CS 327E Class 5

February 24, 2020

No Quiz Today

Milestone 4 Feedback

Did you run into any major issues with the assignment?

A. My group had problems identifying entity types.
B. My group had problems decomposing large tables.
C. A and B.
D. My group did **not** face any big problems.

Beam + Dataflow Setup

https://github.com/cs327e-spring2020/snippets/wiki/Beam--&-Dataflow-Setup

Beam/Dataflow Setup Outcome

Did you successfully complete your setup?

A. Yes, the Wordcount jobs ran without errors.
B. No, I got stuck somewhere and need help.
C. I’m still setting things up and need more time to finish.

Dataflow Concepts

- A system for processing arbitrary computations on large amounts of data
- Can process batch data and streaming data using the same code
- Uses Apache Beam, an open-source programming model
- Designed to be very scalable, millions of QPS

Apache Beam Concepts

- A model for describing data and data processing operations:
  - `Pipeline`: a data processing task from start to finish
  - `PCollection`: a collection of data elements
  - `Transform`: a data transformation operation
- SDKs for Java, Python and Go
- Executed in the cloud on Dataflow, Spark, Flink, etc.
- Executed locally with Direct Runner for dev/testing

Beam Pipeline

- `Pipeline` = A directed acyclic graph where the nodes are the `Transforms` and the edges are the `PCollections`
- General Structure of a `Pipeline`:
  - Reads one or more data sources as input `PCollections`
  - Applies one or more `PTransforms` on `PCollections`
  - Outputs resulting `PCollection` as one or more data sinks
- Executed as a single unit
- Run in batch or streaming mode

PCollection

- `PCollection` = A collection of data elements, either bounded or unbounded
- Elements can be made up primitive and complex types
- `PCollections` are distributed across machines
- `PCollections` are immutable
- Created from a data source or a `PTransform`
- Written to a data sink or passed to another `PTransform`

PTransform

All operations on data in beam are different kinds of `PTransforms`

- Element-wise:
  - maps 1 input to (1, 0, many) outputs
  - Examples: `ParDo`, `Map`, `FlatMap`
- Aggregation:
  - reduces many inputs to (1, fewer) outputs
  - Examples: `GroupByKey`, `CoGroupByKey`
- Composite: combines element-wise and aggregation
  - `GroupByKey -> ParDo`

PTransform Properties

- Serializable
- Parallelizable
- Idempotent

`ParDo` Transform

- `ParDo` = “Parallel Do”
- Maps 1 input to (1, 0, many) outputs
- Takes as input a `PCollection`
- Applies the user-defined `ParDo` to the input `PCollection`
- Outputs results as a new `PCollection`
- Typical usage: filtering, formatting, extracting parts of data, performing computations on data elements

Hello World Example 1

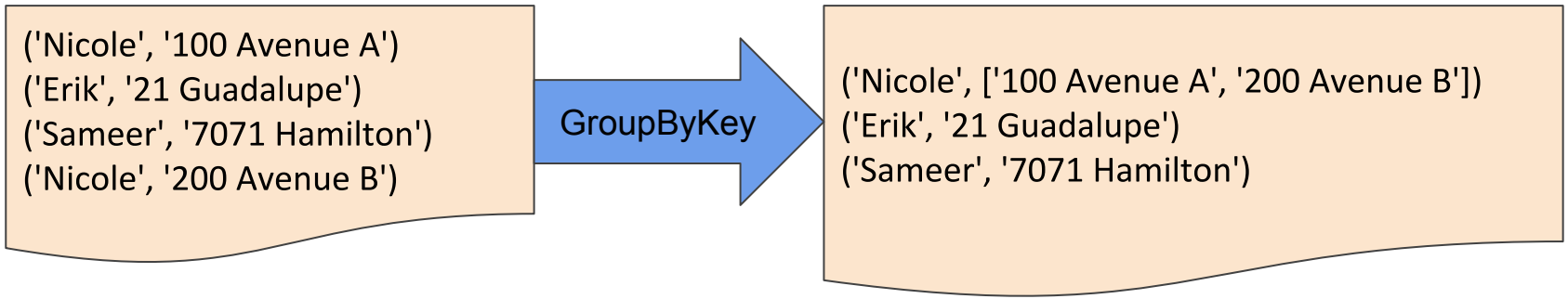
```python
import apache_beam as beam
from apache_beam.io import WriteToText
import logging

class MultiplyDoFn(beam.DoFn):
  def process(self, element):
     return [element * 10]

def run():
     PROJECT_ID = 'cs327e-sp2020' # change to your project id

     options = {
     'project': PROJECT_ID
     }
     opts = beam.pipeline.PipelineOptions(flags=[], **options)

     p = beam.Pipeline('DirectRunner', options=opts)

     in_pcoll = p | beam.Create([1, 2, 3, 4, 5])

     out_pcoll = in_pcoll | 'Multiply' >> beam.ParDo(MultiplyDoFn())

     out_pcoll | 'Write results' >> WriteToText('multiplied_numbers.txt')

     result = p.run()
     result.wait_until_finish()

if __name__ == '__main__':
  logging.getLogger().setLevel(logging.INFO)
  run()
```

Hello World Example 2

```python
import apache_beam as beam
from apache_beam.io import WriteToText
import logging

class SplitIntoWordsDoFn(beam.DoFn):
  def process(self, element):
      words = element.split()
      return [words]

def run():
      PROJECT_ID = 'cs327e-sp2020' # change to your project id

      options = {
      'project': PROJECT_ID
      }
      opts = beam.pipeline.PipelineOptions(flags=[], **options)

      p = beam.Pipeline('DirectRunner', options=opts)

      in_pcoll = p | beam.Create(['Hello Beam', 'This is awesome!'])

      out_pcoll = in_pcoll | 'Split Words' >> beam.ParDo(SplitIntoWordsDoFn())

      out_pcoll | 'Write results' >> WriteToText('split_words.txt')

      result = p.run()
      result.wait_until_finish()

if __name__ == '__main__':
  logging.getLogger().setLevel(logging.ERROR)
  run()
```

`GroupByKey` Transform

- Takes an input `PCollection` where each element is a (key, value) pair
- Groups the values by unique key
- Produces an output PCollection where each element is a (key, list(value)) pair



Hello World Example 3

```python
import apache_beam as beam
from apache_beam.io import WriteToText
import logging

class ExtractFirstLetterDoFn(beam.DoFn):
  def process(self, element):
     tuple = (element[0], element)
     return [tuple]

def run():
     PROJECT_ID = 'cs327e-sp2020' # change to your project id

     options = {
     'project': PROJECT_ID
     }
     opts = beam.pipeline.PipelineOptions(flags=[], **options)

     p = beam.Pipeline('DirectRunner', options=opts)

     in_pcoll = p | beam.Create(['apple', 'ball', 'car', 'bear', 'cheetah', 'ant'])

     out_pcoll = in_pcoll | 'Extract' >> beam.ParDo(ExtractFirstLetterDoFn())

     grouped_pcoll = out_pcoll | 'Grouped' >> beam.GroupByKey()

     grouped_pcoll | 'Write results' >> WriteToText('grouped_letters.txt')

     result = p.run()
     result.wait_until_finish()

if __name__ == '__main__':
  logging.getLogger().setLevel(logging.INFO)
  run()
```

Hands-on Exercises

```
git clone https://github.com/cs327e-spring2020/snippets.git
```

Practice Problem 1

Run `Student_beam1.py` from `college_modeled.ipynb`

iClicker Question 1

How many records are in the resulting `Student_beam` table?

A. 0
B. 12
C. 15

Practice Problem 2

1. Save `Student_beam1.py` as `Student_beam2.py`
2. Fix the logic such that the `Student`'s `status` field does **not** get dropped from the output.
3. Run `Student_beam2.py` from `college_modeled.ipynb`

iClicker Question 2

How many records are in the resulting `Student_beam` table?

A. 0
B. 12
C. 15

Writing Beam Code:

1. Start with a working code sample.
2. Test and debug one `Transform` block at a time.
3. Write temporary and final `PCollections` to log files.
4. Start assignment **early**. The Beam Python documentation is sparse and learning Beam requires **patience**, **perseverance**, and **experimentation**.
5. If you get stuck, go to OHs. If you can't make OHs, make an appointment with the TAs.

Milestone 5

http://www.cs.utexas.edu/~scohen/milestones/Milestone5.pdf