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An Optimized Virtual Machine Migration Algorithm for Energy Efficient Data Centers

Anil Dixit, Dr. Suchithra R
Department of Computer Science Jain Deemed-To-Be University Bangalore, Karnataka, India
Corresponding Author: Anil Dixit

Abstract: *The cloud computing technology is becoming scalable and manageable with the effectiveness of virtualization techniques adopted at data centres. The virtualization at data centres is a very mandatory factor for making the resource utilization proper and reliable. The main aim of the Virtual Machine (VM) should obviously reduce the energy consumption. This paper presents a novel approach for the Virtual Machine migration algorithm such as Random Sampling (RS) policy and Systematic Sampling (SS) policy. In this proposed scheme the list of VM is selected and randomly allocated to the physical machine for resource management. Our novel approach minimizes energy consumption during VM migration and cost-effective when compared with the existing traditional techniques. For finding the effectiveness we have used the CloudSim tool for simulation and analyze the real-time load with the proposed approach. Therefore, from the experimental analyses, it is proved that our proposed algorithm adopts the SLA violation and decreases the energy consumption effectively.*

Keywords: *Virtual Machine, Load balancing, CloudSim, Physical Machine, Virtualization.*

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I. Introduction

The existence of cloud technology in recent years is growing fast with the expansion of customers and numerous services. The number of services providers for cloud computing is also increased due to the expansion of data centres. This factor increases the energy utilized by the cloud data centres and also operational cost. For the fast-growing cloud services, the quality of services is the main criterion which must satisfy with the SLA agreements between the cloud services, providers and customers. The cloud computing infrastructure makes the system configurable with the servers, storages, services through the internet services. It is based on the on-demand systems and services such as IaaS, PaaS, and SaaS. IaaS is based on the infrastructure policy which is based on hardware requirements such as servers, storages respectively. PaaS is nothing but the independent of services provided under different operating systems. SaaS is the service which is based on on-demand of providing the software according to their usage. In general, cloud technology is plagiaristic of grid computing technology which has many advantages including cost-effective services, scalability, easily manageable and various services. This advantages increases and drag the millions of new customers to the cloud technology.

Based on the demand the cloud is becoming scalable therefore, the storage services must also become scalable, for the reason there exists the concept of virtualization on the cloud storages. For efficient utilization of resources there need for efficient resource management services. Therefore, the context of Virtual Machine (VM) exists which is like a real operating system which acts on the physical machine. The VM on the physical machine improves the quality of services, resource utilization and mainly reduces the energy consumptions. The VM enhances the reliability of the cloud services [8]. The VM makes the system that functions independently as a discrete system and it migrates inside the individual data centres to elevate the resource utilization by gradually de-promote the energy consumptions [9].

Numerous algorithms have been developed for migrating the VM efficiently, the traditional relocating algorithm is the bin-packing algorithm. In bin-packing algorithm the collection VM is located on the bins and based on the requirement the VM will be deployed on the physical machine. Takeda and Takemura (2010) worked with the NP-hard problem which solves the issues found in bin-packing approaches [10]. The various heterogeneous servers provide the services which should be optimum and energy efficient. In [11, 12] come across the idea for improving the VM allocation with energy efficiency by proposing the heuristic approach which convinces the protocols and constraints of performance by decreasing the power consumption at data centres. They have handled the switching technique to reduce the power consumption.

In this paper, we have presented the novel approach for VM migration which reduces the energy consumption and computational cost. The response time and servicing time has computed and our proposed approach brings out the superiority over the traditional frameworks. The contribution we made in this work is generally having two streams they are:

- We proposed the Random Sampling policy (RS policy) which makes the resource that must be allocated balancing on the VM.
- We introduced the Systematic Sampling policy (SS policy) which maintains the list of selected VM that must be efficiently allocated on the physical machine which saves energy to the higher extent.

This paper is organized as follows; in Section 2, the brief related work is presented. In Section 3, the methodology of the RS and SS policy is elaborated in detail. Section 4 comprises experimental results and its discussion of the proposed approaches. Section 5 concludes the work of this paper.

II. Related Work

The efficient data centres must have well-organized resource utilization and energy consumption which are the main two factors of data centre cloud technology. For making the data centre more efficient and reliable VM should be adopted and it should migrate proficiently when allocating the resource to it. AlShayeji et al. (2017) developed the VM with the efficient energy utilization formula with the pivotal factors. This technique is employed with Energy-Based Server Selection (ESS) for the server allocation. The other techniques like Arbitrary Server Selection (ASS) and First Fit Strategy (FFS) performs low when compared with the ESS approaches [1]. In [2] the time-series forecasting scheme and Double Exponential Smoothing (DES) approaches are studied and developed with the proficient CPU utilization for migrating the VM the host machine. It uses the dynamic threshold methodology to identify the overloaded and under-loaded host machines. The study shows in [3], improve the performance of the data centres at the time of resource utilization and sharing is achieved when multi-dimensionality of the physical host is avoided. This will imbalances the resource allocations and increases the energy consumptions. Li et al. (2013) developed the EAGLE approach for lower energy consumption [3]. The VM consolidation should be optimized with satisfying QoS, this is achieved by heuristics approaches such as NP-Hard [4]. In [5], with the help of the deterministic algorithm for VM migration and consolidation, the dynamic heuristic approach is proposed with the reduces of energy. Meng et al. (2010) developed the framework that advances the progress of network scalability called traffic-aware VM re-locating. This two-tier architecture improves the optimization and traffic patterns are analysed [6]. The allocation of resource problems like load balancing on server scheduling and configuration of VM on data centres are solved with the Best-Fit approaches [7]. In [11-13], the QoS is the needed factor for any VM migration to balance the under-loaded and an overloaded server. Sometimes the VM will be migrated to the unhealthy nodes to prevent the failure of resource utilization to boost the availability of the machines [14]. Therefore, to full fill these fissures in VM migration research, we presented the two policy such as Random Sampling and Systematic Sampling policy to overcome these challenges.

III. Materials and Methods

In this section, we briefly discuss the various energy efficient virtual machine algorithm. For dynamic virtual machine migration there exist three important procedures to be followed such as making the decision for the need of migration, VM needs to be picked for migration and selecting the appropriate destination for VM migration. In this work we have concentrated on seven different algorithms such as Random Sampling (RS) Policy, Systematic Sampling (SS) Policy, Minimum Time Cost Migration (MTCM) Policy, Minimum Product of Both CPU Utilization and Memory Size, Static VM placement based on MPCM, Virtual machine placement Algorithm based on KP, Dynamic VM placement Algorithm based on MPCM. The detailed flow of this algorithm is comprehended below.

3.1 Random Sampling (RS) Policy

The Random Sampling (RS) policy is the algorithm for random allocation of virtual machine efficiently on the cloud data center. This algorithm will randomly choose the physical machine to mount the virtual machine. Initially, it will maintain the list of a virtual machine which is needed to mount on the physical host machine. Then the selection process is made to adopt it. The stepwise process of RS policy algorithm starts up with obtaining the list of virtual machines which is needed to get migrated. The size of the each VM should be noted and the random number is allocated to the VM from 0 to n-1. Then the process of randomization should start from 0^{th} number till the end of the selected list of VM. Figure 2 describes the flow of VM allocation. The algorithmic way of representing the RS policy is given in Figure 1.

Algorithm 1: RS policy (Random Sampling (RS) Policy**)**

Input: vmList {vm_1, …,vm_n}

Output: selection of Vm(selVm)

1. SelVm = **random**(vmList)
2. **return** selVm

Figure 1. Pseudo-code of Random Sampling Policy

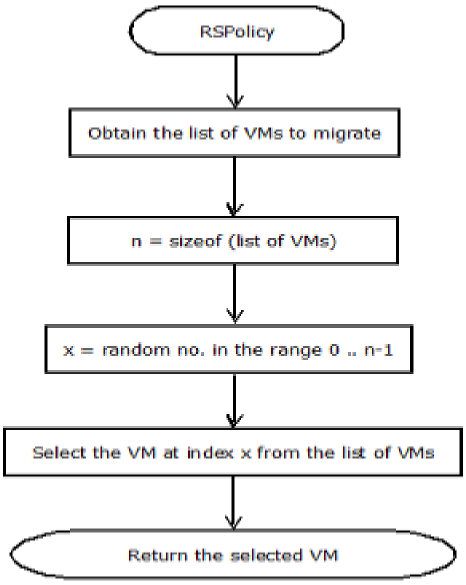


Figure 2. Flow Representation of Random Sampling Policy

3.2 Systematic Sampling (SS) Policy

The Systematic Sampling (SS) Policy is the algorithm that keeps the list of a virtual machine for migrating to the physical machine. Like, the RS policy scheme, in SS policy algorithm also the list of VM is generated which is needed to migrate to the data centre. For allocating the VM into the data centre region, initially, randomly VM is selected from the list and add the selected Virtual Machine to the desired list. Once, the first region of the data centre is completed it, it moves to the next region and again the process will get executed. The pseudo code and the flow diagram of the SS policy are given in Figure 3 and Figure 4 respectively.

Algorithm 2: SS policy (Systematic Sampling (SS) Policy)

Input: vmList {vm_1, …,vm_n}

Output: selection of Vm(selVm)

1. **Choose** number of possible solution (S)
2. **For** each S_i**do**
3. tempSelVm = **random**(S_i)
4. **add**tempSelVm's element to **array**tempVm
5. tempSelVm = **random**(tempVm)
6. return tempSelVM

Figure 3. Pseudo-code of Systematic System

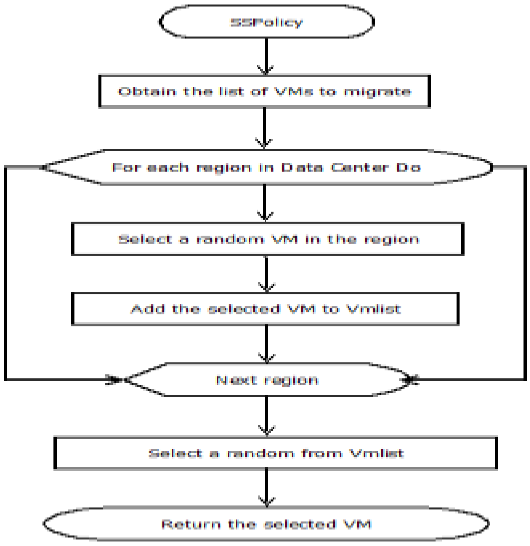


Figure 4. Flow representation of Systematic Sampling Policy

IV. Experimental Result and Analysis

The experimental analysis of the proposed work is stimulated using the CloudSim stimulator which has the many advantages for designing the cloud technology virtualization for resource allocating and Virtual Machine migrating. The proposed approaches such as RS policy and SS policy is experimented with the CloudSim tool to evaluate the response time which is tabulated in Table 1, 2, 6, 7 respectively.

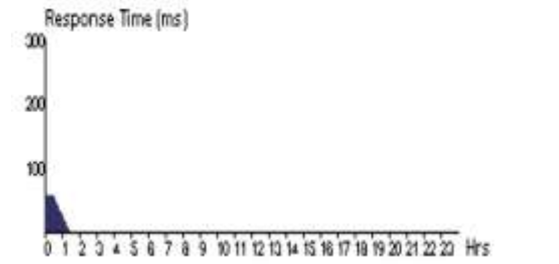
In Table 1, the summary of the on the whole response time and the data center processing time is table for RS policy. The response time for region wise is evaluate and it is tabulated in Table 2.

Table 1. Summary of Overall Response Time of Random Sampling Policy

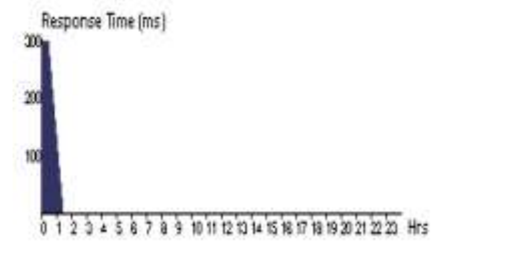
Time Factor	Avg(ms)	Min(ms)	Max(ms)
Overall Response Time	15.45	43.38	339.52
Data Center Processing Time	9.17	0.00	13.50

Table 2.Response Time by Region of Random Sampling Policy

User Base	Avg(ms)	Min(ms)	Max(ms)
UB1	58.51	45.88	68.13
UB2	300.85	261.02	339.52
UB3	216.97	188.89	276.64
UB4	58.07	43.38	66.26



(a)



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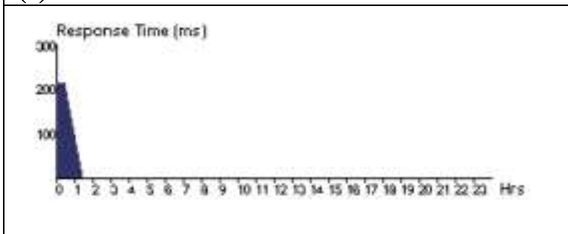

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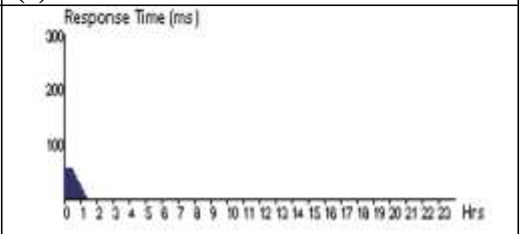


(d)

Figure 5. User Base Hourly Response Times of Random Sampling Policy (a) User base 1 (b) User base 2(c) User base 3 (d) User base 4

The response time of the user base for four different users is calculated for RS policy and represented in Figure 5. From this analyze it is observe that the response time user 2 and user 3 has maximum when comparing with the user 1 and 4.

The data center servicing time for sending the request is calculated and it is tabulated in Table 3 for RS policy. Here we have taken four different data center for analyzing purpose and their results are evaluated.

Table 3. Data Center Request Servicing Times of Random Sampling Policy

Data Center	Avg(ms)	Min(ms)	Max(ms)
DC 1	7.41	0.88	12.14
DC 2	8.77	0.26	13.50
DC 3	0.00	0.00	0.00
DC 4	11.92	11.38	12.51

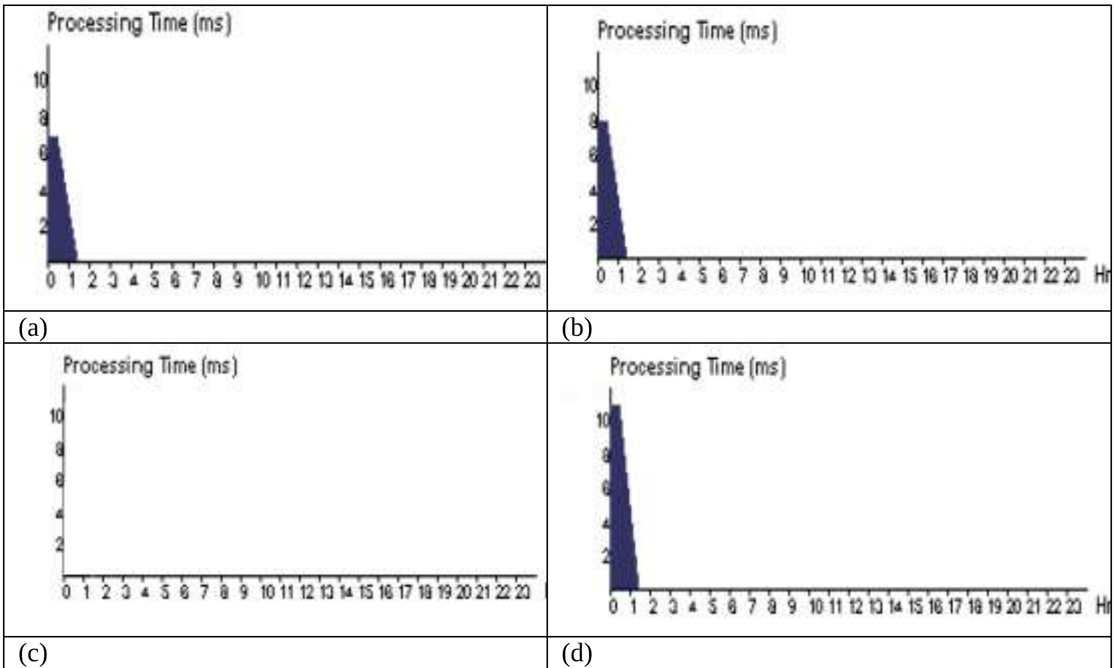


Figure 6. Data Center Hourly Average Processing Times of Random Sampling Policy(a) Data Center 1 (b) Data Center 2(c) Data Center 3 (d) Data Center 4

The graphical representation of the data center is shown in Figure 6 for RS policy, from the above graph it is understood that the data center 3 gives the zero response serving time and other three produces the desirable result.

Table 4. Cost of Random Sampling Policy

Data Centers	VM Cost $	Data Transfer Cost $	Total $
DC 1	0.17	0.00	0.17
DC 2	0.08	0.03	0.12
DC 3	0.15	0.00	0.15
DC 4	0.08	0.01	0.09

Table 5. Total Cost of Random Sampling Policy

Total Virtual Machine Cost ($)	**0.49**
Total Data Transfer Cost ($)	**0.04**
Grand Total: ($)	**0.53**

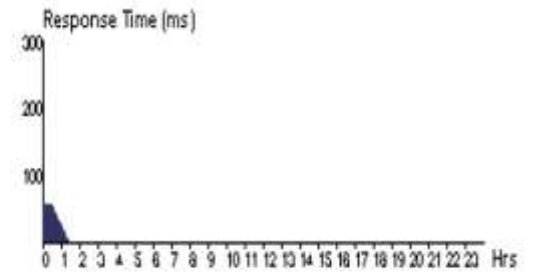
Table 6. Summary of Overall Response Time of Systematic Sampling Policy

Time Factor	Avg(ms)	Min(ms)	Max(ms)
Overall Response Time	155.69	43.38	339.52
Data Center Processing Time	9.15	0.00	14.88

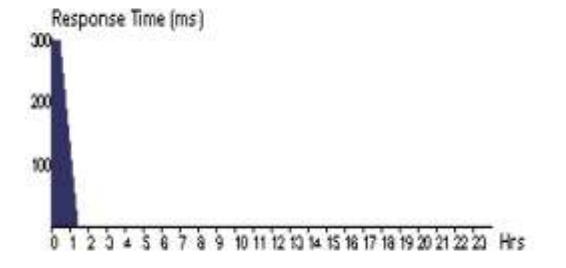
Table 7. Response Time by Region Systematic Sampling Policy

User Base	Avg(ms)	Min(ms)	Max(ms)
UB1	59.39	45.88	73.52
UB2	301.70	261.02	339.52
UB3	216.97	188.89	276.64
UB4	57.34	43.38	65.26

The Table 6 and 7 shows the response time of the SS policy for four different user and its graphical representation is given in 7.



(a)



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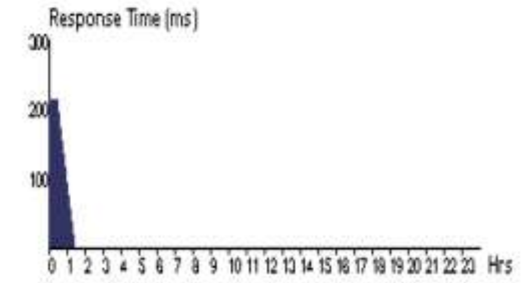
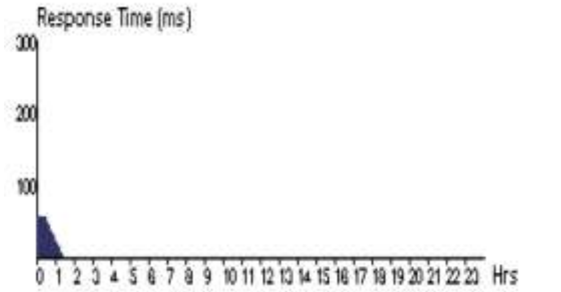


(c)

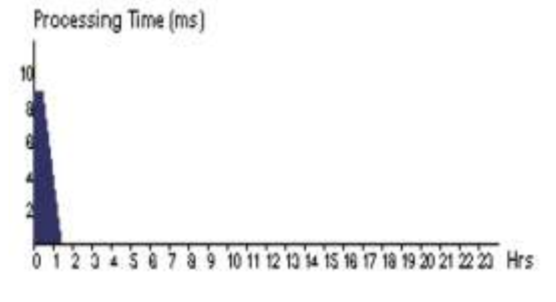


(d)

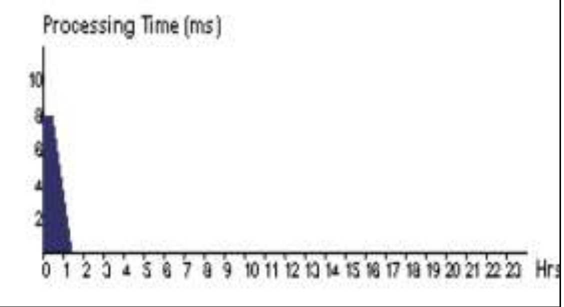
Figure 7. User Base Hourly Response Times of Systematic Sampling Policy (a) User base 1 (b) User base 2 (c) User base 3 (d) User base 4

Table 8. Data Center Request Servicing Times of Systematic Sampling Policy

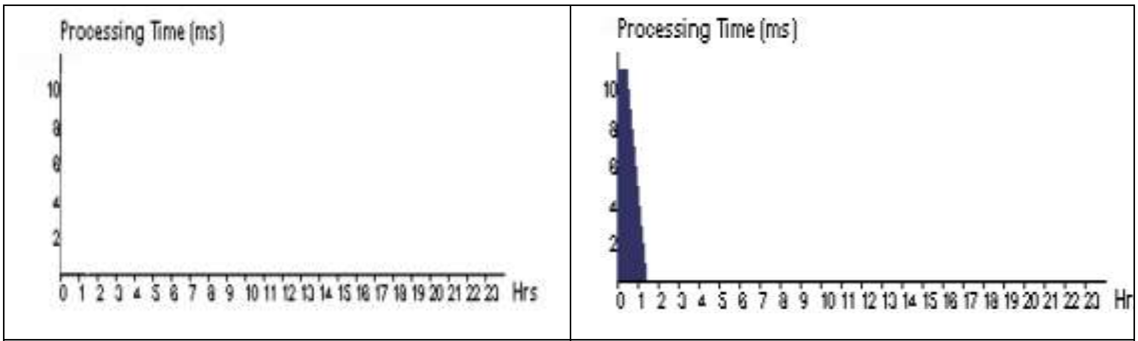
Data Centers	VM Cost $	Data Transfer Cost $	Total $
DC 1	0.17	0.00	0.17
DC 2	0.08	0.03	0.12
DC 3	0.15	0.00	0.15
DC 4	0.08	0.01	0.09



(a)



(b)



(c) (d)

Figure 8. Data Center Hourly Average Processing Times of Systematic Sampling Policy (a) User base 1 (b) User base 2 (c) User base 3 (d) User base 4

The result of the SS policy for the servicing time request is given in Table 8 and its graphical representation is shown in Figure 8 for four different data center named DC1, DC2, DC3, and DC4 respectively. Like the result obtained from the RS policy for response serving time, the SS policy also yields the similar output.

Table 9. Cost of Systematic Sampling Policy

Data Centers	VM Cost $	Data Transfer Cost $	Total $
DC 1	0.17	0.01	0.17
DC 2	0.08	0.03	0.12
DC 3	0.15	0.00	0.15
DC 4	0.08	0.00	0.09

Table 10. Total Cost of Systematic Sampling Policy

Total Virtual Machine Cost ($)	**0.49**
Total Data Transfer Cost ($)	**0.04**
Grand Total: ($)	**0.53**

Table 4, 5, 9, 10 shows the computational cost of the RS policy and SS policy approaches. Both of the approaches almost require the same cost for VM migration. Therefore, from the experimental analyses it is understood that the RS policy and SS policy performance well in all criteria.

V. Conclusion

This paper is concluded by presenting the novelty and the significance of the two novel algorithms such as Random Sampling (RS) policy and Systematic Sampling policy for VM migration. In the related study, we have discussed the challenges and possible solution to overcome the VM migration with the less power consumption with least cost and that we have achieved with our proposed system. The random allocation of the VM meets the manageable fault tolerant, load balancing in the various clouds computing environment. In our study, we have also studied the overloaded and under-loaded server before VM allocation randomly. The experimental Section discusses the superiority of the two proposed scheme which outperforms the existing techniques.

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