OPERA-P

OPportunistic Elastic Resource Allocation & Provisioner

A Big Data Plumbing with HTCondor and Hadoop Yarn

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HTCondor High Throughput Computing

Outlines

- Background
  - Scheduling Large-Scale Clusters (LSC)
  - State of Resource Management in Big Data
- Challenges
  - Proposed solutions
- Introducing OPERA-P
  - What is it and What's not
- OPERA-P architecture
- Use case - MapReduce
- Opportunities
- Future work

Scheduling Large-scale Clusters

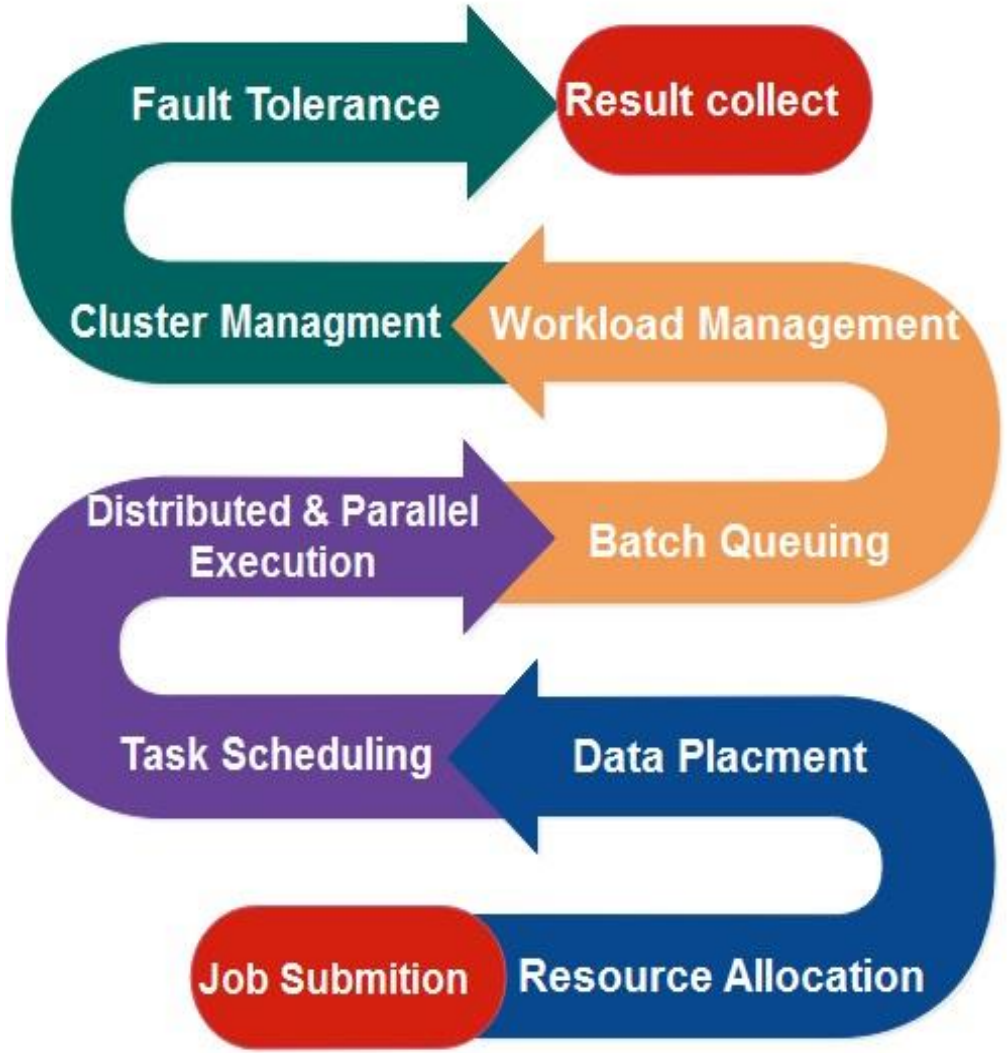
- Goals:
  - Highest Utilization
  - Maintain ultimate efficiency
  - Scalable (whenever, however we want)
  - High fault tolerance

- Issues:
  - Un-predictable load
  - Increasing workload, clients and cluster size
  - Common delusion
    - Network reliable and homogeneous
    - Transport cost is zero

Resource Management Terminology

- Different cluster scheduler architectures.
  - Monolithic schedulers
  - Two-level schedulers
  - Shared-state schedulers
  - Hybrid solutions

- Hide the details so that the user focus on application development
- Maintain in high availability, reliability and support frameworks to do so
- Open source resource management solution:
  - Hortworks, Cloudera, MapR - YARN
  - Apache Mesos and Myriad
  - Container-based Clusters - Docker Swarm, etc,.



LSDS Challenges

- The utilization problem…
- Multi-tenancy problem…
  - Virtualization impacts performance
  - Difficult to do short term borrowing of capacity
- Installing new infrastructure
  - Cost, cost and cost
- Fault tolerance, Failure management and security

Schedulers wish list!

- Applications request resources when they need them
  - Automated without user intervention
- Scale-out on demand to a free resources
  - Elastically provisioning
- Multi-tenancy with strong isolation
  - Sandbox with the required libraries etc,
- Minimal configuration
  - Updated/restarted without affecting current running tasks

The problem!

- Creating infrastructure silos to accommodate BD apps is inefficient

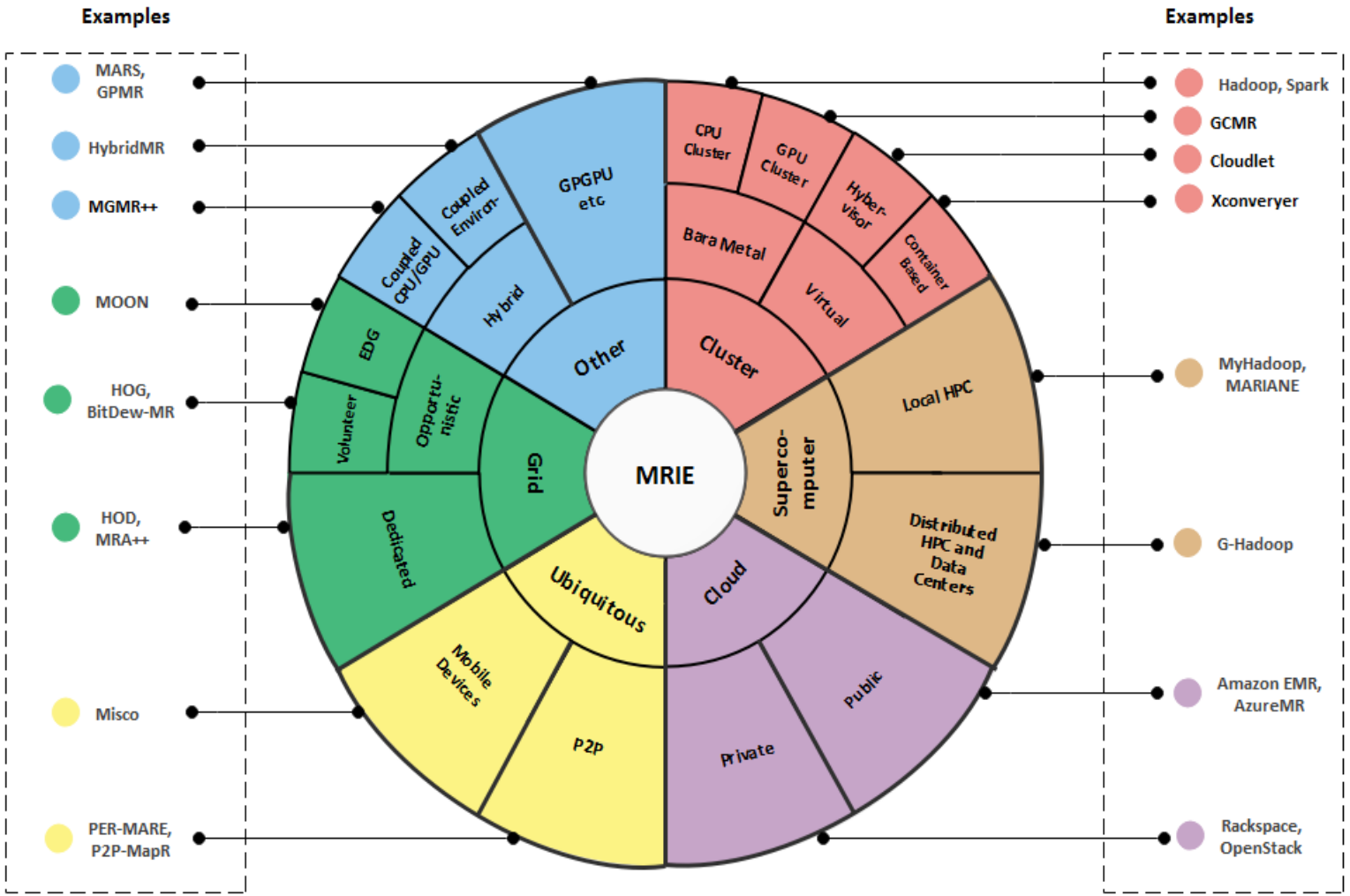
Low Utilization
= Higher cost

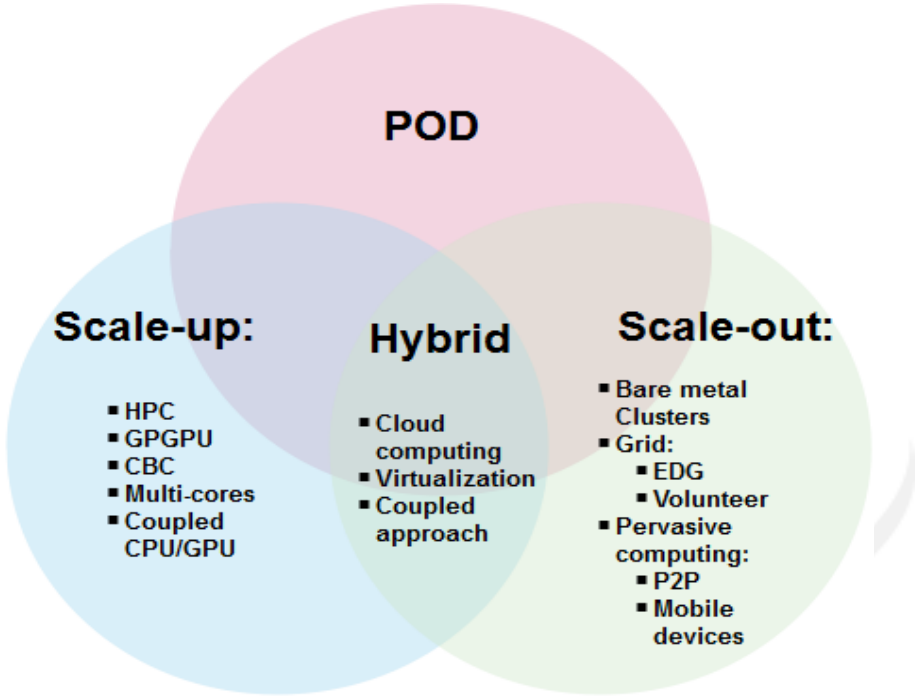
- Workloads tend to be bursty
  - Having periods of heavy utilization (e.g., Quarte reports) followed by periods of light utilization.
    - No one size fit all
- Deploying parallel infrastructures is not an easy task, it can be costly as well.
  - Wasted Computation within an enterprise

Current solutions

- Statically cluster sizing based on peak utilization
- Installing new infrastructure on-demand
  - Easy with Hadoop (scale-out)
  - Though, it's not elastic or auto-scale technique
- Virtual Machines
  - High virtualization costs
  - VM licensing
  - Data movement issues
- New development environments
  - Adaptive and untraditional analytical environments

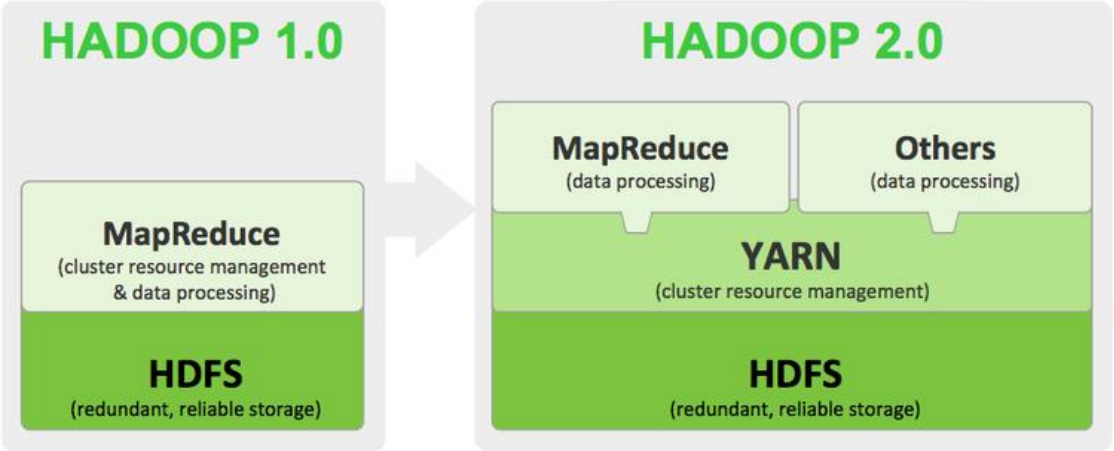
Big Data job execution Environments





Big Data era - The Hadoop Stack

- Hadoop moves to become a BD operating system

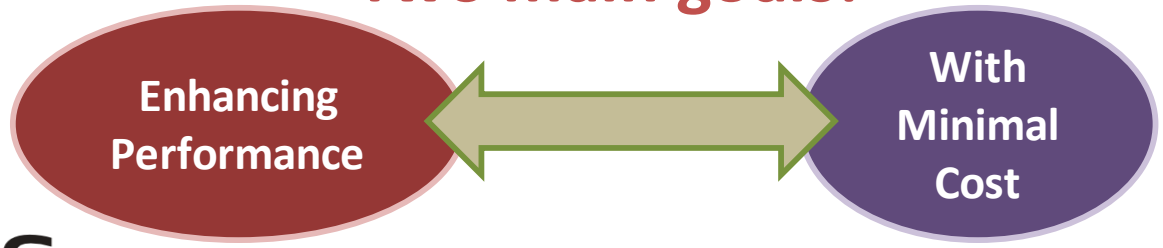


  - Store all your data in one place (HDFS)
  - Interact with that data in multiple ways (YARN Platform + Apps (frameworks))
  - Scale as you go, shared, multi-tenant, secure and multi-workloads type

What problem are we trying to solve?

- Many new complex solutions ⇨ Leads to costly, siloed, under-utilized infrastructure
- Running the fat elephant in a high-throughput computing – Toward efficient, elastic and free auto-scale of Hadoop clusters on-demand
- Creating a BD platform without infrastructure partitioning to accommodate Data-intensive apps efficiently

Two main goals:



Effective usage of resources!!

Current Hadoop Yarn

- Don’t approve dynamically Sharing of cluster resources
- Emphasizes infrastructure silos and static partitioning
- Not elastic or automated scaling
- Don’t take advantage of on premise capabilities

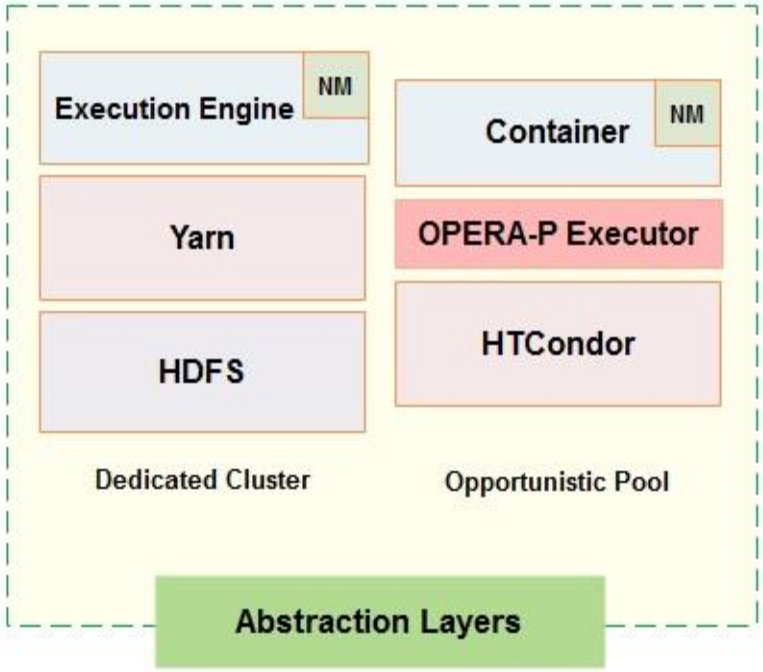
OPERA-P: a BD Platforms Provisioner

- A POD service that automatically and continuously spawns containers in a HTCondor pool
  - According to the available resources
- An opportunistically analytical environment
  - Runs as a standalone instance on each HTCondor machine
  - Represent a new CaaS service
  - Disposable pilot approach → one job - one container
- Extended BD platform
  - No additional cost
  - Better return on infrastructure investments

OPERA-P: a BD Platforms Provisioner

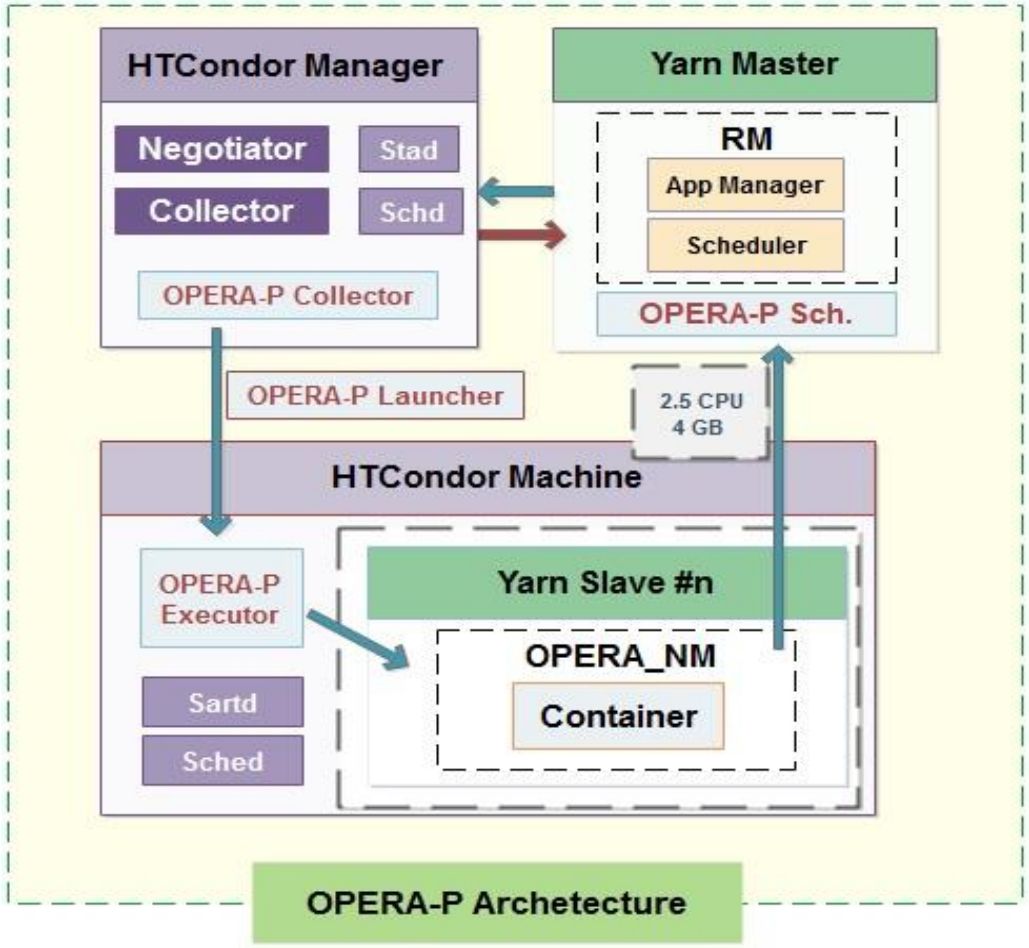
Cont…

- OPERA-P increase agility by provisioning a logical Hadoop clusters by multiple Condor Machines (or at POD)
- This model means that a shared pool of resources can be shared among many BD processing frameworks
  - Each capable of allocating additional resources elastically when needed and releasing them when not.



OPERA-P Architecture

- Resource management framework:
  - second level
    - HTCondor offers resource
    - Framework schedulers accept or reject offered resource
- Lightly used resource allocation:
  - Thanks to HTCondor
  - Elastically provisioning needed frameworks on-demand
- Frameworks Integration
  - Hybrid analytical environment
  - Modify framework scheduler in the container to com- with Yarn master through its API



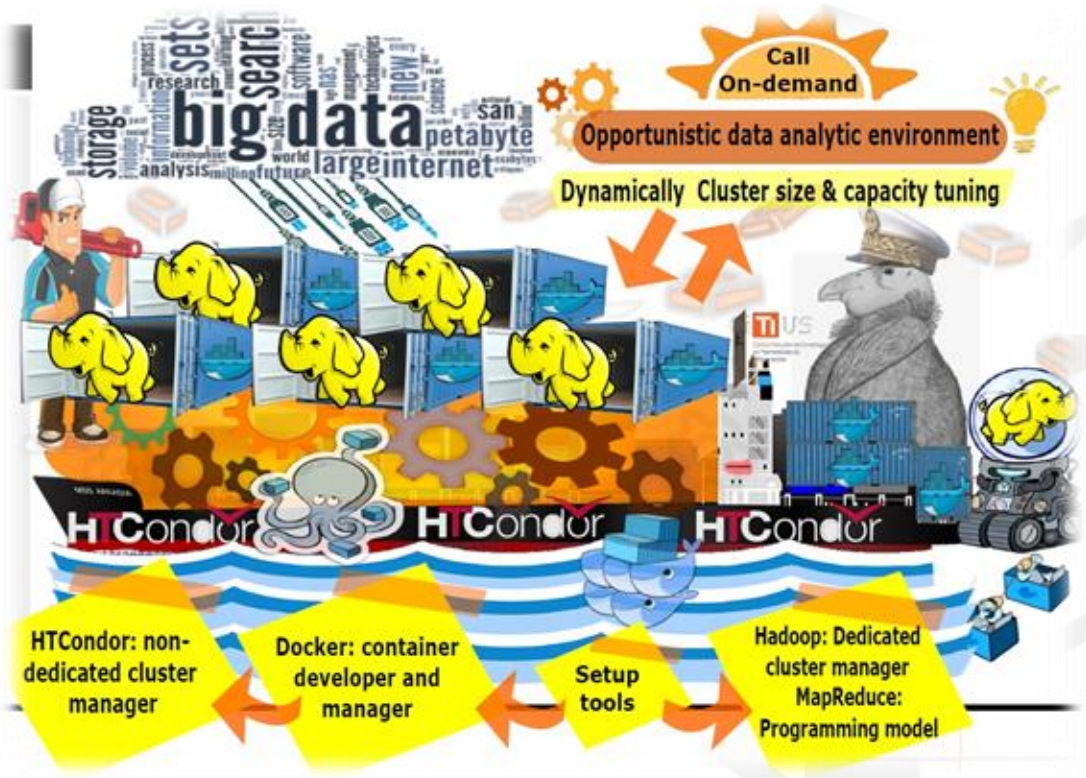
What and What's not OPERA

YES

- ✓ A provisioning service
- ✓ Workflow manager
- ✓ Opp- analytical platform

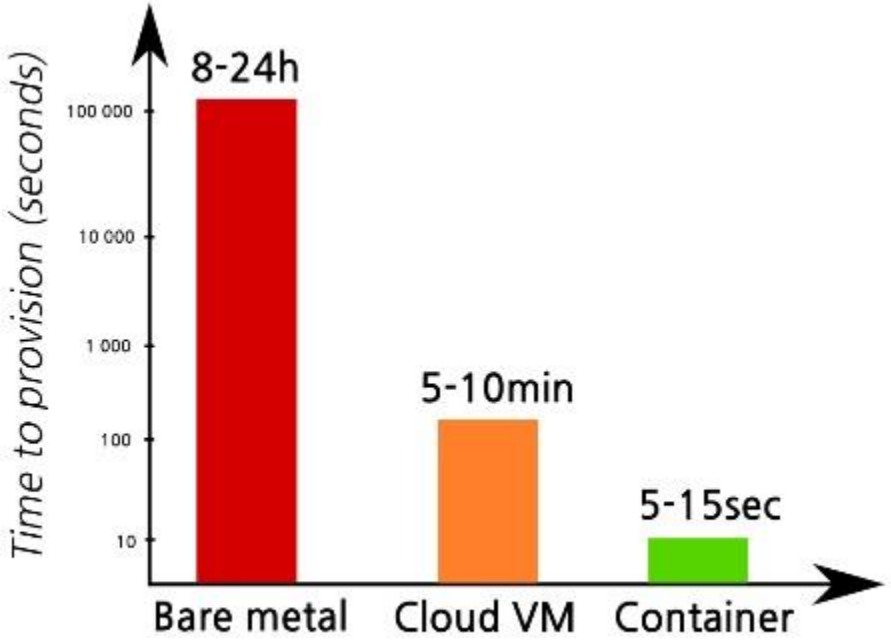
NOPE

- ✗ Container scheduler
- ✗ Hadoop distribution
- ✗ MR implementation



Design considerations

- On-premise prototype
  - Network is reliable
  - Minimal Data transport cost
- Light weight virtualization
  - Near Bare-metal
  - Thanks to Docker containers
- Resource capping and isolation
  - Workloads don't interfere with operational applications



Architecture [1]

1- Introduction to Apache Mesos: https://www.slideshare.net/tomasbart/introduction-to-apache-mesos

Fault tolerance

"design your system for failure"

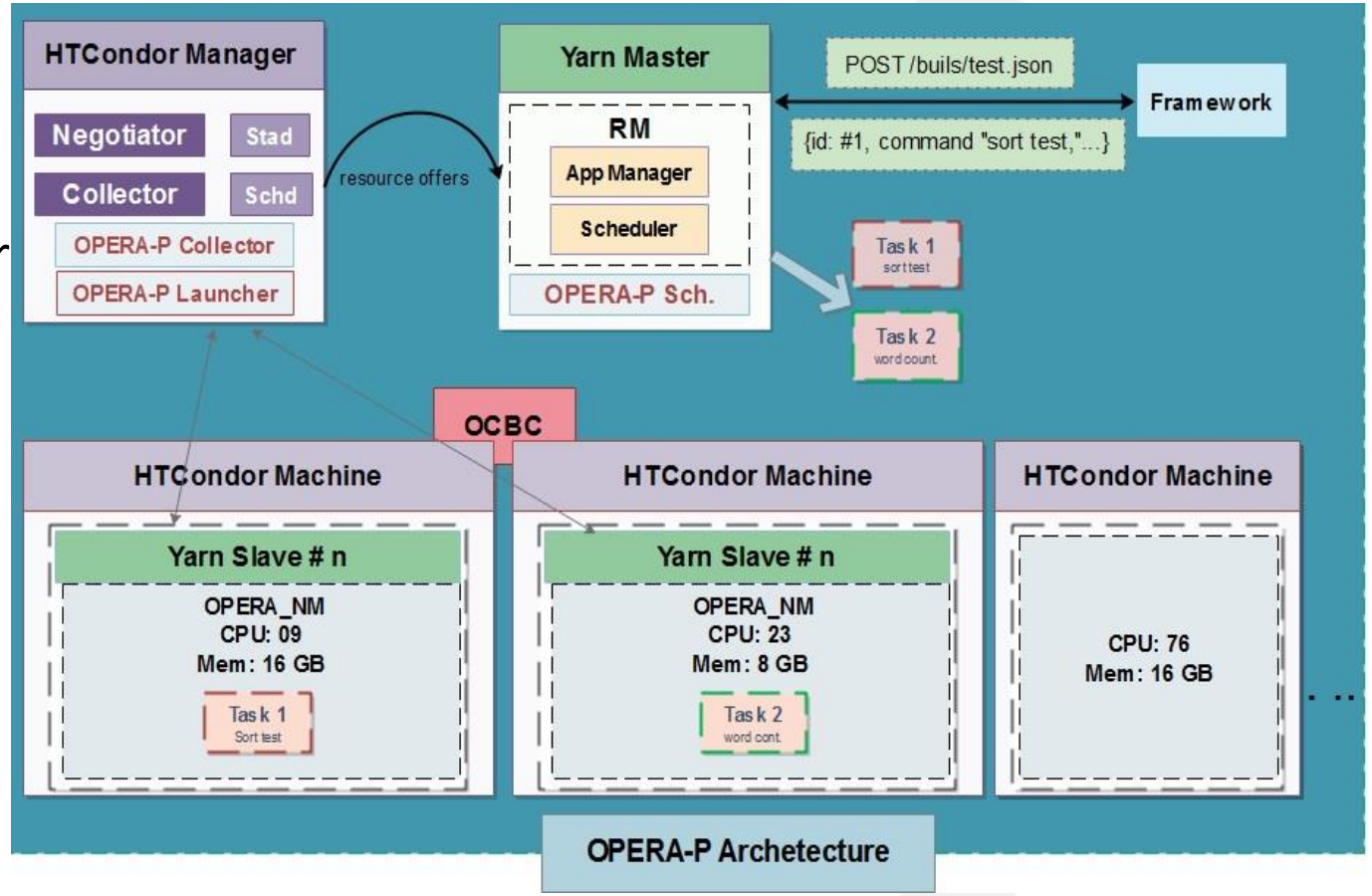
- Every component must have redundancy
  - No single point of failure!
- Tuning the heartbeat
- Majority voting (result checking):
  - Leaving work-done flag until collect two out of three results
  - Directly enhance fault tolerance as well

Use case

EME: An Enhanced Mapreduce Environment

How it works

- Very similar to how multiple apps run concurrently on a laptop or smartphone
- New threads are spawned, and more resources are joining the Hadoop cluster as they are needed
- OPERA-P will match the request to incoming HTCondor resource offers and can then consume the resources as it sees fit
- HTCondor, in turn, will pass it on to its worker machines, and launches pilot containers among the underutilized nodes (idle workstations)



Use case example

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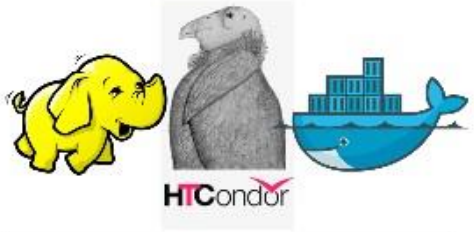

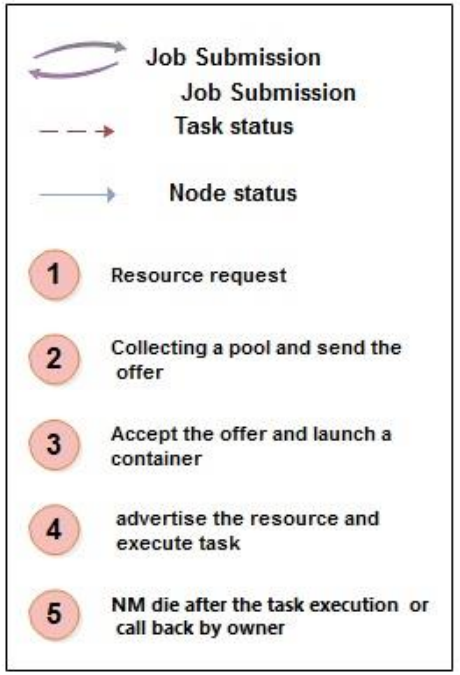

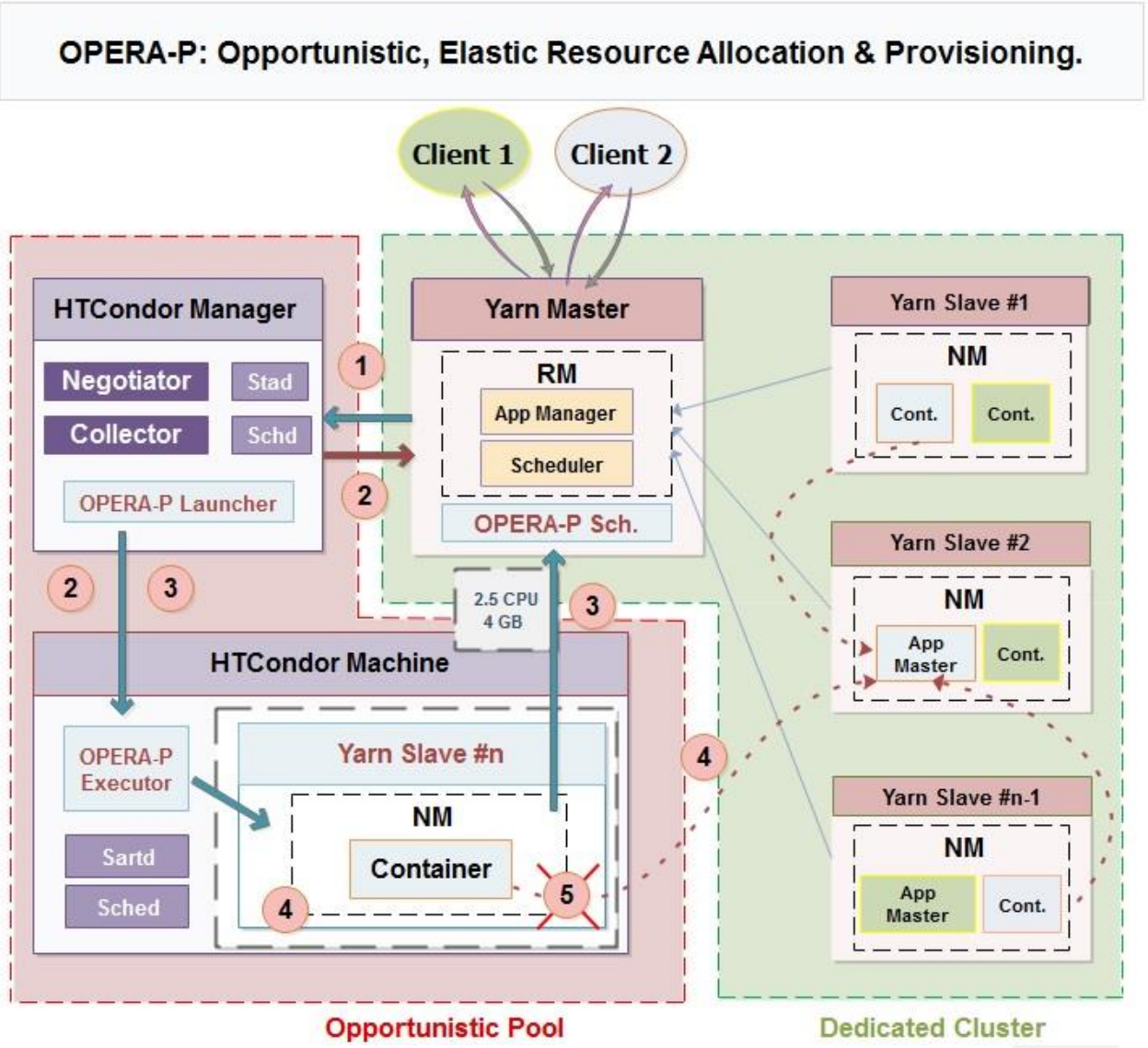

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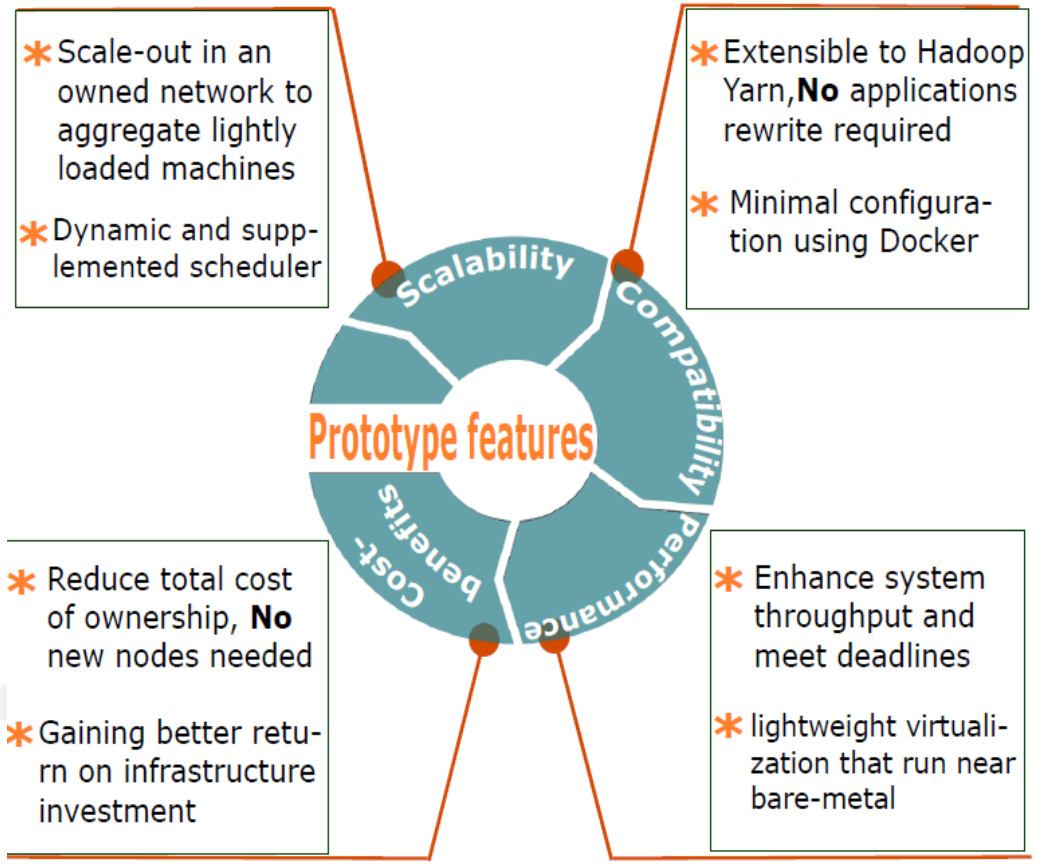
Feature

- High utilization
  - High throughput , an enhanced performance
- Scalable (Scale-out/up)
  - Automated and elastic on-demand
- Isolation
  - Ensuring that workloads don't interfere with operational applications
- Load balancing
  - Various load patterns, with deferent workloads (job types)
- Minimal cost
  - Installed infrastructure (Capital expander)
  - Operational & Scaling cost



Opportunities

- Exploit more than 2TB of RAM & 65PB HDD available resources at the CiTIUS
- Opportunistic Container-based Cluster (OCBC)
  - A new CaaS service
- A 3D models
  - Running dedicated only
  - Running Opportunistic only
  - Provisioning BD platforms on-demand
- Organizations can deploy, manage, and monitor their BD system, on both dedicated Hadoop cluster and opportunistic HTCondor pool as a single machine

Conclusion & Future

- OPERA-P is an enabling technology to take advantage of leveraging all of available resources within an enterprise or cloud as a single pool of resources
- OPERA-P provides a seamless bridge from the pool of resources available in HTCondor to the YARN tasks that want those resources.
- OPERA prototype can easily be adapted to other resource managers, e.g., Apache Mesos and Docker Swarm
- OPERA-P is an ongoing project, we start prototyping in a virtualized cluster and, when proving its usefulness, test it in a bare-metal environment.

Thank you for your attention

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