Unit III

Energy efficiency in clouds . Energy-efficient and green cloud computing architecture, Market-based management of clouds, Market-oriented cloud computing, Reference model, A reference model for MOCC , Technologies and initiatives supporting MOCC , Federated clouds/InterCloud- Characterization, Cloud federation stack, Aspects of interest, Technologies for cloud federations, Third-party cloud services. Cloud Applications- Scientific applications(Healthcare, Biology, Geoscience), Business and consumer applications

Energy efficiency in clouds

Datacenters are not only expensive to maintain, they are also unfriendly to the environment. Carbon emissions due to datacenters worldwide are now more than the emissions of both Argentina and the Netherlands . High energy costs and huge carbon footprints are incurred due to the massive amount of electricity needed to power and cool the numerous servers hosted in these datacenters. Cloud service providers need to adopt measures to ensure that their profit margins are not dramatically reduced due to high energy costs. There is also increasing pressure from governments worldwide to reduce carbon footprints, which have a significant impact on climate change. To address these concerns, leading IT vendors have recently formed a global consortium, called The Green Grid, to promote energy efficiency for data centers and minimize their impact on the environment. Pike Research forecasts that datacenter energy expenditures worldwide will reduce from $23.3 billion in 2010 to $16.0 billion in 2020, as well as causing a 28% reduction in greenhouse gas (GHG) emissions from 2010 levels as a result of the adoption of the cloud computing model for delivering IT services.

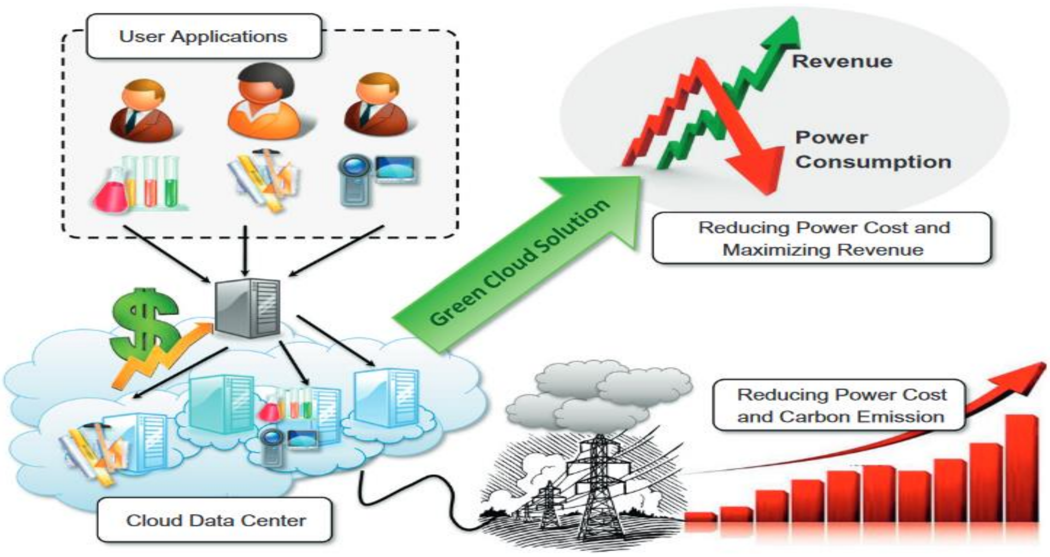


FIGURE 11.1

A "green" cloud computing scenario.

Lowering the energy usage of datacenters is a challenging and complex issue because computing applications and data are growing so quickly that larger servers and disks are needed to process them fast enough within the required time period. Green cloud computing is intended to achieve not only efficient processing and utilization of computing infrastructure but also minimize energy consumption. This is essential for ensuring that the future growth of cloud computing is sustainable. Cloud computing, with increasingly pervasive front-end client devices such as iPhones interacting with back-end datacenters, will cause an enormous escalation in energy usage. To address this problem, datacenter resources need to be managed in an energy-efficient manner to drive green cloud computing. In particular, cloud resources need to be allocated not only to satisfy QoS requirements specified by users via service-level agreements (SLAs) but also to reduce energy usage. This can be achieved by applying market-based utility models to accept user requests that can be fulfilled to enhance revenue along with energy-efficient utilization of cloud infrastructure.

==

Energy-efficient and green cloud computing architecture

A high-level architecture for supporting energy-efficient resource allocation in a green cloud computing infrastructure consists of four main components:- Consumers/brokers, Green Resource Allocator, VMs. Physical Machines

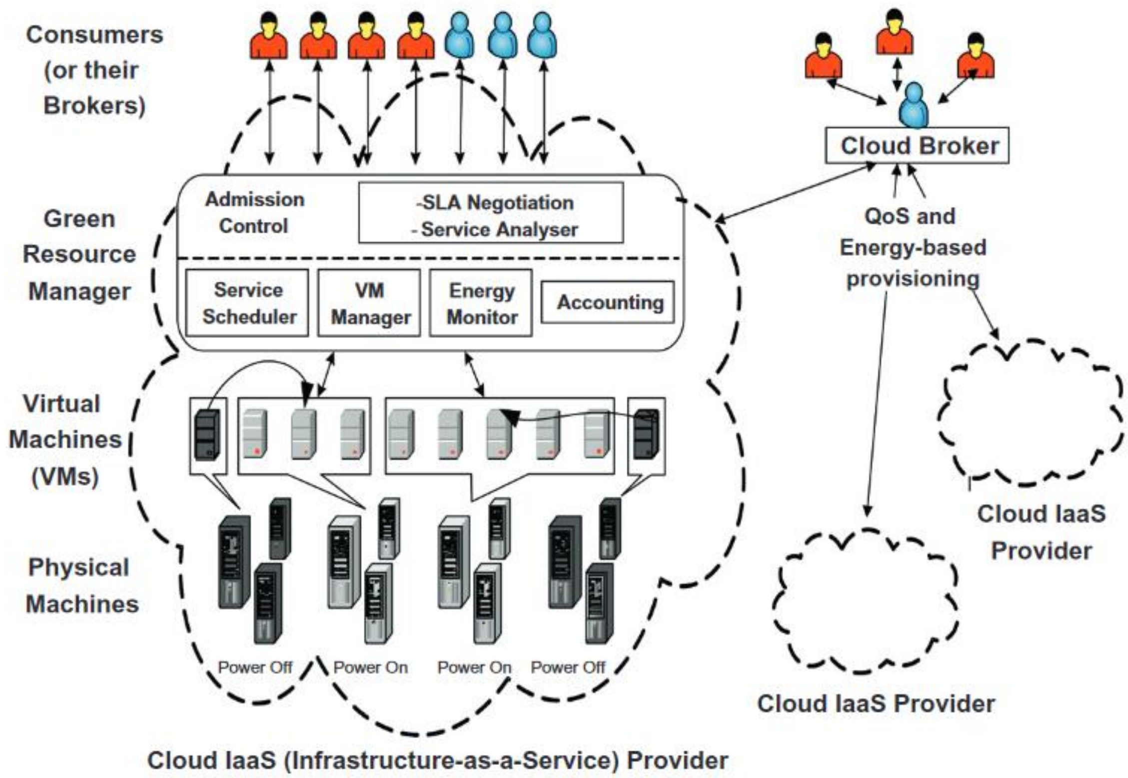


FIGURE 11.2

High-level system architectural framework for green cloud computing.

- **Consumers/brokers**. Cloud consumers or their brokers submit service requests from anywhere in the world to the cloud. It is important to note that there can be a difference between cloud consumers and users of deployed services. For instance, a consumer can be a company deploying a Web application, which presents varying workloads according to the number of "users" accessing it.

- **Green Resource Allocator**. Acts as the interface between the cloud infrastructure and consumers. It requires the interaction of the following components to support energy-efficient resource management:

  - Green Negotiator. Negotiates with the consumers/brokers to finalize the SLAs with specified prices and penalties (for violations of SLAs) between the cloud provider and the consumer, depending on the consumer's QoS requirements and energy-saving schemes. In Web applications, for instance, the QoS metric can be 95% of requests being served in less than 3 seconds.

  - Service Analyzer. Interprets and analyzes the service requirements of a submitted request before deciding whether to accept or reject it. Hence, it needs the latest load and energy information from VM Manager and Energy Monitor, respectively.

  - Consumer Profiler. Gathers specific characteristics of consumers so that important consumers can be granted special privileges and prioritized over other consumers.

  - Pricing. Decides how service requests are charged to manage the supply and demand of computing resources and facilitate prioritizing service allocations effectively.

  - Energy Monitor. Observes and determines which physical machines to power on or off.

  - Service Scheduler. Assigns requests to VMs and determines resource entitlements for allocated VMs. It also decides when VMs are to be added or removed to meet demand.

  - VM Manager.Keeps track of the availability of VMs and their resource entitlements. It is also in charge of migrating VMs across physical machines.

  - Accounting. Maintains the actual usage of resources by requests to compute usage costs. Historical usage information can also be used to improve service allocation decisions.

• **VMs.** Multiple VMs can be dynamically started and stopped on a single physical machine to meet accepted requests, hence providing maximum flexibility to configure various partitions of resources on the same physical machine to different specific requirements of service requests. Multiple VMs can also run concurrently applications based on different operating system environments on a single physical machine. In addition, by dynamically migrating VMs across physical machines, workloads can be consolidated and unused resources can be put on a low power state, turned off, or configured to operate at low performance levels (e.g., using Dynamic Voltage and Frequency Scaling, or DVFS) to save energy.

• **Physical machines.** The underlying physical computing servers provide hardware infrastructure for creating virtualized resources to meet service demands.

Market-Based Management of Clouds

Cloud computing is still in its infancy, and its prominent use is twofold:
(1) complete replacement of in-house IT infrastructure and services with the same capabilities rented by service providers; and
(2) elastic scaling of existing computing systems in order to address peak workloads.

The efforts in research and industry have been mostly oriented to design and implement systems that actually enable business vendors and enterprises to achieve these goals. The real potential of cloud computing resides in the fact that it actually facilitates the establishment of a market for trading IT utilities. This opportunity until now has been mildly explored and falls in the domain of what it is called market-oriented cloud computing.

Market-oriented cloud computing

Cloud computing already embodies the concept of providing IT assets as utilities. Then, what makes cloud computing different from market-oriented cloud computing? First, it is important to understand what we intend by the term market. The Oxford English Dictionary (OED) defines a market as a "place where a trade is conducted". More precisely, market refers to a meeting or a gathering together of people for the purchase and sale of goods. A broader characterization defines the term market as the action of buying and selling, a commercial transaction, a purchase, or a bargain. Therefore, essentially the word market is the act of trading mostly performed in an environment—either physical or virtual—that is specifically dedicated to such activity.

If we consider the way IT assets and services are consumed as utilities, it is evident that there is a trade-off between the service provider and the consumer; this enables the use of the service by the user under a given SLA. Therefore, cloud computing already expresses the concept of trade, even though the interaction between consumer and provider is not as sophisticated as happens in real markets: Users generally select one cloud computing vendor from among a group of competing providers and leverage its services as long as they need them. Moreover, at present, most service providers have inflexible pricing, generally limited to flat rates or tariffs based on usage thresholds. In addition, many providers have proprietary interfaces to their services, thus restricting the ability of consumers to quickly move—and with minimal conversion costs—from one vendor to another.

This rigidity, known as vendor lock-in, undermines the potential of cloud computing to be an open market where services are freely traded. Therefore, to remove such restrictions, it is required that vendors expose services through standard interfaces. This enables full commoditization and thus would pave the way for the creation of a market infrastructure for trading services. What differentiates market-oriented cloud computing (MOCC) from cloud computing is the presence of a virtual marketplace where IT services are traded and brokered dynamically. This is something that still has to be achieved and that will significantly evolve the way cloud computing services are eventually delivered to the consumer. More precisely, what is missing is the availability of a market where desired services are published and then automatically bid on by matching the requirements of customers and providers. At present, some cloud computing vendors are already moving in this direction; this phenomenon is happening in the IaaS domain—which is the market sector that is more consolidated and mature for cloud computing—but it has not taken off broadly yet. We can clearly characterize the relationship between cloud computing and MOCC as follows:

Market Oriented Computing has the same characteristics as Cloud Computing; therefore it is a dynamically provisioned unified computing resource allowing you to manage software and data storage as on aggregate capacity resulting in “real-time” infrastructure across public and private infrastructures. Market Oriented Cloud Computing goes one step further by allowing spread into multiple public and hybrid environments dynamically composed by trading service.

The realization of this vision is technically possible today but is not probable, given the lack of standards and overall immaturity of the market. Nonetheless, it is expected that in the near future, with the introduction of standards, concerns about security and trust will begin to disappear and enterprises will feel more comfortable leveraging a market-oriented model for integrating IT infrastructure and services from the cloud. Moreover, the presence of a demand- based marketplace represents an opportunity for enterprises to shape their infrastructure for dynamically reacting to workload spikes and for cutting maintenance costs. It also allows the possibility to temporarily lease some in-house capacity during low usage periods, thus giving a better return on investment. These developments will lead to the complete realization of market- oriented cloud computing.

==

Reference model of market oriented cloud computing (MOCC):-

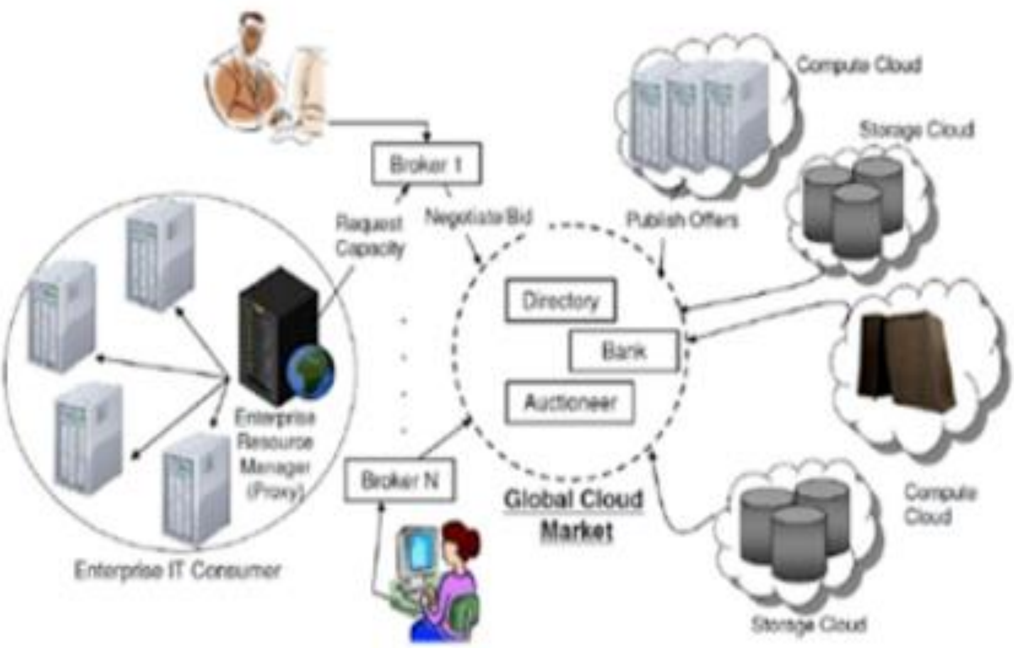
MOCC originated from the coordination of several components service consumers, service providers, and other entities that make trading between these two groups possible.

here are three major components of cloud exchange are:-

Directory:-the market directory contains a listing of all the published services that are available in the cloud marketplace.

Auctioneer:-the auctioneer is in charge of keeping track of the running auctions in the marketplace and of verifying that the auctions for services are properly conducted and that malicious market players are prevented from performing illegal activities.

Bank:-the bank is the component that takes care of the financial aspect of all the operations happening in the virtual market place.



==

A global view of market-oriented cloud computing

GLOBAL VIEW

Several components and entities contribute to the definition of a global market-oriented architecture.
The fundamental component is the virtual marketplace—represented by the

Cloud Exchange (CEx)—which acts as a market maker, bringing service producers and consumers together.

The principal players in the virtual market place are the

Cloud coordinators and the Cloud Brokers. The **cloud coordinators** represent the cloud vendors and publish the services that vendors offer.

The **cloud brokers** operate on behalf of the consumers and identify the subset of services that match customers' requirements in terms of service profiles and quality of service.

Brokers perform the same function as they would in the real world: They mediate between coordinators and consumers by acquiring services from the first and subleasing them to the latter.

Directory: The market directory contains a listing of all the published services that are available in the cloud market place. The directory not only contains a simple mapping between service names and the corresponding vendor (or cloud coordinators) offering them. It also provides additional metadata that can help the brokers or the end users in filtering from among the services of interest those that can really meet the expected quality of service. Moreover, several indexing methods can be provided to optimize the discovery of services according to various criteria. This component is modified in its content by service providers and queried by service consumers.

Auctioneer: The auctioneer is in charge of keeping track of the running auctions in the market place and of verifying that the auctions for services are properly conducted and that malicious market players are prevented from performing illegal activities.

Bank: The bank is the component that takes care of the financial aspect of all the operations happening in the virtual market place. It also ensures that all the financial transactions are carried out in a secure and dependable environment. Consumers and providers may register with the bank and have one or multiple accounts that can be used to perform the transactions in the virtual marketplace.

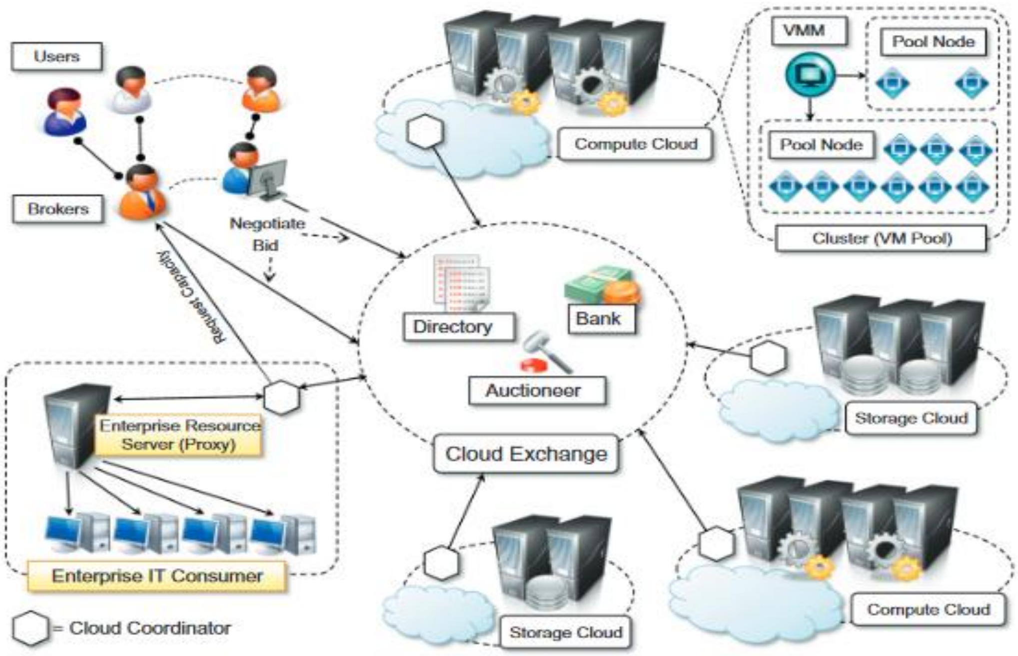


FIGURE 11.3
Market-oriented cloud computing scenario.

==

Technologies and initiatives supporting MOCC

Existing cloud computing solutions have very limited support for market-oriented strategies to deliver services to customers. Most current solutions mainly focused on enabling cloud computing concern the delivery of infrastructure, distributed runtime environments, and services.

Framework for trading computing utilities

From an academic point of view, a considerable amount of research has been carried out in defining models that enable the trading of computing utilities, with a specific focus on the design of market-oriented schedulers for grid computing systems.

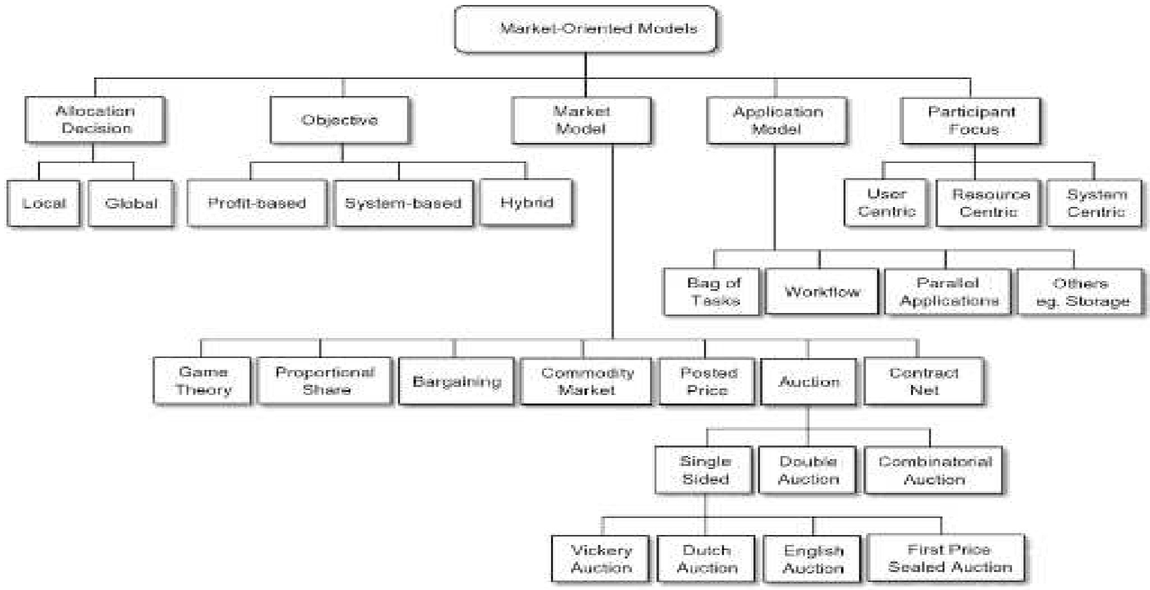


FIGURE 11.5
Market-oriented scheduler taxonomy.

Garg and Buyya have provided a complete taxonomy and analysis of such schedulers, which is reported in Figure 11.5. A major classification categorizes these schedulers according to allocation decision, objective ,market model, application model, and participant focus. Of particular interest is the classification according to the market model, which is the mechanism used for trading between users and providers. Along this dimension, it is possible to classify the schedulers into the following categories

Game theory.

In market models that are based on game theory, participants interact in the form of an allocation game, with different payoffs as a result of specific actions that employ various strategies.

Proportional share.

This market model originates from proportional share scheduling, which aims to allocate jobs fairly over a set of resources. This original concept has been contextualized within a market-oriented scenario in which the shares of the cluster are directly proportional to the user's bid.

Commodity market.

In this model the resource provider specifies the price of resources and charges users according to the amount of resources they consume. The provider's determination of the price is the result of a decision process involving investment and management costs, current demand, and supply. Moreover, prices might be subject to vary over time.

Posted price.

This model is similar to the commodity market, but the provider may make special offers and discounts to new clients. Furthermore, with respect to the commodity market,prices are fixed over time.

Contract-Net.

In market models based on the Contract-Net protocol, users advertise their demand and invite resource owners to submit bids. Resource owners check these advertisements with respect to their requirements. If the advertisement is favorable to them, the providers will respond with a bid. The user will then consolidate all the bids and compare them to select those most favorable to him. The providers are then informed about the outcome of their bids, which can be acceptance or rejection

Bargaining.

In market models based on bargaining, the negotiation among resource consumers and providers is carried out until a mutual agreement is reached or it is stopped when either of the parties is no longer interested.

Auction.

In market models based on auctions, the price of resources is unknown, and competitive bids regulated by a third party—the auctioneer—contribute to determining the final price of a resource. The bid that ultimately sets the price of a resource is the winning bid, and the corresponding user gains access to the resource.

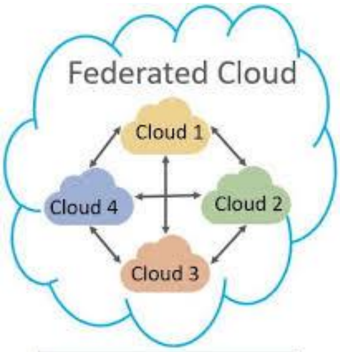
==

Federated clouds/InterCloud

The terms cloud federation and InterCloud, often used interchangeably, convey the general meaning of an aggregation of cloud computing providers that have separate administrative domains

A federation is the union of several smaller parts that perform a common action.

he term InterCloudrefers mostly to a global vision in which interoperability among different cloud providers is governed by standards, thus creating an open platform where applications can shift workloads and freely compose services from different sources. On the other hand, the concept of a cloud federation is more general and includes adhoc aggregations between cloud providers on the basis of private agreements and proprietary interfaces.



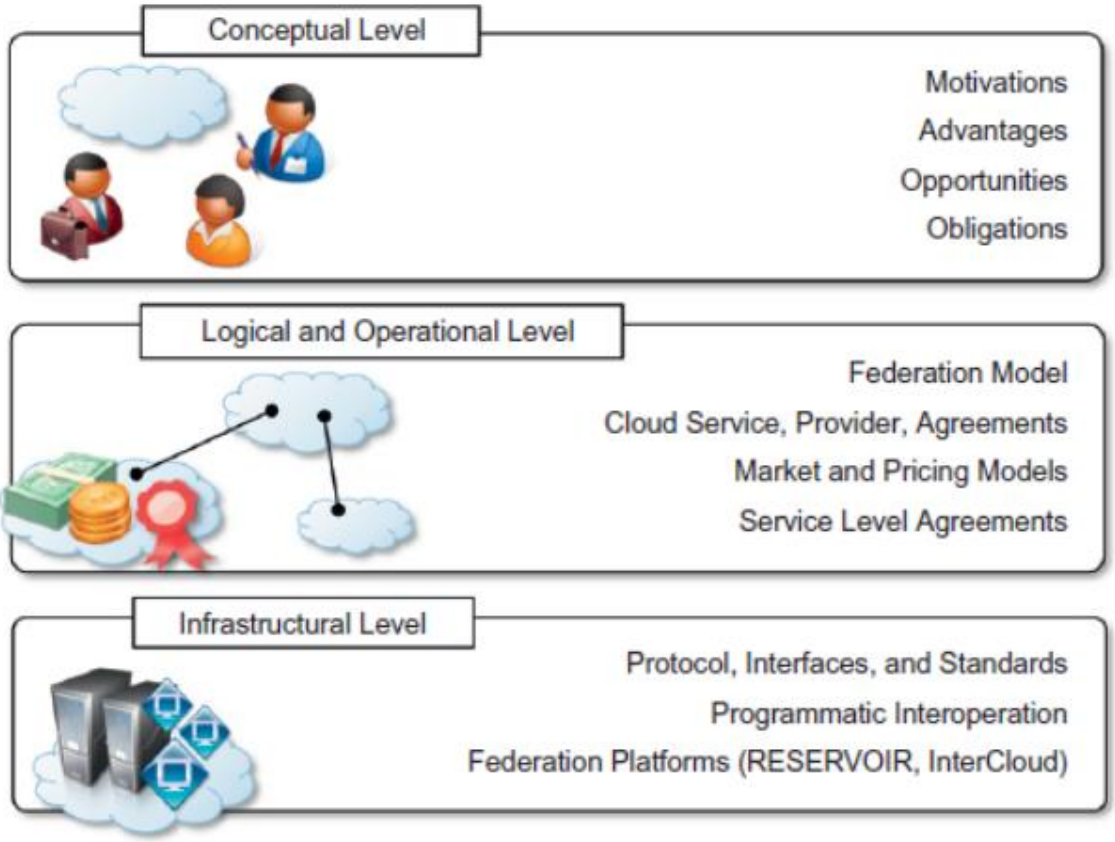
Federated Cloud

CLOUD FEDERATION BENEFITS/ CHARACTERIZATION

- The federation of cloud resources allows clients to optimize enterprise IT service delivery.
- The federation of cloud resources allows a client to choose the best cloud services provider, in terms of flexibility, cost and availability of services, to meet a particular business or technological need within their organization.
- Federation across different cloud resource pools allows applications to run in the most appropriate infrastructure environments.
- The federation of cloud resources also allows an enterprise to distribute workloads around the globe, move data between disparate networks and implement innovative security models for user access to cloud resources.

CLOUD FEDERATION STACK

Creating a cloud federation involves research and development at different levels: **conceptual, logical and operational, and infrastructural.**



CLOUD FEDERATION REFERENCE STACK

Figure provides a comprehensive view of the challenges faced in designing and implementing an organizational structure that coordinates together cloud services that belong to different administrative domains and makes them operate within a context of a single unified service middleware.

Each cloud federation level presents different challenges and operates at a different layer of the IT stack. It then requires the use of different approaches and technologies. Taken together, the solutions to the challenges faced at each of these levels constitute a reference model for a cloud federation.

CONCEPTUAL LEVEL

The conceptual level addresses the challenges in presenting a cloud federation as a favourable solution with respect to the use of services leased by single cloud providers. In this level it is important to clearly identify the advantages for either service providers or service consumers in joining a federation and to delineate the new opportunities that a federated environment creates with respect to the single-provider solution.

Elements of concern at this level are:

- Motivations for cloud providers to join a federation.
- Motivations for service consumers to leverage a federation.
- Advantages for providers in leasing their services to other providers.

- Obligations of providers once they have joined the federation.
- Trust agreements between providers.
- Transparency versus consumers.

.

Among these aspects, the most relevant are the motivations of both service providers and consumers in joining a federation

LOGICAL & OPERATIONAL LEVEL

The logical and operational level of a federated cloud identifies and addresses the challenges in devising a framework that enables the aggregation of providers that belong to different administrative domains within a context of a single overlay infrastructure, which is the cloud federation.

At this level, policies and rules for interoperation are defined. Moreover, this is the layer at which decisions are made as to how and when to lease a service to—or to leverage a service from— another provider.

The logical component defines a context in which agreements among providers are settled and services are negotiated, whereas the operational component characterizes and shapes the dynamic behaviour of the federation as a result of the single providers' choices.

This is the level where MOCC is implemented and realized. It is important at this level to address the following challenges:

• How should a federation be represented?
• How should we model and represent a cloud service, a cloud provider, or an agreement?
• How should we define the rules and policies that allow providers to join a federation?
• What are the mechanisms in place for settling agreements among providers?
• What are provider's responsibilities with respect to each other?
• When should providers and consumers take advantage of the federation?
• Which kinds of services are more likely to be leased or bought?
• How should we price resources that are leased, and which fraction of resources should we lease?

The logical and operational level provides opportunities for both academia and industry.

INFRASTRUCTURE LEVEL

The infrastructural level addresses the technical challenges involved in enabling heterogeneous cloud computing systems to interoperate seamlessly.

It deals with the technology barriers that keep separate cloud computing systems belonging to different administrative domains. By having standardized protocols and interfaces, these barriers can be overcome.

At this level it is important to address the following issues:

• What kind of standards should be used?
• How should design interfaces and protocols be designed for interoperation?
• Which are the technologies to use for interoperation?
• How can we realize a software system, design platform components, and services enabling interoperability?

Interoperation and composition among different cloud computing vendors is possible only by means of open standards and interfaces. Moreover, interfaces and protocols change considerably at each layer of the Cloud Computing Reference Model.

Aspects of interest

Several aspects contribute to the successful realization of a cloud federation. Besides motivation and technical enablers, other elements should be considered. In particular, standards for interoperability, security, and legal issues have to been taken into consideration while defining a platform for interoperability among cloud vendors.

Standards

Standards play a fundamental role in building a federation. Their main role is to organize a plat-form for interoperation that goes beyond adhoc aggregations and private settlements between pro-viders. Standardized interfaces and protocols facilitate the realization of an open organization where providers can easily join.

Interoperation between vendors has always been an element of concern for enterprises and one of the reasons that initially prevented them from fully embracing the cloud computing model. More specifically, the absence of common standards for developing applications and systems in a portable way initially developed the fear of vendor lock-in. Applications and systems developed to be deployed on a specific cloud computing vendor's infrastructure could not be easily moved to another vendor.

Open cloud manifesto

The Open Cloud Manifesto15constitutes the first step toward the realization of a cloud inter operability platform. The manifesto was drafted in 2009 as a result of the coordinated activity of differ-ent cloud vendors and currently lists more than 400 cloud computing services providers that support the vision it embodies.

Distributed management task force

The Distributed Management Task Force (DMTF)is an organization involving more than 4,000active members, 44 countries, and nearly 200 organizations. It is the industry organization leading the development, adoption, and promotion of interoperable management standards and initiatives. With specific reference to cloud computing, the DMTF introduced the Open Virtualization Format(OVF). The Open Virtualization Format (OVF) is a vendor-independent format for packaging standards designed to facilitate the portability and deployment of virtual appliances across different virtualization platforms.

Cloud data management interface

The Cloud Data Management Interface (CDMI) is a specification for a functional interface that applications will use to create, retrieve, update, and delete data elements from the cloud.

Cloud security alliance

The Cloud Security Alliance (CSA)is nonprofit organization with the mission of promoting the use of best practices for providing security assurance in cloud computing and education on the use of cloud computing to help secure all other forms of computing. Rather than acting as a standardizing body, CSA offers a context in which to discuss security practices and provide guidance for developing reliable and secure cloud computing systems.

==

Cloud Applications

(refer unit 3- set 2)

==

IMP QUESTIONS

- **Write a note on** Energy efficiency in clouds
- Explain the need of Energy efficiency in clouds
- **With a neat diagram explain** Energy-efficient and green cloud computing architecture
- Explain in detail Market-oriented cloud computing
- Explain reference model for MOCC
- Write a note on global view of market-oriented cloud computing
- With a neat diagram explain market-oriented architecture for datacenters
- Briefly explain Technologies and initiatives supporting MOCC
- Write a note on federated cloud
- With a neat diagram explain Cloud federation stack,
- Explain aspects contribute to the successful realization of a cloud federation.
- What are the types of applications that can benefit from cloud computing?
- What fundamental advantages does cloud technology bring to scientific applications?
- Describe how cloud computing technology can be applied to support remote ECG monitoring.
- Describe an application of cloud computing technology in the field of biology.
- What are the advantages cloud computing brings to the field of geoscience? Explain with an example.
- Describe some examples of CRM and ERP implementations based on cloud computing technologies.

========================***==========================