Overhead-Aware-Best-Fit(OABF) Resource Allocation Algorithm for Minimizing VM Launching Overhead

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Presenter: Hao Wu

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Introduction: Fermilab

Fermi National Accelerator Laboratory:

- Lead United States particle physics laboratory

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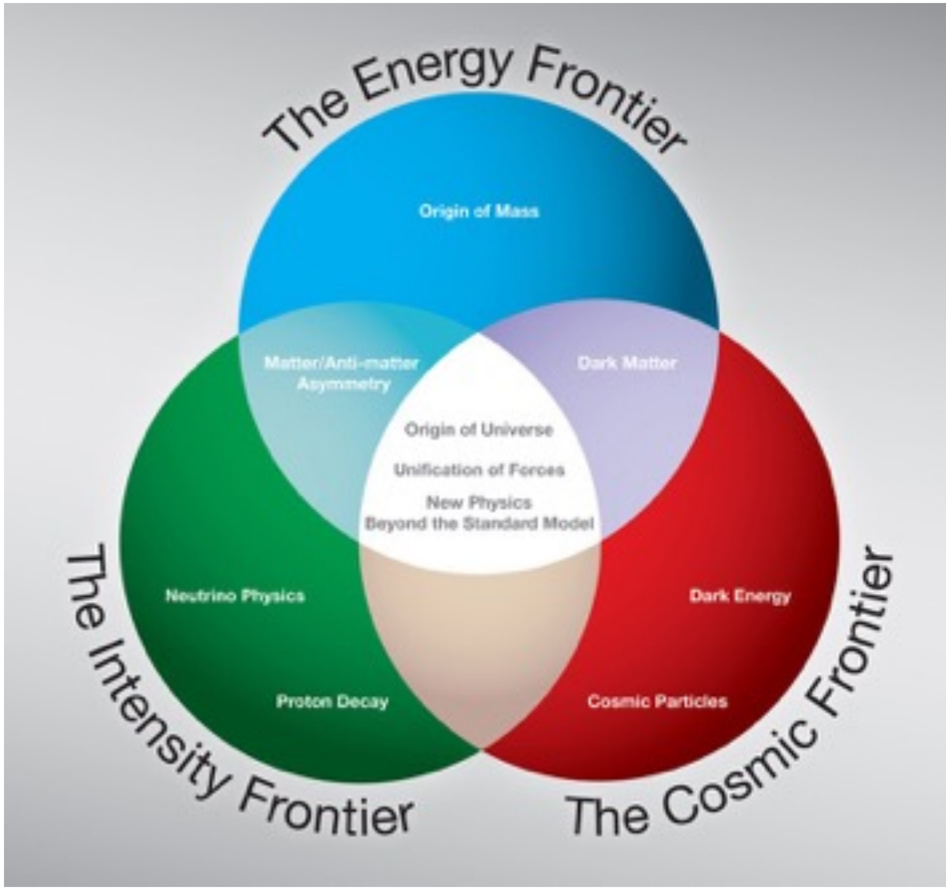

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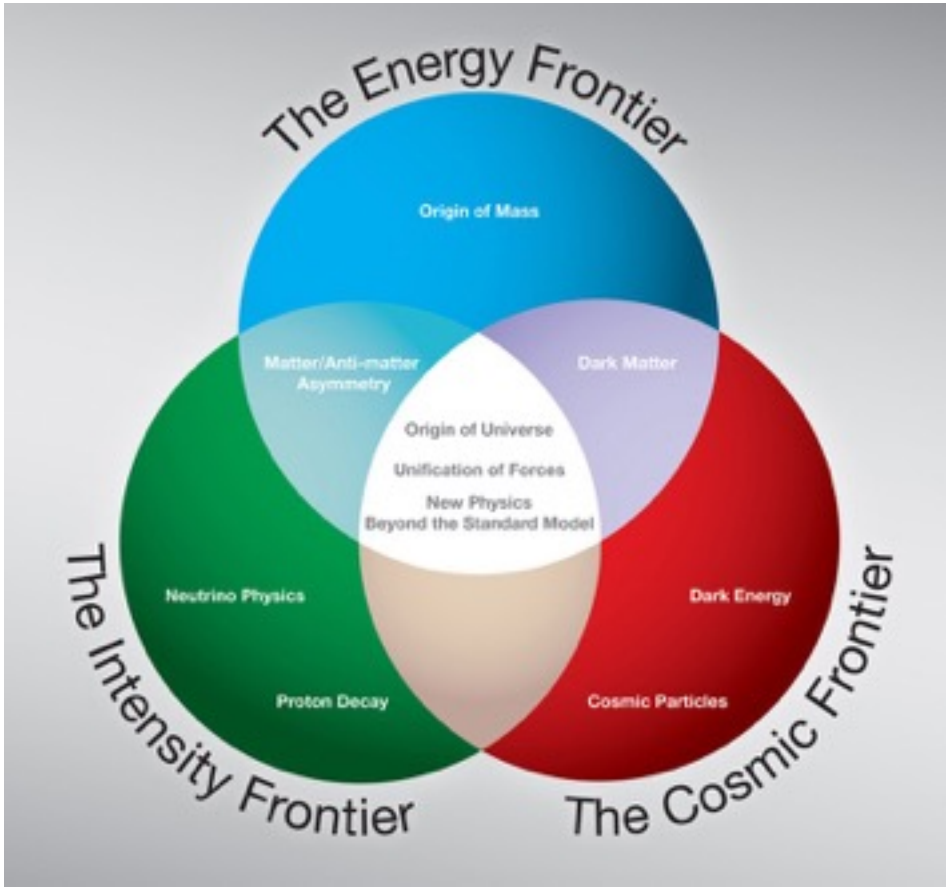

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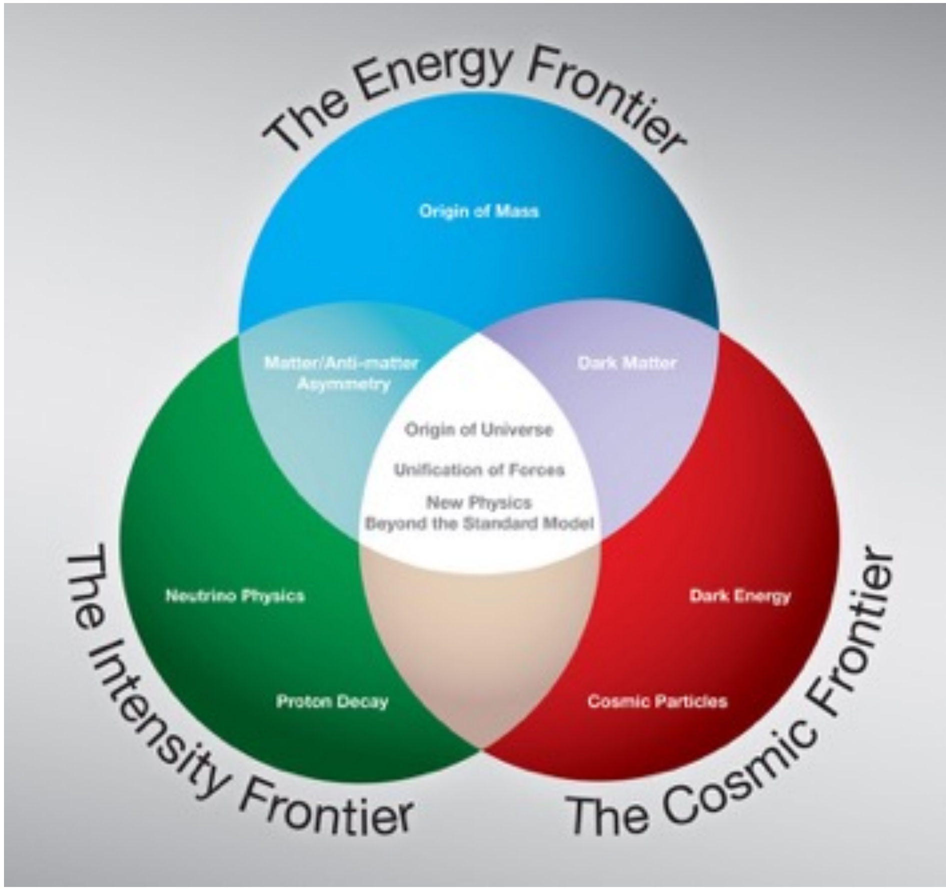

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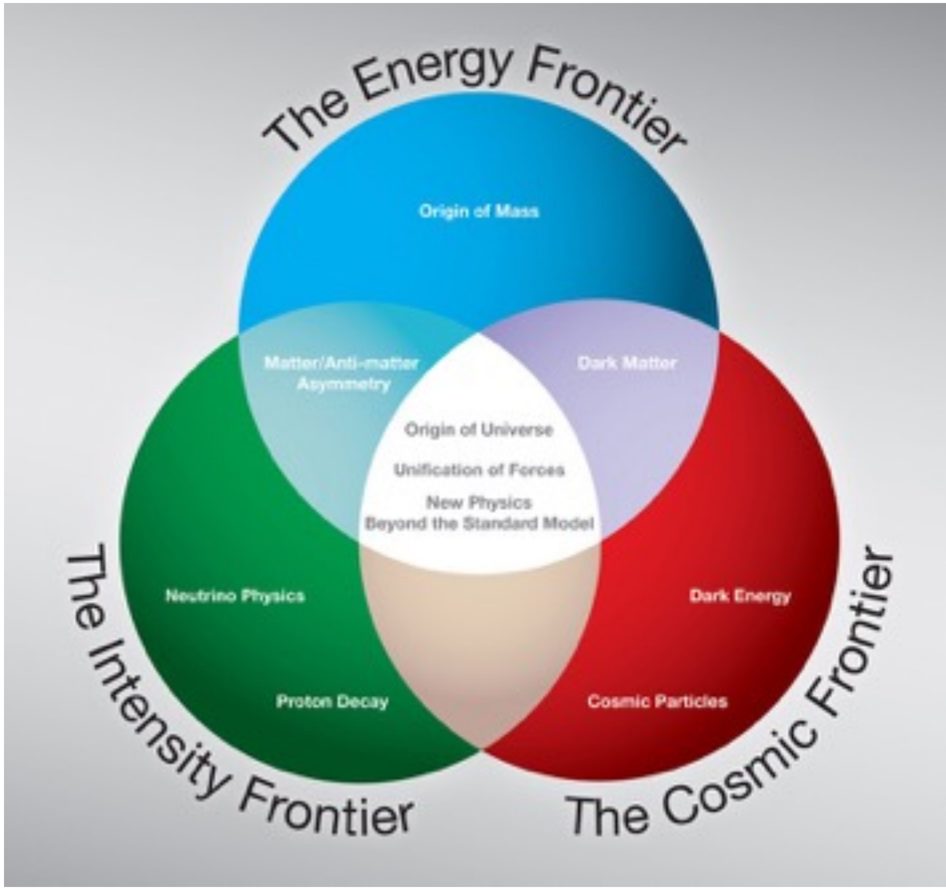
  - Intensity Frontier (LBNE, Mu2e, MINOS, etc.)



Introduction: FermiCloud

- FermiCloud Project was established in 2009 with the goal of developing and establishing Scientific Cloud capabilities for the Fermilab Scientific Program.
- FermiCloud Infrastructure as a Service (IaaS) running since 2010.
- FermiCloud Project now focusing on On-demand Services for Scientific Users (PaaS, SaaS).
- The FermiCloud project is a program of work that is split over several overlapping phases.
  - Each phase builds on the capabilities delivered as part of the previous phases.

Introduction: KISTI

Korea Institute of Science and Technology Information:

- Provision of World-Class Infrastructure for Global Collaboration
- Leading Nation-wide Super Computing Infrastructure
- Leading Nation-wide Scientific IaaS Infrastructure

www.kisti.re.kr

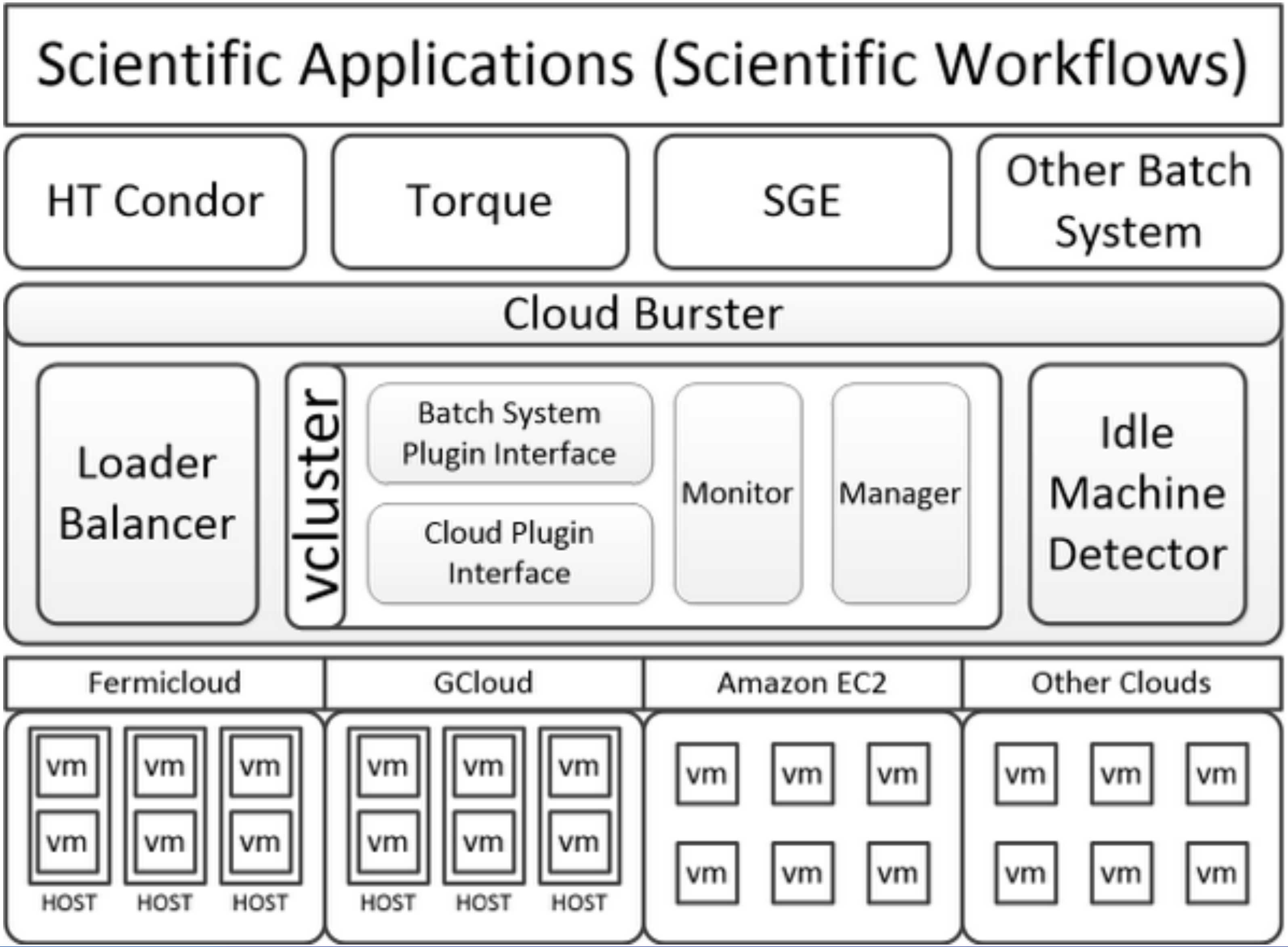
한국과학기술정보연구원

Korea Institute of Science and Technology Information

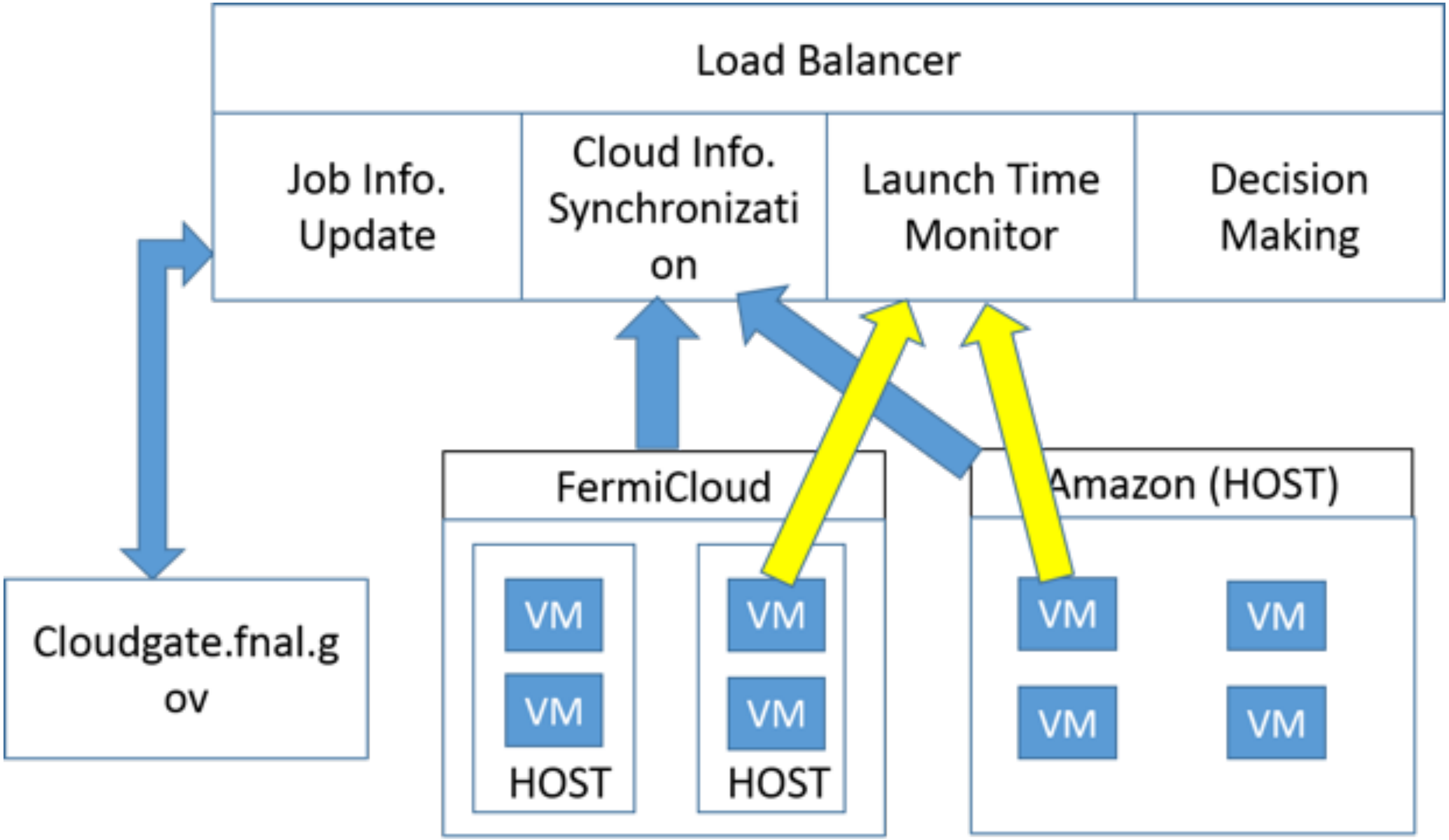
Introduction: Collaboration on Cloud Computing

- Fermilab and KISTI both support global physics collaborations, (CMS, CDF, STAR, ALICE, etc.)
- IIT has joint activities on cloud computing with Fermilab
- These experiments identify cloud computing as key technology for
  - ✓Data preservation
  - ✓Burst capacity
  - ✓Software distribution
- Global collaborations will not converge on single cloud solution.
- Three key components for success:
  - ✓Federation—Group of users run transparently on many resources
  - ✓Interoperability—Find common method that works on all resources
  - ✓Throughput—Data flow to and from resources across WAN.
- Goal is to enable real scientific stakeholders to get their computing done.

Cloud Bursting Implementation: vcluster



Design of the Load Balancer



Cloud Bursting

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  - When to burst

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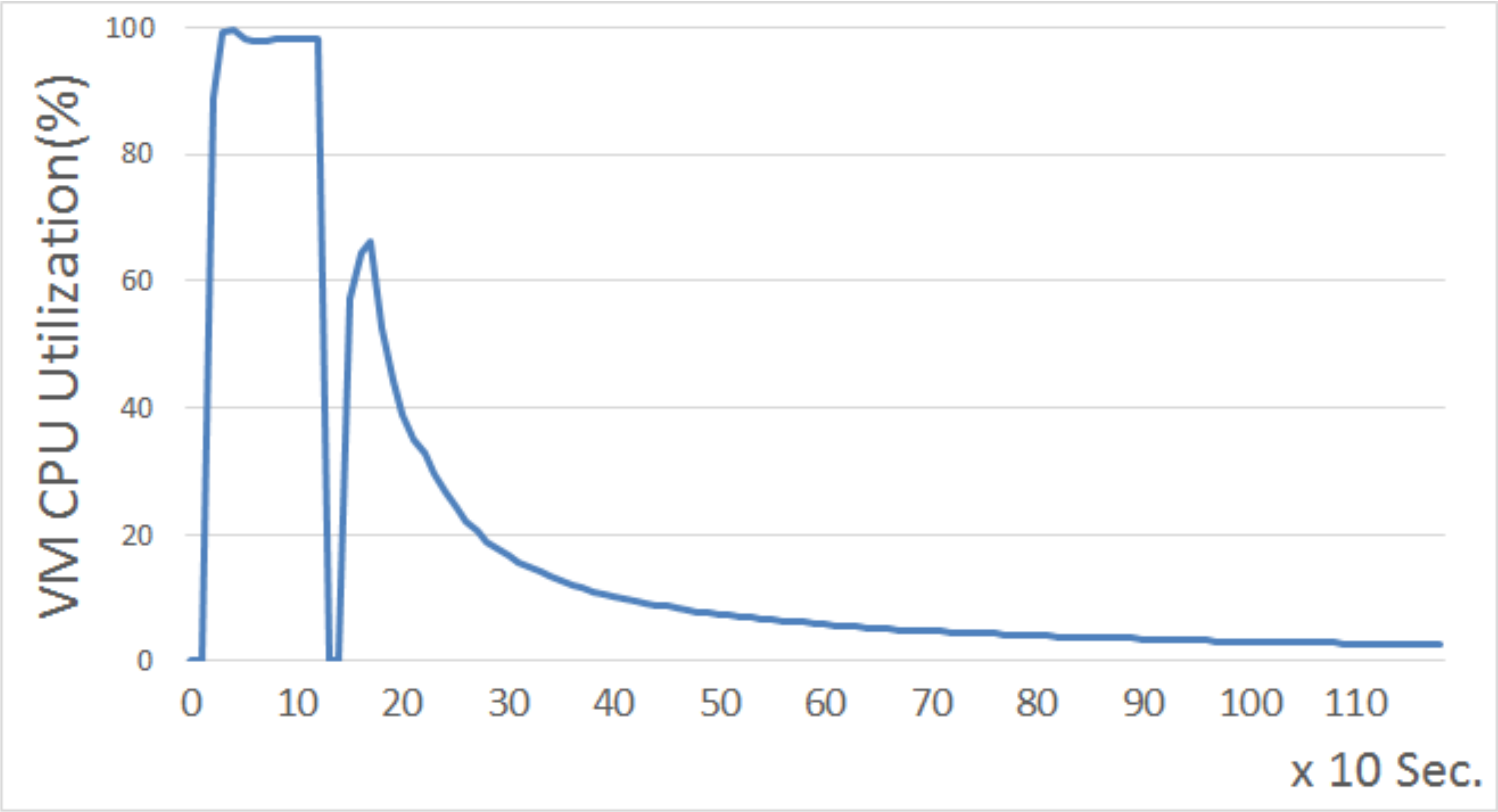
To minimize the VM launching overhead!

VM Launching Overhead



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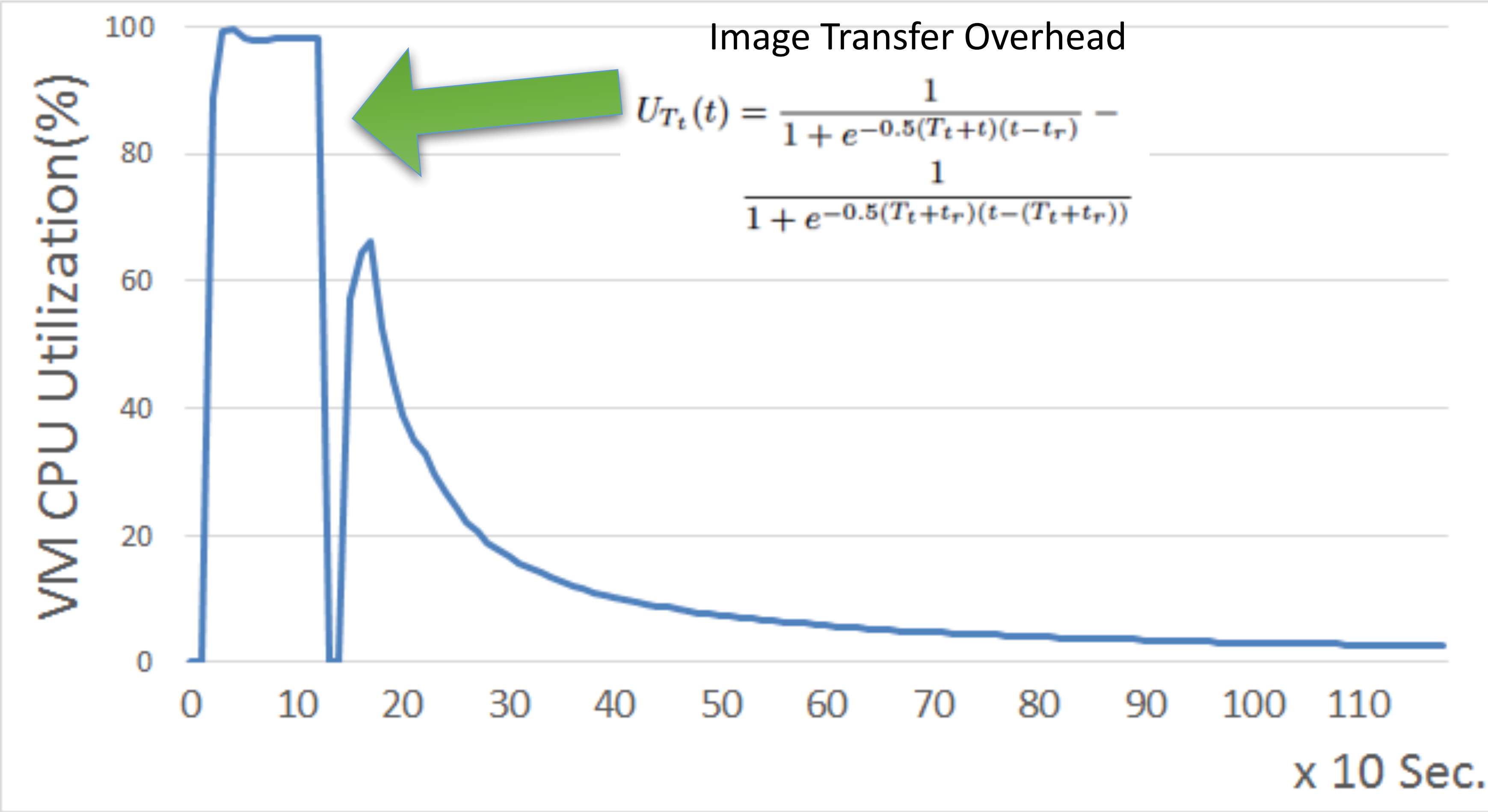

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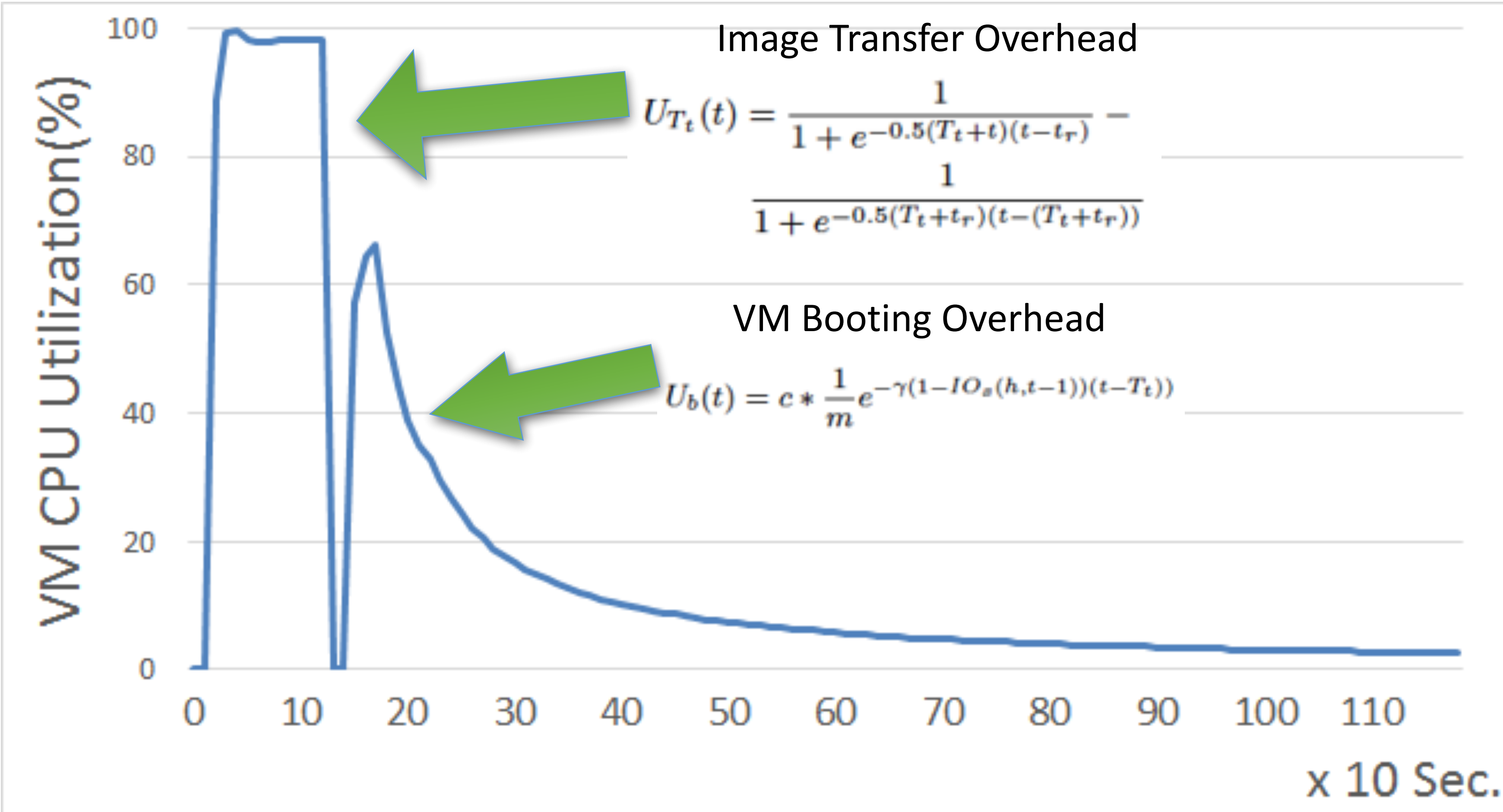

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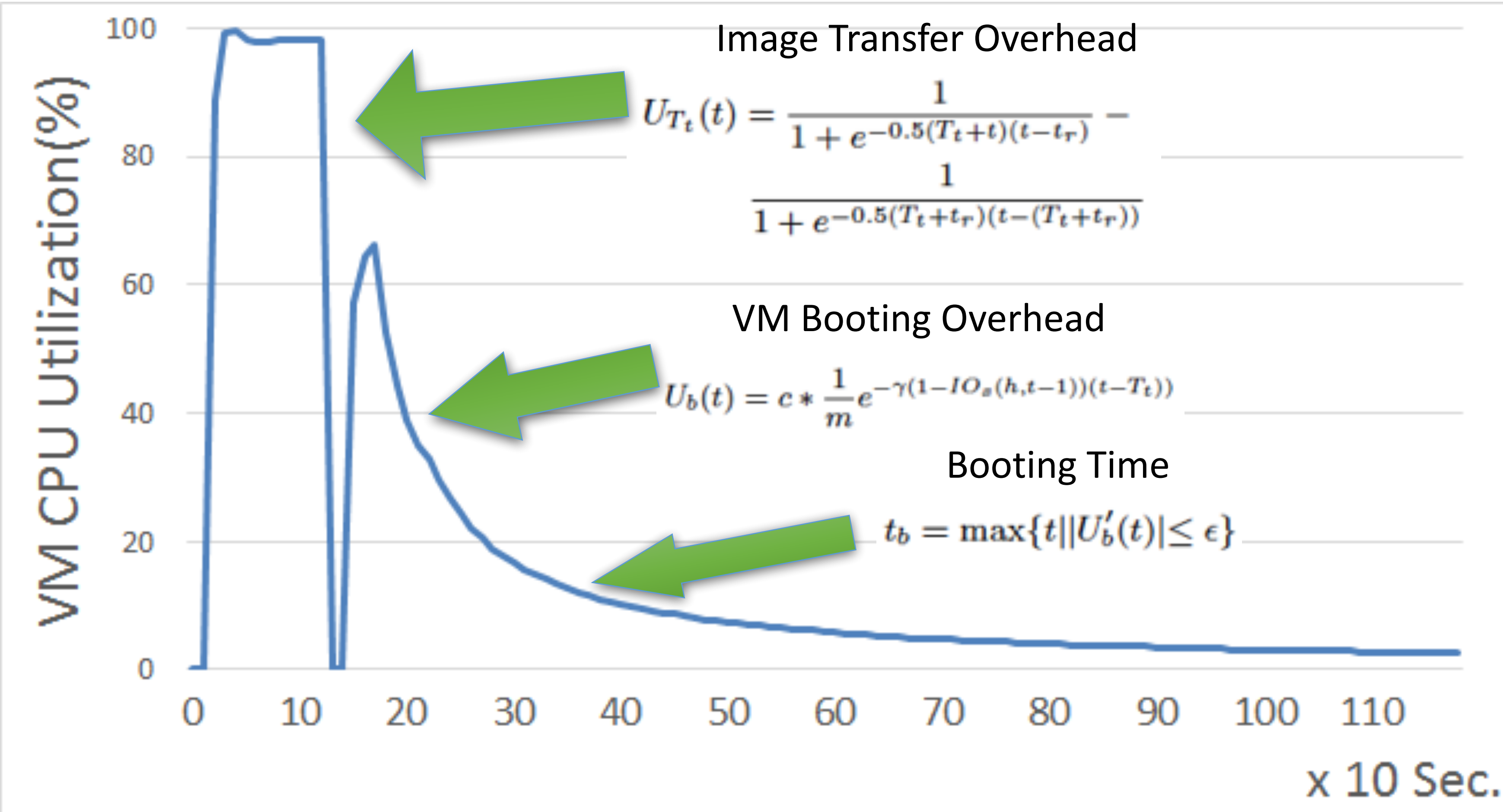


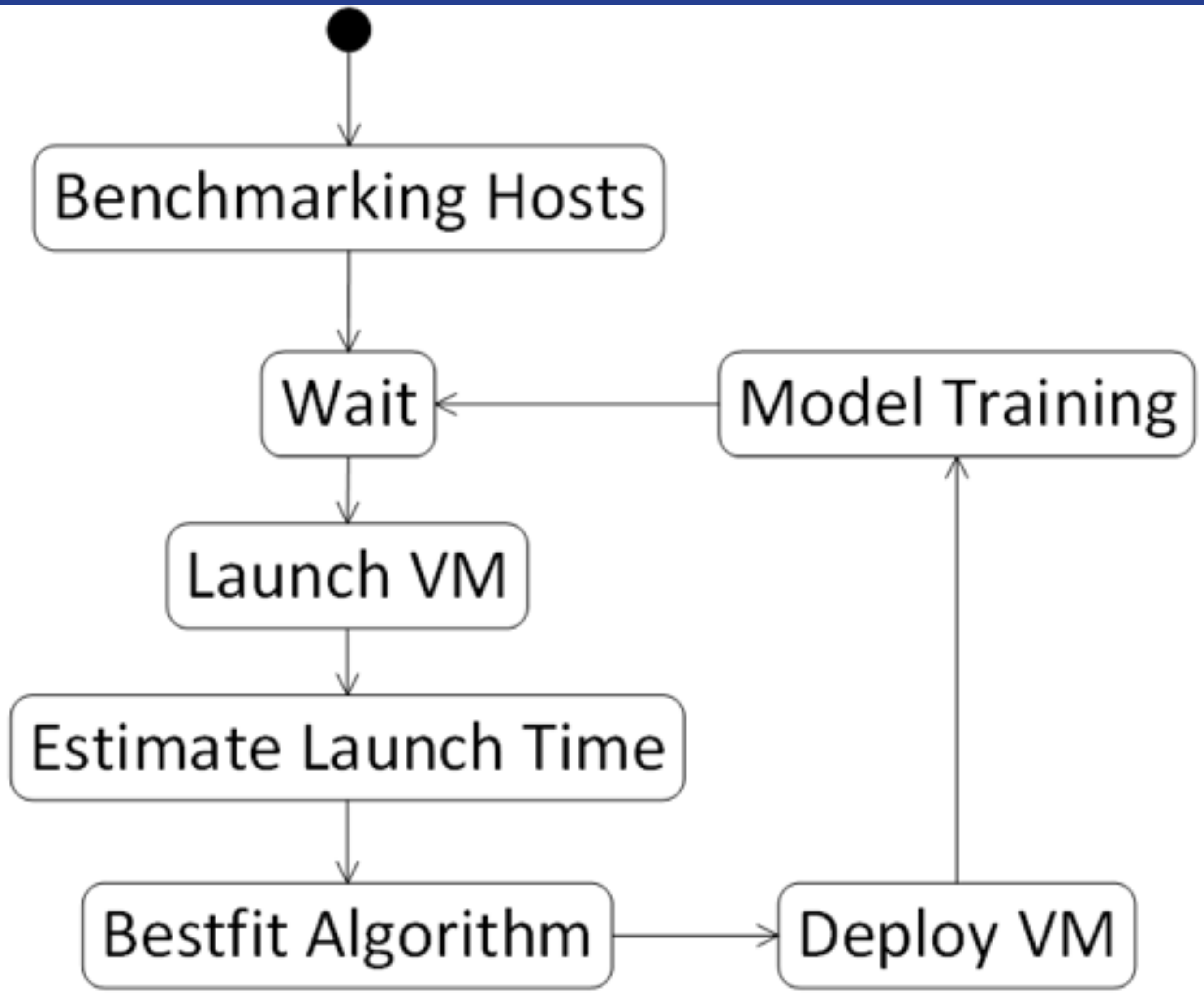
VM Launching Overhead Model Training

- Prediction Accuracy Evaluation
- Mean Absolute Scaled Error:

$$MASE = mean(|q_t|)$$

$$q_t = \frac{e_t}{\frac{1}{n-1}\sum_{i=2}^{n}|Y_i - Y_{i-1}|}$$

Resource Allocation Automation Workflow



Model Training Algorithm

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Assume the calibrated error from last round training is 0.032

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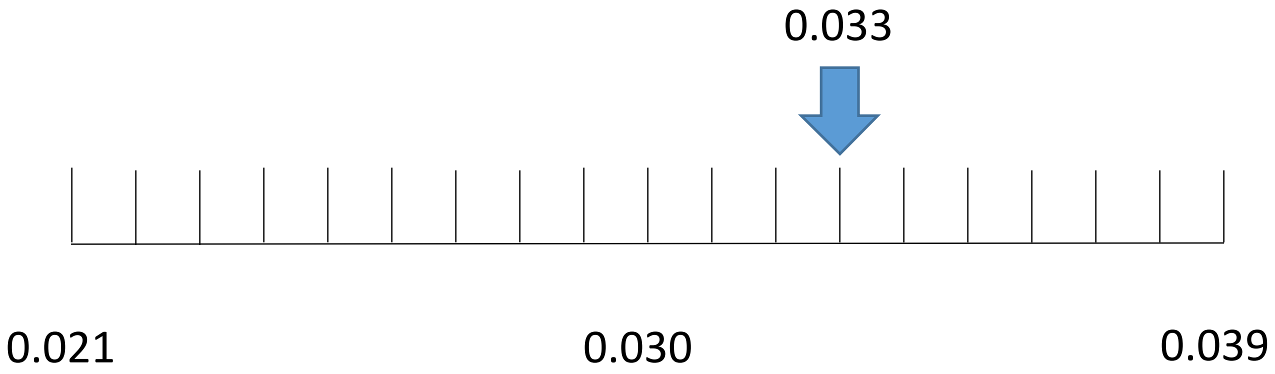
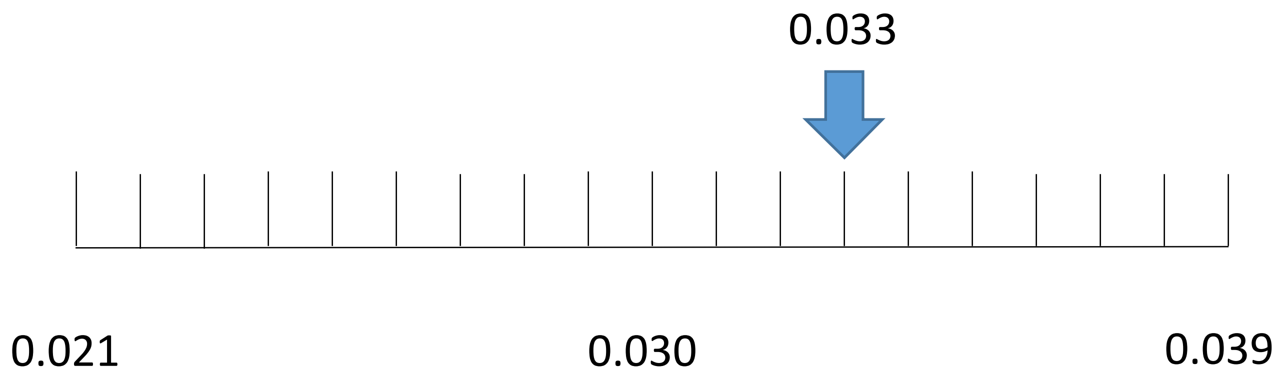
Step1: Round the error to 0.030



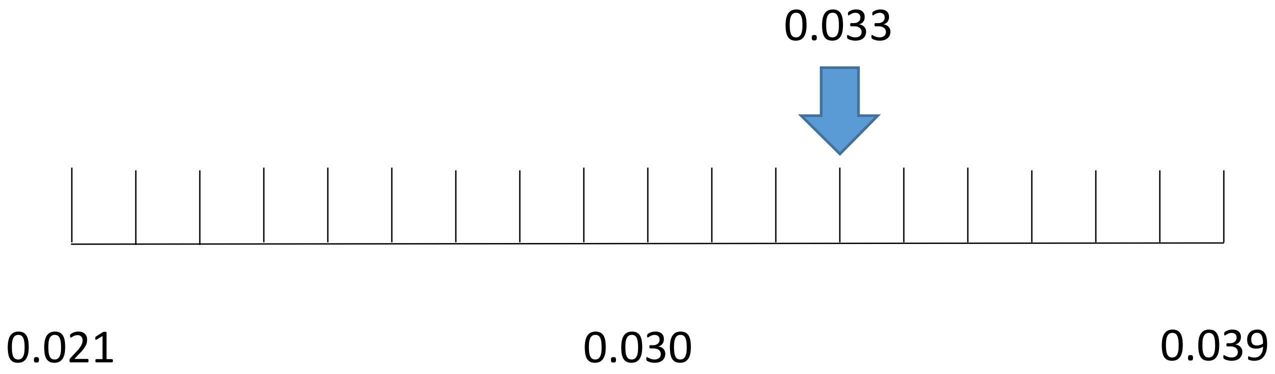
Model Training Algorithm

Assume the calibrated error from last round training is 0.032
Step1: Round the error to 0.030
Step2: Calculate the precision of the error: 0.001



Model Training Algorithm

Assume the calibrated error from last round training is 0.032
Step1: Round the error to 0.030
Step2: Calculate the precision of the error: 0.001
Step3: Calculate MASE for each error within range 0.021 - 0.039



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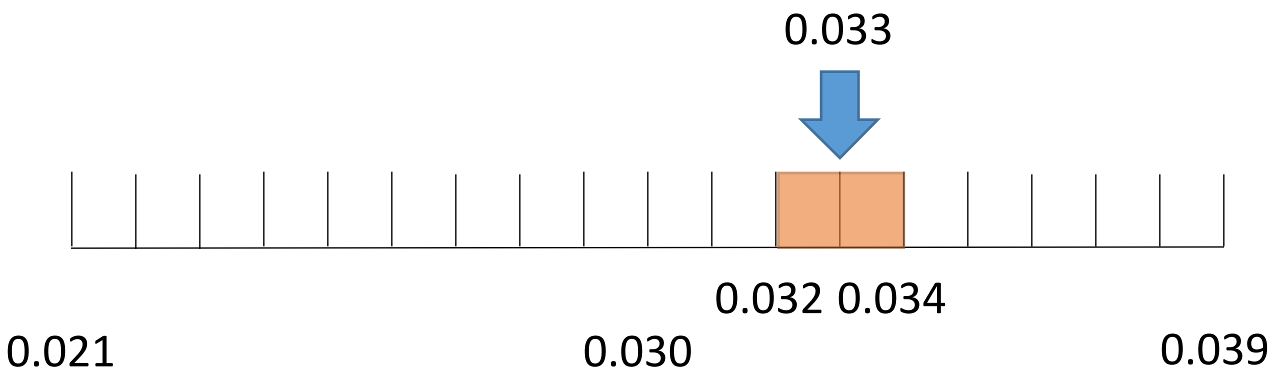

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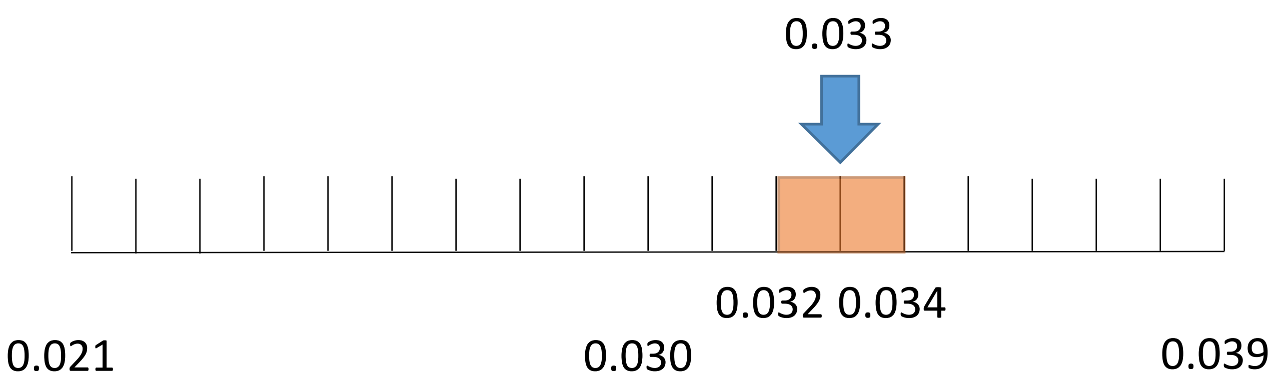

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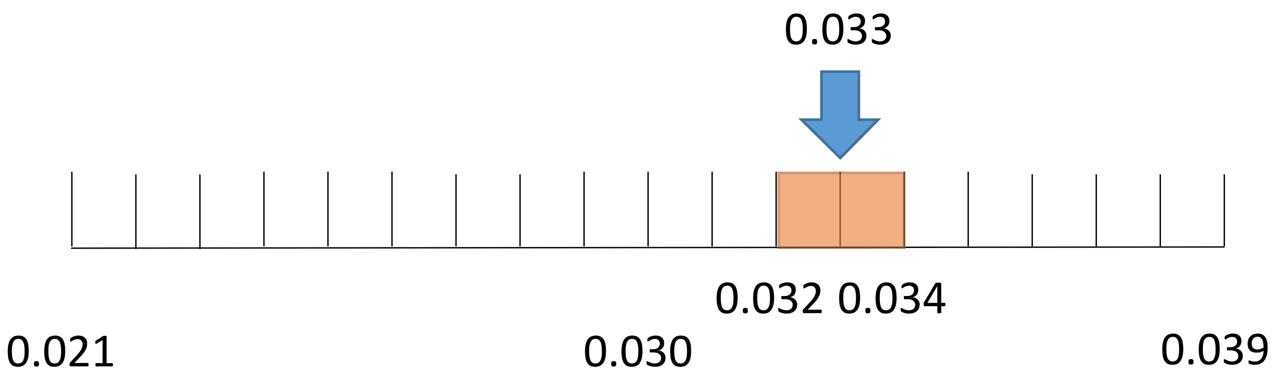
1: Error is smaller than threshold



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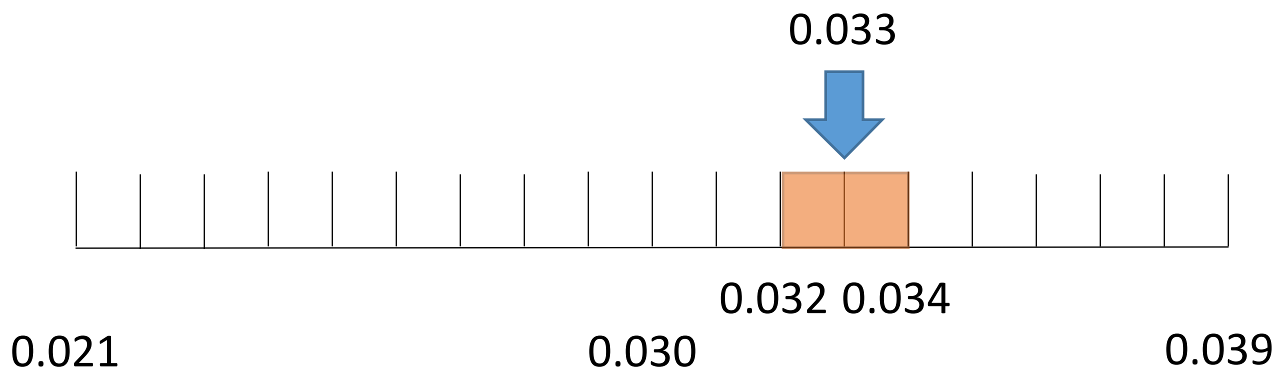
2: Training round is smaller than threshold



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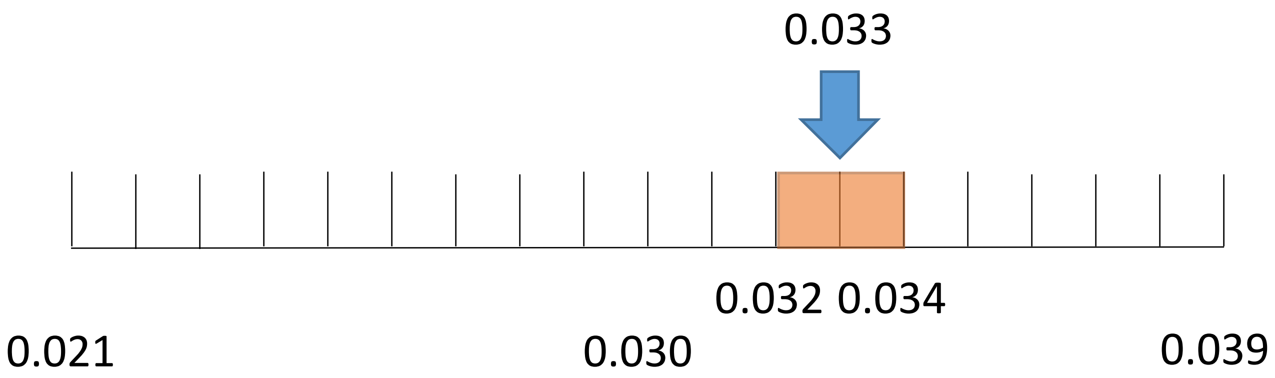


Overhead-Aware-Best-Fit (OABF) Algorithm

Algorithm 2: overhead-aware-best-fit Algorithm

Input : Empty Virtual Machine $v = \{t_r, h, t_w\}$, Host set $H = \{h_1, \ldots, h_n\}$, VM waiting queue $Q = \{v_1^q, \ldots, v_m^q\}$

Output: Virtual Machine $v = \{t_r, h, t_w\}$ with host and waiting time information

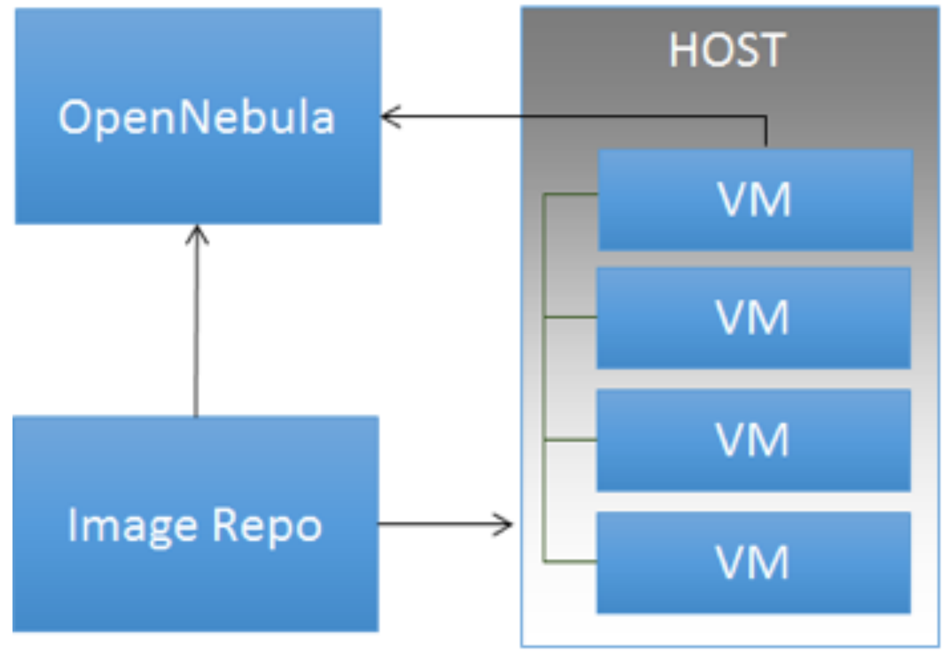
$v.h \leftarrow$ null; $v.t_w \leftarrow 0$; $h' \leftarrow null$
$t'_w \leftarrow 0$; $t_b \leftarrow \infty$; $t'_r \leftarrow v.t_r$
for $i \leftarrow 1$ *to* n **do**
    $v.t_r \leftarrow t'_r$
    $t_p \leftarrow$ calculatePredictLaunchTime(h_i, v)
    if $t_p \leq t_b$ **then**
        $t_b \leftarrow t_p$; $h' \leftarrow h_i$
    end
    for $j \leftarrow 1$ *to* m **do**
        if v_j^q *is deployed on* h_i **then**
            $t_t \leftarrow v_j^q$'s predicted image transfer time
            if $t_t + v_j^q.t_r + v_j^q.t_w \geq v.t_r$ **then**
                $v.t_r \leftarrow t_t + v_j^q.t_r + v_j^q.t_w$
                $t_p \leftarrow$ calculatePredictLaunchTime(h_i, v)
                if $t_p + t_t + v_j^q.t_r + v_j^q.t_w - v.t_r \leq t_b$ **then**
                    $t_b \leftarrow t_p$; $h' \leftarrow h_i$
                    $t'_w \leftarrow t_t + v_j^q.t_r + v_j^q.t_w - v.t_r$
                end
            end
        end
    end
end
$v.t_r \leftarrow t'_r$; $v.h \leftarrow h'$; $v.t_w \leftarrow t'_w$
return v

Evaluation: Environment

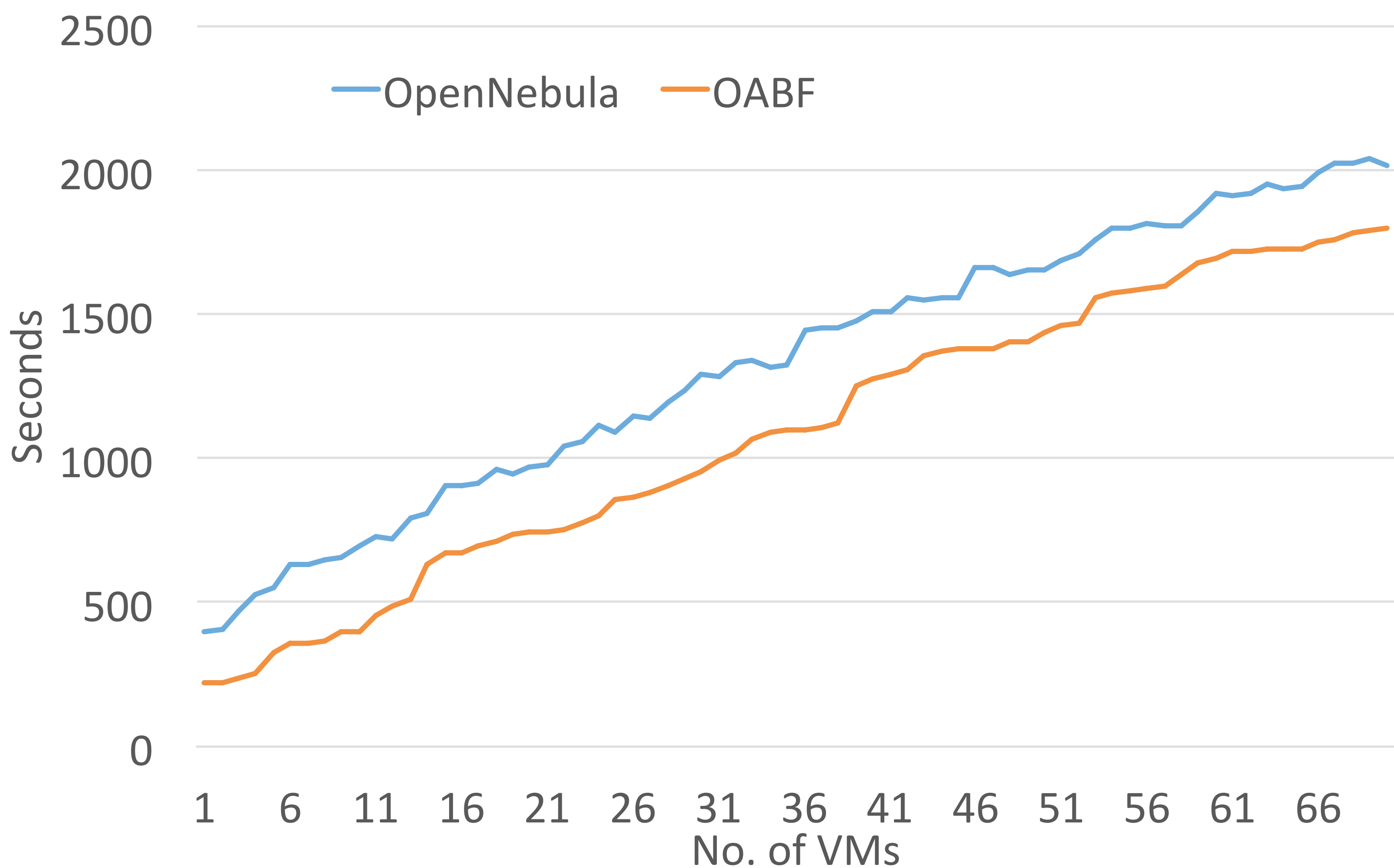
System Configuration:

- Front-end: 16-core Intel(R)Xeon(R) CPU E5640 @ 2.67GHz, 48GB memory.
- 15 VM hosts: 8-core Intel(R) Xeon(R) CPU X5355 @ 2.66GHz and 16GB memory

- Cloud Platform: OpenNebula



Evaluation: Small Image (2.6GB QCOW2)



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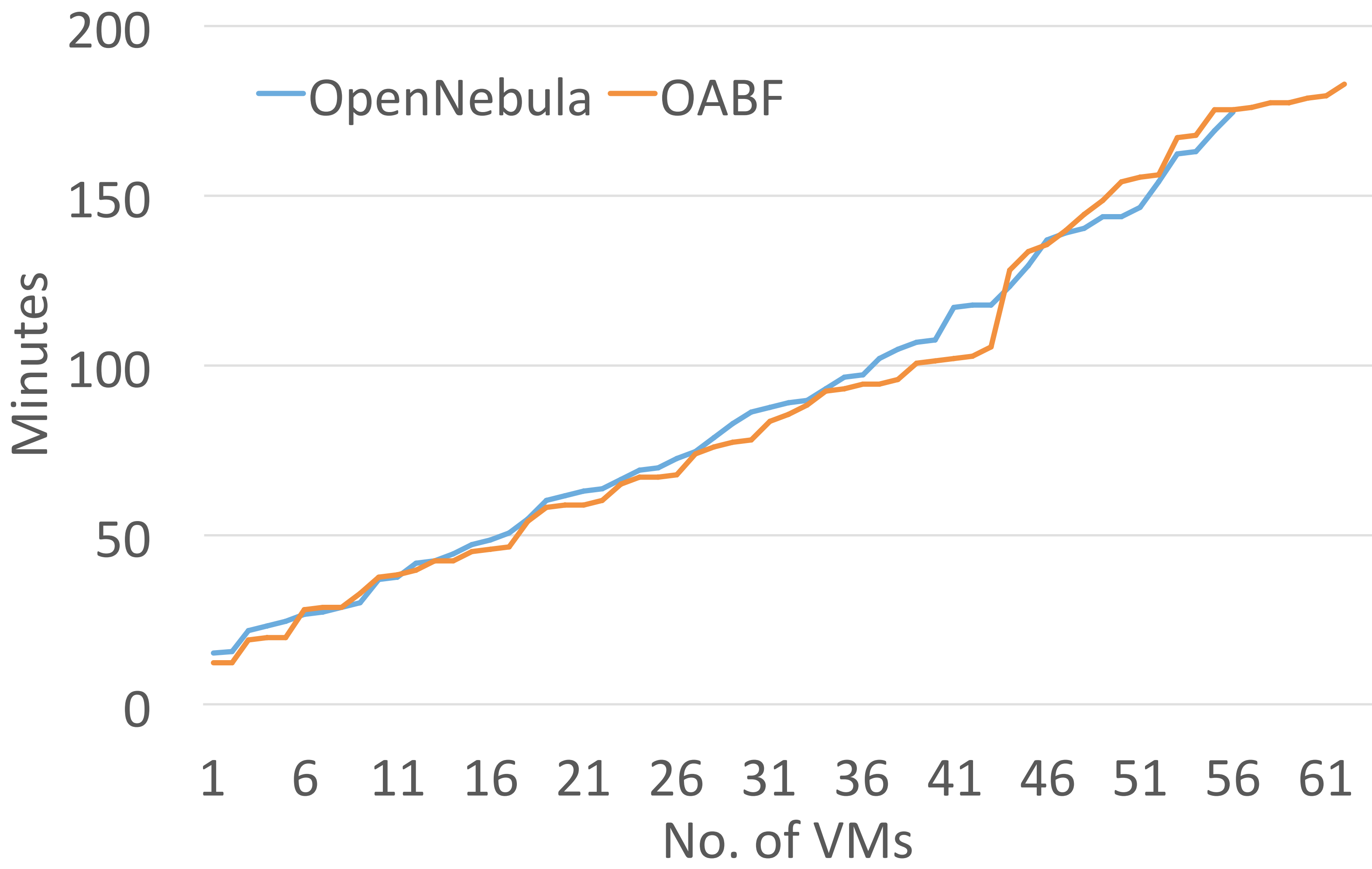
Evaluation: Large Image (16GB RAW)



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Conclusion

- Present a mechanism to automatically train the VM launching overhead reference model that we previously developed.
- Based on the virtual machine launching overhead reference model, we have developed in this paper an overhead-aware-best-t resource allocation algorithm to help the cloud reduce the average VM launching time.
- Presented an implementation of the developed OABF algorithm on FermiCloud
- For relatively small VM images commonly used in FermiCloud, OABF provides significant improvement in launch time.

Thanks!

Questions?