The Construction Concept of Cloud Computing Based Virtual Range

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Abstract: The virtual range can realize the interfacing, integration, and interoperability of test resources in different ranges, which can avoid excessive investment and repeated construction. This paper proposed a new construction concept of virtual range based on cloud computing. The proposed architecture, which combines the advantages of high performance and high scalability, can overcome the weakness of traditional distributed virtual range. The key technologies of the new architecture are also analyzed in this paper.

1. Introduction

In order to avoid the repeated construction, and improve the interfacing, integration, and interoperability of different ranges, USA army proposed the concept of virtual range. In the 1990s, the Joint Mission Environment Test Capacity (JMETC) was approved by United Stated Department of Defense (DOD), which can link the distributed equipment and facilities experiments, simulation resources and test resources. The JMETC provide a distributed, real-time, constructive test capacity, which can support joint test and training [1].

At present, the construction of virtual range are still in the exploratory stage, which is lack of unified architecture. In this paper, a new architecture based on cloud computing was presented, and that can make good use of rapid developing technologies. The idea in this paper provide a new approach for the realization of virtual range.

2. TENA Research

2.1 Brief Introduction of TENA

The JMETC program has used TENA to prototype a new testing support infrastructure. (Test and Training Enabling Architecture) is proposed by US military based on HLA (High Level Architecture). Through the establishment of a common architecture, the Test and Training Enabling Architecture (TENA), reuse and interoperability of range assets will be tremendously improved, thus reducing range development, operation, and maintenance costs [2]. The main purpose for TENA is to improve the interfacing, integration, and interoperability in the field of test and training, so that the simulation and high-performance computational capacity can be integrated to constitute logic ranges for test and training.

2.2 The Architecture of TENA

The TENA architecture is a technical blueprint for achieving an interoperable, composability set of geographically distributed live and simulated range resources that can be rapidly combined to meet new testing and training missions. TENA is made up of several components, including a domain-specific object model that supports information transfer throughout the event lifecycle, common real-time and non-real-time software infrastructures for manipulating objects, as well as standards, protocols, rules, supporting software, and other key components [2]. The architecture of TENA for virtual test system is shown in Fig.1, which includes the parts as follows:

(1) TENA applications: The applications which are established by the developer of equipment systems and can complete all the important functions (such as acquisition, processing, controlling and motoring of the information) in virtual test. This kind of applications are developed following the TENA interactive standard.

(2) TENA common infrastructures: includes the TENA middleware, TENA repository and logical range data archive. The TENA repository is used for the storage of applications, object models and other information. The logical range data archive is used for the storage of scenario data, the information connected in the running process of simulation and the test result. The TENA Middleware combines distributed shared memory, anonymous publish-subscribe, and model-driven distributed object-oriented programming paradigms into a single distributed middleware system. This unique combination of high-level programming abstractions yields a powerful middleware system that enables the middleware users to rapidly develop complex yet reliable distributed applications [2].

3. Research Status of cloud computing based simulation

Srikanth B. Yoginath provide the first quantitative basis for establishing the need for generalized virtual time scheduling of virtual machines in network simulators, based on an actual prototyped implementations[3]. Massimiliano Rak present the structure of a new simulation engine “in the cloud” (mJades), which is able automatically to acquire the computing resources needed from the cloud and to distribute the simulation runs to be executed [4]. Shashank Shekhar presents cloud-based simulation-as-a-service (SIMaas), which is a lightweight solutions using Linux containers instead of heavyweight hypervisor-based solutions [5].

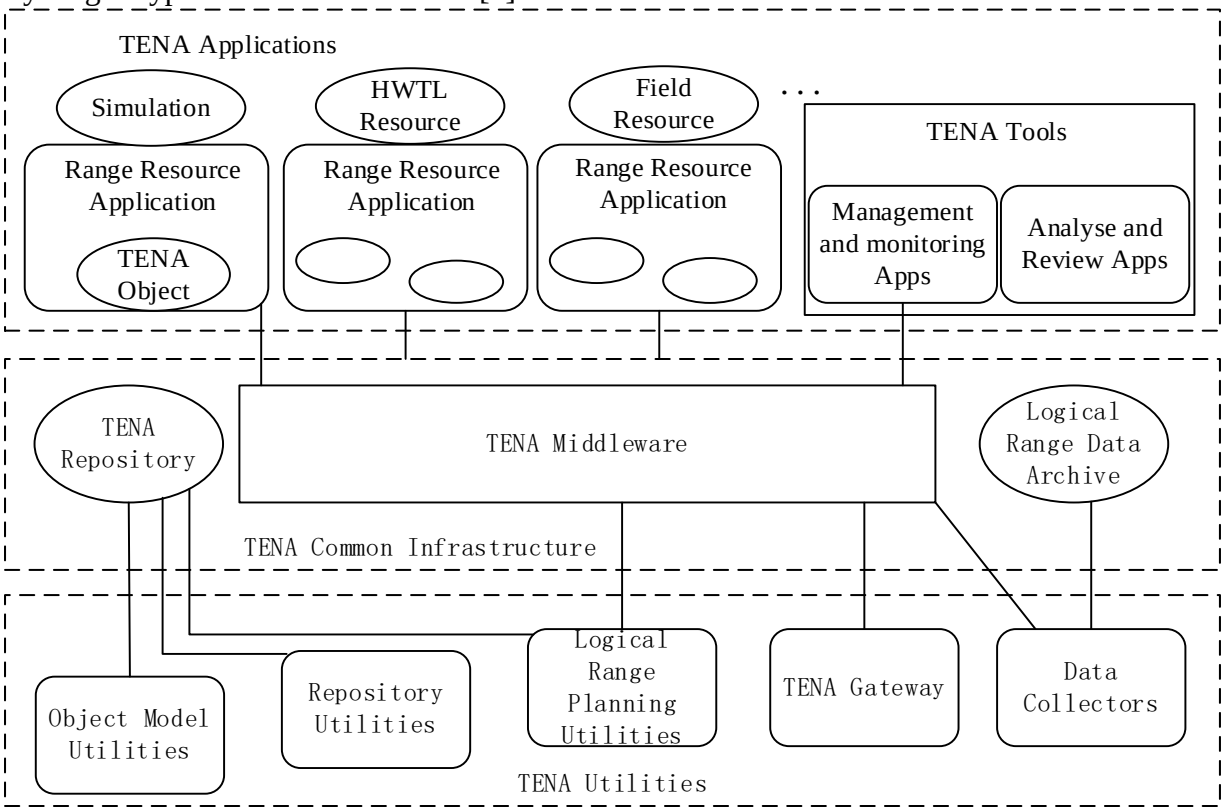

Figure 1. TENA architecture overview

There are also some researches about the cloud computing based simulation in China. Based on the research fruits of simulation grid, Li Bohu put forward a networked modeling & simulation platform on the concept of cloud computing [6]. Gao Wuqi put forward the infrastructure and realizing framework of a cloud simulation based on HLA Evolved, which is on the reference of cloud computing and the technical improvement of HLA Evovled [7]. Zhang Yabin design a

virtualization-based cloud simulation running environment dynamic building model [8]. Li Tan propose a layered simulation service description framework (SSDF) oriented to cloud simulation [9]. Sun Xiangjun establish a model service platform based on cloud computing for military model management and reuse [10].

4. Virtual Range based on Cloud Computing

4.1 Basic Concept of Cloud Computing

According to the definition of NIST (National Institute of Standards and Technology), Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [11]. Cloud computing is developed from parallel computing, distributed computing, grid computing, utility computing, virtualization and network storage technologies.

Cloud computing is composed of five essential characteristics, which are on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service, respectively. There are three models for cloud computing: software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS).

4.2 The Characteristics of Cloud Computing Corresponding to Virtual Range

Cloud computing has made great progress in the past years in civil applications, but further researches are still needed in the military applications. The traditional distributed simulation meets a lot of difficult problems, such as the low utilization rate of computing resource, lack of balance ability for dynamic loads, difficult to store and process the mass data, and so on. The virtual range needs to construct a new simulation architecture, which have the characteristics of distributed, heterogeneous, synergetic and interoperable. Cloud computing, which can offer the users service resource wherever and whenever, can meet the requirement of virtual range. So the model of cloud computing is corresponding to the integrated test capacity and high information sharing capacity of virtual range (Fig. 2). We put forward a new architecture for virtual range based on cloud computing technologies in this paper. The proposed model service platform of virtual range can share the different resources (including system model resources, computing resources, storage resources, network resources, data resources and information resources) safely and on demand.

4.3 The Architecture of Virtual Range based on Cloud Computing

The architecture of virtual range based on cloud computing is shown in Fig. 2. All the projects are formed as services.

The bottom layer is the infrastructure layer. The network, computations, and storage resources are virtual packaged in the bottom layer, which can offer the users with high performance of computation and network sharing.

The second layer is called resources as service. According to the actual characteristics of range test, this layer is the resource layer of test and training. This layer includes: data base resource, model resource of equipment, knowledge base resource, tools of optimization, algorithm resource, test and measurement equipment resource, simulator, physical effect equipment, analysis and evaluation resource, and so on.

The third layer is called platform as service. It includes CAD/CAE resource, parallel simulation engine, edit tools of operational test scenario, development tools of equipment models, management tools of virtual prototype, management tools of simulation/model/knowledge base, problem solving environment of system simulation, visualization development tools of parallel simulation, and so on. This layer can support the process of simulation applications development, simulation running, analysis and evaluation. The management service of simulation applications is also offered by this layer.

The fourth layer is called software as service, which offers the user of virtual range the corresponding applications. It includes the design and optimization system of test program, operational test system, performance test system of equipment, test analysis and evaluation system, integrated test system, and other range applications.

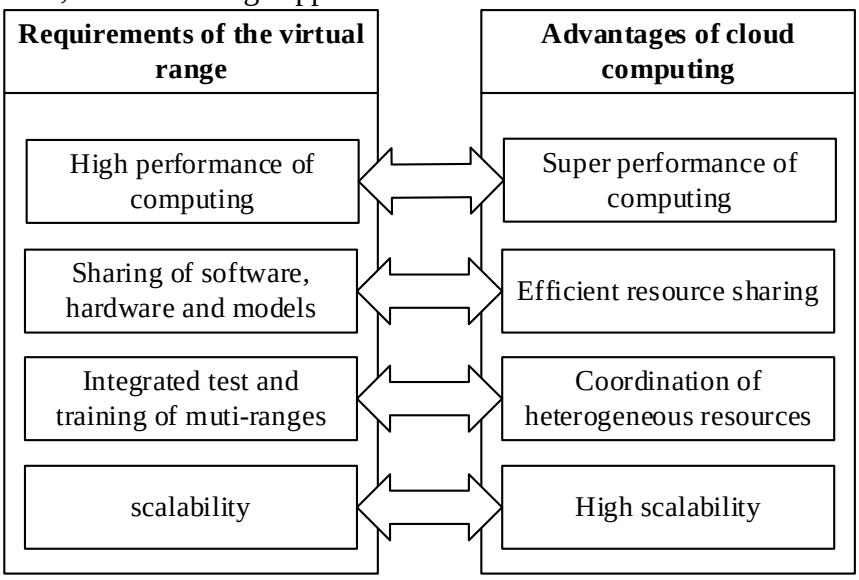

Figure 2. TENA architecture overview comparision chart for requirements of the virtual range and advantages of cloud computing

4.4 Key Technologies

(1) Description of heterogeneous simulation resources

In the cloud environment, the simulation models are used to assemble simulation applications. The description of simulation should be convenient for the assembling and discovering the simulation models. There are kinds of simulation resources in the virtual range, and their properties and semantics are complicated. In order to ensure the interoperability of heterogeneous simulation resources, the models should be descripted by specification languages. The properties, behaviors and interfaces of simulation resources should be descripted respectively. The property description, which is used for model discovering, describes the static characteristics includes model's name, functions and the environment relied. The behavior description that includes different behaviors of simulation resources, is used for assembling of different models. The interface description includes the information and data interface between different models.

(2) Virtualized encapsulation of resources

The simulation models in the virtual range are developed in different environment, different programming languages and different development modes. The virtualization technology of cloud computing can make full use of a large quantity of dispersed resources, and also can realize the centralized management and unified management of dispersed resources. At present, there are two ways for the virtualized encapsulation: the virtual machine technology and the Docker container technology. The virtual machine operates on the hardware layer, and the Docker container works on the operation layer. Compared with virtual machine, the Docker container has high efficiency and utilization ratio, which is the tendency of future virtualization technology for cloud computing. The virtual range based on cloud computing can use the Docker container technology to virtualize the software and models resources. For the computing resources, the virtual machine can be used to realize the abstraction and partition of computer hardware resources.

(3) Scheduling technology of simulation resources

In the virtual range based on cloud computing, the simulation resources are spread out over different places. For an equipment test mission, the user should submit the mission requirements through the cloud simulation platform. Then the system can search the resources according the requirements. In this way the simulation resources are scheduled, which can help quickly discovering

and distribution. The proper scheduling refers to different contents, includes computers, network communication, modeling software and simulation models. In the cloud computing based virtual range, the simulation applications need the computers in different places cooperate by the network. At present, the fuzzy cluster and genetic algorithm can be used for the scheduling of a great amount of simulation resources.

(4) Assembling technology of simulation resources

In the cloud environment, the simulation resources are dispersed in different areas. For one simulation application of virtual range, the resources required are acquired by assembling distributed simulation model. The assembly technology of simulation models is fundamental for reuse and interoperability of simulation resource. Simulation resource is present as services in virtual range based on cloud. The urgent problem to be resolved is how the services is autonomously assembled in order to achieve reusing and interoperability.

Acknowledgments

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References

[1] Cui Kan, Cao Yuhua. Development of the US military equipment testing range and enlightenment. Journal of Academy of Equipment, 2013, 24 (4): 110 - 113.

[2] TENA architecture reference document. https://www.tena-sda.org.

[3] Srikanth B. Yoginath, Kalyan S. Perumalla, Brian J. Henz. Taming wild horses: the need for virtual time-based scheduling of VMs in network simulations. 2012 IEEE 20th International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems. Washington, DC USA. 68 - 77.

[4] Massimiliano Rak, Antonio Cuomo, Umberto Villano. MJADES: Concurrent simulation in the cloud. 2nd International workshop on Intelligent Computing at Large Scale, 2012, Palermo, Italy. 853 - 860.

[5] Shashank Shekhar, Hamzah Abdel-Aziz, Michael Walker, Faruk Caglar, Aniruddha Gokhale, Xenofon Koutsoukos. A simulation as a service cloud middleware. Annals of Telecommunications, 2016, 71 (3): 93 - 108.

[6] Li Bohu, Chai Xudong, Hou Baocun, Li tan. Networked modeling & simulation platform based on concept of cloud computing—cloud simulation platform. Journal of System Simulation. 2009, 21 (17): 5292 - 5299.

[7] Gao Wuqi, Kang Fengju, Zhong Lianjiong, Fu Yanfang. Cloud simulation technology based on HLA Evovled, Journal of System Simulation, 2011, 23 (8): 1643 - 1647.

[8] Zhang Yabin, Li Bohu, Chai Xudong, Yang Chen. Research on virtualization-based cloud simulation running environment dynamic building technology. Systems Engineering and Electronics, 2012, 34 (3): 619 - 624.

[9] Li Tan, Li Bohu, Chai XuDong. Layered simulation service description framework oriented to cloud simulation. Computer Integrated Manufacturing Systems, 2012, 18 (9): 2091 - 2098.

[10] Sun Xiangjun, Lu Qinfu. Research on model service platform based on cloud computing. Ship Electronic Engineering, 2011, 31(8): 119 - 122.

[11] Peter Mell, Timothy Grance. The definition of cloud computing. NIST Special Publication 800-145.