PySpark Certification T...

Apache Spark Streaming - Processing Multiple Batches > Presentation

Course Content

- Deep Dive into Spark ...
- Understanding Apache...
- Apache Spark Streami...
  - Presentation
  - In Class Demo - Inpu...
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COURSE OUTLINE

MODULE 10

- Introduction to Big Data Hadoop and Spark
- Introduction to Python for Apache Spark
- Functions, OOPs, Modules in Python
- Deep Dive into Apache Spark Framework
- Playing with Spark RDDs
- Data Frames and Spark SQL
- Machine Learning using Spark MLlib
- Deep Dive into Spark MLlib
- Understanding Apache Kafka and Apache Flume
- **Apache Spark Streaming - Processing Multiple Batches**
- Apache Spark Streaming - Data Sources
- Implementing an End-to-End Project

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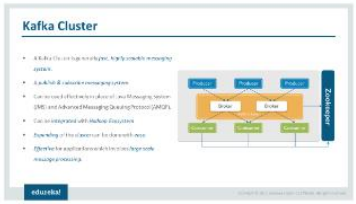
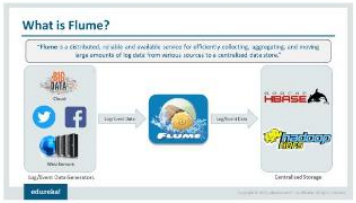
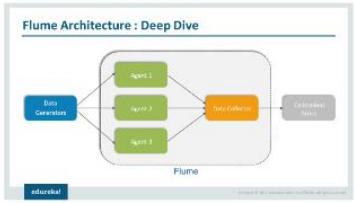
Recap







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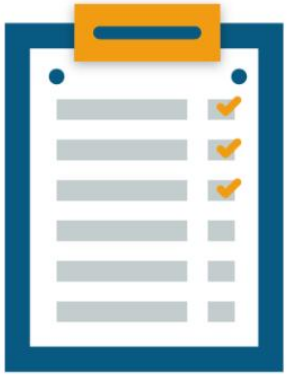
Topics

- Spark Streaming Features
- Spark Workflow
- Streaming Context
- Dstream
- Caching
- Accumulators, Broadcast Variables and Checkpoints
- Streaming Word Count
- Stateful Operators



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Objectives

After completing this module, you should be able to:

- Analyze the Drawbacks in Existing Computing Methods
- Describe why Streaming is Necessary
- Explain what is Spark Streaming
- Describe Spark Streaming Features
- Describe Spark Streaming Workflow
- Understand how Uber uses Streaming Data
- Explain Streaming Context and DStreams
- Describe Transformations on DStreams
- Execute a Streaming WordCount Program

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Drawbacks in Traditional Computing Methods

- Traditionally we used to perform analysis only on saved data
- That gives us results, but sometimes ***it's too late to act according to that result***
- Our best understanding comes ***when conclusions fit evidence*** and evidence and analysis leads to a good way of life
- Companies need to work on real time data, to improve their ***business and customer review***
- Banks can't detect ***online real-time fraud detection*** on saved data

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Solution : Spark Streaming

Spark Streaming

Spark Streaming is used to stream real-time data from various sources like *Twitter*, *Stock Market* and *Geographical Systems* and perform *powerful analytics* to help businesses

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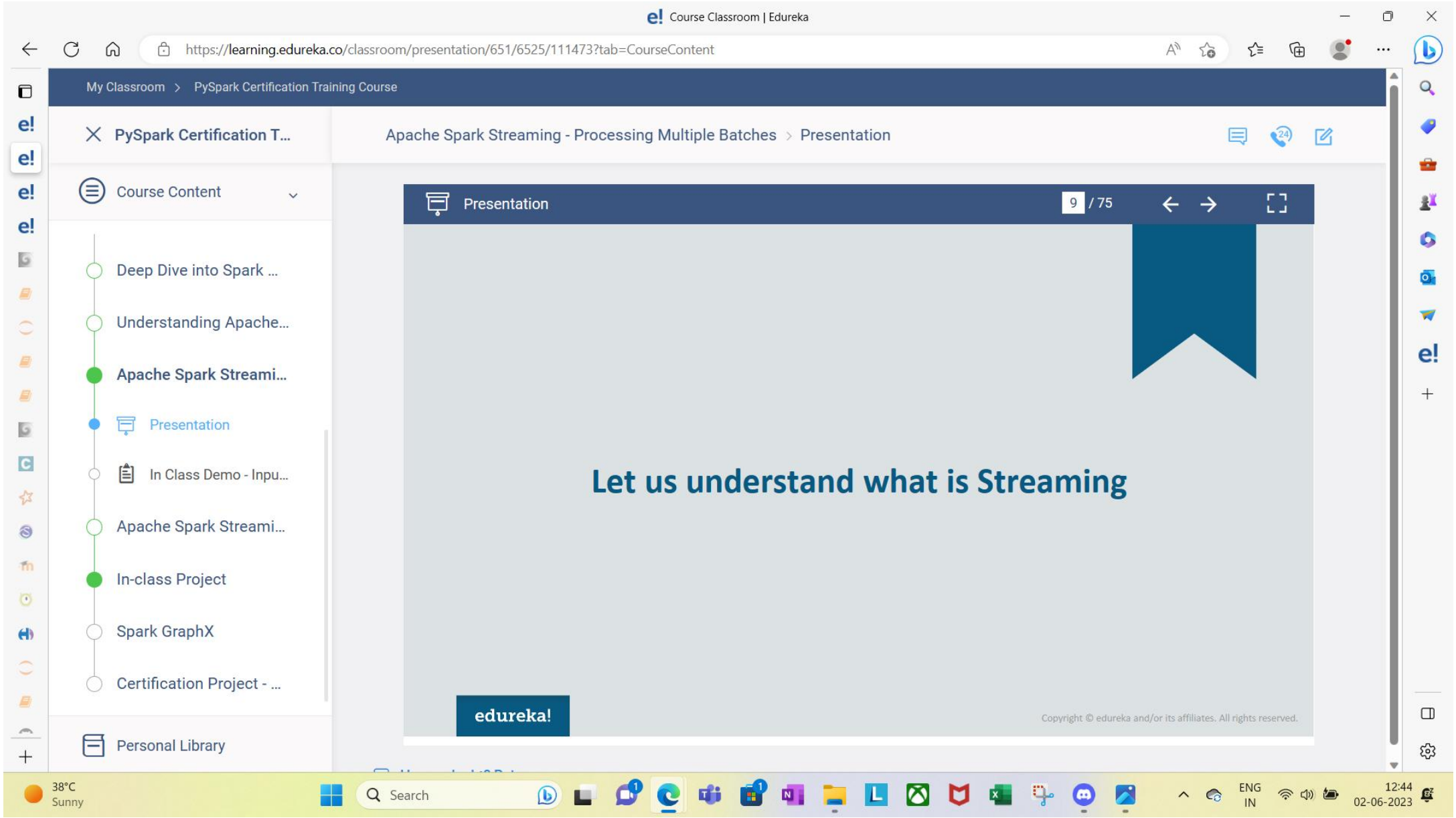
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Let us understand what is Streaming
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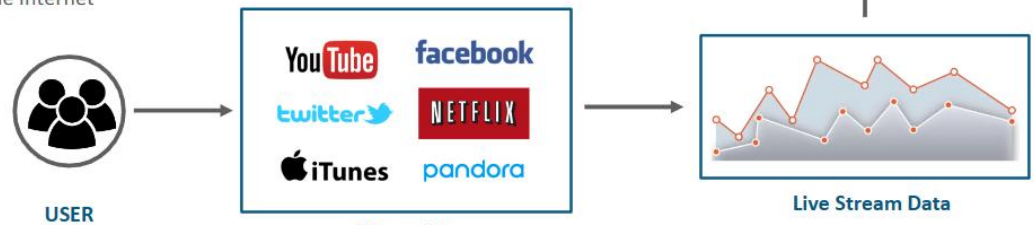
What is Streaming?

- ***Data Streaming*** is a technique for transferring data so that it can be processed as a steady and continuous stream
- A ***data stream*** is an unbounded sequence of data arriving continuously
- Streaming technologies are becoming increasingly important with the growth of the Internet



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Spark Streaming Overview

- ***Spark Streaming*** is used for processing ***real-time streaming data***
- It is a useful ***addition*** to the ***core Spark API***
- Spark Streaming enables ***high-throughput*** and ***fault-tolerant*** stream processing of live data streams
- The fundamental stream unit is ***DStream*** which is basically a series of RDDs to process the real-time data

Spark Streaming

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Spark Streaming Overview : Representation

Streaming Data Sources

Static Data Sources

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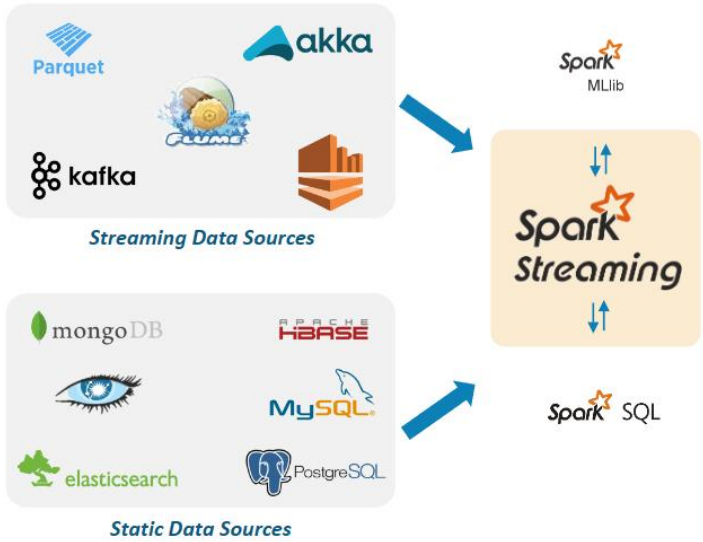
Spark Streaming Overview : Representation



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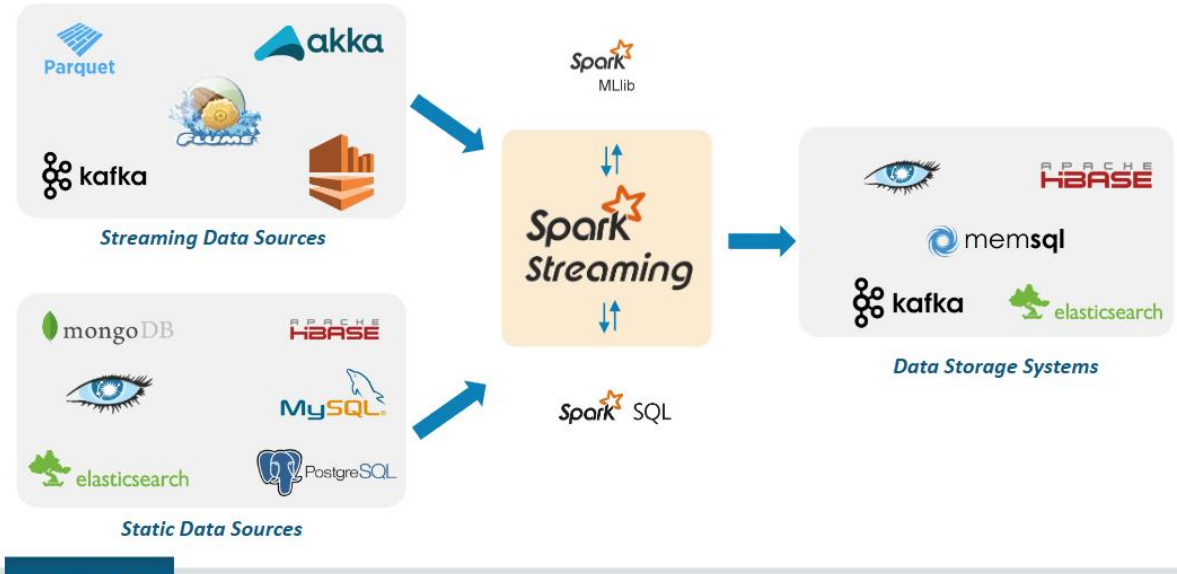
Spark Streaming Overview : Representation



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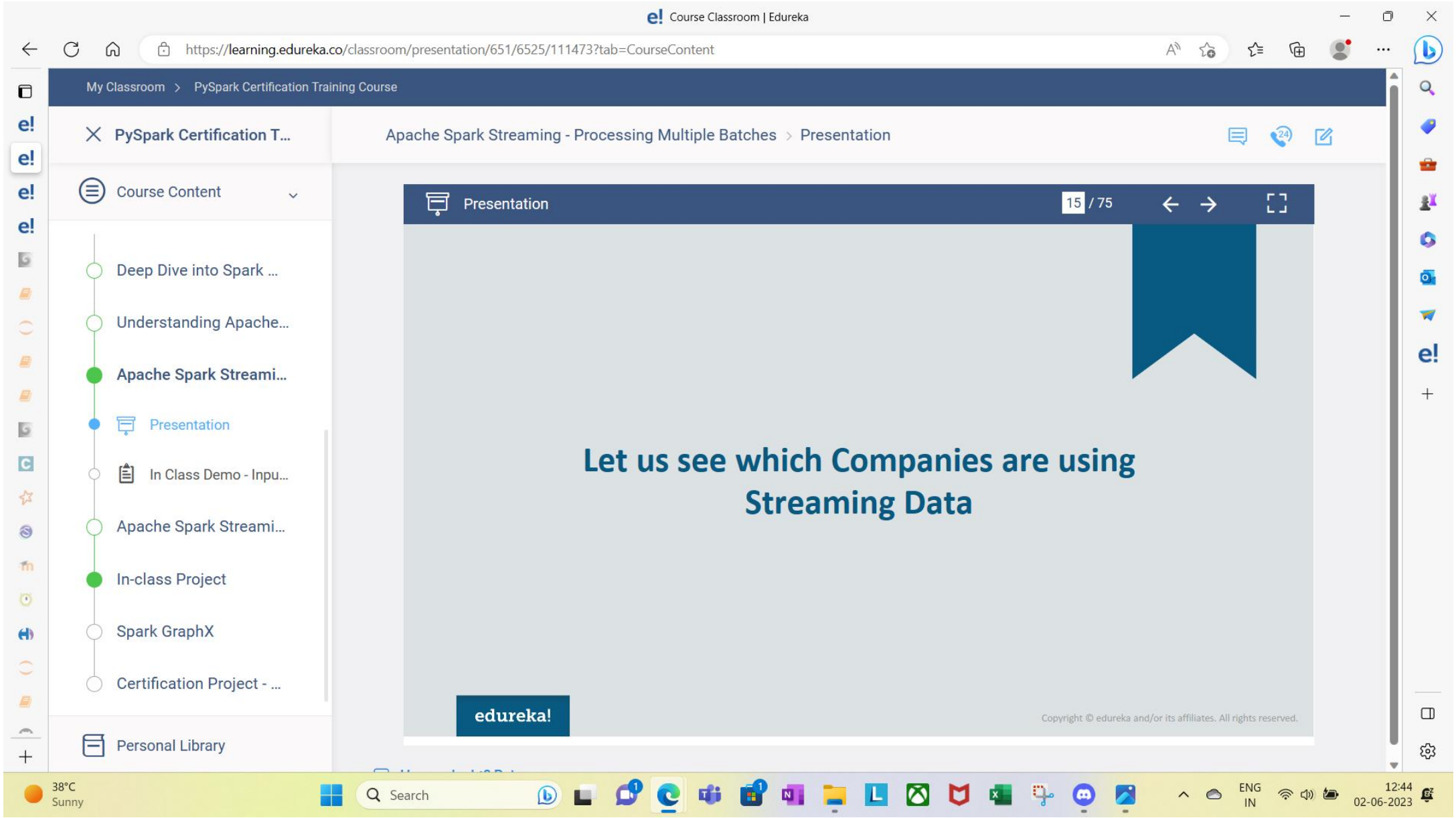
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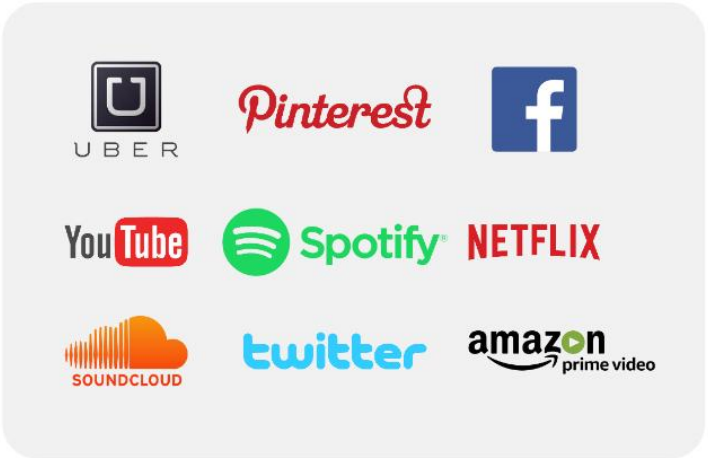
Companies using Streaming Data



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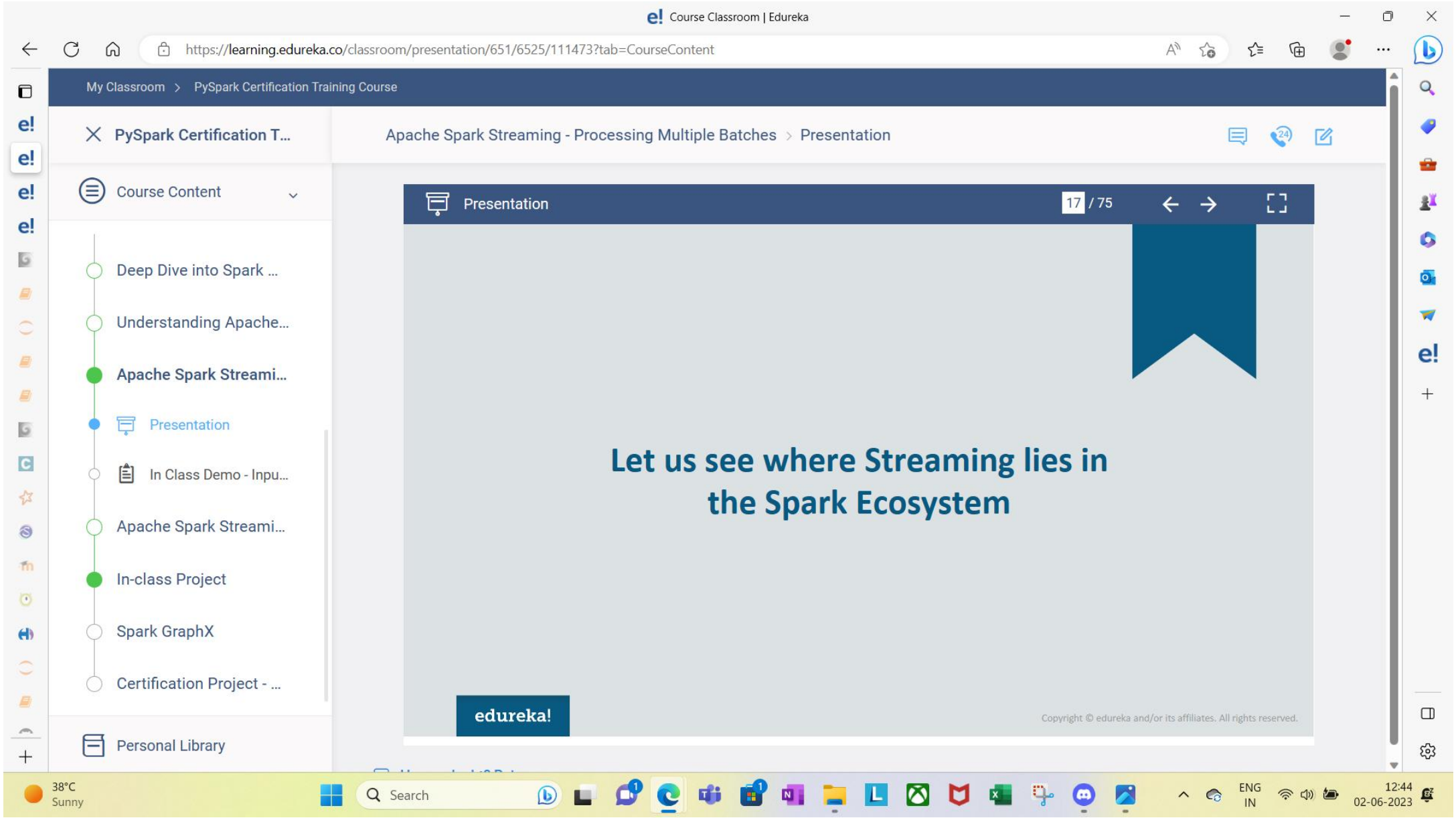
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Let us see where Streaming lies in the Spark Ecosystem
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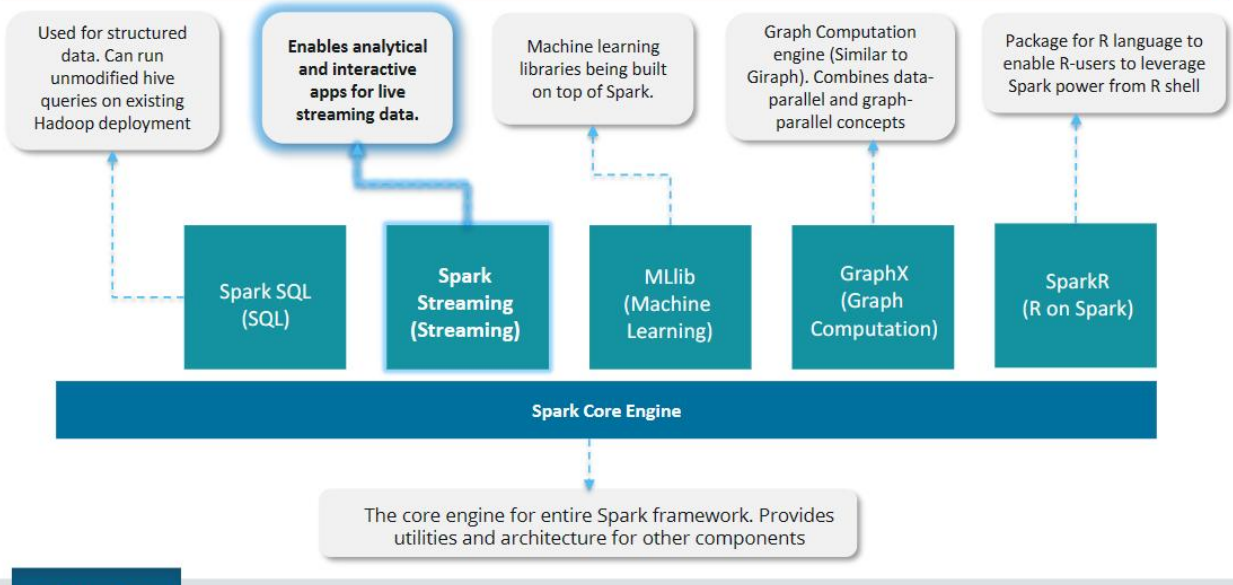
Spark Streaming in Spark Ecosystem



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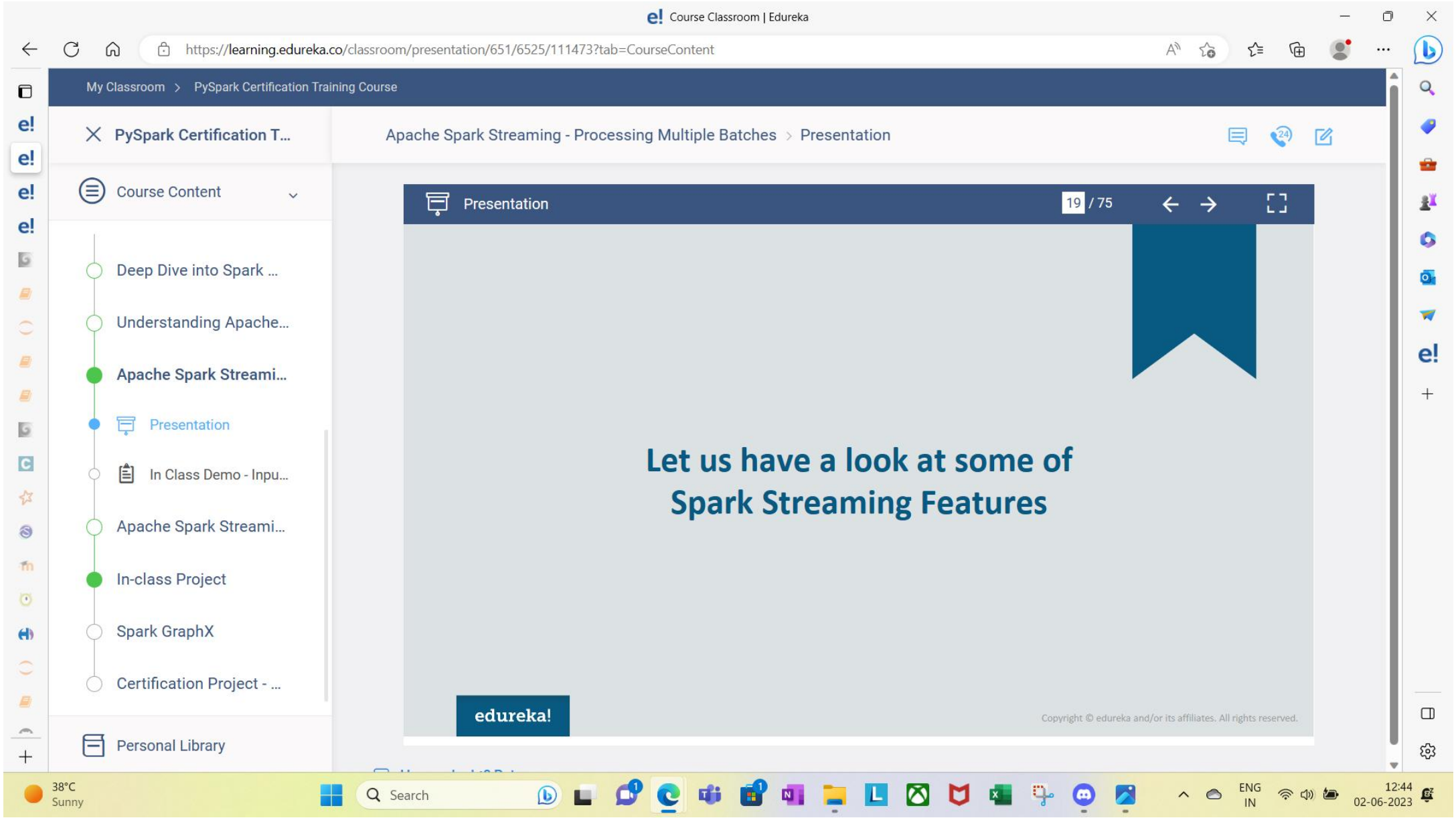
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Let us have a look at some of Spark Streaming Features
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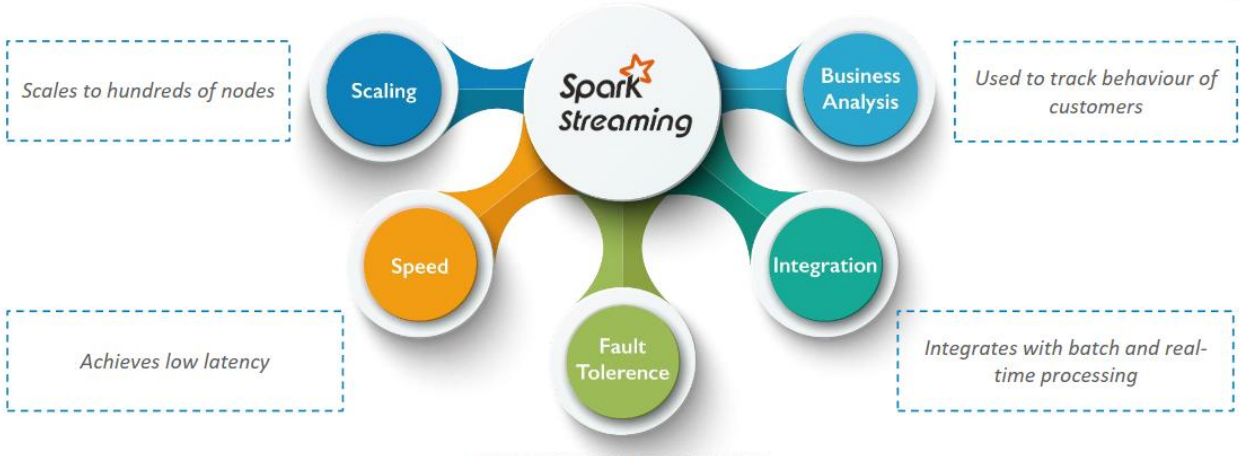
Spark Streaming Features



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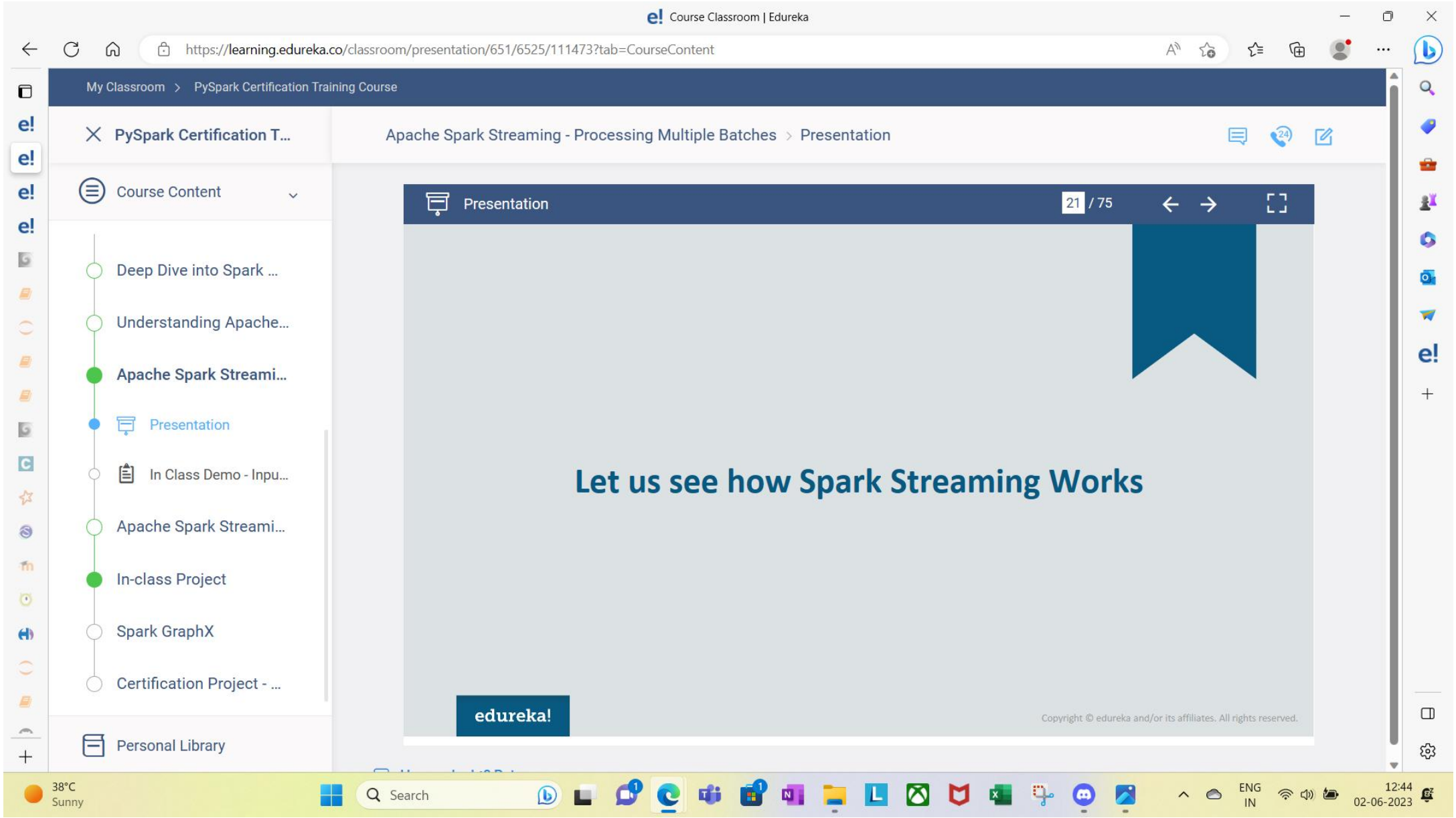
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Spark Streaming Workflow

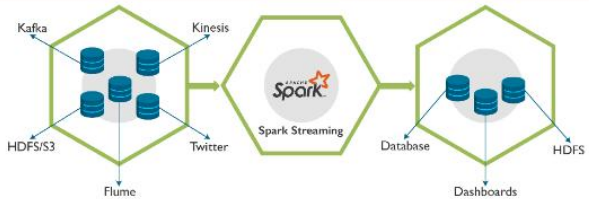

Figure: Data from a variety of sources to various storage systems

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Spark Streaming Workflow

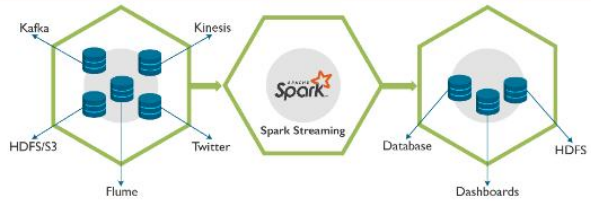

Figure: Data from a variety of sources to various storage systems

Figure: Incoming streams of data divided into batches

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Spark Streaming Workflow

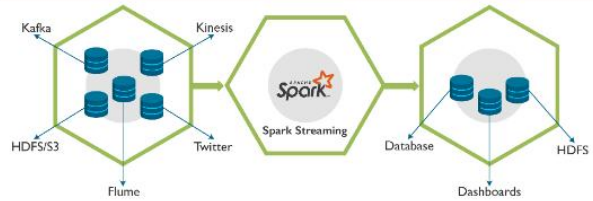

Figure: Data from a variety of sources to various storage systems

Figure: Incoming streams of data divided into batches

Figure: Input data stream divided into discrete chunks of data

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Spark Streaming Workflow

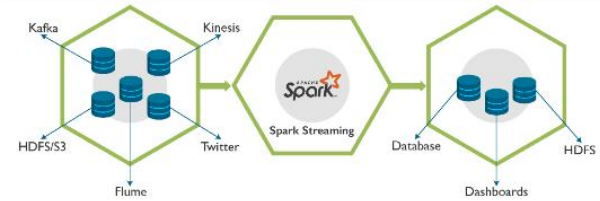

Figure: Data from a variety of sources to various storage systems

Figure: Incoming streams of data divided into batches

Figure: Input data stream divided into discrete chunks of data

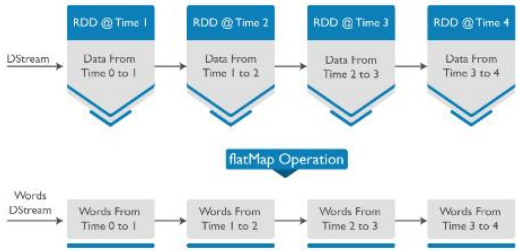

Figure: Extracting words from an Input Stream

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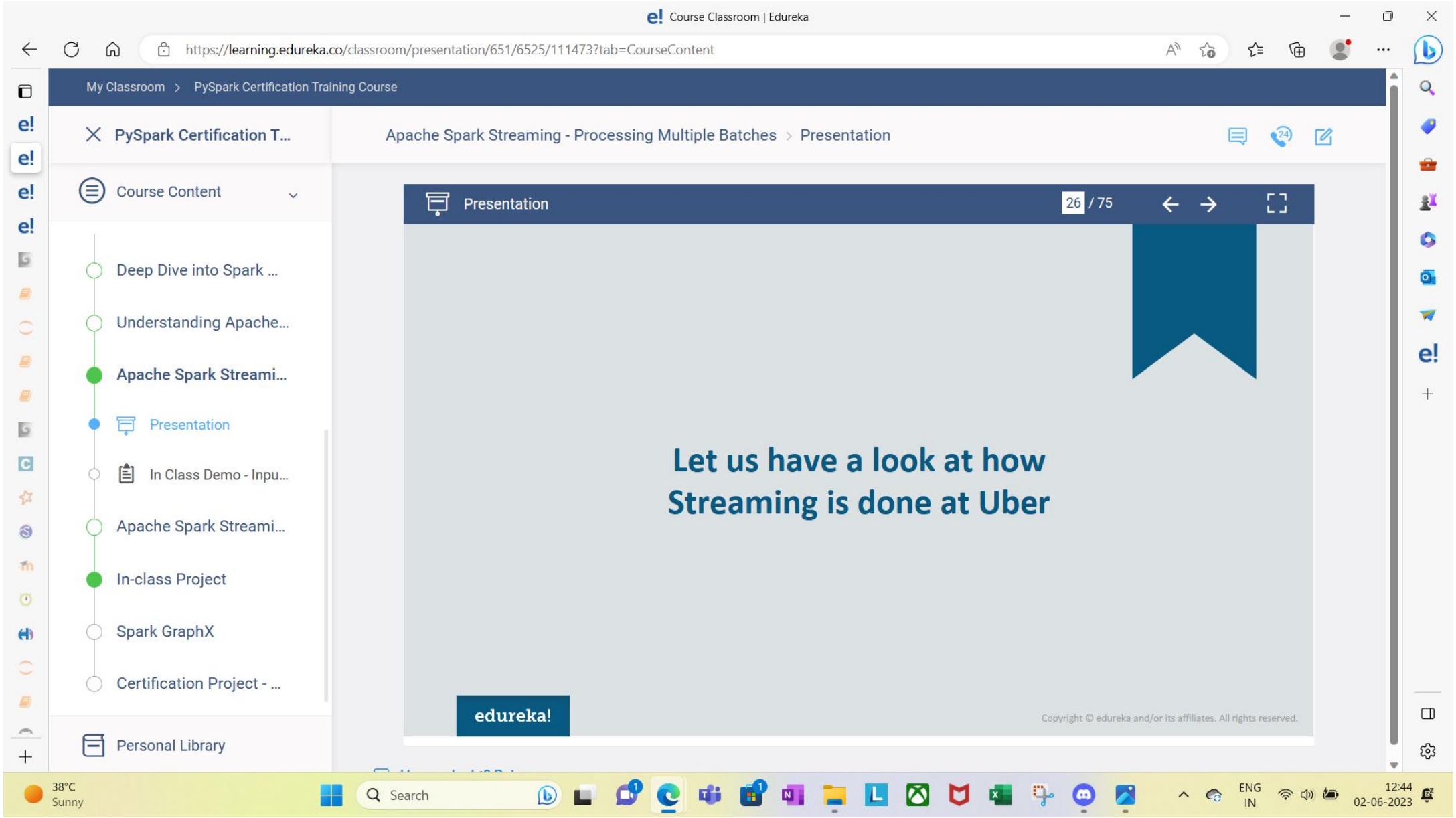
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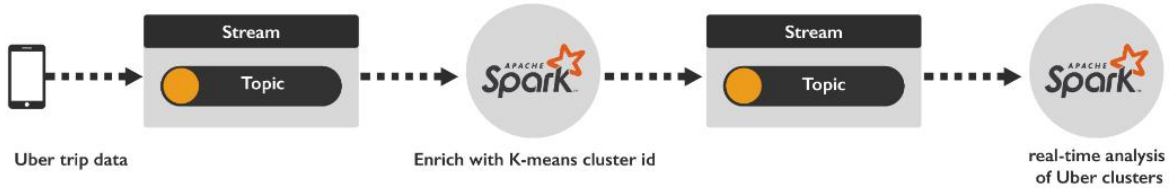
Uber Streaming : Process

- Uber trip data is published to a MapR Streams topic using the Kafka API
- A Spark streaming application subscribed to the first topic:
  - *Ingests a stream of uber trip events*
  - *Identifies the location cluster corresponding to the latitude and longitude of the uber trip*
  - *Adds the cluster location to the event and publishes the results in JSON format to another topic*
- A Spark streaming application subscribed to the second topic:
  - *Analyses the uber trip location clusters that are popular by date and time*



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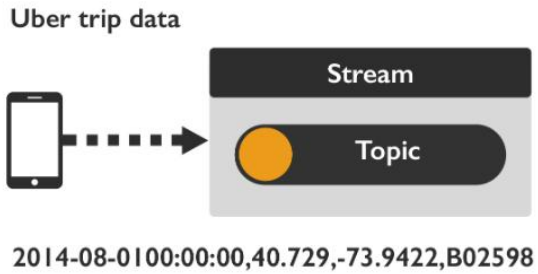
Getting Data

- The example data set is Uber trip data
- The incoming data is in CSV format, an example is shown below , with the header:

date/time, latitude, longitude, base

2014-08-01 00:00:00,40.729,-73.9422,B02598



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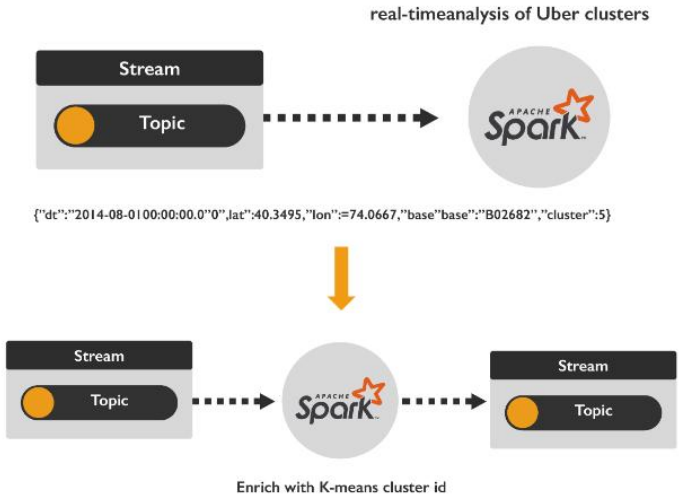
Workflow

The enriched Data Records are in JSON format. An example line is shown below :



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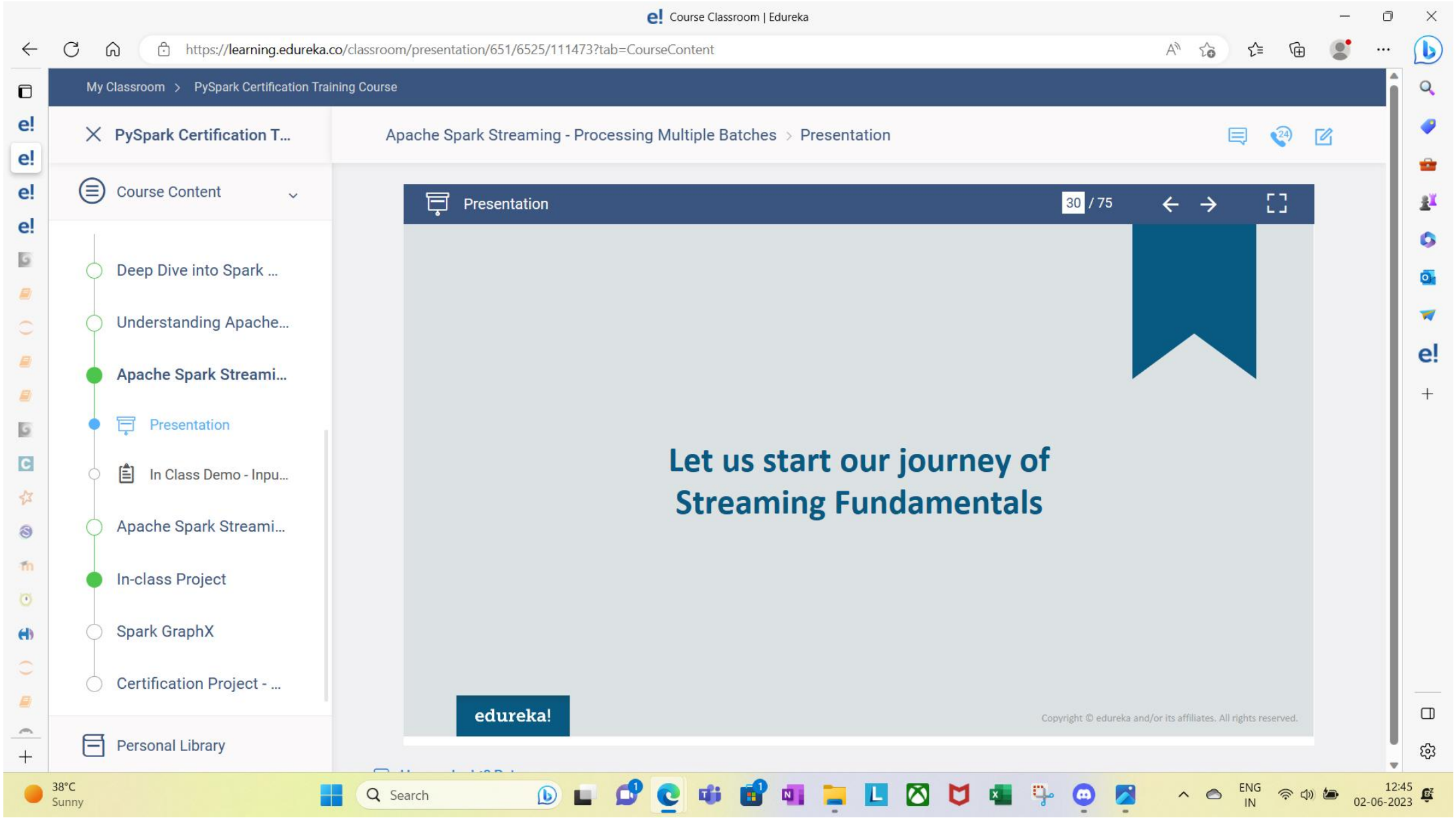
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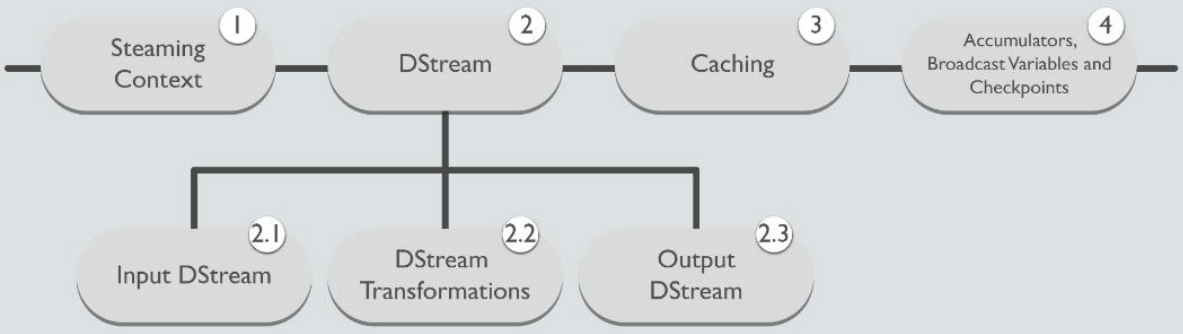

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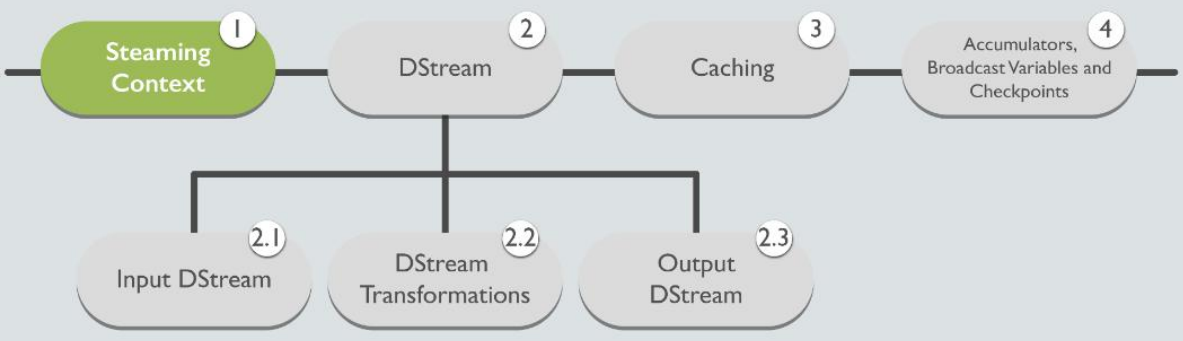

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Streaming Context

- It is the main ***entry point*** for Spark functionality
- Spark provides a number of default implementations of sources like ***Twitter, Akka Actor*** and ***ZeroMQ*** that are accessible from the context
- Whatever we do in Spark Streaming has to start from creating an instance of ***StreamingContext***

- Consumes a stream of data in Spark
- Registers an ***InputDStream*** to produce a ***Receiver*** object
- It provides methods used to create DStreams from various input sources

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Streaming Context : Initialization

- Streaming Context can be created in 3 ways:
  - By providing a *Spark master URL* and *an appName*, or
  - from a *org.apache.spark.SparkConf* configuration, or
  - from an *existing org.apache.spark.SparkContext*
- The associated SparkContext can be accessed using *context.sparkContext*. After creating and transforming DStreams, the streaming computation can be started and stopped using *context.start()* and *context.stop()*, respectively
- Let's see a simple initialization of StreamingContext :

```
#    Spark
from pyspark import SparkContext
#    Spark Streaming
from pyspark.streaming import StreamingContext
sc = SparkContext(appName="PythonSparkStreaming")
ssc = StreamingContext(sc, 60)
```

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Streaming Context : Creation : Steps

1 A ***DStreamGraph*** is created

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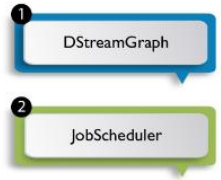
Streaming Context : Creation : Steps

1. A ***DStreamGraph*** is created
2. A ***JobScheduler*** is created



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Streaming Context : Creation : Steps

1. A ***DStreamGraph*** is created
2. A ***JobScheduler*** is created
3. A ***StreamingJobProgressListener*** is created

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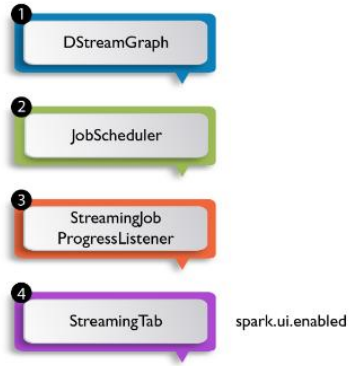
Streaming Context : Creation : Steps

1. A ***DStreamGraph*** is created
2. A ***JobScheduler*** is created
3. A ***StreamingJobProgressListener*** is created
4. Streaming tab in web UI is created (when ***spark.ui.enabled*** is enabled)



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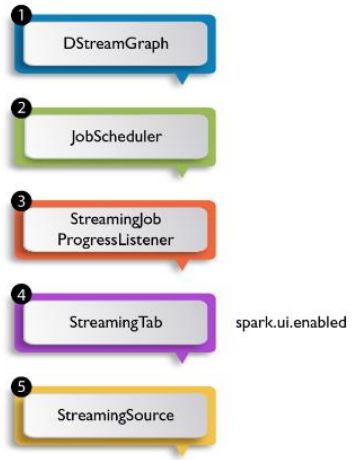
Streaming Context : Creation : Steps

1. A ***DStreamGraph*** is created
2. A ***JobScheduler*** is created
3. A ***StreamingJobProgressListener*** is created
4. Streaming tab in web UI is created (when ***spark.ui.enabled*** is enabled)
5. A ***StreamingSource*** is instantiated



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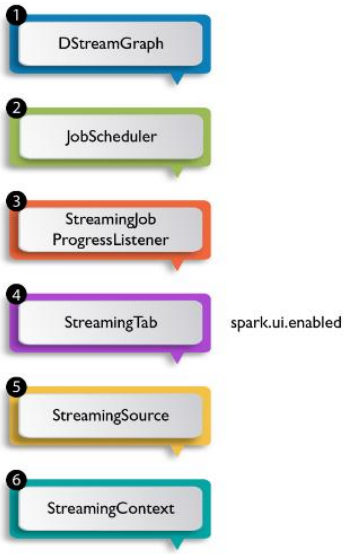
Streaming Context : Creation : Steps

1. A ***DStreamGraph*** is created
2. A ***JobScheduler*** is created
3. A ***StreamingJobProgressListener*** is created
4. Streaming tab in web UI is created (when ***spark.ui.enabled*** is enabled)
5. A ***StreamingSource*** is instantiated
6. At this point, StreamingContext enters ***INITIALIZED*** state



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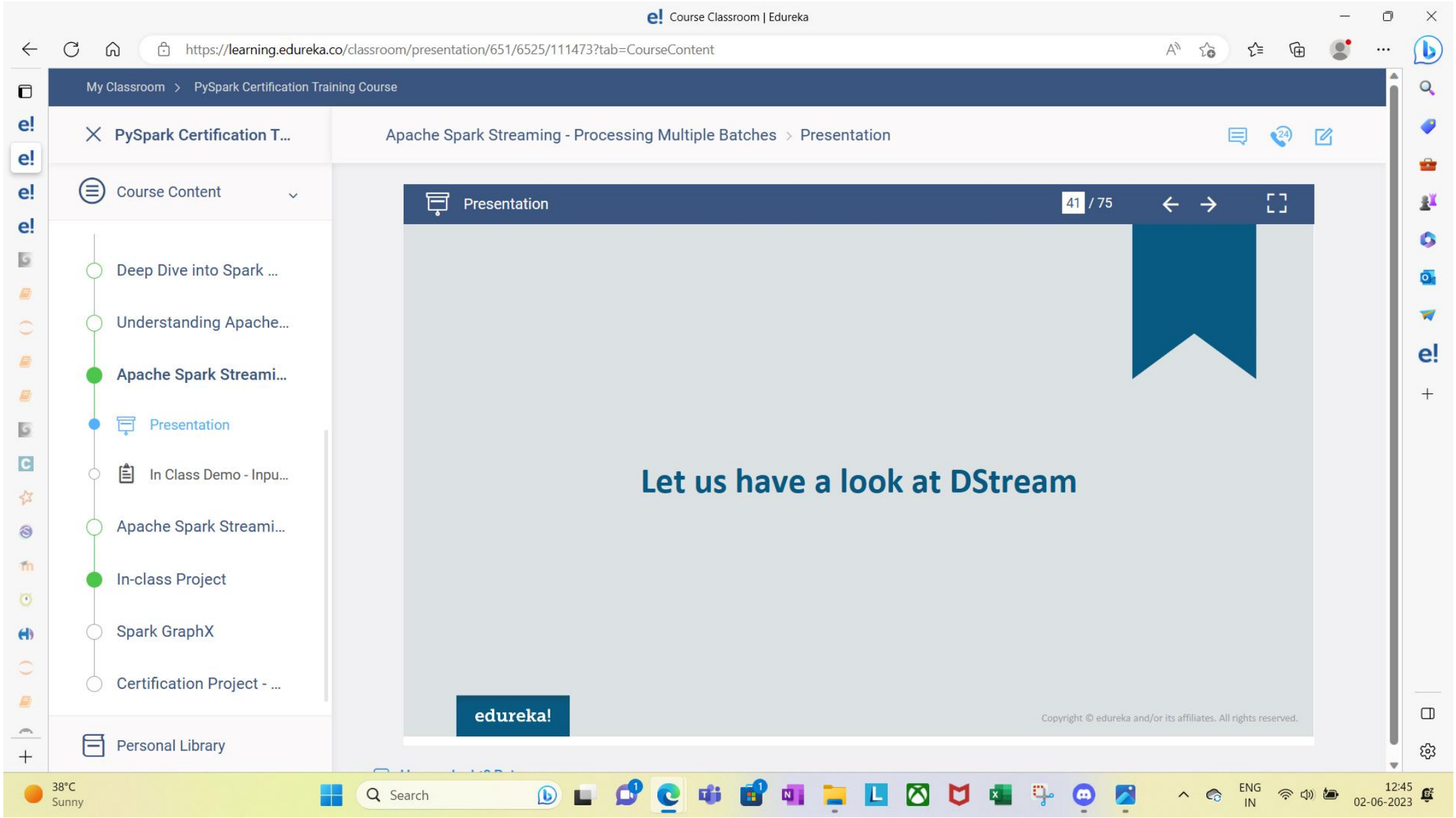
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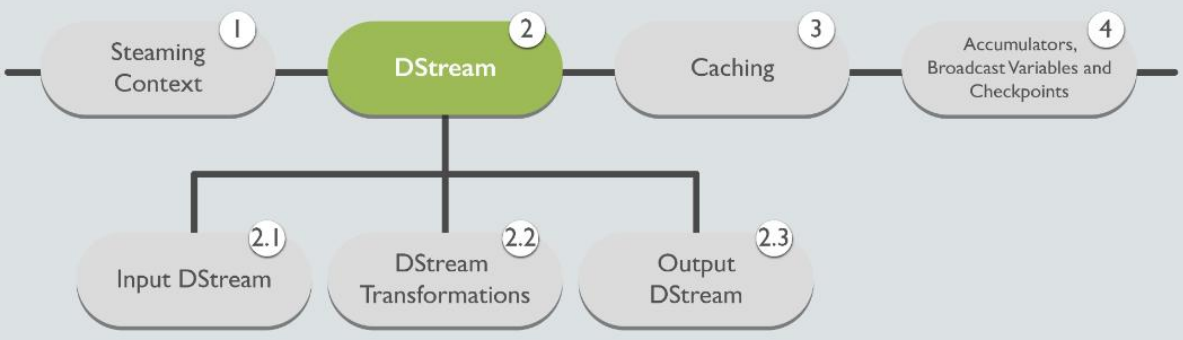

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DStream

- ***Discretized Stream*** (DStream) is the basic abstraction provided by Spark Streaming
- It is a ***continuous stream*** of data

Figure: Input data stream divided into discrete chunks of data

- It is received from ***source*** or from a ***processed data stream*** generated by transforming the input stream
- Internally, a DStream is represented by a continuous ***series of RDDs*** and each ***RDD*** contains data from a ***certain interval***

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DStream Operation

- Any operation applied on a DStream translates to operations on the underlying RDDs
- For example, in the example of converting a stream of lines to words, the ***flatMap*** operation is applied on each RDD in the lines DStream to generate the RDDs of the words ***DStream***

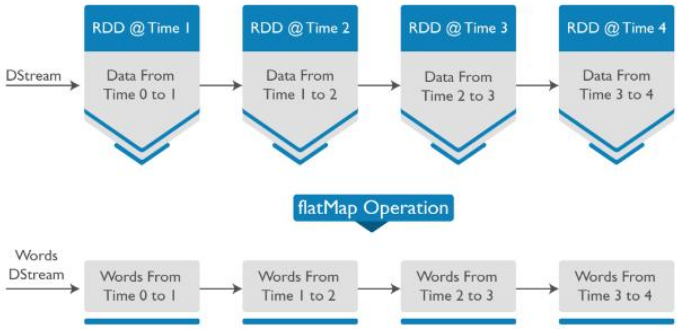

Figure: Extracting words from an Input Stream

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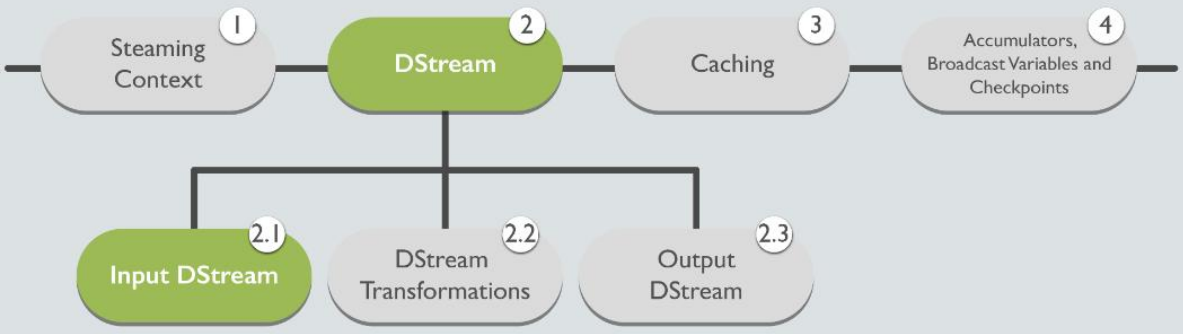

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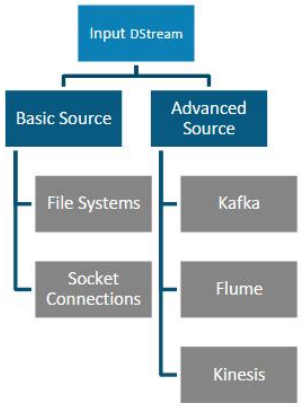
Input DStreams

- ***Input DStreams*** are DStreams representing the stream of ***input data*** received from streaming ***sources***



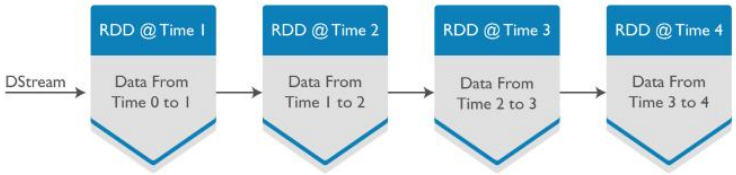


Figure: Input data stream divided into discrete chunks of data

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Receiver

- Every input DStream is associated with a **Receiver** object which receives the data from a **source** and stores it in **Spark's memory** for processing

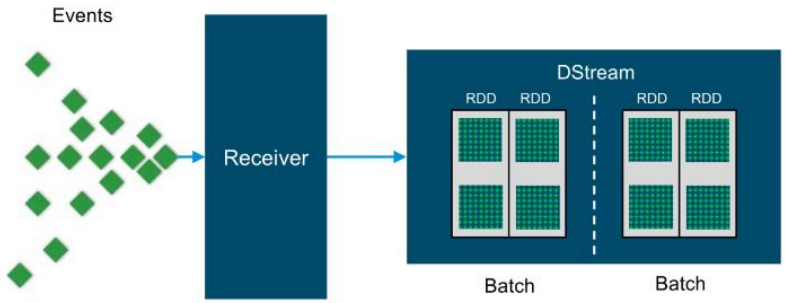

Figure: The Receiver sends data onto the DStream where each Batch contains RDDs

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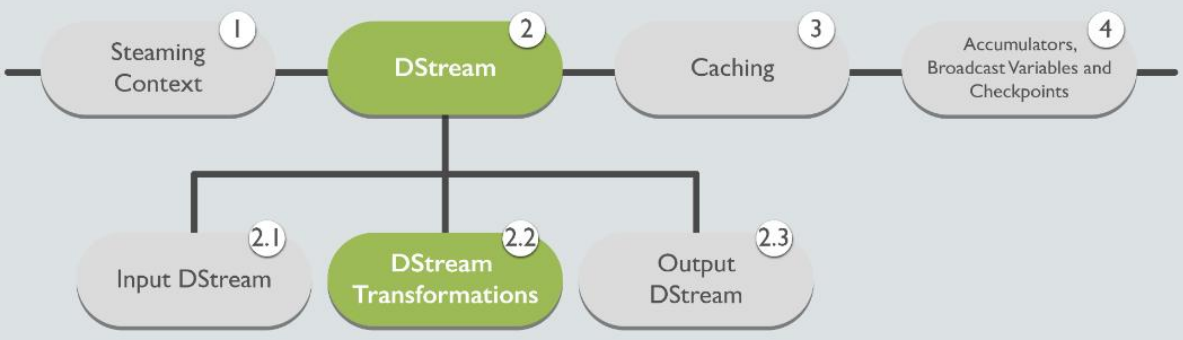

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Transformations on DStreams

Most Popular Spark Streaming Transformations

1. map
2. flatMap
3. filter
4. reduce
5. groupBy

- **Transformations** allow the data from the **input DStream** to be **modified** similar to RDDs
- DStreams support many of the transformations available on normal Spark RDDs

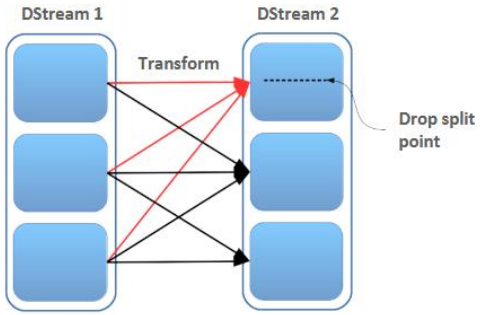

Figure: *DStream Transformations*

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Transformations on DStreams

1. map
2. flatMap
3. filter
4. reduce
5. groupBy

- **map(*func*)**
- **map(*func*)** returns a new **DStream** by passing each element of the source DStream through a function ***func***

Figure: Input DStream being converted through map(func)

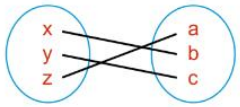

Figure: Map Function

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Transformations on DStreams

1. map
2. flatMap
3. filter
4. reduce
5. groupBy

- **flatMap(*func*)**
- **flatMap(*func*)** is similar to **map(*func*)** but each input item can be mapped to **0 or more** output items and returns a new **DStream** by passing each source element through a function ***func***

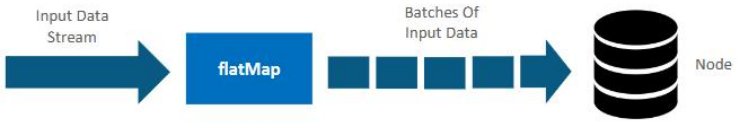

Figure: Input DStream being converted through flatMap(func)

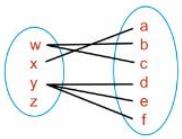

Figure: flatMap Function

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Transformations on DStreams

1. map
2. flatMap
3. filter
4. reduce
5. groupBy

- **filter(*func*)**
- **filter(*func*)** returns a new **DStream** by **selecting** only the records of the source DStream on which ***func*** returns true

Figure: Input DStream being converted through filter(func)

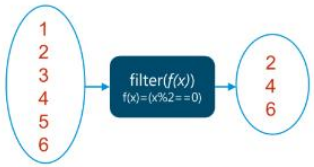

Figure: Filter Function For Even Numbers

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Transformations on DStreams

1. map
2. flatMap
3. filter
4. reduce
5. groupBy

- **reduce(*func*)**
- **reduce(*func*)** returns a new DStream of **single-element RDDs** by **aggregating** the elements in each RDD of the source DStream using a function ***func***

Figure: Input DStream being converted through reduce(func)

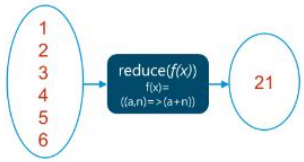

Figure: Reduce Function To Get Cumulative Sum

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Transformations on DStreams

1. map
2. flatMap
3. filter
4. reduce
5. groupBy

- **groupBy(*func*)**
- **groupBy(*func*)** returns the new RDD which basically is made up with a **key** and **corresponding list** of items of that group

Figure: Input DStream being converted through groupBy(func)

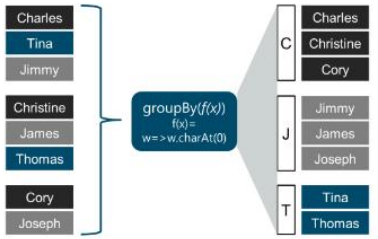

Figure: Grouping By First Letters

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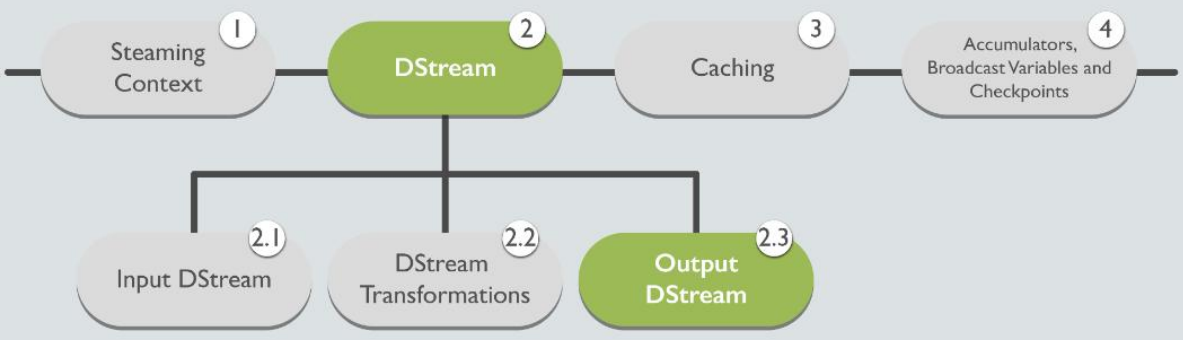

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Output Operations on DStreams

- ***Output operations*** allow DStream's data to be pushed out to ***external systems*** like ***databases*** or ***file systems***
- Output operations ***trigger*** the ***actual execution*** of all the DStream transformations

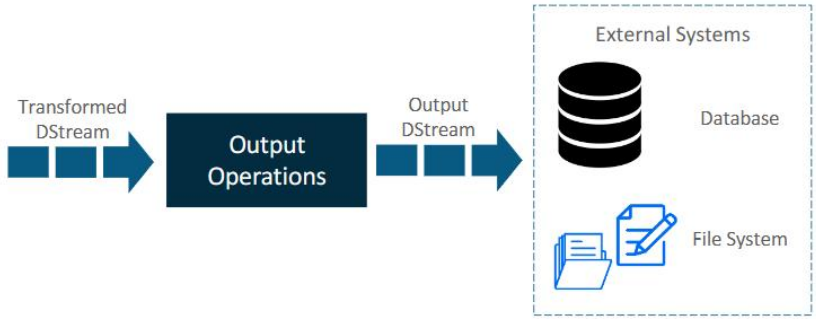

Figure: Output Operations on DStreams

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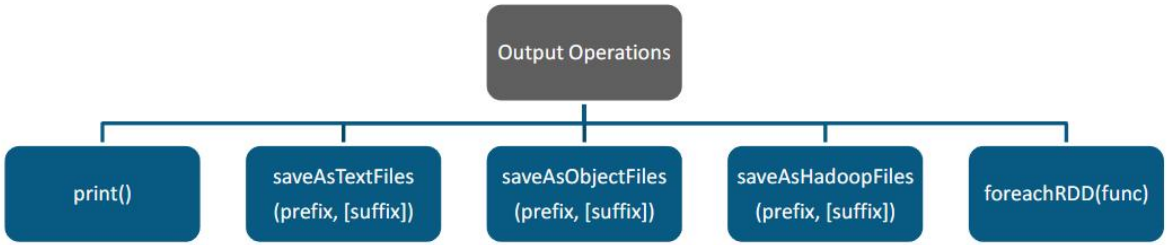
Output Operations on DStreams

- Currently, the following output operations are defined:



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Output Operations Example - foreachRDD

- *foreachRDD*
- *dstream.foreachRDD* is a powerful primitive that allows data to be sent out to external systems
- The lazy evaluation achieves the most efficient transfer of data

```
def sendRecord(record):
        connection = createNewConnection()
        connection.send(record)
        connection.close()
dstream.foreachRDD(lambda rdd: rdd.foreach(sendRecord))
```

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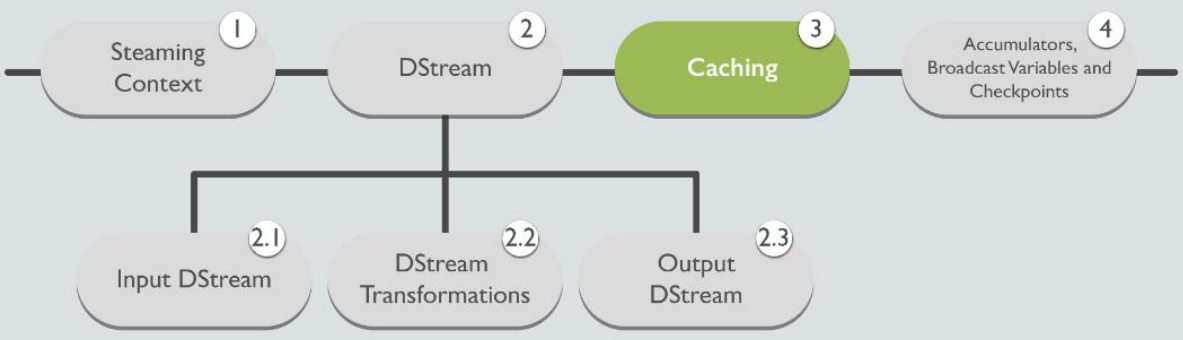

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Caching/Persistence

- ***DStreams*** allow developers to ***cache/ persist*** the stream's data in memory
- This is useful if the data in the DStream will be computed multiple times
- This can be done using the ***persist()*** method on a DStream
- For input streams that receive data over the network (such as Kafka, Flume, Sockets, etc.), the default persistence level is set to replicate the data to two nodes for fault-tolerance

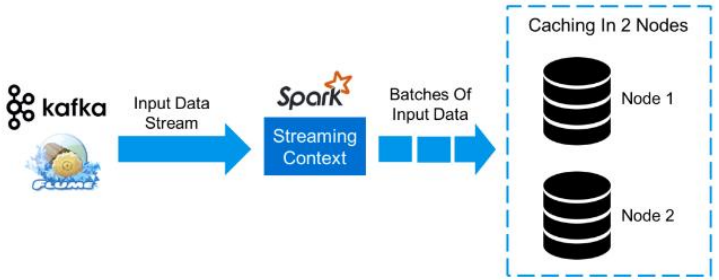

Figure: Caching Into 2 Nodes

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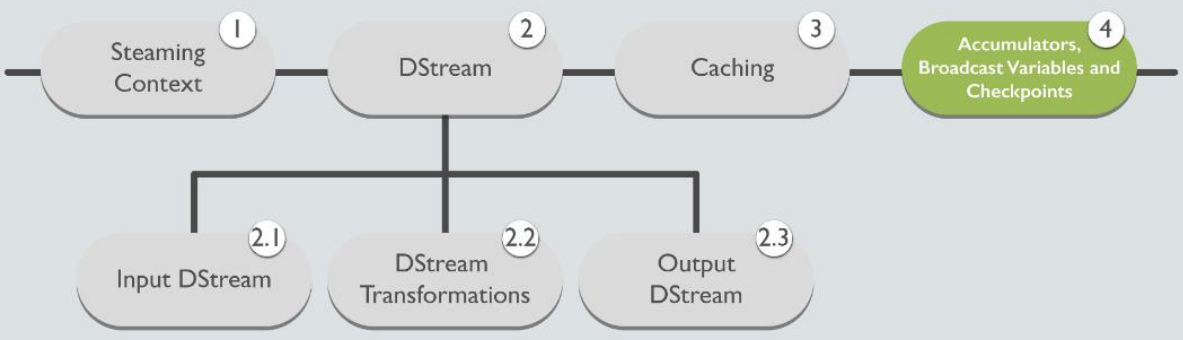

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Accumulators

- ***Accumulators*** are variables that are only added through an associative and commutative operation
- They are used to implement ***counters*** or ***sums***
- Tracking accumulators in the UI can be useful for ***understanding*** the ***progress*** of running stages
- Spark natively supports ***numeric*** accumulators. We can create ***named*** or ***unnamed*** accumulators

Accumulators

Accumulable	Value
counter	45

Tasks

Index ▲	ID	Attempt	Status	Locality Level	Executor ID / Host	Launch Time	Duration	GC Time	Accumulators	Errors
0	0	0	SUCCESS	PROCESS_LOCAL	driver / localhost	2016/04/21 10:10:41	17 ms			
1	1	0	SUCCESS	PROCESS_LOCAL	driver / localhost	2016/04/21 10:10:41	17 ms		counter: 1	
2	2	0	SUCCESS	PROCESS_LOCAL	driver / localhost	2016/04/21 10:10:41	17 ms		counter: 2	
3	3	0	SUCCESS	PROCESS_LOCAL	driver / localhost	2016/04/21 10:10:41	17 ms		counter: 7	
4	4	0	SUCCESS	PROCESS_LOCAL	driver / localhost	2016/04/21 10:10:41	17 ms		counter: 5	
5	5	0	SUCCESS	PROCESS_LOCAL	driver / localhost	2016/04/21 10:10:41	17 ms		counter: 6	
6	6	0	SUCCESS	PROCESS_LOCAL	driver / localhost	2016/04/21 10:10:41	17 ms		counter: 7	
7	7	0	SUCCESS	PROCESS_LOCAL	driver / localhost	2016/04/21 10:10:41	17 ms		counter: 17	

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Broadcast Variables

- ***Broadcast variables*** allow the programmer to keep ***a read-only variable cached*** on ***each machine*** rather than shipping a copy of it with tasks
- They can be used to give every node a ***copy*** of a ***large input dataset*** in an efficient manner
- ***Spark*** also attempts to distribute broadcast variables using efficient ***broadcast algorithms*** to reduce communication cost

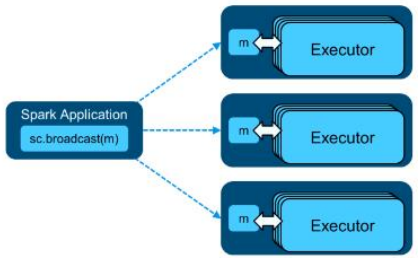

Figure: Broadcasting A Value To Executors

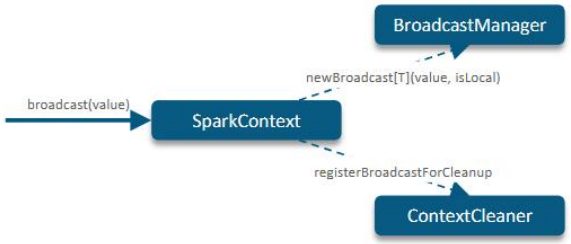

Figure: SparkContext and Broadcasting

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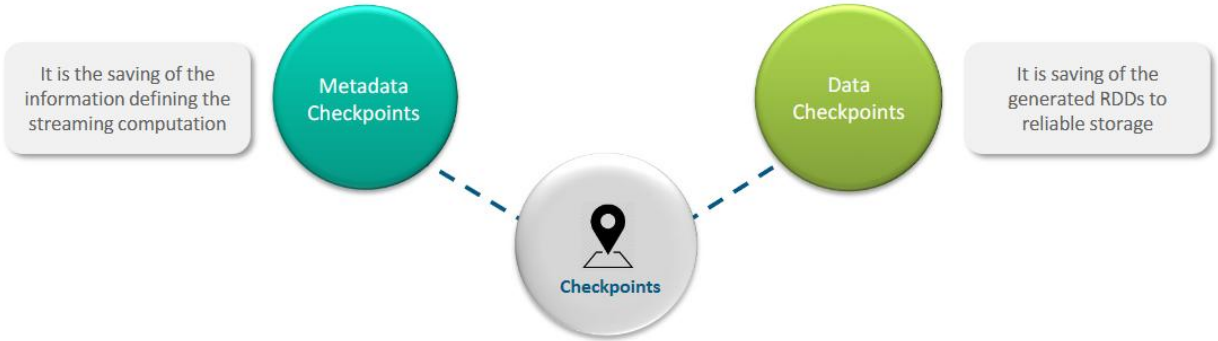
Checkpoints

- ***Checkpoints*** are similar to checkpoints in ***gaming***. They make it ***run 24/7*** and make it ***resilient to failures*** unrelated to the application logic



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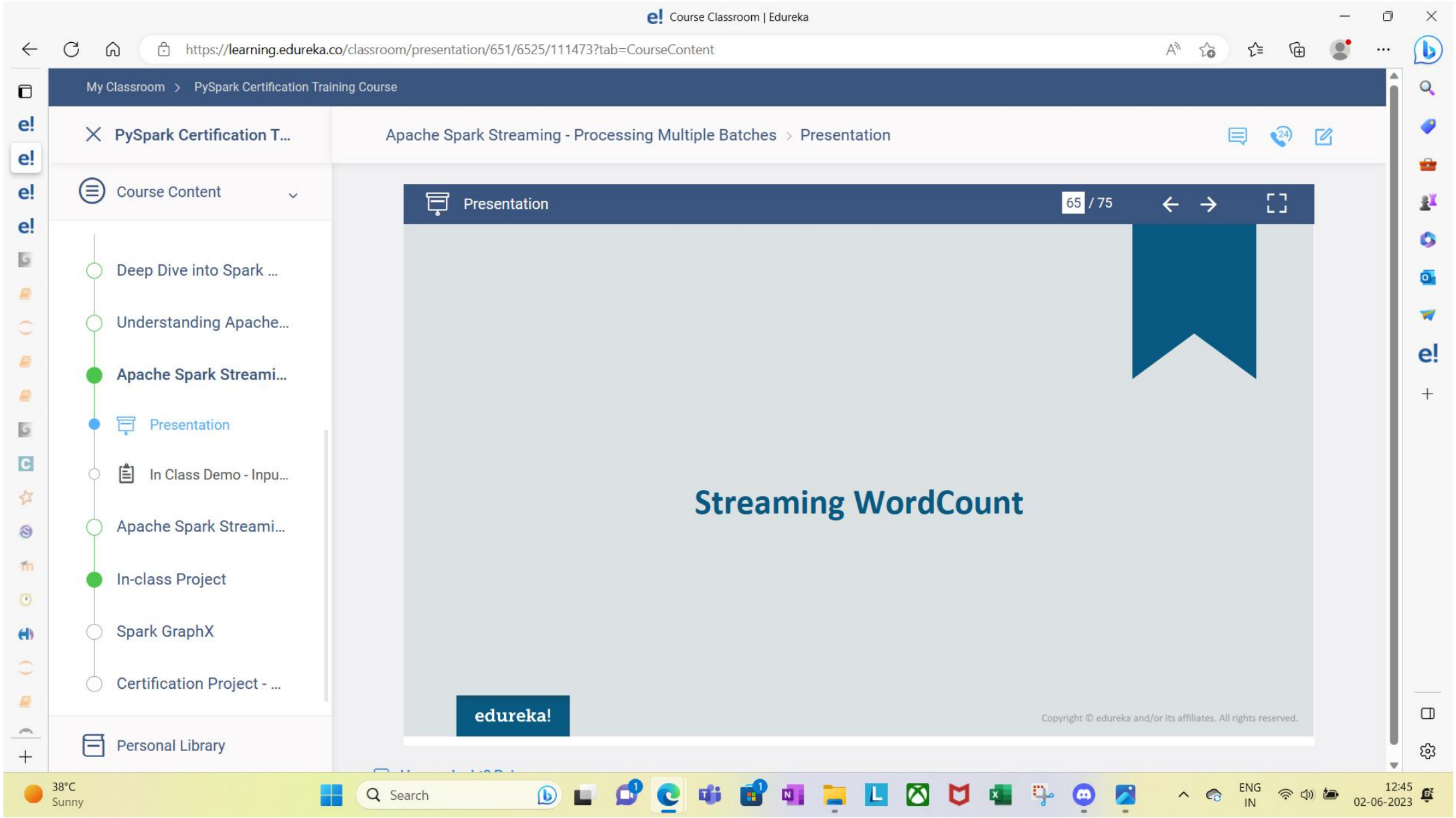
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Streaming WordCount

```
from pyspark import SparkContext
from pyspark.streaming import StreamingContext
# Create a local StreamingContext with two working thread and batch interval of 1 second
sc = SparkContext("local[2]", "NetworkWordCount")
ssc = StreamingContext(sc, 1)
# Create a DStream that will connect to hostname:port, like localhost:9999
lines = ssc.socketTextStream("localhost", 9999)
#Split each line into words
words = lines.flatMap(lambda line: line.split(" "))
```

Importing StreamingContext

Creating a local StreamingContext with two execution threads, and batch interval of 1 second

The lines DStream represents the stream of data that will be received from the data server

Each line will be split into multiple words and the stream of words is represented as the **words** DStream

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Streaming WordCount

```
# Count each word in each batch
pairs = words.map(lambda word: (word, 1))

wordCounts = pairs.reduceByKey(lambda x, y: x + y) # Print the first ten elements of each RDD generated in this DStream to the console

wordCounts.pprint()

ssc.start() # Start the computation

ssc.awaitTermination() # Wait for the computation to terminate
```

To start the processing, ssc.start() command is used

The **words** DStream is to a DStream of (word, 1) pairs, which is then reduced to get the frequency of words in each batch of data

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Windowed Operators

- In short, ***windowed operators*** allow you to apply transformations over a ***sliding window*** of data
- *There are mainly 3 types of operators :*

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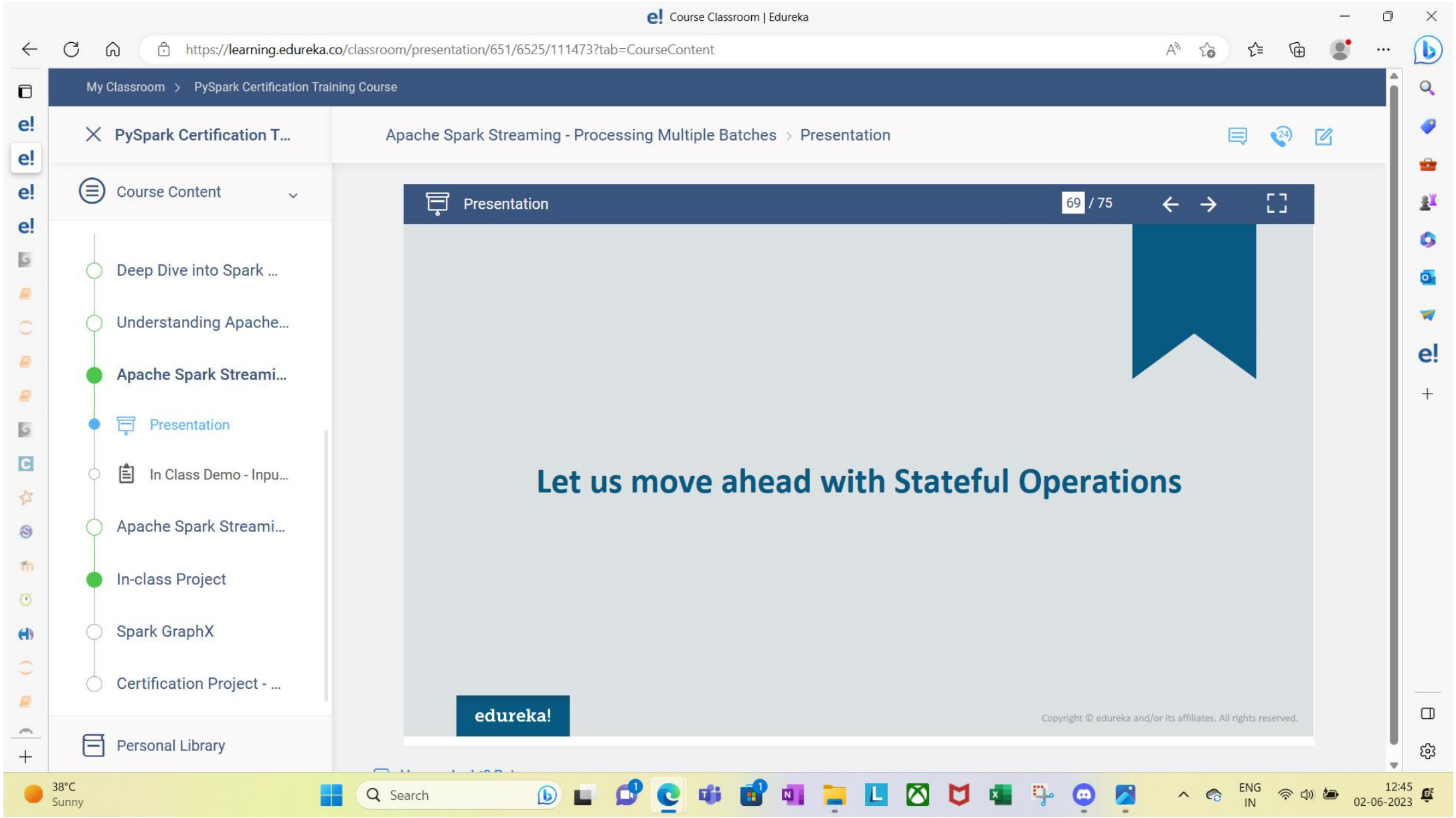
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Apache Spark Streami...
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Let us move ahead with Stateful Operations
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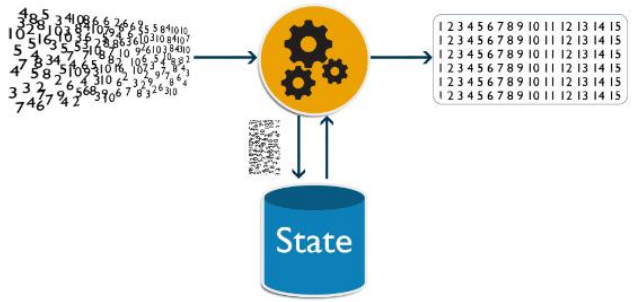
Stateful Operators

- ***Stateful operators*** (like `mapWithState` or `updateStateByKey`) are part of the set of additional operators available on DStreams of *key-value pairs*, i.e. instances of *DStream[(K, V)]*
- They allow you to build stateful stream processing pipelines and are also called cumulative calculations
- By design streaming operators are *stateless* and know nothing about the previous records and hence a state
- If we'd like to react to new records appropriately given the previous records we would have to resort to using ***persistent storages*** outside Spark Streaming
- Few Examples of Stateful Operators are:
  - ***mapWithState***
  - ***StateSpec***
  - ***updateStateByKey***



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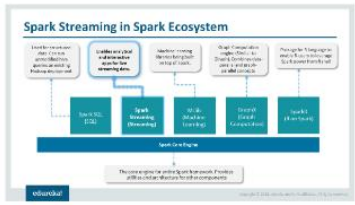
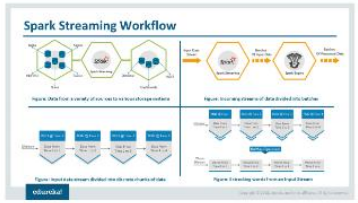
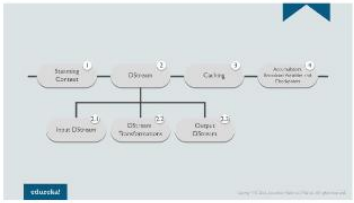
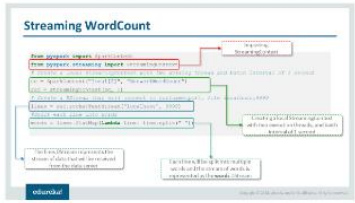
Summary









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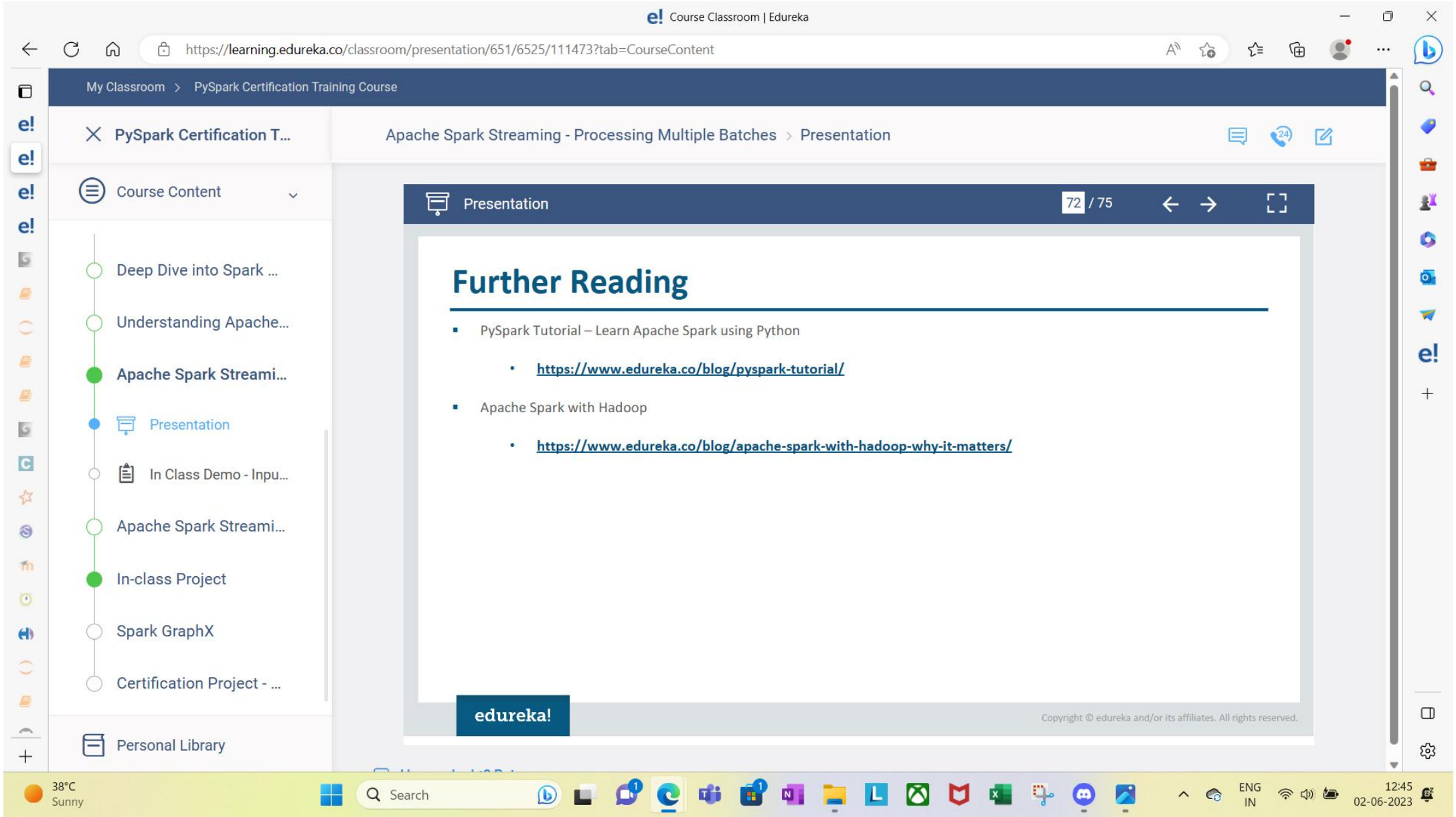
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Further Reading
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