南京大学
NANJING UNIVERSITY

SLA-Aware and Green Resource Management of IaaS Clouds

程硕

MF1533007

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提纲

- 简介
- 动机
- 相关工作
- 我们的工作
- 实验
- 总结
- 未来工作

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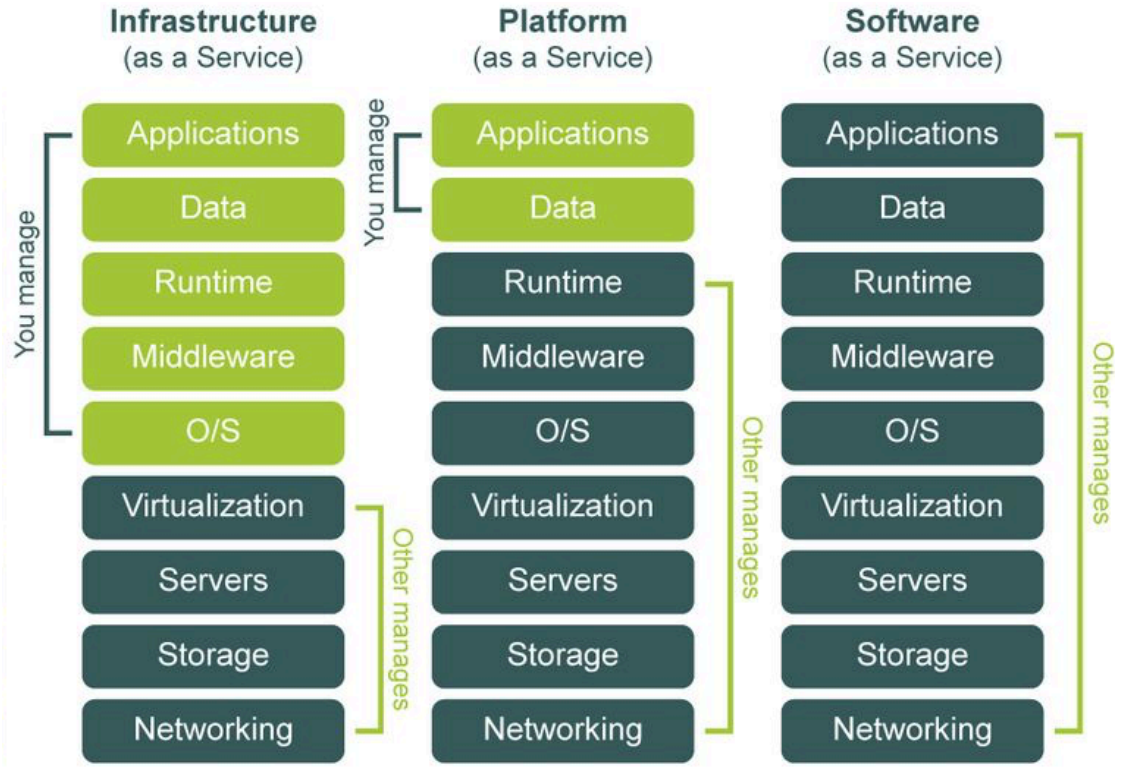
云计算

- 特点
  - 按需定制
  - 易扩展
  - 灵活性
  - 低成本
  - ...



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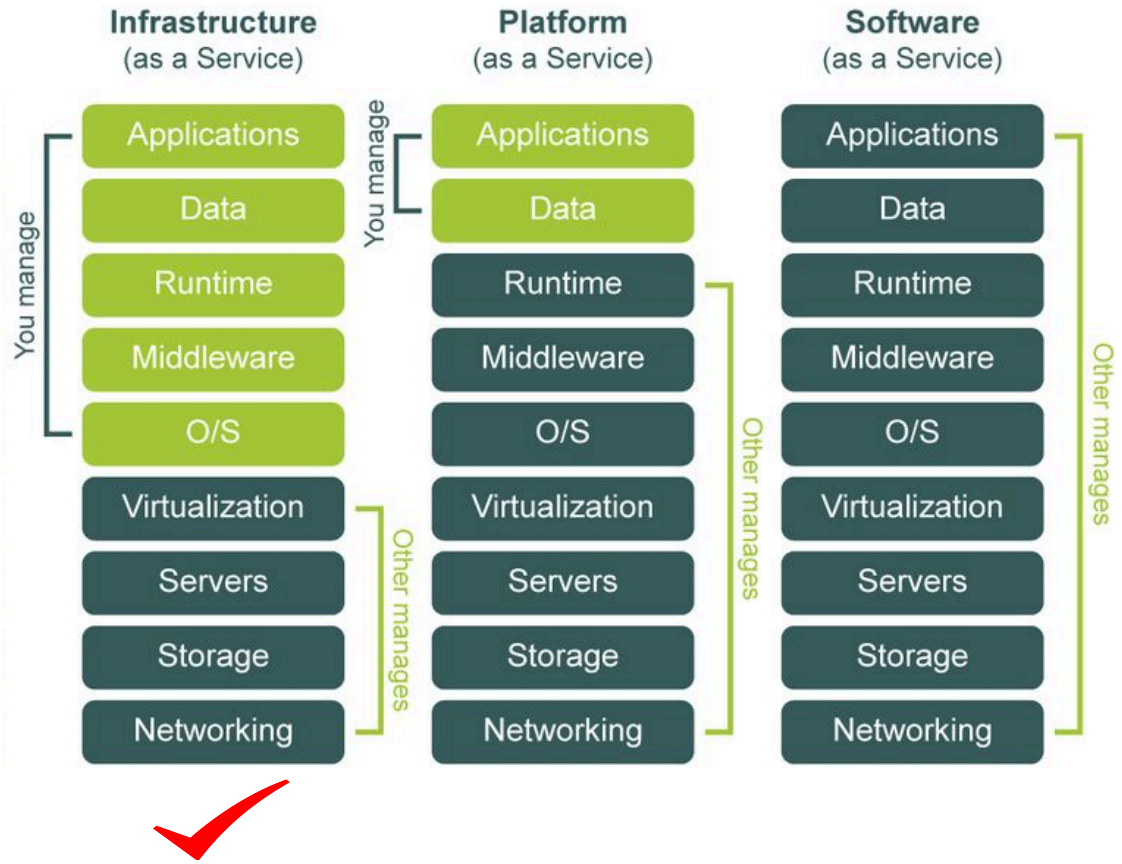
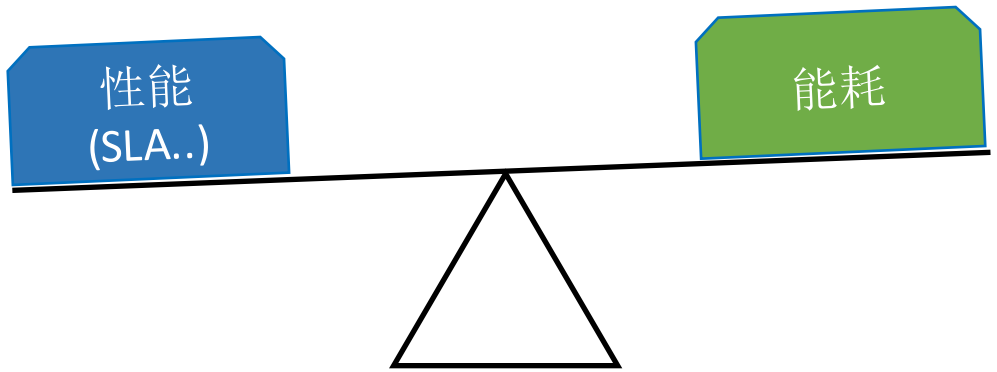


存在的问题

- 能耗
  - 数据中心的耗电量是世界总耗电量的1.5% [3].
  - 高能耗产生大量二氧化碳排放, 危害环境.
- 服务等级协议 (SLA)
  - 用来描述应用或虚拟机性能标准的协议.
  - 云服务提供商需要提供足够的资源来保证特定的SLA.

动机

- 降低能耗.
- 保证较低的 SLA 违反率.



Trade-off!

相关工作

- 使用DVFS技术来动态管理服务器的能耗 [5].
- 模式驱动的云平台中虚拟机动态整合 [9].
- 将虚拟机的放置刻画为装箱问题, 提出一种能耗感知的启发式算法 [2].
- 使用基于规则的方法来实施 SLA [1].

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概念规约

- 能耗 ≈ 活动服务器数目
  - 服务器在空闲状态下的能耗大约是满载时的70% [2].

- SLA 的违反
  - 在 SLA 限制下, 一个虚拟机实际得到的资源量小于请求量.

总体想法

Healthy Threshold (*HT*)

- 一个用来指示资源使用健康状态的概念; 基于传统的双阈值方法 (*UT:* upper threshold, *LT*: lower threshold).

$$HT = \mu * LT + (1 - \mu) * UT \qquad 0 < \mu < 1$$

- 目标: 所有活跃服务器的资源使用率是均衡的, 且接近 *HT*; 空闲服务器被关闭以实现能耗的降低.

虚拟机动态放置

三个子问题:

1. 什么时候迁移虚拟机?
2. 迁移哪一个虚拟机?
3. 迁移到哪个主机?

迁移时机

负载预测: 三次指数平滑 (Cubic Exponential Smoothing).

- 服务器超载
  - 服务器的任意一种资源使用率超出对应的上限(*UT*).
- 服务器欠载
  - 服务器所有资源的使用率都低于对应的下限(*LT*).

迁移虚拟机的选择

- *Overload Degree (OD)*

$$OD = \sum_{r_i \in R_{ut}} \left(\frac{U_{r_i}}{UT_{r_i}} - 1\right)$$

R_{ut} : The set of resources whose utilization rates exceed their UT.

U_{r_i} : The Utilization rate of resource r_i.

UT_{r_i} : The upper threshold of resource r_i.

Algorithm 2: OD_based VM Selection

```
input : overloadHost
output: vmsToMigrate
vmList ← getVMList(overloadHost);
vmsToMigrate ← [];
while isOverload(overloadHost) do
    selectedVM ← NULL;
    maxODReduction ← 0;
    originOD ← calculateOD(overloadHost);
    for vm in vmList do
        estOD ← estimateOD(vm, overloadHost) ;
        reduction ← originOD − estOD;
        if reduction > maxODReduction then
            selectedVM ← vm ;
            maxODReduction ← reduction ;
        end
    end
    vmsToMigrate.add(selectedVM);
    vmList.remove(selectedVM);
end
return vmsToMigrate;
```

目的主机的选择

- *Closeness Degree (CD)*

$$CD = \sum_{r_i \in R} (\frac{U_{r_i}}{HT_{r_i}} - 1)^2$$

R : The set of all resources of a server.

U_{r_i} : The Utilization rate of resource r_i.

HT_{r_i} : The healthy threshold of resource r_i.

Algorithm 1: LB-BFD VMs Reallocation

```
   input : vmsToMigrate
   output: migrationMap
1  migrationMap = {};
2  vmsToMigrate.sortDcrOverallUtilization() ;
3  for vm in vmsToMigrate do
4      minCD ← MAX;
5      targetServer ← NULL;
6      idleServers = getIdleServers();
7      candidateServers ← serverFiltered(vm) ;
8      if sizeOf(candidateServers) > 0 then
9          for server in candidateServers do
10             serverCD ←
               estimateServerCD(vm, server);
11             if serverCD < minCD then
12                 targetServer ← server ;
13                 minCD ← serverCD ;
14             end
15         end
16     else if sizeOf(idlerServers) > 0 then
17         targetServer ← randomSelect(idleServers);
18     else
19         targetServer ← NULL;
20     end
21     migrationMap.add(vm, targetServer);
22 end
23 return migrationMap;
```

严格的SLA执行策略

- 进一步降低 SLA 违反率.

$$\begin{cases} U_{r_i}^m > UT_{r_i}^m, \\ r_i^m * (1 - U_{r_i}^m) > r_i * (UT_{r_i} - U_{r_i}) \end{cases}$$

r_i^m : Resource r_i that VM m demands in SLA.

$U_{r_i}^m$: The utilization rate of r_i^m.

$UT_{r_i}^m$: The upper threshold set for r_i^m.

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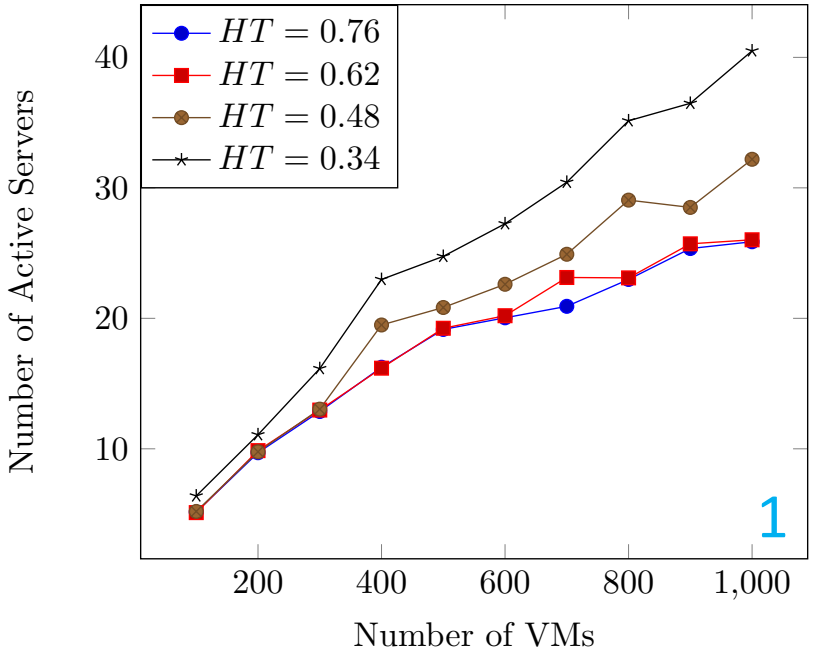
实验

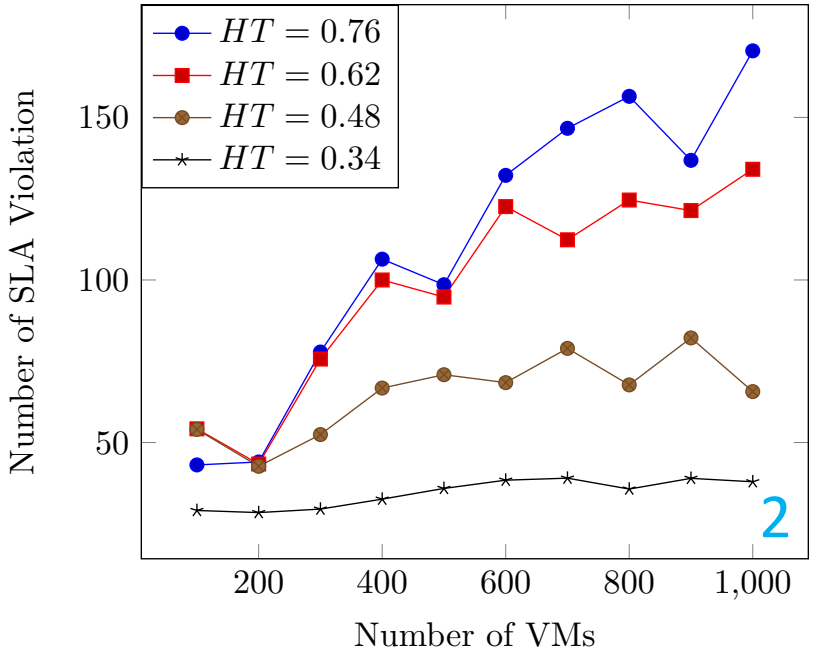
- 模拟平台
  - CloudSim: 一个用来云计算设施和服务进行建模和模拟的平台[7].
- 实验设置
  - 400个服务器: 2*6000MIPS, 4G RAM, 1TB Storage.
  - 1000个 PlanetLab 虚拟机的负载轨迹 [8].
  - 虚拟机配置: 2500, 2000, 1000, 500 MIPS.
  - 阈值设置: UT = 0.9, LT = 0.2.
- 基准程序
  - MBFD [2].

实验结果

- 性能指标
  - 活跃服务器数目
  - SLA 违反率
  - 虚拟机迁移次数

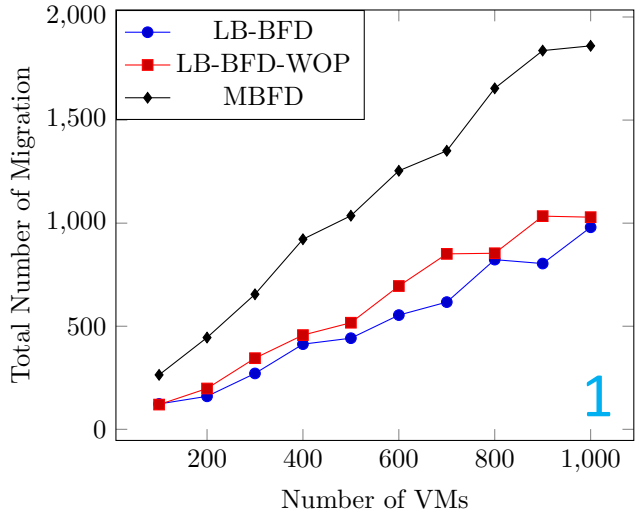
实验结果

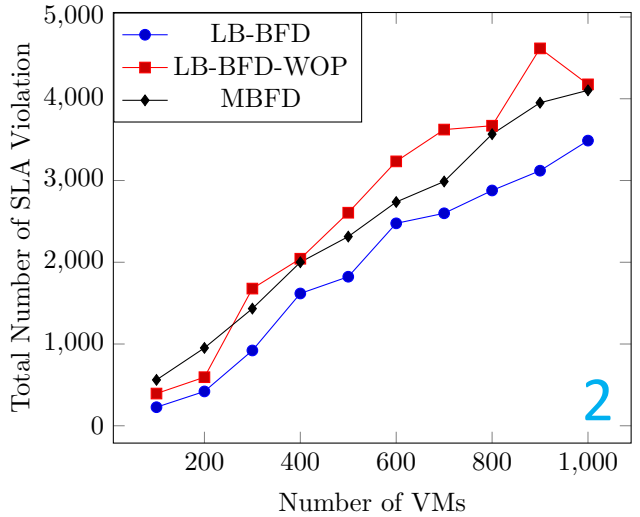


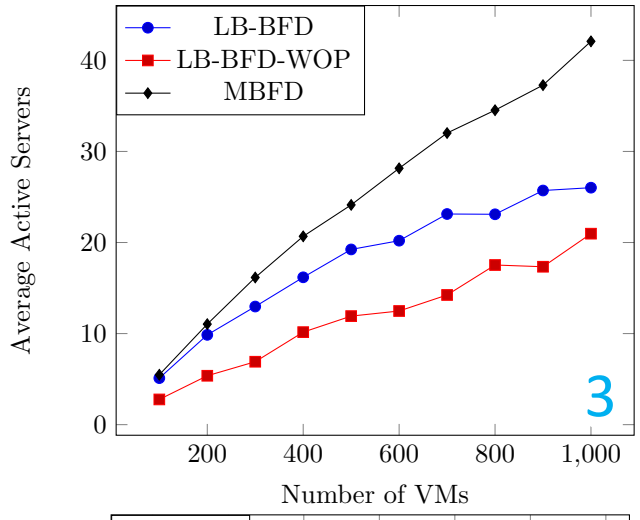


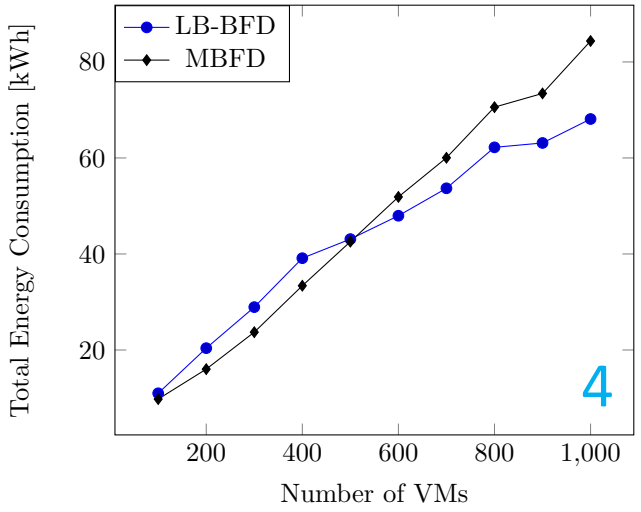
HT 的性能影响

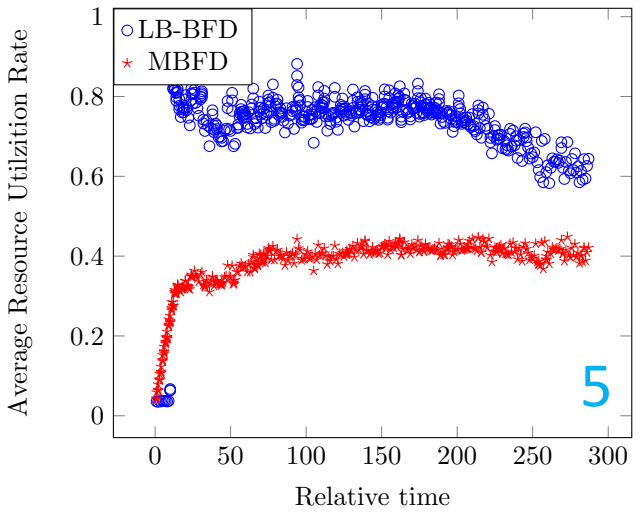
实验结果

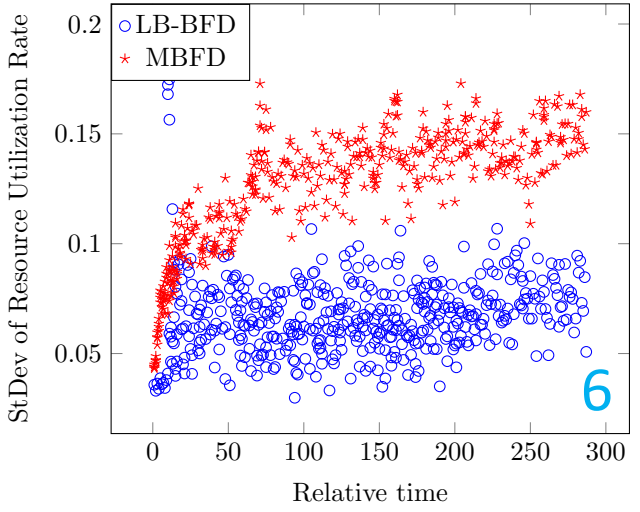












性能对比 (*HT* = 0.62)

总结

- 提出了概念 “Healthy Threshold”作为IaaS 云平台资源使用均衡的目标.
- 基于 *Healthy Threshold* 和负载预测, 设计了用于虚拟机动态放置的启发式贪心算法
- 开展了使用真实负载轨迹的模拟实验, 实验结果表明在降低 IaaS 云平台能耗和 SLA 违反率方面，我们的算法要优于其他的工作.

未来工作

- 使用包含更多资源的负载轨迹来完成更充分的模拟实验.
- 在真实的云计算平台上完成实验来进一步验证算法的有效性.

引用

[1] M.Maurer,I.Brandic,andR.Sakellariou,"Enacting slas in clouds using rules," in *European Conference on Parallel Processing*. Springer, 2011, pp. 455–466.

[2] A. Beloglazov, J. Abawajy, and R. Buyya, "Energy-aware resource allocation heuristics for efficient management of data centers for cloud computing," *Future generation computer systems*, vol. 28, no. 5, pp. 755–768, 2012.

[3] A. Qureshi, R. Weber, H. Balakrishnan, J. Guttag, and B. Maggs, "Cutting the electric bill for internet-scale systems," in *ACM SIGCOMM computer communication review*, vol. 39, no. 4. ACM, 2009, pp. 123–134.

[4] Z. Gong and X. Gu, "Pac: Pattern-driven application consolidation for efficient cloud computing," in *2010 IEEE International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems*. IEEE, 2010, pp. 24–33.

[5] C.-M. Wu, R.-S. Chang, and H.-Y. Chan, "A green energy-efficient scheduling algorithm using the dvfs technique for cloud datacenters," *Future Generation Computer Systems*, vol. 37, pp. 141–147, 2014.

[6] J. Heo, X. Zhu, P. Padala, and Z. Wang, "Memory overbooking and dynamic control of xen virtual machines in consolidated environments," in *2009 IFIP/IEEE International Symposium on Integrated Network Management*. IEEE, 2009, pp. 630–637.

[7] R.N.Calheiros,R.Ranjan,A.Beloglazov,C.A.DeRose,andR.Buyya, "Cloudsim: a toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms," *Soft- ware: Practice and Experience*, vol. 41, no. 1, pp. 23–50, 2011.

[8] B. Chun, D. Culler, T. Roscoe, A. Bavier, L. Peterson, M. Wawrzoniak, and M. Bowman, "Planetlab: an overlay testbed for broad-coverage services," *ACM SIGCOMM Computer Communication Review*, vol. 33, no. 3, pp. 3–12, 2003.

[9] Z. Gong and X. Gu, "Pac: Pattern-driven application consolidation for efficient cloud computing," in *2010 IEEE International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems*. IEEE, 2010, pp. 24–33.

[10] R.Buyya,A.Beloglazov,andJ.Abawajy,"Energy-efficient management of data center resources for cloud computing: A vision, architectural elements, and open challenges," *arXiv preprint arXiv:1006.0308*, 2010.

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谢谢!