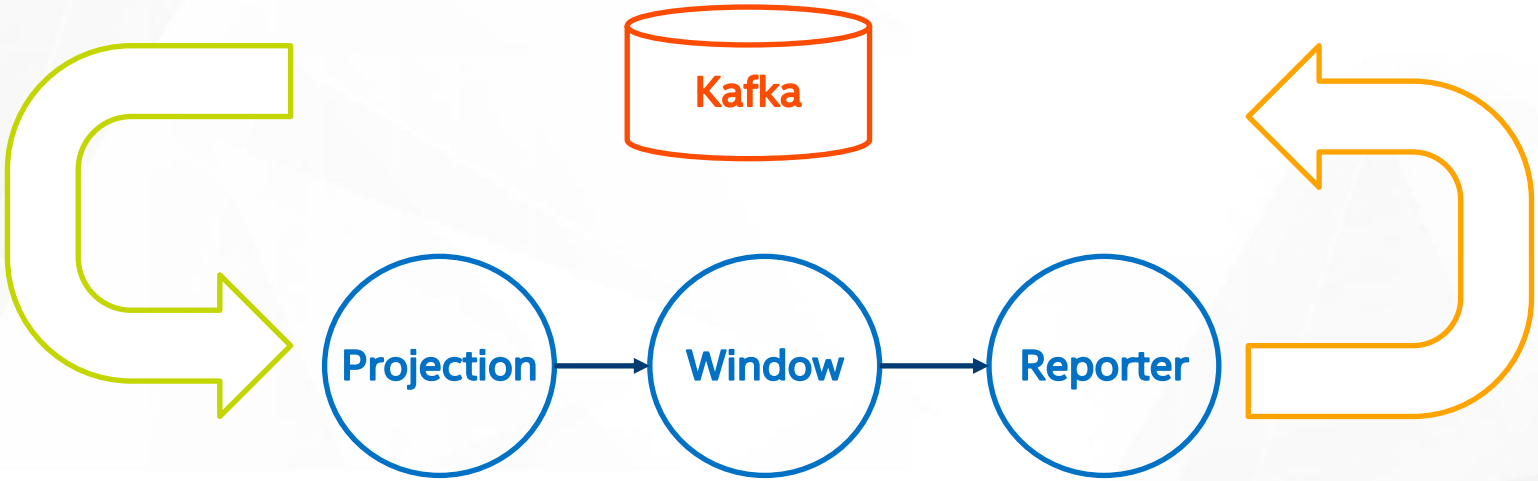
Observation

- 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.

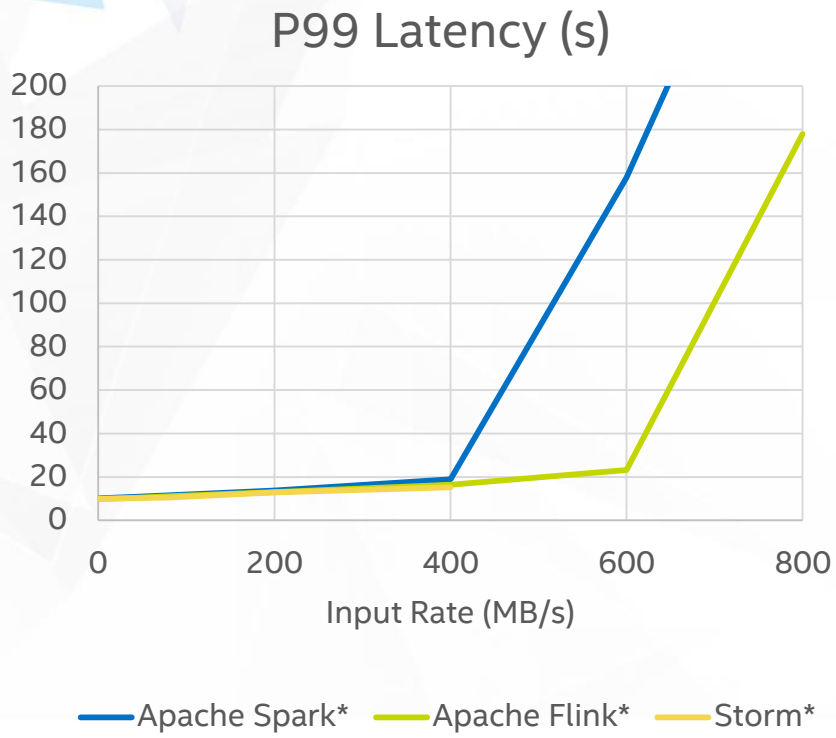
Q: How about Window Operation?

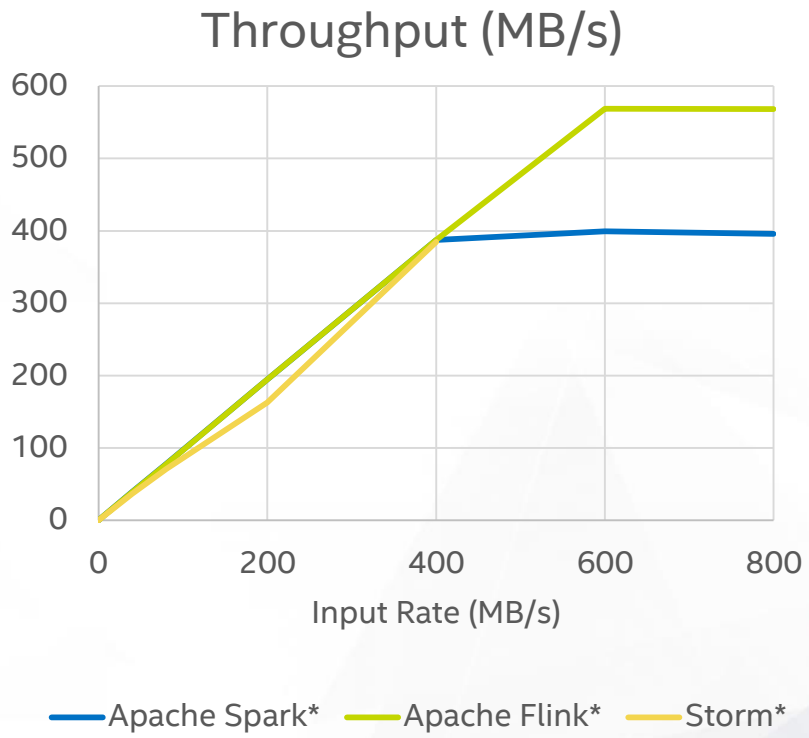
Test Case: Window Based Aggregation

This test case manages a 10-seconds sliding window



Result





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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]

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Configurations:

Hardware:

Apache Kafka* Cluster - CPU: 2 x Intel(R) Xeon(R) CPU E5-2699 v3@ 2.30GHz, Mem: 128 GB, Disk: 8 x HDD (1TB), Network: 10 Gbps.

Test Cluster - CPU: 2 x Intel(R) Xeon(R) CPU E5-2697 v2@ 2.70GHz，Core: 20 / 24, Mem: 80 / 128 GB, Disk: 8 x HDD (1TB), Network: 10 Gbps.

Software:

the software framework configuration is shown in page 29. The test results in page 34, 37, 41 and 45 used above configurations.

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

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