

Cloud Computing and the Cloud Simulation

Kritika Sharma¹, Raman Maini²

¹M.Tech Student, Department Of Computer Engineering, Punjabi University, Patiala, Punjab (India)

²Professor, Department Of Computer Engineering, Punjabi University, Patiala, Punjab (India)

Abstract- Cloud Computing is an emerging technology that is used to provide resources as services to its users on the utility basis. The customers of Cloud Computing enjoy these services in the form of applications, platform, or infrastructure. Before deploying these services on Clouds, their allocation policies need to be tested. But testing them on real Cloud infrastructure is very difficult and expensive in terms of time, money and effort. Thus, we use the concept of simulation for this purpose. In this paper, we discuss CloudSim (Cloud Simulation toolkit). CloudSim is analysed as an efficient toolkit for simulating Cloud scheduling and allocation policies.

Keywords- Cloud computing, virtualisation, simulation, application scheduling.

I. INTRODUCTION

Cloud Computing is an emerging technology in which user data and applications are stored at a remote server. And the users can access their data and applications through internet. We can also say that, Cloud Computing is used to provide various computing resources to its users. These resources may be memory, storage, bandwidth, etc. To completely understand the concept of Clouds and Cloud Computing, let us consider the following scenario (Fig 1).

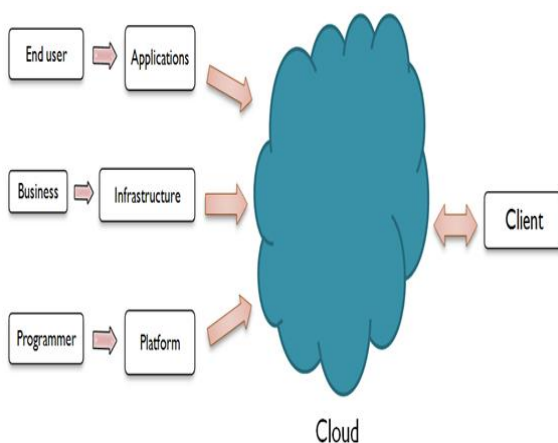


Fig 1. Description of Cloud and Cloud Computing

Let us consider three different users- an end user, a business person and a developer. These three users have different kind of needs. Like, an end user requires some kind of application to perform his task. Thus he may have to download or buy the application and the install it on his system. He also has to update the application time to time.

The second user, business person, he may want to design a website. Thus he has to buy and set up the proper infrastructure to carry out his job of website development. The third user, developer, wants to develop his applications. For this purpose, he requires a proper platform and he also has to update from time to time.

In our traditional computing environment, all the three users fulfil their requirements on their own. This would take a lot of time, money and effort on the part of the users. An alternative to this is Cloud Computing. In Cloud Computing the requirements of all these users can be fulfilled by the cloud providers. The cloud providers provide the required applications to end-user, without any need to install them. All the updations are carried out by the cloud providers. Similarly, the business person doesn't need to buy the entire infrastructure. They can hire them from the cloud provides. And the developers also need not worry about their platforms. The cloud providers provide them with the platform and also update them on their own. Thus, all the users can access the clouds as clients through an internet connection and fulfil their requirements.

There have been several definitions for cloud computing. The definition of cloud computing provided by National Institute of Standards and Technology (U.S Department of Commerce) is as follows:

“Cloud Computing is a model for enable infinite network access, convenient usage, on-demand service and scalable resources that are billed on utility basis. Cloud Computing model provides five essential characteristics, four deployment models and three service models.”[4]

There are three main categories of service models of cloud computing: Infrastructure as a Service (abbreviated as IaaS), Platform as a Service (abbreviated as PaaS), and Software as a Service (abbreviated as SaaS). The four deployment models are: public cloud, private cloud, community cloud and hybrid cloud.

II. CLOUD CHARACTERISTICS

According to NIST [4], the essential characteristics of Cloud Computing are:

- On-demand service
- Infinite network access
- Location independence and resource pooling
- Scalable resources
- Service is measured

On-demand service: To utilize the services provided by the clouds the customer can directly use it, there is no need of any kind of interaction with the service provider.

Infinite network access. Cloud computing capabilities are available over very wide range. An user can utilize these with the help of just an internet connection. Thus, all one requires is an internet access and he/she can enjoy the cloud services.

Location independence and resource pooling. Cloud computing basically means providing resources to its users through an internet connection. These resources may be memory, storage, bandwidth, processing power, etc. The providers provide these resources to a large number of users at the same time. All the users enjoy same services and the users have no knowledge and control over the location of these resources. This is called location independence.

Scalable resources. The cloud services provide the feature of rapid elasticity. The cloud capabilities can be very easily scaled-in or scaled-out. Thus these services appear as unlimited services to the customers.

Service is measured. The cloud services are charged on the utility basis. It follows a pay-as-you-use model. The users have to pay only for the resources they use and only upto the time they use these resources.

III. CLOUD SERVICE MODELS

The cloud providers provide services to its users in the form of software, platform, or infrastructure. Thus, we have three basic service models of clouds. These are as follows:

- a) Software as a Service (SaaS)
- b) Platform as a Service (PaaS)
- c) Infrastructure as a Service (IaaS)

a). Software as a Service (SaaS)

Software as a Service (SaaS) is the model in which an application is provided to the customers as a service, who access it by the Internet. The customers don't have to install the applications on their machines, nor they have to maintain or update them, it is the responsibility of the cloud providers. The customer has no control over the application. Some of the SaaS applications include: Customer Resource Management (CRM), Video conferencing, invoicing, Accounting, Enterprise Resource Planning, Web content management, etc

Benefits: The Software as a Service models has many advantages like, it saves a lot of time and money of its users, provides reliable applications, etc. Some more benefits of SaaS are listed below:

- + SaaS services are very easy to use. Users just have to type the url of the application and access it through their machines.
- + SaaS applications don't require any kind of updations by the customers, so they don't need to appoint any IT staff to manage and update these applications.
- + SaaS applications are reliable and help to save a lot of user's time and effort.
- + The SaaS applications have better marketing opportunities as the whole world is open to them.

Hurdles: SaaS faces the following obstacles to its implementation:

- If an organisation has some specific computational needs then they may need be able to fulfil them through SaaS applications. In this case, they might need to buy the software and install it.

- It may also be possible that the SaaS applications may not be as powerful as the non-SaaS ones. Like, SaaS application, Google Excel Sheet is less powerful than the MS Excel.

b). Platform as a Service (PaaS)

Platform as a Service is another service model of the clouds. The PaaS model is basically for the developers. In this model the developers are provided with platform so that they can build their applications. Management of the platform is done by the providers. The developers need to concentrate only on their applications and need not worry about managing the platform. Some examples of PaaS providers are: Google App Engine enables anybody to develop, maintain and run application on Google infrastructure; Microsoft Windows Azure Platform allows users to develop windows applications.

Benefits: PaaS applications provide following benefits:

- + PaaS services have simplified the job of application deployment.
- + In PaaS model, developer has no overhead of updating the softwares.
- + No need of any supporting IT staff to carry out the task of software management and updation.
- + PaaS service model also helps in improving the speed of the development process.
- + PaaS is a *pas-as-you-use* model. The users have to pay for the services they use.

Hurdles: Vendor lock-in is one of the biggest hurdles that the users face while using the PaaS services. Vendor lock-in implies that the migrating the applications to some other cloud provider becomes an extremely difficult task. If one happens to do so, then he may have to incur huge costs.

c). Infrastructure as a Service (IaaS)

The third service model for clouds is Infrastructure as a Service(IaaS), also called as Hardware as a Service(HaaS). IaaS service model offers hardware of infrastructure to its users. The customers have to pay on the utility basis. The customers hire the infrastructure like server space, memory, cpu cycles, etc from the IaaS providers and pay for their usage. This models helps to scale up or scale the down the infrastructure as per the requirements.

Benefits: Some of the benefits of IaaS model are:

- + The users have to pay only for the services they use.
- + This model helps to rapidly scale in or out.
- + IaaS model promotes Green IT as the same infrastructure can be used by many users by divided them into several instances.
- + IaaS models is economic. It helps to save a lot of money. The users need not buy the complete infrastructure, they can hire them instead.

Hurdles: Along with the benefits, this model has several hurdles as well:

- The biggest hurdle in this model is security. Since the same infrastructure is being shared by many

users at the same time, so the data stored at these infrastructure may not be safe.

- In case the hardware of the IaaS provider gets crashed due to natural calamities or any other reasons, then the data stored at these hardware may be lost forever.

IV. CLOUD DEPLOYMENT MODEL

The deployment of clouds depends on the nature of their users. There are basically four cloud deployment models. These are: private clouds, public clouds, community clouds, and hybrid clouds.

Public Clouds are those, which are accessible to the public. The cloud infrastructure in this case is available to the general public. These clouds are owned by the organisations selling the cloud services. Some examples of public clouds are: online photo storage services, social networking websites, or e-mail services.

Private Clouds refers to the model when the cloud infrastructure is available to the organisation only and is not available to the general public. These clouds may be owned by the organisation itself or they may hire it from some third party. For example, a financial organisation may build its own private cloud to store its data. This cloud will be available only to this organisation and could not be accessible to anyone else.

Community Clouds are the cloud models in which the cloud infrastructure is set up for the benefit of several organisations that share some common requirements. These cloud infrastructures are accessible to all these organisations. The management of the cloud infrastructure is the responsibility of community as a whole. For example, all govt. Organisations within California have build a community cloud to share and manage the data related to citizens residing in California.

Hybrid Cloud is the deployment model which is the combination of two or more deployment models. For example, an organisation could hold sensitive data on their private clouds and all other data on their public clouds.

V. ADVANTAGES AND DISADVANTAGES OF CLOUD COMPUTING

Advantages of Cloud Computing: Cloud Computing offers several advantages. Some of these are as follows:

- *Economic:* Cloud Computing serves to be very economic. We need not buy and install the required softwares on our machine. Thus, our computer systems need not have much storage space or processing power. In this way, it helps to save a lot of money.
- *Cloud Computing helps to improve system's performance:* We do not need to install many softwares on our system. Thus most of the memory remains free, leading to an increase in system's performance.
- *No need to buy software:* In Cloud Computing, we need not buy any of the softwares, because these software may be available to us as services by the cloud providers.
- *Providers make software updates:* The burden of updating the softwares from time to time is removed

with the help of Cloud Computing. The providers make all the required updates themselves.

- *The Storage capacity increases:* If we use our personal computers to store data, then the storage space is very small and very limited. But with the concept of Cloud Computing, the storage space becomes unlimited as the clouds can be very easily scaled up.
- *Increases data reliability:* In case of Cloud Computing, if one server fails then we have other backup servers. Thus, minimising the chances of losing user data.
- *Documents can be accessed from any location:* With Cloud Computing, we need not carry our documents to other locations. Instead we can easily access our documents from any location in the world with internet access.
- With Cloud Computing, we do not have to access our email accounts from the same device, we can instead access our accounts from any device at any location. This is the best available feature of Cloud Computing.

Disadvantages Of Cloud Computing: Alongwith the advantages stated above, Cloud Computing has many disadvantages as well. These are as follows:

- *Constant and continuous internet connection is required:* Cloud Computing is useful only if we have a constant and continuous internet connection. Without the internet connection, we cannot access any of the Cloud Computing services.
- *Does not work well with slow internet connection:* Accessing Cloud services becomes a very tough task when the speed of our internet is very slow.
- *Does not have much features:* The Applications provided by the clouds may have lesser features as compared to the desktop applications.
- *Speed can be slow:* Even when we have a fast internet connection, accessing the Cloud services can be very slow as compared to accessing the desktop applications.
- *Data can be lost:* Although the data stored at clouds have backup, but in case the data on clouds is lost, we have no local backup or recovery of that data.

VI. CLOUDSIM: CLOUD SIMULATION TOOLKIT

As we have already seen that Cloud Computing is used to provide various services over the internet. But before deploying these services over internet, we need to test the performance of application scheduling policies. But testing these policies on real Cloud environment is a very difficult task to accomplish because of the following reasons:

- The size of clouds and the resources is not fixed.
- All the users may not have same requirements and their requirements may be changing dynamically.
- The workload of applications is also not fixed.

Hence, it is not possible to evaluate the performance of scheduling policies on real Cloud environment. This

leads to using the simulation based approaches to evaluate these policies. The benefits of using simulation based approaches are:

- + Tests can be conducted in repeatable manner and in the controlled environment.
- + System bottlenecks can be checked in advance before deploying the application on real Cloud environment.
- + Tests can be conducted under different workloads.

One such simulation toolkit that we use in case of Cloud Computing is: CloudSim. CloudSim is the Cloud simulation toolkit that is used to test the performance of Cloud services. Depending on these results, we can make changes in the services and thus improve the performance.

CloudSim offers following features[]:

- Models the Cloud infrastructure on a single computer.
- Models Cloud scheduling and allocation policies.
- It supports simulation of network connections.
- Provides virtualisation engine.
- Also, provides the flexibility to switch between time shared policy and space shared policies.

CloudSim Architecture

Fig shows the design of CCloudSim architecture. The lowest layer **SimJava** Is present only in the earlier releases of CloudSim. The SimJava Discrete Event

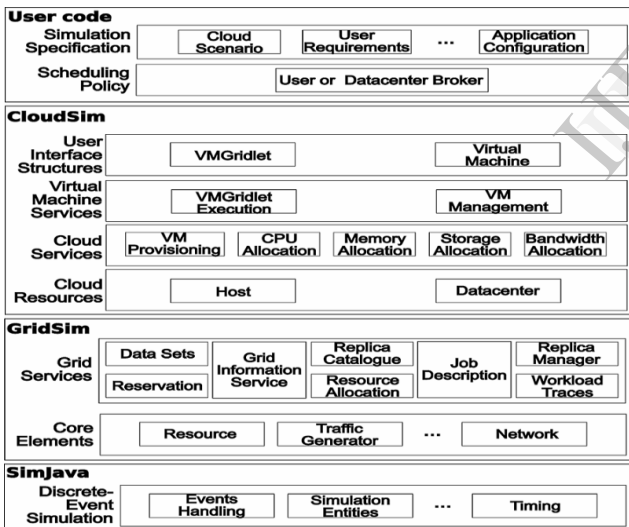


Fig. 7 Layered CloudSim architecture[11]

simulation Engine implements the core functionalities. These core functionalities include queuing and processing of events, system components creation, communication between the entities, and simulation clock management.

The **GridSim** layer includes the libraries that implement the GridSim toolkit. These libraries model multiple Grid infrastructures by supporting high level software components.

The **CloudSim** layer involves the actual implementation of CloudSim. The core functionalities of the GridSim layer are extended at this layer. This layer manage the execution of Vms, hosts, datacenters and applications, which are core entities. The main issues handled at this layer are:provisioning

oh hosts to virtual machines based on user’s request, and managing & monitoring execution of applications.

The topmost layer, **UserCode** , gives information about the configuration of hosts .i.e. number of machines on hosts and their specifications, Applications .i.e. Number tasks in an application and their requirements, Virtual machines, No. of users and types of application their, and the scheduling policies.[11]

Cloud Modelling using CloudSim

The Cloud consists of tasks, applications, virtual machines, hosts, datacenters, and federations. The federations are inter-networking of clouds. The *Datacenter* component are used to model the core hardware infrastructures related to the cloud. A Datacenter consists of Hosts.

The *Host* is the component which represents a physical node or a single machine. Each machine is assigned processing, memory, storage and a VM scheduling policy. The processing cores are allocated to the virtual machines on the basis of this scheduling policy. The *VM Scheduler* component allocates processing cores to Vms. VM Scheduler implements either time shared or space shared policy for allocating cores to Vms.

VM Allocation using CloudSim

CloudSim allows provisioning of Vms at two levels: firstly, at host level, and secondly, at VM level. At host level, the processing power of cores is divided among the Vms, and at the VM level, the processing power of Vms is divided among the tasks in the application. Both at host and VM level time shared and space shared policies can be implemented.

To understand these policies at different levels, let us consider the following scenario. There is a host with two cores and there are two Vms: VM1 & VM2. Each VM requires two cores and can host four tasks. There are eight tasks. Tasks t1, t2, t3, t4 will be hosted at VM1 and t5, t6, t7, t8 will be hosted at VM2. Now, let us see the four kinds of allocation policies:

- i. *Both Vms and tasks are provisioned on space shared basis:* When Vms are provisioned on space shared basis, VM1 takes both the cores and VM2 cannot run till the time VM1 has not finished. In Vms, the tasks are also provisioned on the space shared basis. In VM1, firstly tasks t1 and t2 occupy the space and start to execute. The tasks t3 and t4 can execute only after t1 and t2 have finished execution. Similarly , tasks in VM2 are also provisioned on the space shared basis.

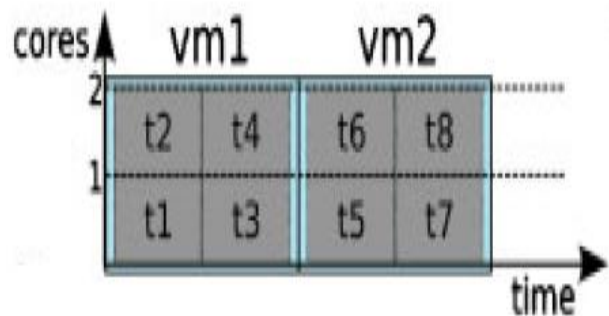


Fig. 8 VMs and tasks have Space-shared provisioning [11]

ii. *Vms are provisioned on the space shared basis, and tasks are provisioned on the time shared basis:* The Vms are provisioned on space shared basis, thus first VM1 occupies both the cores and VM2 waits till VM1 finishes its execution. The tasks in Vms are provisioned on time shared basis.



Fig. 9 Vms have Space-shared provisioning and tasks time-shared provisioning [11]

iii. *Vms are provisioned on time shared basis and tasks are provisioned on space shared basis:* The Vms are provisioned on time shared basis. So, each Vm is assigned a time slice and both the Vms execute in their time slices. The tasks within Vms are provisioned on space shared basis. Thus, in VM1 first t1 executes and after that t3 is executed.

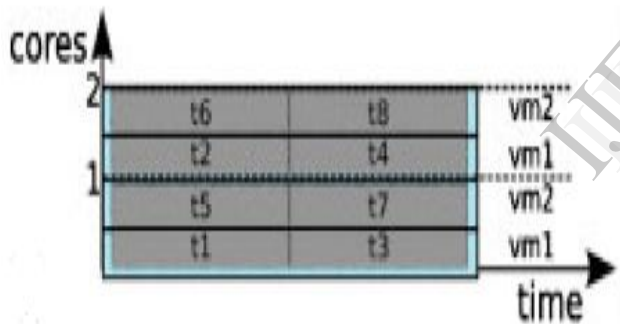


Fig. 10 Vms have Time-shared provisioning, & tasks have space-shared provisioning [11]

iv. *Both tasks and Vms are provisioned on the time shared basis:* In this provisioning policy both Vms and tasks are provisioned on the time shared basis. In this provisioning policy there is no queuing delay.

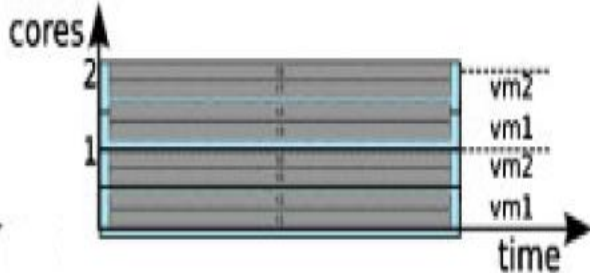


Fig 11. Vms and tasks both have Time-shared provisioning. [11]

✚ *Using CloudSim to model Cloud Market:* Since cloud services are based on pay-as-you-go model, thus evaluating the cloud market becomes very important. In CloudSim, to allow modelling of cloud market four properties are related with datacenter: cost per processing, cost per unit of memory, cost per unit of storage, and cost per unit of used bandwidth. Cost per memory and storage occur during virtual machine creation. Cost per bandwidth occurs during data transfer. Besides all these costs, the other cost is the cost associated to the use of processing resources. This cost that is related to execution of task units. If virtual machines are created but no task is executed on them then only the cost of storage and memory is incurred.

✚ *Classes of CloudSim:* The inbuilt classes are the building blocks of CloudSim simulator. The fundamental classes of CloudSim are listed below:

- *DataCenter* : DataCenter class simulates the core infrastructure services provided by the cloud providers. The direct known subclasses of DataCenter class are NetworkDatacenter and PowerDatacenter. DataCenter class instantiates a component that implements policies for allocating memory, bandwidth & storage to hosts and Vms.
- *DatacenterBroker*: DatacenterBroker implements broker. A broker acts on behalf of the cloud users. Broker is the intermediate between users and service providers. This class is extended for conducting experiments with various application allocation policies.
- *SANStorage*: SAN means Storage Area Network which consists of hard disks to store data. This class models Storage Area Network which is used to store large chunks of data.
- *Vm*: This class models the virtual machines. The virtual machines are hosted at the hosts. Each Vm component can access the following characteristics related to a VM .i.e. memory, storage, processor & VM provisioning policy.
- *Cloudlet*: Cloudlet implies the cloud based applications that are deployed on the clouds. Each application has a pre-defined length. CloudSim represents the complexity of an application.
- *BWProvisioner*: BWProvisioner is an abstract class. This class is used to model the bandwidth allocation policy of VMs. The researchers can extend this class by defining their own policies for bandwidth provisioning.
- *MemoryProvisioner*: MemoryProvisioner is also an abstract class. This class is used to represent the memory allocation policies to VM. If the MemoryProvisioner component finds that the host has adequate memory to run the VM only then the deployment of VM on a host is possible .

- *VMProvisioner*: VMProvisioner is an abstract class that is used to represent the provisioning policy for allocating Vms to hosts. This class is basically used to select the datacenter that has characteristics such that a particular Vm can be deployed on it.
- *VMMAllocationPolicy*: VMMAllocation policy is an abstract class that is implemented by the host component of CloudSim. By overriding this class the processor sharing policies that are specific to a particular application can be implemented.
- ✦ *Using CloudSim to model Network Behaviour*: It is very important to simulate the network behaviour in the Cloud Computing environment so that the messages are not delayed. To simulate network behaviour, we use latency matrix. This matrix involves the values of the latency (that a message can experience on its path from one entity to other).
For all entities the CloudSim maintains an $m \times n$ latency matrix. Each entry e_{ij} means the latency that a message incurs when it is transferred from entity i to entity j . The event from entity i to entity j will be forwarded only if the total simulation time reaches $t+d$ (t : simulation time when message was sent; & d : network latency between i and j).
- ✦ *Using CloudSim to model Federation of Clouds*: To model the federation of Clouds the CloudSim simulator provides CloudCoordinator entity. No other simulation tool provides this entity. CloudCoordinator entity monitors and manages the internal state of data center. The information that is received after the monitoring process is then used to make decisions related to provisioning among the clouds in the federations. Basically there are two main features that must be considered while modelling the federations: communication and monitoring. Communication is done with event based messages and the monitoring of data centers is carried by the CloudCoordinator. For this purpose, another entity (sensor entity) is used. Sensor keeps tracks of host utilization and heating. While CloudCoordinator entity is monitoring the data center, it queries the sensors. If the sensor responds that the hosts have achieved a pre-defined threshold, the CloudCoordinator then starts communication with other CloudCoordinators in the federations for possible load shedding of that host.
- ✦ *Using CloudSim to model dynamic workloads*: CloudSim helps to model the dynamic workload by using Utilization Model simulation entity. Utilization Model is an abstract class that can be extended to implement the workload patterns. By overriding the method, getUtilization(), the users get the percentage of computational resource required by a task. Thus helping to model the dynamic workload.
- ✦ *Using CloudSim to model Power Consumption at Data center*: Energy conscious provisioning policies can be evaluated and validated using CloudSim simulator. CloudSim provides the abstract class PowerModel for this purpose. By overriding the method getPower() of PowerModel class we can achieve this objective. This function tells about the power consumption value. This helps in creating the provisioning policies that are energy-conscious. It also helps in accounting total energy consumed by the system in the simulation period.
- ✦ *Creation of Entities dynamically using CloudSim*: In Cloud Computing, cloud providers have to deal with customers who can leave or enter the system any time. And CloudSim allows simulation of such scenarios. It supports dynamic creation of different CloudSim entities (user, broker and data center) at run-time. The entities can join, fail, or leave the system any time. When new entities are created, they register themselves automatically in the Cloud Information Service (CIS).

VII. NETBEANS

NetBeans IDE(Integrated Development Environment) is a development environment. NetBeans is open-source environment. It is an integrated development environment that supports development of all types of Java application. NetBeans provide following features:

➤ Supports latest java technologies

NetBeans IDE provides best support for the latest Java technologies. It is the first free IDE that provides support for JDK 8 and JDK 7. It also provides many other rich features and tools.

➤ Provides fast environment for code editing

The NetBeans IDE provides a fast code editing environment. When we start writing a class name or some method's name, the IDE gives all the names of the classes and methods that start with the given initials. It indents lines and matches words and brackets.

➤ Managing projects becomes very easy

While working with some projects, we have many number of folders and files with millions of lines of code in these projects. Keeping an overview such large applications is very tough job. NetBeans IDE helps us in this.

➤ Very helpful in finding and removing errors

The NetBeans IDE helps the developer to check the errors even before compiling the code manually. The lines of codes consisting of errors and warnings are marked in some color at the left side of the window. These errors can then be removed to make the error free.

VIII. CONCLUSION

Cloud computing uses internet & remote servers to maintain data as well as the applications. Users need not install applications on their machine and can access their data from any computer which has internet access. They use the services provided by Cloud providers on utility basis. Managing the Clouds is a very difficult task. Before deployment of various provisioning policies on real Cloud environment, they need to be tested. This testing and evaluating cannot be done on real Cloud infrastructure. Thus,

we use Simulation-based approaches for this purpose. We have discussed one such simulation toolkit: CloudSim, for modeling and simulating Clouds. CloudSim helps in modeling clouds, cloud market, VM provisioning policies, federations, dynamic workloads and network behaviour in a time efficient manner. The results from the CloudSim are used to make changes in the provisioning policies and remove the bottlenecks.

REFERENCES

- [1] Cyril Onwubiko, "Security Issues to Cloud Computing," in Cloud Computing: Principles, Systems and Applications, Computer Communications and Networks, DOI 10.1007/978-1-84996-241-4_16, © Springer-Verlag London Limited 2010
- [2] Kevin Curran *et.al.*, "Security Issues in Cloud Computing," Copyright © 2012, IGI Global.
- [3] Michael Armbrust *et.al.*, "Above the Clouds: A Berkeley View of Cloud Computing," Electrical Engineering and Computer Sciences University of California at Berkeley, Technical Report No. UCB/EECS-2009-28, February 10, 2009.
- [4] Peter Mell, Timothy Grance, "The NIST Definition of Cloud Computing (Draft)," Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology, Gaithersburg, January 2011.
- [5] Kevin Hamlen *et.al.*, "Security Issues for Cloud Computing," International Journal of Information Security and Privacy, April-June 2010.
- [6] Abhishek Goel, Shikha Goel, "Security Issues in Cloud Computing," International Journal of Application or Innovation in Engineering & Management (IAIEM), vol 1, Issue 4, December 2012.
- [7] *Introduction to Cloud Computing* Office of Privacy Commissioner of Canada, 1989.
- [8] Zoran Pantić and Muhammad Ali Babar, "Guidelines for Building a Private Cloud Infrastructure," IT University of Copenhagen, Technical Report No. TR-2012-153, 2012.
- [9] Cyril Onwubiko, "Security Issues to Cloud Computing," in Cloud Computing: Principles, Systems and Applications, Computer Communications and Networks, DOI 10.1007/978-1-84996-241-4_16, © Springer-Verlag London Limited 2010
- [10] Wikipedia, "Cloud computing," http://en.wikipedia.org/wiki/Cloud_computing.
- [11] Rodrigo N. Calheiros., Rajiv Ranjan, Anton Beloglazov, César A. F. De Rose and Rajkumar Buyya "CloudSim: a toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms", CLOUDS Laboratory, Department of Computer Science and Software Engineering, The University of Melbourne, Australia , DOI: 10.1002/spe.995.
- [12] Buyya R, Yeo CS, Venugopal S, Broberg J, Brandic I. "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility." *Future Generation Computer Systems* 2009; 25(6):599–616
- [13] NetBeans IDE Features [Online]. Available: <https://netbeans.org/features/index.html>.
- [14] cloudsim 3.0 API [Online]. Available: <http://www.cloudbus.org/cloudsim/doc/api/overview-summary.html>

IJERT