**Required Viewing**

Before starting this assignment, you must watch two videos:

1. **Week 4 Fundamentals Lecture Video**
   * Explains how Spark applications are submitted with spark-submit.
   * Introduces working with Spark in both Scala and PySpark.
   * Covers the basics of RDDs and provides the background needed to understand what you are learning.
   * Link: <https://youtu.be/YyWoTZOkDSE>
2. **Week 4 Assignment Walkthrough Video**
   * Demonstrates step by step how to complete the tasks, including commands and expected outputs.
   * It is not enough to simply run commands. You must verify that your commands execute correctly. Incorrect or incomplete results will lose points.

Watching both videos is mandatory. The **fundamentals video** explains what you are learning and why it matters, while the **walkthrough video** shows how to complete the assignment.

**Submission Guidelines**

* Submit your work as a **single Word or PDF document** (no raw screenshots or multiple files).
* Include the following in your submission:
  + Screenshots of each required step.
  + A short explanation for each screenshot:
    - The command/action you ran.
    - What the output shows.
    - Whether the result matched your expectation.
* Organize your work in the **same order as the assignment guide** so it is easy to follow.
* This is a **master’s level course** – professionalism and clarity are expected. Well-structured submissions demonstrate your ability to communicate technical work effectively.

**Week 4 Assignment – Objectives and Points**

* **Objective 1 – Conceptual Foundations**: 8 pts
* **Objective 2 – Running SparkPi with PySpark**: 10 pts
* **Objective 3 – Spark Scala Shell (Random Numbers)**: 20 pts
* **Objective 4 – Custom Transformation with Scala**: 20 pts
* **Objective 5 – Spark IDE + week4.py Development**: 30 pts

**Total: 88 points**

## Week 4 Assignment: Introduction to Apache Spark using Scala and PySpark

Apache Spark is an open-source, distributed computing system that enables lightning-fast data processing across large datasets. It’s designed to handle both batch and real-time data, making it one of the most versatile tools in the big data ecosystem. Spark’s in-memory processing capabilities drastically improve the speed of applications compared to traditional disk-based engines like Hadoop MapReduce, allowing for faster data analytics, machine learning, and graph processing.

In this assignment, you will:

* **Explore Spark's Core Concepts**: Learn how Spark leverages **Resilient Distributed Datasets (RDDs)** to efficiently distribute and process data across a cluster of machines.
* **Work with PySpark and Scala**: Gain hands-on experience with both Python and Scala APIs for Spark, two of the most commonly used languages for big data processing.
* **Understand Distributed Data Processing**: See how Spark splits tasks into smaller units, distributes them across different nodes in a cluster, and processes them in parallel for maximum efficiency.
* **Perform Data Transformations**: Use Spark’s powerful transformation functions like map and filter to manipulate datasets and observe how Spark executes these transformations in a distributed manner.
* **Run Jobs Using YARN**: Interact with **YARN**, the cluster manager responsible for resource allocation, to see how Spark jobs are scheduled and executed in a distributed environment.

By the end of this assignment, you will understand why Spark is a cornerstone of modern big data architectures and how to leverage its capabilities for efficient and scalable data processing.

# Objective 1 – Conceptual Foundations: (8 points)

Before beginning the assignment, watch the instructor-led fundamentals video, which introduces and explains the key concepts for this week:  
<https://youtu.be/YyWoTZOkDSE>  
  
**Deliverable:** Write a 3–4 paragraph summary in your own words. Your write-up should explain the main ideas, highlight why these concepts are important, and connect them to the Spark tasks in this assignment.

# Objective 2 – Running SparkPi with PySpark (10 points)

#### **1. Environment Initialization**

* As you did in the Week 2 and Week 3 assignments, begin by navigating to the appropriate directory:
* cd dsc650-infra/bellevue-bigdata/hadoop-hive-spark-hbase
* Start your Docker containers:
* docker-compose up -d
* Access the master container:
* docker-compose exec master bash

#### **2. Running a Built-in Spark Example with PySpark**

Here, you will run the built-in **SparkPi** example using PySpark. This simple example calculates an approximation of Pi by using PySpark to distribute the computation across the cluster. This step provides a basic introduction to running a Spark job and observing how Spark manages resources under the hood.

To get hands-on experience with PySpark, we will execute the provided SparkPi example using the following command in the master container:

spark-submit --class org.apache.spark.examples.SparkPi \  
 --master yarn \  
 --deploy-mode client \  
 --driver-memory 2g \  
 --executor-memory 1g \  
 --executor-cores 1 \  
 $SPARK\_HOME/examples/jars/spark-examples\*.jar \  
 10

# Deliverable: Screenshot of the SparkPi output, plus 1–2 sentences explaining what command you ran and what the result shows (why it is an approximation of Pi).

# Objective 3 – Spark Scala Shell (20 points)

#### **1. Starting the Spark Scala Shell**

After running the PySpark job, you will now start the **Spark Scala shell**. Spark was originally developed in Scala, and this shell gives you the ability to interact with Spark using Scala commands. Here, you will begin experimenting with Spark’s core features in its native language.

In the master container’s terminal, initiate the Spark Scala shell:

$SPARK\_HOME/bin/spark-shell --master yarn --driver-memory 2g --executor-memory 1g --executor-cores 1

#### **2. Generating and Printing Random Numbers in the Scala Shell**

In the Scala shell, you will generate a list of random numbers and distribute them across your Spark cluster. By using the parallelize function, you are distributing the data to be processed in parallel, which is one of Spark’s key features. Printing a subset of these numbers will confirm that the data has been distributed correctly.

Execute the following commands in the Spark Scala shell:

val numNumbers = 10000  
val numbers = (1 to numNumbers).map(\_ => scala.util.Random.nextInt(1000))  
val numbersRDD = sc.parallelize(numbers)  
numbersRDD.take(100).foreach(println)

**Deliverable:** Screenshot of the first 100 generated random numbers, plus a short explanation of what the code did, how Spark parallelized the numbers, and why this matters for distributed processing.

# Objective 4 – Custom Transformation with Scala (20 points)

#### **1. Generating and Transforming Random Sentences in the Scala Shell**

In this final section, you will generate random sentences from a predefined list of words and apply transformations to the data. By using Spark’s map function, you’ll gain experience in applying transformations to distributed data. This demonstrates how Spark allows you to manipulate large datasets in parallel using simple functional programming constructs.

Modify the transformation placeholder in the following command to apply your custom logic (e.g., convert sentences to uppercase, reverse the words, etc.).

Generate random sentences and apply a transformation of your choice:

val numberOfSentences = 1000  
val words = List("apple", "banana", "cherry", "date", "elderberry", "fig", "grape", "honeydew")  
val sentences = (1 to numberOfSentences).map(\_ => scala.util.Random.shuffle(words).take(scala.util.Random.nextInt(6) + 1).mkString(" ") + ".")  
val sentencesRDD = sc.parallelize(sentences)  
  
// Apply your custom transformation here  
val transformedSentences = sentencesRDD.map(sentence => /\* Your transformation code here \*/)  
transformedSentences.take(100).foreach(println)

**Instructions:** Modify the placeholder /\* Your transformation code here \*/ to apply a unique transformation to each sentence.

**Deliverable:** Screenshot of a segment of your generated and transformed sentences, plus a short explanation of the unique transformation you applied and what the output confirms.

# Objective 5 – Spark IDE + week4.py Development (30 points)

**This part of the assignment is critical as it will be required for the final project.**

**Watch the walkthrough here:**  <https://youtu.be/XXxFYUCCzhM>

#### **1. Download VS Code**

<https://code.visualstudio.com/download>

#### **2. Install python 3 on your Computer**

Mac: <https://formulae.brew.sh/formula/python@3.11>

PC: <https://www.python.org/downloads/>

#### **3. Install git on the master container**

apk add git

#### **3. The initial week4.py**

from pyspark.sql import SparkSession

import random

# Start Spark

spark = SparkSession.builder.appName("SentenceGenerator").getOrCreate()

sc = spark.sparkContext

# Word list

words = ["apple", "banana", "cherry", "date", "elderberry", "fig", "grape", "honeydew"]

# Generate sentences on the driver

num\_sentences = 1000

sentences = [

" ".join(random.sample(words, random.randint(1, 6))) + "."

for \_ in range(num\_sentences)

]

# Parallelize into RDD

sentences\_rdd = sc.parallelize(sentences)

# Transformation (replace with your own logic)

transformed = sentences\_rdd.map(lambda s: s.upper())

# Show some results (will go to YARN driver logs in cluster mode)

for line in transformed.take(100):

print(line)

spark.stop()

#### **4. The Updated week4.py**

from pyspark.sql import SparkSession

import random

# Start Spark

spark = SparkSession.builder.appName("SentenceGenerator").getOrCreate()

sc = spark.sparkContext

# Word list

words = ["apple", "banana", "cherry", "date", "elderberry", "fig", "grape", "honeydew"]

# Generate sentences on the driver

num\_sentences = 1000

sentences = [

" ".join(random.sample(words, random.randint(1, 6))) + "."

for \_ in range(num\_sentences)

]

# Parallelize into RDD

sentences\_rdd = sc.parallelize(sentences)

# Transformation (replace with your own logic)

transformed = sentences\_rdd.map(lambda s: s.upper())

# Save to HDFS (change the path to something you have write access to)

output\_path = "hdfs:///tmp/week4\_output"

transformed.saveAsTextFile(output\_path)

spark.stop()

#### **5. Spark Submit Command**

spark-submit \

--master yarn \

--deploy-mode cluster \

--name SentenceGenerator \

week4.py

* **Deliverable 1**: Screenshot of your IDE (VS Code) showing your Spark code, plus 1–2 sentences explaining what it shows.
* **Deliverable 2:** Screenshot of your Spark job completing successfully, plus a short explanation of the output.
* **Deliverable 3:** Screenshot of the hdfs dfs -ls command showing the output directory, with an explanation of what it confirms.
* **Deliverable 4:** Screenshot of the hdfs dfs -cat command displaying the output data, with a short explanation of what it confirms.

## Shutting Down

Ensure all Docker containers are turned off with docker-compose down for each directory. If you’re using google cloud, please shut down your virtual machine to preserve cloud costs.