http://arnaud-nauwynck.github.io

Big Data – Part 4

Hadoop Ecosystem
HiveMetaStore, Parquet, (Spark) IO Optims

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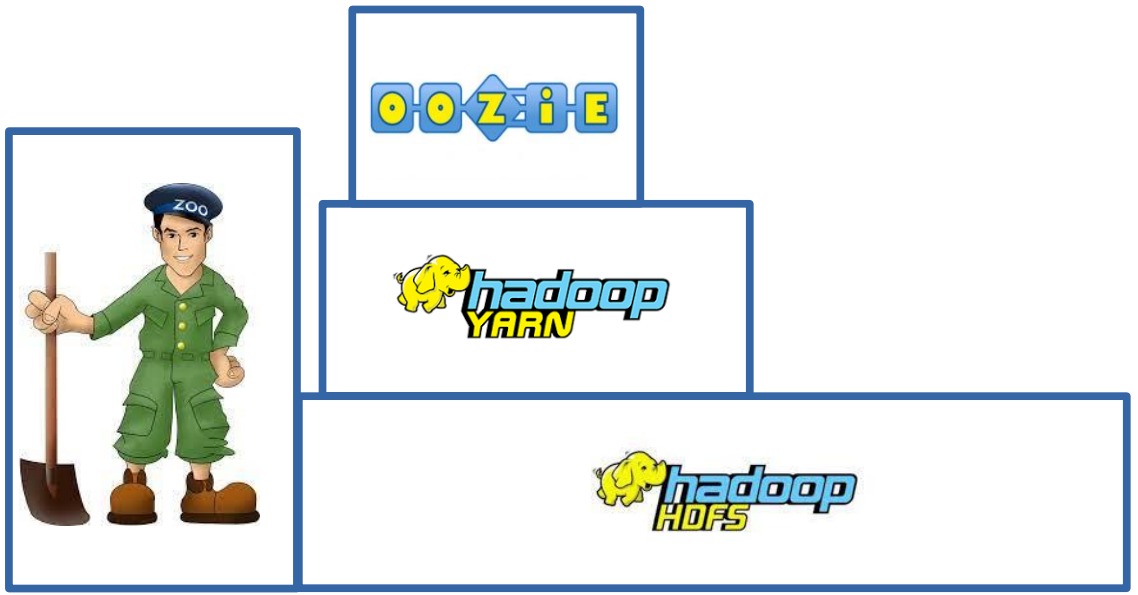
Outline

- Prev Part3: Low-Level Hadoop components
  - ZooKeeper, Hdfs, Yarn, Oozie
- Hive MetaStore
- Parquet
- Analytics IO Optims

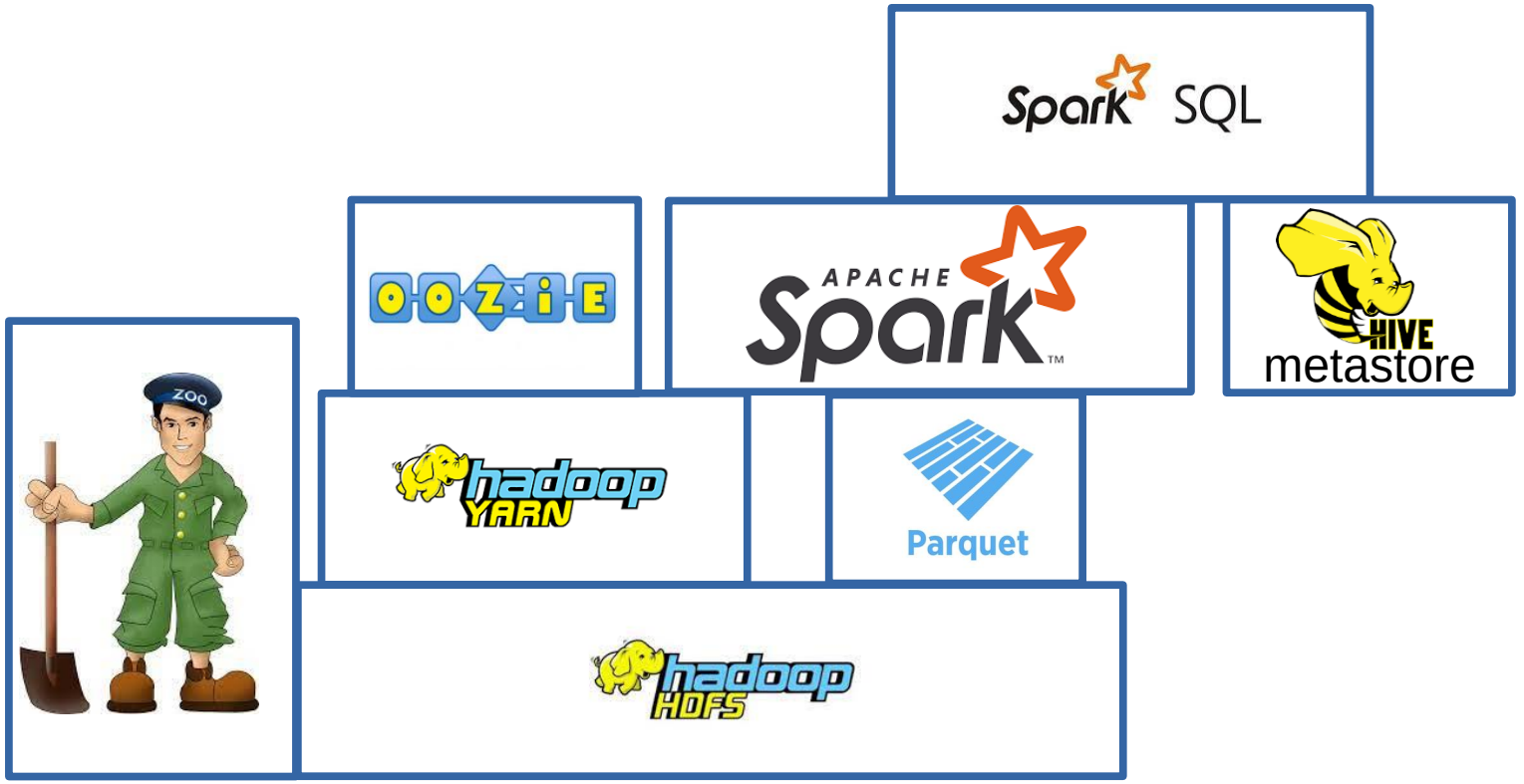
  Splittable blocks format, Partitions Pruning, Columns Pruning, PPD

Prev Part3: Low-Level Focus

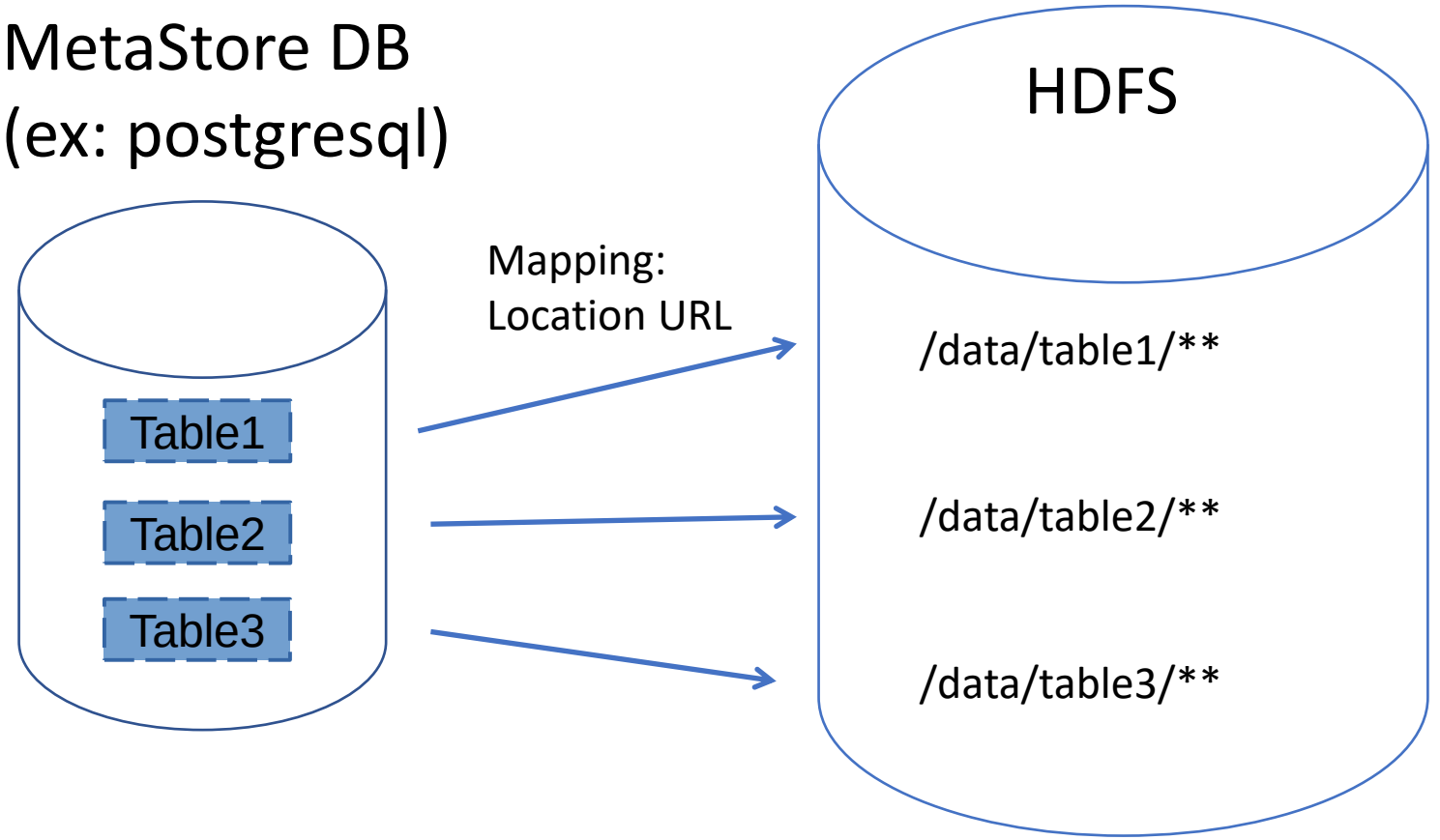
ZooKeeper, HDFS, Yarn, Oozie



This Part … High-Level Focus
MetaStore, Parquet, Spark



(Hive) MetaStore



MetaStore

Contains only **DDL** (Data Definition Langage)
metadata (no HDFS data)

Logical view mapping : **name in SQL ⇔ location in HDFS**

File format encoding: parquet, orc, avro, csv, json, …

Schema : **column types**

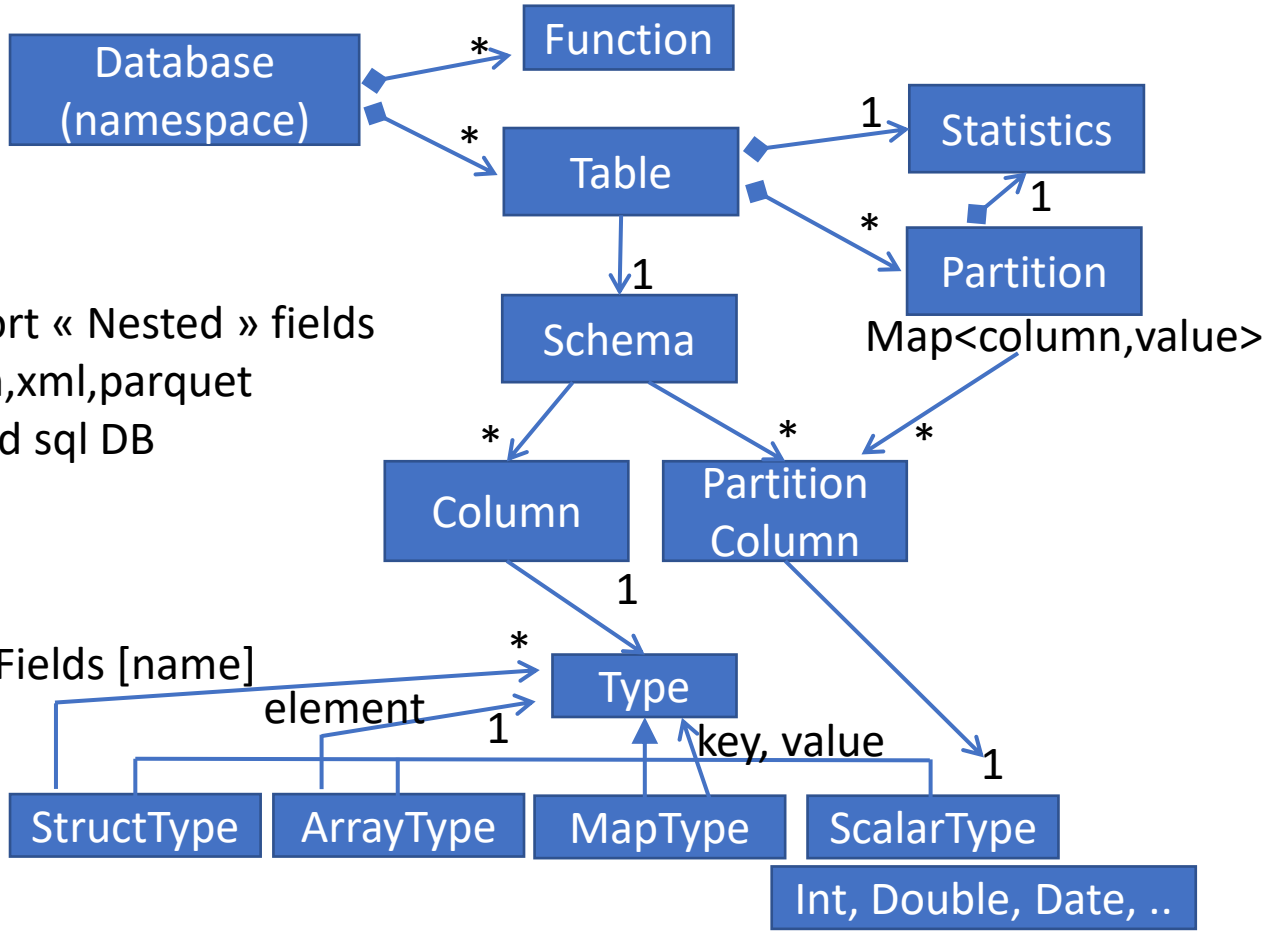
Sample CREATE EXTERNAL TABLE

```
CREATE EXTERNAL TABLE db.student (
   id int,
   firstName string,
   lastName string
)
PARTITIONED BY (
  promo int
)
STORED AS parquet
LOCATION ‘/data/student’
```

Advanced CREATE EXTERNAL TABLE

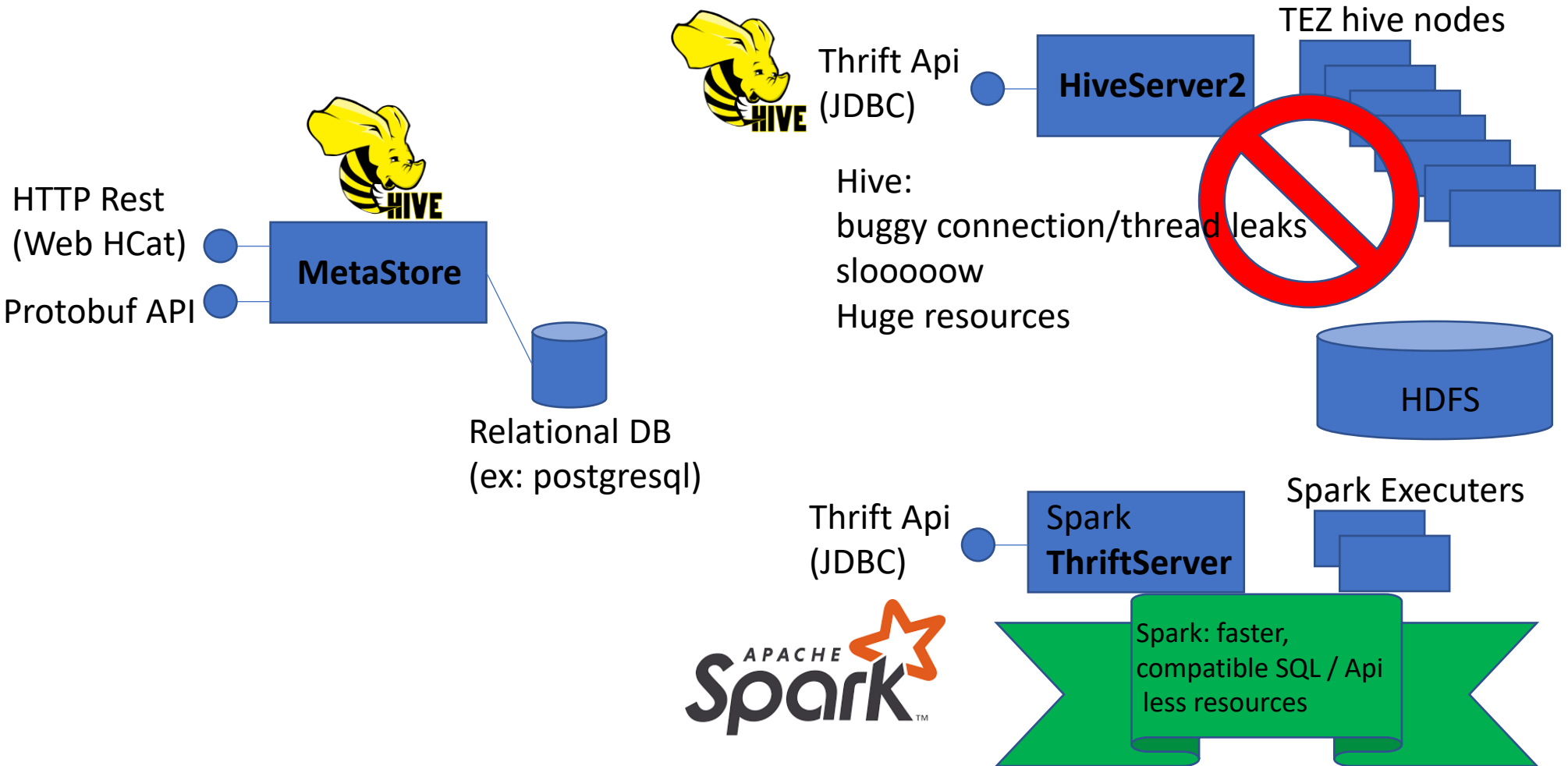
```
CREATE EXTERNAL TABLE db.student (
  id int, firstName string, lastName string,
  address struct< street string,number int,zipcode int >,
  graduations array< struct< name string, obtentionDate date > >,
  extraData map< string,string >
)
PARTITIONED BY ( promo int )
CLUSTERED BY ( id, ...)  SORTED BY (lastName, firstName )
STORED AS parquet
LOCATION ‘/data/student’
```

MetaStore Model

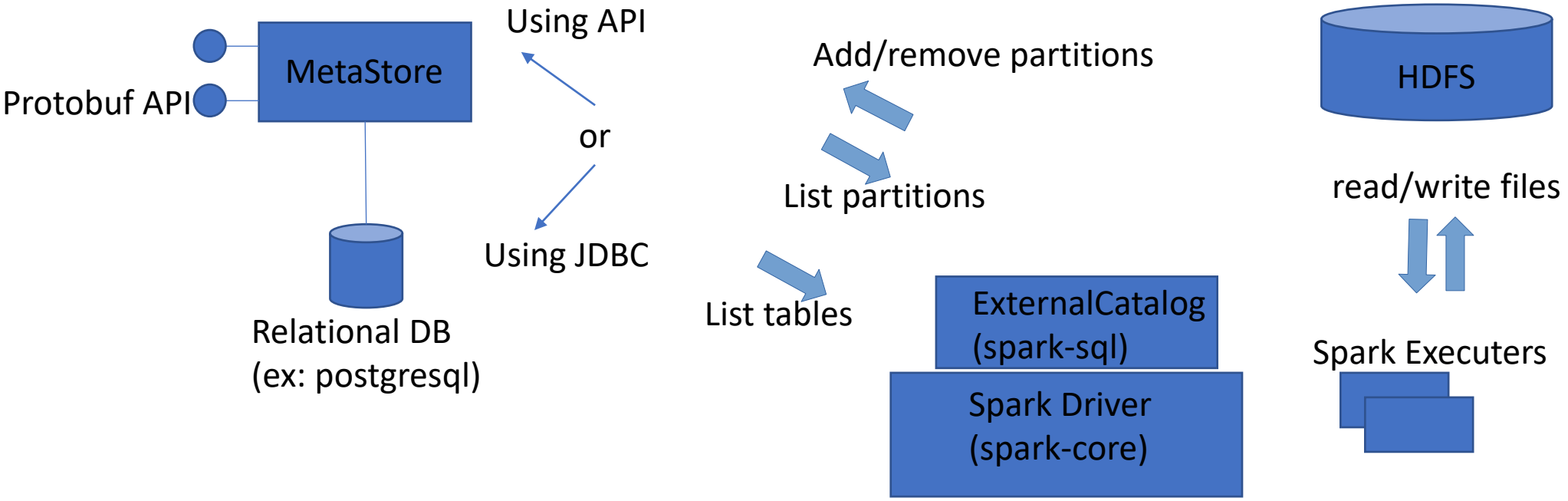


Schema support « Nested » fields
like typed json,xml,parquet
unlike standard sql DB

Hive MetaStore Architecture



Spark supports Hive MetaStore



Sql> DDL

Sql>
show databases;
use ‘db’;

show tables in ‘db’;
show tables in ‘db’ like ‘s*’;
describe table db.student;
show create table db.student;

alter table db.student set location ‘/data/student2’;
drop table db.student;

DDL.. EXTERNAL table

« EXTERNAL TABLE » : data exists independently of metastore

when creating table ... Schema must be compatible with existing files
Non-sense to « alter table » for column
When dropping … files are not deleted

Do not use opposite « MANAGED TABLE »
When creating => create empty dir, location= « {db.location}/{table} »
When dropping => delete all files !

Sql> DML

Sql>
INSERT INTO table values(..)
  => save to new file(s) !!
      preserve existing ones
      (also preserve partially uncommited ones..)

INSERT OVERWRITE / DELETE
  => reload all files
      + save all to new files
      + delete old files

Sql> Update? DML

by default Spark 3.x does NOT support UPDATE
(nor UPSERT, MERGE)

Only with extensions of « DeltaLake », « Iceberg », ..

Spark> Update?
read().map().write()

```
spark
    .read().format(« PARQUET »).load(« /data/table1 »)

    .map( x -> {   …transform row to ‘update’ values; return newRow } )

    .write().format(« PARQUET »).move(SaveMode.Overwrite).save(« /data/table1 »)
```

Full Scan ALL files
Load ALL
in-memory

Process ALL
In-memory

Delete ALL files
+ save ALL
in-memory

Sql> … NO « ACID »


tomic


onsistent


solated

D urable

Granularity of insert (append / overwrite)

Write a single ROW → in 1 new **File**

HDFS hates Small Files (Too many files) !!

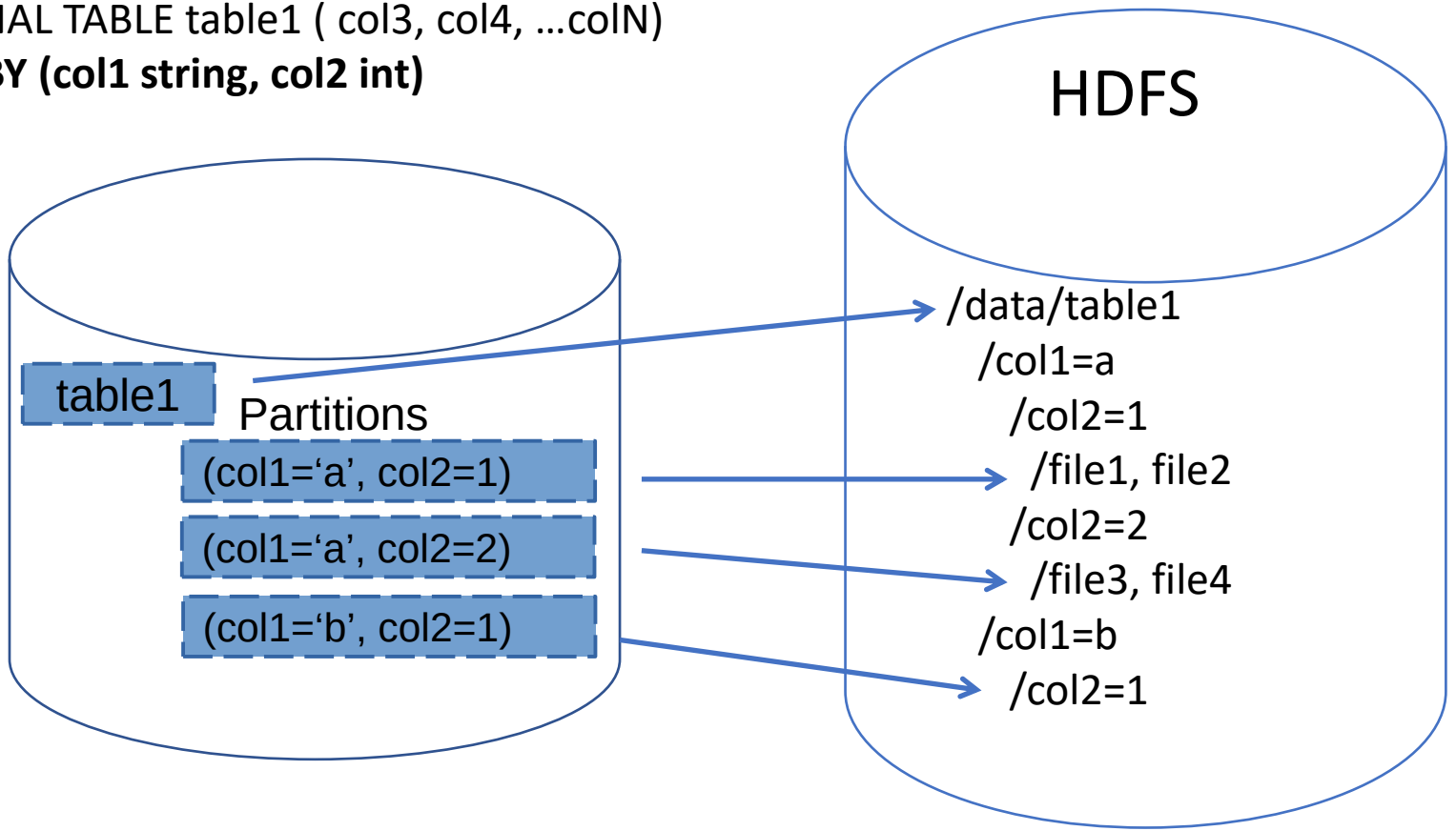
Write from shuffled RDD (several executors) → **each** in 1 new **File**

by default spark.sql.shuffle.partitions=200 !!

Overwrite some files, and no touch others → Possible only by **partition**

PARTITIONED BY (col1, col2)

CREATE EXTERNAL TABLE table1 (col3, col4, …colN)
PARTITIONED BY (col1 string, col2 int)



Alter table ADD PARTITION / MSCK REPAIR TABLE

Need EXPLICIT add !!
Otherwise dir/files not scanned => 0 result

Sql>
ALTER TABLE .. **ADD PARTITION** (col1='a', col2=1);
… Or (inneficient rescan all)
MSCK REPAIR TABLE ..;

Discover.partitions ??
… False good idea

ALTER TABLE … SET TBLPROPERTIES ('discover.partitions' = 'true')

hive-site.xml
  metastore.partition.management.task.frequency=600

  … => INNEFICIENT : Polling metastore thread every 10mn to scan HDFS, and alter spark still using explicit partitions

What if you have Peta bytes, with millions of dirs?

Optim: Partitions Pruning

Sql> select … from db.student where promo=2020 and …

Condition on partitioned column

Need only scan files partition
dir /data/student/promo=2020/**

Skip all others: /promo=2019/, /promo=2018/ …

Partition: what for ?

NOT for searching faster !!!!

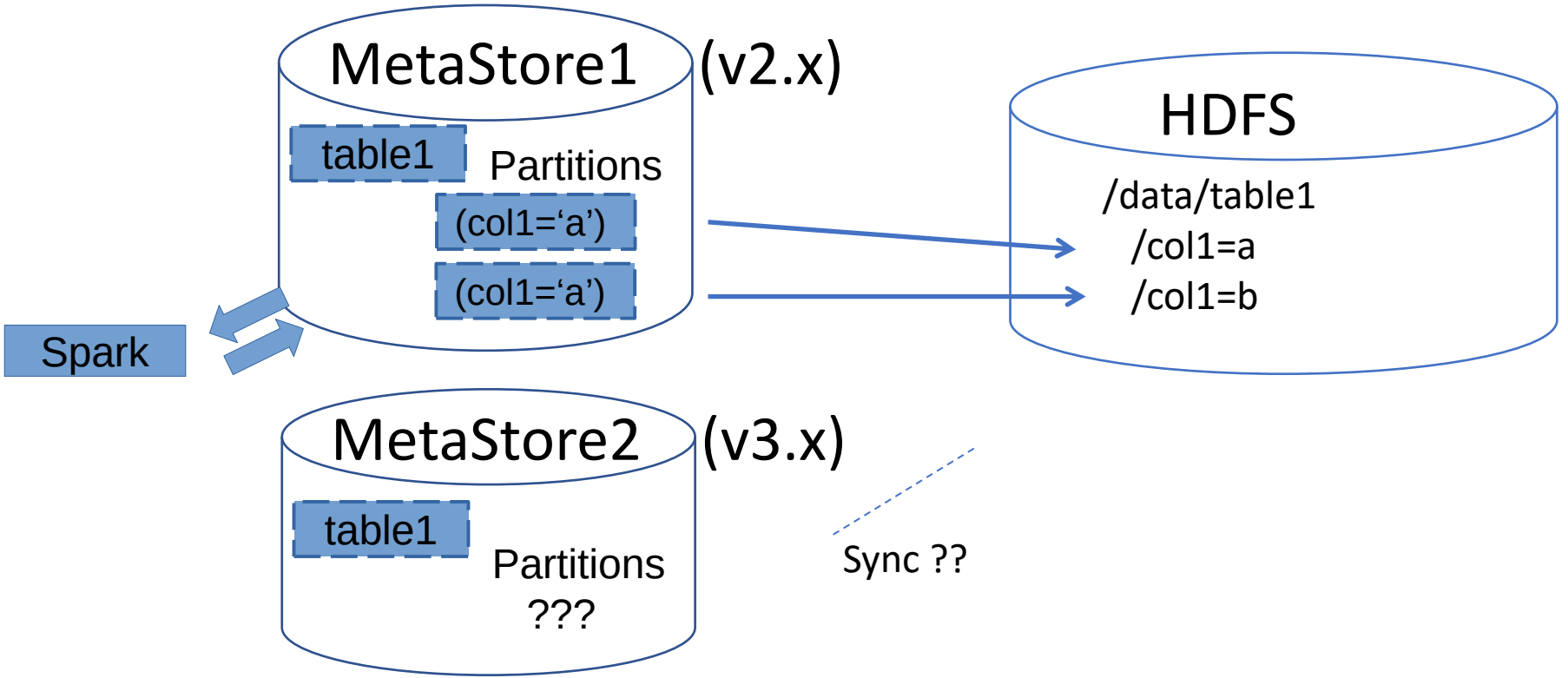
(worst than parquet Predicate-Push-Down)

Granularity of Save mode Overwrite

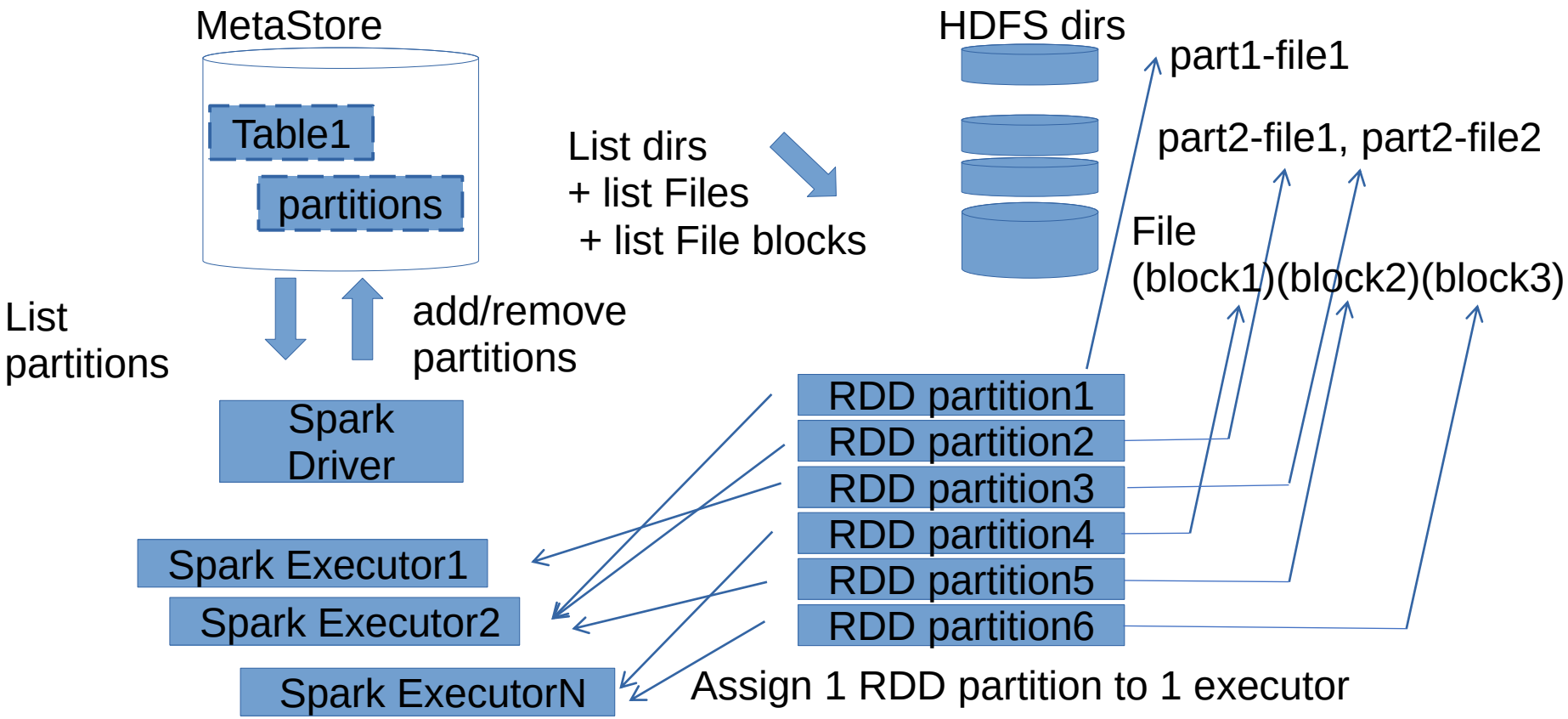
… adapt to your batch scope

DO NOT define too (>2) many partition levels

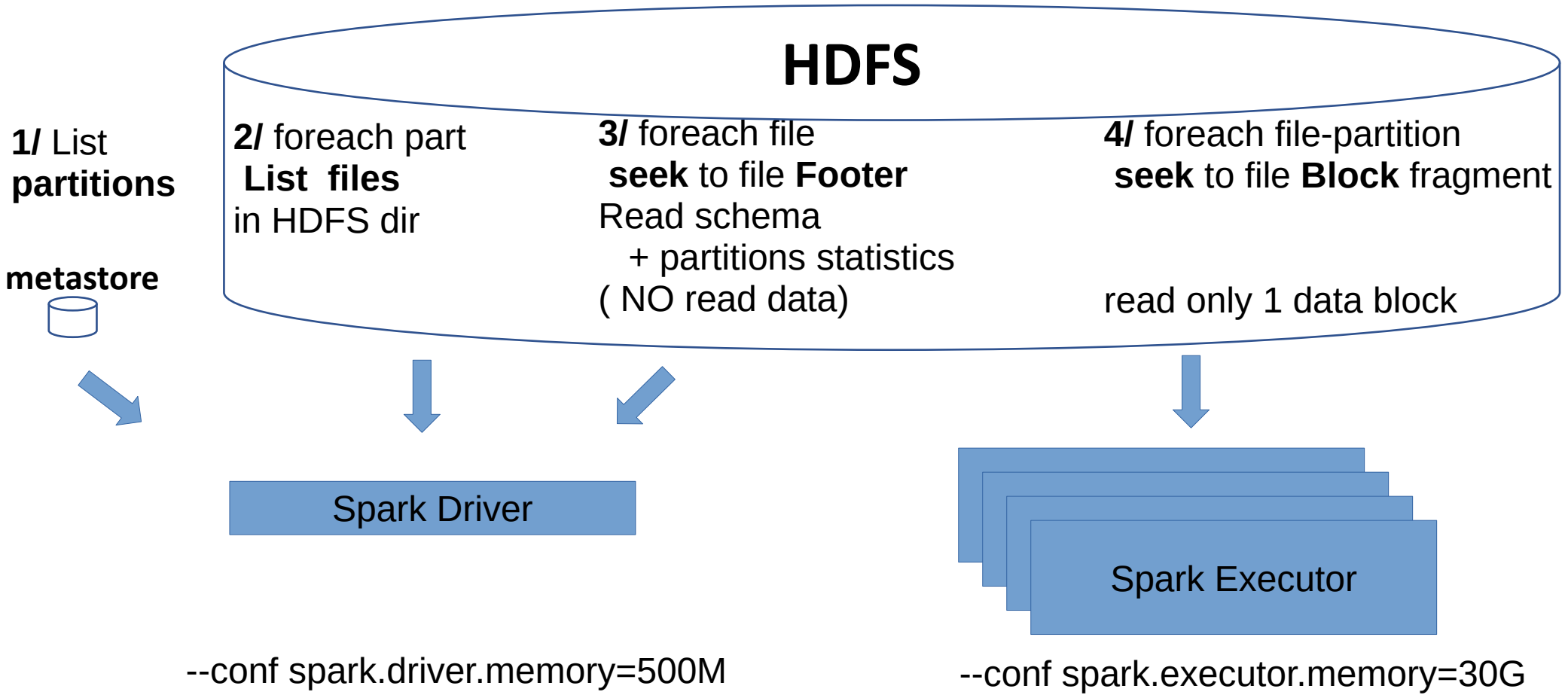
Synchronize HDFS with several MetaStores?



Spark RDD Partitions >> MetaStore Partitions

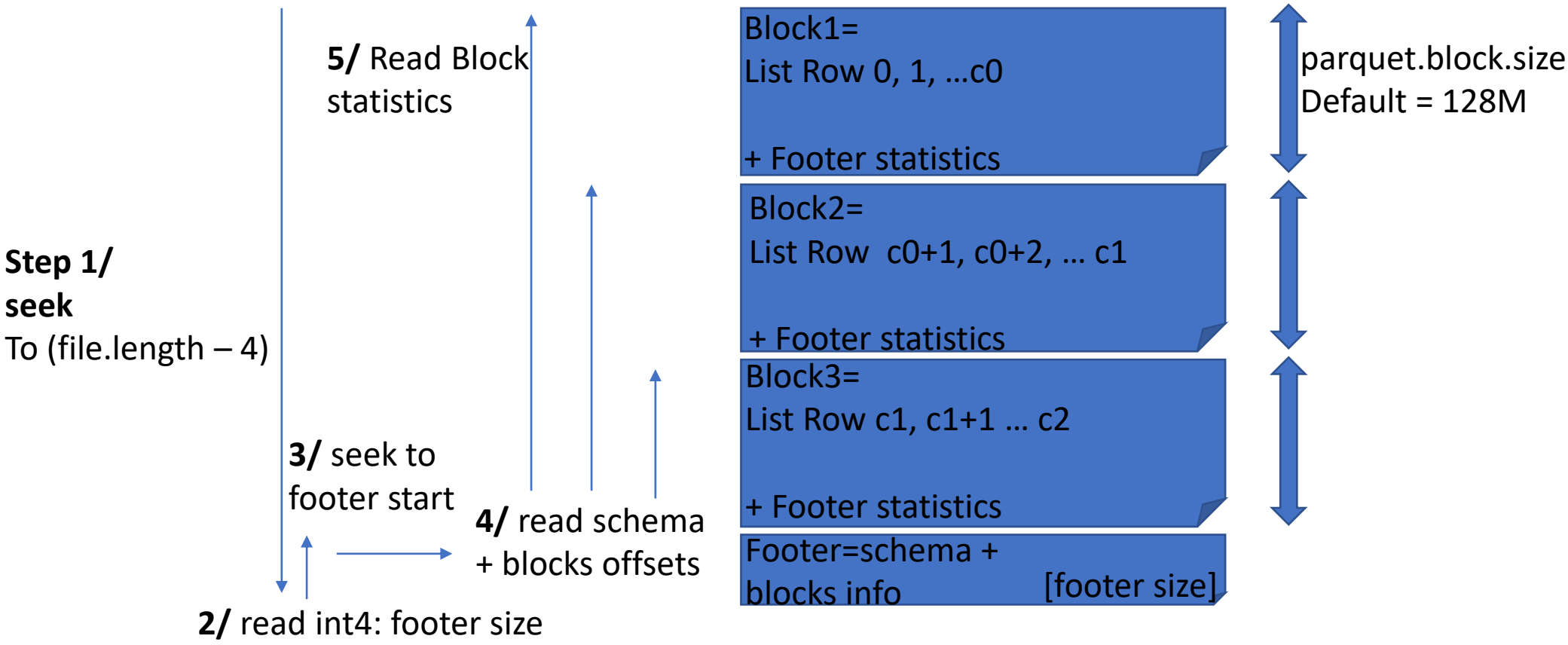


Spark RDD Partitions
= MetaStore Partition * Files * Blocks



PARQUET File Format

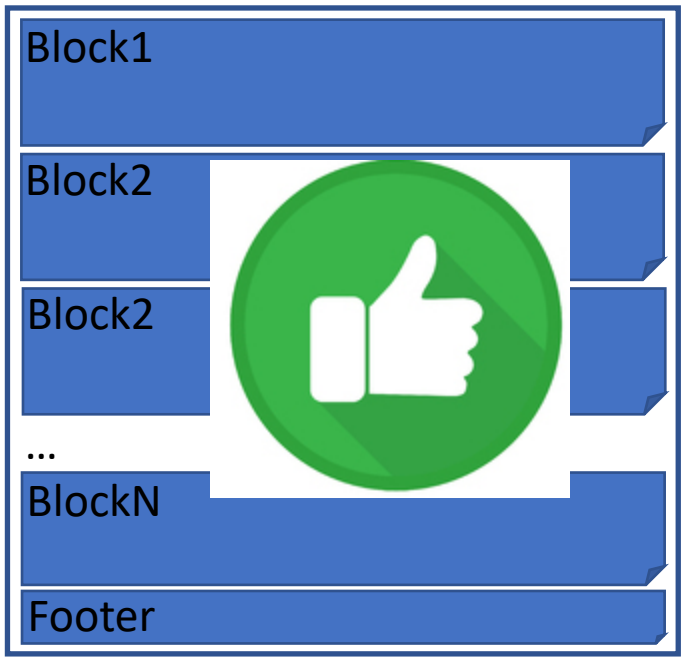
Splitteable File Format



Performances

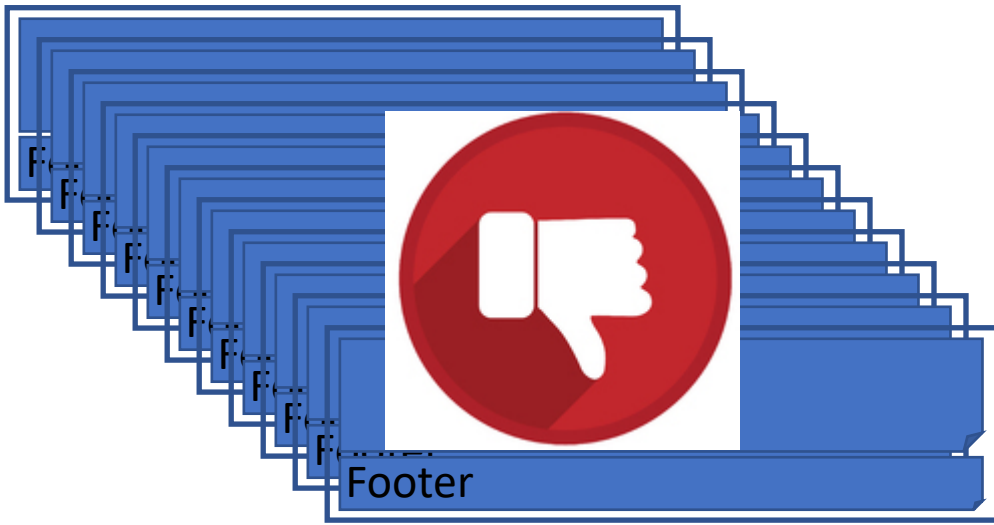
File Blocks >> MetaStore + HDFS Dir + Files

Better to
have 1 Huge HDFS file
(several Go)



than

Too MANY
Too Small files
(few 128+1 Mo)



Typical Partition / Files Volumes

For daily batch

1 partition per day … 5 year of data = ~1500 partitions OK

1 file per partition … OK, even if strange to have 1 file per directory

(maybe 2,3 files per partition … if no fit in spark executor mem)

File may be >= several Giga bytes …. OK great

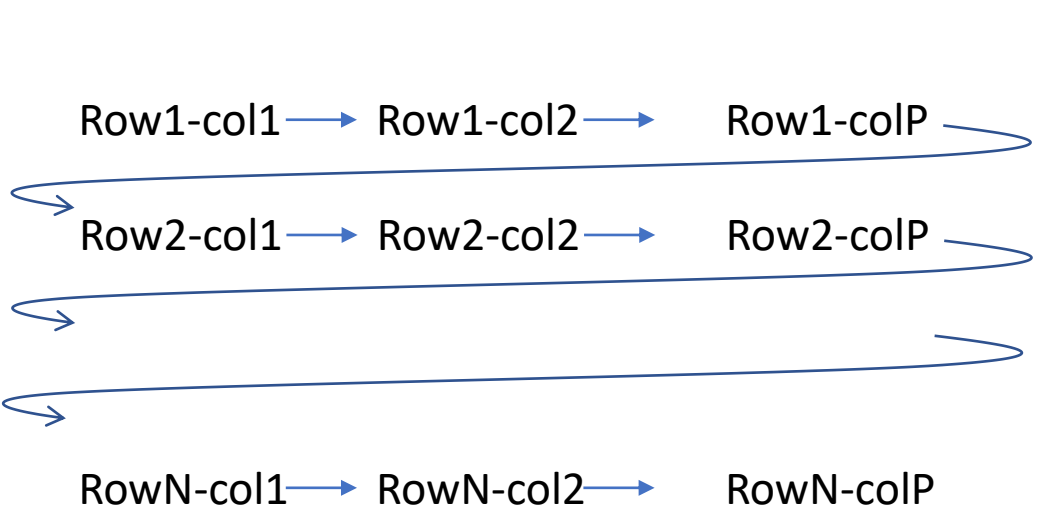
File parquet.block.size = 16M, 32M (? overwrite default 128M)

compromise:
Smaller => more dictionary encoding,
better PPD, maybe less compression
Bigger => less partitions

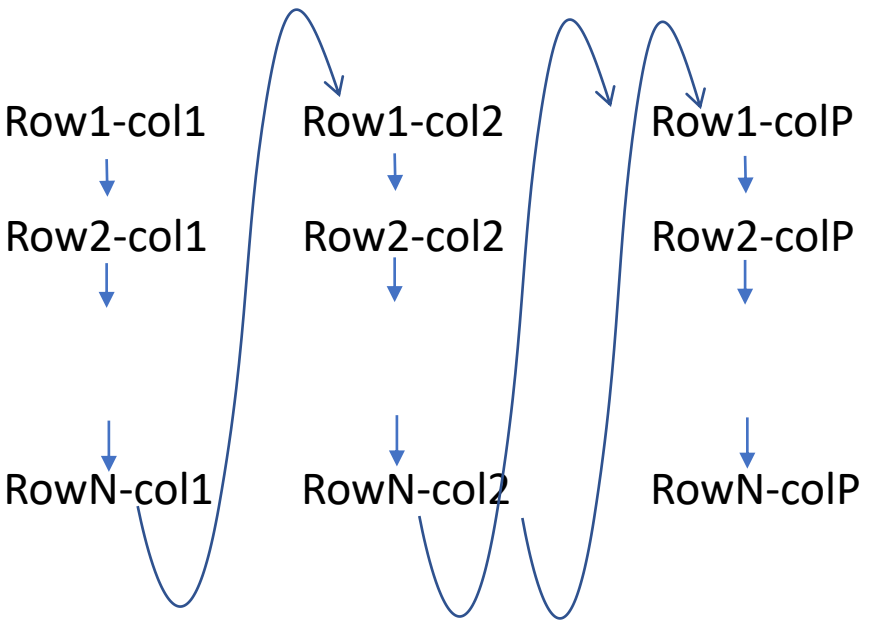
« Columnar » Storage File

Content = List<Row> = row1, row2, .. rowN … Row=col1, col2, … colP

Classic (row-storage) file



Columnar-storage file



Why columnar ?

Read only needed columns data

Seek to skip unneeded ones

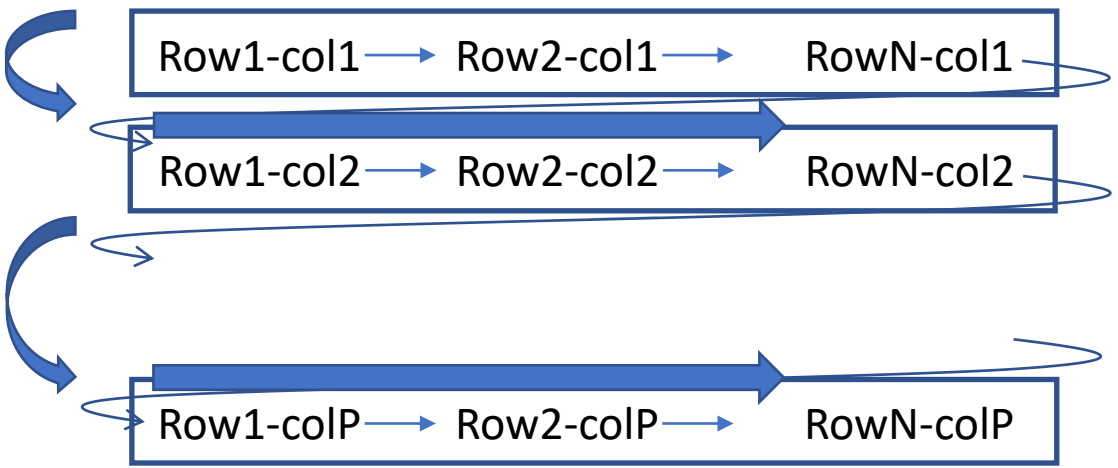
Example: SELECT col2, colP from …

1/ seek() to col2 offset
(Skip sequential bytes for col1)

2/ Full read col2

3/ seek to colP offset
(Skip bytes for col3, col4, … colP-1)

4/ Full read colP

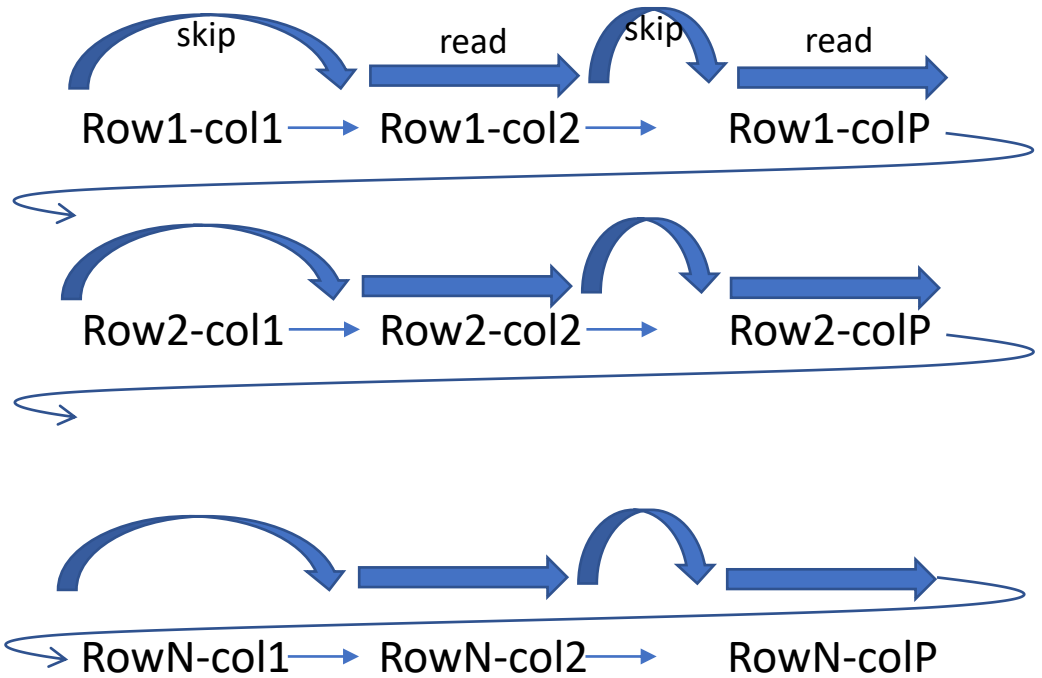


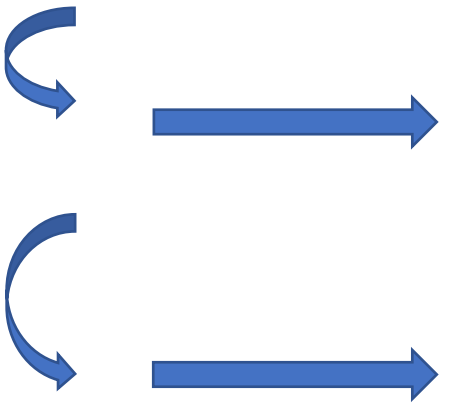
Comparison .. Full Read & Garbage

2*N skips
+ 2*N small unitary reads

vs

2 skips
+ 2 array reads





Much faster
Fewer data IO / fewer ops

Optim: « Column Pruning »

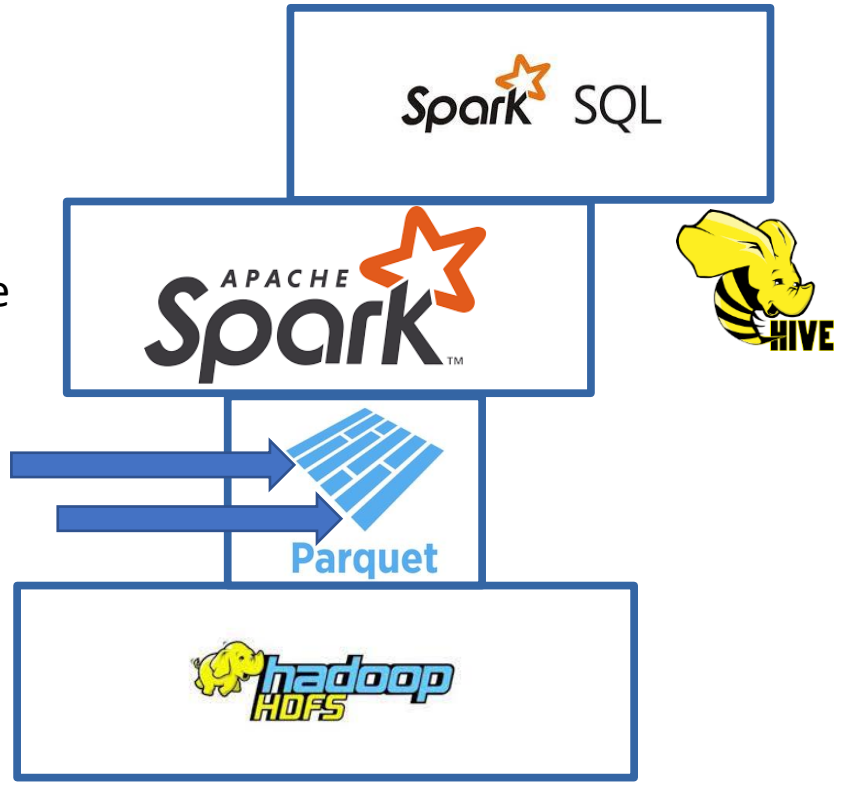
From SQL to Parquet IO .. Hadoop IO

Select col2, colP from table…
(prune all other columns)

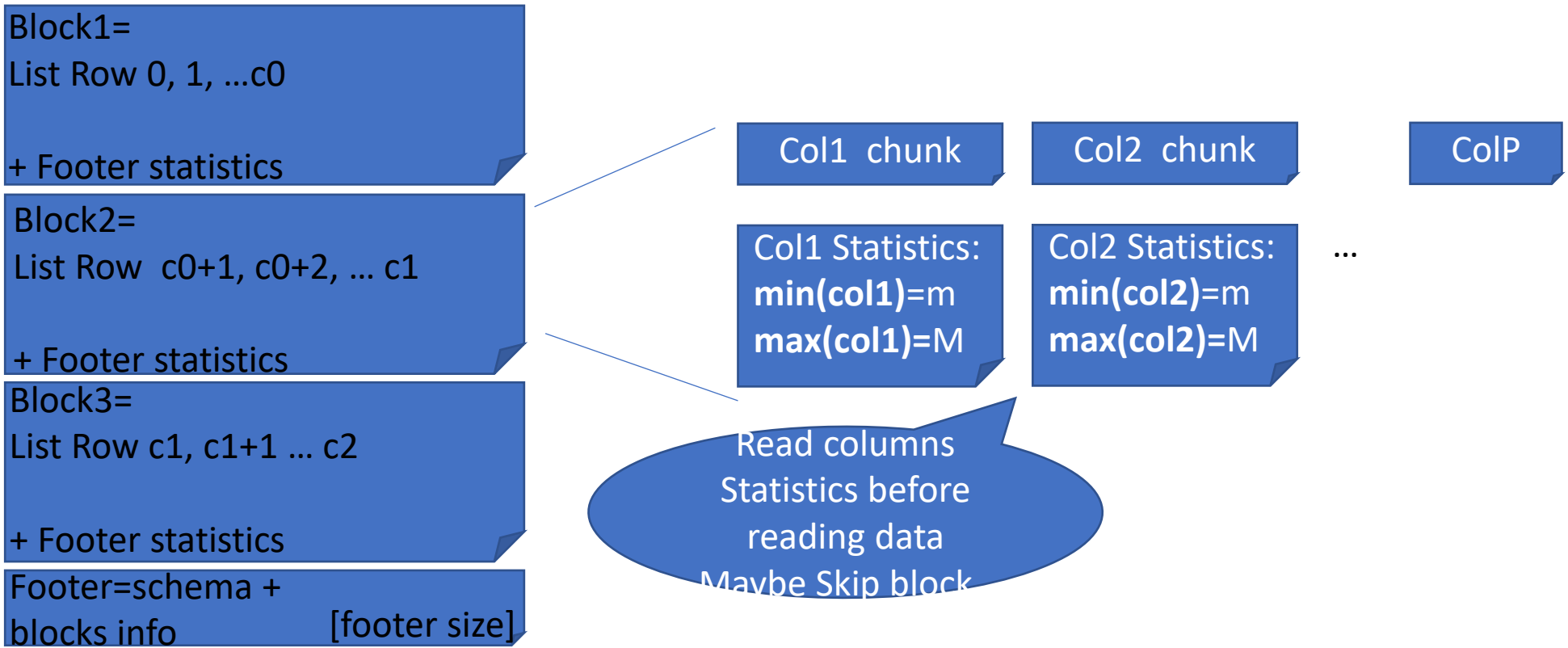
DataSet / RDD on Parquet file

Parquet API
to read columns chunks

Fewer IO

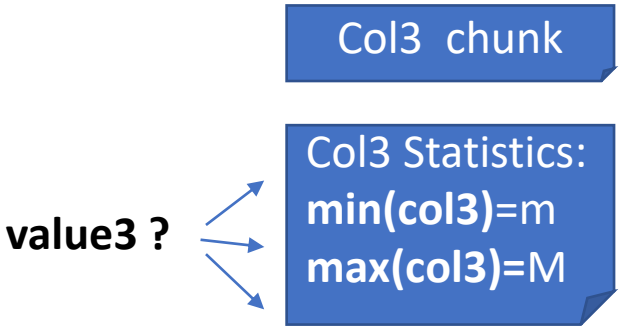


Last but not Least Optim
Using column statistics



Predicate… skip with statistics (maybe False Positive)

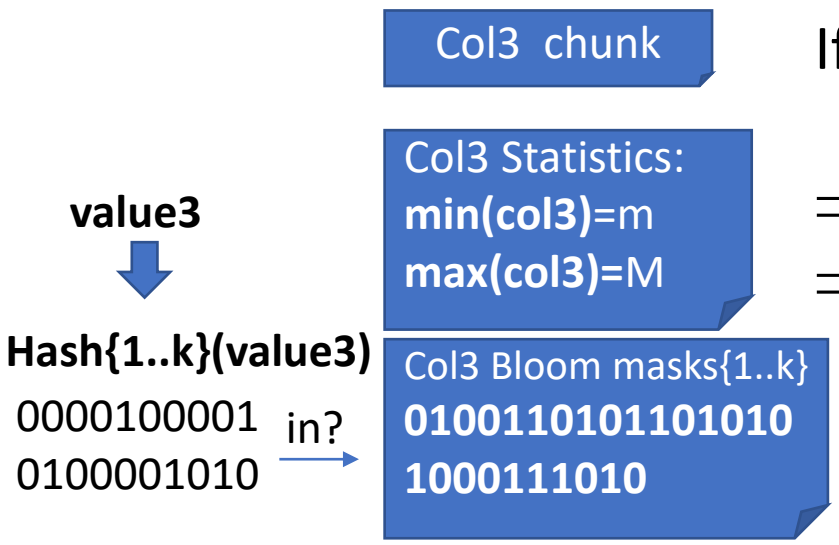
Example:
SELECT col2, colP FROM … WHERE **col3 = value3**



If (**(value3 < m) OR (value3 > M)**)
… AND check for null to please SQL semantic ?!
⇒Impossible to find row in this block
⇒Skip block!

Bloom Filter = Union mask(hash(..)

New in Parquet … (older in ORC)
statistics can contains also Bloom filter mask



Bitmask hash3 = hash(value3)
If (**(hash3 & bloom) == hash3**)
… AND check for null to please SQL semantic ?!
⇒Impossible to find row in this block
⇒Skip block!

k hashes, *m* bits, *n* elements
=> False positive rate ~ $(1-e^{-kn/m})^k$

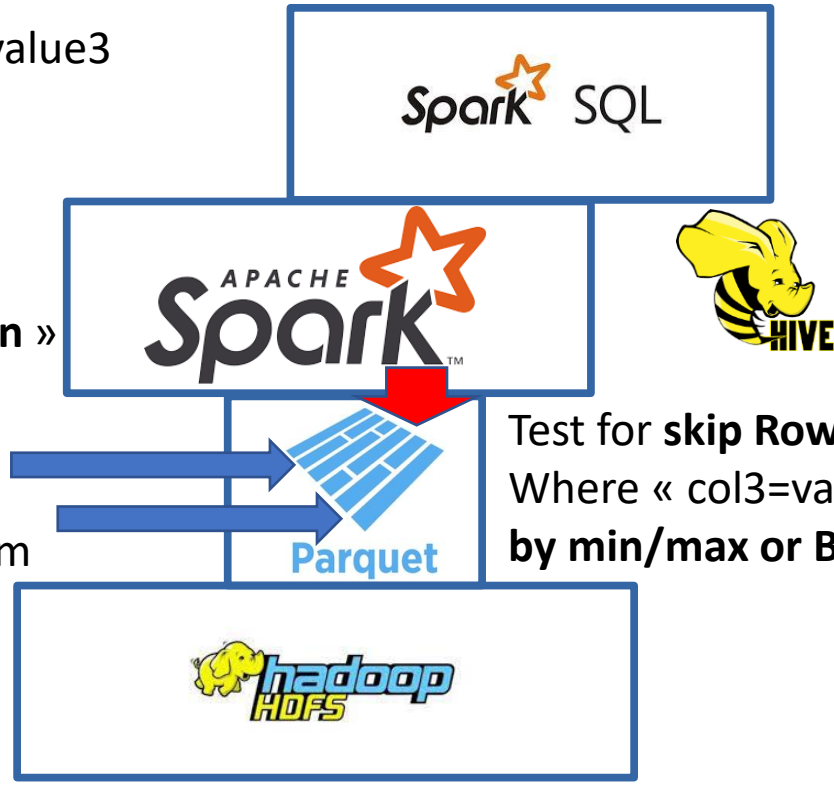
« PPD » : Predicate-Push-Down

Select .. from … where col3=value3

DataSet / RDD on Parquet file
WITH PREDICATE « **pushed-down** »

Parquet API
to read columns statistics+bloom

Fewer IO



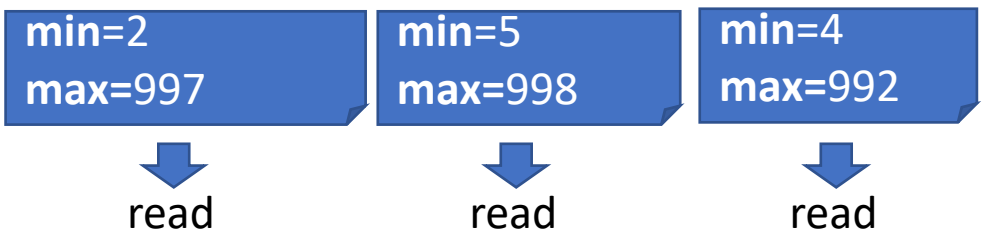
Test for **skip RowGroups**(=blocks)
Where « col3=value3 »
by min/max or Bloom

Sort + parquet.block.size for better Predicate-Push-Down

When writting PARQUET files
… think to optimize reads later (PPD)

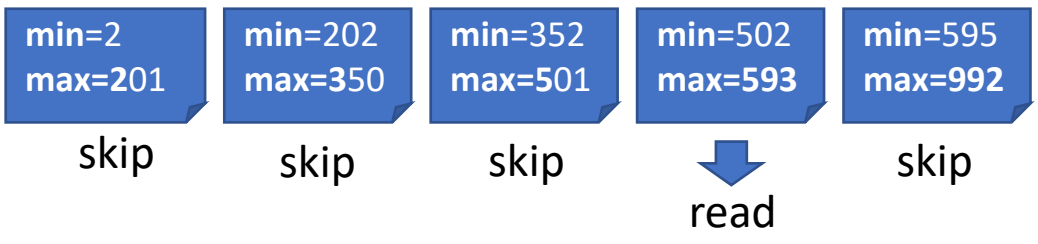
Example: id in range 1..1000 predicate id=542

Unsorted, Big block 128M

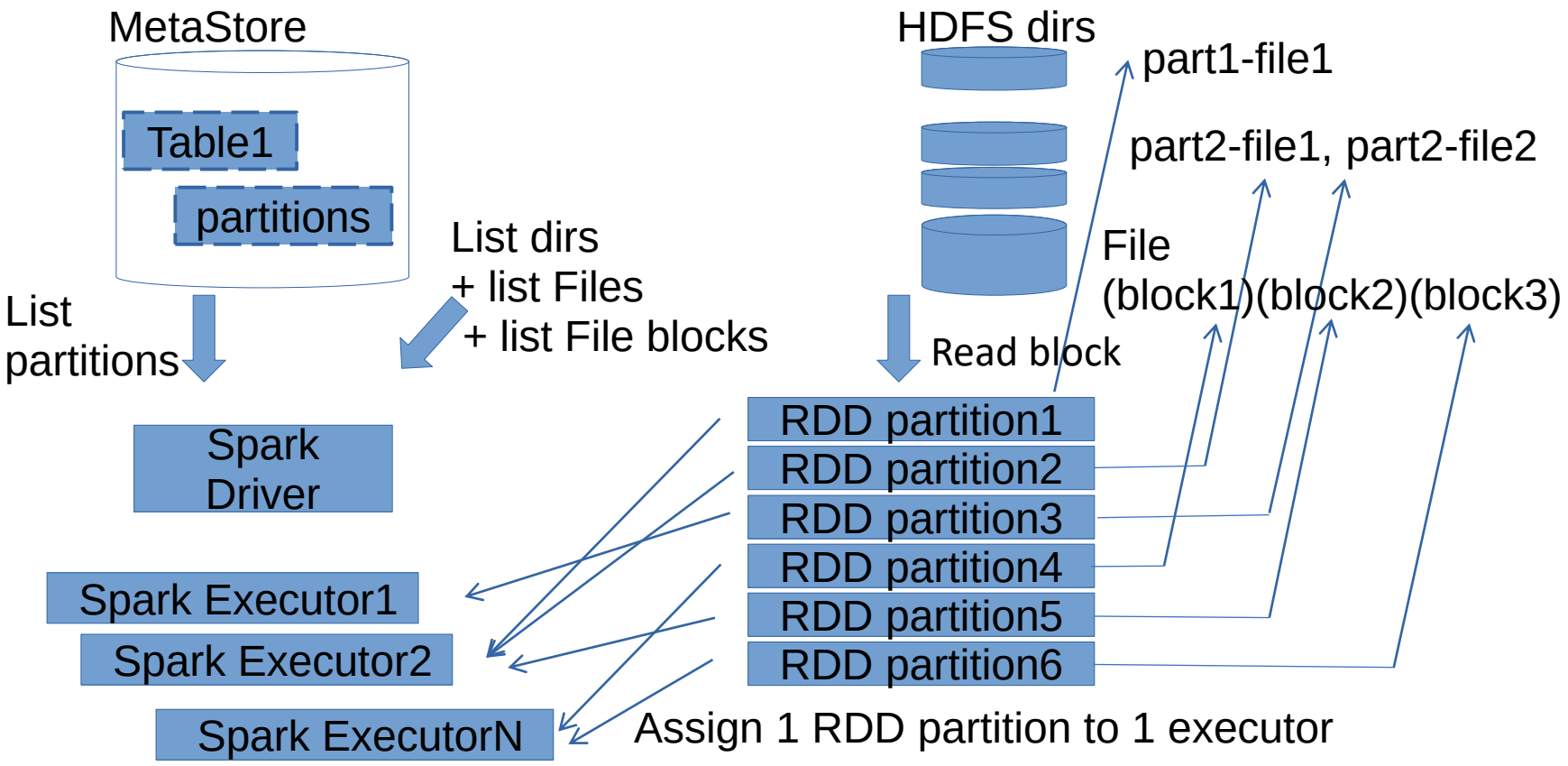


… value within min/Max of all blocks
=> NO skipped block … only False positives

Sorted + Small blocks 16M

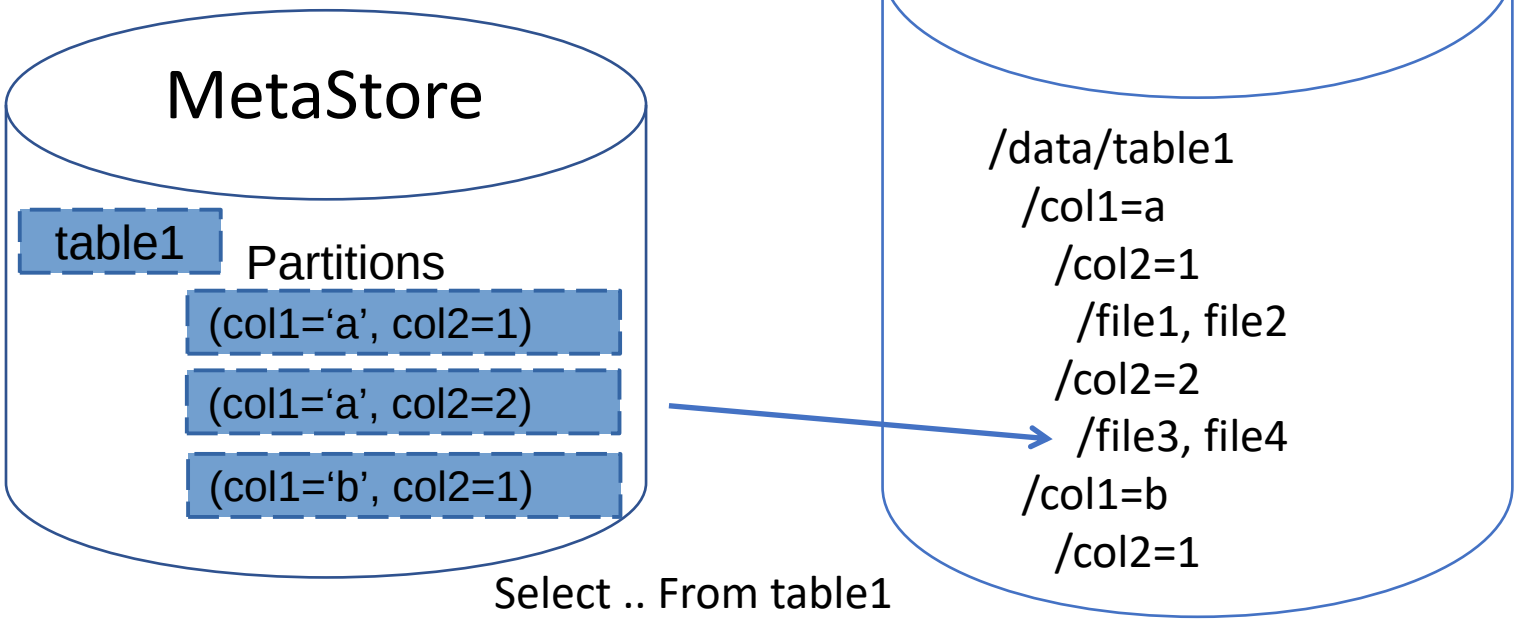


Recap Optimizations 1/5
Distributed RDD: Splittable File Blocks



Recap Optimizations 2/5
Hive Metastore Partitions Pruning

CREATE EXTERNAL TABLE table1 (col3, col4, …colN)
PARTITIONED BY (col1 string, col2 int)



Select .. From table1
Where col1=a and col2=2
-- partitioned columns

Recap Optimizations 3/5
Schema, Binary Encoding, Dictionary

CSV, Xml, ND-JSON	Schema-less file formats ! … innefficient text encoding Redundant <xml> value</xml> or « json »: « value»
PARQUET, ORC	Strongly typed Schema embedded in file … efficient binary encoding Efficient incremental encoding, or Dictionary

Recap Optimizations 4/5

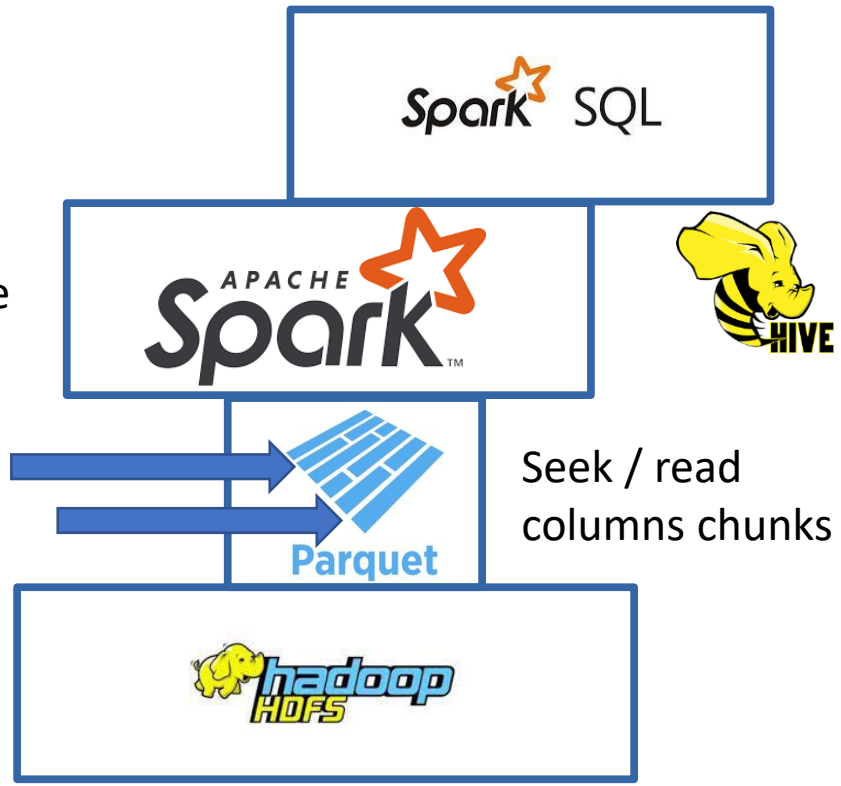
Columns Pruning
(seek in Columnar Format)

Select col2, colP from table…
(prune all other columns)

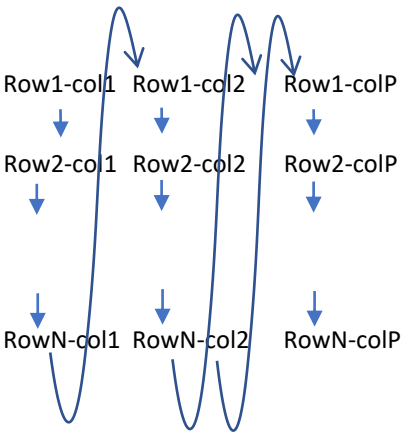
DataSet / RDD on Parquet file

Parquet API
to read columns chunks

Fewer IO



Seek / read
columns chunks



Recap Optimizations 5/5

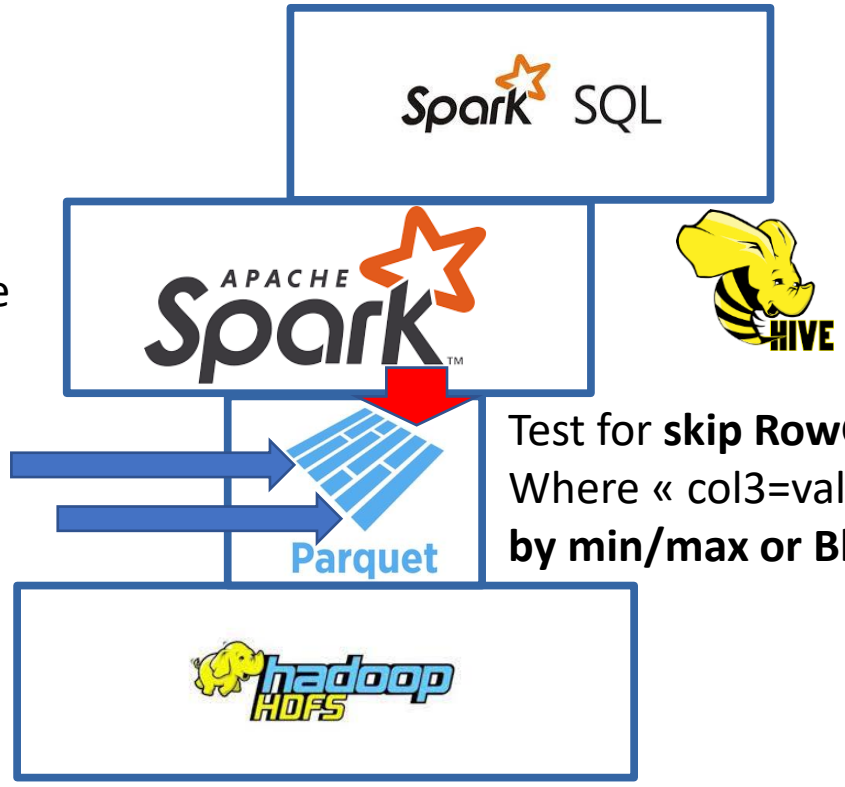
PredicatePushDown (min-max statistics/Bloom)

Select col2, colP from table…
(prune all other columns)

DataSet / RDD on Parquet file

Parquet API
to read columns chunks

Fewer IO



Test for **skip RowGroups**(=blocks)
Where « col3=value3 »
by min/max or Bloom

Next… part 5

Spark