Mobile Cloud Computing Network Attack and Defense Learning System Based on Fuzzy Soft Sets

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Abstract

In this paper, we propose a new decision-making system ranking method for the virtual machine startup problems by introducing the concept of fuzzy soft sets. Then this method is used for virtual machine management by AMCCM way. It turns the management of a network attack and defense learning system from semi-automatic to fully automatic. Based on the functional and structural design of mobile cloud computing network attack and defense learning system, we hope to bring new ideas to the field of mobile cloud computing.

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1. Introduction

With the development of mobile computing and wireless communication technology, mobile learning as a branch of digital learning, is drawing ever growing interest, and becomes a new hot spot in educational technology and related fields. Mobile network attack and defense learning system is reproduced by the offensive and defensive simulation technology and other ways, i.e. the terminal learning for mobile phone, network attack and defense technology and skills, universal education network security, network security training for senior personnel, information warfare for senior personnel and the training platform development. However, the performance of smart phones, tablet PCs, notebooks and other mobile terminal equipment is limited, and the computing power, storage capacity and the media's ability to run are also inadequate. Therefore, it will cause paralysis of the system when large number of users accessing cloud computing at the same time.

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New ideas for the development of mobile learning systems are urgently needed to meet the requirement of users. Sharing the resources of distributed computing and large-scale heterogeneous system are the key method in implementing mobile learning systems. Cloud computing provides the ideal technical solution for this situation. The powerful computing and storage capacity derived from cloud computing are applied to educational resources, mobile computing technology for the portable devices, mobile and location-based service applications. It can also be combined with mobile education and builds integrated mobile learning system based on cloud computing. Network attack and defense which required rich, real-time, accurate learning will be supported by collaborative learning and situated learning. Domestic research on cloud service management platform and the core software are still at the initial stage, and the management algorithm is mainly initiated by scientific research institutes and universities.

Current cloud service resource management algorithm primarily concentrated in system level, but the study in view of the application level is relatively limited. Beside the form of management described above, resource management method oriented basic units could provide automatic deployment, scheduling, execution and resource recycling and other functions that users need.

We have proposed an application oriented mobile cloud computing middleware in the paper [5]. The AMCCM (Adaptive Mobile Cloud Computing Middleware) with cloud computing combined the hardware resource management with the application-layer software services in the system to automatically adjust the hardware resources which is responsible for the management, coordination and monitoring for the hardware and software resources on cloud platform. We introduce the concept of fuzzy soft sets for the virtual machine startup problems and propose a new decision-making system ranking method using AMCCM. With the utilization of AMCCM, we turned the management of the virtual machine from semi-automatic to fully automatic, and we achieved this through the functional design and the structural design for cloud computing mobile network attack and defense learning system.

2. Basic Concepts of the Soft Set Theory

In order to take advantage of mathematical approach to research and deal with some vague phenomenon, cybernetics expert of the University of California, L.A. Zadeh founded fuzzy set (Fuzzy Sets) in 1965, which is the expansion of classical set. Comparing with classical set collection, the fuzzy set refers to all objects with some kind of vague concepts. Fuzzy math has been widely applied in many fields, such as soft science of artificial intelligence, automatic control and so on. However, fuzzy set theory is not the only way. It is part of the uncertain information theory which has lots of tools to solve realistic problems. In 1999, Molodtsov [2] proposed the concept of soft set to solve many practical problems. In real world, soft set theory has succeeded in many areas. PKMAJI showed the detail of soft set theory [3] and applied it to the decision-making system [4].

Definition 1. (Soft Set)
Let $U$ be a set of objects and let $E$ be a set of parameters. Let $P(U)$ denote the power set of $U$. A pair $(F, E)$ is called a soft set over $U$, where $F$ is a mapping given by $F : E \rightarrow P(U)$.

Definition 2. (Soft Subset)
Let $(F, A)$ and $(G, B)$ be two soft sets over $U$, if satisfying the following conditions:
1. $A \subseteq B$
2. $\forall e \in A$, $F(e) = G(e)$
Then a pair $(F, A)$ is called a soft subset over $(G, B)$, that is $(F, A) \subseteq (G, B)$.

Definition 3. (Fuzzy Soft Set)
Let $U$ be a set of objects and let $E$ be a non-null set of parameters. Let $\mathcal{F}(U)$ denote the power set
of $U$. $A \subseteq E$, a pair $(F, A)$ is called a fuzzy soft set over $U$, where $F$ is a mapping given by $F : E \rightarrow \mathcal{P}(U)$.

Definition 4. (Fuzz Soft Subset)
Let $(F, A)$ and $(G, B)$ be two fuzzy soft sets over $U$, if satisfying the following conditions:
1. $A \subseteq B$
2. $\forall e \in A$, $F(e) = G(e)$

Then a pair $(F, A)$ is called a soft subset over $(G, B)$, that is $(F, A) \subseteq (G, B)$.

3. Ranking method on fuzzy soft set

In order to sort objects this paper proposed a ranking method based on fuzzy soft and used this method in AMCCM. This procedure is illustrated as the following example.

3.1. Representation of Fuzzy Soft Set

Suppose we are given a finite set of objects $U = \{V_1, V_2, V_3, V_4\}$, $U$ contains four virtual machines.

Parameter Set
$E = \{\text{disk_usage}, \text{cpu_usage}, \text{thread_usage}, \text{web_unit_time_response_rate}\}$

Expressed as $E = \{e_1, e_2, e_3, e_4\}$, it describes a virtual machine load.

Hence we can assume that:

\[
F(e_1) = \{V_1 / 0.5, V_2 / 1, V_3 / 0.4, V_4 / 0.3\}
\]
\[
F(e_2) = \{V_1 / 0.6, V_2 / 0.4, V_3 / 1, V_4 / 0.4\}
\]
\[
F(e_3) = \{V_1 / 0.2, V_2 / 0.3, V_3 / 1, V_4 / 0.8\}
\]
\[
F(e_4) = \{V_1 / 1, V_2 / 0.1, V_3 / 0.5, V_4 / 0.7\}
\]

Then, we can get the fuzzy soft set $(F, E) = \{(\text{disk_usage_higher_V}=F(e_1), \text{cpu_usage_higher_V}=F(e_2), \text{thread_usage_higher_V}=F(e_3), \text{web_unit_time_response_rate_higher_V}=F(e_4))\}$

$V_i$ represents virtual machine, $e_j$ is parameters, $V_{ij}$ is value, can be drawn under the Table1:

<table>
<thead>
<tr>
<th>$U$</th>
<th>$e_1$</th>
<th>$e_2$</th>
<th>$e_3$</th>
<th>$e_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_1$</td>
<td>0.5</td>
<td>0.6</td>
<td>0.2</td>
<td>1</td>
</tr>
<tr>
<td>$V_2$</td>
<td>1</td>
<td>0.4</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>$V_3$</td>
<td>0.4</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>$V_4$</td>
<td>0.3</td>
<td>0.4</td>
<td>0.8</td>
<td>0.7</td>
</tr>
</tbody>
</table>
3.2. Build Table of Fuzzy Soft Set

Let \( C_{ij} \) is numerical measurement, as number for \( V_i \) membership degree greater than or equal to \( V_j, C_{ij}, i, j = 1, 2, ..., n \). \( 0 \leq C_{ij} \leq k, and C_{ij} = k \) can be drawn under the Table2:

<table>
<thead>
<tr>
<th>( U )</th>
<th>( V_1 )</th>
<th>( V_2 )</th>
<th>( V_3 )</th>
<th>( V_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_1 )</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>( V_2 )</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>( V_3 )</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>( V_4 )</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 2. Fuzzy Soft Set

3.3. Ranking Method of Fuzzy Soft Set

The ranking method as follows:
(1) Input fuzzy soft set \((F, E)\);
(2) Build table of \((F, E)\);
(3) Compute by membership degree;
(4) Compute sum of line \( R_i \), sum of column is \( T_i \);
(5) Compute score \( S_i \);
(6) Find \( k, S_k = Max S_i \).

Using the above ranking method, if sum of line is \( R_i, R_i = \sum_{j=1}^{n} C_{ij} \), sum of column is \( T_i, T_i = \sum_{j=1}^{n} C_{ij} \), score is \( S_i, S_i = R_i - T_i \) can be drawn under the Table3:

<table>
<thead>
<tr>
<th>( U )</th>
<th>( R_i )</th>
<th>( T_j )</th>
<th>( S_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_1 )</td>
<td>8</td>
<td>12</td>
<td>-4</td>
</tr>
<tr>
<td>( V_2 )</td>
<td>12</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>( V_3 )</td>
<td>9</td>
<td>10</td>
<td>-1</td>
</tr>
<tr>
<td>( V_4 )</td>
<td>10</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3. Ranking Result

Then, \( S_2 = Max S_i = 4 \), so the first stop of the virtual machine is \( V_2 \), next is \( V_4 \), the ranking is \( V_2, V_4, V_3, V_1 \).
3.4. Used in AMCCM

The ranking results applied to system monitoring component of AMCCM, this method not only is clear in concept, simple in calculation, but also has better editing and strong practicability.

4. Introduction of AMCCM

Writer describes an environment from cloud computing middleware resource deployment, resource management, resource monitoring, resource control and other aspects in last paper. This environment can help us to dynamic management the relationship between systems and applications, achieve an advantage complementary. Either through virtualization products from the hardware point of view to manage the virtual machine, you can also manage the virtual machine from an application perspective; the ultimate aim is to let the server to provide better quality access speed for our customers. The management strategies driven by the real load situation of each application to start and stop virtual machine, and formed a mobile office framework based on cloud computing. The author put forward a strategy of virtual machine resources management, so that the virtual machine instead of artificial self-management in accordance with need. This framework enables cloud computing implementation has a new option, and cloud computing to provide a multi-business resource balance, thereby improving the efficiency of data reuse.

4.1. Structure of AMCCM

The structure of AMCCM is described in Fig.1. It’s mainly composed by two main components: one is the system monitoring component, monitoring software that comes with VMware products; other is application control component, it is mainly the deployment of applications in each virtual machine. See below for detail description of these two components.

![Fig.1. Structure of AMCCM](image)

The basic principles of their work is this: system monitoring component is responsible for system level monitoring, from the bottom to the virtual machine level CPU, memory, network, disk usage rule customization, once the present conditions it would process by written procedures. Application of monitoring module is prepared to use JAVA, to monitor the operation of middleware application. It mainly monitor the user number, on-line number, accesses the data in response to conditions in current application, can also be through the preparation of procedures for increasing function, strong extensibility.

4.2. Functions of AMCCM

AMCCM be essentially similar to the resource monitor. It is responsible for the management of all cloud platform hardware and software resources, coordinating and monitoring work, including the following three
functions:

a) Perform hardware resources are virtualized management, including new virtual environment, modify the virtual environment, and delete the virtual environment and so on.

b) Dynamically adjust the virtual state through monitoring and management coordination. When the application's access has a higher pressure, automatic boot has a virtualized resource to ease the pressure of the reality of running server. When an application server pressure reduction, automatic stops resources to reduce unnecessary waste of resources.

c) Real-time monitor the work of all system, the work of virtual device and the access pressure of application server.

4.3. Workflow of AMCCM

And then the middle agent running in the cloud computing virtual machine, Virtual machine object placed on object pool, and easy to middleware to understand the current state of virtual machine running. The working flow of AMCCM including the following steps:

Step1: Start virtual machine, and initialization;
Step2: According to a defined minimum number of virtual start virtual machine, adding the virtual machine identifier into the object pool.
Step3: Real-time listening received message form monitoring component.
Step4: Start and stop virtual machine.
Step5: Maintain management for object pool.

5. Mobile network attack and defense learning system based on cloud computing

5.1. Structure deployment

According to WEB application group, Fig.2 describes the architecture deployment diagram of cloud computing system. It makes resource layer and application layer clearly divided. When the user puts forward new application requirement, the background administrator need increase corresponding resource server through the AMCCM. Deployment and web services which are required by customers could be completed by a series changing operations. Therefore, the cost of the deployment for integration is saved.
The cloud-based mobile network attack and defense learning system is constructed on a three-tier architecture (UI, BLL, DAL) network platform and cloud platform as showed in Fig.3.

**Mobile terminal**

Through mobile terminals, system content is rendered for the users and users interact with the system media. Support equipment could be a mobile phone, PDA and other mobile devices. The system provides different interface and functionalities for different categories of users. The users use the mobile terminal through the mobile communication network or a wireless network for communicating with the network platform. The wireless network is either a private network established by a number of institutions, or public network held by communication operators.

**Based on the three-tier network platform**

The platform is a bracket system, and does not host any specific data content. The main capabilities of this platform is to identify users and the kind of services, and then according to the interface calls cloud computing platform provides related services for users. The presentation layer (UI) user interface handles system interaction and the user's session. The program running in mobile devices is mainly through the browser located in user and the business logic layer. The business logic layer (BLL) is responsible for the presentation of the application request which includes training sets preparing, programs training, system configuration, system booting, real-time monitoring, process monitoring, load training, storage processing, training evaluating, results assessment, analysis the correction of different functions and taking the intervention. When the request of the users is referred to database access, business logic layer will call the service provided by the database access layer. Once database access layer receives business command from the business logic layer, further analyzing and processing requests are submitted to the cloud computing platform through the interface program. If the operations needn’t any help of database access layer, they are directly submitted to the cloud computing platform for processing.

**Cloud platform**

The cloud computing platform is the core part of the system and is also the final implementation of the entire functions module. All the services needed by the user interface are handed over to the cloud computing platform. Cloud platform includes data storage, calculation and management three major modules. Calculation module splits the user's computing tasks into small ones, and then assigns them to distributed nodes for parallel computing with corresponding functions. After all related calculations, cloud platform collects the final results, makes the integration (such as sorting, merging, etc.) and return the final result to users. Data management
module holds self-management and self-tuning to facilitate inquiry and search operations. The storage module is divided into five sub-modules that is user repository, learning repository, exchange library, service repository, software library according to the three-tier structure network platform.

6. Conclusions

From the discussions as above, this decision-making system ranking method not only is clear in concept, simple in calculation, but also has better editing and strong practicability. Currently, education system supported by mobile cloud computing technology is still in the exploratory stage, but the attractive advantages indicate that cloud computing has a strong potential in the field of mobile education. This article introduces an exploration of cloud-based mobile network attack and defense learning system. Based on this system, we hope to bring new ideas to the field of mobile cloud computing.

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