Study of Market-Oriented Cloud Techniques

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Abstract:- In recent times, Cloud computing has emerged as one of the most preferred computing paradigm that offers assorted services to the users without violating SLA and QoS requirements. With the increased use of ICT enabled services, it is paramount to understand the current market scenario from both user and service provider's perspectives and utilize the cloud resources. The survey work carried out in this research presents a comprehensive study of Market-Oriented Cloud Computing, its architecture and taxonomy of resource management techniques as per current market trend.

Keywords – Cloud Computing, Market-Oriented Techniques, Cloud Platforms, SLA

I. INTRODUCTION

The recent [1] advancements in human society has led to easy provisioning of necessary utility services which includes water, electricity, telephony, gas etc. These services have become vital for survival of humans and should be made accessible when desired. The consumers of such services are ready to pay for provider's offerings and services on pay-per-use model. In 1969, Leonard Kleinrock in [2] announced that shortly the use of computer utilities will facilitate basic services in the homes and offices across the countries. It has led to a massive transformation of computer sector in offering computing utility that follows an adequate service provisioning model. With growing demands [1], a number of challenges are being faced by software practitioners to provide readily available software's to the consumers on the web rather than on individual machines. With the emergence of technology era, new computing paradigms are being facilitated and adopted by the software practitioners to edge closer towards building a stronger networked and multi-core processing and computing environments.

A number of paradigms emerged in past years comprising of assorted attributes or capabilities that has led to realization of the great vision quoted above. The various paradigms are Service Computing, Grid Computing, Web, Utility Computing, Market-Oriented Computing and Cloud Computing. But a challenge that has been faced in this system is that who will own the system that will serve millions or trillions of the users. The issue has been raised by co-founder of Sun Microsystems Mr. Bill Joy [3]**.** Further, it has been addressed that the Quality of Service parameter and Service Level Agreements needs to be clearly designed taking into account factors like reliability, scalability, heterogeneous user demands and many more.

Among the paradigms mentioned above, Cloud Computing has emerged as latest model that offers reliable services using its promising characteristics like virtualization and massive data storage capabilities. The biggest advantage it had offered can be realized from the inclusion of term "Cloud" in its definition. It addresses single point of access to the users requiring computing or storage facilities. The providers have assured the consumers about the robust Cloud Infrastructure that is available to user as per requirement [4].

The research work discusses Utility-Oriented Clouds in Section 2. Section 3 presents Market- Oriented Cloud Architecture. In Section 4, some of the emerging Cloud Platforms have been discussed. Section 5 illustrates various existing Market-Oriented Techniques for Cloud Data Center**.** In Section 6, the research work has been summarized.

II. UTILITY-ORIENTED CLOUDS

Cloud computing or utility computing [5] aims to power the next generation systems by delivering platform, software and infrastructure as a service on pay-as-you-go model to the users of the system. Cloud as a technology has become a long-held dream of computing as it offers every utility service on subscription basis. Cloud computing in recent times has been reached to plateau of productivity phase in just 3-5 years and has been enforced by service providers such as IBM, SalesForce2, Google, Amazon, Sun Microsystems and Microsoft. The service providers has established new and huge data centres to fulfill varied requirements of users for hosting applications such as media content delivery, business applications, social networking, scientific workflows etc.

Cloud computing works on a Service-Oriented Architecture (SOA) that follows concepts of distributed computing and virtualization[6]. In cloud computing SOA, shared pool of resources can be accessed via network and can be configured as per users' requirement [7].

To realize SOA [5], Service Level Agreements (SLAs) are established between customers and Cloud providers. An SLA is a kind of agreement that specifies the metrics agreed upon by all the entities involved in exchange of services or fund. Besides, it includes Quality of Service requirements and penalties for violation of the expectations.

SLAs can be considered as a warranty for users to move their business to the Cloud platform. It thus assists enterprises in reducing the administrative and maintenance costs by renting out the needed IT infrastructure with Cloud vendors. Likewise, end-users leverage the services of Cloud without purchasing expensive software and hardware and can access their personal data anywhere from web. These characteristics places Cloud into a market oriented perspective.

To deal with bursts in varying Cloud demands, cloud providers are focusing towards introducing scalability in Cloud services. In Figure 1, components of service-oriented architectural framework are depicted. It consists of cloud's utility-driven management aspects supported by client's brokering and coordinator services. Such aspects takes into inclusion the terms: migration of workloads, application scheduling and resource allocation [8**].**

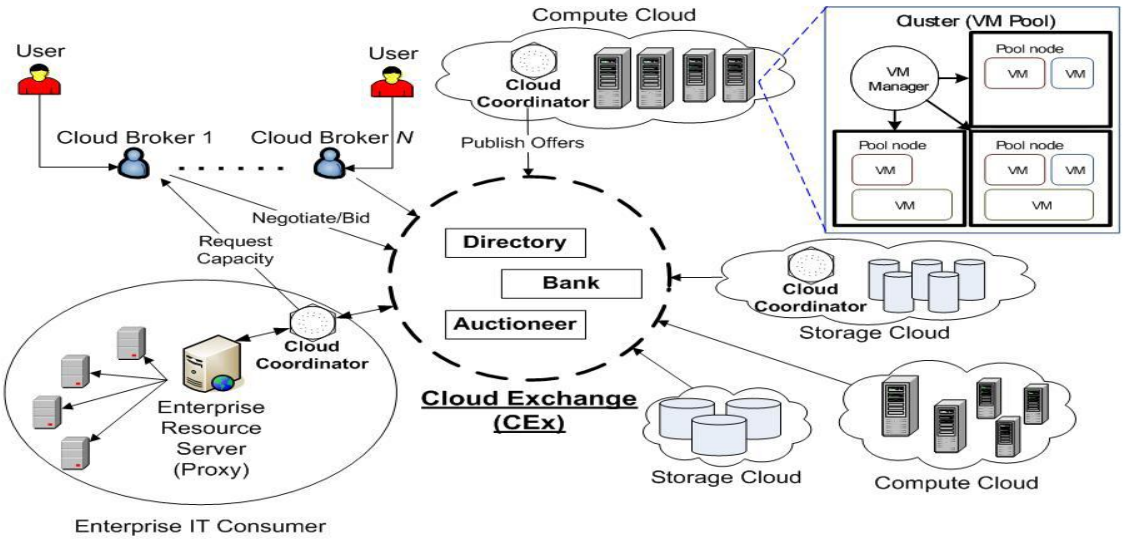

Figure 1. Utility-Oriented Clouds [14]

As depicted in the Figure 1, the Cloud Exchange (CEx) module is used to bridge service gaps between consumers of cloud and the service providers by acting as market maker. It collects the demands of infrastructure from the application brokers and further assesses them on the basis of supply information provided by the Cloud Coordinators. It supports exchange of Cloud services taking into account competitive economic models like auctions and commodity markets. CEx module allows the Coordinators and Cloud Brokers to easily locate consumers and providers by extending great offers. This leads to creation of dynamic market infrastructure that further facilitates trading based on SLAs. The banking system within the market is provided to ensure that all the financial transactions within cloud pertaining to SLAs should be carried out within a secure and dependable environment. Each client is required to instantiate a Cloud brokering service which dynamically establishes service contracts with the Coordinators of the cloud via the trading functions uncovered by the Cloud Exchange. The market directory lets the participants to locate the consumers or providers carrying the right offers.

Auctioneers periodically clear the bids received from the market participants. Brokers mediate between the consumers and providers by purchasing capacity from the provider and further sub-leasing these to the users. In cloud environment, users are being offered flexibility of submitting their service requests to different brokers. A broker is also allowed to accept requests from multiple users.

A price-setting mechanism is being adopted by the providers to decide upon the price for a resource depending upon current market conditions, resource utilization and user demand. Besides, providers follow admission-control mechanism to choose the participating auctions on the basis of some initial estimate of utility. The negotiation process is realized by SLA. Such mechanisms are supported by interfacing with the resource management systems that guarantees the allocation being offered so that SLA violations cannot be violated. The

system also takes into account advance reservations to guarantee provisioning of resource capacity. A negotiation module is provided with a broker to keep the broker updated about the current user resource demands.
The consumers' perspective of the market covers parameters such as turnaround time, deadlines, fidelity of results etc. The budget constraint of the user poses restriction on amount of resource requests quoted by the user [9]. Figure 2 presents market-oriented perspective of service providers and users.

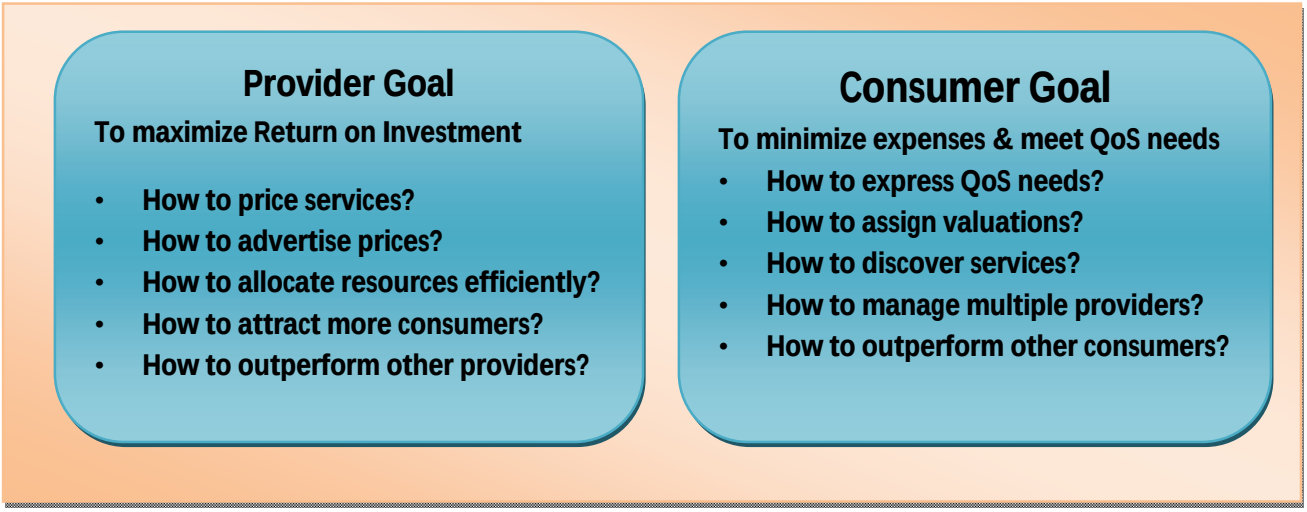

Figure 2.Market Oriented Provider and User Perspective[9]

Therefore, a consumer enters into the utility market via a resource management proxy that chooses a set of brokers depending upon their offerings. A SLA is then established with the brokers that guarantees resources to the consumer. This facilitates the enterprise consumer to deploy his own environment on the resources that were leased.
The idea behind utility markets for storage and computing resources is taking its shape for a long time. A number of research projects such as Shirako [10**],** SHARP [11], Bellagio [12] and Tycoon [13] have presented market structures for resource allocation tradings.

III. MARKET-ORIENTED CLOUD ARCHITECTURE

A glimpse of Cloud marketplace is depicted in the Figure 3**.** As described in [14], marketplace of a typical Cloud is composed of varied types of services it offers, such as content delivery to enterprises and end-users, computing and storage. The users of the cloud interact with its market by making requests for acquiring resources as per need or through applications that leverages the Cloud environment. Currently, Cloud Providers are facilitating the users to access the Cloud services. The communication happens through a market maker also called as meta-broker component which is responsible for provisioning of the best service taking into consideration budget constraints of the user. The client of cloud broker is often embedded within the applications directly or can be seen as a separate tool. The client communicates with the market maker by specifying the required QoS parameters through establishing Service Level Agreement. Among the raised requests, the meta-broker selects the best request option among the Cloud providers. Such interaction is made possible via standardized brokering services or through interfaces exposed by provider.

The cloud provider aims to provide better services to the clients. In order to achieve this, peering arrangements are being made among themselves by getting served from other providers' service requests. Such arrangements fosters the generation of policies and provisions standard interface for interconnection of heterogeneous Clouds. The success of Cloud marketplace can be realized by integration of various technologies and their possible solutions into a single domain. A number of solutions exist for leveraging the workload and balancing the use of private resources from public clouds through provisioning virtual resources. One such example is Aneka [15]. In order to offer enhanced services to users, cloud providers maintain specific QoS requirements. Such needs are met by negotiating the terms mentioned in SLA's. To regulate supply and demand as per market equilibrium, market oriented resource management has been necessitated by cloud providers. This is attained by promoting QoS based resource management techniques to differentiate among multiple requests as per their desired utility levels [16**].**

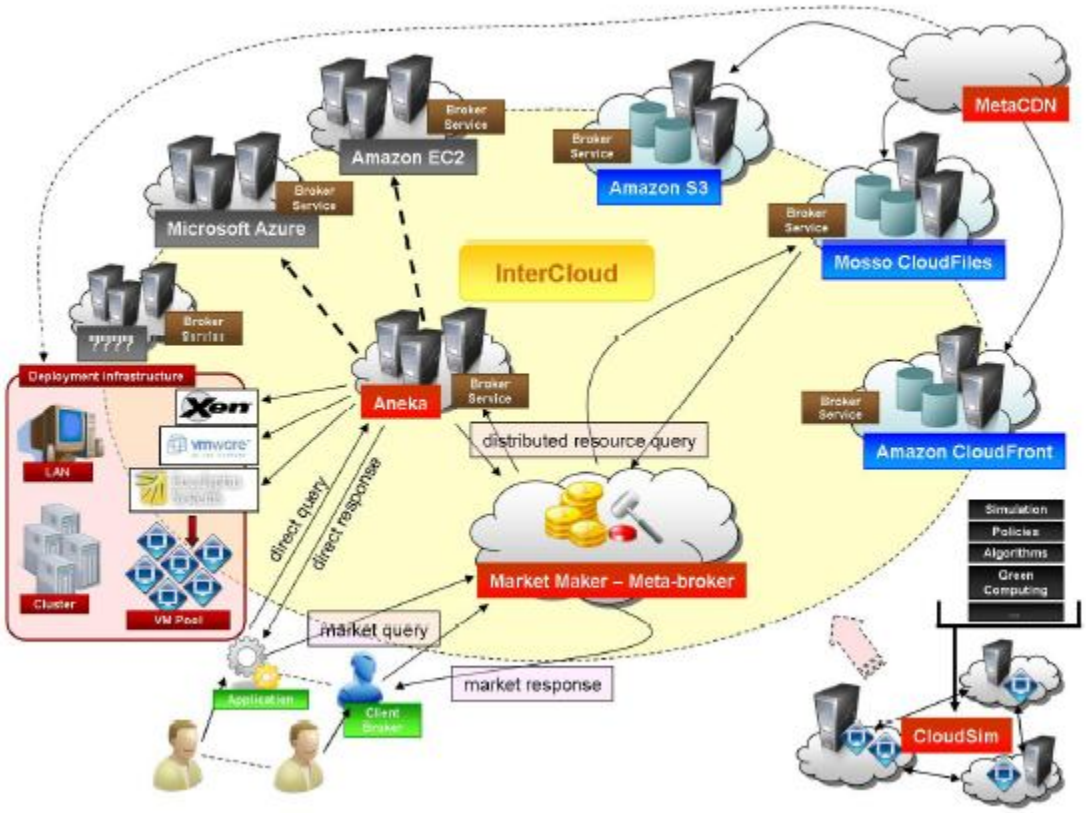

Figure 3. Cloud Computing Marketplace [14]

A [1] high-level Market Oriented Architecture is being depicted in the Figure 4. The figure illustrates the process of market-oriented resource allocation being performed in Cloud Data Centers. The diagram comprises of four main entities which are described as under:-

***Users/Brokers*:** This entity is responsible for submission of requests from anywhere in the world. The request gets submitted to the desired cloud Data center which is capable of processing it

***SLA Resource Allocator*:** The entity acts as an interface between the service provider or the Data Center and the user/broker. SLA-oriented resource management is empowered by different mechanisms which supports the entity in its operations.

The different components of the entity SLA Resource Allocator are explained below:-

Service Request Examiner and Admission Control: Upon submission of service request, it is interpreted by the Service Request Examiner and Admission Control mechanism module against the QoS requirements for its acceptance or rejection. Thus, the module ensures no overloading of resources. It collects and maintains information regarding resource availability from VM Monitor mechanism. The workload processing information is collected from Service Request Monitor mechanism module to make efficient resource allocation decisions. Further, the module assigns the requests to VMs. Besides, it determines resource entitlements for VMs that have been allocated.

Pricing: The module is responsible for making decisions related to charging of service requests. For instance, the parameters taken into consideration are: submission time (peak/off-peak), availability of resources (supply/demand) and pricing rates (fixed/changing). Deciding upon a suitable price manages the supply and demand availability and allocation of computing resources within a Cloud Data Center. It also facilitates prioritization of resource allocations in an effective manner.

Accounting: The module keeps track of actual usage of resources by the submitted requests to compute the final cost to be beard by the user. The Service Request Examiner and Admission Control mechanism maintains historical usage information to improve decisions related to resource allocation.

VM Monitor: The module tracks the availability of VMs along with their resource entitlements.

Dispatcher: The module initiates the execution of the service requests that has been accepted on allocated VMs.

Service Request Monitor: The module tracks progress in execution of service requests.

***Virtual Machines*:** Multiple VMs can be instantiated dynamically on a single physical host to fulfill accepted service requests. Therefore, it provisions maximum flexibility in creating various partitions of resources on a single host machine to meet requirements raised by submitted requests. Since, each virtual machine is isolated from one another on a host, so multiple VMs can concurrently run their applications supporting different operating system environments.

***Physical Machines*:** To meet the increasing service demands posed by users residing at heterogeneous locations, the Data Centers of a cloud comprises of multiple computing servers.

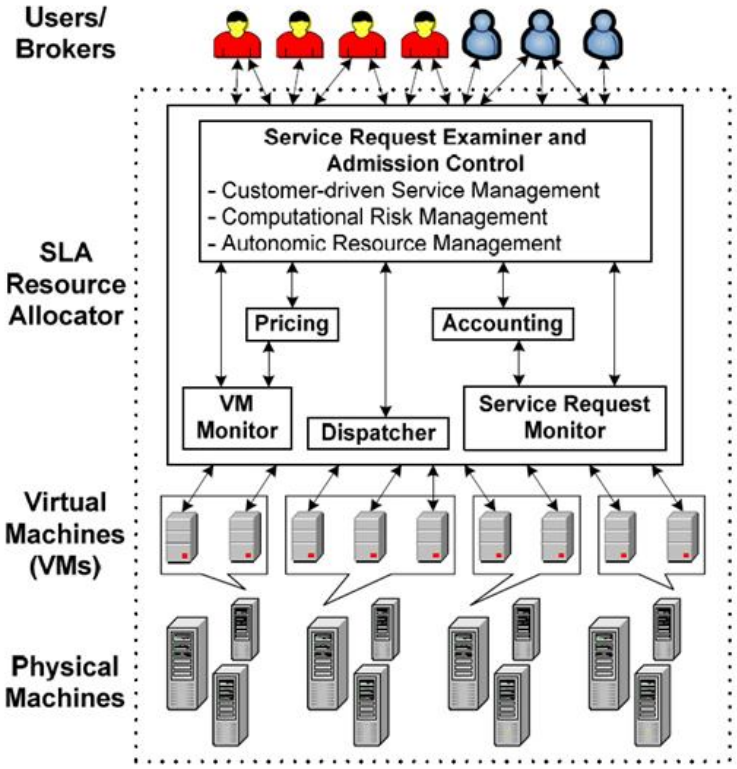

Figure 4. Market Oriented Cloud Architecture [1]

IV. EMERGING CLOUD PLATFORMS

Research study presented in [17] has identified Cloud computing in recent times as one of the high up technology trends. A number of Cloud platforms are made available to meet growing demands of consumers and enterprises regardless of time and location. Slowly and slowly the computing industry is shifting towards providing Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) to its consumers as depicted in Figure 5.

In recent times, several industrial and academic organizations are competing among themselves in investigating and developing technologies to offer a flexible infrastructure for Cloud Computing. Amazon Elastic Compute Cloud (EC2) as illustrated in [18] offers a virtual computing environment and enables a consumer to run Linux-based applications. The user is offered flexibility in terms of creating a new Amazon Machine Image (AMI) that contains the data, applications, libraries and associated configuration settings. In addition, user can select from a library of AMIs that are available globally. To start, stop or monitor the instances of uploaded AMIs, the user has to first upload the selected or created AMIs to the Amazon Simple Storage Service (S3). Amazon EC2 service obtains the payment from the user for the duration while the instance is alive. Amazon S3 obtains payment from the user for any data transfer in terms of upload and download.

Google App Engine as presented in [19] permits a user to run Web based applications. Besides, Google App Engine supports Application Programming Interfaces (APIs) for the datastore, URL fetch, image manipulation, Google Accounts and email services. It also provisions a Web-based Administration Console for the consumer to manage the running Web applications created and deployed by user.

Microsoft Live Mesh as explained in [20] provides a centralized location for the users or consumers to store their applications and data to be accessed from anywhere in the world from the devices (such as computers and mobile phones). The user can access the uploaded applications and data via a Web-based Live Dekstop or other devices after installing Live Mesh software. Security is ensured as authenticated user's can login via his Windows Live Login password. All file transfers are made secured using Secure Socket Layers (SSL).

Sun network.com (Sun Grid) [21] facilitates the user to run Java, C, C++, Solaris OS and FORTRAN based applications. The user initiates the process by building and debugging the applications and scripts in a local development environment. Then, the user creates a bundled zip archive that contains all the related scripts, executable binaries, input data and libraries. Further, the created archive gets uploaded to Sun Grid by the user. Finally, using the Sun Grid Web portal or API the application gets executed and monitored. The results can be downloaded to local development environment of user as when required.

Category	Characteristics	Product Type	Vendors & Products
SaaS	Customers are provided with applications that are accessible anytime and from anywhere.	Web applications and services (Web 2.0)	SalesForce.com (CRM) Clarizen.com (Project Management) Google Documents, Google Mail (Automation)
PaaS	Customers are provided with a platform for developing applications hosted in the Cloud.	Programming APIs and frameworks; Deployment system.	Google AppEngine Microsoft Azure Manjrasoft Aneka
IaaS/HaaS	Customers are provided with virtualized hardware and storage on top of which they can build their infrastructure.	Virtual machines management infrastructure, Storage management	Amazon EC2 and S3; GoGrid; Nirvanix

Figure 5. Cloud Computing Service Classification [14]

GRIDS Lab Aneka (commercialized through Manjrasoft) as detailed in [22], is a .NET-based service-oriented platform that can be utilized for constructing enterprise Grids. It is capable of supporting multiple application models, communication protocols and persistence and security. Aneka provides SLA support that enables the user to specify QoS requirements that primarily includes as deadline (specifies the maximum duration which the application takes for its completion) and budget constraints (maximum cost that the consumer is willing to pay to meet the deadline). The Aneka Enterprise Grid can be remotely accessed through the Gridbus broker. The Gridbus broker also extends the facility of negotiating and agreeing upon the QoS requirements that can be provided by service provider. Aneka is briefly outlined in the next section.

V. EXISTING MARKET-ORIENTED TECHNIQUES FOR CLOUD DATA CENTER

A number of challenges [14] are being faced by developers, administrators and service providers. Virtualization technique poses challenge of managing vms effectively to achieve quality expectations of the user. The security concern of cloud is a crucial element as it affects the complete cloud stack. As third party services and infrastructure is being promoted in a cloud environment, so trust is an important aspect that ensures desired level of privacy in all the applications hosted on Cloud.

Apart from security, there are many legal and regulatory issues being faced by service providers. Cloud computing poses threats of geographical constraint as different countries have their own laws that can be applied on data. For, example, certain cryptography techniques cannot be applied they are not allowed in many countries. Specific classes of users like banks, do not desire to place their sensitive data into Cloud so as to protect their customers

confidentiality. A major initiative in this regard has been taken by Amazon EC2 by introducing the concept of availability zones as these zones identify the resources belonging to specific geographic location. The two regions that are currently grouping the availability zones are US and Europe. This initiative is majorly concerned with offering of better services by focusing at isolation from failures and service downtime. Thus, it is an interesting example for discovering legal and regulatory issues. Another issue being faced by data centres is of high electricity consumption. As a solution to this problem, energy efficient resource allocation algorithms are being explored and developed. The solution to the above issues lies in the Cloudbus Toolkit which is a collection of components and technologies. The Cloudbus Toolkit has been presented in the Figure 6.

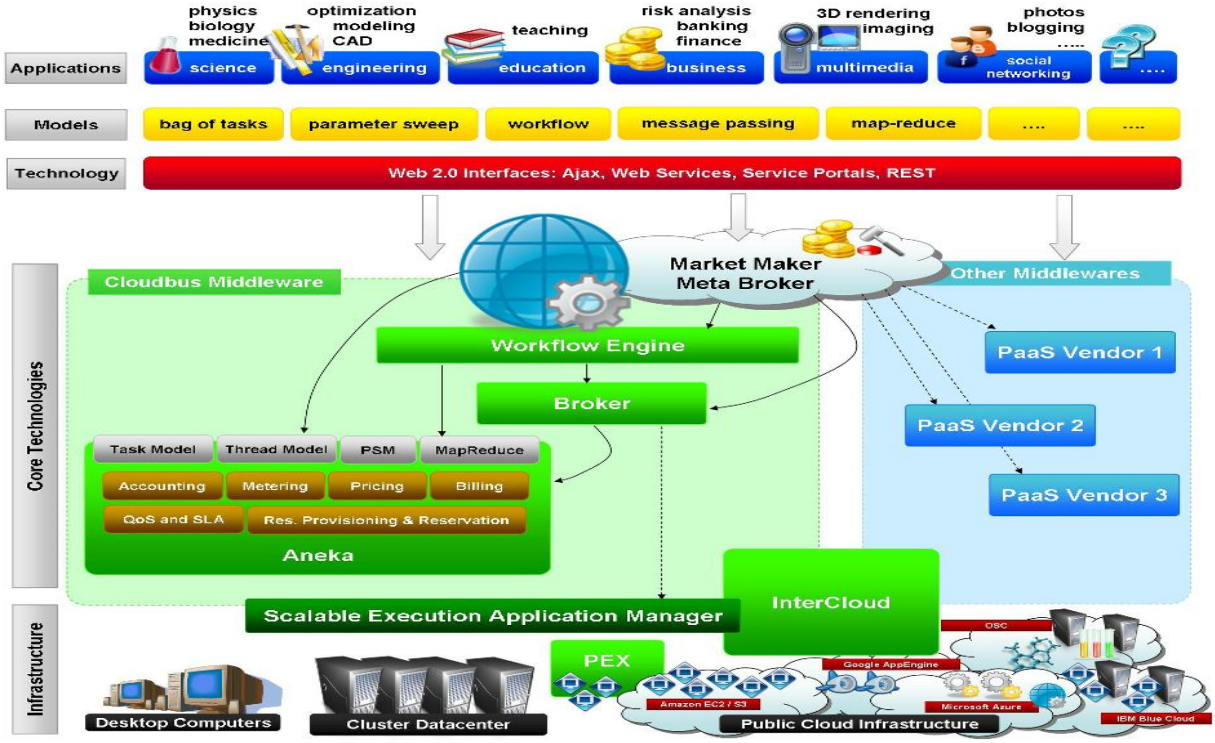

Figure 6. Cloudbus Toolkit[14]

In this research work, existing market-oriented cloud techniques for data centres have been explored to derive solutions pertaining to the challenges being faced by cloud users and service providers. At the top [14], real life applications pertaining to different categories like science, finance, engineering multimedia resides. The resources that are available in cloud are acquired and accessed via third party brokering services [5]. Various market-oriented techniques are discussed below:-

Aneka:- Aneka mainly is implied in "Platform as a Service" type and offers platform in cloud computing to its users making it convenient for them to create and deploy applications. Its unique feature is its flexible design and customization capability that allows it to target different application scenarios. The Aneka container acts as the nucleus of any Aneka based Cloud and it can be deployed into any computing resource that is connected to the Internet be it physical or virtual. This facilitates the integration of applications with public and private Clouds transparently. To exploit the power of cloud, specific services that possible the dynamic provisioning of resources are built into the framework. Characteristics of Aneka are underlying:-

- It is a configurable software container that constitutes the building blocks of the Cloud.
- Many open ended set of programming models are available for developers to express distributed applications.
- A collection of tools for prototyping and porting applications to Cloud.

Broker:- The Broker component [23**]** mediates access to physical and virtual resources distributed over network. It does the following tasks:-

- Discovers suitable data sources for given analysis scenario.

- Selects suitable computational resources.
- Optimally maps analysis jobs to compute resources.
- Deployment and monitoring of job execution on selected resources.
- Manages access of data from local or remote data source at the time of job execution.
- Collating and presenting results.

Various application models such as workflow, parameter sweep and parallel and bag of tasks are supported by Broker. It carries plug-in support system for integrating with other middleware technologies that includes Unicore **[24**], Globus [25**],** and SSH plug-in for accessing Condor [26**],** SGE[27**]** and Unix based platforms via fork, PBS [28**]**. The broker provisions compute and storage services in resources on Cloud via SSH.

Workflow Engine:- The Workflow Management System (WMS) as presented in [29] assists users in representing their applications as a workflow. It then executes these workflows on the Cloud platform from higher level of abstraction. The WMS provisions an easy-to-use workflow editor that allows for application composition. It also acts as an XML-based workflow language for representation in a structured manner, and also presents itself as a user-friendly portal with components like discovery, monitoring and scheduling. It can be used along with either Aneka and/or Broker to manage applications that can be run on distributed resources. Up till, WMS has been used in several real-world applications like: fMRI brain imaging analysis [30] and intrusion detection systems with varied models [31**].**

Market-Maker/ Meta-Broker:- Market Maker/Meta-broker [32] [33] is a component of global market place that works in support of both the users and service providers to discover a suitable match for each other. It renders access to distributed resources by determining suitable Cloud providers according to application type. It offers various services to its customers like resource discovery, reservation service, queuing service, meta-scheduler, accounting and pricing services.

MetaCDN:-MetaCDN as explained in [34] creates an integrated overlay network at a very low cost by exploiting "Storage Cloud" resources being offered by multiple IaaS vendors. It eradicates the difficulty arose due to dealing with multiple storage providers. This becomes possible by wisely matching and placing user content onto a single or multiple storage providers depending upon their quality of service, budget and coverage preferences.

From InterGrid to InterCloud:-In the long run, the Clouds may opt for sharing their load with other Cloud service providers due to selection of multiple cloud services by the users. Therefore, such dispersion may lead to creation of disparate Clouds that may have very less or no interaction between them. The InterCloud model happens to promote interlinking of islands of Clouds by making peering arrangements which will enable inter-Cloud resource sharing. Besides, it aims to provide a scalable structure that allows them to interconnect with each other and grow in a sustainable way. It is expected to create a global Cyberinfrastructure that will support e-Science & e-Business applications.

Currently, the InterGrid project [35**]** has been taken as an initiative towards realizing the InterCloud vision. To realize its implementation, existing Grid infrastructure has been used. Virtual machines have been used as building blocks to construct its execution environments that Spans across multiple computing sites that are further combination of physical machines typically hosted on Grid sites or may be virtual machines running on existing cloud infrastructures like Amazon EC2.

Energy Efficient Computing: With increase in computing facilities, Cloud providers are suffering from the challenge of increase in Energy consumption which brings with itself hazards like global warming due to high carbon emission and raised power bills. The problem exaggerates as data centres span across multiple geographic locations. In order to provide solution to this problem, a number of researchers are working hard to reduce consumption of electricity in huge data centres. The work presented in [36] is one example of technique explored to reduce energy consumption in cloud data centers. The paper addresses a bin packing technique that reduces energy consumption significantly in many vm and physical host allocations. The technique has been implemented using virtualization methodology. Reduction in energy consumption also reduces operational cost and increases system reliability.

CloudSim:-The CloudSim toolkit [37] offers an environment to the users that enable them to model and simulate extensible Clouds. They offers platform where user can get their applications executed. It is a complete customizable tool that allows extension and description of policies in the software stack. This relieves researchers

from handling the complexities that arises from deploying, provisioning and configuring real resources in physical environments.
CloudSim offers the following advantages:-

- Supports simulation and modeling of large scale Cloud infrastructure that includes data centers comprising of a physical computing node.
- It is a self-contained platform that models data centers, scheduling system, service brokers and allocations policies.

For enabling a stimulated simulation environment CloudSim offers features such as virtualization engine and provides flexibility in switching between time-shared allocation and space-shared allocation. These features allows speed up the generation of resource allocation policies and algorithms related to scheduling for Cloud computing.
CloudSim has evolved from GridSim which has been discussed in [38]. GridSim is a Grid simulation toolkit that facilitates resource modeling and scheduling of applications for parallel and distributed computing. GridSim provisions a comprehensive facility that can create different classes of heterogeneous resources which can be aggregated through resource brokers for resolving compute and data intensive applications. It offers a framework that can incorporate failures, advance reservations, data models, allocation policies, background traffic and load, network model extensions and many more. Such features are also supported by CloudSim toolkit.

Resource Management:- Resource management[39] in cloud computing is considered as an important aspect as it leads to proper utilization of available resources for making a cloud as an optimum computing environment. The taxonomy of resource management falls under various categories such as Energy-Aware, SLA-Aware, market-oriented, load balanced, Network Load-Aware, Hybrid Cloud and Mobile Cloud Computing.

VI. CONCLUSION AND FUTURE SCOPE

Cloud Computing, in recent times have been emerged as a service paradigm that offers greater flexibility in heterogeneous operations to user at a much reduced cost. Still a lot of advancement is required in the Cloud services due to increase in use of ICT enabled technologies. As the entire market is switching to cloud based infrastructure, so a lot more elastic applications needs to be explored, developed and deployed in cloud environment that can serve millions of users simultaneously. Devising newer market-oriented resource management techniques could lead to better management of cloud resources while meeting users SLA and QoS requirements.
The boom of cloud computing is acting as a milestone in automated world, but still the service providers of the cloud environment are facing issues related to software licensing as proprietary software technologies are to be made available to millions and trillions of the users. Another issue that is of paramount importance to the customers and providers of the cloud computing are security and privacy. So, there is a need to establish a globally accredited body that can certify and enforce common laws and regulations concerning usage of cloud resources in terms of SLA, QoS parameters, standardized data formats and many more. Looking at such issues, there is a need to enhance the Cloudbus Toolkit to become more robust and scalable.

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