Flow Partitioning

Module Objectives

In this module, you will learn:

- Flowlet batch execution
- Instances and scaling of Flowlets
- Flow partitioning
- Different strategies for partitioning
- Configuring the number of Flowlet instances

Recap of the Flow System 1/2

Flows:

- User-implemented real-time stream processors
- Comprised of one or more **Flowlets** wired together into a directed acyclic graph or DAG

Flowlets:

- Pass data between one another
- Able to perform custom logic
- Execute data operations for each individual data object it processes
- Processes the data objects from its input one by one
- Multiple inputs are consumed (by default) in a round-robin fashion

Recap of the Flow System 1/2

When processing a single input object, all operations, including the removal of the object from the input, and emission of data to the outputs, are executed in a transaction

This provides:

- *Atomicity, Consistency, Isolation,* and *Durability* (ACID) properties
- Helps assure a unique and core property of the Flow system: atomic and "exactly-once" processing of each input object by each Flowlet in the DAG

Flowlet Batch Execution

By default, a Flowlet processes a single data object at a time within a single transaction

Increase throughput by processing batches of data objects within the same transaction:

```
@Batch(100)
@ProcessInput
public void process(Iterator<String> words) {
  ...
}
```

In this example, up to 100 data objects can be read from the input and processed at one time

Flowlets, Instances and Scaling

- Can have one or more instances of any given Flowlet
- Each consumes a disjoint partition of each input queue
- Enables you to scale your application to meet capacity at runtime
- Can control the number of instances, either:
    - Programmatically using the REST API, or via
    - The Continuuity Reactor Dashboard
- In the **Local Reactor**, multiple Flowlet instances are run in threads, so in some cases actual performance may not be improved
- In the **Hosted** and **Enterprise Reactors** each Flowlet instance runs in its own Java Virtual Machine (JVM) with independent compute resources
- Scaling the number of Flowlets can improve performance and have a major impact depending on the implementation

Flow Partitioning Strategies

With have multiple instances of a Flowlet, the input queue is partitioned among the Flowlets

A Flowlet can specify one of these three partitioning strategies:

- **First-in first-out (FIFO):** Default strategy
- **Round-robin:** The number of items is distributed evenly among the instances
- **Hash-based:** The emitting Flowlet annotates each data object with a hash key

Details of Flow Partitioning Strategies 1/2

First-in first-out (FIFO):

- Every Flowlet instance receives the next available data object in the queue
- Since multiple consumers may compete for the same data object, access to the queue must be synchronized
- This may not always be the most efficient strategy

Round-robin:

- The number of items is distributed evenly among the instances
- In general, the most efficient partitioning, more efficient than FIFO
- Not ideal when the application needs to group objects into buckets according to business logic

Details of Flow Partitioning Strategies 2/2

Hash-based:

- The emitting Flowlet annotates each data object with a hash key
- Ensures that all objects of a given key are received by the same consumer instance
- Useful for aggregating by key and can help reduce write conflicts

Example Flow Partitioning Strategy: FIFO

A Flowlet that counts words and uses the default strategy of FIFO:

```
public class Counter extends AbstractFlowlet {

  @UseDataSet("wordCounts")
  private KeyValueTable wordCountsTable;

  @ProcessInput("wordOut")
  public void process(String word) {
    this.wordCountsTable
        .increment(Bytes.toBytes(word), 1L);
  }
}
```

Example Flow Partitioning Strategy: Round-robin 1/2

To increase throughput when this Flowlet has many instances, specify round-robin partitioning:

```
@RoundRobin
@ProcessInput("wordOut")
public void process(String word) {
  this.wordCountsTable.increment(Bytes.toBytes(word), 1L);
}
```

Example Flow Partitioning Strategy: Round-robin 2/2

If we have three instances of this Flowlet, every instance will receive every third word

For the sequence of words in the sentence

I scream, you scream, we all scream for ice cream:

- The first instance receives: *I scream scream cream*
- The second instance receives: *scream we for*
- The third instance receives: *you all ice*

Potential problem: the first two instances might both attempt to increment the counter for the word *scream* at the same time, leading to a write conflict

Example Flow Partitioning Strategy: Hash-based 1/3

To avoid conflicts, use hash-based partitioning:

```
@HashPartition("wordHash")
@ProcessInput("wordOut")
public void process(String word) {
  this.wordCountsTable.increment(Bytes.toBytes(word), 1L);
}
```

Only one of the Flowlet instances will receive the word *scream*, and there are no more write conflicts

Example Flow Partitioning Strategy: Hash-based 2/3

To use, the emitting Flowlet must annotate each data object with the partitioning key:

```
@Output("wordOut")
private OutputEmitter<String> wordOutput;
...
public void process(StreamEvent event) {
  ...
  // emit the word with the partitioning
  // key name "wordHash"
  wordOutput.emit(word, "wordHash", word.hashCode());
}
```

Example Flow Partitioning Strategy: Hash-based 3/3

- The emitter must use the same name ("wordHash") for the key that the consuming Flowlet specifies as the partitioning key
- If the output is connected to more than one Flowlet, you can also annotate a data object with multiple hash keys
- Each consuming Flowlet can then use different partitioning
- Useful if you want to aggregate by multiple keys, such as counting purchases by product ID as well as by customer ID

Combining Flow Partitioning and Batch Execution

Partitioning can be combined with batch execution:

```
@Batch(100)
@HashPartition("wordHash")
@ProcessInput("wordOut")
public void process(Iterator<String> words) {
   ...
```

Number of Flowlet Instances: REST API 1/3

You can query and set the number of instances executing a given Flowlet by using the `instances` parameter with HTTP GET and PUT methods:

```
GET <base-url>/apps/<app-id>/flows/<flow-id>/flowlets/
    <flowlet-id>/instances
PUT <base-url>/apps/<app-id>/flows/<flow-id>/flowlets/
    <flowlet-id>/instances
```

with the arguments as a JSON string in the body:

```
{ "instances" : <quantity> }
```

Parameter : ***Description***

`<app-id>` : Name of the Application being called `<flow-id>` : Name of the Flow `<flowlet-id>` : Name of the Flowlet `<quantity>` : Number of instances to be used

Number of Flowlet Instances: REST API 2/3

Example

Find out the number of instances of the Flowlet *saver* in the Flow *WhoFlow* of the Application *HelloWorld*

```
GET <base-url>/apps/HelloWorld/flows/WhoFlow/flowlets/
 saver/instances
```

Number of Flowlet Instances: REST API 3/3

Example

Set the number of instances of the Flowlet *saver* in the Flow *WhoFlow* of the Application *HelloWorld*

```
PUT <base-url>/apps/HelloWorld/flows/WhoFlow/flowlets/
 saver/instances
```

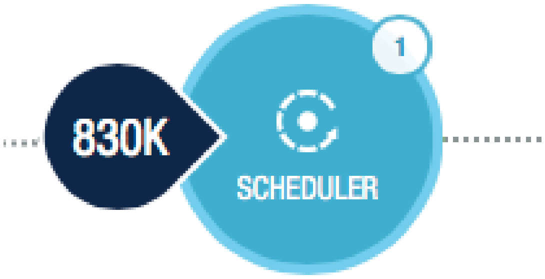
with the arguments as a JSON string in the body:

```
{ "instances" : 2 }
```

Setting Number of Flowlet Instances: Dashboard 1/2

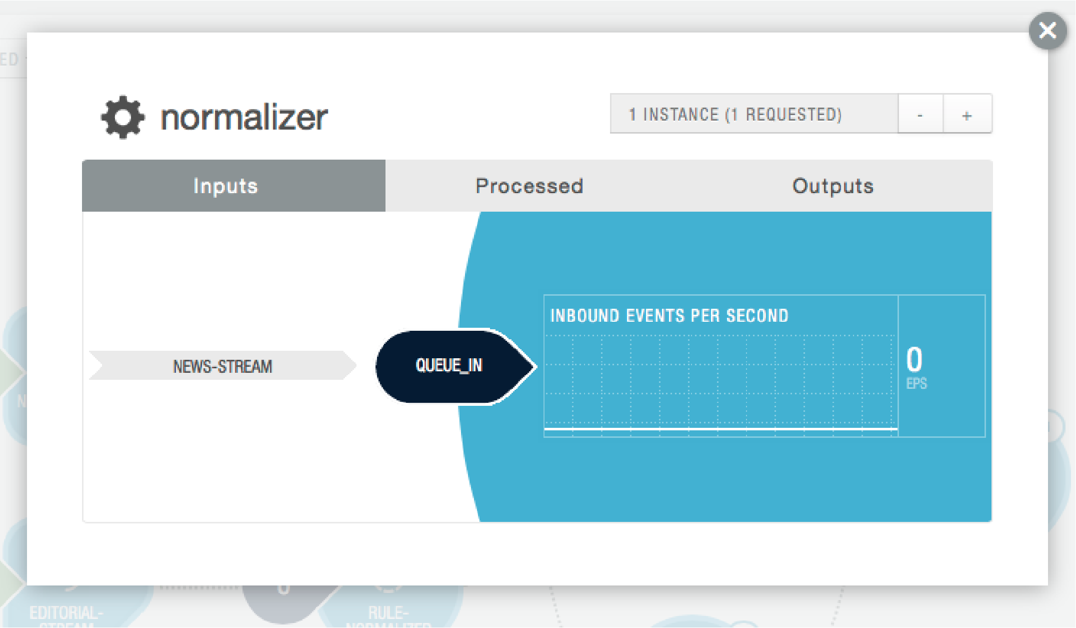
A Flowlet icon in the DAG shows:

- The name of the Flowlet
- The number of events processed in the current sampling period
- The number of instances of that Flowlet in the small circle in the upper right of the icon:



Setting Number of Flowlet Instances: Dashboard 2/2

Clicking on a Flowlet's icon in the DAG brings up the configuration dialog for setting the number of instance of the Flowlet:



normalizer

1 INSTANCE (1 REQUESTED)

Module Summary

You should now be able to:

- Specify Flowlet batch execution
- Describe the different Flow partitioning strategies
- Select and specify an appropriate Flow partitioning strategy
- Configure the number of Flowlet instances

Module Completed