Dataflow/Apache Beam

A Unified Model for Batch and Streaming Data Processing

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STREAM 2016

Google Cloud Platform

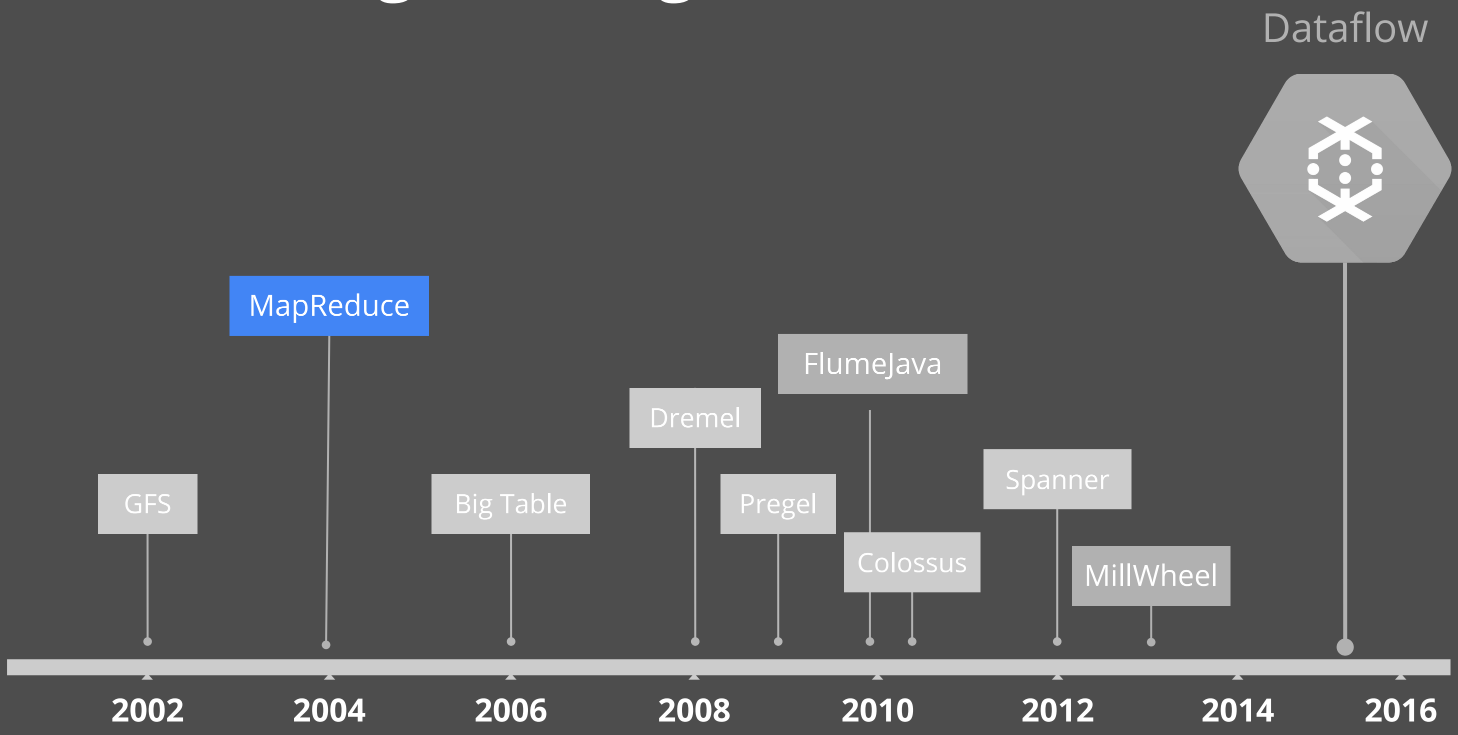
Agenda

1. Google's Data Processing Story
2. Philosophy of the Beam programming model
3. Apache Beam project

1

Google's
Data Processing Story

Data Processing @ Google



MapReduce: SELECT + GROUP BY

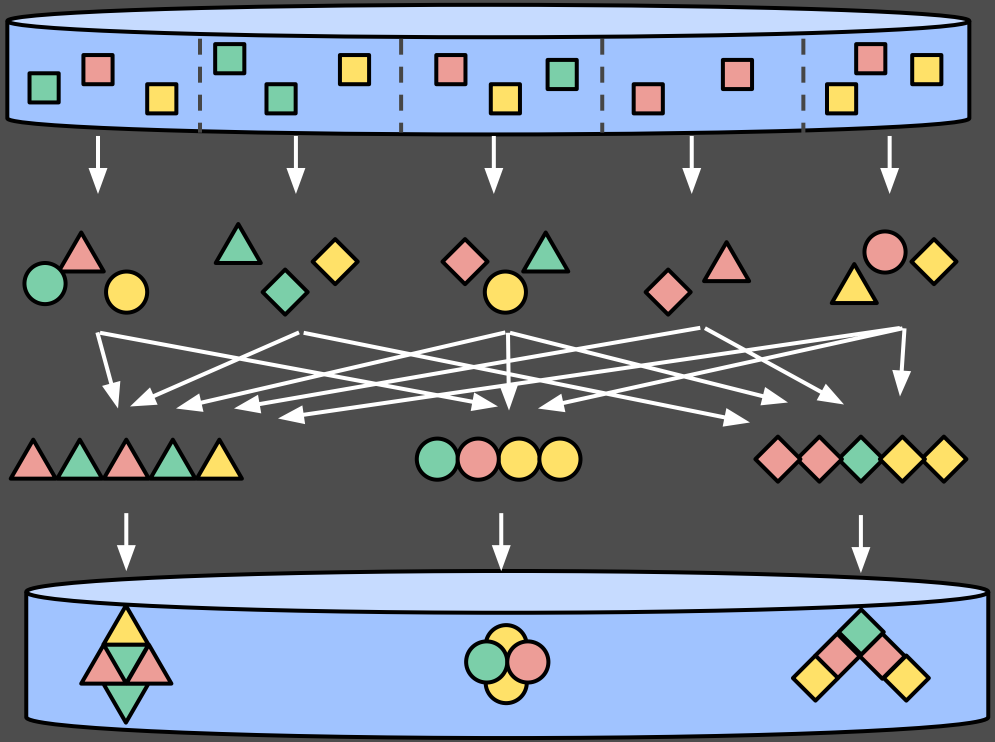
(distributed input dataset)

Map (SELECT)

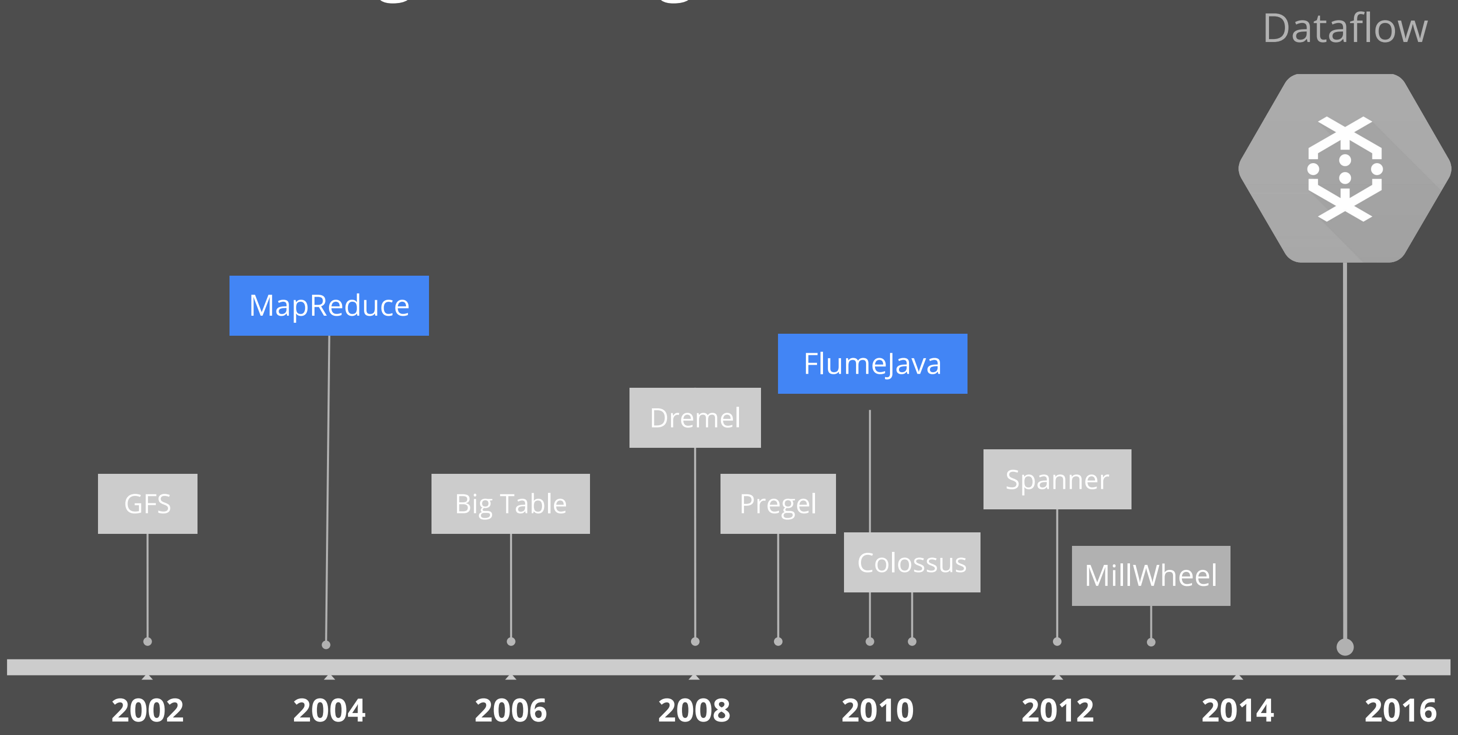
Shuffle (GROUP BY)

Reduce (SELECT)

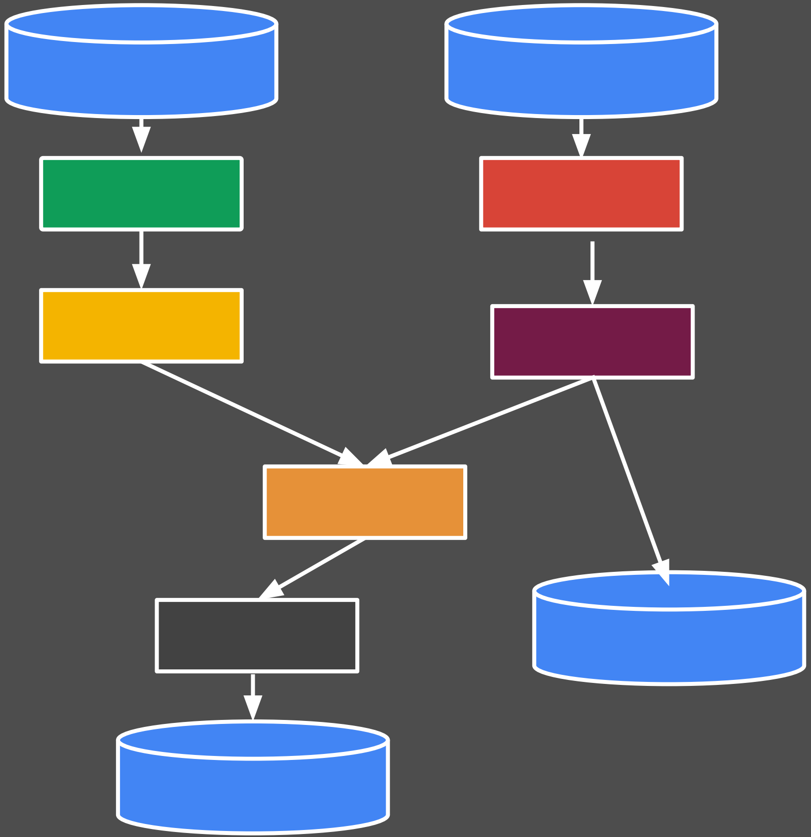
(distributed output dataset)



Data Processing @ Google



FlumeJava Pipelines

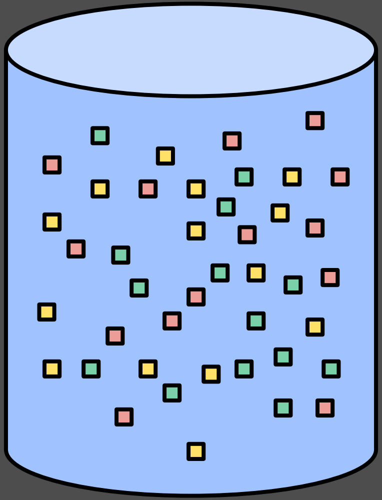


- A Pipeline represents a graph of data processing transformations
- PCollections flow through the pipeline
- Optimized and executed as a unit for efficiency

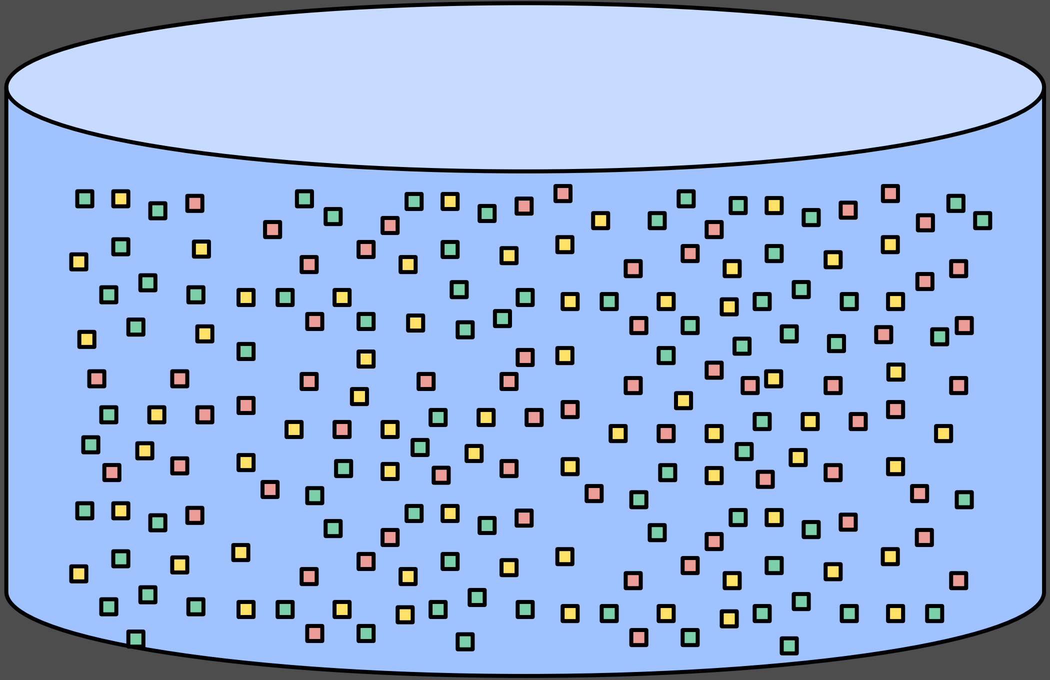
Example: Computing mean temperature

```
// Collection of raw events
PCollection<SensorEvent> raw = ...;
// Element-wise extract location/temperature pairs
PCollection<KV<String, Double>> input =
    raw.apply(ParDo.of(new ParseFn()))
// Composite transformation containing an aggregation
PCollection<KV<String, Double>> output = input
  .apply(Mean.<Double>perKey());
// Write output
output.apply(BigtableIO.Write.to(...));
```

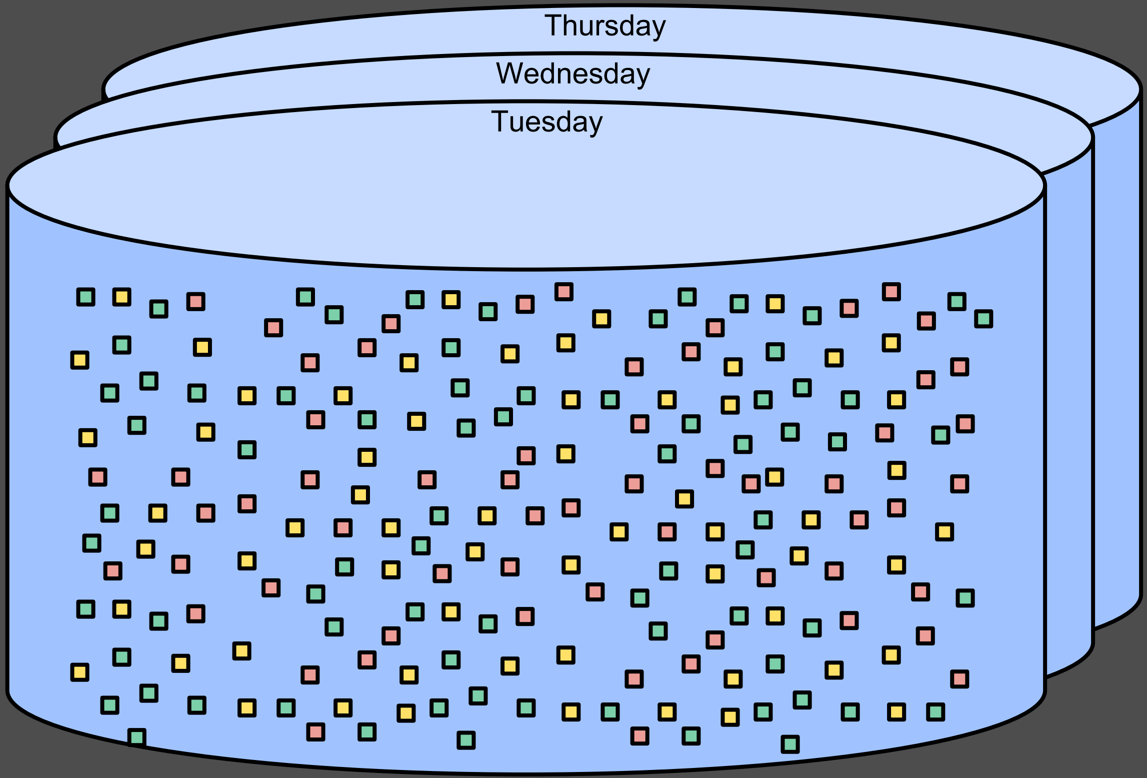
So, people used FJ to process data...



...big data...



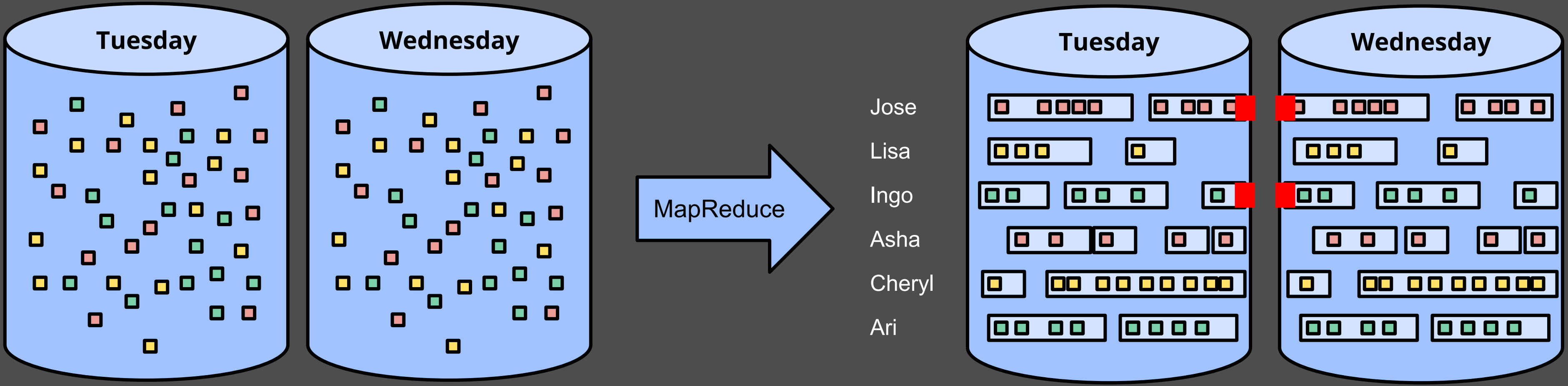
...really, really big...



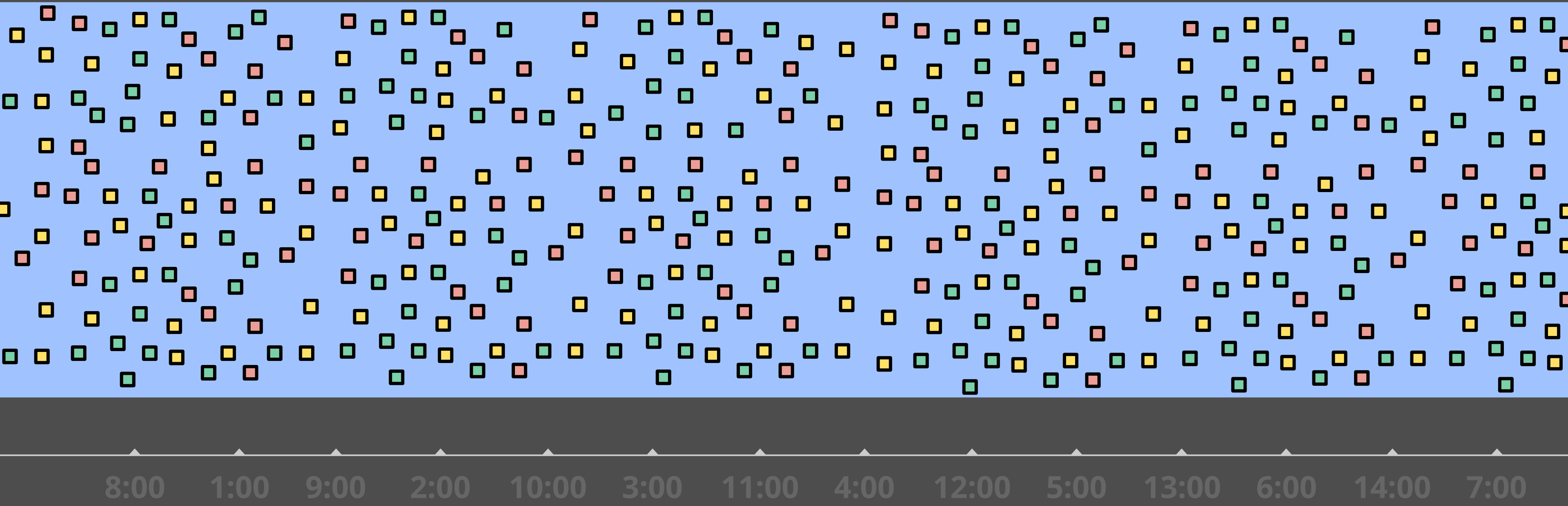
Batch failure mode #1

Latency

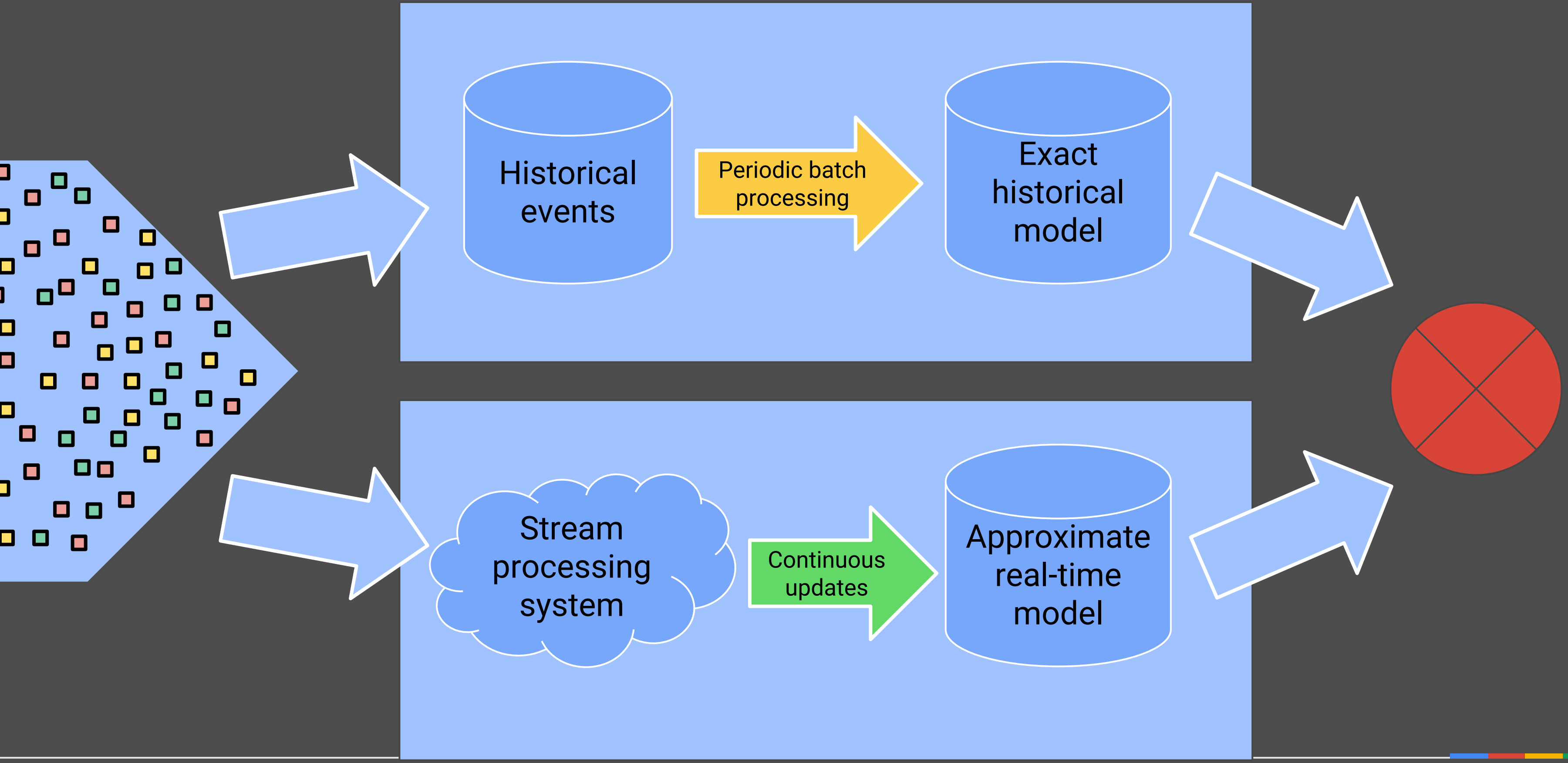
Batch failure mode #2: Sessions



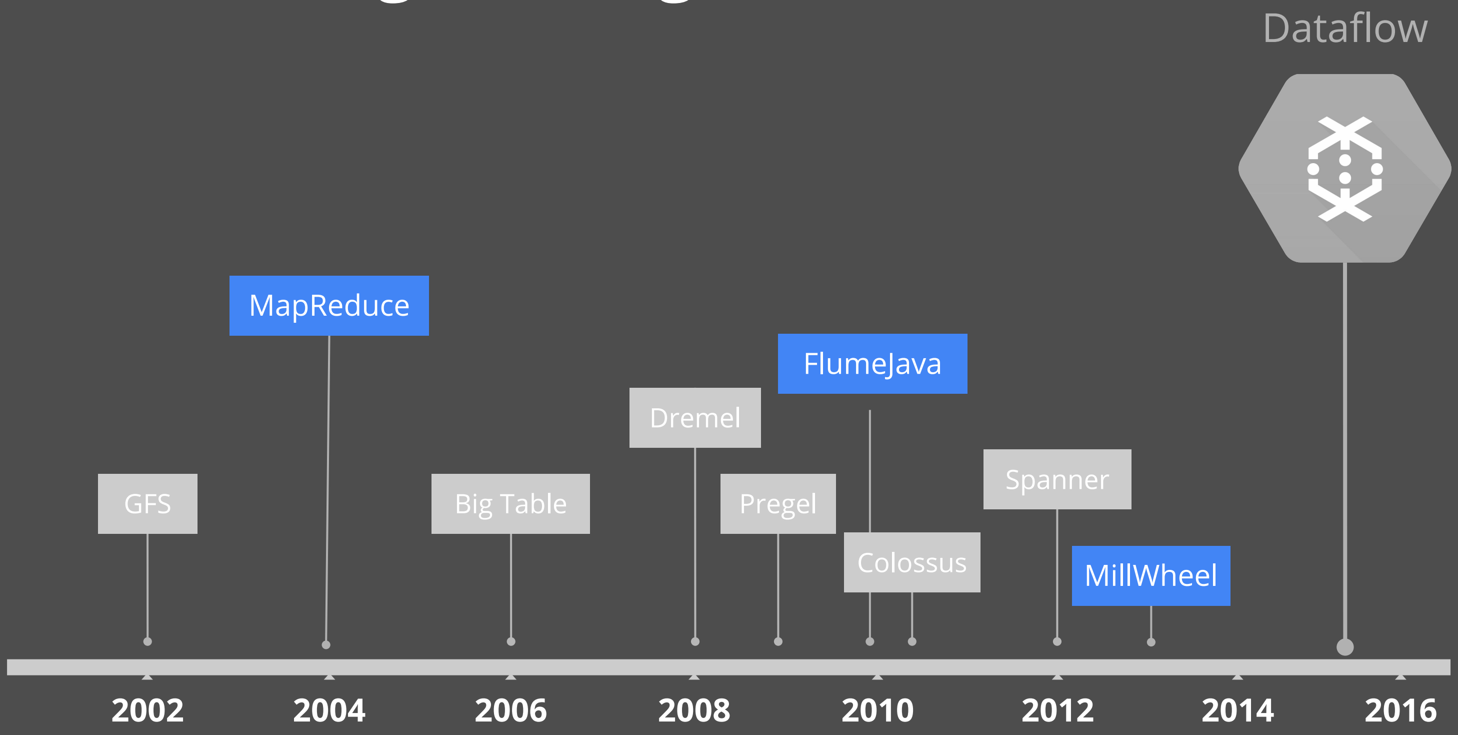
Continuous & Unbounded



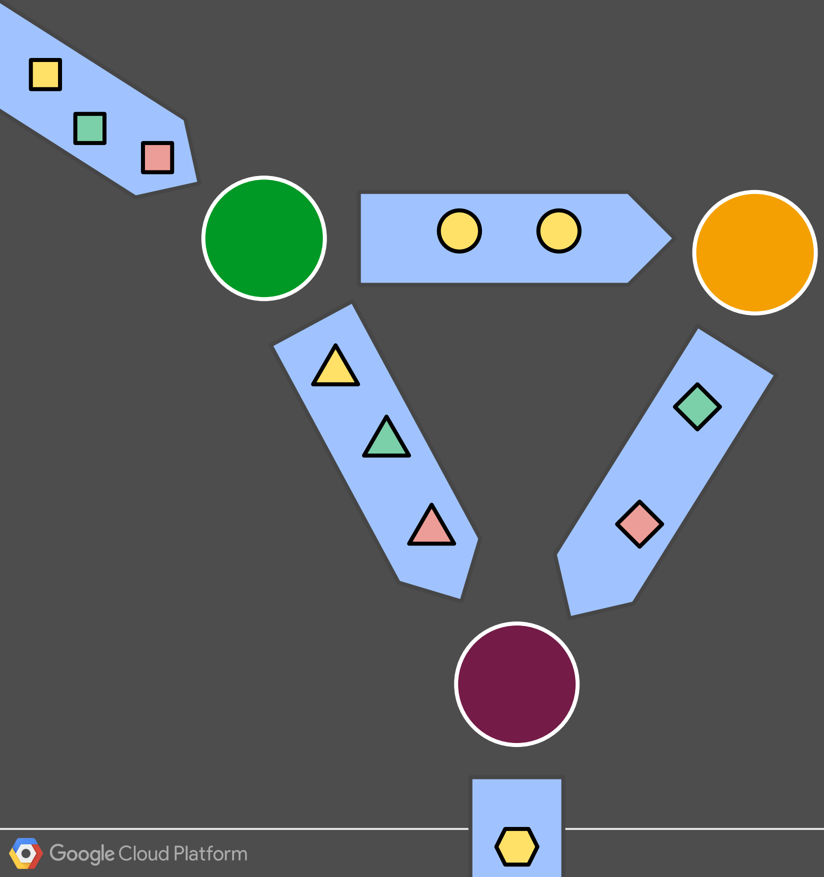
State of the art until recently: Lambda Architecture



Data Processing @ Google



MillWheel: Deterministic, low-latency streaming



- Framework for building low-latency data-processing applications
- User provides a DAG of computations to be performed
- System manages state and persistent flow of elements

Streaming or Batch?

1+1=2

Correctness

Latency

Why not both?

What are you computing?

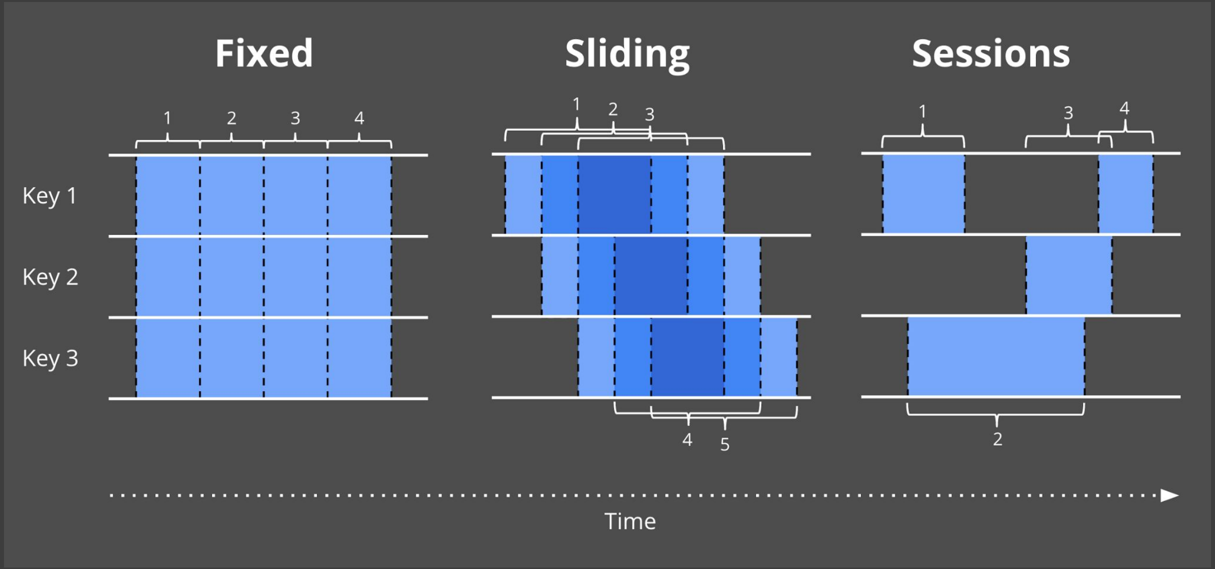
Where in event time?

When in processing time?

How do refinements relate?

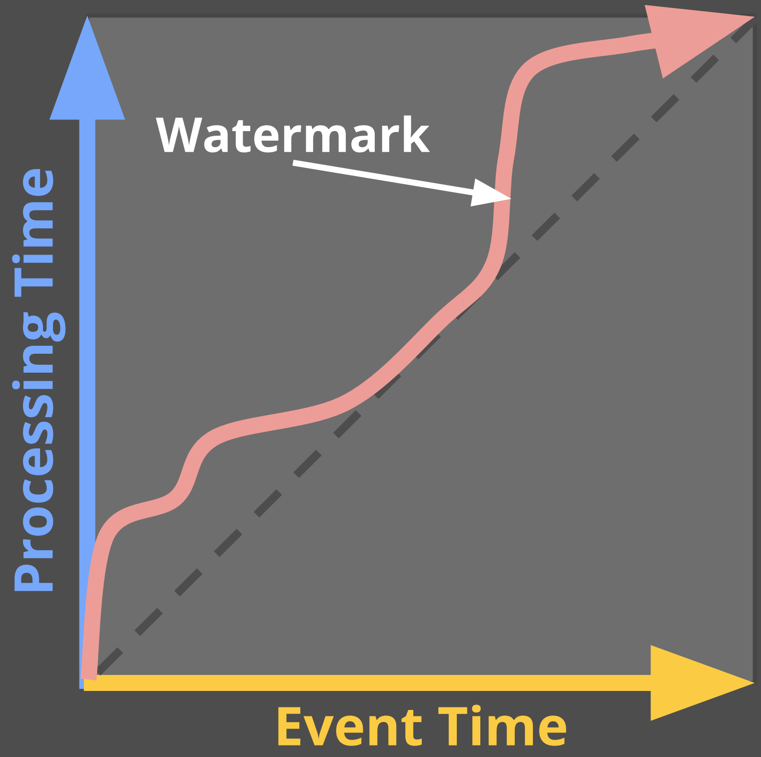
Where in event time?

- Windowing divides data into event-time-based finite chunks.



- Required when doing aggregations over unbounded data.

When in Processing Time?

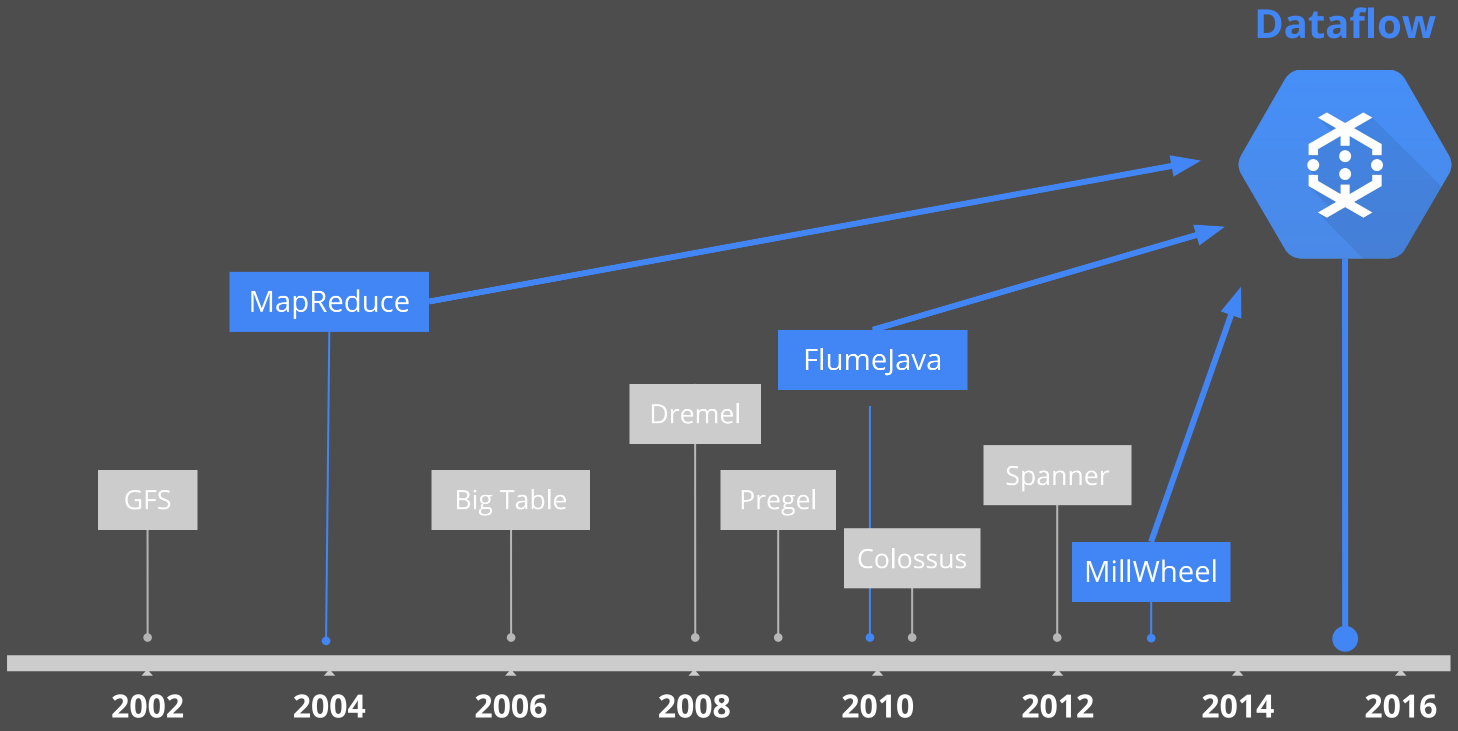


- Triggers control when results are emitted.
- Triggers are often relative to the watermark.

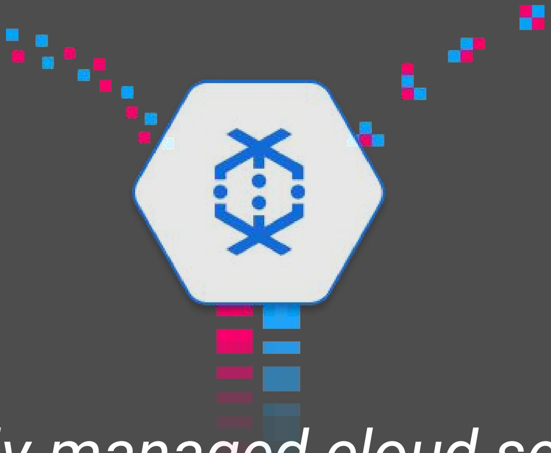
How do refinements relate?

```
PCollection<KV<String, Integer>> output = input
  .apply(Window.into(Sessions.withGapDuration(Minutes(1)))
               .trigger(AtWatermark()
                 .withEarlyFirings(AtPeriod(Minutes(1)))
                 .withLateFirings(AtCount(1)))
               .accumulatingAndRetracting())
  .apply(new Sum());
```

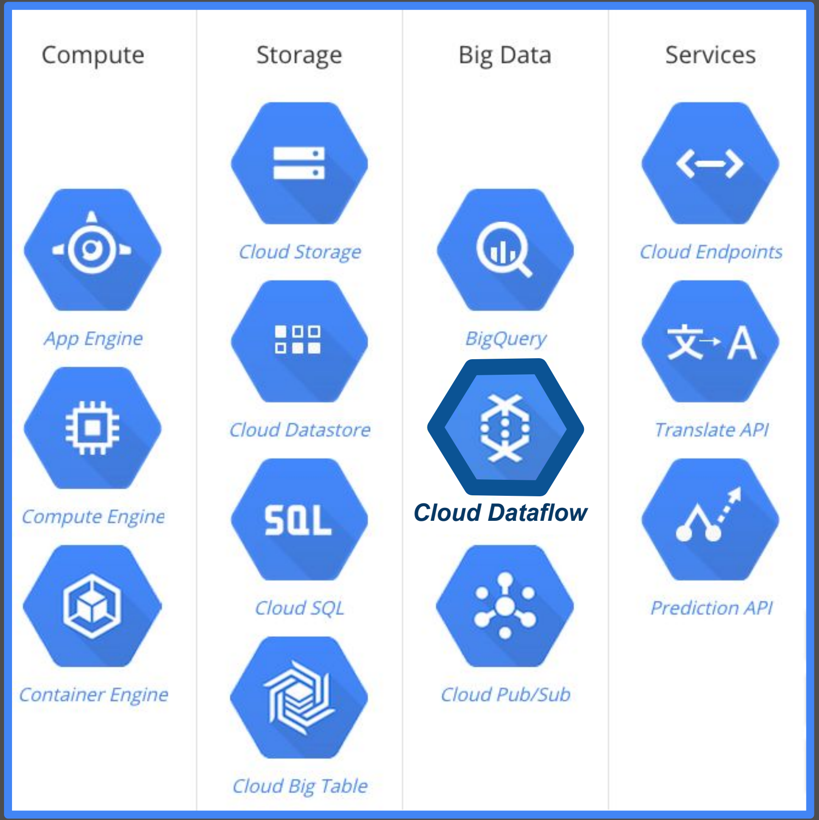
Data Processing @ Google

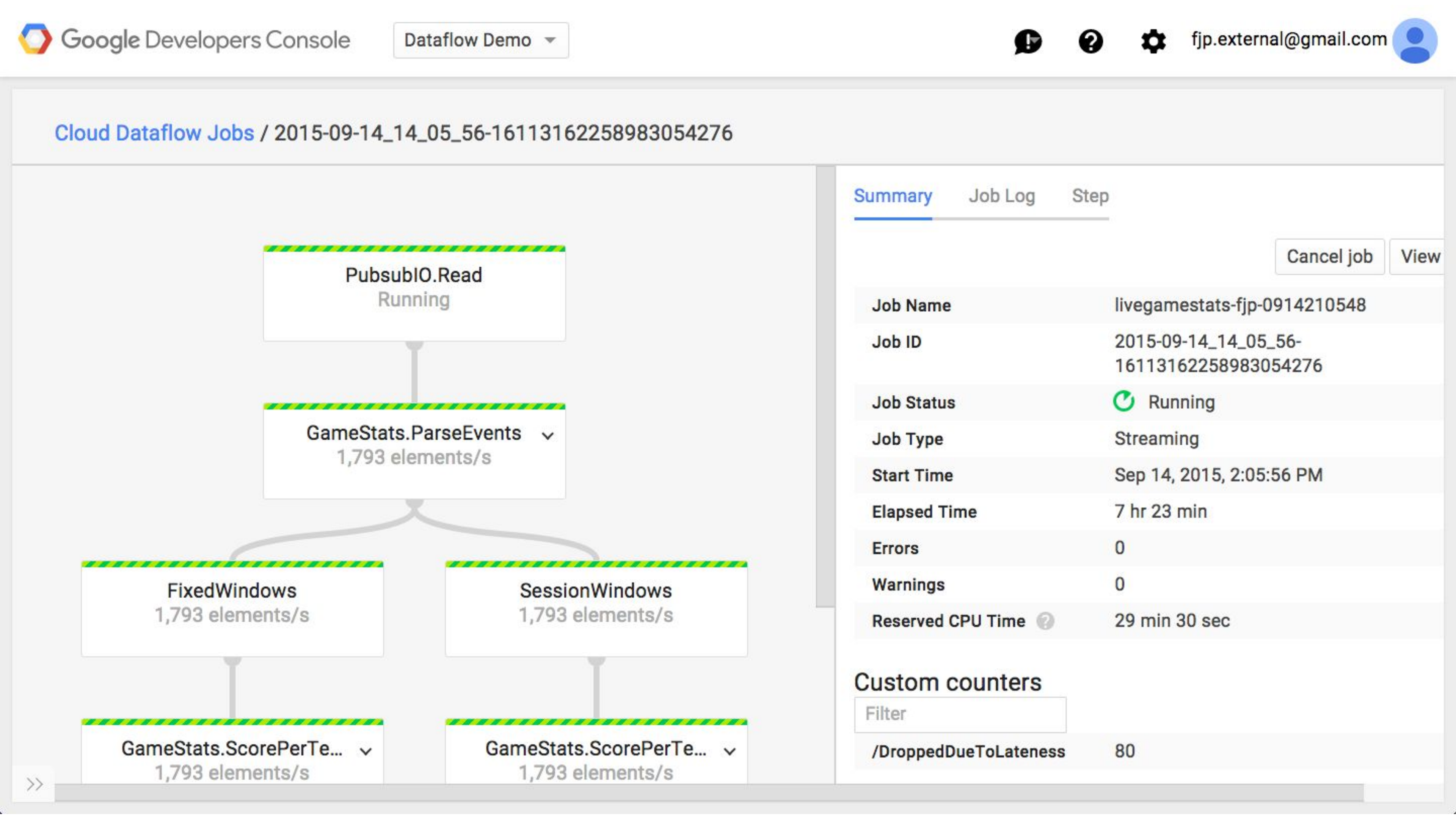


Google Cloud Dataflow



A fully-managed cloud service and programming model for batch and streaming big data processing.





Cloud Dataflow Jobs / 2015-09-14_14_05_56-16113162258983054276

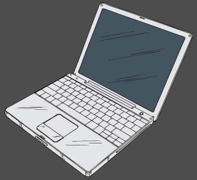
Job Name	livegamestats-fjp-0914210548
Job ID	2015-09-14_14_05_56-16113162258983054276
Job Status	Running
Job Type	Streaming
Start Time	Sep 14, 2015, 2:05:56 PM
Elapsed Time	7 hr 23 min
Errors	0
Warnings	0
Reserved CPU Time	29 min 30 sec

Custom counters

/DroppedDueToLateness	80

Dataflow SDK

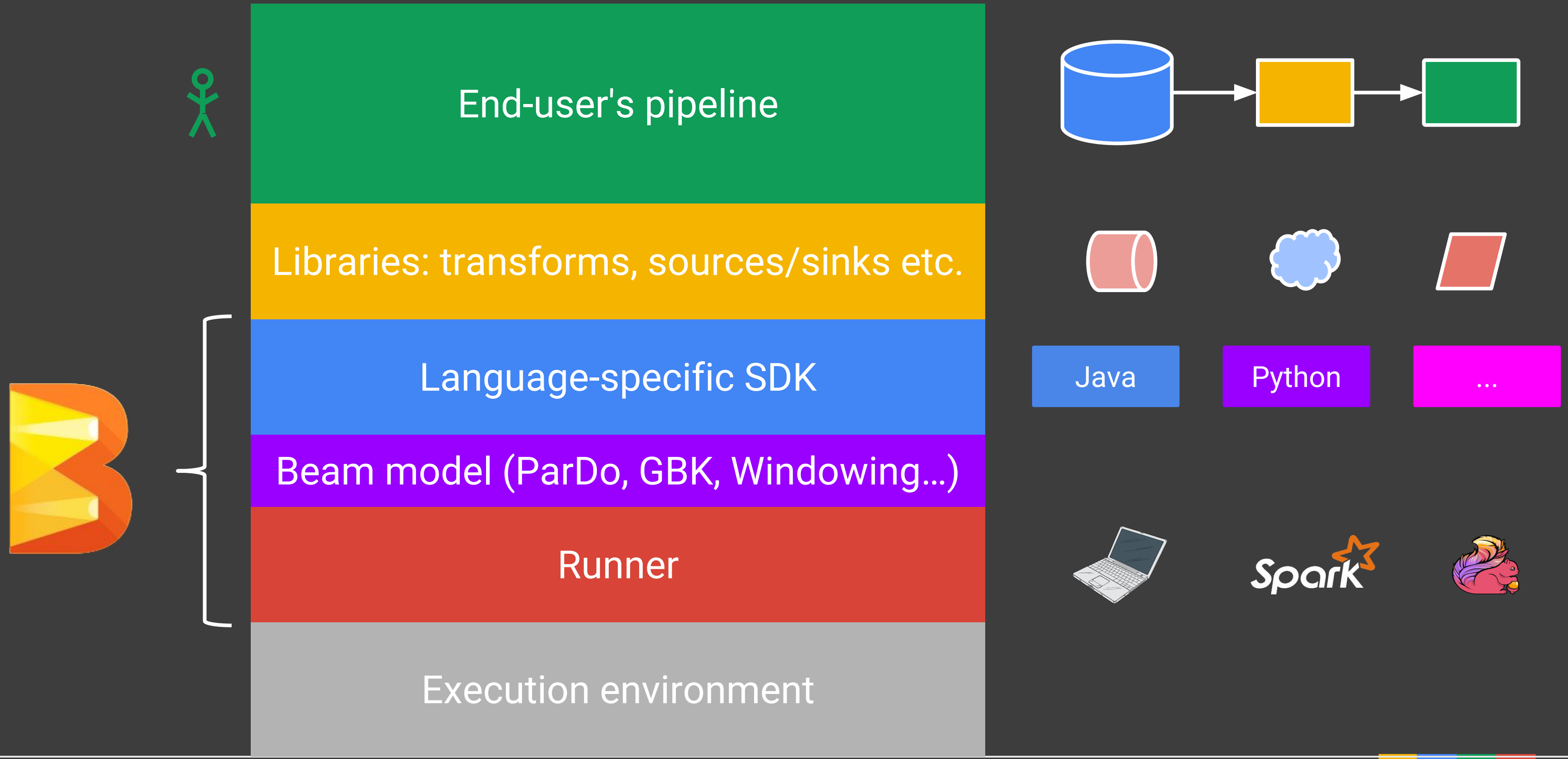
- Portable API to construct and run a pipeline.
- Available in Java and Python (alpha)
- Pipelines can run…
  - On your development machine
  - On the **Dataflow Service** on **Google Cloud Platform**
  - On third party environments like Spark or Flink.



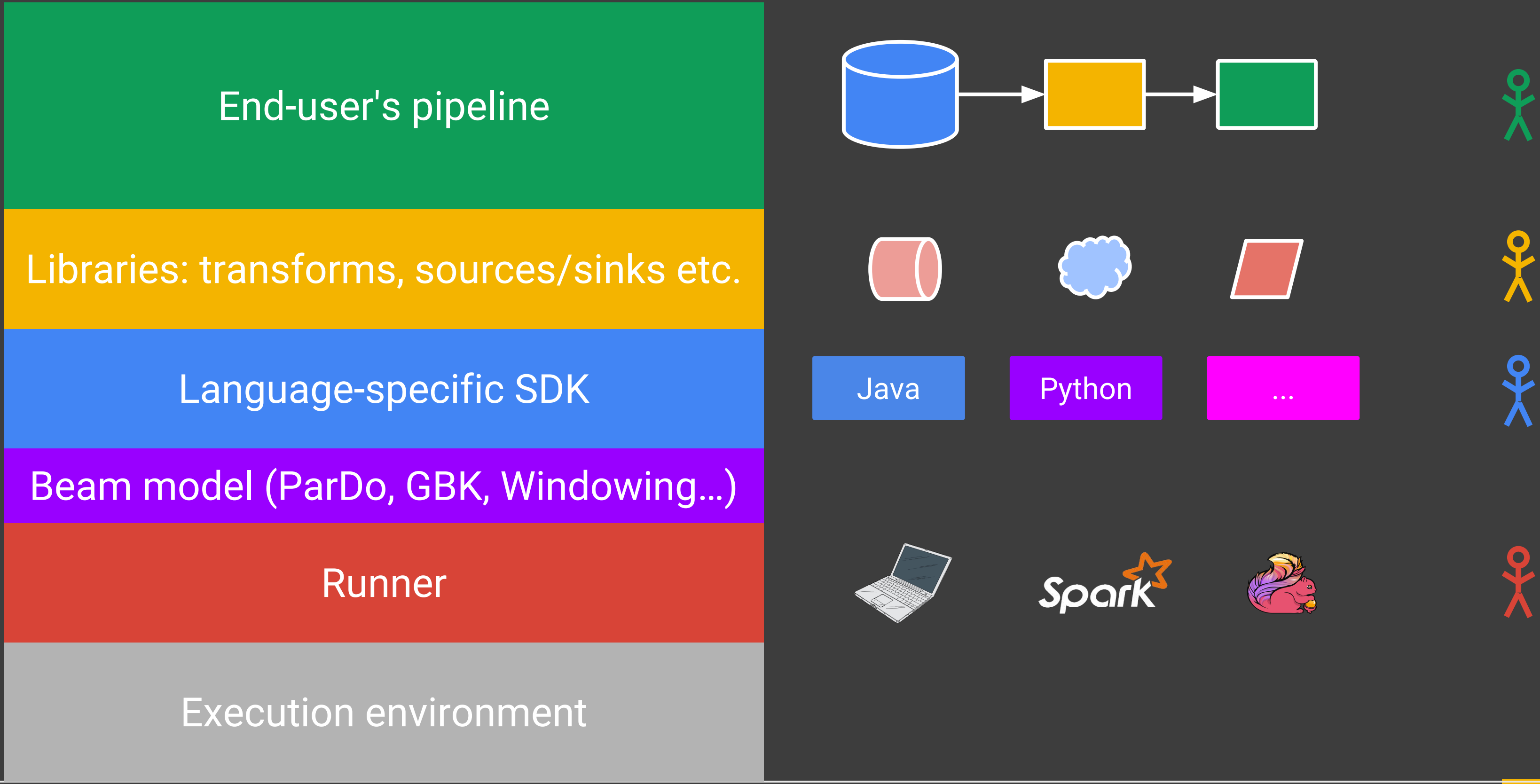
3 Dataflow ⇒ Apache Beam

```
Pipeline p = Pipeline.create(options);
p.apply(TextIO.Read.from("gs://dataflow-samples/shakespeare/*"))
 .apply(FlatMapElements.via(
     word → Arrays.asList(word.split("[^a-zA-Z']+"))))
 .apply(Filter.byPredicate(word → !word.isEmpty()))
 .apply(Count.perElement())
 .apply(MapElements.via(
     count → count.getKey() + ": " + count.getValue())
 .apply(TextIO.Write.to("gs://.../..."));
p.run();
```

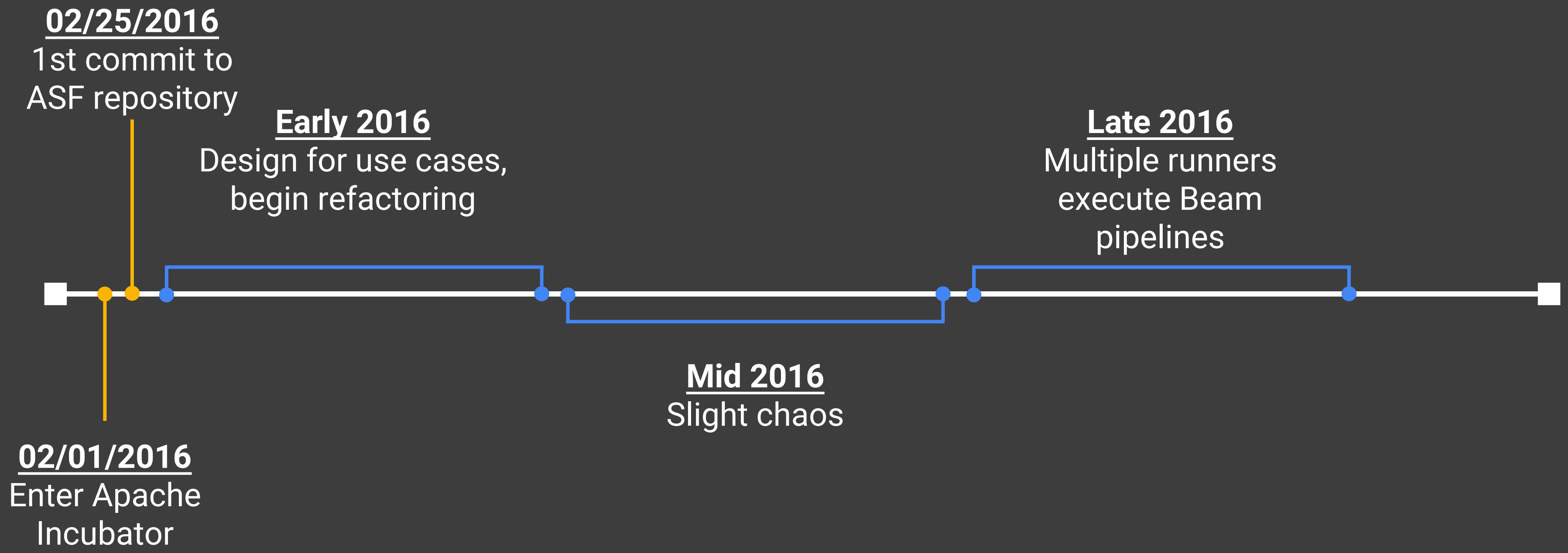
Apache Beam ecosystem



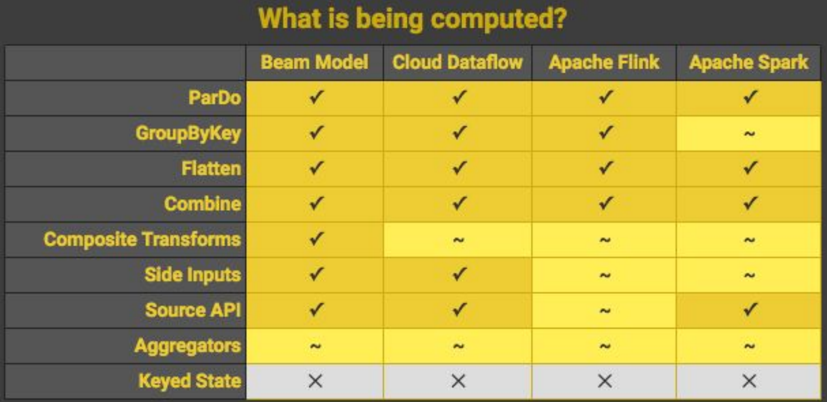
Apache Beam ecosystem



Apache Beam Roadmap

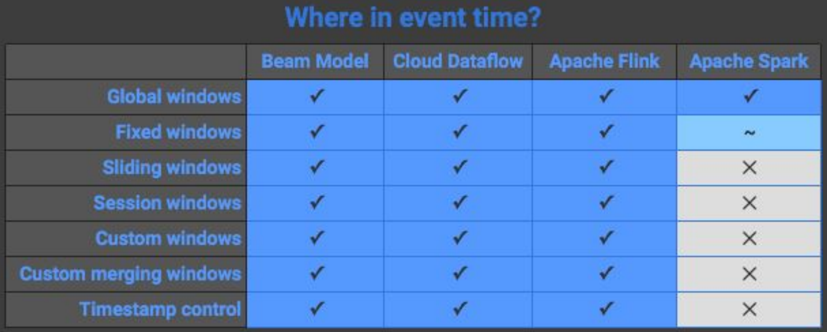

02/25/2016
1st commit to ASF repository
Early 2016
Design for use cases, begin refactoring
Late 2016
Multiple runners execute Beam pipelines
Mid 2016
Slight chaos
02/01/2016
Enter Apache Incubator

Runner capability matrix



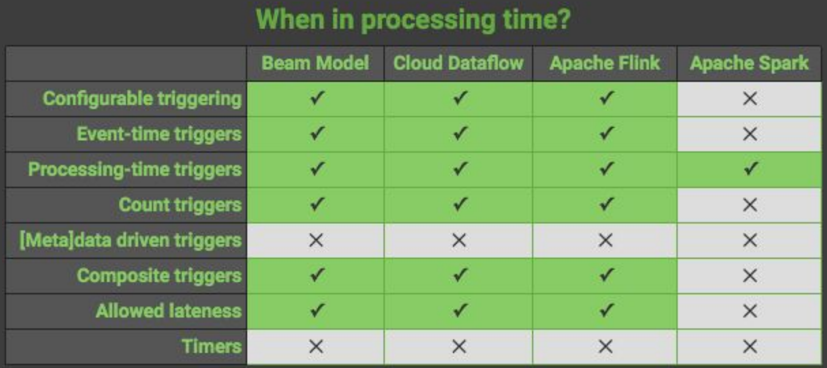
What is being computed?

	Beam Model	Cloud Dataflow	Apache Flink	Apache Spark
ParDo	✓	✓	✓	✓
GroupByKey	✓	✓	✓	~
Flatten	✓	✓	✓	✓
Combine	✓	✓	✓	✓
Composite Transforms	✓	~	~	~
Side Inputs	✓	✓	~	~
Source API	✓	✓	~	✓
Aggregators	~	~	~	~
Keyed State	✕	✕	✕	✕



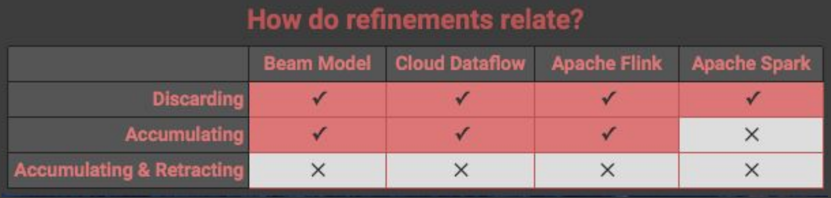
Where in event time?

	Beam Model	Cloud Dataflow	Apache Flink	Apache Spark
Global windows	✓	✓	✓	✓
Fixed windows	✓	✓	✓	~
Sliding windows	✓	✓	✓	✕
Session windows	✓	✓	✓	✕
Custom windows	✓	✓	✓	✕
Custom merging windows	✓	✓	✓	✕
Timestamp control	✓	✓	✓	✕



When in processing time?

	Beam Model	Cloud Dataflow	Apache Flink	Apache Spark
Configurable triggering	✓	✓	✓	✕
Event-time triggers	✓	✓	✓	✕
Processing-time triggers	✓	✓	✓	✓
Count triggers	✓	✓	✓	✕
[Meta]data driven triggers	✕	✕	✕	✕
Composite triggers	✓	✓	✓	✕
Allowed lateness	✓	✓	✓	✕
Timers	✕	✕	✕	✕

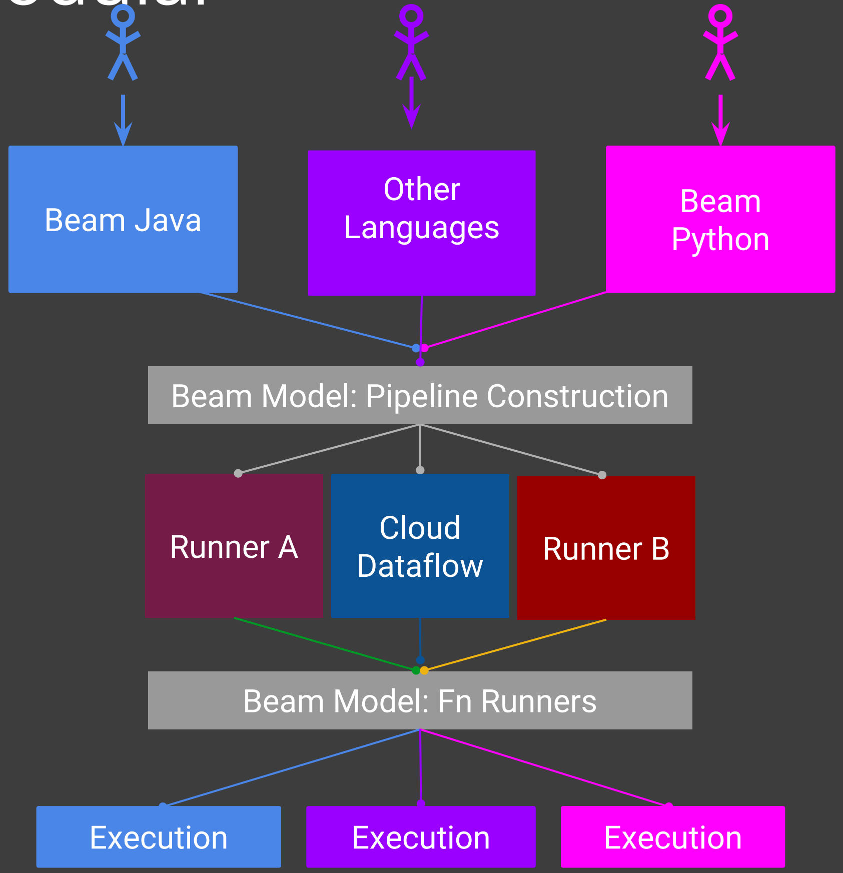


How do refinements relate?

	Beam Model	Cloud Dataflow	Apache Flink	Apache Spark
Discarding	✓	✓	✓	✓
Accumulating	✓	✓	✓	✕
Accumulating & Retracting	✕	✕	✕	✕

Technical Vision: Still more modular

- **Multiple SDKs**
  with shared pipeline representation
- **Language-agnostic runners**
  implementing the model
- **Fn Runners**
  run language-specific code



Recap: Timeline of ideas

2004	**MapReduce** (SELECT / GROUP BY) Library > DSL Abstract away fault tolerance & distribution
2010	**FlumeJava:** High-level API (typed DAG)
2013	**MillWheel:** Deterministic stream processing
2015	**Dataflow:** Unified batch/streaming model Windowing, Triggers, Retractions
2016	**Beam:** Portable programming model Language-agnostic runners

Learn More!

Programming model

The World Beyond Batch: Streaming 101, Streaming 102

The Dataflow Model paper

Cloud Dataflow

http://cloud.google.com/dataflow/

Apache Beam

https://wiki.apache.org/incubator/BeamProposal

http://beam.incubator.apache.org/

Dataflow/Beam vs. Spark

Thank you

Google Cloud Platform