Unified Batch & Stream Processing in Apache Flink

Apache Flink Meetup Berlin #6
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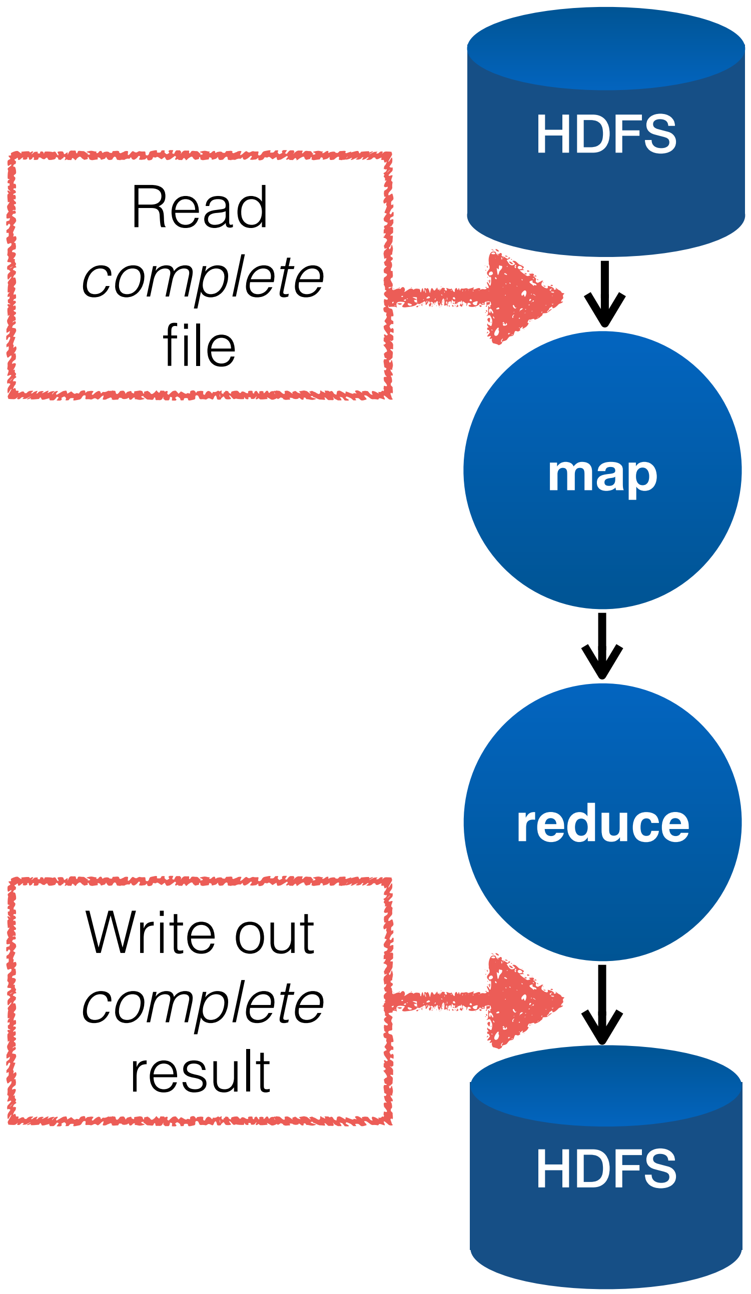
Batch vs. Stream Processing

Batch Processing	**Stream** Processing
High Latency	**Low** Latency
Batch Processors	**Stream Processors**
Static Files	**Event Streams**

What's the *difference* between a **Batch** and **Streaming** *Runtime*?

Batch Processing



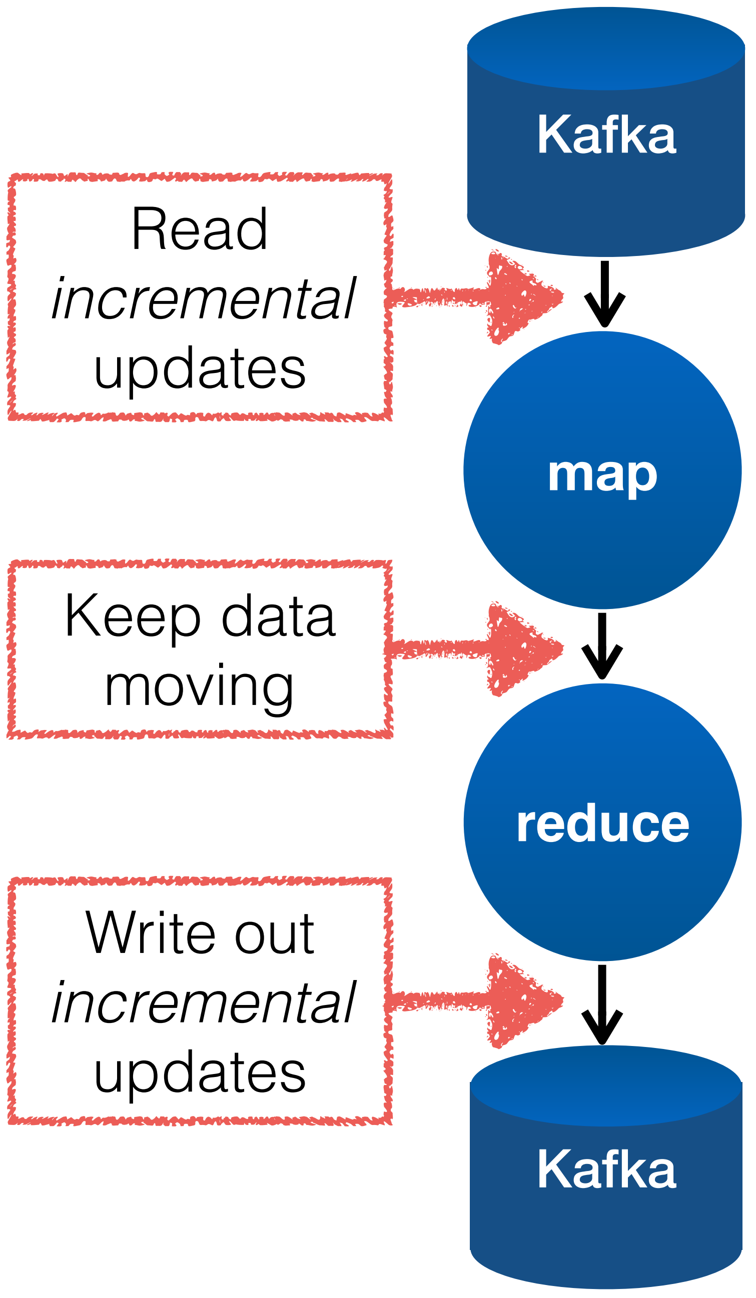
O Romeo, Romeo,
wherefore art thou Romeo?

Romeo, 1
Romeo, 1
wherefore, 1
art, 1
thou, 1
Romeo, 1

Write out intermediate data set

Romeo, 3
wherefore, 1
art, 1
thou, 1

Stream Processing



O	Romeo	Romeo	
wherefore	art	thou	Romeo

Romeo, 1
Romeo, 1
wherefore, 1
art, 1
thou, 1
Romeo, 1

Romeo, 3
wherefore, 1
art, 1
thou, 1

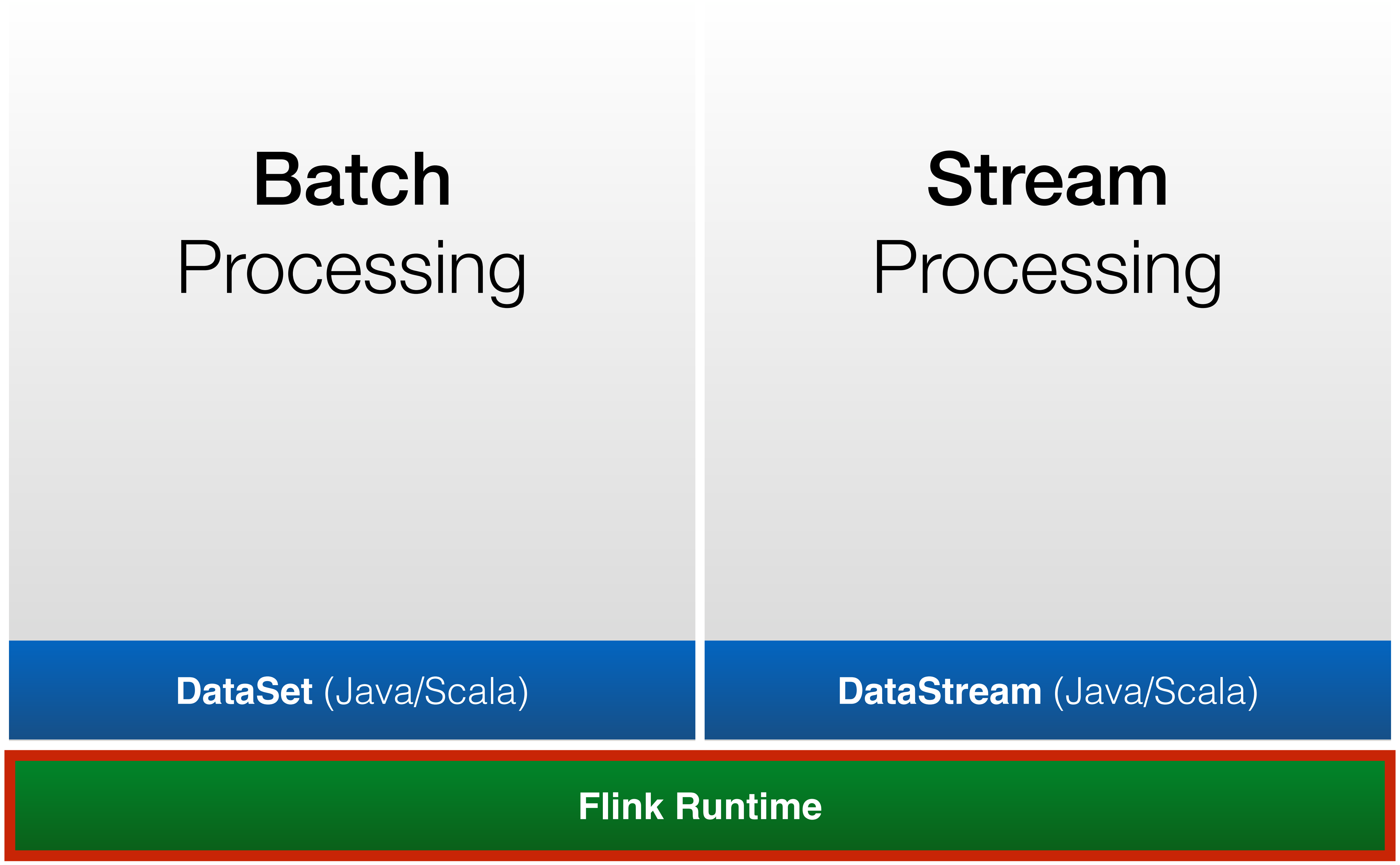
and

Batch ~~vs.~~ Stream

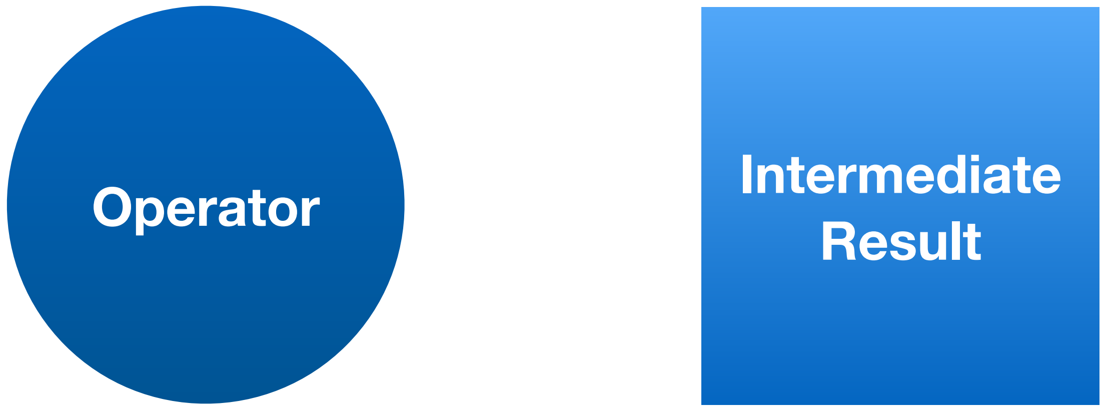
Processing

Do we *really* need two **separate systems** for this?

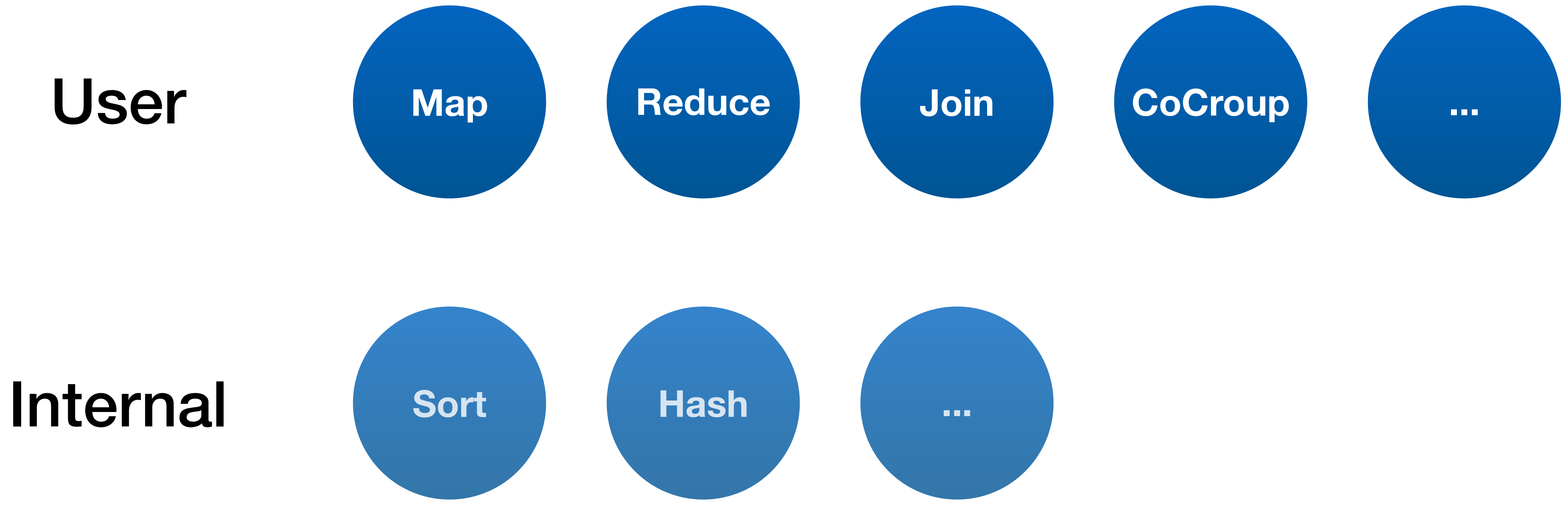
Apache Flink



Flink Runtime

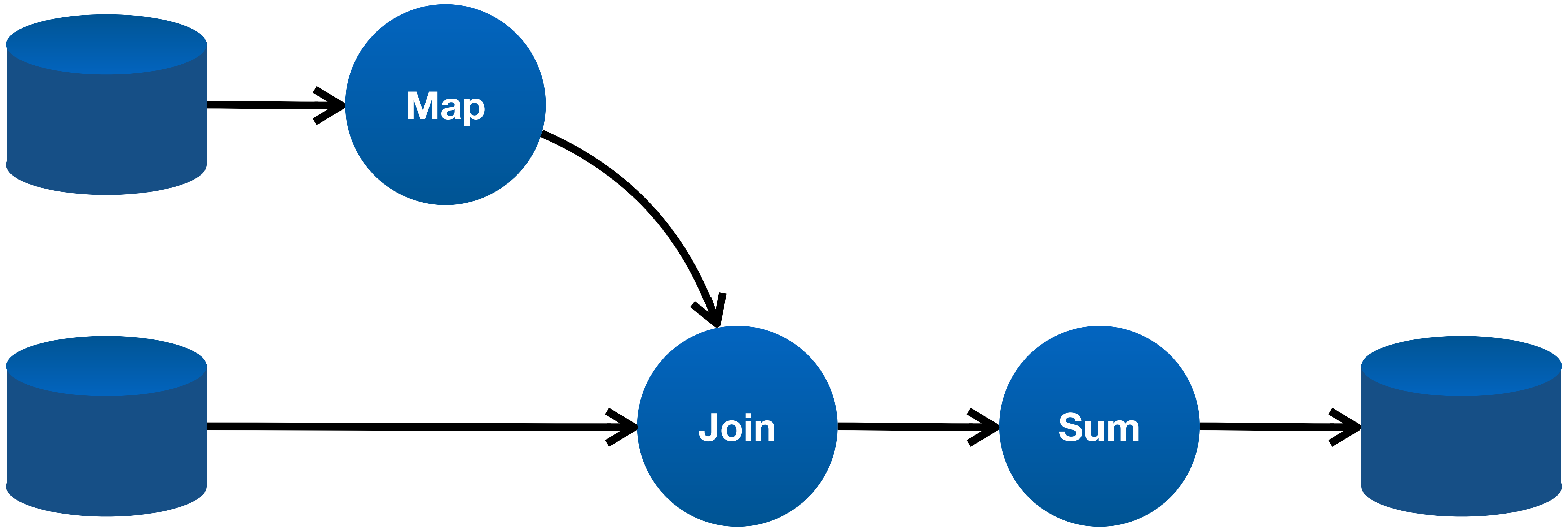


Operators



Operators represent computations over data.

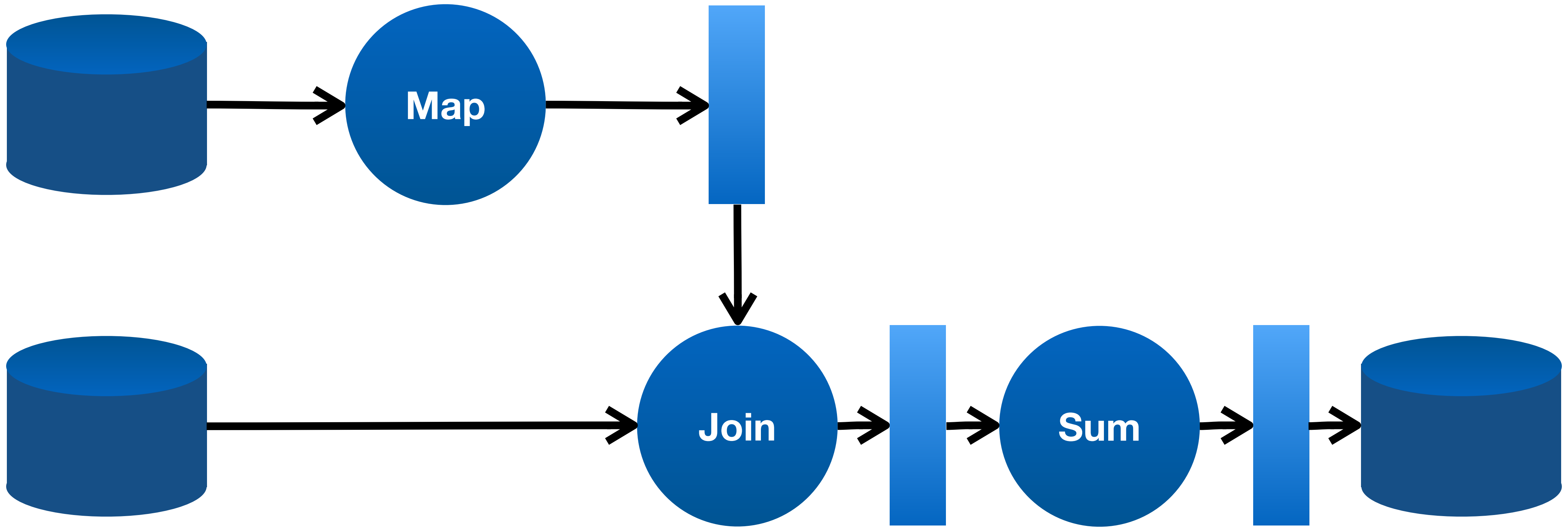
Operators



Intermediate Results

Logical handle to data produced by operators.

Intermediate Results

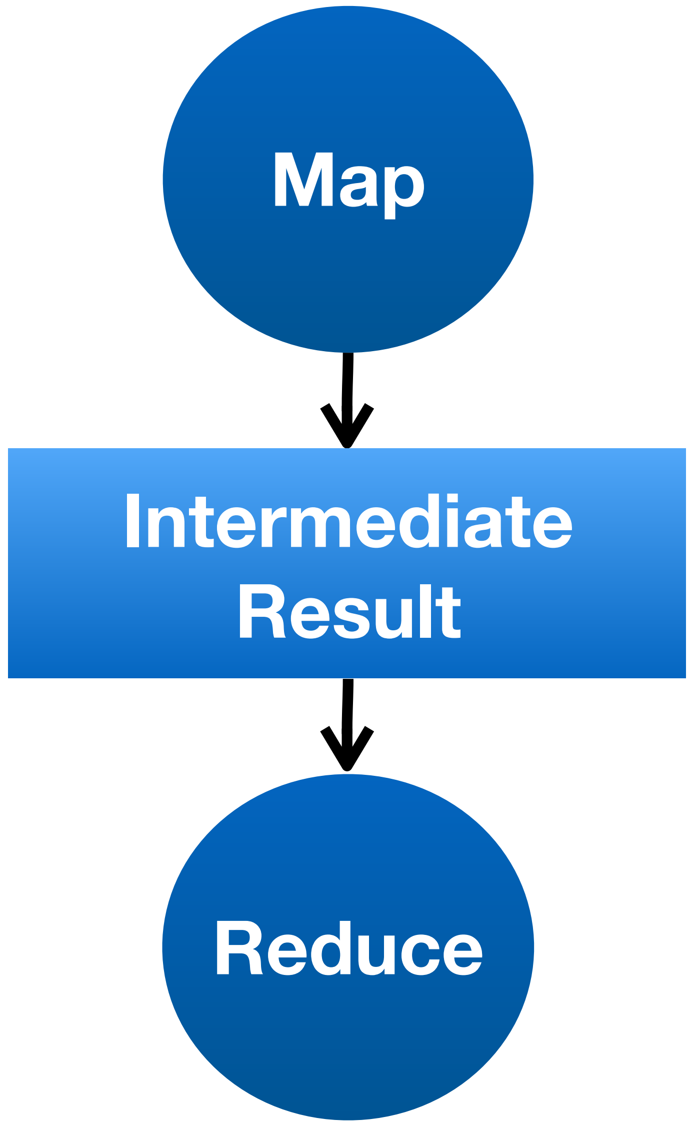


Logical handle to data **produced by operators.**

Map-Reduce Example

```
DataSet<Tuple2<String, Integer>>
  counts;

counts = input
  .flatMap(new LineSplitter())
  .groupBy(0)
  .sum(1);
```



Logical handle to data produced by operators.

Result Characteristics

Pipelined vs. **Blocking**

Ephemeral vs. **Checkpointed**

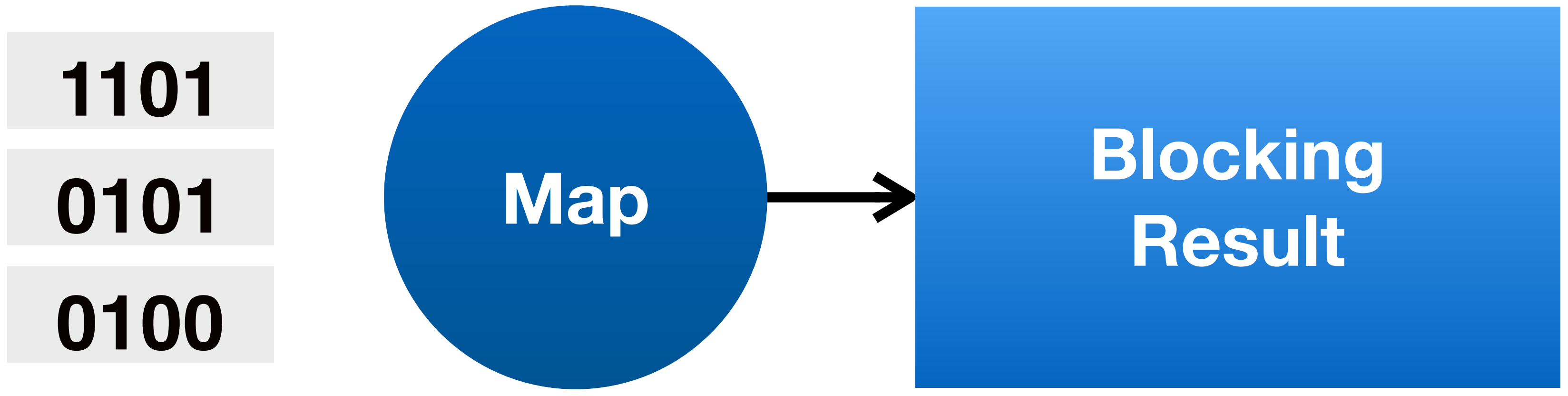
Result Characteristics

Pipelined vs. **Blocking**

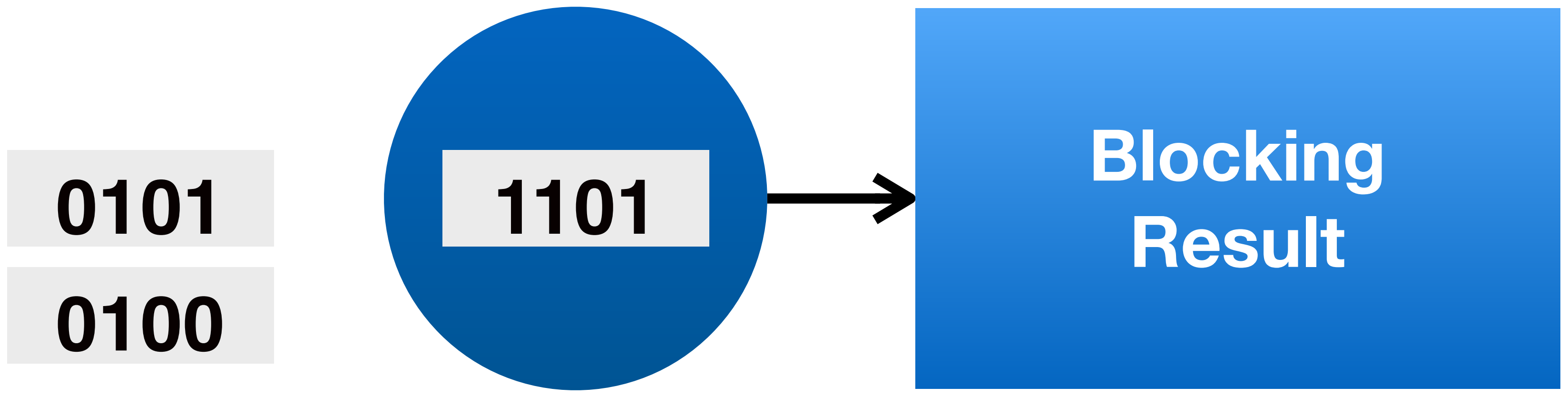
Ephemeral vs. Checkpointed

How and when to do data exchange?

Blocking Results



Blocking Results



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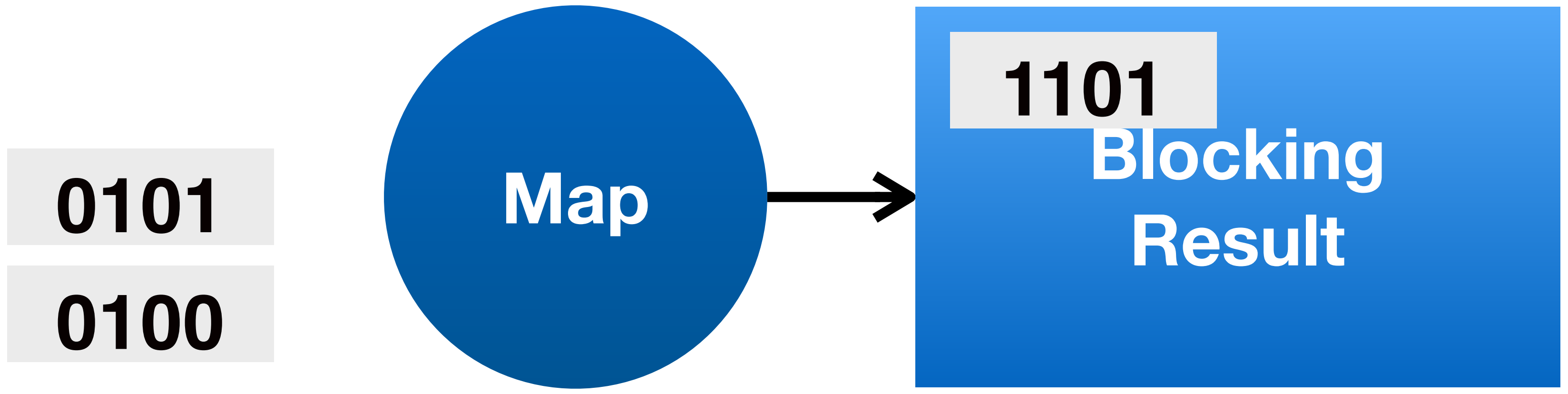

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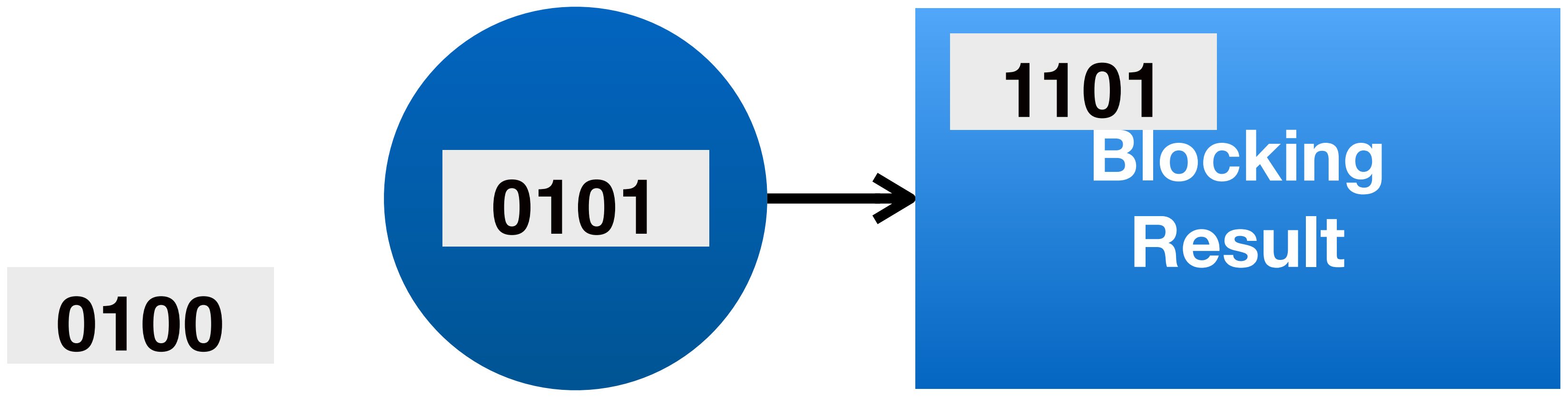

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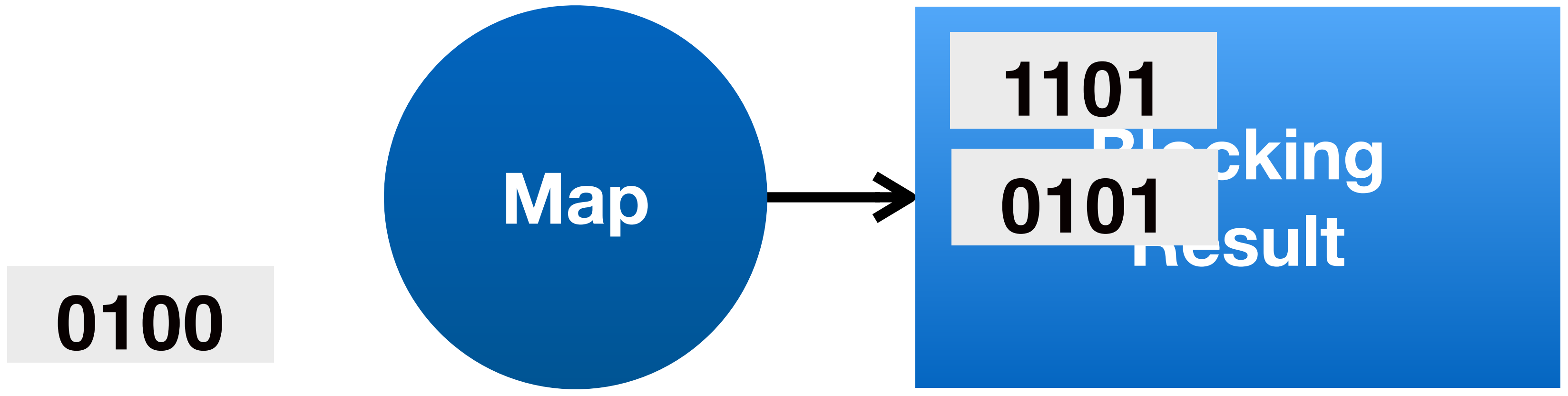
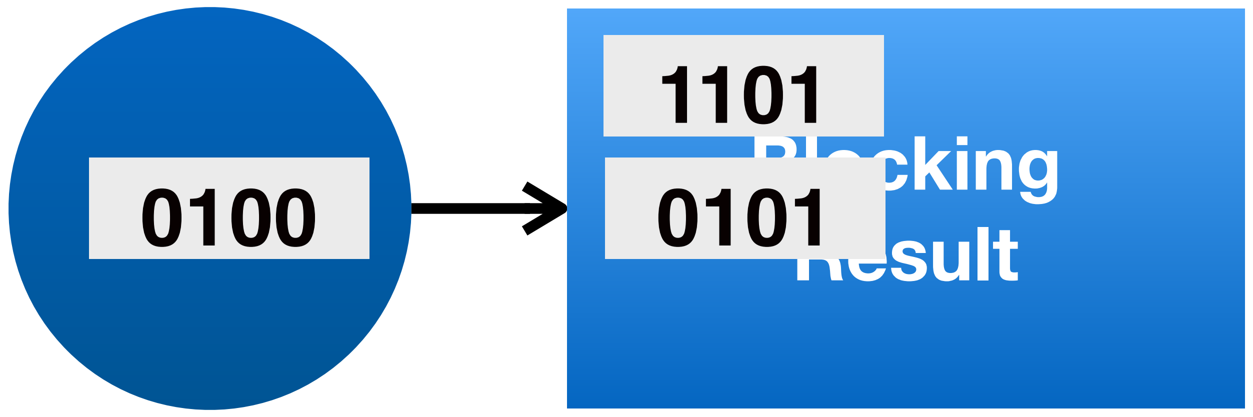
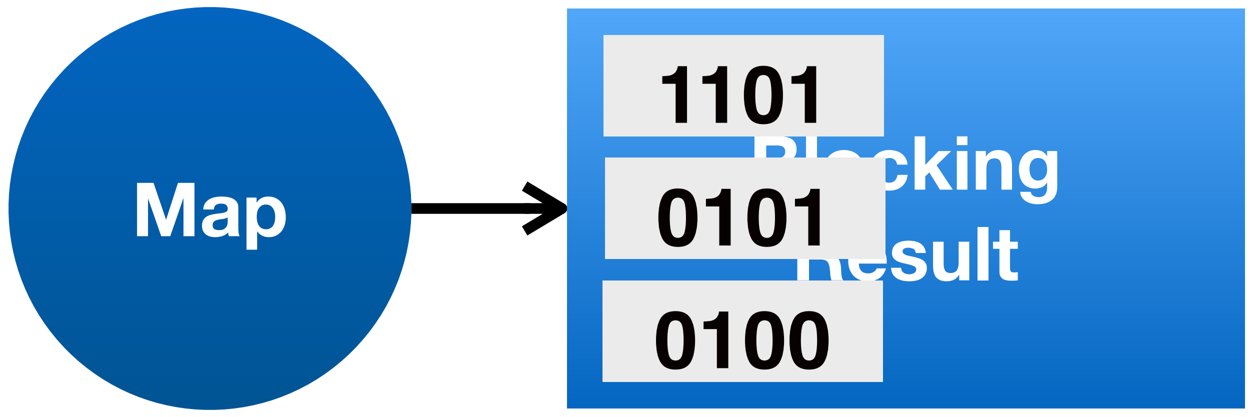


Blocking Results



Blocking Results



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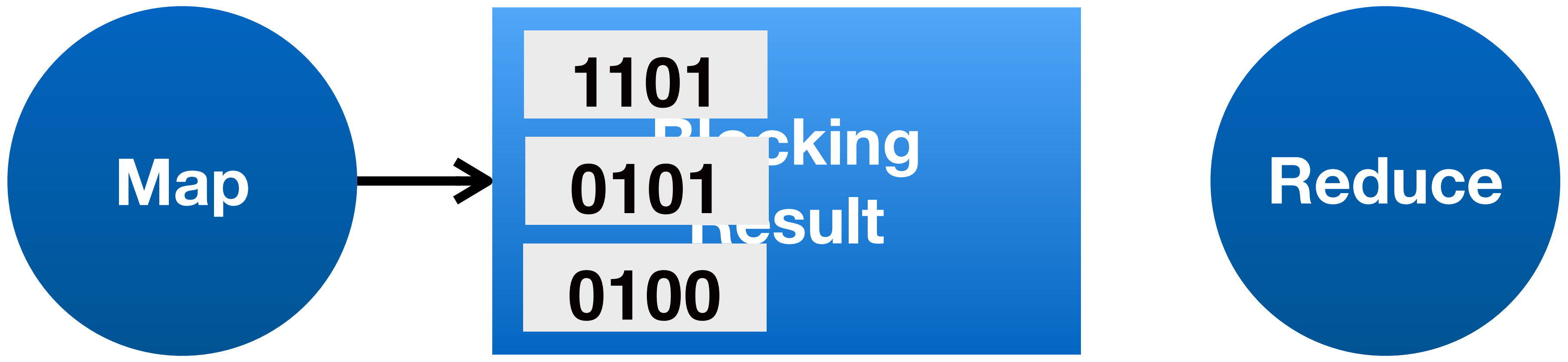

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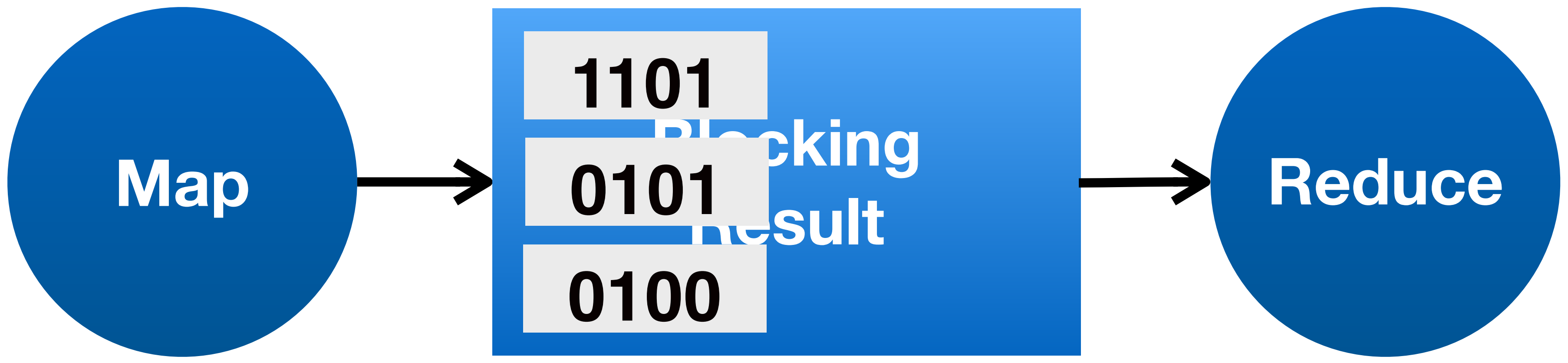

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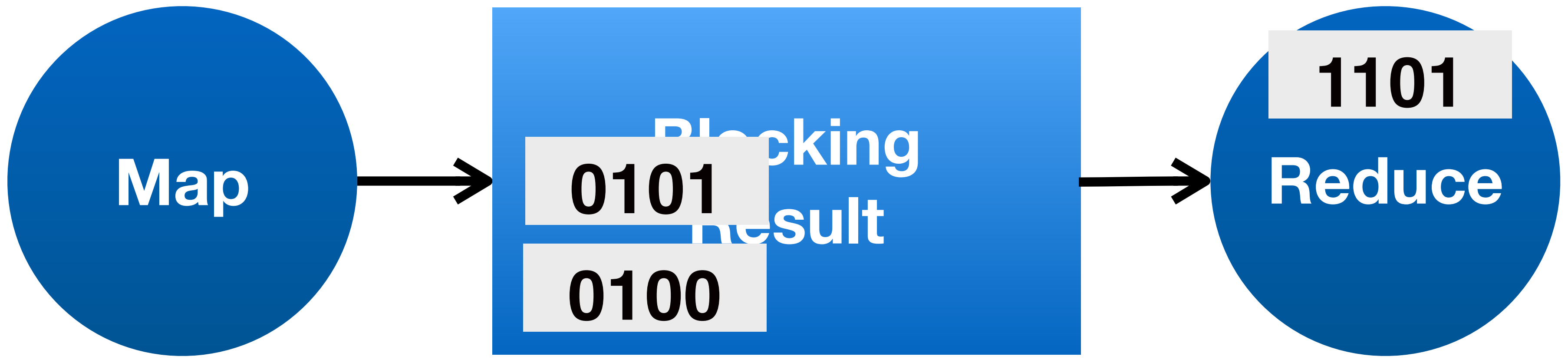

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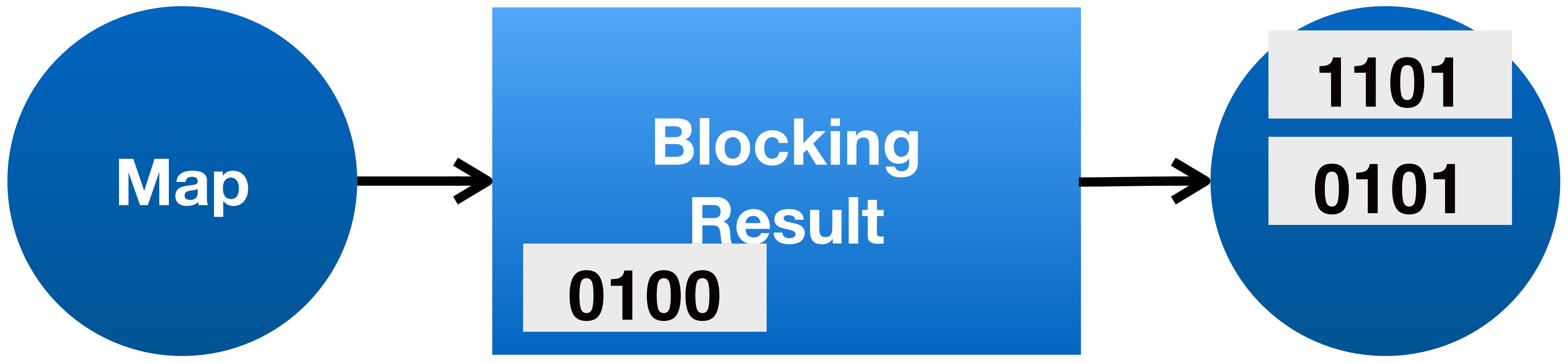

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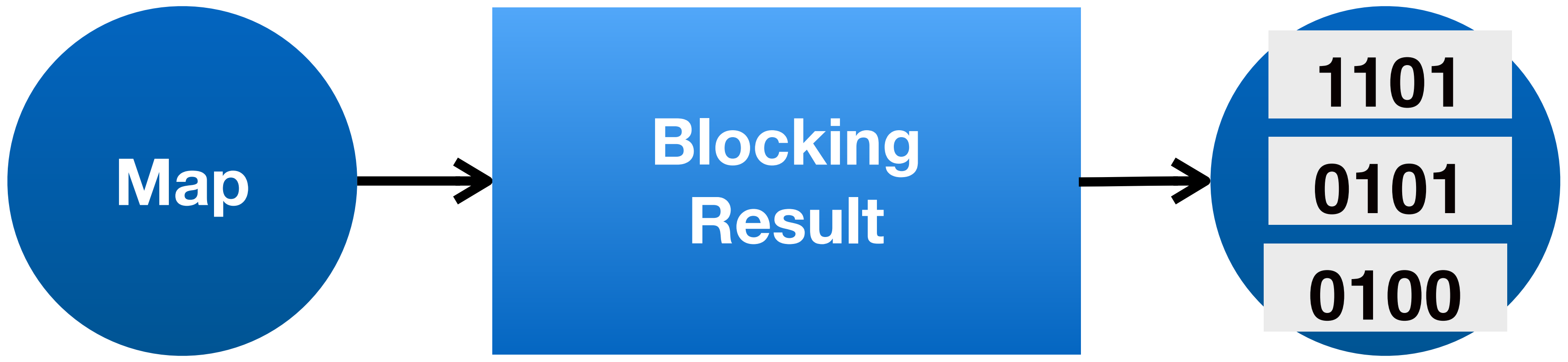
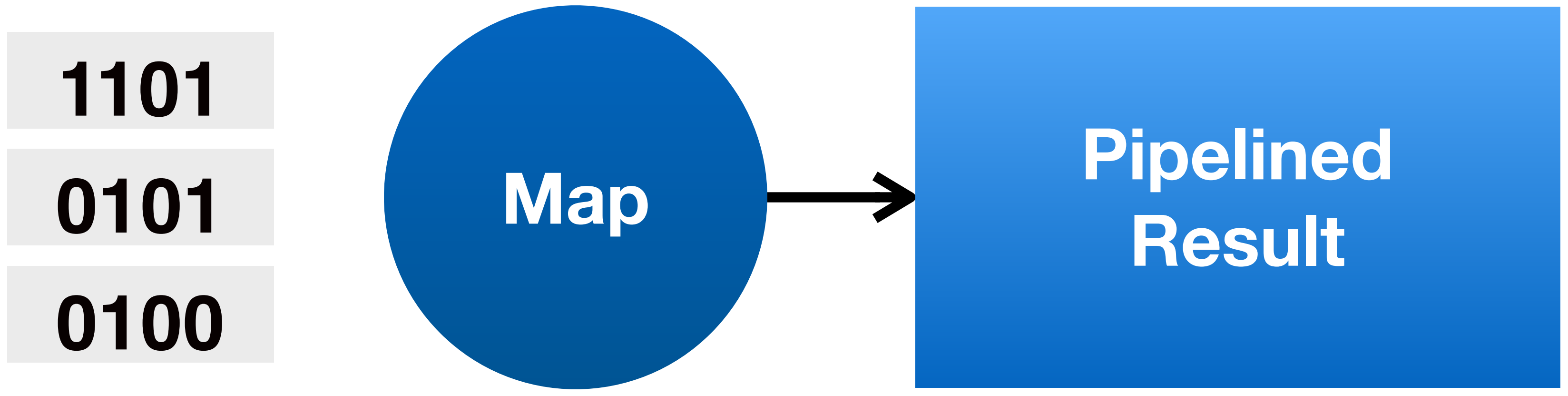
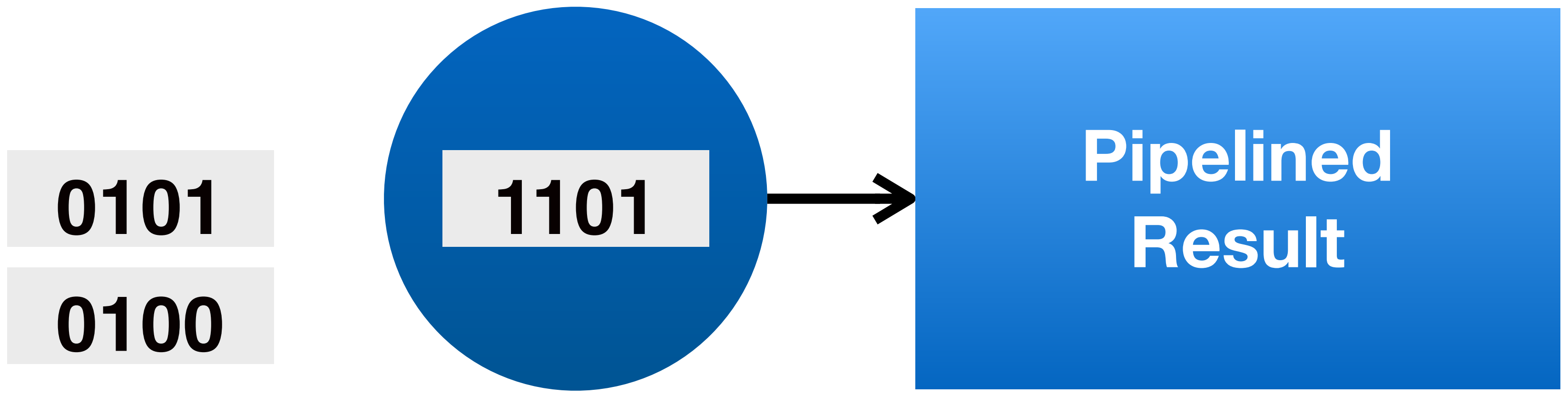


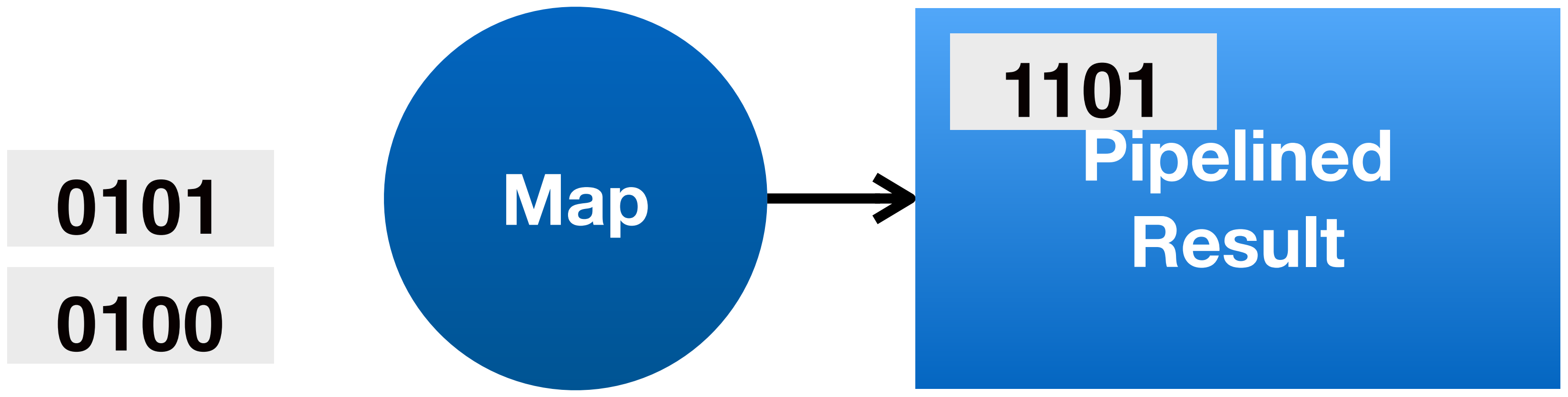
Pipelined Results



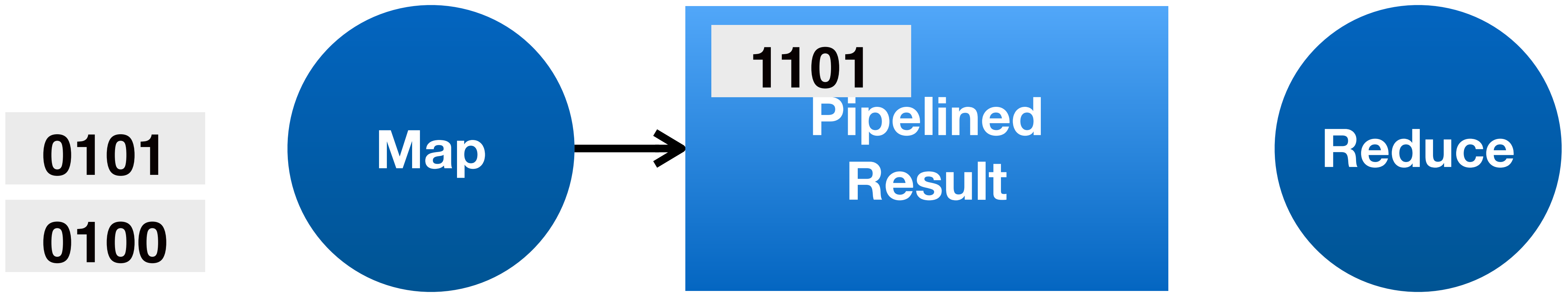
Pipelined Results



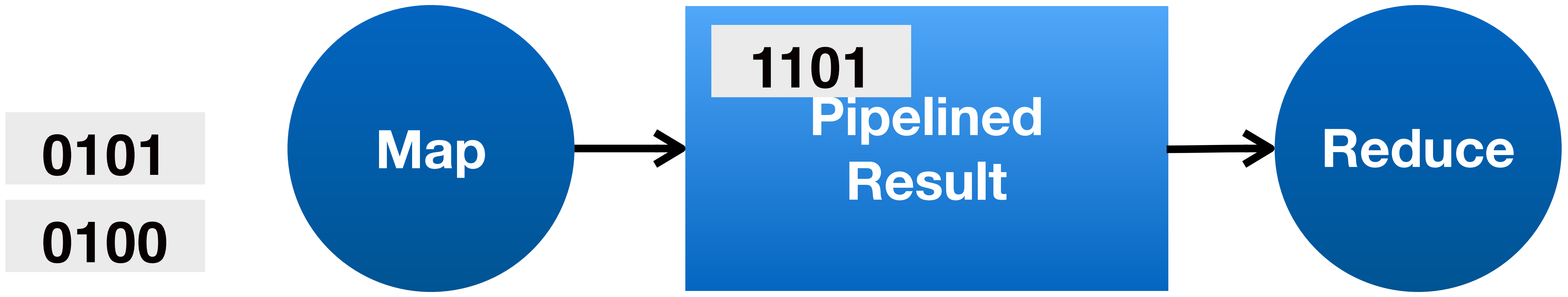
Pipelined Results



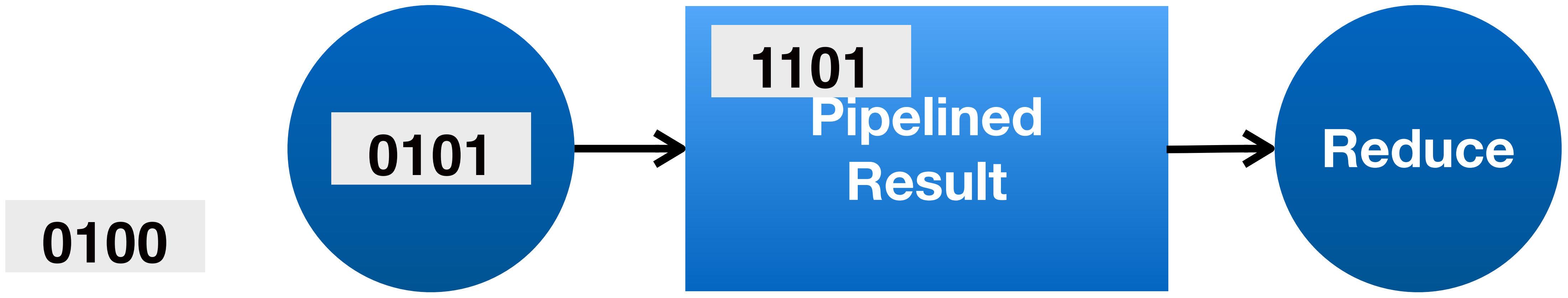
Pipelined Results



Pipelined Results



Pipelined Results



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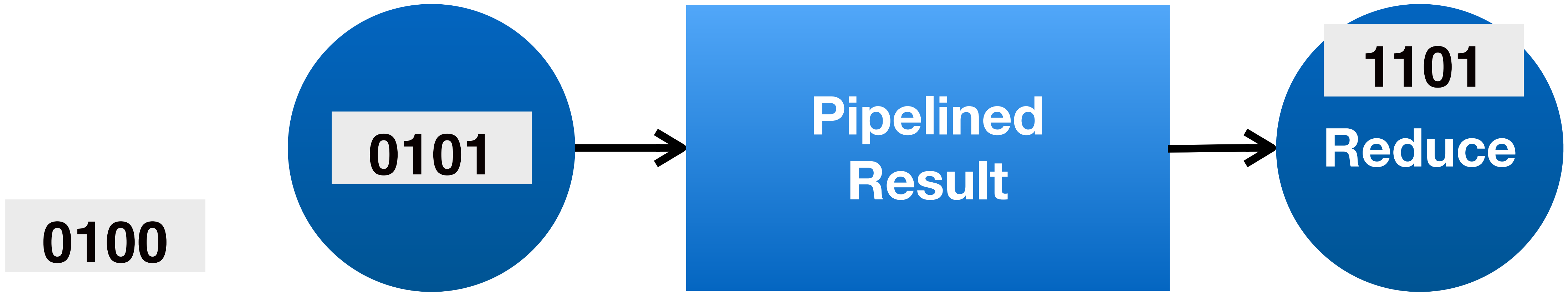
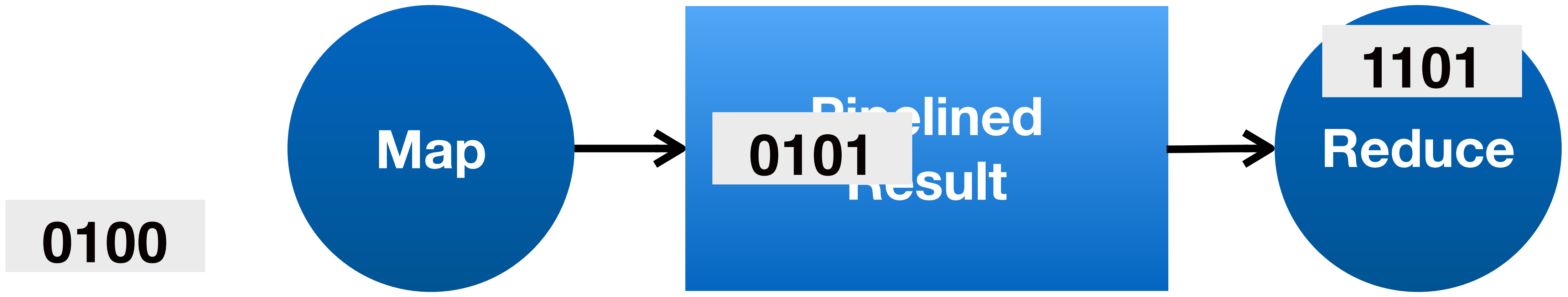
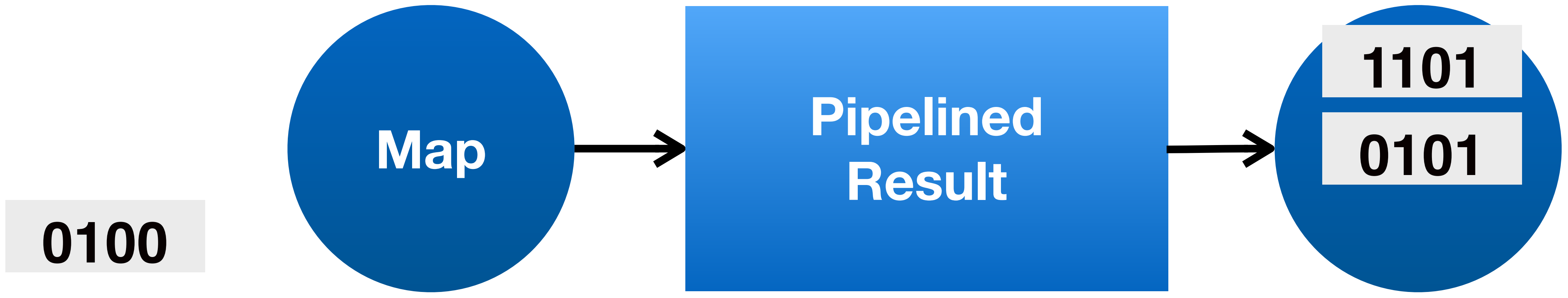


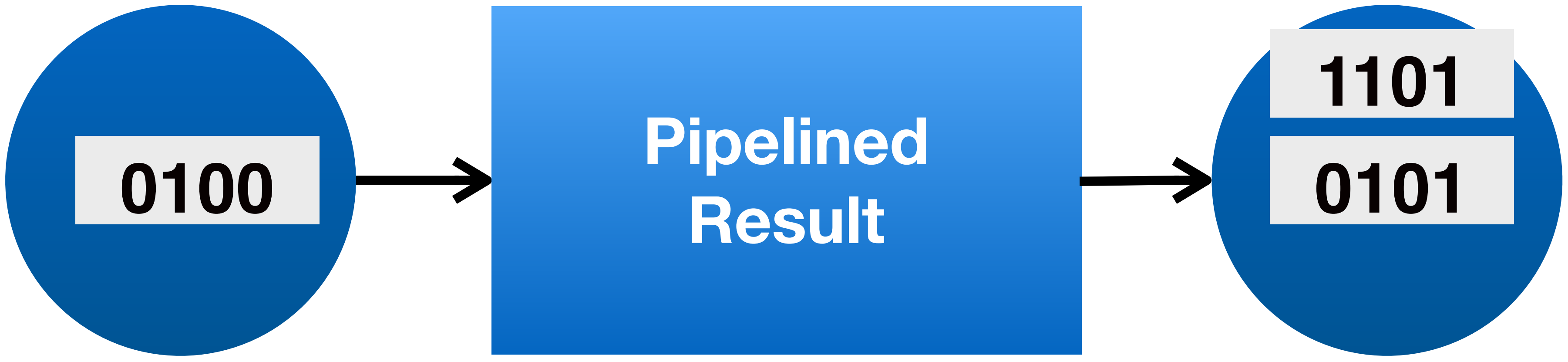
Pipelined Results



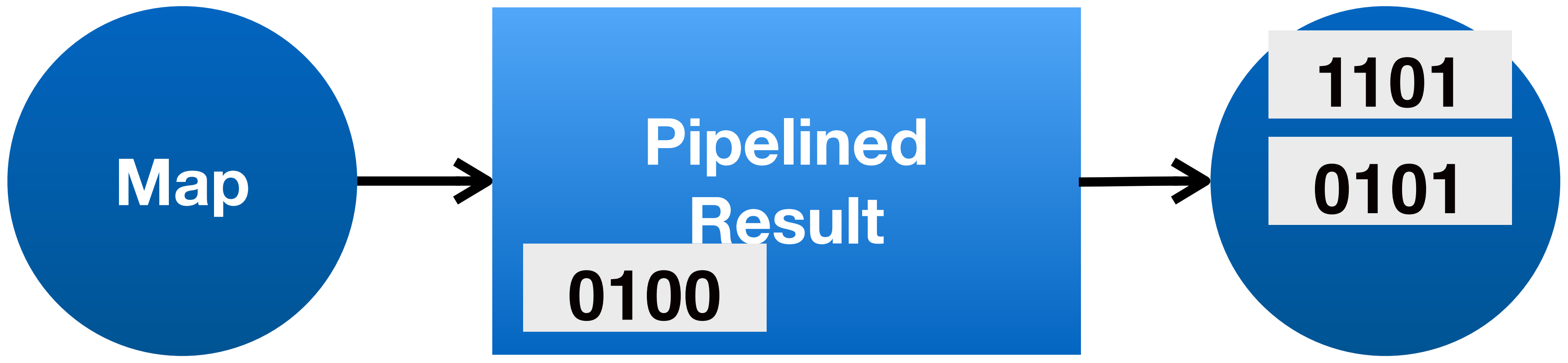
Pipelined Results



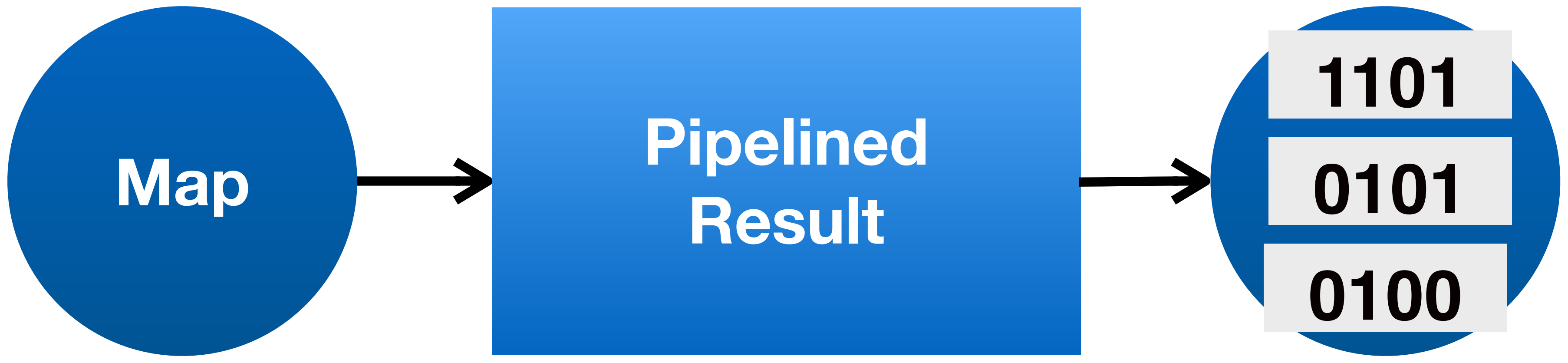
Pipelined Results



Pipelined Results



Pipelined Results



Result Characteristics

	Ephemeral	Checkpointed
Pipelined	Low-latency	Low-latency
Blocking	Easy to reason about resource consumption	Easy to reason about resource consumption

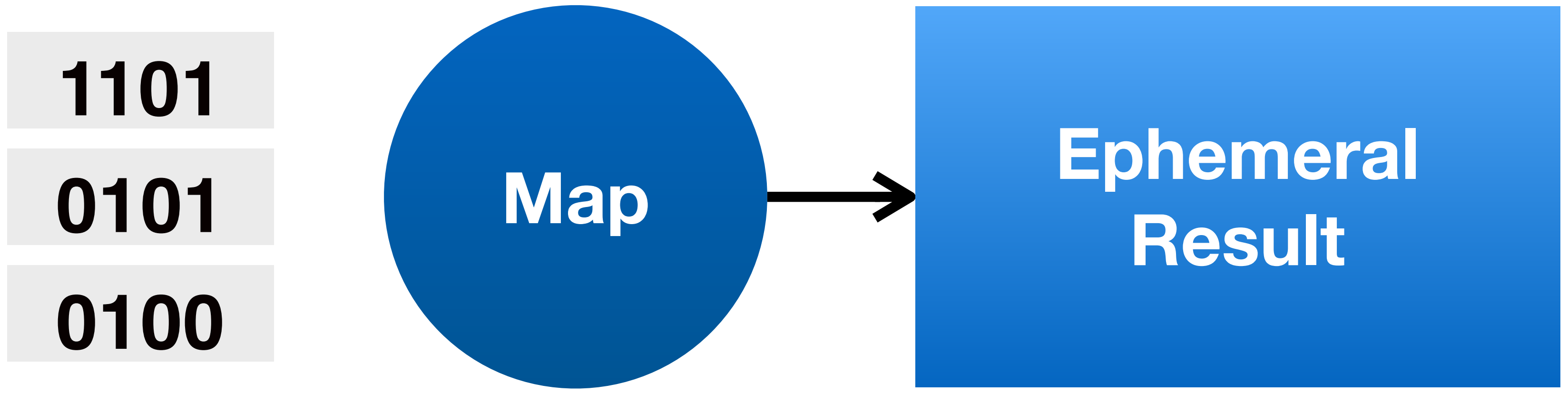
Result Characteristics

Pipelined vs. Blocking

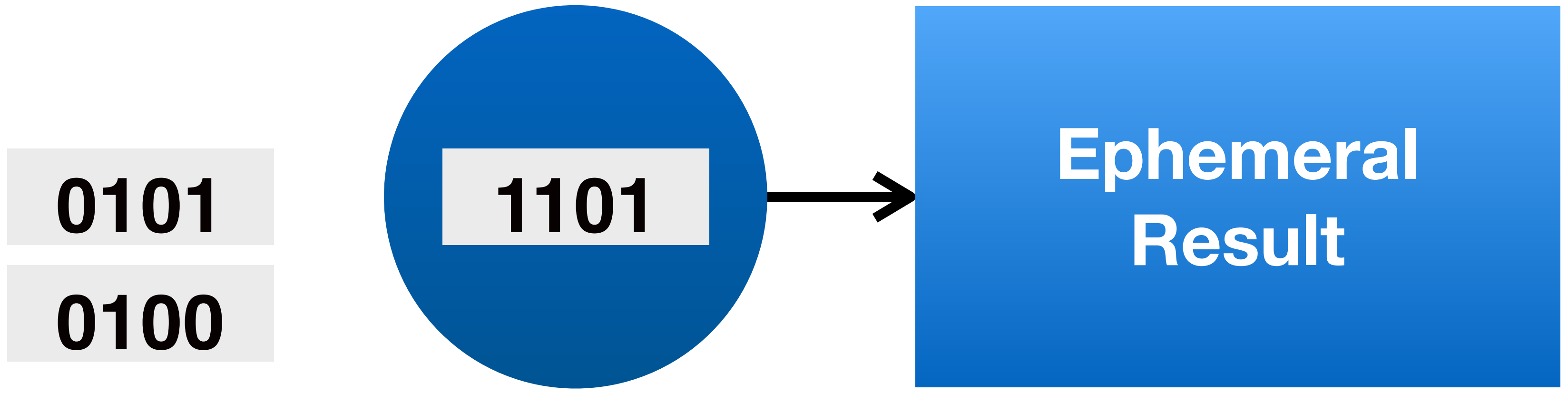
Ephemeral vs. **Checkpointed**

How long to keep results around?

Ephemeral Results



Ephemeral Results



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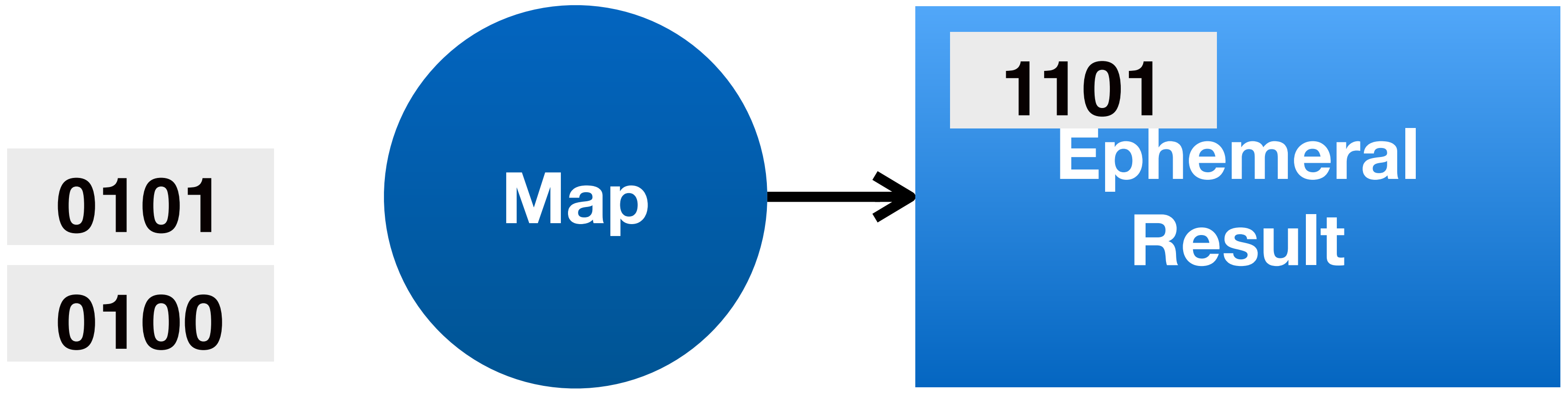

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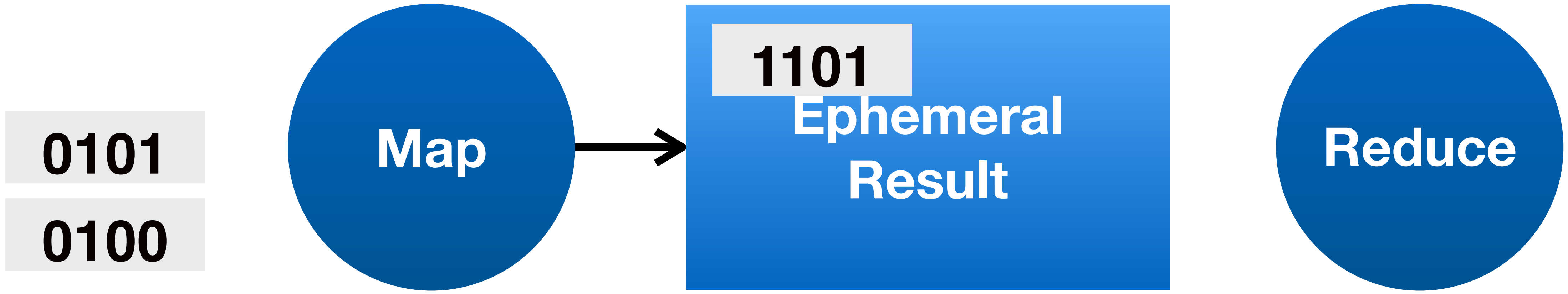

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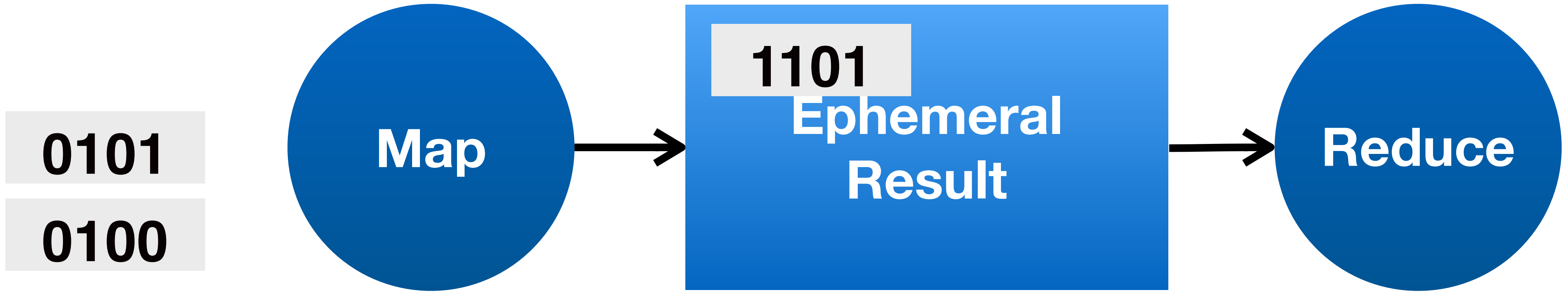
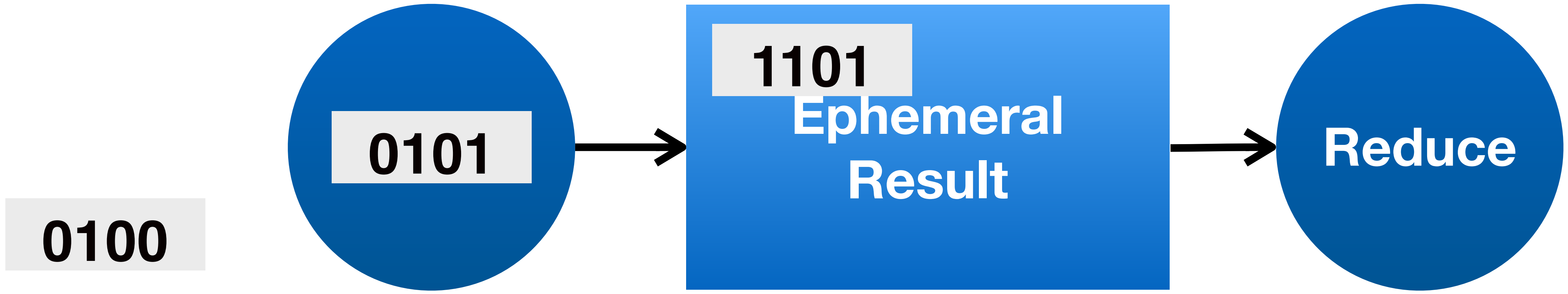
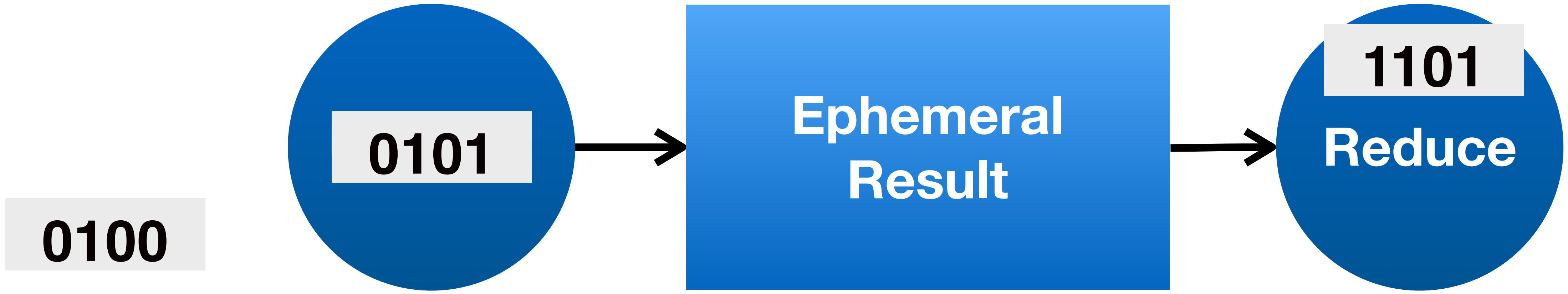


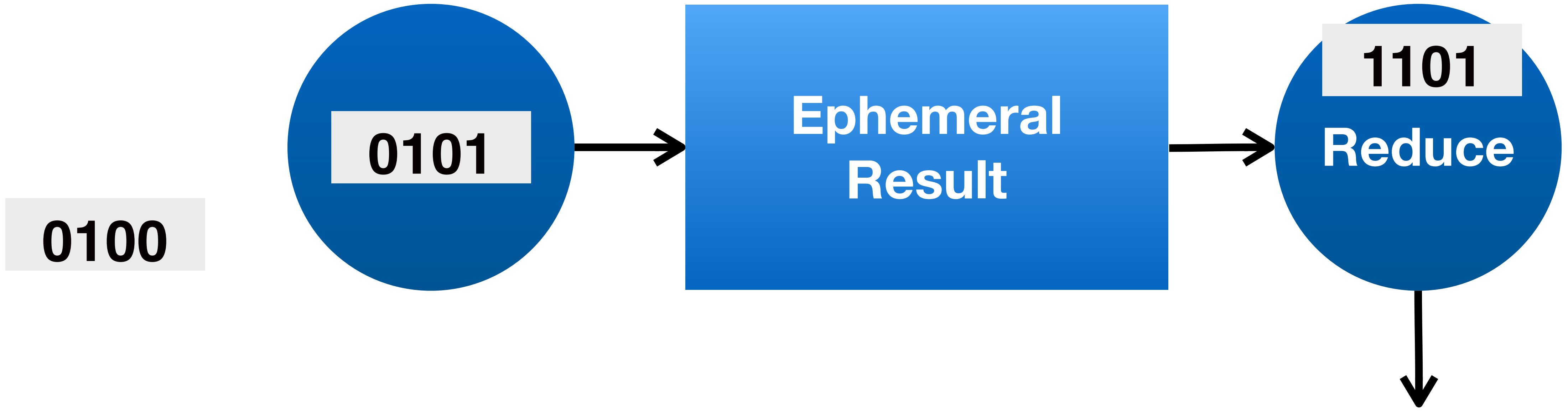
Ephemeral Results



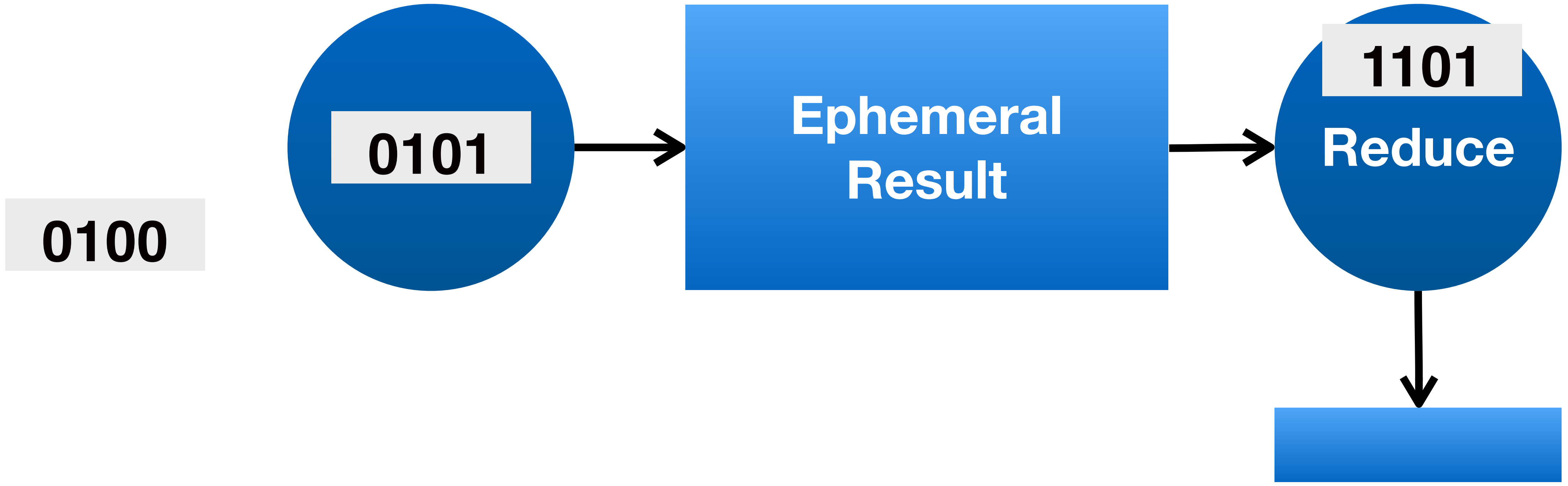
Ephemeral Results



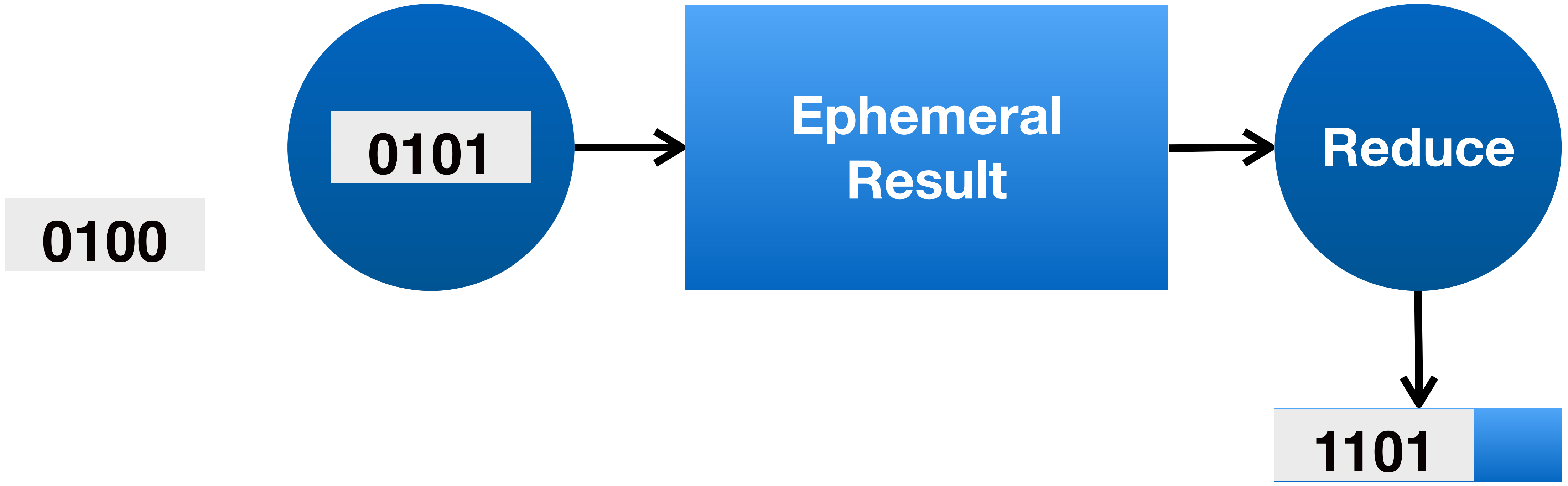
Ephemeral Results



Ephemeral Results



Ephemeral Results



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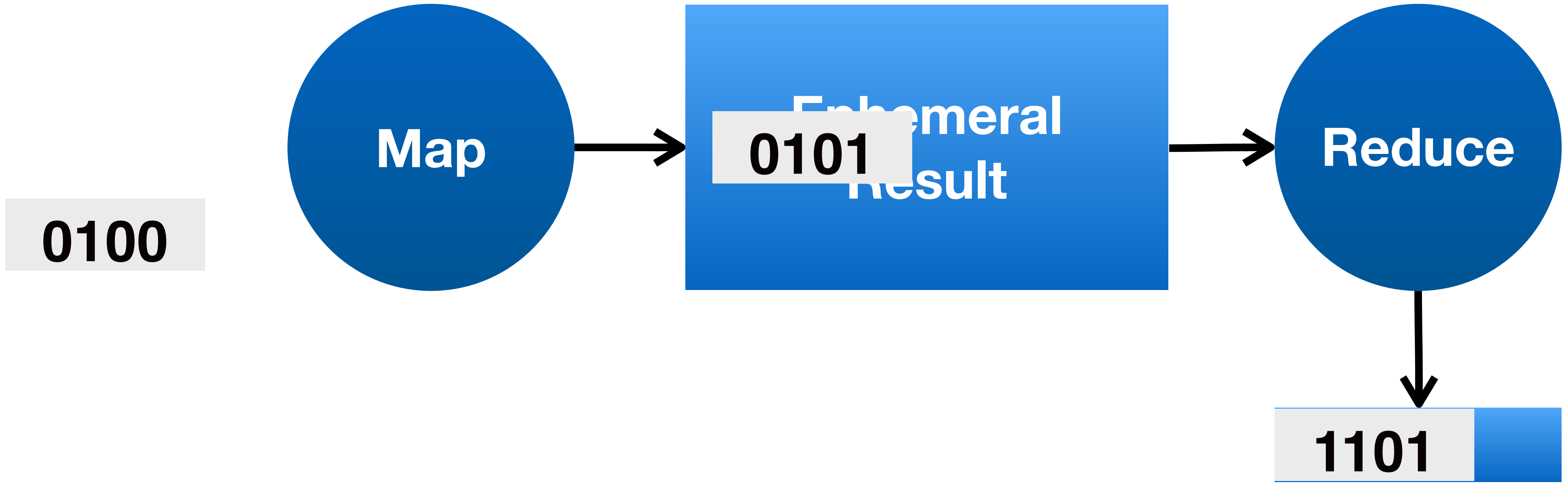
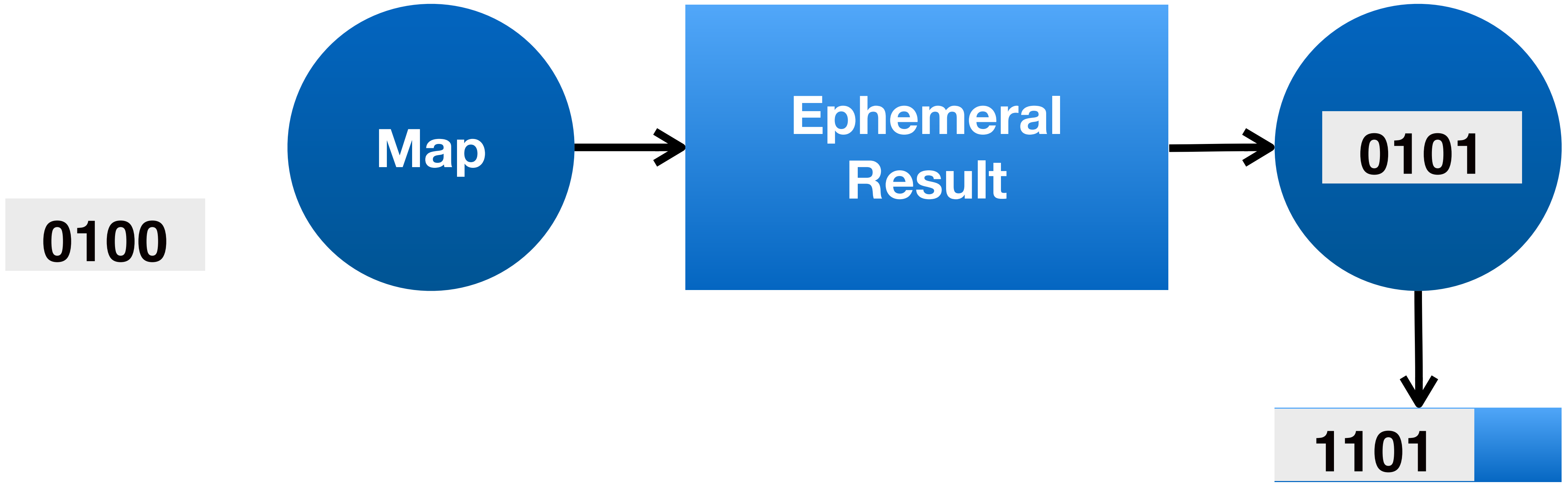


Ephemeral Results



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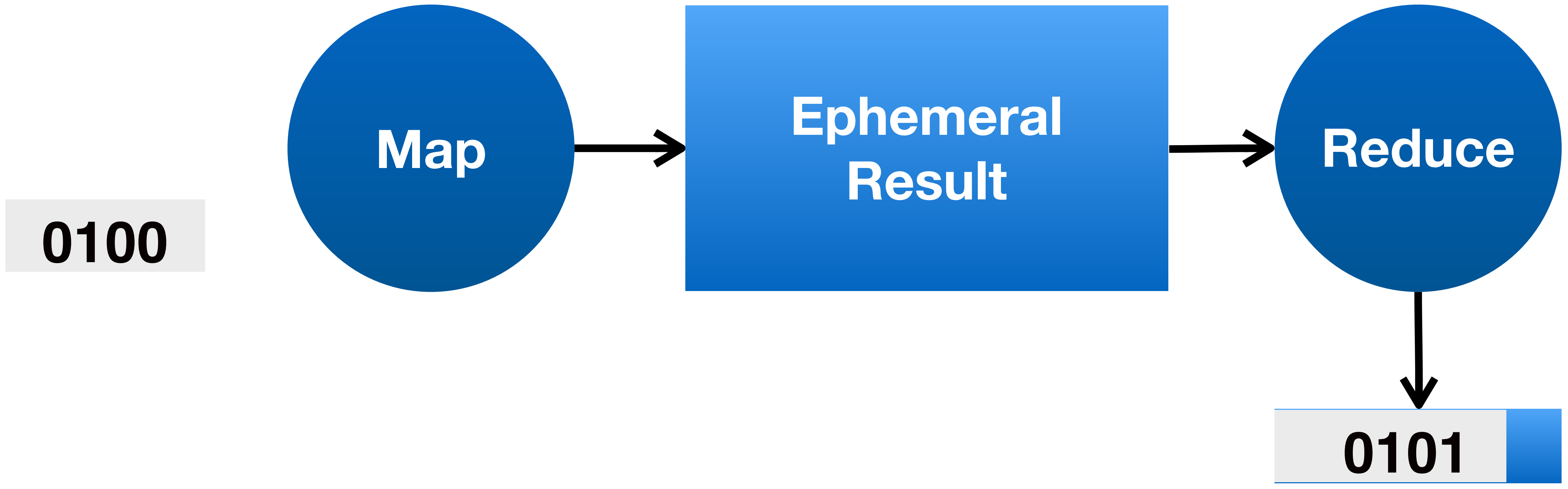
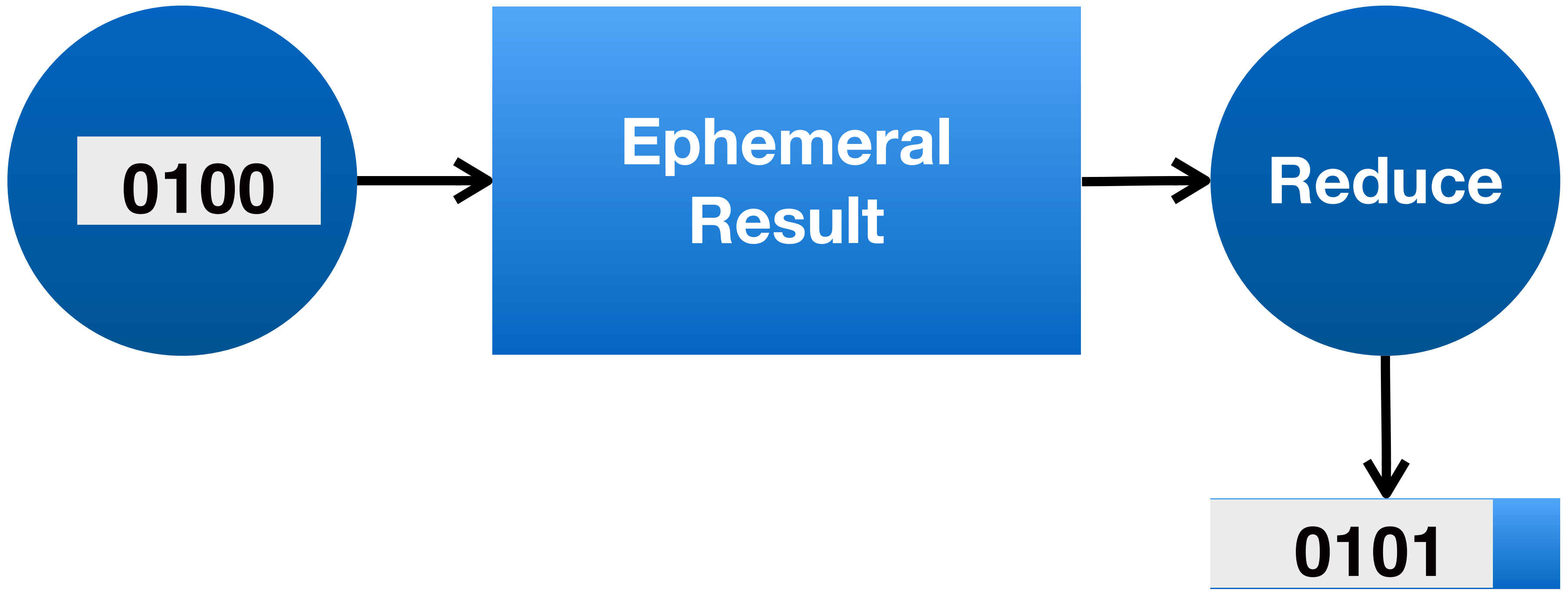
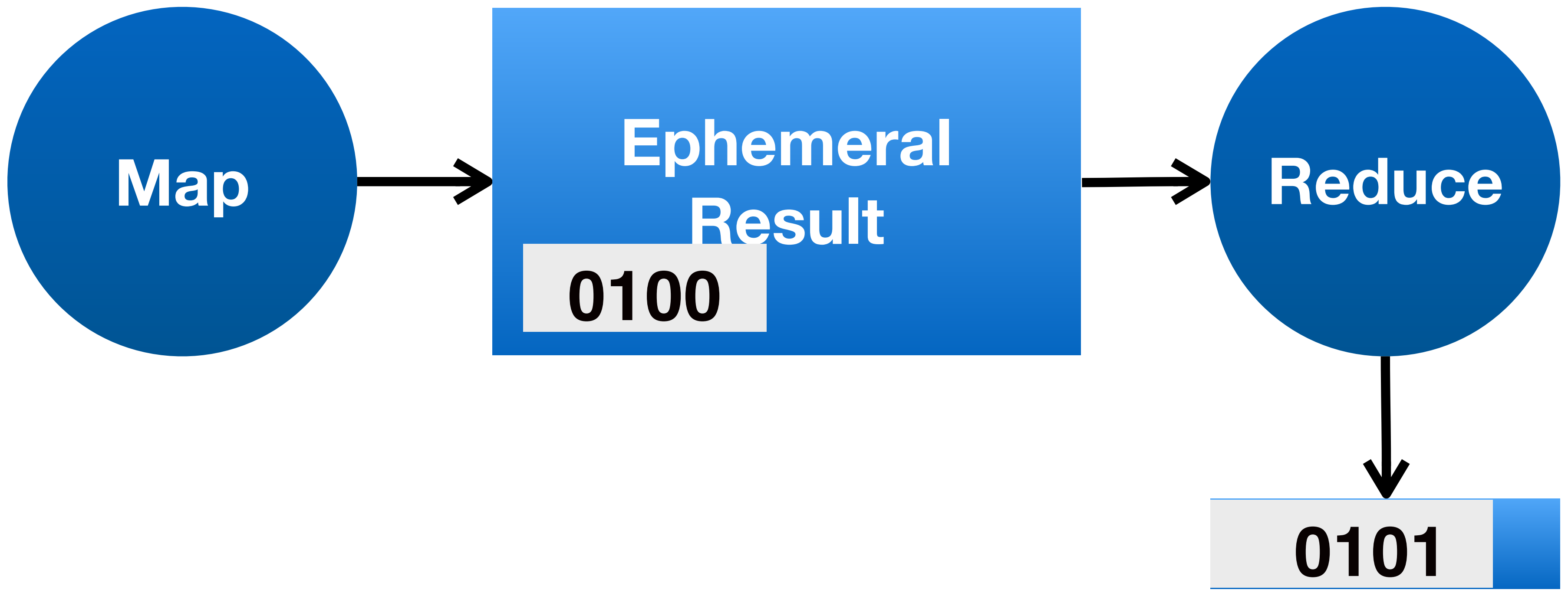


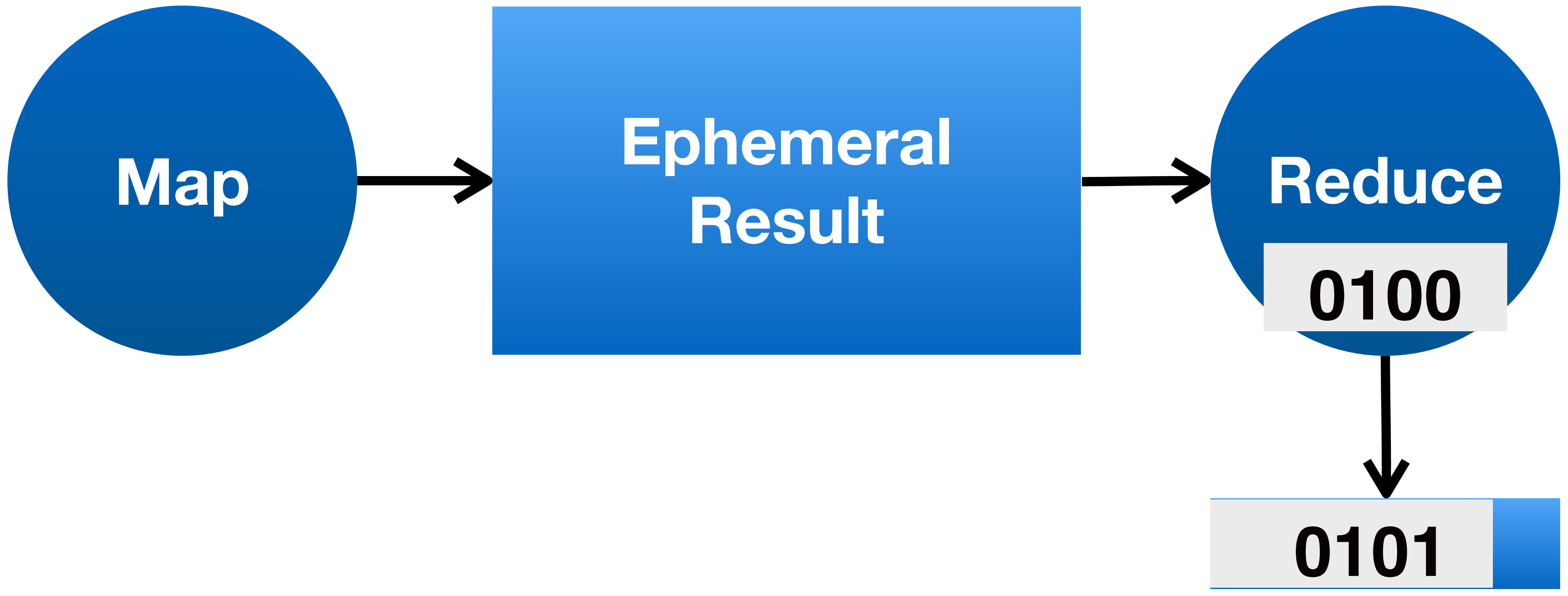
Ephemeral Results



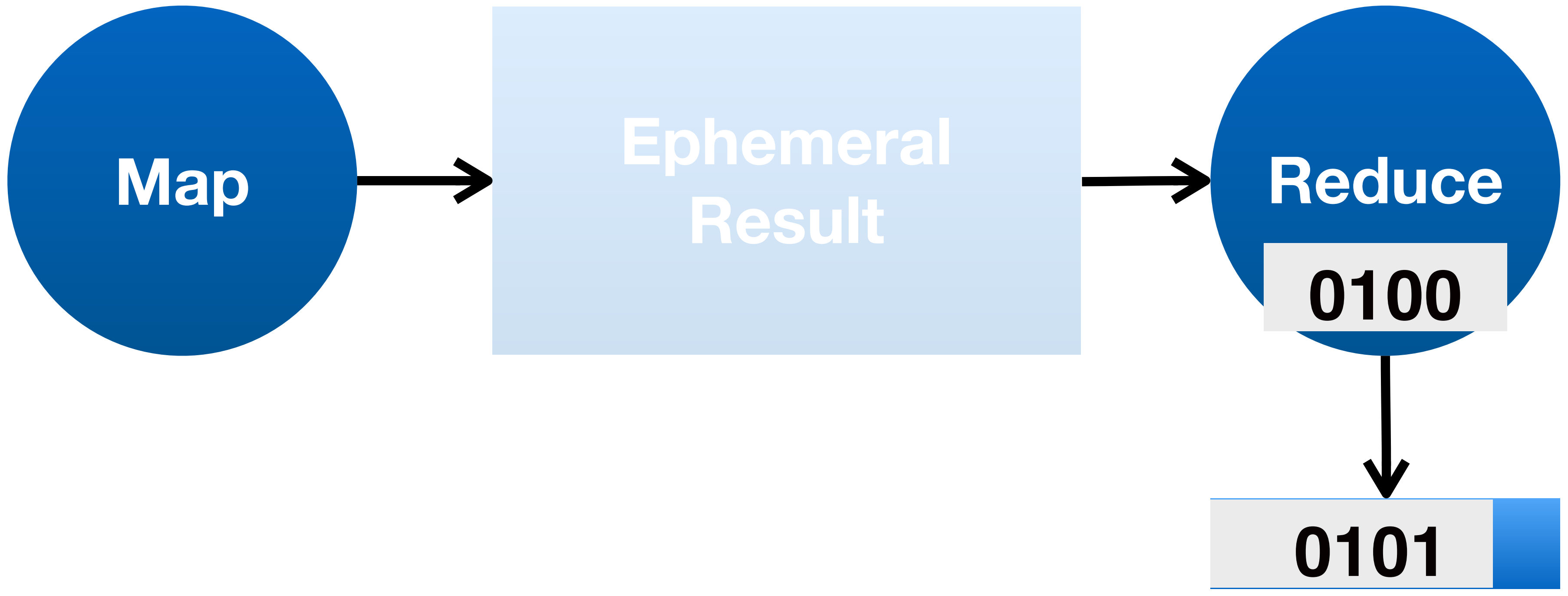
Ephemeral Results



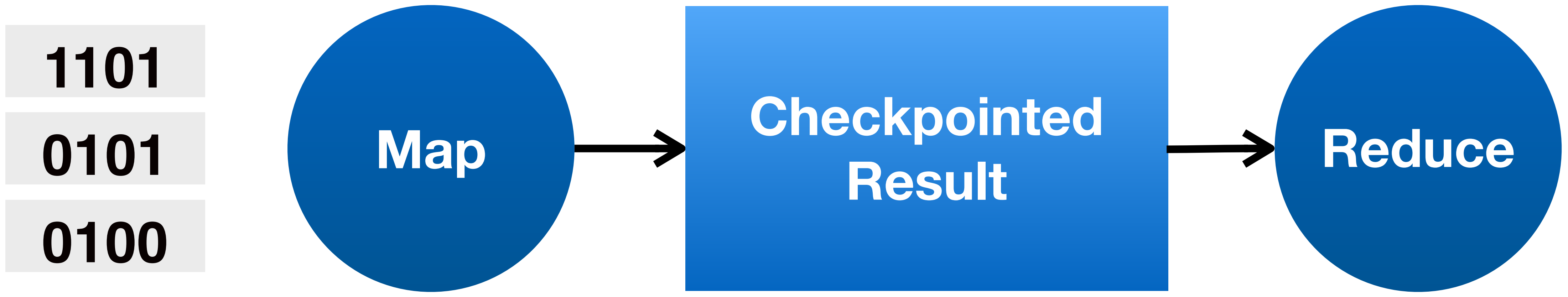
Ephemeral Results



Ephemeral Results



Checkpointed Results



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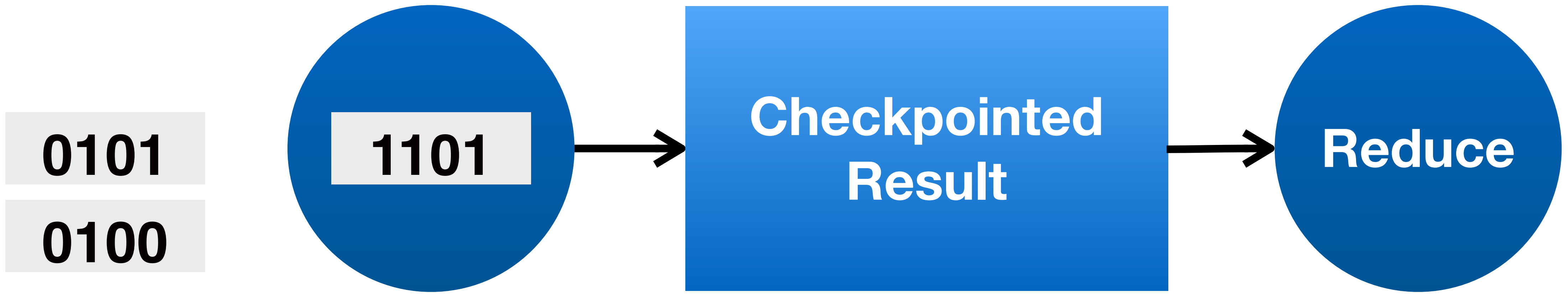

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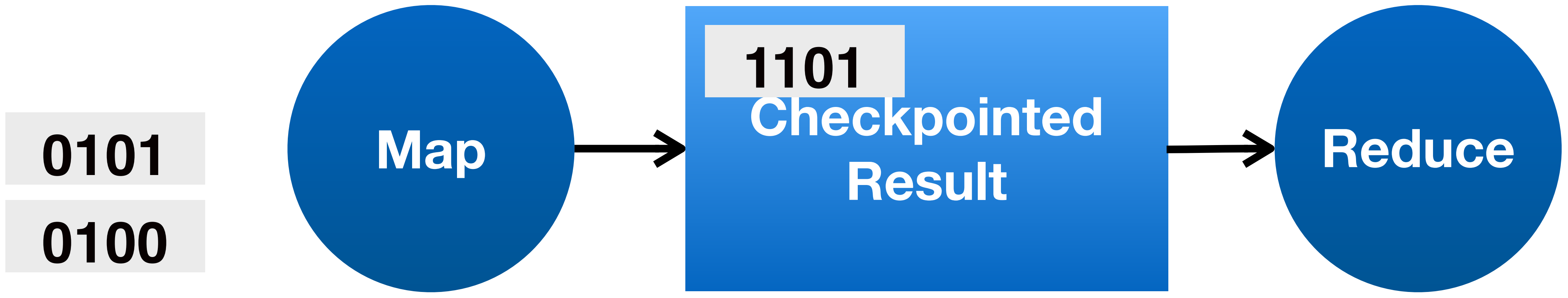

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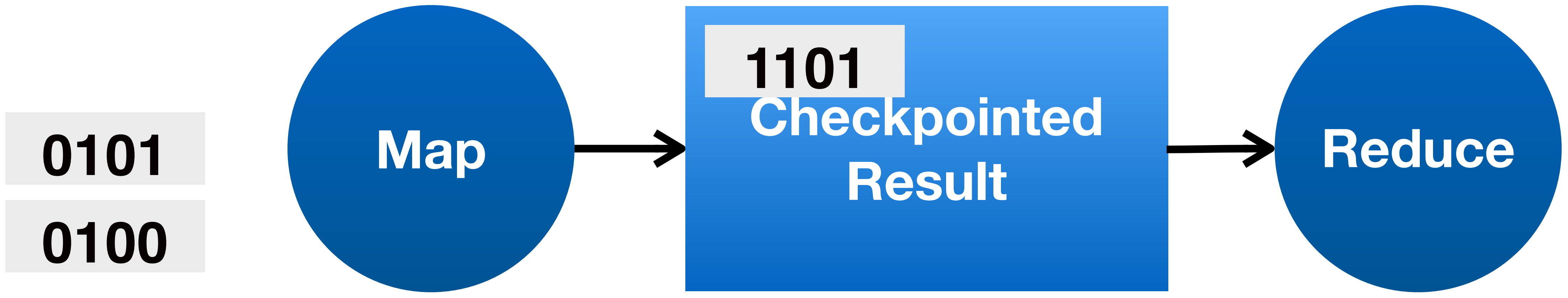

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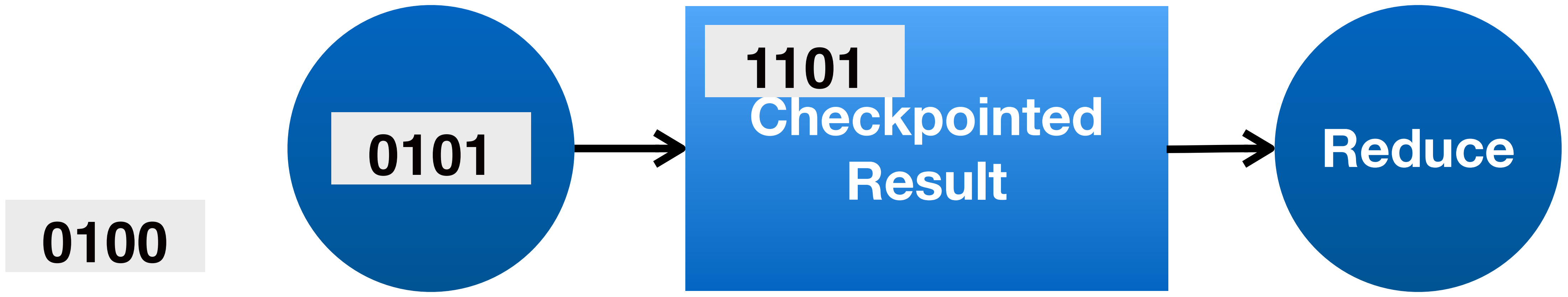

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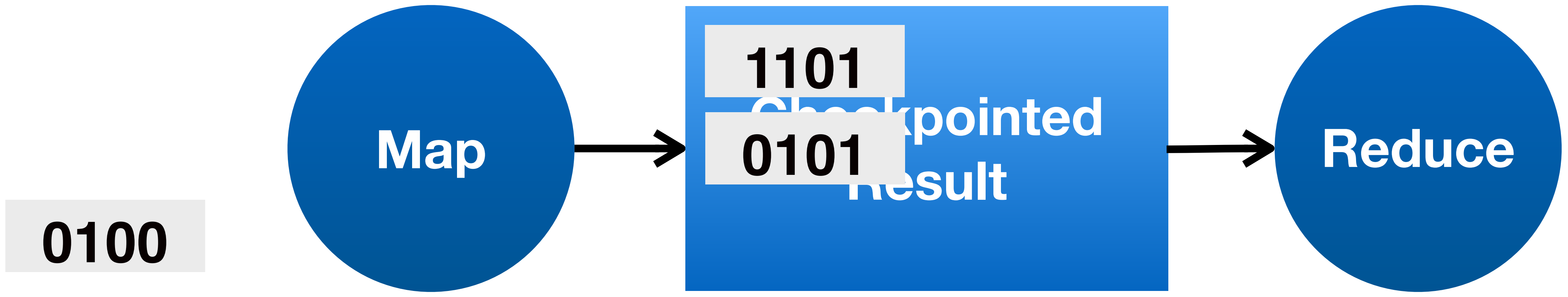

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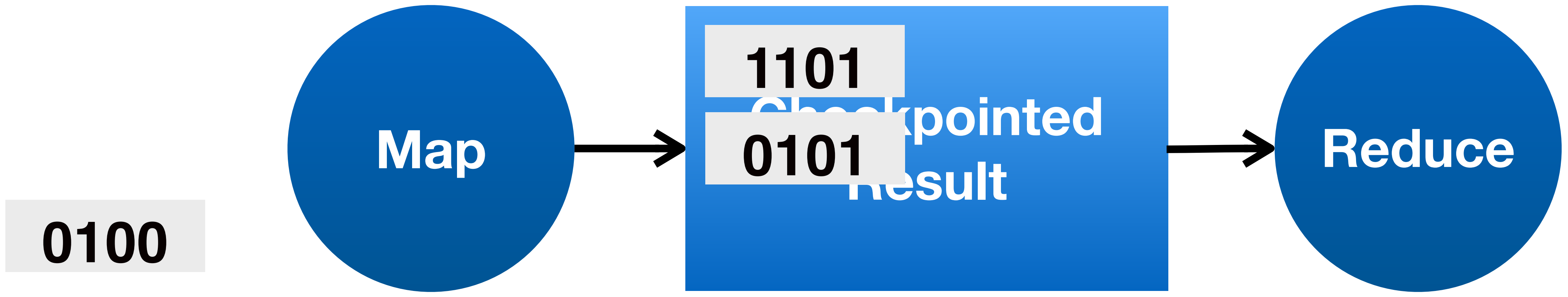

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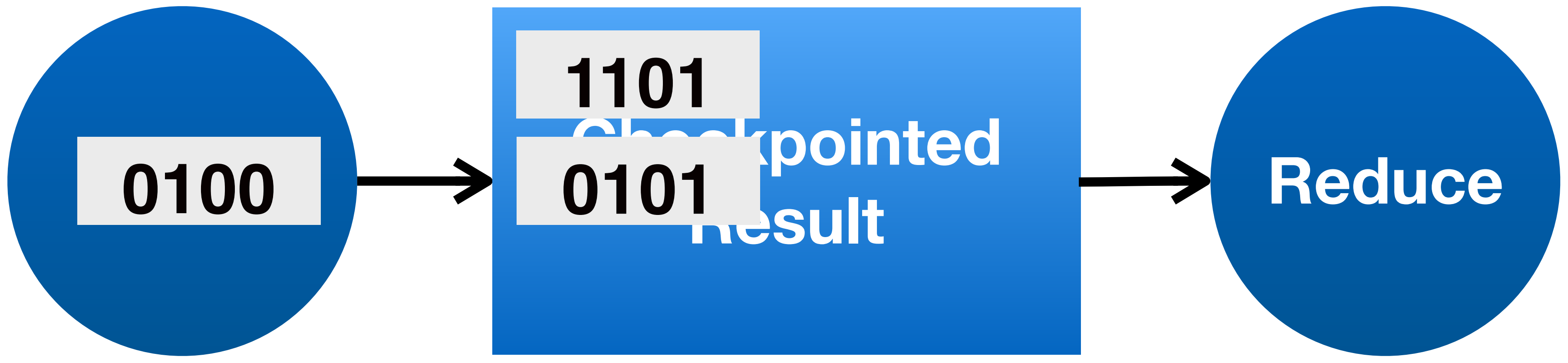
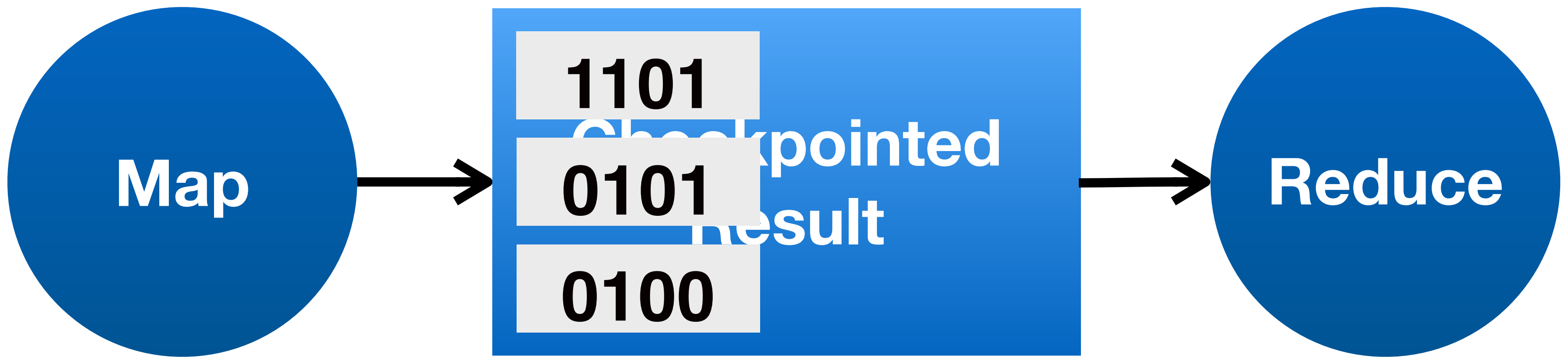


Checkpointed Results



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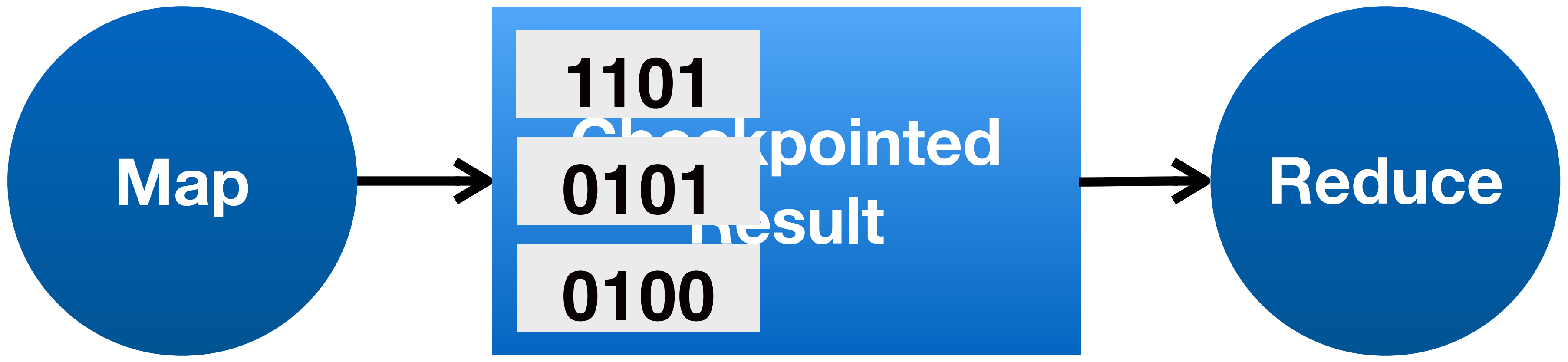

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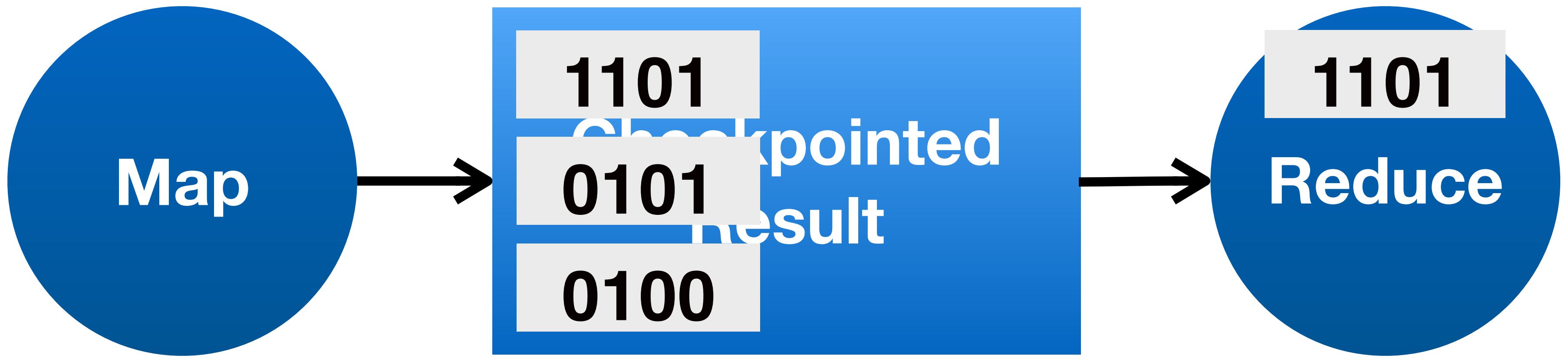

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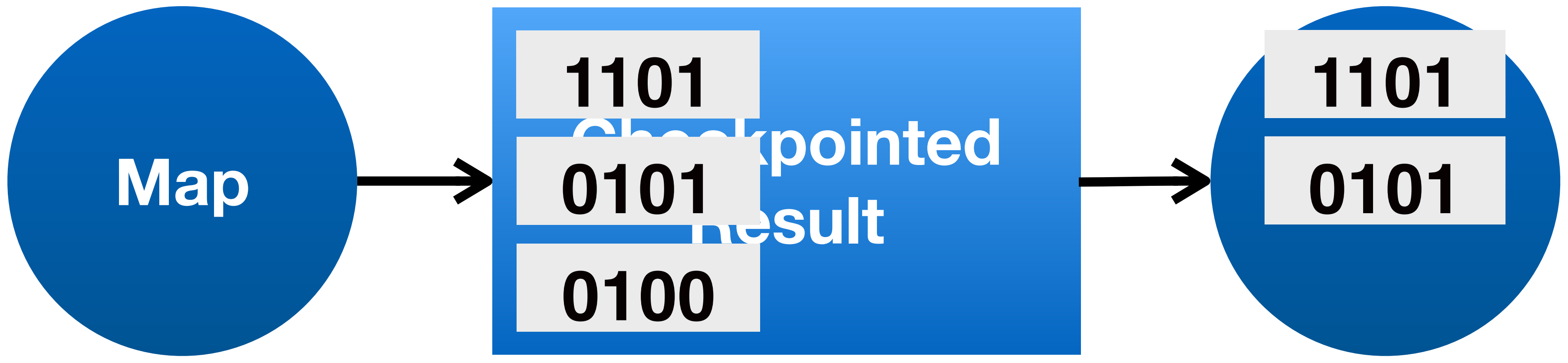
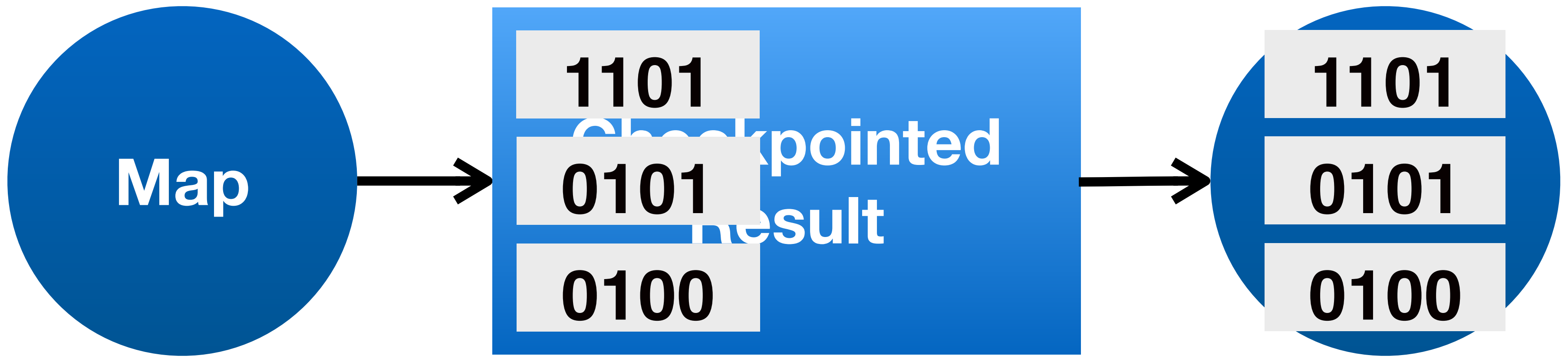


Checkpointed Results



Result Characteristics

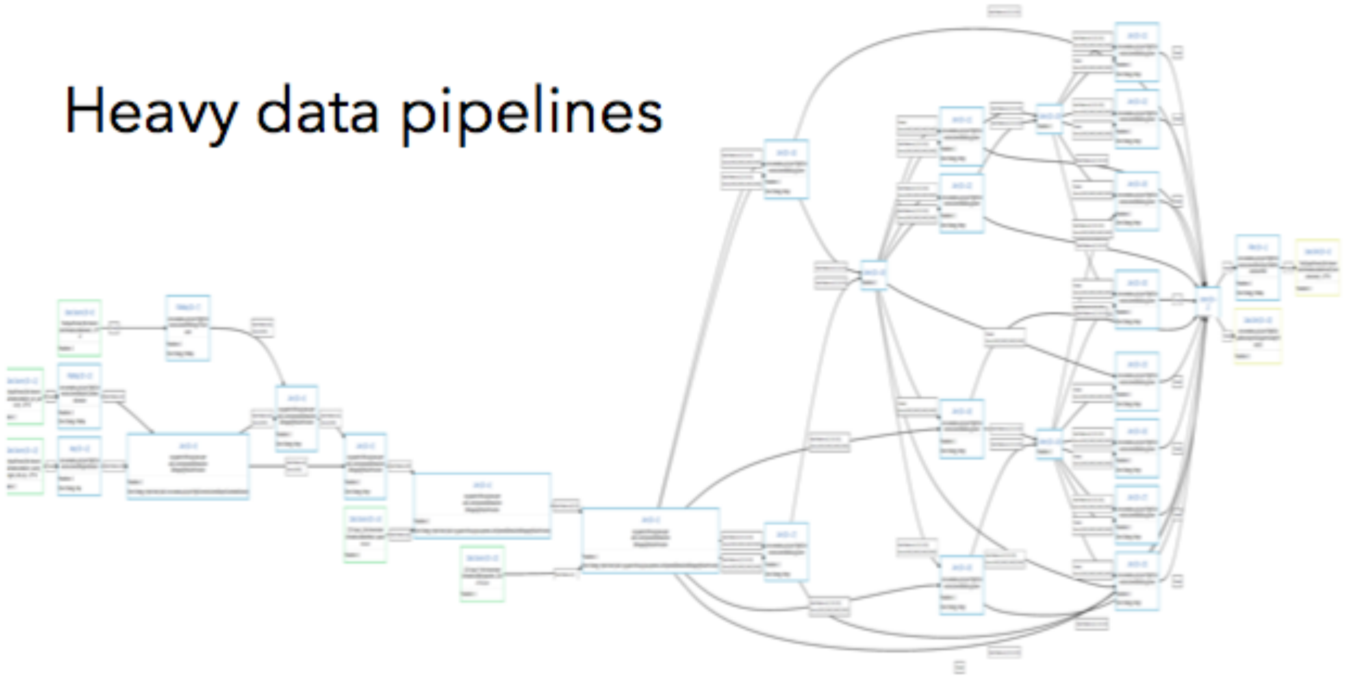
	Ephemeral	Checkpointed
Pipelined	Low-latency	Low-latency **Fine-grained fault tolerance**
Blocking	Easy to reason about resource consumption	**Fine-grained fault tolerance** Easy to reason about resource consumption

Benefits

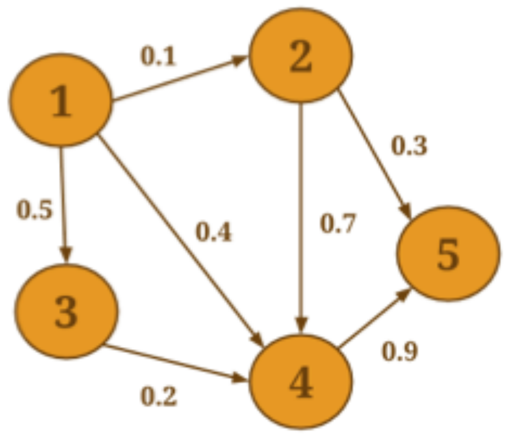
- Very flexible design
- Decouples **high-level requirements** from runtime
  - Fault tolerance for batch vs. streaming
  - Different program optimization paths
  - Iterative programs
  - Interactive queries

Use cases

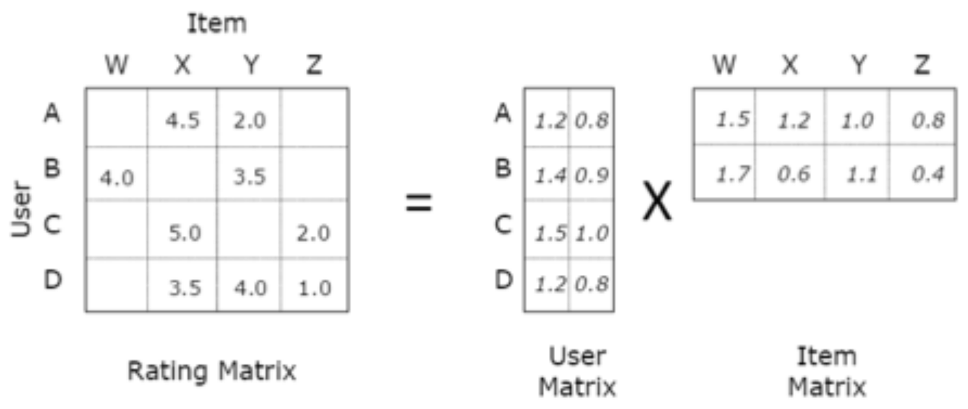
Heavy data pipelines



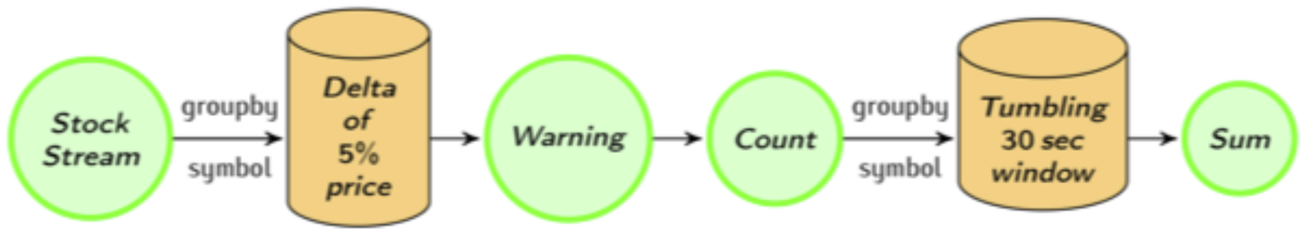
Graph analytics



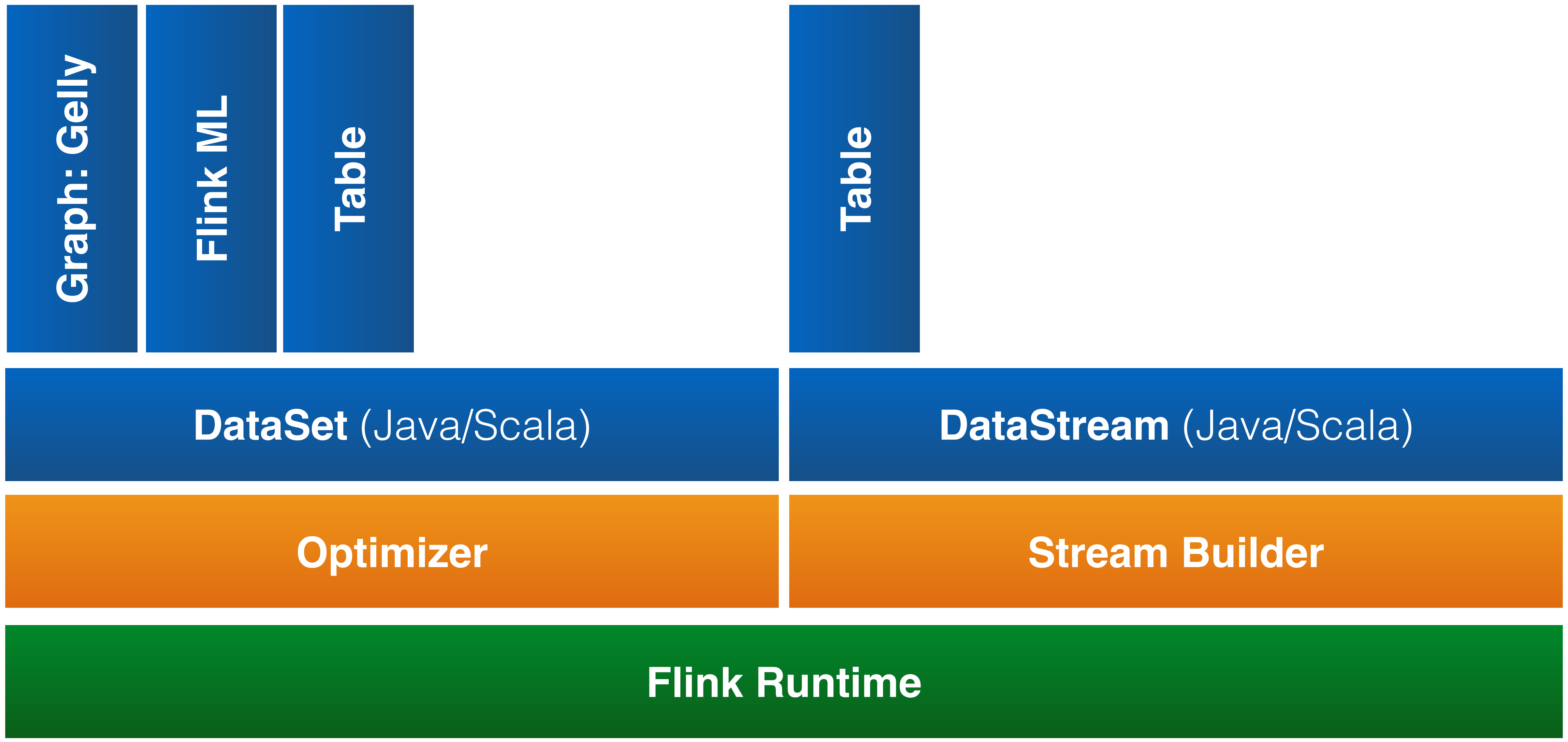
Large-scale Machine Learning



Real-time stream processing



Flink Stack


Graph: Gelly
Flink ML
Table
Table
DataSet (Java/Scala)
DataStream (Java/Scala)
Optimizer
Stream Builder
Flink Runtime

Current Implementations

Pipelined vs. Blocking

Ephemeral vs. Checkpointed

Backpressure vs. No Backpressure

Current Implementations

Pipelined vs. **Blocking**

Ephemeral vs. **Checkpointed**

Backpressure vs. **No Backpressure**

Pipelined vs. Blocking in Flink

- Default type for both batch and streaming programs: **Pipelined**
- In batch mode only: use blocking exchange if necessary (e.g. to avoid deadlocks or break up long pipelines)
- More details: https://cwiki.apache.org/confluence/display/FLINK/Data+exchange+between+tasks

ExecutionConfig

```
// Set up the execution environment
ExecutionEnvironment env = ExecutionEnvironment
  .getExecutionEnvironment();

ExecutionConfig conf = env.getConfig();

// Remote data exchange is blocking (local is pipelined)
conf.setExecutionMode(ExecutionMode.BATCH);

// Remote and local data exchange is blocking
conf.setExecutionMode(ExecutionMode.BATCH_FORCED);

// Remote and local data exchange is pipelined except
// when necessary to avoid deadlocks etc. [DEFAULT]
conf.setExecutionMode(ExecutionMode.PIPELINED);

// Remote and local data exchange is always pipelined
conf.setExecutionMode(ExecutionMode.PIPELINED_FORCED);
```

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