# SIMULATOR'S REQUIREMENTS FOR MODELING AND SIMULATION OF CLOUD ENVIRONMENT

**Article** · November 2015

READS
98

**2 authors:**

Muhammad Imran Tariq
Superior University
**13** PUBLICATIONS **16** CITATIONS
SEE PROFILE

Vito Santarcangelo
Centro Studi , Buccino (SA), Italy
**40** PUBLICATIONS **15** CITATIONS
SEE PROFILE

# SIMULATOR'S REQUIREMENTS FOR MODELING AND SIMULATION OF CLOUD ENVIRONMENT

**Muhammad Imran Tariq[1], Vito Santarcangelo[2,3]**

*1. Department of Computer Science, The Superior University, Lahore, Pakistan*
*2.iInformatica S.r.l.s. – Corso Italia, 77, Trapani, Italy*
*3.Centro Studi S.r.l. – Zona Industriale – Buccino (SA), Italy*

***Abstract***

*Cloud computing has brought new innovations in the paradigm of IT industry through virtualization and by offering low price services on pay-as-per-use basis. Since the development of cloud computing, several issues like security, privacy, cost, load balancing, power consumption, scheduling algorithms are still under research. Cloud simulators are used to model and simulate these issues. It also used to decrease the complexity, testing and enhance quality concerns. Several cloud simulators having different features and build for specific purposes are available now for the researchers. Cloud simulators have to achieve the features and requirements that are proposed in this research paper. The purpose of this study is to dig out famous cloud simulator's props and cons, make comparison among these simulators based on cloud simulator's requirements and finally propose future direction.*

***Keywords*** *Cloud Computing; Cloud Simulators, Simulators features, CloudSim, Grid Computing, CloudAnalyst, GreenCloud, DCSim, SimIC, Comparision of simulators.*

## 1. INTRODUCTION

Cloud Computing is a new research field for the researchers due to its unique features like pay as per use, low prices, better resources utilization and sharing, rapid elasticity and many more. Cloud computing idea was derived from Grid Computing but it is different from it due to its virtualization feature [2]. Cloud Computing has basically 03 deployment models i.e. Private Cloud, Public Cloud and Hybrid Cloud. In Public Cloud, the organization builds its own infrastructure and manages as well while in Public Cloud, the organization render different services of Cloud Services Provider (CSP) as per its requirements and use it as long as organization required [2]. The Hybrid Cloud is a combination of Cloud Private, Public models. It has characteristics of all deployment models. Private and Public Clouds are connected with each other through gateways, share data, applications and resources. There is no location binding on hybrid cloud, it may located at private organization premises or Cloud Service Provider premises [2]. Cloud computing has 03 service models i.e. Software as a Service (SaaS) wherein the cloud customer render the cloud applications and its maintenance services from CSP. Salesforce, Dropbox and Google Drive are the example of SaaS. The Infrastructure as Service (IaaS) has provided hardware, storage and infrastructure relates services. Amazon EC2 is very famous example of Infrastructure as Service (IaaS). Platform as Service (PaaS) provides environment, tools, libraries to applications development framework, machines and operating system services to its customers. The Cloud computing has several advantages over the traditional computing but it has several constraints that are roadblock in the fully deployment of Cloud computing. Security, privacy, cost, energy balancing, load balancing, power consumption, scheduling algorithms are one of the major constraints that organizations are facing in the deployment of Cloud computing [4]. The deployment and testing of real cloud is required great effort and immense resources and incur heavy cost. The cloud simulators can be used before deployment and testing in order to reduce cost [1]. The simulators have various advantages like: **cost** , in fact, only cost of software will incur and it is very less as compared to hardware; **repeatable tests**, in fact, organizations may take a number of tests until organization get desirable results, **scenarios,** in fact, the organization may evaluate different scenarios by taking different load and cost variables. Furthermore, through simulations, researchers can develop and test the cost, performance of

applications in a certain required environment [1]. The Cloud simulators have different features and build for specific purposes. Every Cloud simulator does not fulfill all requirements of the researcher to test its model. A good Cloud simulator should have to meet the following simulator requirements:

### A. Ease of use

Ease of use is very basic requirement for a good simulator. The simulator must have easily setting up and executing simulation environment [5].

### B. Graphical User Interface Support

The simulators have to provide an easy to use graphical user interface which is instinctive yet wide-ranging [23].

### C. Configuration and Flexibility

Configuration of the tool is the most important feature for the simulators. To perform same nature of complex experiments like Internet Applications with different parameters, the simulator should be flexible to facilitate the researcher to easily, quickly and repeatedly change parameters [23].

### D. Repeatability

It is very important requirement for a simulator. During experiments, the researcher desired to perform same experiment with different parameters to get required output. Thus, the simulator must have the ability to facilitate user to easy and quick change parameters to perform another experiment and save its previous experiment input values and results in a file [8].

### E. Graphical Output

The output in the shape of graph (tables and charts) saves thousand words. These are also used to summarize the large amount of statistics that are gathered during simulation. Such effective presentation helps in identifying the important patterns of the output parameters and helps in comparisons between related parameters [18].

### F. Ease of Extension

As stated in Repeatability and Configuration and flexibility, the input and output parameters can be changed to achieve desirable results of the complex simulations and the simulator is expected to give extendable facility to its user. Therefore, the architecture of the simulator should support easy, quick and minimal effort change facility [5].

### G. Simulation Time in Seconds

This is the time that is required for the execution of simulation. The simulation time of the simulator should in seconds either the simulation is simple or complex; some simulators time minutes to execute the simulation which is not appreciable for good simulator [18].

### H. TCP/IP Support

The communication and networking related experiments required the TCP/IP support in order to evaluate the performance and cost of the Servers, hosts, switches and communication link. The simulators who have not the facility of TCP/IP have the provision of extension by integrating with other software [23].

### I. Object Oriented Programming feature

Most of the simulators use programming languages like Java and C++ for the modeling of simulation and these languages gives facility to the researcher to extend their simulation using the object oriented methods [23].

### J. Economic-driven Resource Management

The management of the resources is very complex in the cloud and grid environment as the resources are heterogeneous and distributed in different locations. The simulator should provide dynamic resource trading service that is required in the scheduling of applications in internet simulation [5].

### K. Energy Modeling

Energy related module is required in the simulator to know the energy consumption in the data centre and the networking devices like (Router, Switches, Gateway and Communication links) [6].

### L. Federation Policy

As we know that the Cloud computing is based on distributed networking. We render the Cloud services from different Cloud Service Providers and these are located on different geographical locations. Through Federation Policy, these CSPs can be connected with each other and their coordination is also possible as well in order to achieve high quality services [6].

### M. Communication Model

It is very important requirement for simulators especially build for networking through which communication is possible within data centre and application [6].

### N. Cost Model

As we also know that the core benefit of the Cloud Computing is pay as per use and one of the challenges for the Cloud simulators. The researcher can easily evaluate the cost effect of the new policy of the CSP [6].The researchers are required to understand about the merits and demerits of cloud simulators before developing new cloud computing environment in cloud simulator.

The main objectives of this research is to give clear understanding to the researchers about existing virtualization simulators so that researchers may select an appropriate cloud simulator according to their requirements and related work. The Section 2 of this research paper describes about the related work which has already been done in the line of Cloud simulators. The Section 3 gives detail of each Cloud simulator which has been identified during the literature review and accordingly in Section 4, these different kinds of Cloud simulators are compared on the basis of Cloud simulator's requirements and in the last section of this paper i.e. Section 5, new features are highlighted as future work that should be included in the existing Cloud simulators.

## 2. RELATED WORK

Research in the line of Cloud computing is still continue and to overcome the issues of the Cloud computing [6]. A number of researches have already been done to find out these challenges and its solution. There are many Cloud simulators like Cloudsim [10], CloudAnalyst [14], GreenCloud [16], iCanCloud [18], VisualCloud [6], SimGrid and etc. These simulators have different characteristics, features and made to meet specific requirements of the researcher like GreenCloud is developed only to test/calculate the energy consumption related issues, CloudAnalyst is developed particularly for SaaS cloud service model in which it is used to know the performance of the social media websites like Facebook, LinkedIn, twitter, SimGrid is a generic simulator used for the simulation of distributed applications in Grid Computing [7], GangSim is also used in Grid computing for the modeling of Grid based resources and etc [6]. SimGrid has also provision for economic-driven resource management.

During literature review, we find out many cloud simulators and studied their features so that these features may compare with the requirements of the cloud simulators. A number of researches have already been carried out on Cloud simulators but alongwith studying the different research papers; we will explain different types of problems to the readers and accordingly suitable Cloud simulators. These Cloud simulators are also compared on the basis of Cloud simulator's requirements.

## 3. CLOUD SIMULATORS

As mentioned above, Cloud simulators have different characteristics and functions that can be used to address different Cloud related issues. Several Grid Computing simulators are available like SimGrid that is good for Grid Computing but does not support the model of Cloud Infrastructure [6]. Traditional IT simulators are also available now for the simulation and modeling. Virtualization simulation and modeling simulations are most widely used for the development of private as well as public Cloud models. CloudSim is one the leading Cloud simulator which provides modeling at a large scale [7]. It also supports heterogeneous Grid resources and multiple scheduling applications which run across multiple organizations [9]. The section will describe famous Cloud simulators that are studied during literature review.

**CloudSim**

CloudSim is developed by the University of Melbourne in its project namely CloudBus. CloudSim is most famous simulator that used for seamless modeling, simulation and algorithm testing. The main feature of said simulator is its support of cloud computing environment and event driven simulation. It is built on the engine of the GridSim and Java i.e. most famous object oriented language is used for programming in this simulator. By using Java programming, the user can easily extend its modules up to its requirement [10].

CloudSim is toolkit that provides environment to its users to develop scenario according to experiment, desired output as well as input parameters. The users can easily develop scenario and extend it with limited efforts [7]. Furthermore, the researchers can focus on concerned critical system design issues only without involve them into low level cloud infrastructure and services related details. Among other discusses features of CloudSim, it is an open source web applications that begins before configuration machines [11].

The complex system's modules can be easily developed by the support of SimJava which is running at the kernel level of the CloudSim and represent simulation objects as icon on the screen. SimJava is also used to handle the low level requirements of the system [6].

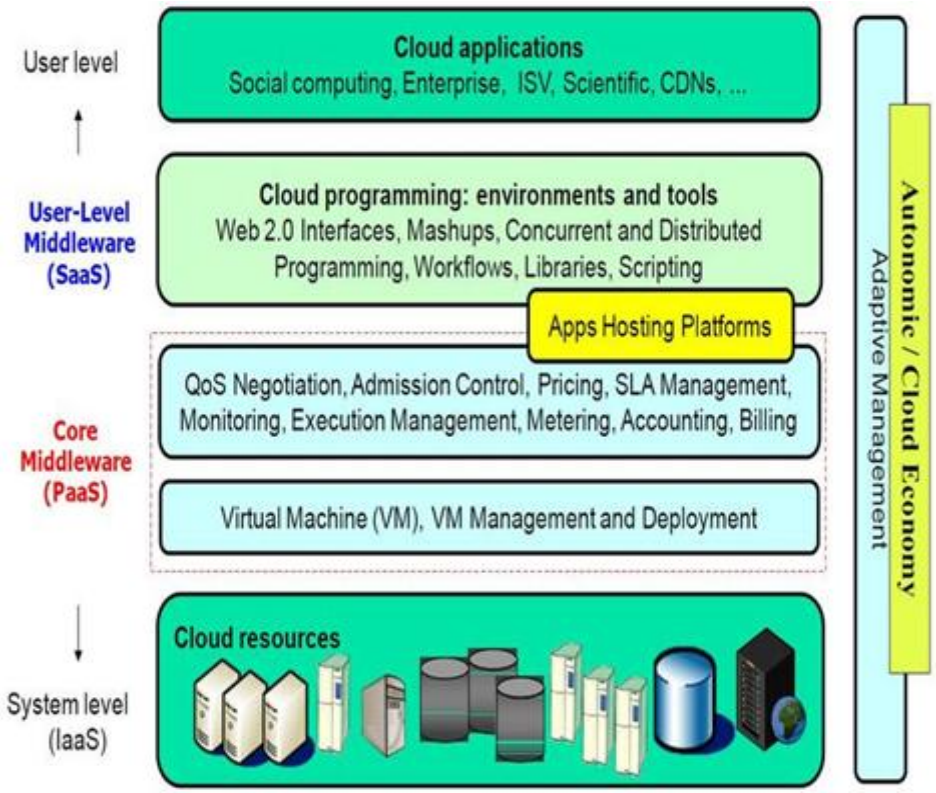


**Figure 1. Layed Cloud Computing Architecture [24]**

The Fig. 1 shows that Cloud computing architecture is consist of three layers i.e. System Layer, Core Middleware Layer and User-Level Middleware Layer. The said three layers are parallel to the top cloud computing architecture layers i.e. IaaS, PaaS and SaaS respectively.

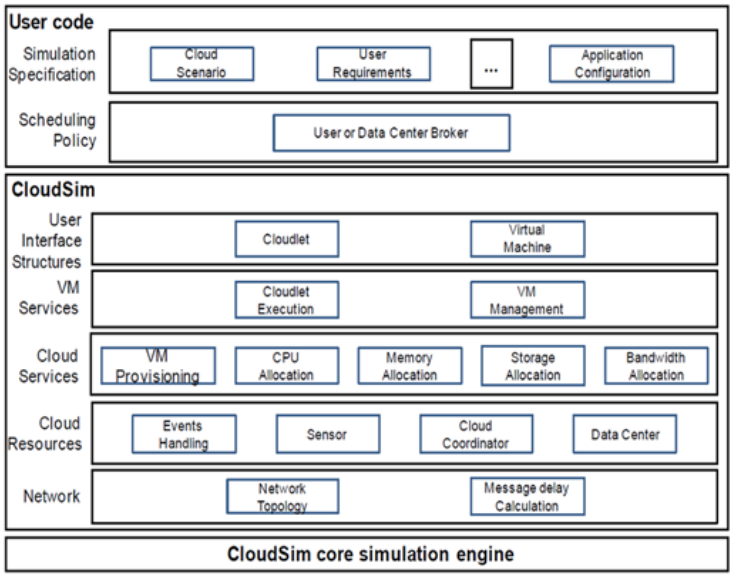


**Figure 2. CloudSim simulation engine [24]**

The Fig. 2 is showing the complete components of CloudSim. The core components of the CloudSim are briefly discussed as under:

1)Data Centre: It has a number of hosts which are used to manage the virtual machines and low level processing. These hosts are used to start the simulation[13].
2)Hosts: It is used in processing, memory and scheduling policy to allocate processing capabilities to more than one virtual machine which are being managed under the list of hosts.
3)Virtual machine: it manages a number of virtual machines and hosts at a same time in order to schedule the processing cores. The first come-first serve algorithm is used for the allocation of virtual machines [13].
4)DataCentre broker: It is used to act as mediate researcher and Cloud Service Provider based upon requirements of excellence of service that researcher gives in simulator. It also finds the appropriate Service Provider and deals with it as per requirements of the researcher. In broker class requirements can be further extended to perform experiments [12].
5)Cloudlet: It is a class and used to model the application based services in terms of computational requirements.
6)CloudCoordinator: It is also a class that is used to make sure smooth communication between other Cloud Coordination services and brothers and to continuously monitor the internal activities of data Centre that are connected with CloudCoordinator [13].

**CloudAnalyst**

CloudAnalyst execute its functionality based on the lower layer of CloudSim. It extends the capabilities and features of the CloudSim.

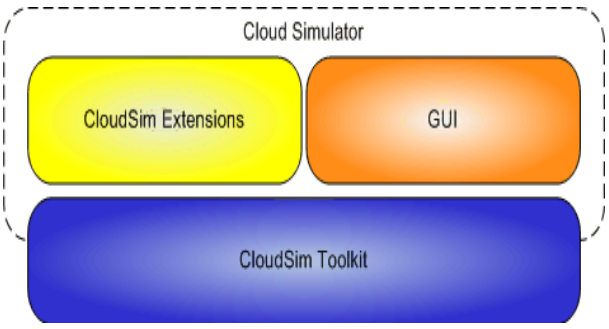


**Figure 3. CloudAnalyst View [15]**

It also gives the facility to the researcher to repeatedly perform simulations to conduct different experiments with the changes of input and output parameters. The researcher can quickly and early perform their

experiments because in CloudAnalyst less effort is required in programming. Similar to CloudSim, it is widely used to check the behavior of the large scale application in the cloud [15].

Furthermore, the main purpose for the development of CloudAnalyst is to measure the performance and cost of the large-scale and workload based Cloud systems that are spread in different locations. The Graphical User Interface of the CloudAnalyst gives opportunities to researchers to configure any system settings [14].

CloudAnalyst has unique output features that researcher can generate the output in form of charts, tables as well as generate summary of huge amount of output data [6].

**GreenCloud**

GreenCloud is developed by the University of Notre Dame under its project supercomputing. It is easy to use and an open source Cloud Simulator. It has numerous features but it cannot be used to measure the energy efficiency of cloud. GreenCloud is extension of Network Simulator NS-2. Its primarily focus on packet level communication within the Cloud. GreenCloud is made energy aware environment [16].

GreenCloud also facilitate the researchers to find out the energy consumption of the computation and the communication devices like switches and routers. GreenCloud focused on the capture of communication patterns that can be used for the design and development of the Data Centres. It has virtual computing platform to reduce the cluster maintenance costs [7].

The core drawback of the GreenCloud is that it takes too much time for simulation and huge memory as well and due to this drawback, its scalability is restricted. Both C++ and Otcal are used for the programming purpose in the GreenCloud which is another drawback of the said simulator [6].

**iCanCloud**

The main function of the iCanCloud is to simulate large storage networks. The core architecture of iCanCloud is SIMCAN. It has further feature of cost analysis, it can calculate / predict the trade off cost and performance. As the user / researcher can use it he/she can pay according to it. It has also GUI feature through which researcher can design and run experiments. In addition to this, the user can perform one experiment on

more than one machine at the same time. C++ is the programming language that is used for the creation of models and user can add different inherited classes i.e. hypervisor class [18].

In order to perform application related experiments, iCanCloud allows the researcher to add many adapted MPI library as well as POSIX based APIs [6].

**DCSim**

DCSim is event simulator and developed by the Pennsylvania state University. Virtualized Data Centre can be deployed by using the DCSim simulation [7]. The DCSim has numerous tenants which are connected with each other and managing their own resource management and CPU scheduling algorithms policies in order to evaluate data centre management techniques [20]. DCSim is most powerful tool to use network simulation and it also generates output in the form of graphs. It can also be used to calculate the power consumption of the different network components running in the Data Centre like Switches, Routers, links, tenants and servers. Java programming language is used for the modeling of simulation [19].

**GroudSim**

It has capabilities to simulate both Grid and Cloud computational, network resources and application base simulations on scalable event base core. It has a numerous features which facilitate the researchers to perform complex simulation scenarios relating to IaaS [6]. It also support other cloud deployment models i.e. PaaS and SaaS but with extendable support of additional modules. The user can integrate GroudSim with ASKALON environment to perform real application environment experiments. Java is used as a programming language for the modeling of complex experiments and its object oriented feature is used to extend the simulation from simple to complex [21]. Furthermore, through Java, it can integrate with other software. Literature review also revealed that the experiments of GroudSim match with real executions. Its wide analysis of cloud experiments is free of cost. Beside the other features, it has also facility to perform same experiments repeatedly with the minor change of input and output values [22].

**SimIC**

It is discrete event driven simulator to get the Inter Cloud services information. Stelios Sotiriadis proposed this to measure inter-cloud activities. SimJava package is the core architecture of this simulator [6]. It is

the only Cloud simulator that was only made to cater the requirements to inter-cloud users, data centre, hypervisor and brokers. It has many modules like energy consumption, cost modeling and communication. ICMS is used in SimIC for the scheduling algorithm. Pay-as-per-use facility is also available in this simulator. Java is the programming language used in this simulator and by using the feature of said object oriented language, the researcher extend its functions and inherit different modules of other simulators [7].

## 4. COMPARISON OF CLOUD SIMULATORS

The Section-III of this paper has discussed the popular Cloud simulators. Before selecting any an appropriate simulator for simulating an environment, the researcher must know about simulators. In order to facilitate the researchers, we compared the famous Cloud simulators based on the Cloud simulator's requirements given in Section-I of this research paper. The analysis shows that CloudSim and CloudAnalyst simulators fulfill major requirements for cloud simulator. The SimIC simulator is developed in 2013. The SimIC simulator needs more improvement to meet the proposed generic requirements of the simulator. The Fig.4 shows that the number of simulator requirements fulfilled by the Cloud simulators and Fig. 5 the same in percentage. The analysis revealed that CloudAnalyst supported 86% requirements and CloudSim supported 79% requirements. It is pertinent to add here that during literature review, it is revealed that the CloudSim is the most favorite and popular Cloud Simulator. CloudSim has other numerous features over the CloudAnalyst which are not discussed in this research paper. The GroudSim and SimIC only met 43% of the requirements and DCSim is ranked lowest by fulfilling only 29% of the requirements. CloudSim, CloudAnalyst and SimIC are fulfilling 14% partial proposed requirements of a good simulator. The Fig. 6 clearly shows that ease of extension, Object oriented programming feature and repeatability features are 100% supported by the all famous Cloud simulators that are discussed in this research papers. The ease of use is also approximately supported by all the famous Cloud simulators. Communication model, Graphical output, Economic-driven Resource Management and Graphical user Interface Support are 29% supported by the simulators and these requirements are required to be included in the new version of the simulators who are not supported this feature/requirement. Cost Model,

TCP/IP support and Configuration and Felexibility features are 57% supported by the simulators and also in the category of these requirements which required being included in the forthcoming versions of the simulators who does not support these features.

| Simulator | CloudSim | CloudAnalyst | GreenCloud | iCanCloud | DCSim | GroudSim | SimIC |
|---|---|---|---|---|---|---|---|
| Ease of use | Yes | Yes | Yes | Yes | Yes | Yes | No |
| Graphical User Interface Support | No | Yes | Partial | Yes | No | Partial | No |
| Configuration and Flexibility | Yes | Yes | Yes | Yes | No | No | No |
| Repeatability | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Graphical Output | Partial | Yes | Partial | Yes | No | No | No |
| Ease of Extension | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Simulation Time in Seconds | Yes | Yes | No | Yes | No | Yes | Yes |
| TCP/IP Support | Yes | No | Yes | Yes | No | Yes | No |
| Object Oriented Programming feature | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Economic-driven Resource Management | Yes | Yes | No | No | No | No | No |
| Energy Modeling | Yes | Yes | Yes | No | No | No | Partial |
| Federation Policy | Yes | Yes | No | No | No | No | Yes |
| Communication Model | Partial | Partial | Yes | Yes | Partial | No | Partial |
| Cost Model | Yes | Yes | No | Yes | No | No | Yes |

**Table 1. Comparison of cloud simulators**

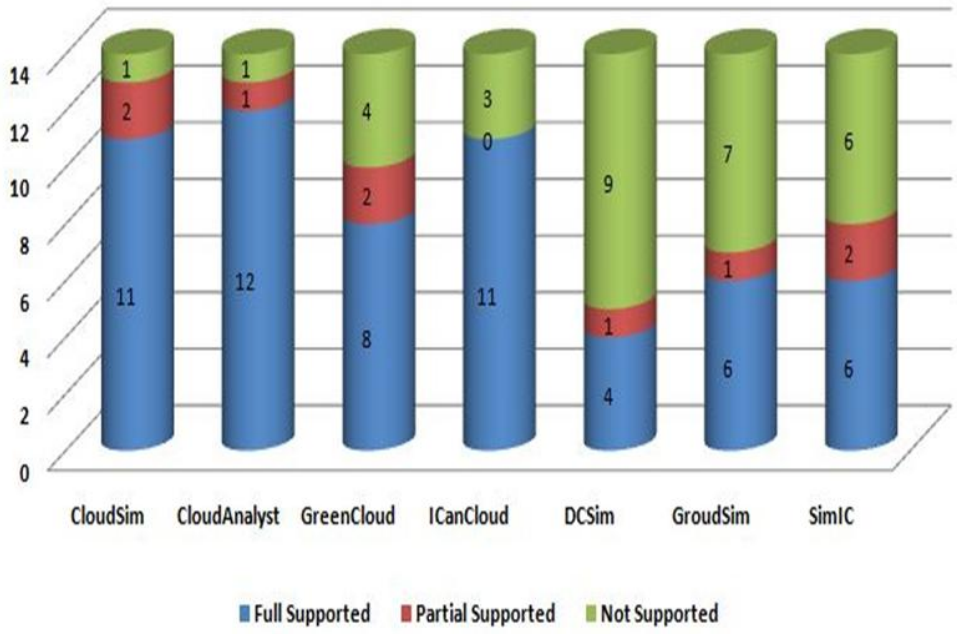


**Figure 4. Simulator requirements supported by the Cloud simulators**

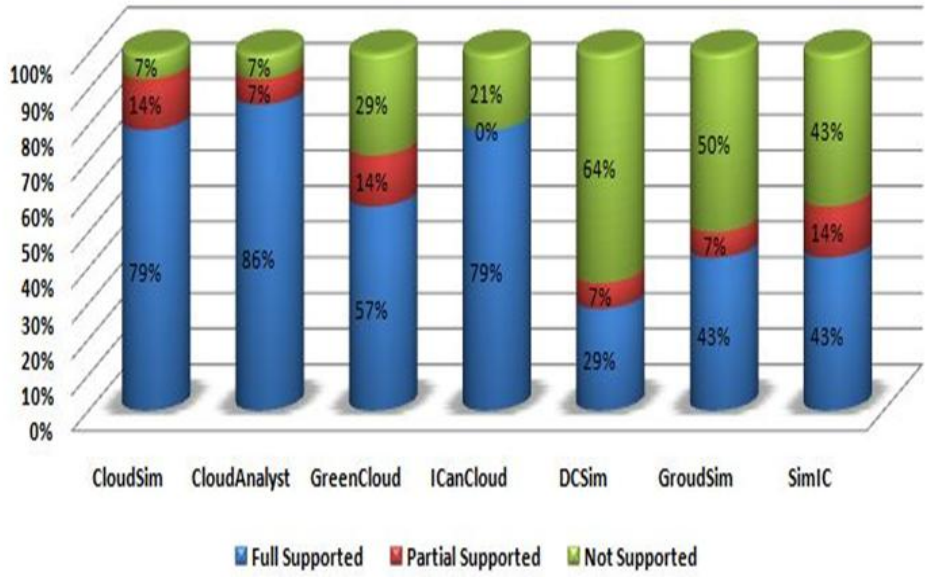


**Figure 5. Simulator requirements supported by Cloud simualtors in percentage**

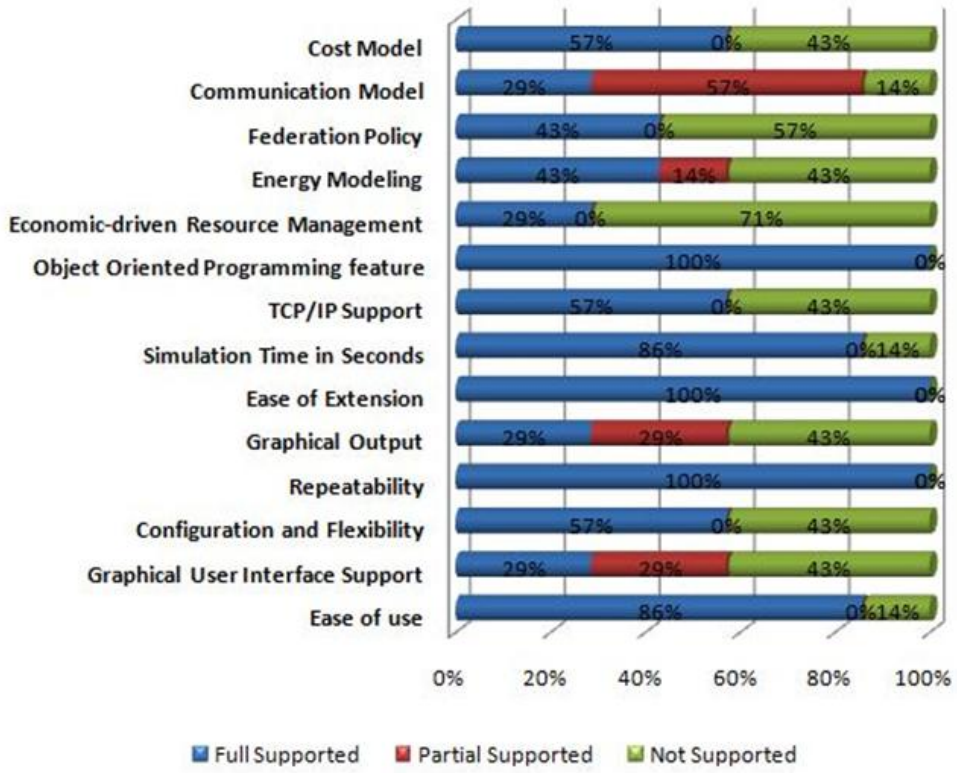


**Figure 6. No of Cloud simulator requirements included in the simulators**

## 5. CONCLUSION AND FUTURE WORK

Cloud Computing is the very fast growing, scalable and low priced services in IT industry. Simulations are used by the academia and researcher to evaluate the performance of different aspects of the cloud computing. Several Cloud computing simulators have been developed for the evaluation of specific model or more than one model. The famous cloud simulators are CloudSim, CloudAnalyst, GreenCloud, icanCloud, DCSim, GroudSim, SimIC, CDOSim, TechCloud, SPECI, NetworkCloudSim, VisualSim, SimGrid, EMUSIM, MR-CloudSim and etc. The CloudSim is the most famous and popular simulator and most of the Cloud researchers used this for the experiments purpose. The Cloud simulators have different features

and build for specific purposes. Every Cloud simulator does not fully fulfill all requirements of the researcher to test their model. There a number of features in respect of Cloud computing that a simulator should have to facilitate researcher but at least a good Cloud simulator should be easy to use, extendable to perform same experiment with change of input and output parameters, repeatability and easy and quick configurable. The Cloud simulator's requirements / features have been proposed and the famous Cloud simulators features are mapped to check their support level. After mapping, it is revealed that CloudSim and CloudAnalyst simulators fulfill major requirements for cloud simulator. GreenCloud and icanCloud are also widely used for the Cloud simulation. Object oriented programming feature and repeatability features are 100%, Cost Model, TCP/IP support and Configuration and Flexibility features are 57% and Communication model, Graphical output, Economic-driven Resource Management and Graphical user Interface Support are 29% supported by the existing Cloud Simulators. If we take the average of fully supported then it is 60%, it means in average a simulator 60% fulfill the requirements of a Cloud Simulator. The given above quantitative analysis show that simulators have many limitations that required to be addressed and needs the attention of the researchers / development team to add more features in the above simulators. There are many future directions in simulators but our work is to proposed a framework to address the issues of mobile cloud computing.


### *Acknowledgment*

The author wishes to thank several people. I would like to thank my teacher Natash Ali Mian, Assistant Professor, Beacon House National University, Lahore for his kindness and support. Furthermore, I would also like to thank Dr. Syed Aziz Haider for his assistance and guidance in this paper.


## REFERENCES


**[1] Zhao, Wei, et al.** "Modeling and simulation of cloud computing: A review." Cloud Computing Congress (APCloudCC), 2012 IEEE Asia Pacific. IEEE, 2012.

**[2] M. I. Tariq**, "Towards Information Security Metrics Framework for Cloud Computing", IJ-CLOSER, vol. 1, pp. 209-217,2012.

**[3] M. I. Tariq, I. ul. Haq and J. Iqbal**, "SLA Based Information Security Metric for Cloud Computing from COBIT 4.1 Framework." International Journal of Computer Networks and Communications Security, vol. 1, pp. 95-101, 2013.

**[4] M.I. Tariq**, SLA based Information Security Metrics in Cloud Computing. Saarbrücken: LAP LAMBERT Academic Publishing, 2014.

**[5] R. Buyya, D. Abramson and J. Giddy**, "An Economy Driven Resource Management Architecture for Global Computational Power Grids", PDPTA, pp. 26-29, 2000.

**[6]A. Ahemd and A. S. Sabyasachi**, "Cloud computing simulators: A detailed survey and future direction." In Advance Computing Conference (IACC), 2014 IEEE International, IEEE, pp. 866-872, 2014.

**[7] W. Zhao, Y. Peng, F. Xie and Z. Dai**, "Modeling and simulation of cloud computing: A review." In Cloud Computing Congress (APCloudCC), 2012 IEEE Asia Pacific, IEEE, pp. 20-24. 2012.

**[8] T. Sharma and V. K. Banga**, "Efficient and Enhanced Algorithm in Cloud Computing." International Journal of Soft Computing and Engineering, vol. 3, pp. 385-390.

**[9] A. Beloglazov**, J. Abawajy and R. Buyya, "Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing", Future generation computer systems, pp. 755-768, 2012.

**[10]W. Long, L. Yuqing, and X. Qingxin**, "Using cloudsim to model and simulate cloud computing environment." In Computational Intelligence and Security (CIS), 2013 9th International Conference on, pp. 323-328, IEEE, 2013.

**[11]X. Li, X. Jiang, K. Ye, and P. Huang**, "DartCSim+: Enhanced CloudSim with the Power and Network Models Integrated." In Cloud Computing (CLOUD), 2013 IEEE Sixth International Conference on, pp. 644-651. IEEE, 2013.

**[12]F. Jrad, J. Tao, and Achim Streit**, "SLA based Service Brokering in Intercloud Environments.", CLOSER, pp.76-81, 2012.

**[13]R. N. Calheiros, R. Ranjan, A. Beloglazov**, C. A. F. D. Rose and R. Buyya, "CloudSim: a toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms", Software: Practice and Experience, vol. 1, pp.23-50, 2011.

**[14] T. Ahmed, and Y. Singh**, "Analytic Study Of Load Balancing Techniques Using Tool Cloud Analyst." International Journal of Engineering Research and Applications (IJERA) vol 2, pp. 1027-1030, 2012.

**[15]S. Domanal, and G. R. M. Reddy**, "Load Balancing in Cloud Computingusing Modified Throttled Algorithm." In Cloud Computing in Emerging Markets (CCEM), 2013 IEEE International Conference on, IEEE, pp. 1-5, 2013.

**[16]J. Berral, Í. Goiri, T. D. Nguyen, R. Gavalda, J. Torres, and R. Bianchini.** ", Building Green Cloud Services at Low Cost." In Distributed Computing Systems (ICDCS), 2014 IEEE 34th International Conference on, IEEE, pp. 449-460, 2014.

**[17]Monteiro, R. Castellar, M. A. R. Dantas, and M. V. R. Y. Rodriguez,** "Green Cloud Computing: An Experimental Validation.", In Journal of Physics: Conference Series, IOP Publishing , vol. 540, pp. 012005, 2014.

**[18]K. Goga, O. Terzo, P. Ruiu, and F. Xhafa**, "Simulation, modeling and performance evaluation tools for cloud applications", In Proceedings of the 8th International Conference on Complex, Intelligent and Software Intensive Systems (CISIS2014), pp. 226-232. 2014.

**[19]S. Soriano and Joan**, "Simulation of Hierarchical Data Centre Resource Allocation Strategies using DCSim", 2014.

**[20]R. Rajan, and F. S. Francis**, "Experimenting with Request Assignment Simulator (RAS)", 2014.

**[21]H. Casanova, A. Giersch, A.Legrand, M. Quinson, and F. Suter**, "Versatile, scalable, and accurate simulation of distributed applications and platforms." Journal of Parallel and Distributed Computing, vol. 74, pp. 2899-2917, 2014.

**[22]A. Paya and D. C. Marinescu**", Cloud-Based Simulation of a Smart Power Grid.", In Parallel & Distributed Processing Symposium Workshops (IPDPSW), 2014 IEEE International, IEEE, pp. 875-884, 2014.

**[23]C. Kim, J. Kim, and W. J. Lee**", Design of Simulator for Cloud Computing Infrastructure and Service." International Journal of Smart Home, vol.8, 2014.

**[24]B. Pranggono, D. Alboaneen, and H. Tianfield** ", 11 Simulation Tools for Cloud Computing." Simulation Technologies in Networking and Communications: Selecting the Best Tool for the Test, 2014.