Spark on YARN

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Agenda

- YARN - Introduction
- Need for YARN
- OS Analogy
- Why run Spark on YARN
- YARN Architecture
- Modes of Spark on YARN
- Internals of Spark on YARN
- Recent developments
- Road ahead
- Hands-on

YARN

- Yet another resource negotiator.
- a general-purpose, distributed, application management framework.

Need for YARN

Hadoop 1.0

- Single use system
- Capable of running only MR

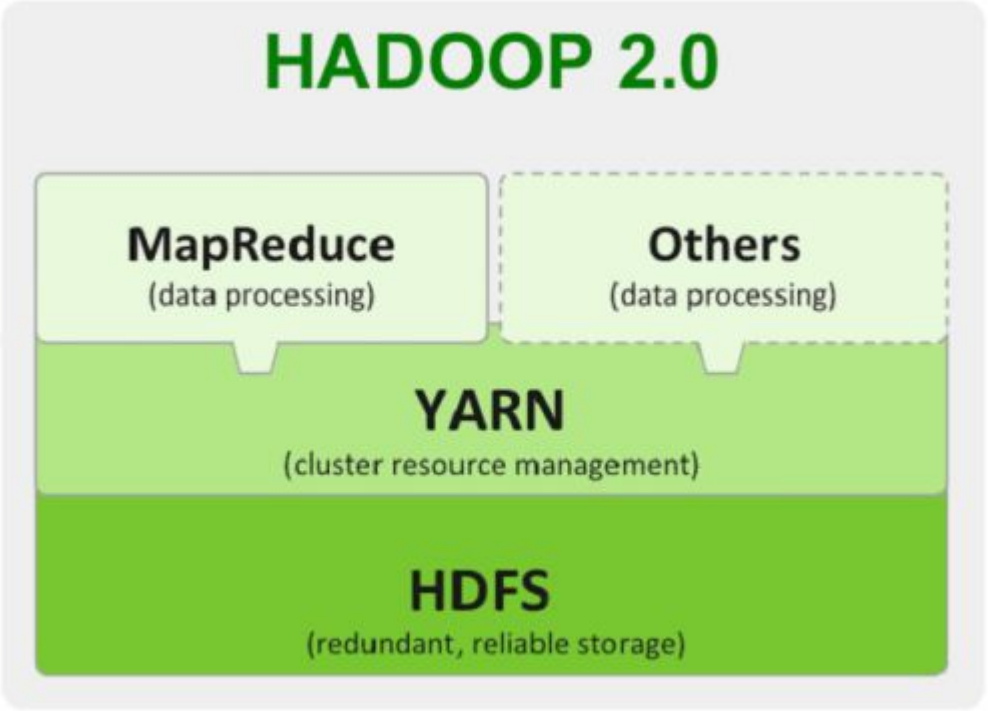
Need for YARN

- Scalability
  - 2009 – 8 cores, 16GB of RAM, 4x1TB disk
  - 2012 – 16+ cores, 48-96GB of RAM, 12x2TB or 12x3TB of disk.
- Cluster utilization
  - distinct map slots and reduce slots
- Supporting workloads other than MapReduce
  - MapReduce is great for many applications, but not everything.

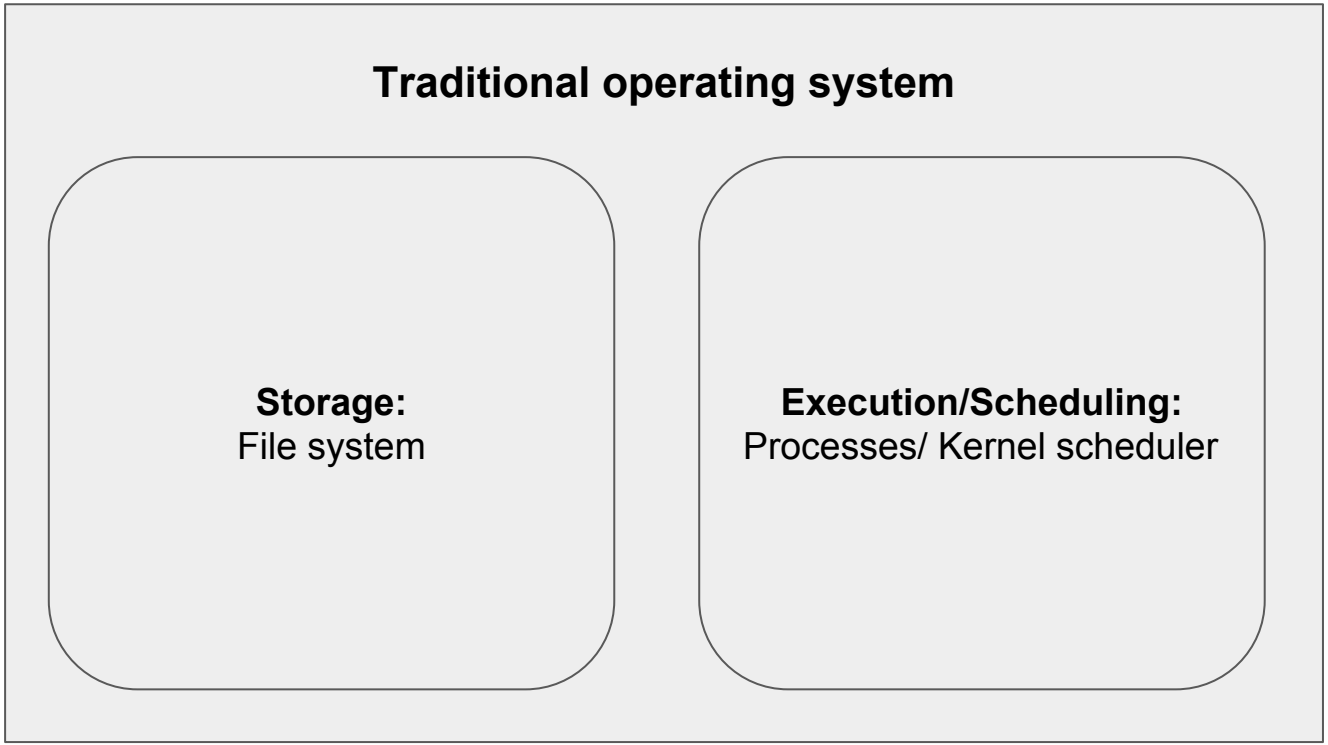
Need for YARN

Hadoop 2.0

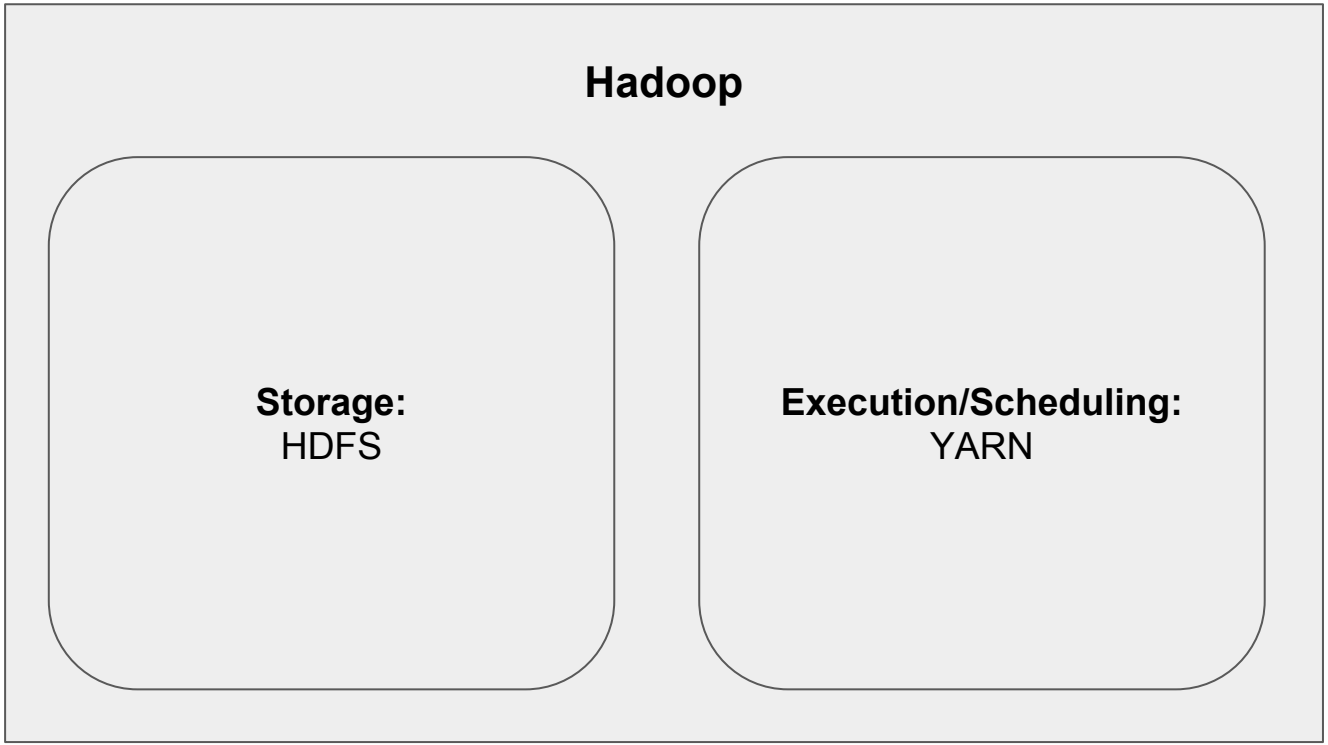
- Multi purpose platform
- Capable of running apps other than MR



OS analogy


Traditional operating system
Storage:
File system
Execution/Scheduling:
Processes/ Kernel scheduler

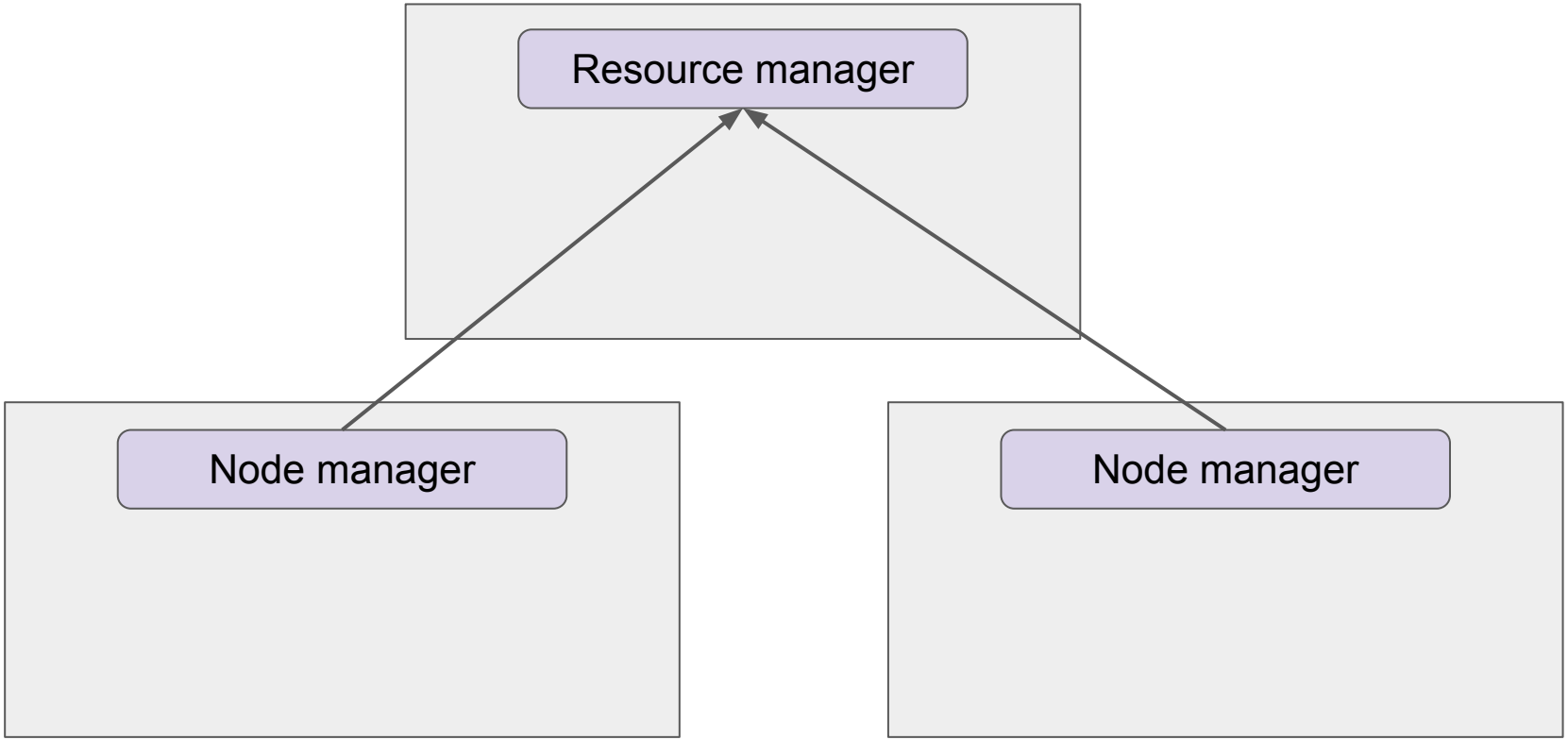
OS analogy



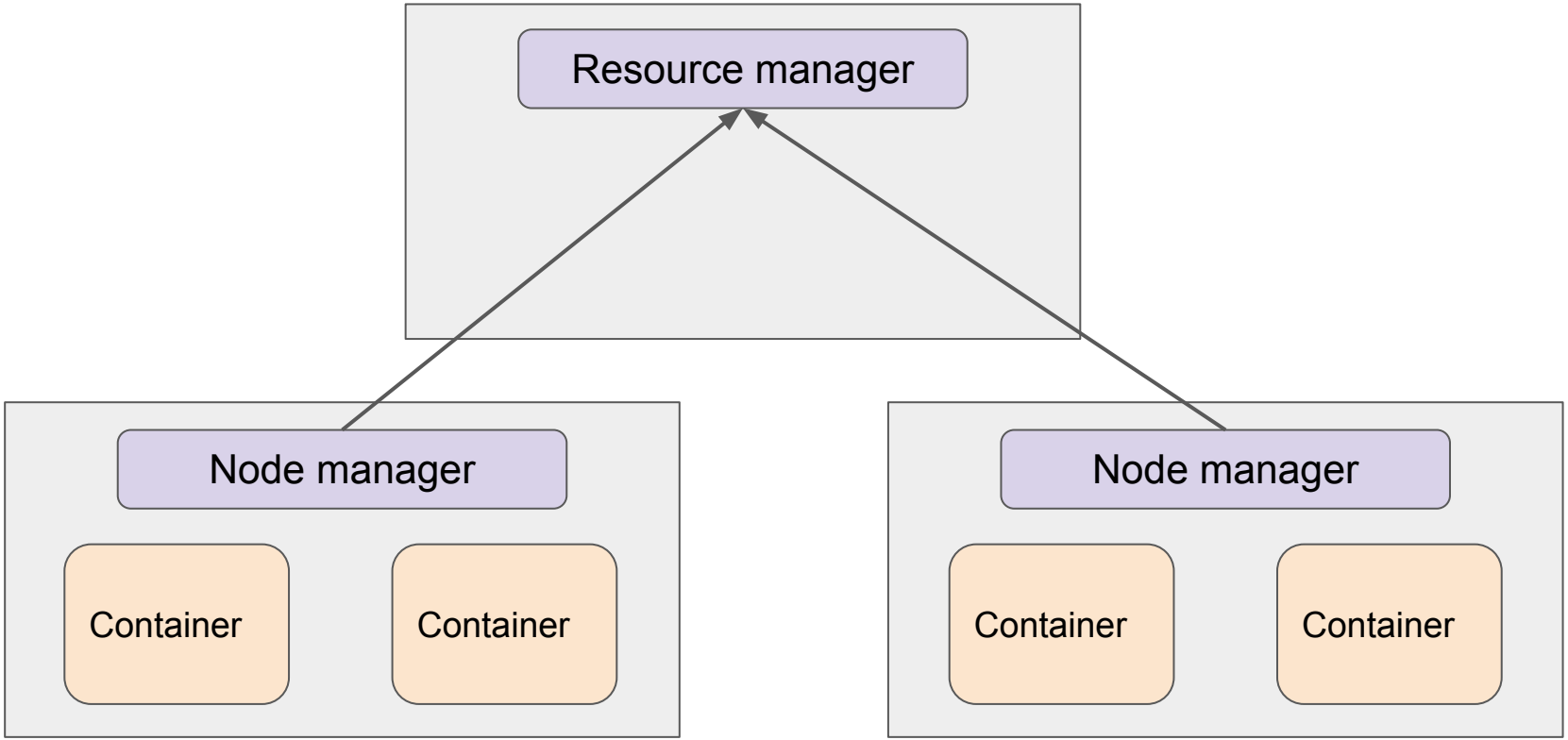
Why run Spark on YARN

- Leverage existing clusters
- Data locality
- Dynamically sharing the cluster resources between different frameworks.
- YARN schedulers can be used for categorizing, isolating, and prioritizing workloads.
- Only cluster manager for Spark that supports security

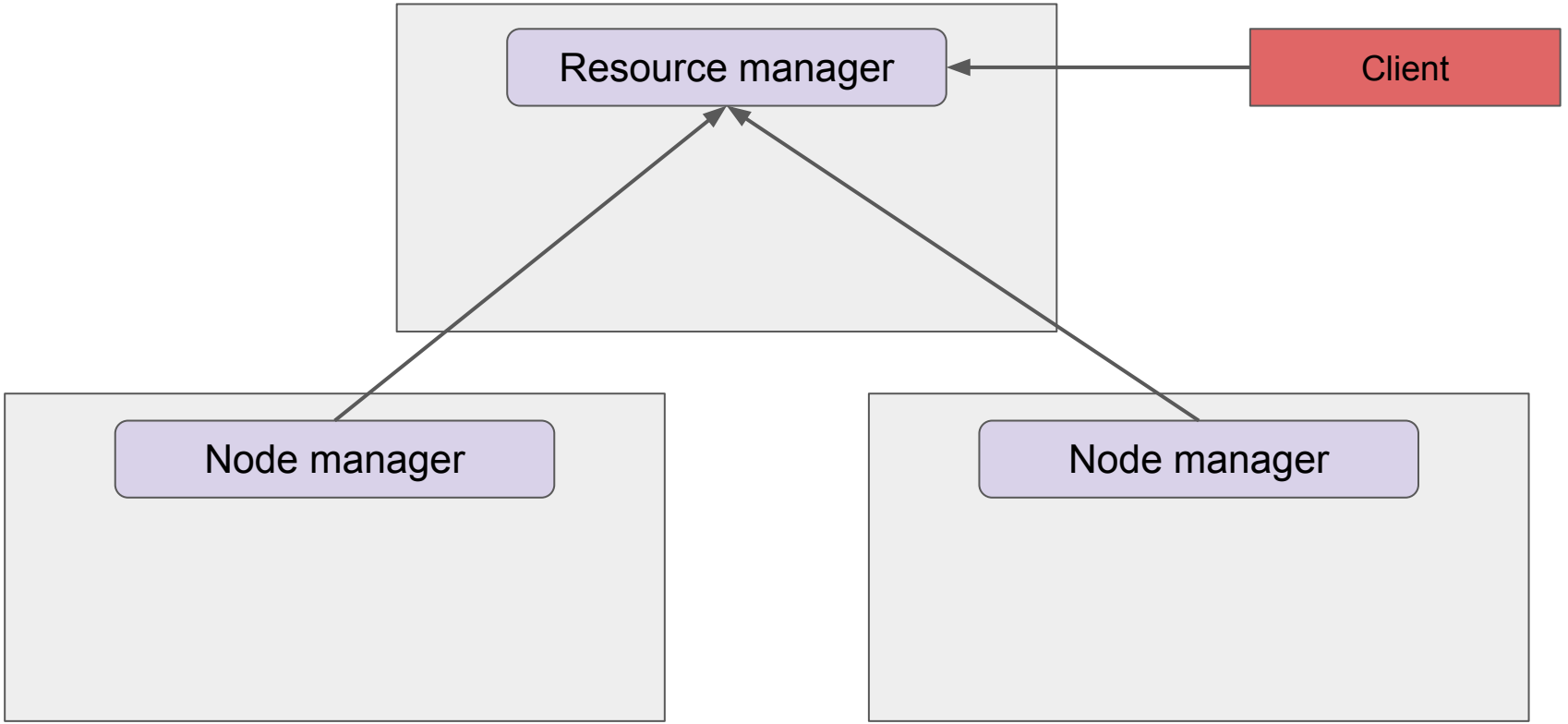
YARN architecture



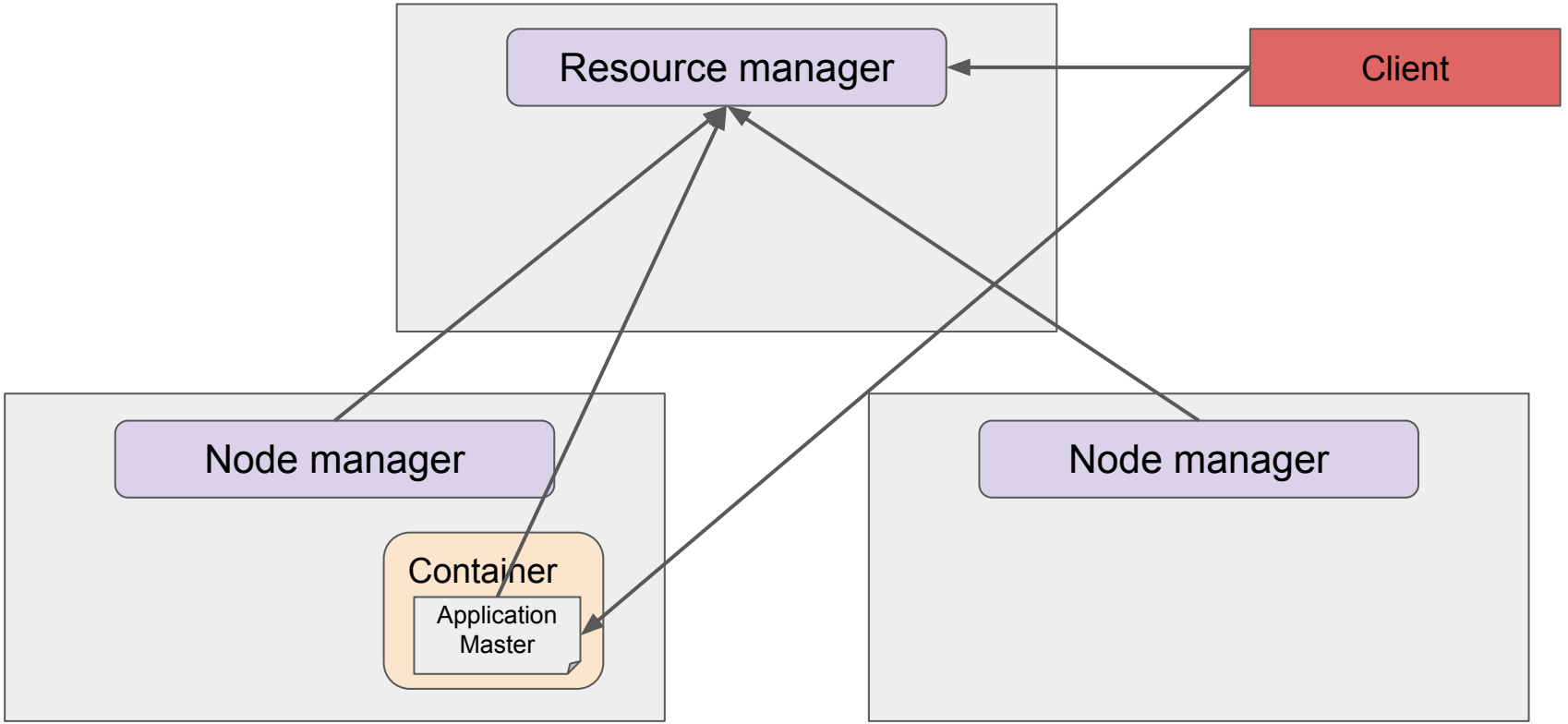
YARN architecture



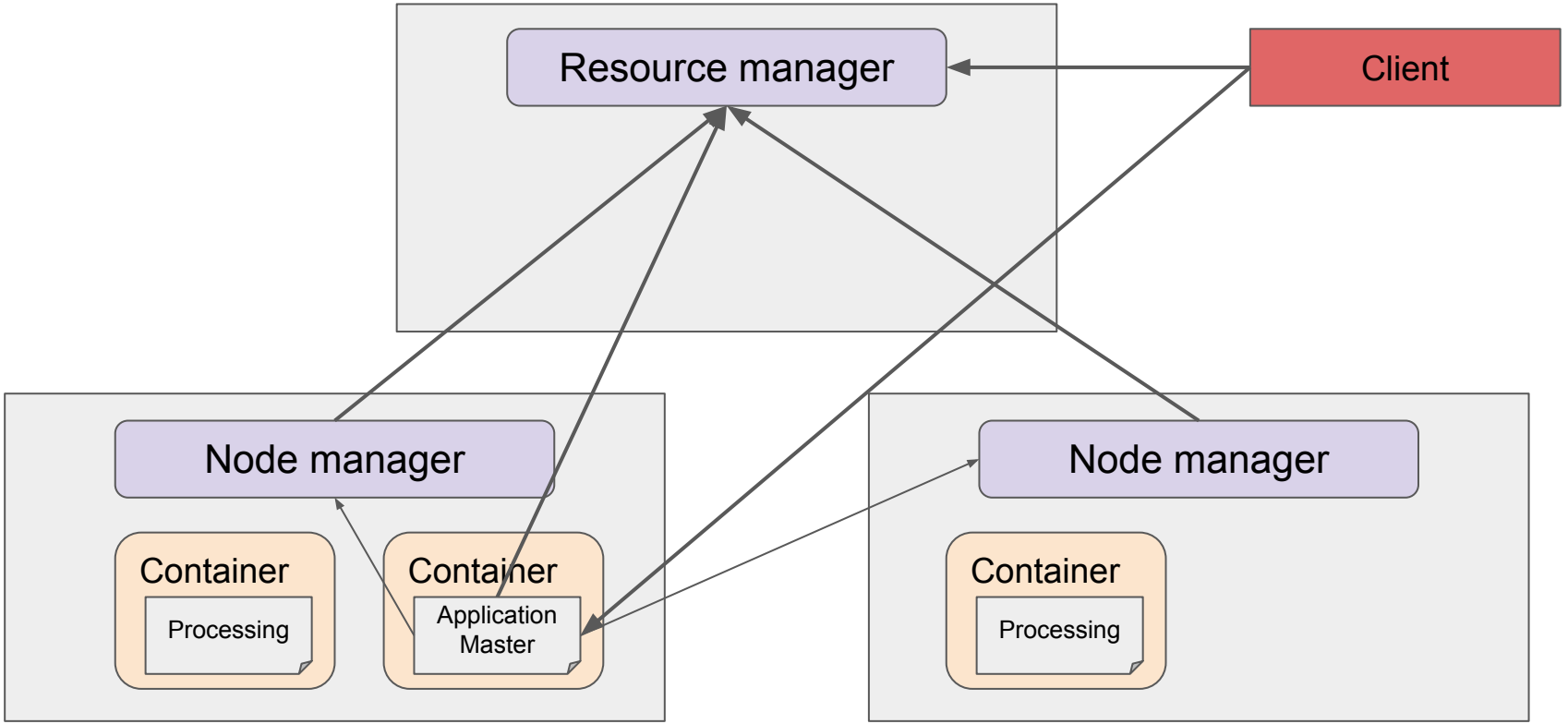
YARN architecture



YARN architecture

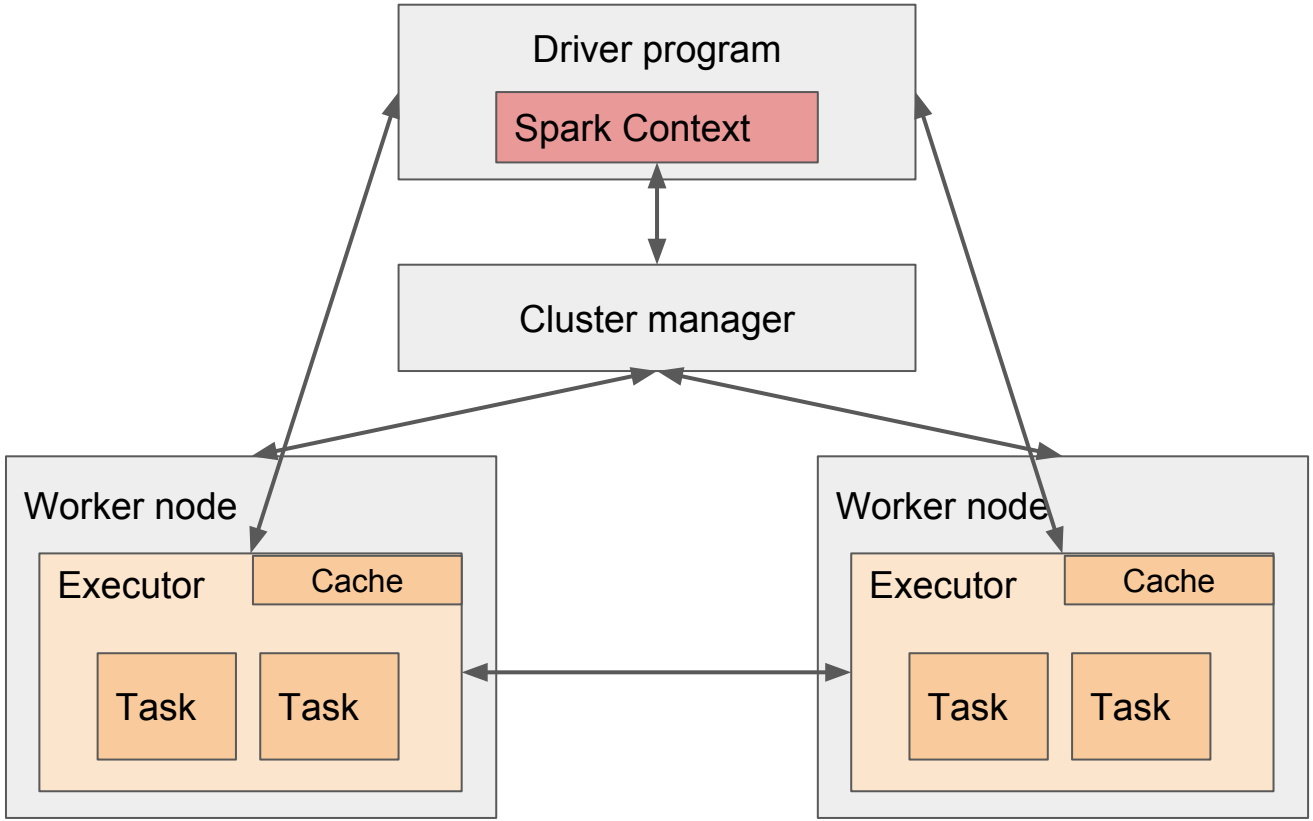


YARN architecture



Running Spark on YARN

Spark architecture



Spark architecture

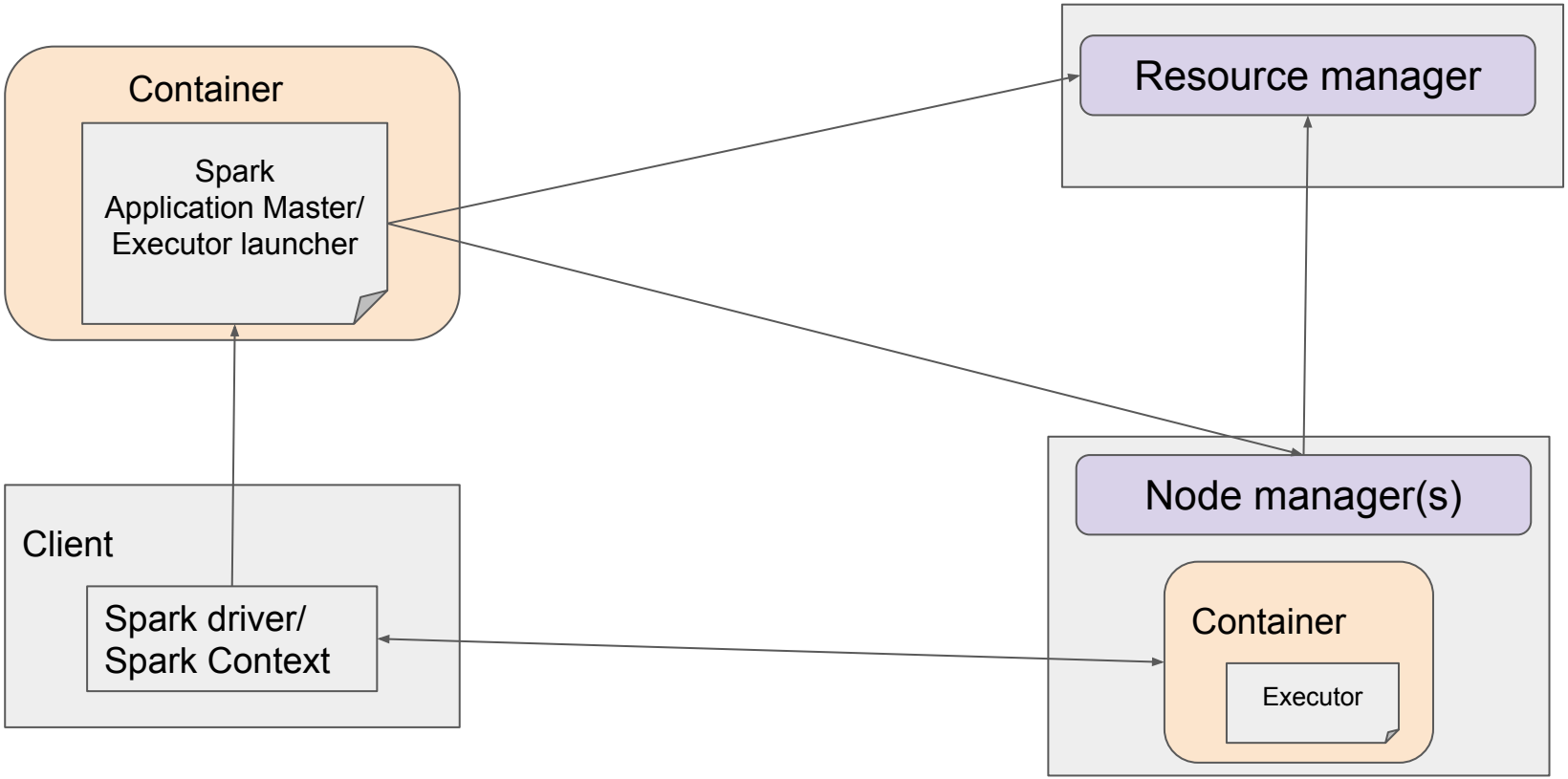
- **Driver Program** is responsible for managing the job flow and scheduling tasks that will run on the executors.
- **Executors** are processes that run computation and store data for a Spark application.
- **Cluster Manager** is responsible for starting executor processes and where and when they will be run. Spark supports pluggable cluster manager, it supports

  Example: YARN, Mesos and “standalone” cluster manager

Modes on Spark on YARN

- YARN-Client Mode
- YARN-Cluster Mode

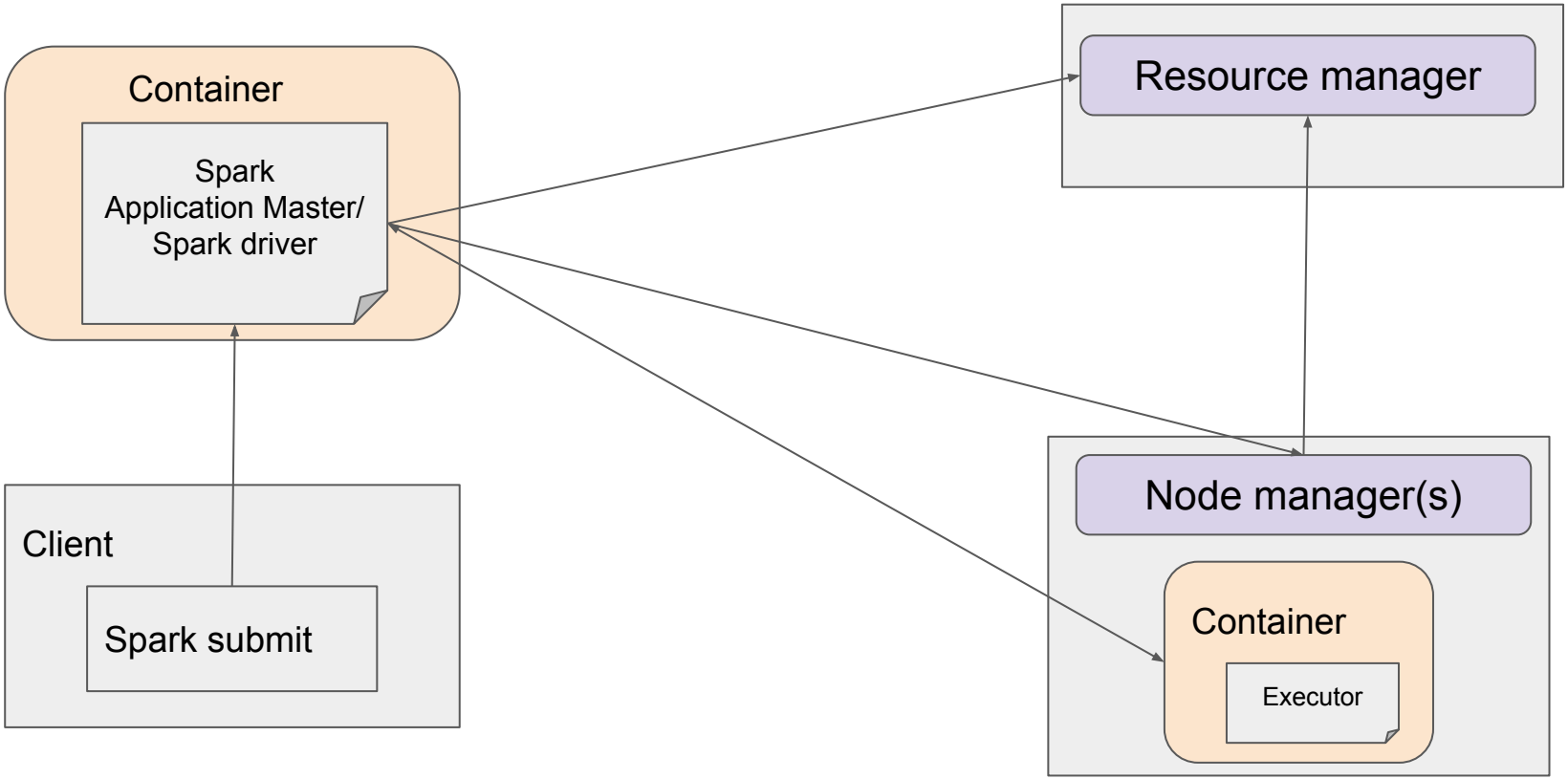
YARN client mode



YARN client mode

- Driver runs in the client process, and the application master is only used for requesting resources from YARN.
- Used for interactive and debugging uses where you want to see your application’s output immediately (on the client process side).

YARN cluster mode



YARN cluster mode

- In yarn-cluster mode, the Spark driver runs inside an application master process which is managed by YARN on the cluster, and the client can go away after initiating the application.
- Yarn-cluster mode makes sense for production jobs.

Concurrency vs Parallelism

- Concurrency is about dealing with lots of things at once.
- Parallelism is about doing lots of things at once.

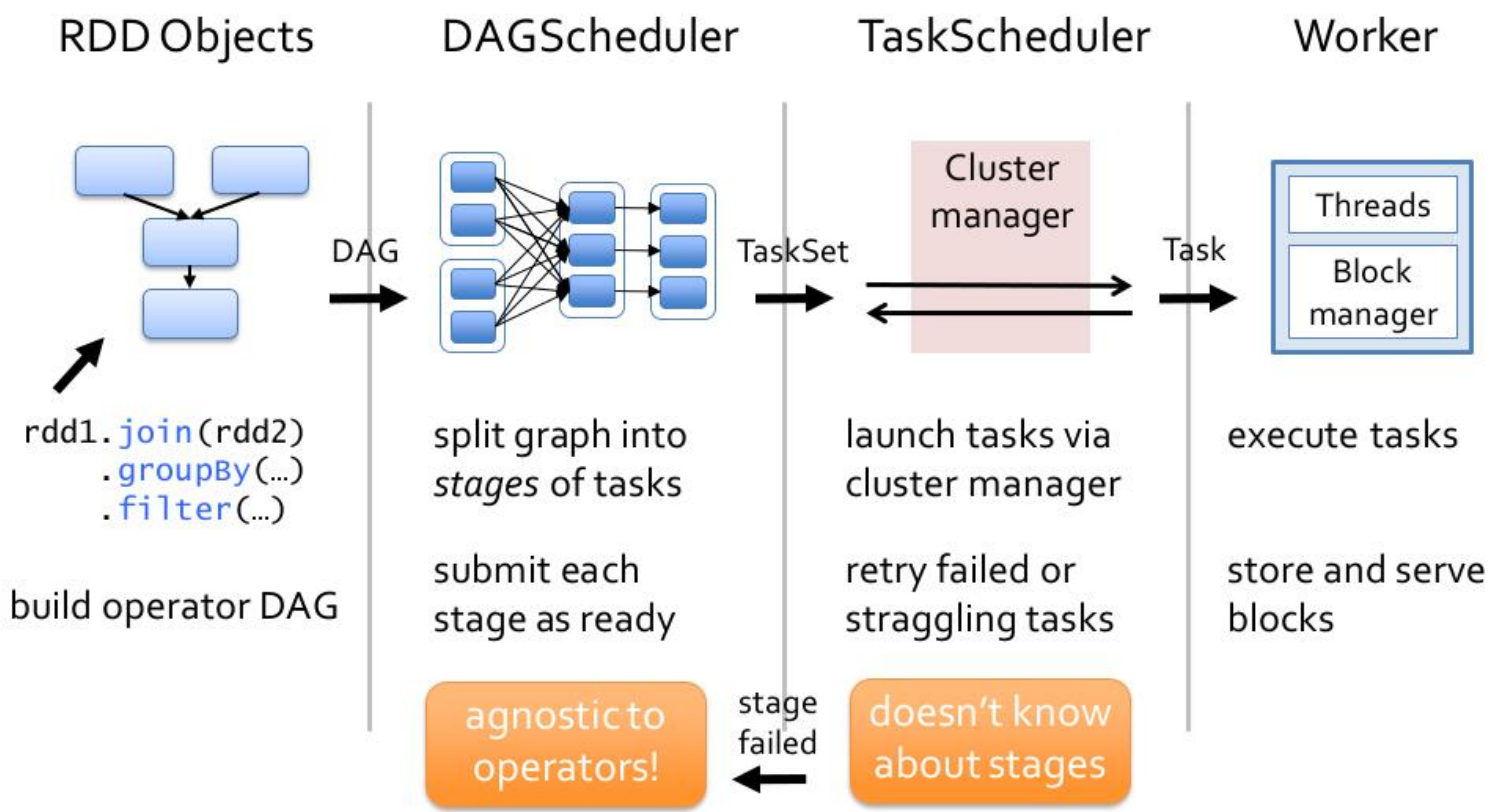
Akka

- Follows Actor model
  - Keep mutable state internally and communicate through async messages
- Actors

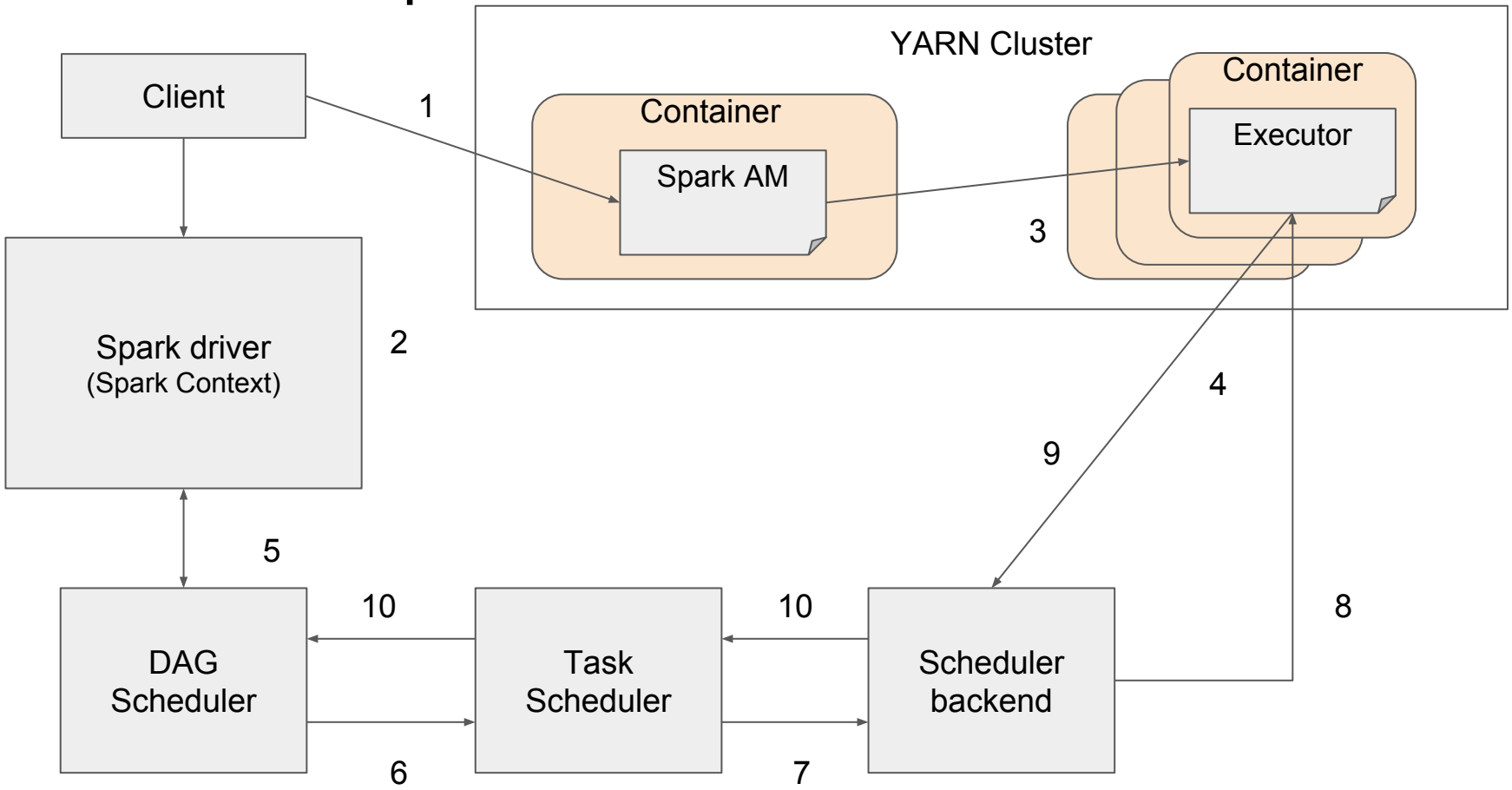
  Treat Actors like People. People who don't talk to each other in person. They just talk through mails.

  - Object
  - Runs in its own thread
  - Messages are kept in queue and processed in order

Internals of Spark



Internals of Spark on YARN



Internals of Spark on YARN

1. Requests container for the AM and launches AM in the container
2. Creates SparkContext (inside AM / inside Client).
   This internally creates a DAG Scheduler, Task scheduler and Scheduler backend.
   Creates an Akka actor system.
3. Application master based on the required resources will request for the containers. Once it get the containers it runs executor process in the container.
4. The executor process when it comes up registers with the Schedulerbackend through Akka.
5. When few lines of code has to be run on the cluster. RDD runJob method calls the DAG scheduler to create a DAG of tasks.

Internals of Spark on YARN

6. Set of tasks which is capable of running in parallel is sent to the Task Scheduler in the form of TaskSet.
7. Task scheduler in turn will contact the Schedulerbackend to run the tasks on the executor.
8. Scheduler backend which keeps track of running executors and its statuses, will schedule tasks on executors
9. Task output if any are sent through heartbeats to Schedulerbackend/
10. SchedulerBackend passes the task output onto the Task and DAG scheduler which could make use of that output.

Recent developments

- Dynamic resource allocation
  - No need to specify number of executors
  - Application grows and shrinks based on outstanding task count
  - Need to specify other things
- Data locality
  - Allocate executors close to data
  - SPARK-4352
- Cached RDDs
  - Keep executors around

Road ahead

- Making dynamic allocation better
  - Reduce allocation latency
  - Handle cached RDDs
- Simplified allocation
- Encrypt shuffle files
- File distribution
  - Replace HTTP with RPC

Yarn Hands On

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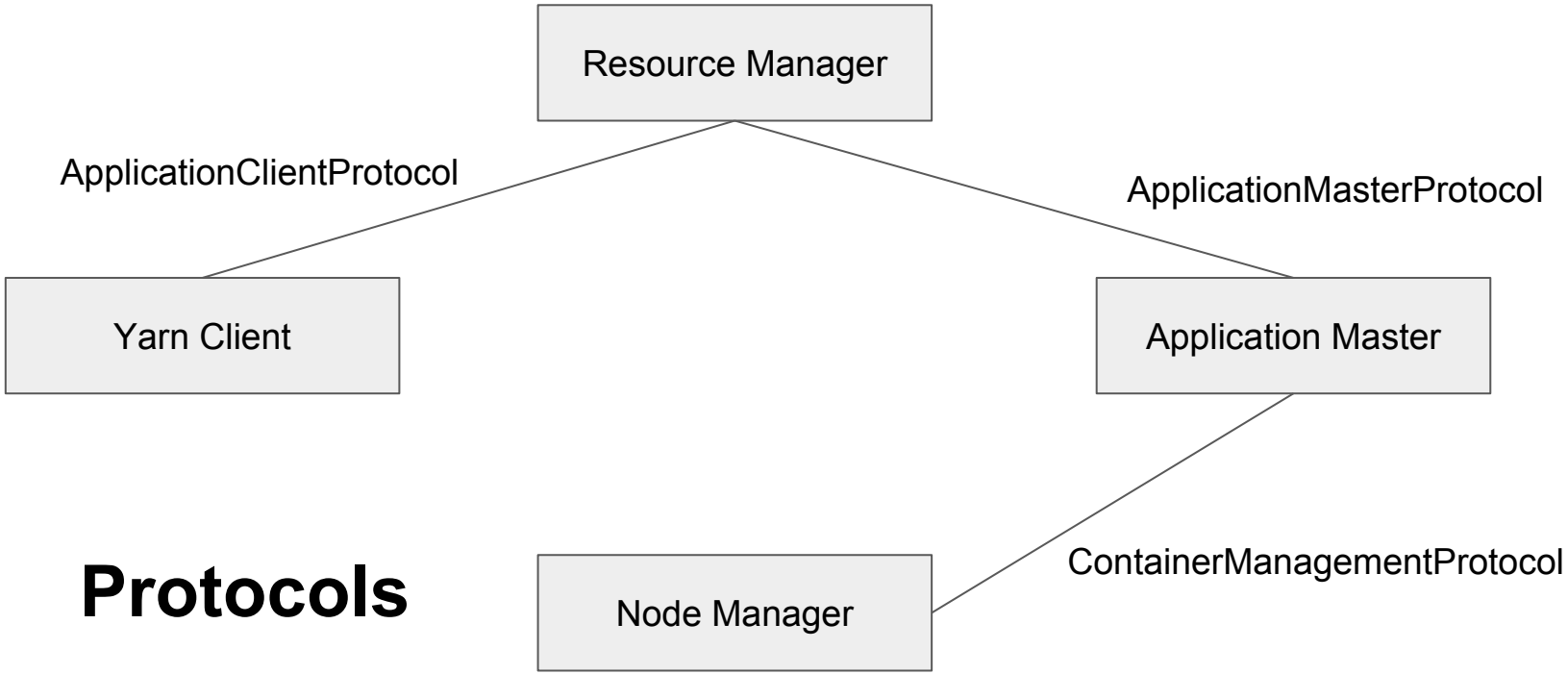
Yarn components in different phases



Protocols

Protocols

Application Client Protocol (Client<-->RM)(org.apache.hadoop.yarn.api.ApplicationClientProtocol)

Application Master Protocol (AM<-->RM)(org.apache.hadoop.yarn.api.ApplicationMasterProtocol)

Container Management Protocol (AM<-->NM)(org.apache.hadoop.yarn.api.ContainerManagementProtocol)

Application Client Protocol

- Protocol between client and resource manager
- Allows clients to submit and abort the jobs
- Enables clients to get information about applications
  - Cluster metrics - Active node managers
  - Nodes - Node details
  - Queues - Queue details
  - Delegation Tokens - Token for containers to interact with the services.
  - ApplicationAttemptReport - Application Details (host,port,diagnostics)
  - etc

Application Master Protocol

- Protocol between AM and RM
- Key functionalities
  - RegisterAM
  - FinishAM - Notify RM about completion
  - Allocate - RM responds with available/unused containers

Container Management Protocol

- Protocol between AM and NM
- Key functionalities
  - Start Containers
  - Stop Containers
  - Status of running containers - (NEW,RUNNING,COMPLETE)

Building Blocks of Communication

Records

Each component in YARN architecture communicates between each other by forming records.Each request sent is a record

Ex: localResource requests,applicationContext, containerLaunchContext etc

Each response obtained is a record

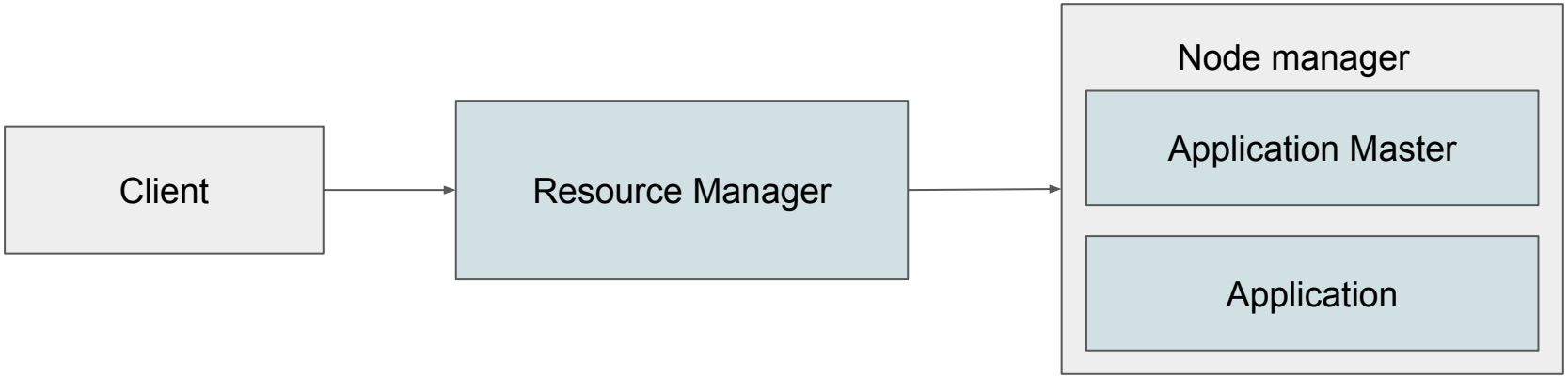
Ex: applicationResponse, applicationMasterResponse, allocateResponse etc

Custom Yarn Application

Components

- Yarn Client
- Yarn Application Master
- Application

Yarn Hello world



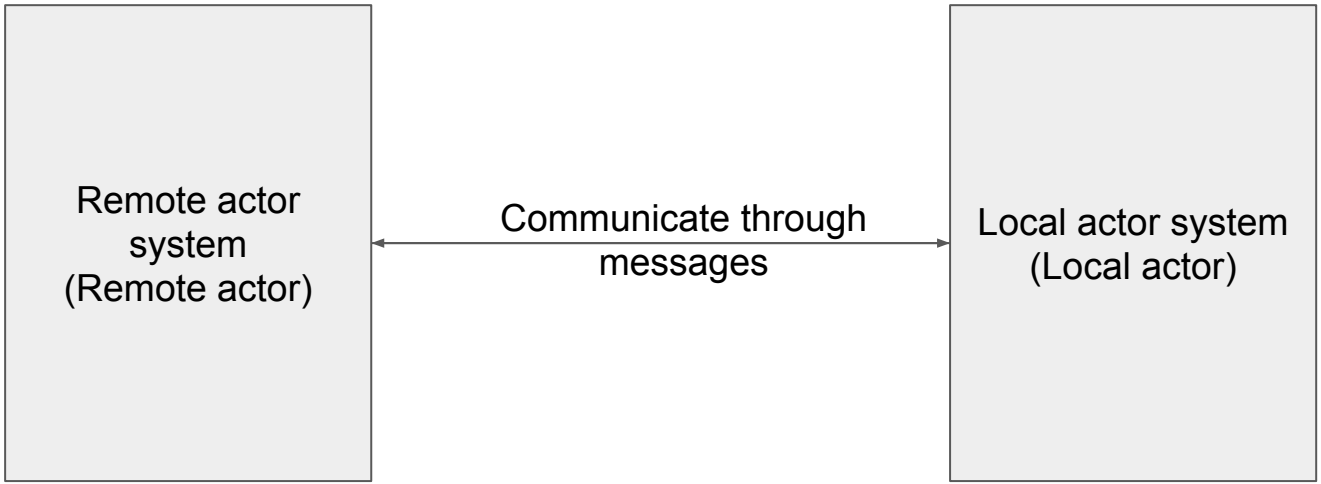
Package : com.madhukaraphatak.yarnexamples.helloworld

Yarn Hello world

Steps:

- Create application client
  - Communicate with RM to launch AM
  - Specify AM resource requirements
- Application master
  - Communicate with RM to get containers
  - Communicate with NM’s to launch containers
- Application
  - Specify the application logic

AKKA remote example



Package : com.madhukaraphatak.yarnexamples.akka

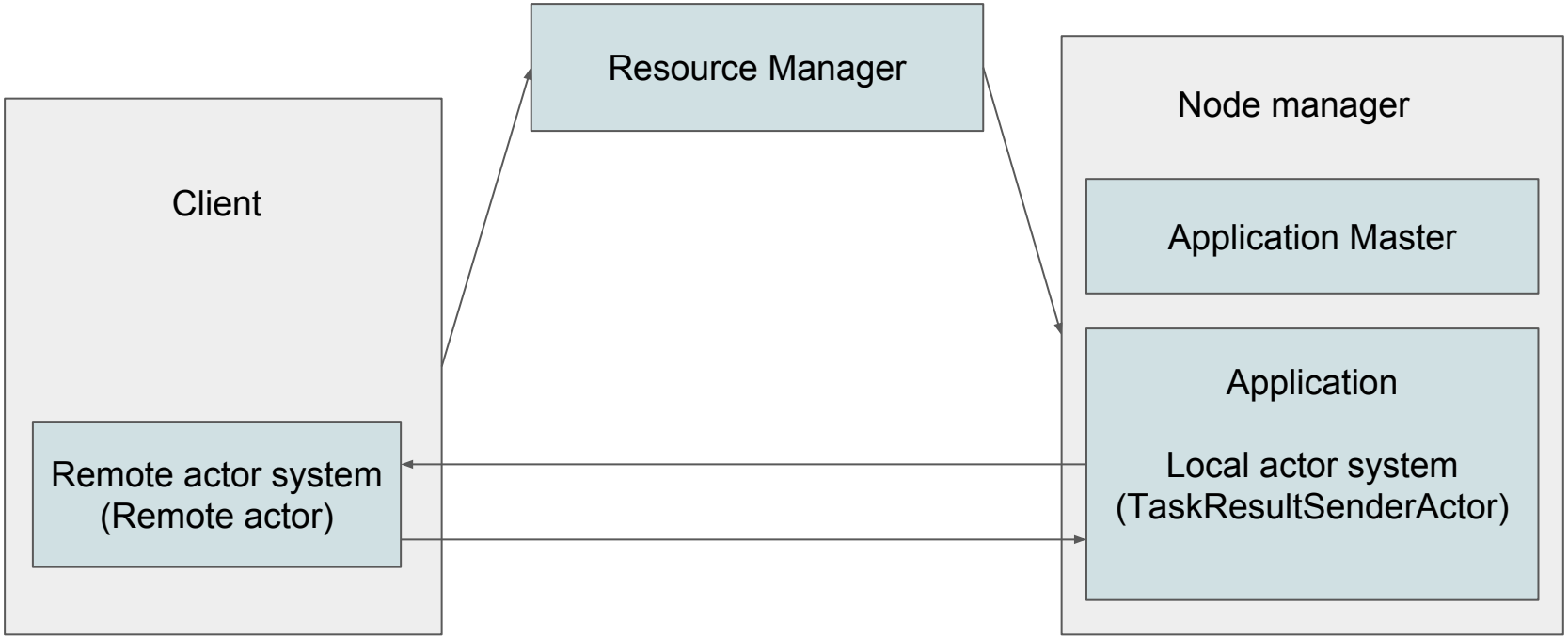
AKKA remote example

Steps:

- Create Remote client with following properties
  - Actor ref provider - References should be remote aware
  - Transports used - Tcp is the transport layer protocol
  - hostname - 127.0.0.1
  - port - 5150
- Create Local Client with following properties
  - Actor ref provider - We are specifying the references should be remote aware
  - Transports used - tcp is the transport layer protocol
  - hostname - 127.0.0.1
  - port - 0

1. Akka actors behave like peers rather than client-server.
2. They talk in similar transport.
3. Only difference is port : 0 -> any free port.

AKKA application on Yarn



AKKA application on Yarn

- Client
  - Defines the tasks to be performed
  - Submits tasks as separate set
- Scheduler
  - Create receiver actor (Remote Actor) for orchestration
  - Set up resources for AM
  - Launch AM for set of tasks
- Application Master
  - Create Executor for each single task
  - Set up resources for Containers

AKKA application on Yarn

- Executor
  - Create local Actor
  - Run task
  - Send response to remote actor
  - Kill local actor