Real-time Semantic Enrichment & Online Clustering of Text Documents

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Machine Learning Engineer @ ML6

Outline

Motivation

Semantic Enrichment

Online Clustering

Stateful Processing

Demo

Summary

ML6

Machine Learning services company.

We help our clients build
machine learning applications using
technologies such as Apache Beam.

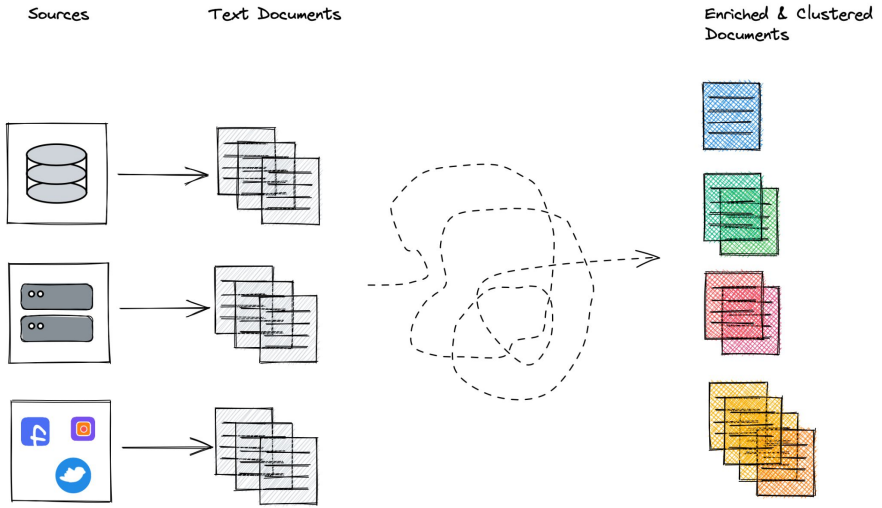
Motivation

Semantic Enrichment

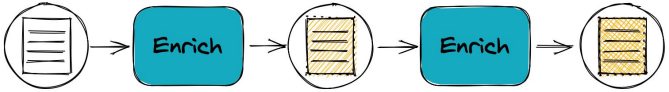
Add semantic information to text documents.

Online Clustering

Arrange documents into not yet defined groups as they come in.



Semantic Enrichment



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- Add geo location
- Categorise: Add predefined labels
- Sentiment Analysis
- Filter profanity
- Extract keywords
- Named-Entity Recognition/Linking
- Summarize
- Word/sentence/document embeddings
- OCR correction
- Translation
- Coreference Resolution

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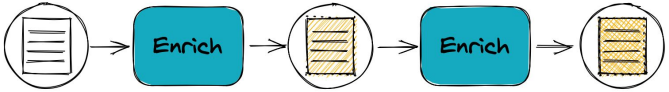

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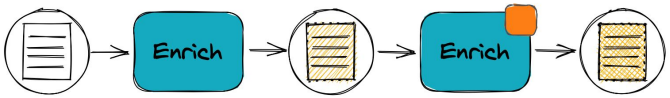

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    """Get the text embedding using the Universal Sentence Encoder."""

    def embed(self, texts):
        module_url = "https://tfhub.dev/google/universal-sentence-encoder/4"
        model = hub.load(module_url)

        if isinstance(texts, list):
            return np.array(model(texts))
        else:
            return np.array(model([texts]))

    def process(self, element, *args, **kwargs):
        text = element.get('text', "")

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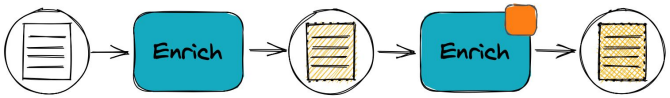

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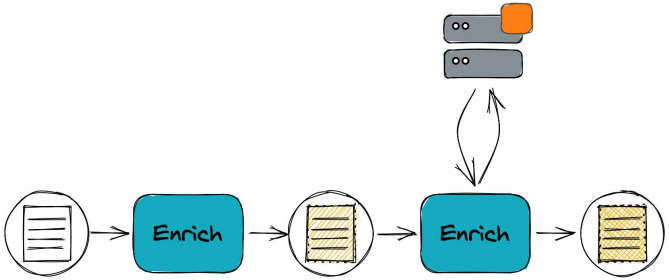

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        payload = {'text': text}
        response = requests.post(model_url, json=payload, headers=headers)
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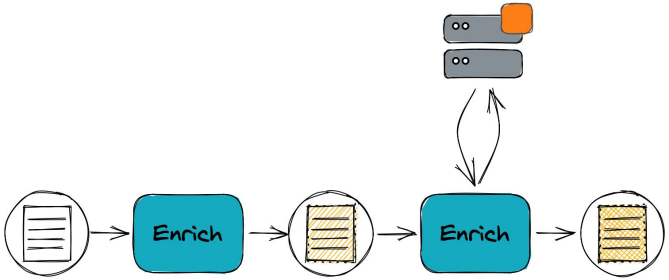

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Online Clustering

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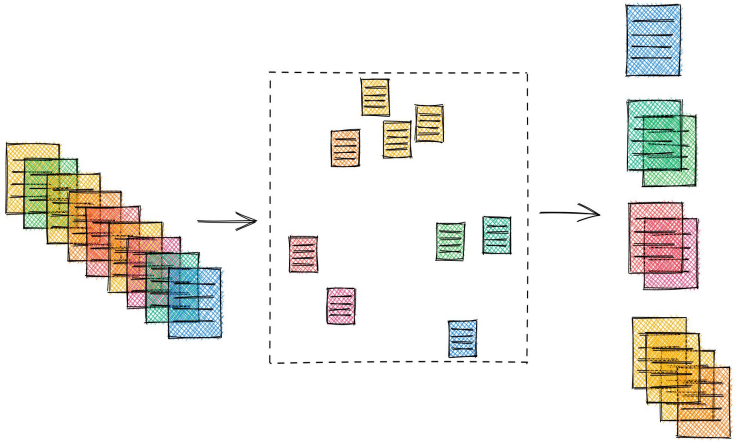

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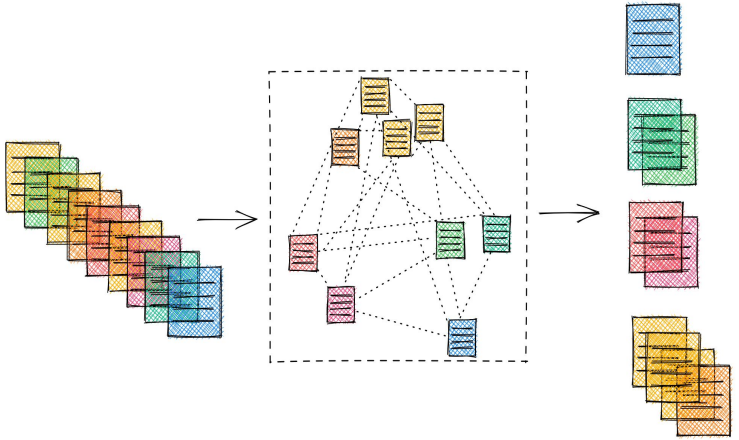

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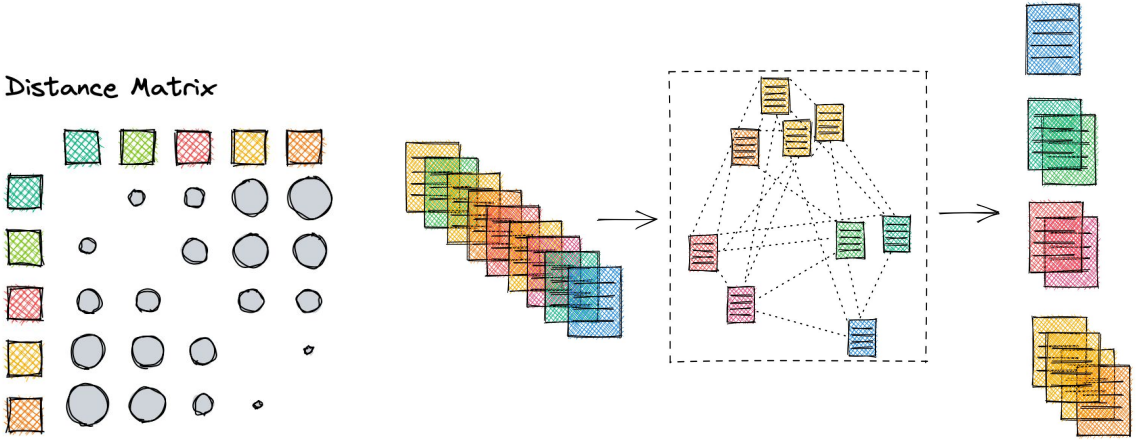

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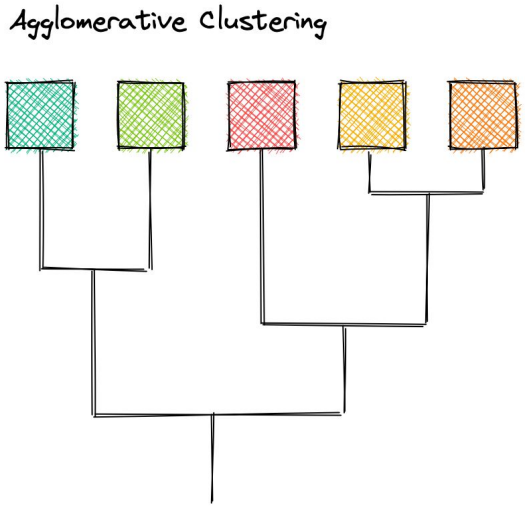

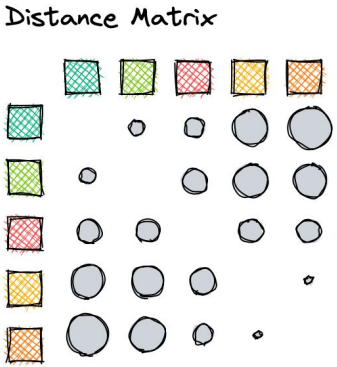

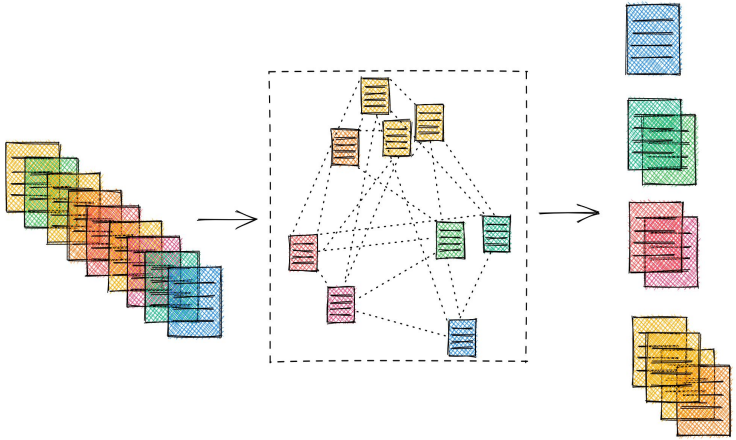

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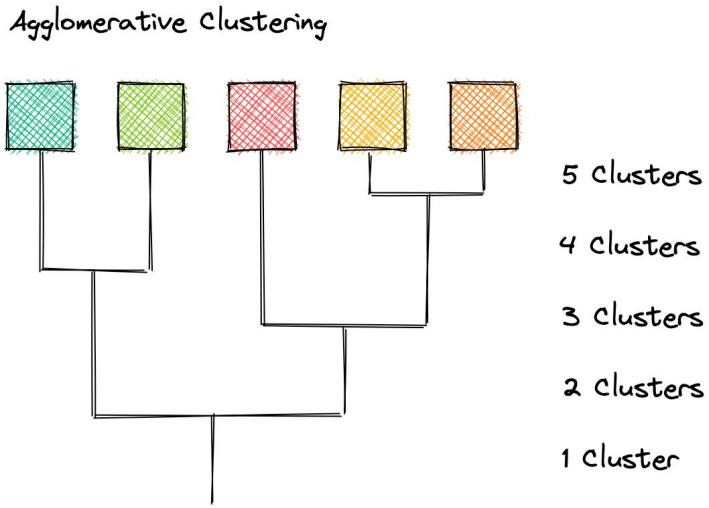
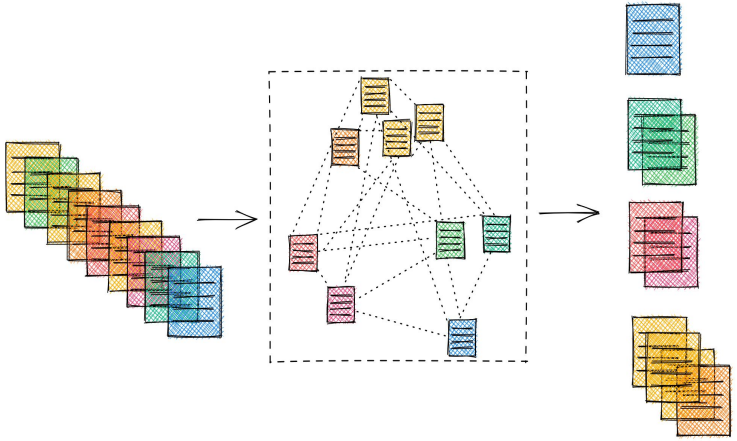
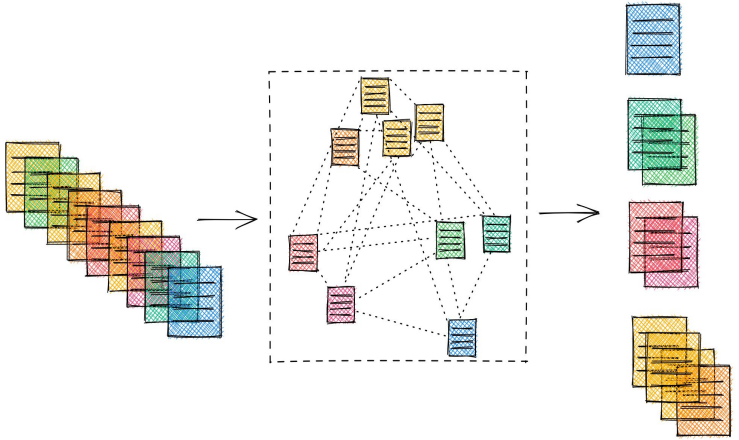




Online Clustering

Clustering is usually a **batch operation**.



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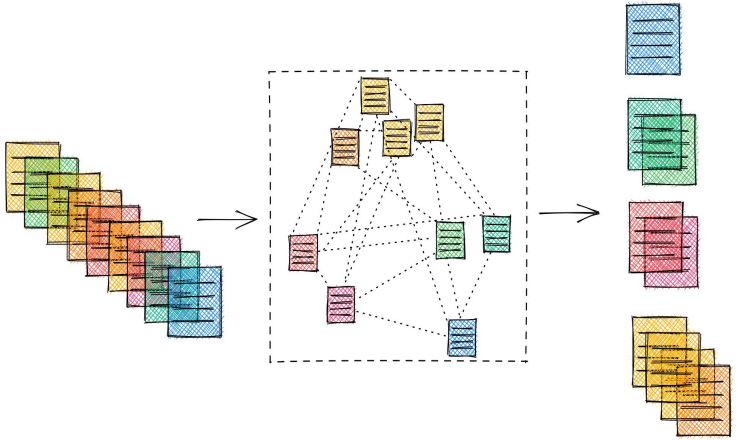
What do we need?



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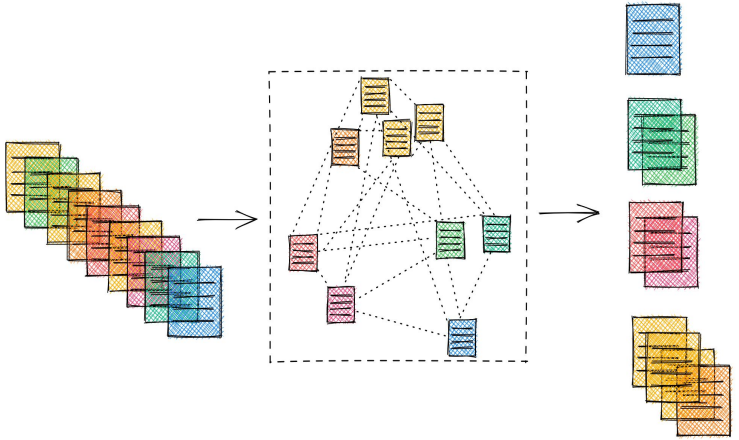
What do we need?

A **clustering** algorithm that works **iteratively**.



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A **clustering** algorithm that works **iteratively**.

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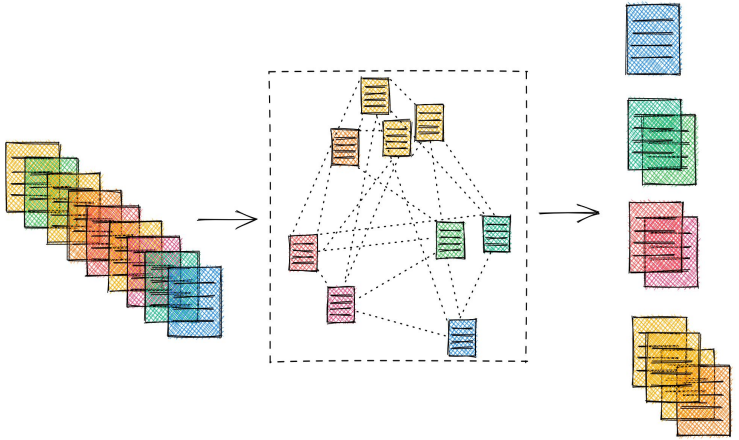
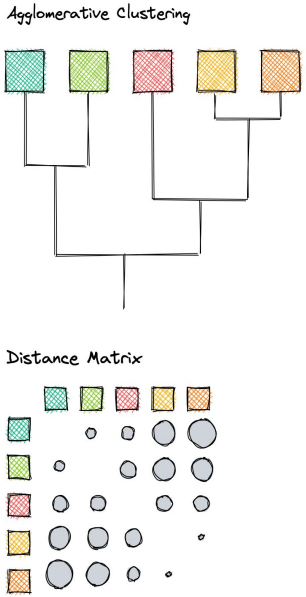
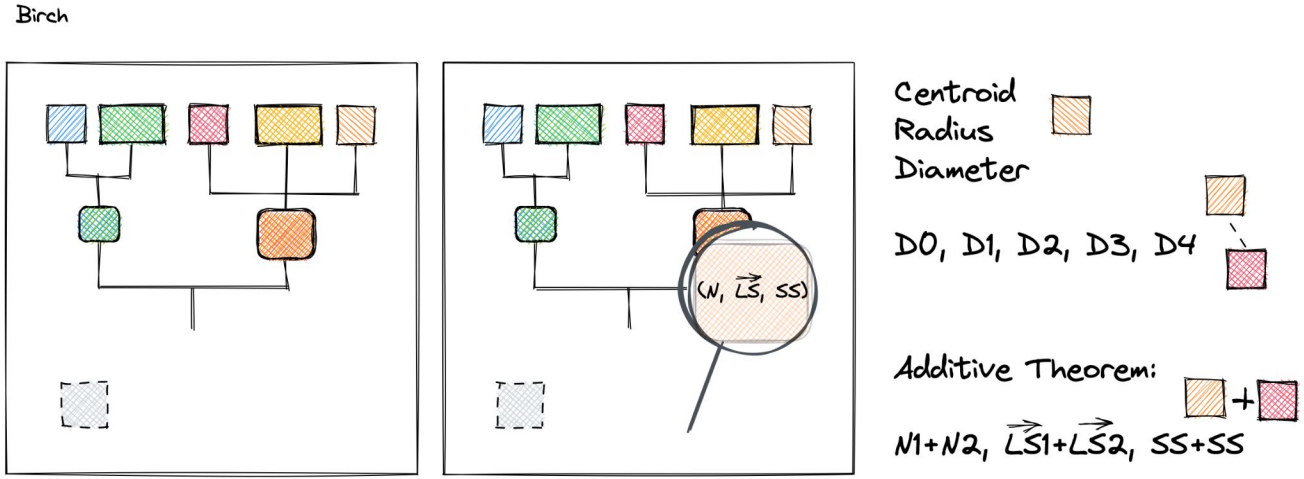
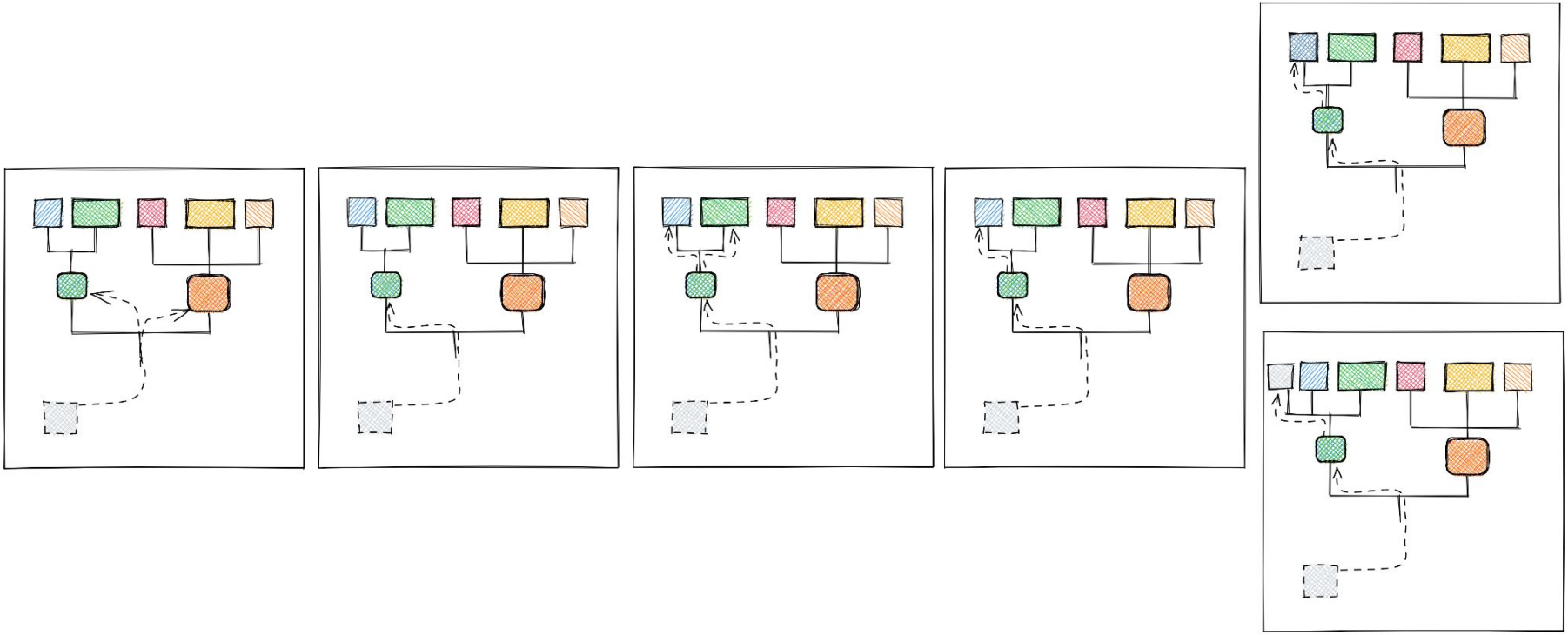


BIRCH


Agglomerative Clustering
Distance Matrix


Birch
(N, LS, SS)
Centroid
Radius
Diameter
D0, D1, D2, D3, D4
Additive Theorem:
N1+N2, LS1+LS2, SS+SS

BIRCH



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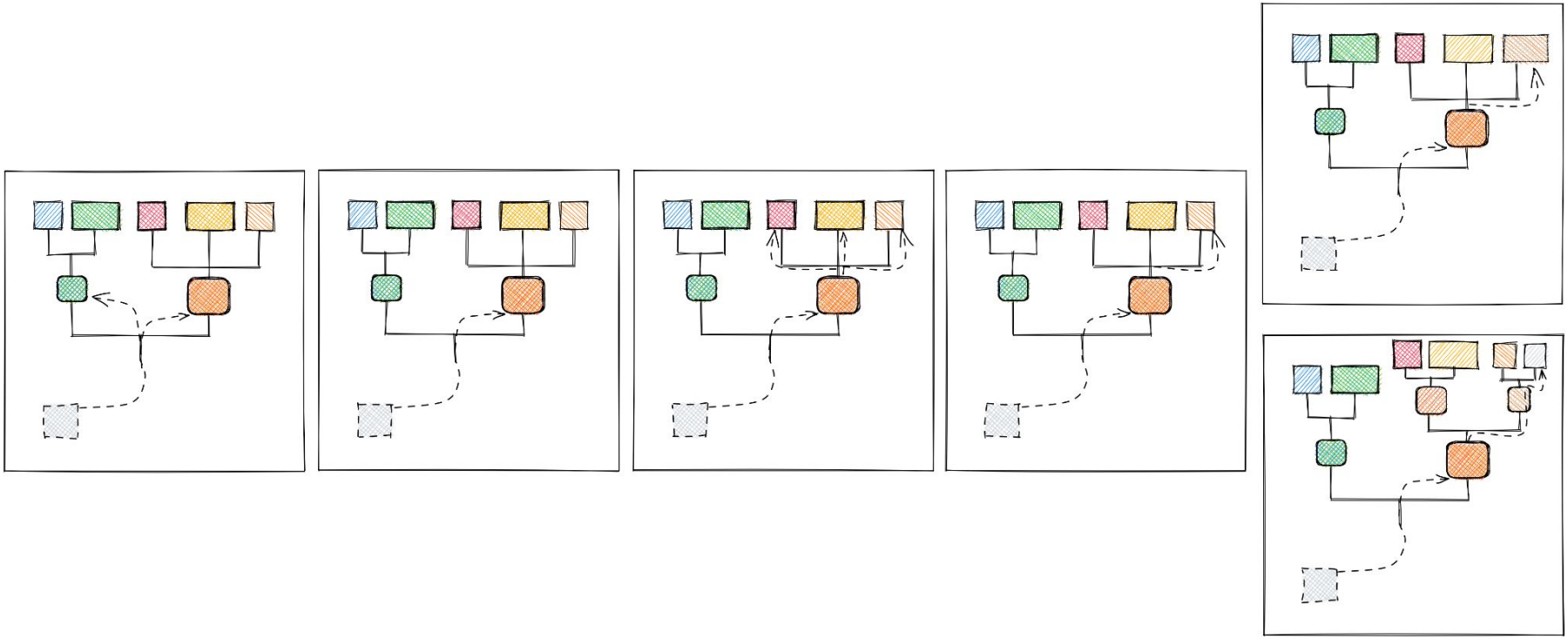


BIRCH

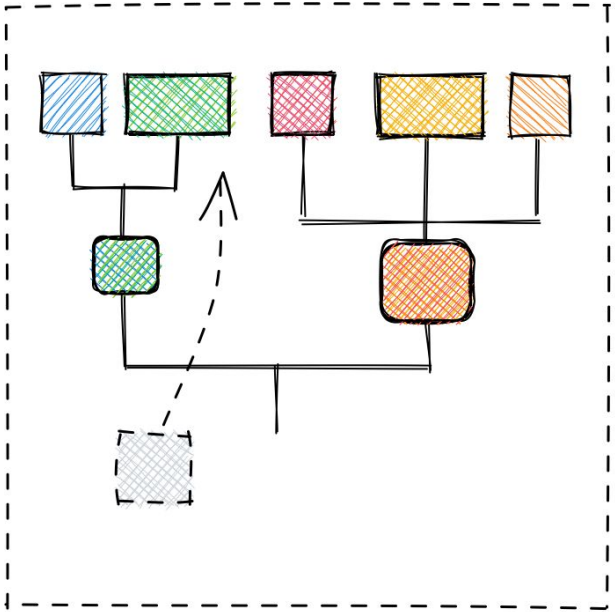
Add documents **iteratively**.

Build a **tree** structure that contains **summaries of subclusters** that are **sufficient** for cluster **decisions.**

***Tight,* local subclusters** are summarised.

Very **fast**, input **data** only needs to be **read once**, O(n).

Resulting summaries can be used as input to other clustering algorithms.



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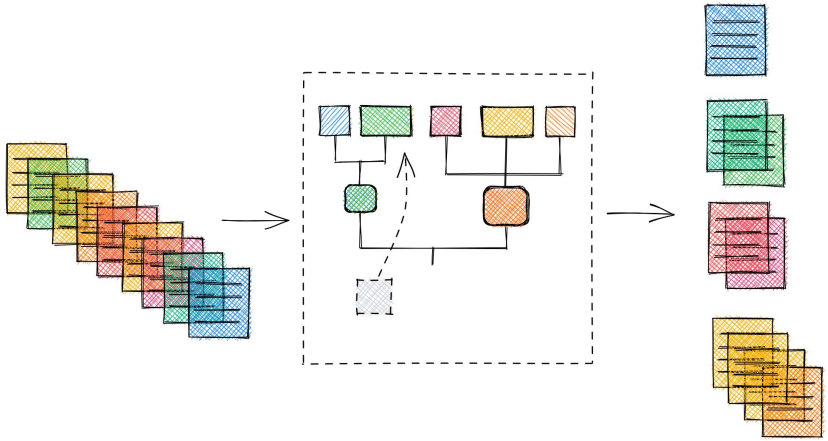
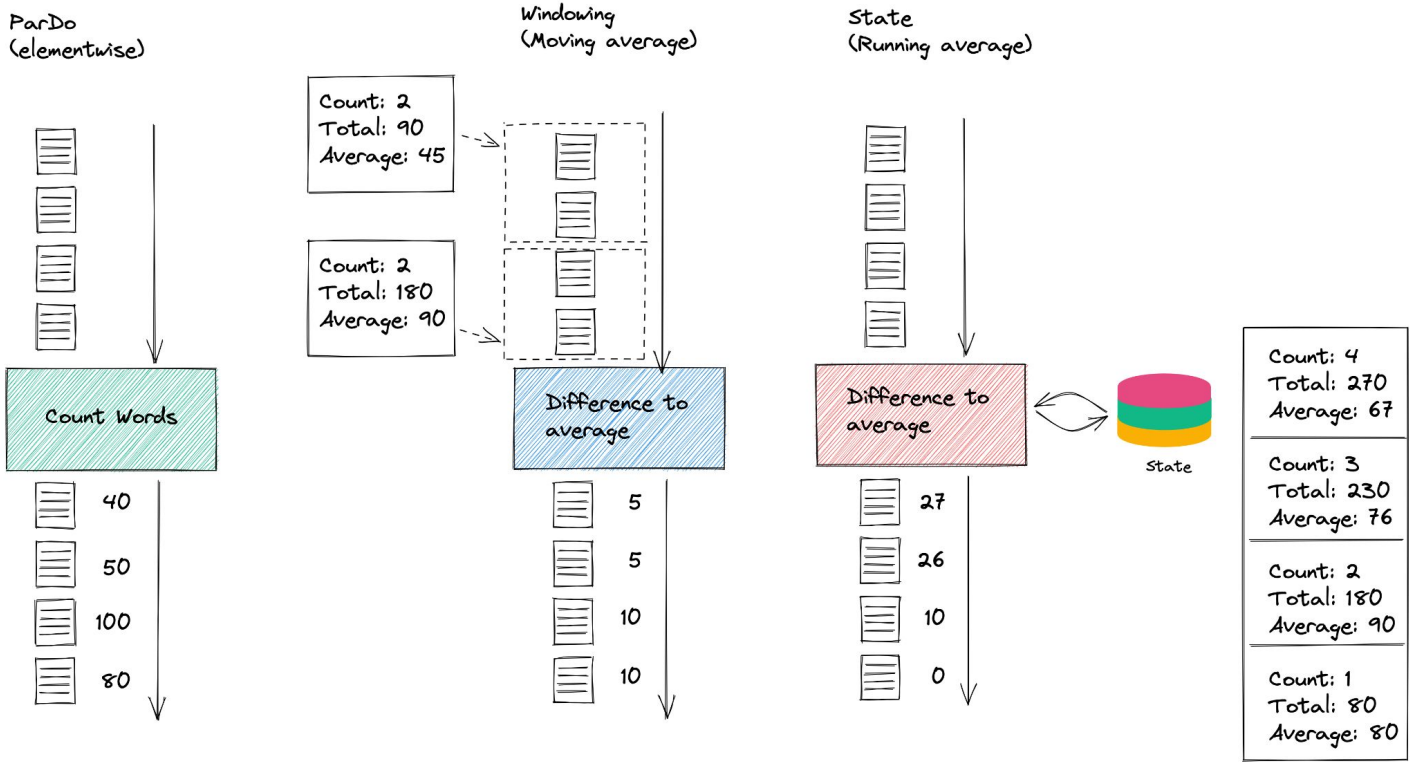


Stateful Processing



Stateful Processing

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        text = element.get('text', "")
        words = text.split(' ')
        yield {
            **copy.deepcopy(element),
            'word_count': len(words)
        }
```

```python
def run():
    """Main function that defines the pipeline and runs it."""
    pipeline = beam.Pipeline()

    # Input text documents
    docs = (
        pipeline
        | "Load documents" >> beam.Create(example_docs)
    )

    # Enrichment
    enriched_docs = (
        docs
        | "Count words" >> beam.ParDo(CountWords())
    )

    # Difference to running average
    differences = (
        enriched_docs
        # The state is partitioned by key: Use a single key
        | "Make key-value pair" >> beam.Map(lambda e: (1, e))
        | "Difference to Running Average" >> beam.ParDo(StatefulAverageDifference())
    )

    # Print
    _ = (
        differences
        | "Print" >> beam.Map(pprint)
    )

    pipeline.run().wait_until_finish()
```

```python
class StatefulAverageDifference(beam.DoFn):

    DOCUMENT_COUNT_SPEC = ReadModifyWriteStateSpec('document_count', PickleCoder())
    WORD_TOTAL_SPEC = ReadModifyWriteStateSpec('word_total', PickleCoder())

    def process(self, element,
                document_count_state=beam.DoFn.StateParam(DOCUMENT_COUNT_SPEC),
                word_total_state=beam.DoFn.StateParam(WORD_TOTAL_SPEC),
                *args, **kwargs):

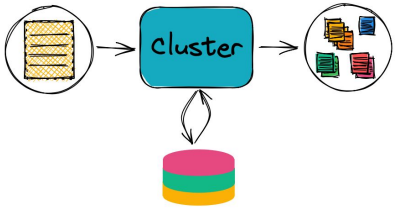
        # 1. Initialise or load states
        document_count = document_count_state.read() or int()
        word_total = word_total_state.read() or int()

        # 2. Extract document, update state, and calculate average
        _, doc = element # The state is partitioned by key
        document_count = document_count + 1
        word_total = word_total + doc['word_count']
        average = word_total / document_count
        difference = abs(doc['word_count'] - average)

        # 3. Write states
        document_count_state.write(document_count)
        word_total_state.write(word_total)

        # 4. Yield element
        yield {
            'uuid': doc['uuid'],
            'word_count': doc['word_count'],
            'difference': difference,
        }
```

Online Clustering



BIRCH:

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Stateful processing:

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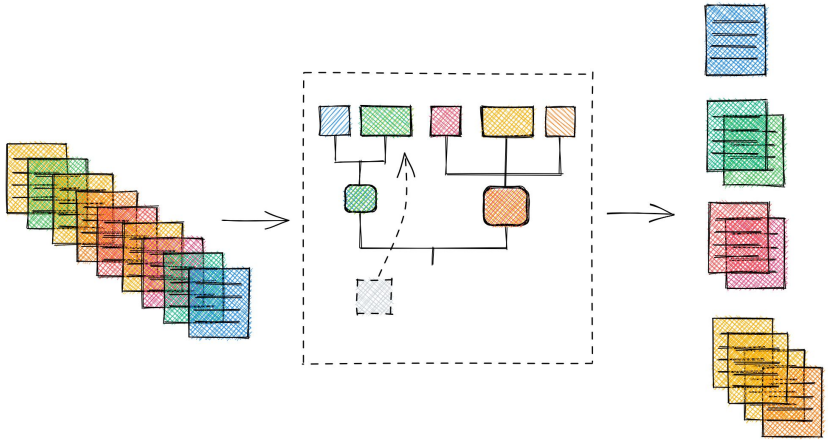

Demo

Semantic Enrichment &
Online Clustering
using the Python Apache Beam SDK

Result

```
New cluster: 10940495-f79e-436a-92db-ef1f274ba44c
Documents:
        Movies (Star Wars 1)

Update:      10940495-f79e-436a-92db-ef1f274ba44c
Documents:
        Movies (Star Wars 1)
        Movies (Star Wars 2)

New cluster: 072a9e0d-4763-4afa-bf98-42aa70ac05db
Documents:
        Turtles

New cluster: fbdae2ec-9cc6-48b3-83bf-f1b4edd29e0d
Documents:
        Weather 1

Update:      10940495-f79e-436a-92db-ef1f274ba44c
Documents:
        Movies (Star Wars 1)
        Movies (Star Wars 2)
        Movies (Star Trek)

Update:      fbdae2ec-9cc6-48b3-83bf-f1b4edd29e0d
Documents:
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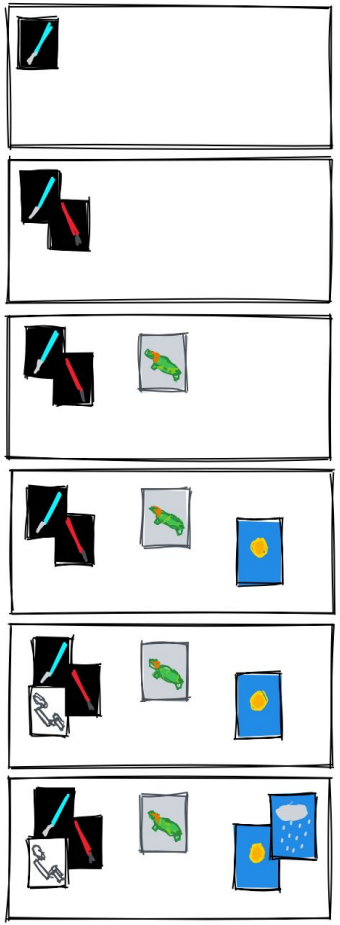
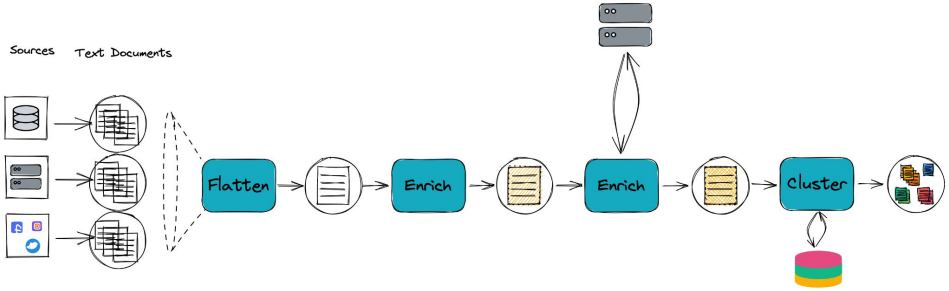


Summary



Semantic enrichment adds information from the content to the documents. This often involves **machine learning** which are **expensive operations**.

Online clustering allows the grouping of text documents into groups that are unknown up-front in real-time. **Stateful processing** enables **iterative cluster model building**.

BIRCH is an **iterative** clustering algorithm that can handle very **large amounts of data**.

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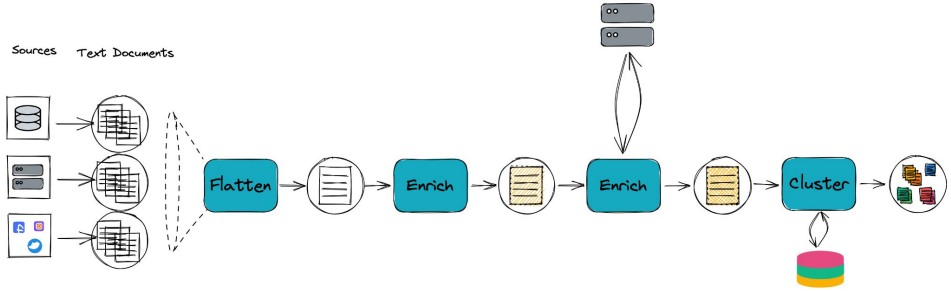

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Real-time Productionizing**: Streaming** pipeline

Enrichment

Serve Machine Learning models using **microservices**. Initialise connection in the **setup** of the DoFn & use **time-batched** requests.

Clustering: Tidy up the **state** once in a while by pruning outdated elements.

Thank you!

ML6 is hiring → https://www.ml6.eu/join-us

Further Reading

- Stateful Processing with Apache Beam
- Timely (and Stateful) Processing with Apache Beam
- BIRCH: An Efficient Data Clustering Method for Very Large Databases (paper)