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Virtual Machine Migration based on Trust Measurement of Computer Node

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Abstract. Currently, the study of virtual machine migration in cloud computing platform which usually did not consider the trustworthiness of target physical machine. For this, the paper proposes a trusted virtual machine migration with performance constraints algorithm (TVM^2PC). The trustworthiness of target physical machine includes direct trustworthiness and indirect trustworthiness. By this method, a virtual machine will be migrated to a trusted physical machine. A large of experiment shows that the proposed method can give a better result than the existing method in load balancing and trustworthiness.

Introduction

Currently, as a new computing paradigm, cloud computing has the advantages of high scalability and high availability, which quickly become a hot topic in academia and industry. The virtualization technology is a key technology to realize the capacity of elastic scalability. In the running process of cloud computing, virtual machine migration is what often happens, when the load is imbalance among physical nodes, or the failure of physical nodes, or something wrong happen. For this phenomenon, many experts and scholars have proposed various methods of virtual machine migration.

In 2011, Jinjun LIU et al [1] presented a scheduling strategy of virtual machine migration based on load characteristic. This strategy aims at the trigger types of nodes and the load characteristics of virtual machines, using multi-threshold mode to trigger the migration, the virtual machine to be migrated is selected and the destination node is positioned.

In 2012, Yong LIU et al [2] proposed an energy-aware and trust-driven virtual machine scheduling algorithm. The algorithm matched the task and virtual machine by the trust mechanism between resources and tasks，reached the purpose of ensuring the user task performance and energy-aware in data centers.

In 2013, Wei Huang et al [3] presented a virtual machine scheduling algorithm based on K-means clustering. The correlation of virtual machine resource allocation is used as the standard of clustering，and a virtual machine is placed on the physical node complementary to it on resource，so that its resource is used fully and it is effective and stable.

However, there is also a problem when the virtual machine migrates which is whether the target physical node is safe and trusted. For an example, when a virtual machine will migrate, although a physical node’s performance meet the needs of the virtual machine, but this physical node has a poor reliability, for example, this physical node has a high probability of crash. So this physical node will not be an appropriate target node. Therefore, in order to ensure that the target physical node is trusted. This paper presents a virtual machine migration method based on the trust measurement of physical node.

Trust Concepts and Computing Method of Trust

According to the experts' research of trusted computing [4,5], trusted computing describes an entity can be trusted if it always behaves in the expected manner for the intended purpose. A trusted node should have high integrity, high dependability, high availability and high operating system (OS) security level.

Definition 1 (Integrity): Integrity describes the degree of physical node configuration information, system software, user data and other information has not been tampered or destroyed. The integrity of physical node c_i is denoted by in_i ($0 \leqslant in_i \leqslant 1$).

Definition 2 (Dependability): Dependability describes the ability of a physical node to function under stated conditions for a specified period of time. The dependability of physical node c_i is denoted by de_i ($0 \leqslant de_i \leqslant 1$).

Definition 3 (Availability): Availability describes the proportion of time a physical node is in a functioning condition. It is often described as a mission capable rate. Mathematically, the ratio of the total time a physical node is capable of being used during a given interval to the length of the interval. The availability of physical node c_i is denoted by av_i ($0 \leqslant av_i \leqslant 1$).

Definition 4 (OS security level): OS security level describes the security level of physical node's operating system (OS). The OS security level of physical node c_i is denoted by se_i ($se_i \in \{1, 0.75, 0.5, 0.25, 0.1\}$)[6], the bigger the value, the higher the OS security level.

Definition 5 (Direct trustworthiness): Direct trustworthiness is depended on integrity, dependability, availability and OS security level, the direct trustworthiness of physical node c_i is denoted by t'_i ($0 \leqslant t'_i \leqslant 1$). In mathematical sense, direct trustworthiness is a function of integrity, dependability, availability and OS security level, that is $t'_i = f(in_i, de_i, av_i, se_i)$.

In cloud computing system, if a virtual machine migrates from node c_i to c_j, we suppose the node c_i trusts c_j. Similarly, if a virtual machine migrates from node c_j to c_k, we suppose the node c_j trusts c_k. So a trust chain ($c_i \rightarrow c_j \rightarrow c_k$) is formed. Usually, in cloud computing system, there are many physical nodes, and many virtual machines have been migrated in the past period. So all these trust chains will form a trust network.

Definition 6 (Trust network): Trust network describes the trust relation between any two physical nodes, the trust network is directed weighted graph (DWG), trust network is denoted by $G=(C, T', E, W)$. $C=\{c_1, c_2,\ldots, c_N\}$ is the set of physical nodes, $T'=\{t'_1, t'_2,\ldots, t'_k)$ is the set of direct trustworthiness of physical nodes, $E=\{e_1, e_2,\ldots, e_K\}$is set of edges, describes the trust relation between two physical nodes, $W=\{w_1, w_2,\ldots, w_K)$ is the set of edge's weight, describes the frequency of virtual machine migration from one node to another.

Definition 7 (In-degree): In trust network, in-degree of a vertex c_i describes the number of edges with this vertex c_i as the terminated vertex. In-degree of vertex c_i is denoted by id_i.

Definition 8 (Indirect trustworthiness): Indirect trustworthiness of physical node c_i is depended on the in-degree of c_i, weights of incoming edge which with node c_i as the terminated vertex, and the direct trustworthiness of the incoming edges' initial vertex. Indirect trustworthiness is denoted by t''_i ($0 \leqslant t''_i \leqslant 1$).

Definition 9(Comprehensive trustworthiness): Comprehensive trustworthiness is depended on direct trustworthiness and indirect trustworthiness, it is denoted by t_i ($0 \leqslant t_i \leqslant 1$). In mathematical sense, $t_i = f(t'_i, t''_i)$.

Because the direct trustworthiness is depended on integrity, dependability, availability and OS security level, the direct trustworthiness of physical node c_i can be calculated by the Eq. 1:

$$t'_i = \alpha_1 in_i + \alpha_2 de_i + \alpha_3 av_i + \alpha_2 se_i \qquad (1)$$

where $\sum_{i=1}^{4} \alpha_i = 1$.

Because indirect trustworthiness of physical node c_i is depended on the in-degree of c_i ; weights w_k of incoming edge e_k which with node c_i as the terminated vertex, c_j as the initial vertex; and the direct trustworthiness t'_j of the initial vertex c_j. The concept of indirect trustworthiness works by counting the number and quality of migration to a node to determine how trusted the node is. The underlying assumption is that more trusted nodes are likely to receive more virtual machines from other nodes. The indirect trustworthiness t''_i of physical node c_i can be calculated by the Eq. 2:

$$t''_i = \frac{1}{\left|V_{in_i}\right|} \times \sum_{c_j \in V_{in_i}} \left\{ t'_j \times [EXP(\frac{w_j - Max\{w_j\}}{Max\{w_j\}})]^2 \right\} \quad (2)$$

where EXP() represents exponential function.

According to the above analysis, the comprehensive trustworthiness is depended on the direct and indirect trustworthiness, the comprehensive trustworthiness t_i of physical node c_i can be calculated by the Eq. 3:

$$t_i = \alpha t'_i + (1-\alpha) t''_i \quad (3)$$

Where α denotes trust factor, and $0 \leqslant \alpha \leqslant 1$.

Trusted Virtual Machine Migration Algorithm with Performance Constraints

According to the problem of how virtual machine migrates to a trusted physical node, we design a trusted virtual machine migration algorithm with performance constraints (TVM^{2}PC). Although we focus on how to implement a trusted virtual machine migration, in the actual cloud computing platform, performance and load balancing is still the most important factor that we must consider. So we not only take account of the trustworthiness of target physical node, but also the performance before virtual machine migration. If we only consider the trustworthiness of target physical node, a large number of virtual machines may migrate to a few physical nodes which have higher trustworthiness, which will result in load imbalance.

The main idea of TVM^{2}PC is described as follow:

According to the load of physical node, all the physical nodes are divided into three sets $C=\{C_{light}, C_{normal}, C_{heavy}\}$, where $C_{light}=\{c_j|1\leq j\leq N, 0\leq l_j\leq l_{light}\}$, $C_{normal}=\{c_j|1\leq j\leq N, l_{light}<l_j<l_{heavy}\}$, $C_{heavy}=\{c_j|1\leq j\leq N, l_{heavy}\leq l_j\leq 1\}$. Where l_j denotes load of physical node c_j, l_{light} denotes light load threshold, l_{heavy} denotes heavy load threshold. When a virtual machine will migrate,

① If $C_{light}\neq\varnothing$, these physical nodes in C_{light} have a priority with virtual machine migration, and the lighter the load, the higher the priority;

② If $C_{light}=\varnothing$ and $C_{normal}\neq\varnothing$, these physical nodes in C_{normal} have a priority with virtual machine migration, and the higher the trustworthiness, the higher the priority;

③ If $C_{light}=\varnothing$, $C_{normal}=\varnothing$ and $C_{heavy}\neq\varnothing$, these physical nodes in C_{heavy} will be considered when virtual machines migrate, and the lighter the load, the higher the priority;

The seudo-code of TVM^{2}PC is described as follow:

```
for each Migration Virtual Machine vm_i{
  for each computer c_j∈C{
    l_j←load(c_j);
    t_j←trusted(c_j);
  }
  C_light, C_normal, C_heavy ← divide(l_1, l_2, …, l_N);
  if C_light≠∅{
    for each computer c_j∈C_light{
     l_min= l_1;
      if l_j< l_min then
         l_min = l_j;
  }
```

```
  return c_j;
}
else if (C_light=∅)∩(C_normal≠∅){
  for each computer c_j∈ C_normal{
    t_max= t_1;
    if t_max < t_j then
      t_max= t_j;
  }
  return c_j;
}
 else if (C_light=∅)∩(C_normal=∅)∩(C_heavy≠∅){
   for all computer c_j∈ C_heavy{
     l_min= l_1;
     if l_j< l_min then
       l_min = l_j;
   }
   return c_j;
}
}
```

In order to prove the superiority of the proposed TVM^{2}PC algorithm, we design another two algorithms, lightest load priority (LLP) and highest trustworthiness priority (HTP). The main idea of LLP is to migrate the virtual machine to node of the lightest load. Similarly, the main idea of HTP is to migrate the virtual machine to the node of highest trustworthiness.

Experiment Results and Analysis

In this section we present the simulation results that show the behavior, regarding virtual machine migration, of three virtual machine migration algorithms that are examined. In the experiments, these parameters' value is described as follow: the number of physical nodes N=16; the number of virtual machines that need to be migrated M=1000; the trustworthiness of each physical node $t_i \in [0, 1]$, which is generated randomly; the load of each physical node $l_i \in [0, 1]$, which is generated randomly; trust factor α=0.6; light load threshold l_{light}=0.3; heavy load threshold l_{heavy}=0.8; the dependability of physical node $de_i \in [0.99, 1]$ and availability $av_i \in [0.99, 1]$, which are generated randomly. The experiment results are shown in Fig. 1 and 2.

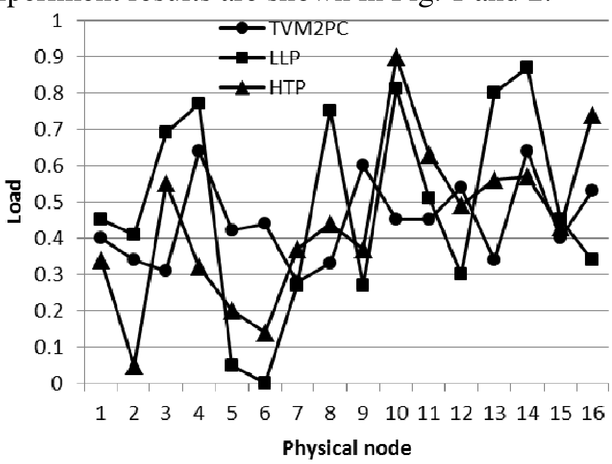

Fig. 1 Load of each virtual machine

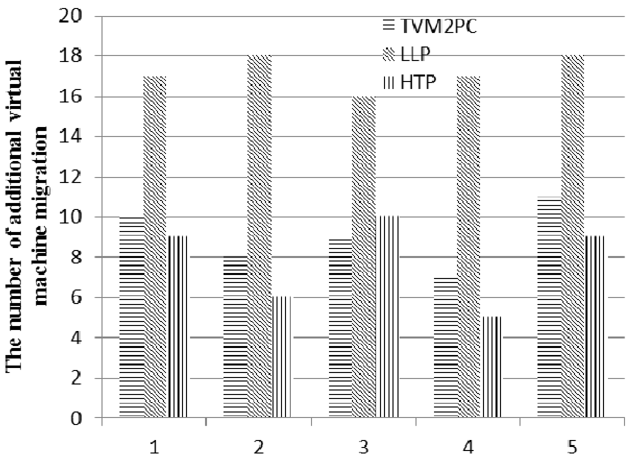

Fig. 2 The number of additional virtual machine migration

Fig. 1 presents the load of the 16 nodes for the three virtual machine migration algorithms. First of all, we observe that the load of the 16 nodes is imbalance for LLP and HTP algorithms, that is, the curves of LLP and HTP algorithms are dramatic ups and downs. But the curve of TVM^{2}PC algorithm is smoother than LLP and HTP.

In the real cloud computing platform, some physical nodes may crash sometimes. So when a node crashes, all the virtual machines, which are running on this node, need to be migrated to other nodes. As a result, the crash of physical nodes will lead to the additional virtual machine migration.
Fig. 2 presents the condition of additional virtual machine migration for the three virtual machine migration algorithms in five experiments. We observe that the number of additional virtual machine migration for HTP algorithm is less than TVM^2PC and LLP, that is, HTP algorithm is better than TVM^2PC and LLP in this regard. LLP algorithm is the worst, but the difference between TVM^2PC and HTP is not too many. So, taking into account the factor of load balancing, TVM^2PC is a good virtual machine migration algorithm,

Conclusions

In this paper, for the problem of virtual machine migration in the cloud computing platform, we designed a trusted virtual machine migration algorithm with performance constraints (TVM^2PC), which consider the trustworthiness and performance when choose a target physical machine. The algorithm not only achieves the load balancing of cloud computing platform, but also implements a trusted migration, that is, virtual machine will be migrated to a trusted physical machine. Experiment results showed that the proposed method can achieve a better effect in load balancing and trustworthiness.

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References

[1]J.J. LIU, G.L CHEN, C.X HU. Virtual machine migration scheduling strategy based on load characteristic. Computer Engineering, 2011, 37 (17):276-278.
[2]Y. LIU, X.H. WANG, Z. WANG, et al. Energy-aware and trust-driven virtual machine scheduling. Application Research of Computers, 2012, 29 (7):2479-2483.
[3]W. Huang, Z.P. Wen, C, Cheng. Virtual machine scheduling algorithm based on K-means clustering in cloud computing. Journal of Nanjing University of Science and Technology, 2013, 37 (6): 807－812.
[4]Trusted Computing Group (TCG). TCPA Main Specification, Version 1.lb. 2002.
[5]C.X. SHEN, H.G. ZHANG, H.M. WANG, et al. Research and development on trusted computing technology. SCIENTIA SINICA Informationis, 2010,40(2):139-166.
[6]Standardization Administration of the Peoples Republic of China, GB/T 20272-2006, Information security technology-security techniques requirement for operating system, Standard Press of China, 2006.