# Final Project
# Graph mining on MapReduce and Spark

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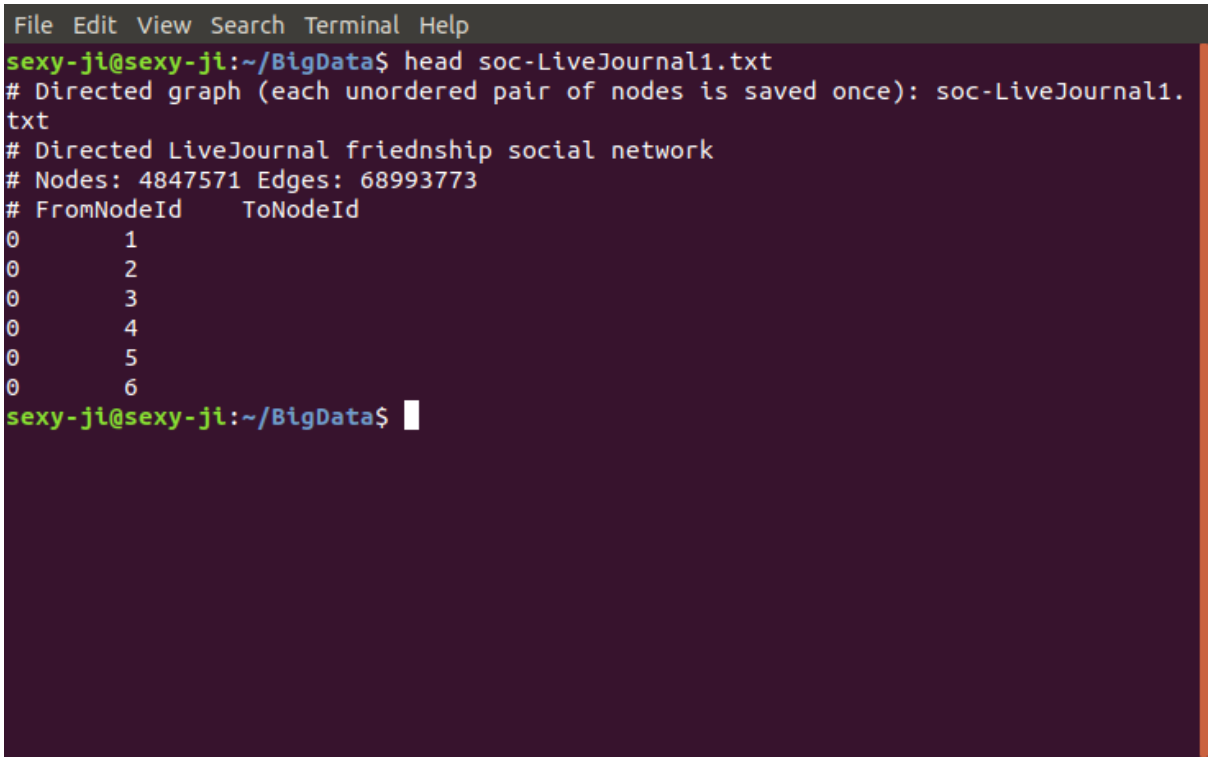
# 프로젝트 개요

- 프로젝트 목표: 대용량 그래프의 군집계수(Clustering Coefficient) 분석을 위한 효율적인 분산 알고리즘을 설계, 구현 및 실험한다.
- 프로젝트는 다음과 같은 세부 과업으로 구성된다.
  - Task 1) 그래프의 중복 edge 및 self-loop 제거 (Hadoop)
  - Task 2) 각 node u 의 degree d(u) 구하기 (Hadoop)
  - Task 3) 각 node u 마다, u 를 포함하는 삼각형 수 t(u) 구하기 (Spark)
  - Task 4) 각 node u 마다, 군집계수 cc(u) 구하기 (Spark)

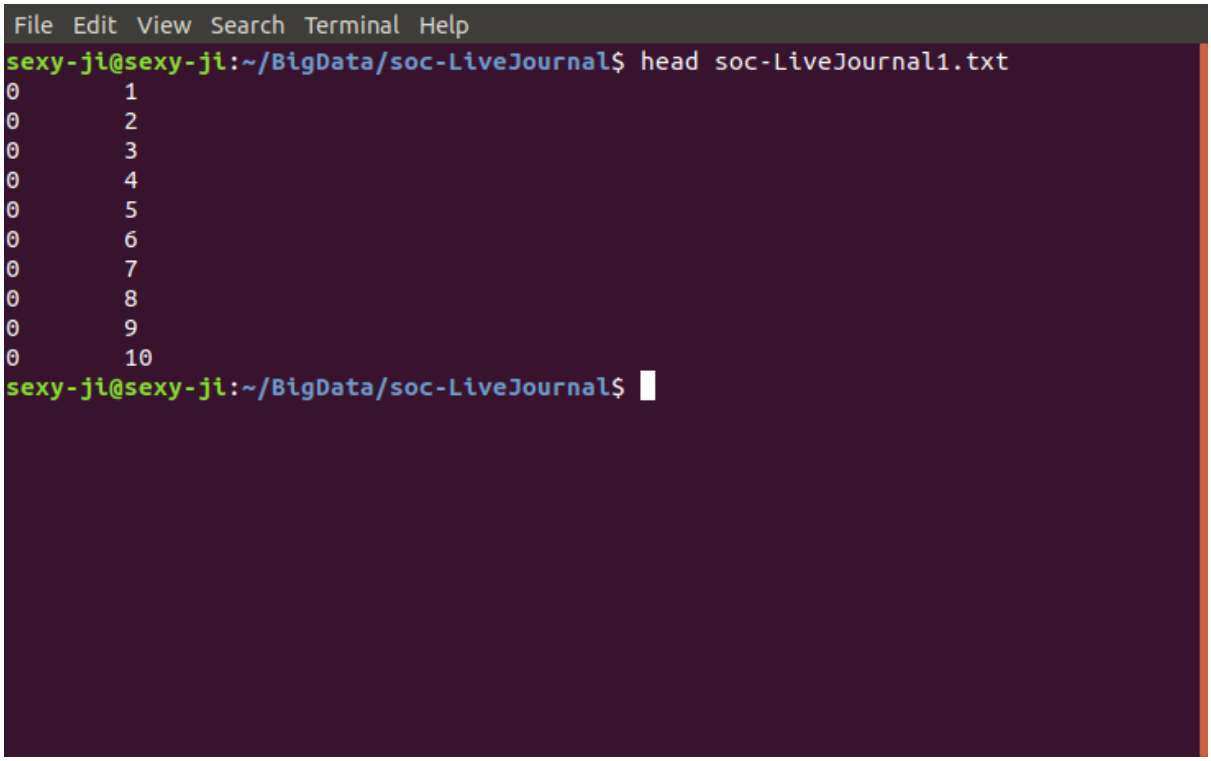
구현한 프로그램들을 구글 클라우드 플랫폼에서 실행

- LiveJournal Dataset 을 HDFS 에 업로드 하는 과정과 결과를 캡처하여 첨부
  - LiveJournal Dataset 다운로드 경로 http://snap.stanford.edu/data/soc-LiveJournal1.html
- 각 Task 의 프로그램을 실행하는 과정과 결과를 캡처하여 첨부
  - 과정에는 실행 명령어, 실행 중 및 실행 후의 Web UI 포함
  - 결과에는 결과파일 경로, 목록 및 결과파일 내용 일부 포함

soc-LiveJournal1.txt 파일에 edge list 정보를 제외하고는 삭제를 해주었다. <그림 1>처럼 문자들이 들어있어서 <그림 2>로 파일의 내용을 일부 수정하였다.




**<그림 1>**




**<그림 2>**

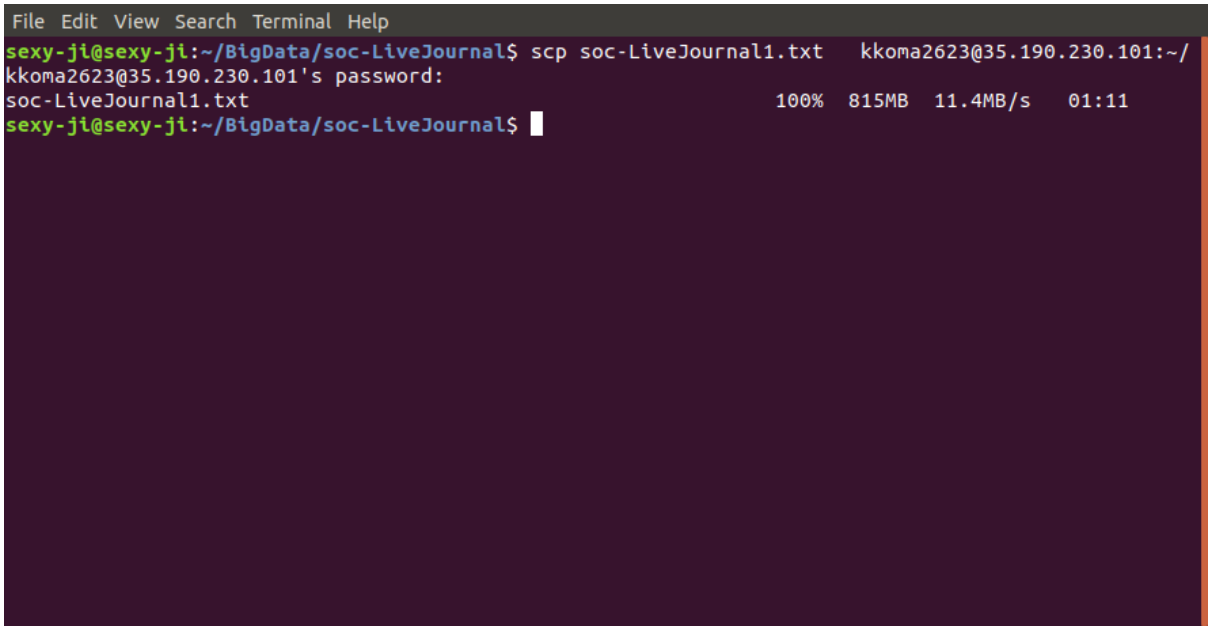
soc-LiveJournal1.txt 파일을 구글 클라우드 플랫폼(이하 GCP)에 업로드 하는 과정이다.

scp soc-LiveJournal1.txt kkoma2623@35.190.230.101:~/ 명령어를 사용하여 GCP 의 클러스터에 업로드 하였다.


**<그림 3>**

<그림 4>는 업로드하는 중간 과정이고 <그림 5>는 업로드를 완료한 그림이다.

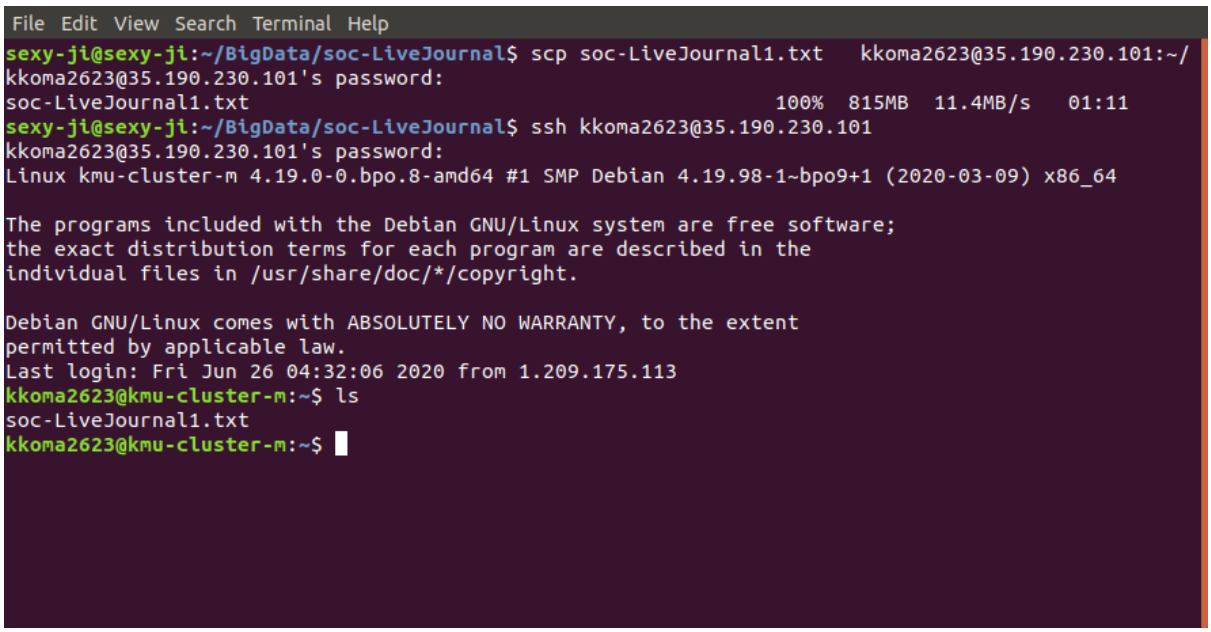

**<그림 4>**




**<그림 5>**

클러스터의 ip 를 입력하고 비밀번호를 입력하여 클러스터에 ssh 접속하였다.

그리고 ls 명령어를 사용하여 soc-LiveJournal1.txt 파일이 업로드 된 것을 확인하였다.




**<그림 6>**

HDFS 에 soc-LiveJournal1.txt 파일을 업로드하였다.

hdfs dfs -put soc-LiveJournal1.txt 명령어를 사용하여 업로드하였고, hdfs dfs -ls 명령어를 사용하여 HDFS 에 업로드 한 것을 확인하였다.

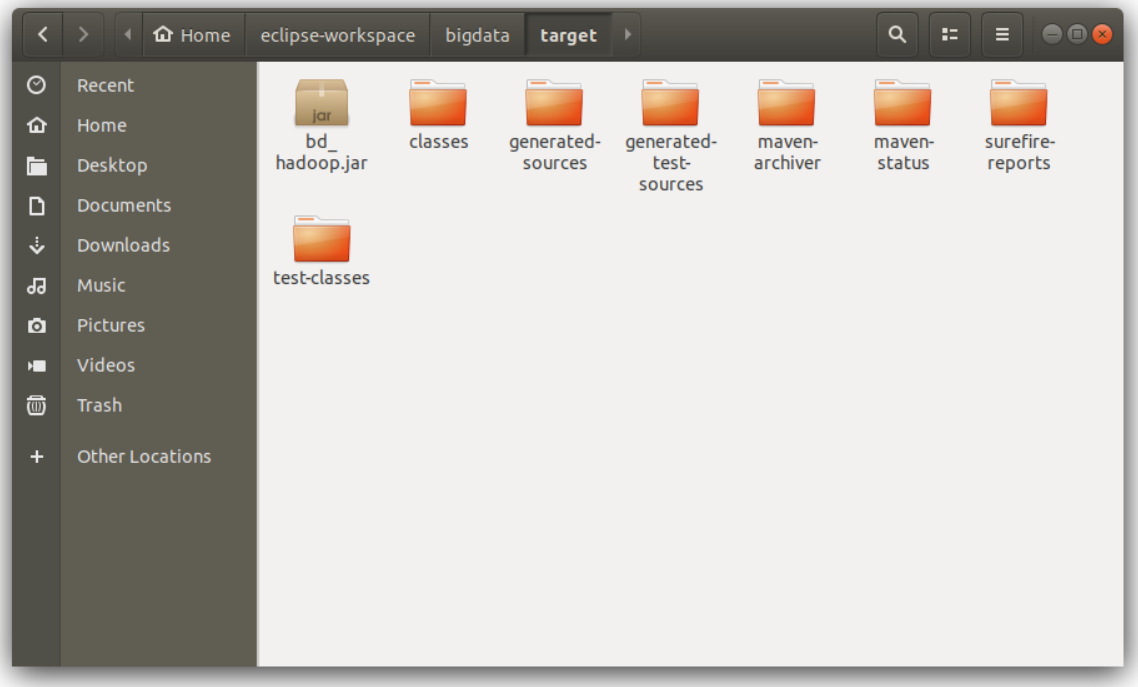
```
File  Edit  View  Search  Terminal  Help
sexy-ji@sexy-ji:~/BigData/soc-LiveJournal$ scp soc-LiveJournal1.txt   kkoma2623@35.190.230.101:~/
kkoma2623@35.190.230.101's password:
soc-LiveJournal1.txt                                          100%  815MB  11.4MB/s   01:11
sexy-ji@sexy-ji:~/BigData/soc-LiveJournal$ ssh kkoma2623@35.190.230.101
kkoma2623@35.190.230.101's password:
Linux kmu-cluster-m 4.19.0-0.bpo.8-amd64 #1 SMP Debian 4.19.98-1~bpo9+1 (2020-03-09) x86_64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Fri Jun 26 04:32:06 2020 from 1.209.175.113
kkoma2623@kmu-cluster-m:~$ ls
soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$ hdfs dfs -put soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls
Found 2 items
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-25 15:38 .sparkStaging
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$
```

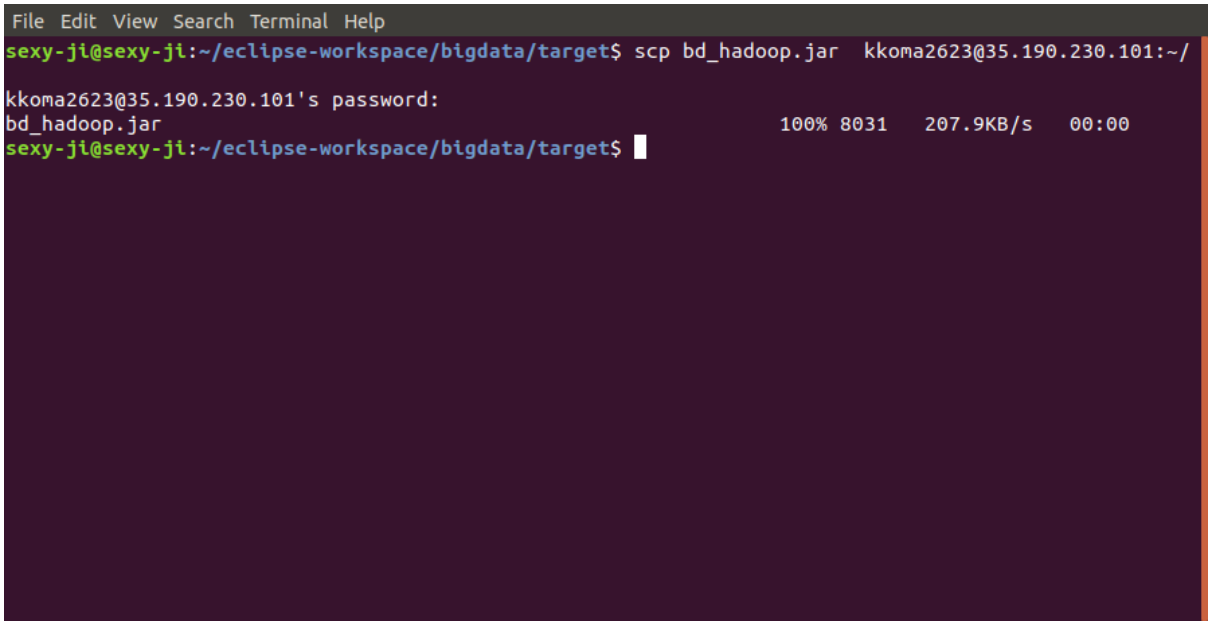
**<그림 7>**

Task1 과 Task2 를 구현한 프로그램이 있는 bd_hadoop.jar 파일을 생성하였다.



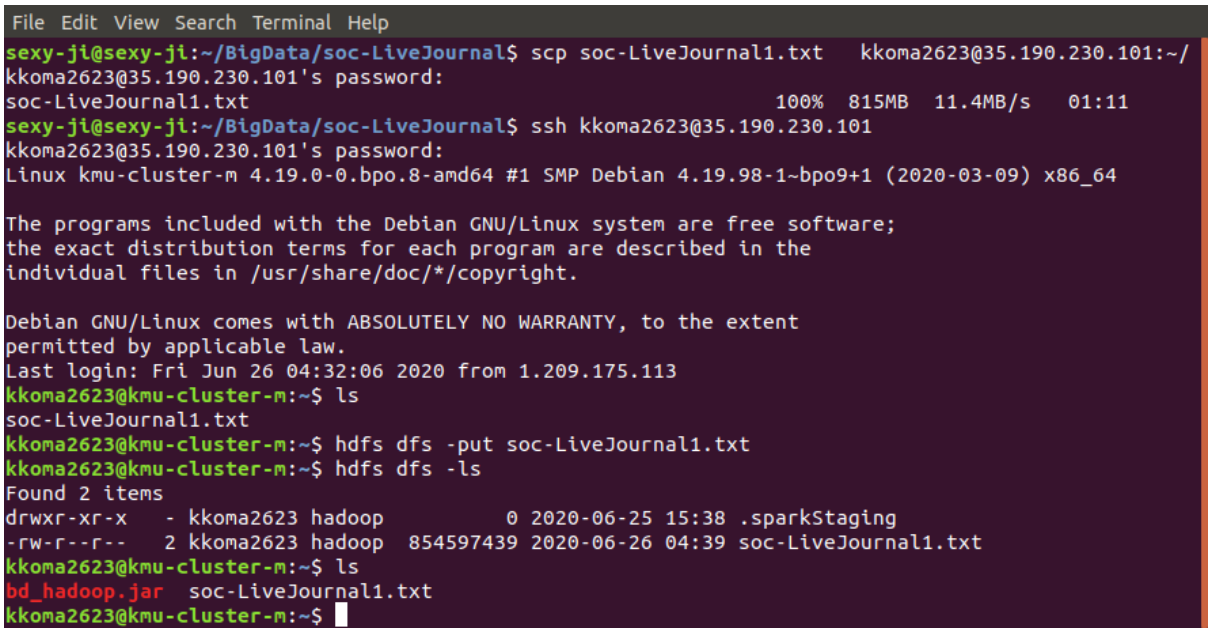

**<그림 8>**

bd_hadoop.jar 파일을 scp 명령어를 통해서 GCP 에 업로드하였다.




**<그림 9>**

클러스터에서 ls 명령어를 사용하여 업로드 된 것을 확인하였다.




**<그림 10>**

bd_hadoop.jar 파일을 HDFS 에 업로드 하였다.

hdfs dfs -put bd_hadoop.jar 명령어를 통해 업로드하였고, hdfs dfs -ls 명령어를 통해 업로드 된 것을 확인하였다.

```
File  Edit  View  Search  Terminal  Help

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Fri Jun 26 04:32:06 2020 from 1.209.175.113
kkoma2623@kmu-cluster-m:~$ ls
soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$ hdfs dfs -put soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls
Found 2 items
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-25 15:38 .sparkStaging
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$ ls
bd_hadoop.jar  soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$ hdfs dfs -put bd_hadoop.jar
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls
Found 3 items
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-25 15:38 .sparkStaging
-rw-r--r--   2 kkoma2623 hadoop       8031 2020-06-26 04:43 bd_hadoop.jar
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$
```

**<그림 11>**

hadoop jar bd_hadoop.jar bigdata.Task1  -Dmapreduce.job.reduces=5 soc-LiveJournal1.txt task1Outputs 명령어를 통해 bigdata 패키지의 Task1 을 실행하였다.

-Dmapreduce.job.reduces=5 옵션을 통해 리듀서의 개수를 5 로 설정하였다.

args[0]에 입력파일 경로를, args[1]에 출력 파일 경로를 설정해주었다.

입력 파일 경로는 soc-LiveJournal1.txt 이고 출력 파일 경로는 task1Outputs 이다.

```
File  Edit  View  Search  Terminal  Help
kkoma2623@kmu-cluster-m:~$ hadoop jar bd_hadoop.jar bigdata.Task1 -Dmapreduce.job.reduces=5 soc-LiveJour
nal1.txt task1Outputs
20/06/26 04:54:12 INFO client.RMProxy: Connecting to ResourceManager at kmu-cluster-m/10.146.0.9:8032
20/06/26 04:54:12 INFO client.AHSProxy: Connecting to Application History server at kmu-cluster-m/10.146
.0.9:10200
20/06/26 04:54:12 INFO input.FileInputFormat: Total input files to process : 1
20/06/26 04:54:12 INFO mapreduce.JobSubmitter: number of splits:7
20/06/26 04:54:13 INFO Configuration.deprecation: yarn.resourcemanager.system-metrics-publisher.enabled
is deprecated. Instead, use yarn.system-metrics-publisher.enabled
20/06/26 04:54:13 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1593072483341_0014
20/06/26 04:54:13 INFO impl.YarnClientImpl: Submitted application application_1593072483341_0014
20/06/26 04:54:13 INFO mapreduce.Job: The url to track the job: http://kmu-cluster-m:8088/proxy/applicat
ion_1593072483341_0014/
20/06/26 04:54:13 INFO mapreduce.Job: Running job: job_1593072483341_0014
```

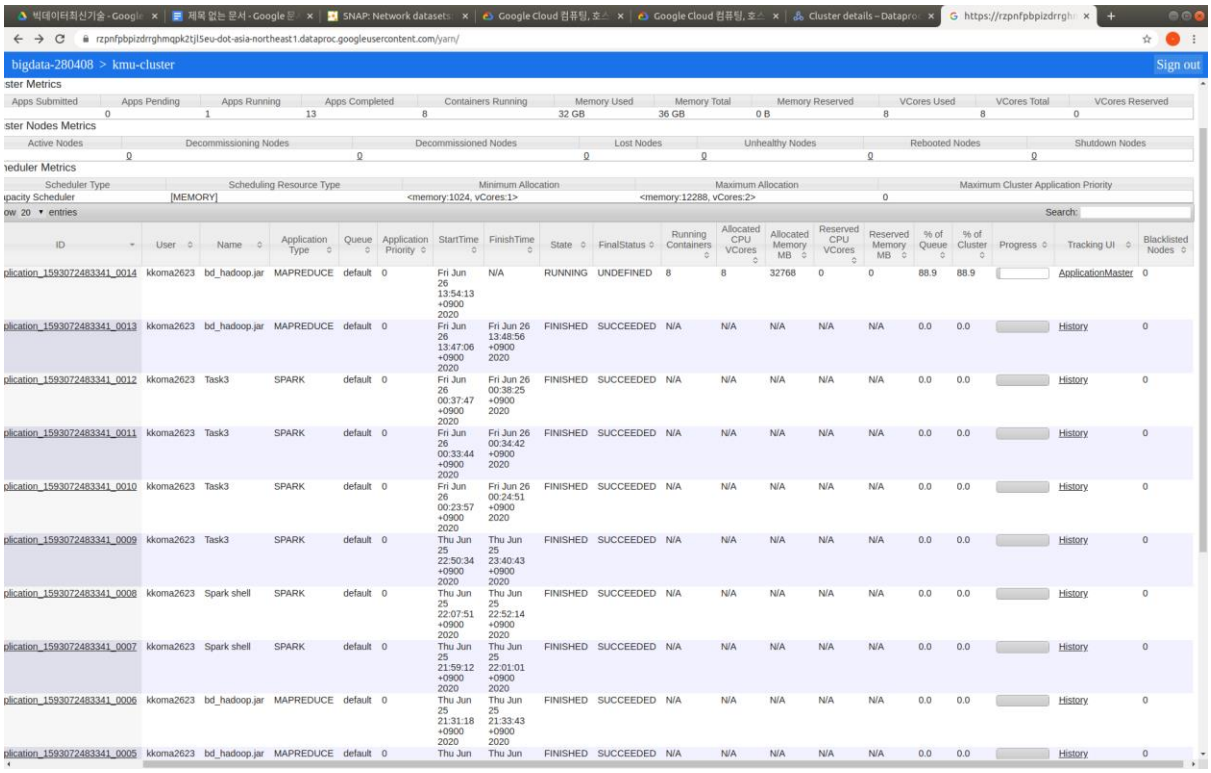
**<그림 12>**

<그림 13>은 터미널에서 Task1 을 실행하는 과정을 본 그림이다.

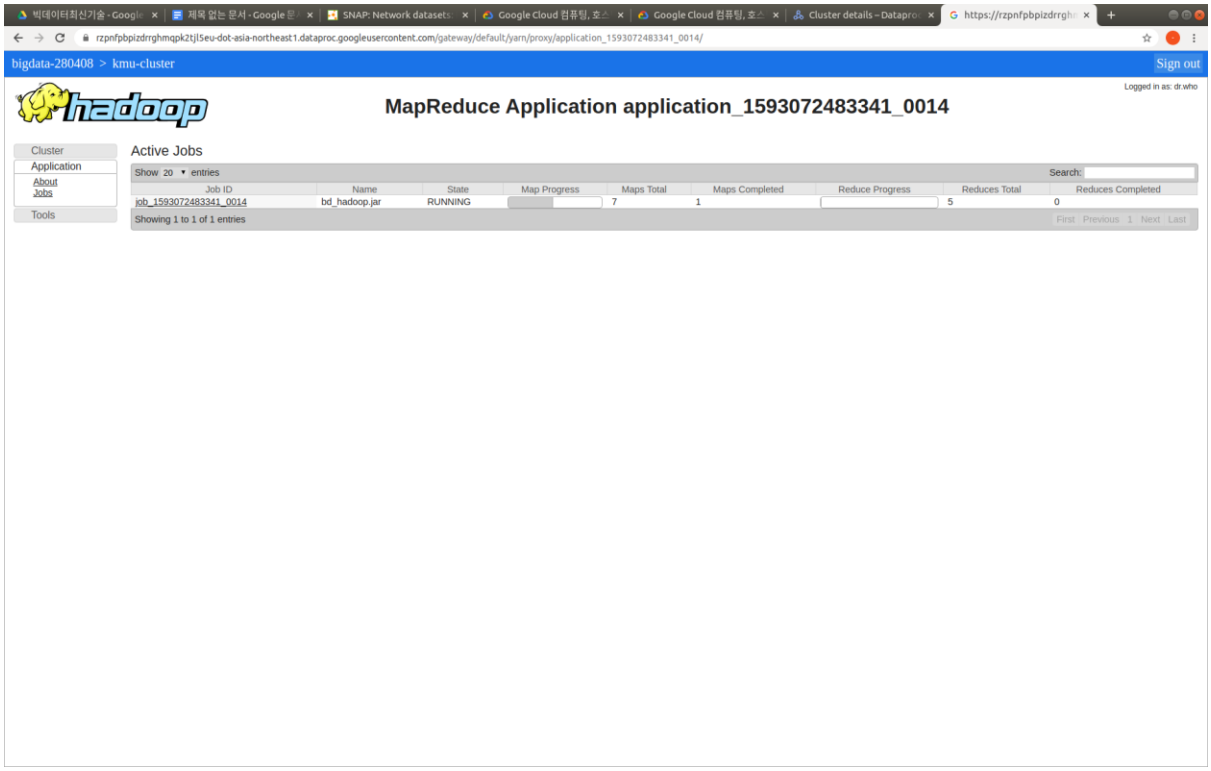
```
File  Edit  View  Search  Terminal  Help
20/06/26 04:54:12 INFO input.FileInputFormat: Total input files to process : 1
20/06/26 04:54:12 INFO mapreduce.JobSubmitter: number of splits:7
20/06/26 04:54:13 INFO Configuration.deprecation: yarn.resourcemanager.system-metrics-publisher.enabled
is deprecated. Instead, use yarn.system-metrics-publisher.enabled
20/06/26 04:54:13 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1593072483341_0014
20/06/26 04:54:13 INFO impl.YarnClientImpl: Submitted application application_1593072483341_0014
20/06/26 04:54:13 INFO mapreduce.Job: The url to track the job: http://kmu-cluster-m:8088/proxy/applicat
ion_1593072483341_0014/
20/06/26 04:54:13 INFO mapreduce.Job: Running job: job_1593072483341_0014
20/06/26 04:54:20 INFO mapreduce.Job: Job job_1593072483341_0014 running in uber mode : false
20/06/26 04:54:20 INFO mapreduce.Job:  map 0% reduce 0%
20/06/26 04:54:33 INFO mapreduce.Job:  map 14% reduce 0%
20/06/26 04:54:42 INFO mapreduce.Job:  map 25% reduce 0%
20/06/26 04:54:43 INFO mapreduce.Job:  map 47% reduce 0%
20/06/26 04:54:48 INFO mapreduce.Job:  map 51% reduce 0%
20/06/26 04:54:49 INFO mapreduce.Job:  map 69% reduce 0%
20/06/26 04:54:54 INFO mapreduce.Job:  map 70% reduce 0%
20/06/26 04:54:55 INFO mapreduce.Job:  map 71% reduce 0%
20/06/26 04:55:14 INFO mapreduce.Job:  map 76% reduce 0%
20/06/26 04:55:22 INFO mapreduce.Job:  map 81% reduce 0%
20/06/26 04:55:23 INFO mapreduce.Job:  map 91% reduce 0%
20/06/26 04:55:25 INFO mapreduce.Job:  map 95% reduce 0%
20/06/26 04:55:26 INFO mapreduce.Job:  map 100% reduce 0%
```

**<그림 13>**

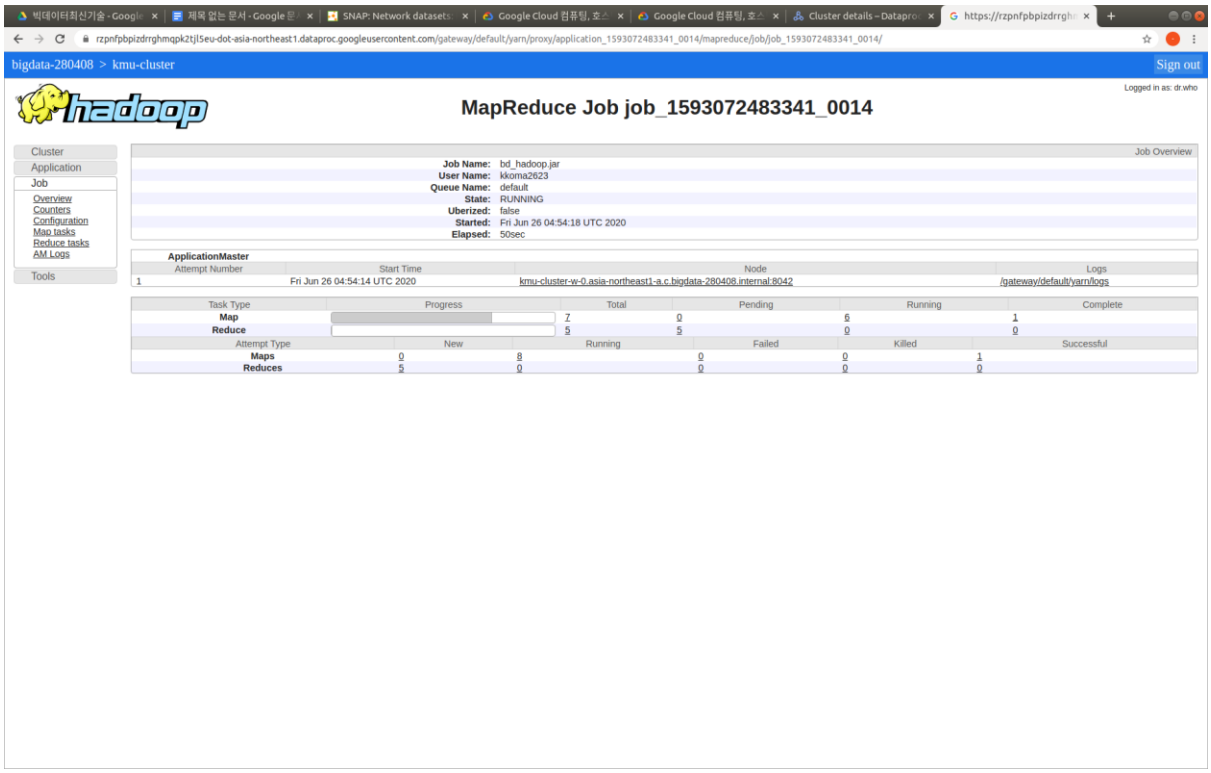
<그림 14>, <그림 15>, <그림 16>는 web UI 를 통해 Task1 이 실행중인 것을 캡처한 그림이다.




**<그림 14>**

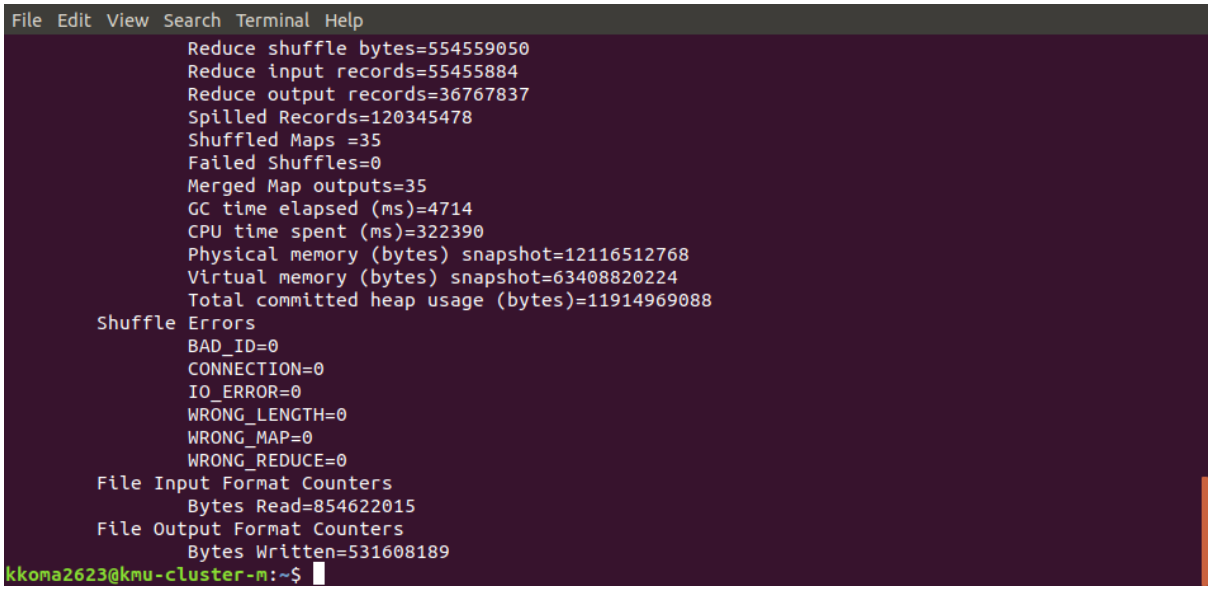

rzpnfpbpizdrrghmqpk2tjl5eu-dot-asia-northeast1.dataproc.googleusercontent.com/gateway/default/yarn/proxy/application_1593072483341_0014/
bigdata-280408 > kmu-cluster
Sign out
Logged in as: dr.who
hadoop
MapReduce Application application_1593072483341_0014
Cluster
Application
About
Jobs
Tools
Active Jobs
Show 20 entries
Search:
Job ID
Name
State
Map Progress
Maps Total
Maps Completed
Reduce Progress
Reduces Total
Reduces Completed
job_1593072483341_0014
bd_hadoop.jar
RUNNING
7
1
5
0
Showing 1 to 1 of 1 entries
First
Previous
1
Next
Last

**<그림 15>**


rzpnfpbpizdrrghmqpk2tjl5eu-dot-asia-northeast1.dataproc.googleusercontent.com/gateway/default/yarn/proxy/application_1593072483341_0014/mapreduce/job/job_1593072483341_0014/
bigdata-280408 > kmu-cluster
Sign out
Logged in as: dr.who
hadoop
MapReduce Job job_1593072483341_0014
Cluster
Application
Job
Overview
Counters
Configuration
Map tasks
Reduce tasks
AM Logs
Tools
Job Overview
Job Name: bd_hadoop.jar
User Name: kkoma2623
Queue Name: default
State: RUNNING
Uberized: false
Started: Fri Jun 26 04:54:18 UTC 2020
Elapsed: 50sec
ApplicationMaster
Attempt Number
Start Time
Node
Logs
1
Fri Jun 26 04:54:14 UTC 2020
kmu-cluster-w-0.asia-northeast1-a.c.bigdata-280408.internal:8042
/gateway/default/yarn/logs
Task Type
Progress
Total
Pending
Running
Complete
Map
7
0
6
1
Reduce
5
5
0
0
Attempt Type
New
Running
Failed
Killed
Successful
Maps
0
8
0
0
1
Reduces
5
0
0
0
0

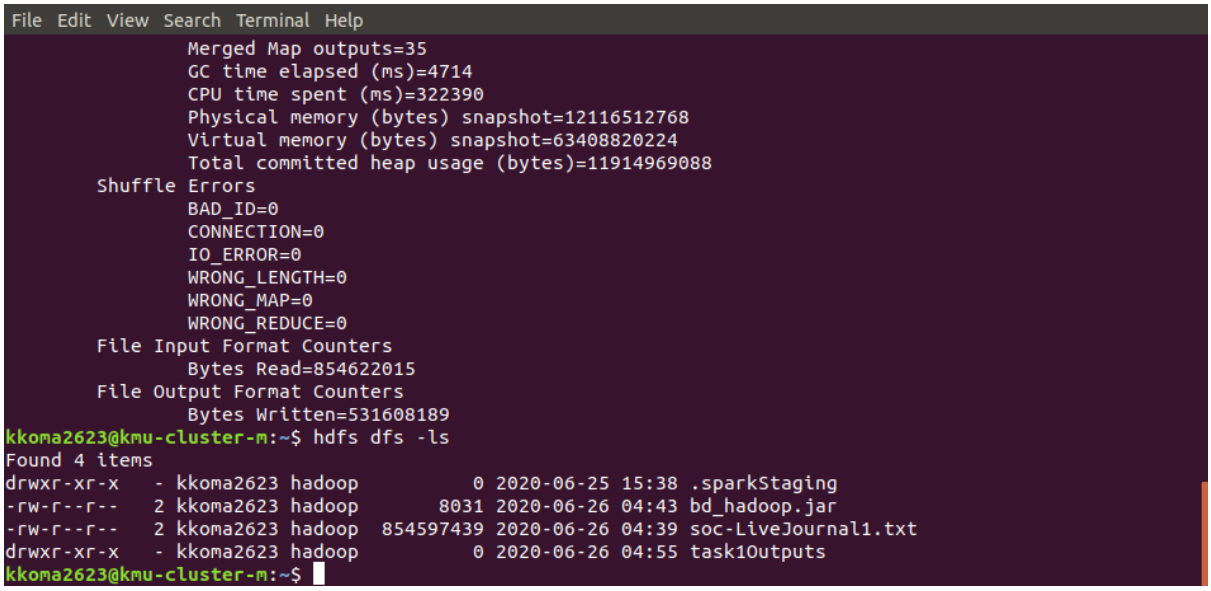
**<그림 16>**

<그림 17>은 터미널에서 Task1 이 실행 된 후의 그림이다.



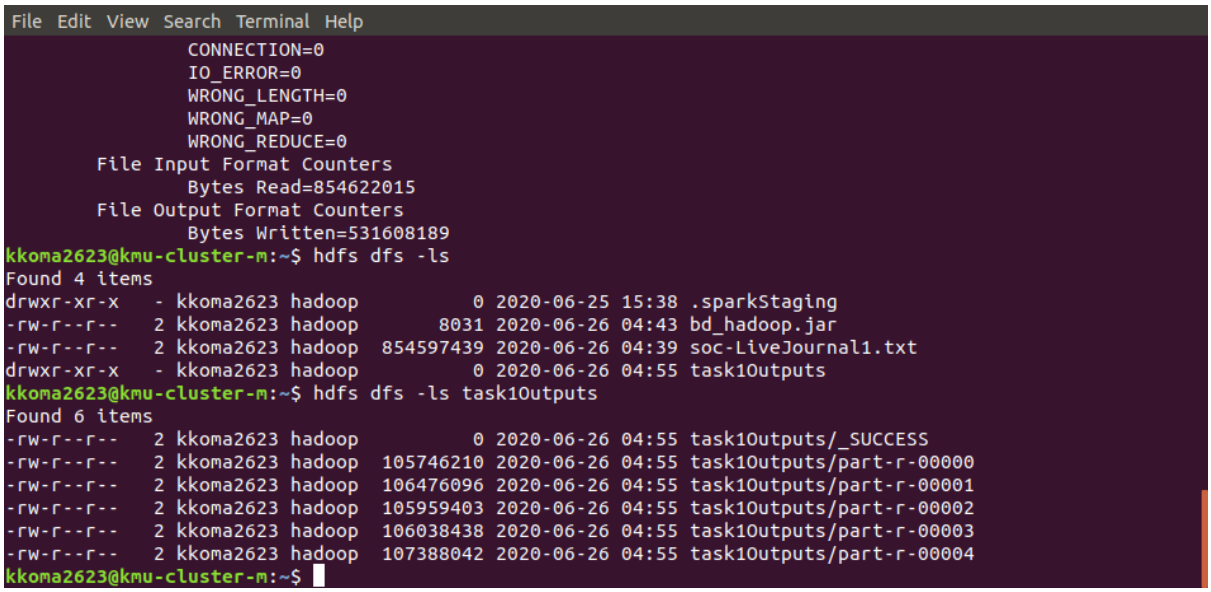

**<그림 17>**

hdfs dfs -ls 명령어를 통해 HDFS 에 출력 파일 경로에 설정한 출력파일이 생성된 것을 확인하였다.



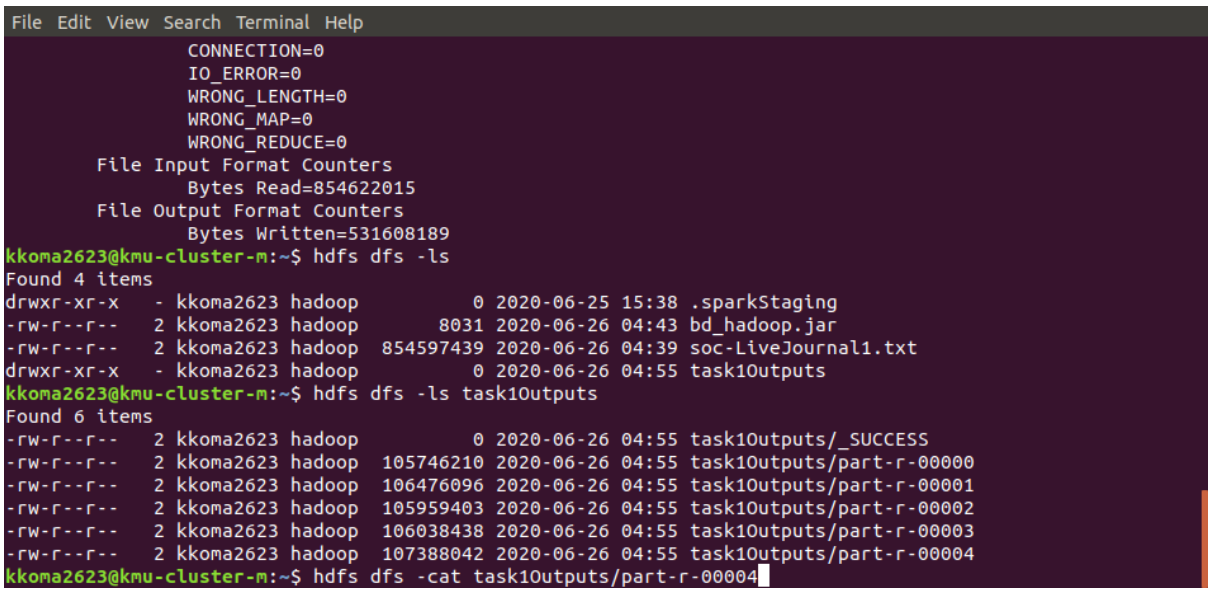

**<그림 18>**

hdfs dfs -ls task1Outputs 명령어를 통해 task1Outputs 디렉터리에 생성된 결과 파일들을 확인하였다.




**<그림 19>**

hdfs dfs -cat task1Outputs/part-t-00004 명령어를 통해 파일의 내용을 출력하겠다.




**<그림 20>**

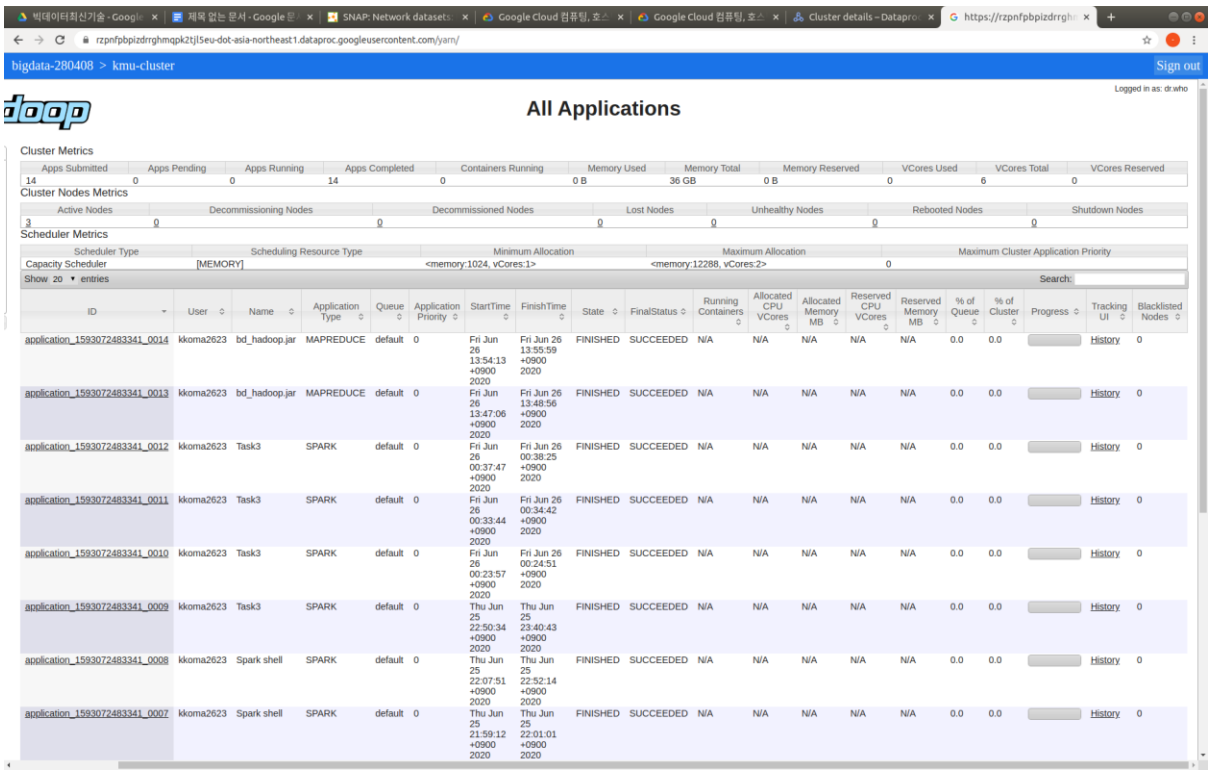
<그림 21>은 출력이 너무 길어서 keyboard interrupt 를 통해서 출력을 멈춘 그림이다.

simple graph 를 생성하는 것을 확인하였다.

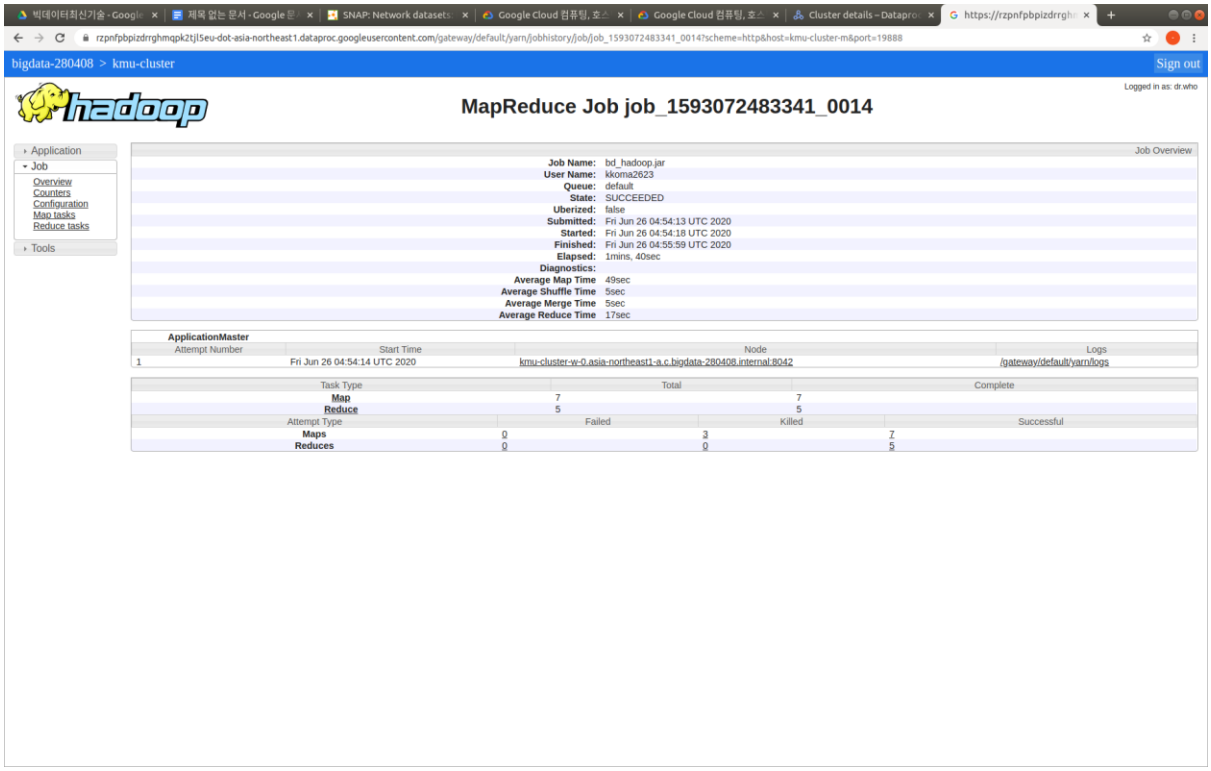
```
File  Edit  View  Search  Terminal  Help
4994    954804
4994    311743
4994    954803
4994    1722791
4994    321984
4994    642508
4994    741836
4994    22983
4994    2203112
4994    1605076
4994    190931
4994    1347014
4994    300496
4994    1526210
4994    1233399
4994    403936
4994    353772
4994    1893878
4994    168431
4994    168435
4994    2086382
4994    831992
49cat: Filesystem closed
kkoma2623@kmu-cluster-m:~$
```

**<그림 21>**

<그림 22>와 <그림 23>은 Task1 을 수행한 후에 web UI 를 통해 확인한 그림이다.




**<그림 22>**




**<그림 23>**

hadoop jar bd_hadoop.jar bigdata.Task2 -Dmapreduce.job.reduces=5 task1Outputs/* task2Outputs 명령어를 통해 bigdata 패키지의 Task2 를 실행하였다.

-Dmapreduce.job.reduces=5 옵션을 통해 리듀서의 개수를 5 로 설정하였다.

args[0]에 입력파일 경로를, args[1]에 출력 파일 경로를 설정해주었다.

입력 파일 경로는 task1Outputs/* 이고 출력 파일 경로는 task2Outputs 이다.

```
File  Edit  View  Search  Terminal  Help
4994    311743
4994    954803
4994    1722791
4994    321984
4994    642508
4994    741836
4994    22983
4994    2203112
4994    1605076
4994    190931
4994    1347014
4994    300496
4994    1526210
4994    1233399
4994    403936
4994    353772
4994    1893878
4994    168431
4994    168435
4994    2086382
4994    831992
49cat: Filesystem closed
kkoma2623@kmu-cluster-m:~$ hadoop jar bd_hadoop.jar bigdata.Task2 -Dmapreduce.job.reduces=5  task1Output
s/* task2Outputs
```

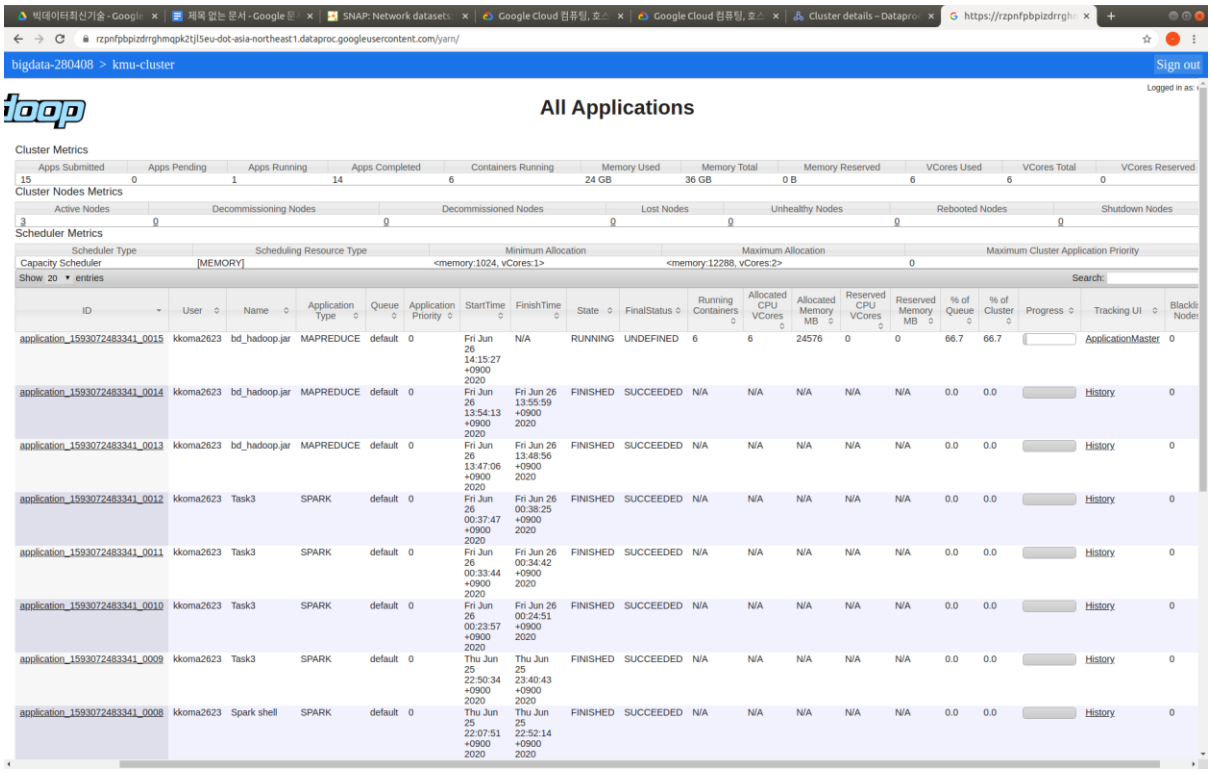
**<그림 24>**

<그림 25>는 Task2 를 실행하는 그림이다.

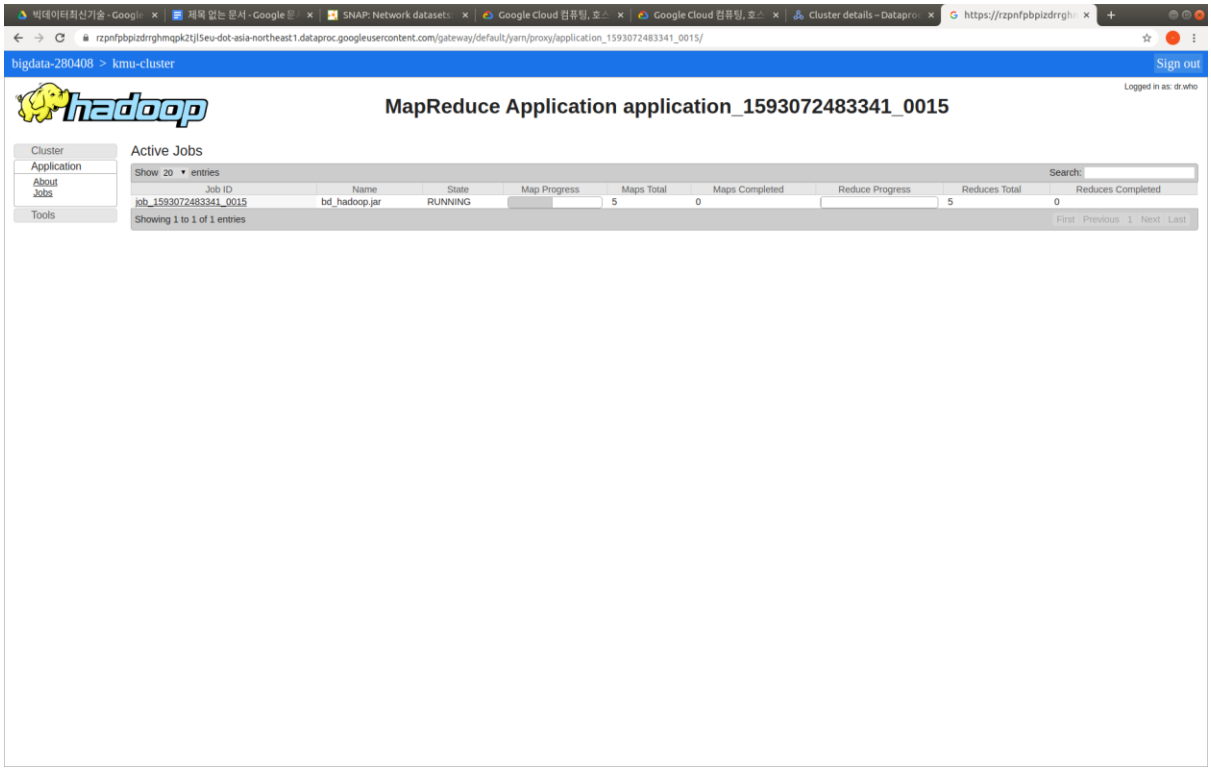
```
File  Edit  View  Search  Terminal  Help
4994    1233399
4994    403936
4994    353772
4994    1893878
4994    168431
4994    168435
4994    2086382
4994    831992
49cat: Filesystem closed
kkoma2623@kmu-cluster-m:~$ hadoop jar bd_hadoop.jar bigdata.Task2 -Dmapreduce.job.reduces=5  task1Output
s/* task2Outputs
20/06/26 05:15:26 INFO client.RMProxy: Connecting to ResourceManager at kmu-cluster-m/10.146.0.9:8032
20/06/26 05:15:26 INFO client.AHSProxy: Connecting to Application History server at kmu-cluster-m/10.146
.0.9:10200
20/06/26 05:15:27 INFO input.FileInputFormat: Total input files to process : 5
20/06/26 05:15:27 INFO mapreduce.JobSubmitter: number of splits:5
20/06/26 05:15:27 INFO Configuration.deprecation: yarn.resourcemanager.system-metrics-publisher.enabled
is deprecated. Instead, use yarn.system-metrics-publisher.enabled
20/06/26 05:15:27 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1593072483341_0015
20/06/26 05:15:27 INFO impl.YarnClientImpl: Submitted application application_1593072483341_0015
20/06/26 05:15:28 INFO mapreduce.Job: The url to track the job: http://kmu-cluster-m:8088/proxy/applicat
ion_1593072483341_0015/
20/06/26 05:15:28 INFO mapreduce.Job: Running job: job_1593072483341_0015
```

**<그림 25>**

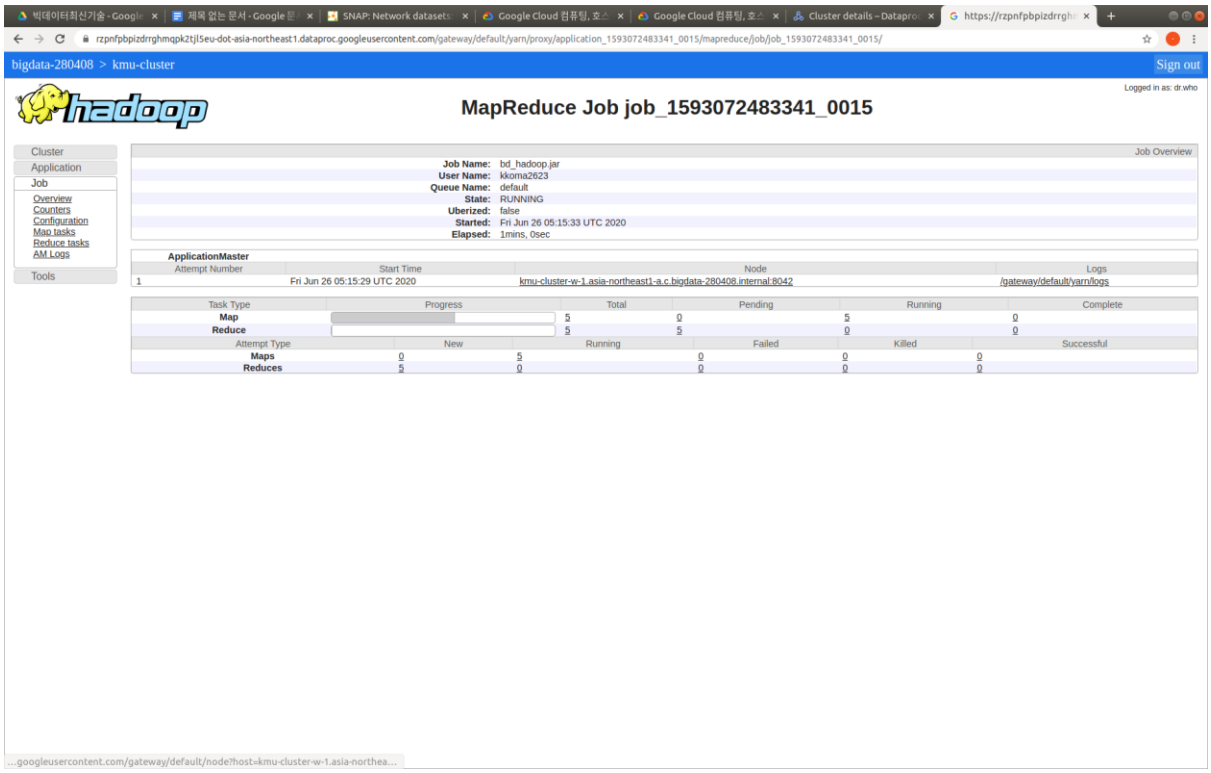
<그림 26>, <그림 27>, <그림 28>은 Task2 를 실행중인 것을 Web UI 를 통해서 보는 그림이다.




**<그림 26>**


rzpnfpbpizdrrghmqpk2tjl5eu-dot-asia-northeast1.dataproc.googleusercontent.com/gateway/default/yarn/proxy/application_1593072483341_0015/
bigdata-280408 > kmu-cluster
Sign out
Logged in as: dr.who
MapReduce Application application_1593072483341_0015
Cluster
Application
About
Jobs
Tools
Active Jobs
Show 20 entries
Search:
Job ID
Name
State
Map Progress
Maps Total
Maps Completed
Reduce Progress
Reduces Total
Reduces Completed
job_1593072483341_0015
bd_hadoop.jar
RUNNING
5
0
5
0
Showing 1 to 1 of 1 entries
First Previous 1 Next Last

**<그림 27>**


rzpnfpbpizdrrghmqpk2tjl5eu-dot-asia-northeast1.dataproc.googleusercontent.com/gateway/default/yarn/proxy/application_1593072483341_0015/mapreduce/job/job_1593072483341_0015/
bigdata-280408 > kmu-cluster
Sign out
Logged in as: dr.who
MapReduce Job job_1593072483341_0015
Cluster
Application
Job
Overview
Counters
Configuration
Map tasks
Reduce tasks
AM Logs
Tools
Job Overview
Job Name: bd_hadoop.jar
User Name: kkoma2623
Queue Name: default
State: RUNNING
Uberized: false
Started: Fri Jun 26 05:15:33 UTC 2020
Elapsed: 1mins, 0sec
ApplicationMaster
Attempt Number
Start Time
Node
Logs
1
Fri Jun 26 05:15:29 UTC 2020
kmu-cluster-w-1.asia-northeast1-a.c.bigdata-280408.internal:8042
/gateway/default/yarn/logs
Task Type
Progress
Total
Pending
Running
Complete
Map
5
0
5
0
Reduce
5
5
0
0
Attempt Type
New
Running
Failed
Killed
Successful
Maps
0
5
0
0
0
Reduces
5
0
0
0
0

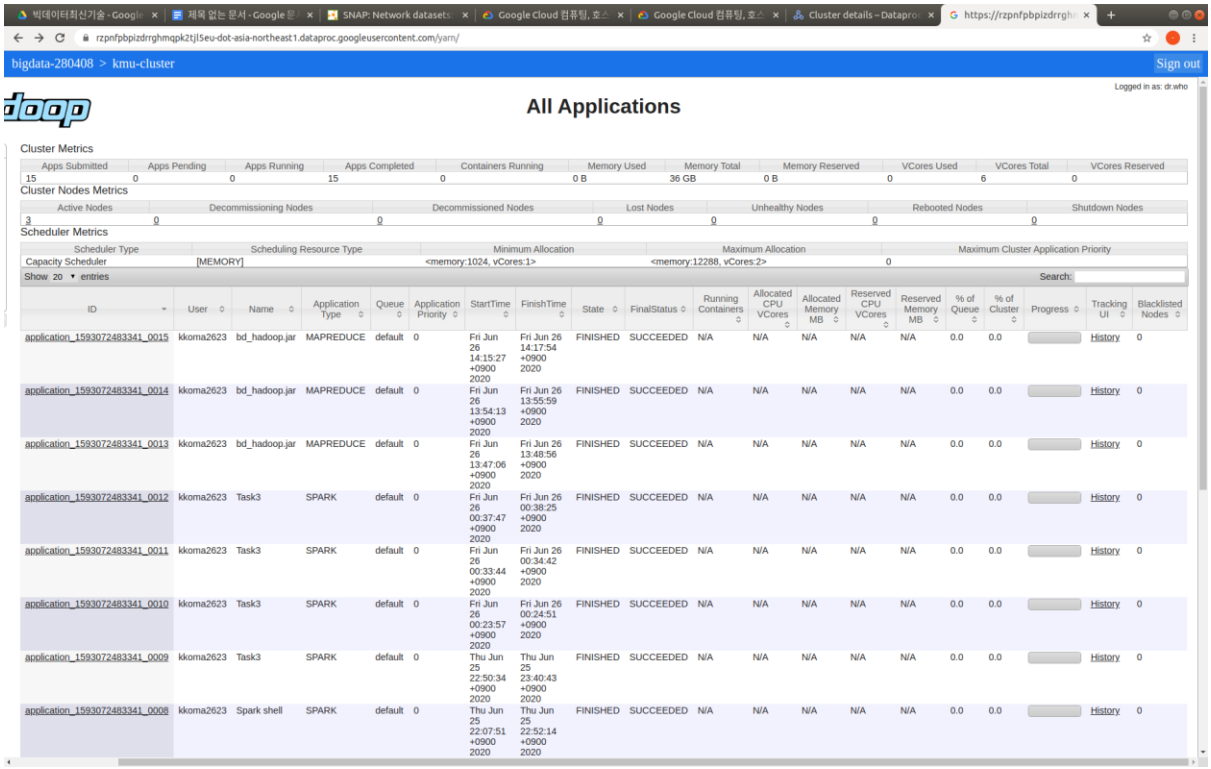
**<그림 28>**

Task2 를 실행 중인 것을 터미널을 통해 확인하는 그림이다.

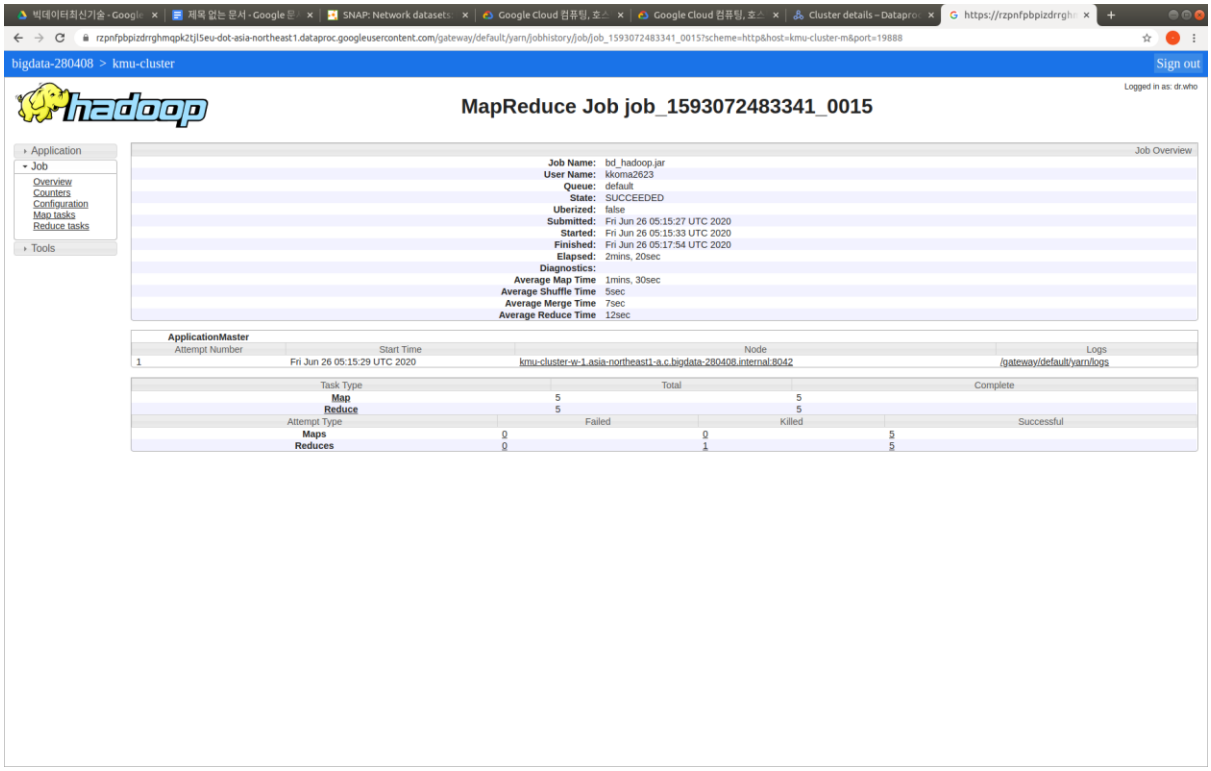
```
File  Edit  View  Search  Terminal  Help
20/06/26 05:15:27 INFO input.FileInputFormat: Total input files to process : 5
20/06/26 05:15:27 INFO mapreduce.JobSubmitter: number of splits:5
20/06/26 05:15:27 INFO Configuration.deprecation: yarn.resourcemanager.system-metrics-publisher.enabled
is deprecated. Instead, use yarn.system-metrics-publisher.enabled
20/06/26 05:15:27 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1593072483341_0015
20/06/26 05:15:27 INFO impl.YarnClientImpl: Submitted application application_1593072483341_0015
20/06/26 05:15:28 INFO mapreduce.Job: The url to track the job: http://kmu-cluster-m:8088/proxy/applicat
ion_1593072483341_0015/
20/06/26 05:15:28 INFO mapreduce.Job: Running job: job_1593072483341_0015
20/06/26 05:15:35 INFO mapreduce.Job: Job job_1593072483341_0015 running in uber mode : false
20/06/26 05:15:35 INFO mapreduce.Job:  map 0% reduce 0%
20/06/26 05:15:55 INFO mapreduce.Job:  map 18% reduce 0%
20/06/26 05:15:58 INFO mapreduce.Job:  map 41% reduce 0%
20/06/26 05:16:01 INFO mapreduce.Job:  map 42% reduce 0%
20/06/26 05:16:04 INFO mapreduce.Job:  map 47% reduce 0%
20/06/26 05:16:19 INFO mapreduce.Job:  map 51% reduce 0%
20/06/26 05:16:25 INFO mapreduce.Job:  map 55% reduce 0%
20/06/26 05:16:37 INFO mapreduce.Job:  map 57% reduce 0%
20/06/26 05:16:40 INFO mapreduce.Job:  map 68% reduce 0%
20/06/26 05:16:43 INFO mapreduce.Job:  map 74% reduce 0%
20/06/26 05:16:46 INFO mapreduce.Job:  map 75% reduce 0%
20/06/26 05:16:48 INFO mapreduce.Job:  map 79% reduce 0%
20/06/26 05:16:49 INFO mapreduce.Job:  map 80% reduce 0%
```

**<그림 29>**

<그림 30>, <그림 31>은 Task2 가 실행이 종료된 후 Web UI 를 통해 본 그림이다.

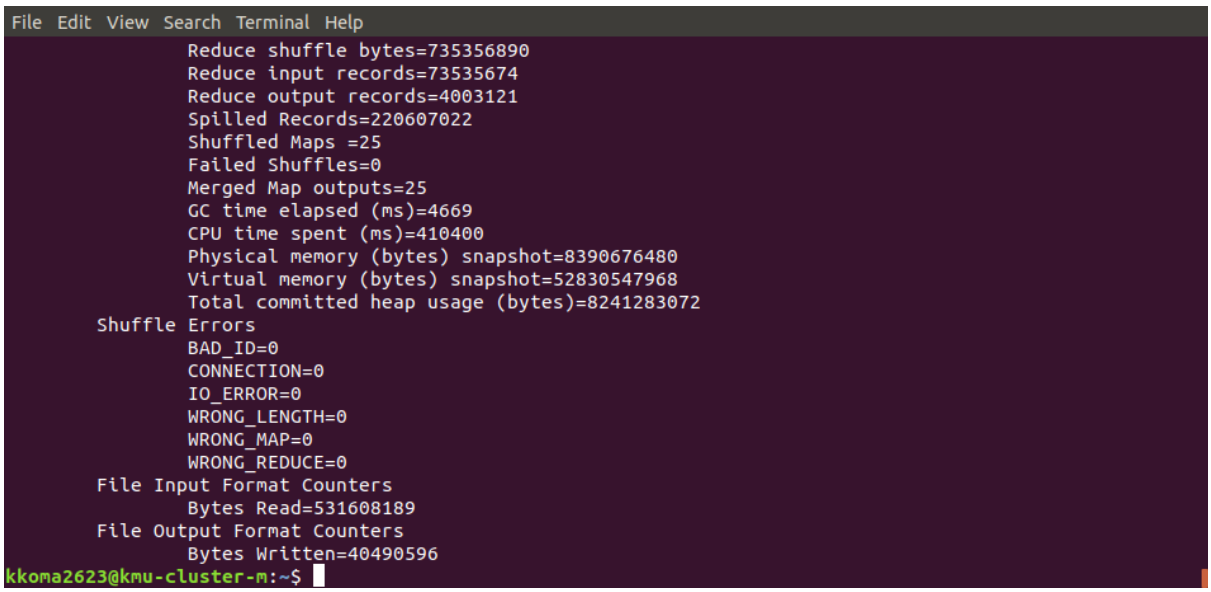



**<그림 30>**




**<그림 31>**

<그림 32>는 실행이 종료된 것을 터미널을 통해 확인한 그림이다.




**<그림 32>**

hdfs dfs -ls 명령어를 통해 HDFS 에 Task2 에서 출력 경로로 설정해둔 곳에 파일이 생성된 것을 확인하였다.

```
File  Edit  View  Search  Terminal  Help
                GC time elapsed (ms)=4669
                CPU time spent (ms)=410400
                Physical memory (bytes) snapshot=8390676480
                Virtual memory (bytes) snapshot=52830547968
                Total committed heap usage (bytes)=8241283072
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=531608189
        File Output Format Counters
                Bytes Written=40490596
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls
Found 5 items
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-25 15:38 .sparkStaging
-rw-r--r--   2 kkoma2623 hadoop       8031 2020-06-26 04:43 bd_hadoop.jar
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 04:55 task1Outputs
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs
kkoma2623@kmu-cluster-m:~$
```

**<그림 33>**

hdfs dfs -ls task2Outputs 명령어를 통해 task2Outputs 디렉터리 안에 생성된 출력 파일들의 목록을 확인하였다.

```
File  Edit  View  Search  Terminal  Help
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=531608189
        File Output Format Counters
                Bytes Written=40490596
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls
Found 5 items
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-25 15:38 .sparkStaging
-rw-r--r--   2 kkoma2623 hadoop       8031 2020-06-26 04:43 bd_hadoop.jar
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 04:55 task1Outputs
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls task2Outputs
Found 6 items
-rw-r--r--   2 kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs/_SUCCESS
-rw-r--r--   2 kkoma2623 hadoop    8100999 2020-06-26 05:17 task2Outputs/part-r-00000
-rw-r--r--   2 kkoma2623 hadoop    8098472 2020-06-26 05:17 task2Outputs/part-r-00001
-rw-r--r--   2 kkoma2623 hadoop    8094956 2020-06-26 05:17 task2Outputs/part-r-00002
-rw-r--r--   2 kkoma2623 hadoop    8098317 2020-06-26 05:17 task2Outputs/part-r-00003
-rw-r--r--   2 kkoma2623 hadoop    8097852 2020-06-26 05:17 task2Outputs/part-r-00004
kkoma2623@kmu-cluster-m:~$
```

**<그림 34>**

hdfs dfs -cat task2Outputs/part-r-00004 명령어를 통해 출력 파일의 일부를 확인하겠다.

```
File  Edit  View  Search  Terminal  Help
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=531608189
        File Output Format Counters
                Bytes Written=40490596
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls
Found 5 items
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-25 15:38 .sparkStaging
-rw-r--r--   2 kkoma2623 hadoop       8031 2020-06-26 04:43 bd_hadoop.jar
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 04:55 task1Outputs
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls task2Outputs
Found 6 items
-rw-r--r--   2 kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs/_SUCCESS
-rw-r--r--   2 kkoma2623 hadoop    8100999 2020-06-26 05:17 task2Outputs/part-r-00000
-rw-r--r--   2 kkoma2623 hadoop    8098472 2020-06-26 05:17 task2Outputs/part-r-00001
-rw-r--r--   2 kkoma2623 hadoop    8094956 2020-06-26 05:17 task2Outputs/part-r-00002
-rw-r--r--   2 kkoma2623 hadoop    8098317 2020-06-26 05:17 task2Outputs/part-r-00003
-rw-r--r--   2 kkoma2623 hadoop    8097852 2020-06-26 05:17 task2Outputs/part-r-00004
kkoma2623@kmu-cluster-m:~$ hdfs dfs -cat task2Outputs/part-r-00004
```

**<그림 35>**

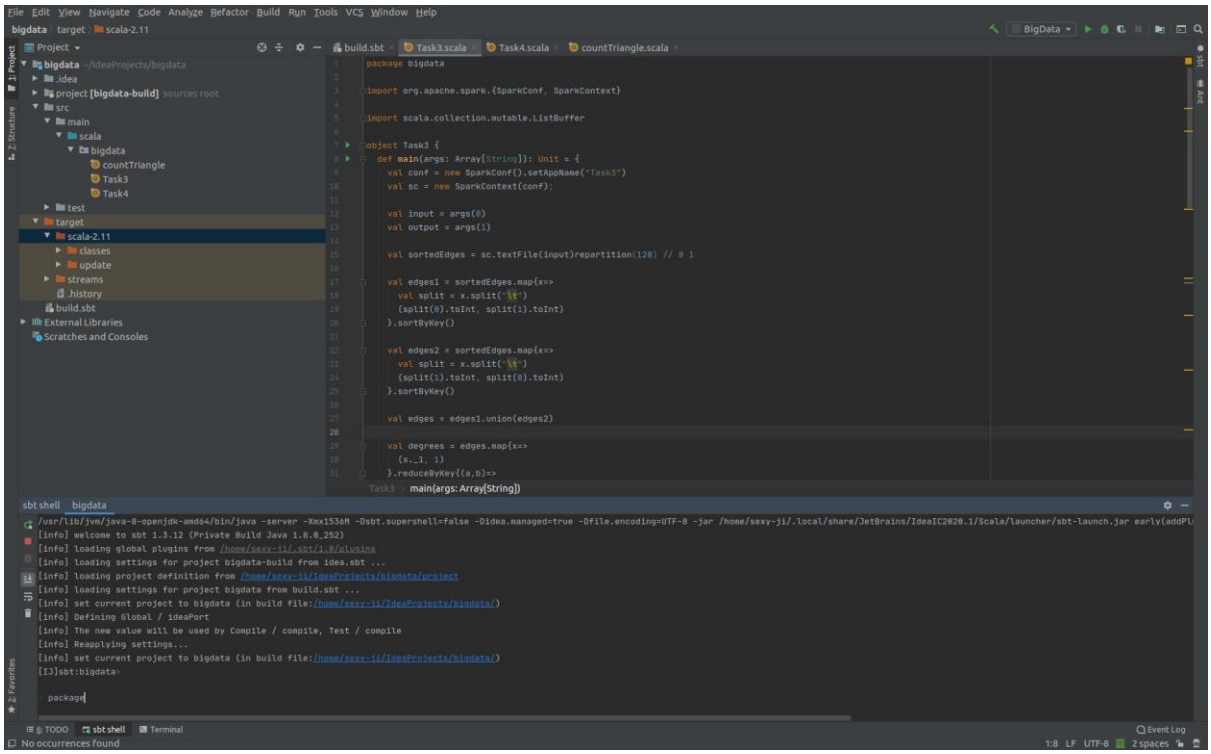
출력이 너무 길어서 keyboard interrupt 를 사용하여 출력을 끊었다.

다음 그림은 Task2 의 출력물 중 일부이다.

```
File  Edit  View  Search  Terminal  Help
1529364 5
1529369 30
1529374 105
1529379 33
1529384 49
1529389 23
1529394 13
1529399 1
1529404 48
1529409 7
1529414 13
1529419 17
1529424 19
1529429 25
1529434 24
1529439 27
1529444 5
1529449 3
1529454 28
1529459 35
1529464 37
1529469 11
1529474 cat: Filesystem closed
kkoma2623@kmu-cluster-m:~$
```

**<그림 36>**

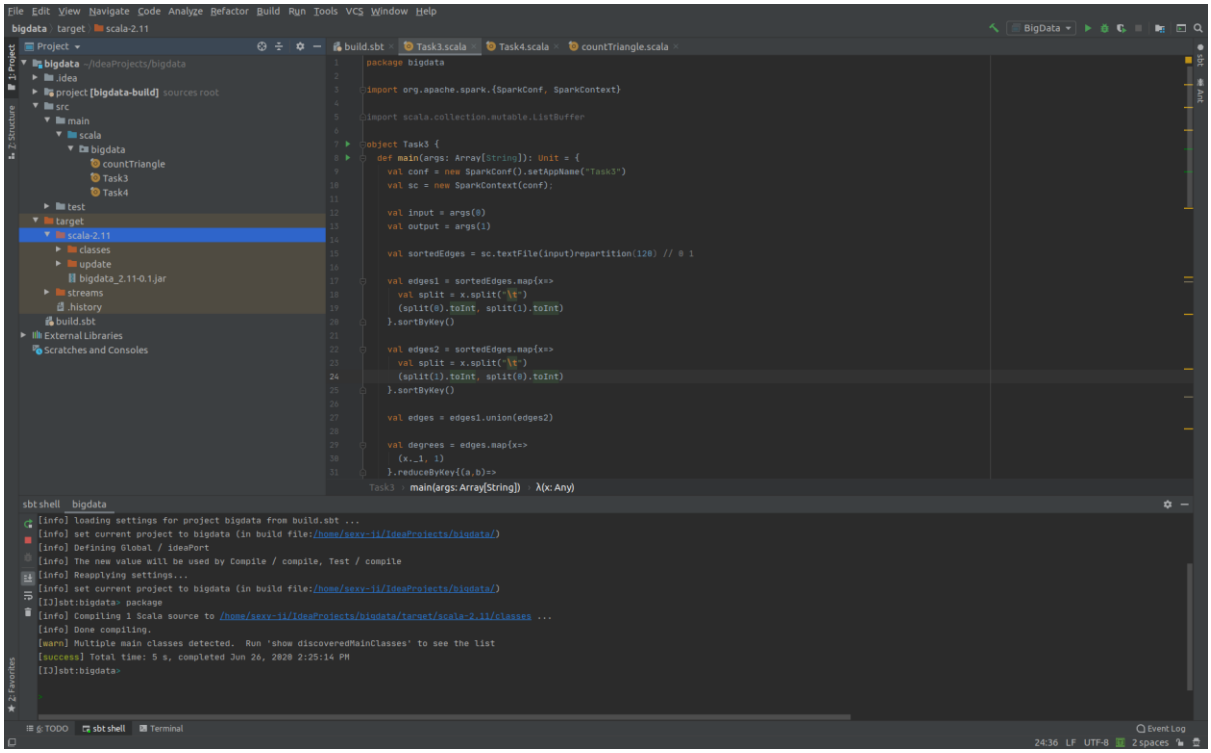
IntelliJ 에서 sbt shell 에서 package 명령어를 통해 Task3 와 Task4 를 수행할 수 있는 jar 파일을 생성하겠다.



**<그림 37>**

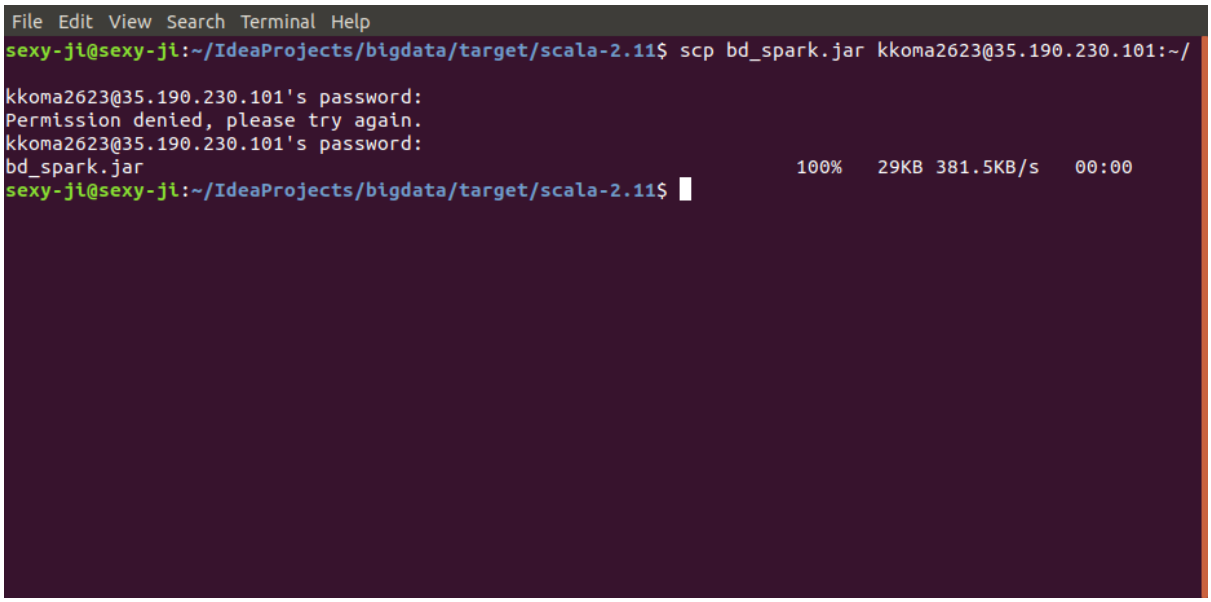
<그림 38>은 jar 파일을 생성을 완료한 그림이다.

bigdata_2.11-0.1.jar 파일이 생성된 것을 확인하였다. 이를 bd_spark.jar 로 리팩토링 하였다.



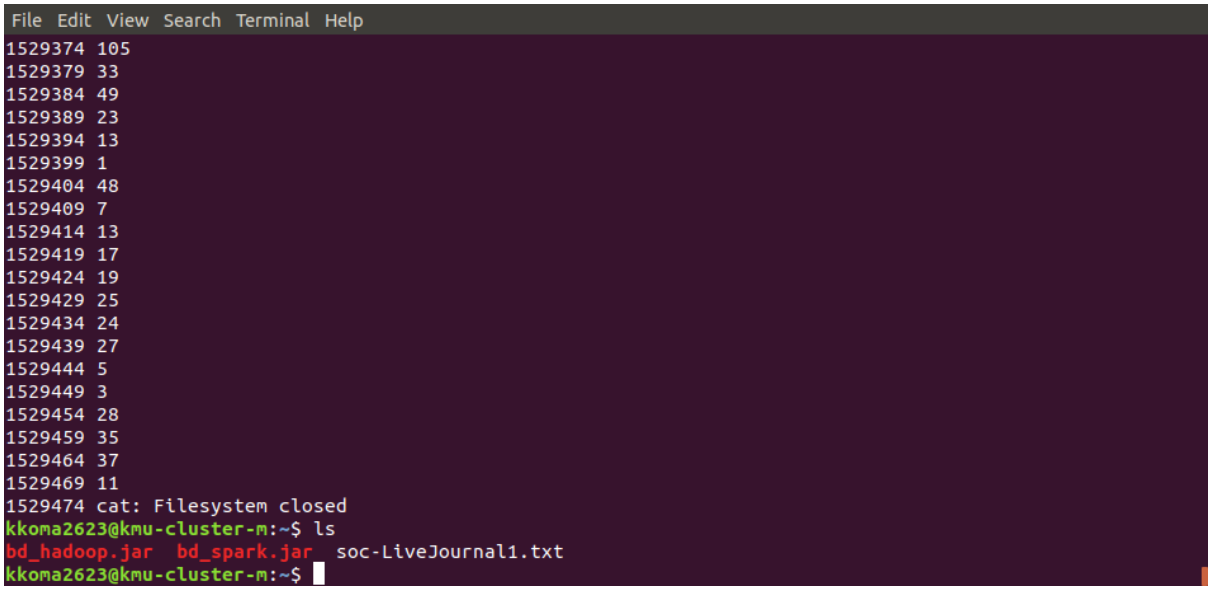
**<그림 38>**

scp bd_spark.jar kkoma2623@35.190.230.101:~/ 명령어를 통해 bd_spark.jar 파일을 GCP 에 업로드 하였다.




**<그림 39>**

클러스터에서 ls 명령어를 통해 bd_spark.jar 파일이 업로드 된 것을 확인하였다.




**<그림 40>**

hdfs dfs -put bd_spark.jar 명령어를 통해 bd_spark.jar 파일을 HDFS 에 업로드 하였다.

hdfs dfs -ls 명령어를 통해 HDFS 에 bd_spark.jar 파일이 업로드 된 것을 확인하였다.

```
File  Edit  View  Search  Terminal  Help
1529419 17
1529424 19
1529429 25
1529434 24
1529439 27
1529444 5
1529449 3
1529454 28
1529459 35
1529464 37
1529469 11
1529474 cat: Filesystem closed
kkoma2623@kmu-cluster-m:~$ ls
bd_hadoop.jar  bd_spark.jar  soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$ hdfs dfs -put bd_spark.jar
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls
Found 6 items
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-25 15:38 .sparkStaging
-rw-r--r--   2 kkoma2623 hadoop       8031 2020-06-26 04:43 bd_hadoop.jar
-rw-r--r--   2 kkoma2623 hadoop      29497 2020-06-26 05:27 bd_spark.jar
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 04:55 task1Outputs
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs
kkoma2623@kmu-cluster-m:~$
```

**<그림 41>**

spark-submit –num-executors 12 –class bigdata.Task3 bd_spark.jar task1Outputs/* task3Outputs 명령어를 통해 bigdata 패키지의 Task3 를 실행하겠다.

--num-executoers 12 옵션을 통해 executors 를 12 로 설정하였다.

args[0]에 입력파일 경로를, args[1]에 출력 파일 경로를 설정해주었다.

입력 파일 경로는 task1Outputs/* 이고 출력 파일 경로는 task3Outputs 이다.

```
File  Edit  View  Search  Terminal  Help
1529424 19
1529429 25
1529434 24
1529439 27
1529444 5
1529449 3
1529454 28
1529459 35
1529464 37
1529469 11
1529474 cat: Filesystem closed
kkoma2623@kmu-cluster-m:~$ ls
bd_hadoop.jar  bd_spark.jar  soc-LiveJournal1.txt
kkoma2623@kmu-cluster-m:~$ hdfs dfs -put bd_spark.jar
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls
Found 6 items
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-25 15:38 .sparkStaging
-rw-r--r--   2 kkoma2623 hadoop       8031 2020-06-26 04:43 bd_hadoop.jar
-rw-r--r--   2 kkoma2623 hadoop      29497 2020-06-26 05:27 bd_spark.jar
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 04:55 task1Outputs
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs
kkoma2623@kmu-cluster-m:~$ spark-submit --num-executors 12 --class bigdata.Task3 bd_spark.jar task1Outpu
ts/* task3Outputs
```

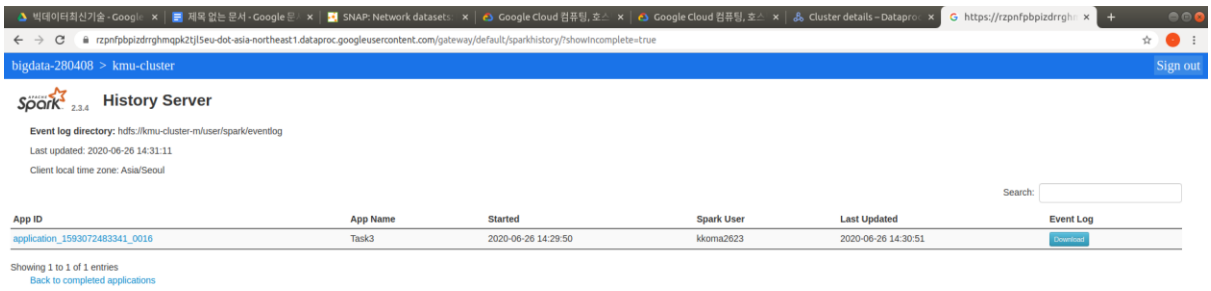
**<그림 42>**

bigdata 패키지의 Task3 를 실행하는 화면이다.

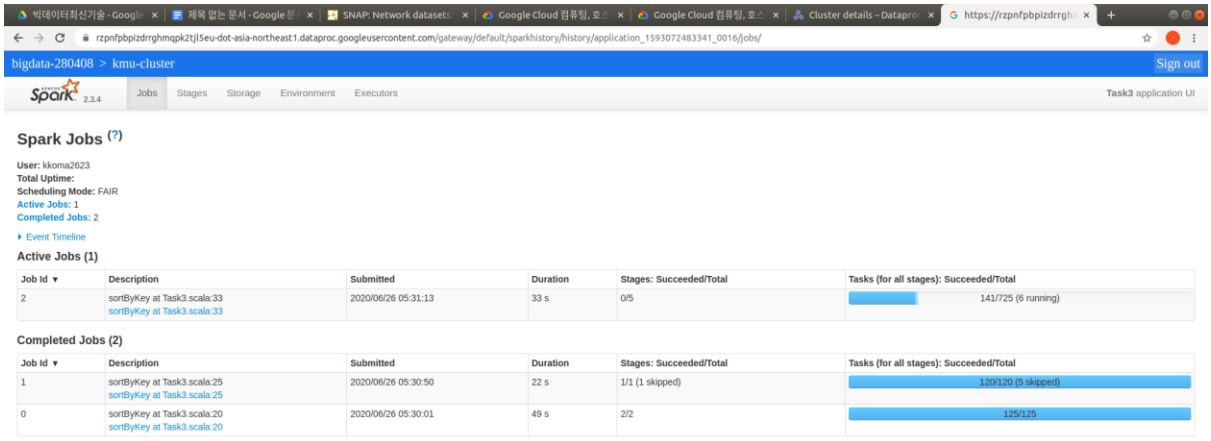
```
File  Edit  View  Search  Terminal  Help
-rw-r--r--   2 kkoma2623 hadoop       8031 2020-06-26 04:43 bd_hadoop.jar
-rw-r--r--   2 kkoma2623 hadoop      29497 2020-06-26 05:27 bd_spark.jar
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 04:55 task1Outputs
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs
kkoma2623@kmu-cluster-m:~$ spark-submit --num-executors 12 --class bigdata.Task3 bd_spark.jar task1Outpu
ts/* task3Outputs
20/06/26 05:29:51 INFO org.spark_project.jetty.util.log: Logging initialized @2512ms
20/06/26 05:29:51 INFO org.spark_project.jetty.server.Server: jetty-9.3.z-SNAPSHOT, build timestamp: unk
nown, git hash: unknown
20/06/26 05:29:51 INFO org.spark_project.jetty.server.Server: Started @2588ms
20/06/26 05:29:51 INFO org.spark_project.jetty.server.AbstractConnector: Started ServerConnector@5426b0d
6{HTTP/1.1,[http/1.1]}{0.0.0.0:4040}
20/06/26 05:29:51 WARN org.apache.spark.scheduler.FairSchedulableBuilder: Fair Scheduler configuration f
ile not found so jobs will be scheduled in FIFO order. To use fair scheduling, configure pools in fairsc
heduler.xml or set spark.scheduler.allocation.file to a file that contains the configuration.
20/06/26 05:29:52 INFO org.apache.hadoop.yarn.client.RMProxy: Connecting to ResourceManager at kmu-clust
er-m/10.146.0.9:8032
20/06/26 05:29:53 INFO org.apache.hadoop.yarn.client.AHSProxy: Connecting to Application History server
at kmu-cluster-m/10.146.0.9:10200
20/06/26 05:29:55 INFO org.apache.hadoop.yarn.client.api.impl.YarnClientImpl: Submitted application appl
ication_1593072483341_0016
20/06/26 05:30:01 INFO org.apache.hadoop.mapred.FileInputFormat: Total input files to process : 5
```

**<그림 43>**

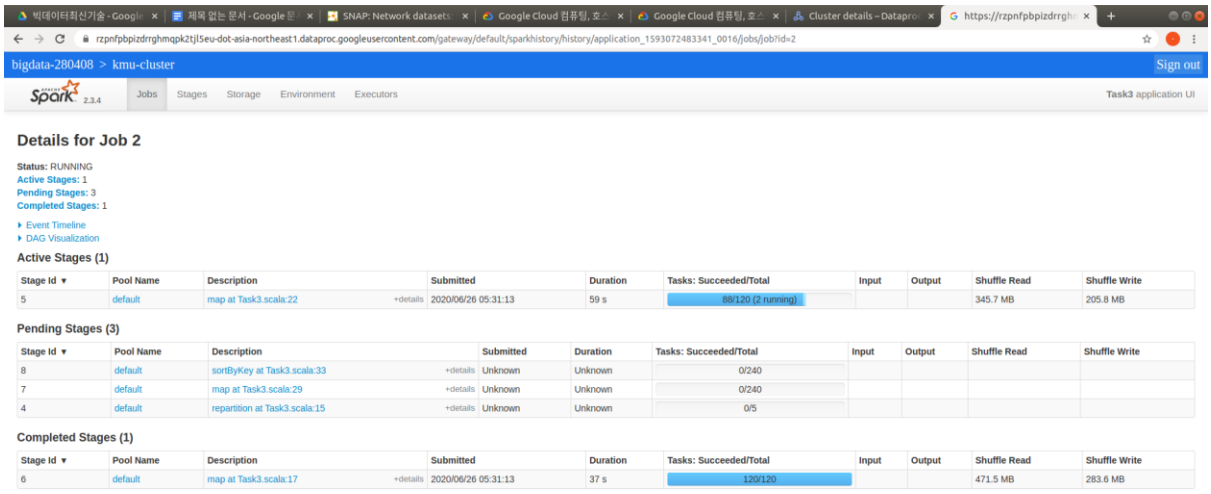
<그림 44>~<그림 50>은 Web UI 에서 실행중인 것을 확인하는 그림이다.



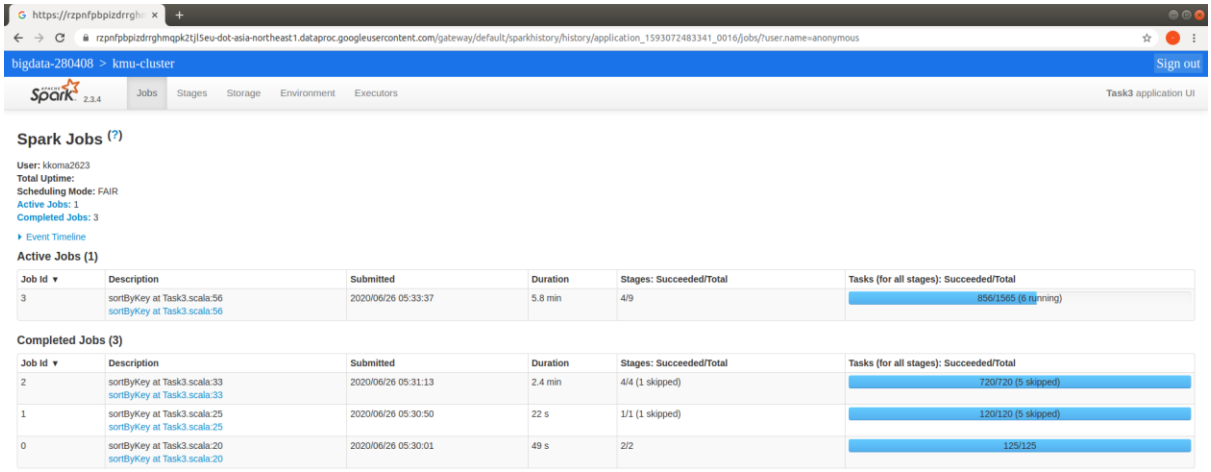

**<그림 44>**


rzpnfpbpizdrrghmqpk2tjl5eu-dot-asia-northeast1.dataproc.googleusercontent.com/gateway/default/sparkhistory/history/application_1593072483341_0016/jobs/
bigdata-280408 > kmu-cluster
Sign out
Spark 2.3.4
Jobs
Stages
Storage
Environment
Executors
Task3 application UI
Spark Jobs (?)
User: kkoma2623
Total Uptime:
Scheduling Mode: FAIR
Active Jobs: 1
Completed Jobs: 2
Event Timeline
Active Jobs (1)
Job Id ▼ | Description | Submitted | Duration | Stages: Succeeded/Total | Tasks (for all stages): Succeeded/Total
2 | sortByKey at Task3.scala:33 sortByKey at Task3.scala:33 | 2020/06/26 05:31:13 | 33 s | 0/5 | 141/725 (6 running)
Completed Jobs (2)
Job Id ▼ | Description | Submitted | Duration | Stages: Succeeded/Total | Tasks (for all stages): Succeeded/Total
1 | sortByKey at Task3.scala:25 sortByKey at Task3.scala:25 | 2020/06/26 05:30:50 | 22 s | 1/1 (1 skipped) | 120/120 (5 skipped)
0 | sortByKey at Task3.scala:20 sortByKey at Task3.scala:20 | 2020/06/26 05:30:01 | 49 s | 2/2 | 125/125

**<그림 45>**

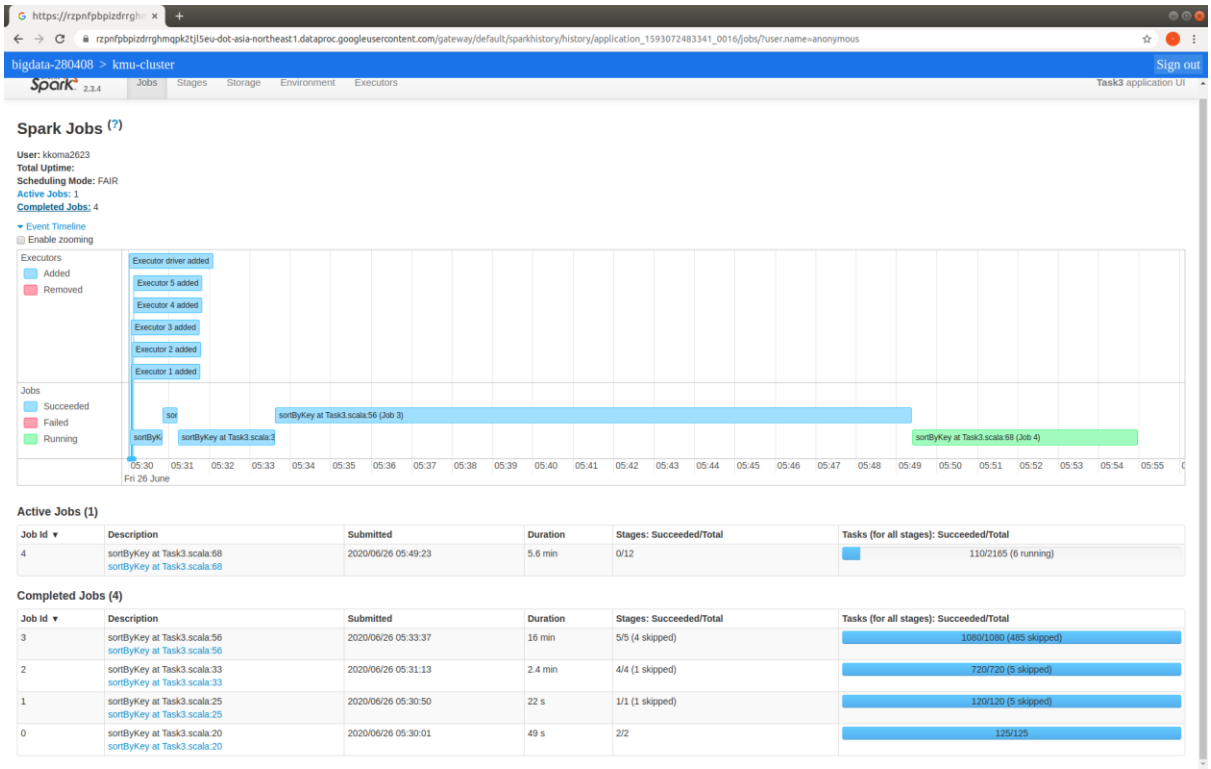

rzpnfpbpizdrrghmqpk2tjl5eu-dot-asia-northeast1.dataproc.googleusercontent.com/gateway/default/sparkhistory/history/application_1593072483341_0016/jobs/job?id=2
bigdata-280408 > kmu-cluster
Sign out
Spark 2.3.4
Jobs
Stages
Storage
Environment
Executors
Task3 application UI
Details for Job 2
Status: RUNNING
Active Stages: 1
Pending Stages: 3
Completed Stages: 1
Event Timeline
DAG Visualization
Active Stages (1)
Stage Id ▼ | Pool Name | Description | Submitted | Duration | Tasks: Succeeded/Total | Input | Output | Shuffle Read | Shuffle Write
5 | default | map at Task3.scala:22 +details | 2020/06/26 05:31:13 | 59 s | 88/120 (2 running) | | | 345.7 MB | 205.8 MB
Pending Stages (3)
Stage Id ▼ | Pool Name | Description | Submitted | Duration | Tasks: Succeeded/Total | Input | Output | Shuffle Read | Shuffle Write
8 | default | sortByKey at Task3.scala:33 +details | Unknown | Unknown | 0/240
7 | default | map at Task3.scala:29 +details | Unknown | Unknown | 0/240
4 | default | repartition at Task3.scala:15 +details | Unknown | Unknown | 0/5
Completed Stages (1)
Stage Id ▼ | Pool Name | Description | Submitted | Duration | Tasks: Succeeded/Total | Input | Output | Shuffle Read | Shuffle Write
6 | default | map at Task3.scala:17 +details | 2020/06/26 05:31:13 | 37 s | 120/120 | | | 471.5 MB | 283.6 MB

**<그림 46>**



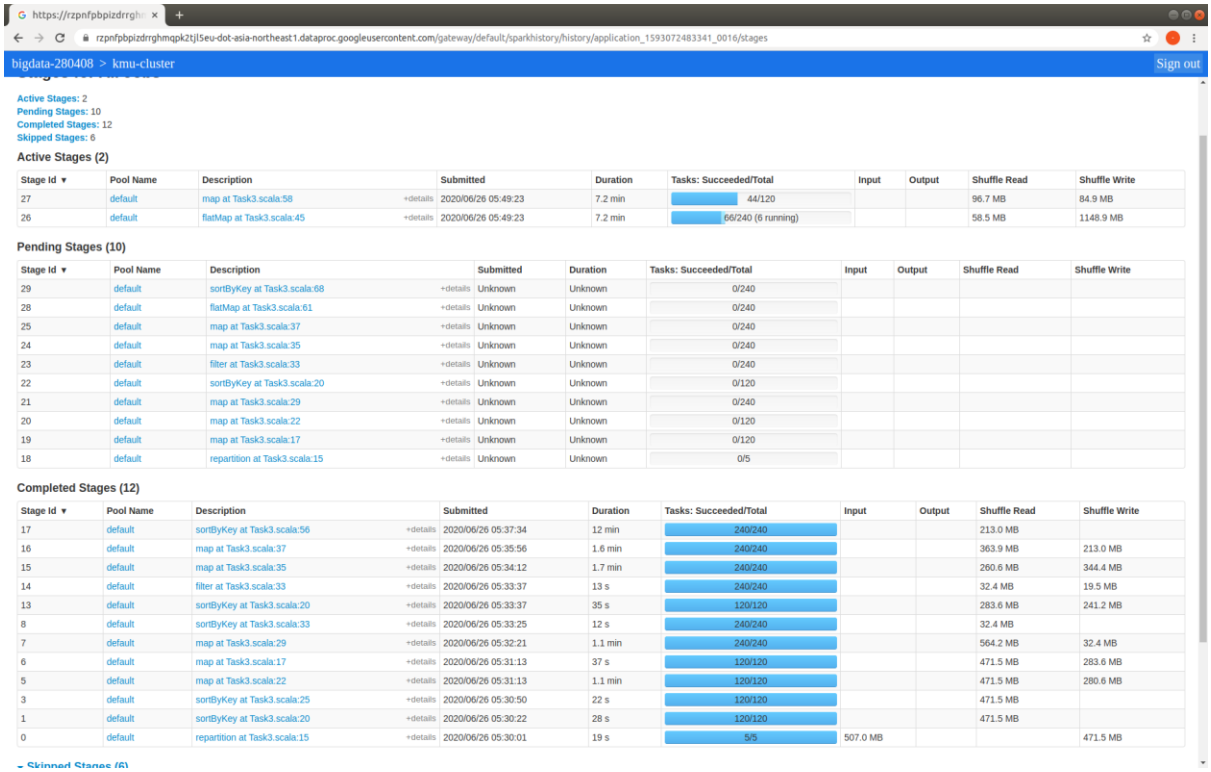

**<그림 47>**

유독 시간이 오래 걸리는 Job 의 Event Timeline 을 캡처해보았다.



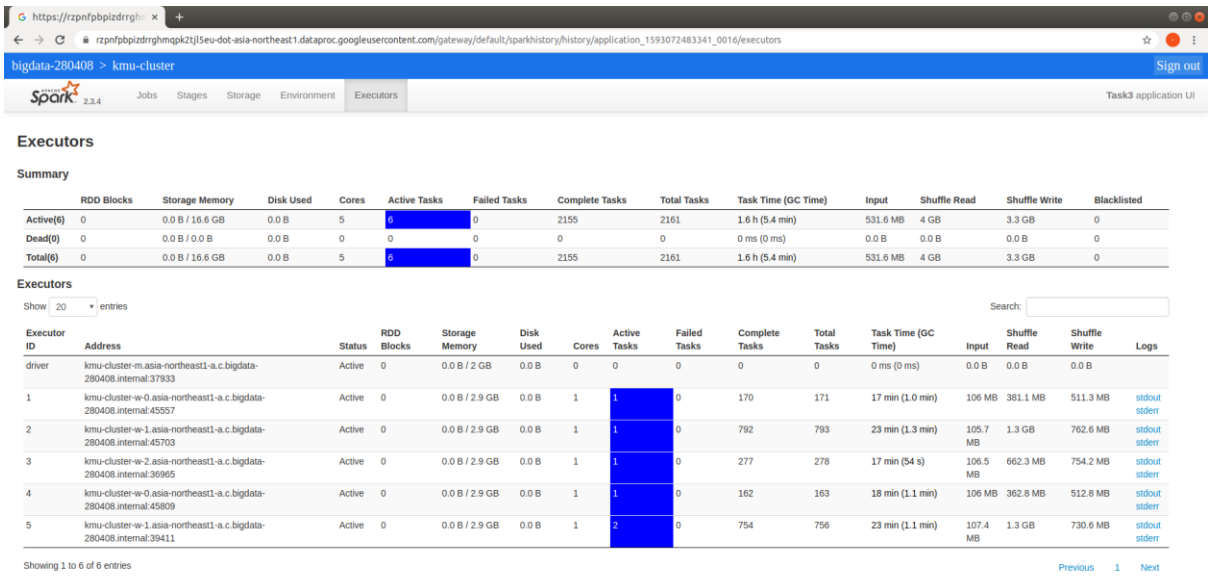

**<그림 48>**

실행중인 Task3 의 stages 를 캡처해보았다.



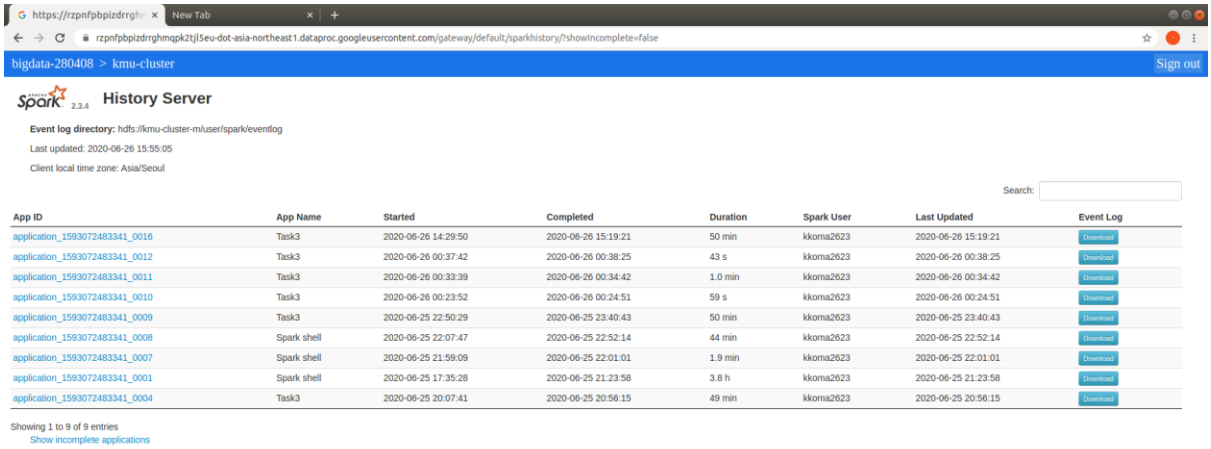

**<그림 49>**

실행중인 Task3 의 executors 를 캡처해보았다.

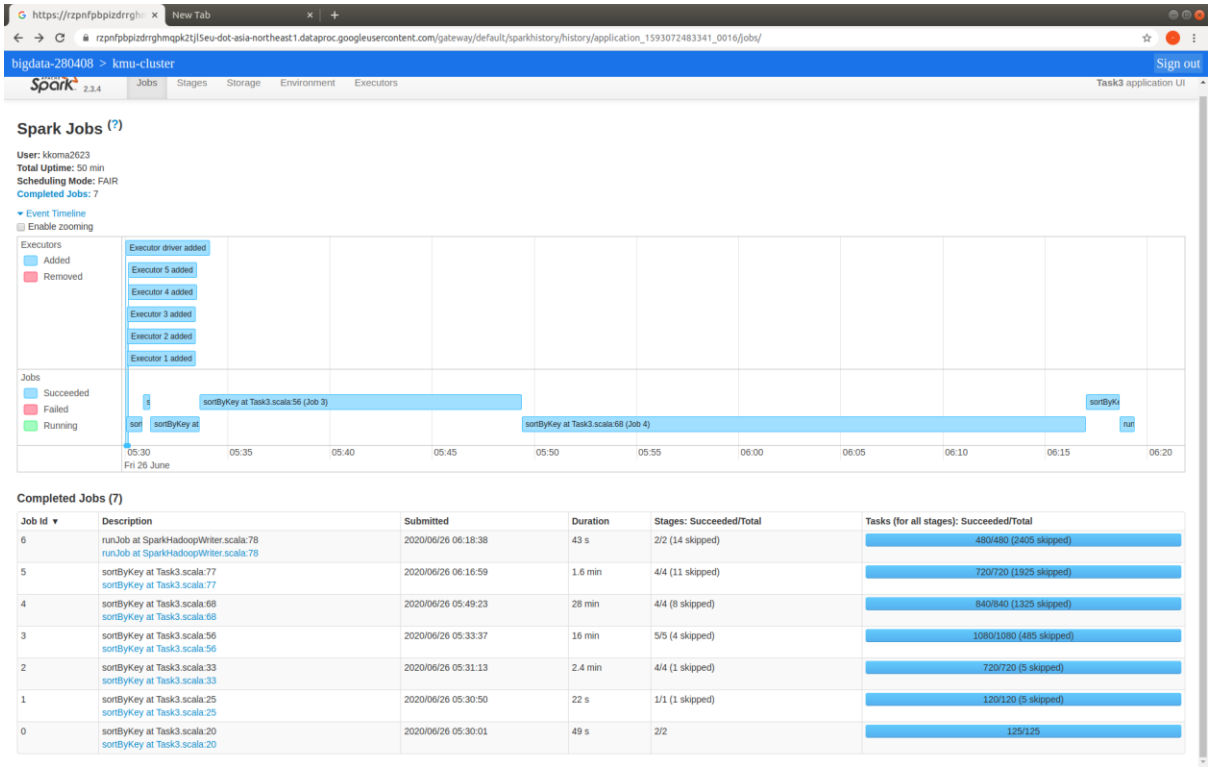



**<그림 50>**

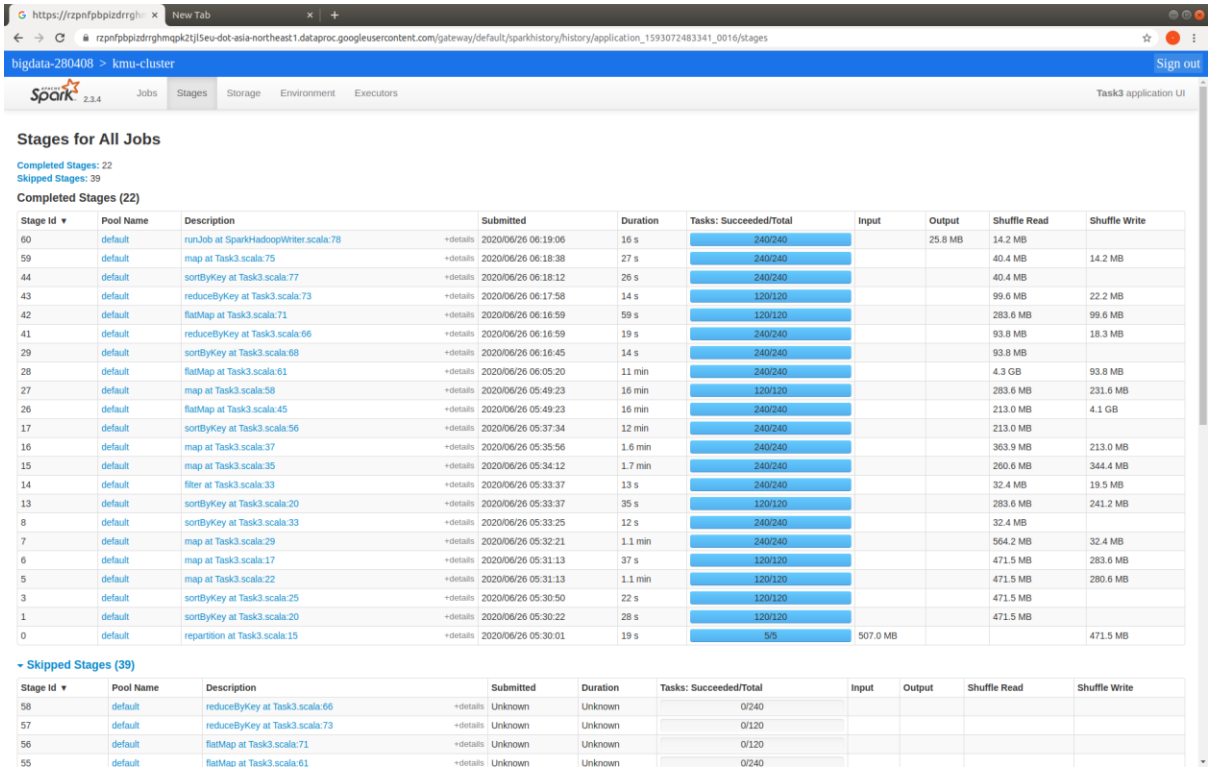
<그림 51> ~ <그림 55>는 Task3 가 종료되고 WebUI 를 통해 확인한 그림이다.



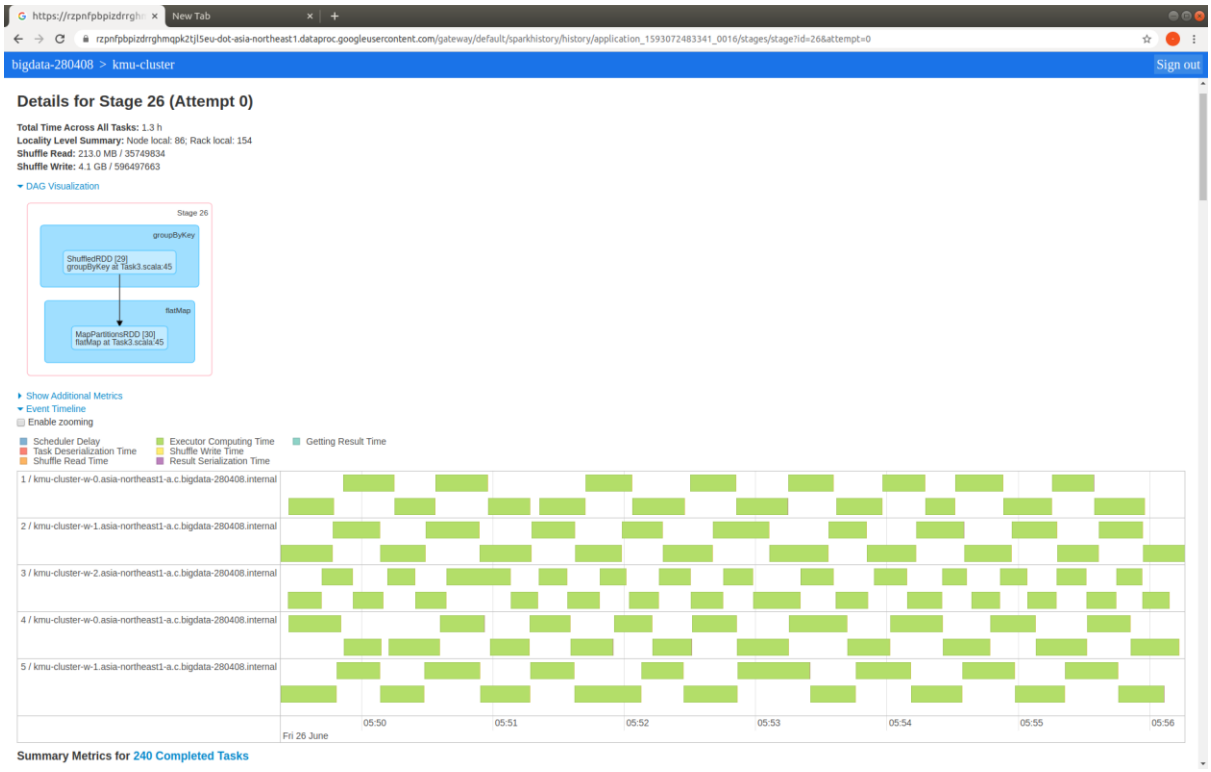

**<그림 51>**



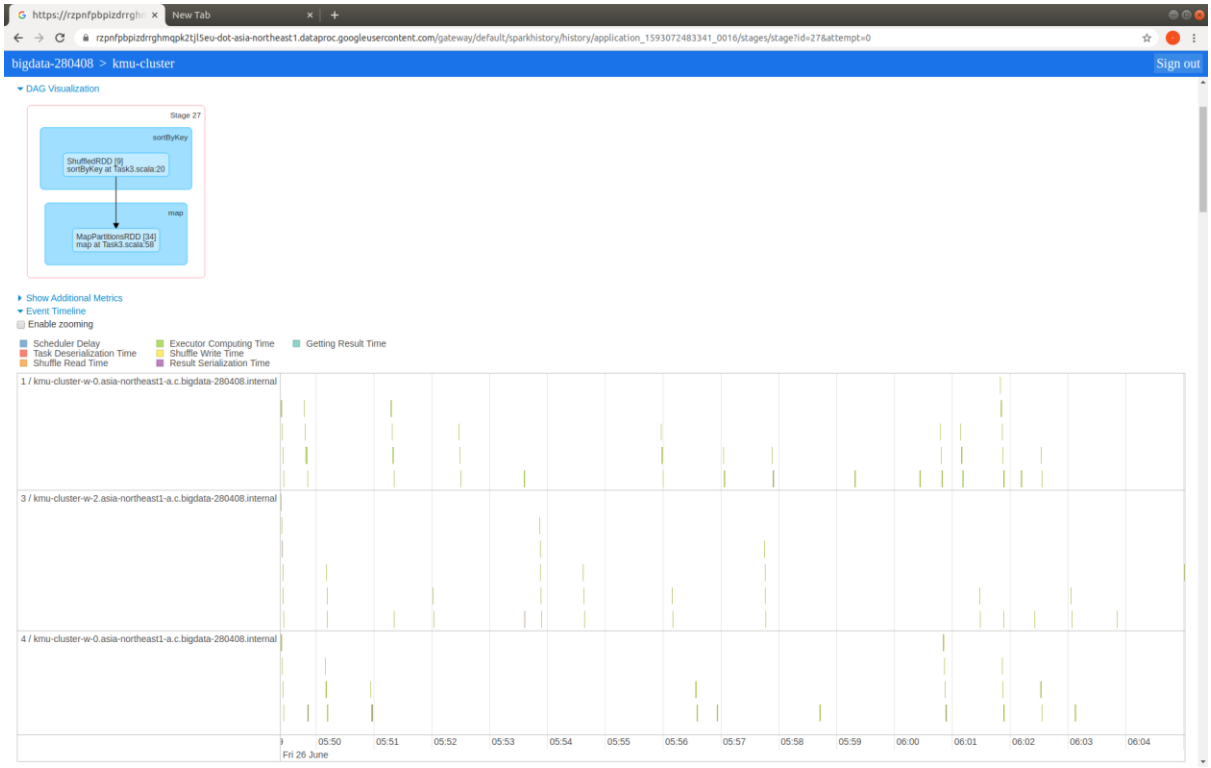

**<그림 52>**


https://rzpnfpbpizdrrghm
New Tab
rzpnfpbpizdrrghmqpk2tjl5eu-dot-asia-northeast1.dataproc.googleusercontent.com/gateway/default/sparkhistory/history/application_1593072483341_0016/stages
bigdata-280408 > kmu-cluster
Sign out
Spark 2.3.4
Jobs
Stages
Storage
Environment
Executors
Task3 application UI
Stages for All Jobs
Completed Stages: 22
Skipped Stages: 39
Completed Stages (22)
Stage Id ▼ | Pool Name | Description | Submitted | Duration | Tasks: Succeeded/Total | Input | Output | Shuffle Read | Shuffle Write
60 | default | runJob at SparkHadoopWriter.scala:78 +details | 2020/06/26 06:19:06 | 16 s | 240/240 | | 25.8 MB | 14.2 MB |
59 | default | map at Task3.scala:75 +details | 2020/06/26 06:18:38 | 27 s | 240/240 | | | 40.4 MB | 14.2 MB
44 | default | sortByKey at Task3.scala:77 +details | 2020/06/26 06:18:12 | 26 s | 240/240 | | | 40.4 MB |
43 | default | reduceByKey at Task3.scala:73 +details | 2020/06/26 06:17:58 | 14 s | 120/120 | | | 99.6 MB | 22.2 MB
42 | default | flatMap at Task3.scala:71 +details | 2020/06/26 06:16:59 | 59 s | 120/120 | | | 283.6 MB | 99.6 MB
41 | default | reduceByKey at Task3.scala:66 +details | 2020/06/26 06:16:59 | 19 s | 240/240 | | | 93.8 MB | 18.3 MB
29 | default | sortByKey at Task3.scala:68 +details | 2020/06/26 06:16:45 | 14 s | 240/240 | | | 93.8 MB |
28 | default | flatMap at Task3.scala:61 +details | 2020/06/26 06:05:20 | 11 min | 240/240 | | | 4.3 GB | 93.8 MB
27 | default | map at Task3.scala:58 +details | 2020/06/26 05:49:23 | 16 min | 120/120 | | | 283.6 MB | 231.6 MB
26 | default | flatMap at Task3.scala:45 +details | 2020/06/26 05:49:23 | 16 min | 240/240 | | | 213.0 MB | 4.1 GB
17 | default | sortByKey at Task3.scala:56 +details | 2020/06/26 05:37:34 | 12 min | 240/240 | | | 213.0 MB |
16 | default | map at Task3.scala:37 +details | 2020/06/26 05:35:56 | 1.6 min | 240/240 | | | 363.9 MB | 213.0 MB
15 | default | map at Task3.scala:35 +details | 2020/06/26 05:34:12 | 1.7 min | 240/240 | | | 260.6 MB | 344.4 MB
14 | default | filter at Task3.scala:33 +details | 2020/06/26 05:33:37 | 13 s | 240/240 | | | 32.4 MB | 19.5 MB
13 | default | sortByKey at Task3.scala:20 +details | 2020/06/26 05:33:37 | 35 s | 120/120 | | | 283.6 MB | 241.2 MB
8 | default | sortByKey at Task3.scala:33 +details | 2020/06/26 05:33:25 | 12 s | 240/240 | | | 32.4 MB |
7 | default | map at Task3.scala:29 +details | 2020/06/26 05:32:21 | 1.1 min | 240/240 | | | 564.2 MB | 32.4 MB
6 | default | map at Task3.scala:17 +details | 2020/06/26 05:31:13 | 37 s | 120/120 | | | 471.5 MB | 283.6 MB
5 | default | map at Task3.scala:22 +details | 2020/06/26 05:31:13 | 1.1 min | 120/120 | | | 471.5 MB | 280.6 MB
3 | default | sortByKey at Task3.scala:25 +details | 2020/06/26 05:30:50 | 22 s | 120/120 | | | 471.5 MB |
1 | default | sortByKey at Task3.scala:20 +details | 2020/06/26 05:30:22 | 28 s | 120/120 | | | 471.5 MB |
0 | default | repartition at Task3.scala:15 +details | 2020/06/26 05:30:01 | 19 s | 5/5 | 507.0 MB | | | 471.5 MB
Skipped Stages (39)
Stage Id ▼ | Pool Name | Description | Submitted | Duration | Tasks: Succeeded/Total | Input | Output | Shuffle Read | Shuffle Write
58 | default | reduceByKey at Task3.scala:66 +details | Unknown | Unknown | 0/240
57 | default | reduceByKey at Task3.scala:73 +details | Unknown | Unknown | 0/120
56 | default | flatMap at Task3.scala:71 +details | Unknown | Unknown | 0/120
55 | default | flatMap at Task3.scala:61 +details | Unknown | Unknown | 0/240

<그림 53>


https://rzpnfpbpizdrrghm
New Tab
rzpnfpbpizdrrghmqpk2tjl5eu-dot-asia-northeast1.dataproc.googleusercontent.com/gateway/default/sparkhistory/history/application_1593072483341_0016/stages/stage?id=26&attempt=0
bigdata-280408 > kmu-cluster
Sign out
Details for Stage 26 (Attempt 0)
Total Time Across All Tasks: 1.3 h
Locality Level Summary: Node local: 86; Rack local: 154
Shuffle Read: 213.0 MB / 35749834
Shuffle Write: 4.1 GB / 596497663
DAG Visualization
Stage 26
groupByKey
ShuffledRDD [29]
groupByKey at Task3.scala:45
flatMap
MapPartitionsRDD [30]
flatMap at Task3.scala:45
Show Additional Metrics
Event Timeline
Enable zooming
Scheduler Delay
Task Deserialization Time
Shuffle Read Time
Executor Computing Time
Shuffle Write Time
Result Serialization Time
Getting Result Time
1 / kmu-cluster-w-0.asia-northeast1-a.c.bigdata-280408.internal
2 / kmu-cluster-w-1.asia-northeast1-a.c.bigdata-280408.internal
3 / kmu-cluster-w-2.asia-northeast1-a.c.bigdata-280408.internal
4 / kmu-cluster-w-0.asia-northeast1-a.c.bigdata-280408.internal
5 / kmu-cluster-w-1.asia-northeast1-a.c.bigdata-280408.internal
05:50
05:51
05:52
05:53
05:54
05:55
05:56
Fri 26 June
Summary Metrics for 240 Completed Tasks

<그림 54>




**<그림 55>**

<그림 56>은 Task3 가 종료된 것을 터미널을 통해 확인한 그림이다.

```
File  Edit  View  Search  Terminal  Help
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 04:55 task1Outputs
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs
kkoma2623@kmu-cluster-m:~$ spark-submit --num-executors 12 --class bigdata.Task3 bd_spark.jar task1Outpu
ts/* task3Outputs
20/06/26 05:29:51 INFO org.spark_project.jetty.util.log: Logging initialized @2512ms
20/06/26 05:29:51 INFO org.spark_project.jetty.server.Server: jetty-9.3.z-SNAPSHOT, build timestamp: unk
nown, git hash: unknown
20/06/26 05:29:51 INFO org.spark_project.jetty.server.Server: Started @2588ms
20/06/26 05:29:51 INFO org.spark_project.jetty.server.AbstractConnector: Started ServerConnector@5426b0d
6{HTTP/1.1,[http/1.1]}{0.0.0.0:4040}
20/06/26 05:29:51 WARN org.apache.spark.scheduler.FairSchedulableBuilder: Fair Scheduler configuration f
ile not found so jobs will be scheduled in FIFO order. To use fair scheduling, configure pools in fairsc
heduler.xml or set spark.scheduler.allocation.file to a file that contains the configuration.
20/06/26 05:29:52 INFO org.apache.hadoop.yarn.client.RMProxy: Connecting to ResourceManager at kmu-clust
er-m/10.146.0.9:8032
20/06/26 05:29:53 INFO org.apache.hadoop.yarn.client.AHSProxy: Connecting to Application History server
at kmu-cluster-m/10.146.0.9:10200
20/06/26 05:29:55 INFO org.apache.hadoop.yarn.client.api.impl.YarnClientImpl: Submitted application appl
ication_1593072483341_0016
20/06/26 05:30:01 INFO org.apache.hadoop.mapred.FileInputFormat: Total input files to process : 5
20/06/26 06:19:21 INFO org.spark_project.jetty.server.AbstractConnector: Stopped Spark@5426b0d6{HTTP/1.1
,[http/1.1]}{0.0.0.0:4040}
kkoma2623@kmu-cluster-m:~$
```

**<그림 56>**

hdfs dfs –ls 명령어를 통해 출력 경로로 설정해준 곳에 출력 파일이 생성된 것을 확인하였다. hdfs dfs -ls task3Outputs 명령어를 통해 task3Outputs 디렉터리에 출력 파일들이 생성된 것을 확인해보았다.

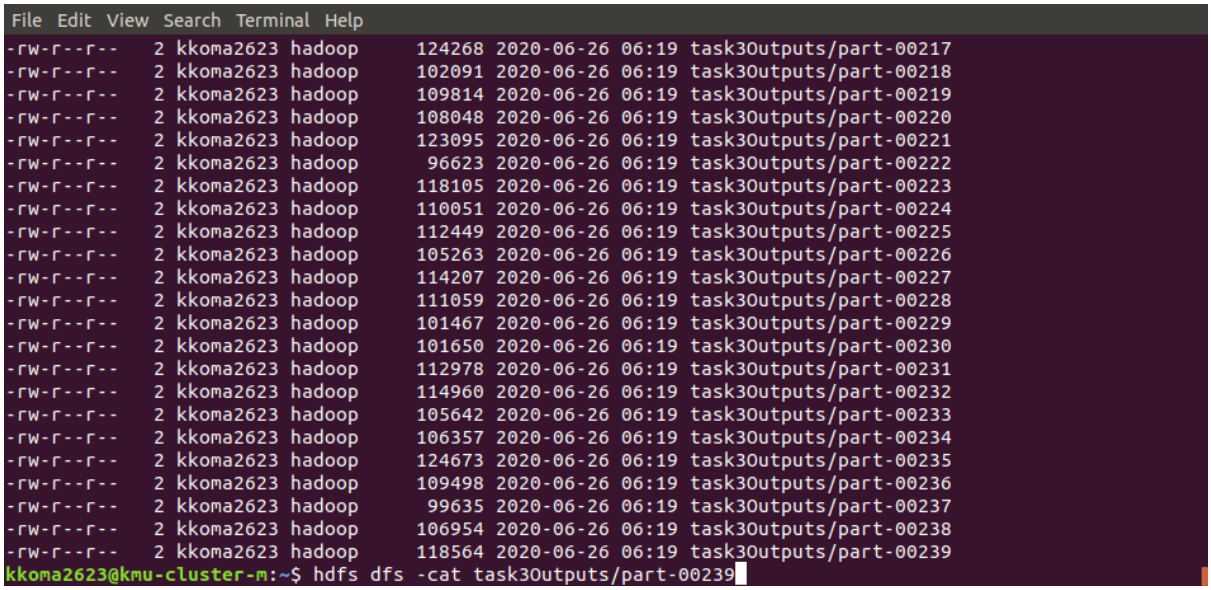
```
File  Edit  View  Search  Terminal  Help
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls
Found 7 items
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 06:19 .sparkStaging
-rw-r--r--   2 kkoma2623 hadoop       8031 2020-06-26 04:43 bd_hadoop.jar
-rw-r--r--   2 kkoma2623 hadoop      29497 2020-06-26 05:27 bd_spark.jar
-rw-r--r--   2 kkoma2623 hadoop  854597439 2020-06-26 04:39 soc-LiveJournal1.txt
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 04:55 task1Outputs
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 05:17 task2Outputs
drwxr-xr-x   - kkoma2623 hadoop          0 2020-06-26 06:19 task3Outputs
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls task3Outputs
Found 241 items
-rw-r--r--   2 kkoma2623 hadoop          0 2020-06-26 06:19 task3Outputs/_SUCCESS
-rw-r--r--   2 kkoma2623 hadoop      92994 2020-06-26 06:19 task3Outputs/part-00000
-rw-r--r--   2 kkoma2623 hadoop      95125 2020-06-26 06:19 task3Outputs/part-00001
-rw-r--r--   2 kkoma2623 hadoop     103451 2020-06-26 06:19 task3Outputs/part-00002
-rw-r--r--   2 kkoma2623 hadoop     101313 2020-06-26 06:19 task3Outputs/part-00003
-rw-r--r--   2 kkoma2623 hadoop      99283 2020-06-26 06:19 task3Outputs/part-00004
-rw-r--r--   2 kkoma2623 hadoop     109561 2020-06-26 06:19 task3Outputs/part-00005
-rw-r--r--   2 kkoma2623 hadoop      97421 2020-06-26 06:19 task3Outputs/part-00006
-rw-r--r--   2 kkoma2623 hadoop     100612 2020-06-26 06:19 task3Outputs/part-00007
-rw-r--r--   2 kkoma2623 hadoop     102194 2020-06-26 06:19 task3Outputs/part-00008
-rw-r--r--   2 kkoma2623 hadoop     122543 2020-06-26 06:19 task3Outputs/part-00009
-rw-r--r--   2 kkoma2623 hadoop     112342 2020-06-26 06:19 task3Outputs/part-00010
-rw-r--r--   2 kkoma2623 hadoop     109817 2020-06-26 06:19 task3Outputs/part-00011
```

**<그림 57>**

```
File  Edit  View  Search  Terminal  Help
-rw-r--r--   2 kkoma2623 hadoop     124268 2020-06-26 06:19 task3Outputs/part-00217
-rw-r--r--   2 kkoma2623 hadoop     102091 2020-06-26 06:19 task3Outputs/part-00218
-rw-r--r--   2 kkoma2623 hadoop     109814 2020-06-26 06:19 task3Outputs/part-00219
-rw-r--r--   2 kkoma2623 hadoop     108048 2020-06-26 06:19 task3Outputs/part-00220
-rw-r--r--   2 kkoma2623 hadoop     123095 2020-06-26 06:19 task3Outputs/part-00221
-rw-r--r--   2 kkoma2623 hadoop      96623 2020-06-26 06:19 task3Outputs/part-00222
-rw-r--r--   2 kkoma2623 hadoop     118105 2020-06-26 06:19 task3Outputs/part-00223
-rw-r--r--   2 kkoma2623 hadoop     110051 2020-06-26 06:19 task3Outputs/part-00224
-rw-r--r--   2 kkoma2623 hadoop     112449 2020-06-26 06:19 task3Outputs/part-00225
-rw-r--r--   2 kkoma2623 hadoop     105263 2020-06-26 06:19 task3Outputs/part-00226
-rw-r--r--   2 kkoma2623 hadoop     114207 2020-06-26 06:19 task3Outputs/part-00227
-rw-r--r--   2 kkoma2623 hadoop     111059 2020-06-26 06:19 task3Outputs/part-00228
-rw-r--r--   2 kkoma2623 hadoop     101467 2020-06-26 06:19 task3Outputs/part-00229
-rw-r--r--   2 kkoma2623 hadoop     101650 2020-06-26 06:19 task3Outputs/part-00230
-rw-r--r--   2 kkoma2623 hadoop     112978 2020-06-26 06:19 task3Outputs/part-00231
-rw-r--r--   2 kkoma2623 hadoop     114960 2020-06-26 06:19 task3Outputs/part-00232
-rw-r--r--   2 kkoma2623 hadoop     105642 2020-06-26 06:19 task3Outputs/part-00233
-rw-r--r--   2 kkoma2623 hadoop     106357 2020-06-26 06:19 task3Outputs/part-00234
-rw-r--r--   2 kkoma2623 hadoop     124673 2020-06-26 06:19 task3Outputs/part-00235
-rw-r--r--   2 kkoma2623 hadoop     109498 2020-06-26 06:19 task3Outputs/part-00236
-rw-r--r--   2 kkoma2623 hadoop      99635 2020-06-26 06:19 task3Outputs/part-00237
-rw-r--r--   2 kkoma2623 hadoop     106954 2020-06-26 06:19 task3Outputs/part-00238
-rw-r--r--   2 kkoma2623 hadoop     118564 2020-06-26 06:19 task3Outputs/part-00239
kkoma2623@kmu-cluster-m:~$
```

**<그림 58>**

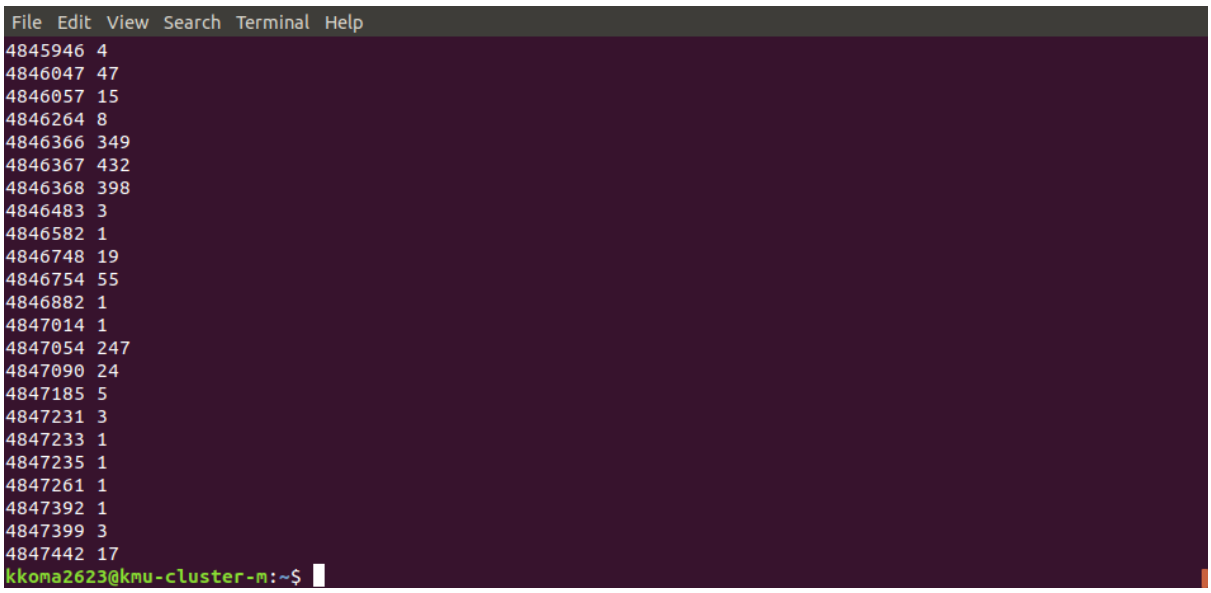
hdfs dfs -cat task3Outputs/part-00239 명령어를 통해 출력 파일의 일부를 확인해보겠다.




**<그림 59>**

빠르게 출력이 되어서 따로 keyboard interrupt 를 주지 않았다.

<그림 60>은 출력 화면이다.



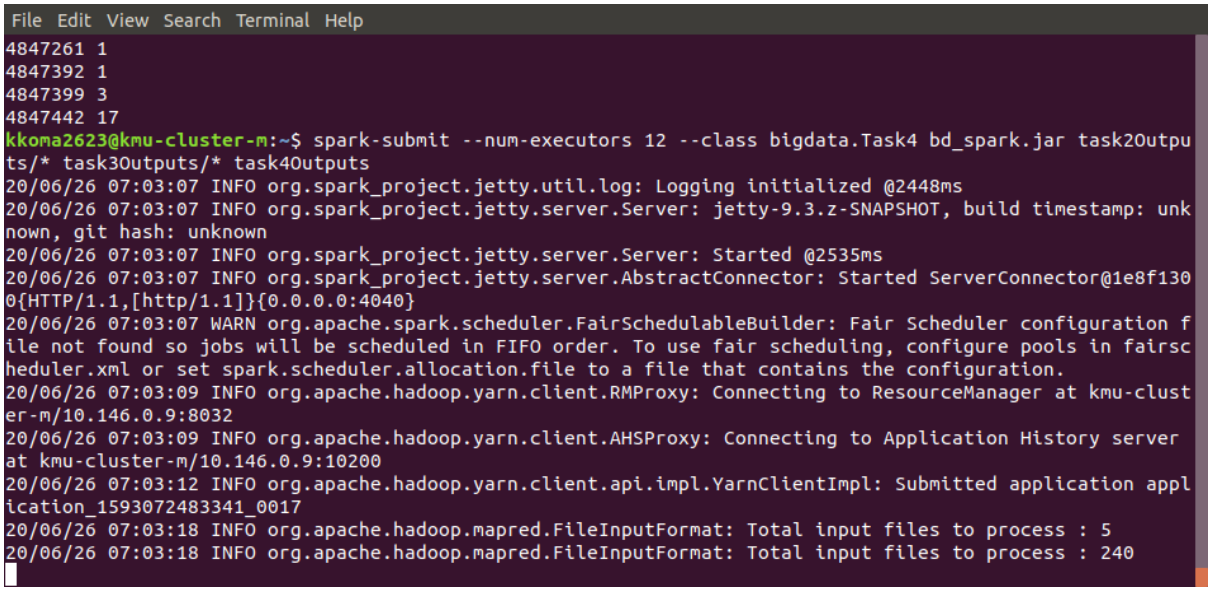

**<그림 60>**

spark-submit –num-executors 12 –class bigdata.Task4 bd_spark.jar task2Outputs/* task3Outputs/* task4Outputs 명령어를 통해 bigdata 패키지의 Task4 를 실행하겠다.

--num-executoers 12 옵션을 통해 executors 를 12 로 설정하였다.

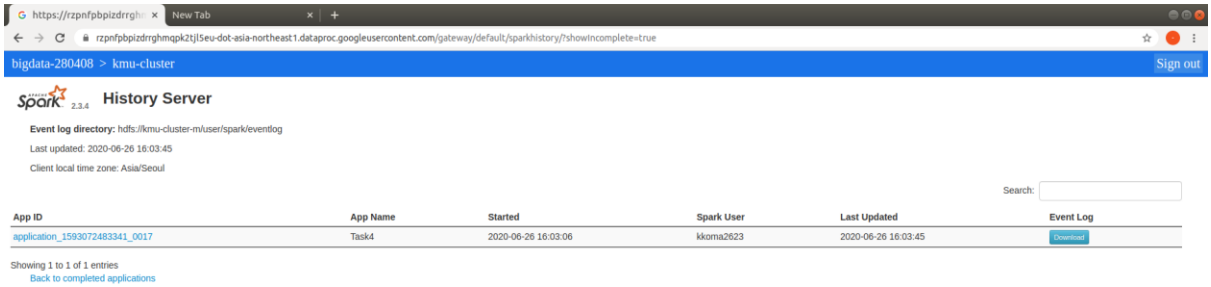
args[0]와 args[1]에 입력파일 경로를, args[2]에 출력 파일 경로를 설정해주었다.

입력 파일 경로는 task2Outputs/* 와 task3Outputs/* 이고 출력 파일 경로는 task4Outputs 이다.




**<그림 61>**

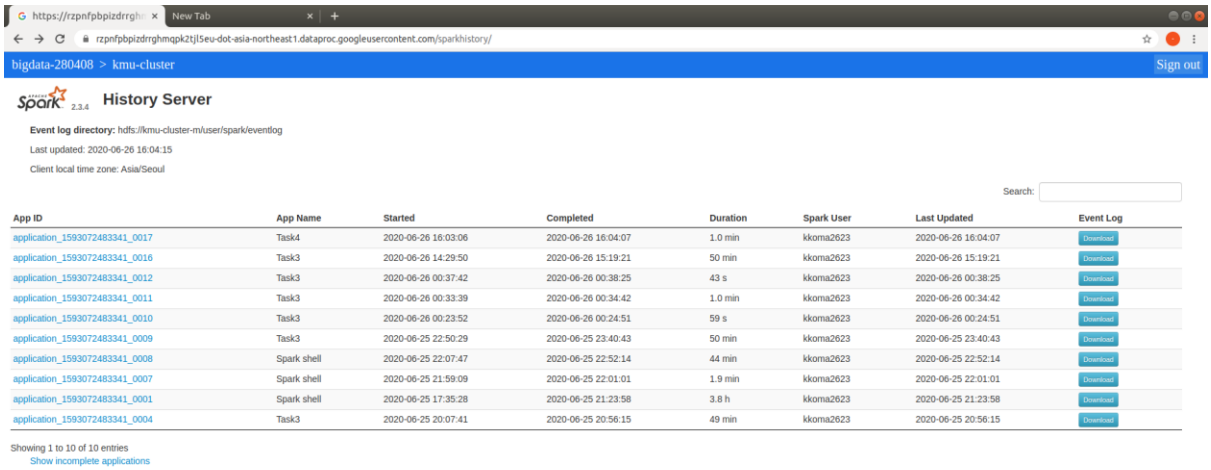
Task4 를 실행중인 것을 WebUI 를 통해 확인하였다.



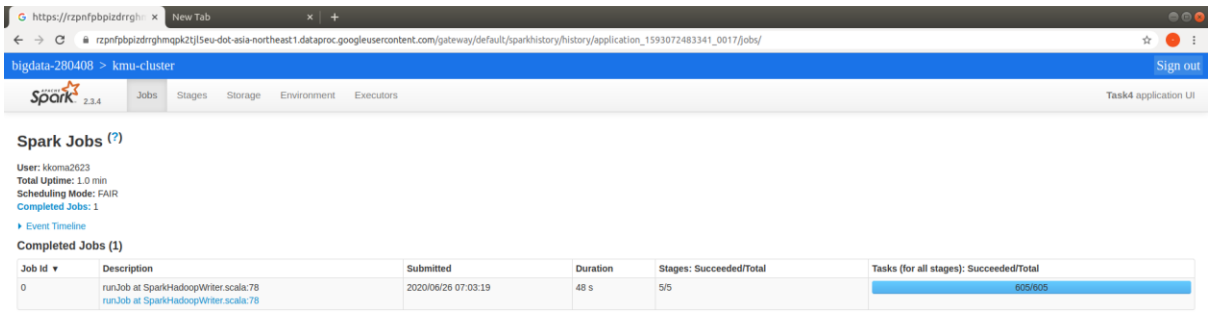

**<그림 62>**

너무 빠르게 끝나서 실행중인 화면은 한 장 밖에 캡처하지 못했다.

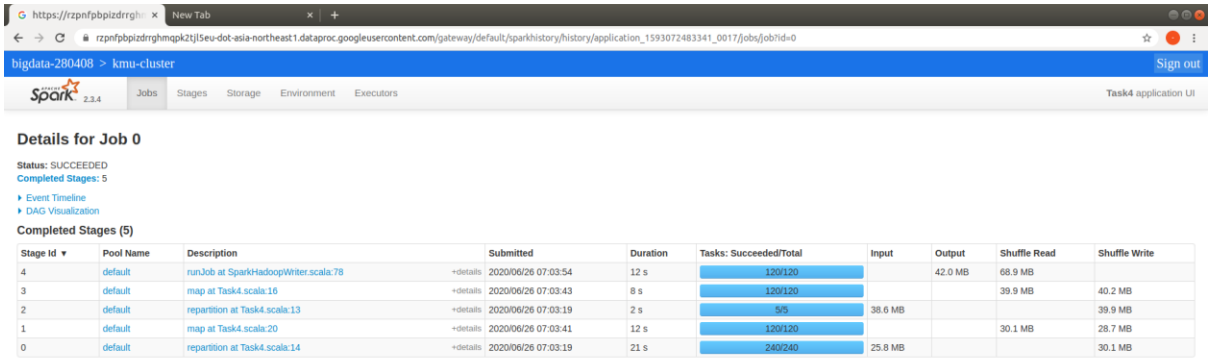
다음은 실행이 종료된 후 캡처한 WebUI 그림들이다.



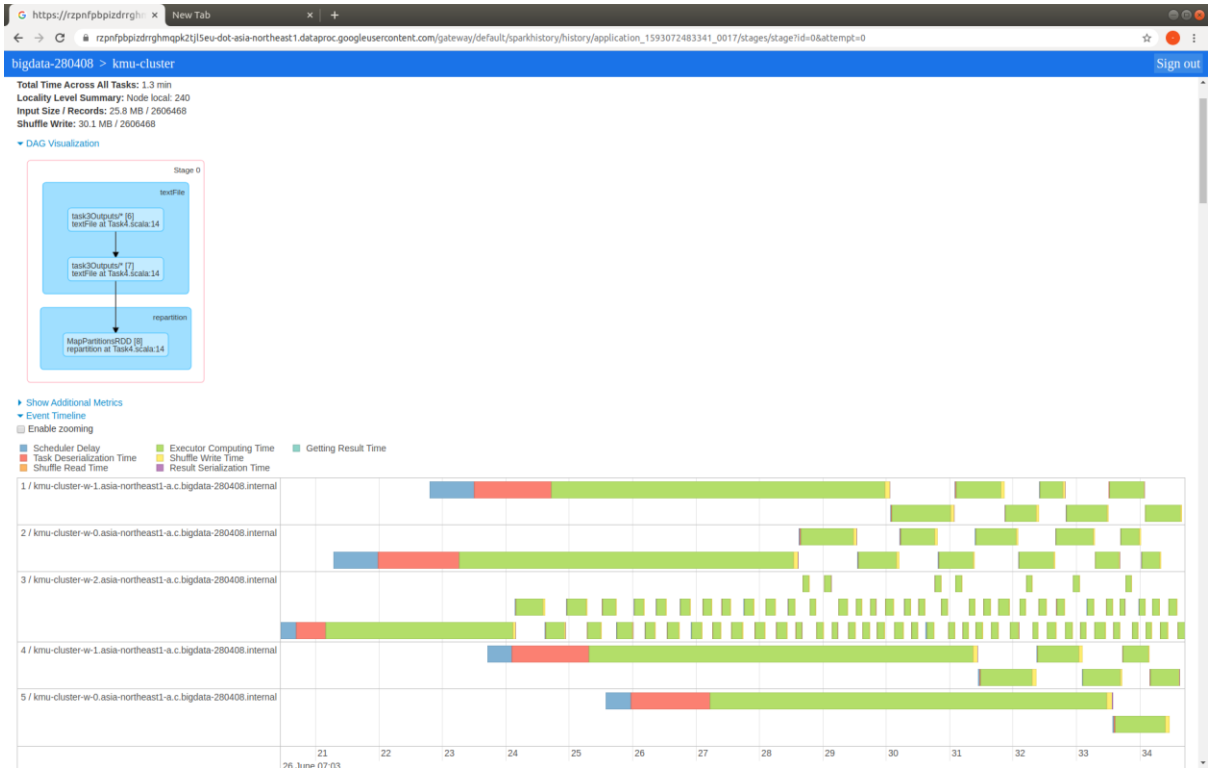

**<그림 63>**




**<그림 64>**


bigdata-280408 > kmu-cluster
Sign out
Jobs
Stages
Storage
Environment
Executors
Task4 application UI
Details for Job 0
Status: SUCCEEDED
Completed Stages: 5
Event Timeline
DAG Visualization
Completed Stages (5)
Stage Id
Pool Name
Description
Submitted
Duration
Tasks: Succeeded/Total
Input
Output
Shuffle Read
Shuffle Write
4 default runJob at SparkHadoopWriter.scala:78 2020/06/26 07:03:54 12 s 120/120 42.0 MB 68.9 MB
3 default map at Task4.scala:16 2020/06/26 07:03:43 8 s 120/120 39.9 MB 40.2 MB
2 default repartition at Task4.scala:13 2020/06/26 07:03:19 2 s 5/5 38.6 MB 39.9 MB
1 default map at Task4.scala:20 2020/06/26 07:03:41 12 s 120/120 30.1 MB 28.7 MB
0 default repartition at Task4.scala:14 2020/06/26 07:03:19 21 s 240/240 25.8 MB 30.1 MB

<그림 65>


bigdata-280408 > kmu-cluster
Sign out
Total Time Across All Tasks: 1.3 min
Locality Level Summary: Node local: 240
Input Size / Records: 25.8 MB / 2606468
Shuffle Write: 30.1 MB / 2606468
DAG Visualization
Stage 0
textFile
task3Outputs* [6]
textFile at Task4.scala:14
task3Outputs* [7]
textFile at Task4.scala:14
repartition
MapPartitionsRDD [8]
repartition at Task4.scala:14
Show Additional Metrics
Event Timeline
Enable zooming
Scheduler Delay
Task Deserialization Time
Shuffle Read Time
Executor Computing Time
Shuffle Write Time
Result Serialization Time
Getting Result Time
1 / kmu-cluster-w-1.asia-northeast1-a.c.bigdata-280408.internal
2 / kmu-cluster-w-0.asia-northeast1-a.c.bigdata-280408.internal
3 / kmu-cluster-w-2.asia-northeast1-a.c.bigdata-280408.internal
4 / kmu-cluster-w-1.asia-northeast1-a.c.bigdata-280408.internal
5 / kmu-cluster-w-0.asia-northeast1-a.c.bigdata-280408.internal
21
22
23
24
25
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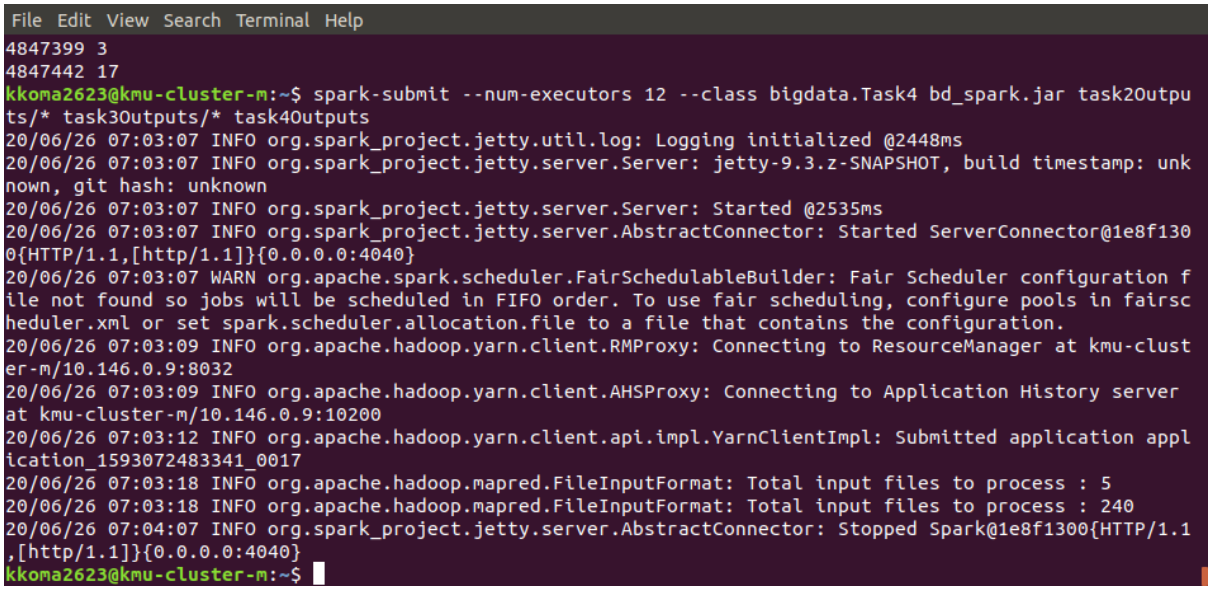
34

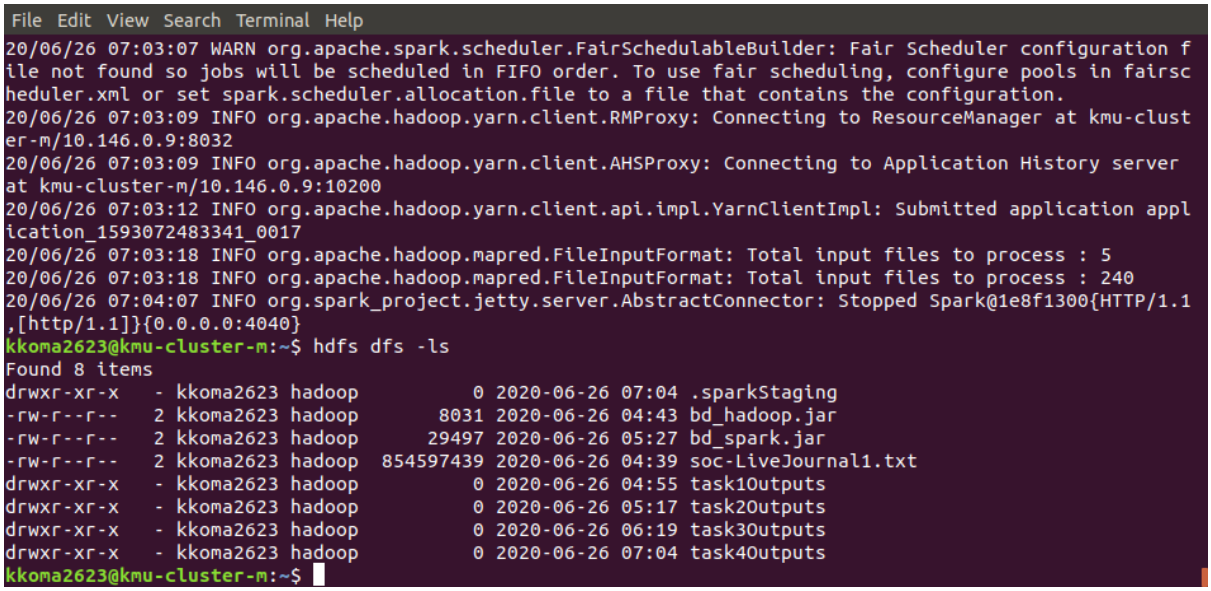
<그림 66>

Task4 가 종료된 것을 터미널을 통해 확인하였다.




**<그림 67>**

hdfs dfs -ls 명령어를 통해 HDFS 에 출력 경로로 설정해둔 곳에 출력물이 생성된 것을 확인하였다.




**<그림 68>**

hdfs dfs -ls task4Outputs 명령어를 통해 task4Outputs 디렉터리 안에 생성된 파일들을 확인하였다.

```
File  Edit  View  Search  Terminal  Help
kkoma2623@kmu-cluster-m:~$ hdfs dfs -ls task4Outputs
Found 121 items
-rw-r--r--   2 kkoma2623 hadoop          0 2020-06-26 07:04 task4Outputs/_SUCCESS
-rw-r--r--   2 kkoma2623 hadoop     250180 2020-06-26 07:03 task4Outputs/part-00000
-rw-r--r--   2 kkoma2623 hadoop     255062 2020-06-26 07:03 task4Outputs/part-00001
-rw-r--r--   2 kkoma2623 hadoop     263255 2020-06-26 07:03 task4Outputs/part-00002
-rw-r--r--   2 kkoma2623 hadoop     276200 2020-06-26 07:03 task4Outputs/part-00003
-rw-r--r--   2 kkoma2623 hadoop     295444 2020-06-26 07:03 task4Outputs/part-00004
-rw-r--r--   2 kkoma2623 hadoop     317981 2020-06-26 07:03 task4Outputs/part-00005
-rw-r--r--   2 kkoma2623 hadoop     340162 2020-06-26 07:03 task4Outputs/part-00006
-rw-r--r--   2 kkoma2623 hadoop     364987 2020-06-26 07:03 task4Outputs/part-00007
-rw-r--r--   2 kkoma2623 hadoop     389062 2020-06-26 07:03 task4Outputs/part-00008
-rw-r--r--   2 kkoma2623 hadoop     414294 2020-06-26 07:03 task4Outputs/part-00009
-rw-r--r--   2 kkoma2623 hadoop     430932 2020-06-26 07:03 task4Outputs/part-00010
-rw-r--r--   2 kkoma2623 hadoop     454135 2020-06-26 07:03 task4Outputs/part-00011
-rw-r--r--   2 kkoma2623 hadoop     467936 2020-06-26 07:03 task4Outputs/part-00012
-rw-r--r--   2 kkoma2623 hadoop     476632 2020-06-26 07:03 task4Outputs/part-00013
-rw-r--r--   2 kkoma2623 hadoop     479917 2020-06-26 07:03 task4Outputs/part-00014
-rw-r--r--   2 kkoma2623 hadoop     479048 2020-06-26 07:03 task4Outputs/part-00015
-rw-r--r--   2 kkoma2623 hadoop     477882 2020-06-26 07:03 task4Outputs/part-00016
-rw-r--r--   2 kkoma2623 hadoop     467654 2020-06-26 07:03 task4Outputs/part-00017
-rw-r--r--   2 kkoma2623 hadoop     452827 2020-06-26 07:03 task4Outputs/part-00018
-rw-r--r--   2 kkoma2623 hadoop     436770 2020-06-26 07:03 task4Outputs/part-00019
-rw-r--r--   2 kkoma2623 hadoop     418311 2020-06-26 07:03 task4Outputs/part-00020
```

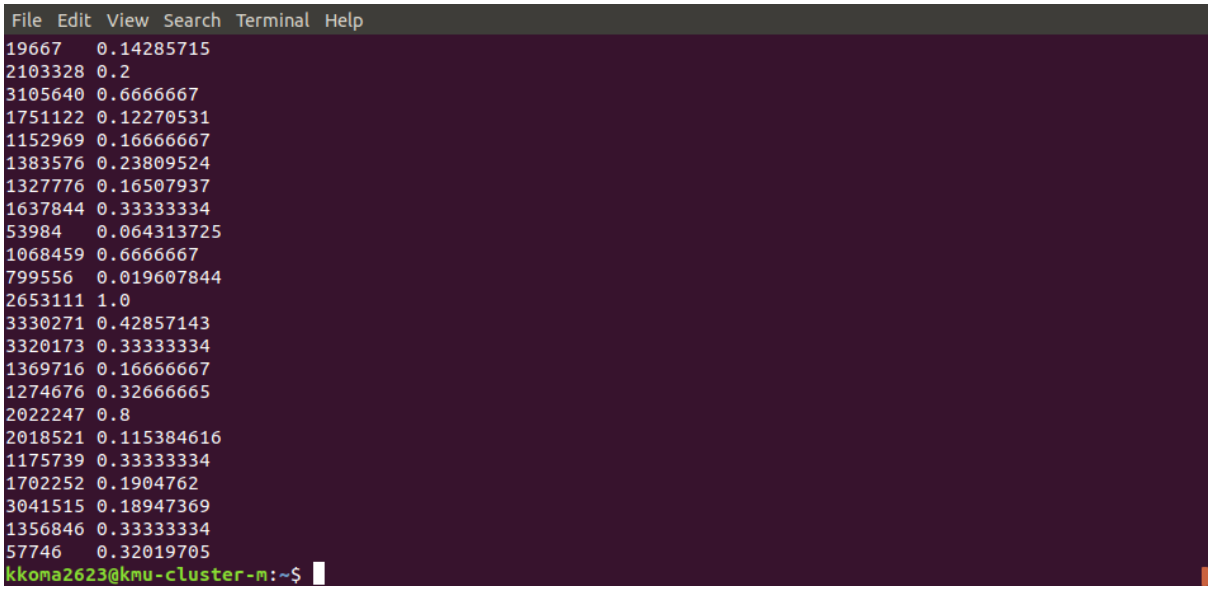
**<그림 69>**

hdfs dfs -cat task4Outputs/part-00119 명령어를 통해 생성된 파일의 일부를 출력해보겠다.

```
File  Edit  View  Search  Terminal  Help
-rw-r--r--   2 kkoma2623 hadoop     366691 2020-06-26 07:04 task4Outputs/part-00097
-rw-r--r--   2 kkoma2623 hadoop     391463 2020-06-26 07:04 task4Outputs/part-00098
-rw-r--r--   2 kkoma2623 hadoop     412455 2020-06-26 07:04 task4Outputs/part-00099
-rw-r--r--   2 kkoma2623 hadoop     436719 2020-06-26 07:04 task4Outputs/part-00100
-rw-r--r--   2 kkoma2623 hadoop     454333 2020-06-26 07:04 task4Outputs/part-00101
-rw-r--r--   2 kkoma2623 hadoop     467401 2020-06-26 07:04 task4Outputs/part-00102
-rw-r--r--   2 kkoma2623 hadoop     477678 2020-06-26 07:04 task4Outputs/part-00103
-rw-r--r--   2 kkoma2623 hadoop     481295 2020-06-26 07:04 task4Outputs/part-00104
-rw-r--r--   2 kkoma2623 hadoop     483020 2020-06-26 07:04 task4Outputs/part-00105
-rw-r--r--   2 kkoma2623 hadoop     475454 2020-06-26 07:04 task4Outputs/part-00106
-rw-r--r--   2 kkoma2623 hadoop     468157 2020-06-26 07:04 task4Outputs/part-00107
-rw-r--r--   2 kkoma2623 hadoop     454504 2020-06-26 07:04 task4Outputs/part-00108
-rw-r--r--   2 kkoma2623 hadoop     436942 2020-06-26 07:04 task4Outputs/part-00109
-rw-r--r--   2 kkoma2623 hadoop     416001 2020-06-26 07:04 task4Outputs/part-00110
-rw-r--r--   2 kkoma2623 hadoop     392413 2020-06-26 07:04 task4Outputs/part-00111
-rw-r--r--   2 kkoma2623 hadoop     370410 2020-06-26 07:04 task4Outputs/part-00112
-rw-r--r--   2 kkoma2623 hadoop     348643 2020-06-26 07:04 task4Outputs/part-00113
-rw-r--r--   2 kkoma2623 hadoop     325910 2020-06-26 07:04 task4Outputs/part-00114
-rw-r--r--   2 kkoma2623 hadoop     302232 2020-06-26 07:04 task4Outputs/part-00115
-rw-r--r--   2 kkoma2623 hadoop     284832 2020-06-26 07:04 task4Outputs/part-00116
-rw-r--r--   2 kkoma2623 hadoop     270725 2020-06-26 07:04 task4Outputs/part-00117
-rw-r--r--   2 kkoma2623 hadoop     258821 2020-06-26 07:04 task4Outputs/part-00118
-rw-r--r--   2 kkoma2623 hadoop     252666 2020-06-26 07:04 task4Outputs/part-00119
kkoma2623@kmu-cluster-m:~$ hdfs dfs -cat task4Outputs/part-00119
```

**<그림 70>**

다음과 같이 출력이 되는 것을 확인할 수 있다.




**<그림 71>**