- YARN cluster resource allocation concepts
- Requesting resources in YARN: CPU and memory
- How does YARN handle job failures?
- Monitoring YARN Using the YARN web-UI and command line

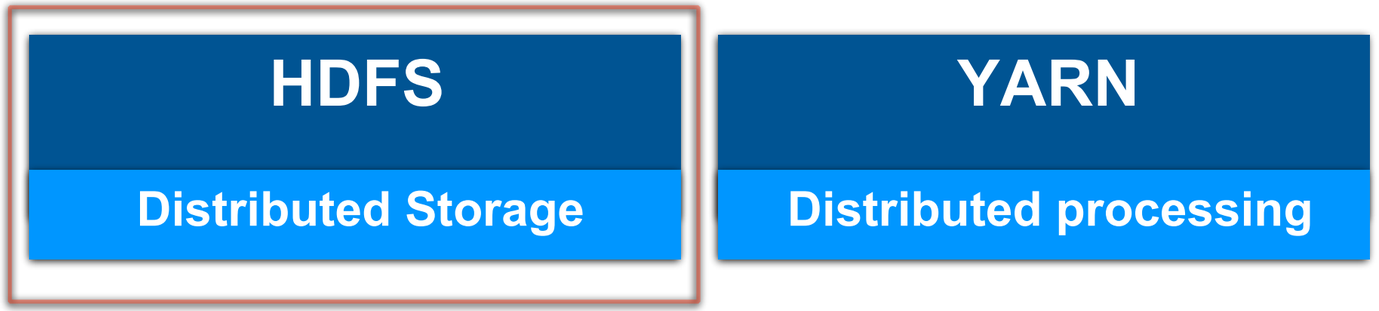
COURSE AGENDA

CORE HADOOP 2.0

“Core” Hadoop

HDFS IN A NUTSHELL

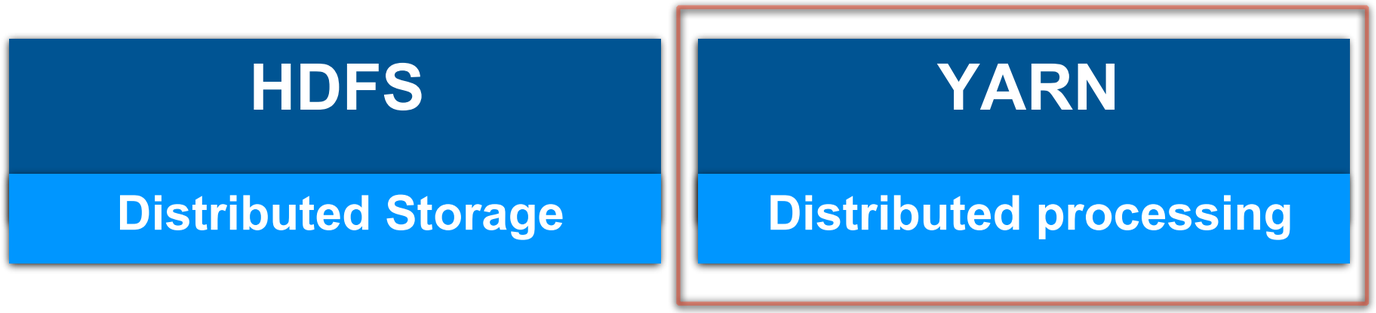
- HDFS facilitates data storage in Hadoop
- Provides redundant storage for massive amounts of data
- Provides parallel read performance when accessing data



“Core” Hadoop

YARN IN A NUTSHELL

- YARN is the architecture for managing and controlling resources in an Hadoop cluster
- YARN allows for running jobs / applications



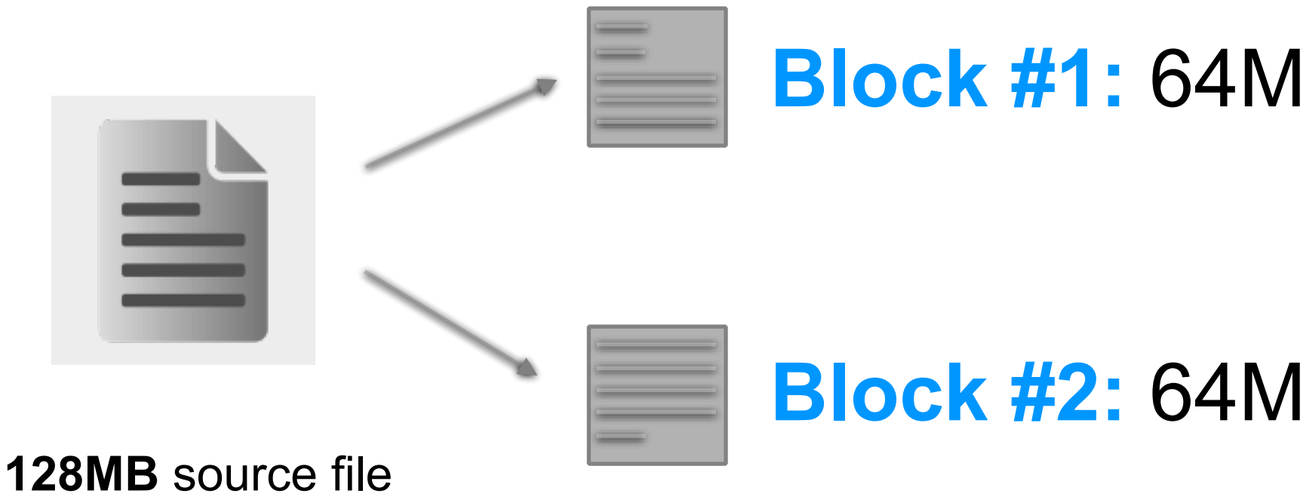
“Core” Hadoop

HDFS: DIGGING DEEPER

- High performance
- Fault tolerant
- Simple management: master / slave architecture
- Optimized for distributed processing of data
- Allows for easy scalability

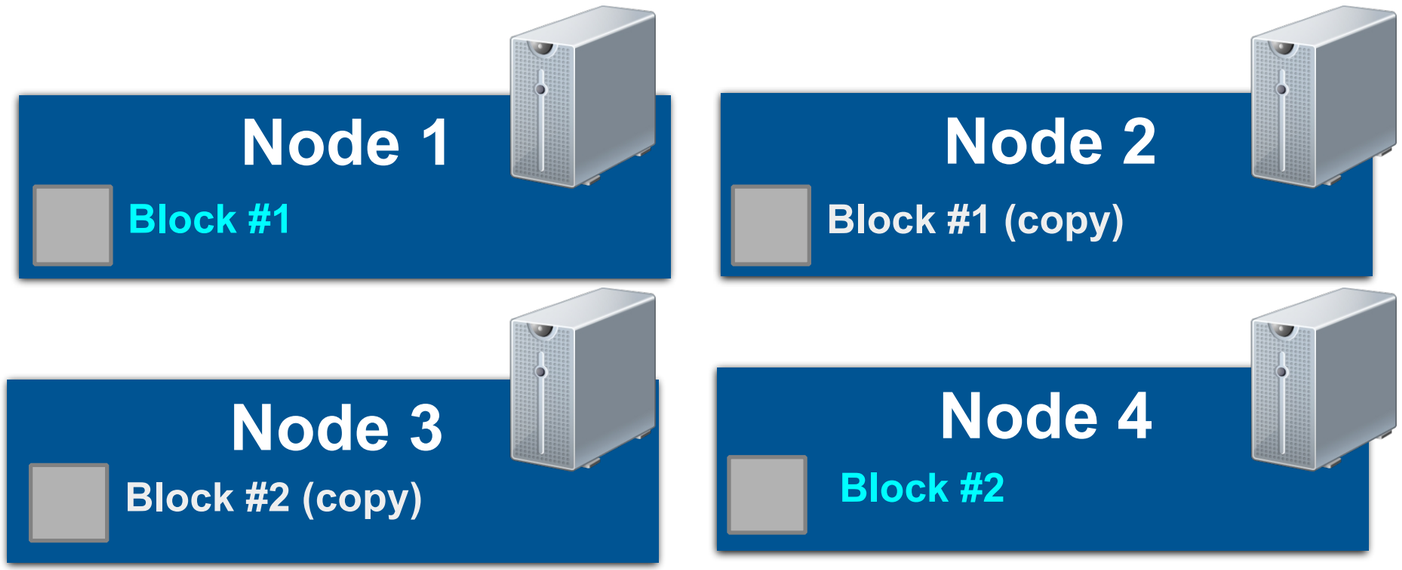
HDFS: DIGGING DEEPER

- When a file is uploaded to HDFS, it is stripped into “blocks”



HDFS: DIGGING DEEPER

- Each block is stored on a different Hadoop node + replicas:



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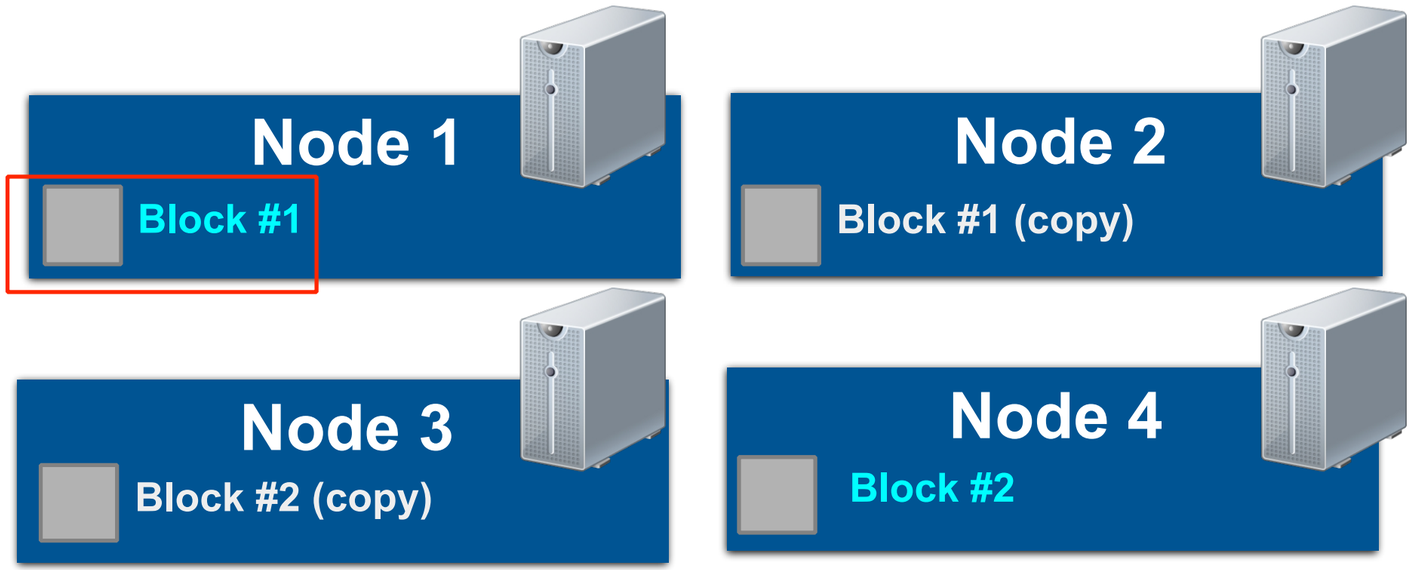

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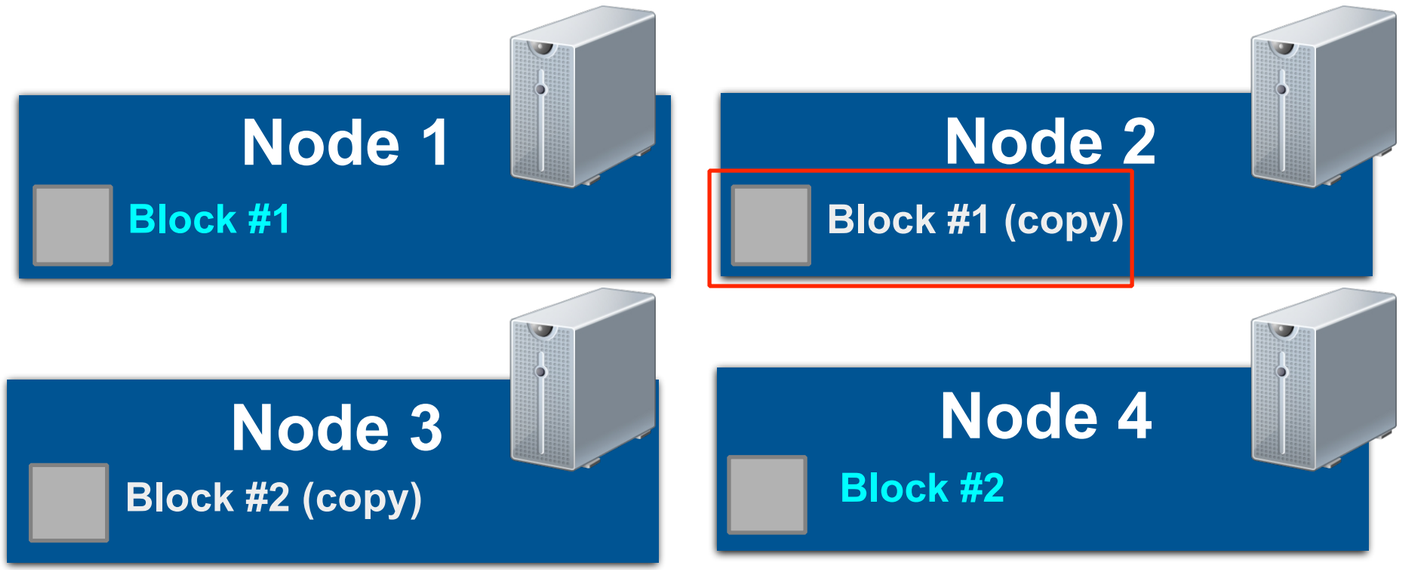

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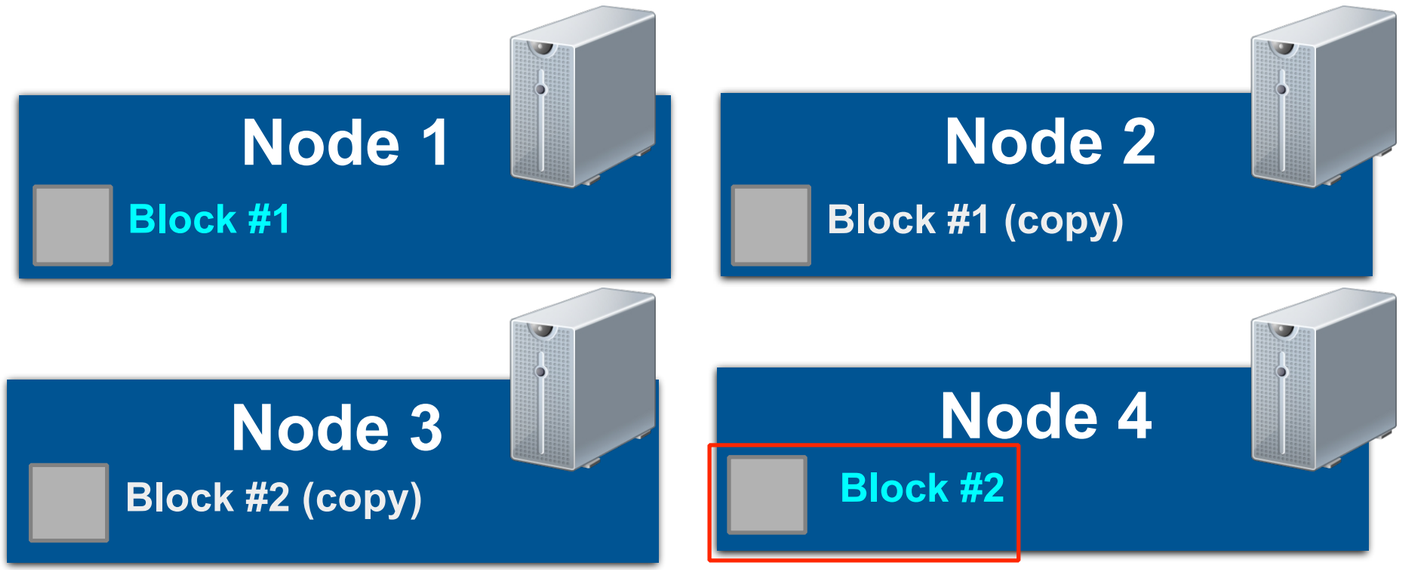

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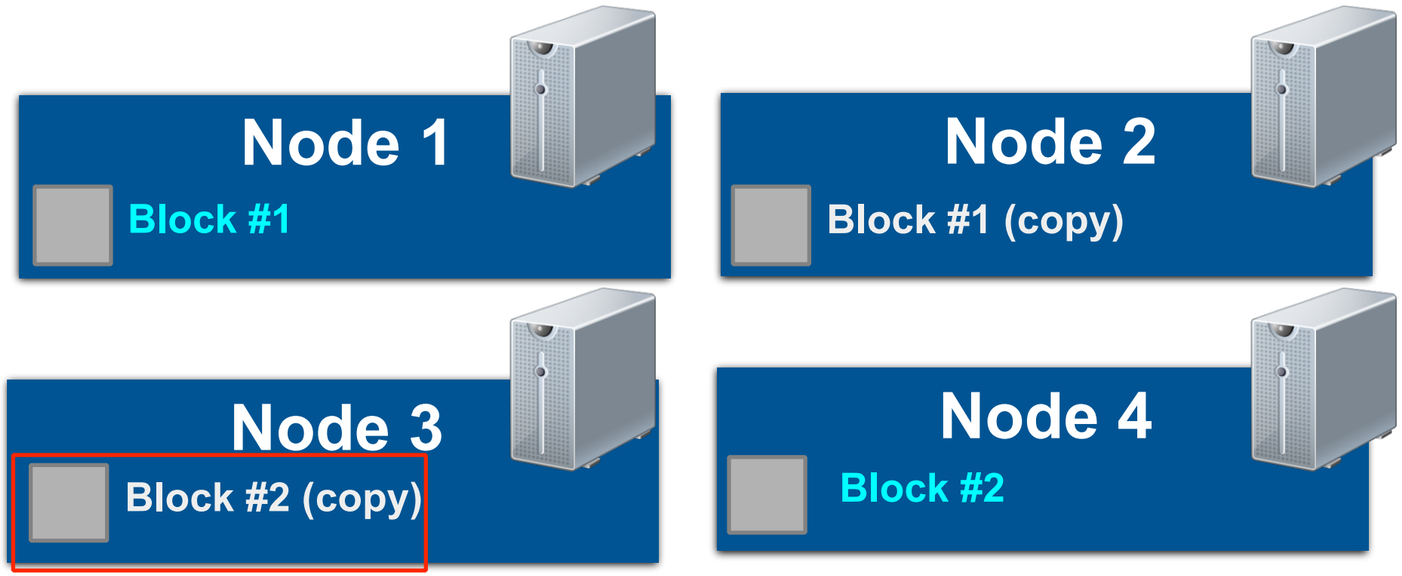

HDFS: DIGGING DEEPER

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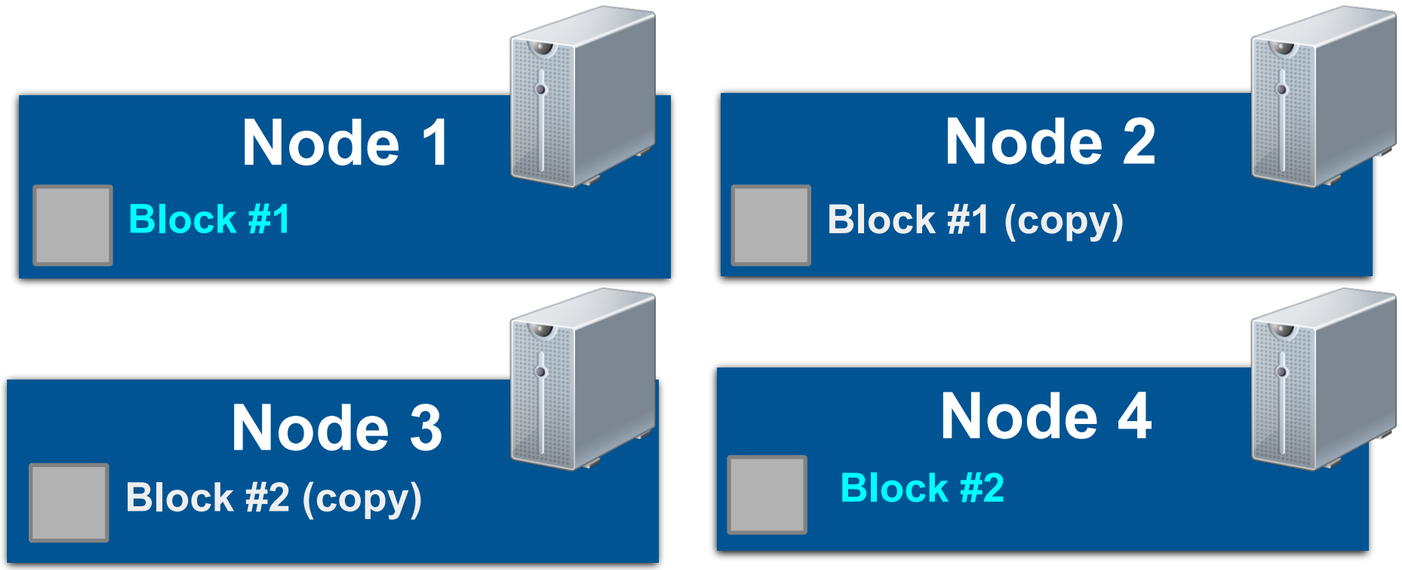
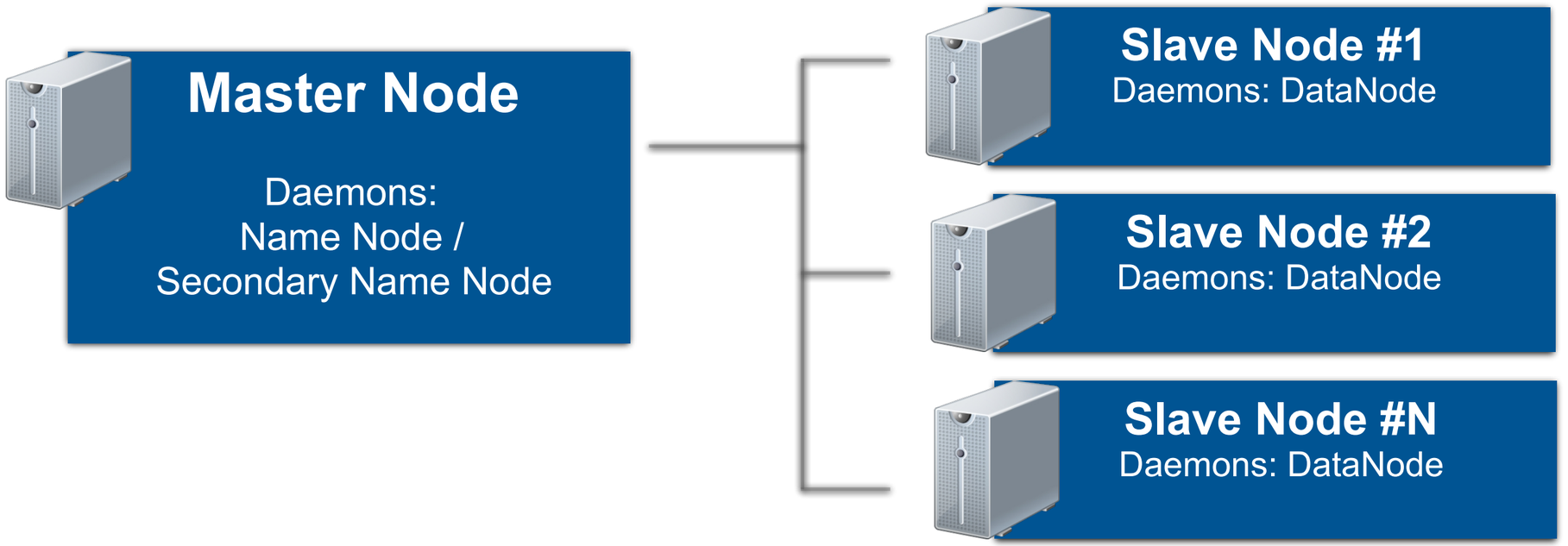


HDFS: DIGGING DEEPER

- Master node (Name Node / Secondary Name Node daemons): stores HDFS metadata.
- Slave Node (DataNode daemons): store actual data blocks (which make up HDFS files)

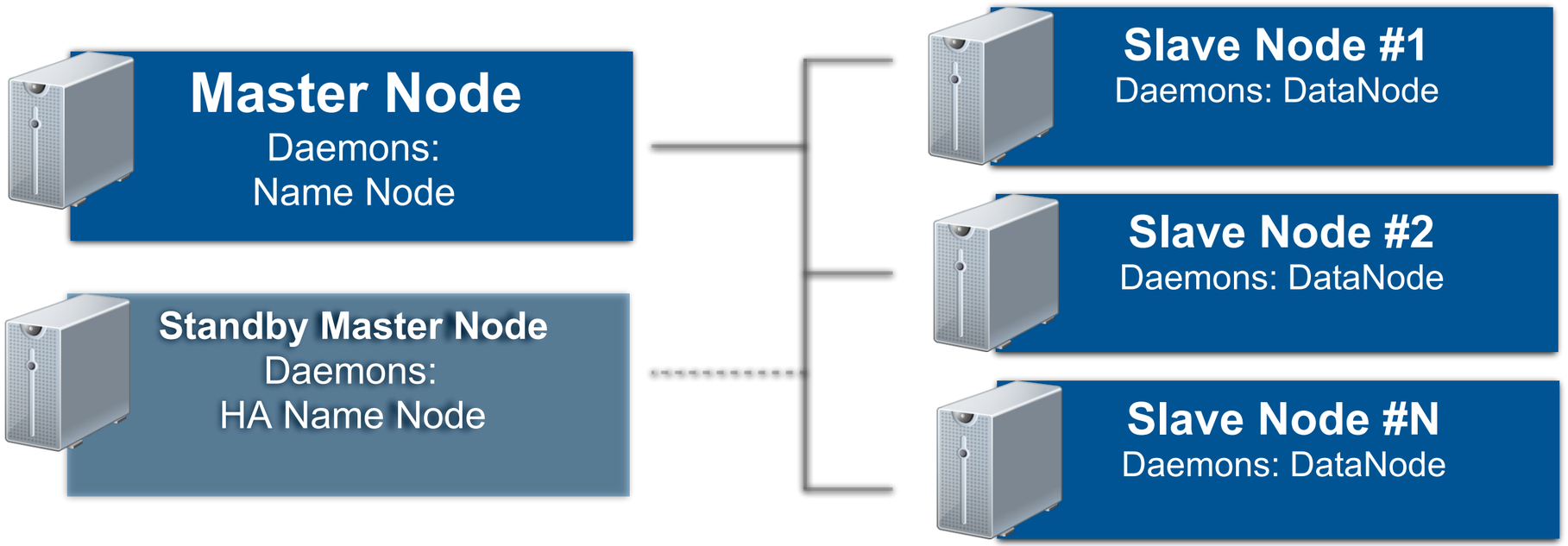
HDFS: DIGGING DEEPER



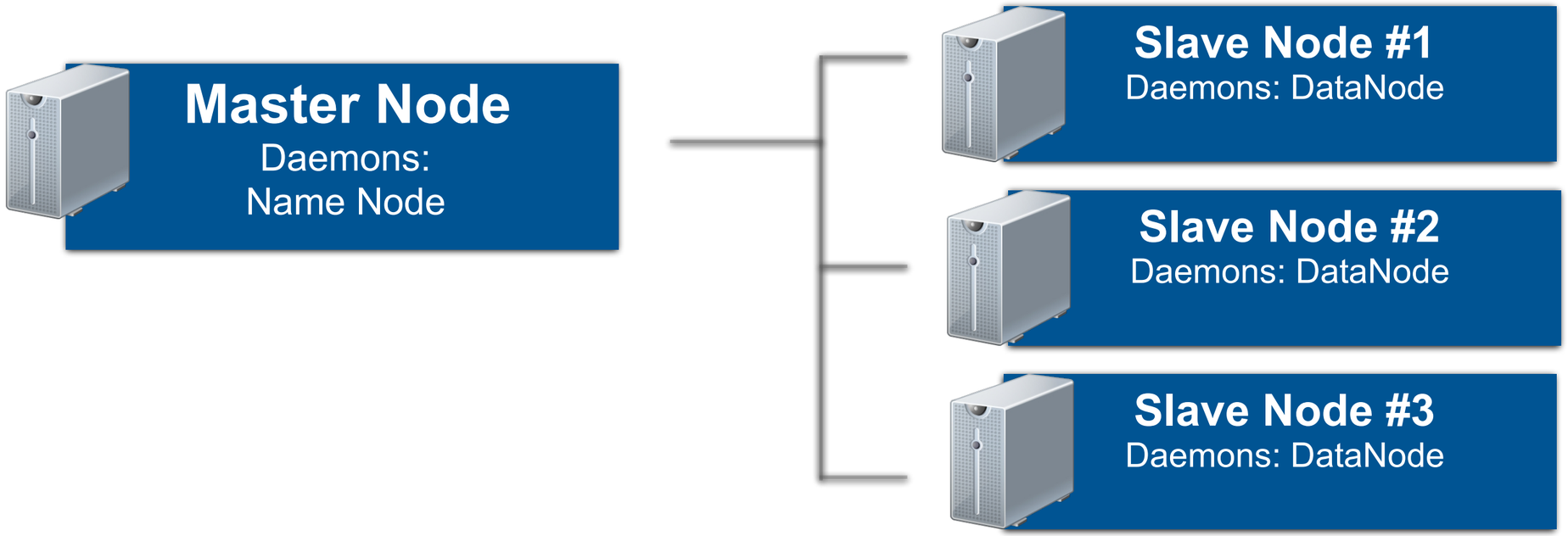
HDFS: DIGGING DEEPER

- Master node (Name Node daemon): stores HDFS metadata.
- Standby Master node (HA Name Node daemon): high availability for master node.
- Slave Node (DataNode daemons): store actual data blocks (which make up HDFS files)

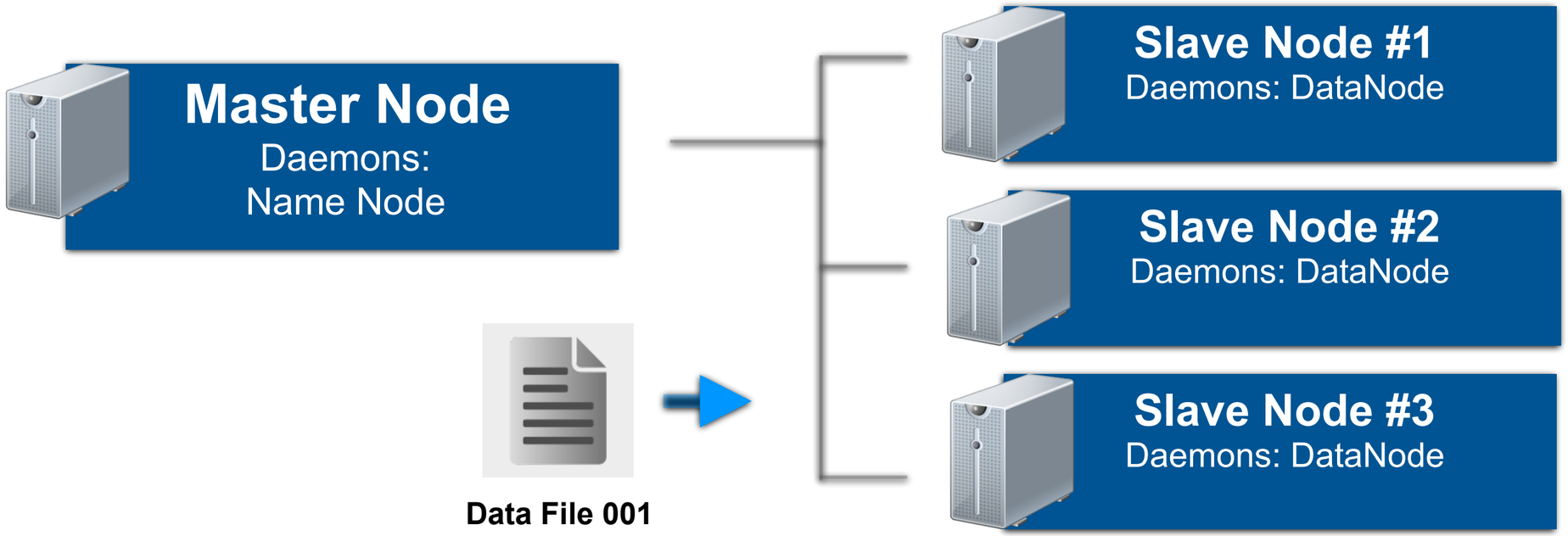
HDFS: DIGGING DEEPER



HDFS: SCALABILITY



HDFS: SCALABILITY



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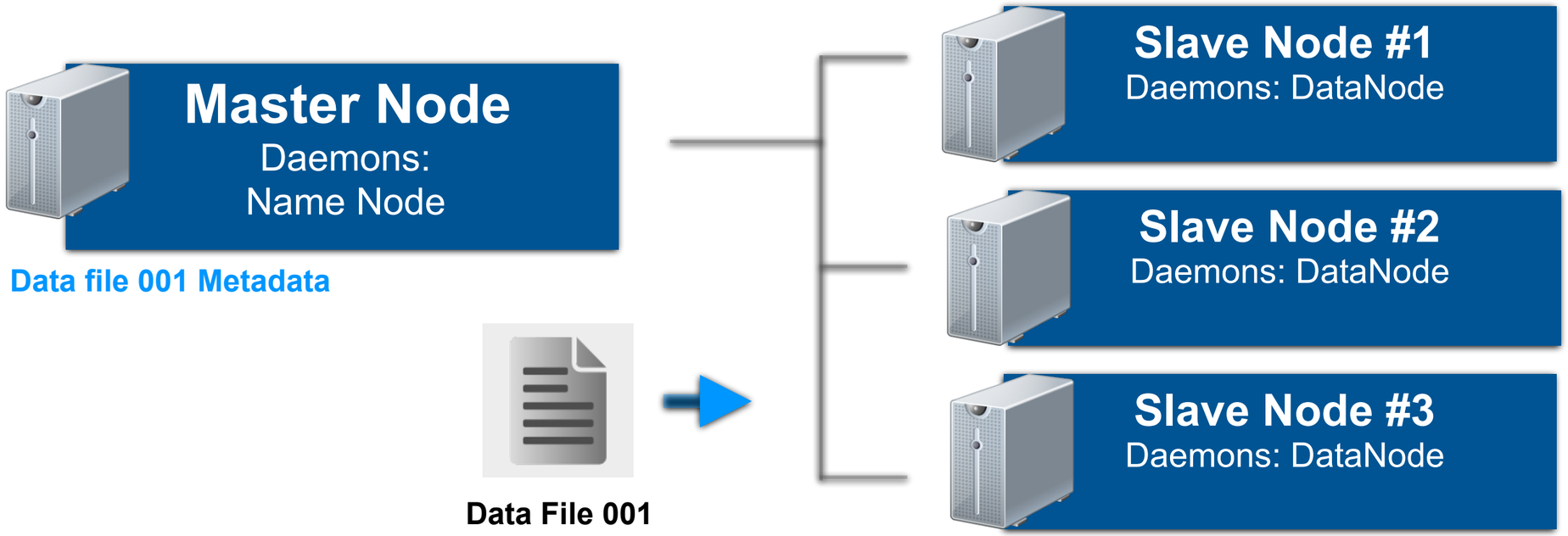
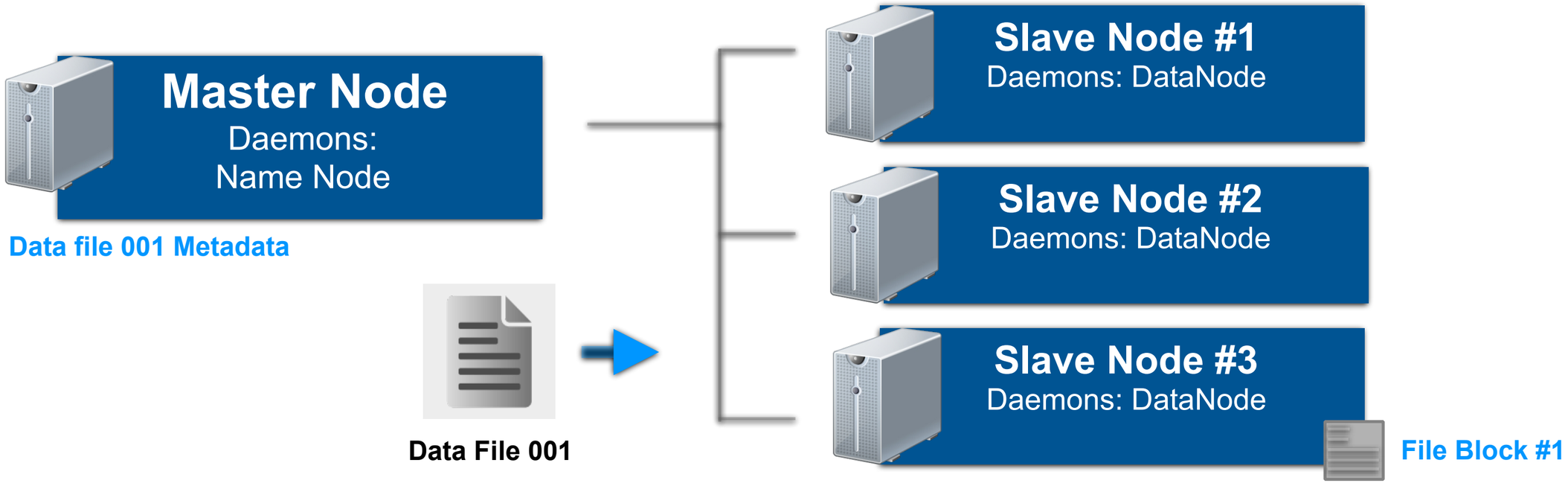
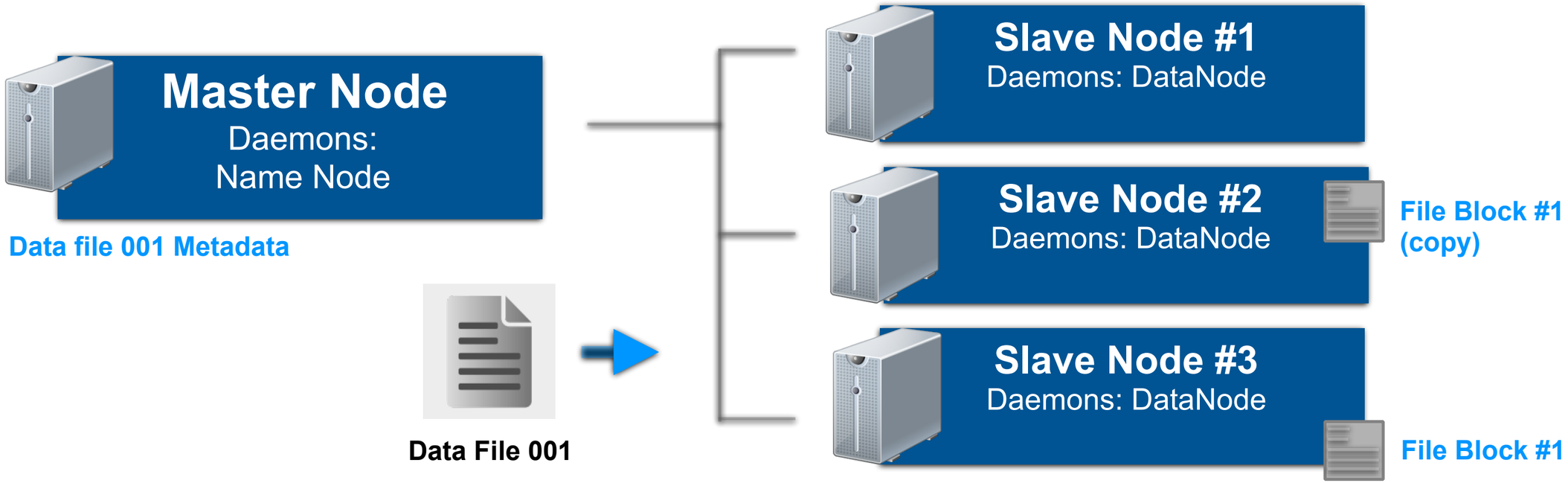


HDFS: SCALABILITY



HDFS: SCALABILITY



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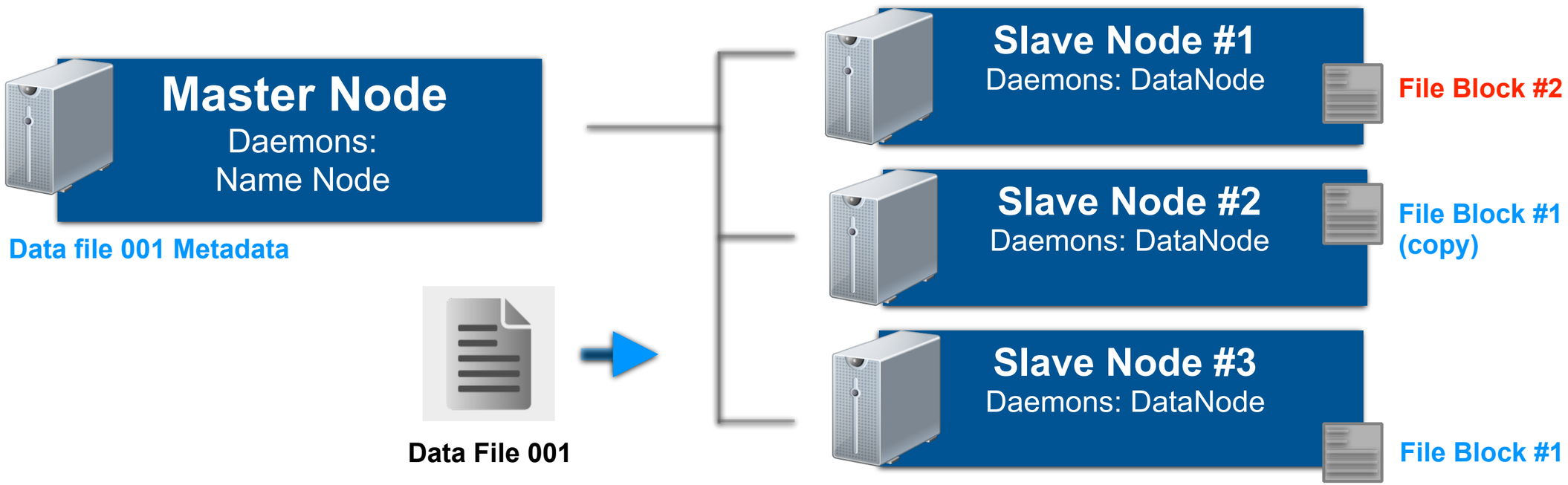

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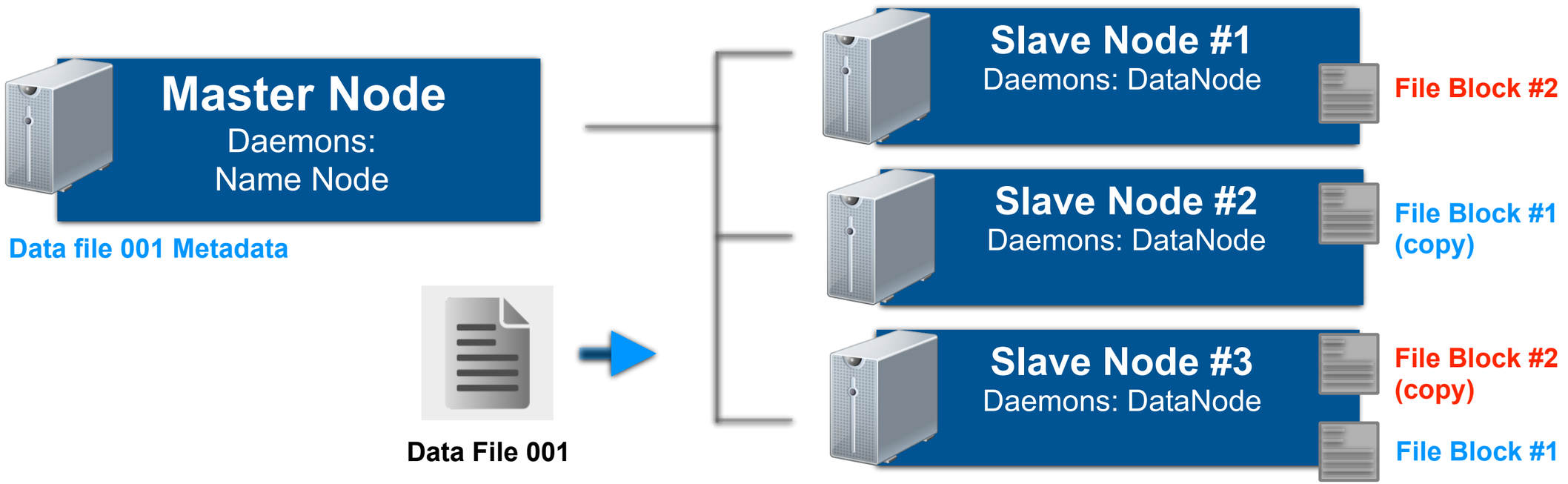

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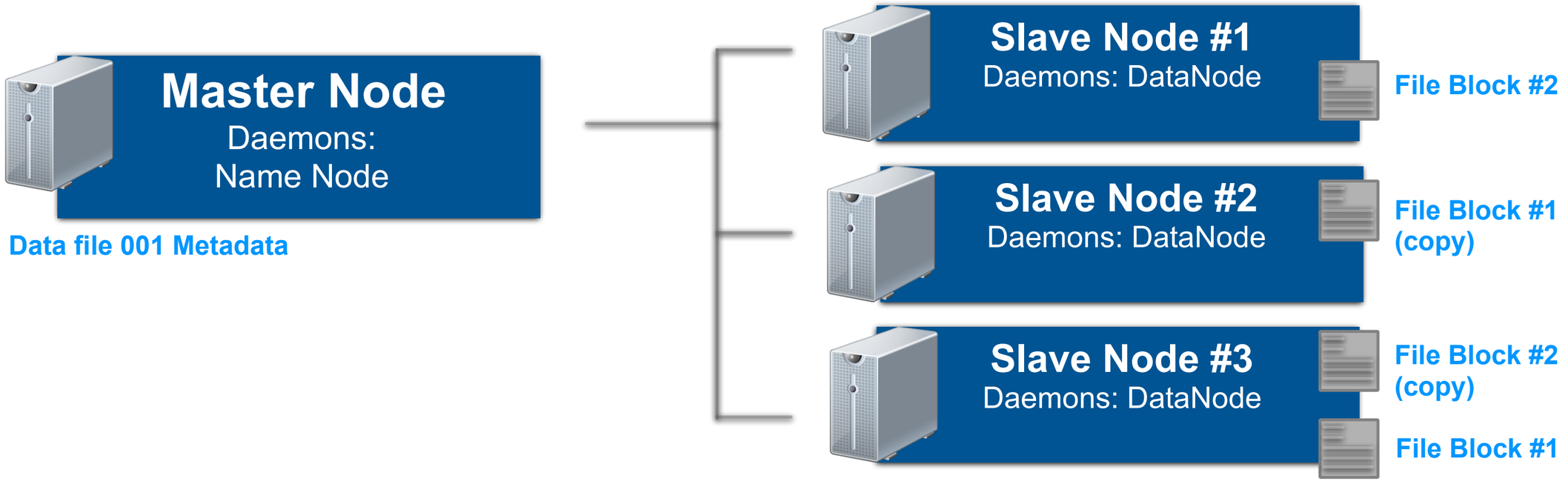

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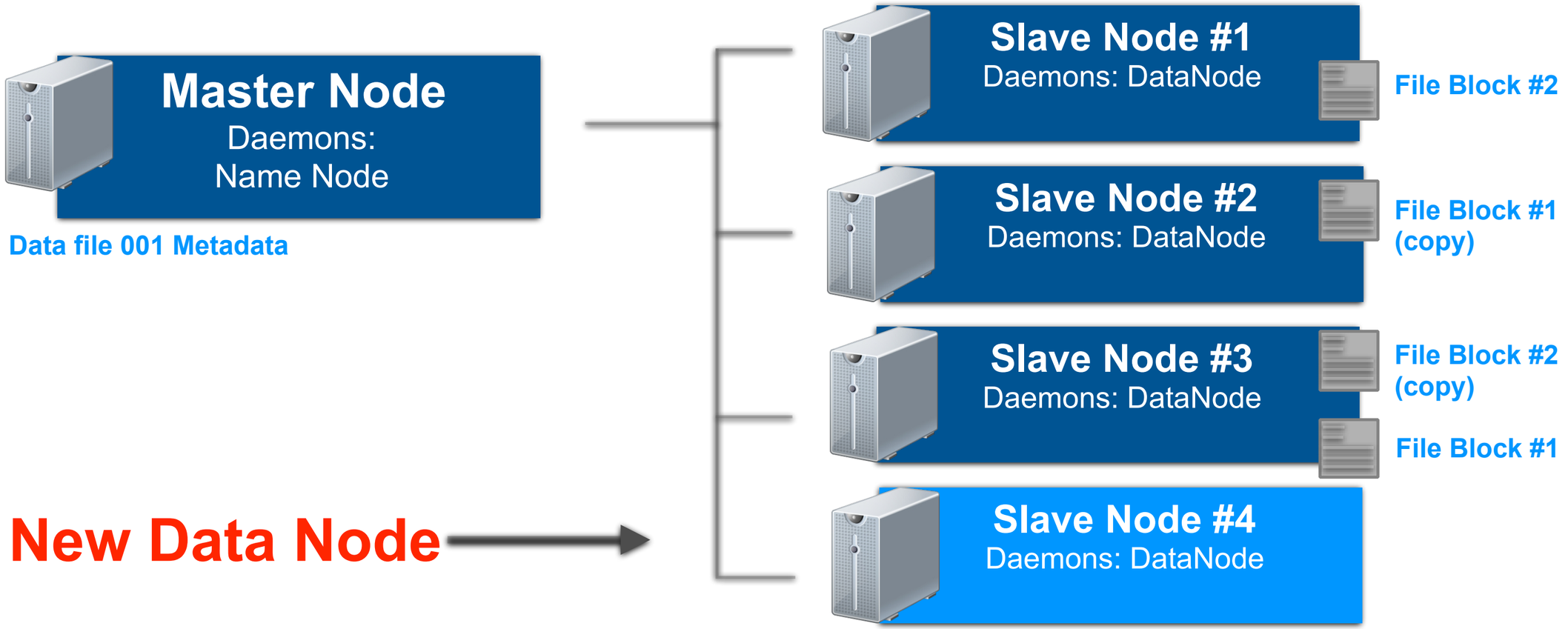

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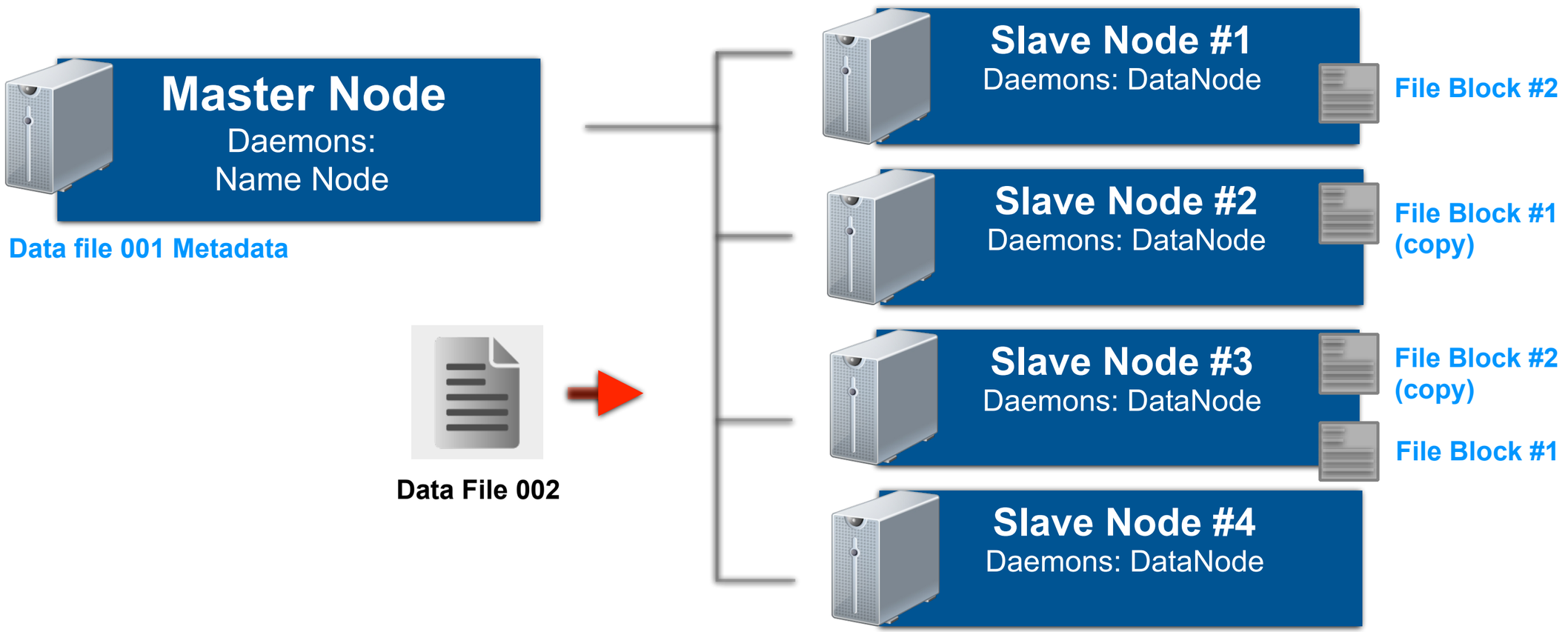

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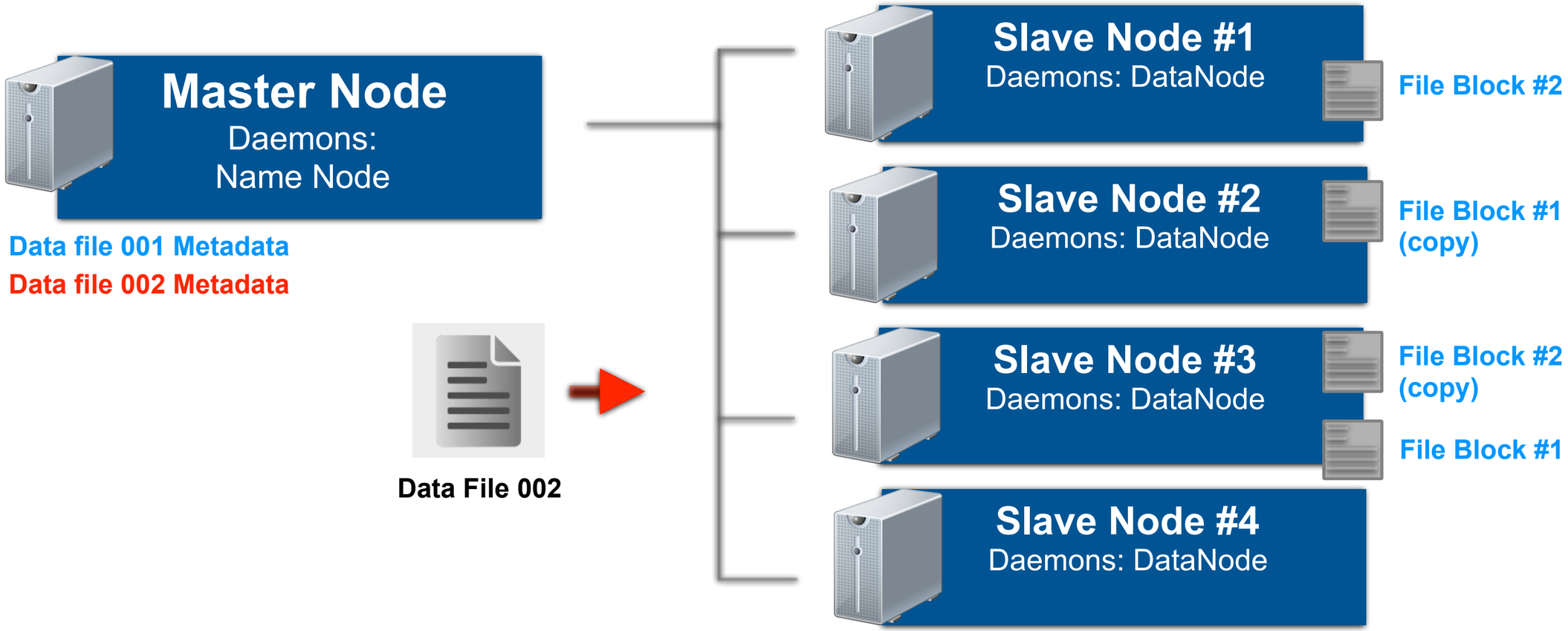

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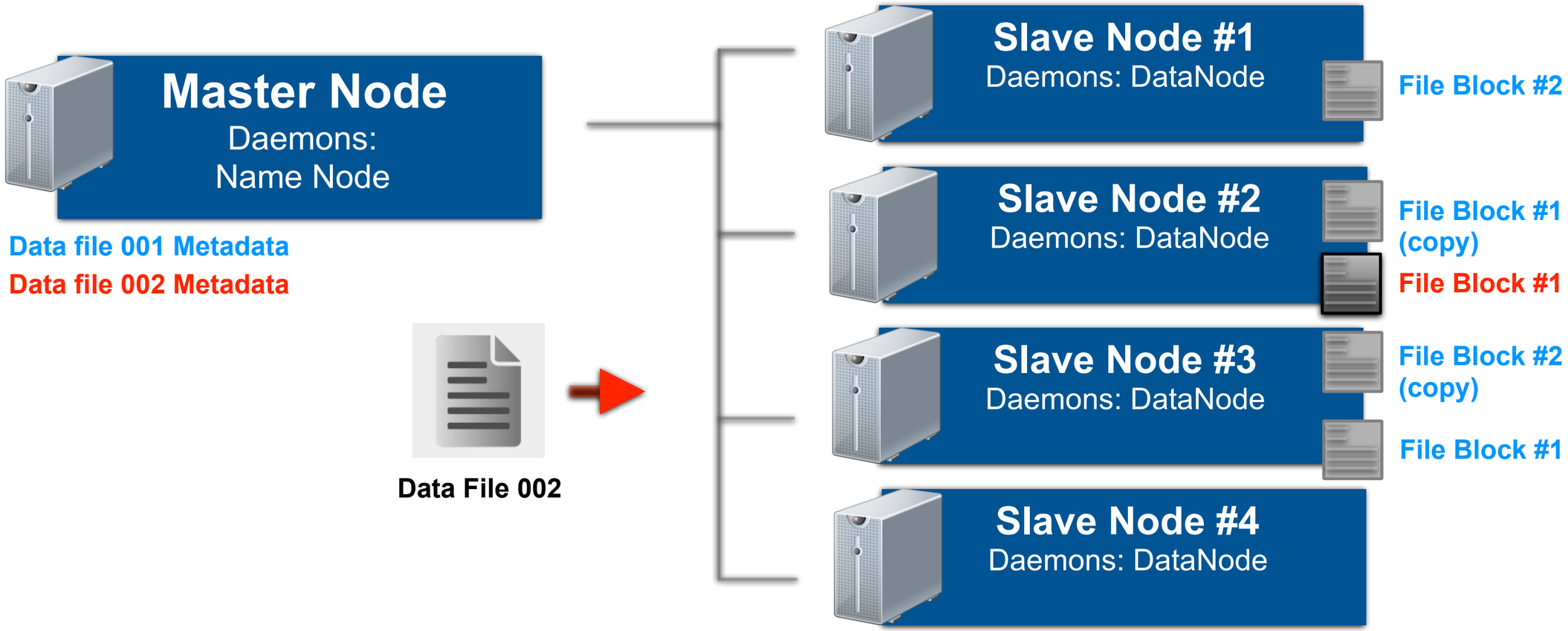

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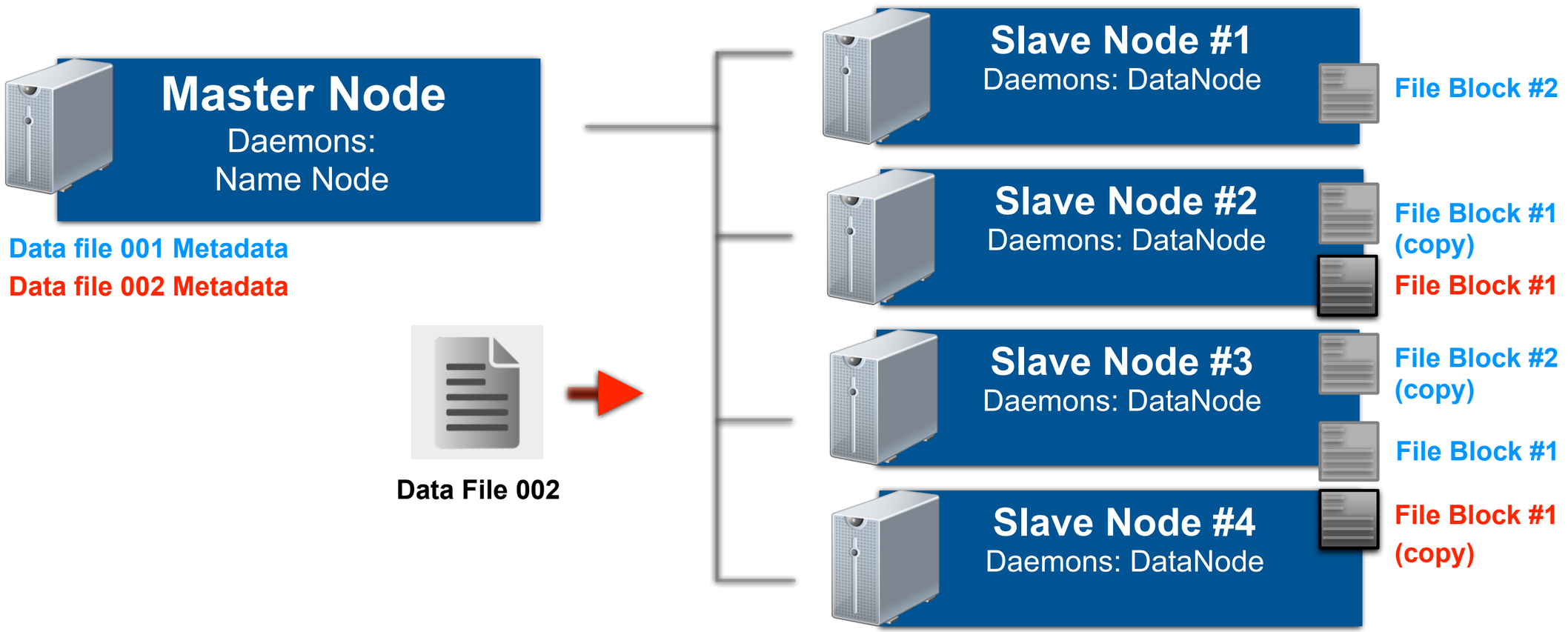

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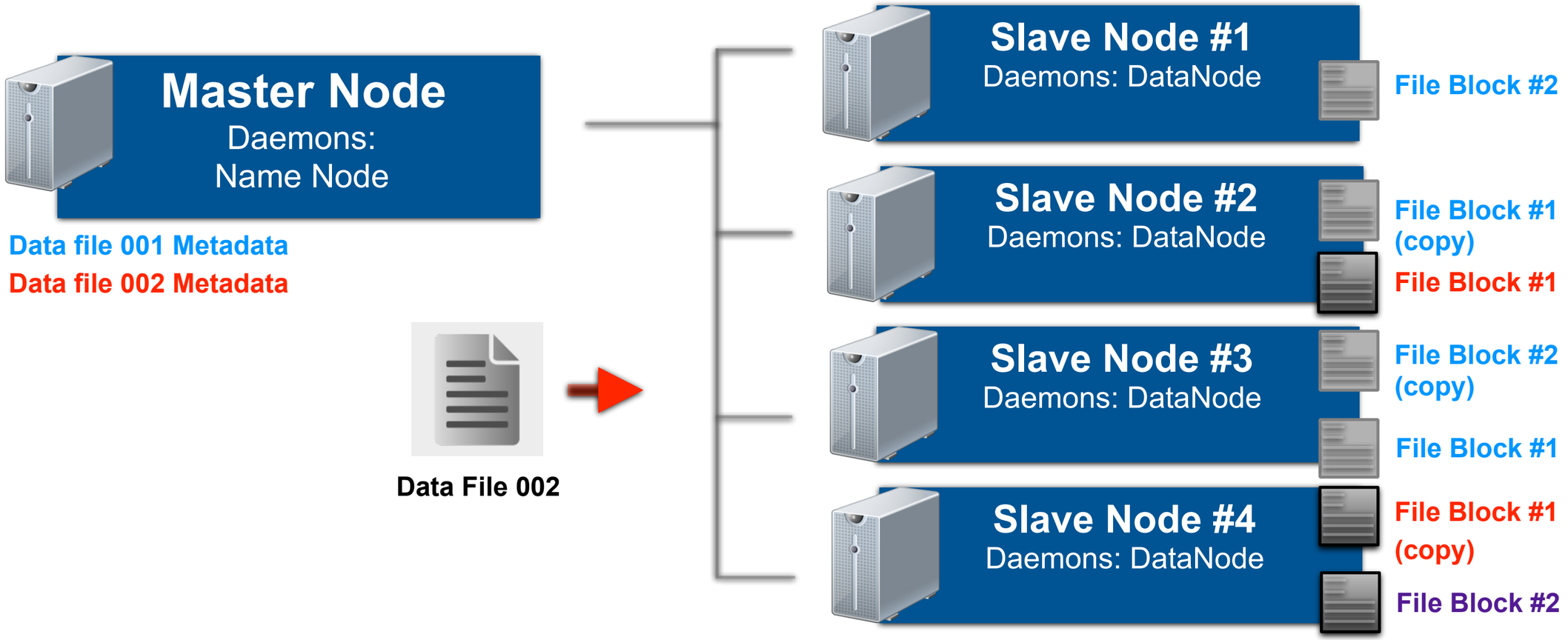

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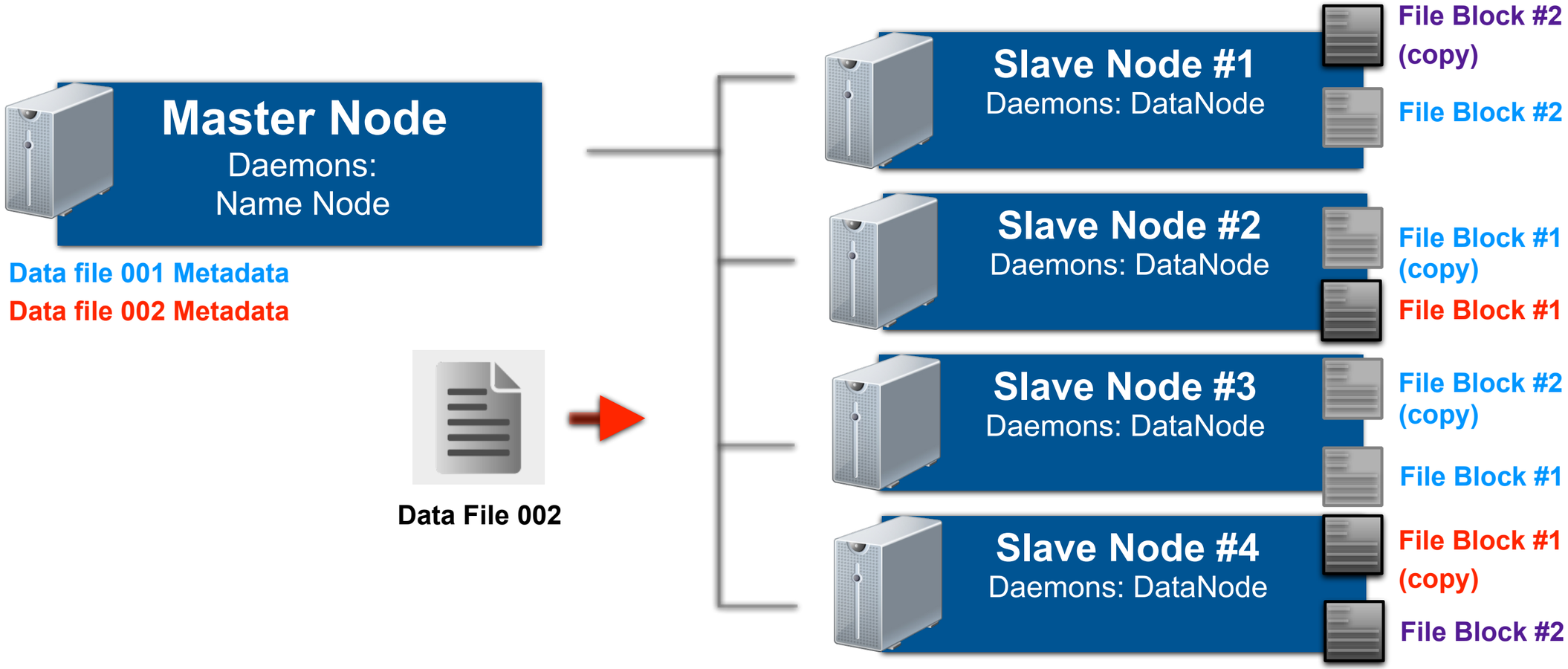

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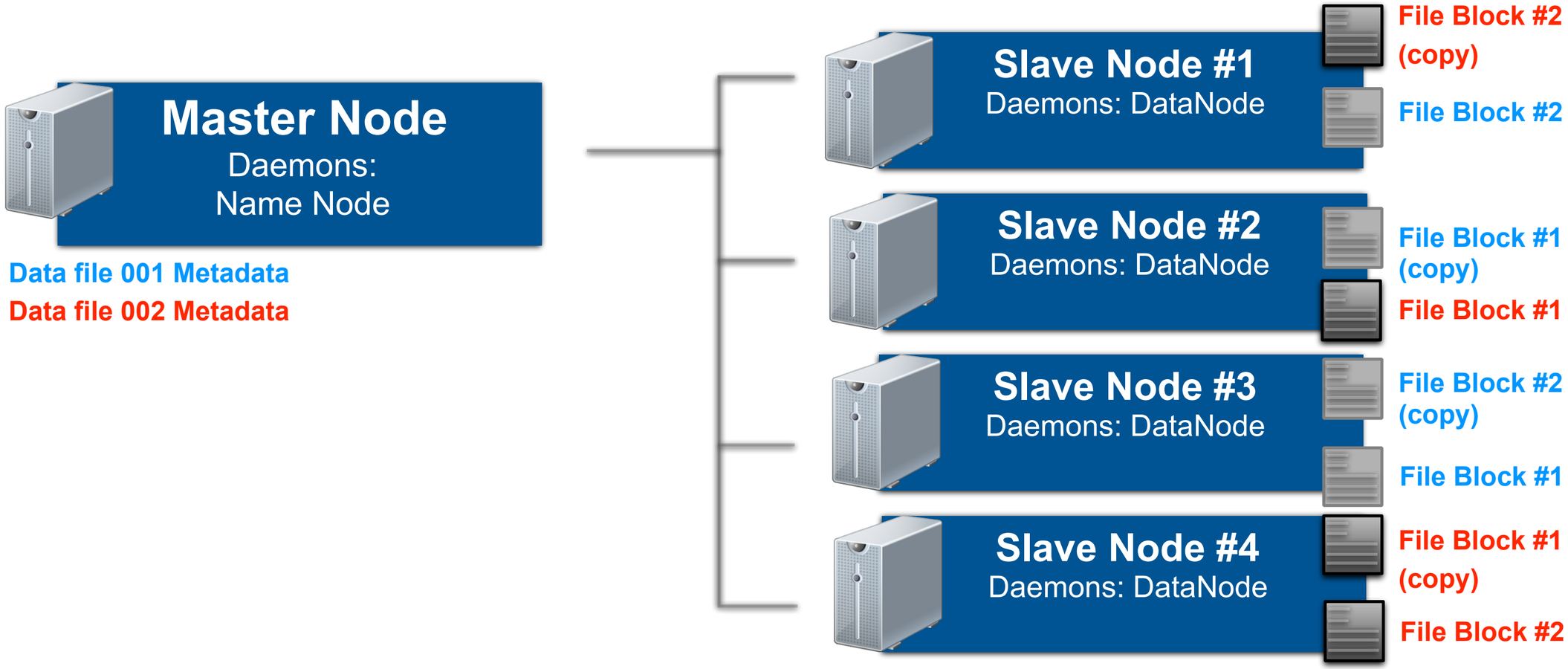


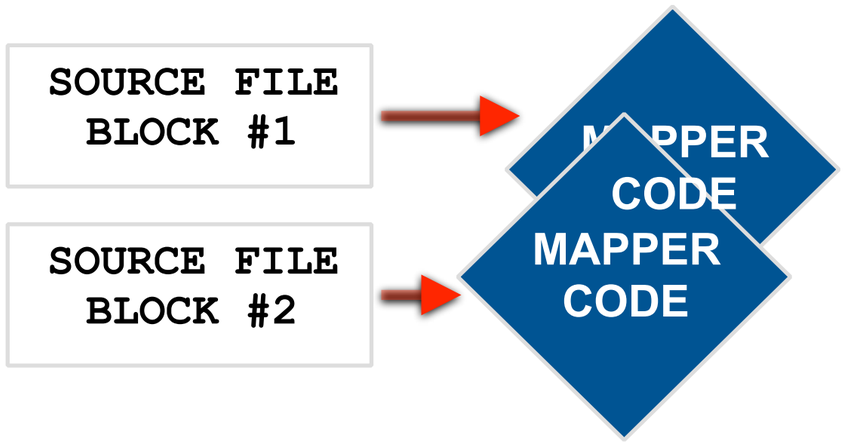
MAPREDUCE OVERVIEW

- Provides the **framework** for developers to write scalable code easily
- MapReduce is a ***programming model*** in Hadoop and not a specific language
- Always processes records in ***key/value format***
- Allows for data distribution between nodes

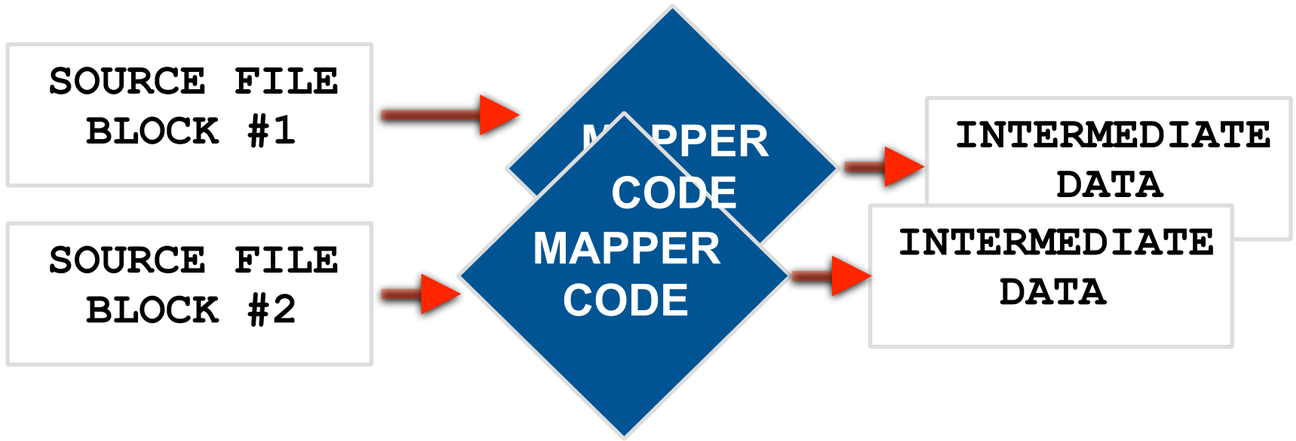
MAPREDUCE OVERVIEW

- Requires a developer to ***only*** write two phases in a given program:
  - (1) Map
  - (2) Reduce
- Allows the developer to focus on ***business logic***

MAPREDUCE OVERVIEW



MAPREDUCE OVERVIEW



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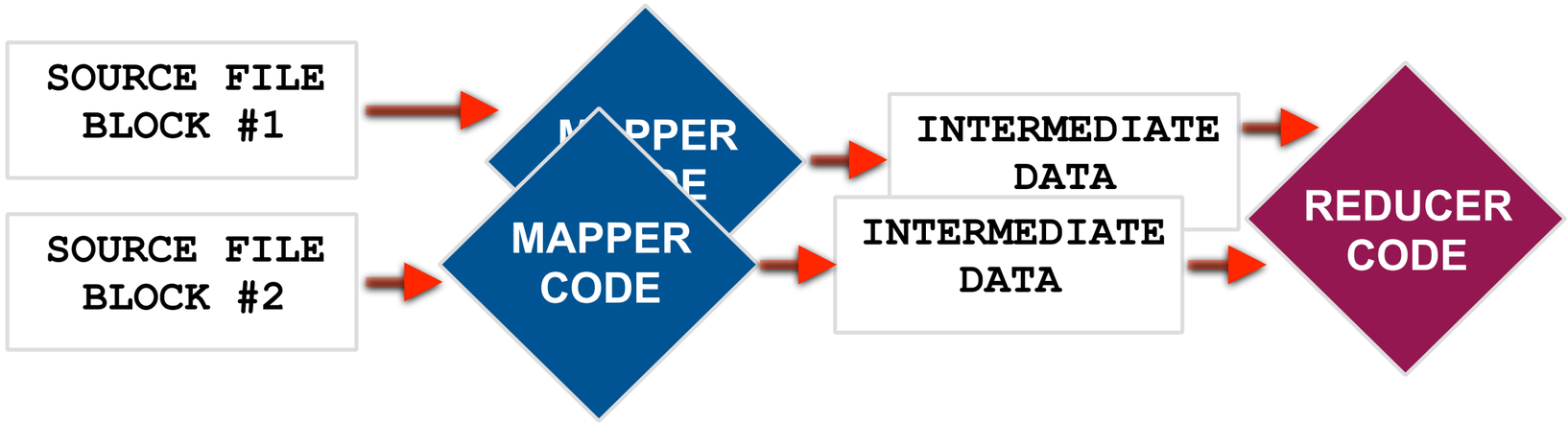
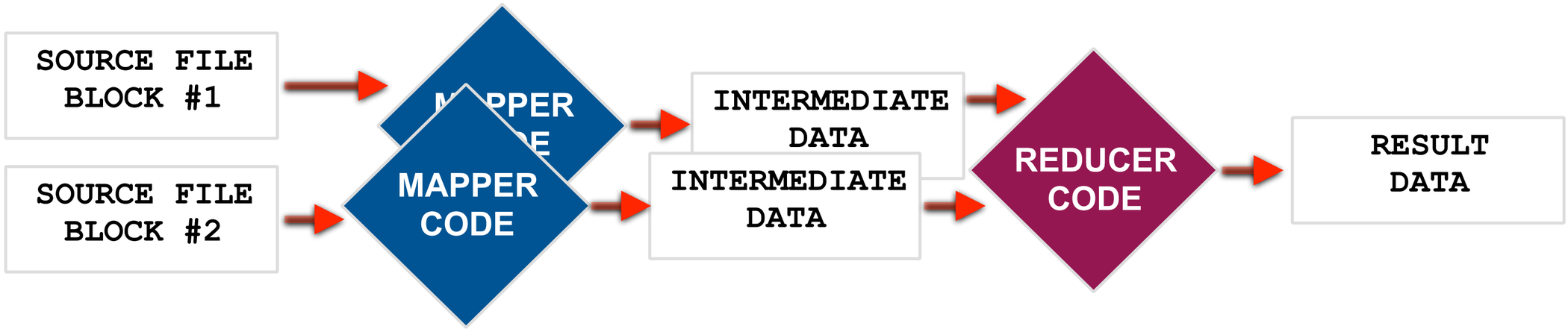


MAPREDUCE OVERVIEW



MAPREDUCE CAPABILITIES

- Provides automatic ***parallelization*** of data processing
- Provides ***fault tolerance*** for MapReduce tasks and handles failures
- Takes care of ***job monitoring***
- ***Abstraction for programs*** - takes care of all the “nitty gritty” and hides it from developers
- MapReduce is ***usually written in JAVA***

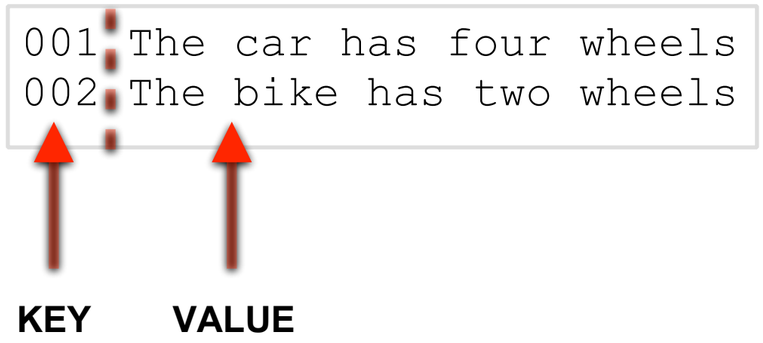
MAPREDUCE DEMO

```
001 The car has four wheels
002 The bike has two wheels
```

Raw data sent to Mapper

(code that count word occurrences)

MAPREDUCE DEMO



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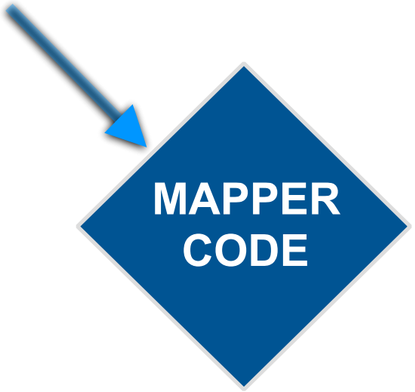

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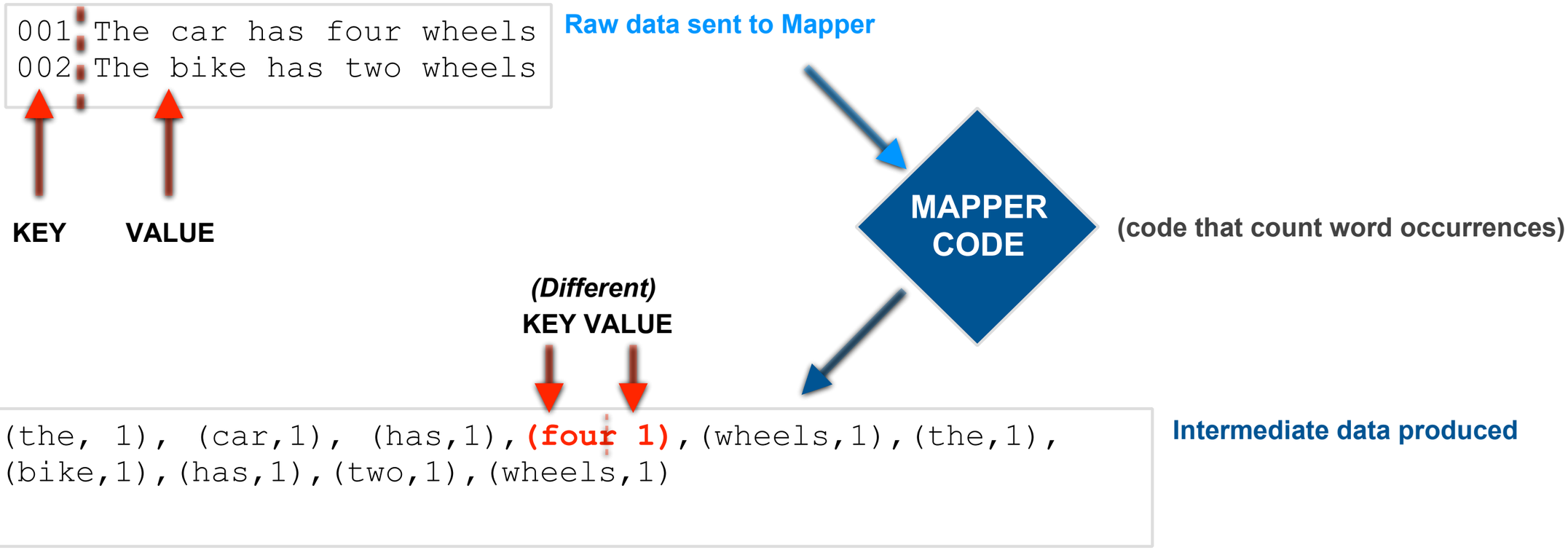
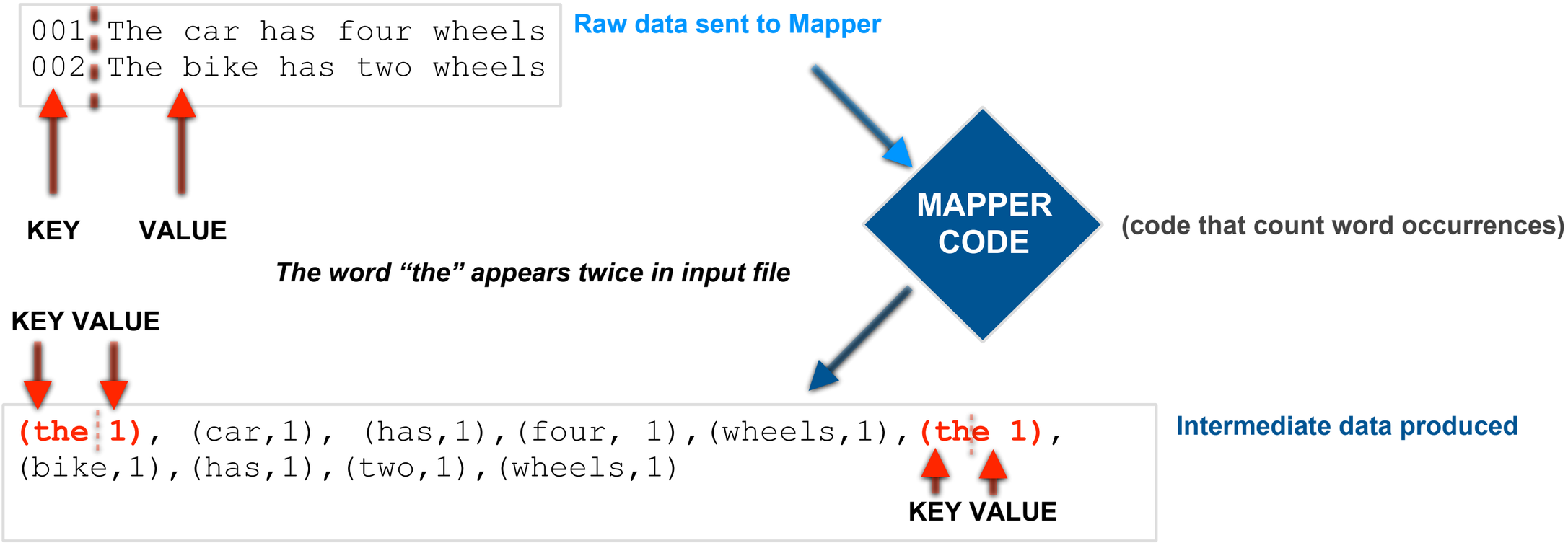
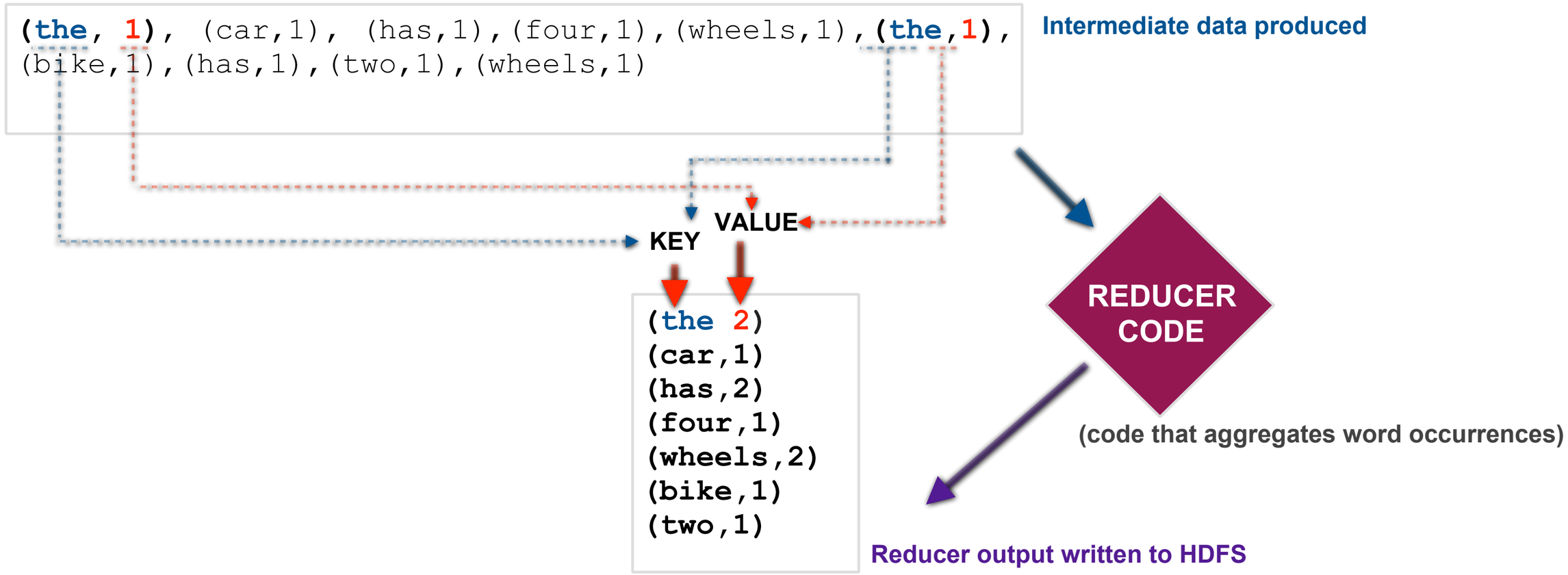
MAPREDUCE DEMO



MAPREDUCE DEMO



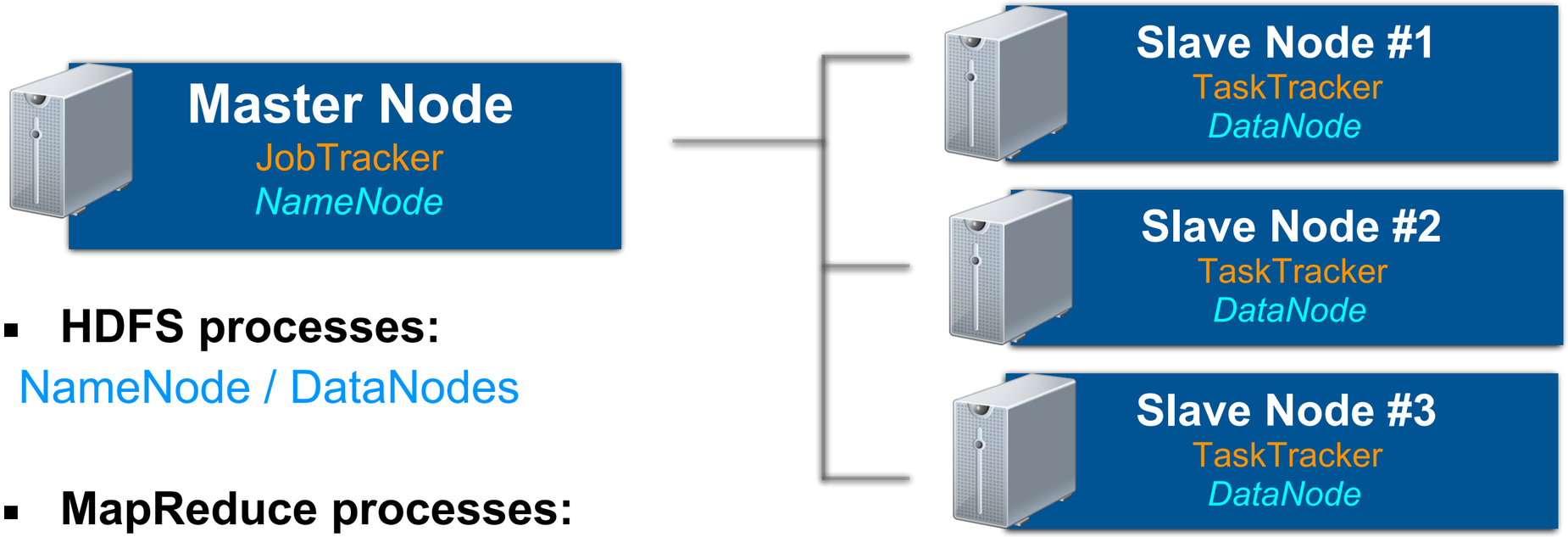
MAPREDUCE DEMO



BEFORE YARN EXISTED

- **MapReduce V1**
  - Single **JobTracker** process- ***one per cluster***
    - Manages MapReduce jobs
    - Distributes tasks to JobTrackers
  - Multiple **TaskTracker** process- ***one per slave node***
    - Starts and monitors Map/Reduce tasks

MAPREDUCE V1 ARCHITECTURE



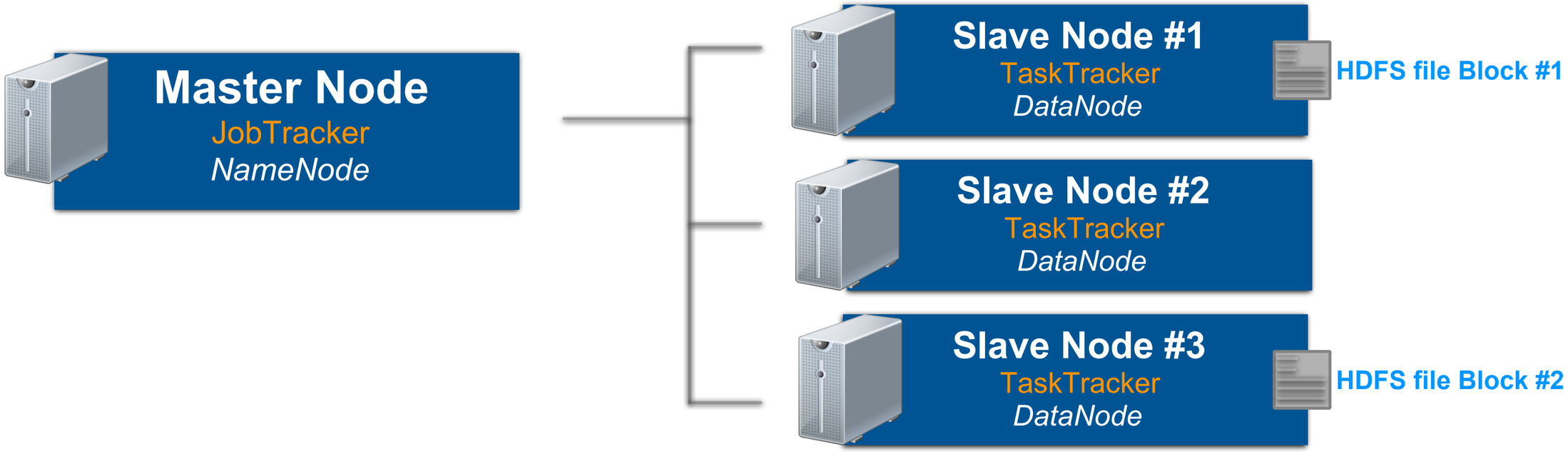
- **HDFS processes:**

  NameNode / DataNodes

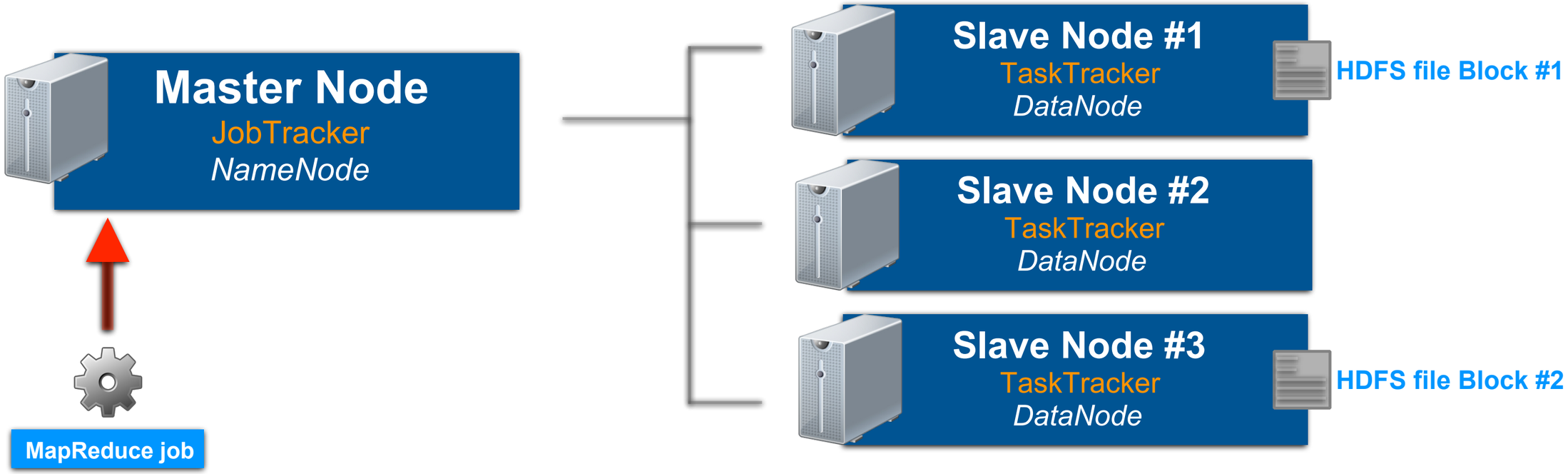
- **MapReduce processes:**

  JobTracker / TaskTrackers

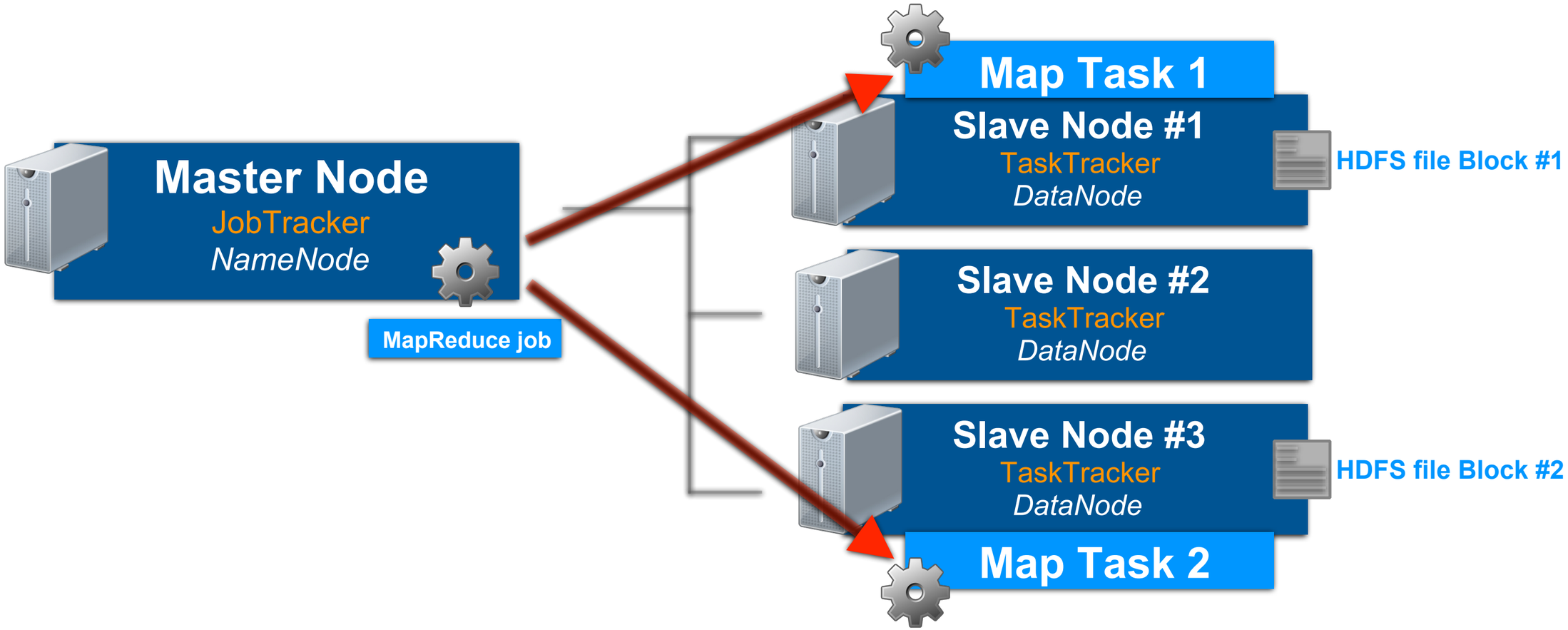
RUNNING JOBS IN MAP/REDUCE V1



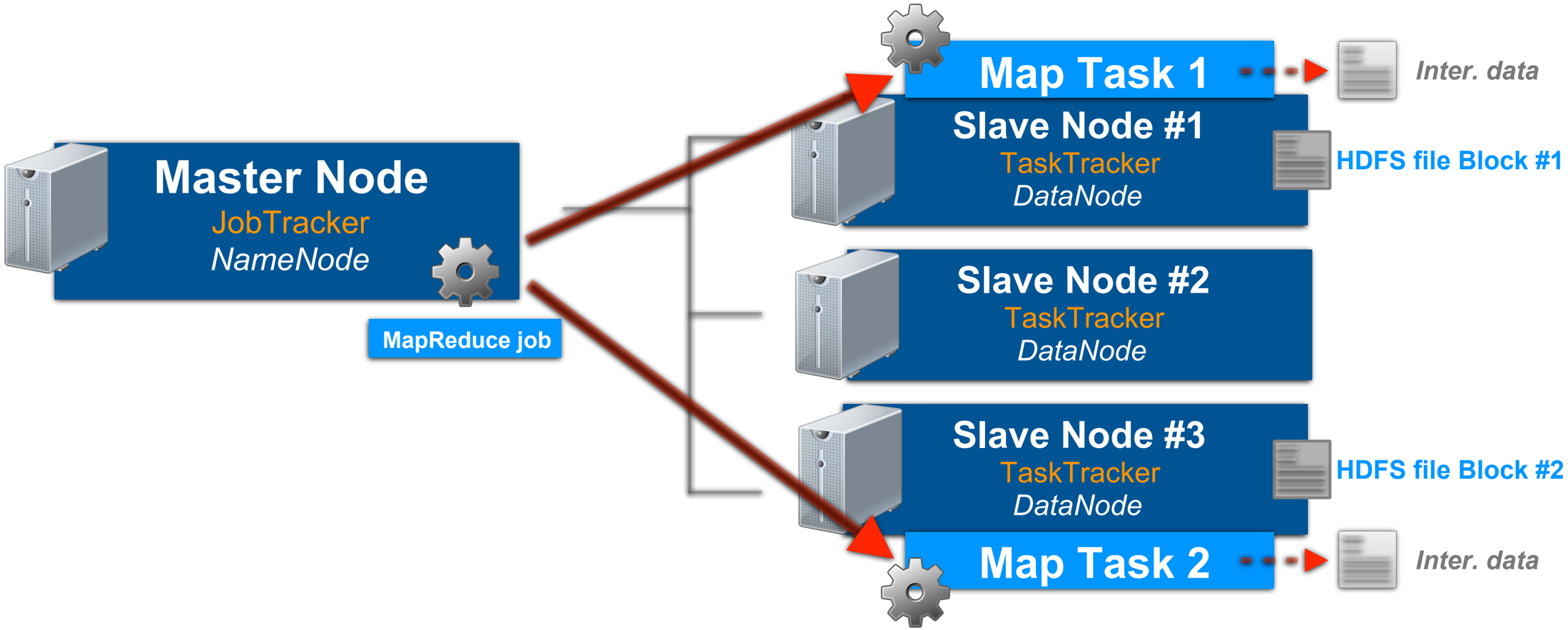
RUNNING JOBS IN MAPREDUCE V1



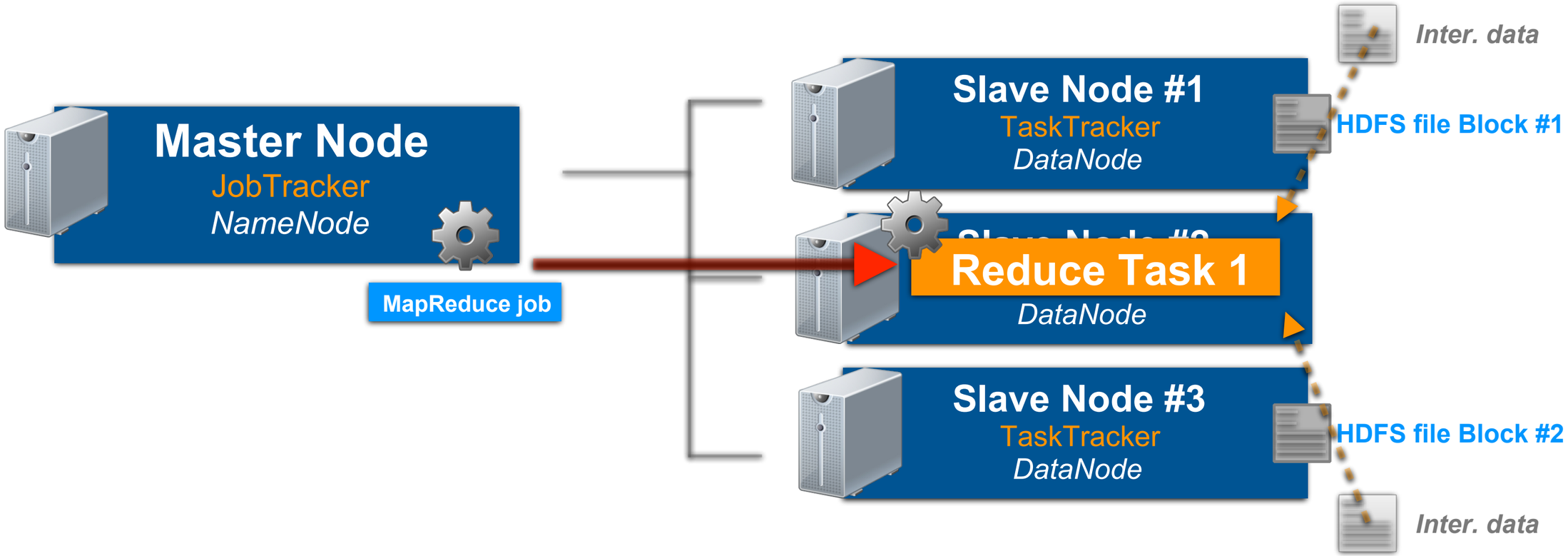
RUNNING JOBS IN MAPREDUCE V1



RUNNING JOBS IN MAPREDUCE V1



RUNNING JOBS IN MAPREDUCE V1



THE LIMITATIONS OF MAPREDUCE V1

- **Resource allocation:**
  - Slave nodes are configured with a fixed number of “slots” to run Map and Reduce tasks
- **Resource management process limitation:**
  - One JobTracker per cluster
- **Job types:**
  - Limited to MapReduce jobs only

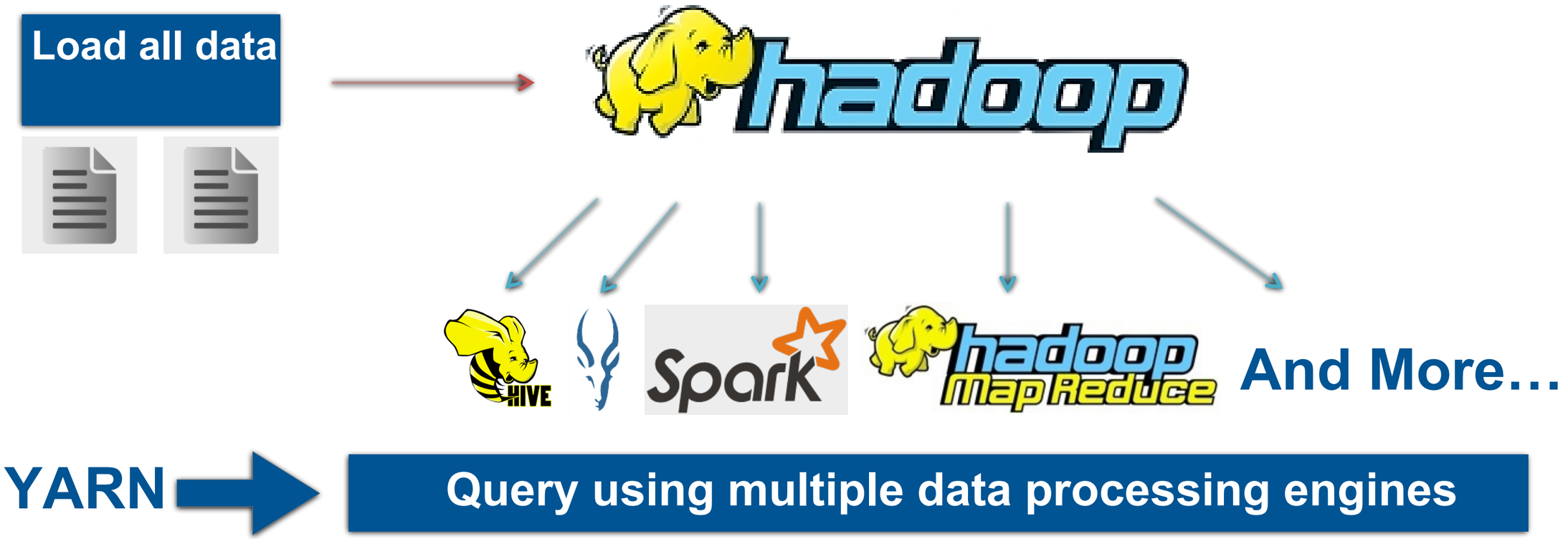
GETTING TO KNOW YARN

- YARN is new for Hadoop V2 and provides many improvements over MapReduce in Hadoop V1

- YARN support ***multiple*** distributed processing frameworks:
  - MapReduce V2
  - Impala
  - Spark
  - Etc…

And More…

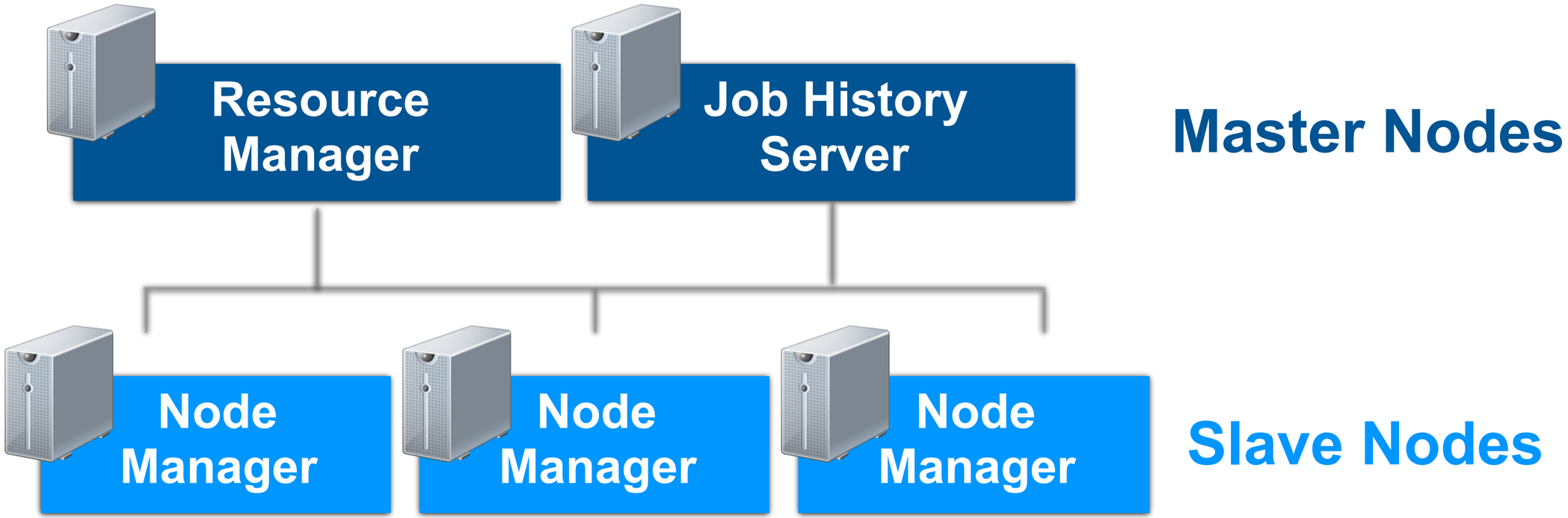
YARN ARCHITECTURE



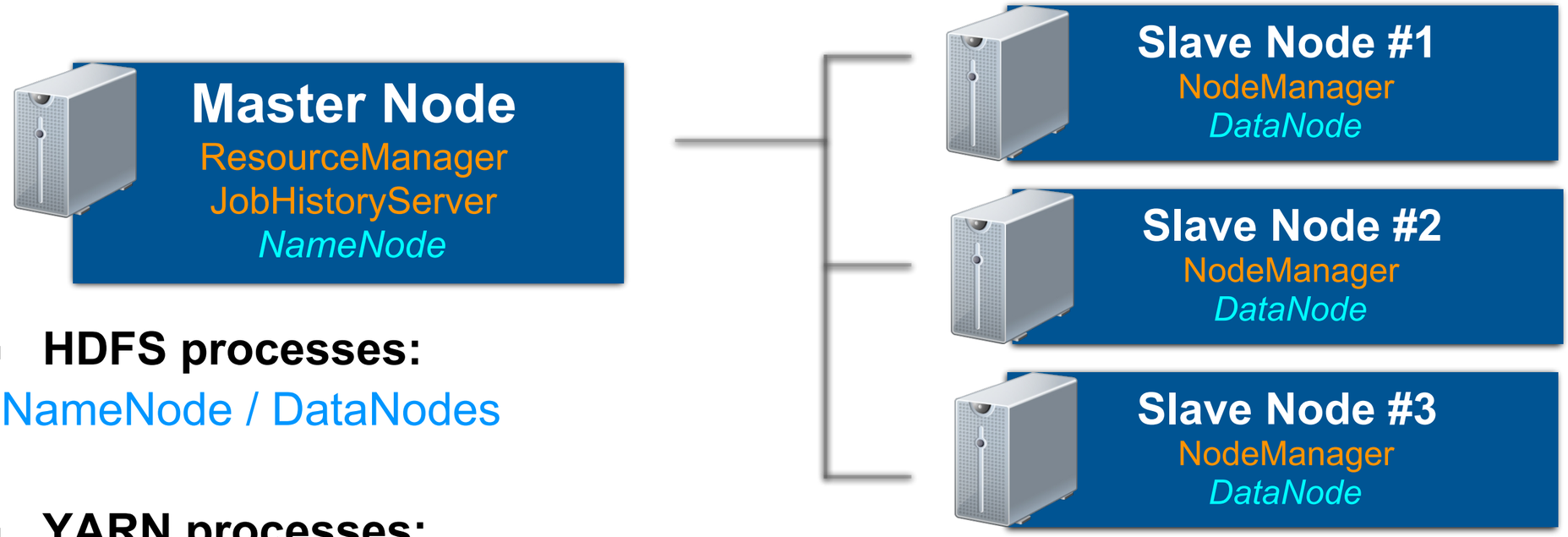
YARN DAEMONS

- **Resource Manager** - one per cluster
  - Controls application startup
  - Schedule resources on the slave nodes
- **Node Manager** - one per slave node
  - Starts all processes for a running application
  - Manages resources on the slave nodes
- **Job History Server** - one per cluster
  - Archival of job log files

THE YARN ARCHITECTURE



THE YARN ARCHITECTURE



- **HDFS processes:**

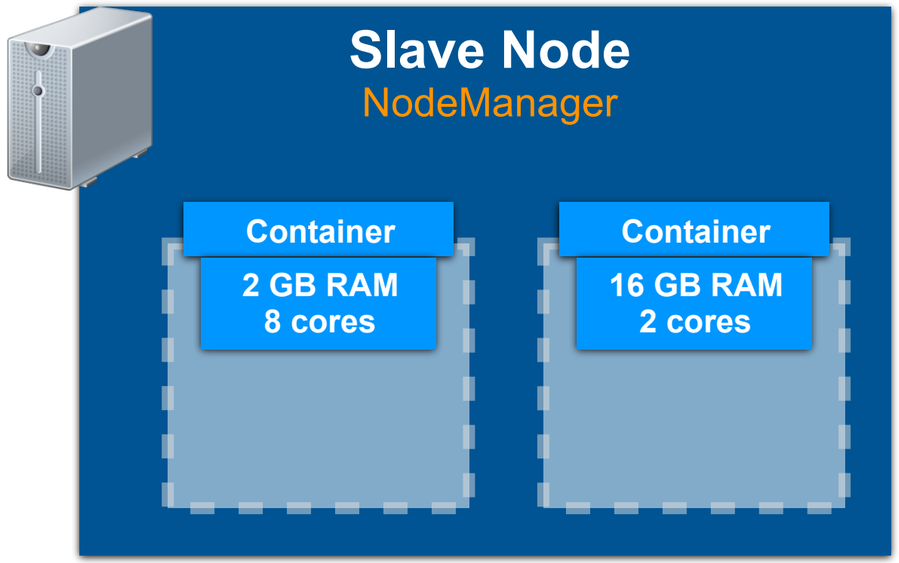
  NameNode / DataNodes

- **YARN processes:**

  ResourceManager & JobHistoryServer / NodeManagers

THE YARN ARCHITECTURE

- **Containers**
  - Allocation of Containers is done by the ResourceManager process
  - Containers allocate CPU and memory on a slave node
  - Containers run an application task



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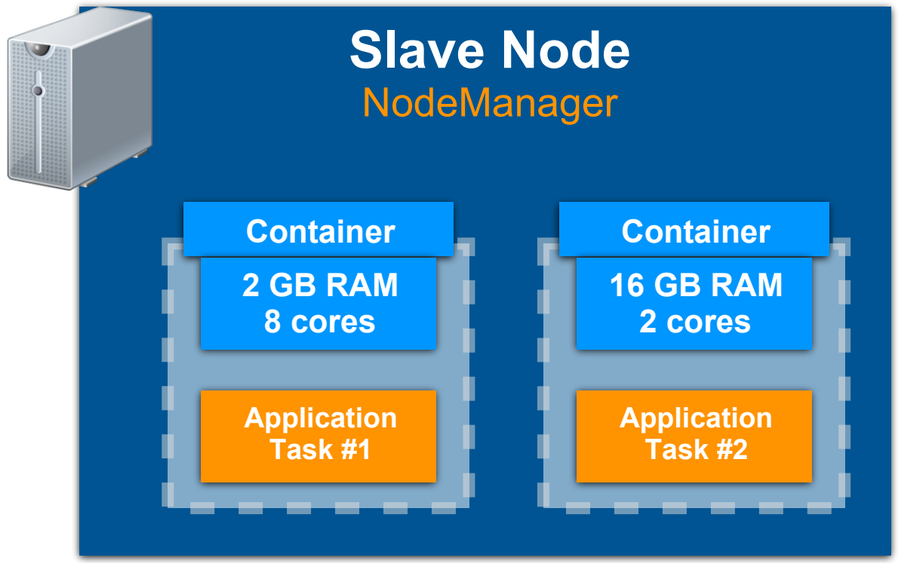
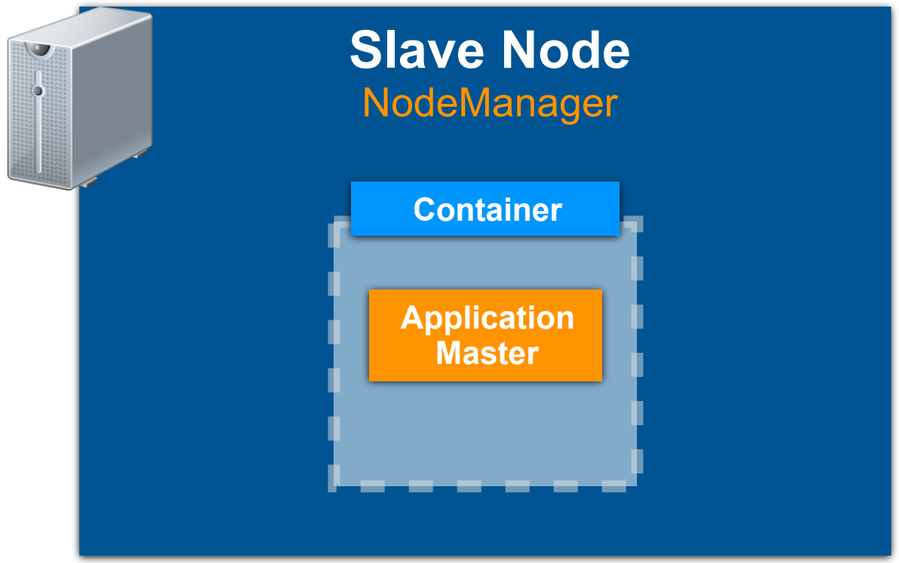


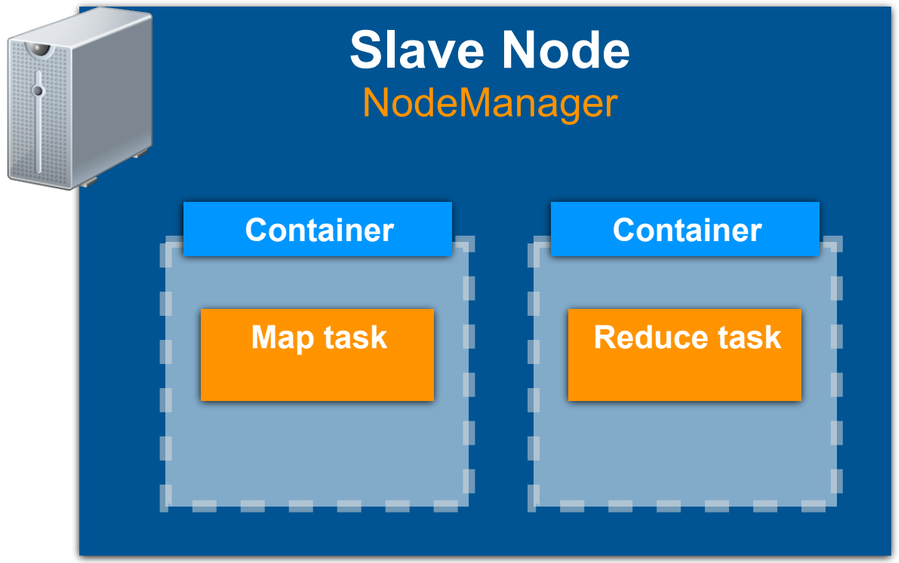
THE YARN ARCHITECTURE

- **Application Masters**
  - Single Application Master per application
  - Runs inside a Container
  - Responsible for requesting additional containers on behalf of the application itself

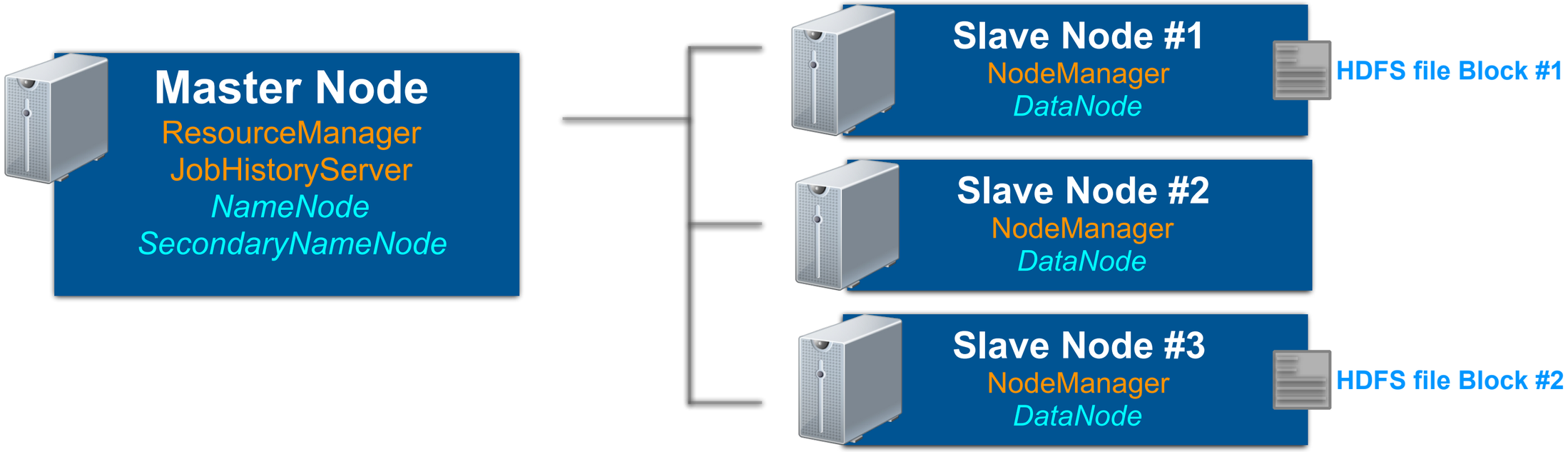


THE YARN ARCHITECTURE

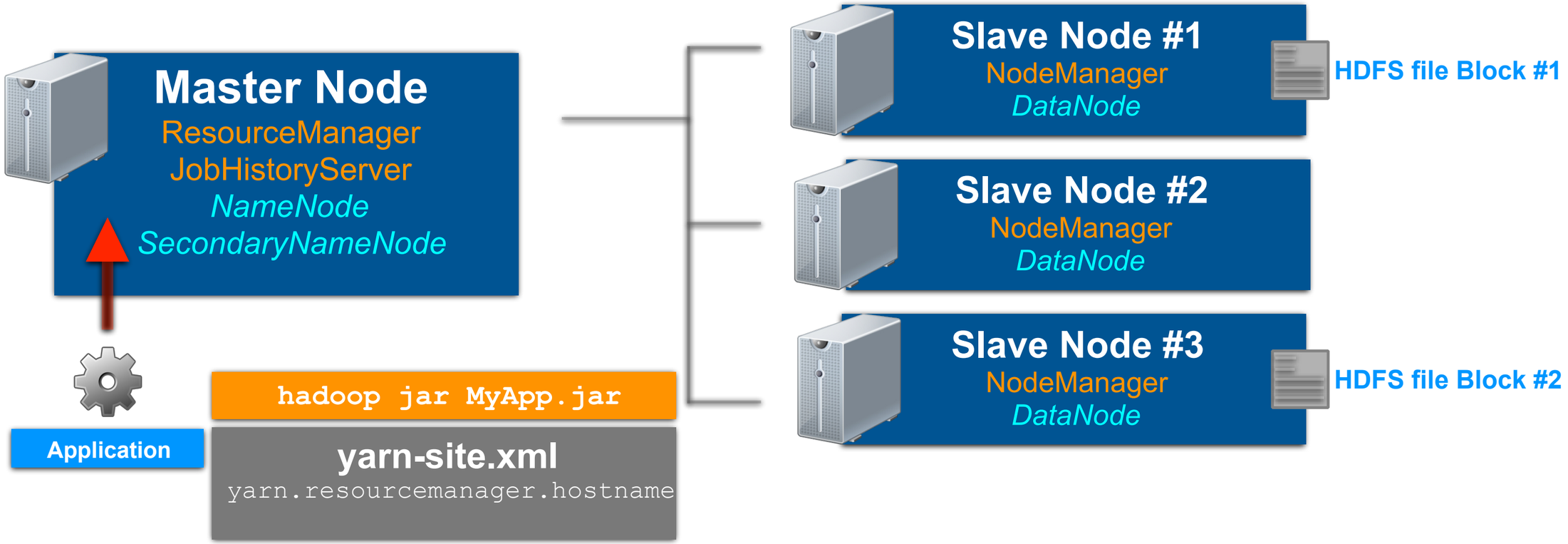
- **Task**
  - A single user-submitted job or application is “broken down” to multiple tasks
  - Each task runs in a container in Hadoop slave node



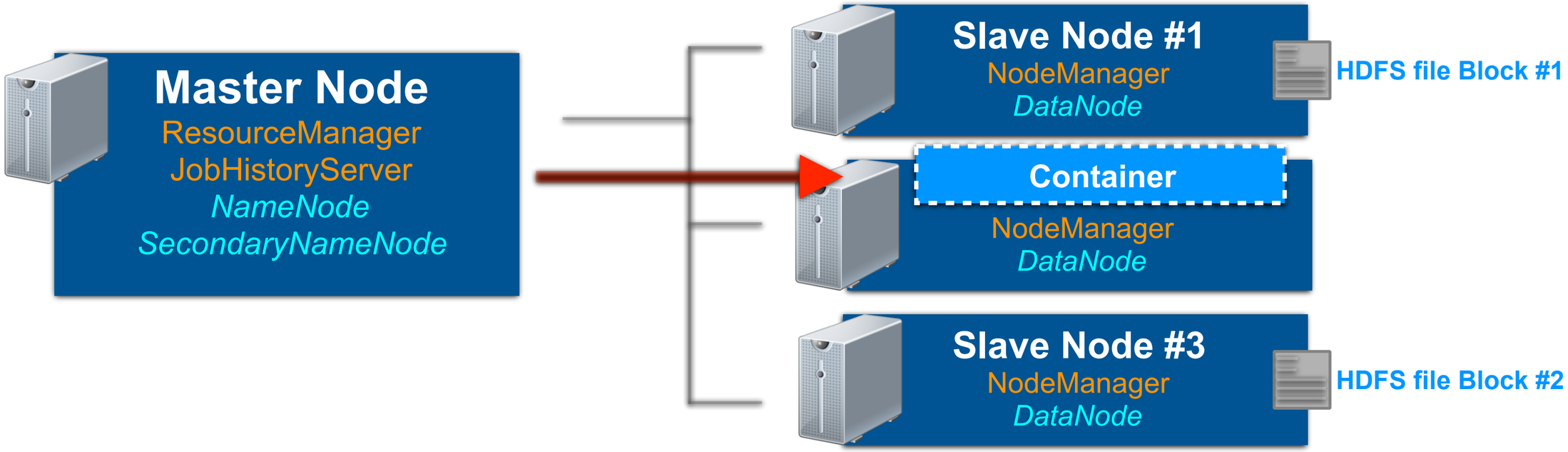
RUNNING JOBS IN YARN



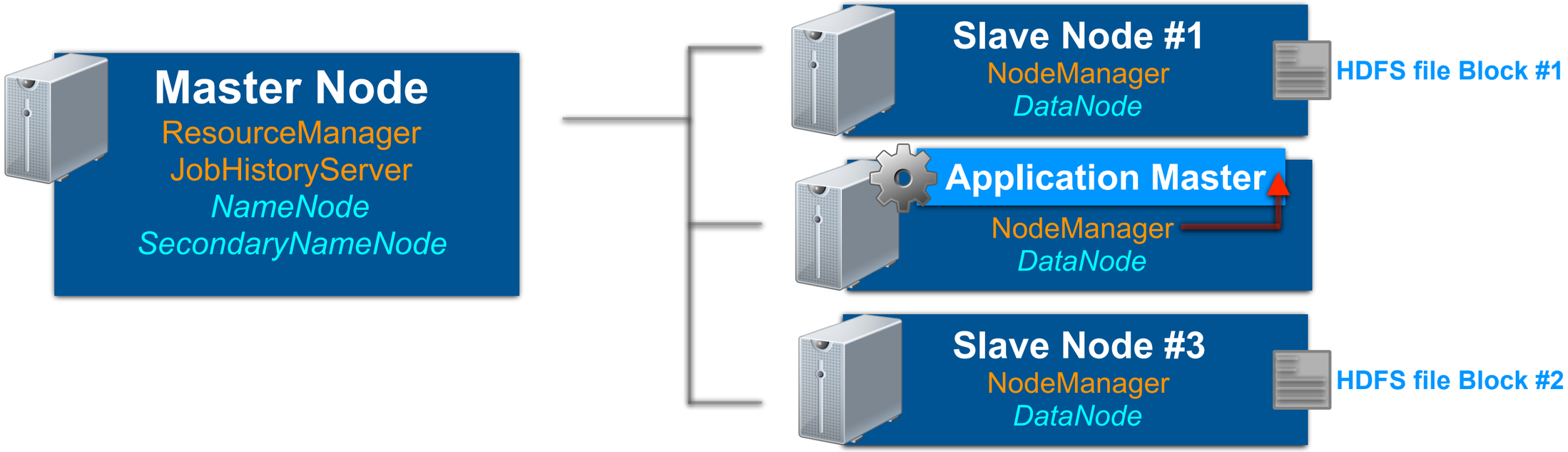
RUNNING JOBS IN YARN



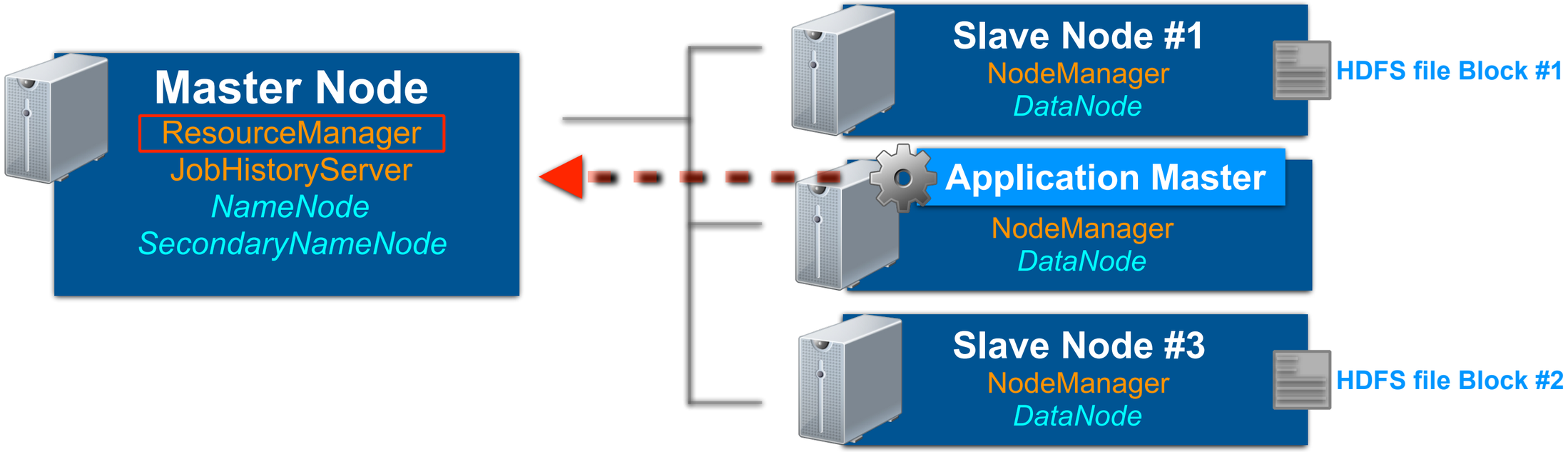
RUNNING JOBS IN YARN



RUNNING JOBS IN YARN



RUNNING JOBS IN YARN



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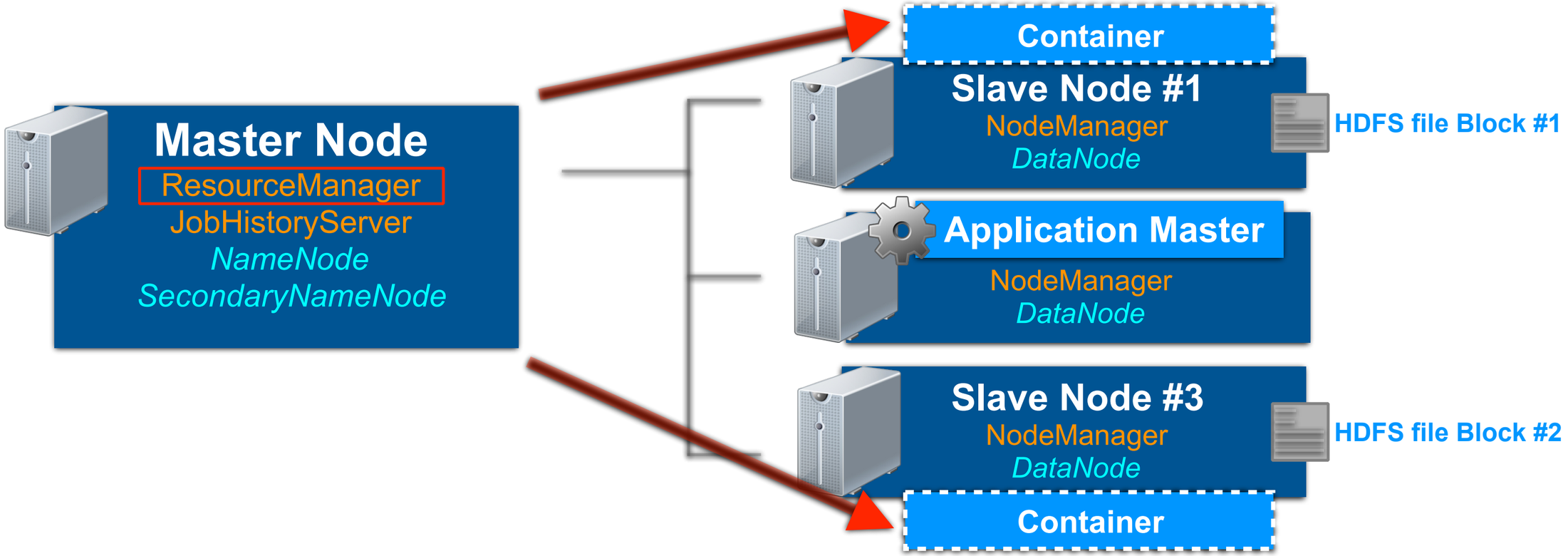

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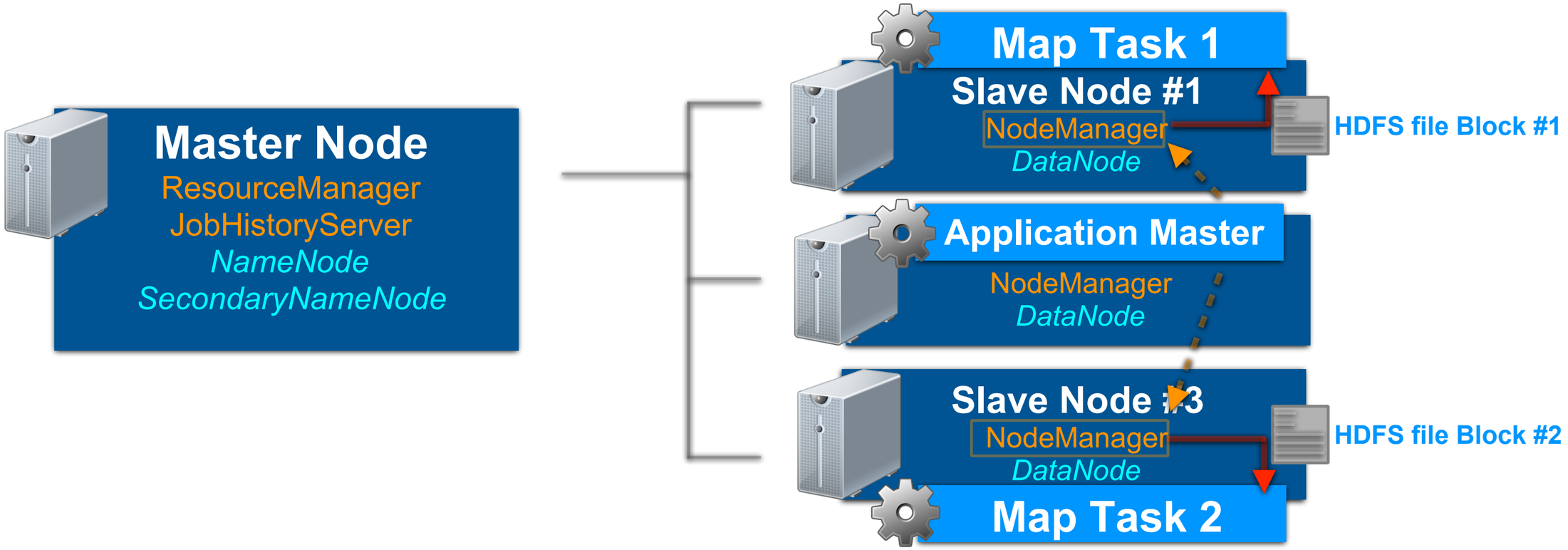
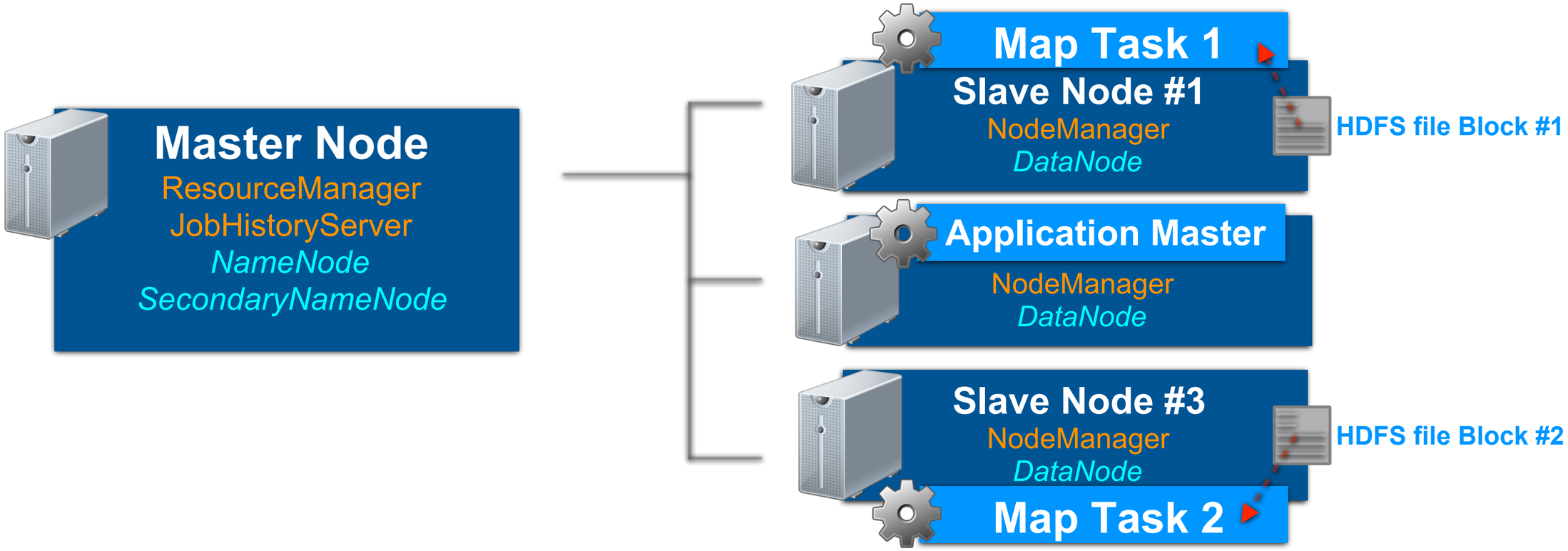


RUNNING JOBS IN YARN



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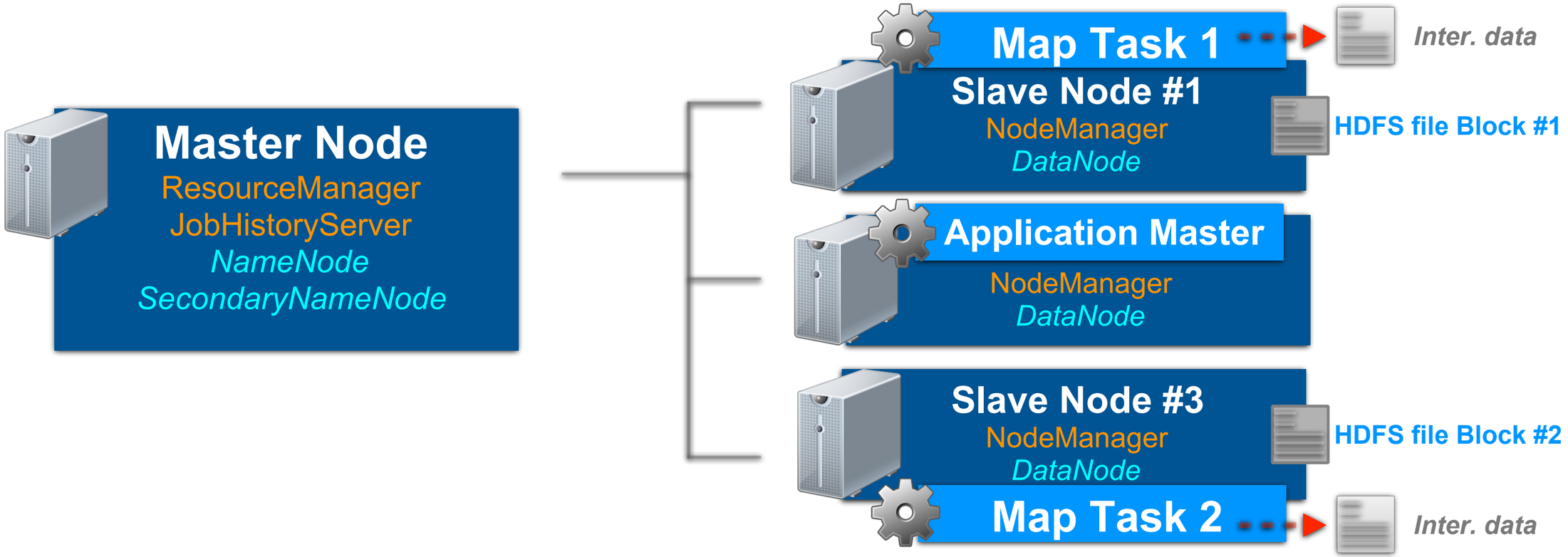

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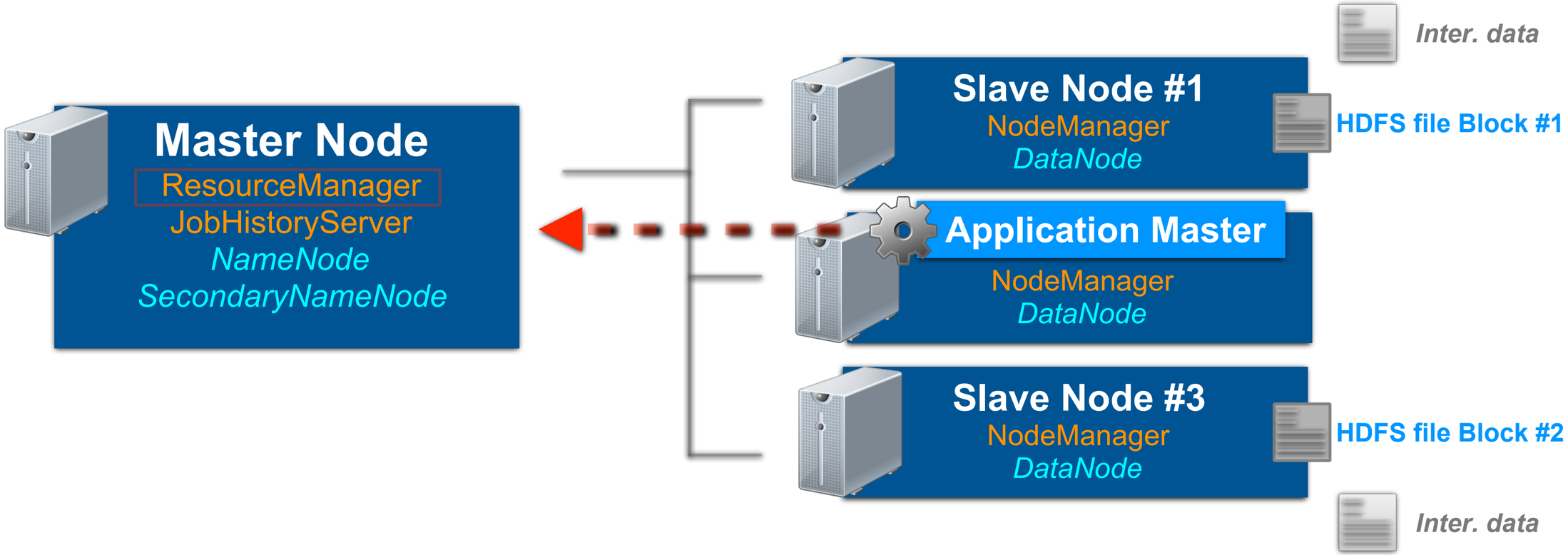
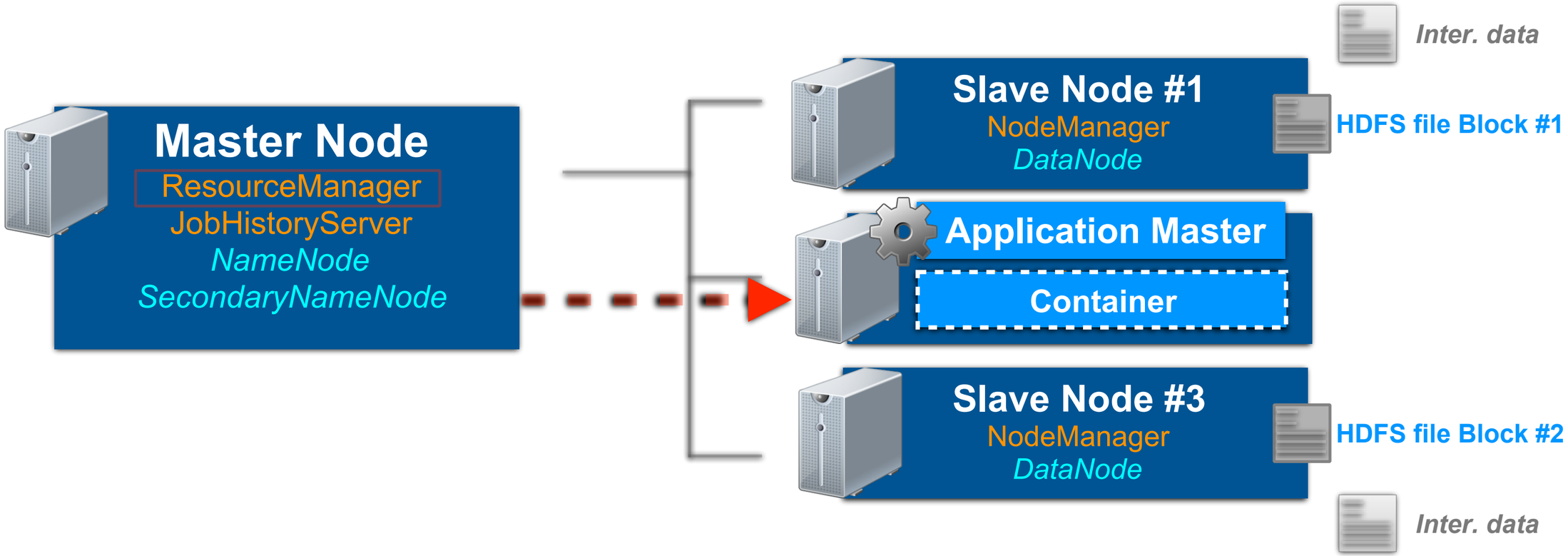
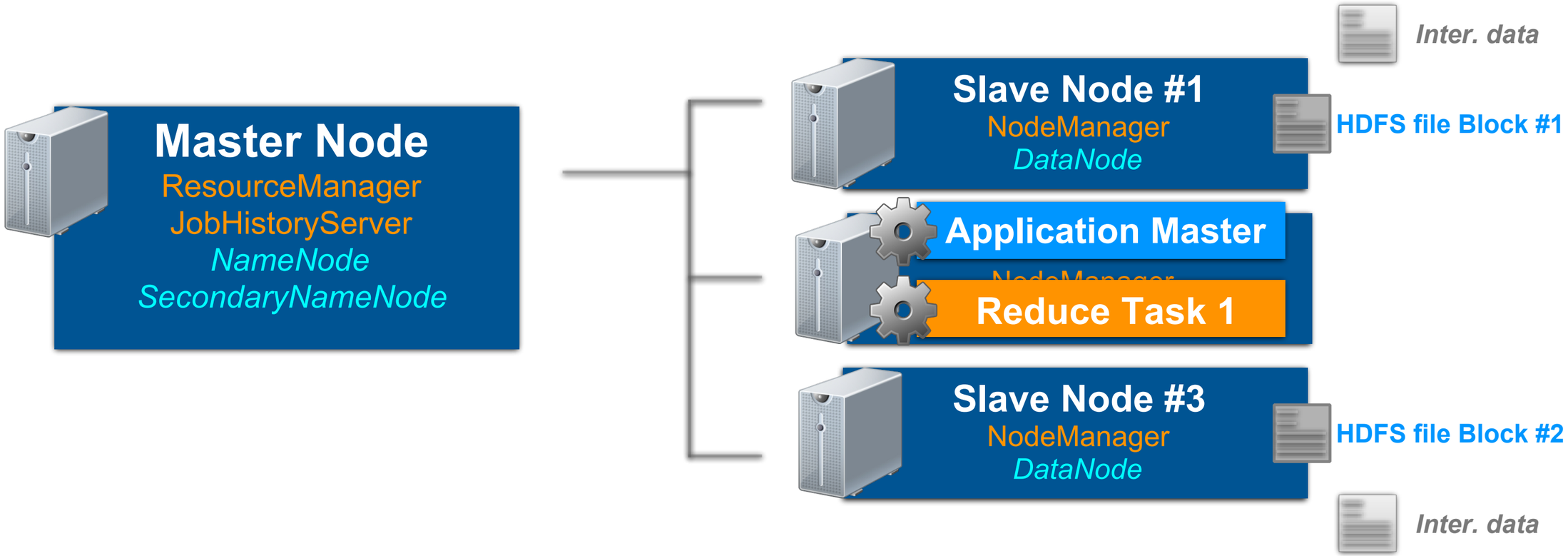


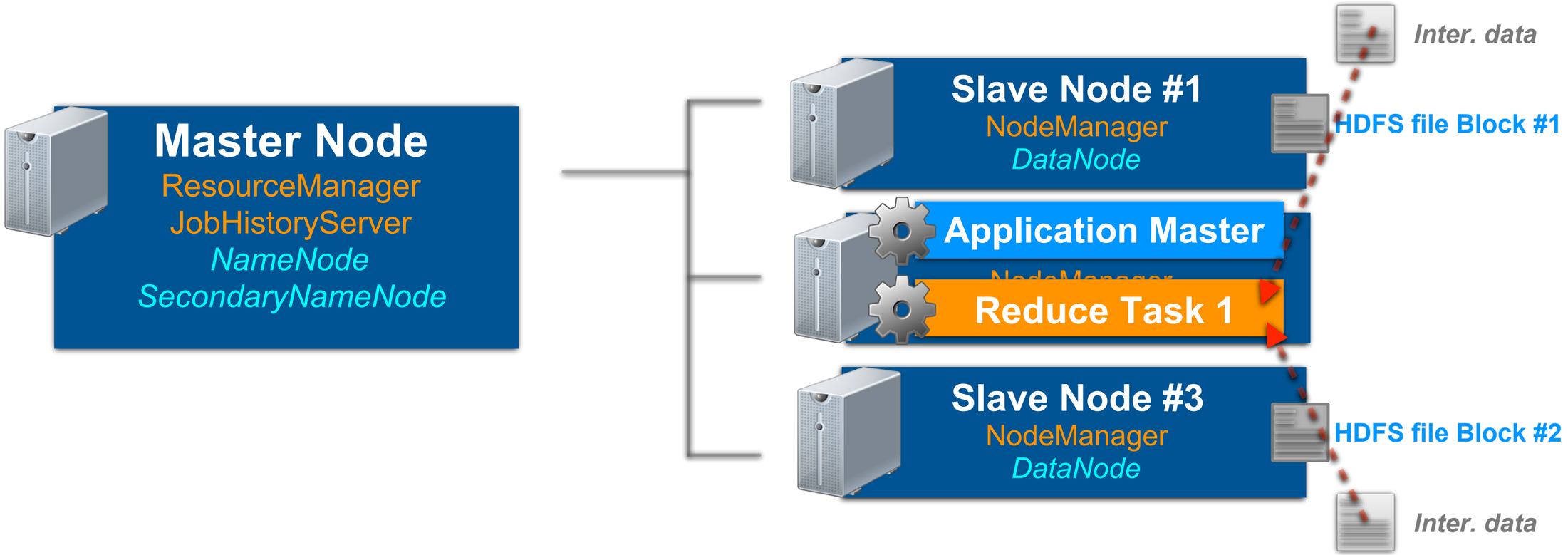
RUNNING JOBS IN YARN



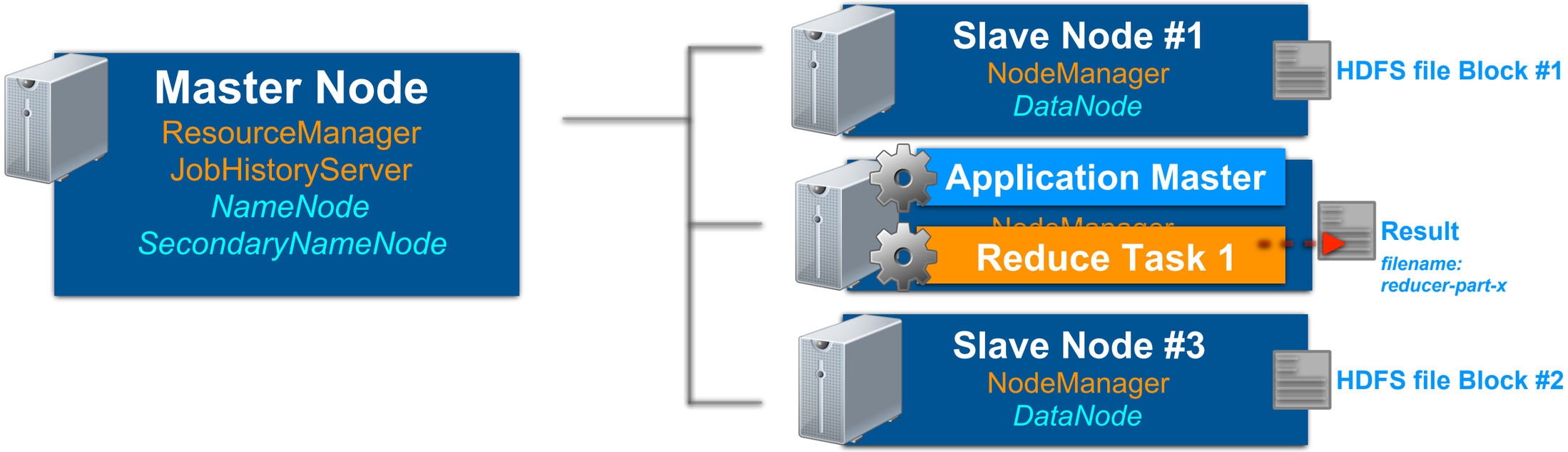
RUNNING JOBS IN YARN



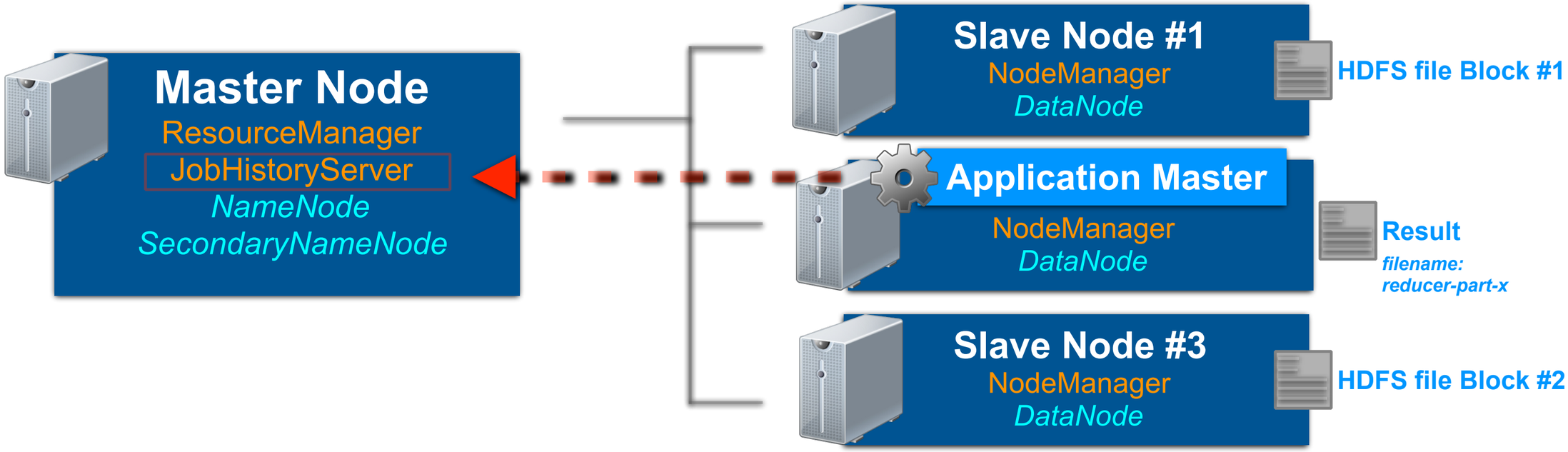
RUNNING JOBS IN YARN



RUNNING JOBS IN YARN



RUNNING JOBS IN YARN



YARN DAEMONS

- **Resource Manager** - one per cluster
  - Manages slave nodes and tracks heartbeats from NodeManagers
  - Running a resource scheduler which determines how resources are allocated
  - Responsible for the ApplicationMaster: allocates an Application Master container
  - Managers containers: both accepts request from Application Masters to startup new containers and releases containers when they finished executing tasks

YARN DAEMONS

- **Node Manager** - one for each slave node
  - Communicates with the Resource Manager, registers with the ResourceManager to provide details on available node resources
  - Starts ApplicationMasters on request from ResourceManager
  - Starts job tasks on request from ApplicationMaster
  - Manages tasks in Containers
  - Monitors resource usage and “kills” tasks over-consuming resources
  - Stores applications logs on HDFS

YARN CONFIGURATION

- Configuration files for YARN & MapReduce in Hadoop

`yarn-site.xml` `mapred-site.xml`

YARN CONFIGURATION

- Configuration file for YARN: **yarn-site.xml**

yarn.nodemanager.local-dirs

The directory in which local resource files are stored such as intermediate output files and the distributed cache

```
<name>yarn.nodemanager.local-dirs</name>
    <value>/disks/yarn/nm</value>
```

YARN CONFIGURATION

- Configuration file for YARN: **yarn-site.xml**

yarn.nodemanager.aux-services

One or more auxiliary services that support application frameworks running under YARN

```
<name>yarn.nodemanager.aux-services</name>
    <value>mapreduce_shuffle</value>
```

YARN CONFIGURATION

- Master configuration file for YARN: **yarn-site.xml**

`yarn.log-aggregation-enable`

`yarn.nodemanager.remote-app-log-dir`

`yarn.nodemanager.log-dirs`

Parameter which control YARN log aggregation

We will discuss these in the YARN log chapter of the course…

YARN CONFIGURATION

- MapReduce configuration file: **mapred-site.xml**

mapreduce.framework.name

MapReduce execution framework. Default is **local** should be changed to **yarn**

```
<name>mapreduce.framework.name</name>
<value>yarn</value>
```

YARN CONFIGURATION

- MapReduce configuration file: **mapred-site.xml**

yarn.app.mapreduce.am.staging-dir

The HDFS directory in which users job files (jar files) needed by applications are stored. Should usually be set to “/user”. Used mainly by the clients and Appellation Master

```
<name>yarn.app.mapreduce.am.staging-dir</name>
<value>/user</value>
```

YARN CONFIGURATION

- MapReduce configuration file: **mapred-site.xml**

mapreduce.jobhistory.address

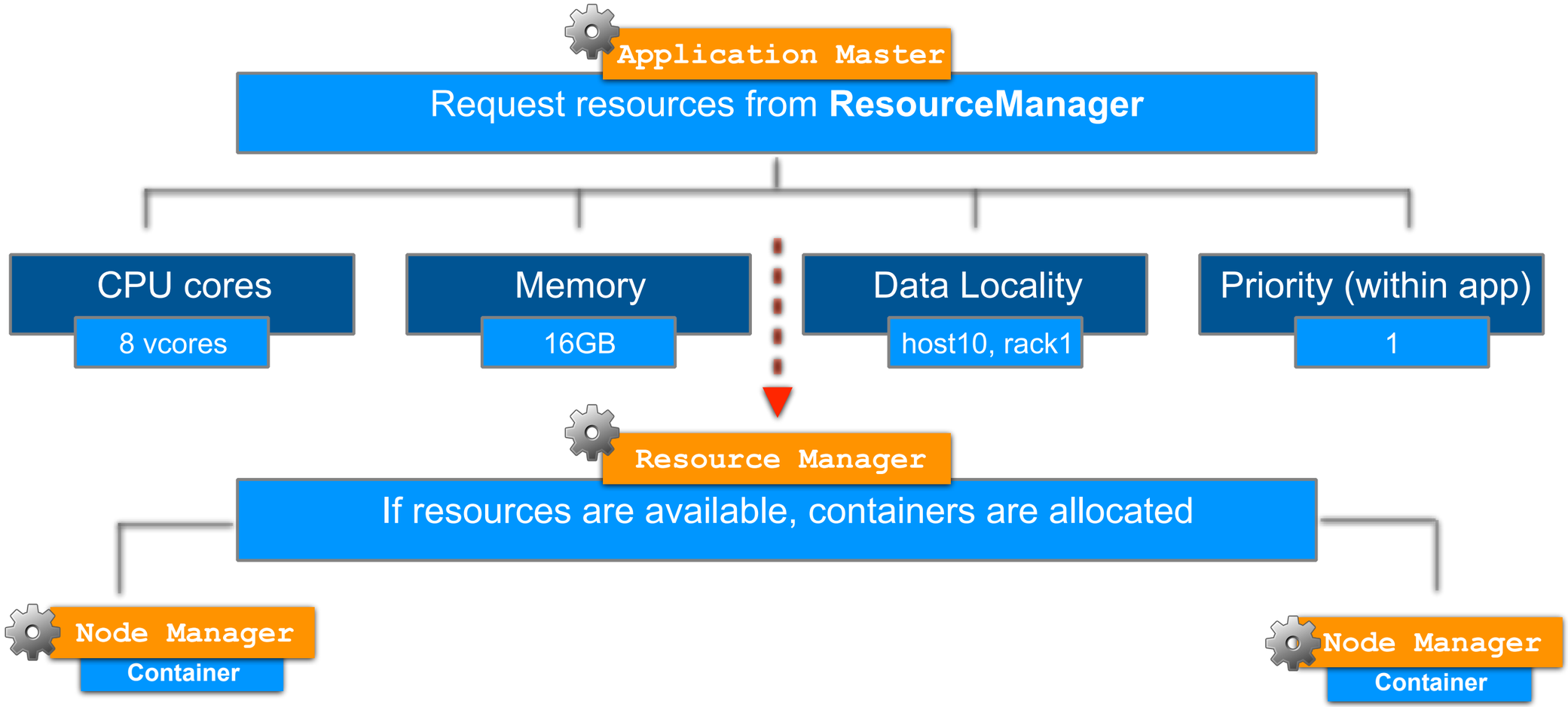
The address and port used for cluster internal communication with the JobHistoryServer

```
<name>mapreduce.jobhistory.address</name>
<value>HADOOPM1:10020</value>
```

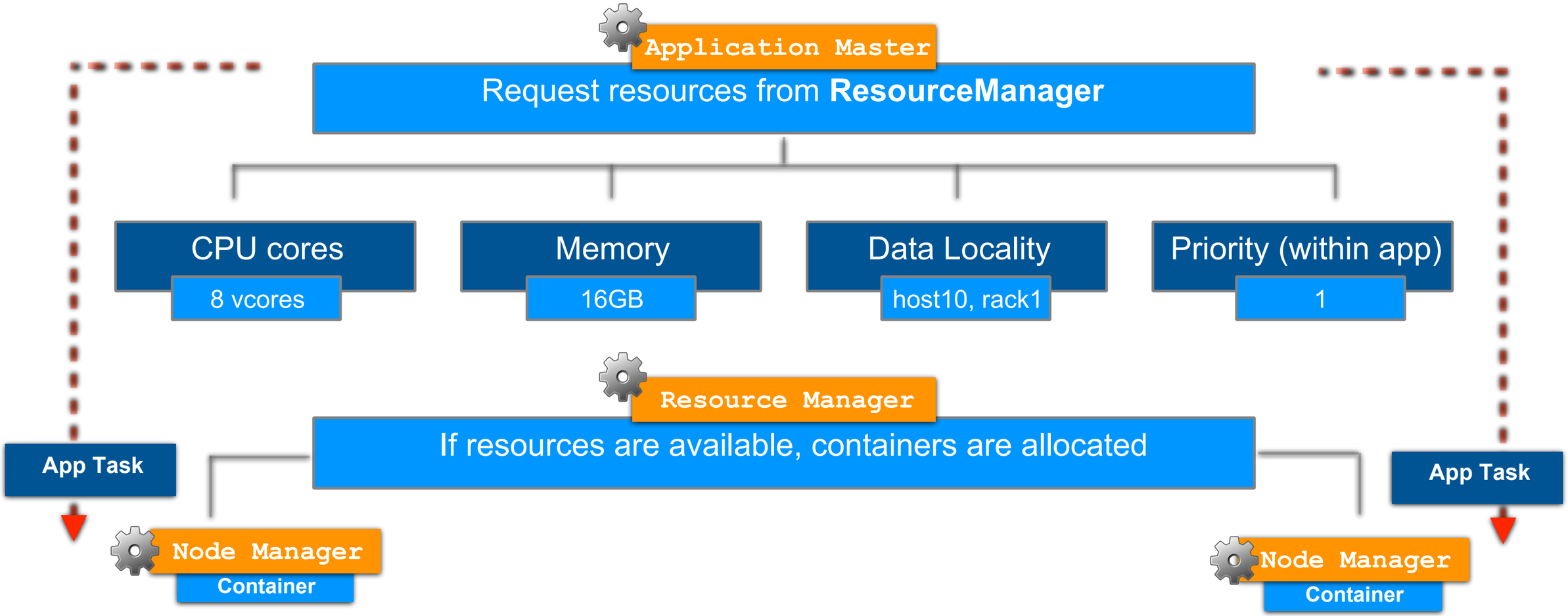
YARN RESOURCE ALLOCATION

- **Application Master** negotiates with ResourceManger to obtain resources for the job and presents the containers to the NodeManagers
- **Resource Manager** is responsible for granting containers in the YARN-enabled Hadoop cluster
- **Node Manager** is responsible for managing the containers, running MapReduce jobs in the containers and monitors resource usage

YARN RESOURCE ALLOCATION



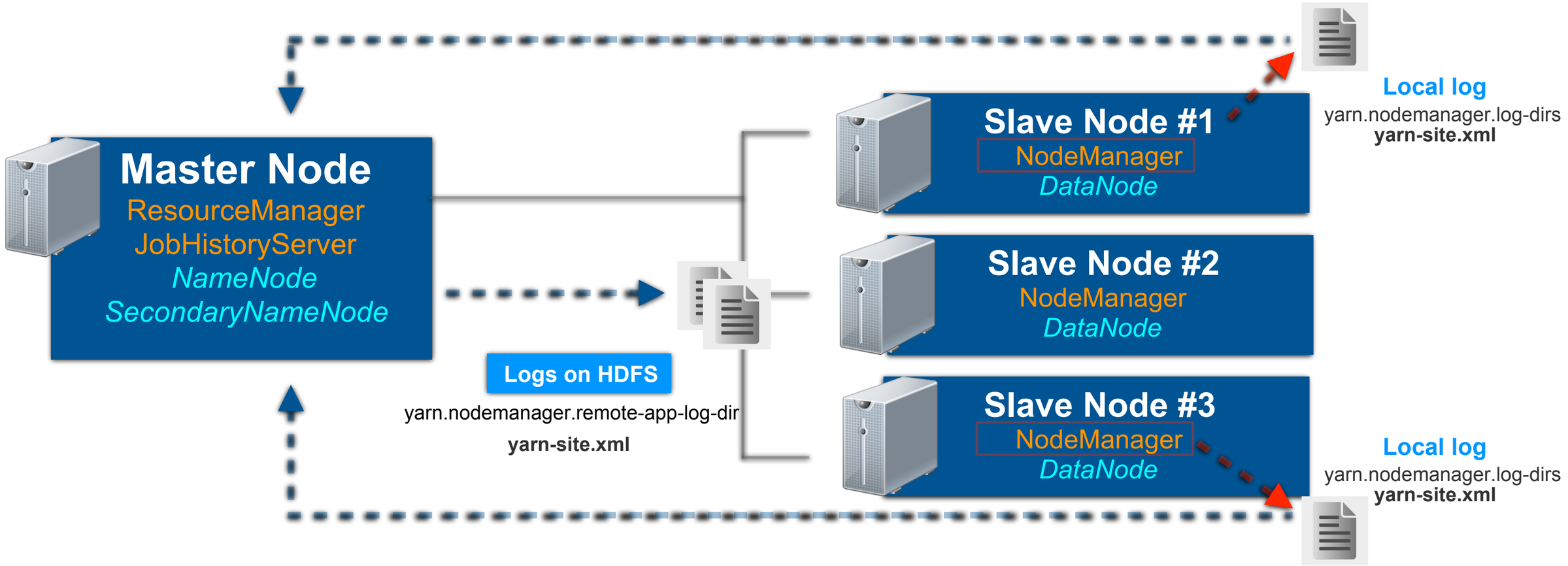
YARN RESOURCE ALLOCATION



YARN LOGS

- Debugging jobs running in **distribution** isn’t easy.
- Multiple processes running different nodes.
- YARN aggregates local logs from ***NodeManagers*** to a central location - HDFS.
- Logs are ordered by application / job.
- Accessible on HDFS or using a WEB interface.
- **Disabled** by default, usually enabled after installation

YARN LOGS


Master Node
ResourceManager
JobHistoryServer
NameNode
SecondaryNameNode
Slave Node #1
NodeManager
DataNode
Slave Node #2
NodeManager
DataNode
Slave Node #3
NodeManager
DataNode
Local log
yarn.nodemanager.log-dirs
yarn-site.xml
Logs on HDFS
yarn.nodemanager.remote-app-log-dir
yarn-site.xml
Local log
yarn.nodemanager.log-dirs
yarn-site.xml

YARN FAULT TOLERANCE

- **If a task running in a container fails**
  - Application Master will retry the task again.
  - If too many application tasks have failed the entire application is considered as failed.
  - Job Recovery can be configured so that Application Master can retry all tasks or only tasks which have not completed.

- **If an Application Master fails**, the Resource Manager will restart the entire application - up to two times by default.

YARN FAULT TOLERANCE

- **If a NodeManager fails** - ResourceManager will remove it from the list of “active nodes”.
  - Tasks on that node will be treated as failed by Application Master.
  - If the node running the Application Master fails, the Resource Manager will treat it as a failed application.

YARN FAULT TOLERANCE

- **If the Resource Manager fails**
  - No applications or tasks cane executed until Resource Manager is back online.
  - We can configure high availability for the resource manager to handle such failures.

  - Tasks on that node will be treated as failed by Application Master.

  - If the node running the Application Master fails, the Resource Manager will treat it as a failed application.