Big Data

Spark deployment

Stéphane Vialle & **Gianluca Quercini**

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Spark deployment

1. **DAG of lazy operations**
2. Ex of Spark execution on cluster (standalone mode)
3. Ex of Spark execution on cloud

A1 - Ex of Spark execution on cluster (YARN manager)
A2 - Ex of Spark execution on cluster (MESOS manager)

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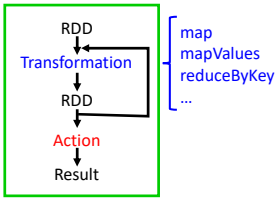
DAG of lazy operations

- *A RDD is a dataset distributed among the Spark compute nodes*
- *Transformations* are **lazy** operations: saved and executed further
- *Actions* **trigger** the execution of the sequence of transformations

A *job* is a sequence of RDD transformations, ended by an action



A ***Spark application*** is ***a set of jobs*** to run sequentially or in parallel
→ A DAG of tasks

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DAG of lazy operations

The *Spark application driver* controls the application run

- It creates the Spark context
- It analyses the Spark program

- It **creates** a **DAG of tasks** for each job
- It **optimizes** the DAG
  - pipelining narrow transformations
  - identifying the tasks that can be run in parallel

- It **schedules** the DAG of tasks on the available worker nodes (the *Spark Executors*) **in order to maximize parallelism** (and to reduce the execution time)

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Task DAG execution

Spark job trace: on 10 Spark executors, with 3GB input file

```
DAGScheduler: Submitting 24 missing tasks from ShuffleMapStage 0 ...
TaskSchedulerImpl: Adding task set 0.0 with 24 tasks
...
TaskSetManager: Starting task 1.0 in stage 0.0 (TID 1, 172.20.10.14, executor 0, partition 1, ...)
TaskSetManager: Starting task 2.0 in stage 0.0 (TID 2, 172.20.10.11, executor 7, partition 2, ...)
...
TaskSetManager: Starting task 10.0 in stage 0.0 (TID 10, 172.20.10.11, executor 7, partition 10, ...)

TaskSetManager: Finished task 2.0 in stage 0.0 (TID 2) in 18274 ms … (executor 7) (1/24)
TaskSetManager: Starting task 11.0 in stage 0.0 (TID 11, 172.20.10.7, executor 8, partition 11, ...)
TaskSetManager: Finished task 8.0 in stage 0.0 (TID 8) in 18459 ms … (executor 8) (2/24)
...

TaskSchedulerImpl: Removed TaskSet 0.0, whose tasks
                   have all completed, from pool
...
```

Submitting the 10 first tasks on the 10 Spark executor processes

Submitting a new task when a previous one has finished

End of task graph execution

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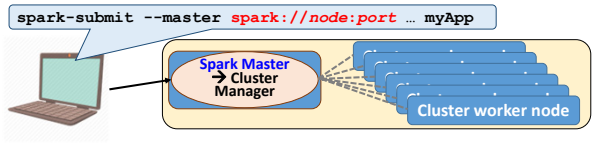
Using the Spark Master as cluster manager (standalone mode)



Spark cluster configuration:

- Add the list of cluster worker nodes in the Spark Master config.
- Specify the maximum amount of memory per Spark Executor
  `spark-submit --executor-memory XX …`
- Specify the total amount of CPU cores used to process one Spark application (through all its Spark executors)
  `spark-submit --total-executor-cores YY …`

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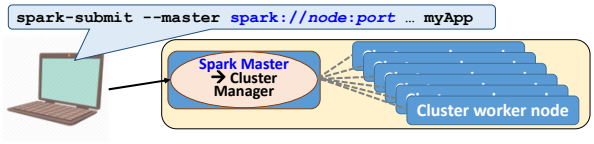
Using the Spark Master as cluster manager (standalone mode)



Spark cluster configuration:

- Default config :
  - (only) 1GB/Spark Executor
  - Unlimited nb of CPU cores per application execution
  - The Spark Master creates one mono-core Executor on all Worker nodes to process each job …
- You can limit the total nb of cores per job
- You can concentrate the cores into few multi-core Executors

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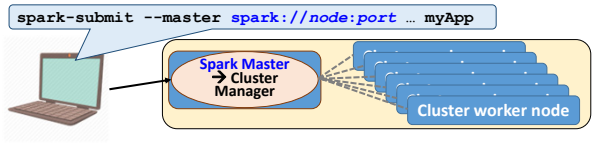
Using the Spark Master as cluster manager (standalone mode)



Spark cluster configuration:

- Default config :
  - (only) 1GB/Spark Executor
  - Unlimited nb of CPU cores per application execution
  - The Spark Master creates one **multi**-core Executor on all Worker nodes to process each job (invading all cores!)
  - But you can fix the nb of cores per Spark Executor
- You can limit the total nb of cores per job
- You can concentrate the cores into few multi-core Executors

Exp 2019

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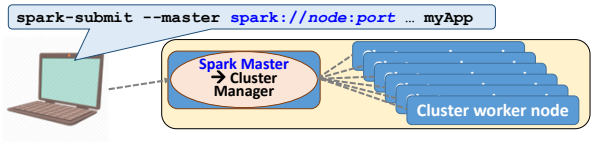
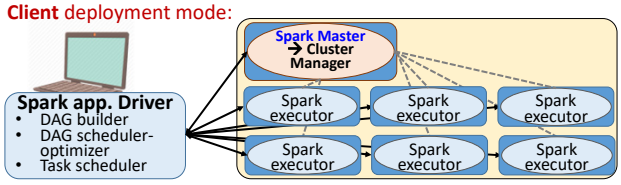
Using the Spark Master as cluster manager (standalone mode)



Client deployment mode:



Interactive control of the application: development mode

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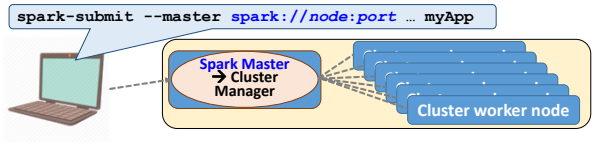
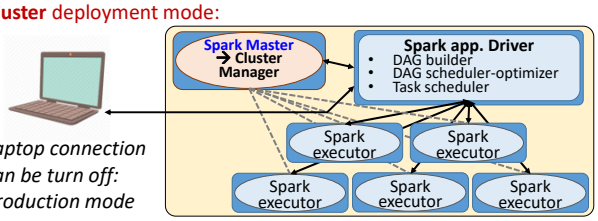
Using the Spark Master as cluster manager (standalone mode)



Cluster deployment mode:



Laptop connection can be turn off: production mode

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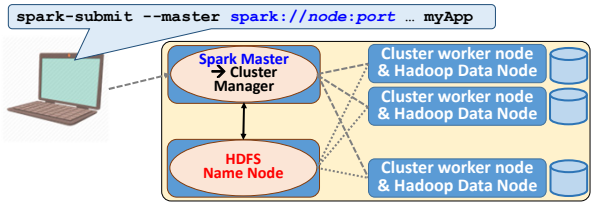
Using the Spark Master as cluster manager (standalone mode)



The Cluster Worker nodes should be the Data nodes, storing initial RDD values or new generated (and saved) RDD

→ Will improve the global data-computations locality

→ **When using HDFS**: the Hadoop data nodes should be re-used as worker nodes for Spark Executors

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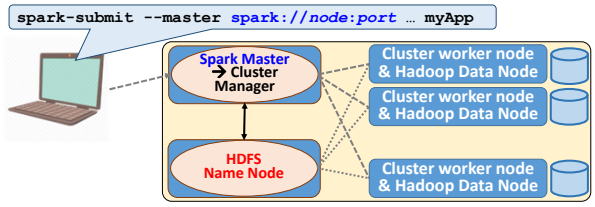
Using the Spark Master as cluster manager (standalone mode)



The Cluster Worker nodes should be the Data nodes, storing initial RDD values or new generated (and saved) RDD

When using the Spark Master as Cluster Manager:

…there is no way to localize the Spark Executors on the data nodes hosting the right RDD blocks!

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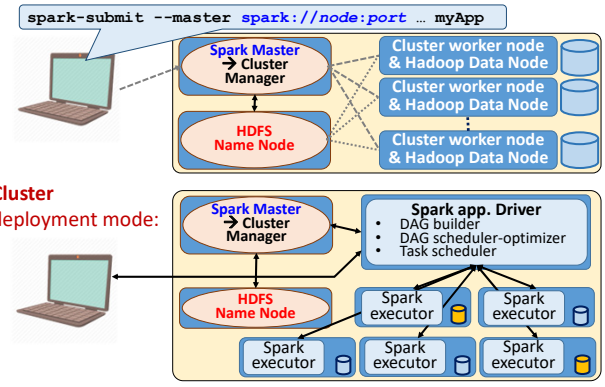
Using the Spark Master as cluster manager (standalone mode)



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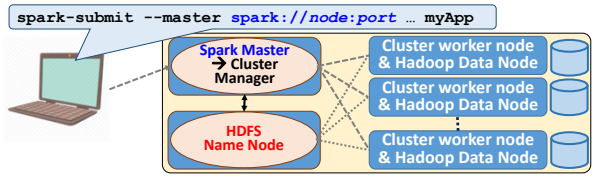
Using the Spark Master as cluster manager (standalone mode)



Strenght and weakness of standalone mode:

- Nothing more to install (included in Spark)
- Easy to configure
- Can run different jobs concurrently
- Can not share the cluster with non-Spark applications
- Can not launch Executors on the data nodes hosting input data
- Limited scheduling mechanism (unique queue)

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3. **Ex of Spark execution on cloud**

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A2 - Ex of Spark execution on cluster (MESOS manager)

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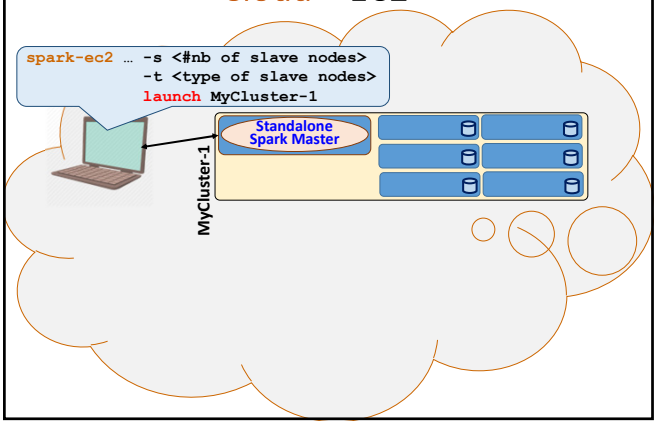
Using Amazon Elastic Compute Cloud « EC2 »



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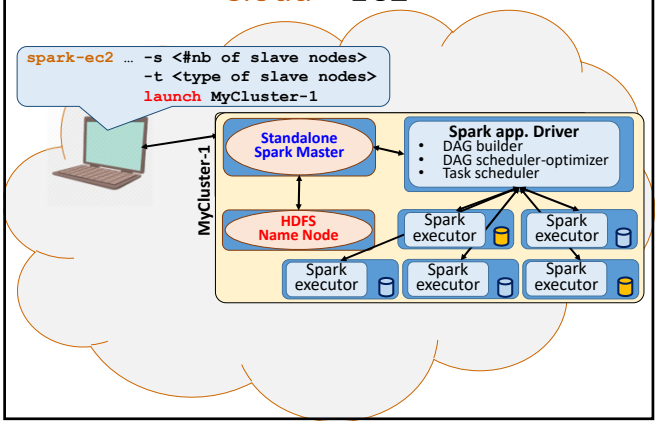

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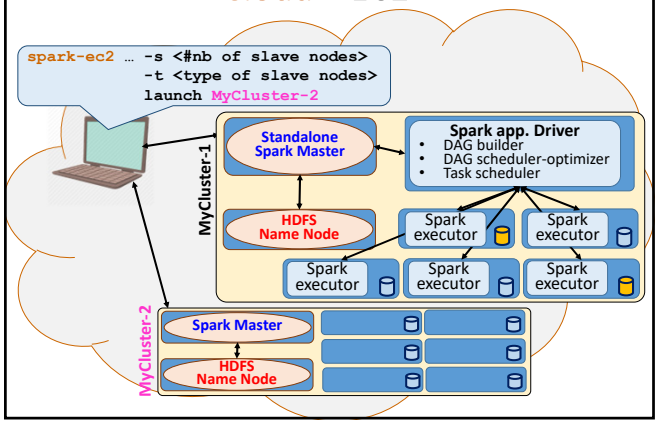

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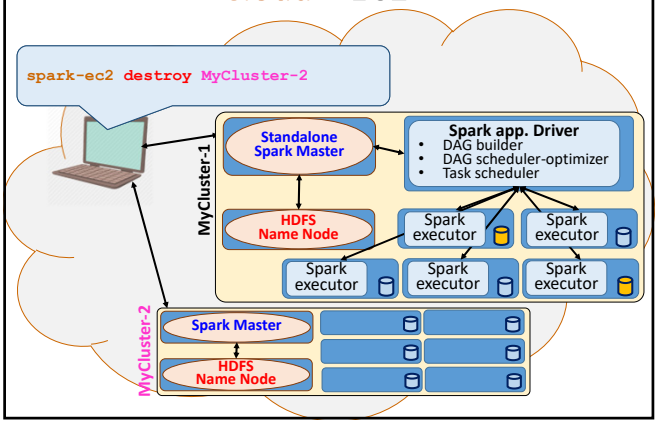

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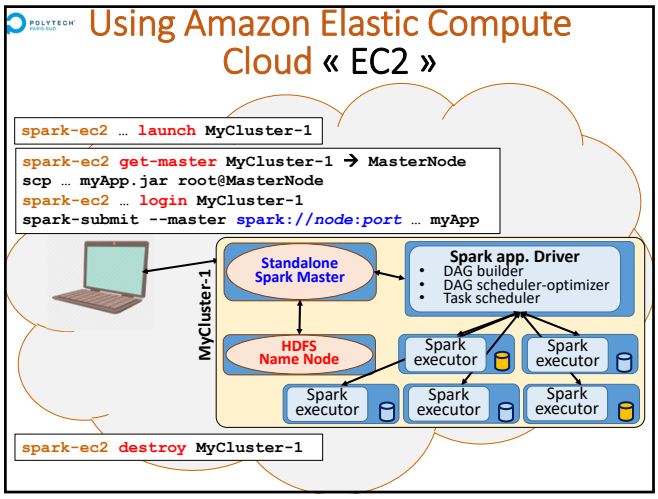

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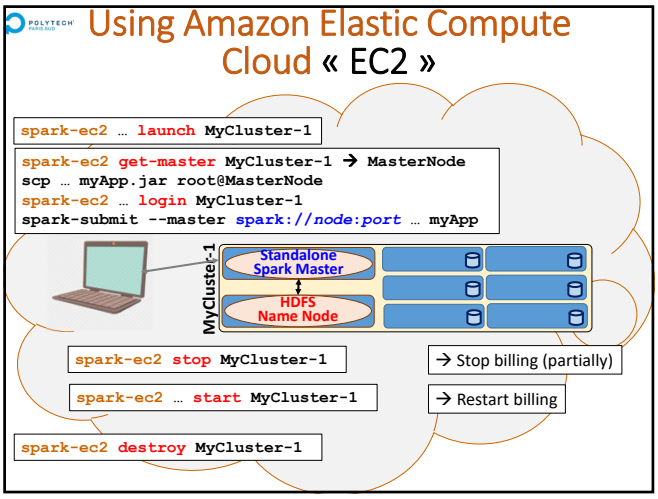

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Using Amazon Elastic Compute Cloud « EC2 »

Start to learn to deploy HDFS and Spark architectures

Then, learn to deploy these architectecture in a CLOUD
… or use a ''Spark Cluster service'': ready to use in a CLOUD!

Learn to minimize the cost (€) of a Spark cluster:

- Allocate the right number of nodes
- Stop Spark cluster when you do not use, and re-start further
- Do not forget to release the allocated machines at the end

Choose to allocate reliable or preemptible machines:

- Reliable machines during all the session (standard)
- Preemptibles machines (5x less expensive!)
  → require to support to loose some tasks, or to checkpoint…

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Spark deployment

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Spark deployment – Appendix

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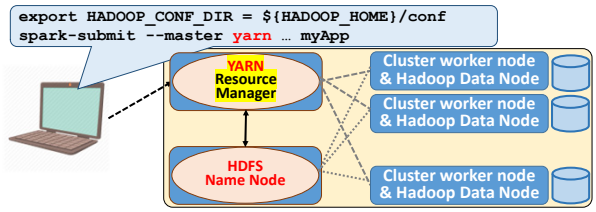
Using YARN as cluster manager



Spark cluster configuration:

- Add an env. variable defining the path to Hadoop conf directory
- Specify the maximum amount of memory per Spark Executor
- Specify the amount of CPU cores used per Spark executor
  `spark-submit --executor-cores YY …`
- Specify the nb of Spark Executors per job: `--num-executors`

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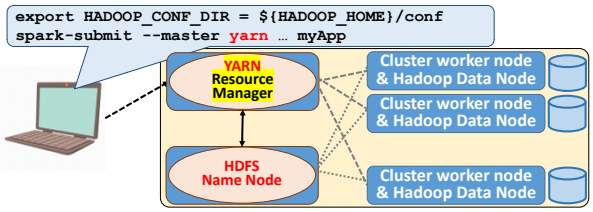
Using YARN as cluster manager



Spark cluster configuration:

- By default:
  - (only) 1GB/Spark Executor
  - (only) 1 CPU core per Spark Executor
  - (only) 2 Spark Executors per job
- Usually better with few large Executors (RAM & nb of cores)…

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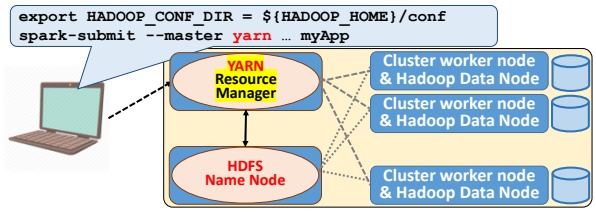
Using YARN as cluster manager



Spark cluster configuration:

- Link Spark RDD meta-data « prefered locations » to HDFS meta-data about « localization of the input file blocks »

```
val sc = new SparkContext(sparkConf,
           InputFormatInfo.computePreferredLocations(
             Seq(new InputFormatInfo(conf,
               classOf[org.apache.hadoop.mapred.TextInputFormat], hdfspath ))...
```

Spark Context construction

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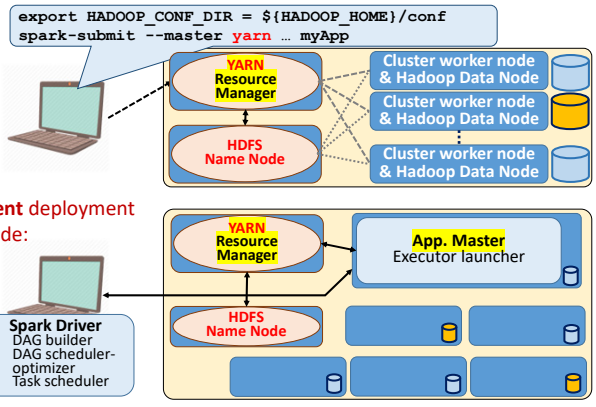
Using YARN as cluster manager



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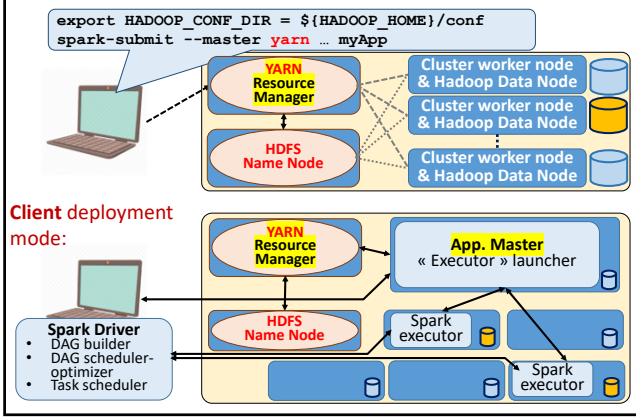
Using YARN as cluster manager



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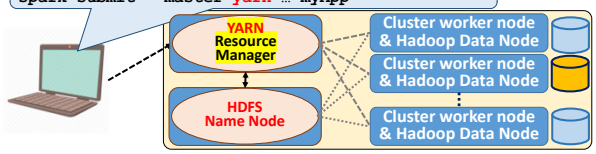
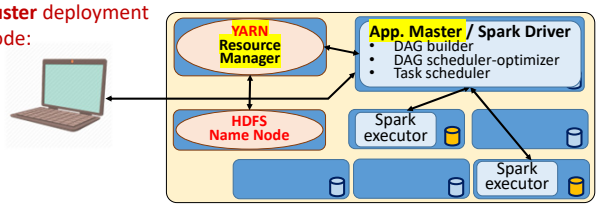
Using YARN as cluster manager

```
export HADOOP_CONF_DIR = ${HADOOP_HOME}/conf
spark-submit --master yarn … myApp
```



Cluster deployment mode:



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Using YARN as cluster manager

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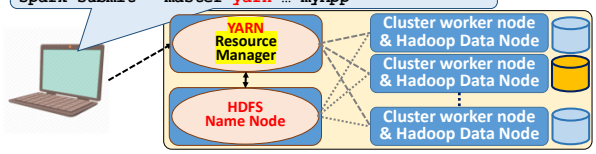

YARN ***vs*** **standalone Spark Master:**

- Usually available on HADOOP/HDFS clusters
- Allows to run Spark and other kinds of applications on HDFS (*better to share a Hadoop cluster*)
- Advanced application scheduling mechanisms (*multiple queues, managing priorities…*)

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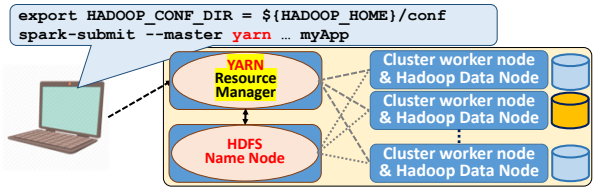
Using YARN as cluster manager

```
export HADOOP_CONF_DIR = ${HADOOP_HOME}/conf
spark-submit --master yarn … myApp
```



YARN ***vs*** **standalone Spark Master:**

- Improvement of the data-computation locality…but is it critical ?
  - Spark reads/writes only input/output RDD from Disk/HDFS
  - Spark keeps intermediate RDD in-memory
  - With cheap disks: disk-IO time > network time

  → Better to deploy many Executors on unloaded nodes ?

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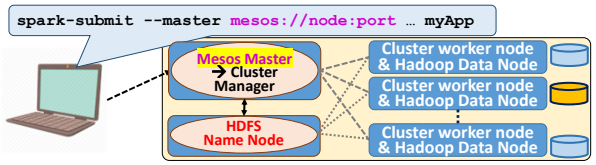
Using MESOS as cluster manager

```
spark-submit --master mesos://node:port … myApp
```



Mesos is a generic cluster manager

- Supporting to run both:
  - short term distributed computations
  - long term services (like web services)
- Compatible with HDFS

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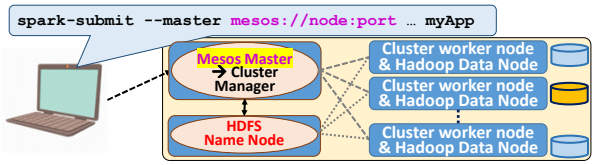
Using MESOS as cluster manager

```
spark-submit --master mesos://node:port … myApp
```



- Specify the maximum amount of memory per Spark Executor
  `spark-submit --executor-memory XX …`
- Specify the total amount of CPU cores used to process one Spark application (through all its Spark executors)
  `spark-submit --total-executor-cores YY …`
- Default config:
  - create few Executors with max nb of cores → like standalone…
  - use all available cores to process each job …in 2019

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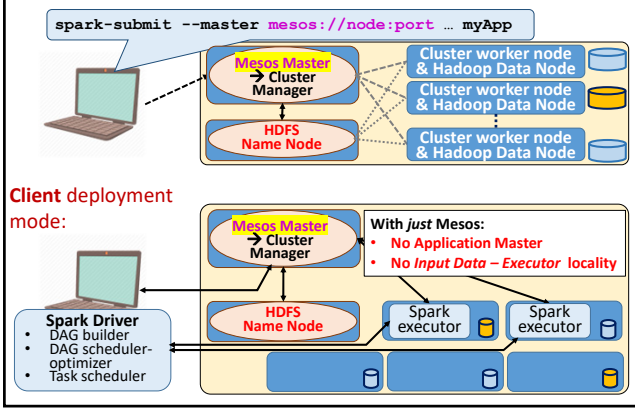
Using MESOS as cluster manager



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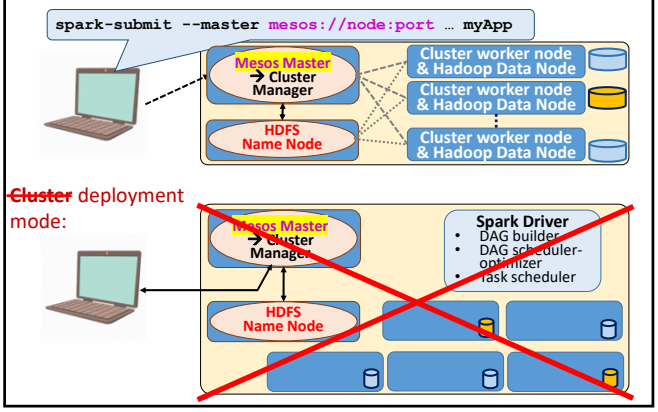
Using MESOS as cluster manager



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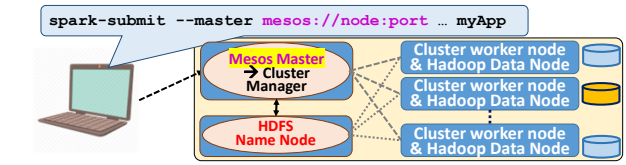
Using MESOS as cluster manager



- **Coarse grained mode**: number of cores allocated to each Spark Executor are set at launching time, and cannot be changed
- **Fine grained mode**: number of cores associated to an Executor can dynamically change, function of the number of concurrent jobs and function of the load of each executor **(specificity!)**

→ Better solution/mechanism to support **many shell interpretors**
→ **But latency can increase** (*Spark Streaming* lib can be disturbed)

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Spark deployment

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