面向云计算的虚拟系统验证框架

朱 斌 丰晋军 陈芳园 王名扬

（ 江南计算技术研究所 无锡 214083 ）

摘 要 本文针对面向需求的云计算提出了一种虚拟系统验证框架。该框架包括六中测试类型：功能测试、性能测试、可扩展性测试、压力测试、容错检验和功耗测试。框架给出了每种测试的测试目标、方法和过程。最后，本文进行了多种性能测试，并给出了测试结果和分析。

关键词 虚拟化；云计算；验证；性能；可扩展性

An Evaluation Framework of Virtualization Systems for Cloud Computing

ZHU Bin FENG Jin-jun CHEN Fang-yuan WANG Ming-yang

(*Jiangnan Institute of Computing Technology, Wuxi* 214083, *China*)

Abstract This paper gives a virtualization system evaluation framework, which is needs-oriented cloud computing. The framework contains 6 testing types, including functional testing, performance testing, scalability testing, stress testing, fault-tolerance test, and power testing. For each type, the framework gives specific test objectives, methods and procedures. Finally, we give the results and analysis of multiple performance tests.

Keywords virtualization; cloud computing; evaluation; performance; scalability

1 Introduction

The virtualization technology is able to achieve resource logic abstraction and unified representation, and therefore becomes the foundation for cloud computing[1]. The virtualization technology enables OS with application software and data to free switch among a group of computers or in a computer, which improves the system runtime efficiency and reliability. Meanwhile, a wide variety of computing resources can be dynamically organized by virtual computing to achieve a transparent and scalable system framework. Consequently, we can flexibly construct a computing environment with high utility and high polymerization efficiency. In conclusion, the virtualization technology can improve following problems:

- The difficulty in the management and usage of heterogeneous systems.
- Management and rapid deployment of various types or versions of OS.
- Software development and transplant.
- To improve system reliability and fault-tolerant performance.

However, the virtual machine with such features increases system complexity and reduces the performance of specific operations. Meanwhile, challenges occur to the corresponding test.

This paper focuses on the research of virtual testing techniques and proposes a virtual evaluation framework for cloud applications. The proposed framework reveals the deficiency of cloud computing based on the virtualization technology, with which we can dynamically construct a high efficient, high reliable, scalable and easy-to-manage cloud computing environment.

- HPC virtual platform: coordinate work oriented

作者简介：朱斌，硕士，高级工程师，研究方向为计算机工程，E-mail:zhub,jn@gmail.com。

multiple nodes; coordinate manage platform with multi-VMM.

- Traditional virtual platform: centralized management oriented single sever; centralized OS.

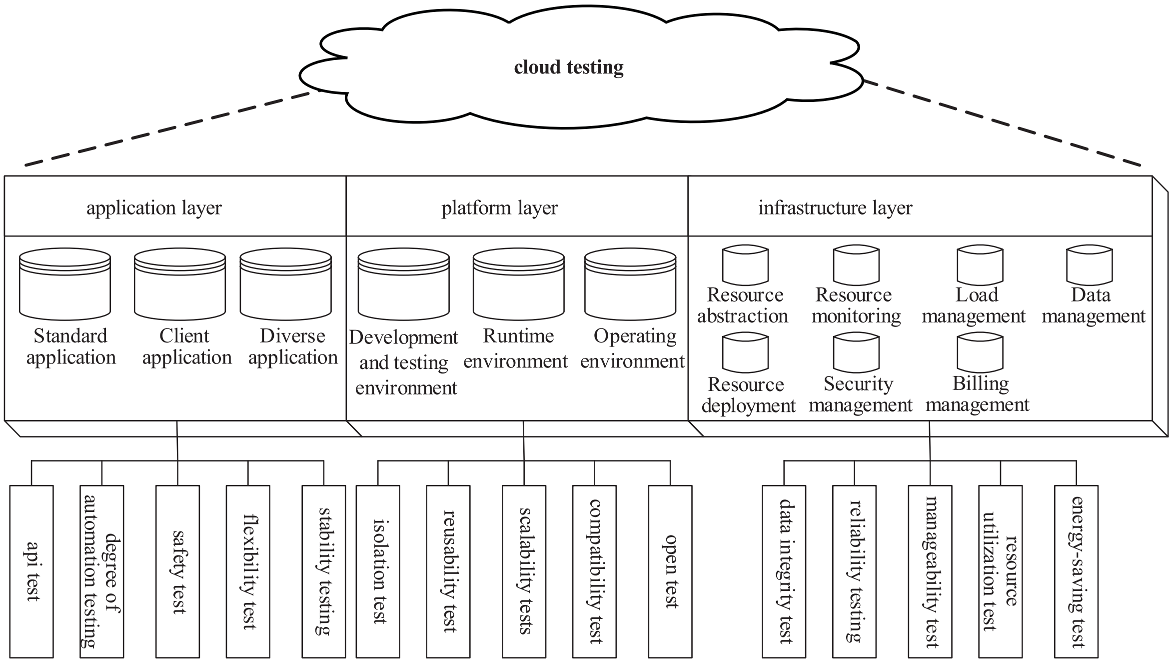


Figure. 1 Evaluation Framework of Cloud Testing

2 Related Work

For the performance test of virtual computing systems, SPEC set up SPEC Virtualization Committee. It devotes to the standard development of virtualization system performance evaluation[2]. So far a test set, SPECvirt_sc2010, has been issued to evaluate the virtualization performance of server consolidation in datacenters. The test set consists of three-group benchmark representing typical server applications: SPECweb2005, SPECjAppServer2004 and SPECmail2008[3]. The test results reflect the performance, QoS and the ratio of peak performance to power of virtual systems[4].

VMware released the test set Vmmark 2.0 to evaluate the virtualization performance across a variety of hardware platforms. Vmmark 2.0 consists of six-group benchmark representing typical server applications: mail server, Java server, backup server, Web server, database server and file server. All of these typical applications run in respective virtual machines TITE which are loaded in a single physical server. The test result is a single value which includes 80% application performance and 20% base platform performance.

For virtualization test, academic communities focus on two aspects: the performance loss and fault isolation[3-7].

3 Virtual Evaluation Framework

We propose an evaluation framework of virtualization systems for cloud computing to evaluate the functionality, performance, reliability and other key attribute of virtualization systems. With the proposed framework some problems and improvable space can be discovered, which provide optimal basis to improve performance, power consumption and reliability. The framework consists of a set of metrics and corresponding test methods. While the evaluation performs 6 tests: functionality, performance, scalability, pressure, fault tolerance and power consumption.

3.1 Functionality Test

For basic functionality test we focus on VMM management as well as GUEST OS support.

(1) VMM management test

Test the basic services VMM provides, especially the memory management, interrupt handling, and thread scheduling.

(2) Basic functionality and system call of GUEST OS test

The test is used to evaluate the functionality implementation. First, test the basic functions of the Guest OS, including memory management, process management, systems management, document management, and network management; Second, test the Client OS's API, including commands and system calls.

3.2 Performance Test

The performance test focuses on the overhead of performance and resource, performance isolation degree as well as the performance loss.

(1) VMM resource occupancy, performance overhead, load balancing capability and performance isolation degree.

(2) The performance losses of VM basic integer operations, floating-point operations, process, context switching, local communication bandwidth, local communication latency, file systems and memory operations.

(3) VM migration performance and the transparency to users and computation.

3.3 Scalability Test

Scalability test focuses on VMM scalability as well as the scalability of virtual CPU, virtual network, virtual I/O and virtual memory.

3.4 Pressure Test

Pressure test focuses on the pressure of VMM and GUEST OS.

(1) The pressure of VMM

This test creates multiple VMs and does various combined types of tests with large-load pressure.

(2) The pressure of VM

A typical OS pressure test, for example, a typical computation-intensive Benchmark communication intensive Benchmark IO intensive BenchMark, or a combination of a sophisticated application of the above characteristics.

3.5 Fault Tolerance Test

Fault tolerance test focuses on VMM monitoring mechanism for GUEST OS state, task migration and active fault tolerant capability.

3.6 Power Consumption Test

It tests the runtime power consumption after virtualization. Then we make a compare between the obtained power consumption and the OS power consumption in physical machine. Above process can identify the main aspects resulting power consumption increase in order to perform optimization.

In addition, power consumption test also checks the system capability of dynamical adjustment of VM open, close and distribution in terms of runtime states.

4 Experiments

4.1 Experimental Setup

The systems are briefly characterized in Table 1.

4.2 Experimental Results: Performance

(1) Process performance

For the basic process operation, the performance loss to open/close files is high and is up to 13%. Other operations have low performance loss.

Table 1. Table Type Styles

	Stand alone machine	Vmm machine	Virtual machine
OS Kernel	Red Hat Linux 2.6.18	Red Hat + XEN Linux 2.6.18	Red Hat + XEN Linux 2.6.18
machine type	Dell DPTIPLEX 760	Dell DPTIPLEX 760	Dell DPTIPLEX 760
CPU	Intel Core2 4 CPU Q8200 2.33GHz	Intel Core2 4 CPU Q8200 2.33GHz	Intel Core2 4 CPU Q8200 2.33GHz
GCC version	4.1.2 20080704	4.1.2 20080704	4.1.2 20080704

(2) Performance of process creation

There are three types: to call process creation by fork system, to call process creation by exec system and to create process by shell. From Fig. 3 we find that the performance loss of process creation is high. The performance loss of VMM is 71%~164% while that of VM is 16%~80%.

(3) Context switching

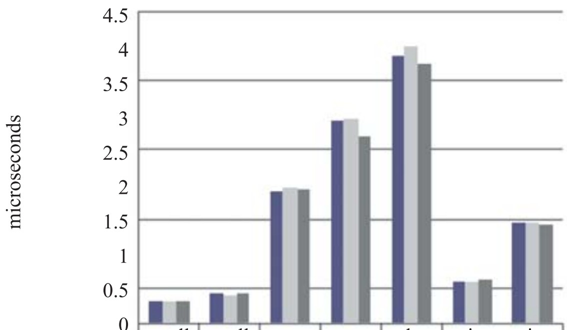
Fig. 4 shows that the performance difference of Domain 0 and Domain 1 is not significant.

(4) Performance and performance loss of virtual memory

4.3 Experimental Results: Scalability

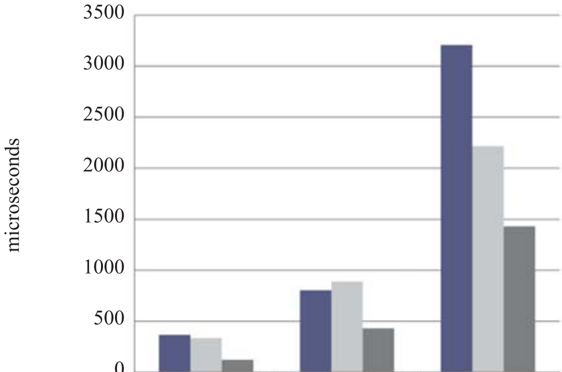
(1) Process scalability

Figure 6~8 shows, in the process of operation scalability, VMM and SA system have little difference, however, VM and VMM differ.



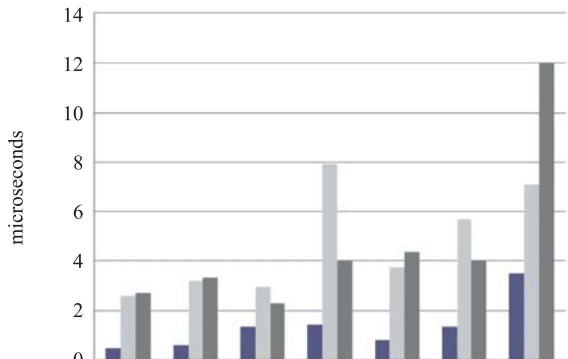
	null call	null i/o	stat	open clos	slct tcp	sig inst	sig hndl
xen vmm	0.32	0.42	1.9	2.94	3.86	0.59	1.43
xen vm	0.32	0.41	1.96	2.96	4.01	0.59	1.44
sa liunx	0.32	0.42	1.92	2.7	3.75	0.61	1.4

Figure. 2 Basic process performance



	fork proc	exec proc	sh proc
xen vmm	374	813	3208
xen vm	345	893	2226
sa liunx	130	434	1437

Figure. 3 Performance of process creation



	2p /ok	2p /16k	2p /64k	8p /16k	8p /64k	16p /16k	16p /64k
sa linux	0.51	0.63	1.37	1.43	0.81	1.37	3.54
xen vmm	2.62	3.25	3	7.95	3.75	5.72	7.14
xen vm	2.73	3.34	2.32	4.03	4.37	4	12

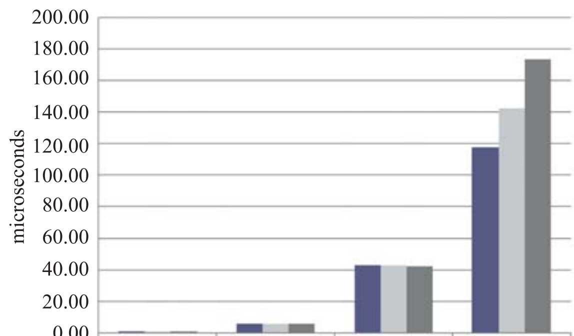
Figure. 4 Time overhead of context switching

(2) Scalability of context switching

Fig. 9 shows that the performance scalability difference of context switching of VMM and VM is significant.

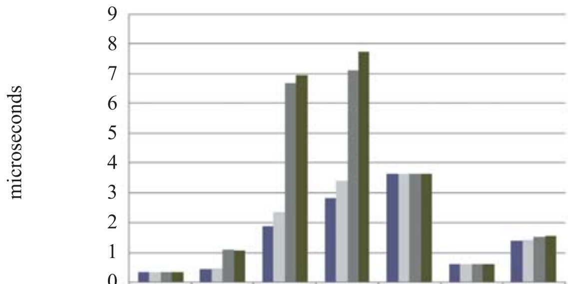
4.4 Experimental Results Conclusions and Analysis

Through performance test and scalability test we find some characters of Xen as follows:



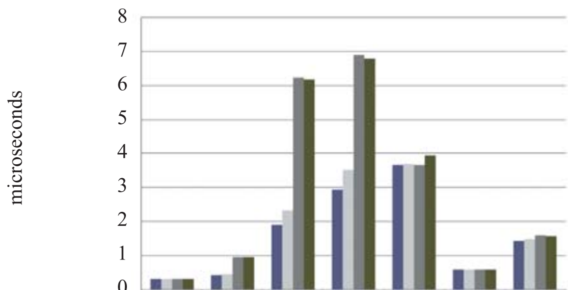
	11 cache	12 cache	main mem	rand mem
sa linux	1.29	6.50	43.30	117.90
xen vmm	1.29	6.48	43.30	143.10
xen vm	1.29	6.48	42.70	173.90

Figure. 5 Memory access performance



	null call	null i/o	stat	open clos	slct tcp	sig inst	sig hndl
sa linux.1copy	0.32	0.42	1.87	2.79	3.61	0.59	1.38
sa linux.2copy	0.32	0.46	2.53	3.38	3.62	0.59	1.43
sa linux.4copy	0.32	1.08	6.69	7.11	3.62	0.59	1.53
sa linux.5copy	0.33	1.07	6.97	7.74	3.63	0.59	1.56

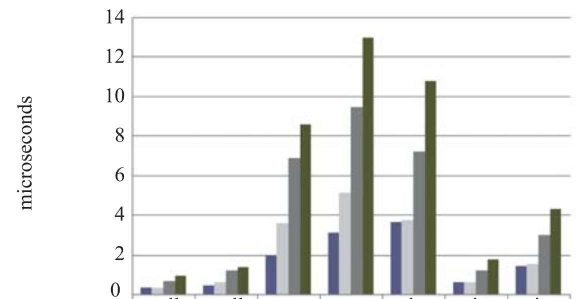
Figure. 6 Scalability of sa Linux process



	null call	null i/o	stat	open clos	slct tcp	sig inst	sig hndl
xen vmm.1copy	0.32	1.43	1.91	2.95	3.66	0.59	1.43
xen vmm.2copy	0.32	0.46	2.31	3.53	3.68	0.59	1.47
xen vmm.4copy	0.32	0.94	6.25	6.91	3.66	0.59	1.6
xen vmm.5copy	0.32	0.95	6.18	6.8	3.94	0.59	1.57

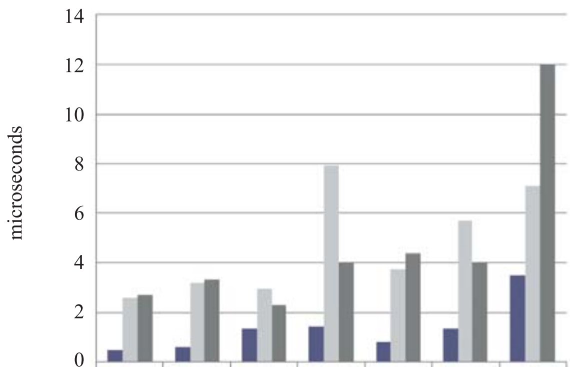
Figure. 7 Scalability of Xen VMM process

- Basic integer operations have little performance loss.
- The performance loss of basic floating-point operations is less than 1%.



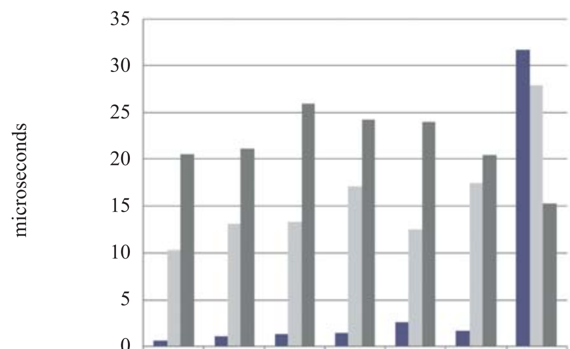
	null call	null i/o	stat	open clos	slct tcp	sig inst	sig hndl
xen vm.1copy	0.32	0.43	1.97	3.07	3.62	0.6	1.42
xen vm.2copy	0.32	0.61	3.58	5.1	3.73	0.59	1.54
xen vm.4copy	0.64	1.23	6.91	9.46	7.24	1.19	2.96
xen vm.5copy	0.96	1.4	8.58	13	10.8	1.78	4.28

Figure. 8 Scalability of Xen VM process



	2p /ok	2p /16k	2p /64k	8p /16k	8p /64k	16p /16k	16p /64k
sa linux	0.51	0.63	1.37	1.43	0.81	1.37	3.54
xen vmm	2.62	3.25	3	7.95	3.75	5.72	7.14
xen vm	2.73	3.34	2.32	4.03	4.37	4	12

(a)



	2p /ok	2p /16k	2p /64k	8p /16k	8p /64k	16p /16k	16p /64k
sa linux.4copy	0.53	1.06	1.28	14	2.59	1.56	31.8
xen vmm.4copy	10.3	13.02	13.32	17.1	12.5	17.4	28
xen vm.4copy	20.6	21.1	26	24.3	24	20.4	15.2

(b)

Figure. 9 Scalability of context switching

5 Conclusions

The virtualization technology is the basis of cloud computing[1]. Its key characteristics, such as system functionality, performance, scalability, reliability, largely determine the capacity of cloud computing systems in the infrastructure layer[8].

In this paper, we propose a virtualization system evaluation framework, which contains 6 testing types, including functional testing, performance testing, scalability testing, stress testing, and fault-tolerance test, power testing. For each testing type, the framework gives specific test objectives, methods and procedures.

The experimental results show that, the proposed virtualization system evaluation framework can effectively analyse the virtualization system performance loss, as well as the virtual machine relative to the standalone system in the function, performance, scalability of fine-grained distinctions, which can provide a basis for further optimizing the virtualization system. The next step, we plan to further study for the Domain0 security testing.

References

[1] Armbrust M, et al. A view of cloud computing [J]. Communications of the Association for Computing Machinery, 2010, 53(4): 50-58.

[2] Ostermann S, et al. A performance analysis of EC2 cloud computing services for scientific computing [J]. Cloud Computing, 2010: 115-131.

[3] Evangelinos C, Hill C N. Cloud computing for parallel scientific hpc applications: feasibility of running coupled atmosphere-ocean climate models on amazon's EC2 [J]. Ratio, 2008, 2(2.40): 2.34.

[4] Menon A, et al. Diagnosing performance overheads in the xen virtual machine environment [C] // Association for Computing Machinery, 2005.

[5] Barham P, et al. Xen and the art of virtualization [C] // Association for Computing Machinery, 2003.

[6] Gupta D, et al. Enforcing performance isolation across virtual machines in Xen [M]. Springer-Verlag New York Incorporated, 2006.

[7] Napper J, Bientinesi P. Can cloud computing reach the top500? [C] // Association for Computing Machinery, 2009.

[8] Voorsluys W, et al. Cost of virtual machine live migration in clouds: A performance evaluation [J]. Cloud Computing, 2009: 254-265.