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Dealing with order in streams using Apache Beam

Israel Herraiz

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Getting started with Apache Beam Quest

Svetak Sundhar

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Too Big to Fail - A Pattern for Enriching a Stream using State and Timers

By Tobi Kaymak
& Israel Herraiz

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Enrich me, if you can - A Pattern for Enriching a Stream using State and Timers

By Tobi Kaymak & Israel Herraiz

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The Problem

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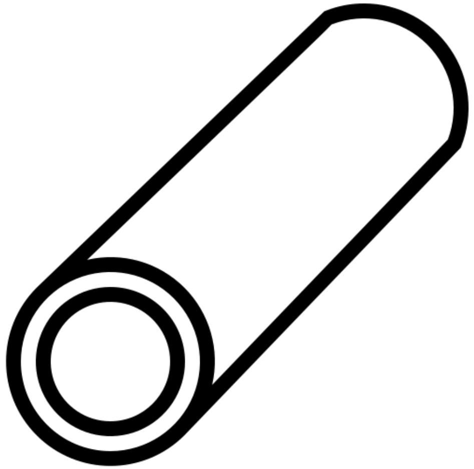
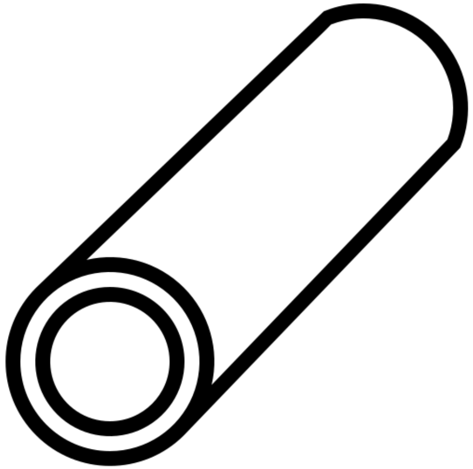
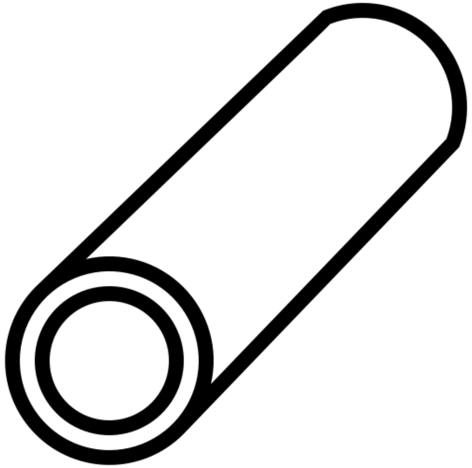
Two Streams Need to be Joined





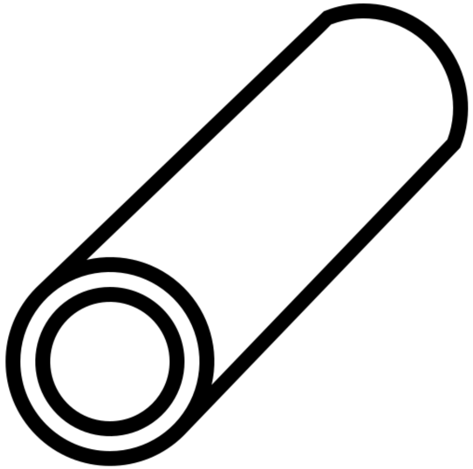
The “Core” one with the core info



```
{
  "id": 123,
  "color": "gold",
  "can_dance": true
}
```

The Second one with “Lookups”

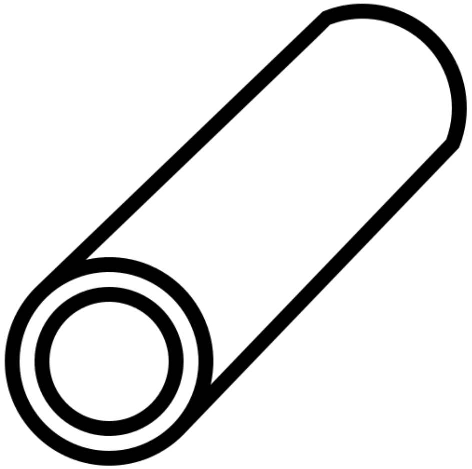
```
{
  "id": 123,
  "serial_number": 456
}
```

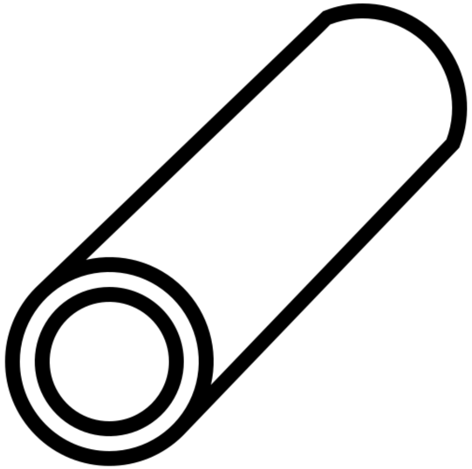


Two Streams Need to be Joined

```
{
  "id": 123,
  "color": "gold",
  "can_dance": true
}
```

```
{
  "id": 123,
  "current_serial": 456
}
```

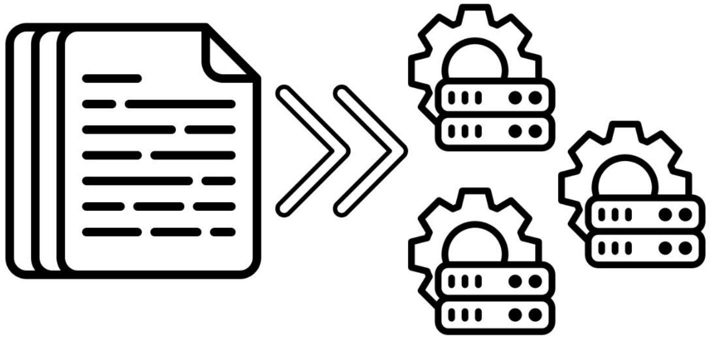


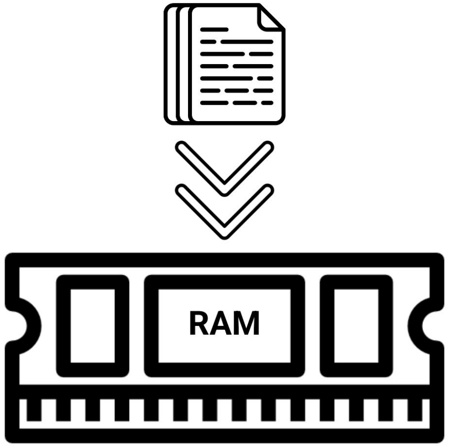


Enriching Streaming Data

Enriching Streaming Data

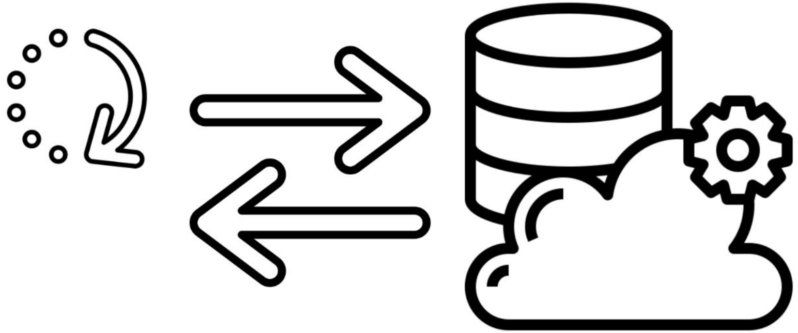
(Slowly) updating side inputs

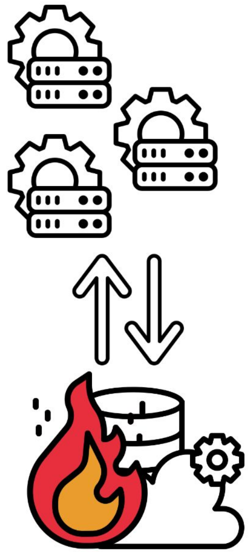




Enriching Streaming Data

(Batched) RPC calls





Is there another way?

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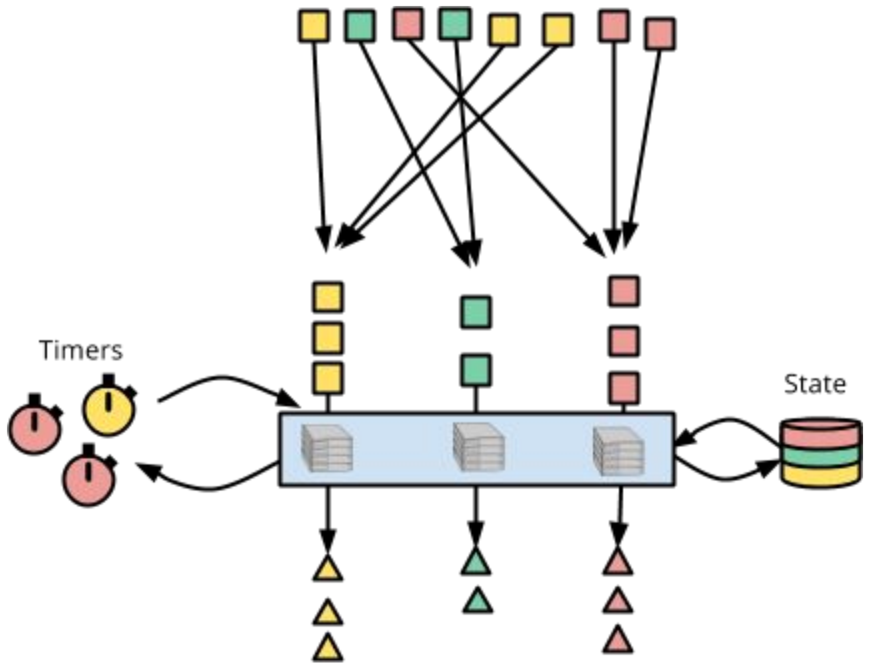
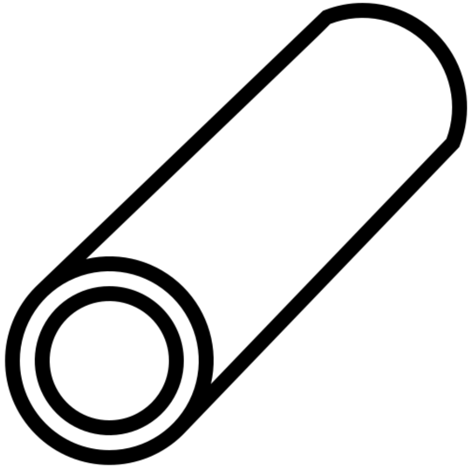
State & Timers



Implementation details

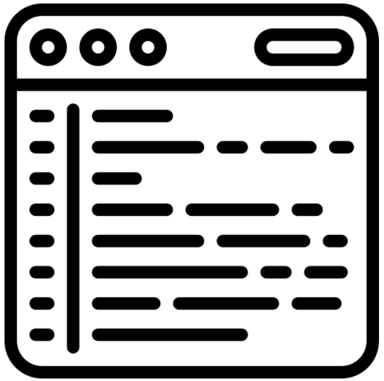
Message Queues

kafka

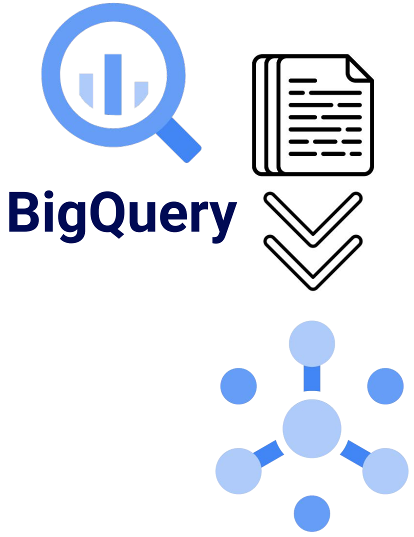


Google Pub/Sub

1. Preload the Lookup Topic



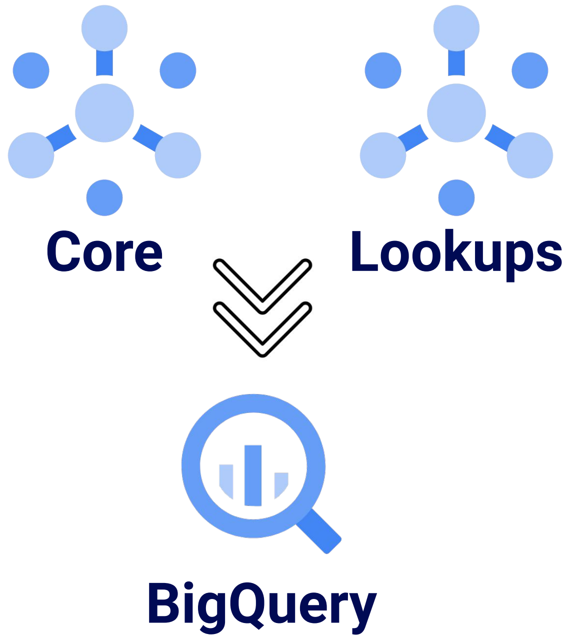
(Shell) Script



Pub/Sub
Topic Lookups

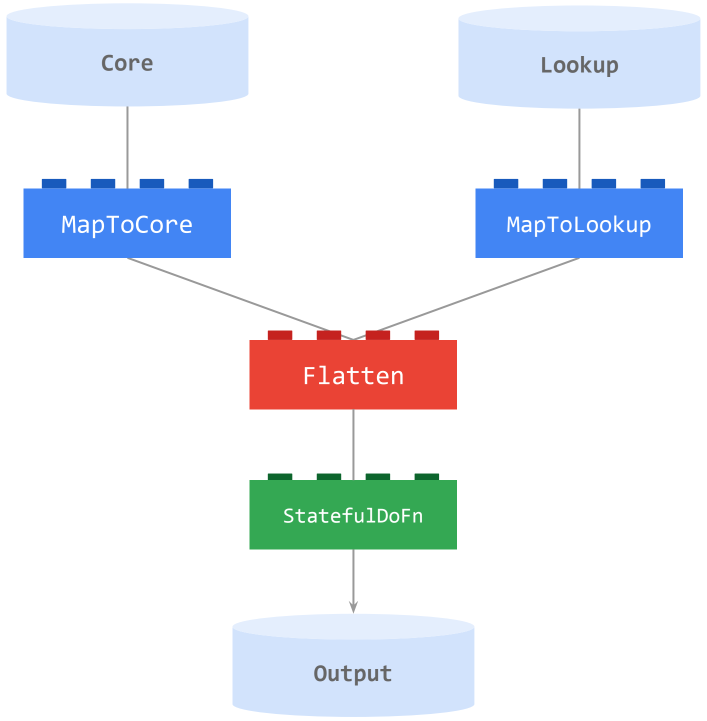
2. Start the Beam Pipeline

(Shell) Script

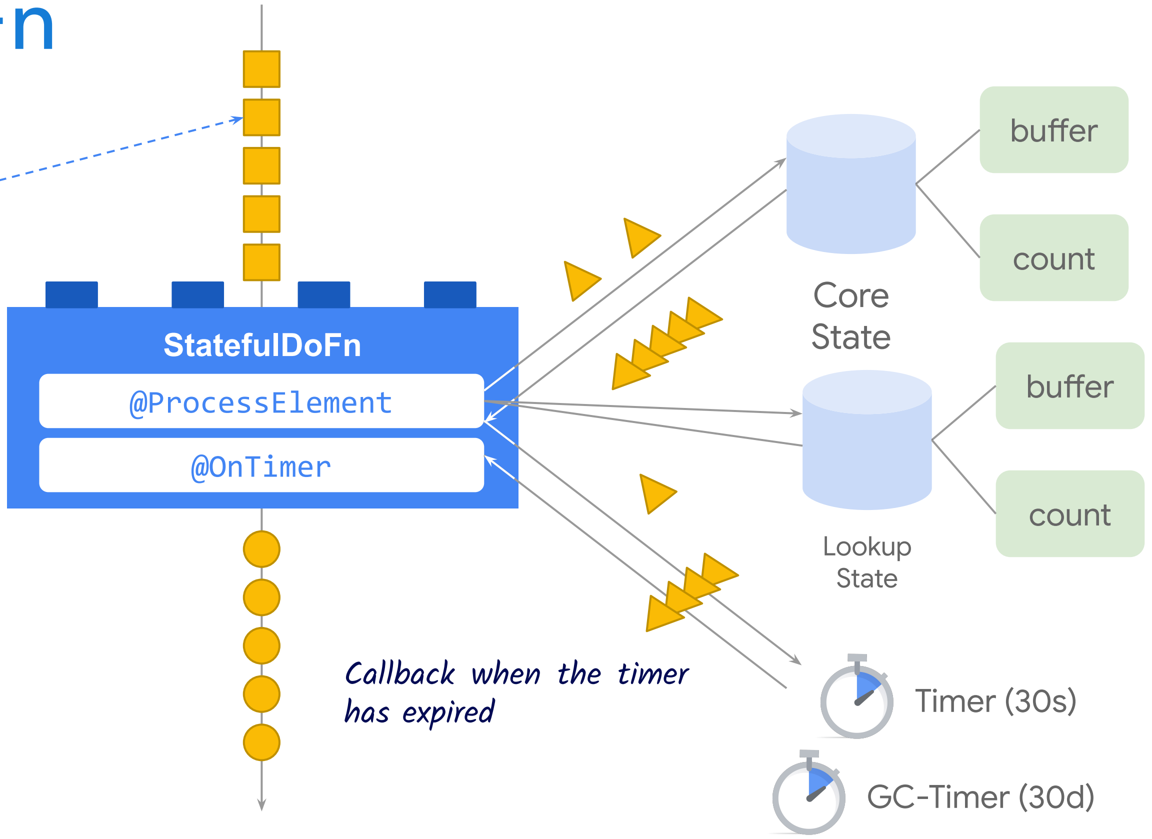


The Beam Pipeline

The Beam Pipeline



The StatefulDoFn



The input needs to be a PCollection *of* KV

Callback when the timer has expired

The StatefulDoFn (2)

```python
class StatefulJoinFn(beam.DoFn):
 BUFFER_TIMER = TimerSpec('expiry', TimeDomain.WATERMARK)
 GC_TIMER = TimerSpec('gc_timer', TimeDomain.WATERMARK)

 CORE_BUFFER_BAG = BagStateSpec('core', coders.registry.get_coder(CoreType))
 CORE_COUNT_STATE = CombiningValueStateSpec('count_core', combine_fn=sum)
 LOOKUP_BUFFER_BAG = BagStateSpec('lookup', coders.registry.get_coder(LookupType))
 LOOKUP_COUNT_STATE = CombiningValueStateSpec('count_lookup', combine_fn=sum)

 def __init__(self):
   self.time_seconds = 30

 def process(
     self,
     input_element: Union[Tuple[str, CoreType], Tuple[str, LookupType]],
     element_timestamp=beam.DoFn.TimestampParam,
     core_count_state=beam.DoFn.StateParam(CORE_COUNT_STATE),
     core_state=beam.DoFn.StateParam(CORE_BUFFER_BAG),
     lookup_count_state=beam.DoFn.StateParam(LOOKUP_COUNT_STATE),
     lookup_state=beam.DoFn.StateParam(LOOKUP_BUFFER_BAG),
     timer=beam.DoFn.TimerParam(BUFFER_TIMER),
     gc_timer=beam.DoFn.TimerParam(GC_TIMER),
 ): [...]
```

Don’t miss out!

Talk: “Design considerations to operate a stateful streaming pipeline as a service”
on Wednesday from 12:30-12:55 in Palisades
with Bhupinder and Israel!

Workshop: “Complex Event Processing With State & Timers”
on Thursday from 10:45-12:15 in Palisades
with Miren and Israel!

Thank you ❤️

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References

- Prathap Reddy - Cache reuse across DoFn's in Beam: https://medium.com/google-cloud/cache-reuse-across-dofns-in-beam-a34a926db848
- Chirag Shankar - Stateful Processing In Apache Beam/Cloud Dataflow: https://medium.com/google-cloud/stateful-processing-in-apache-beam-cloud-dataflow-109d1880f76a
- Iñigo San Jose - Dataflow Cookbook: https://cloud.google.com/blog/products/data-analytics/introducing-dataflow-cookbook
- Kenneth Knowles - Timely (and Stateful) Processing with Apache Beam: https://beam.apache.org/blog/timely-processing/

github.com/tkaymak/beam_summit_2023_talk

Do you have a Question for us?

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Deduplicating and analysing time-series data with Apache Beam & QuestDB

Javier Ramirez

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Design considerations to operate a stateful streaming pipeline as a service

Israel Herraiz
& Bhupinder Sindhwani

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Parallelizing Skewed Hbase Regions using Splittable Dofn

Prathap Reddy
Google

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Agenda

- HBase and BigTable Overview
- HBase Snapshot Storage Structure
- Import Snapshots Pipeline
- Challenges & Resolutions

HBase

- Open Source Distributed Scalable Big Data Store
- Random read/write access patterns
- Automatic sharding of tables across regions
- Server side processing using Coprocessors

Bigtable

- Fully managed by Google
- High availability and automatic replication
- Auto Scaling based on application traffic
- Enterprise grade security and control

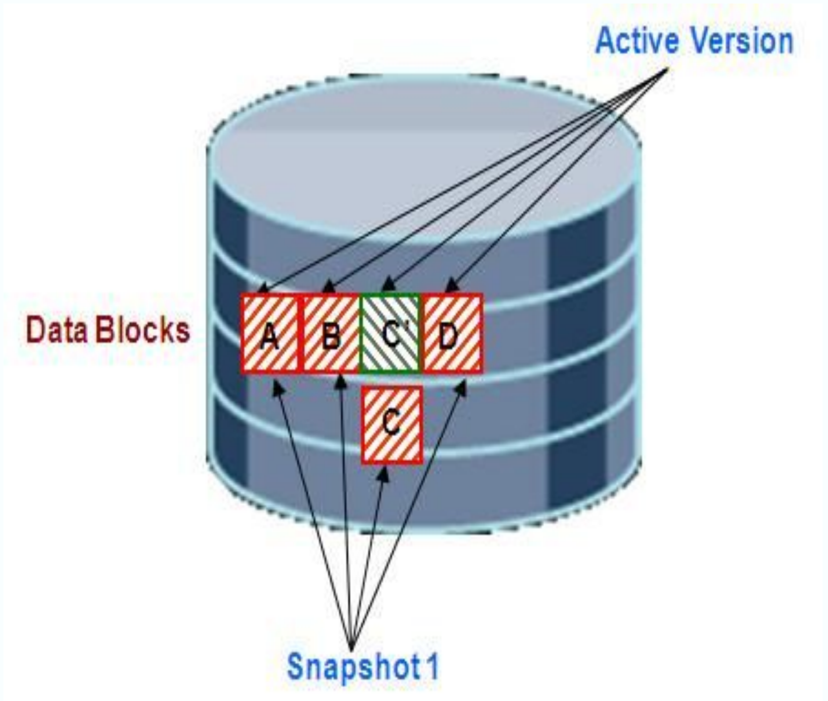
Hbase Snapshots

- Representation of table at point in time
- Zero Data Copying
- Minimal impact on region servers
- Creating Snapshot

```
hbase> snapshot 'tableName', 'snapshotName'
```

- Export Snapshot to Google Cloud Storage

```
hbase> hbase \
org.apache.hadoop.hbase.snapshot.ExportSnapshot \
-snapshot $SNAPSHOT_NAME \
-copy-to  $BUCKET_NAME$SNAPSHOT_EXPORT_PATH/data \
-mappers  $NUM_MAPPERS
```



Hbase Storage Structure

```
Table                    (HBase table)
    Region               (Regions for the table)
        Store            (Store per ColumnFamily for each Region for the table)
            MemStore     (MemStore for each Store for each Region for the table)
            StoreFile    (StoreFiles for each Store for each Region for the table)
                Block    (Blocks within a StoreFile within a Store for each Region for the table)
```

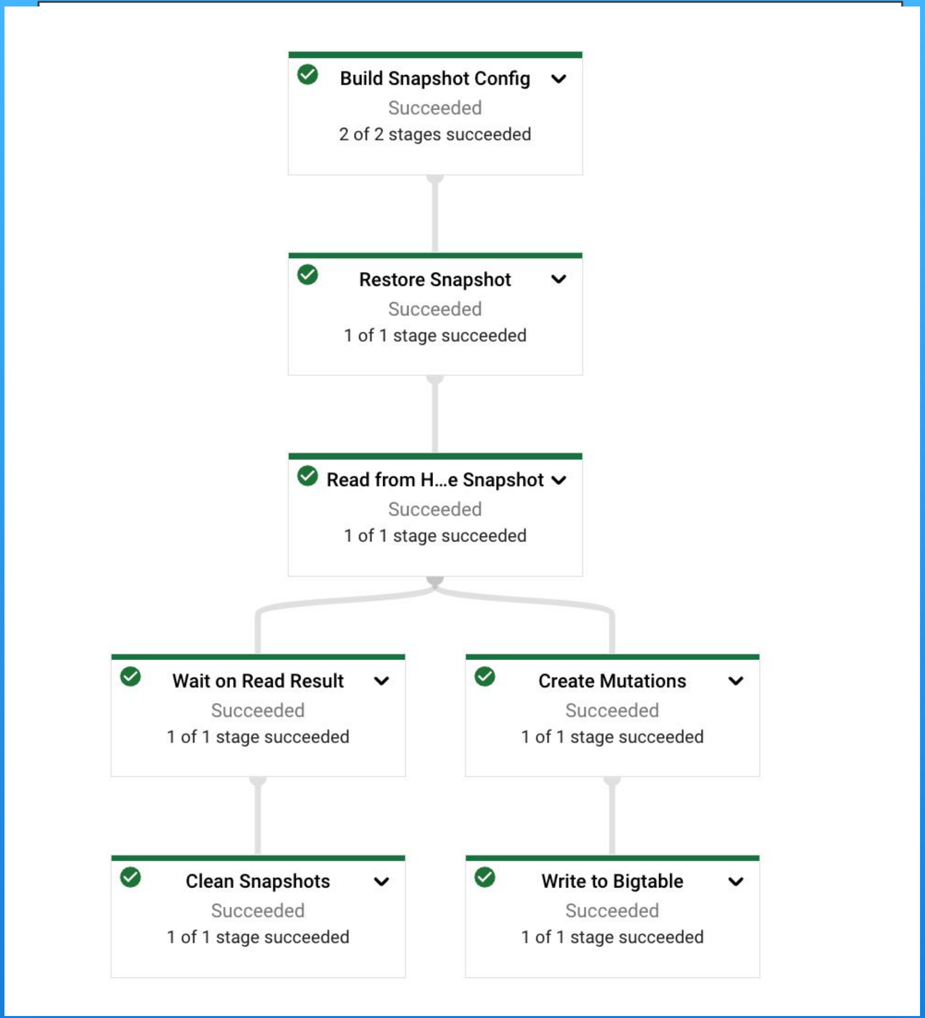
* *Region represents a key range (startKey - endKey) and may live on a different region server*

* *Store Files are also known as Hfiles*

Importing to BigTable (v1)

- ❖ Build Snapshot Config
- ❖ Read Snapshot (HadoopFormatIO)
- ❖ Create Mutation
- ❖ Write to Bigtable

* Pipeline Source



Challenges

- Skewed regions
- Single Table Snapshots

Importing to BigTable (v2)

- ❖ Read multiple Snapshot Configs
- ❖ List Regions
- ❖ Read Region Splits (in parallel)
- ❖ Create mutation
- ❖ Write to multiple tables in Bigtable

* Snapshot config provides snapshot name, source path and target table name

Splittable Dofn

- Powerful abstraction with support to split each element of work

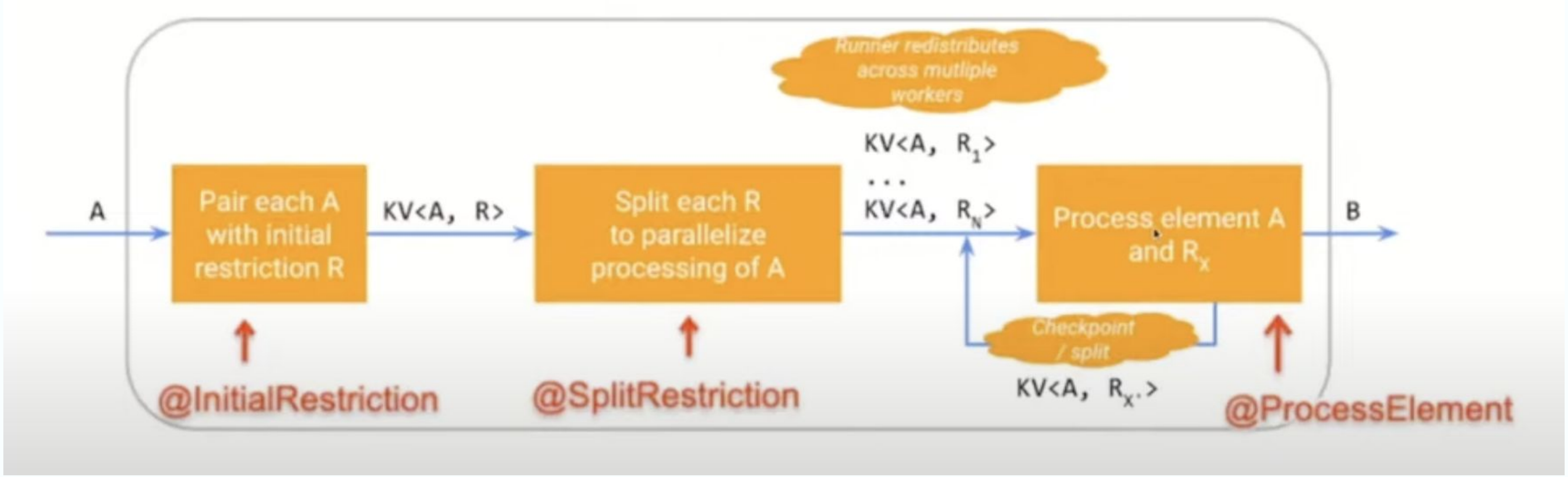
  (element, restriction) -> (element,restriction_1) + (element, restriction_2)

- Dynamic rebalancing to avoid stragglers

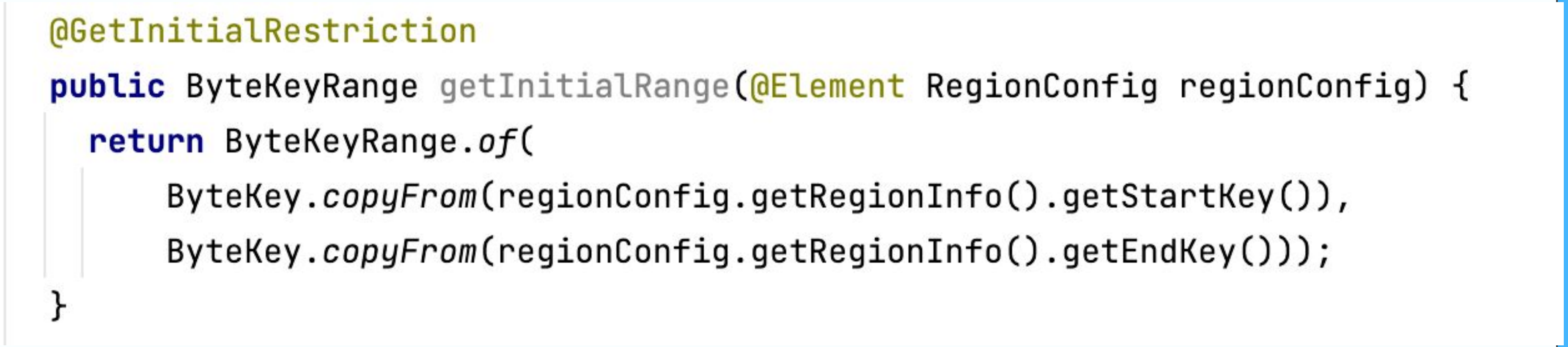
Splittable Dofn

- Restriction represents a portion of work (e.g: OffsetRange, ByteKeyRange)
- Similar Syntax as DoFn with an additional **RestrictionTracker** parameter to ***@ProcessElement*** method
- ***@GetInitialRestriction*** *- Represents the complete work for a given element*
- ***@SplitRestriction*** (Optional) - Supports pre-splitting initial restriction

Execution of Splittable Dofn

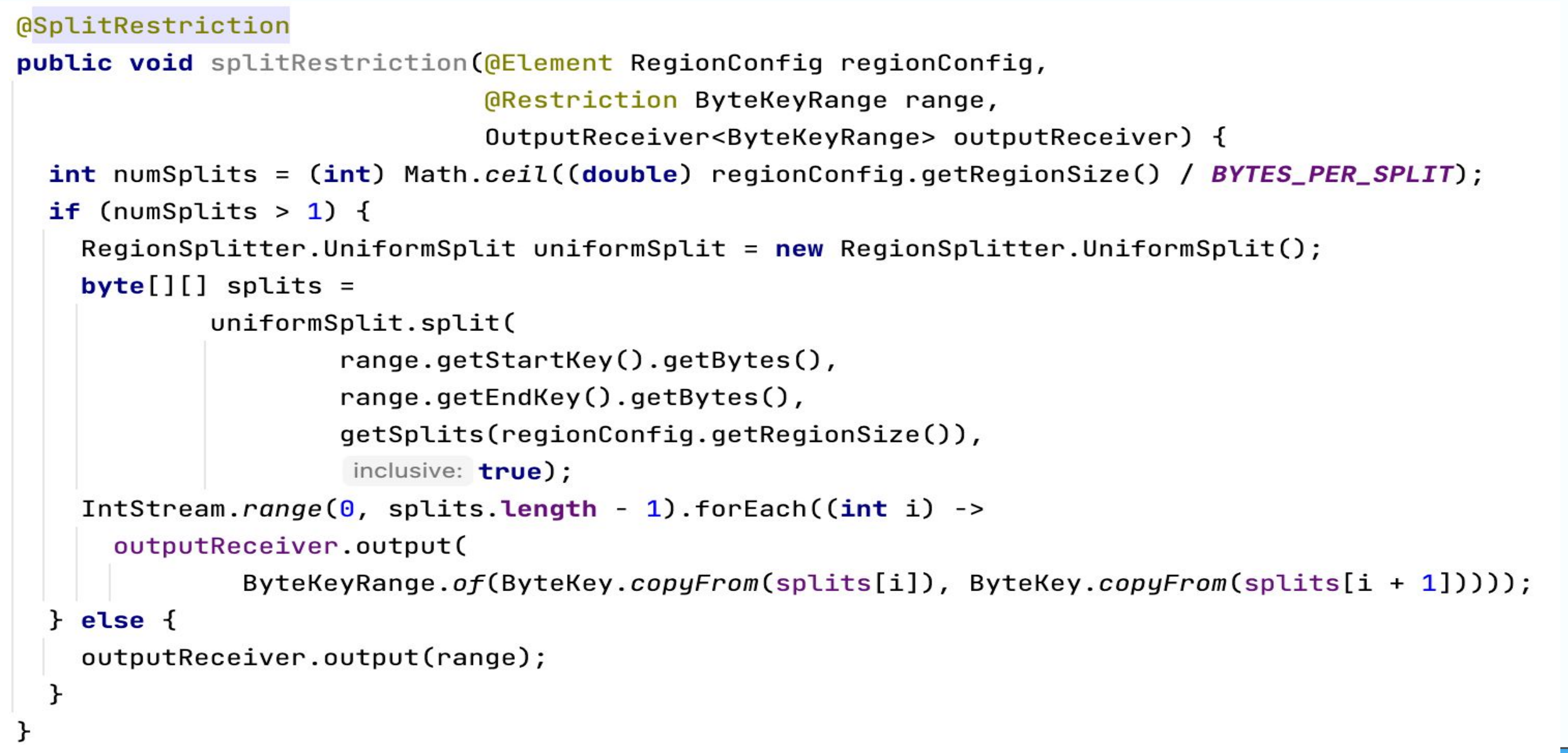


Splittable Dofn



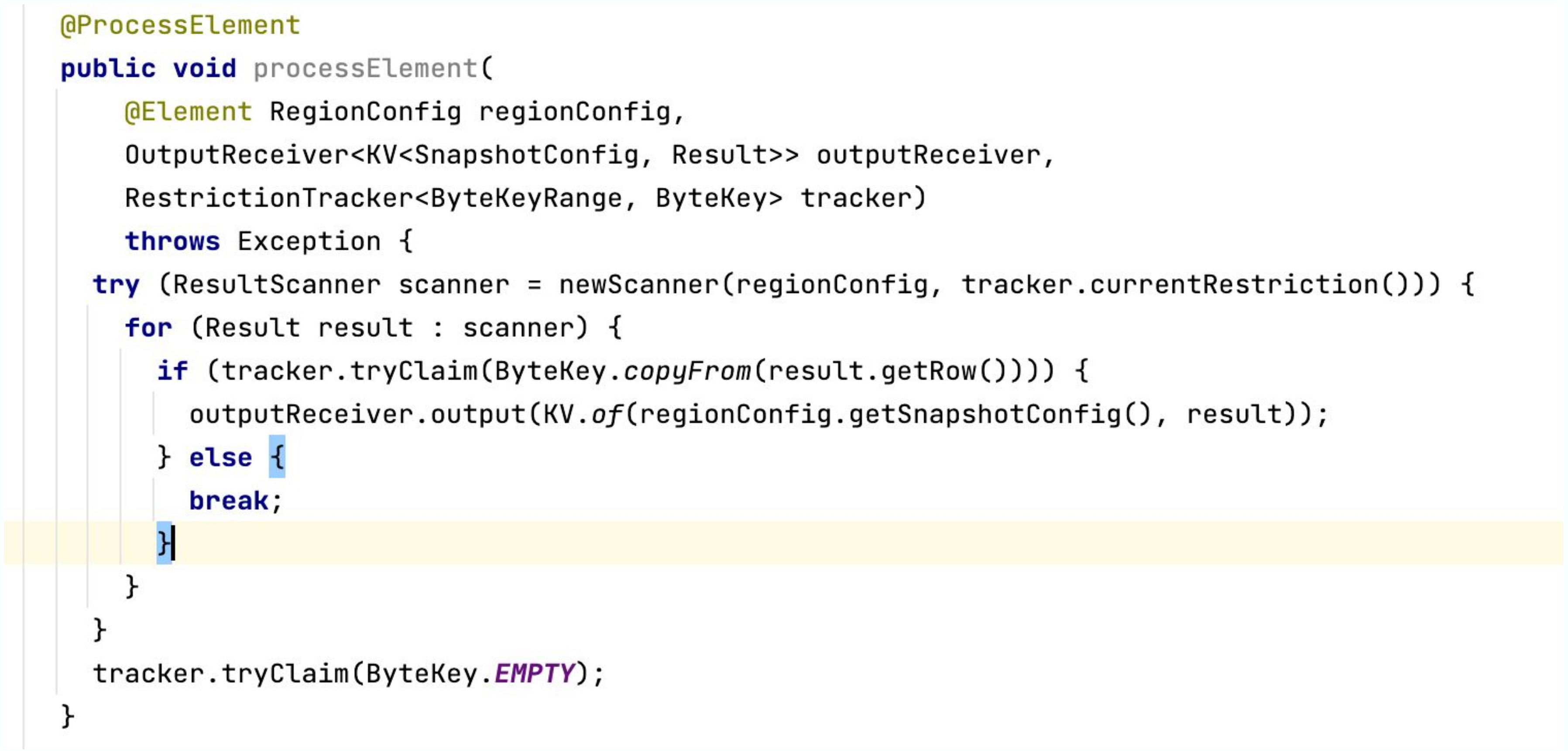
```java
@GetInitialRestriction
public ByteKeyRange getInitialRange(@Element RegionConfig regionConfig) {
  return ByteKeyRange.of(
      ByteKey.copyFrom(regionConfig.getRegionInfo().getStartKey()),
      ByteKey.copyFrom(regionConfig.getRegionInfo().getEndKey()));
}
```

Splittable Dofn



```java
@SplitRestriction
public void splitRestriction(@Element RegionConfig regionConfig,
                             @Restriction ByteKeyRange range,
                             OutputReceiver<ByteKeyRange> outputReceiver) {
  int numSplits = (int) Math.ceil((double) regionConfig.getRegionSize() / BYTES_PER_SPLIT);
  if (numSplits > 1) {
    RegionSplitter.UniformSplit uniformSplit = new RegionSplitter.UniformSplit();
    byte[][] splits =
            uniformSplit.split(
                    range.getStartKey().getBytes(),
                    range.getEndKey().getBytes(),
                    getSplits(regionConfig.getRegionSize()),
                    inclusive: true);
    IntStream.range(0, splits.length - 1).forEach((int i) ->
      outputReceiver.output(
              ByteKeyRange.of(ByteKey.copyFrom(splits[i]), ByteKey.copyFrom(splits[i + 1]))));
  } else {
    outputReceiver.output(range);
  }
}
```

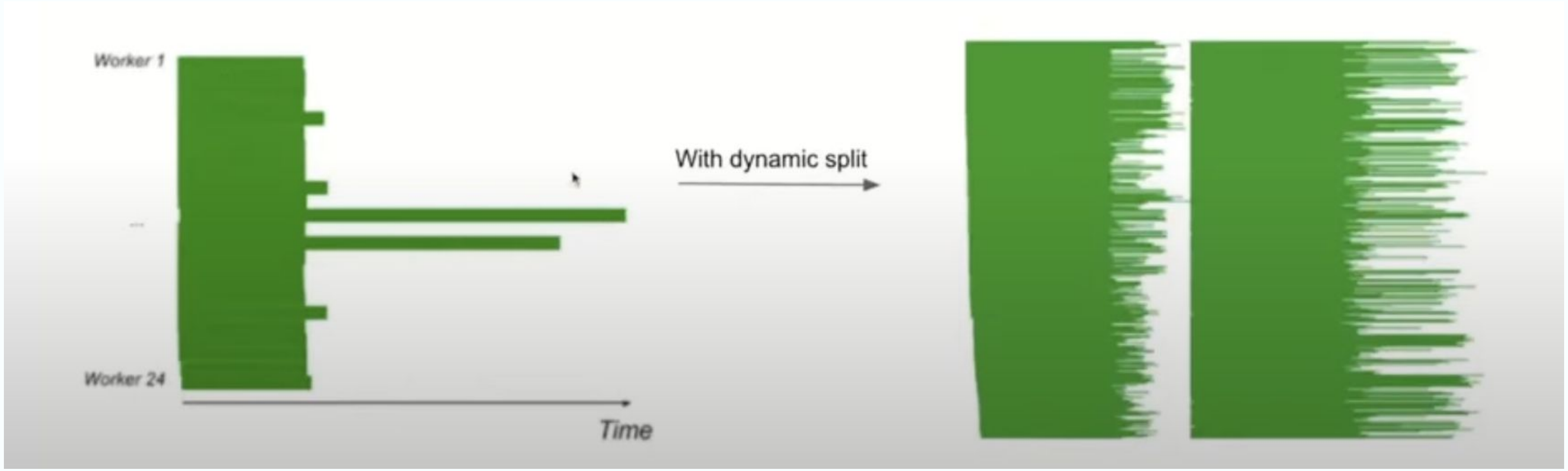
Splittable Dofn



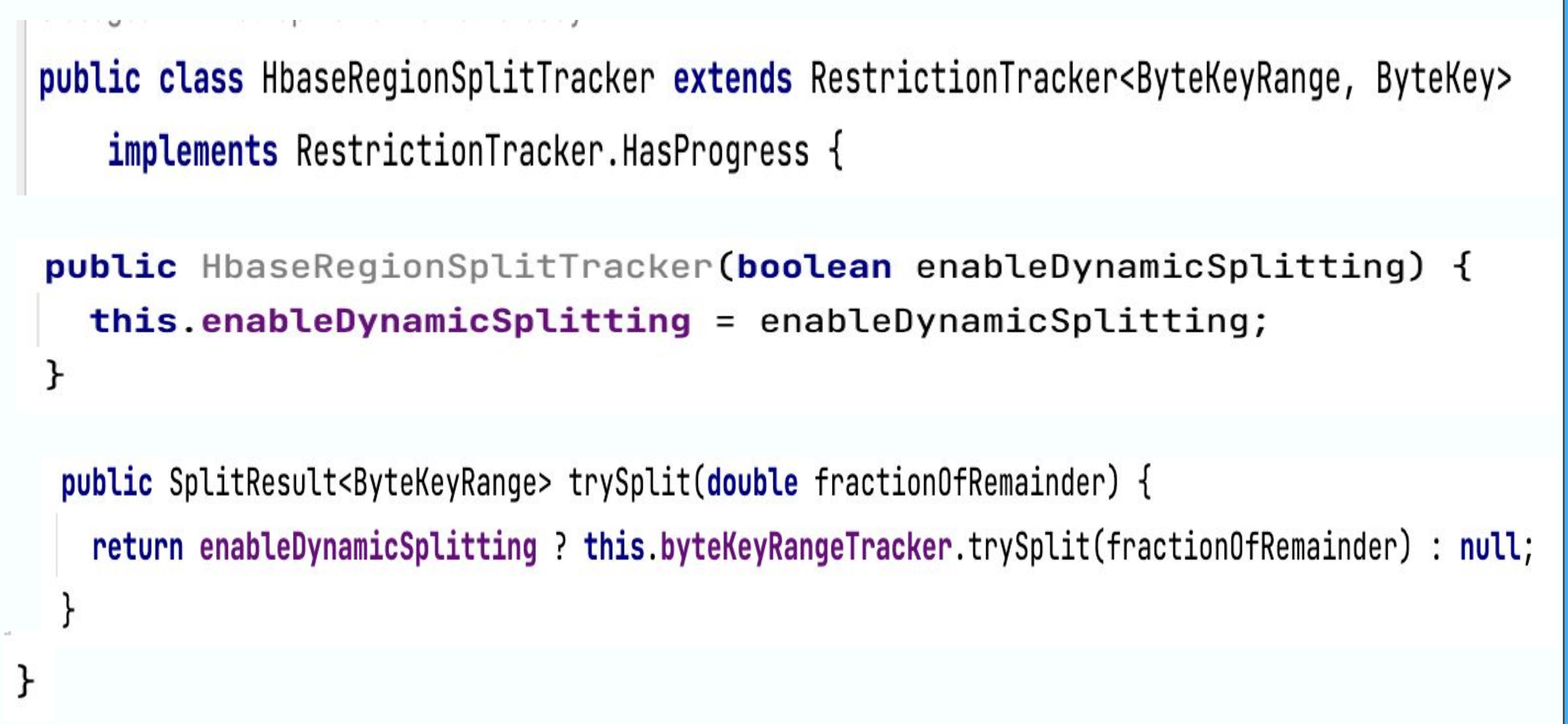
```java
@ProcessElement
public void processElement(
    @Element RegionConfig regionConfig,
    OutputReceiver<KV<SnapshotConfig, Result>> outputReceiver,
    RestrictionTracker<ByteKeyRange, ByteKey> tracker)
    throws Exception {
  try (ResultScanner scanner = newScanner(regionConfig, tracker.currentRestriction())) {
    for (Result result : scanner) {
      if (tracker.tryClaim(ByteKey.copyFrom(result.getRow()))) {
        outputReceiver.output(KV.of(regionConfig.getSnapshotConfig(), result));
      } else {
        break;
      }
    }
  }
  tracker.tryClaim(ByteKey.EMPTY);
}
```

Dynamic Splitting

- Splits current processing element into primary and residual parts
- Runners schedules residual part onto another instance



Dynamic Splitting

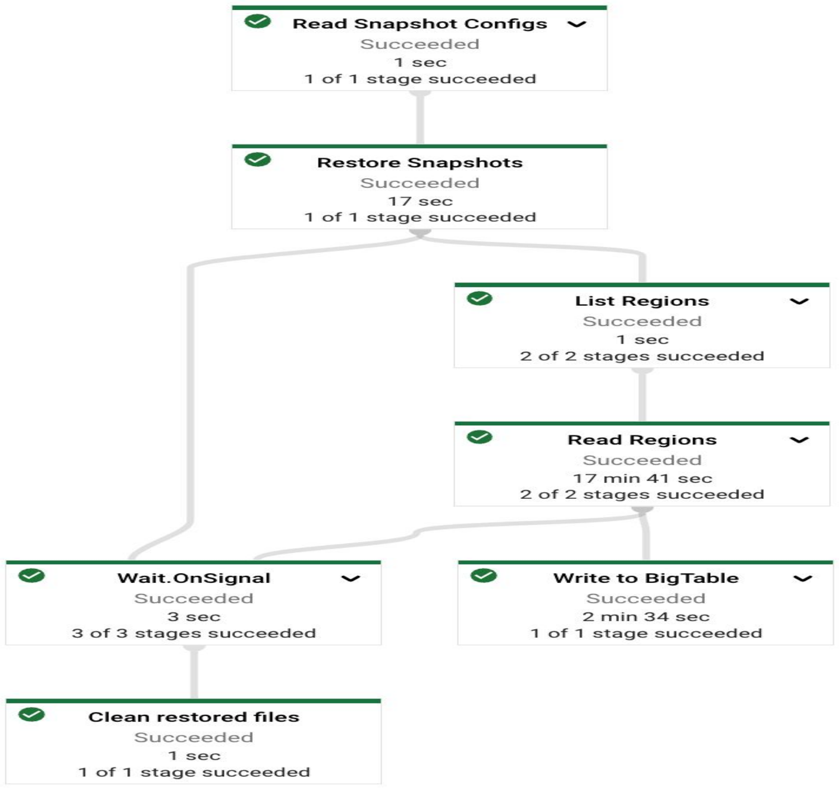


```
public class HbaseRegionSplitTracker extends RestrictionTracker<ByteKeyRange, ByteKey>
    implements RestrictionTracker.HasProgress {

public HbaseRegionSplitTracker(boolean enableDynamicSplitting) {
  this.enableDynamicSplitting = enableDynamicSplitting;
}

  public SplitResult<ByteKeyRange> trySplit(double fractionOfRemainder) {
    return enableDynamicSplitting ? this.byteKeyRangeTracker.trySplit(fractionOfRemainder) : null;
  }
}
```

Pipeline Graph



Read Snapshot Configs
Succeeded
1 sec
1 of 1 stage succeeded

Restore Snapshots
Succeeded
17 sec
1 of 1 stage succeeded

List Regions
Succeeded
1 sec
2 of 2 stages succeeded

Read Regions
Succeeded
17 min 41 sec
2 of 2 stages succeeded

Wait.OnSignal
Succeeded
3 sec
3 of 3 stages succeeded

Write to BigTable
Succeeded
2 min 34 sec
1 of 1 stage succeeded

Clean restored files
Succeeded
1 sec
1 of 1 stage succeeded

Benchmark Tests

- ❖ Snapshot Datasets
  - ➢ 104 GB with 19 regions (6 regions of 3.5 GB in size and remaining 13 regions are approximately 7 GB)
  - ➢ 875 GB with 14 regions (Mixed region sizes varying from 30GB to 98 GB)
- ❖ Enabled and Disabled Dynamic Splitting
- ❖ 10 - 30% improvements in Job Duration with reduced VCPU Consumption

* Beyond Initial splits enabling further splitting didn’t yield significant differences

Prathap Reddy

QUESTIONS?

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https://www.linkedin.com/in/prathapparvathareddy

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Case study: Using statefulDofns to process late arriving data

Amruta Deshmukh

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CI CD for Dataflow with Flex Templates and Cloud Build

Mazlum Tosun

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The Future of the Apache Beam Community

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