Spark og HDFS

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Lese/skrive CSV/PARQUET filer

Før vi kan begynne å lage aggregeringer, må vi gjøre datasettene om til Parquet filer. Det er alltid lurt å gjøre om til Parquet først, siden de tilbyr komprimering.

Generell Kode for lesing/skriving

```
val myDf = spark.read.option("header","true").csv("student-performance.csv")

myDf.write.format('parquet').option('header','true').mode('overwrite').save('student-performance.parquet')


val PDF = spark.read.option("header","true").parquet("student-performance.parquet")
```

Student Performance Dataset (KV-database)

First aggregation{

```
val result1 = PDF.groupBy("Fedu").agg(expr(" avg(G1) as FirstYear"), expr( " avg(G2) as SecondYear"),expr( " avg(G3) as ThirdYear"))


val result2 = PDF.groupBy("Medu").agg(expr(" avg(G1) as FirstYear"), expr( " avg(G2) as SecondYear"),expr( " avg(G3) as ThirdYear"))


val joined = result1.joinWith(result2, result1("Fedu") === result2("Medu"))


val temp = joined.selectExpr("_1 as Father, "_2 as Mother")


val temp2 = temp.select(col("Father.*"),col("Mother.*"))


val flattenTemp = temp2.toDF("FatherEdu","FFirstYear","FSecondYear","FThirdYear", "MotherEdu","MFirstYear","MSecondYear","MThirdYear")

flattenTemp.write.format("csv").option("header","true").mode("overwrite").save("grades-average.csv")
```

}

Second aggregation {

```
val temp = PDF.groupBy("studytime").agg(expr(" avg(G1) as FirstYear"), expr( " avg(G2) as SecondYear"),expr( " avg(G3) as ThirdYear"))


val setString = udf {(freetime: Integer) => if(freetime == 1) "Very little" else if(freetime == 2) "Little" else if(freetime == 3) "Medium" else if(freetime == 4) "Much" else "Very Much"}

val temp2 = temp.withColumn("freetime", setString(temp("freetime")))


temp2.write.format("csv").option("header","true").mode("overwrite").save("freetime-grades.csv")

}
```

Third aggregation{

```
        val temp = PDF.groupBy("studytime").agg(expr(" avg(G1) as FirstYear"), expr( " avg(G2) as SecondYear"),expr( " avg(G3) as ThirdYear"))


val setString = udf {(studytime: Integer) => if(studytime == 1) "Very little" else if(studytime == 2) "Little" else if( studytime == 3) "Medium" else if( studytime == 4) "Much" else "Very Much"}

val temp2 = temp.withColumn("studytime", setString(temp("studytime")))

temp2.write.format("csv").option("header","true").mode("overwrite").save("studytime-grades.csv")

}
```

Socio-Economic Country Profiles (Dokumentdatabase)

First aggregation{

```
val temp = myDf.select("country", "Population in thousands (2017)", "GDP: Gross domestic product (million current US$)","GDP per capita (current US$)","Unemployment (% of labour force)","Population growth rate (average annual %)","Urban population (% of total population)_x","Urban population growth rate (average annual %)","Health: Total expenditure (% of GDP)","Education: Government expenditure (% of GDP)","Individuals using the Internet (per 100 inhabitants)","Quality Of Life Index","Purchasing Power Index","Safety Index","Health Care Index","Property price to income ratio","Affordability Index","Cost Of Living Index","Cost Of Living Plus Rent Index","Life expectancy at birth, total (years)","Military expenditure (% of GDP)", Tax revenue (% of GDP)")

temp.write.option('header','true').mode('overwrite').parquet('country-profiles-trimmed.parquet')


val customSchema = StructType(Array(StructField("country",StringType, true),

StructField("Population in thousands (2017)", IntegerType, true),

StructField("GDP: Gross domestic product (million current US$)", DoubleType, true),

StructField("GDP per capita (current US$)", DoubleType, true),

StructField("Unemployment (% of labour force)", DoubleType, true),

StructField("Population growth rate (average annual %)", DoubleType, true),

StructField("Urban population (% of total population)_x", DoubleType, true),

StructField("Urban population growth rate (average annual %)", DoubleType, true),

StructField("Health: Total expenditure (% of GDP)", DoubleType, true),

StructField("Education: Government expenditure (% of GDP)", DoubleType, true),

StructField("Individuals using the Internet (per 100 inhabitants)", IntegerType, true),

StructField("Quality Of Life Index", DoubleType, true),

StructField("Purchasing Power Index", DoubleType, true),

StructField("Safety Index", DoubleType, true),

StructField("Health Care Index", DoubleType,true),

StructField("Property price to income ratio", DoubleType,true),

StructField("Affordability Index", DoubleType, true),

StructField("Cost Of Living Index", DoubleType, true),

StructField("Cost Of Living Plus Rent Index", DoubleType, true),

StructField("Life expectancy at birth, total (years)", DoubleType, true),

StructField("Military expenditure (% of GDP)", DoubleType, true),
```

StructField("Tax revenue (% of GDP)", DoubleType,true))

val myDf = spark.read.option("header","true").option('customSchema', 'true').parquet("country-profiles.parquet")

val oldCol = Seq("country", "Population in thousands (2017)", "GDP: Gross domestic product (million current US$)","GDP per capita (current US$)","Unemployment (% of labour force)","Population growth rate (average annual %)","Urban population (% of total population)_x","Urban population growth rate (average annual %)","Health: Total expenditure (% of GDP)","Education: Government expenditure (% of GDP)","Individuals using the Internet (per 100 inhabitants)","Quality Of Life Index","Purchasing Power Index","Safety Index","Health Care Index","Property price to income ratio","Affordability Index","Cost Of Living Index","Cost Of Living Plus Rent Index","Life expectancy at birth, total (years)","Military expenditure (% of GDP)", "Tax revenue (% of GDP)")

val newCol = Seq("country", "population", "gdp", "gdpPerCapita","unemployment", "populationGrowthRate", "urbanPop","urbanPopGrowth", "healthTotal", "educationTotal", "internetUsers", "qualityOfLifeI", "PPI", "safetyI", "HealthI", "propPriceToIncome","affordabilityI", "costI", "costPlusRentI", "lifeExpectancy", "militaryTotal", "taxes")

val list = oldCol.zip(newCol).map(f=>{col(f._1).as(f._2)})

val newDF = myDf.select(list:_*)

newDF.write.format("csv").mode("overwrite").option("header", true).save("country-profiles.csv")

}

Second aggregation {

val thisTemp = PDF.coalesce(1).select(col("country"), expr("(costPlusRentI / 100) * gdp as RealCost ")).sort(desc("RealCost"))

}

World University Rankings (Kolonnefamiliedatabase)

Først leser vi csv filen med «inferSchema» satt til «true» for å opprette schema.

```
scala> val universityDf = spark.read.format("csv").option("header", "true").option("inferSchema", "true").load("datasets/timesData.csv")
universityDf: org.apache.spark.sql.DataFrame = [world_rank: string, university_name: string ... 12 more fields]

scala> universityDf.printSchema()
root
 |-- world_rank: string (nullable = true)
 |-- university_name: string (nullable = true)
 |-- country: string (nullable = true)
 |-- teaching: double (nullable = true)
 |-- international: string (nullable = true)
 |-- research: double (nullable = true)
 |-- citations: double (nullable = true)
 |-- income: string (nullable = true)
 |-- total_score: string (nullable = true)
 |-- num_students: string (nullable = true)
 |-- student_staff_ratio: double (nullable = true)
 |-- international_students: string (nullable = true)
 |-- female_male_ratio: string (nullable = true)
 |-- year: integer (nullable = true)
```

Jeg legger merke til at noen av datatypene ikke stemmer. Jeg ser at «world_rank» er satt til streng, selv om det tilsynelatende er int. Men det går fin, siden den også inneholder verdier som «100-150». Derimot, «international» var satt til streng, fordi null-verdier var byttet ut med bindestrek (-), I tillegg så jeg at «international_students» hadde verdier med tall og %-tegnet. Begge fikset jeg ved å bruke find&replace funksjonen i libreOffice og endre på csv-filen.

Da brukte jeg universityDf.printSchema() igjen for å sjekke at ting stemte, og det gjorde det.

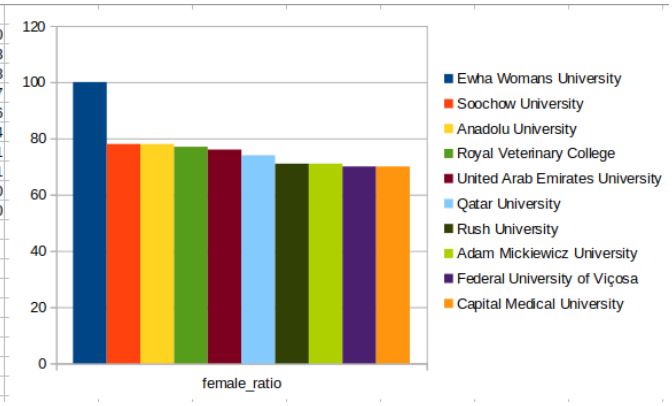
```
scala> universityDf.printSchema()
root
 |-- world_rank: string (nullable = true)

scala> universityDf.write.format("parquet").mode("errorIfExists").save("parquets/university_write.parquet")
 |-- international: string (nullable = true)
 |-- research: double (nullable = true)
 |-- citations: double (nullable = true)
 |-- income: string (nullable = true)
 |-- total_score: string (nullable = true)
 |-- num_students: string (nullable = true)
 |-- student_staff_ratio: double (nullable = true)
 |-- international_students: string (nullable = true)
 |-- female_male_ratio: string (nullable = true)
 |-- year: integer (nullable = true)
```

Det neste er å lagre den som en Parquet fil.

Da er det på tide å skrive aggregeringer. Den første aggregeringen jeg lagde viser de ti skolene med flest kvinnelige studenter.

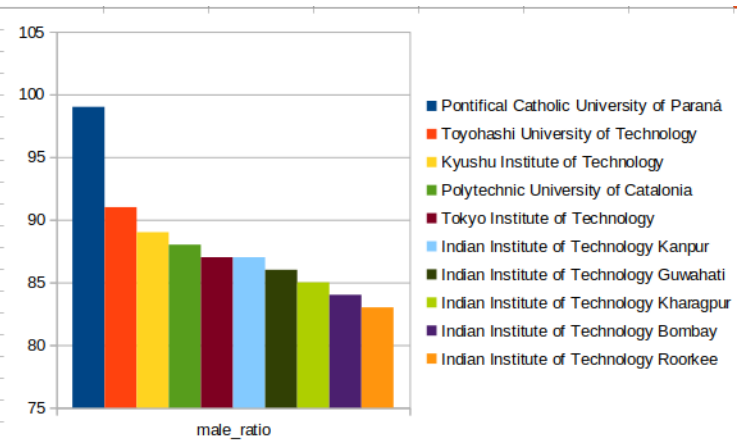
```
scala> val universityByFemaleRatio = universityPDf.select(col("country"), col("university_name"), split(col("female_male_ratio"), " : ").getItem(0).cast("int").as("female_ratio")).distinct().sort(desc_n
lls_last("female_ratio")).limit(10)
universityByFemaleRatio: org.apache.spark.sql.Dataset[org.apache.spark.sql.Row] = [country: string, university_name: string ... 1 more field]

scala> university
universityByFemaleRatio   universityPDf

scala> universityByFemaleRatio.show()
+--------------------+--------------------+------------+
|             country|     university_name|female_ratio|
+--------------------+--------------------+------------+
|         South Korea|Ewha Womans Unive...|         100|
|               China|  Soochow University|          78|
|              Turkey|  Anadolu University|          78|
|      United Kingdom|Royal Veterinary ...|          77|
|United Arab Emirates|United Arab Emira...|          76|
|               Qatar|    Qatar University|          74|
|United States of ...|     Rush University|          71|
|              Poland|Adam Mickiewicz U...|          71|
|              Brazil|Federal Universit...|          70|
|               China|Capital Medical U...|          70|
+--------------------+--------------------+------------+
```

country	university_name	female_ratio
South Korea	Ewha Womans University	100
China	Soochow University	78
Turkey	Anadolu University	78
United Kingdom	Royal Veterinary College	77
United Arab Emirates	United Arab Emirates University	76
Qatar	Qatar University	74
United States of America	Rush University	71
Poland	Adam Mickiewicz University	71
Brazil	Federal University of Viçosa	70
China	Capital Medical University	70



Tilsvarende, lagde jeg en for mannlige studenter også.

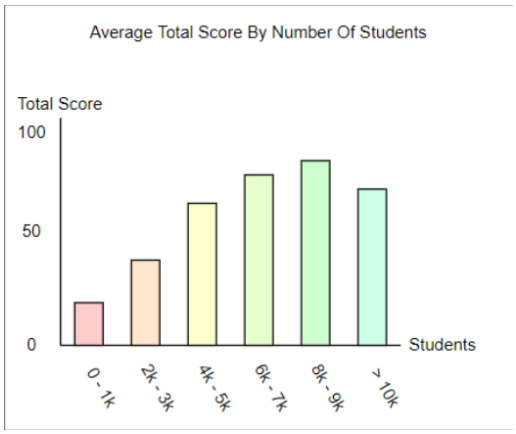
country	university_name	male_ratio
Brazil	Pontifical Catholic University of Paraná	99
Japan	Toyohashi University of Technology	91
Japan	Kyushu Institute of Technology	89
Spain	Polytechnic University of Catalonia	88
Japan	Tokyo Institute of Technology	87
India	Indian Institute of Technology Kanpur	87
India	Indian Institute of Technology Guwahati	86
India	Indian Institute of Technology Kharagpur	85
India	Indian Institute of Technology Bombay	84
India	Indian Institute of Technology Roorkee	83



Så lagret jeg begge aggregeringene som CSV filer med én partisjon hver.

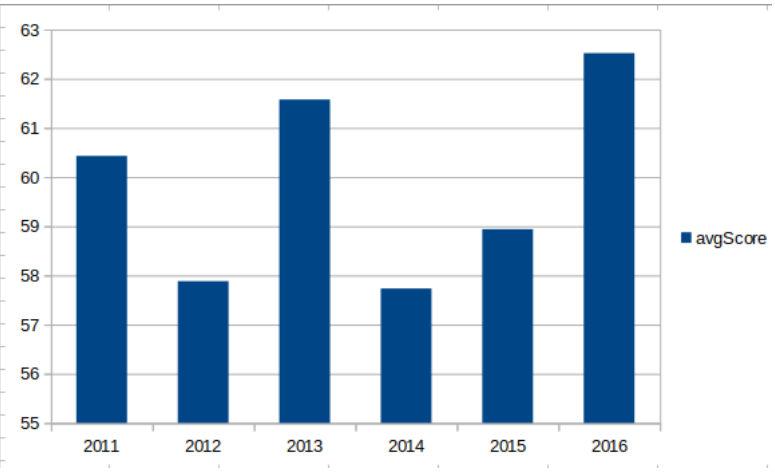
```
scala> universityByFemaleRatio.repartition(1).write.format("csv").option("header", "true").mode("overwrite").save("components/university_by_female_ratio")

scala> universityByMaleRatio.repartition(1).write.format("csv").option("header", "true").mode("overwrite").save("components/university_by_male_ratio")
```

Jeg lagde også en aggregering som viser gjennomsnitts-poeng per år. Denne var, til å begynne med, ment til å representere «Average Total Score by Number Of Students» komponentet fra forrige milepæl:



Her er den nye aggregeringen (Glemte å ta bilde av scala koden):

year	avgScore
2011	60.4295
2012	57.8815
2013	61.576
2014	57.7335
2015	58.9407960199005
2016	62.52



Government Types Of The World (Grafdatabase)

Begynner med å lese csv filene. Merk at i dette datasettet er det 4 forskjellige csv-filer.

```
scala> val leaderDf = spark.read.format("csv").option("header", "true").option("inferSchema", "true").load("datasets/REIGN_dataset/leader_list_6_21.cs
leaderDf: org.apache.spark.sql.DataFrame = [stateabb: string, ccode: int ... 16 more fields]
```

```
scala> val reignDf = spark.read.format("csv").option("header", "true").option("inferSchema", "true").load("datasets/REIGN_dataset/REIGN_2021_6.csv")
reignDf: org.apache.spark.sql.DataFrame = [ccode: double, country: string ... 39 more fields]
```

```
scala> val regimeDf = spark.read.format("csv").option("header", "true").option("inferSchema", "true").load("datasets/REIGN_dataset/regime_list.csv")
regimeDf: org.apache.spark.sql.DataFrame = [cowcode: int, gwf_country: string ... 4 more fields]
```

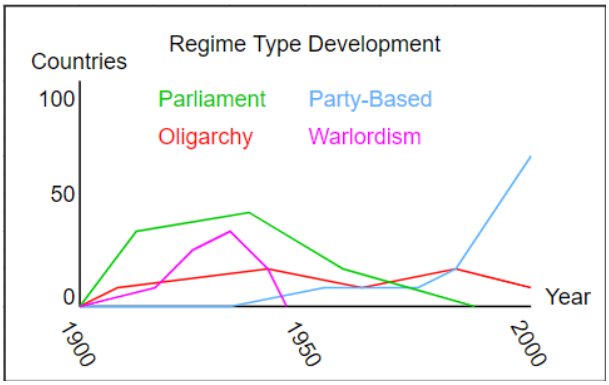
Så skrive de til parquet filer.

```
scala> reignDf.repartition(1).write.format("parquet").mode("overwrite").save("parquets/reign_write.parquet")
```

```
scala> regimeDf.repartition(1).write.format("parquet").option("header", "true").save("parquets/regime_write.parquet"
```

```
scala> electionDf.repartition(1).write.format("parquet").option("header", "true").save("parquets/election_write.parquet"
```

Da er det på tide å skrive aggregeringer. Her lagde jeg kun en aggregering, men til prosjektinnleveringen vil vi bruke de andre også. Aggregeringen viser hvordan hver styremåte har utviklet seg i popularitet gjennom årene. Den opprinnelige skissen fra milepæl 4 ser slik ut:



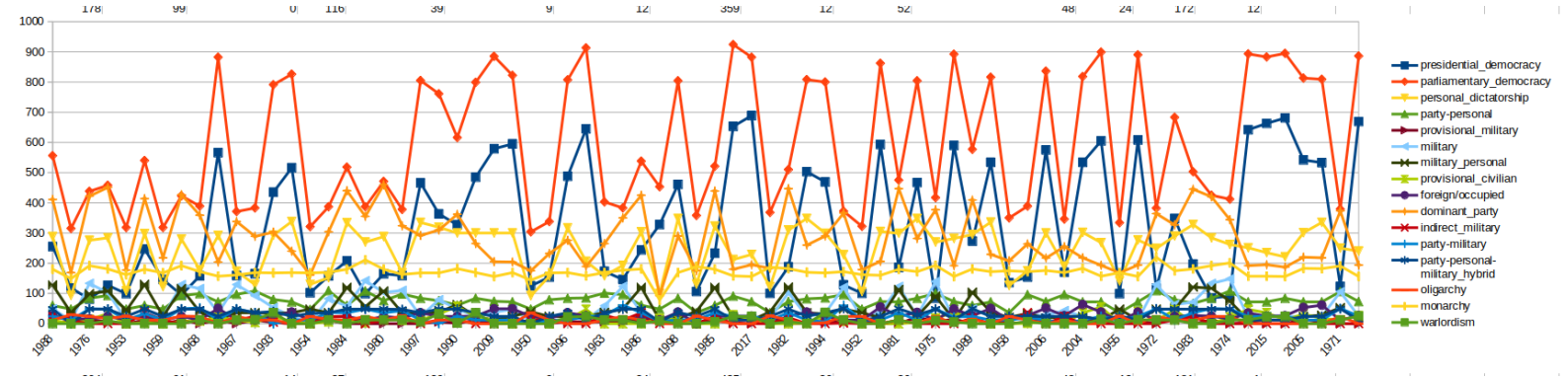
Til å begynne med, tenkte jeg å gruppere først på år, så på styremåte, og dermed telle antall opplistinger.

```
scala> val governmentPopularity = reignPDf.groupBy(col("year"), col("government")).agg(count("*")).as("count").orderBy(asc("year"), asc("government"))
governmentPopularity: org.apache.spark.sql.Dataset[org.apache.spark.sql.Row] = [year: double, government: string ... 1 more field]

scala> governmentPopularity.show(10)
+------+--------------------+--------+
|  year|          government|count(1)|
+------+--------------------+--------+
|1950.0|      Dominant Party|     175|
|1950.0|    Foreign/Occupied|      24|
|1950.0|   Indirect Military|      12|
|1950.0|            Military|       9|
|1950.0|   Military-Personal|      39|
|1950.0|            Monarchy|     144|
|1950.0|           Oligarchy|      36|
|1950.0|Parliamentary Dem...|     304|
|1950.0|      Party-Military|       4|
|1950.0|      Party-Personal|      48|
+------+--------------------+--------+
only showing top 10 rows


scala> governmentPopularity.repartition(1).write.format("csv").option("header", "true").save("components/government_popularity.csv")
```

Men dessverre var ikke dette optimalt for lesing av grafiske programmer (excel, libreoffice). Så jeg bestemte meg for å gjøre om på komponenten. I denne nye versjonen har jeg en kolonne for år, og en kolonne for hver styremåte. Da ble aggregeringen slik:

```
scala> val governmentPopularityByYear = reignPDf.groupBy("year").agg(
     |     count(when(col("government") === "Presidential Democracy", true)).as("presidential_democracy"),
     |     count(when(col("government") === "Parliamentary Democracy", true)).as("parliamentary_democracy"),
     |     count(when(col("government") === "Personal Dictatorship", true)).as("personal_dictatorship"),
     |     count(when(col("government") === "Party-Personal", true)).as("party-personal"),
     |     count(when(col("government") === "Provisional - Military", true)).as("provisional_military"),
     |     count(when(col("government") === "Military", true)).as("military"),
     |     count(when(col("government") === "Military-Personal", true)).as("military_personal"),
     |     count(when(col("government") === "Provisional - Civilian", true)).as("provisional_civilian"),
     |     count(when(col("government") === "Foreign/Occupied", true)).as("foreign/occupied"),
     |     count(when(col("government") === "Dominant Party", true)).as("dominant_party"),
     |     count(when(col("government") === "Indirect Military", true)).as("indirect_military"),
     |     count(when(col("government") === "Party-Military", true)).as("party-military"),
     |     count(when(col("government") === "Party-Personal-Military Hybrid", true)).as("party-personal-military_hybrid"),
     |     count(when(col("government") === "Oligarchy", true)).as("oligarchy"),
     |     count(when(col("government") === "Monarchy", true)).as("monarchy"),
     |     count(when(col("government") === "Warlordism", true)).as("warlordism"),
```

Framstilling i libreoffice:


178
99
0
116
39
9
12
359
12
52
48
24
172
12
1000
900
800
700
600
500
400
300
200
100
0
1988
1976
1953
1959
1968
1967
1993
1954
1984
1980
1997
1990
2009
1950
1996
1963
1986
1998
1985
2017
1982
1994
1952
1981
1975
1989
1958
2005
2004
1955
1972
1983
1974
2015
2005
1971
presidential_democracy
parliamentary_democracy
personal_dictatorship
party-personal
provisional_military
military
military_personal
provisional_civilian
dominant_party
foreign/occupied
indirect_military
party-military
party-personal-military_hybrid
oligarchy
monarchy
warlordism

Endringer på nettsiden

På grunn av endringene i komponentene …

HDFS

Listing/remove

hadoop fs -ls hdfs:/// -rm

Read from HDFS

val PDF = spark.read.option("header","true").option("inferSchema","true").load("hdfs:///country-profiles.parquet")

val PDF = spark.read.option("header","true").parquet("hdfs://localhost:9000/filepath")

(.csv() kommando hvis fil er av type CSV)

Copy from local to HDFS

hadoop fs -copyFromLocal country-profiles.parquet /country-profiles.parquet

hadoop fs -copyFromLocal university_write.parquet /university-write.parquet

hadoop fs -copyFromLocal student-performance.parquet /student-performance.parquet

hadoop fs -copyFromLocal reign_write.parquet /reign-write.parquet

hadoop fs -copyFromLocal regime_write.parquet /regime-write.parquet

hadoop fs -copyFromLocal leader_write.parquet /leader-write.parquet

hadoop fs -copyFromLocal election_write.parquet /election-write.parquet

//-copyToLocal for motsatt

Hva skjer egentlig?

Det første vi gjør er å kopiere de lokale parquet-filene til HDFS, det vil fungere ca slik:

1. ber namenode om å opprette en fil. Namenode vil returnere en liste over noder for å lage replika blokker (første replika er lokalt plassert, andre på en annen rack, tredje på samme rack som replika 2)

    -Bare en replika per node

    -To replika per rack(om det er nok racks)

2. blokkdata skrives da til første node i namenode listen

3. ber namenode å hente ut neste sett med blokklokasjoner, skriv blokken

4. iformerer namenode om at filen er ferdig skrevet og gjør filen tilgjengelig

Nå som det er lagret på noder i HDFS kan vi da hente ut parquet-filene derfra via Spark med read-kommando og gjøre aggregeringer.

Eks:

1. I average-grades.csv aggregeringen(aggregering 1) henter først ut hele listen fra HDFS og legger det i en dataframe.

2. Etter det lages det to Row() elementer som holder på hver sin del av dataen, en for fars utdanning og en for mors.

3. Etter det gjør vi en joinWith på dataen, og legger de sammen basert på verdien i utdanningsnivå som er 0-4.

4. Når har vi en dataframe bestående av to structs som vi bytter navn på

5. Vi «flater» så ut struct-typen som har blitt skapt av den tidligere joinWith for å pakke ut til to hovedgrupper.

6. Til slutt skrives filen til disk som csv fil, eller den kan skrives til HDFS.