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Analysis of The Utilization and Implementation of Cloud Computing Infrastructure Services on The Azure Microsoft Platform

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ABSTRACT

This final project discusses cloud computing infrastructure services, where cloud computing is the evolution of various computing technologies that have existed since the early 1960s. This final project will discuss cloud computing infrastructure services on the Microsoft Azure platform. Microsoft Azure is a hyperscale cloud computing platform that has many services, one of which is infrastructure as a services. DNS server implementation will be carried out to test the functionality of the Microsoft Azure service. Analysis of the performance of both the processor compute, memory bandwidth, network throughput and storage media performance will be tested and compared with the on-premise system. The applications used for performance testing are LINPACK, STREAM, iperf and also fio. The on-premise system being compared is a virtualization-based system using the VMware vSphere platform and hardware specifications that are made closer to the server specifications on Microsoft Azure. Costs incurred for operations and investment as total cost of ownership of an on-premise infrastructure system with Microsoft Azure infrastructure services will be compared, including the costs required to implement a server on an on-premise system with implementation on Microsoft Azure.

1. Introduction

Information technology is one of the crucial things in business processes. All business processes must require information technology. In today's digital era, infrastructure technology is needed to accelerate and simplify one's work style. Not to mention the trend of bring your own device which has started to be embraced by many people today, where this trend can actually be used so that we can carry out productivity wherever we are. Connectivity, as well as accessibility, is the key to a dynamic, fast, and anywhere work process. Smartphones, laptops, tablet computers are a number of commodities that are not only owned by special groups, so that adaptation to mobile-based technology and services will be very fast and easy.
To provide computing services, especially those that can connect with many people in real time, we need a compute infrastructure service. Computing infrastructure services allow us to provide several application services, either directly or indirectly, to the application users. For example, when we are going to create a website that can be accessed by the public, we need a server. The server will serve the application content that we created to the user. The server itself is actually a software and hardware system integrated into a single unit, namely a computer system consisting of a CPU, memory, and storage media.

To implement servers, especially those that can be accessed by the public and must continue to operate 24 hours a day, there are several other components that must be implemented as well, for example the datacenter room, internet network, network devices, datacenter security systems, and server software platforms. itself. In general, for a company to run a capable server and have a good service level, it requires a large investment and complex operational techniques. For all these things, cloud computing infrastructure services will be very useful and valuable for a company. This is because cloud computing infrastructure services are in the form of third party resource systems that we can access online, so that we can lease them from third parties flexibly in their use. With these problems, the authors want to help companies overcome problems related to servers, namely by analyzing the use of cloud computing-based infrastructure services on the Microsoft Azure platform so that companies can provide reliable and flexible application services according to the needs of the company itself.

2. Research Methods

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In this study, the authors to be able to collect data or generate data, the authors use several methods:

2.1 Method of collecting data

The data collection methods used in this study are:

a. Observation
the author goes directly to the field to observe, understand the situation carefully, deeply and focused on the research subject.

b. Literature Study
In this literature study, the author visits the library by collecting books as reference material or theoretical basis relevant to the problem being studied.

2.2 Method of collecting data

The analytical methods used in this research are:

a. Analyze data and information to get an overview of the cloud computing system that will be implemented
b. Perform analysis related to the infrastructure topology used
c. Analyze hardware and software that are being used

2.3 Design Methods

The design methods that will be used in this research are:

a. Designing server implementations in cloud computing infrastructure services with the type of public cloud.
b. Simulating the use of cloud computing infrastructure services on the Microsoft Azure platform.

3. Result and Discussion

3.1 Specifications and Topology of Infrastructure Services to be Analyzed

The author will conduct a comparative analysis of various aspects of both technical installations, technical performance and costs between infrastructure that is implemented using either the Microsoft Azure platform and also on-premise infrastructure. As a comparison system in the analysis of implementation and performance, the authors prepare an on-premise infrastructure whose comparison can be seen in the table below.

Table 1
Analyzed Server Hardware Configuration

Konfigurasi Hardware *Server*	**Microsoft Azure**	***On-premise***
Platform fisik *hardware server*	Tidak diketahui	DL360 Gen10
Processor	Intel Xeon Platinum 8272CL, Intel® Xeon 8171M 2.1GHz, Intel® Xeon® E5-2673 v4 2.3 GHz, atau Intel® Xeon® E5-2673 v3 2.4 GHz	Intel Xeon Silver 4216 2.1 GHz
Memori	Tidak diketahui	256GB DDR4 2666MHz *ECC Registered*
Network Interface	Tidak diketahui	4 port 1 *gigabit ethernet* untuk t*raffic VM* & manajemen, 2 port 10 *gigabit* untuk *traffic storage*
Platform virtualisasi	Hyper-V yang sudah dimodifikasi	vSphere Standard 7.0 Update 1
Platform manajemen	Microsoft Azure	vCenter Standard 7.0 Update 1

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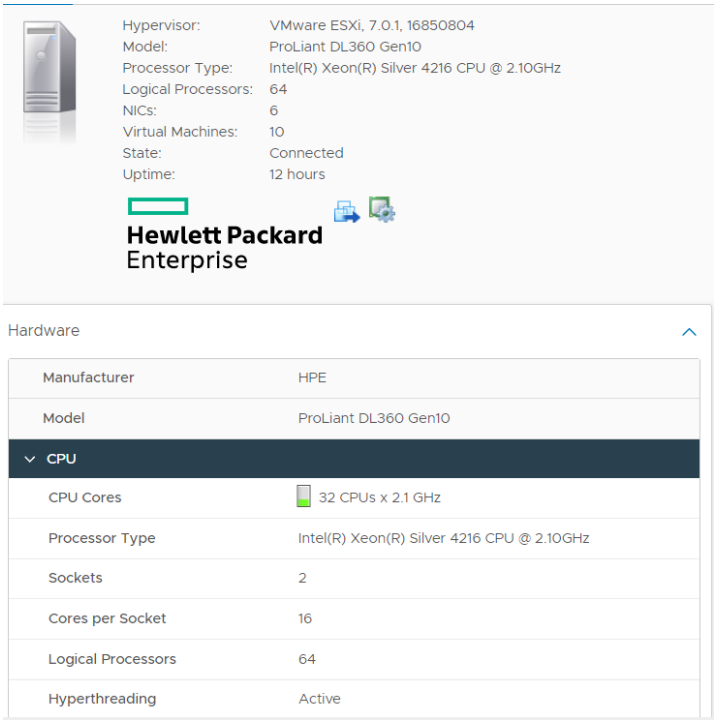

Fig 1 Display of Host Hardware Information on On-Premise Systems

The storage media that is analyzed has specifications which we can see in the table below.

Table 2
Analyzed Hardware Storage Configuration

Konfigurasi Hardware *Storage*	**Microsoft Azure**	***On-premise***
The type of storage used	*Network storage*, Unknown model	*Network storage*
The storage platform used	Unknown	MSA 2050 LFF SAN
Storage and host interconnection used	Unknown	8 port 10 *Gigabit Ethernet* lewat *direct attached cable* untuk *traffic* data yang melewati *switch storage*.
Switch Storage	Unknown	Nexus 7000 Series
The disc used	Mechanical Disc Standard, size, level *RAID*, spin speed unknown.	*Mechanical Disk* 8TB 7200 rpm x 8 dan 4 SSD 800GB *Mixed Use* for *read cache*. *volume configuration* 4x8TB *RAID 5* + 2 x 800GB *SSD RAID 0*.
The protocol used	Unknown	iSCSI with option *multipath round-robin* active.

3.2 Performance Analysis and Comparison of On-premise-based Infrastructure Service Installation with Microsoft Azure Cloud Computing

In this section, the author will compare the performance and comparison in terms of the installation of infrastructure services between those based on premise and those using Microsoft Azure cloud computing. On the on-premise server, we can access the vCenter Server to manage and create virtual machines. The process of creating a virtual machine is almost the same as what is done in Microsoft Azure, but the procedure is simpler. The workflow of the server implementation above the on-premise system can be seen in Figure 4.4.

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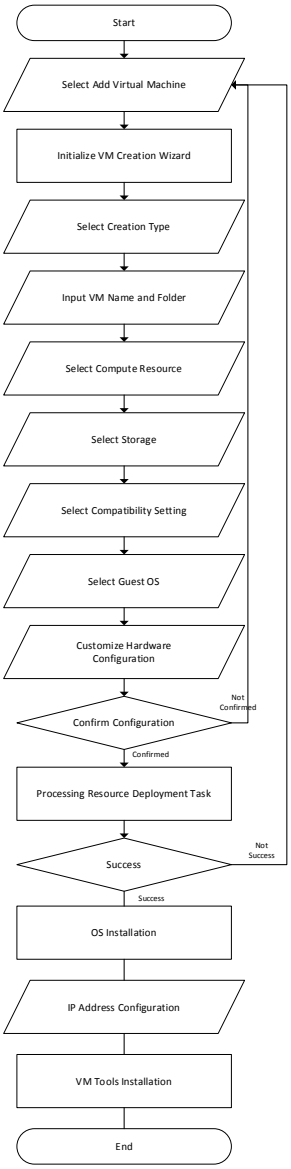

Fig 2 Server Implementation Workflow on On-Premise Systems

To show the difference between the server implementation process on the Microsoft Azure platform and the on-premise system, it can be seen in the table below.

Table 3

Server Implementation Process Differences between Microsoft Azure and on-premise systems

Komponen	**Microsoft Azure**	***On-premise***
Hardware host selection	This can be done if you use a dedicated host service.	Yes, as needed.
Availability Set	Yes	Yes
Customize VM specifications	can't, you have to choose a package that is already available.	Yes, the specifications can be adjusted according to your needs as long as they do not exceed the existing hardware capacity.
Storage selection options	Yes, *Standard HDD*, *Standard SSD*, *Premium SSD*.	Yes, but it depends on the hardware that has been implemented.
Stack SDN	Yes, using virtual networks and other related services.	Yes, but depending on the type of VMware product used.

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Komponen	**Microsoft Azure**	***On-premise***
Configuration n*etwork*ing *VM*	Can be done on the dashboard, both IP address, access control list, virtual network and others.	In vCenter can only do port group configuration (same as virtual switch). IP addresses and access control lists must be done by means of accessing virtual machines or other methods.
Network Isolation Conditions	Yes, each virtual machine uses a network isolation configuration that has been set by Microsoft. Virtual machine access to the outside environment is separated by a Network Address Translation gateway.	Yes, each virtual machine can use a specific port group that is layer 2 separate even though they are on the same host. This system does not manage Network Address Translation or routing configurations, so virtual machines can be freely connected to the network.
Template-based VM installation	Yes, through Marketplace or Bring Your Own Image.	For VMware products that are used, template-based VM installations are not available.
Autoscaling	Available	Not available, you must use vCloud Suite to be able to use the autoscaling feature.

Installing a virtual machine on an on-premise system is simpler, but more time consuming. This is because if we implement a server in Microsoft Azure, we can choose an image that has been provided on the Marketplace. Whereas on an on-premise system, we have to install the virtual machine operating system manually like on a physical server, and have to configure the IP address manually. The comparison of virtual machine implementation time on Microsoft Azure with on-premise systems from initial initiation until the virtual machine can be accessed remotely using SSH can be seen in the table below.

3.3 Virtual Machine Performance Analysis on Microsoft Azure Cloud Computing Infrastructure services

Pada bagian ini, penulis akan menganalisa dan membandingkan performansi virtual machine pada layanan infrastruktur cloud computing Microsoft Azure dengan sistem infrastruktur on-premise berbasis virtualisasi. Ada beberapa parameter yang akan dianalisa, diantaranya :

a. Performa komputasi prosesor
b. Performa bandwidth memori
c. Performa throughput jaringan virtual machine
d. Performa media penyimpanan

Analisa performa akan menggunakan virtual machine yang sudah diimplementasikan sebelumnya, dan memiliki spesifikasi semirip mungkin sebagaimana yang telah dijelaskan pada bagian sebelumnya.

a. Analisa Performa Komputasi Prosesor

Untuk analisa performa komputasi CPU, kita akan melakukan pengujian performa menggunakan LINPACK. Pada pengujian ini, penulis menggunakan binary pre-compiled LINPACK yang disediakan oleh Intel. Terkait parameter pengujian, penulis akan menggunakan file sample testing, dimana file ini mendefinisikan pengujian berulang dengan beberapa variabel yang berbeda dengan rincian sebagai mana yang bisa kita lihat pada Fig dibawah.

```
Number of tests: 15
Number of equations to solve (problem size) : 1000  2000  5000  10000 15000 18000 20000 22000 25000 26000 27000 30000 35000 40000 45000
Leading dimension of array                  : 1000  2000  5008  10000 15000 18008 20016 22008 25000 26000 27000 30000 35000 40000 45000
Number of trials to run                     : 4     2     2     2     2     2     2     2     2     2     1     1     1     1     1
Data alignment value (in Kbytes)            : 4     4     4     4     4     4     4     4     4     4     4     1     1     1     1
```

Fig 3 Variabel Pengujian LINPACK

Pengujian akan dilakukan kepada masing masing salah satu virtual machine yang berada di Microsoft Azure dan juga yang berada di sistem on-premise.

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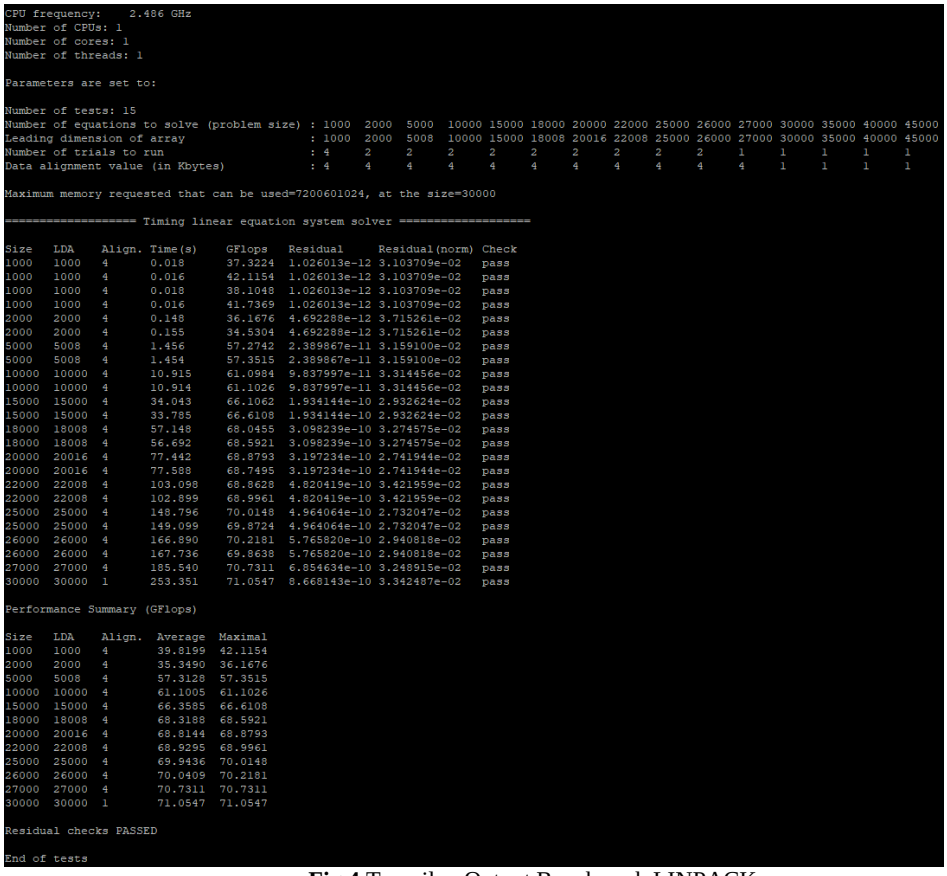

```
CPU frequency:    2.486 GHz
Number of CPUs: 1
Number of cores: 1
Number of threads: 1

Parameters are set to:

Number of tests: 15
Number of equations to solve (problem size) : 1000  2000  5000  10000 15000 18000 20000 22000 25000 26000 27000 30000 35000 40000 45000
Leading dimension of array                  : 1000  2000  5008  10000 15000 18008 20016 22008 25000 26000 27000 30000 35000 40000 45000
Number of trials to run                     : 4     2     2     2     2     2     2     2     2     2     1     1     1     1     1
Data alignment value (in Kbytes)            : 4     4     4     4     4     4     4     4     4     4     1     1     1     1     1

Maximum memory requested that can be used=7200601024, at the size=30000

================== Timing linear equation system solver ==================

Size   LDA    Align. Time(s)    GFlops   Residual     Residual(norm) Check
1000   1000   4      0.018      37.3224  1.026013e-12 3.103709e-02   pass
1000   1000   4      0.016      42.1154  1.026013e-12 3.103709e-02   pass
1000   1000   4      0.018      38.1048  1.026013e-12 3.103709e-02   pass
1000   1000   4      0.016      41.7369  1.026013e-12 3.103709e-02   pass
2000   2000   4      0.148      36.1676  4.692288e-12 3.715261e-02   pass
2000   2000   4      0.155      34.5304  4.692288e-12 3.715261e-02   pass
5000   5008   4      1.456      57.2742  2.389867e-11 3.159100e-02   pass
5000   5008   4      1.454      57.3515  2.389867e-11 3.159100e-02   pass
10000  10000  4      10.915     61.0984  9.837997e-11 3.314456e-02   pass
10000  10000  4      10.914     61.1026  9.837997e-11 3.314456e-02   pass
15000  15000  4      34.043     66.1062  1.934144e-10 2.932624e-02   pass
15000  15000  4      33.785     66.6108  1.934144e-10 2.932624e-02   pass
18000  18008  4      57.148     68.0455  3.098239e-10 3.274575e-02   pass
18000  18008  4      56.692     68.5921  3.098239e-10 3.274575e-02   pass
20000  20016  4      77.442     68.8793  3.197234e-10 2.741944e-02   pass
20000  20016  4      77.588     68.7495  3.197234e-10 2.741944e-02   pass
22000  22008  4      103.098    68.8628  4.820419e-10 3.421959e-02   pass
22000  22008  4      102.899    68.9961  4.820419e-10 3.421959e-02   pass
25000  25000  4      148.796    70.0148  4.964064e-10 2.732047e-02   pass
25000  25000  4      149.099    69.8724  4.964064e-10 2.732047e-02   pass
26000  26000  4      166.890    70.2181  5.765820e-10 2.940818e-02   pass
26000  26000  4      167.736    69.8638  5.765820e-10 2.940818e-02   pass
27000  27000  4      185.540    70.7311  6.854634e-10 3.248915e-02   pass
30000  30000  1      253.351    71.0547  8.668143e-10 3.342487e-02   pass

Performance Summary (GFlops)

Size   LDA    Align.  Average  Maximal
1000   1000   4       39.8199  42.1154
2000   2000   4       35.3490  36.1676
5000   5008   4       57.3128  57.3515
10000  10000  4       61.1005  61.1026
15000  15000  4       66.3585  66.6108
18000  18008  4       68.3188  68.5921
20000  20016  4       68.8144  68.8793
22000  22008  4       68.9295  68.9961
25000  25000  4       69.9436  70.0148
26000  26000  4       70.0409  70.2181
27000  27000  4       70.7311  70.7311
30000  30000  1       71.0547  71.0547

Residual checks PASSED

End of tests
```

Fig 4 Tampilan Output Benchmark LINPACK

Hasil pengujian LINPACK dari virtual machine yang berada di Microsoft Azure bisa dilihat pada tabel dibawah ini.

Tabel 4
Hasil Pengujian LINPACK pada Microsoft Azure

Equation Size	***LDA***	***Alignment***	***Average* (GFLOPS)**	***Maximal* (GFLOPS)**
1000	1000	4	39,8199	42,1154
2000	2000	4	35,3490	36,1676
5000	5008	4	57,3128	57,3515
10000	10000	4	61,1005	61,1026
15000	15000	4	66,3585	66,6108
18000	18008	4	68,3188	68,5921
20000	20016	4	68,8144	68,8793
22000	22008	4	68,9295	68,9961
25000	25000	4	69,9436	70,0148
26000	26000	4	70,0409	70,2181
27000	27000	4	70,7311	70,7311
30000	30000	1	71,0547	71,0547

Perbandingan antara kedua sistem ini dapat dilihat pada grafik dibawah ini.

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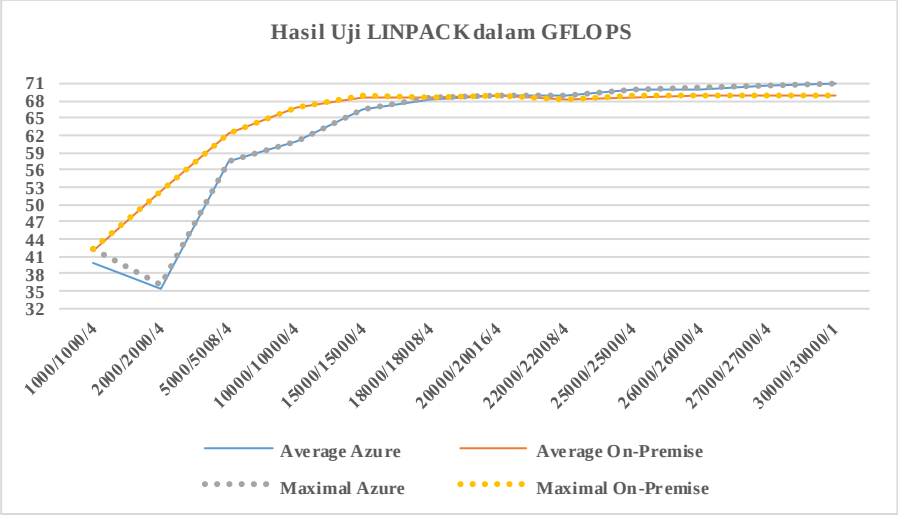

Fig 5 Grafik Perbandingan Hasil Uji LINPACK

Dari pengujian ini, sistem on-premise lebih unggul dalam pengujian 1000/1000 hingga pada pengujian 18000/18008, sedangkan server pada Microsoft Azure lebih unggul pada pengujian 22000/22008 hingga pengujian 30000/30000.

b. Analisa Performa Bandwidth Memori

Pada pengujian *bandwidth* memori, penulis akan menggunakan sebuah aplikasi yang bernama *STREAM*. Sebelum kita melakukan pengujian, aplikasi *STREAM* perlu dikompilasi terlebih dahulu agar menjadi sebuah *binary* aplikasi yang dapat dipergunakan untuk keperluan pengujian.

```
-------------------------------------------------------------
STREAM version $Revision: 5.10 $
-------------------------------------------------------------
This system uses 8 bytes per array element.
-------------------------------------------------------------
Array size = 100000000 (elements), Offset = 0 (elements)
Memory per array = 762.9 MiB (= 0.7 GiB).
Total memory required = 2288.8 MiB (= 2.2 GiB).
Each kernel will be executed 20 times.
 The *best* time for each kernel (excluding the first iteration)
 will be used to compute the reported bandwidth.
-------------------------------------------------------------
Number of Threads requested = 2
Number of Threads counted = 2
-------------------------------------------------------------
Your clock granularity/precision appears to be 1 microseconds.
Each test below will take on the order of 60200 microseconds.
   (= 60200 clock ticks)
Increase the size of the arrays if this shows that
you are not getting at least 20 clock ticks per test.
-------------------------------------------------------------
WARNING -- The above is only a rough guideline.
For best results, please be sure you know the
precision of your system timer.
-------------------------------------------------------------
Function    Best Rate MB/s  Avg time     Min time     Max time
Copy:           28508.3     0.057557     0.056124     0.064153
Scale:          16855.6     0.097084     0.094924     0.107235
Add:            18524.2     0.131308     0.129560     0.143761
Triad:          18541.1     0.131352     0.129442     0.140478
-------------------------------------------------------------
Solution Validates: avg error less than 1.000000e-13 on all three arrays
-------------------------------------------------------------
```

Fig 6 Output Pengujian Menggunakan Tool STREAM

Hasil pengujian STREAM pada *virtual machine* di Microsoft Azure dapat kita lihat pada tabel dibawah ini.

Tabel 5
Hasil Pengujian STREAM pada Microsoft Azure

Function	Best Rate MB/s	Avg time	Min time	Max time
Copy	10575,4	0,154868	0,151295	0,169738
Scale	122275,8	0,133345	0,130338	0,138958
Add	12666,6	0,195048	0,189475	0,202254
Triad	12545,2	0,195179	0,191308	0,198710

Sedangkan hasil pengujian pada *virtual machine* di sistem *on-premise* dapat kita lihat pada tabel dibawah ini.

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Tabel 6
Hasil Pengujian STREAM pada Sistem On-premise

Function	Best Rate MB/s	Avg time	Min time	Max time
Copy	28508,3	0,057557	0,056124	0,064153
Scale	16855,6	0,097084	0,094924	0,107235
Add	18542,2	0,131308	0,129560	0,143761
Triad	18541,1	0,131352	0,129442	0,140478

Pada pengujian ini, terlihat jelas bahwa virtual machine di sistem on-premise lebih unggul dari segala aspek terkait masalah bandwidth memori dibandingkan dengan virtual machine pada layanan infrastuktur cloud computing Microsoft Azure.

3.4 Cost Analysis and Comparison between On-premise-based Infrastructure Service Implementation and Microsoft Azure Cloud Computing

Pada bagian analisa biaya ini, penulis akan melakukan analisa biaya operasional untuk implementasi server serta biaya operasional dan juga investasi antara penggunaan sistem on-premise dengan menggunakan Microsoft Azure. Beberapa poin penting yang menjadi catatan dalam analisa ini adalah :

a. Pada analisa ini, untuk sistem *on-premise* akan diasumsikan bahwa pengguna infrastruktur menggunakan jasa layanan *colocation* dari pihak ketiga pada datacenter yang memiliki sertifikasi *tier III* ke atas (dengan asumsi biaya Rp 6.000.000 per bulan untuk *colocation 3U, bandwidth IIX up to* 1 Gbps, *bandwidth IX up to* 10 Mbps, alamat *IP* publik statik /29).
b. Untuk sistem *on-premise* diasumsikan tidak dihitung dengan biaya instalasi fisik *hardware* pada *datacenter*.
c. Pada sistem *on-premise hardware* yang diasumsikan diperhitungkan biayanya menggunakan *hardware* yang berbeda dari spesifikasi yang dipergunakan dengan analisa performa dan implementasi. *Hardware* yang digunakan untuk analisa biaya ini spesifikasinya dibuat mendekati dengan kebutuhan 2 *virtual machine* yang dipergunakan untuk analisa performa secara kumulatif, serta mempertimbangkan hal lain yang hubungannya terkait dengan *high availibility* dari sebuah sistem.
d. *Hardware* pada sistem *on-premise* merupakan satu kesatuan lengkap dari *server* dan *Storage Area Network*.
e. Analisa ini akan menggunakan beberapa harga retail tertinggi *hardware* yang tersedia pada website resmi Hewlett Packard Enterprise (https://h22174.www2.hpe.com/SimplifiedConfig/Welcome) yang diasumsikan mendapatkan diskon 20%.
f. Sumber daya manusia yang diasumsikan sebagai orang yang mengelola dan memelihara sistem infrastruktur sebanyak 1 orang diasumsikan memiliki gaji sebesar Rp 7.000.000 / bulan (diatas UMK Kota Bandung di tahun 2020).
g. Analisa ini akan mengasumsikan analisa biaya diperhitungkan dalam waktu 5 tahun operasional 3 tahun dalam penyusutan biaya *hardware* dan *hardware refresh* dengan asumsi biaya penggunaan sumber daya Microsoft Azure, biaya investasi *hardware*, biaya *colocation* dan gaji SDM tetap sama selama 5 tahun.
h. Analisa ini mengasumsikan *traffic* data *outbound* dari Azure tiap bulan sebesar 100GB untuk masing-masing virtual machine.

Pada penggunaan Microsoft Azure, kita tidak perlu mengeluarkan biaya tambahan untuk menggaji SDM khusus, dikarenakan sisi infrastruktur sudah dikelola oleh Microsoft sehingga tidak diperlukan lagi SDM khusus untuk keperluan pengelolaan tersebut. Komparasi total cost of ownership antara sistem on-premise dengan penggunaan Microsoft Azure dapat dilihat pada grafik dibawah ini.

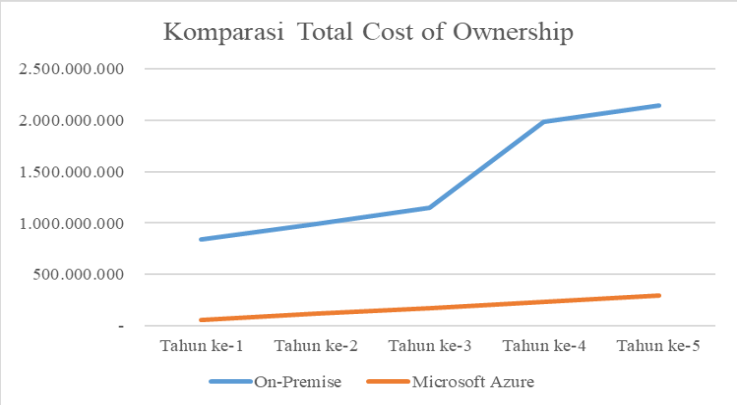

Fig 7 Grafik Komparasi Total Cost of Ownership Microsoft Azure dengan Sistem On-Premise

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Dari hasil analisa tersebut tampak jelas bahwa penggunaan Microsoft Azure memiliki total cost of ownership yang jauh lebih rendah ketimbang menggunakan sistem on-premise. Jika kita melakukan analisa juga terhadap biaya yang ditimbulkan untuk SDM dalam melakukan implementasi server, antara menggunakan Microsoft Azure dengan menggunakan sistem on-premise, dengan melakukan perhitungan biaya asumsi menggunakan biaya gaji SDM sebelumnya dikalikan dengan waktu yang dibutuhkan untuk implementasi, dapat dilihat pada grafik dibawah ini.

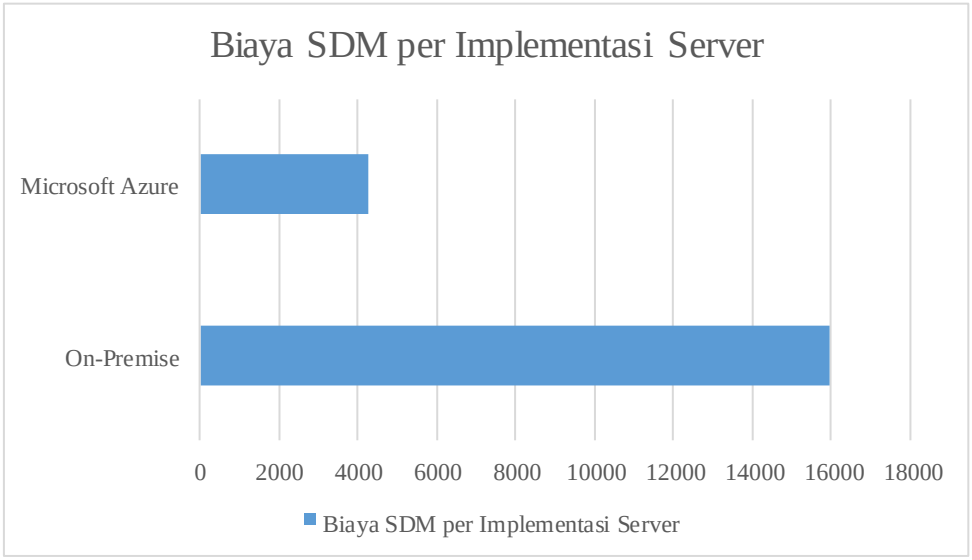

Fig 8 Grafik Perbandingan Biaya SDM per Implementasi Server antara Microsoft Azure dengan Sistem On-Premise

4. Conclusion

At the end of this research, the writer will try to give an explanation of some of the test results and analysis of this research. Broadly speaking, the authors conclude that the use of cloud computing infrastructure services on the Microsoft Azure platform can replace the function of conventional computing services based on on-premise, and overall cloud computing infrastructure services on the Microsoft Azure platform are cheaper both in investment and operationally compared to on-premise systems. premise although it has several shortcomings related to the performance of the infrastructure service itself. Specifically, the authors can draw the following conclusions:

a. The use of infrastructure services on the Microsoft Azure platform can completely replace the functionality of on-premise-based infrastructure services. This can be proven in the results of server implementation testing where the implemented DNS Server can function like a server implemented in an on-premise system.
b. The use of infrastructure services on the Microsoft Azure platform can reduce costs and time required to implement a server. This can be seen in the implementation test, where the server implementation on Microsoft Azure has a shorter time and costs less than on-premise systems.
c. Virtual machine performance on Microsoft Azure has shortcomings in terms of performance of storage media, network and memory bandwidth with hardware specifications that are assumed to be similar. Meanwhile, the processor computation performance between on-premise systems and Microsoft Azure is almost the same. This can be proven in the results of the performance tests carried out in the previous section.
d. Operational and investment costs from using infrastructure services on the Microsoft Azure platform are much lower than on-premise systems. We can see this by comparing the total cost of ownership in 5 years where the on-premise system is IDR 2,144,425,176 and Microsoft Azure is only IDR 293,343,840.

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5. References

Journal Article
[1] Briggs, Barry, and Eduardo Kassner. 2017. Enterprise Cloud Strategy 2nd Edition. Washington: Microsoft Press. 12-14.G. Smith, "Paper Title" (to be published).
[2] Bullynck, Maarten. 2019. What is an Operating System? A historical investigation (1954–1964). France:HAL
[3] C.H. Perry, F. Lu, F. Namavar, N.M. Kalkhoran, &R.A. Soref, "Paper Title" *In Proceeding of ICACSIS 2011*, pp. 456-541, 2010.
[4] Charles Phillips. 2018. "A look at the History of Cloud Computing". A look at the History of Cloud Computing | Charles Phillips. https://charlesphillips.me/a-look-at-the-history-of-cloud-computing/ (diakses 6 September 2020, 16:00).
[5] Crump, Michael and friends. 2020. The Developer's Guide to Azure. Washington: Microsoft Press. 50. *Theses, Dissertation*
[6] Dongarra, Jack J. and friends. 2012. The LINPACK Benchmark : past, present and future. Knoxville: John Wiley & Sons Ltd. 803-812.
[7] Furht, Borko, and Armando Escalante. 2010. Handbook of Cloud Computing. New York: Springer Science+Business Media. 9.
[8] H. Yamagishi, A. Hiroe, H. Nishio, K. Miki, K. Tsuge, & Y. Tawada, U.S. Patent No. 5264710, 23 Nov. 1993.
[9] Guthrie, Forbes and Scott Lowe. 2013. VMware vSphere Design Second Edition. Indianapolis:John Wiley & Sons Inc. 19-20,59.
[10] Liu, Cricket and Paul Albitz. 2006. DNS and BIND, Fifth Edition. Sebastopol:O'Reilly Media. 4,9,25-26.
[11] Tulloch, Mitch, and the Windows Azure team. 2013. Introducing Windows Azure For IT Professionals. Washington: Microsoft Press. 4, 31-39.
[12] Furht, Borko, and Armando Escalante. 2010. Handbook of Cloud Computing. New York: Springer Science+Business Media. 9.
[13] Mell, Peter, and Timothy Grance. 2011. The NIST Definition of Cloud Computing. Gathersburg: National Institute of Standards and Technology.