Performance Comparison of Selected Virtualization Platforms

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Abstract— **The suitability assessment of implemented virtual platform must precede the implementation itself. The aim of the article is to experimentally assess the performance of freely available virtualization tools in several aspects. In the process of virtualization of any environment the performance decreases regarding a host system because of an application of isolating technologies. The performance parameters of CPU, inquired in two different tests, speed of retrieving and writing on a virtualized hard disc and also speed of response of a virtual network interface were chosen for comparison. The aim of the article is also to present the results of testing and chosen tested tools together with used methodology. The measured values are presented in graphs and accompanied by their interpretations. On the grounds of measured values one of the tested virtualization tools is recommended, which measured values shown the best characteristics.**

Keywords- Application virtualization, Computer performance, Oracle VirtualBox, Microsoft Virtual PC.

I. INTRODUCTION

Virtualization as a concept was developed for the first time by IBM in 1960s. During 1980s and 1990s, desktop computers and x86 servers became much more available and, therefore, virtualization had not undergone any significant progress at that period. The client-server applications and emergence of operating systems Windows and Linux made both the server technologies and home PCs markedly cheaper. However, new challenges have appeared, such as time-consuming maintenance of the existing computers, high operating cost or high failure rate, which led to the development of x86 virtualization. Virtualization has increased the effectiveness dramatically and reduced the overall IT expenses.

At present, virtualization is understood to be a relatively new concept by means of which many practical problems related to the information technologies use can be solved [1].

In general, we can say virtualization is a means allowing creation of the so-called virtual objects. Virtualization can be performed on various levels, from the whole computer to the individual components creation: We can have a virtual disc, a virtual memory, or a virtual processor. By means of a virtualization tool, a different operating system can be started in an hosting operating system. Virtualization changes nearly all aspects of the operating system and storages administration. Using the virtualization technology, we can create training, testing, or even developmental environments; there are more possibilities to save physical means and expenses. And we must not forget another important advantage of the virtualization technology – resistance to failures and high availability.

Virtualization allows more operating systems run in one physical machine, e.g. Windows, Linux etc. The number of virtual machines that can run simultaneously in one machine depends on hardware specification.

At present, virtual machines are implemented in most data centres as normal servers but with much less maintenance and administration cost. This technology potential is huge and plays a great role in the computer science future [2].

The aim of this article is to present the basic principles of virtualization and to recommend a tool for software virtualization on the basis of tests performed with some selected freely available virtualization tools. The given tool will be then used at the Faculty of Informatics and Management, University of Hradec Kralove (FIM UHK) for specific operating system tasks testing.

A. Virtualization benefits

Consolidation of servers definitely is the greatest benefit of virtualization. Virtualization has become a saving means of about 60% of companies. Their IT departments have been transforming the physical servers to the virtual ones. Such transformation has several advantages.

Continuity of operation and high availability

The virtual server is separated from a particular physical hardware and can easily be backed up and restored in another hardware or another locality. Advanced virtualization technologies thus allow the transfer of a virtual server to another physical server without disconnection of working users, even in applications not supporting the high availability solution at all.

Scalability

The separation of the physical hardware from the individual virtual servers and stations allows an easy increase of the applications performance by a simple addition of a new hardware in the existing infrastructure. If, for example, the number of demands made on a server is increased, the memory or CPU performance can simply be increased in the administration console. The same it is with the addition of any other hardware allowed by the given virtualization technology.

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Attendance simplification and cost of operation reduction

Thanks to the reduction of the number of physical servers, automated installation of new servers from templates, their easy transferability to another hardware, and thanks to the centralized administration tools, the attendance activities during the servers and applications installation and operation have been simplified significantly.

More effective administration

The symbiosis of a company IT environment and its commercial needs should be the primary aim of the consolidation. The aim of the IT consolidation is mainly to shorten the period of the return on investment in the IT infrastructure and to reduce the expenses related to IT administration. The administration of an increasing number of servers, working stations and other devices of the company IT infrastructure can be expensive and demanding from the capacity point of view. Working stations consolidation eliminates the autonomous administration disadvantages to a great extent. IT departments can administer and maintain the software on such stations much more effectively, including the central application of safety patches and correction packets. A unique, consolidated and consistent environment in a company can increase the employees' labour productivity and reduce the expenses. A unique setting and compliance with the configuration policy guarantees much less vulnerability of the centrally administered stations towards the safety threats [1],[2].

II. MEASUREMENTS OF VIRTUALIZATION TOOLS PERFORMANCE

For the purposes of development, research and teaching, virtualization tools are used. It ensures the possibility to return to previous configuration and mainly an isolated testing environment. The methods of isolation virtualization environment have the crucial impact on performance of an operating system. Individual tools use various methods, which report different performance parameters.

For instance [3] is interested in testing of performances of virtualized systems. In this case performance and throughput in computer networks are tested. The given perspective is not complex as needed when making decisions about implementation of a specific virtualization tool.

The problematic of measuring performance of virtual hypervisors is also dealt by [4]. In this case only two types of hypervisors orientated on server stations, VMware Esxi and Xen, are compared. Testing is reduced and performed only on system Debian as a guest operating system.

On the contrary [5] presents only drafts of load testing of virtualized environments.

None of presented sources offer any comprehensive information about performance of single virtualization tools across various combinations of guest and host operating systems.

Therefore the testing set of virtualization tools was designed and employed. The results of measuring are discussed in the following chapters.

III. CHOICE OF VIRTUALIZATION TOOLS

The virtualization tools were chosen according to possibility to equip the faculty, free availability and possibility of maintenance without advanced knowledge of virtualization technology. The commonly available set was selected for testing in laboratories and classrooms of informatics discipline. This selection partly restricted the selection of available technologies. According to these restrictions two types of tools, Oracle VirtualBox and Microsoft Virtual PC were selected. Both tools were tested using basic configuration without any supplementary settings.

IV. CHOICE OF TESTED QUANTITIES

For the purposes of measuring the quantities were selected in order to represent real system usage. Among these quantities belong computational performance of virtualized processor, speed of retrieving and writing on a virtual hard disc and throughput of network interface with its operation. All quantities tests were conducted with regard to invariable testing conditions.

The above mentioned was reached by restarting host and guest systems before performing another measuring and waiting five minutes for stabilization of starting processes.

The operation of test was delegated on an especially written script which started after elapsing already mentioned stabilization period.

Each tested task was performed on the host system, as a reference to comparison of results with quantities measured on the guest system.

CPU testing went in order to be re-performed on all tested technologies at the same time and under same conditions. As a testing task calculation of PI for constant number of digits (for 8388608 digits) was chosen. To perform the calculation SystemStabilityTester and Gauss-Legendre algorithm were used. Encoding of the tested file of random characters by library OpenSSL was used.

Access speed to the hard disc was represented with the period of copying 1GB file from one place to other within one disc picture. Using the previously mentioned ensured the testing of retrieving and writing.

Network interfaces were tested for the guest system from external source requirements (echo request, echo reply).

Measuring of the running period of all tests was solved with the tool Timeit.exe (Windows) or with equivalent Time (for system Linux).

All test were repeated one hundred times for each combination of host, guest systems and virtualization tools. Thanks to this it was possible to filter out testing anomalies.

V. MEASURED DATA

Referring to software equipment of Faculty of Informatics and Management at the University of Hradec Kralove, the host system Microsoft Windows 7 in 32 bit version was selected as default. The same tests were also run on this host system in order to receive reference values. Guest systems were Windows 7 in 32 bit version and Debian Squeeze 6.0.0. Already mentioned Oracle VirtualBox and

Microsoft VirtualPC were selected as a virtualization environment.

A. Test NIC

The test was aimed to attain time of response of external source requirement, in this case of a local server.

The response was measured with a tool PING. The server and also host were connected via gigabit connectivity tangled with UTP cable in category 5E. The request was sent 100 times and the result was recorded.The results are stated in seconds are listed in the **Error! Reference source not found.**:

TABLE I. RESULTS OF TEST NIC

	Debian on VPC	Debian on VBX	W7 on VPC	W7 on VBX	W7 host
Average [s]	0,840	0,827	0,490	0,418	0,188
Standard deviation [s]	0,055	0,168	0,107	0,055	0,013
Variance	0,003	0,028	0,011	0,003	0,000
Maximum	1,080	1,980	1,090	0,790	0,231
3rd Quartile	0,856	0,823	0,516	0,437	0,193
Median	0,844	0,793	0,479	0,419	0,185
1st Quartile	0,835	0,774	0,448	0,395	0,181
Minimum	0,429	0,393	0,285	0,319	0,171

B. Test CPU – Calculation of PI (π)

The testing was aimed at measurement performance of virtualized system. SystemStabilityTester was used for measuring in all interfaces. The values are stated in seconds and summed up in the Table 2:

TABLE II. RESULTS OF CPU TESTING – CALCULATION OF PI

	Debian on VPC	Debian on VBX	W7 host
Average [s]	336,282	489,921	183,424
Standard deviation [s]	24,986	14,595	0,474
Variance	624,323	213,023	0,225
Maximum	428,495	497,438	185,219
3rd Quartile	329,227	494,560	183,643
Median	324,513	491,599	183,308
1st Quartile	324,165	489,336	183,140
Minimum	316,480	369,320	182,460

	W7 on VPC	W7 on VBX	W7 host
Average [s]	447,645	493,592	183,424
Standard deviation [s]	1,709	3,929	0,474
Variance	2,920	15,436	0,225
Maximum	450,718	503,499	185,219
3rd Quartile	448,783	495,540	183,643
Median	447,950	492,947	183,308
1st Quartile	447,083	490,820	183,140
Minimum	443,970	483,640	182,460

C. Test CPU – Encoding

The algorithm AES 256B was used in the test aimed at encoding. The measuring results are stated in seconds and summed up in the Table 3:

TABLE III. RESULTS OF CPU TESTING - ENCODING

	Debian on VPC	Debian on VBX	W7 on VPC	W7 on VBX	W7 host
Average [s]	18,511	21,362	20,982	26,523	12,428
Standard deviation [s]	2,167	0,809	0,790	1,374	1,085
Variance	4,697	0,654	0,624	1,887	1,177
Maximum	28,390	25,330	22,221	32,506	14,164
3rd Quartile	18,233	21,408	21,300	26,846	13,498
Median	17,955	21,250	21,000	26,227	11,559
1st Quartile	17,445	21,100	20,289	26,015	11,540
Minimum	17,170	18,780	17,620	18,100	11,510

D. Test HDD

The test was aimed at the time period of retrieving and writing of 1 GB file on virtualized HDD. The measured values are stated in seconds and summed up in the Table 4:

TABLE IV. RESULTS OF TEST HDD

	Debian on VPC	Debian on VBX	W7 on VPC	W7 on VBX	W7 host
Average [s]	53,806	40,613	32,028	32,588	27,933
Standard deviation [s]	2,561	1,114	0,688	1,174	1,554
Variance	6,560	1,240	0,474	1,377	2,415
Maximum	62,890	42,240	33,408	37,231	32,510
3rd Quartile	54,980	41,313	32,797	33,057	28,618
Median	53,580	40,655	31,915	32,604	27,979
1st Quartile	51,990	40,235	31,443	31,625	27,338
Minimum	47,990	35,640	30,940	30,940	24,910

VI. SUMMARY OF RESULTS OF MEASUREMENTS

According to results of measurements it is obvious that both tools are usable and meet requirements for being employed in teaching.

The differences between native environment and the virtual machine were in both cases maximally in the multiplication of reference values measured on the host system.

In the case of requirements orientated on performance it would be more suitable to choose Microsoft solution. On the contrary, if a migration to another host platform is expected, it is more suitable to choose Oracle solution. The summary results are shown in the **Error! Reference source not found.**:

TABLE V. SUMMARY OF RESULTS OF MEASUREMENTS

	Linux		Windows 7
	VirtualPC	VirtualBox	
HDD [s]	53,806	40,613	27,933
CPU Encrypting [s]	18,511	21,362	12,428
CPU Computing PI [s]	336,282	489,921	183,424
NIC Echo [ms/10]	83,980	82,650	18,837

	Windows 7		Windows 7
	VirtualPC	VirtualBox	
HDD [s]	32,028	32,588	27,933
CPU Encrypting [s]	20,982	26,523	12,428
CPU Computing PI [s]	447,645	493,592	183,424
NIC Echo [ms/10]	49,030	41,790	18,837

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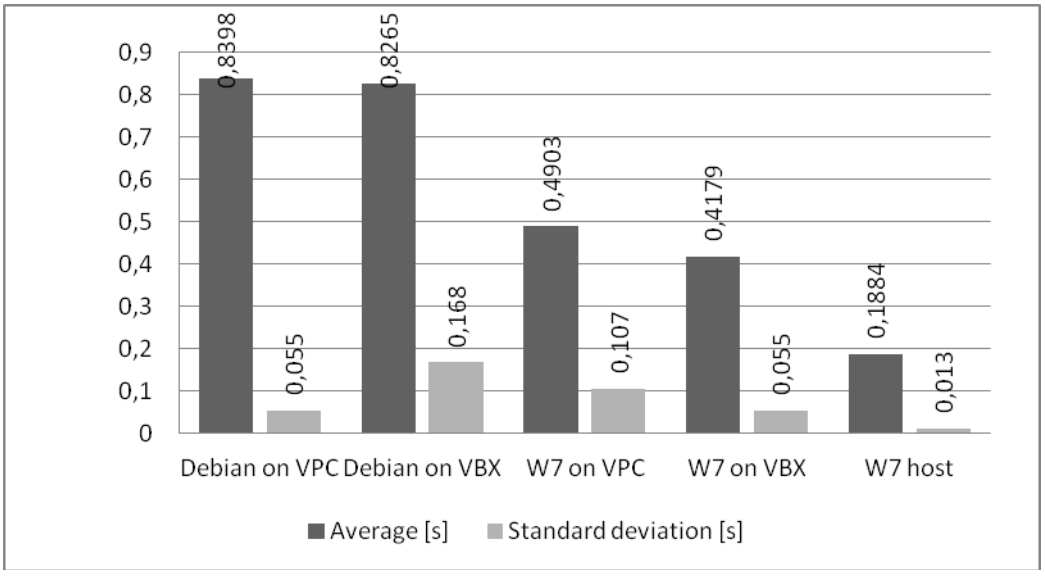

Figure 1. Results of test NIC

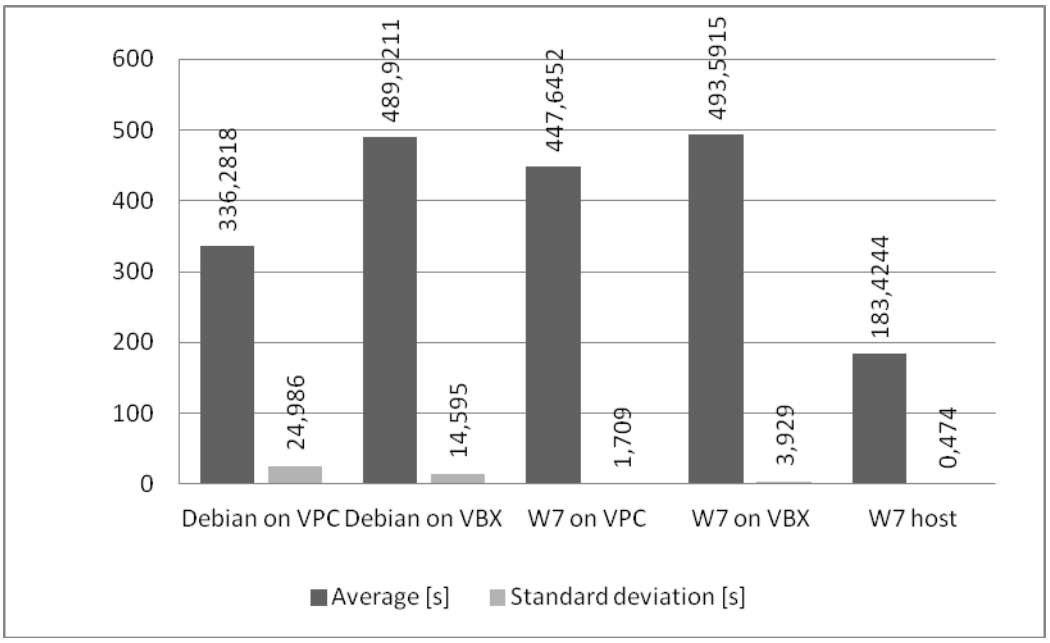

Figure 2. Results of CPU Testing – Calculation of PI

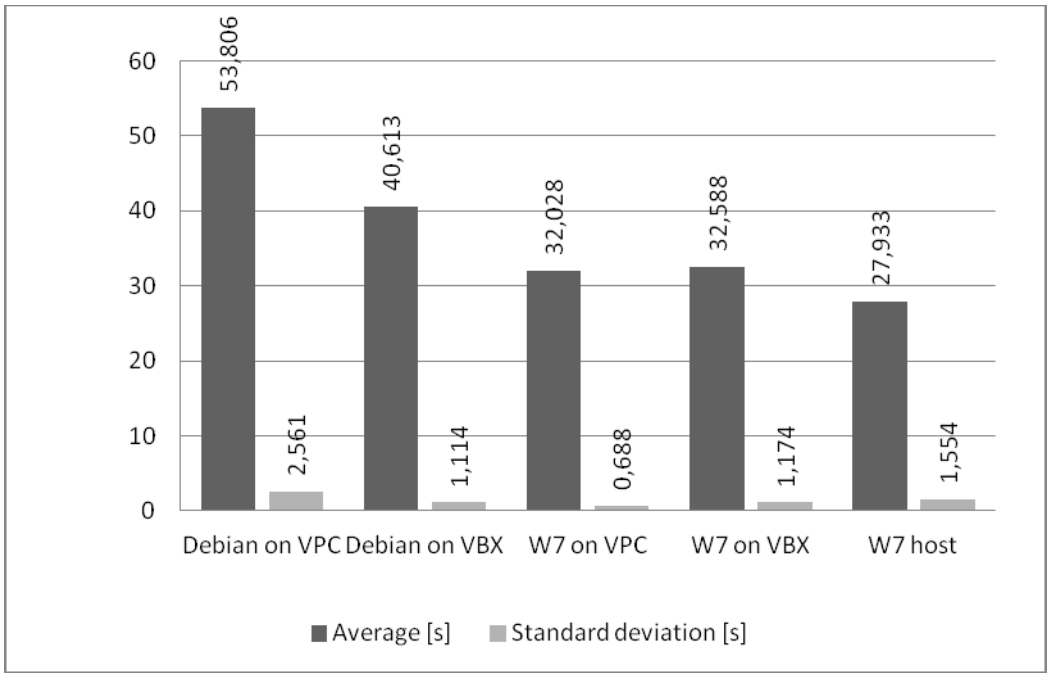

Figure 3. Results of CPU Testing - Encoding

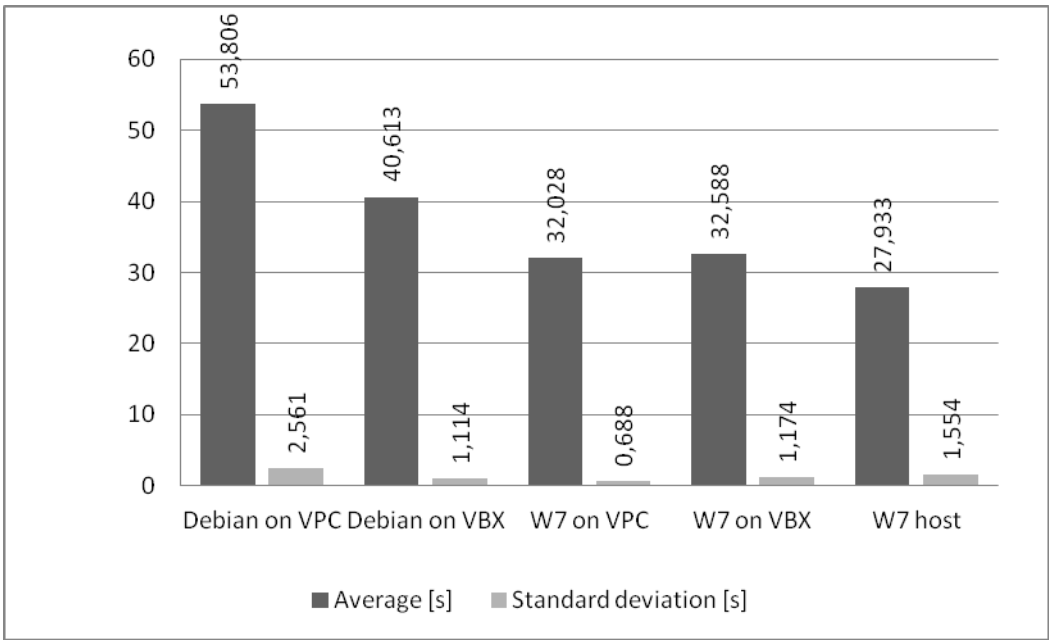

Figure 4. Results of Test HDD .

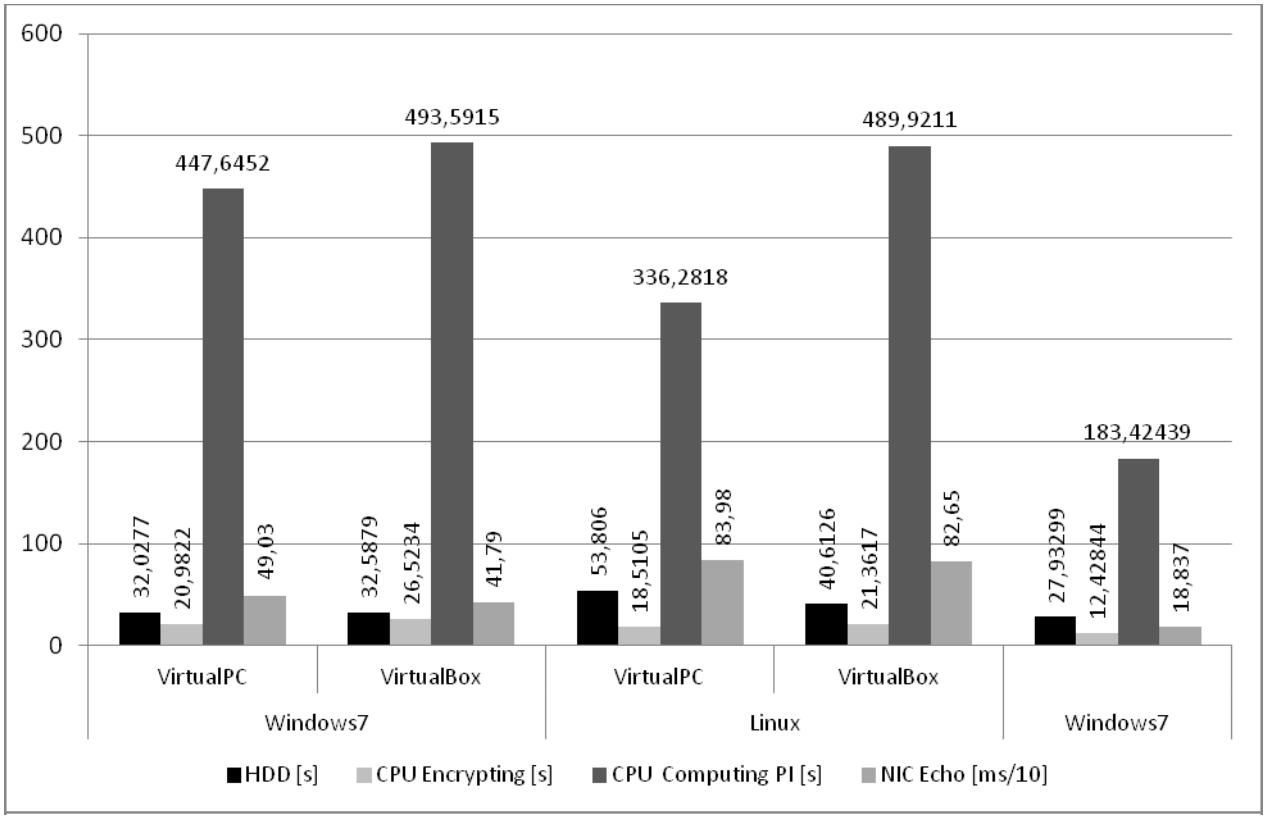

Figure 5. Summary of Results of Measurements