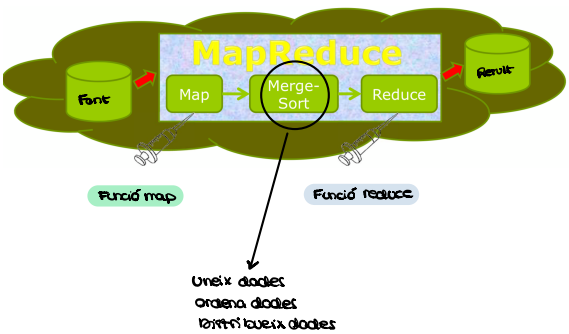
mapReduce

- Treballa sobre Google File System (ara en més)

- Requeriments
  - Tu treballes, ho envies al mapReduce, i ells es distribueixen
  - En comptes de per data shipping, envies query shipping ⇝ s'executa en local on són les dades
  - Paral·lelisme:
    - Problema anterior → claus foranes (per per validacions, joins, ...) → dades estan lluny
    - Volien treballar amb petabytes.
  - Escalable
  - Si una màquina falla ⇝ sistema es recupera

- Basat en functional programming

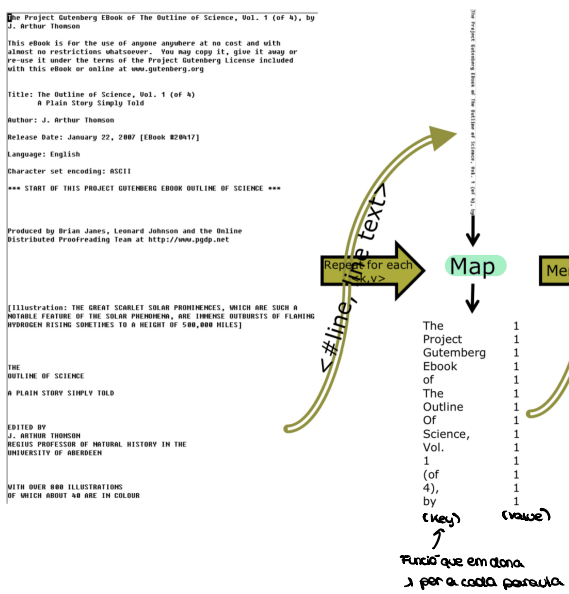


- Processen parelles [key, value] (Es pot repetir)
- Signature ⇝ el que hem de posar nosaltres

map (key k, value v) → [(ik1, iv1), ..., (ikr(k,v), ivm(k,v))]

reduce (key ik, vset) → [ov1, ..., ovr(ik5, ivs)]
(vset: set de values)

Exemple: word count




```
public void map(LongWritable key, Text value) {
    String line = value.toString();
    StringTokenizer tokenizer = new StringTokenizer(line);
    while (tokenizer.hasMoreTokens()) {
        write(new Text(tokenizer.nextToken()), new IntWritable(1))
    }
}

public void reduce(Text key, Iterable<IntWritable> values) {
    int sum = 0;
    for (IntWritable val : values) {
        sum += val.get();
    }
    write(key, new IntWritable(sum));
}
```

```
public void map(key, value) {
    whatever
    key, value
}
```

```
public void reduce(key, value) {
    whatever
    key, value
}
```

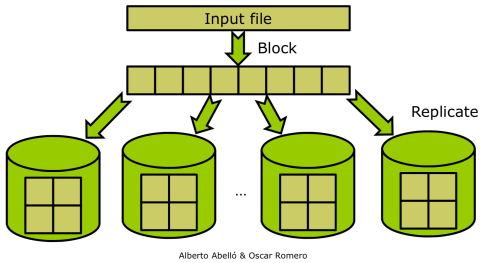
PROBLEMA.

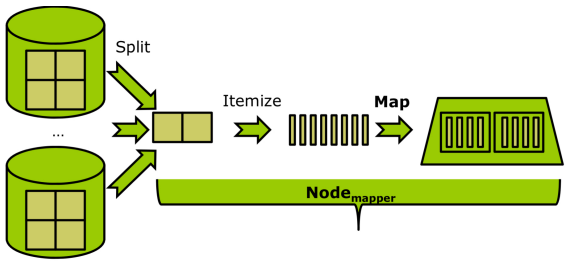
Com que no sap què hi ha al "whatever", no pot optimitzar res.

Versió 2 ⇝ Spark: intenta mirar el "whatever" per optimitzar una mica.

Algoritme

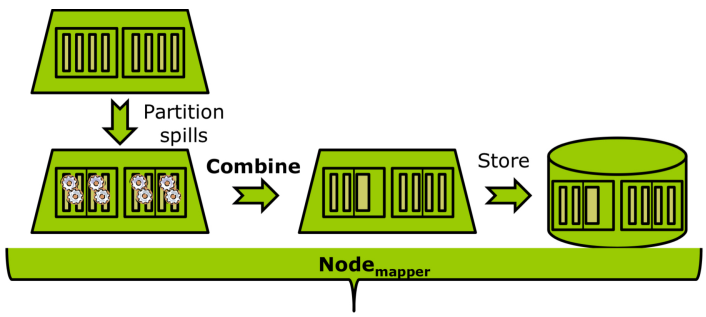
① Pujar fitxer a HDFS (cloud)
- HDFS ho divideix en chunks
- By default, ho replica a 3 imatges.



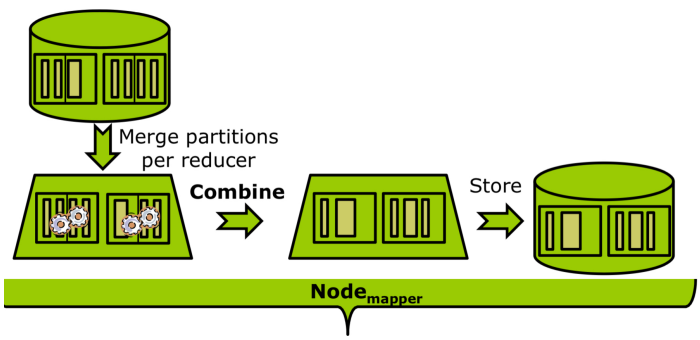


② A cadascun dels workers, se li assigna un split (subset de blocks)
③ Worker el divideix en records
④ Executa la funció del map i els posa a memòria (spill)
↳ conté resultats d'haver executat 1 o més cops "map"

⑤ Fa cada spill, el particiona amb tants trossos com reducers tenim
⑥ Cada partició de l'spill s'ordena de forma independent.
⑦ Cada cop que ordenem, s'executa "combine"
↑ reduce parcial ~> pel merge.

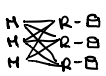


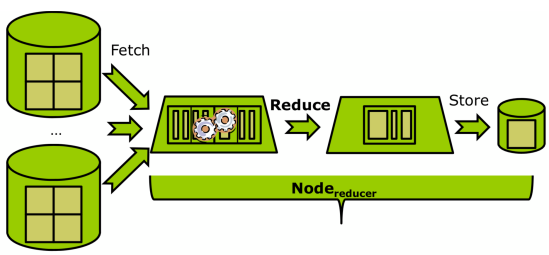
⑧ Guardem les particions de spill a disc (massive writing)



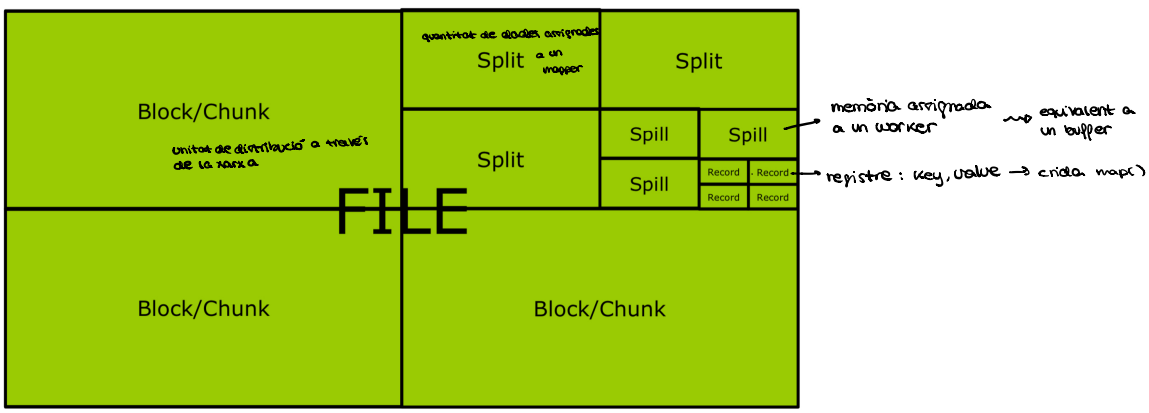
⑨ Agafo les particions de spill ordenades i les combino i ordeno
⑩ Guardem el resultat al disc.

⑪ Reducer fa fetch de les particions que hi ha al mapper
⑫ L'output del mapper es torna a fer merge
⑬ S'executa el reduce
⑭ El guarda al disc un altre cop.





Objectes



Record=Key-Value pair

Combine

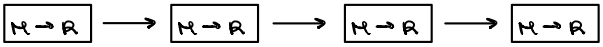
- Permet optimitzar (↓ lectures de disc)
- Redueix transit de xarxa
- Important → commutativa → igual que el reducer
  → associativa
- $\frac{|input|}{|output|}$ >> # CPU

Problemes mapReduce

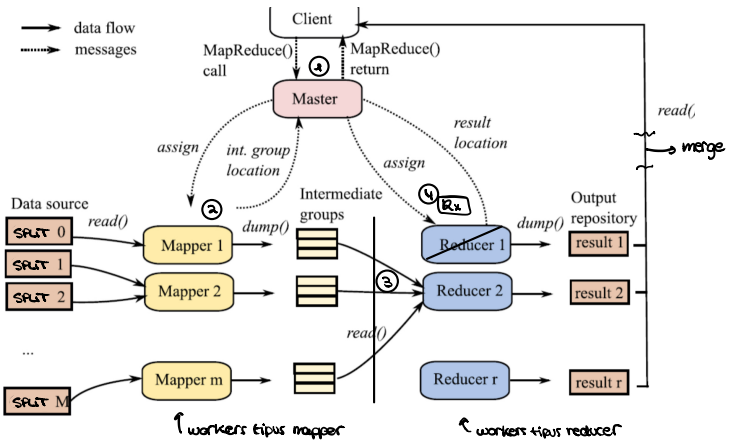
- Massa baix nivell (java) → tant eficient com tu el facis

Avantatges mapReduce

- Pots fer el que vulguis
- Tancat: pots fer cicles entre maps-reduce



Tasques i dataFlow



Sempre que s'escriu, es fa en local
És el "reader" qui va a buscar les dades
→ no perdem fitxer mai

Costos

1. Start-up time
2. Writing intermediate results (necessari per no perdre dades)
3. Transferència de dades (xarxa)
4. Fer pings a master per dir que estan vius (necessari per tenir availability)

PROBLEMES → Reassignments needed (4)
↳ Single-point failure (1 master)

Què fa Spark ?

- menys escriptures a disc : només quan ho veure necessari
- permet més operacions
- et facilita controlar les particions

Exercici mapReduce

Assumim que tenim el següent codi:

```
public void map(LongWritable key, Text value) {
  String line = value.toString();
  StringTokenizer tokenizer = new StringTokenizer(line);
  while (tokenizer.hasMoreTokens()) {
    write(new Text(tokenizer.nextToken()), new IntWritable(1));
  }
}

public void reduce(Text key, Iterable<IntWritable> values) {
  int sum = 0;
  for (IntWritable val : values) {
    sum += val.get();
  }
  write(key, new IntWritable(sum));
}
```

#split ← #màquines virtuals

ta Set:

Ex: Block0: "a b b a c | c d c a e"

Block1: "a b a d a | b b c c f"

configuration

- combine = reduce
- 1 split = 1 block
- '1' divideix els records del block → 2 records/block
- dfs.replication = 1 (hadoop)
- 1 spill = 4 [key,value]
- 2 mappers, 2 reducers
  - machine0 → block0 → mapper0 → reducer0
  - machine1 → block1 → mapper1 → reducer1
- hash per reducers → {b, d, f} → 0
  - {a, c, e} → 1

Fill the gaps:

1) Machine0 contains ..1.. blocks. (block0)
   Machine1 contains ..1.. blocks. (block1)
2) We keep ..2.. replicas (including the master copy) per block.
3) We have ..2.. splits per machine. (1 split = 1 block)

4) Mapper0 reads ..2.... records.
   Mapper1 reads ..2.... records.

5) Spills in Machine0:

Spill1	Spill2	Spill3	Spill4
[a,1][b,1]	[c,1][c,2]	[a,1][e,1]	[,][,]
[b,1][a,1]	[d,1][c,1]	[,][,]	[,][,]

Spills in Machine1:

Spill1	Spill2	Spill3	Spill4
[a,1][b,1]	[a,1][b,1]	[c,1][f,1]	[,][,]
[d,1][d,1]	[b,1][c,1]	[,][,]	[,][,]

amics com.

6) Partitions in machine0:

Spill 1		Spill 2		Spill 3	
Partition 0	Partition 1	Partition 0	Partition 1	Partition 0	Partition 1
[b,1][b,1]	[a,1][a,1]	[d,1][,]	[c,1][c,1]	[,][,]	[a,1][e,1]
[,][,]	[,][,]	[,][,]	[c,1][,]	[,][,]	[,][,]

Partitions in Machine1:

Spill 1		Spill 2		Spill 3	
Partition 0	Partition 1	Partition 0	Partition 1	Partition 0	Partition 1
[b,1][d,1]	[a,1][,]	[b,1][b,1]	[a,1][c,1]	[f,2][,]	[c,1][,]
[d,1][,]	[,][,]	[,][,]	[,][,]	[,][,]	[,][,]

7) Partitions in machine0:

Spill 1		Spill 2		Spill 3	
Partition 0	Partition 1	Partition 0	Partition 1	Partition 0	Partition 1
[b, 2] [,] [,] [,]	[a, 2] [,] [,] [,]	[d, 1] [,] [,] [,]	[e, 3] [,] [,] [,]	[,] [,] [,] [,]	[a, 1] [e, 1] [,] [,]

Partitions in Machine1:

Spill 1		Spill 2		Spill 3	
Partition 0	Partition 1	Partition 0	Partition 1	Partition 0	Partition 1
[b, 1] [d, 2] [,] [,]	[a, 1] [,] [,] [,]	[b, 2] [,] [,] [,]	[a, 1] [e, 1] [,] [,]	[g, 1] [,] [,] [,]	[e, 1] [,] [,] [,]

8) Files in machine0:

File0	File1	File2
[b, 2] [,] [,] [,]	[a, 2] [,] [,] [,]	[d, 1] [,] [,] [,]
File3	File4	File5
[e, 3] [,] [,] [,]	[,] [,] [,] [,]	[a, 1] [e, 1] [,] [,]

Files in Machine1:

File0	File1	File2
[b, 1] [d, 2] [,] [,]	[a, 1] [,] [,] [,]	[b, 2] [,] [,] [,]
File3	File4	File 5
[a, 1] [c, 1] [,] [,]	[g, 1] [,] [,] [,]	[e, 1] [,] [,] [,]

9) Merges in machine0:

Merge0	Merge1
[b, 2] [d, 1] [,] [,] [,] [,]	[a, 3] [c, 3] [e, 1] [,] [,] [,]

Merges in Machine1:

Merge0	Merge1
[b, 3] [d, 2] [g, 1] [,] [,] [,]	[a, 2] [c, 2] [,] [,] [,] [,]

10) Files in machine0:

File0	File1
[b, 2] [a, 1] [,] [,] [,] [,]	[a, 3] [c, 3] [e, 1] [,] [,] [,]

Files in Machine1:

File0	File1
[b, 3] [d, 2] [g, 1] [,] [,] [,]	[a, 2] [c, 2] [,] [,] [,] [,]

11) Reducer0 reads ..... File 0 ..... Files from machine0
and ..... File 0 ..... Files from machine1. (answer which Files)

Reducer1 reads ..... File 1 ..... Files from machine0
and ..... File 1 ..... Files from machine1. (answer which Files)

12) Merge in machine0:

File0	File1
[b, 12, 34] [d, 11, 24] [g, 11 4]	[,] [,] [,]

Merge in Machine1:

File0	File1
[a, 13, 14] [e, 13, 24] [e, 11 4]	[,] [,] [,]

13) Reduce function is executed ... 3 ... times in machine0.
Reduce function is executed ... 3 ... times in machine1.

14) Files in machine0:

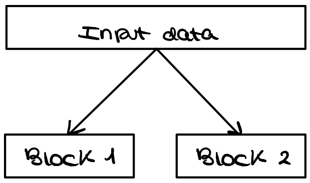
File0	File1
[b, 5] [d, 3] [g, 1] [,] [,] [,]	[,] [,] [,] [,] [,] [,]

Files in Machine1:

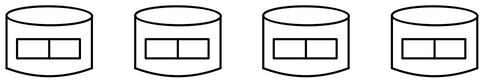
File0	File1
[a, 4] [c, 5] [e, 1] [,] [,] [,]	[,] [,] [,] [,] [,] [,]

Algoritme pas a pas.

① Input data partioned into blocks — Fugem les dades al cloud per blocks ⇝ Block 0, Block 1



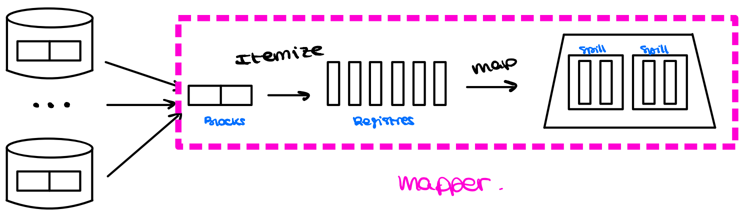
② Replicate them into different nodes — 1 rèplica / block



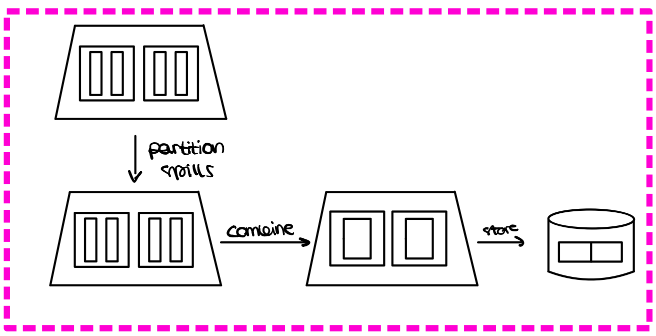
③ Each map subplan reads a subset of blocks (split)

1 mapper ⇝ 1 block = 1 split

④ Divides into records. ⇝ 2 records / block (split)



⑤ Executes the map for each record ⇝ 4 records ⇝ 4 map() ↳ om mir segons map
and leaves them in memory devided into spills



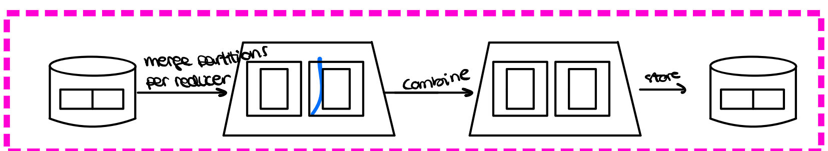
⑥ Each spill is partitioned per reducers ⇝ 2 reducers ⇝ 2 spills

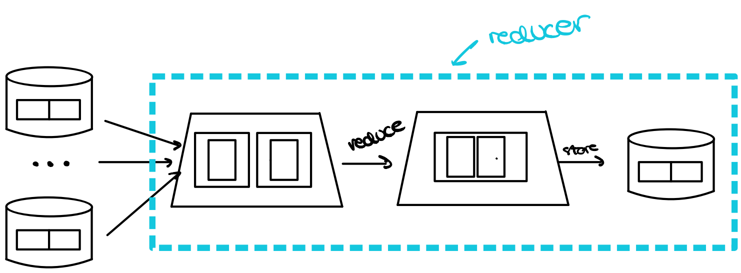
⑦ Each spill is stored independently (+combine)

⑧ Store spill partitions into disk

⑨ Spill partitions are merged and stored independently (+ combine)

⑩ Store into disk.





⑪ Reducers fetch data from mappers

⑫ Mappers output is merged and stored

⑬ Reduce function is executed per key

⑭ Store the result into disk.