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Analysis and Implementation of Data Center Virtualization at the ICT Center Fkip UNS

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Abstract: ***The need for information system at the Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta, is increasing. Yet, the improvement of the information system has not been in proportion to the server availability. A solution is therefore required as to deal with the limitation in hardware resources at the aforementioned institution. In this research, the virtualization of data center at the Faculty of Teacher Training and Education, Sebelas Maret university, Surakarta, was proposed. The virtualization method used in this research was hypervisor virtualization with the software of Proxmox VE. The web server performance was tested, and the web server performance of the virtual environment was compared to that of the physical environment. In addition, the calculation of the server cost and the network cost in the virtual environment used currently was also analyzed. The result of the analysis on the web server performance shows that the web server within the virtual environment can serve users as similarly as the web server within the physical environment prior to the application of virtualization. The result of the test shows the decrease in the web server performance, but it is still acceptable because the average percentage of the decrease in the performance is 7.8 % out of the total percentage of the web server performance within the physical environment. In addition, the ICT Center of the Faculty of Teacher Training and Education, Sebelas Maret University can save the operating costs for the server and the network up to 48.11 % and 35.134% respectively when employing the virtualization infrastructure at the data center.***

Keywords: Data center, ICT Center, Proxmox VE, Virtualization

1. Introduction

The Faculty of Teacher Training and Education, Sebelas Maret University as one of the work units of the university, requires several information systems to process the prevailing data amidst the increasing need for the information system. According to the Guidelines for Business and Budgetting Plan of the Faculty of Teacher Training and Education, Sebelas Maret University 2013 [1], the institution has developed several information systems. However, the improvement of the information system has not been in accordance with the availability of the prevailing hardware. Due to the increasing information system and the short time available for the implementation, the institution is in need of a solution to apply the aforementioned information system into the limited hardware resources. The solution proposed to deal with the prevailing problem is the development of server virtualization infrastructure at the data center unit of the ICT Center of the Faculty of Teacher Training and Education, Sebelas Maret University.

Several researches have claimed that the application of cloud computing and server virtualization in business world, including education world, offers various advantages. Some of them are the saving of SITI infrastructure management cost and the efficiency on management of infrastructures [2][3][4][5]. The further progress of this research following the infrastructure design is the migration of information system from physical server environment to virtual server environment. Such a migration causes the performance decrease of the application operating in the virtual environment. It is due to the reality that the existence of the virtual machine adds one layer, which causes the supplementation of access process to hardware [6]. The objective of this research is to study the web server performance. The result of the performance test on the web server operating within the physical environment to serve its users was compared to that of the performance test on the web server operating within the virtual environment, which used the virtualization software of Proxmox VE. In addition, the calculation of operating costs for the web server and the network of the virtualization infrastructure was done as to investigate the economic advantages on the application of virtualization at the data center of the ICT Center of the Faculty of Teacher Training and Education, Sebelas Maret University.

2. Literature Review

This research refers to several former researches, which discuss the application of virtualization and cloud computing. The research conducted by Jingxian [4] discussed about the virtualization of server, which was used at campus network. The result of his research shows that the virtualization can effectively reduce the addition of servers which usually take place promptly in the digital campus application.

In addition, Che and Yu[10] evaluated the performances of three types of Virtual Machine Monitor, namely: OpenVZ, Xen, and KVM. The performances included those of, among others, processor, memory, disk, network, and application server. The test on OpenVZ, Xen, and KVM was done with the assistance of tools SPECCPU2006, LINPACK, RAMSPEED, LMbench, IOzone, Bonnie + +, NETIO, WebBench, SysBench and SPECjbb2005. The research finds that OpenVZ has the best performance, and it is followed by Xen and KVM whose performances are respectively a little lower below the former.

Meanwhile, Rasian[8] conducted a study on the full virtualization, hardware-assisted virtualization, para-virtualization, and operating system-level virtualization. In

the research, a conclusion is drawn that for an organization whose main duty is to provide the same services for many parties, solutions of virtualization with operating system-level virtualization or even para-virtualization approach would be an appropriate choice whereas for an organization whose information system or proprietary application was old, full-virtualization would be be preferable to choose.

Next, Yokoyama[6] conducted a research on the impact of hypervisor layer on the data base application. The result of the research shows that the database performance in the hypervisor environment is lower than the database performance in the physical environment due to the layered translation to do one time transaction per second in the database machine because it passes the hypervisor layer. As a result, this causes the performance decrease in term of transaction response. In the physical environment, the layered translation only happens in the application positioned at the side of OS, whereas the transaction in the database takes place in the physical machine.

Furthermore, Ahmed Monjour[15] conducted a research on the comparison between the performance of the virtual server and that of the physical server. He compared the performances of database response time, ftp response time, Ethernet traffic load, http response time, and CPU usage. The result of the research shows that the response time and the CPU usage performances in the physical server are respectively better and more stable than those in the virtual server. However, the response time for the http service in the physical service is constant, but it is still more excellent than the one in the virtual server with average performance decreases of 30 % to 33% for http service, of 30 % to 36% for the FTP service, and of 10% for the transaction service per second of the database.

Li[13], moreover, developed the method to calculate the IT ownership assets on the cloud infrastructure. The method used the TCO formula of gartner. Then he developed web-based TCO calculator tools with the calculation domains of server cost, network cost, software cost, support cost, facilities cost, power cost, and cooling cost. The tools were employed to calculate the TCO in the public cloud infrastructure.

In this research a field research was conducted. The cores of the research included the design, implementation, and analysis on the performance of the web servers operating in the virtual environment, and then they were followed with the analysis of the server cost and the network cost. The research was done in phases, starting from mapping the conditions prior to the use of virtualization. The software of virtualization which was chosen based on the literature review was the software of open source Proxmox VE. The next phase was designing the topology of the virtualization infrastructure and conducting the migration in stages. After the migration was fully done, the evaluation on the web server performance was conducted by using the ApacheBenchmark. Then, the analysis and the calculation of the server cost and the network cost were done following the migration of the whole infrastructure to the virtual environment.

3. Research Method

This research used the field research method by conducting the design, implementation, and evaluation of performance of virtualization as well as the calculation of the server cost and the network cost toward the data center virtualization infrastructure by using the Proxmox Virtual Environment at the data center of the ICT Center of the Faculty of Teacher Training and Education, Sebelas Maret University.

3.1 Design and Implementation of Virtualization

Figure 1 and Figure 2 below shows the topology before and after implementing virtualization in the data center FKIP UNS.

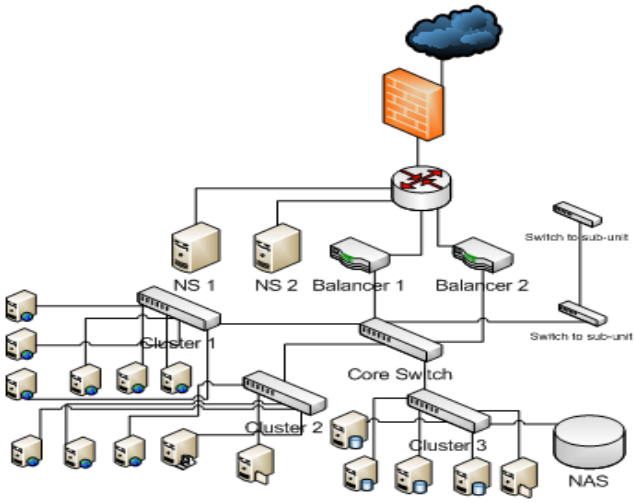

Figure 1: Topology of the Data Center Prior to Virtualization

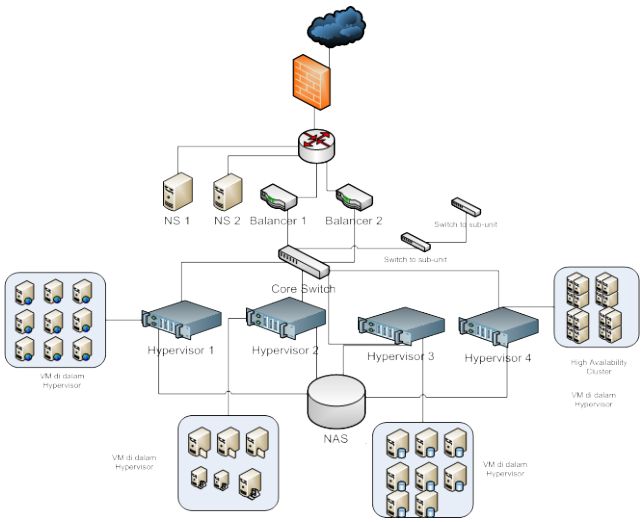

Figure 2: Topology of the Data Center with Virtualization

Figure 2 shows the proposed typology of virtualization at the data center, which would be used to replace the conventional typology, which still uses the physical server as shown in Figure 1.

3.2 Web Server Performance Measurement

In the measurement of performances, the comparison between the performances of the virtual server and those of the physical server (the conditions prior to the migration) was

conducted. It was intended to investigate the difference of the performances following the migration from the physical server to the virtual server.

The evaluation on the performance was done by load testing toward the web servers with different functions. The web servers tested in this research among others are as follows:

- web server of digilib (digilib.fkip.uns.ac.id)
- web server of lecturer information system (dosen.fkip.uns.ac.id)
- web server of graduation information system (wisuda.fkip.uns.ac.id)
- web server of e-learning(semar.fkip.uns.ac.id)
- web server of cloud storage (educloud.fkip.uns.ac.id)

The evaluation of load testing was done by testing the performances of the web servers by using ApacheBench tools. ApacheBench simulated the virtual clients in which each client did request to the http service at each server[9][12]. From the evaluation, the response of web server (http response) and the time required to respond each http request occurred. Of the two results, 2 parameters of request per seconds and time per request (in the unit of milliseconds) were measured[11].

During the evaluation in the virtual environment of the web servers of digilib, lecturer information system, graduation information system, educloud, and e-learning were installed at the server of Dell Poweredge with the processor specification of Intel® Xeon® Processor E5520, 2.26 GHz. On the rack server, there were 16 physical CPUs, and each VM used for the testing was given allocation of 1 CPU and 1 Gigabyte RAM. Meanwhile, the evaluation in the non-virtual environment was done by installing the servers of digilib, lecturer information system, graduation information system, educloud, and e-learning at the physical machine with the processor specification of Intel Centrino M 2.2 GHz and memory of 1 gigabyte.

In the performance testing, the comparison of performances which included *request per seconds* and *time per request* and Total Request on the *web servers* were done. The parameters of the information system at the virtual server environment were then compared to the ones of the information system at the physical server environment. During this comparison testing, the specification of the clock processor and the capacity of memory of the virtual server were configured so as to have the source with the same value as the specification of the clock processor and the capacity of memory of the physical server.

3.3 The Calculation of the Server Cost and the Network Cost

The cost analysis was done on the server cost and network cost. The calculation of the server cost and the network cost by using the TCO metric formula of Gartner[13] was done with the following method:

- Server Cost = VIps * Ns * Arp(time), (I)
  with;
  VIps = the price per physical server used.
  Ns = the number of physical servers used.
  Arp (time) = the amount of asset shrinkage (value depreciation is calculated using the straight-line method, ie the price of goods divided by the age of the life of the goods[14]).

- Network Cost = Ps * Ns * Arp (time); (II)
  with;
  Ps = the price per switch/router.
  Ns = the number of networks used.
  Arp(time) = The total amount od asset shrinkage.

Following the calculation using Formula (I) and Formula (II) for each physical server environment and virtual server environment, the comparison of the total cost for each calculation (the server cost and the network cost) was done. The result of the comparison was presented in table, indicating the total cost for each parameter (the server and the network).

4. The Result of Testing

4.1 Performance Measurement and Comparison

The following is the result of testing of the performance measurement and comparison between the physical web server and the virtual web server at the data center of the ICT Center of the Faculty of Teacher Training and Education, Sebelas Maret University. The testing is done by using ApacheBench so as to measure the request per seconds, time per request, and the total request for 60 seconds of testing period. During the measurement, ApacheBench does the http request at each web server by simulating the concurrent connections, which are increased in stages from one hundred connections to 2000 connections. Each connection is set up as such that it could send 1000 http requests to the web server. The result of the testing is then interpreted into a graph of comparison of request per seconds, time per request, dan the total request between the physical web server and the virtual web server.

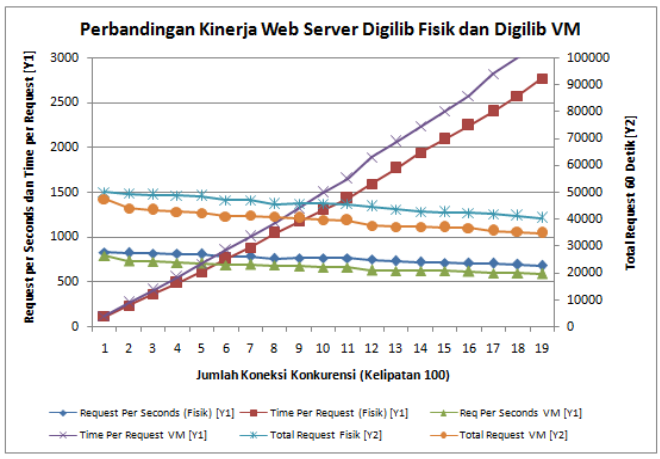

Figure 3: The Comparison of Performance between the Physical Web Server of Digilib and the Virtual Web Server of Digilib

Figure 3 shows that the physical server of digilib can thoroughly handle more request per seconds than the virtual server of digilib. The average decrease of the ability to handle the http request per seconds of the virtual server of digilib is 12.36% against the physical server of digilib, namely: from the average of 762 requests per second to 668

requests per second. The time required to handle each http request per seconds at the virtual server of digilib increases approximately 13.2% on average against the physical server of digilab, namely: from 1,359 milliseconds time per request to 1,567 milliseconds time per request. The total number of requests for 1 minute, is 45,446 http requests for the physical server and 39,772 http requests for the virtual server respectively. Thus the ability to handle all of the http requests for 60 seconds of the virtual server of digilib against the physical server of digilib decreased as much as 13.81%.

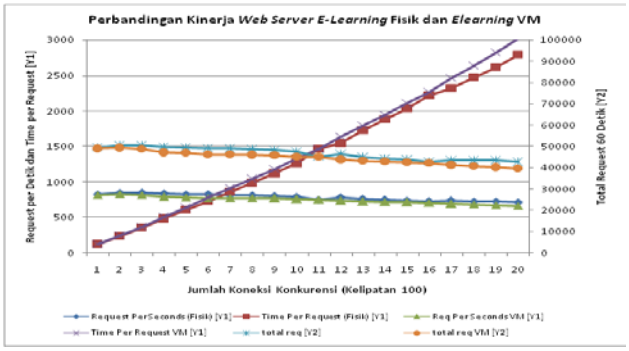

Figure 4: The Comparison between the Performance of the Physical Web Server of E-Learning and that of the Virtual Web Server of E-Learning

Figure 4 shows the decrease in the ability to handle the http request of the virtual server of e-learning as much as 4.25 % against the physical learning, that is, from the average of 780 requests per second to that of 745 requests per second. Meanwhile, the time required to handle each http request at the virtual server of e-learning per second increases up to 4.92% against the time required to handle each http request at the physical server of e-learning, namely: from 1,391 milliseconds per request to 1,463 milliseconds. The total number of requests for one minute for the server comparison is 46,701 http requests for the physical server and 44,682 http requests for the virtual sever. Therefore, the ability to handle all of the http requests for 60 seconds of the virtual server of e-learning against the physical server of e-learning decreases as much as 4.43%.

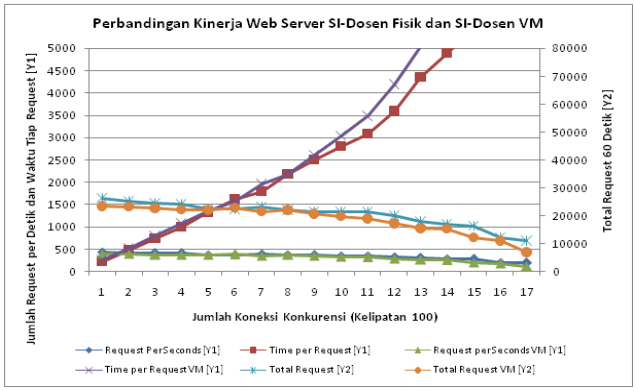

Figure 5: The Comparison between the Physical Web Server of the Lecturer IS and the Virtual Web Server of the Lecturer IS

Figure 5 shows the decrease in the ability to handle the http request per minute of the virtual server of the lecturer information system as much as 10.8 % against the physical server of the lecturer information system, namely: the decrease from the average of 343 http requests per second to 311 http requests per second. The time required to handle each http request per second at the virtual server of the lecturer information system increases up to 17.54% against the time required to handle each http request per second at the physical server of the lecturer information system, namely: the increase from 3,112 milliseconds per request to 3,774 milliseconds per request. The average number of the total requests for 1 minute for the comparison of the two servers is 20,472 http requests for the physical server and 18,639 http requests for the virtual requests. Thus, the ability to handle all of the http requests for 60 seconds of the virtual server of the e-learning against the physical server of the e-learning decreases as much as 9%.

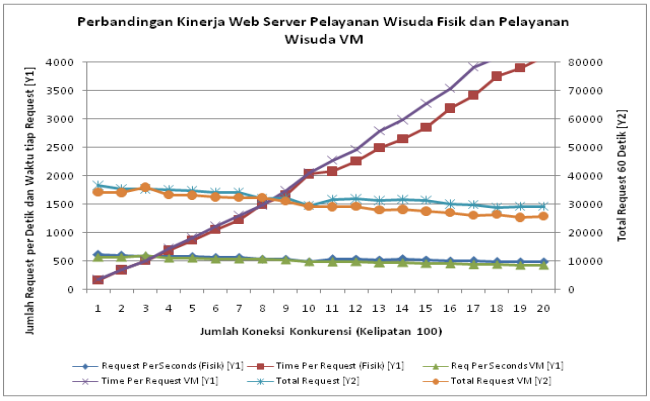

Figure 6: The Comparison of Performance between the Physical Web Server of the Graduation and the Virtual Web Server of the Graduation

Figure 6 shows the decrease in the ability to handle the http request per second of the virtual server of the graduation service as much as 7.3 % against the physical server of the graduation service, namely: from 537 requests per second to 500 requests per second. The time required to handle each http request at the virtual service of graduation service information increases up to 9.15 %, namely: from 2,035 milliseconds per request to 2,240 milliseconds per request. The number of the total requests for one minute for the comparison of the two servers is 32,184 http requests for the physical server and 30,014 http requests for the virtual server. Thus, the ability to handle all of the http requests for 60 seconds of the virtual server of the e-learning decreases as much as 6.74%.

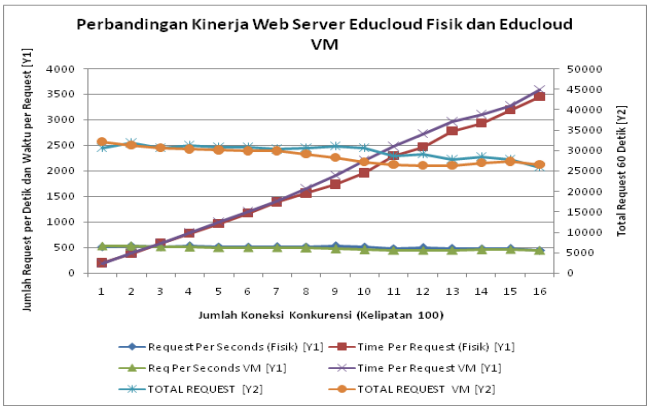

Figure 7: Comparison between the performance of physical Web Educloud of Digilib and that of Virtual Web Educloud of Digilib

Figure 7 shows the decrease in the ability to handle http request per seconds by virtual server of educloud as much as 4.45% against the physical server of educloud, namely: from 484 requests per second to 465 requests per second. The time required to deal with each http request on the virtual server of educloud per second increases up to 5.70% on average toward the physical server of educloud, namely: from 1736 milliseconds for each request on average to 1841 milliseconds. The average number of the total requests for one minute of test to compare the two different servers is 29.752 http requests for the physical server and 28.620 http requests for the virtual server respectively. Thus, the ability to handle the entire http request for 60 seconds between the virtual server of educloud and the physical server of educloud decreases as much as 3.80%.

4.2 The Calculation of the Server Cost and the Network Cost

Table 1: Data Center with Physical Server

Data Center with Physical Server			
Variant	*Quantity*	*Cost (IDR)*	*Amortization (IDR)*
IBM System X3550 M2 7946 - Dual-Core Xeon E5502 1.86 Ghz	5	84.013.845	42.006.922,5
HP PROLIANT ML 150G6-131 Intel Xeon E5502-1.86 GHz	2	22.500.000	11.250.000
IBM 3650 M4 Express X *Server* System X Intel Xeon 1.8GHz	3	44.654.100	16.745.287,5
IBM System x3650 M2 7947 - Xeon E5520 2,26 GHz	2	39.640.362	14.865.135,75
HP DX2710 Tower Core 2 Quad Q9400	1	8.200.000	3.075.000
HP Proliant ML110G7 Intel Core i3 2100-3.1 Ghz	1	11.338.651	4.251.994,125
DELL POWER EDGE T110 II-E3 1230 Intel XEON E3 1220 - 3.1Ghz	1	11.225.151	2806287,75
POWEREDGE R710 E5520 2.26GHz	3	117.179.094	14.647.386
Quantity		338.751.203	109.648.013,625
***SERVER* COST**			448.399.216,6

Table 2: Data Center with Virtual Server

Data Center with Virtual Server			
Variant	*Quantity*	*Cost (IDR)*	*Amortization (IDR)*
POWEREDGE R710 E5520 2.26 GHz	3	117.179.094	14.647.386,75
Ibm System X3550 M2 7946 - Dual-Core Xeon E5502 1.86 Ghz	4	67.211.076	33605538
Quantity		184.390.170	48.252.924,75
Server Cost			232.643.094,8

Table 1 and Table 2 show the comparison of the server ownership cost, which indicates that the implementation of data center virtualization at the ICT Center of the Faculty of Teacher Training and Education, Sebelas Maret University, can reduce the cost for servers up to 8.11 %, or can also be interpreted that the ICT Center of the Faculty of Teacher Training and Education, can save as much as Rp215, 756, 121.8

Table 3: Data Center with Physical Network

Data *Center* with Physical Network			
Variant	Quantity	Cost (IDR)	Amortization (IDR)
NETGEAR Prosafe Plus Switch 24-port	3	8.421.600	10.105.920
Mikrotik Routerboard 1100 AH	1	5.554.500	3.332.700
Switch TP-LINK TL-SG1024 24 ports	2	2.479.400	1.983.520
TP-LINK SL2218*WEB* 16-ports 10/100Mbps	2	1.887.600	1.887.600
Quantity		18.343.100	17.309.740
Network Cost			35.652.840

Table 4: Data Center with Virtual Network

Data Center with Virtual Network			
Variant	Quantity	Cost (IDR)	Amortization (IDR)
NETGEAR Prosafe Plus Switch 24-port Gigabit Ethernet [JGS524E]	2	5.614.400	6.737.280
Mikrotik Routerboard 1100 AH	1	5.554.500	3.332.700
TP-LINK TL-SL2218*WEB* 16-ports 10/100Mbps + 2-ports Gigabit	1	943.800	943.800
Quantity		12.112.700	11.013.780
***Network Cost* (Harga Total + Amortisasi Total)**			23.126.480

Tables 3 and 4 show the comparison of network ownership cost, indicating that the implementation of the virtualization of the data center of the ITC Center of the Faculty of the Teacher Training and Education, Sebelas Maret University can reduce the cost for the network up to 35.134%, or it can be interpreted that the ICT Center of the Faculty of the Teacher Training and Education, Sebelas Maret University can save as much as Rp12,526,630.

5. Conclusion

The implementation of server virtualization can be done in the unit of the ICT Center of the Faculty of Teacher Training and Education, Sebelas Maret University by using the open source-based virtualization software, Proxmox VE. The limitation in the server hardware specification is not a problem for the implementation this virtualization as long as the processor used is 64 bit basis and supports the virtualization and hyperthreading technology.

Web server operating within the virtual environment is still able to serve its users as similarly as the one operating within the physical server is. Several results of the statistical analysis show the performance decreases as follows: (1) the average of the whole server performance decrease analyzed for request per seconds is 7.8%; (2) the whole server performance decrease analyzed in term of the time required to serve each http request is 10.11 %; and (3) the average of the whole virtual server performance decrease in handling the http request for 60 seconds of test is 7.56%.

The ICT Center of the Faculty of Teacher Training and Education, Sebelas Maret University can save the costs for the server and the network up to 48.11 % and 35.134 % respectively.

6. Future Works

The scope of research on the server virtualization can still be developed into several domains such as discussing about the safety of server virtualization environment, disaster recovery, service level agreement, and reliability of virtual server which operates in the hypervisor environment.

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