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Virtual Machine Reallocation in Data Centers through Multi Parameter Decision Making Model

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Abstract. One of the important challenges in datacenters is resource allocation and efficient use of available resources. Virtualization is a new technique which facilitates the process of fair and efficient allocation of physical resources among virtual machines. In this technique, virtual machines running on highly loaded physical servers should be migrated to less loaded machines. We should decide when the migration should occur and also the source and the destination of movement. It is usual to consider some trivial parameters of servers in decision making procedure. However, we evaluate the effects of combining more parameters and the importance of them in decision making procedure. We take advantage of using the "Technique for Order Preference by Similarity to the Ideal Solution" (TOPSIS) as decision making algorithm based on selective weight functions. We simulate our proposed method using FDM software and show the results.

Keywords: TOPSIS, Virtualization, Cluster Server, Migration, Load Balancing, MCDM.

1. Introduction

Nowadays, data centers host many different applications simultaneously. Each application requires a different kind of resources which is specified by its performance level of expectation. So, there is a competition between applications to gain more from the server resources like CPU, RAM, and network bandwidth. Virtualization is a new technique which facilitates the process of resource allocation among various virtual machines running on different physical machines by sharing a physical machine resource amongst multiple virtual machines. By so doing, the resource of physical machines are utilized more efficient, because multiple applications can use them simultaneously based on their defined service level agreement. Migration is one of the techniques embedded in virtualization which handles the resource shortage problem by migrating virtual machines from an overloaded server to a less loaded one [1].

The aim of this paper is to enhance the process of migration by considering more parameters in migration decision making process which leads to more accurate decisions. We use the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) algorithm as a multi criteria decision making algorithm. We take the importance of parameters into account by inserting parameters' weights in TOPSIS algorithm.

1.1. Paper organization

In the sections that follow, we first review related work of other researchers, and then explain TOPSIS algorithm. After that, we talk about attribute types. In the next section we present all the parameters that can be used to take a more accurate decision for migration. In the following sections, we present our simulation results and discuss the number of input parameters and the parameters weights. Finally, we conclude in the last sections.

2. Related Works

VMware Distributed Resource Scheduler (DRS) improves resource allocation across all hosts in a cluster and decides when migration is necessary [2, 3]. Unfortunately, DRS only monitors CPU and memory resource usage and performs migration. Since it doesn't consider the input/output resource usage, it is probable that some network intensive applications running on a host saturate its bandwidth capacity and lead to performance degradation. Furthermore, since DRS is an enterprise solution it does not reveal its decision making algorithm.

Sandpiper is another solution for migration and load balancing of resources. This technique observes CPU, memory, and network consumption of all the virtual and physical machines and automatically detects hotspots. In such a situation it computes a new mapping of virtual machines to physical machines and initiates the necessary migrations [2]. Unluckily, Sandpiper technique does not consider the importance of the parameters in its decision making process. This can lead to incorrect decisions for migration which can degrade the performance of the system.

TLM is another technique which is a new load balancing model to migrate VM(s) between cluster nodes using TOPSIS algorithm. This technique develops an algorithm which considers parameters importance to determine most loaded physical machine and to decide which virtual machine should be migrated [4].

3. TOPSIS

Multiple Criteria Decision Making (MCDM) is a group of methodologies to examine, pick out and sort multiple alternatives. TOPSIS, known as a classical MCDM method, has been developed by Hwang and Yoon [5] for solving the multi dimensional problems. TOPSIS considers the input parameters weighs in its decision making procedure and scores the solutions from finite set of attributes and rank them based on these scores [6, 7]. TOPSIS is a multiple decision method to identify solutions from a finite set of alternatives based upon simultaneous minimization of distance from an ideal point and maximization of distance from a nadir point [8]. We should define the parameters attributes types as input to TOPSIS algorithm prior to running it [9]. Attributes can have two kinds of attributes which are benefit or cost. The benefit attribute type is handled such that the higher magnitude this kind of parameter has, the higher the score of the TOPSIS algorithm becomes. On the contrary, for a parameter that has cost attribute, the higher magnitude the parameter has, the lower the score of the TOPSIS algorithm becomes.

4. Type of Parameters

Three types of information including deterministic, linguistic, and fuzzy can be used as input to TOPSIS algorithm. We should carefully evaluate input parameters to choose which of these types are more suitable for decision making. Our selection indeed affects the result of MCDM algorithm.

4.1. Deterministic parameters

A variable whose value is either known with certainty or is treated as such for simplicity is considered as a deterministic parameter. These kinds of parameters are represented by numerical values.

4.2. Linguistic parameters

Linguistic variables represent crisp information in a form and precision appropriate for the application. Linguistic variables take on values defined in their linguistic term set. The use of linguistic variables in many applications reduces the overall computation complexity of the application. Linguistic variables have been shown to be particularly useful in complex non-linear applications.

To apply linguistic statements over TOPSIS algorithm, it is essential to map them to appropriate numbers. One approach is presented by Tomas Saaty [10]. He introduces a mapping system which divides linguistic variables into seven levels which are depicted in table 1. To substitute the linguistic descriptions with numerical values a transformation table is created. In this technique, VH and VL are mapped to numerical values 9 and 1 respectively. Other linguistic values are assigned numerical values between 1 and 9.

Table 1 The criteria preferences with their numerical values

Rank	Very Low	Low	Moderately Low	Medium	Moderately High	High	Very High
Numerical value	1	3	4	5	6	7	9

4.3. Fuzzy parameters

Fuzzy logic is a form of many-valued logic; it deals with reasoning that is fixed or approximate rather than fixed and exact. In contrast with "crisp logic", where binary sets have two-valued logic: true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1 [11]. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false

5. Input Parameters

Twelve deterministic parameters that illustrate the physical server status are listed in table1. The first three parameters which determine the power of CPU are the CPU-cycle, the CPU-core, and the CPU-bus which represent the clock cycle of the CPU, the number of cores, and the CPU bus bandwidth respectively. Mostly, CPU power is the most important parameter in decision making process. It specifies the amount of computational power a system can offer. The RAM-cap and RAM-Access time parameters define the RAM power of the system which typify RAM capacity and RAM access time respectively. NET-BW which is another deterministic parameter symbolizes network bandwidth. It determines the amount of data that can pass through a network interface over time. %CPU, %RAM, and %NET represent the percentage of CPU power, percentage of RAM power, and percentage of network power respectively. Subscript “a” stands for actual power that is consumed by virtual machines in reality. Subscript “r” represents the power that is reserved for virtual machines. TEMP expresses temperature of the physical machines and is used to make better decisions when evaluating PMs. This parameter can be used to establish a predicting failure mechanism. Although the temperature of the system has relationship with the load of the server, but sometimes high sudden increase in temperature signals some defects in the system. Such a system cannot resume its normal operation. In other words, if the cooling system fails to work properly, the temperature rises rapidly and can lead to system break down. On the other hand, operating temperature varies from one sever to another depending on the hardware configuration [12]. Hence, we describe this parameter as a fuzzy statement. VM-num represents the number of VMs running on PMs. This parameter is considered as a linguistic parameter because specification of each node differs from others. Qos which stands for quality of service is another linguistic parameter. We define this parameter to satisfy the requested service level agreement in decision. This parameter defines the importance of each virtual machine and echoes the money the user pay for running applications. As a result, we prepare more resources for high Qos applications. Cache-Hit ratio, Cache-Access time and Cache-CAP signify the Cache power.

Table 2 input parameters

No.	***Name***	***Data type***	***type***	***PM and VM***	***Description***	***No.***	***Name***	***Data type***	***type***	***PM and VM***	***Description***
1	CPU-cycle	Deterministic	Cost	PM	Node’s CPU clock speed(GHZ)	**11**	$\%NET_a$	Deterministic	Benefit	PM & VM	Average actual network usage (%)
2	CPU-core	Deterministic	Cost	PM	Number of CPU cores	**12**	$\%NET_r$	Deterministic	Benefit	PM & VM	Average reserved network usage (%)
3	CPU-bus	Deterministic	Cost	PM	CPU bus speed	**13**	TEMP	Fuzzy	Benefit	PM	Node temperature
4	RAM-cap	Deterministic	Cost	PM	Node RAM capacity (GB)	**14**	VM-num	Liguistic	Benefit	PM	Number of VMs running on PMs
5	RAM-Access time	Deterministic	Cost	PM	RAM access speed	**15**	Qos	Liguistic	Benefit	VM	Quality of service

6	NET-BW	Deterministic	Cost	PM	Node bandwidth	**16**	HDD-Access time	Deterministic	Cost	PM	Hard Access time
7	$\%CPU_a$	Deterministic	Benefit	PM & VM	Average actual CPU usage (%)	**17**	Cache-Hit Ratio	Deterministic	Cost	PM	Cache-Hit Ratio
8	$\%CPU_r$	Deterministic	Benefit	PM & VM	Average reserved CPU usage (%)	**18**	Cache-Access time	Deterministic	Cost	PM	Cache Access time
9	$\%RAM_a$	Deterministic	Benefit	PM & VM	Average actual RAM usage (%)	**19**	Cache-CAP	Deterministic	Cost	PM	Cache Capacity
10	$\%RAM_r$	Deterministic	Benefit	PM & VM	Average reserved RAM usage (%)						

6. Simulation Results

We use FDM (Fuzzy Decision Making) for simulation to evaluate different scenarios and to show the results of sorting PMs and VMs.

6.1. Number of parameters for decision making

Since the cluster is assumed heterogeneous, the value of CPU%, RAM%, and NET% should be considered along with the power of CPU, RAM and NET respectively. More precisely, since the nodes' configurations are different, considering the above parameters alone do not result in the right answer. For instance, consider two PMs with 10% and 60% CPU consumption which have 1GHz and 10GHz CPU frequency respectively. As figure 1 shows, if we only consider the percentage of CPU consumption, the second physical machine takes score 100 and is a better candidate for the source of migration. As figure 2 shows, when the power of CPUs is taken into account, the first physical machine takes score 58.33 and is a better candidate for the source of migration. Thus, in order to take a better decision we take all these parameters into account.

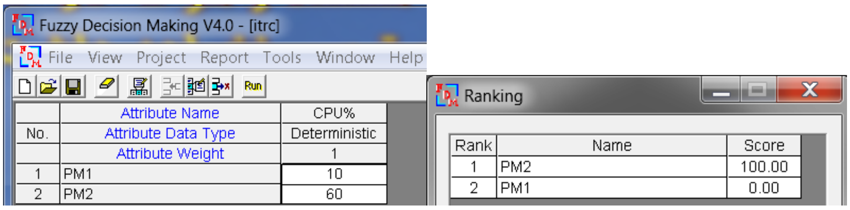

Fig.1: Considering only percentage of CPU

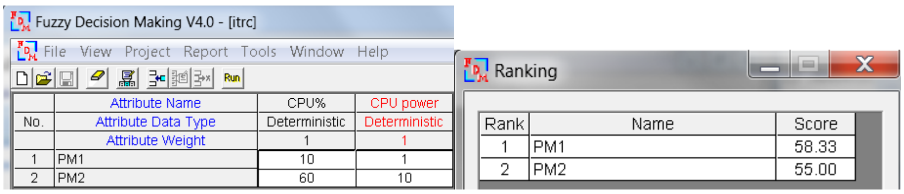

Fig.2: Considering percentage of CPU and power of CPU

6.2. Considering the parameters importance

As stated earlier, DRS and Sandpiper methods do not consider the weights of the parameters in their decision making process. However, if we consider the effects of parameters importance in decision making process, as is done in TOPSIS algorithm, the result is different. For instance, in a case where the parameters are like one depicted in table 3, if the %CPU is more important so that we give it a greater weight, the PM2 takes greater score and is placed at the top of the ranking list. Even though, if the %RAM is more important so that we give it a greater weight, the PM1 takes greater score and takes the first rank in the sorting list. Hence, we should define input parameters weights for TOPSIS algorithm so that the decisions become more realistic and accurate. Figure 1 shows when considering equal weights for CPU% and RAM%, PM1 and PM2 have equal scores. As figure 2 shows, when we give weight 2 to %CPU while preserving 1 for the RAM% weight, PM2 is ranked first with score 83.33

Table 3 example parameters value

	%CPU	%RAM
PM1	30	60
PM2	60	30

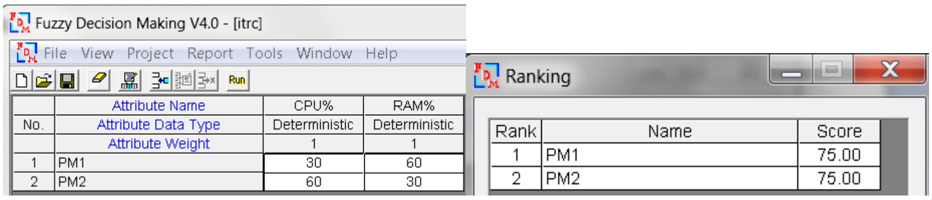

Fig.3: Equal weights for attributes

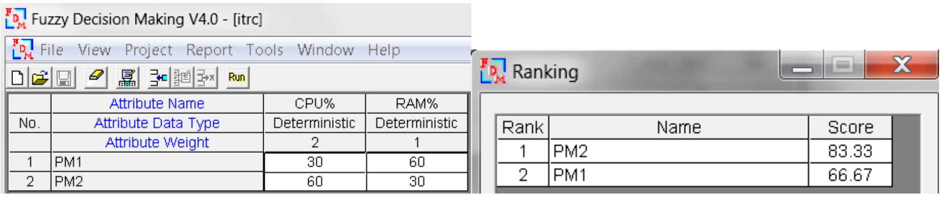

Fig.4: CPU% has a greater weight than RAM%

7. Conclusion

We considered the issue of decision making procedure for migrating virtual machines between physical machines in a virtual system. We used TOPSIS algorithm for decision making. We represented 19 parameters that can be used to take a better decision for migration. We implemented our algorithm in FDM software and showed the importance of considering the number of parameters and also the importance of considering the parameters importance in this software.

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