Virtual Cloud: Rent Out the Rented Resources

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***Abstract*—With the advent in cloud computing technologies, use of cloud computing infrastructure is increasing day by day and a lot of enterprises are shifting their computing from in-house infrastructure to the cloud infrastructure. Over a small period of time, it has substantiated to be an attractive choice for the enterprises. Especially for those, who wants to have minimal upfront cost for their technology infrastructure. This aspect of cloud computing makes it particularly suitable for a new enterprise. Currently, cloud services are a bit expensive, but a good number of enterprises and individuals can be attracted to the cloud computing by providing the low cost cloud services. In a fast growing cloud vendor market, provision of low cost cloud services is a difficult task for the cloud vendors. In this paper, we present a model of Virtual Cloud. The concept of Virtual cloud revolves around the concept, "Rent Out the Rented Resources". It aims to reduce the monetary cost of cloud services. In this model, we propose to virtualize an already virtualized infrastructure. To achieve this, cloud vendor offers the low cost cloud services by acquiring underutilized resources from some big third party enterprise.**

***Keywords*- Cloud computing; Virtualization; Cloud federation**

I. Introduction

Cloud computing is considered to be a new computing paradigm. But it also exists in the computing history in some other simplified forms. An example of this is the UNICORE project [8] of the late 90s, which somehow addressed the type of a cloud computing model. However, recently it has gained a lot of attention due to its usefulness in terms of cost, adaptability, variety of services, and computational support to the devices with less computational power [1]. Though some people are worried about the security in the cloud. But in fact, the cloud is more secure than the proprietary infrastructure. As in the cloud computing, we outsource the computation, not the control [9].

Cloud computing can really be a winsome option for an enterprise. Especially for the new enterprises, which want to reduce the upfront cost for their computing infrastructure. Even established organizations can reduce not only the computing infrastructure cost, but also the administrative and operational cost for the infrastructure. Because after purchasing the computing infrastructure, the organization needs human resources, space, energy and many other resources to manage and administer them. Whereas, in the case of opting for cloud computing services, these costs are reduced [2]. Cloud computing has proved to be a cost benefited option for the enterprises who wants to extend their clusters' capacity [3]. Some of the big cloud infrastructure/service providers are Amazon [15], Salesforce [16], Google App Engine [17], and Microsoft Azur [18]. The major users of these cloud providers are the enterprises.

Along with an enterprise, a home user can also take advantage of cloud computing, if they are available at a reasonable price. The home users commonly use the hand-held devices. The use of new sophisticated hand held devices is increasing sharply day by day. These devices provide variety of services including communication, computing, gaming, photography, navigation, sensing and many more. But still they are lacking far behind the traditional computers in computational power. With the emergence of cheap cloud services, cloud computing can be an ideal candidate to be utilized with them. The use of notebook computers is now transforming into a tablet or a light netbook, which can take advantage of cloud services for intensive computation. In the near future, cloud services will be widely used by the enterprises and individuals, using hybrid computing and communication devices. Thus it is required to provide cloud service to the individuals, at a very low cost. It can be possible by creating competition among cloud vendors and reducing infrastructure cost for them. For this purpose, we propose a cloud computing model (i.e. Virtual Cloud) to achieve the low cost objective. Virtual cloud model is mainly aimed to reduce cost for both the cloud user and cloud vendors. In this model, a cloud vendor rents the resources from some third part enterprise and then further rents out those resources/services to the cloud users i.e. clients. Please note that throughout this paper, we will use the term "Co-operating Venture" for the third party enterprise, which rents the resources to the virtual cloud vendors. These cooperating ventures are normally big enterprises with already existing technology infrastructure. But their technology infrastructure is underutilized.

The rest of the paper is structured as follows. Section 2 gives the overview of some related work and the core idea. Then in section 3, we present our propose model. In Section 4, we describe the working and experiments of our proposed model. We conclude in Section 5 and discuss the future research directions.

II. Related Work & Core Idea

There are different models and ideas for the cloud computing. But there is no exact existing model like our proposed model. However, a few of the concepts that we employed in our model, already exist before (like federation of cloud/grid). There is some work done for the integration of different grids. An example of this type of work is with the name InterGrid [4], [5], [6]. In this model, they have a peer-to-peer multi-grid architecture, which is federated through P2P InterGrid Gateway. There is also a cloud computing test bed named Open Cirrus [10], which has federated data centers for open source systems and services research. Celesti et. al. has done some work in the area of cross-cloud federation [11], [12]. They have proposed a three phase model for cross-cloud federation. These three phases are discovery, match-making, and authentication. Keahey et. al. introduced the concept of Sky Computing [13], which is based on the concept to interconnect the different infrastructure as a service cloud. Bernstein et. el. have proposed a model for the Intercloud architecture [7].

The proposed model of Virtual cloud revolves around the concept to rent out the rented resources. In this model, the cloud vendor rents the resources from some cooperating venture(s) and after performing virtualization, rents it to the clients in form of cloud services. The cooperating venture is paid for its infrastructure utilization. The model of Virtual Cloud is given in Figure 1. The three stakeholders i.e. virtual cloud vendor, cooperating venture, and clients are mentioned in the figure.

The concept of Virtual Cloud is engendered by keeping in view the benefits of all the three stakeholders i.e. cloud operator, user, and cooperating venture. It is based on three core objectives:

- Minimize the cloud infrastructure cost for the cloud vendors.
- Provide low cost cloud services to the clients by reducing infrastructure cost for the cloud vendors and creating a competitive market for them.
- Give the monetary benefit to the established enterprises (cooperating ventures) with the large under-utilized technology infrastructure.

In a typical cloud scenario, a cloud vendor/operator provides the cloud services by renting its resources. The vendor must have a very good cloud infrastructure, which requires state of the art machines, software resources, network technologies and other computing supporting resources. Thus it requires a very high upfront cost to establish a cloud service provider business. It also requires a high administrative cost in provision of cloud services.

On the other hand, the existing big enterprises (cooperating ventures) normally have very good state of the art technology infrastructure like cluster/grid systems. But their resources are mostly wasted in the off-peak hours. So why not to utilize their resources and give them some monetary benefits against it. These enterprises are currently relying on their existing powerful computing resources. So their immediate attraction towards using cloud services for them is relatively less.

We propose the Virtual Cloud, in which upfront cost for a cloud vendor is less. In Virtual Cloud, the cloud vendor does not need to have the complete proprietary technology infrastructure. It borrows the platform resources from cooperating ventures. Virtual cloud vendor and cooperating venture shares those resources. Most of the cloud services/resources are hosted on the cooperating ventures' infrastructure. Virtual cloud vendor rents the resources from the traditional big enterprises and subsequently rents out them to his clients in form of cloud services. These services can be hardware, software, processing, memory or storage resources. Virtual cloud vendor may have its own storage resources, but normally the computing resources are rented from cooperating ventures. So the concept is *to rent out the resources to be rented*. Virtual Cloud provides the following benefits.

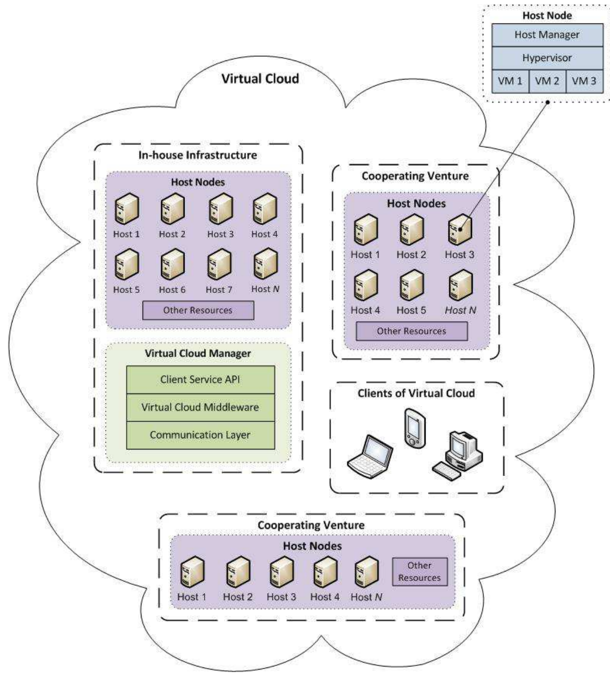

Fig. 1. Model of Virtual Cloud

- The upfront cost for the Virtual cloud vendor is lesser than a typical cloud vendor.
- Administrative cost for the virtual cloud vendor is less, as it has to manage less physical resources at its own. It needs less space, energy, and human resources to manage its own technology infrastructure.
- As the cloud vendor has very reduced upfront and administrative cost, so he can offer services at a comparatively lower rates.
- Cloud user (client) has services available at a cheaper rate as the cloud vendor has very reduced upfront and administrative cost himself. So the client can use more cloud services and can take advantage of the cloud power.
- There can be a high rise in the number of cloud vendors, as the cloud vendor enterprise setup cost is reduced by large.
- Lower cost and high number of virtual cloud vendor will increase the competition among them and subsequently

the virtual cloud vendors have to reduce their services offering price and have to increase the quality of service.

- Enterprise (cooperating venture) providing the resources to the virtual cloud vendor, gets the financial benefits in form of rent paid by the cloud vendor.
- Cooperating venture can purchase further resources by the earned rent amount, to enhance their technology infrastructure.
- Energy is saved, as the computing is performed on the existing resources, instead of the new resources. The new resources consume additional energy to perform operations.

III. Virtual Cloud Architecture

The architecture of Virtual Cloud is a client-server model. Virtual Cloud architecture is partitioned into two main components i.e. Virtual Cloud Manager (VCM) and Host Manager (HM). Virtual Cloud Manager is a server type component, functioning on the cloud vendor's proprietary infrastructure. Host Manager is a component installed at each host machine. Generally, these host machines are located within the cooperating venture's infrastructure. An instance of Host Manager is installed only on those host machines of cooperating ventures, which are available to be rented to the virtual cloud vendor. A generic model of Virtual Cloud is given in Figure 1 which shows the parties involved in a Virtual Cloud scenario.

A. Virtual Cloud Manager

Virtual cloud manager (VCM) is the main and unitary component of the virtual cloud. It is responsible for all the major tasks in the cloud. It is a server type instance running at the cloud vendor's infrastructure. Virtual cloud manager consists of 3 layers i.e. Client Service API, Virtual Cloud Middleware and Communication Layer. Virtual Cloud Manager architecture is shown in Figure 2.

1) Client Service API: Client service API is an interface layer to the Virtual Cloud Middleware. It enables different clients to request different types of services from Virtual Cloud Manager. It understands different types of messages and service requests.

2) Virtual Cloud Middleware: Virtual Cloud Middleware is the core part of the Virtual Cloud Manager. It has different components to deal with different types of tasks. The functionality of these components is given below.

Distributor

It is the central point of the Virtual Cloud Middleware. It is responsible for task assignment and communication among all the components of the Virtual Cloud Middleware. It receives a request from a client through client service API and route it to the appropriate component responsible for the desired task.

AAA Server

It is a module responsible for the Authentication, Authorization, and Auditing of the clients. Authentication is required to use the cloud service. A cloud user must be already registered with all of his credentials in the AAA server. Authorization checks that whether the user is authorized to use a particular

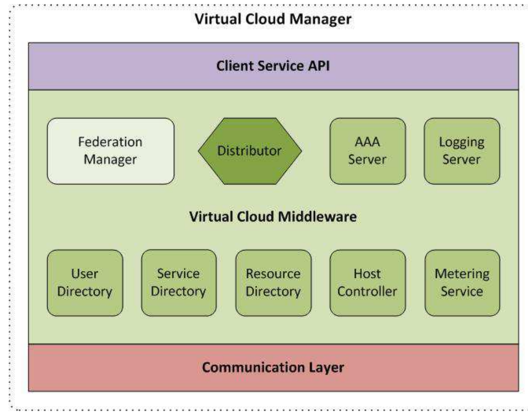

Fig. 2. Architecture of Virtual Cloud Manager

service or not. Whenever a user requests for some cloud resource or service, the request is first passed to the AAA server to check for authorization. Auditing service checks for the user integrity control. It finds which variables are required for correctly identifying and relating all the actions of the user at a particular instant of time. It verifies the correct use of services and resources by the users.

Metering Service

It is an accounting service for both the users and hosts. It calculates the billing for the users on the basis of account and metering settings. User can choose among different types of metering packages depending upon his needs and offers made by virtual cloud vendor. It also calculates the billing for hosts on the basis of type of contract and resource utilization.

Client Directory

All the users/clients are registered in the user directory. It contains detail information about the users and their credentials.

Service Directory

It keeps the record of the available cloud services. It tells the user that what types of cloud services are available at a particular time.

Resource Directory

It keeps record of all the hosts and the information about their infrastructure resources. It also has a record of the federated resources from other cloud vendors.

Host Controller

It is responsible for managing the hosts. It has a capability to perform certain node management tasks, including the node creation, termination, assignment/acquisition, release etc.

Federation Manager/Service

It is responsible for cross-cloud federation with other virtual cloud vendors. It has the record about all the cloud vendors in its federation. It has two main tasks to do. The first is to periodically advertise its own shareable resources and services to the other cloud vendors in its federation. The second task is to receive advertisements from the other virtual cloud vendors for their available resources. It records the details about the resources into the Resource Directory and details about the services in the Service Directory. Federation Manager uses

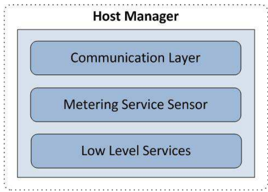

Fig. 3. Architecture of Host Manager

the Instant Messaging and Presence Service (IMPS) protocol to advertise its resources. Federation Manager provides very high level of scalability to the Virtual Cloud. It also registers its federating cloud vendor(s) both as client(s) and cooperating venture(s) respectively in its client directory and resource directory for the metering purpose. If the desired resource is not available locally within the Virtual Cloud then federation manager requests its peer federation manager located on the remote Virtual Cloud for the resources.

Logging Service

It is responsible for keeping record of all the events occurring in the VCM manager. In case of any discrepancy, one can verify the source of problem with its log record.

3) Communication Layer: Communication layer is responsible for communication with the clients, hosts and possibly with other VCM in case of cross-cloud federation. It is responsible to have a guaranteed communication between client & VCM, Host & VCM and VCM & VCM. It is capable to understand different communication protocols and technologies. It is able to communicate across firewalls and non-routed networks using SmartSockets [21].

B. Host Manager

Host manager is responsible for virtualization on the host machines and provision of services to the clients. It creates a virtualized environment with the help of a hypervisor, to provide a set of cloud services. It has three components i.e. Metering Service Sensor, Communication Layer and Low Level Services. Host Manager architecture is shown in Figure 3.

1) Metering Service Sensor: It is responsible for the accounting of resource usage. It helps the metering server at the Virtual Cloud Manager for the billing. It constantly monitors the resource utilization and periodically sends the statistics to the Metering Service at VCM. Metering Service at VCM does the billing for the user on the basis of this information.

2) Communication Layer: Communication layer is responsible for communication with the clients, Virtual Cloud Manager, and other hosts. It is responsible to have a guaranteed communication between client & Host, VCM & Host, and Host & Host. It is capable to understand different communication protocols and technologies. It is able to communicate across the firewalls and non-routed networks using SmartSockets.

3) Low Level Services: It is responsible for interaction with the external environment of the host manager. It works in conjunction with the hypervisor to create virtual machines. It also communicates with the virtual machines at the host node to provide the requested services.

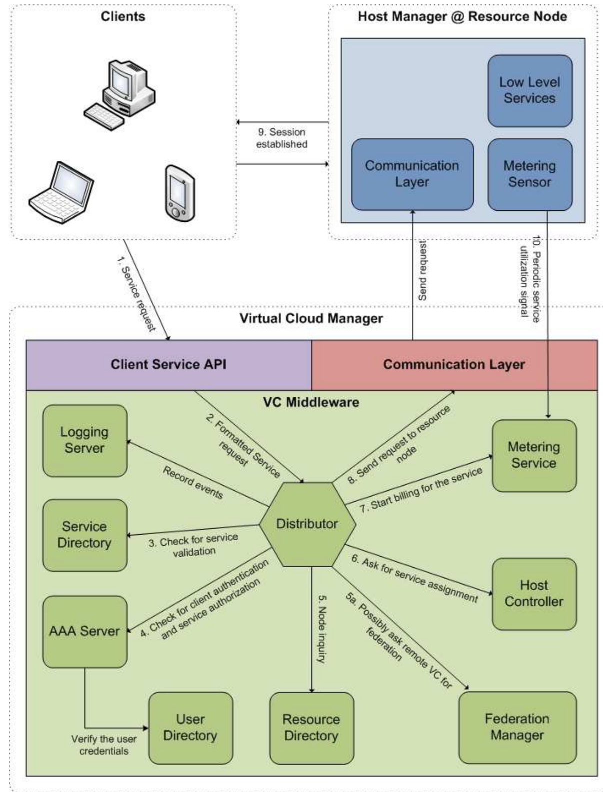

Fig. 4. Interaction model for Virtual Cloud Service Utilization

IV. Working & Interaction Mechanism

A. Virtual Cloud Setup

A virtual cloud vendor installs and sets up its virtual cloud manager (VCM) on some very powerful machines. These machines are normally within the vicinity of the cloud vendor. To provide cloud services, he installs Host Manager on the host machines. Host machines are those which provide the actual services to the clients. Some of these host machines can be within cloud vendor's infrastructure, but normally they belong to the infrastructure of cooperating venture. Host machines also have hypervisor installed. Host manager works with the hypervisor to perform virtualization on the host machines.

B. Service Utilization by the Client

The interaction model for service utilization is given in Figure 4. Client uses the cloud resources/services by the means of web services. It requests the desired service from the virtual cloud vendor, where Virtual Cloud Manager is responsible for handling these requests. The request is first forwarded through Client Service API, which allows the access from different types of client platforms and message formats. It then sends the request to the Distributor, which is responsible for controlling all the activities within Virtual Cloud Middleware.

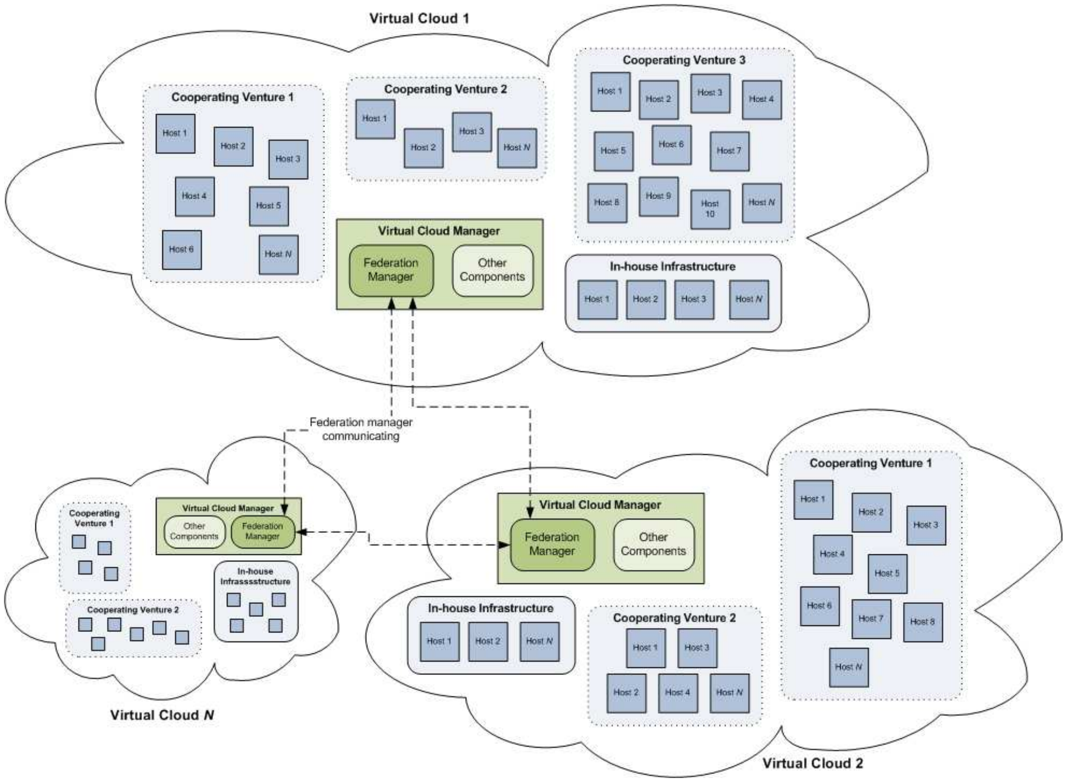

Fig. 5. Virtual Cloud Federation Scenario

Distributor first checks the service validity. In this process, it checks with the service directory that whether the demanded service is within its domain and whether it can be provided at this time or not. Then it verifies the user credentials and the service authorization by AAA Service. It checks for the authentication of user and authorization for particular service. Then it checks from the resource directory that where the resources for the particular service do exists. In case, if the Distributor manages to find a resource to perform the task, it asks the Host controller to assign a host node (expected to run/running the service) to the service. But if the Distributor cannot find an existing resource/host for the service, then it asks the Host Controller to first create/register a host node and then assign that host to the service. Host node creation and termination record is updated in the Resource Directory and host assignment and release is updated in Metering Service. At the time of service assignment, a unique service assignment ID (SaID) is generated, which shows that a particular client is using a particular service. If the distributor totally fails to find an existing resource or to create a new host then it performs the cross-cloud federation. The distributor asks its federation manager to contact the remote federation manager for a service assignment.

Then Host Controller forwards the request to the communication layer, which sends the request with the service assignment ID to the host node. The request is passed through the communication layer at Host Manager, which understands different communication protocols and ensures a reliable communication.

Host node can belong to the virtual cloud vendor or to a cooperating venture. Host node serves the required service to the client/user, on the basis of service request from the VCM. It creates a direct communication link with the client and uses the SaID for reference. Metering sensor periodically sends the service utilization signals to metering service at virtual cloud manager. When a client wants to finish the service utilization, it asks the VCM. Host controller at VCM requests the host node to terminate the service and it releases the node from the service. Then distributor updates the resource directory that the node has been released and also informs metering service to stop metering.

C. Use of Federation Manager for Cloud Federation

In case of cross-cloud federation, Distributor requests its federation service to ask to its peer federation manager on remote Virtual Cloud for the resources, as show in Figure 5. Federation service sends a resource request to the Federation Manager of peer virtual cloud manager. Remote federation service asks the distributor (on that remote Virtual Cloud) to request for the service. Remote Virtual Cloud Manager assigns a host node to the service and informs the local Virtual Cloud Manager through federation service about the service assignment. Then remote VCM starts billing for the service usage in the name of local virtual cloud vendor. The billing rate is normally lesser than the usual client billing rate. The Metering Sensor sends the usage information to the remote VCM, which not only performs its local billing but also forwards it to the local VCM. Local VCM has already registered all the federated clouds as its cooperating ventures as well, so it do the billing for both the client and cooperating ventures at their respective billing rate.

V. Discussion and Conclusions

The proposed model revolves around the concept of "rent out the rented resources". It aims to provide low cost cloud services to the clients by reducing the infrastructure cost for the cloud vendor and giving some monetary benefits to the cooperating ventures. It specifically targets the home users and small enterprises, which are not eagerly concerned about very high level of quality of service. But they are more worried about the cost of cloud services. In case of Virtual Cloud, quality of service can be slightly degraded as compare to the traditional clouds. But the services are available at a cheaper price.

The proposed model is in process of implementation and will be available as an open source solution. It is going to be customizable software, which can be customized according to the needs of the virtual cloud vendor. We are building it on existing *ProActive* cloud/grid middleware [14]. *ProActive* is an open source cloud/grid middleware, which enables the user to execute its tasks on a cluster or cloud infrastructure.

Due to its high applicability, it may also attract some big software manufacturing companies, who wants to venture into the business of creating software platform for virtual cloud computing. These enterprises can have their own virtual cloud software platform based on this model, which can be available to be purchased off the shelf.

We are also working on another framework, named Network Aware Module (NAM) [20]. It is a framework for network aware cloud computing. We had built a module, which assists the cloud scheduler in doing the scheduling decisions on the basis of certain network resource characteristics. We are going to integrate NAM into Virtual Cloud.

There can be few more research issues associated with our proposed model. It contains most of the existing research issues for the traditional cloud and have some more raised due to the hosting resources on the third part infrastructure (cooperating ventures). These issues are computing instance management, organization and distribution of memory pool, storage management and distribution, process and data migration among different hosts and to the host belonging to the other virtual cloud vendor.

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