Analysis of K-means Algorithm For VM Allocation in Cloud Computing

Bramantyo Adrian
Department of Computer Science
Gadjah Mada University
Yogyakarta, Indonesia
bramantyo.adrian@mail.ugm.ac.id

Lukman Heryawan
Department of Computer Science
Gadjah Mada University
Yogyakarta, Indonesia
lukmanh@ugm.ac.id

***Abstract*—Cloud computing is known as dynamic service providers using physical resource or virtualized on the internet. Virtual machine technology is used by cloud computing client who do not require dedicated server. Important challenge in cloud computing is resource management to improve utilization. Virtual machine allocation method is one of the way to improve resource utilization in cloud computing. This research used a framework cloud simulator CloudSim version 3.0 and K-means clustering algorithm is used for virtual machine allocation method. Virtual machine allocation method using K-means clustering algorithm compared with existing FIFO algorithm on CloudSim. The test consists of two scenarios, first scenario each datacenter only has a host and the second scenario each datacenter has two hosts. In both scenarios have same amount of work. The analysis result obtained from both scenario is virtual machine allocation method using K-means is better than FIFO in virtual machine CPU utilization by reducing idle time and performing load balancing virtual machine in each datacenter.**

Keywords— Cloud Computing; Virtual Machine Allocation; K-means; CloudSim

I. INTRODUCTION

Nowadays cloud computing has become an interesting topic. Cloud computing is the next generation in resource management and cloud computing began to grow rapidly because customers do not need to think about maintenance, scalability, and security in the server, but customers can use full resources from the server. Individual and corporate customers can rent the cloud services through a third party cloud provider over the internet. Cloud services are divided into three main parts: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) [11].

Cloud computing becoming a popular solution for data storage and application execution with the provision of pay-per-use or paid in accordance with the resource usage only. Public cloud provided by many companies such as Amazon, Google, Microsoft, or Rackspace. For companies that want to create their own cloud systems, there are several solutions such as Eucalyptus, OpenStack, and Proxmox which serves a virtual environment for cloud systems. In the cloud computing model: infrastructure as a service, one of large problems is the use of resources on a virtual machine in which the resources on the virtual machine can be used like resources on real machines [4].

Allocation of the virtual machine is one of the keys in cloud computing to virtual sharing of physical machines in the datacenter and the efficiency of the allocation of virtual machines based on the algorithm used [7]. Each algorithm for allocation of a virtual machine has its advantages and limitations on their own in a cloud computing environment.

CloudSim is one of the open source framework that provides modeling, simulation, experimentation and management of infrastructure services on cloud computing infrastructure [6]. The above explanation is a challenge faced by cloud computing is increasing efficiency in cloud computing environments, one of solutions is to make better algorithm policy in the allocation of virtual machines on each host and datacenter.

II. RELATED WORK

The research by Patel and Sarje [3] is about virtual machine supply policy to increase the benefits of cloud infrastructure service providers and the methods used for the virtual machine allocation using load balancing algorithms in multiple datacenters. Rathore [4] conducted research on methods to increase the level of efficiency of the virtual machine allocation in cloud computing environments. Another research by Shah [6] about virtual machine allocation method in cloud computing using load balancing algorithms and methods used for the allocation of virtual machine is the development of Throttle Load Balancing Algorithm to estimate the response time of each virtual machine. Another research by Panchal and Kapoor [7] is allocating virtual machine dynamically in cloud computing, the virtual machine allocation using K-means clustering algorithms and the parameter is costs in the datacenter and clustering is done according to the number datacenter then each cluster is allocated on host in each datacenter. Another research by Kanakadurga and Veeramallu [10] is about the virtual machine allocation using K-means clustering algorithms and the parameter is energy savings and clustering is done according to the number of datacenter then allocated to the available hosts on the datacenter same as Panchal and Kapoor research. Subsequent research by Gong [9] is about the virtual machine allocation for near-client-datacenter in the cloud multimedia, methods that used for the

978-1-4673-8430-8/15/$31.00 ©2015 IEEE

virtual machine allocation of resources in the datacenter is a development heuristic algorithm which aims to minimize costs.

III. System Overview

A. Cloud Computing

Cloud Computing is a computing services over the internet network and the service allows individuals and businesses to use software and hardware managed by third parties anywhere. Cloud computing provides access to use the resource anywhere and anytime, cloud computing provide resources including data storage, networking, and computer processing to run a variety of applications by users.

Advantages of cloud computing for enterprises and ordinary users is the reduction of costs, increase the amount of storage, and flexibility. Reduction of costs because it does not need to provide physical computer, if the computer is provided physically, it can cause the required costs would be a bigger plus the cost of server maintenance, security, and others. Therefore with cloud computing only need to pay a rental fee according to the usage resource and it includes the cost of maintenance so with cloud computing will be very low when compared with the providing of a physical computer. The second advantage is the increased storage, as with cloud computing the amount of storage can be arranged according to users need. The third is the flexibility, cloud computing can adapt quickly when business conditions change.

Cloud computing service consists of Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Software as a Service (SaaS) is a model of service that gives the application directly through the internet with web browser. Some of these services are available free and the application can be used via a web browser. Platform as a Service (PaaS) is a service for customers who want to build applications and programming using programming languages, libraries, and tools supported by service providers. Infrastructure as a Service (IaaS) is a service provided to customers to use its full processing, storage, networking and computing resource where customers can run their own programs, including the operating system.

B. K-means Algorithm

Clustering is a method to divide a large dataset into small groups that have similar characteristics. Clustering method is widely used for the application of data mining, text mining, spatial data applications, and others. Pseudocode of basic K-means algorithm can be seen in Figure 1.

Algorithm Basic K-means algorithm.

1: Select K points as initial centroids.
2: **repeat**
3: Form K clusters by assigning each point to its closest centroid.
4: Recompute the centroid of each cluster.
5: **until** Centroids do not change.

Figure 1. Pseudocode K-means algorithm

According to Tan [12], techniques K-means clustering algorithm is a simple technique in clustering, starting from the selection of points as initial centroids K, where K is the number of clusters specified by the user. Every point in dataset made assignment to the nearest centroid and each set of points that have been made is called cluster. Centroid of each cluster then be updated based on the number of points or objects contained in the cluster. Assignment process and the update process will be repeated until the centroid position has not changed or the same as the previous iteration. One way to calculate the distance between the centroid and points is the Euclidian distance as in equation 1.

$$\delta(x,y) = \left(\sum_{i=1}^{d}(x_i - y_i)^2\right)^{1/2} \quad (1)$$

Where d is the number of attributes or dimensions of the objects x and y, then x_i is the i-th attribute of object x and y_i is the i-th attribute of the object y [13]. After distance calculating completed, then any point perform assignment at the nearest centroid. New calculations on each centroid cluster can be done with the equation 2.

$$\mathbf{c}_i = \frac{1}{m_i}\sum_{\mathbf{x}\in C_i}\mathbf{x} \quad (2)$$

Where c_i is centroid from cluster Ci, then mi is number of objects in i-th cluster, x is an object, and Ci is i-th cluster [13].

C. CloudSim

CloudSim is a framework written in the Java programming language that works for modeling simulations on cloud computing. CloudSim developed by Buyya began in 2009 in the laboratory of Grid Computing and Distributed Systems (GRIDS) University of Melbourne [1]. CloudSim have classes that serve as a simulation of cloud computing such as brokers, CIS (Cloud Information Service), a virtual machine, cloudlet (job or task in cloud computing), datacenter, and hosts.

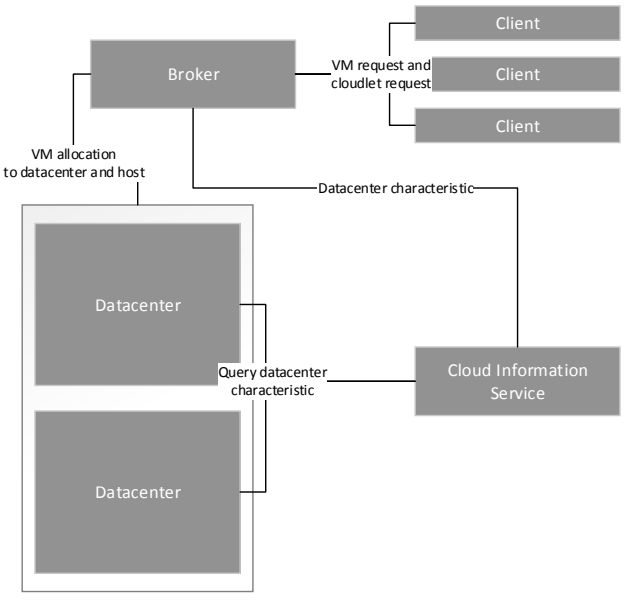

Figure 2. Overall System

Overall system of cloud simulation on this research are provided in figure 2. CloudSim framework starting from the initialization packet CloudSim then CIS (Cloud Information Service) made the datacenter and brokers. Virtual machine demand executed by the broker and then put them to the hosts in the datacenter and sending cloudlet on each virtual machine and the simulation will run and ends with the output result of the simulation like amount of time, the number cloudlet, the number of virtual machines, the number of hosts and number datacenter.

IV. System Design

A. Virtual Machine Clustering

In this research, number of K cluster determined dynamically according to number of datacenter or according to number of host. Datacenter characteristic information received through CIS (Cloud Information Service), which perform a query to cloud provider. After that, the broker will determine number of K cluster.

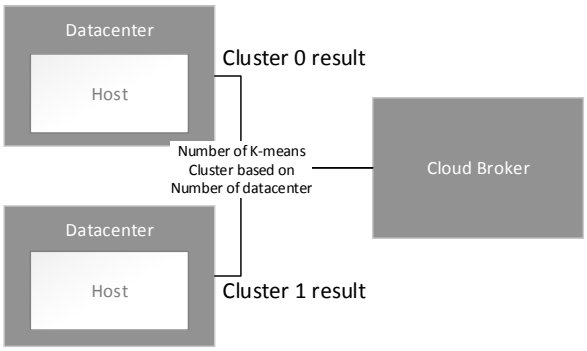

Figure 3. Each datacenter has one host

Shown in figure 3, if each datacenter has only one host then number of K clusters in accordance with the amount of host in each datacenter and then each cluster allocated in host in each datacenter.

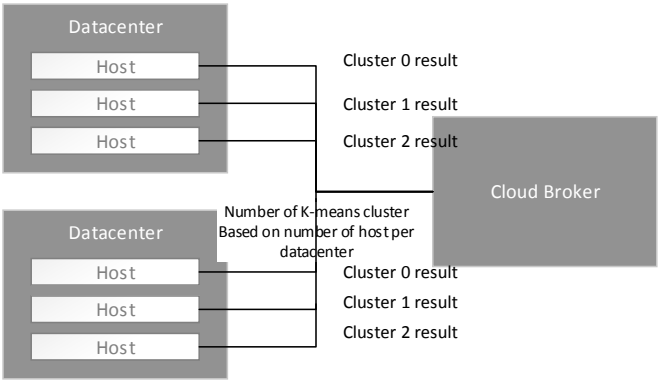

Figure 4. Each datacenter has more hosts

In the other hand, as shown in figure 4, if each datacenter has more than one hosts, then number of K cluster in accordance with the amount of hosts per datacenter (in this research, each datacenter has the same number of hosts). Example in figure 4, number of cluster is 3 because number of host in each datacenter is 3.

After that, clustering against virtual machine request is done with K-means algorithm, then after the clustering result obtained, broker perform the virtual machine allocation on host and datacenter according to the clustering result so in each host and datacenter has an identical virtual machine. After virtual machine has been allocated, then broker began sending cloudlet to virtual machine and cloudlet executed by virtual machine and in the last step, simulation results shown.

B. Cloud Scenario

In this research there are two different scenarios, the first scenario, there are 3 datacenters and each datacenter only has one host. Specification each host in each datacenter is same. The purpose of the first scenario is each virtual machine can be allocated on each datacenter accordance with clustering result with three cluster. The second scenario, there are three datacenters and for each datacenter has two hosts. All hosts in datacenter has same specification. The purpose of second scenario is each virtual machine allocated on host accordance with clustering result with 2 clusters (number of host per datacenter).

Number of virtual machine request is limited only to 35 with different specifications, the number of virtual machine is 35 is to obtain a valid result. Number of cloudlet is limited to 40 and all of cloudlets have same system requirements.

C. Cloudlet Scheduler

This research using space shared scheduler for cloudlet scheduler in cloud computing that has been provided by CloudSim and contained in class `CloudletSchedulerSpaceShared`.

In the cloudlet space scheduler method, cloudlet1 must be completed first before doing execution on cloudlet2. Figure 5 show an example of usage of space shared scheduler in cloudlet scheduler in CloudSim.

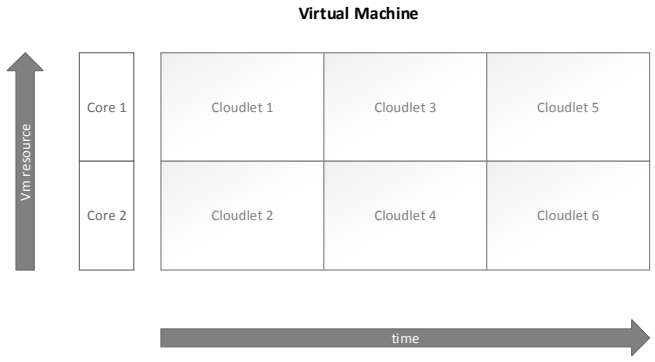

Figure 5. Cloudlet space shared scheduler

If number of core in virtual machine is more than 2 core, then cloudlet3 can be executed on core 3 and cloudlet4 can be executed on core 4 and so on.

V. EXPERIMENTAL RESULT

The following is the experimental result of both scenarios that has been designed before.

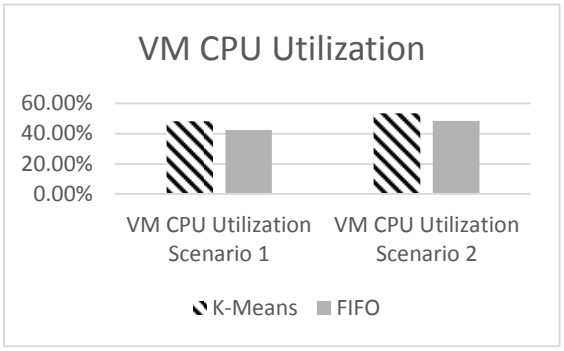

Figure 6. Virtual machine utilization comparison on both scenarios

Seen in figure 6, virtual machine CPU utilization scenario 1 in K-means allocation method is 48.1993% and FIFO method is 42.539%, in other hand, virtual machine CPU utilization scenario 2 in K-means allocation method is 53.4531% while on FIFO allocation method is 48.392%.

Virtual machine in K-means method has less idle time and distributed in a balanced manner (load balance) in each datacenter according to the level of specification similarity within virtual machine. On default cloudlet scheduler used by CloudSim, each datacenter will be given job according to the number of virtual machine accordance with the number of virtual machine without calculate the computational capabilities of that virtual machine. Cloudlet scheduler in CloudSim using round robin algorithm (see figure 10).

In K-means method scenario 1, number of virtual machine in datacenter0 is 11 and number of cloudlet given on that datacenter is 19, while the number of virtual machine in datacenter1 is 12 and number of cloudlet given on datacenter1 is 9. On datacenter2, number of virtual machine is 9 and number of cloudlet given is 9, so total virtual machine that successfully allocated is 32 from total 35 virtual machines requested while in FIFO method, all virtual machines requested has been successfully allocated, but in both methods has the same running time. Therefore idle time that happen in virtual machine in datacenter1 and datacenter 2 for waiting datacenter0 can be reduced.

In K-means method scenario 2, number of virtual machine in datacenter0 is 14 and number of cloudlet in this datacenter is 28, while the number of virtual machine in datacenter1 is 8 and number of cloudlet in this datacenter is 8. The number of virtual machine on datacenter2 is 4 and number of cloudlet is 4. On FIFO allocation method, number of virtual machine in datacenter0 is 14 and number of cloudlet in this datacenter is 22, while the number of virtual machine in datacenter1 is 10 and number of cloudlet in this datacenter is 10. The number of virtual machine in datacenter2 is 8 and number of cloudlet is 8. Total virtual machine that allocated in K-means method scenario 2 is 26 from total 35 virtual machines requested, while virtual machine that allocated in FIFO method scenario 2 is 32 from total 35 virtual machines requested. In both methods in scenario 2 has the same running time, therefore idle time in K-means method can be reduced because in this method has less virtual machine than FIFO method but with the same running time.

Figure 7 is total idle time comparison on both scenarios during simulation progresses.

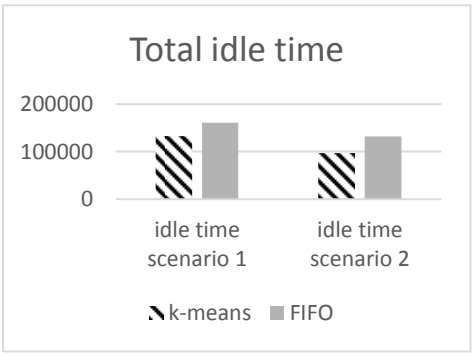

Figure 7. Total idle time

Seen in figure 7, in scenario 1, total idle time with K-means method is 132614.7 seconds and that number is small when compared to the FIFO method that has idle time 160896.6 seconds. This happened because virtual machine allocated in K-means method is less than FIFO method but with the same running time, so allocation of virtual machine with K-means method in scenario 1 is better than FIFO method. That statement proved from bigger level of virtual machine CPU utilization and smaller number of idle time in K-means method.

In scenario 2, total idle time with K-means method is 96821.18 seconds and total idle time on FIFO method is 132121.5 seconds. This happened because virtual machine allocated in K-means method is less than FIFO method in scenario 2 but with the same running time, thus virtual machine allocation using K-means method in scenario 2 is greater than FIFO allocation method.

VI. ANALYSIS

On both scenarios shows that cloudlet scheduler on CloudSim send cloudlet sequentially in each datacenter and the number of cloudlet submitted accordance with total virtual machine in each datacenter. For example, there are 10 requested virtual machine, VM 0-3 are low-end, VM 4-6 are mid-end, and VM 7-9 are high-end. In figure 8**,** the diagram example of scenario 1 with FIFO method but with less virtual machine and less cloudlet. All of requested virtual machine successfully allocated to each datacenter with FIFO method. Compared to figure 9, the diagram example of scenario 1 with K-means method with less virtual machine and less cloudlet. The clustering result will be cluster 0 is VM 0-3, cluster 1 is VM 4-6, and cluster 2 is 7-9, therefore each datacenter has virtual machine according to clustering result, but total virtual machine allocated in this method is 9 because resource limitation in host in datacenter 2.

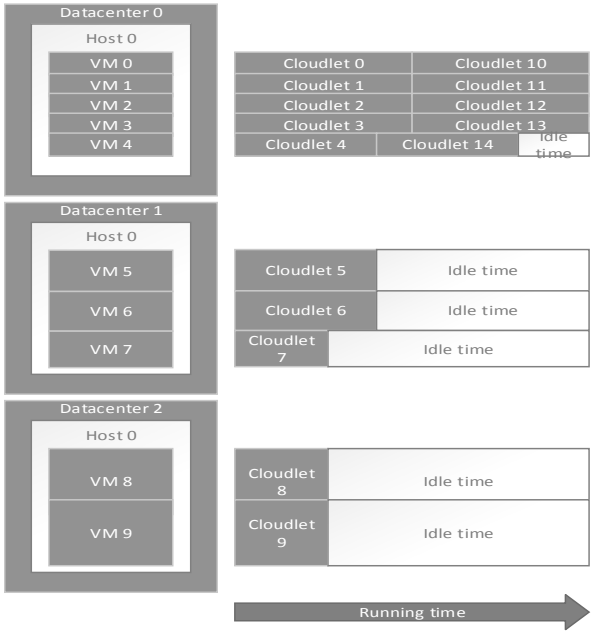

Figure 8. FIFO method analysis

In figure 9, the diagram example of scenario 1 with K-means method with total virtual machine allocated is 9 and has less idle time and bigger CPU utilization when compared to FIFO method.

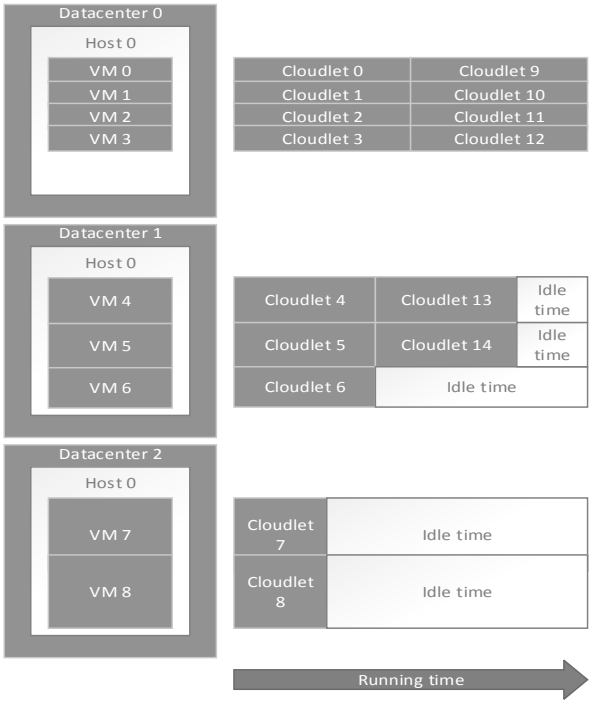

Figure 9. K-means method analysis

If number of virtual machine in datacenter0 is more than the other datacenter, then scheduler will send more cloudlet to that datacenter, round robin algorithm used on this cloudlet scheduler. Figure 10 is an example of sorting cloudlet on each datacenter in CloudSim simulation.

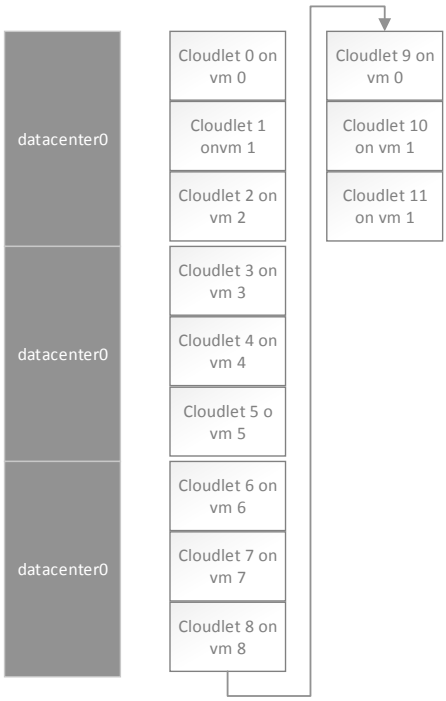

Figure 10. Default CloudSim cloudlet scheduler

If number of cloudlet is not divisible with number of virtual machine, then the rest of cloudlet given to datacenter0 so that datacenter0 has more cloudlet when compared to datacenter1 and datacenter2. Running time on all of virtual machine depend with one virtual machine with the most long running time because all of virtual machines will not shut down until all of cloudlets accepted. Default cloudlet scheduler CloudSim simply dividing total cloudlet to datacenter accordance with number of virtual machine on each datacenter without calculate virtual machine resource performance on each datacenter, therefore, to improve K-means allocation method, cluster that containing high-end performance virtual machine allocated to datacenter0, mid-end performance virtual machine allocated to datacenter1, and low-end performance virtual machine allocated to datacenter2 then running time can be reduced so it can improve virtual machine utilization as describe in figure 11.

Figure 11. Running time when high-end virtual machine cluster allocated to first datacenter and low-end virtual machine cluster allocated to last datacenter

The analysis result is if scheduler still using default cloudlet scheduler from CloudSim, then when using K-means allocation method, total K cluster is better accordance with number of datacenter because cloudlet delivered on each datacenter, and then cluster that contains high-end performance virtual machine allocated on the first datacenter while cluster that contains low-end performance virtual machine allocated on the last datacenter in order to minimize total idle time. K-means allocation method is greater than FIFO allocation method because in K-means method, similar virtual machines will allocated to the same datacenter.

VII. CONCLUSION

The result of this research is virtual machine allocation method with K-means algorithm is better than FIFO algorithm in order to increase virtual machine CPU utilization. If cloudlet scheduler algorithm used is cloudlet scheduler default from CloudSim, then K-means allocation method can increase execution time and level of CPU utilization by allocating cluster that contains high-end performance virtual machine on the first datacenter and cluster that contains low-end performance virtual machine on the last datacenter.

Disadvantage of virtual machine allocation method with K-means algorithm is if each virtual machine requests have uneven differences that can lead virtual machine allocation become unbalanced.

The use of K-means algorithm in virtual machine allocation method also can do load balancing in host resource in datacenter when compared with FIFO algorithm method and virtual machine CPU utilization can increase with K-means algorithm method during simulation.

VIII. FUTURE WORK

On this research, cloudlet scheduler is default from CloudSim, this scheduler using round robin algorithm, therefore, total cloudlet send to each datacenter accordance with total virtual machine on each datacenter. Thus, in future work, development of cloudlet scheduler is required to improve running time, CPU utilization, and reduce virtual machine idle time and new analysis when high-end virtual machine allocated to first datacenter and low-end virtual machine allocated to last datacenter.

REFERENCES

[1] Buyya, R., Ranjan, R., Calheiros, R, N, *Modeling and Simulation of Scalable Cloud Computing Environments and the CloudSim Toolkit: Challenges and Opportunities*. Melbourne: Grid Computing and Distributed Systems (GRIDS) Laboratory, Department of Computer Science and Software Engineering University of Melbourne, 2009.

[2] Boloor, K., Chirkova, R., Viniotis, Y., Salo, T, "Dynamic request allocation and scheduling for context aware applications subject to a percentile response time SLA in a distributed cloud" in *2nd IEEE International Conference on Cloud Computing Technology and Science, vol* 2, 2010, 464-472, 2010.

[3] Patel, K, S., Sarje, A, K, "VM provisioning policies to improve the profit of cloud infrastructure service providers" in *International Conference on Computing Communication and Networking Technology (ICCCNT) 2012,* IEEE-20180.

[4] Rathore, S, "Efficient allocation of virtual machine in cloud computing environment" in *International Journal of Computer Science and Informatics,* ISSN:2231-5292, 2, 2012, 59-62.

[5] Ladha, A, *Cloudsim: A framework for modelling and simulation*. Patiala: Department of Computer Science and Engineering Thapar University, 2013.

[6] Shah, M, D., Kariyani, A, A., Agrawal, D, L, "Allocation of virtual machines in cloud computing using load balancing algorithm" in *International Journal of Computer Science and Information Technology & Security,* ISSN: 2249-9555, 3, 93-95, 2013.

[7] Panchal, B., Kapoor, R, K, Prof, "Dynamic VM allocation algorithm using clustering in cloud computing" in *International Journal of Advanced Research In Computer Science and Software Engineering,* vol 3, issue 9, 143-150, 2013.

[8] Kumar, R., Sahoo, G, "Cloud computing simulation using CloudSim" in *International Journal of Engineering Trends and Technology (IJETT),* 8, 82-86, 2014.

[9] Gong, W., Chen, Z., Yan, J., Qianjun, S, "An optimal VM resource allocation for near-client-datacenter for multimedia cloud" in *The Sixth nternational Conference on Ubiquitous and Future Network 2014*, 6, 249-254.

[10] Kanakardurga, G., Veeramallu, S, B, "Dynamically allocating the resource using virtual machines" in *International Journal of Computer Science and Information Technologies,* ISSN: 0957-9646, 5, 4646-4648, 2014.

[11] Somasundaram, T, S., Govindarajan, K, "CLOUDRB: A framework for scheduling and managing High-Performance computing (HPC) applications in science cloud" in *Future Generation Computer System*, 34, 47-65, 2014.

[12] Tan, P.N., Steibach, M., Kumar, V, *Introduction to Data Mining*. Pearson Addison Wesley, Boston., 2006.

Zaki, M.J., Meira, W, *Data Mining and Analysis: Fundamental Concepts and Algorithms*. Cambridge University Press, Cambridge, 2014