BIG DATA

Job Management and YARN

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What we have learnt so far..

- Data processing distributed over a cluster – Map Reduce
- Job Submission Flow
- How does job management actually happen?
- How is failure management addressed?

... handled by YARN

Lecture Overview

- Need for YARN - history
- YARN Architecture
- Job submission lifecycle –YARN
- Scheduling
- Failure Handling
- Benefits of YARN

Big Data: The need for YARN

Motivation

- Recall
  - Job –the entire map reduce application
  - Task –Individual mappers/reducers

- How do we
  - Allocate resources –determine which nodes will run the jobs
  - Monitor the tasks –start new tasks or restart failed/slow tasks
  - Monitor the overall state of the job?

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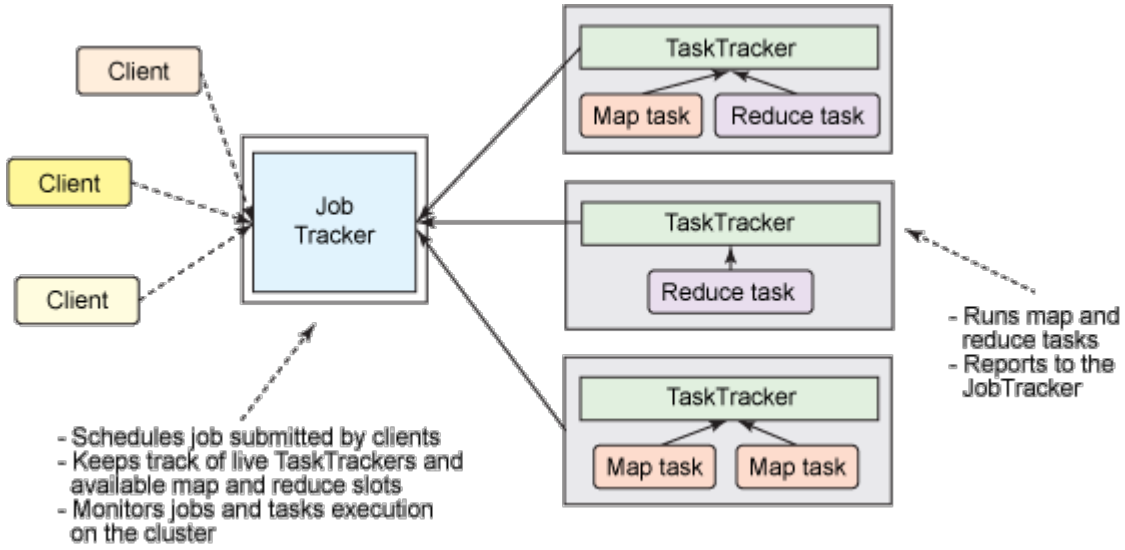
Hadoop 1.0 Job Management

- Job Tracker
  - Manage Cluster resources
  - Job scheduling
- Task Tracker
  - One per task
  - Manage the task
- Fault Tolerance, Cluster resource management and scheduling handled by JobTracker



Hadoop 1.0 Issues

Limits scalability

- Job tracker runs on a single machine and is responsible for cluster management, scheduling and monitoring

Availability

- JobTracker is the single point of availability/failure

Resource utilization problems

- Predefined #map/reduce slots. Utilization issues because map slots may be full but reduce slots are free.

Limitation in running MR applications

- Tightly integrated with Hadoop. Only MR apps can other applications.

Big Data: YARN Architecture

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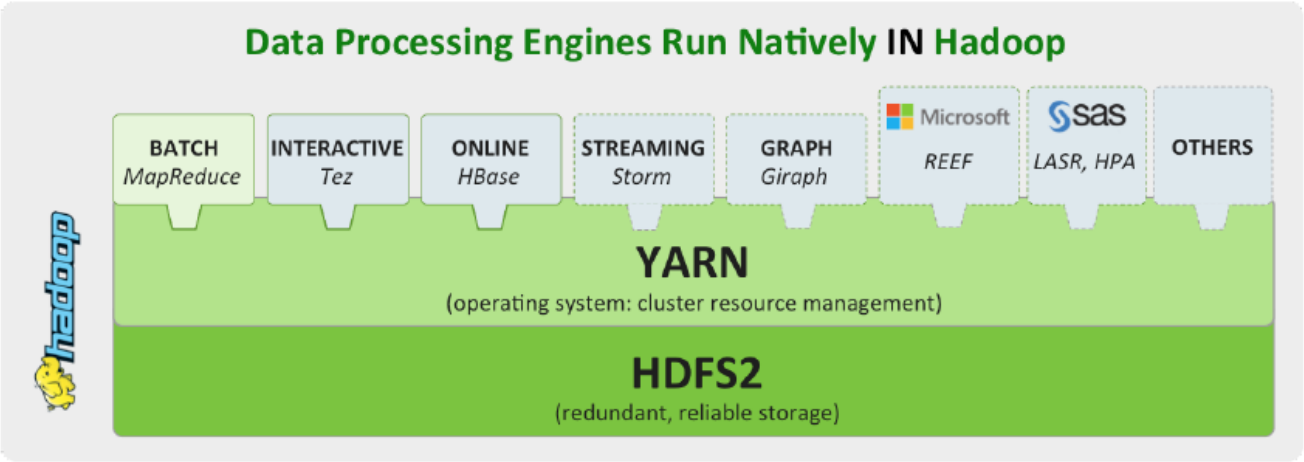
Map Reduce - Motivation



- Issues in managing clusters > 4000 nodes
- 2010 –MapReduce v2 with YARN
  - Yet Another Resource Negotiator
  - YARN Application Resource Negotiator!!

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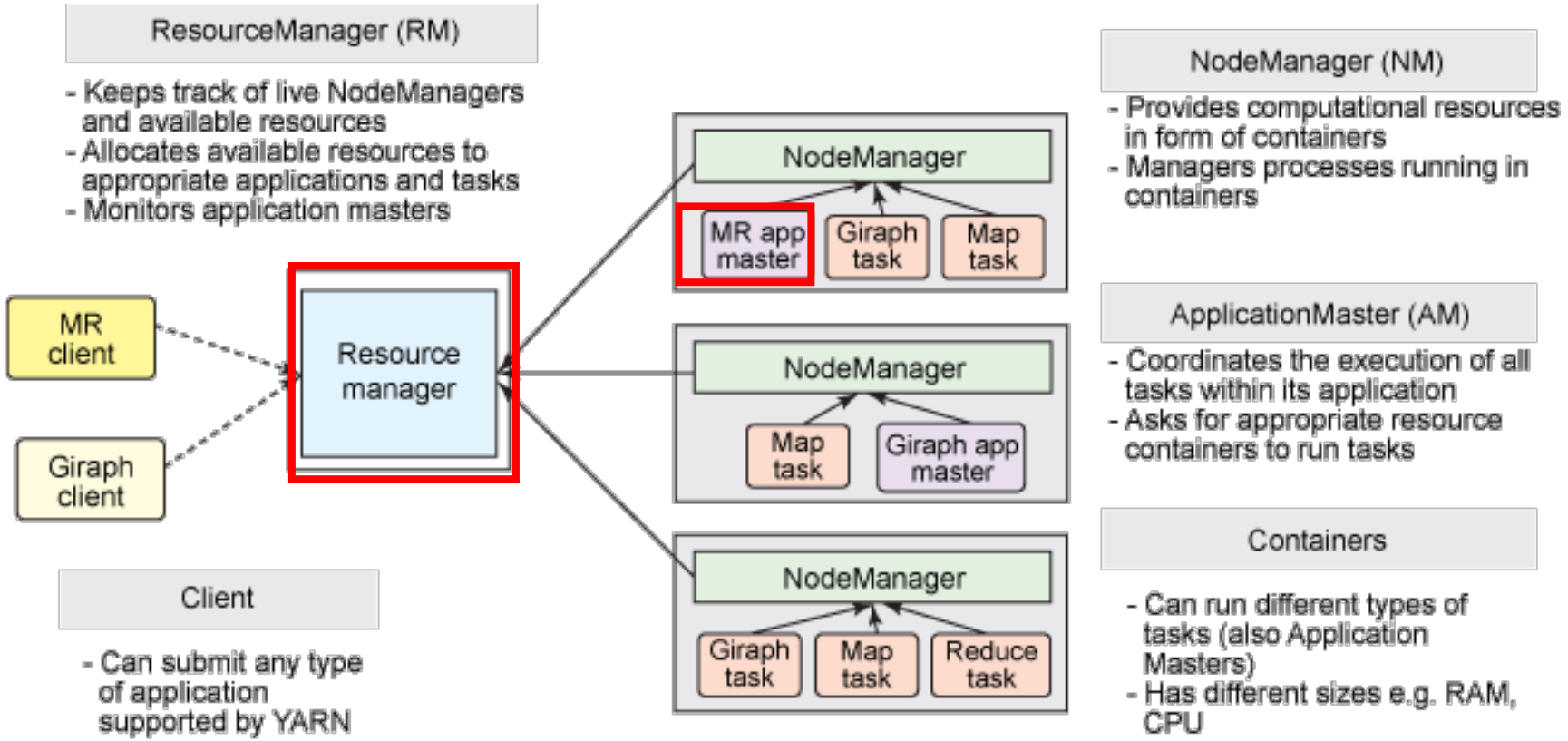
YARN Architecture



- Split responsibility of Job Tracker
- Resource Manager –manage cluster wide resources
- Application Master –manage lifecycle of application

YARN Components

Resource Manager	•Arbitrates resources amongst all applications of the system
Node Manager	•Per machine slave •Responsible for launching application containers •Monitors resource usage
Application Master	•Negotiate appropriate resource containers from the scheduler •Track and monitor the progress of the containers
Container	•Unit of allocation incorporating resources such as memory, CPU, disk

Big Data: Job Submission - YARN

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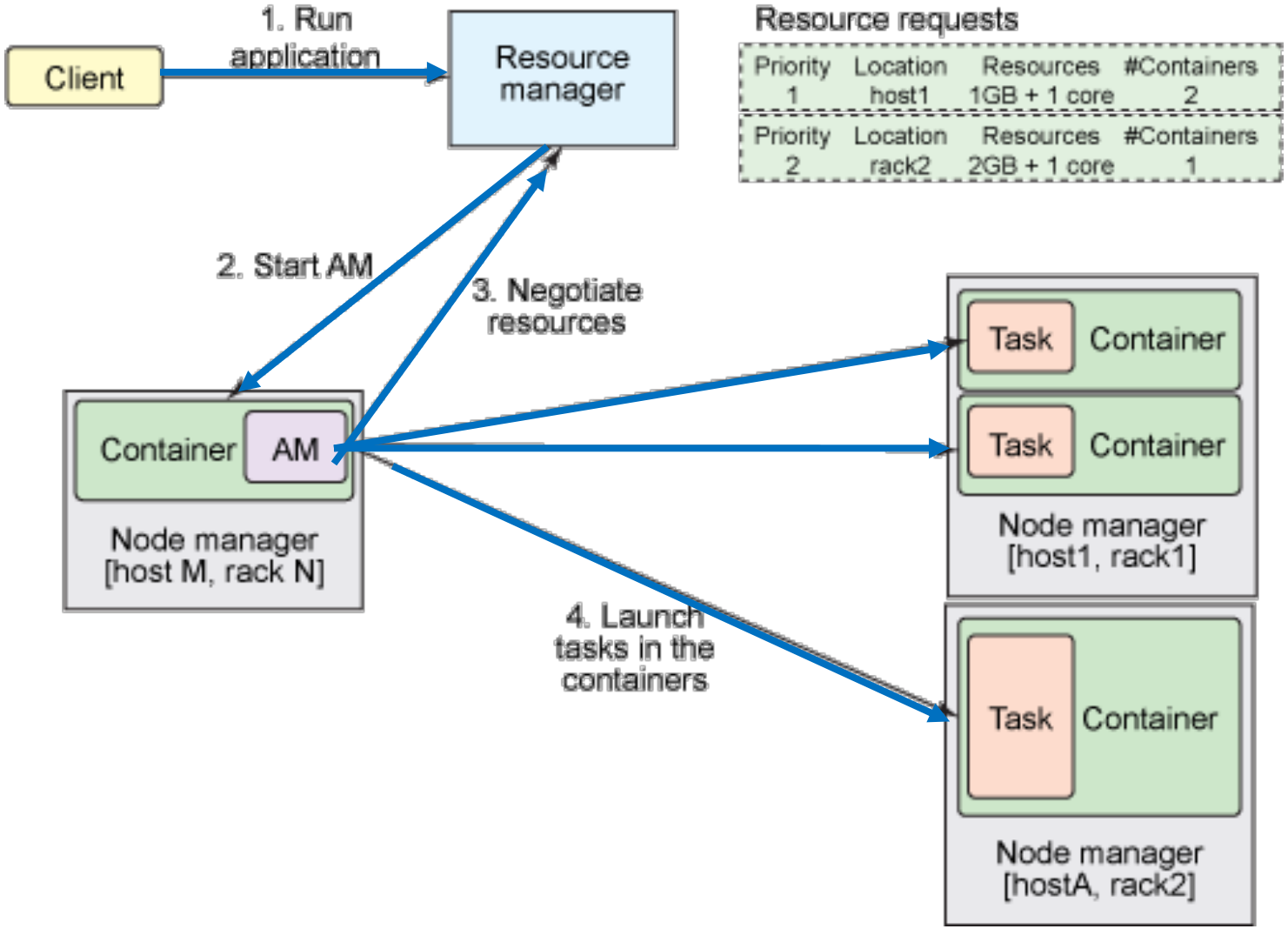
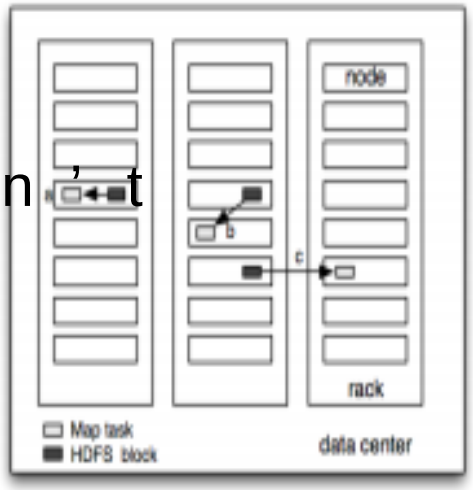
YARN Working



Data Locality in Map Reduce

- Attempts to run the map task on a node where the input data resides in HDFS.
  - *data locality optimization* - it doesn't use valuable cluster bandwidth.
- What happens when all nodes hosting the block replicas are busy?
  - look for a free map slot on a node in the same rack as one of the blocks.
- Very occasionally even this is not possible, so an off-rack node is used, which results in an inter-rack network transfer.



Scheduling in YARN

Schedulers in Hadoop

- Early Hadoop versions → simplistic FIFO scheduler
  - In order of submission
  - each job would use the whole cluster
  - so jobs had to wait their turn.
- How to share resources fairly?
- Balance between
  - Production jobs
  - Ad-hoc jobs

Fair Scheduler

- Aims to give every user a fair share of the cluster capacity over time.
- Jobs are placed in pools,
  - Default → each user gets their own pool.
- If a single job is running, it gets all of the cluster.
- As more jobs are submitted,
  - free task slots are given to the jobs in such a way as to give each user a fair share of the cluster.
- Short job –completes in reasonable time
- Long job –can continue making progress.

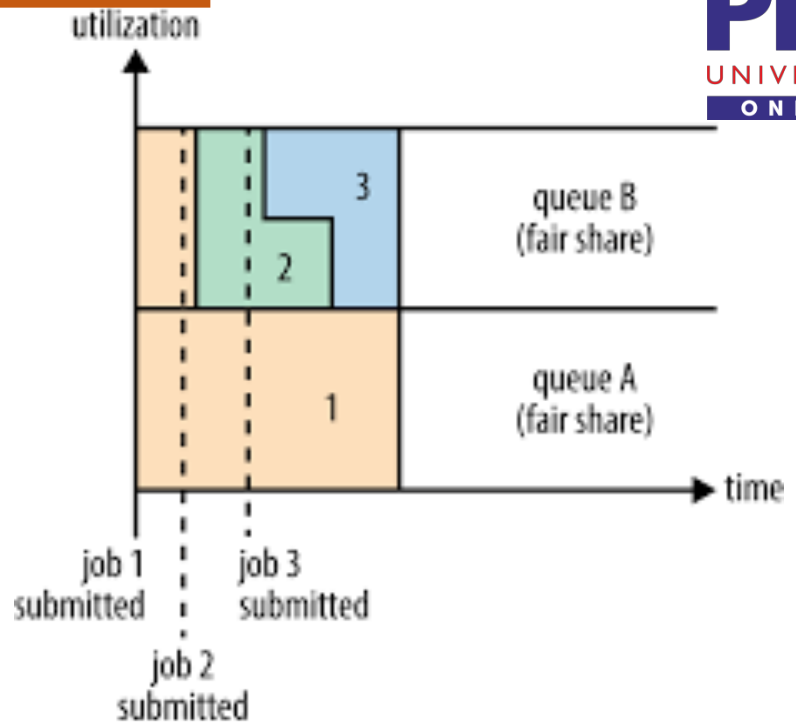


Image courtesy: Tom White, "Hadoop the definitive guide"

Fair Scheduler

- Consider a user who submits more jobs
  - Scheduler ensures → that user does not hog the cluster
- Custom pools
  - Guaranteed minimum capacities with map/reduce slots
  - It is also possible to define custom pools with guaranteed minimum capacities defined in terms of the number of map
- The Fair Scheduler supports preemption
  - If pool not received its fair share over certain time
  - scheduler will kill tasks in pools running over capacity

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Capacity Scheduler

- Different approach
- number of queues (like the Fair Sched
  - Has an allocated capacity
  - Can be hierarchical
  - Within each queue → scheduled using FIFO (with priorities)
- Cannot use free spare capacity even if it exists
- Like breaking up cluster into smaller clusters

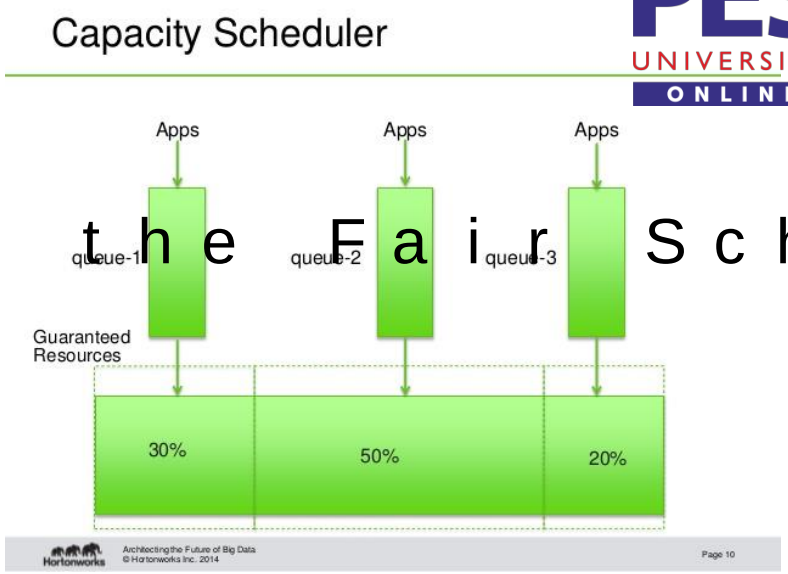


Image: https://www.slideshare.net/Hadoop_Summit/w-525hall1shenv2

Handling Failures

What can fail?

- Task
- Application Manager
- Resource Manager
- Node Manager

Task Failure

Due to runtime exceptions	• JVM reports error back to parent application master
Hanging tasks	• Progress updates not happening for 10 mins • Timeout value can be set.
Killed tasks	• Speculative duplicates can be killed
Recovery	• AM tries restarting task on a different node

Application Master Failure

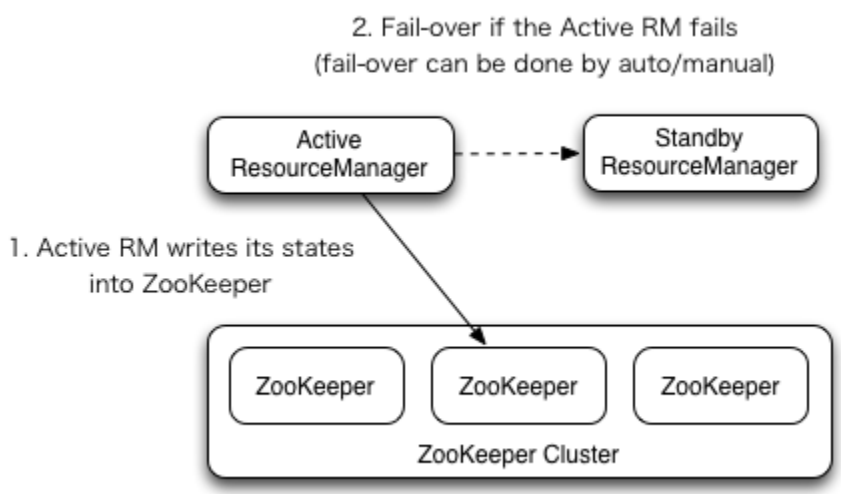
When can failure occur?	• Due to hardware or network failures
How to detect for failures?	• AM sends periodic heartbeats to Resource Manager
Restart	• Max-attempts to restart application • Default = 2

Node Manager Failure

When can failure occur?	•Hardware, crashing, slow network
How to detect for failures?	•When a heartbeat is not received by RM for 10mins
Restart	•Tasks of incomplete jobs will be rerun –maybe on different node

Resource Manager Failure

How is failure handled?	• Active Standby configuration
Impact	• More serious as all tasks fail
Restart	• Handled by failover controller



https://hadoop.apache.org/docs/current/hadoop-yarn/hadoop-yarn-site/ResourceManagerHA.html

Benefits of YARN

YARN Benefits –Case Study @Yahoo

- YARN manages a very large cluster at Yahoo
  - Scalability –to over 40,000 servers with 100,000 CPUs, 455 PB of data
    - Runs over 850,000 jobs per day
  - Flexibility
    - Same cluster has Hadoop, Storm and Spark (100 node cluster) sharing resources using YARN

https://www.techrepublic.com/article/why-the-worlds-largest-hadoop-installation-may-soon-become-the-norm/

Review Exercises

Review Exercises

- All problems listed in T1 as part of LO2.5

Solved Exercises

- A 1000 node YARN cluster has no jobs running. Two pools are configured with max of 50% of the resources. A new job requiring 600 nodes is submitted and on starting consumes all 600 nodes. Which YARN scheduler is active?
  - Either FIFO or Fair because they will use the entire cluster if there is no other job.
- Will the failure of task result in failure of the entire job?
  - No. Task will be restarted
- What are speculative duplicates?
  - Tasks that are started when AM determines that there is a slow running task.

Additional Notes, Reference Material and Notes

YARN Further Reading

- Chapter 2.5 of T1
- Chapter 4 in T2
- https://hadoop.apache.org/docs/current/hadoop-yarn/hadoop-yarn-site/YARN.html
- There is a good description of YARN in the Tom White book.
- Also follow links from slides given before

THANK YOU

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