HỆ THỐNG LƯU TRỮ VÀ XỬ LÝ DỮ LIỆU THÔNG TIN CÁC CHUYẾN BAY

Môn học: Lưu trữ và xử lý dữ liệu lớn

Nhóm sinh viên

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Outline

Đặt vấn đề

- Dữ liệu các chuyến bay trong thực tế thường đến dưới dạng bản ghi (PNR - Passenger Name Record) theo time series với số lượng rất lớn, vì vậy các hệ thống lưu trữ và xử lý dữ liệu truyền thống không còn hiệu quả.
- Cần xây dựng một hệ thống lưu trữ và xử lý dữ liệu phân tán cho dữ liệu lớn với các ràng buộc:
  - Đáp ứng các yêu cầu về tính toán và lưu trữ
  - Có khả năng chịu lỗi tốt khi các máy trong hệ thống không tin cậy
  - Dễ dàng mở rộng
  - Cho phép người dùng có thể xem dữ liệu real-time và thực hiện các truy vấn không real-time như visulize thống kê hay anomaly detection

Đặc tả một bản ghi

ArrivalTime – local time of arrival

BusinessLeisure – if the trip is for business or leisure

CabinCategory – cabin class

CreationDate –PNR creation date (Julian day)

CurrencyCode – 3-letter currency code of payment

DepartureTime – local time of departure

Destination – IATA code of arrival airport

OfficeIdCountry – country code of office placing the reser

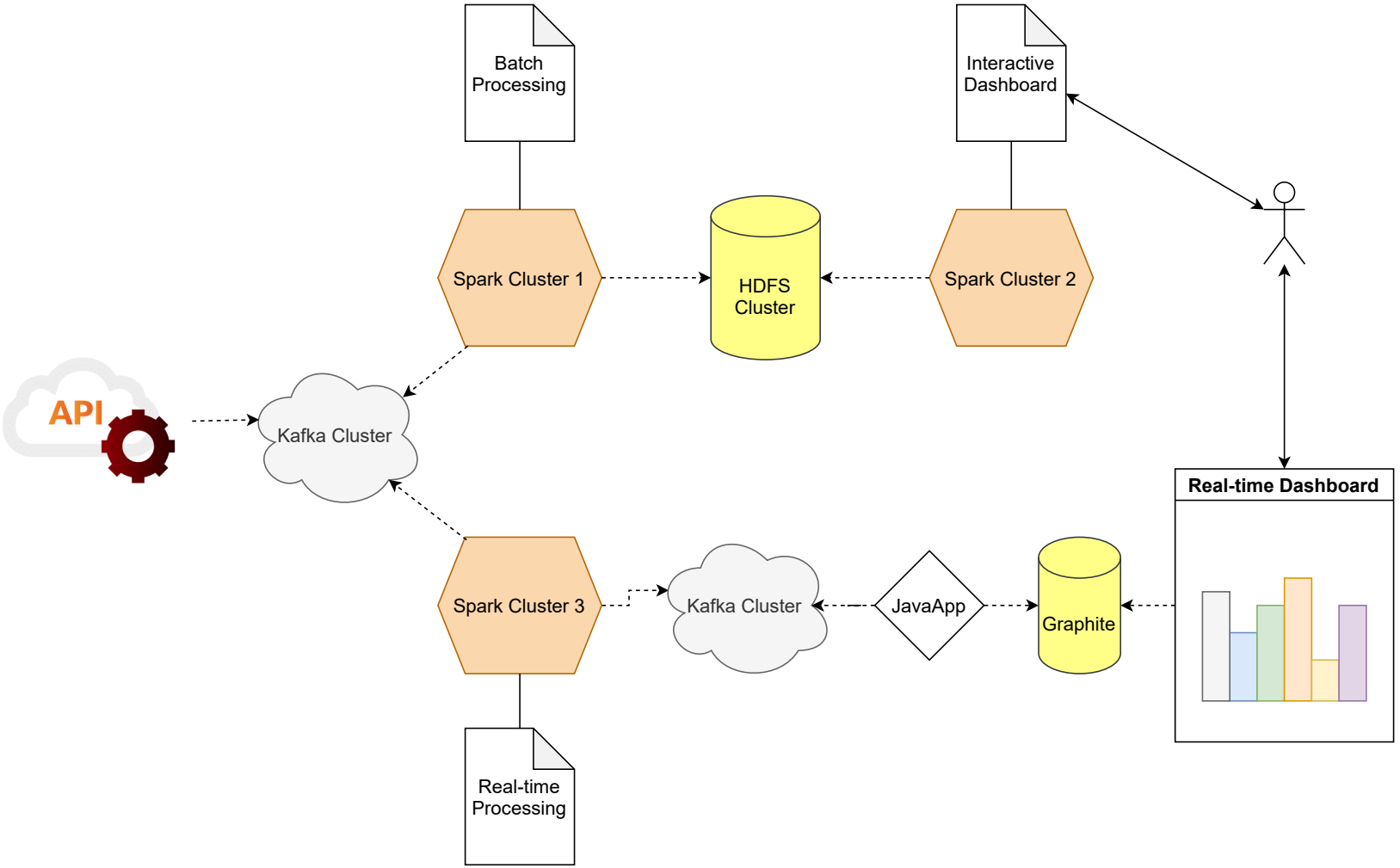
Origin – IATA code of departure airport

TotalAmount – total reservation cost

nPAX – number of passengers


```
{
  "ID": 1188,
  "ArrivalTime": "1453042816",
  "BusinessLeisure": "B",
  "CabinCategory": "40",
  "CreationDate": "2457373",
  "CurrencyCode": "nan",
  "DepartureTime": "1452892672",
  "Destination": "TRD",
  "OfficeIdCountry": "NO",
  "Origin": "ALC",
  "TotalAmount": "nan",
  "nPAX": "1"
}
```


Kiến trúc tổng quan



HDFS Cluster

```
namenode:
  image: bde2020/hadoop-namenode:2.0.0-hadoop2.7.4-java8
  container_name: namenode
  environment:
    - CLUSTER_NAME=test
  env_file:
    - ./hadoop.env
  ports:
    - 8020:8020
    - 50070:50070
datanode-1:
  image: bde2020/hadoop-datanode:2.0.0-hadoop2.7.4-java8
  container_name: datanode-1
  environment:
    SERVICE_PRECONDITION: "namenode:50070"
  env_file:
    - ./hadoop.env
  ports:
    - 50075:50075

datanode-2:
  image: bde2020/hadoop-datanode:2.0.0-hadoop2.7.4-java8
  container_name: datanode-2
  environment:
    SERVICE_PRECONDITION: "namenode:50070"
  env_file:
    - ./hadoop.env
  ports:
    - 50076:50075
```

Kafka Cluster

```yaml
zookeeper:
  image: zookeeper:3.4.10
  container_name: zookeeper
  environment:
    ZOO_MY_ID: 1
    ZOO_SERVERS: server.1=0.0.0.0:2888:3888
    ZOO_TICK_TIME: 15000
  ports:
    - 2181:2181

kafka-broker-1:
  image: wurstmeister/kafka:2.12-2.2.1
  container_name: kafka-broker-1
  depends_on:
    - zookeeper
  ports:
    - "9092:9092"
  environment:
    - KAFKA_ZOOKEEPER_CONNECT=zookeeper:2181
    - ALLOW_PLAINTEXT_LISTENER=yes
    - KAFKA_ADVERTISED_LISTENERS=INSIDE://kafka-broker-1:9093,OUTSIDE://localhost:9092
    - KAFKA_LISTENER_SECURITY_PROTOCOL_MAP=INSIDE:PLAINTEXT,OUTSIDE:PLAINTEXT
    - KAFKA_LISTENERS=INSIDE://kafka-broker-1:9093,OUTSIDE://0.0.0.0:9092
    - KAFKA_INTER_BROKER_LISTENER_NAME=INSIDE
kafka-broker-2:
  image: wurstmeister/kafka:2.12-2.2.1
  container_name: kafka-broker-2
  depends_on:
    - zookeeper
  ports:
    - "9094:9094"
  environment:
    - KAFKA_ZOOKEEPER_CONNECT=zookeeper:2181
    - ALLOW_PLAINTEXT_LISTENER=yes
    - KAFKA_ADVERTISED_LISTENERS=INSIDE://kafka-broker-2:9093,OUTSIDE://localhost:9094
    - KAFKA_LISTENER_SECURITY_PROTOCOL_MAP=INSIDE:PLAINTEXT,OUTSIDE:PLAINTEXT
    - KAFKA_LISTENERS=INSIDE://kafka-broker-2:9093,OUTSIDE://0.0.0.0:9094
    - KAFKA_INTER_BROKER_LISTENER_NAME=INSIDE
```

Spark Cluster

```
post-batch-processing-spark-master:
  image: vutrungnghia99/spark-master:spark2.4.1-python3.7-hadoop2.7
  container_name: post-batch-processing-spark-master
  ports:
    - "8083:8080"
    - "7078:7077"
  environment:
    - INIT_DAEMON_STEP=setup_spark
post-batch-processing-spark-worker-1:
  image: vutrungnghia99/spark-worker:spark2.4.1-python3.7-hadoop2.7
  container_name: post-batch-processing-spark-worker-1
  depends_on:
    - post-batch-processing-spark-master
  environment:
    - "SPARK_MASTER=spark://post-batch-processing-spark-master:7077"
    - "SPARK_WORKER_CORES=1"
    - "SPARK_WORKER_MEMORY=1G"
    - "SPARK_DRIVER_MEMORY=128m"
    - "SPARK_EXECUTOR_MEMORY=256m"
post-batch-processing-spark-worker-2:
  image: vutrungnghia99/spark-worker:spark2.4.1-python3.7-hadoop2.7
  container_name: post-batch-processing-spark-worker-2
  depends_on:
    - post-batch-processing-spark-master
  environment:
    - "SPARK_MASTER=spark://post-batch-processing-spark-master:7077"
    - "SPARK_WORKER_CORES=1"
    - "SPARK_WORKER_MEMORY=1G"
    - "SPARK_DRIVER_MEMORY=128m"
    - "SPARK_EXECUTOR_MEMORY=256m"
```

Systen manager - Graphite - Grafana

```
############################### manager ###################################
  system-manager:
    image: vutrungnghia99/system-manager:spark2.4.1-python3.7-hadoop2.7-kafka2.7.0
    container_name: system-manager
    ports:
      - "8888:8888"
    volumes:
      - $PWD/src:/home/jovyan/work
    environment:
      - JUPYTER_TOKEN=admin

######################## Graphite and Grafana ############################
  graphite:
    image: vutrungnghia99/graphite:1.1.7-6
    container_name: graphite
    ports:
      - "80:80"
      - "2003:2003"
      - "2004:2004"

  grafana:
    image: grafana/grafana:latest
    container_name: grafana
    ports:
      - "3000:3000"
```

Danh sách containers [16]

IMAGE	NAMES
vutrungnghia99/spark-worker:spark2.4.1-python3.7-hadoop2.7	post-batch-processing-spark-worker-2
vutrungnghia99/spark-worker:spark2.4.1-python3.7-hadoop2.7	post-batch-processing-spark-worker-1
vutrungnghia99/spark-worker:spark2.4.1-python3.7-hadoop2.7	speed-processing-spark-worker-1
wurstmeister/kafka:2.12-2.2.1	kafka-broker-1
wurstmeister/kafka:2.12-2.2.1	kafka-broker-2
vutrungnghia99/spark-worker:spark2.4.1-python3.7-hadoop2.7	pre-batch-processing-spark-worker-1
vutrungnghia99/spark-master:spark2.4.1-python3.7-hadoop2.7	speed-processing-spark-master
zookeeper:3.4.10	zookeeper
vutrungnghia99/system-manager:spark2.4.1-python3.7-hadoop2.7-kafka2.7.0	system-manager
vutrungnghia99/spark-master:spark2.4.1-python3.7-hadoop2.7	post-batch-processing-spark-master
bde2020/hadoop-datanode:2.0.0-hadoop2.7.4-java8	datanode-2
grafana/grafana:latest	grafana
vutrungnghia99/spark-master:spark2.4.1-python3.7-hadoop2.7	pre-batch-processing-spark-master
bde2020/hadoop-namenode:2.0.0-hadoop2.7.4-java8	namenode
vutrungnghia99/graphite:1.1.7-6	graphite
bde2020/hadoop-datanode:2.0.0-hadoop2.7.4-java8	datanode-1

Spark cluster 1

Spark Master at spark://7a6c33b85408:7077

2.4.1

URL: spark://7a6c33b85408:7077
Alive Workers: 1
Cores in use: 1 Total, 0 Used
Memory in use: 1024.0 MB Total, 0.0 B Used
Applications: 0 Running, 0 Completed
Drivers: 0 Running, 0 Completed
Status: ALIVE

Workers (1)

Worker Id	Address
worker-20201223081126-172.18.0.12-34753	172.18.0.12:34753

Running Applications (0)

Application ID	Name	Cores	Memory per Executor

Completed Applications (0)

Application ID	Name	Cores	Memory per Executor

Chương trình BatchProcessing

```
def get_categorical(x, m):
    if str(x) == 'nan':
        return 0.0
    else:
        v = m['mapping'][str(x)]
        return (v - m['statistic']['mean']) / m['statistic']['std']

def json_to_processed_data(s):
    t = json.loads(s)
    return [
        t['ID'],
        get_continous(t['ArrivalTime'], mapping_and_statistic['ArrivalTime']),
        get_categorical(t['BusinessLeisure'], mapping_and_statistic['BusinessLeisure']),
        get_categorical(t['CabinCategory'], mapping_and_statistic['CabinCategory']),
        get_continous(t['CreationDate'], mapping_and_statistic['CreationDate']),
        get_categorical(t['CurrencyCode'], mapping_and_statistic['CurrencyCode']),
        get_continous(t['DepartureTime'], mapping_and_statistic['DepartureTime']),
        get_categorical(t['Destination'], mapping_and_statistic['Destination']),
        get_categorical(t['OfficeIdCountry'], mapping_and_statistic['OfficeIdCountry']),
        get_categorical(t['Origin'], mapping_and_statistic['Origin']),
        get_continous(t['TotalAmount'], mapping_and_statistic['TotalAmount']),
        get_continous(t['nPAX'], mapping_and_statistic['nPAX']),
        s
    ]
```

In [*]:
```
ks = KafkaUtils.createDirectStream(
    ssc, ['trips'], {'metadata.broker.list': 'kafka-broker-1:9093,kafka-broker-2:9093'})
lines = ks.map(lambda x: x[1])

transform1 = lines.map(lambda tripInfo: json_to_list(tripInfo))
transform1.foreachRDD(handle_rdd1)

transform2 = lines.map(lambda tripInfo: json_to_processed_data(tripInfo))
transform2.foreachRDD(handle_rdd2)

ssc.start()
ssc.awaitTermination()
```

Spark cluster 2

Spark Master at spark://3d40737aa3f2:7077

2.4.1

URL: spark://3d40737aa3f2:7077
Alive Workers: 2
Cores in use: 2 Total, 0 Used
Memory in use: 2.0 GB Total, 0.0 B Used
Applications: 0 Running, 0 Completed
Drivers: 0 Running, 0 Completed
Status: ALIVE

Workers (2)

Worker Id	Address
worker-20201223081126-172.18.0.16-38487	172.18.0.16:38487
worker-20201223081126-172.18.0.17-37513	172.18.0.17:37513

Running Applications (0)

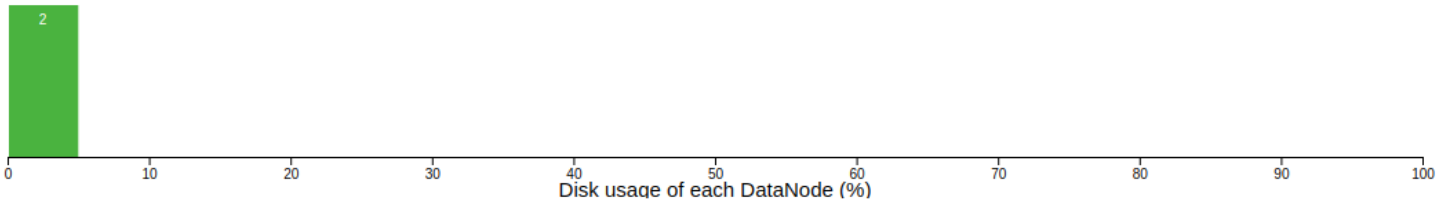
Application ID	Name	Cores	Memory per Executor

Completed Applications (0)

HDFS

Datanode Information

Datanode usage histogram



In operation

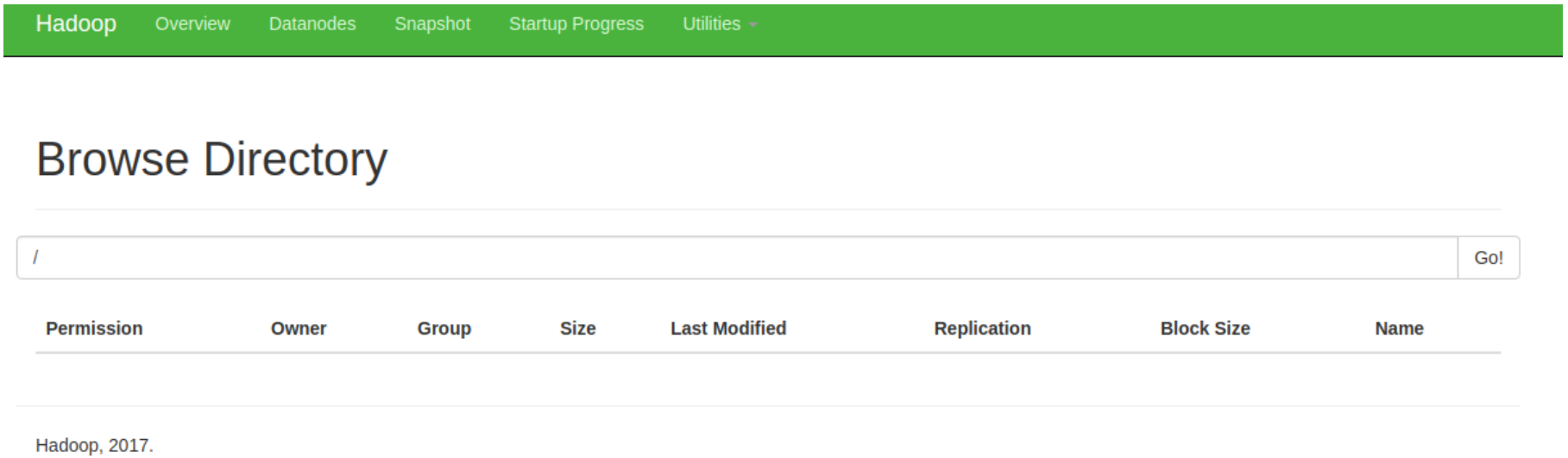
Node	Last contact	Admin State	Capacity	Used	Non DFS Used	Remaining	Blocks	Block pool used	Failed Volumes	Version
c65069a49aa9:50010 (172.18.0.3:50010)	1	In Service	355.6 GB	24 KB	83.51 GB	253.96 GB	0	24 KB (0%)	0	2.7.4
5abe514e7d51:50010 (172.18.0.8:50010)	0	In Service	355.6 GB	24 KB	83.51 GB	253.96 GB	0	24 KB (0%)	0	2.7.4

Decomissioning

Node	Last contact	Under replicated blocks	Blocks with no live replicas	Under Replicated Blocks In files under construction

Hadoop, 2017.

HDFS


Hadoop
Overview
Datanodes
Snapshot
Startup Progress
Utilities
Browse Directory
/
Go!
Permission
Owner
Group
Size
Last Modified
Replication
Block Size
Name
Hadoop, 2017.

Gửi 10000 bản ghi từ local vào topic "trips"

```
Topic: trips    PartitionCount: 2       ReplicationFactor: 2    Configs: segment.bytes=1073741824
        Topic: trips    Partition: 0    Leader: 1002    Replicas: 1002,1001     Isr: 1002,1001
        Topic: trips    Partition: 1    Leader: 1001    Replicas: 1001,1002     Isr: 1001,1002
```

```
late event
late event
late event
late event
late event
late event
100%|
Sent 10000 records in 23.760411262512207 seconds
Sending rate: 420.86813605694687 records/s
```

Partition 0 trên hai brokers

ation": "LHR", "OfficeIdCountry": "GB", "Origin": "LHR", "TotalAmount": "nan",
 "nPAX": "1"}◆H◆, ◆v◆◆◆v◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆{"ID": 9981, "ArrivalTime": "144346
9312", "BusinessLeisure": "nan", "CabinCategory": "40", "CreationDate": "24571
98", "CurrencyCode": "nan", "DepartureTime": "1443745408", "Destination": "KUL
", "OfficeIdCountry": "DE", "Origin": "MUC", "TotalAmount": "nan", "nPAX": "1"
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sinessLeisure": "nan", "CabinCategory": "40", "CreationDate": "2457292", "Curr
encyCode": "nan", "DepartureTime": "1445481088", "Destination": "BCN", "Office
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ation": "LHR", "OfficeIdCountry": "GB", "Origin": "LHR", "TotalAmount": "nan",
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sinessLeisure": "nan", "CabinCategory": "40", "CreationDate": "2457292", "Curr
encyCode": "nan", "DepartureTime": "1445481088", "Destination": "BCN", "Office
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ivalTime": "1444902656", "BusinessLeisure": "nan", "CabinCategory": "40", "Cre
ationDate": "2457162", "CurrencyCode": "nan", "DepartureTime": "1445120256", "
Destination": "JNB", "OfficeIdCountry": "PL", "Origin": "PRG", "TotalAmount":
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Partition 0,1 trên broker 0

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98", "CurrencyCode": "nan", "DepartureTime": "1443745408", "Destination": "KUL
", "OfficeIdCountry": "DE", "Origin": "MUC", "TotalAmount": "nan", "nPAX": "1"
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sinessLeisure": "nan", "CabinCategory": "40", "CreationDate": "2457292", "Curr
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IdCountry": "SE", "Origin": "ARN", "TotalAmount": "nan", "nPAX": "1"}◆◆{"ID":
9983, "ArrivalTime": "1437361280", "BusinessLeisure": "nan", "CabinCategory":
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lAmount": "nan", "nPAX": "1"}◆Hs◆◆◆v◆◆◆◆v◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆{"ID": 9985, "Arr
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": "KHI", "OfficeIdCountry": "SA", "Origin": "RUH", "TotalAmount": "0.0", "nPA
X": "1"}bash-4.4#

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n": "MLE", "OfficeIdCountry": "DK", "Origin": "CPH", "TotalAmount": "nan", "nP
AX": "2"}rH
          c◆v◆◆◆◆v◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆{"ID": 9999, "ArrivalTime": "1438053120
", "BusinessLeisure": "nan", "CabinCategory": "40", "CreationDate": "2457169",
 "CurrencyCode": "nan", "DepartureTime": "1438486912", "Destination": "TNR", "
OfficeIdCountry": "KE", "Origin": "LPA", "TotalAmount": "nan", "nPAX": "1"}bas
h-4.4#

Kết quả xử lý và nhận trên Batch Processing Notebook

In [*]:
```
ks = KafkaUtils.createDirectStream(
    ssc, ['trips'], {'metadata.broker.list': 'kafka-broker-1:9093,kafka-broker-2:9093'})
lines = ks.map(lambda x: x[1])

transform1 = lines.map(lambda tripInfo: json_to_list(tripInfo))
transform1.foreachRDD(handle_rdd1)

transform2 = lines.map(lambda tripInfo: json_to_processed_data(tripInfo))
transform2.foreachRDD(handle_rdd2)

ssc.start()
ssc.awaitTermination()
```

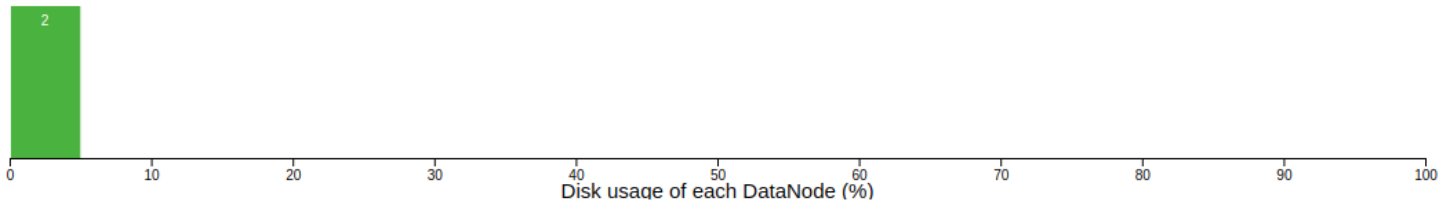
```
Recieved 606 records - transform 1
Recieved 606 records - transform 2
Recieved 5832 records - transform 1
Recieved 5832 records - transform 2
Recieved 3562 records - transform 1
Recieved 3562 records - transform 2
```

Dữ liệu lưu trong HDFS

Hadoop | Overview | Datanodes | Datanode Volume Failures | Snapshot | Startup Progress | Utilities

Datanode Information

Datanode usage histogram



In operation

Node	Last contact	Admin State	Capacity	Used	Non DFS Used	Remaining	Blocks	Block pool used	Failed Volumes	Version
c65069a49aa9:50010 (172.18.0.3:50010)	2	In Service	355.6 GB	1.91 MB	84.55 GB	252.92 GB	24	1.91 MB (0%)	0	2.7.4
5abe514e7d51:50010 (172.18.0.8:50010)	1	In Service	355.6 GB	1.91 MB	84.55 GB	252.92 GB	24	1.91 MB (0%)	0	2.7.4

Dữ liệu lưu trong HDFS

Hadoop Overview Datanodes Snapshot Startup Progress Utilities

Browse Directory

/trips Go!

Permission	Owner	Group	Size	Last Modified	Replication	Block Size	Name
drwxr-xr-x	jovyan	supergroup	0 B	12/23/2020, 3:29:46 PM	0	0 B	processed_trips.parquet
drwxr-xr-x	jovyan	supergroup	0 B	12/23/2020, 3:29:45 PM	0	0 B	trips.parquet

Hadoop, 2017.

Dữ liệu lưu trong HDFS

Hadoop Overview Datanodes Snapshot Startup Progress Utilities

Browse Directory

/trips/trips.parquet Go!

Permission	Owner	Group	Size	Last Modified	Replication	Block Size	Name
-rw-r--r--	jovyan	supergroup	0 B	12/23/2020, 3:29:45 PM	3	128 MB	_SUCCESS
-rw-r--r--	jovyan	supergroup	88.21 KB	12/23/2020, 3:29:41 PM	3	128 MB	part-00000-19bb1bf0-592d-492d-9595-8487c8c2bcc7-c000.snappy.parquet
-rw-r--r--	jovyan	supergroup	30.03 KB	12/23/2020, 3:29:45 PM	3	128 MB	part-00000-29e54c4e-d45c-4c86-8dbf-5d6dcd4cc17d-c000.snappy.parquet
-rw-r--r--	jovyan	supergroup	87.09 KB	12/23/2020, 3:29:33 PM	3	128 MB	part-00000-4d646859-ab52-4db8-ad0a-aaec01a80740-c000.snappy.parquet
-rw-r--r--	jovyan	supergroup	91.86 KB	12/23/2020, 3:29:38 PM	3	128 MB	part-00000-5ad763d6-a1ff-4f85-993c-4c36eb4580f6-c000.snappy.parquet
-rw-r--r--	jovyan	supergroup	90.76 KB	12/23/2020, 3:29:36 PM	3	128 MB	part-00000-74231608-9c1f-4f52-9d4f-e1ea64568ebb-c000.snappy.parquet
-rw-r--r--	jovyan	supergroup	42.25 KB	12/23/2020, 3:29:30 PM	3	128 MB	part-00000-c90b3fa1-d391-4476-93b1-ed7d511ed249-c000.snappy.parquet
-rw-r--r--	jovyan	supergroup	81.64 KB	12/23/2020, 3:29:41 PM	3	128 MB	part-00001-19bb1bf0-592d-492d-9595-8487c8c2bcc7-c000.snappy.parquet
-rw-r--r--	jovyan	supergroup	29.43 KB	12/23/2020, 3:29:45 PM	3	128 MB	part-00001-29e54c4e-d45c-4c86-8dbf-5d6dcd4cc17d-c000.snappy.parquet
-rw-r--r--	jovyan	supergroup	91.71 KB	12/23/2020, 3:29:33 PM	3	128 MB	part-00001-4d646859-ab52-4db8-ad0a-aaec01a80740-c000.snappy.parquet
-rw-r--r--	jovyan	supergroup	88.01 KB	12/23/2020, 3:29:39 PM	3	128 MB	part-00001-5ad763d6-a1ff-4f85-993c-4c36eb4580f6-c000.snappy.parquet

Đọc dữ liệu từ HDFS và visualize

Read data from parquet file "trips.parquet" in hdfs

```
df = ss.read.parquet("hdfs://namenode:9000/trips/trips.parquet")
```

```
print(f"Number of records: {df.count()}")
df = df.sort('ArrivalTime')
```

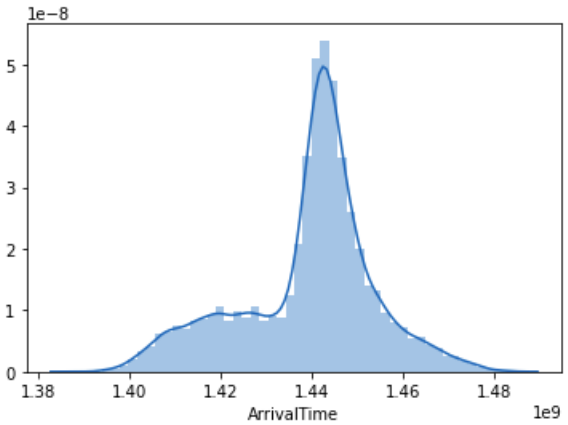
```
Number of records: 10000
```

Data Mining

Distribution of trips over time

```
arrivalTime = df.select('ArrivalTime').toPandas()['ArrivalTime'].astype('int64')
sns.distplot(arrivalTime)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f27d875bf90>
```



Đưa dữ liệu real time từ kafka => kafka

- Chương trình spark đọc dữ liệu từ kafka, xử lý và đẩy vào kafka

```
ss = SparkSession.Builder() \
     .appName("SparkBatchStreamingKafka") \
     .master("spark://speed-processing-spark-master:7077") \
     .config("spark.jars", "./spark-streaming-kafka-0-10-assembly_2.11-2.4.1.jar,./kafka-clients-0.10.1.0.jar,./spark-sql-kafka-0-10_2.11-2.4.1.jar") \
     .config("spark.sql.warehouse.dir", "hdfs://namenode:9000/") \
     .getOrCreate()
```

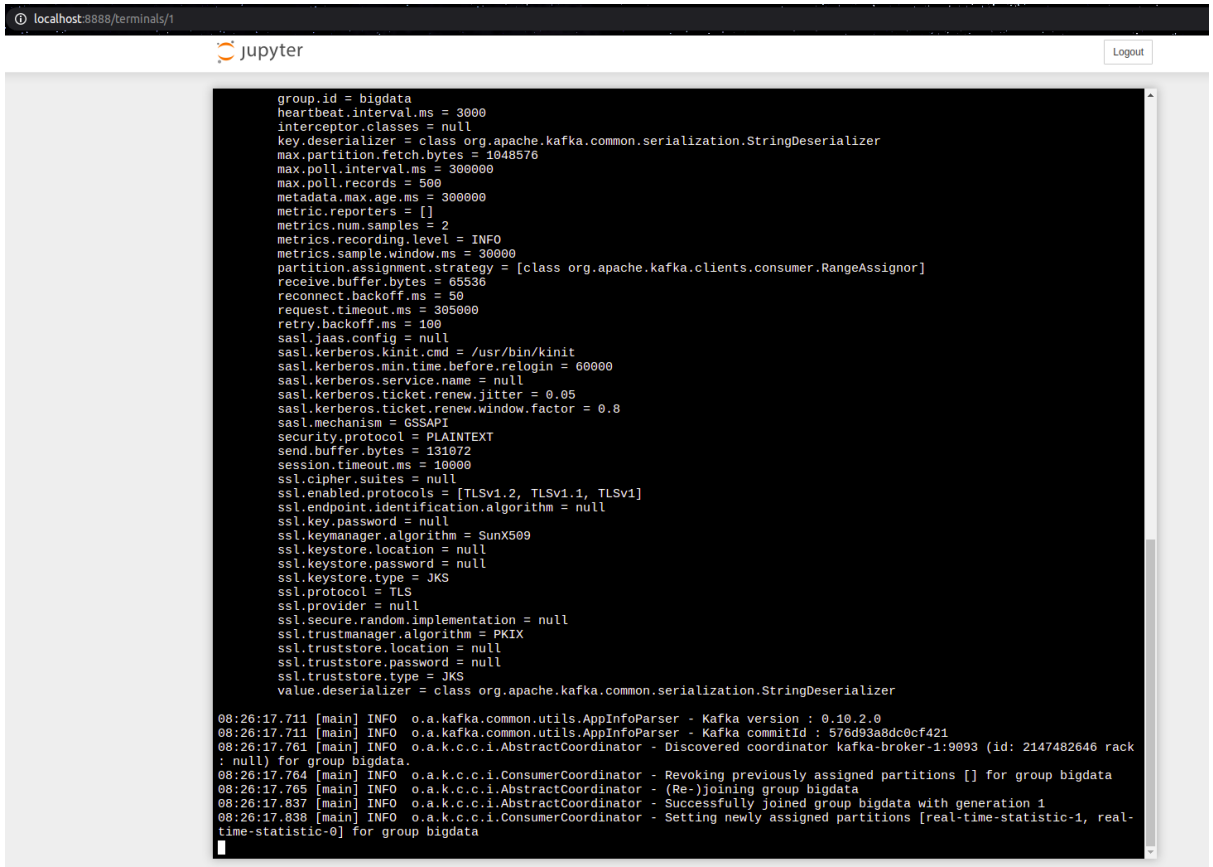
```
df = ss \
  .readStream \
  .format("kafka") \
  .option("kafka.bootstrap.servers", "kafka-broker-1:9093,kafka-broker-2:9093,kafka-broker-3:9093") \
  .option("partition.assignment.strategy", "none") \
  .option("subscribe", "trips") \
  .load()
```

```
import random

def transform_window(s):
    """
    s = Row(start=datetime.datetime(2020, 12, 21, 17, 9, 30), end=datetime.datetime(2020, 12, 21, 17, 9, 40))
    """
    return str(int(s.end.timestamp()))

def transform_count(s):
    """
    s = 941
    """
    return str(s)
udf_transform_window = udf(transform_window)
udf_transform_count = udf(transform_count)
```

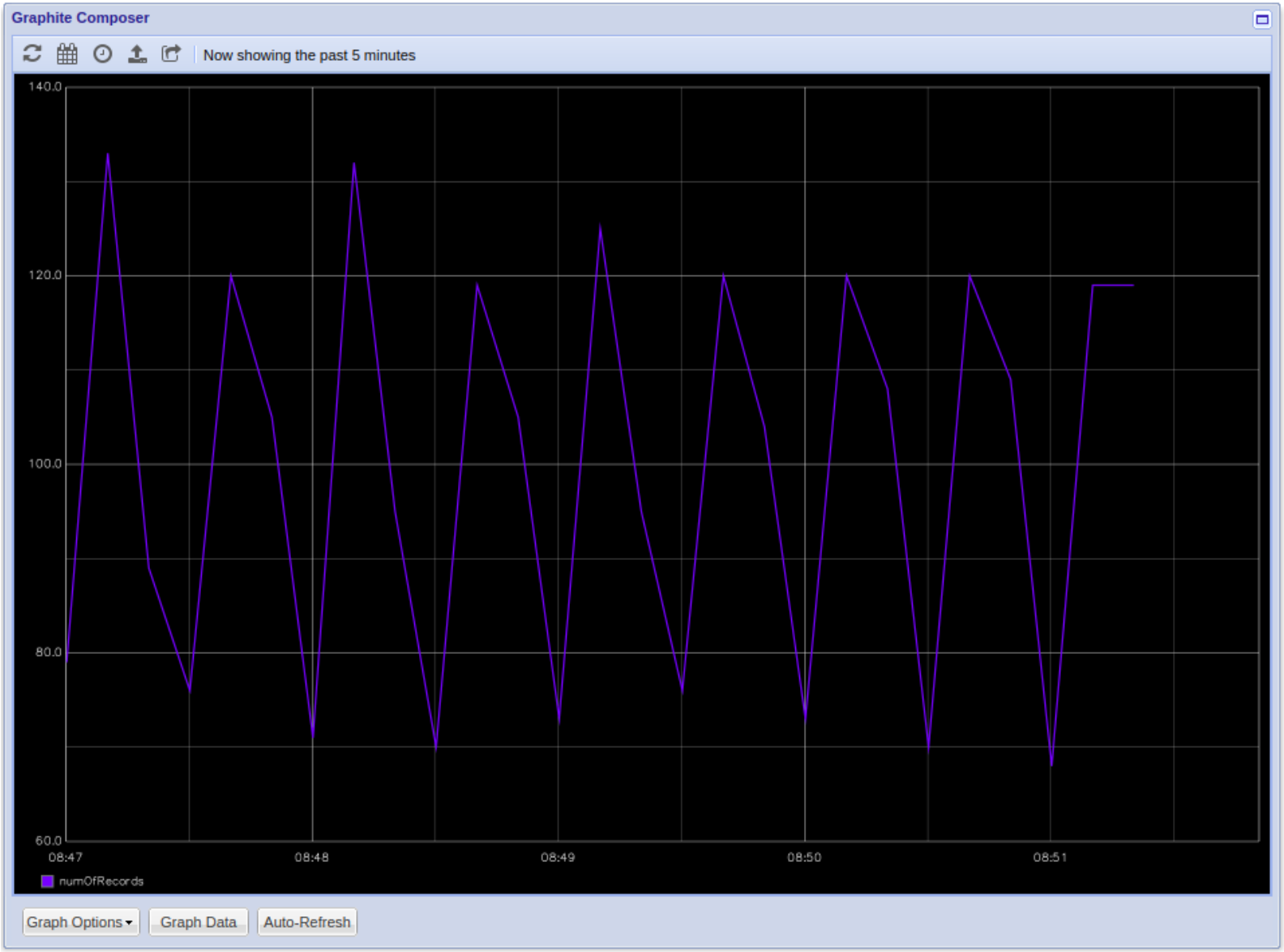
```
query = df.withWatermark("timestamp", "15 seconds") \
        .groupBy(window("timestamp", "5 seconds", "5 seconds")) \
        .count() \
        .withColumn("count", udf_transform_count("count")) \
        .withColumn("window", udf_transform_window("window")) \
        .withColumn('value', sf.concat(sf.col('window'),sf.lit('_'), sf.col('count'))) \
        .writeStream \
        .format("kafka") \
        .option("kafka.bootstrap.servers", "kafka-broker-1:9093,kafka-broker-2:9093,kafka-broker-3:9093") \
        .option("topic", "real-time-statistic") \
        .option("checkpointLocation", "/tmp/checkpoint") \
        .outputMode("append") \
        .option("truncate", False) \
        .start()
query.awaitTermination()
```

Đưa dữ liệu real time từ kafka vào graphite

- Chương trình chạy java để đẩy dữ liệu từ kafka vào graphite



Dữ liệu sau khi được đưa vào graphite



Visualize dữ liệu của graphite với grafana

Đánh giá khả năng chịu tải của kafka

	2 brokers			1 brokers		
Delay (s)	Tốc độ gửi (records/s)	Số gói tin nhận	Số gói tin bị mất	Tốc độ gửi (records/s)	Số gói tin nhận	Số gói tin bị mất
0	4501.5	10000	0	4990.3	10000	0
	5045.5	10000	0	4945.3	10000	0
	5120.8	10000	0	5003.4	9973	27
0.0000001	1525.6	10000	0	1572.5	10000	0
	1621.1	10000	0	1962.5	10000	0
	1551.4	10000	0	1558.5	10000	0
0.000001	1335.4	10000	0	1126.4	10000	0
	1596.8	10000	0	1866.5	10000	0
	1597.2	10000	0	1581.1	10000	0

Đánh giá khả năng chịu lỗi của kafka

```
(base) vutrungnghia@Lusheeta:~/kafka_2.13-2.6.0$ bin/kafka-topics.sh --describe --topic trips --bootstra
p-server localhost:9092,localhost:9094
Topic: trips    PartitionCount: 2       ReplicationFactor: 2    Configs: segment.bytes=1073741824
        Topic: trips    Partition: 0    Leader: 1002    Replicas: 1002,1001     Isr: 1002,1001
        Topic: trips    Partition: 1    Leader: 1002    Replicas: 1001,1002     Isr: 1002,1001
(base) vutrungnghia@Lusheeta:~/kafka_2.13-2.6.0$ bin/kafka-topics.sh --describe --topic trips --bootstra
p-server localhost:9092,localhost:9094
Topic: trips    PartitionCount: 2       ReplicationFactor: 2    Configs: segment.bytes=1073741824
        Topic: trips    Partition: 0    Leader: 1002    Replicas: 1002,1001     Isr: 1002
        Topic: trips    Partition: 1    Leader: 1002    Replicas: 1001,1002     Isr: 1002
(base) vutrungnghia@Lusheeta:~/kafka_2.13-2.6.0$
```

Read data from parquet file "trips.parquet" in hdfs

```
df = ss.read.parquet("hdfs://namenode:9000/trips/trips.parquet")
```

```
print(f"Number of records: {df.count()}")
df = df.sort('ArrivalTime')
```

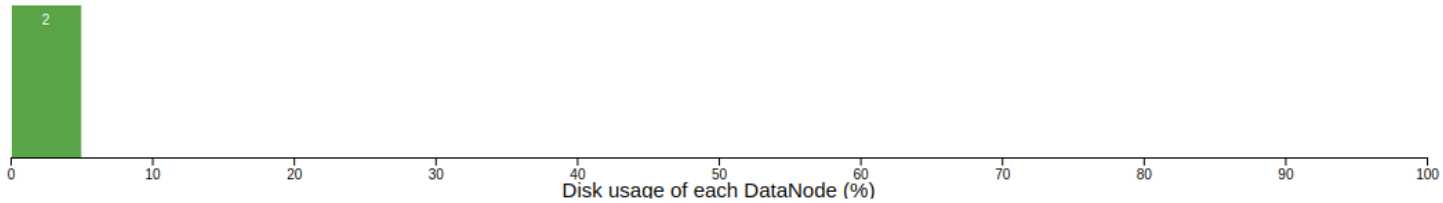
```
Number of records: 10000
```

Đánh giá khả năng chịu lỗi của HDFS

Hadoop | Overview | Datanodes | Datanode Volume Failures | Snapshot | Startup Progress | Utilities

Datanode Information

Datanode usage histogram



In operation

Node	Last contact	Admin State	Capacity	Used	Non DFS Used	Remaining	Blocks	Block pool used	Failed Volumes	Version
f4a27057f907:50010 (172.18.0.3:50010)	1	In Service	355.6 GB	1.97 MB	88.41 GB	249.06 GB	60	1.97 MB (0%)	0	2.7.4
3e4473579333:50010 (172.18.0.8:50010)	1	In Service	355.6 GB	1.97 MB	88.41 GB	249.06 GB	60	1.97 MB (0%)	0	2.7.4

Đánh giá khả năng chịu lỗi của HDFS

```
20/12/23 17:29:34 INFO FileScanRDD: Reading File path: hdfs://namenode:9000/trips/trips.parquet/part-00001-2b
range: 0-166672, partition values: [empty row]
20/12/23 17:29:52 WARN BlockReaderFactory: I/O error constructing remote block reader.
java.net.NoRouteToHostException: No route to host
        at sun.nio.ch.SocketChannelImpl.checkConnect(Native Method)
        at sun.nio.ch.SocketChannelImpl.finishConnect(SocketChannelImpl.java:716)
        at org.apache.hadoop.net.SocketIOWithTimeout.connect(SocketIOWithTimeout.java:206)
        at org.apache.hadoop.net.NetUtils.connect(NetUtils.java:531)
        at org.apache.hadoop.hdfs.DFSClient.newConnectedPeer(DFSClient.java:3436)
        at org.apache.hadoop.hdfs.BlockReaderFactory.nextTcpPeer(BlockReaderFactory.java:777)
        at org.apache.hadoop.hdfs.BlockReaderFactory.getRemoteBlockReaderFromTcp(BlockReaderFactory.java:694)
        at org.apache.hadoop.hdfs.BlockReaderFactory.build(BlockReaderFactory.java:355)
        at org.apache.hadoop.hdfs.DFSInputStream.blockSeekTo(DFSInputStream.java:673)
        at org.apache.hadoop.hdfs.DFSInputStream.readWithStrategy(DFSInputStream.java:882)
        at org.apache.hadoop.hdfs.DFSInputStream.read(DFSInputStream.java:934)
        at org.apache.hadoop.hdfs.DFSInputStream.read(DFSInputStream.java:735)
        at java.io.FilterInputStream.read(FilterInputStream.java:83)
        at org.apache.parquet.io.DelegatingSeekableInputStream.read(DelegatingSeekableInputStream.java:61)
        at org.apache.parquet.bytes.BytesUtils.readIntLittleEndian(BytesUtils.java:80)
        at org.apache.parquet.hadoop.ParquetFileReader.readFooter(ParquetFileReader.java:520)
        at org.apache.parquet.hadoop.ParquetFileReader.readFooter(ParquetFileReader.java:505)
        at org.apache.parquet.hadoop.ParquetFileReader.readFooter(ParquetFileReader.java:499)
        at org.apache.parquet.hadoop.ParquetFileReader.readFooter(ParquetFileReader.java:448)
        at
```

Đánh giá khả năng chịu lỗi của HDFS

```
20/12/23 17:31:00 WARN DFSClient: Failed to connect to /172.18.0.3:50010 for block, add to deadNodes
java.net.NoRouteToHostException: No route to host
        at sun.nio.ch.SocketChannelImpl.checkConnect(Native Method)
        at sun.nio.ch.SocketChannelImpl.finishConnect(SocketChannelImpl.java:716)
        at org.apache.hadoop.net.SocketIOWithTimeout.connect(SocketIOWithTimeout.java:206)
        at org.apache.hadoop.net.NetUtils.connect(NetUtils.java:531)
        at org.apache.hadoop.hdfs.DFSClient.newConnectedPeer(DFSClient.java:3436)
        at org.apache.hadoop.hdfs.BlockReaderFactory.nextTcpPeer(BlockReaderFactory.java:777)
        at org.apache.hadoop.hdfs.BlockReaderFactory.getRemoteBlockReaderFromTcp(BlockReaderFactory.j
        at org.apache.hadoop.hdfs.BlockReaderFactory.build(BlockReaderFactory.java:355)
        at org.apache.hadoop.hdfs.DFSInputStream.blockSeekTo(DFSInputStream.java:673)
        at org.apache.hadoop.hdfs.DFSInputStream.readWithStrategy(DFSInputStream.java:882)
        at org.apache.hadoop.hdfs.DFSInputStream.read(DFSInputStream.java:934)
        at org.apache.hadoop.hdfs.DFSInputStream.read(DFSInputStream.java:735)
        at java.io.FilterInputStream.read(FilterInputStream.java:83)
        at org.apache.parquet.io.DelegatingSeekableInputStream.read(DelegatingSeekableInputStream.jav
        at org.apache.parquet.bytes.BytesUtils.readIntLittleEndian(BytesUtils.java:80)
        at org.apache.parquet.hadoop.ParquetFileReader.readFooter(ParquetFileReader.java:520)
        at org.apache.parquet.hadoop.ParquetFileReader.readFooter(ParquetFileReader.java:505)
        at org.apache.parquet.hadoop.ParquetFileReader.readFooter(ParquetFileReader.java:499)
        at org.apache.parquet.hadoop.ParquetFileReader.readFooter(ParquetFileReader.java:448)
        at
```

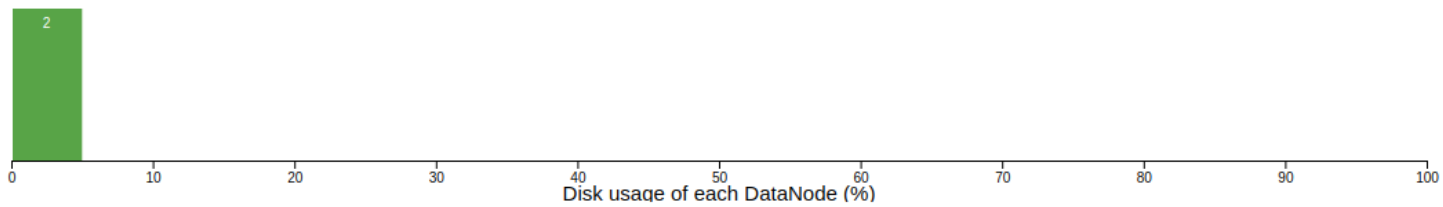
Đánh giá khả năng chịu lỗi của HDFS

```
        at org.apache.spark.sql.execution.BufferedRowIterator.hasNext(BufferedRowIterator.java:43)
        at org.apache.spark.sql.execution.WholeStageCodegenExec$$anonfun$13$$anon$1.hasNext(WholeStageCode
        at scala.collection.Iterator$$anon$11.hasNext(Iterator.scala:409)
        at org.apache.spark.shuffle.sort.BypassMergeSortShuffleWriter.write(BypassMergeSortShuffleWriter.j
        at org.apache.spark.scheduler.ShuffleMapTask.runTask(ShuffleMapTask.scala:99)
        at org.apache.spark.scheduler.ShuffleMapTask.runTask(ShuffleMapTask.scala:55)
        at org.apache.spark.scheduler.Task.run(Task.scala:121)
        at org.apache.spark.executor.Executor$TaskRunner$$anonfun$10.apply(Executor.scala:403)
        at org.apache.spark.util.Utils$.tryWithSafeFinally(Utils.scala:1360)
        at org.apache.spark.executor.Executor$TaskRunner.run(Executor.scala:409)
        at java.util.concurrent.ThreadPoolExecutor.runWorker(ThreadPoolExecutor.java:1149)
        at java.util.concurrent.ThreadPoolExecutor$Worker.run(ThreadPoolExecutor.java:624)
        at java.lang.Thread.run(Thread.java:748)
20/12/23 17:31:00 INFO DFSClient: Successfully connected to /172.18.0.8:50010 for BP-1621182885-172.18.0.7
20/12/23 17:31:00 INFO Executor: Finished task 0.0 in stage 4.0 (TID 5). 1716 bytes result sent to driver
20/12/23 17:31:18 INFO CoarseGrainedExecutorBackend: Got assigned task 7
20/12/23 17:31:18 INFO Executor: Running task 0.0 in stage 5.0 (TID 7)
20/12/23 17:31:18 INFO MapOutputTrackerWorker: Updating epoch to 2 and clearing cache
20/12/23 17:31:18 INFO TorrentBroadcast: Started reading broadcast variable 7
20/12/23 17:31:18 INFO MemoryStore: Block broadcast_7_piece0 stored as bytes in memory (estimated size 3.8
20/12/23 17:31:18 INFO TorrentBroadcast: Reading broadcast variable 7 took 13 ms
20/12/23 17:31:18 INFO MemoryStore: Block broadcast_7 stored as values in memory (estimated size 7.1 KB, f
20/12/23 17:31:18 INFO MapOutputTrackerWorker: Don't have map outputs for shuffle 1, fetching them
20/12/23 17:31:18 INFO MapOutputTrackerWorker: Doing the fetch; tracker endpoint = NettyRpcEndpointRef(spa
20/12/23 17:31:18 INFO MapOutputTrackerWorker: Got the output locations
20/12/23 17:31:18 INFO ShuffleBlockFetcherIterator: Getting 2 non-empty blocks including 1 local blocks an
20/12/23 17:31:18 INFO ShuffleBlockFetcherIterator: Started 1 remote fetches in 1 ms
20/12/23 17:31:18 INFO Executor: Finished task 0.0 in stage 5.0 (TID 7). 1782 bytes result sent to driver
```

Đánh giá khả năng chịu lỗi của HDFS

Datanode Information

Datanode usage histogram



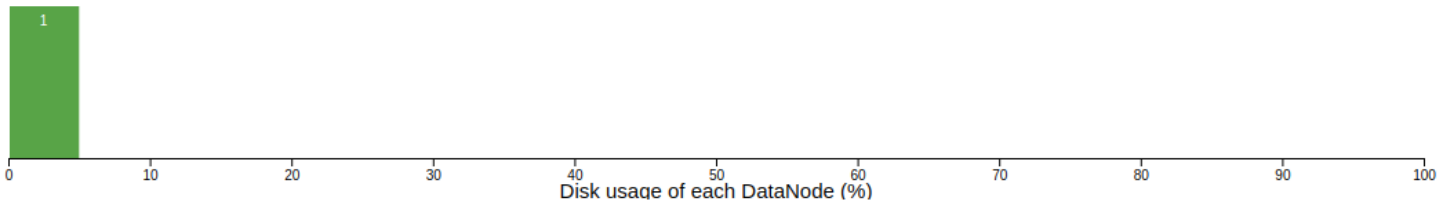
In operation

Node	Last contact	Admin State	Capacity	Used	Non DFS Used	Remaining	Blocks	Block pool used	Failed Volumes	Version
f4a27057f907:50010 (172.18.0.3:50010)	470	In Service	355.6 GB	2.38 MB	88.43 GB	249.04 GB	116	2.38 MB (0%)	0	2.7.4
3e4473579333:50010 (172.18.0.8:50010)	1	In Service	355.6 GB	2.98 MB	88.43 GB	249.03 GB	116	2.98 MB (0%)	0	2.7.4

Đánh giá khả năng chịu lỗi của HDFS

Datanode Information

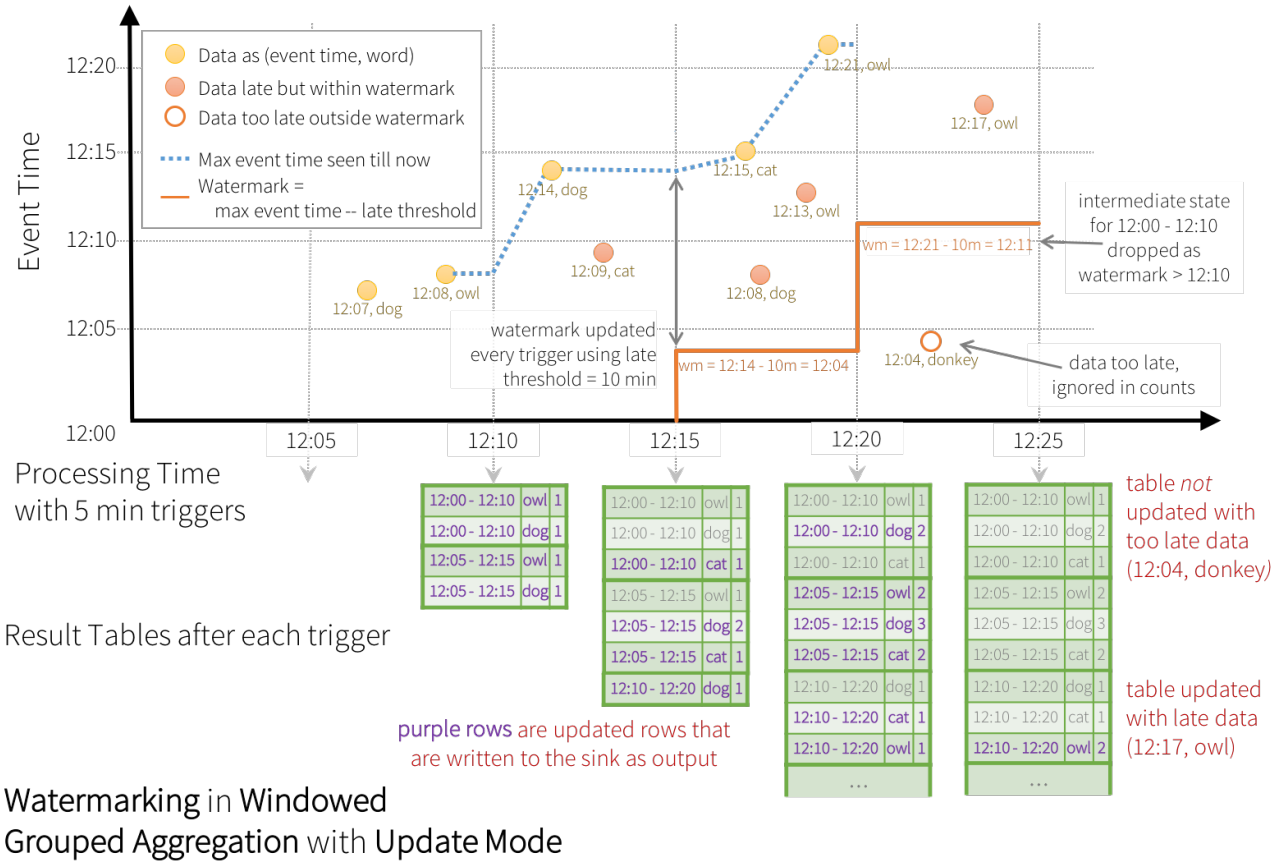
Datanode usage histogram



In operation

Node	Last contact	Admin State	Capacity	Used	Non DFS Used	Remaining	Blocks	Block pool used	Failed Volumes	Version
3e4473579333:50010 (172.18.0.8:50010)	2	In Service	355.6 GB	2.98 MB	88.44 GB	249.02 GB	116	2.98 MB (0%)	0	2.7.4
f4a27057f907:50010 (172.18.0.3:50010)	Thu Dec 24 2020 00:29:21 GMT+0700 (Indochina Time)	Dead	-	-	-	-	-	-	-	-

Đánh giá khả năng xử lý gói tin đến sai thứ tự của Spark



(*) source: https://spark.apache.org

Đánh giá khả năng xử lý gói tin đến sai thứ tự của Spark

```
query = df.withWatermark("timestamp", "20 seconds") \
        .groupBy(window("timestamp", "10 seconds", "10 seconds")) \
        .count() \
```

- Để đưa các gói tin về đúng khoảng thời gian chính xác mà nó được gửi, Structured Spark sử dụng Window Grouped Aggregation.
- Đối với các dạng event đến quá trễ và trở nên vô giá trị, Watermaking bỏ qua các gói tin đến trễ so với khoảng thời gian cho trước.

Đánh giá khả năng xử lý gói tin đến sai thứ tự của Spark

```
Row(start=datetime.datetime(2020, 12, 22, 4, 22), end=datetime.datetime(2020, 12, 22, 4, 22, 10))_108
Row(start=datetime.datetime(2020, 12, 22, 4, 22, 10), end=datetime.datetime(2020, 12, 22, 4, 22, 20))_138
Row(start=datetime.datetime(2020, 12, 22, 4, 22, 20), end=datetime.datetime(2020, 12, 22, 4, 22, 30))_51
Row(start=datetime.datetime(2020, 12, 22, 4, 22, 30), end=datetime.datetime(2020, 12, 22, 4, 22, 40))_106
Row(start=datetime.datetime(2020, 12, 22, 4, 22, 40), end=datetime.datetime(2020, 12, 22, 4, 22, 50))_135
Row(start=datetime.datetime(2020, 12, 22, 4, 22, 50), end=datetime.datetime(2020, 12, 22, 4, 23))_56
Row(start=datetime.datetime(2020, 12, 22, 4, 23), end=datetime.datetime(2020, 12, 22, 4, 23, 10))_103
Row(start=datetime.datetime(2020, 12, 22, 4, 23, 10), end=datetime.datetime(2020, 12, 22, 4, 23, 20))_136
Row(start=datetime.datetime(2020, 12, 22, 4, 23, 20), end=datetime.datetime(2020, 12, 22, 4, 23, 30))_58
Row(start=datetime.datetime(2020, 12, 22, 4, 23, 30), end=datetime.datetime(2020, 12, 22, 4, 23, 40))_104
Row(start=datetime.datetime(2020, 12, 22, 4, 23, 40), end=datetime.datetime(2020, 12, 22, 4, 23, 50))_134
Row(start=datetime.datetime(2020, 12, 22, 4, 23, 50), end=datetime.datetime(2020, 12, 22, 4, 24))_59
```

Hình: Bài toán đến số lượng bản ghi trong 10s gần nhất

- Sử dụng KafkaProducer để giả lập luồng dữ liệu có các events đến trễ.
- Cứ sau 20s, một nửa các gói tin được gửi đi từ Producer trong 10s tiếp theo được đánh dấu là trễ 10s, nửa còn lại gửi đi theo đúng thời gian thực.

Hạn chế

- Các ứng dụng Graphite, Grafana và JavaApp không cần nhiều tài nguyên nên có thể đóng gói để chạy trên 1 container
- Ngoại trừ Interactive Dashboard Notebook, các notebook còn lại có thể chuyển sang ngôn ngữ Scala hay Java và đóng gói thành 1 ứng dụng, từ đó giúp tăng tốc độ tính toán cũng như phù hợp hơn với môi trường production

Hướng phát triển tiếp theo

- Xử lý các hạn chế
- Xử lý nhiều luồng dữ liệu với các bài toán khác nhau thay vì chỉ 1 luồng dữ liệu cho 1 bài toán
- Xây dựng các mô hình học máy mạnh mẽ hơn cho các bài toán phức tạp
- Triển khai trên cụm máy tính thật

Tài liệu tham khảo

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