Apache Flink

Next-gen data analysis

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What is Flink

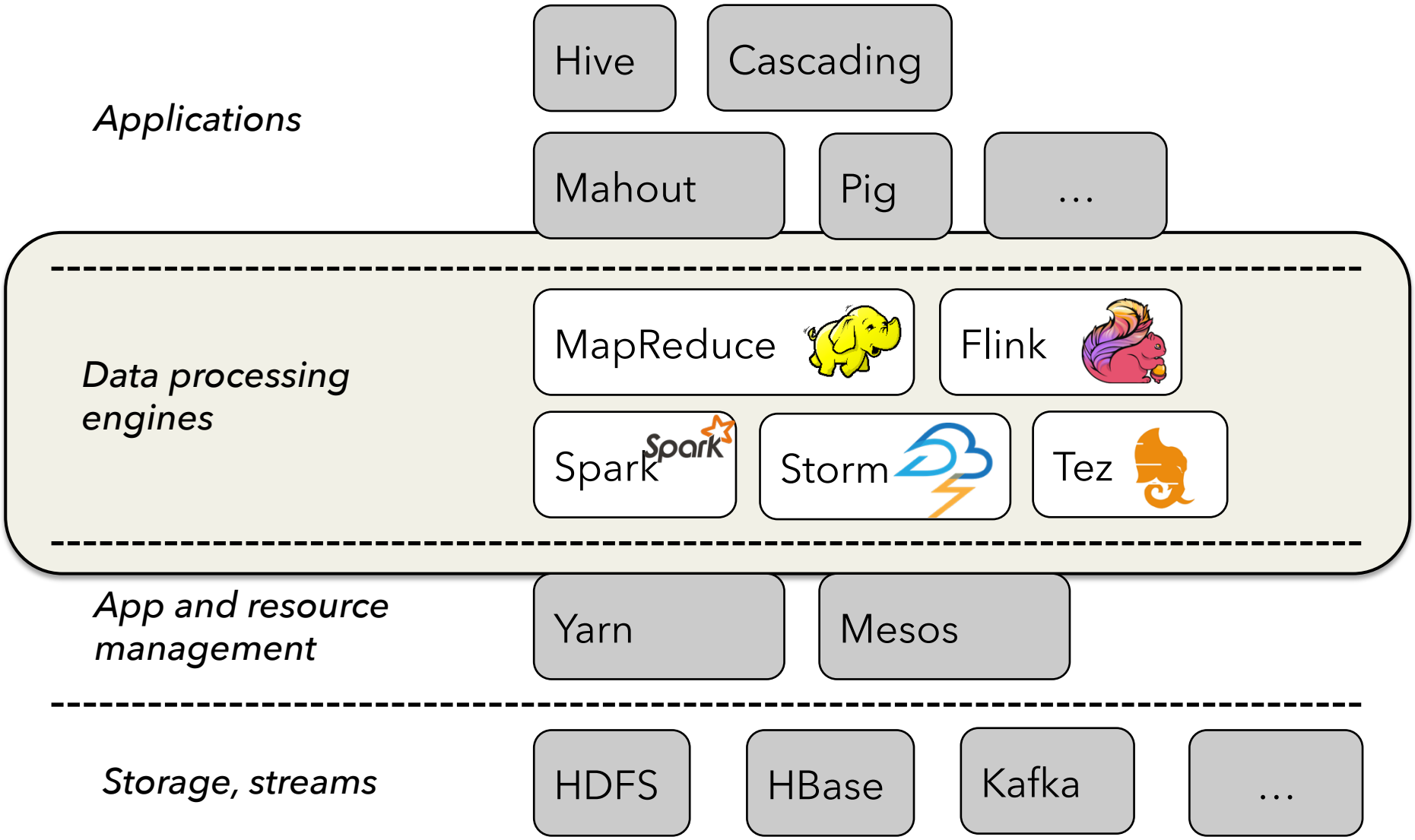
- Project undergoing incubation in the Apache Software Foundation
- Originating from the Stratosphere research project started at TU Berlin in 2009
- http://flink.incubator.apache.org
- 58 contributors (doubled in ~ 4 months)
- Has a cool squirrel for a logo

This talk

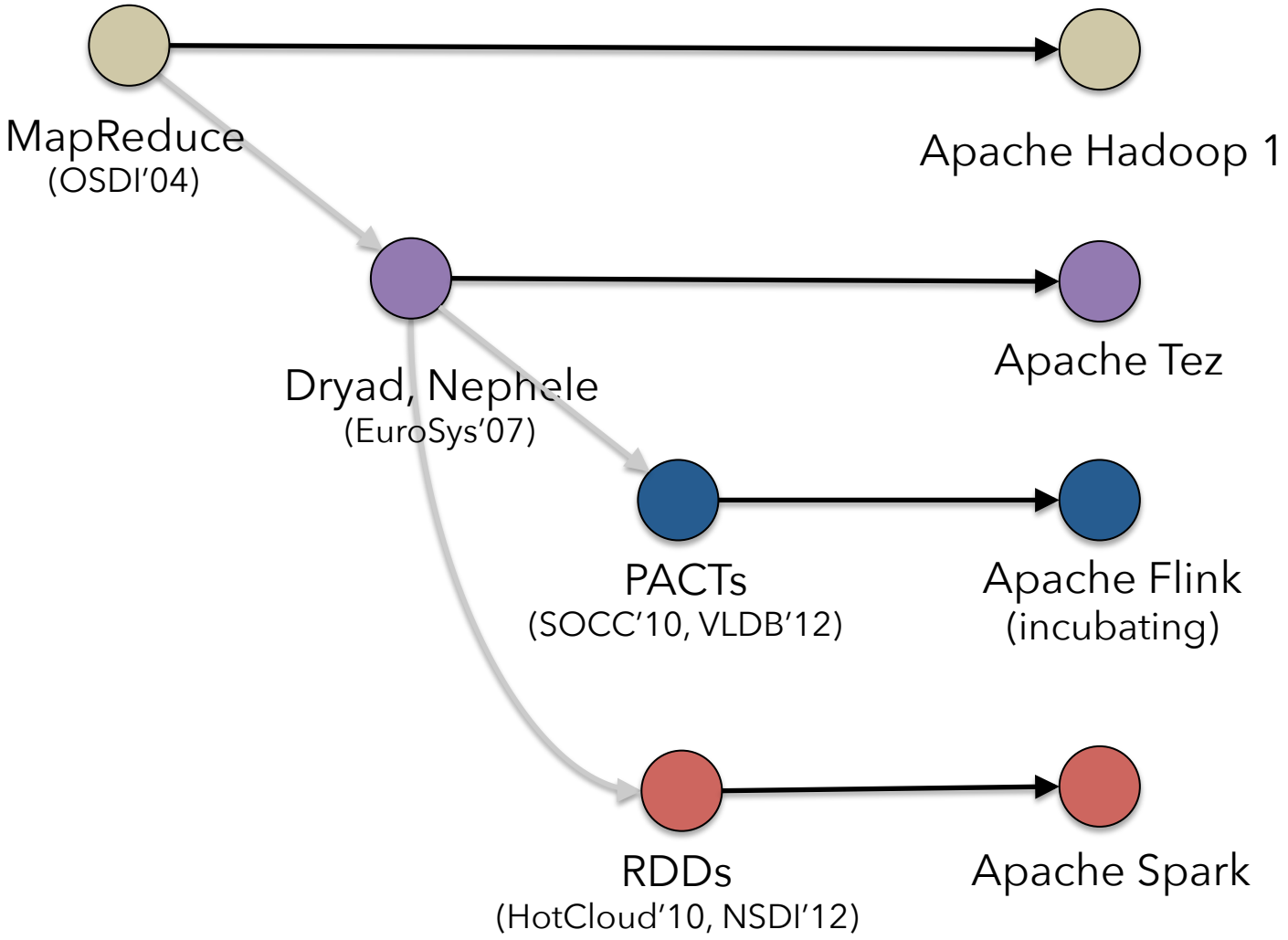
- Data processing engines in Hadoop
- Flink from a user perspective
- Tour of Flink internals
- Closing

Data Processing In The Hadoop Ecosystem

Open source data infrastructure – an era of choice



Engine paradigms & systems



- Small recoverable tasks
- Sequential code inside map & reduce functions

Dryad

- Extends map/reduce model to DAG model
- Backtracking-based recovery

Spark

- Functional implementation of Dryad recovery (RDDs)
- Restrict to coarse-grained transformations
- Direct execution of API

- Embed query processing runtime in DAG engine
- Extend DAG model to cyclic graphs
- Incremental construction of graphs

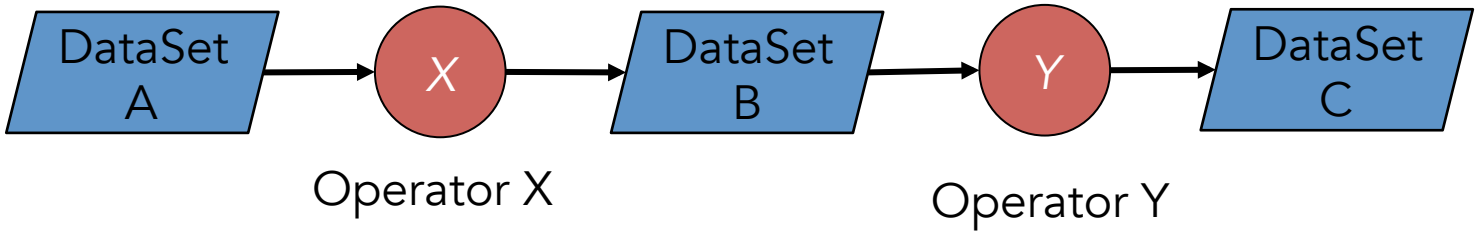
Engine comparison

				
API	MapReduce on k/v pairs	k/v pair Readers/Writers	Transformations on k/v pair collections	Iterative transformations on collections
Paradigm	MapReduce	DAG	RDD	Cyclic dataflows
Optimization	none	none	Optimization of SQL queries	Optimization in all APIs
Execution	Batch sorting	Batch sorting and partitioning	Batch with memory pinning	Stream with out-of-core algorithms

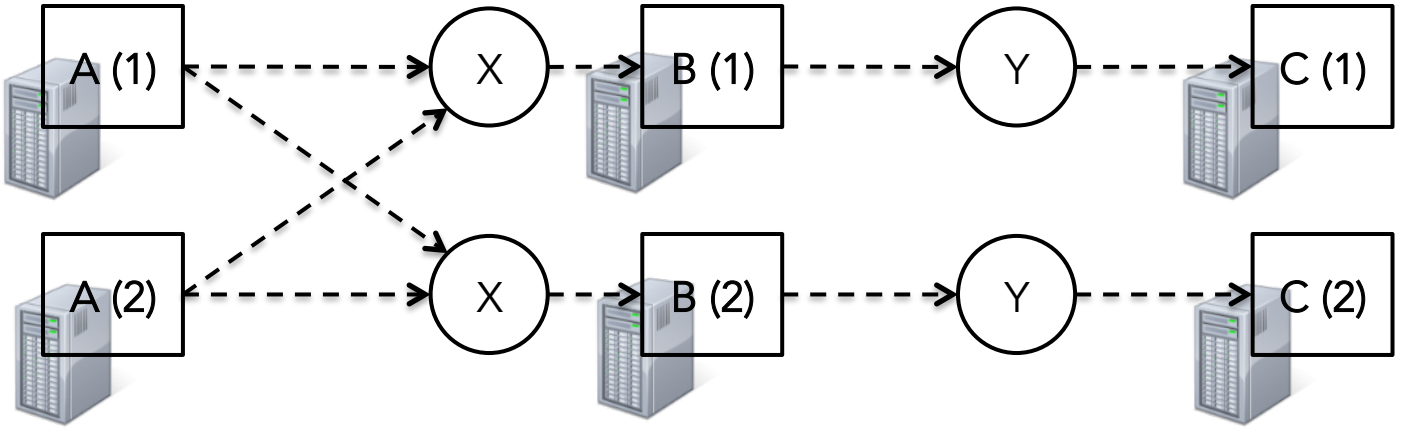
USING FLINK

Data sets and operators

Program

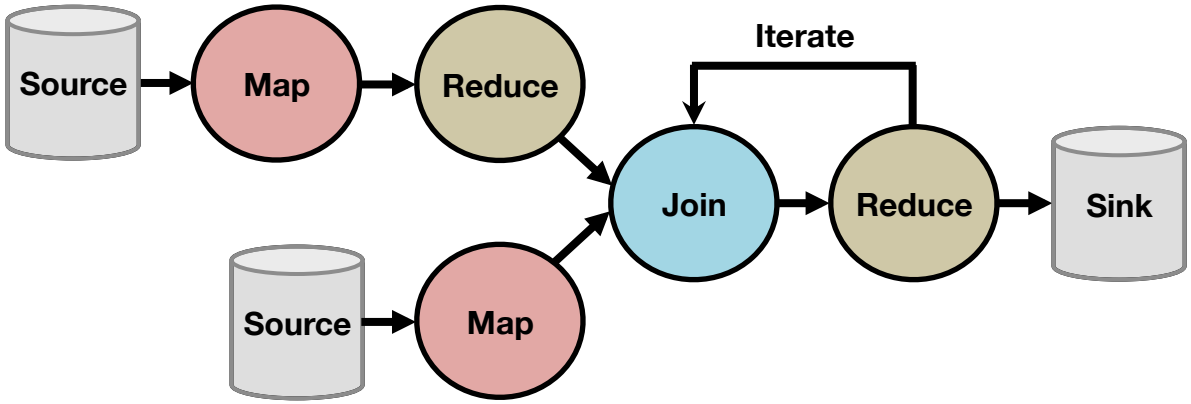


Parallel Execution



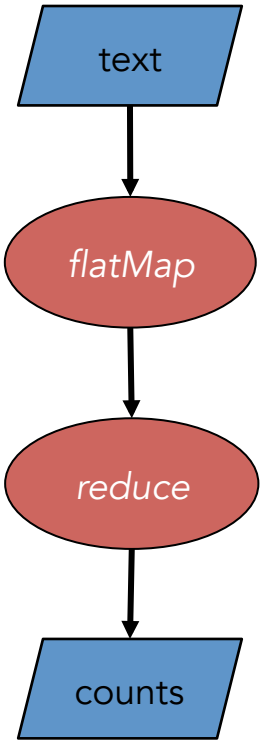
Rich operator and functionality set

Map, Reduce, Join, CoGroup, Union, Iterate, Delta Iterate, Filter, FlatMap, GroupReduce, Project, Aggregate, Distinct, Vertex-Update, Accumulators



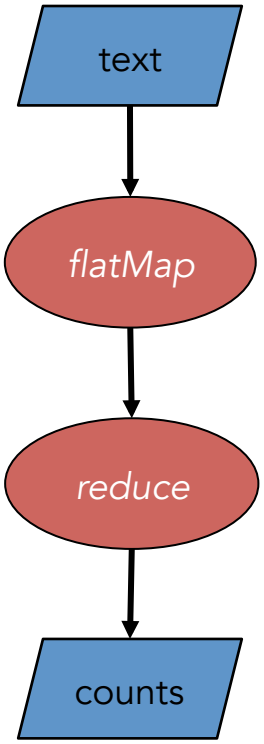
WordCount in Java

```
ExecutionEnvironment env =
  ExecutionEnvironment.getExecutionEnvironment();

DataSet<String> text = readTextFile (input);

DataSet<Tuple2<String, Integer>> counts= text
  .map (l -> l.split("\\W+"))
  .flatMap ((String[] tokens,
             Collector<Tuple2<String, Integer>> out) -> {
     Arrays.stream(tokens)
     .filter(t -> t.length() > 0)
     .forEach(t -> out.collect(new Tuple2<>(t, 1)));
   })
  .groupBy(0)
  .sum(1);

env.execute("Word Count Example");
```



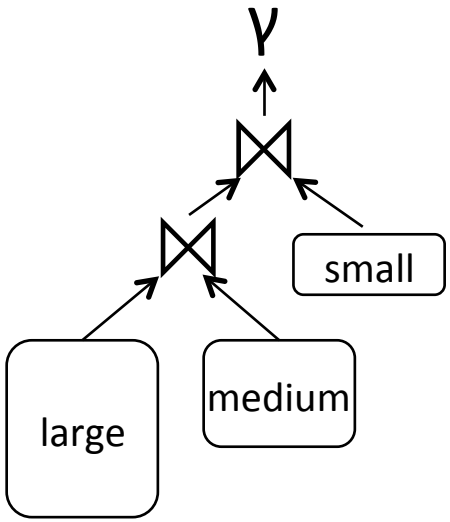
WordCount in Scala

```
val env = ExecutionEnvironment
  .getExecutionEnvironment

val input = env.readTextFile(textInput)

val counts = text
  .flatMap { l => l.split("\\W+")
  .filter { t => t.nonEmpty } }
  .map { t => (t, 1) }
  .groupBy(0)
  .sum(1)

env.execute()
```



Long operator pipelines

```
DataSet<Tuple...> large = env.readCsv(...);
DataSet<Tuple...> medium = env.readCsv(...);
DataSet<Tuple...> small = env.readCsv(...);

DataSet<Tuple...> joined1 = large
                .join(medium)
                .where(3).equals(1)
                .with(new JoinFunction() { ... });

DataSet<Tuple...> joined2 = small
                .join(joined1)
                .where(0).equals(2)
                .with(new JoinFunction() { ... });

DataSet<Tuple...> result = joined2
                .groupBy(3)
                .max(2);
```



Beyond Key/Value Pairs

```
DataSet<Page> pages = ...;
DataSet<Impression> impressions = ...;

DataSet<Impression> aggregated =
 impressions
  .groupBy("url")
  .sum("count");

pages.join(impressions).where("url").equalTo("url")


// custom data types

class Impression {
    public String url;
    public long count;
}
```

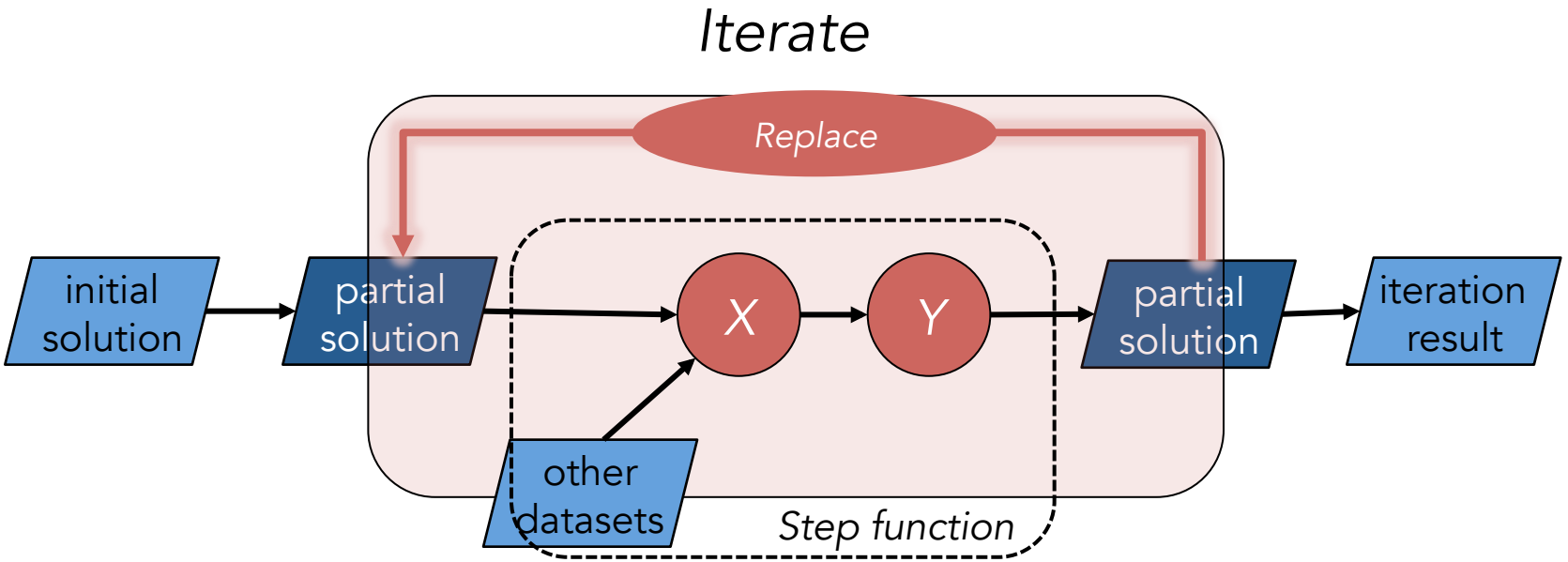
```
class Page {
    public String url;
    public String topic;
}
```

Beyond Key/Value Pairs

Why not key/value pairs

- Programs are much more readable ;-)
- Functions are self-contained, do not need to set key for successor)
- Much higher reusability of data types and functions
  - Within Flink programs, or from other programs

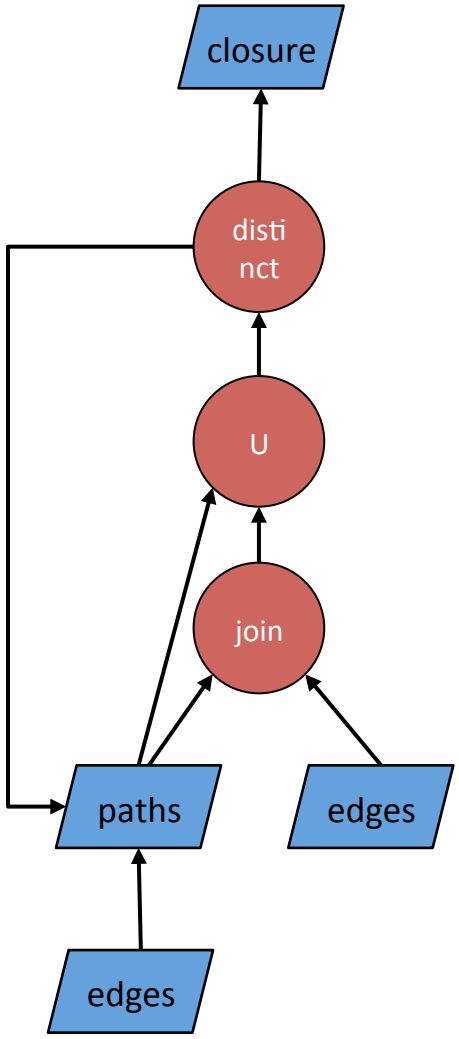
“Iterate” operator



- Built-in operator to support looping over data
- Applies step function to partial solution until convergence
- Step function can be arbitrary Flink program
- Convergence via fixed number of iterations or custom convergence criterion

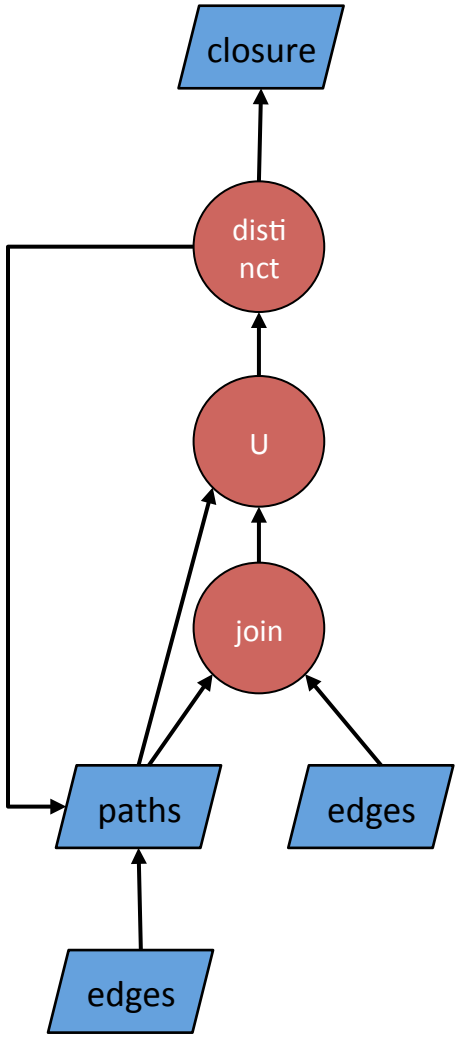
Transitive closure in Java

```
DataSet<Tuple2<Long, Long>> edges = …

IterativeDataSet<Tuple2<Long,Long>> paths =
  edges.iterate(10);

DataSet<Tuple2<Long,Long>> nextPaths = paths
  .join(edges)
  .where(1).equalTo(0)
  .with((left, right) -> {
              return new Tuple2<Long, Long>(
                new Long(left.f0),
                new Long(right.f1));})
  .union(paths)
  .distinct();

DataSet<Tuple2<Long, Long>> transitiveClosure =
  paths.closeWith(nextPaths);
```

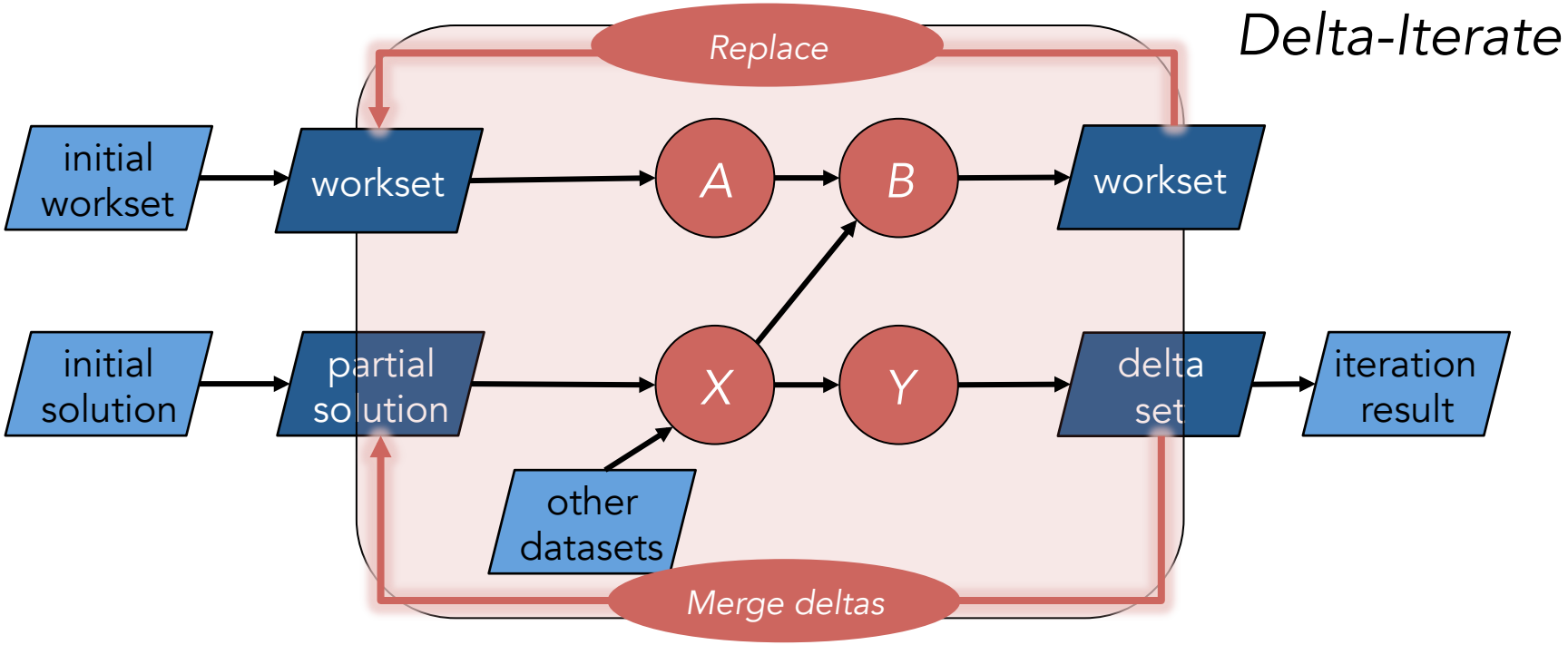


Transitive closure in Scala

```
val edges = …

val paths = edges.iterate (10) {
  prevPaths: DataSet[(Long, Long)] =>
    prevPaths
      .join(edges)
      .where(1).equalTo(0) {
        (left, right) =>
            (left._1,right._2)
      }
      .union(prevPaths)
      .groupBy(0, 1)
      .reduce((l, r) => l)
}
```



“Delta Iterate” operator



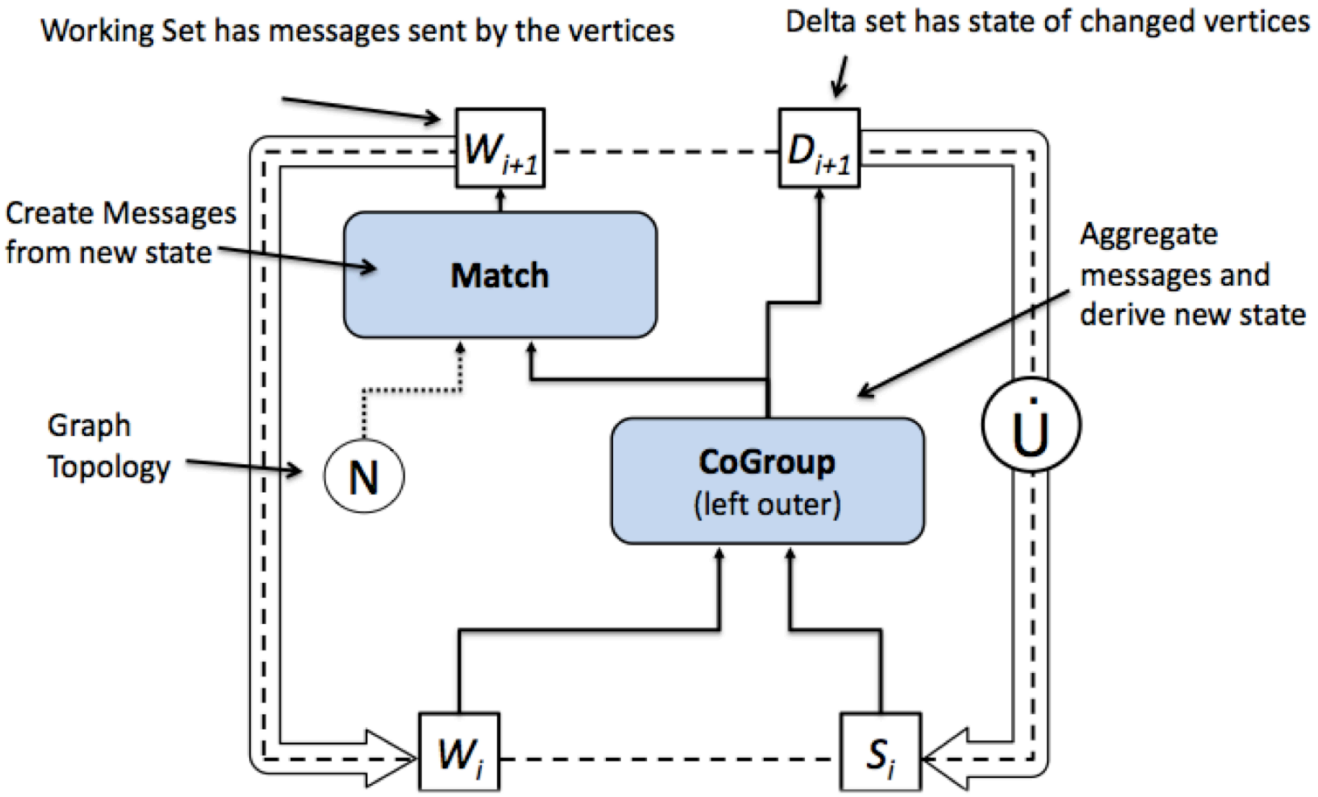
- Compute next workset and changes to the partial solution until workset is empty
- Similar to semi-naïve evaluation in datalog
- Generalizes vertex-centric computing of Pregel and GraphLab

Using Spargel: The graph API

```
ExecutionEnvironment env = getExecutionEnvironment();

DataSet<Long> vertexIds = env.readCsv(...);
DataSet<Tuple2<Long, Long>> edges = env.readCsv(...);

DataSet<Tuple2<Long, Long>> vertices = vertexIds
                    .map(new IdAssigner());

DataSet<Tuple2<Long, Long>> result = vertices.runOperation(
        VertexCentricIteration.withPlainEdges(
                edges, new CCUpdater(), new CCMessager(), 100));

result.print();
env.execute("Connected Components");
```

Pregel/Giraph-style Graph Computation

Spargel: Implementation

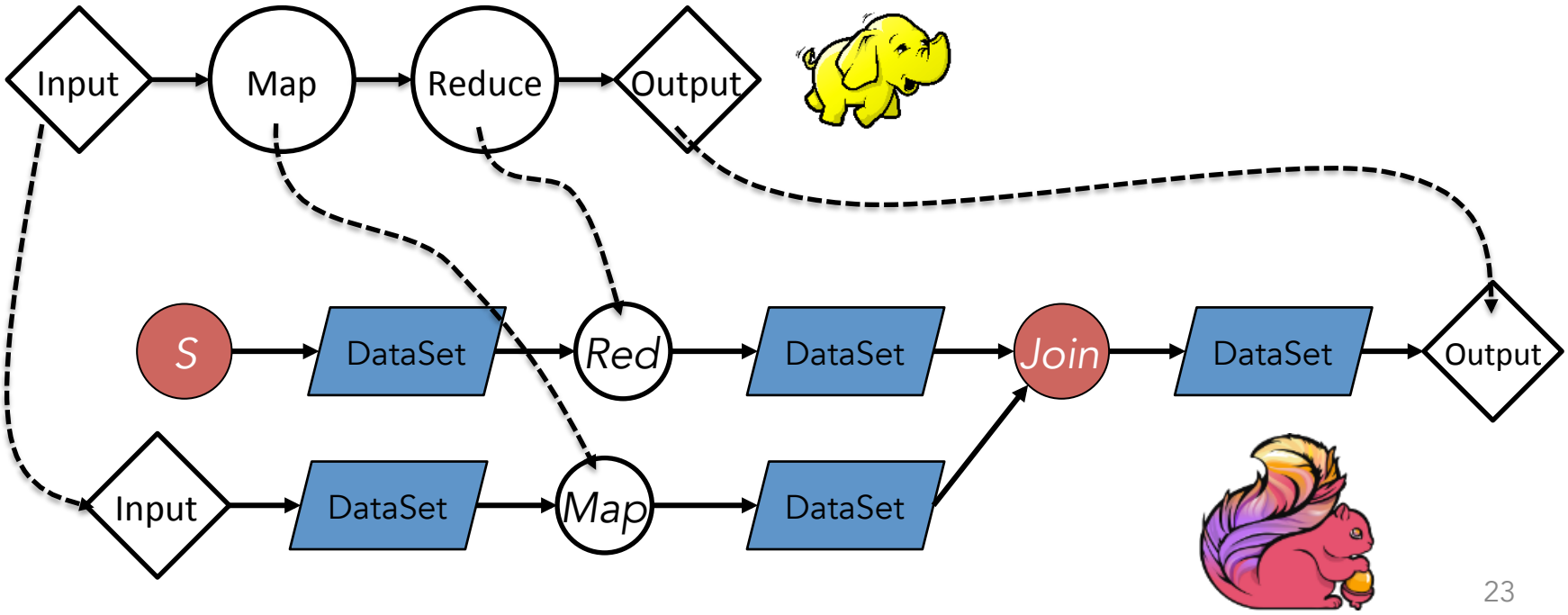


Spargel is implemented in < 500 lines of code on top of delta iterations

Hadoop Compatibility

Flink supports out-of-the-box supports

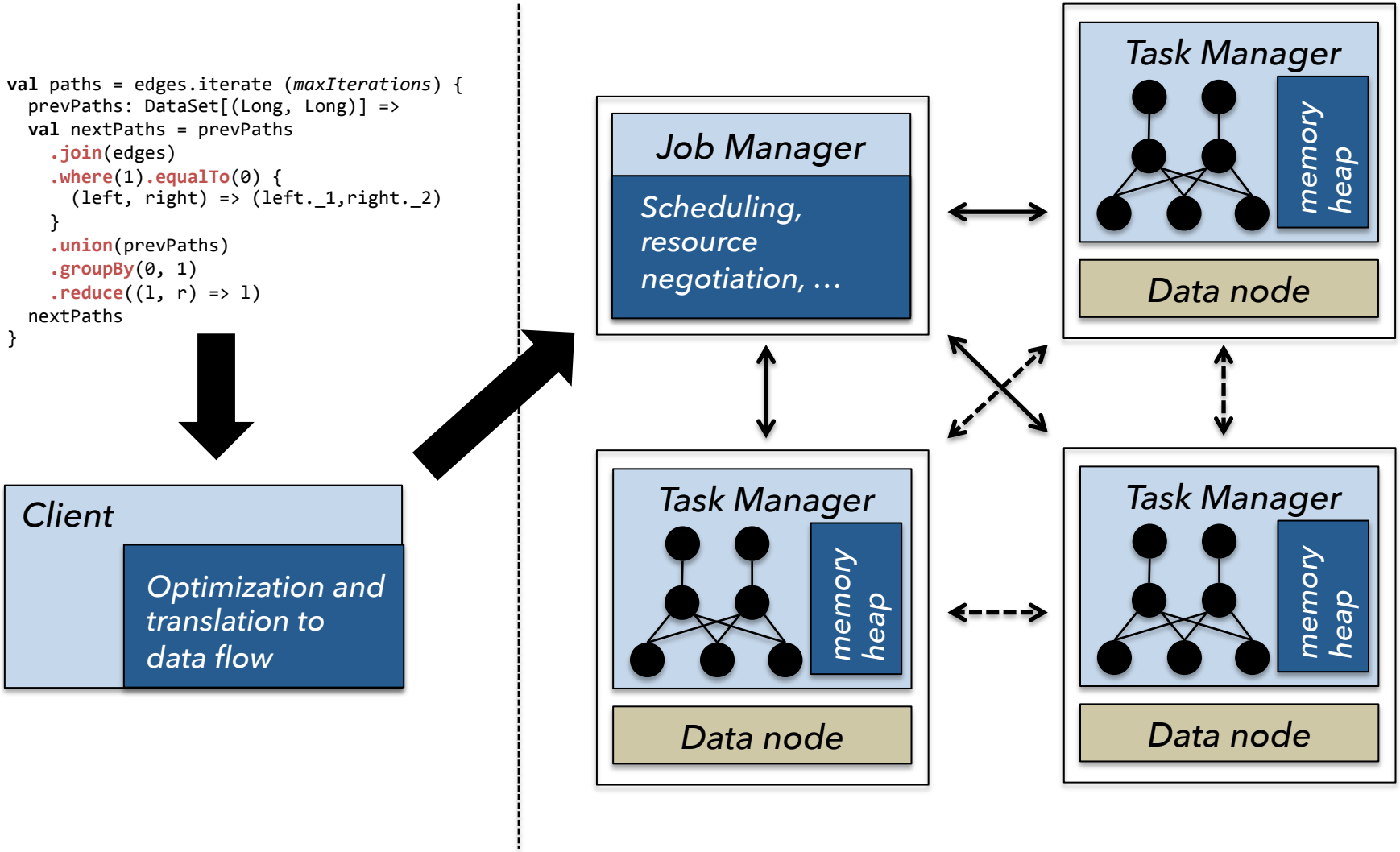
- Hadoop data types (writables)
- Hadoop Input/Output Formats
- Hadoop functions and object model



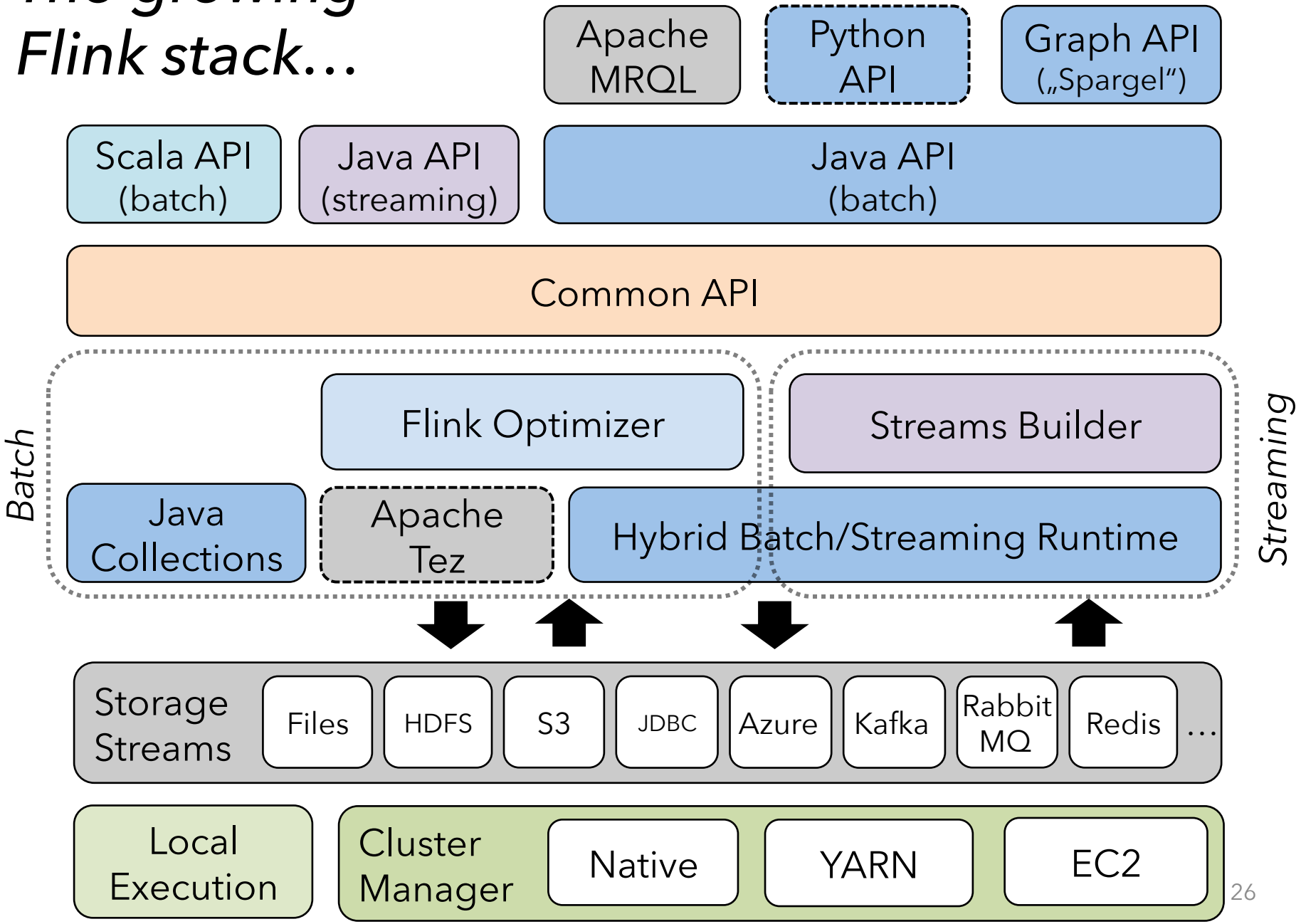
FLINK INTERNALS

Distributed architecture

```
val paths = edges.iterate (maxIterations) {
  prevPaths: DataSet[(Long, Long)] =>
  val nextPaths = prevPaths
    .join(edges)
    .where(1).equalTo(0) {
      (left, right) => (left._1,right._2)
    }
    .union(prevPaths)
    .groupBy(0, 1)
    .reduce((l, r) => l)
  nextPaths
}
```

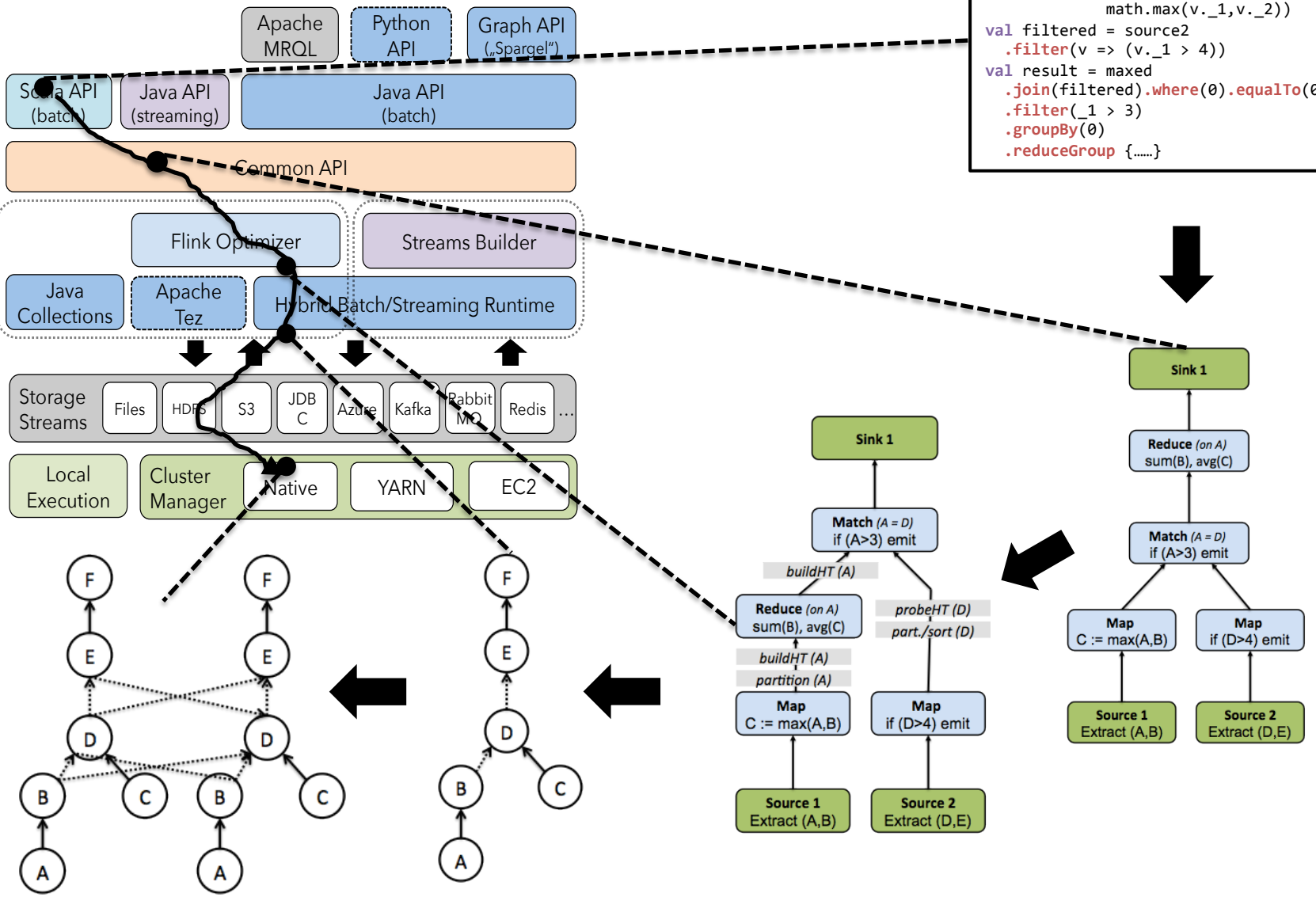


The growing Flink stack…

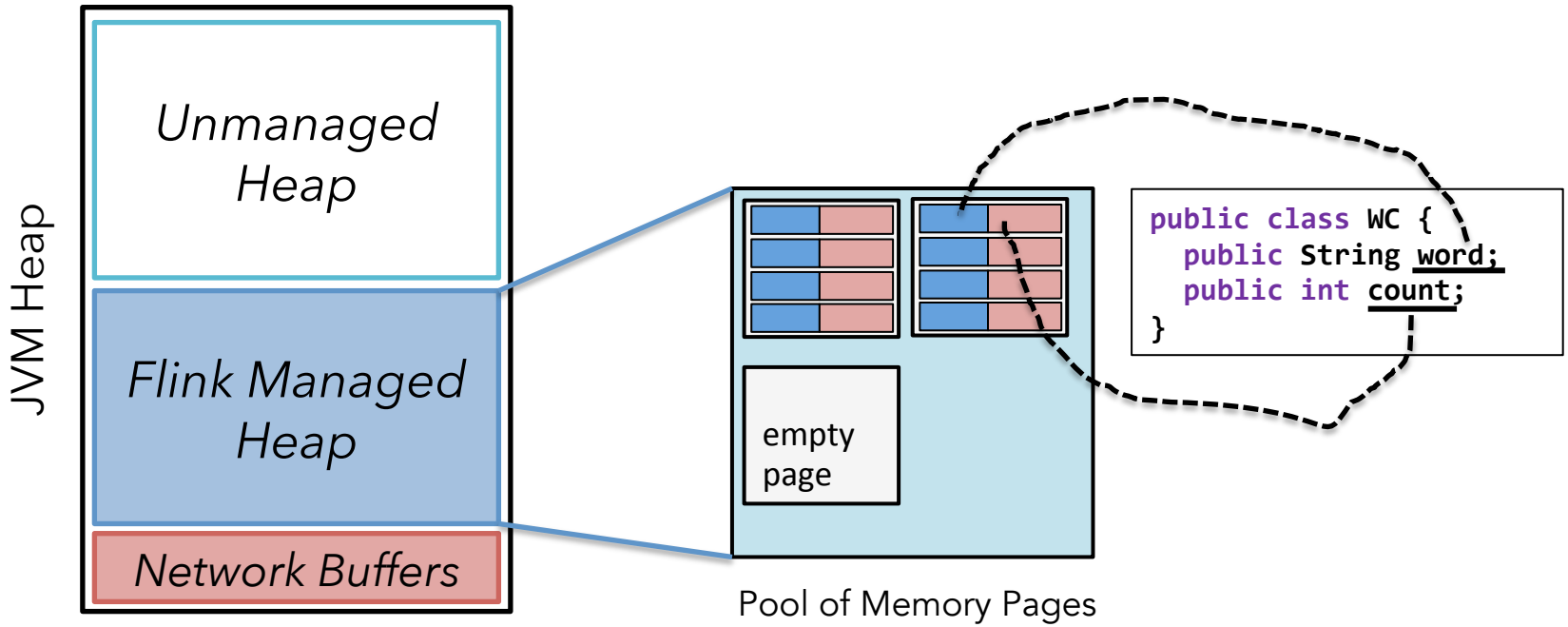


Program lifecycle

```
val source1 = …
val source2 = …
val maxed = source1
  .map(v => (v._1,v._2,
             math.max(v._1,v._2))
val filtered = source2
  .filter(v => (v._1 > 4))
val result = maxed
  .join(filtered).where(0).equalTo(0)
  .filter(_1 > 3)
  .groupBy(0)
  .reduceGroup {……}
```



Memory management



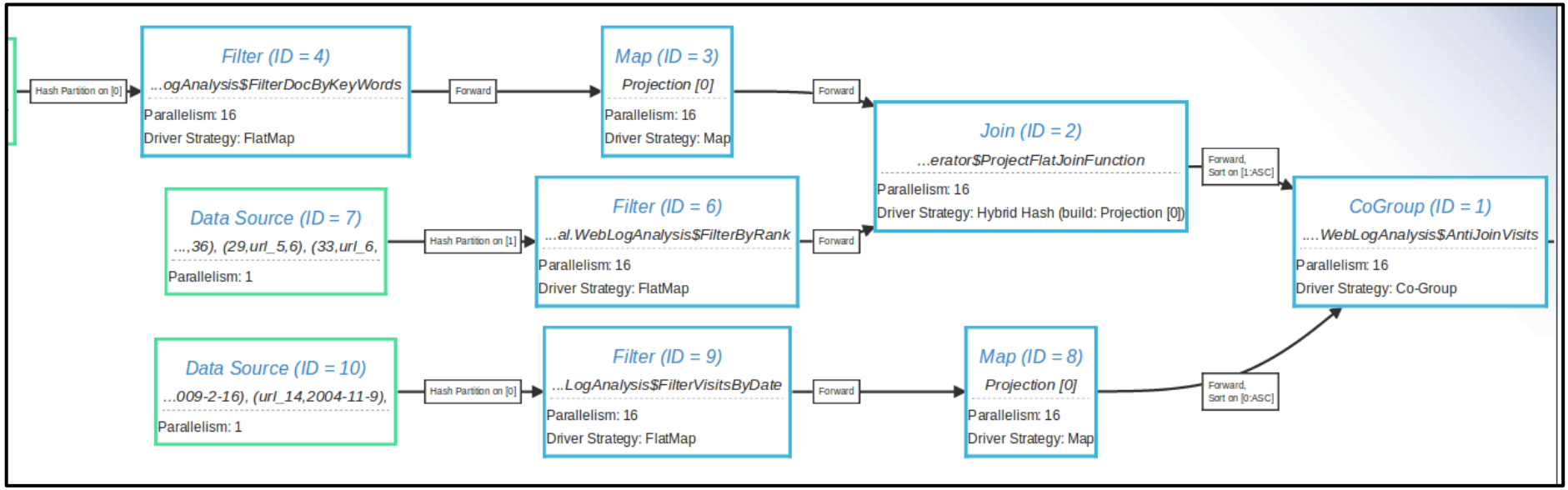
- Flink manages its own memory
- User data stored in serialize byte arrays
- In-memory caching and data processing happens in a dedicated memory fraction
- Never breaks the JVM heap
- Very efficient disk spilling and network transfers

Little tuning or configuration required

- Requires no memory thresholds to configure
  - Flink manages its own memory
- Requires no complicated network configs
  - Pipelining engine requires much less memory for data exchange
- Requires no serializers to be configured
  - Flink handles its own type extraction and data representation
- Programs can be adjusted to data automatically
  - Flink's optimizer can choose execution strategies automatically

Understanding Programs

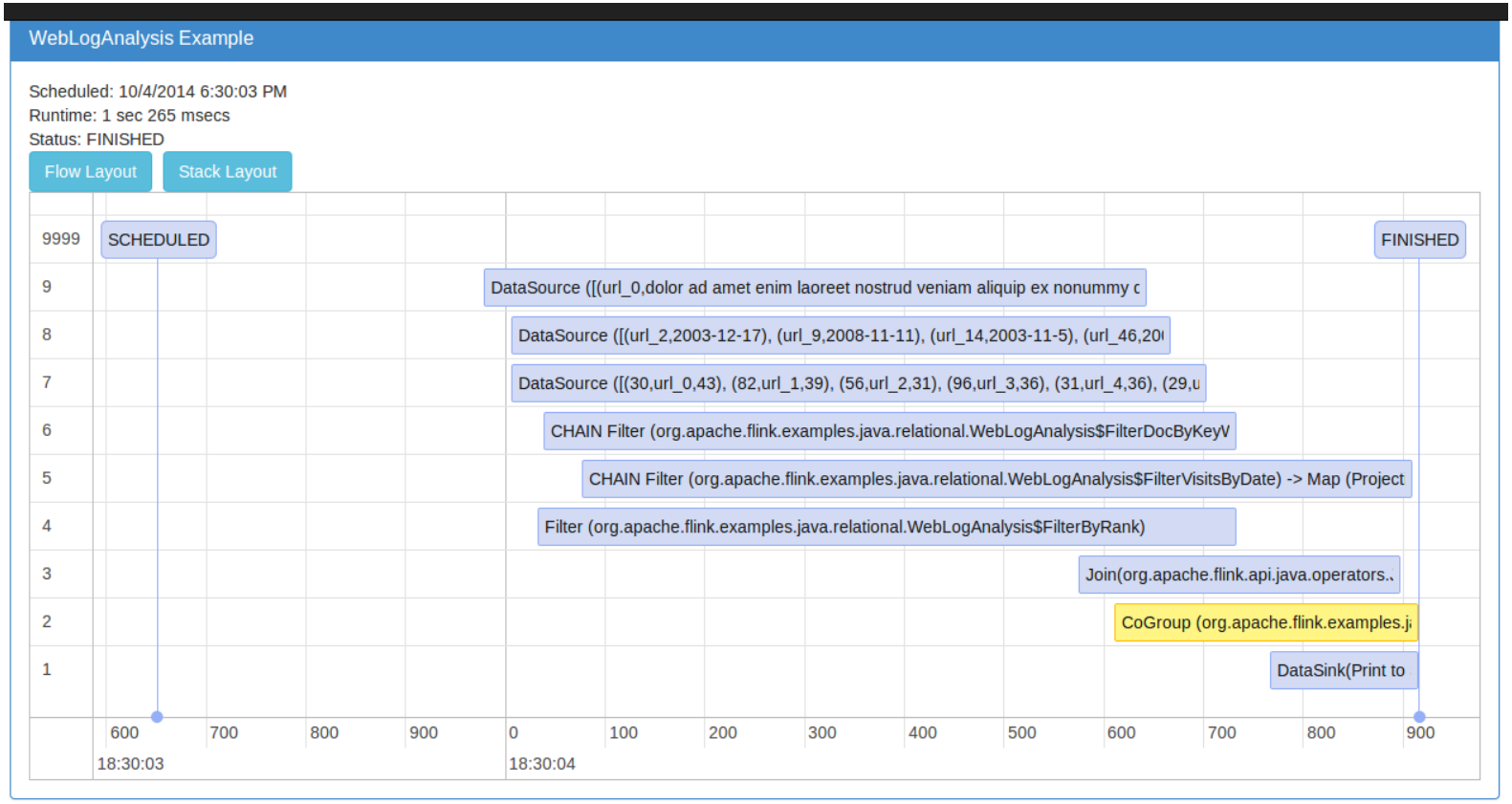
Visualize and understand the operations and the data movement of programs



Screenshot from Flink's plan visualizer

Understanding Programs

Analyze after execution (times, stragglers, …)



Understanding Programs

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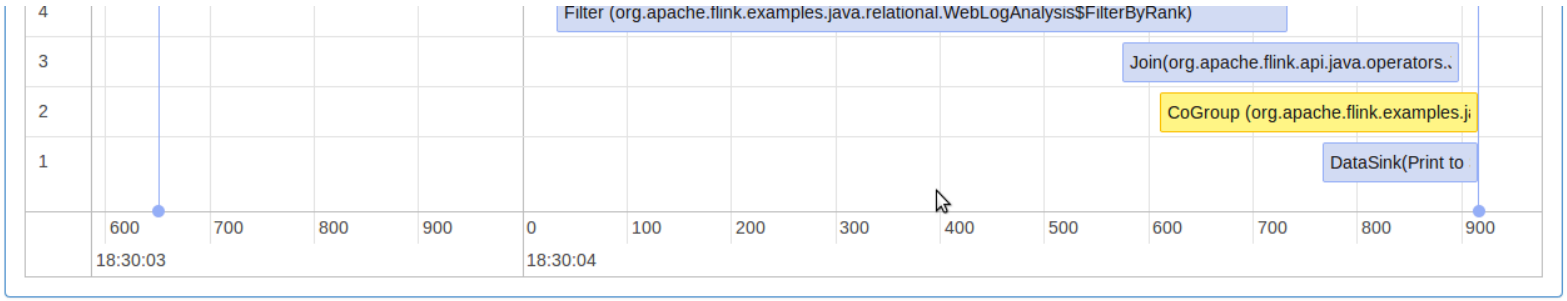
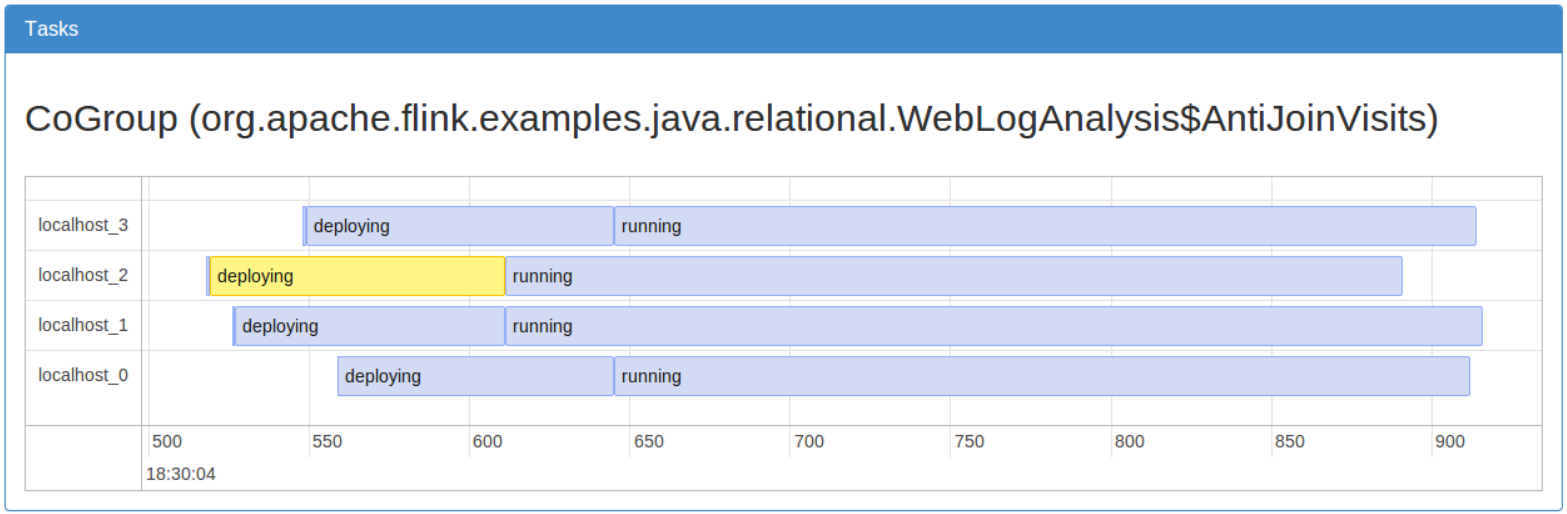
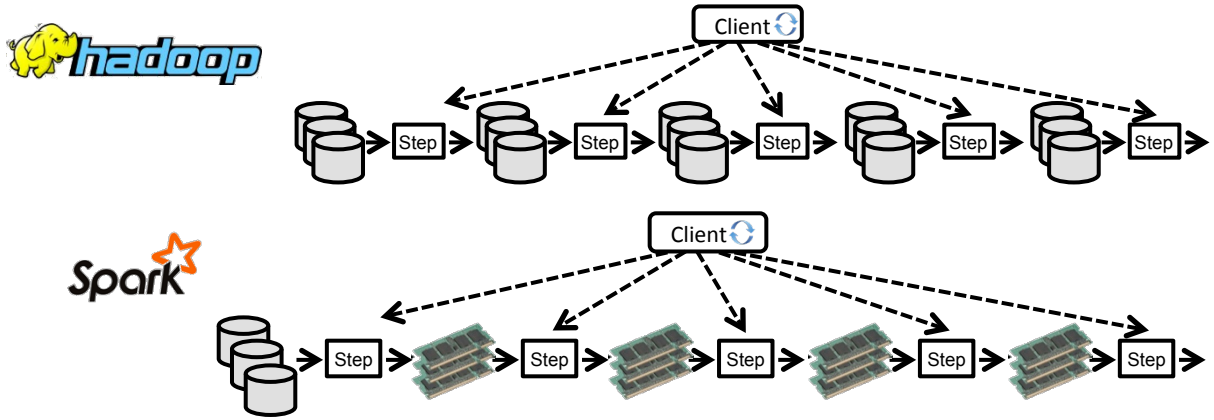


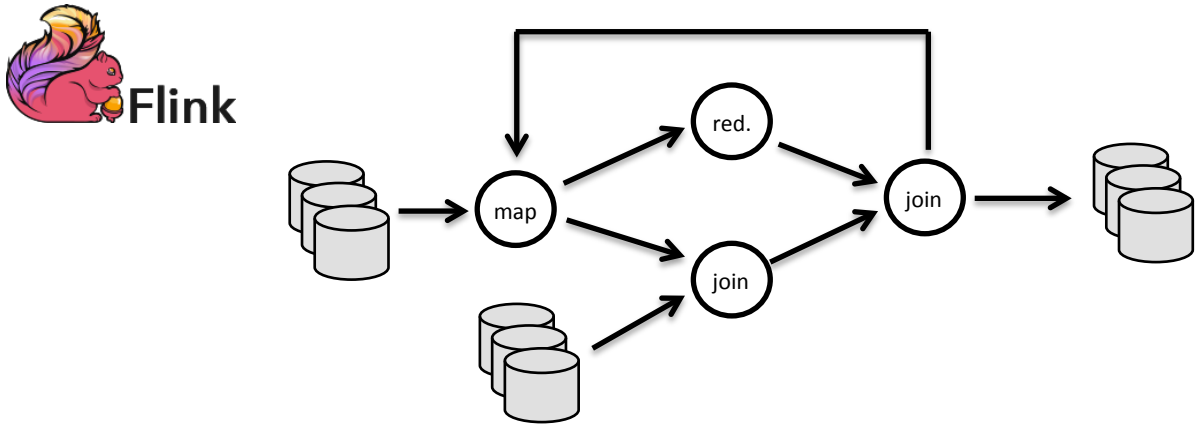


Built-in vs driver-based iterations



Loop outside the system, in driver program

Iterative program looks like many independent jobs

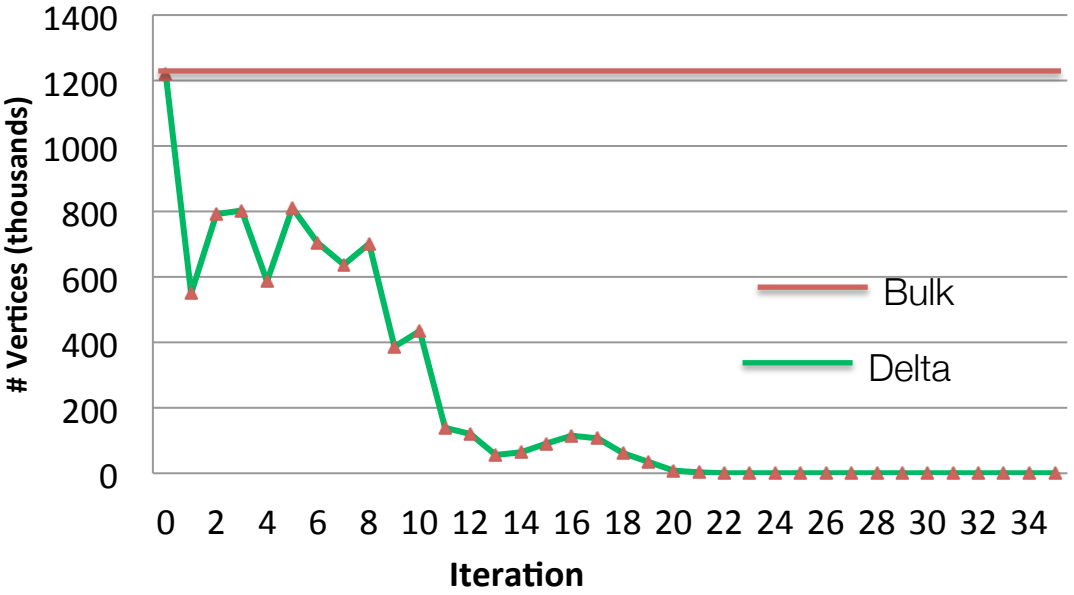


Dataflows with feedback edges

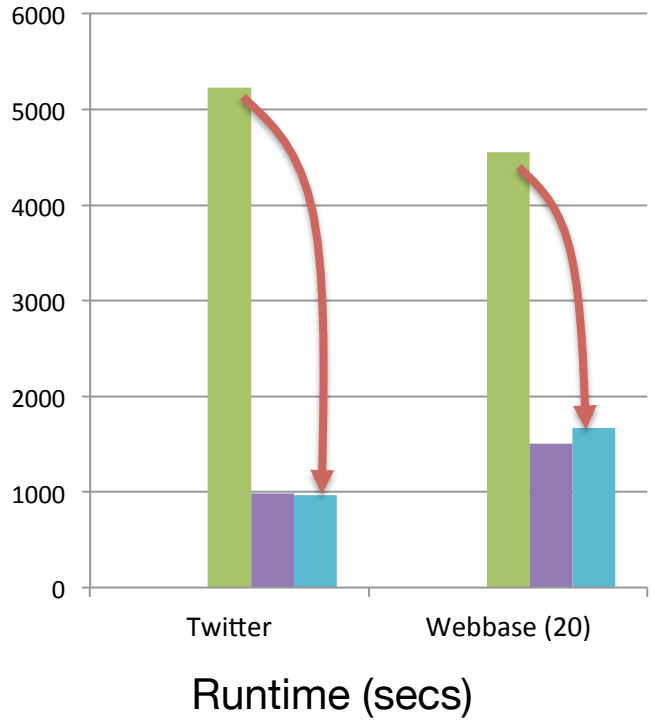
System is iteration-aware, can optimize the job

Delta iterations

Cover typical use cases of Pregel-like systems with comparable performance in a generic platform and developer API.

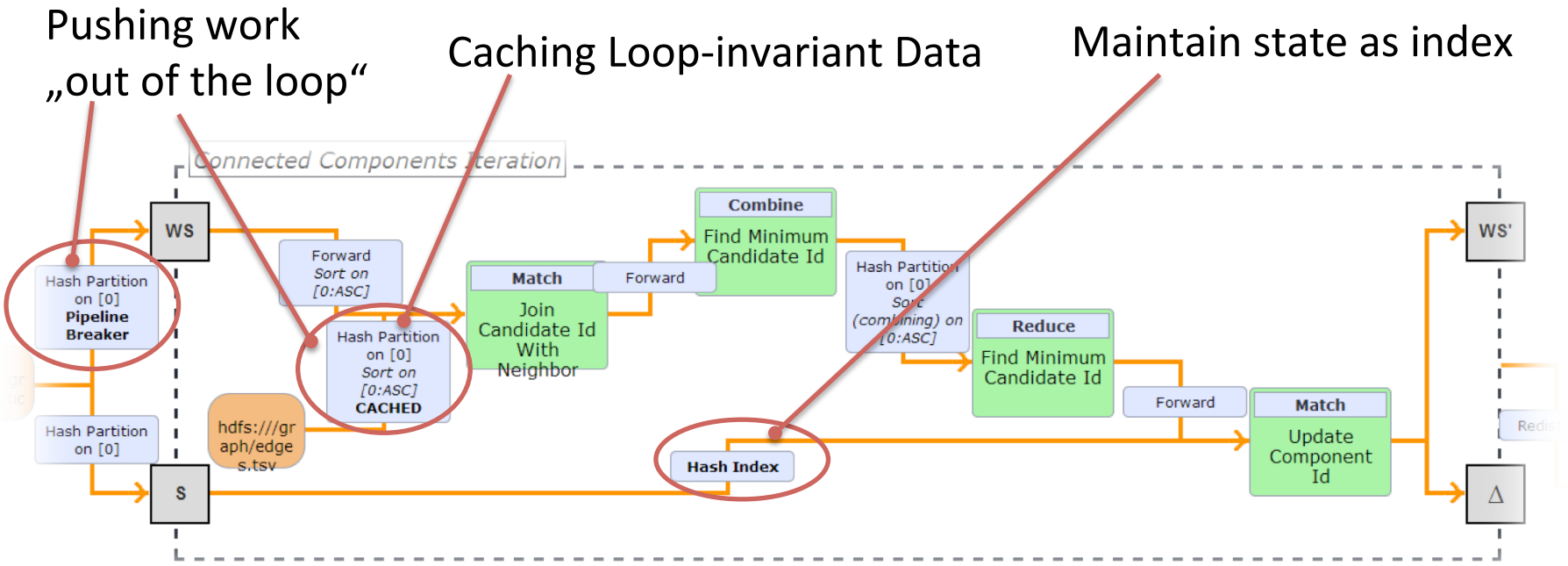


Computations performed in each iteration for connected communities of a social graph

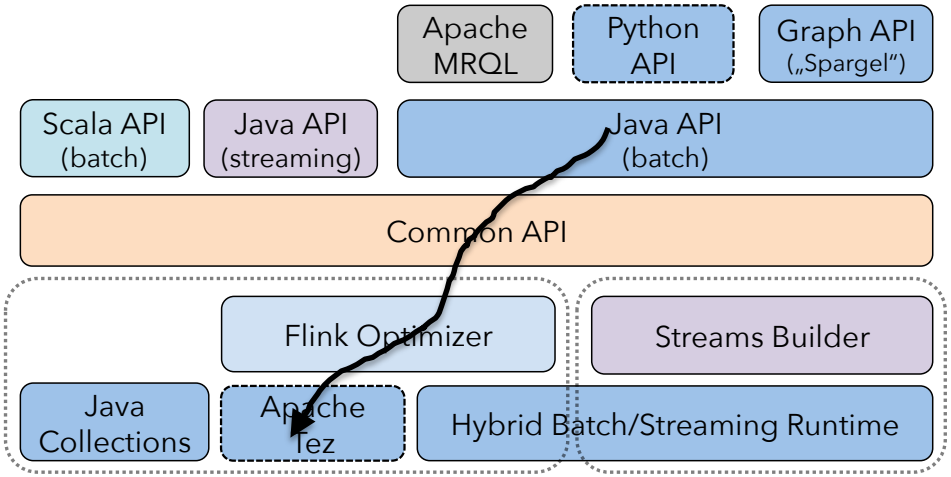


*Note: Runtime experiment uses larger graph

Optimizing iterative programs



WIP: Flink on Tez



First prototype will be available in the next release

- Flink has a modular design that makes it easy to add alternative frontends and backends
- Flink programs are completely unmodified
- System generates a Tez DAG instead of a Flink DAG

CLOSING

Upcoming features

- Robust and fast engine
  - Finer-grained fault tolerance, incremental plan rollout, optimization, and interactive shell clients
- Alternative backends: **Flink on ***
  - Tez backend
- Alternative frontends: ***** **on Flink**
  - ML and Graph functionality, Python support, logical (SQL-like) field addressing
- Flink Streaming
  - Combine stream and batch processing in programs

flink.incubator.apache.org

@ApacheFlink

“Flink Stockholm week”

Wednesday

- Flink introduction and hackathon @ 9:00
- Flink talk at Spotify (SHUG) @ 18:00

Thursday

- Hackathons at KTH (streaming & graphs) @ 9:00