A ~~Green~~ *(Less brown)* Cloud

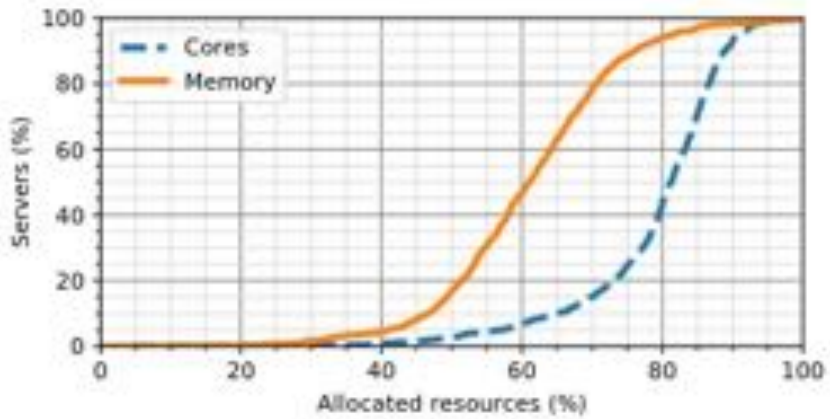
How to use less resources?

Pierre Jacquet
Under the supervision of Romain Rouvoy, Thomas Ledoux

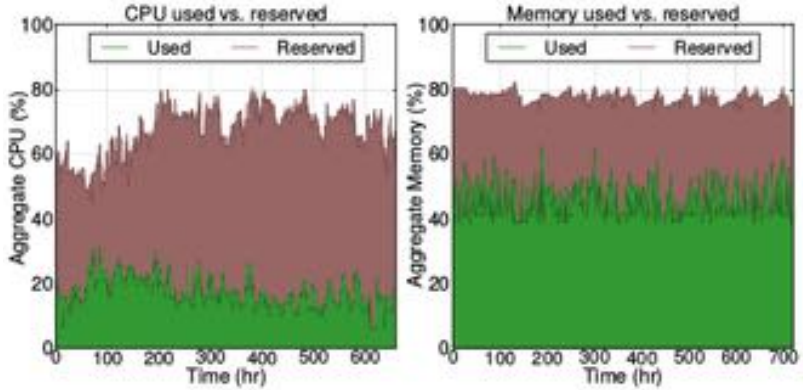
Green Days, IRIT Toulouse, 2024

State-of-the-Art of Cloud Resource Utilization

Cloud infrastructure are under-used



Not all resources are **allocated** [1]

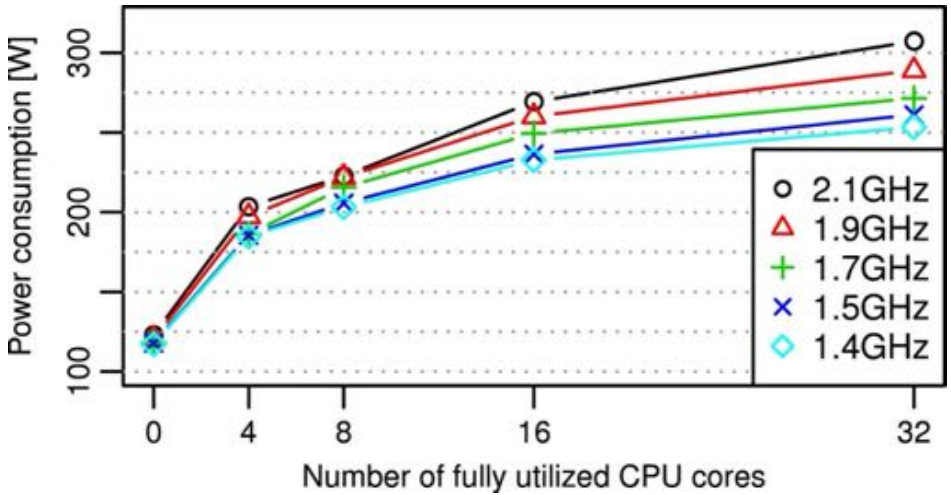


Not all allocated resources are **used** [2]

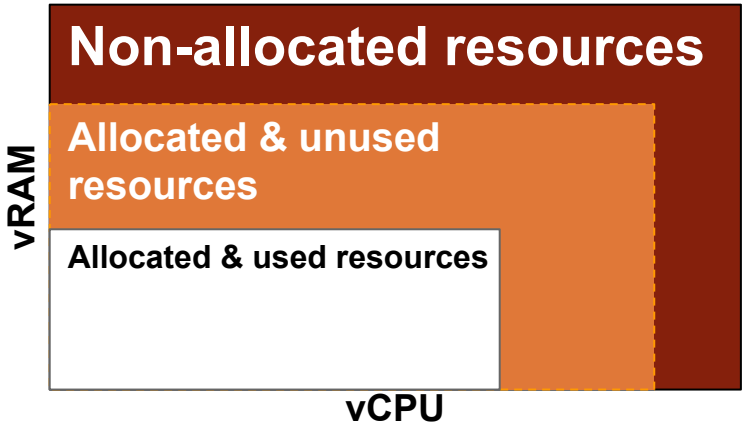
[1] *Memory-harvesting VMs in cloud platforms*, Microsoft Research, ASPLOS 2022
[2] *Quasar: Resource-Efficient and QoS-Aware Cluster Management,* Christina Delimitrou *et al.*, ASPLOS 2014

State-of-the-Art of Cloud Resource Utilization

Cloud infrastructure are under-used



Impacts **server consumption** [1]



Impacts the number of **provisioned servers**

[1] *Power-performance tradeoffs in data center servers, Jakub Krzywda et al., FGCS 2018*

State-of-the-Art of Cloud Resource Utilization

- A problem addressed using different (complementary) approaches:
  - Fill with **heterogeneous workloads,** *e.g. Batch, FaaS, HarvestVM*
  - Fill with **homogeneous workloads** using oversubscription (n:1) ⟵

From adopting oversubscription techniques

- Ratios at the cluster level
  - Statically defined
- Ratios at the server level
  - Statically defined
  - Dynamically defined
    - Generic formulas on VM percentile or host standard deviation

To extending oversubscription techniques

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    - Per server formula customization
- Ratios at the VM level
- Ratios at the resource level (vCPU)

Contribution 1: **ScroogeVM**

- Ratios at the cluster level
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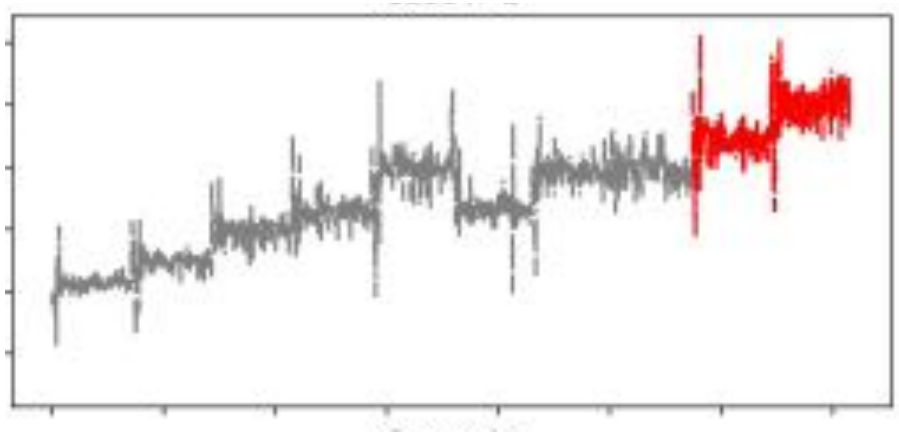
Contribution 1: **ScroogeVM**

- **Adjust resources oversubscription ratios according to quiescent state**



adjust optimistic degree
of next peak prediction

Being closer to the usage improves packing

ScroogeVM: Boosting Cloud Resource Utilization with Dynamic Oversubscription, *accepted at IEEE Transactions on Sustainable Computing*

Contribution 2: **SlackVM**

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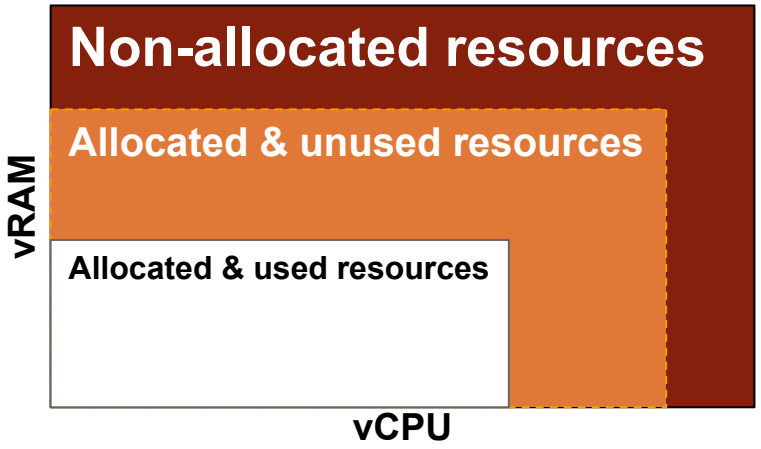
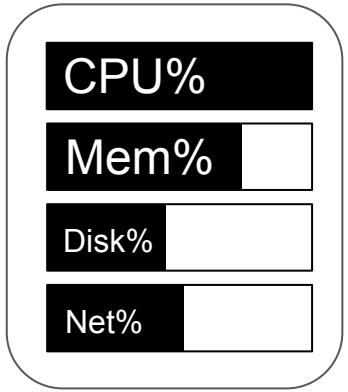
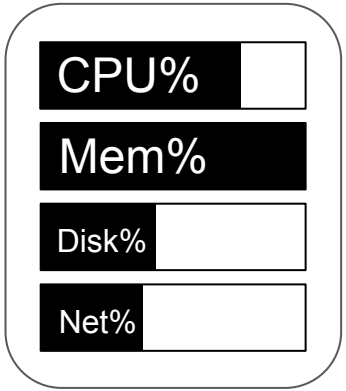




Host A



Host B

Oversubscription reduces unused resources…

…But may also reduce unallocated resources

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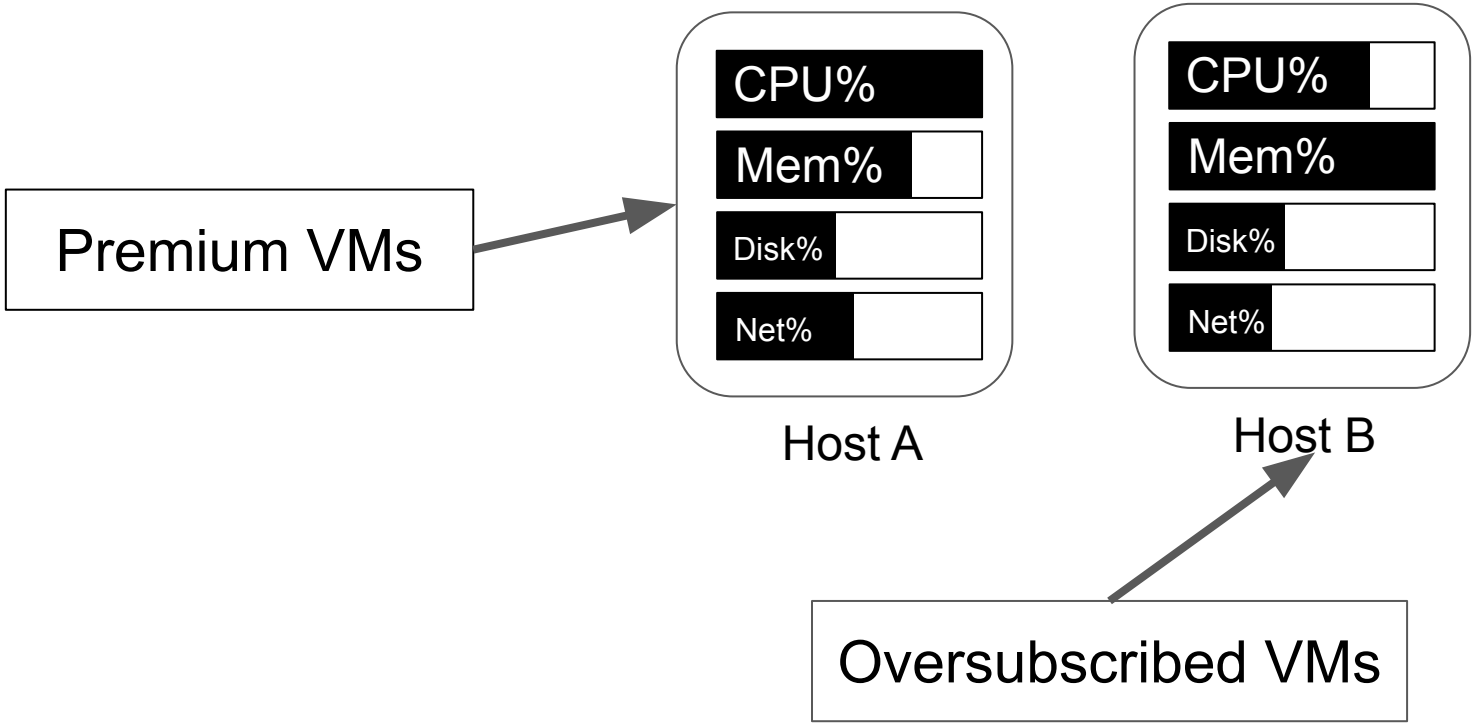
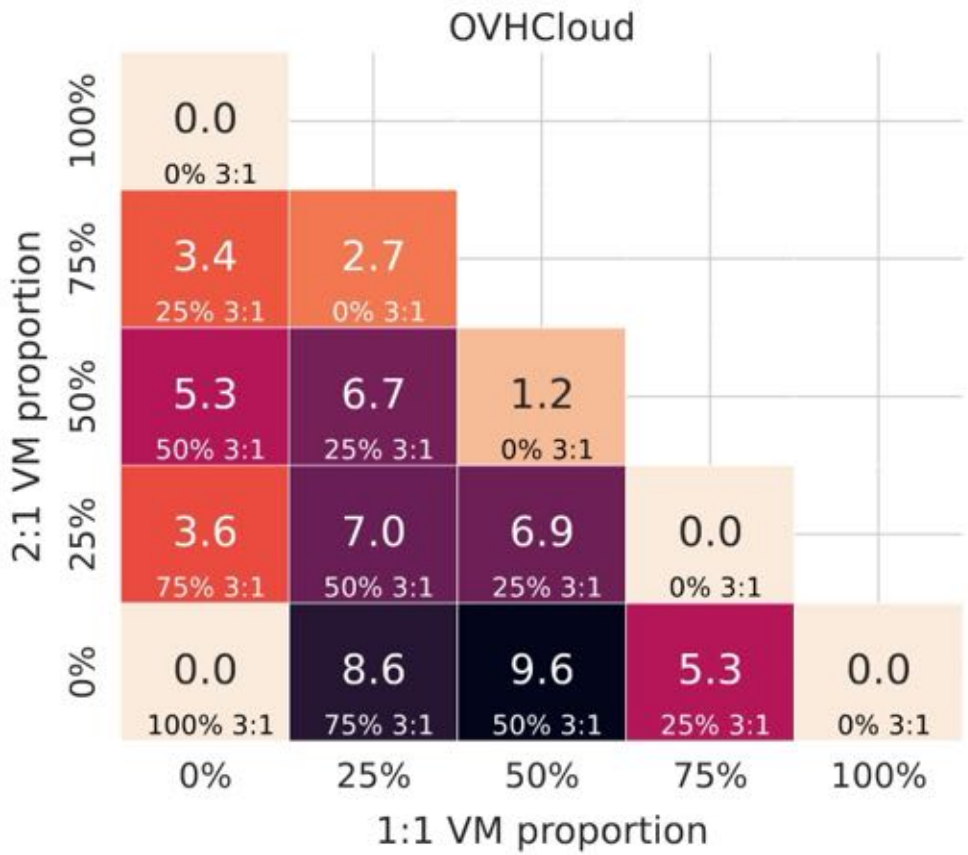


SlackVM: Packing Virtual Machines in Oversubscribed Cloud Infrastructures, *submitted to Cluster'24*

Contribution 2: **SlackVM**

Combining oversubscription levels can **save up to 10% physical machines**



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- **Ratios at the resource level (vCPU)**

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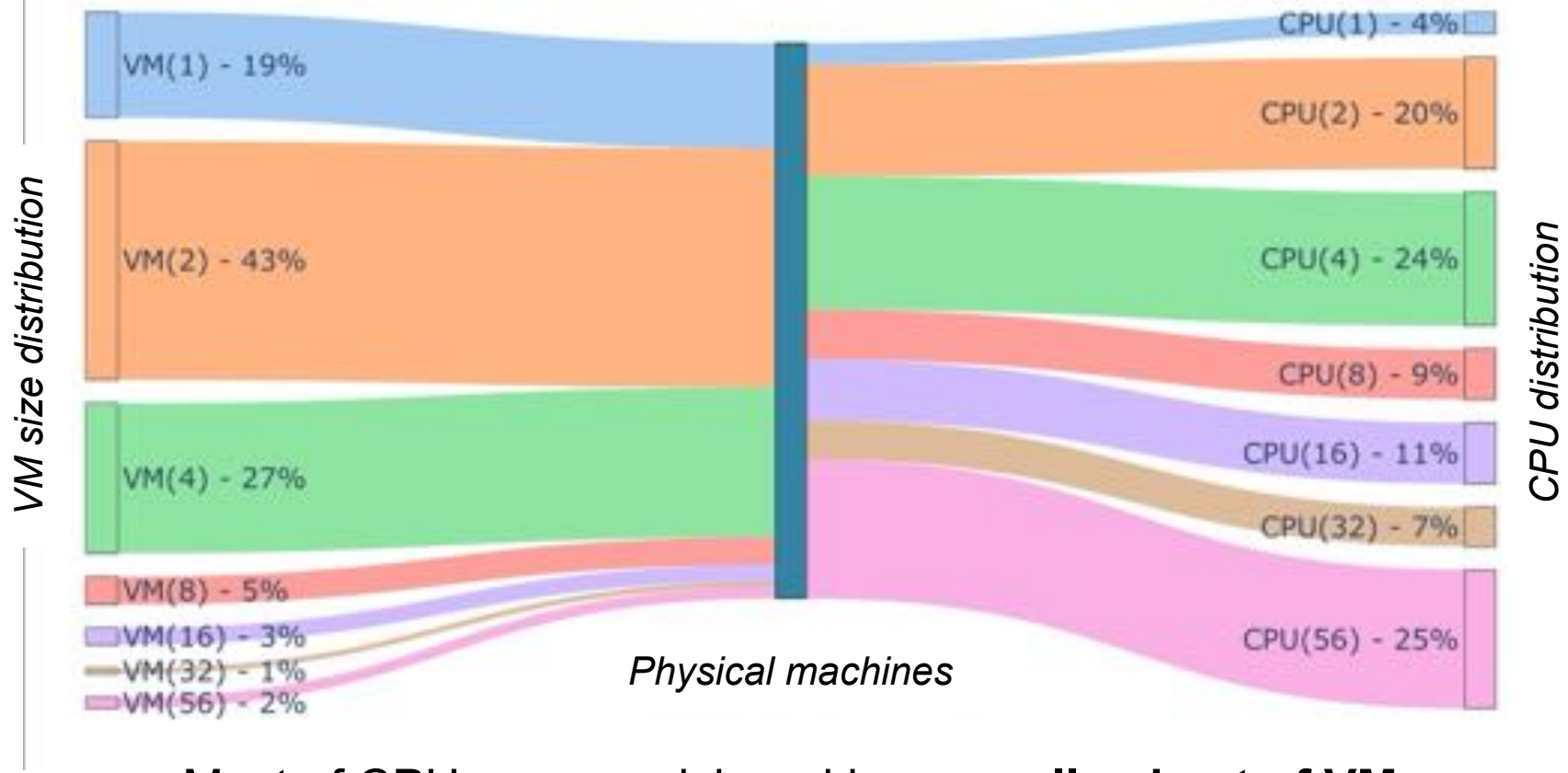
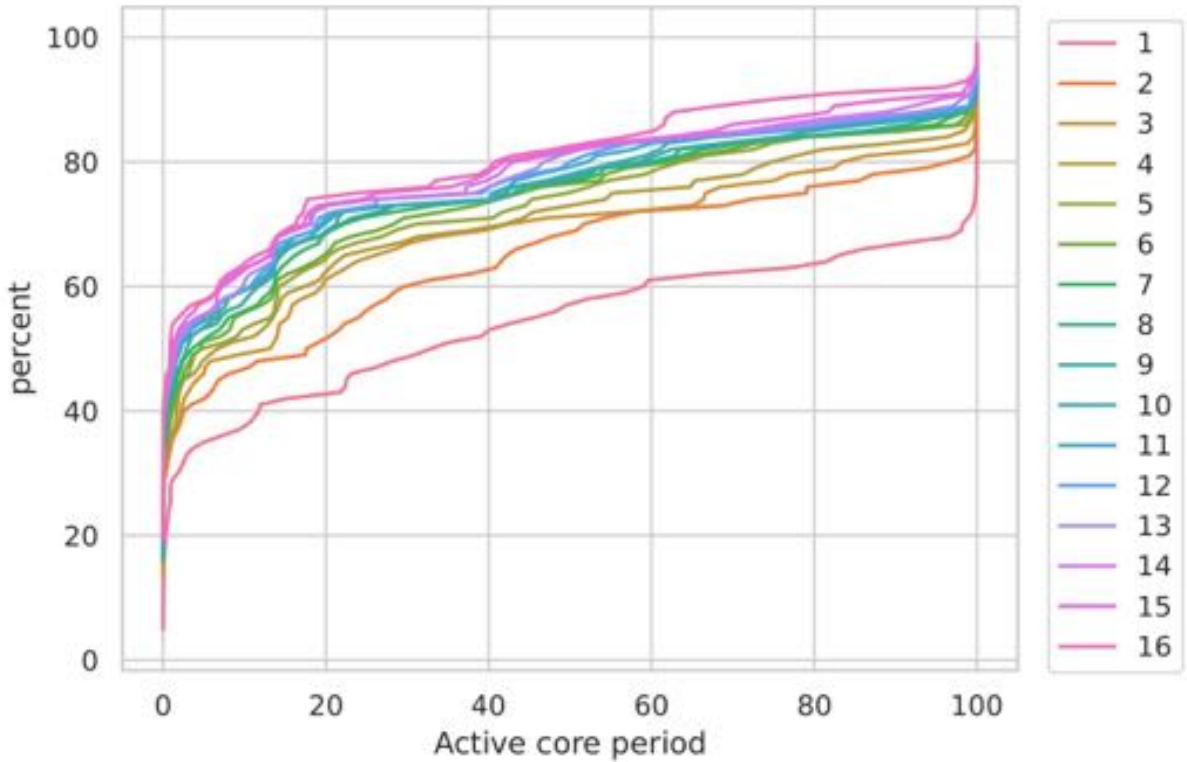


Most of CPUs are provisioned by a **small subset of VMs**

Contribution 3: **SweetspotVM**



Large VMs hosted by OVHCloud **do not use all vCPUs equally**

SweetspotVM: Oversubscribing CPU without Sacrificing VM Performance, *accepted at CCGrid'24*

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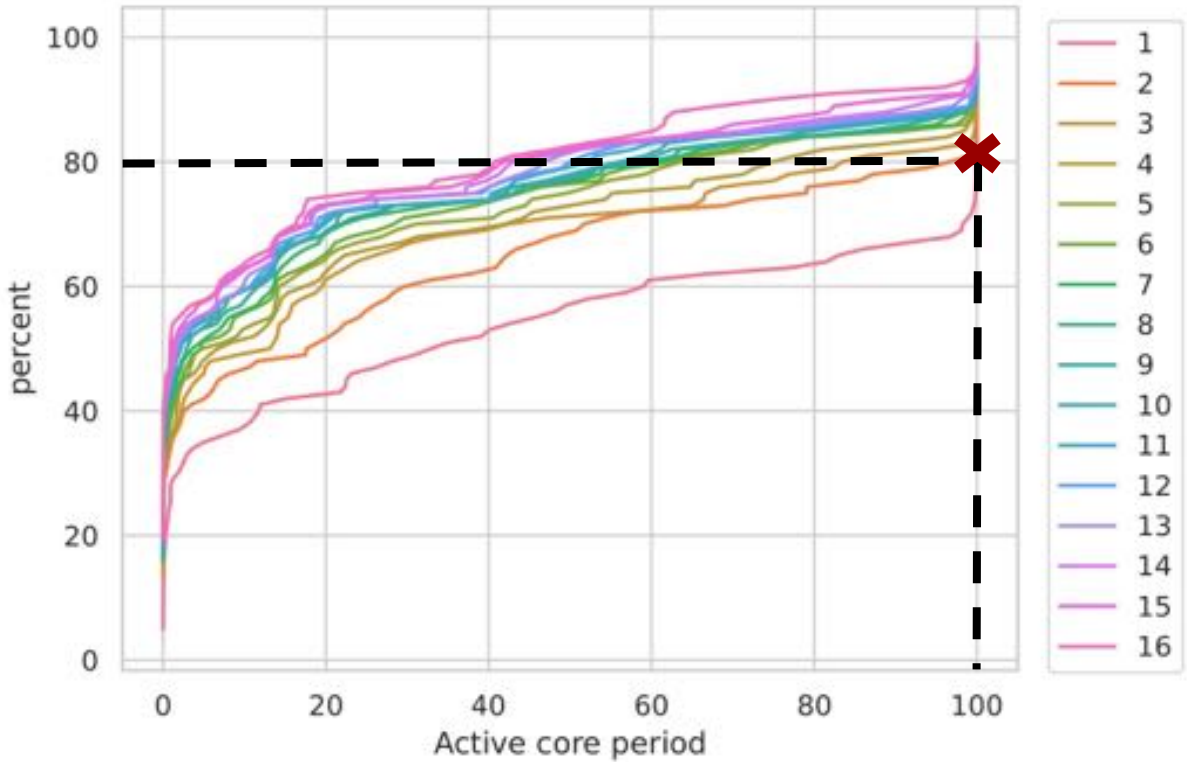

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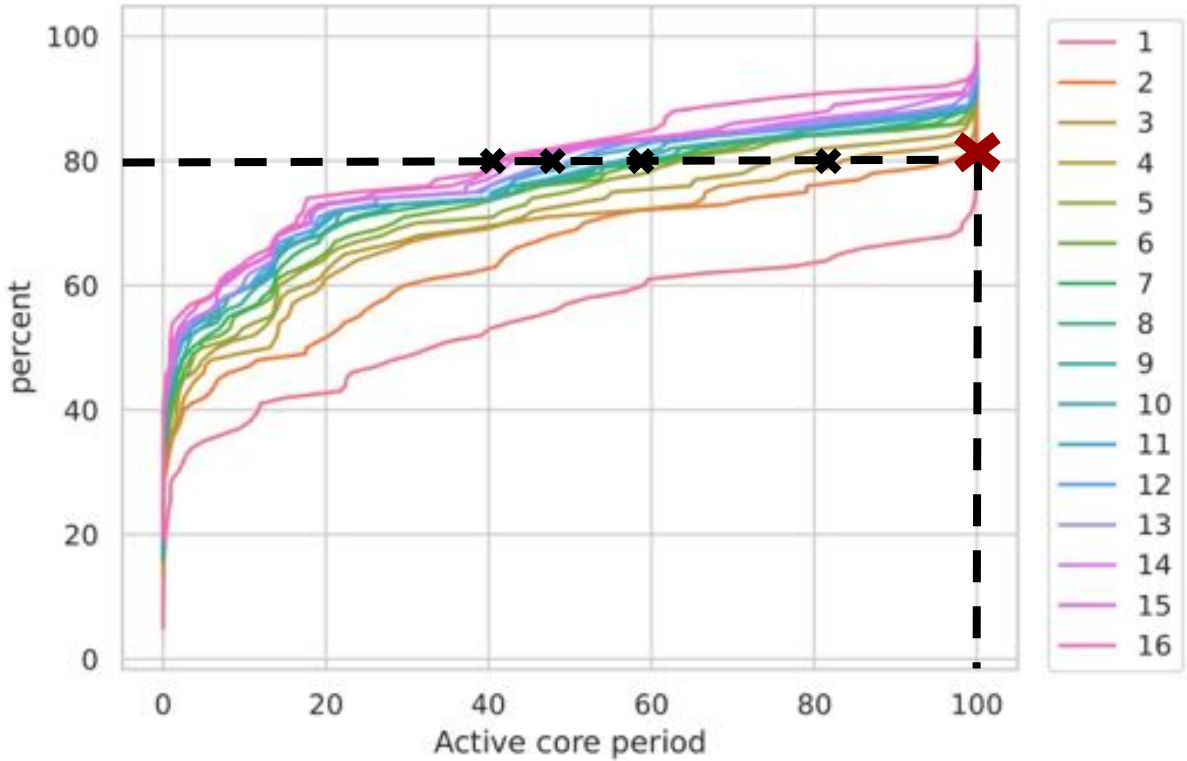

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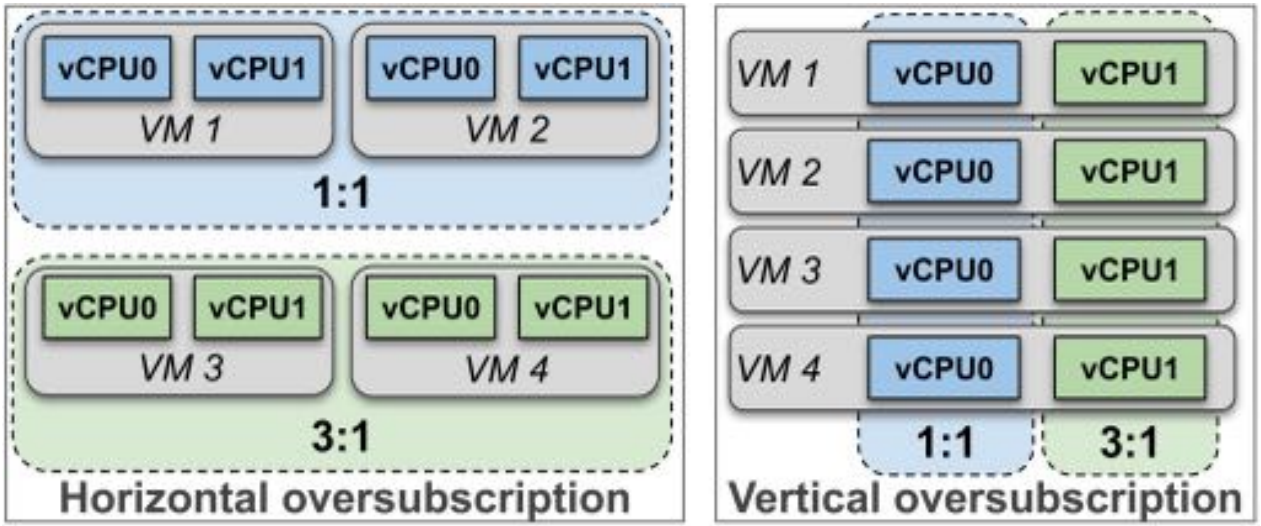

Changing the perspective on vCPU oversubscription

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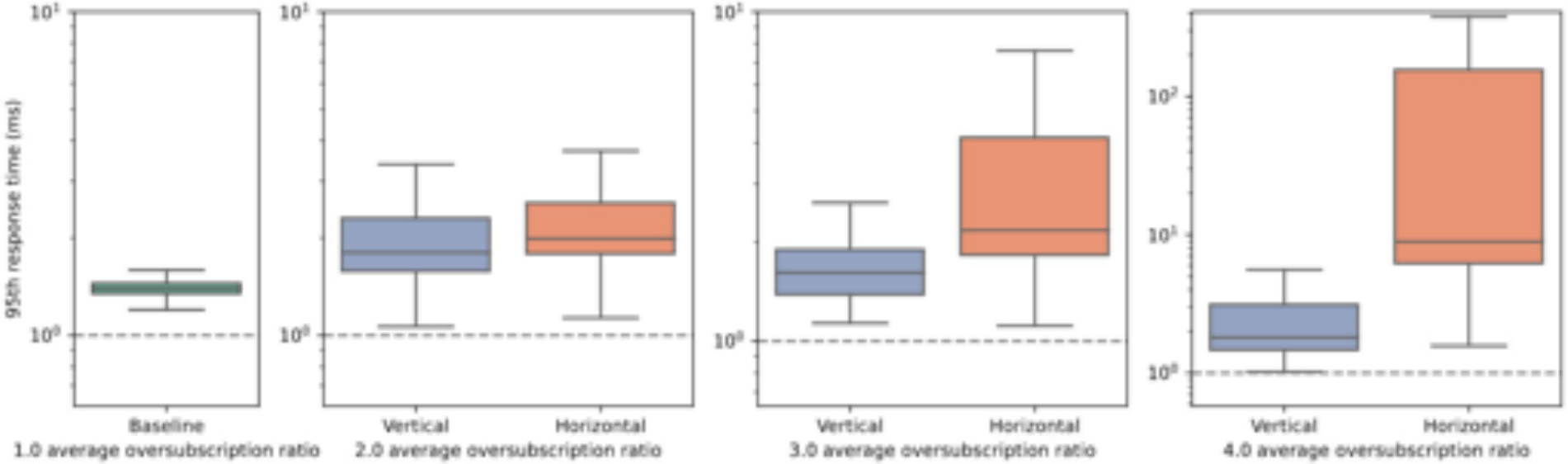

Oversubscribing differently vCPUs **reduces the performance overhead**

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Contribution 4: **CloudFactory**

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Validation

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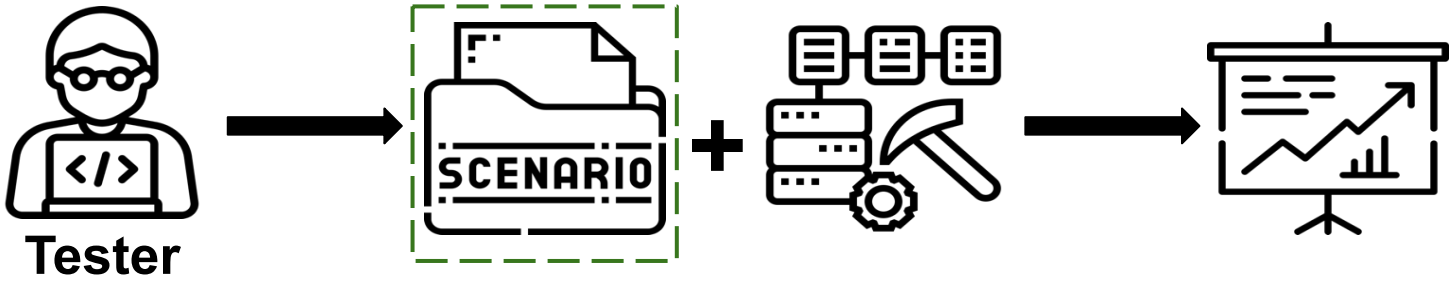

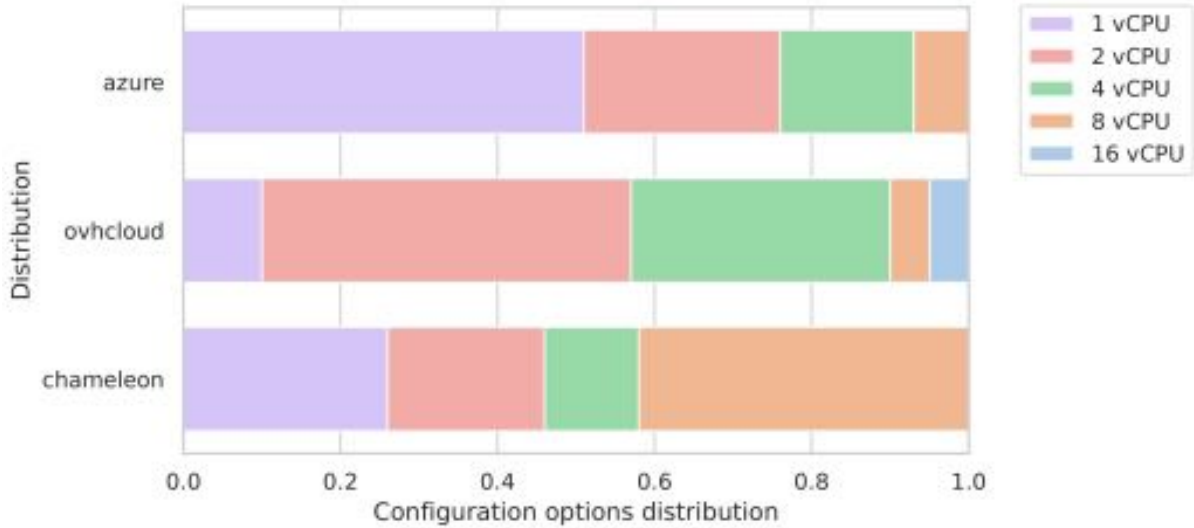

CLOUDFACTORY: An Open Toolkit to Generate Production-like Workloads for Cloud Infrastructures, *accepted at IC2E'23*

Takeaways

- Cloud resources are underused
  - “All clients do not need all their resources all the time”
- Oversubscription is a way to improve server packing
- Defining oversubscription ratios closer to individual usage is promising

Papers & code here!

Backup

Algorithm 1 Quiescent state detection algorithm

Input Historical dataset, last window
Output Quiescent state

$\mathcal{M}_{LSTM} \leftarrow$ Generate model from historical dataset
$forecasted \leftarrow predict(\mathcal{M}_{LSTM}, historical\_set)$
$predicted \leftarrow predict(\mathcal{M}_{LSTM}, last\_window)$
$\delta \leftarrow |RMSE(forecasted) - RMSE(predicted)|$
if $\delta > threshold$ **then**
    return `UNSTABLE`
end if
return `QUIESCENT`

QUANTITATIVE EVALUATION OF QUIESCENT STATE CLASSIFIERS

Classifier	Accuracy	Precision	Recall	F-score
Average	0.68	0.8	0.52	0.63
Percentile	0.57	0.55	**0.87**	0.67
P-value	0.52	**1.0**	0.06	0.12
LSTM	**0.88**	0.93	0.84	**0.88**

Using SotA Google N-Sigma peak predictor: $\overline{cpu} + N \times \sigma$

Backup

- How to oversubscribed to multiple levels a given host?

vCPU vCPU
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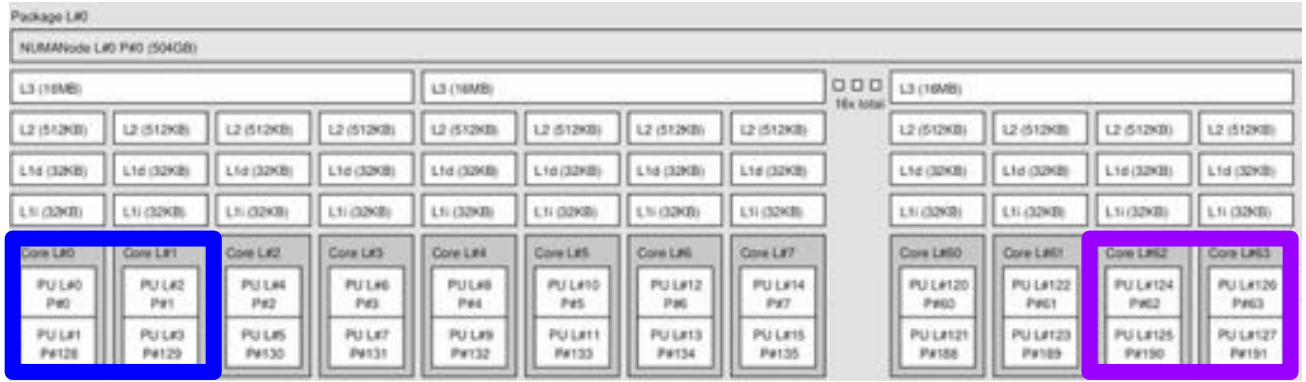

vCPU vCPU
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