CM Cloud Simulator: A Cost Model Simulator Module for Cloudsim

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***Abstract*—The vast cloud computing environment holds out good prospects for researchers in the computing technology field. However, with several Cloud providers offering different pricing models, the evaluation and modeling of Cloud environments and applications are getting harder because there is a lack of tools for this task. We propose the CM Cloud Simulator to fill this gap since it provides a comprehensive and dynamic simulation of applications with various deployment configurations and incurs the cost it would require when implemented in a Cloud Provider, according to the cost model of any service provider. The CM Cloud Simulator also provides custom-built cost models through the XML file.**

***Index Terms*—cloud computing, pricing models, cost model simulator**

I. Introduction

Cloud computing is a subject of great interest in both the academic and industrial world, because it is regarded as an efficient and profitable alternative for the infrastructure of companies.

Cloud computing can help businessmen improve the creation and delivery of their services, by providing faster access at a reasonable cost. Moreover, it can be viewed as a continuous technology, which is able to offer flexibility and elasticity for applications [1].

The services offered by the Cloud providers are described by Mell and Grance [2] as Software as a Service (SaaS), Platform as a service (PaaS) and Infrastructure as a service (IaaS).

A detailed evaluation of a cloud computing infrastructure with all the necessary features can be obtained by simulation. The simulation can be used to obtain a greater control and accurate results on the behavior of an infrastructure or service. In this context, CloudSim [3] allows simulations to be modeled and designed by specifying infrastructure features like data centers, hosts and VMs, as well as scheduling policies and mapping the differences between physical and virtual resources.

In this paper, we propose a module called CM Cloud Simulator, which extends the CloudSim functionality by supporting different cost models. It is possible to design any cost model using XML. The CM Cloud Simulator also supports the main current Cloud service market providers such as Microsoft Azure, Amazon and Google by retrieving the values directly from their Web page dynamically. By estimating the total cost of the resulting simulation, it is possible to measure the financial cost of the system and compare the results of the different Cloud providers.

The use of the CM Cloud Simulator in IT (Information Technology) companies or even by researchers allows determining the best strategy for the allocation of a Cloud environment and selecting the best provider to deploy the applications considering the cost for it.

This paper is structured as follows: Section II carries out a literature review of existing approaches in cost models; Section III describes the proposed module framework and how its functionalities; Section IV describes the methodology and configurations used for the experiments and results; finally, Section V summarizes the conclusions and makes suggestions for future work.

II. Related Work

The cost models of the service providers are heterogeneous since each provides different types of services. Furthermore, making a comparison between these services requires an examination of some important details since they are constantly being updated in accordance with periodical changes.

Some previous studies have employed simulation techniques to determine the price of each instance on the basis of a

service provider. Owing to the complexity of determining the importance of each cost model attribute and still making comparisons between the available pricing models, a few studies have stressed the need to approximate the results obtained in a simulation environment with the results in a real current market considering the services prices. In the CloudSim simulator is possible to model cloud environments and fix the prices in a simple way, since it acts as a teaching framework for users and as a base for researchers who are designing their cloud systems and pricing models. The CloudSim was proposed to assist researchers and businessmen to have a better view of how their applications would be implemented in a cloud, but this project is still undergoing improvements [**?**].

A number of studies that involve the CloudSim environment are largely concerned with providing some kind of functionality that the simulator does not show or even improving its existing features. The idea of adding new features to the CloudSim simulator has been highlighted in several studies but the cost models are always treated in a very simplified way. In addition, the authors generally employ mechanisms that only use one service provider, as shown in [4], where the authors discuss a new concept of cost simulation that is still based on CloudSim. In this approach the user is responsible for selecting the Amazon EC2 instance types, which will be used to carry out the specified tasks at a predefined cost. In this case, apart from the fact that this approach does not provide a dynamic modeling of the service cost, the comparison between the types of instances does not allow the user to decide what is the ideal resource to run the service. Furthermore, the proposed mechanism is limited to only one service provider.

An important study that attempts to provide a better understanding for the simulator user and, at the same time, reduces the need for a knowledge of programming in the CloudSim environment, is CloudAnalyst [5]. CloudAnalyst is a CloudSim-based visual modeler for analyzing cloud computing environments and applications, which has a friendly graphical interface and extends CloudSim features by, for example, generating graphics output for the results and making it possible to define a less complex configuration, as it has greater control of the data.

There are also several works in the literature that propose and evaluate pricing models for cloud computing, including studies that conduct an analysis of this line of research like in [6], [7], [8], [9], [10] and [11].

In the analyzed papers, we did not find any works that provide a tool that allows the users to analyze the prices of the resources and services dynamically. To fill this gap, the next Section outlines a new simulator for cost analysis.

III. Cost Model Cloud Simulator

The use of simulation can assist in choosing the system configuration to host applications. Simulators such as CloudSim are widely used, since they help model the major components of the infrastructure and lead to satisfactory results in the simulation.

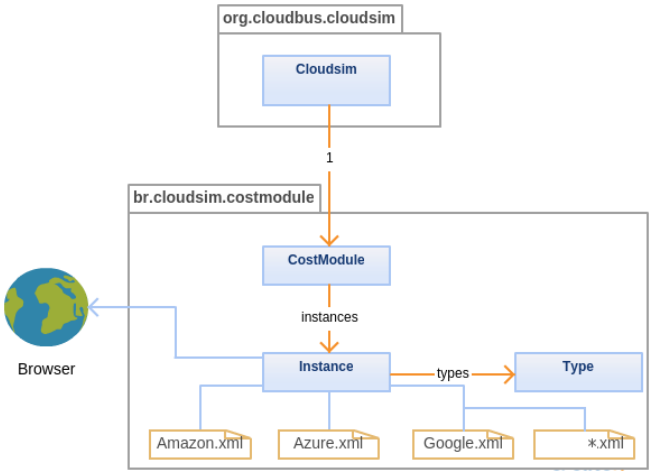

Fig. 1. CM Cloud Simulator Diagram

The CM Cloud Simulator was developed as a CloudSim module and it is designed to run cost models of different service providers, as well as obtain the best price from them dynamically. One of the main objectives of the CM Cloud Simulator is to be able to assess the cost models by providing an organized infrastructure that is easy for the user to maintain and understand.

A. Module Implementation

The CM Cloud Simulator is implemented as a CloudSim module so that is can extend its functionality and be able to run a cost model of different Cloud providers. The way that the module is designed and interacts with the CloudSim can be seen in Figure 1.

The main components of the CM Cloud Simulator are:

- **CostModule**: responsible for the activation of the instances and execution of the cost models. All the interaction with the CloudSim is carried out though this system.
- **Instance**: instances are created with the ability to access cost models from the service providers or custom-built cost models. Moreover, the functionality of the dynamic mapping cost models is achieved by this system, by converting the cost models of the providers in a standard XML file format for a CM Cloud Simulator.
- **Type**: describes types of instances.

In figure 2 displays the XSD (XML Schema Definition) used to define the cost model of the Cloud providers.

Other important feature of the CM Cloud simulator module is the capability of automatic search for information in three of the major Cloud providers which are Amazon, Google and Azure. The module keep the instance databases updated, since it constantly conducts searches in the web pages of the Cloud providers. Through this filter, it is possible to select only the appropriate values in the tables from the web site, that model the cost of the instances and arrange them in XML files which follows the standard presented in figure 2. Therefore, it is also

```
<?xml version="1.0"?>
- <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">
  - <xs:element name="Instance">
    - <xs:complexType>
      - <xs:sequence>
        - <xs:element name="types">
          - <xs:complexType>
            - <xs:sequence>
              - <xs:element name="Type" minOccurs="0" maxOccurs="unbounded">
                - <xs:complexType>
                  - <xs:sequence>
                      <xs:element name="name" type="xs:string"/>
                      <xs:element name="vCPU" type="xs:integer"/>
                      <xs:element name="ecu" type="xs:float"/>
                      <xs:element name="memory" type="xs:float"/>
                      <xs:element name="storage" type="xs:short"/>
                      <xs:element name="pricePerHour" type="xs:float"/>
                    </xs:sequence>
                  </xs:complexType>
                </xs:element>
              </xs:sequence>
            </xs:complexType>
          </xs:element>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
</xs:schema>
```

Fig. 2. CM Cloud Simulator XSD

possible to implement this kind of filter for any other Cloud Provider, since the cost table is available online.

B. Use of features

In this paper we have used the US data values for cost modeling in the CM Cloud Simulator; this also uses instances on-demand, where the price is charged according to use. Regarding the type of instance, Linux instances were used for IaaS in all the service providers.

The first stage for the user when using the CM Cloud Simulator is i) to determine the characteristics of each component of the Cloud environment, which are usually employed in CloudSim, and ii) instantiate the main class of CloudModule. Subsequently, this module uses the functions designed in the CM Cloud Simulator to obtain all the options which have a similar infrastructure to that specified by the user. The results obtained can be divided for each service provider, while always making a trace of the characteristics of the selected instance and the total price for its use.

IV. Case Study

A. Simulation scenario

For the purpose of demonstration, we proposed a simulation scenario which uses three instances that would be responsible for analyzing some data at certain times of the day. In addition, each set of data would be processed by a different instance. We considered the idea of using instances on Linux machines and based on the U.S. cost model.

The experimental design was is shown in Table I. The planning and analysis of experiments include both factors and levels, where the factors correspond to environmental characteristics and the levels are the possible environmental variations. In this way, three factors which are Instances, Application and Cloud providers were defined, each of which have three levels. The experiments are conducted according to experiment design presented in [12].

TABLE I
Experiment design

Factor	**Levels**		
Instances	VM1	VM2	VM3
Applications	Cloutlet 1	Cloutlet 2	Cloutlet 3
Cloud providers	Amazon	Google	Azure

In table II the Instances configurations are shown in detail. We used three configurations of Virtual Machines that were characterized as VM1 (small instance), VM2 (medium instance) and VM3 (large instance). These specifications for Virtual Machines are the minimum requirements to run the experiments.

TABLE II
Instances

Instances			
	VM1	**VM2**	**VM3**
Size(GB)	80	160	320
Ram(GB)	4	4	12
vCPU	1	2	4

Table III shows the applications that must be executed in the Instances. We proposed three types of applications for this simulation, called Cloudlet 1 (small), Cloudlet 2 (medium) and Cloudlet 3 (large). In the simulator, the instructions are given in MI (Millions of Instructions).

TABLE III
Applications

Applications			
	Cloudlet 1	**Cloudlet 2**	**Cloudlet 3**
Instructions(MI)	200000	8000000	900000000
inputFileSize(MB)	200	400	600
outputFileSize(MB)	200	400	600

With regard to the configuration details of the simulation environment, it should be noted that virtual machines of a small, medium and large size were used to demonstrate the use of the simulator in each case.

The three Instances were in a single data center and the resource allocation policy between the instances was time-shared. It is also possible to simulate a more complex scenario with multiple data centers, where each of these contains many virtual machines and has different users.

B. Results

Table IV shows the cost of each Cloud provider for the instances which were used in the experiments. In the case of the Google provider, there is just one instance since there was no difference between the price of the storage for the use of 160 GB and 80 GB and the n1-standard-2 had suitable features to meet the user requirements.

Table V shows the results of the use case. Simulation 1 represents the execution of Cloudlet 1 on the VM1, Simulation 2 the execution of Cloudlet 2 in VM2 and Simulation 3 the

TABLE IV
PRICE IN THE EXPERIMENT DAY

Provider / Type of Instance	US$/hour
Amazon / m3.xlarge	$0.2800
Amazon / m3.2xlarge	$0.5600
Amazon / c3.4xlarge	$0.8400
Google / n1-standard-2	$0.1000
Google / n1-standard-4	$0.2000
Azure / D2	$0.1880
Azure / D3	$0.3760
Azure / D4	$0.7520

execution of Cloudlet 3 in VM3. In this scenario, it can be seen that the Google provider can provide the infrastructure which meets the user needs at a lower price, followed by Azure and last of all by Amazon.

TABLE V
SIMULATION RESULTS

Results			
	Amazon	Google	Azure
Simulation 1			
Type	m3.xlarge	n1-standard-2	D2
vCPU	4	2	2
Memory(GB)	15	7.5	7
Size(GB)	80	80	100
Monthly cost($)	8.4	3.726	5.1
Simulation 2			
Type	m2.2xlarge	n1-standard-2	D3
vCPU	8	2	4
Memory(GB)	30	7.5	14
Size(GB)	160	160	200
Monthly cost($)	100.8	24.789	56.781
Simulation 3			
Type	c3.4xlarge	n1-standard-4	D4
vCPU	16	4	8
Memory(GB)	30	15	28
Size(GB)	320	320	400
Monthly cost($)	327.6	111.333	255

The objective of the module was achieved with satisfactory results, since it provided a tool to analyze different situations for the user and yielded results that could help the user decide which Cloud Provider could best suit his requirements. This took account of all the output responses already present in Cloudsim, together with the variable costs.

V. CONCLUSION

Owing to the growing interest of companies and researchers in Cloud technologies, questions have arisen regarding the cost-benefits of starting or migrating an application to cloud and there is a growing demand for tools which can assist this decision-making. The CM Cloud Simulator is a module that has been developed to meet this demand, and was designed as a CloudSim module.

With the aid of this module, it was shown that cost models can be simulated and analyzed through different cases, either for research purposes or even to demonstrate the usability of real cases. As cited, an example involving large amounts of data analysis concepts requires a particular and robust infrastructure. For this, the CM Cloud Simulator functionalities can be used to help obtain results about the best types of instances and lower prices, and allow the user to make a more effective investment.

The original purpose of developing this module was to improve simulations based on CloudSim and obtain results best suited to the current market price. This means that the updates that can be obtained in this module will involve including the new cost model, support for new types of services and an ability to make broader comparisons, so that further differences and similarities between service providers can be found.

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Support information as well as the CM Cloud Simulator code is available at https://github.com/diegoca80/CloudModule.

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