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Subject Name: Cloud Computing (IT702 (B))

UNIT I

Syllabus: Introduction of Grid and Cloud computing, characteristics, components, business and IT perspective, cloud services requirements, cloud models, Security in public model, public verses private clouds, Cloud computing platforms: Amazon EC2,Platform as Service: Google App Engine, Microsoft Azure, Utility Computing, Elastic Computing.

INTRODUCTION OF GRID AND CLOUD COMPUTING

Grid computing is made up of applications used for computational computer problems that are connected in a parallel networking environment. It connects each PC and combines information to form one application that is computation-intensive. Grids have a variety of resources based on diverse software and hardware structures, computer languages, and frameworks, either in a network or by using open standards with specific guidelines to achieve a common goal.

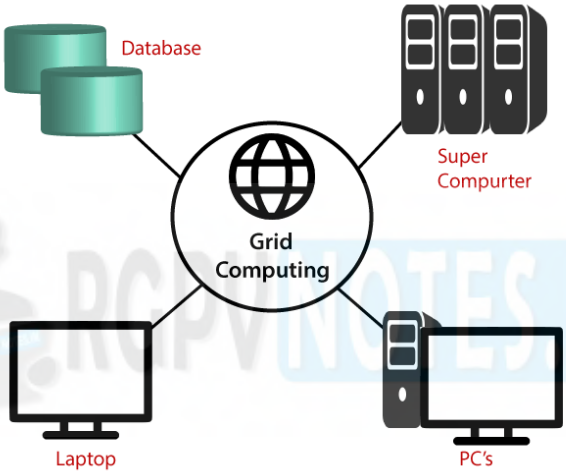

Figure 1.1: Grid computing

Grid operations are generally classified into two categories:

1. Data Grid: A system that handles large distributed data sets used for data management and controlled user sharing. It creates virtual environments that support dispersed and organized research. The Southern California Earthquake Center is an example of a data grid; it uses a middle software system that creates a digital library, a dispersed file system and continuing archive.
2. CPU Scavenging Grids: A cycle-scavenging system that moves projects from one PC to another as needed. A familiar CPU scavenging grid is the search for extraterrestrial intelligence computation, which includes more than three million computers.

Cloud computing is the use of various services, such as software development platforms, servers, storage and software, over the internet, often referred to as the "cloud."

In general, there are three cloud computing characteristics that are common among all cloud-computing vendors:

1. The back-end of the application (especially hardware) is completely managed by a cloud vendor.
2. A user only pays for services used (memory, processing time and bandwidth, etc.).
3. Services are scalable

Many cloud computing advancements are closely related to virtualization. The ability to pay on demand and scale quickly is largely a result of cloud computing vendors being able to pool resources that may be divided among multiple clients. It is common to categorize cloud computing services as infrastructure as a service (IaaS), platform as a service (PaaS) or software as a service (SaaS).

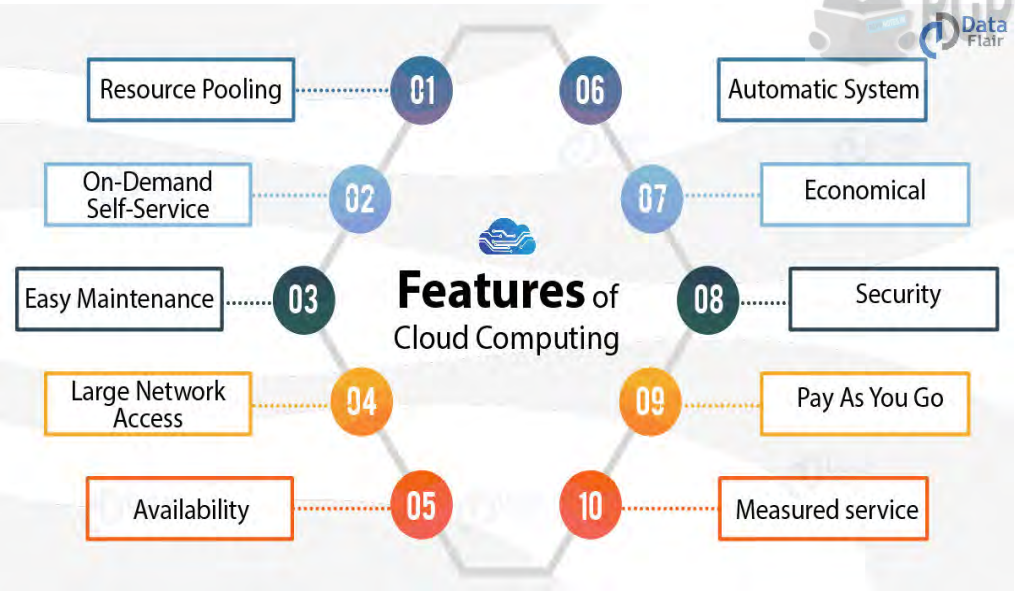

Figure 1.2: Characteristics of Cloud computing

CHARACTERISTICS

Following are the characteristics of Cloud Computing:

1. Resources Pooling: It means that the Cloud provider pulled the computing resources to provide services to multiple customers with the help of a multi-tenant model. There are different physical and virtual resources assigned and reassigned which depends on the demand of the customer. The customer generally has no control or information over the location of the provided resources but is able to specify location at a higher level of abstraction

2. On-Demand Self-Service: It is one of the important and valuable features of Cloud Computing as the user can continuously monitor the server uptime, capabilities, and allotted network storage. With this feature, the user can also monitor the computing capabilities.

3. Easy Maintenance: The servers are easily maintained and the downtime is very low and even in some cases, there is no downtime. Cloud Computing comes up with an update every time by gradually making it better. The updates are more compatible with the devices and perform faster than older ones along with the bugs which are fixed.

4. Large Network Access: The user can access the data of the cloud or upload the data to the cloud from anywhere just with the help of a device and an internet connection. These capabilities are available all over the network and accessed with the help of internet.

5. Availability: The capabilities of the Cloud can be modified as per the use and can be extended a lot. It analyzes the storage usage and allows the user to buy extra Cloud storage if needed for a very small amount.

6. Automatic System: Cloud computing automatically analyzes the data needed and supports a metering capability at some level of services. We can monitor, control, and report the usage. It will provide transparency for the host as well as the customer.

7. Economical: It is the one-time investment as the company (host) has to buy the storage and a small part of it can be provided to the many companies which save the host from monthly or yearly costs. Only the amount which is spent is on the basic maintenance and a few more expenses which are very less.

8. Security: Cloud Security, is one of the best features of cloud computing. It creates a snapshot of the data stored so that the data may not get lost even if one of the servers gets damaged. The data is stored within

the storage devices, which cannot be hacked and utilized by any other person. The storage service is quick and reliable.

9. Pay as you go: In cloud computing, the user has to pay only for the service or the space they have utilized. There is no hidden or extra charge which is to be paid. The service is economical and most of the time some space is allotted for free.

10. Measured Service: Cloud computing resources used to monitor and the company uses it for recording. This resource utilization is analyzed by supporting charge-per-use capabilities. This means that the resource usages which can be either virtual server instances that are running in the cloud are getting monitored measured and reported by the service provider. The model pay as you go is variable based on actual consumption of the manufacturing organization.

COMPONENTS

The basic components of cloud computing are divided into 3 (three) parts, namely clients, data-center, and distributed servers. The three basic components have specific goals and roles in running cloud computing operations.

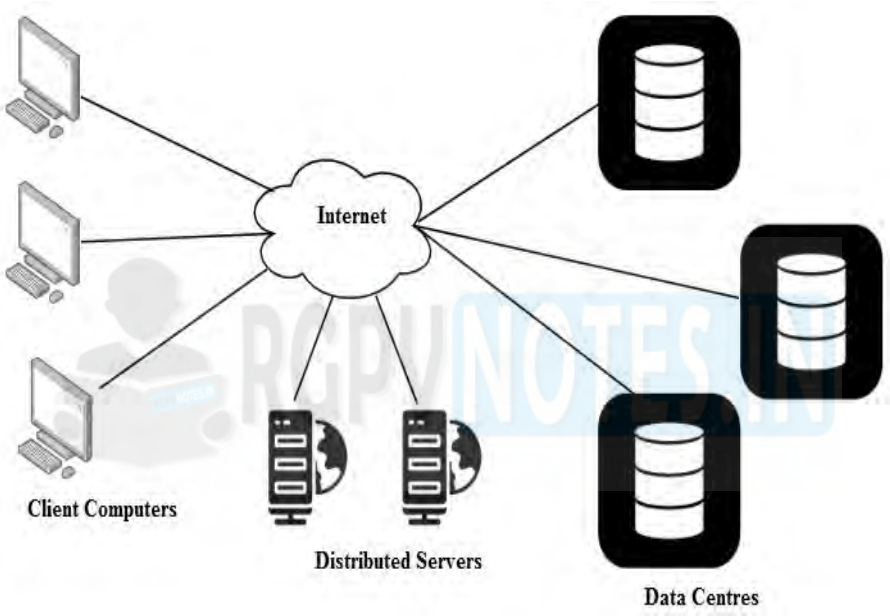

Figure 1.3: Components of Cloud computing

The three components can be described as follows:

1. **Clients** on cloud computing architecture are said to be the exact same things that are plain, old, everyday local area networks (LANs). They are, typically, the computers that just sit on your desk. But they might also be laptops, tablet computers, mobile phones, or PDAs - all big drivers for cloud computing because of their mobility. Clients are interacting with to manage their information on the cloud.
2. **Data-center** is collection of servers where the application to which you subscribe is housed. It could be a large room in the basement of your building full of servers on the other side of the world that you access via the Internet. A growing trend in the IT world is virtualizing servers. That is, software can be installed allowing multiple instances of virtual servers to be used. In this way, you can have half a dozen virtual servers running on one physical server.
3. **Distributed Servers** is a server placement in a different location. But the servers don't have to be housed in the same location. Often, servers are in geographically disparate locations. But to you, the cloud subscribers, these servers act as if they're humming away right next to each other. Another component of cloud computing is Cloud Applications cloud computing in terms of software architecture. So that the user does not need to install and run applications using a computer. Cloud

Platform is a service in the form of a computing platform that contains hardware infrastructure and software. Usually have certain business applications and use services PaaS as its business application infrastructure. Cloud Storage involves processes delivering data storage as a service. Cloud Infrastructure is the delivery of computing infrastructure as a service

BUSINESS AND IT PERSPECTIVE

Cloud Computing becoming the trend and the new way to do business, organizations are opting for the cloud model to work. The main factor in favour of cloud computing is the reduced cost of infrastructure and applications. Added to that, the lower or no costs for support and maintenance is another important aspect promoting the acceptance of cloud computing.

There are some business drivers which promote the acceptance and adoption of cloud. These are directly dependent on the business goals and customers. The key business drivers for the adoption of cloud are in fact called the benefits of the Cloud model itself.

- The first factor driving businesses to opt the cloud model is the reduced IT costs itself.
- Once on cloud, the business continuity is assured. Even if your system crashes or you lose data due to natural disasters, your data is safe on the cloud. You can use the backup so that your business is not impacted.
- As your applications and software are on the cloud, you need not worry about the updates and upgrades. These are seamless and taken care by the cloud vendor.
- The performance and scalability of the applications on the cloud are commendable.

When you are deciding whether or not to adopt the cloud model for your business, the best approach to analyze the situation is by creating a Business Use Case for the Cloud Model. For this, you would require collecting data, do comparative analysis, create reports, and understand the technical details involved.

- Understand the business requirement – Talk to all the customer facing and non-customer facing team heads, get a clearer picture of the business requirement and draw out the direct relation between the business requirement and business aspects involved.
- Cost study – Create a comparative analysis report to understand the cost involved in using the services of the cloud compared to having infrastructure and services in-house.
- Taking expert advice and professional help – Have sessions with Cloud advocates to understand the principles and technicalities of having your business on the cloud.
- Study other relevant business use cases – Study the business cases of other similar businesses, who are on cloud as well as not on cloud.
- Data security – Have professionals deployed to do a detailed study on the data security factors involved, if migrating to the cloud.
- Migration effort – Create a detailed report of the manual as well as automatic requirements for the migration to cloud, if the business was already running with another vendor or in-house.
- Choosing the right model – Understand the options of the different cloud deployment models and chooses the model rightly suiting your requirements.

CLOUD SERVICES REQUIREMENTS

1. Availability - with loss less disaster recovery

Customers want their IT services be up and available at all times. But in reality, computers sometimes fail. This implies that the service provider should have implemented a reliable disaster recovery (DR) mechanism - where in the service provider can move the customer from one data center to another seamlessly and the customer does not even have to know about it.

As a cloud service provider, there will be enormous pressure to minimise costs by optimally utilizing all the IT infrastructure. The traditional Active-Passive DR strategy is very expensive and cost inefficient. Instead, service providers will have to create an Active-Active disaster recovery mechanism - where more than one data center will be active at all times and ensures that the data and services can be accessed by the customer from either of the data centres seamlessly.

2. Portability of Data & Applications

Customers hate to be locked into a service or a platform. Ideally a cloud offering must be able to allow customers to move out their data & applications from one service provider to another - just like customers can switch from one telephone service provider to another.

As applications are being written on standard platforms - Java, PHP, Python, etc. It should be possible to move the customer owned applications from one service provider to another. Customers should also take care to use only the open standards and tools, and avoid vendor specific tools. Azure or Google services offers several tools/applications/utilities which are valuable - but it also creates a customer lockin - as the customer who uses these vendors specific tools cannot migrate to another service provider without rewriting the applications.

To illustrate this, today in India, customers can move from one cell phone service provider to another without changing their handsets, but in US, if one were to move from AT&T to Verizon, one needs to pay for the handset - which forms a customer lock in instrument.

With public cloud services, customers should be able to move their data & applications from one cloud to another - without disrupting the end user's IT services. This movement should be transparent to the end user.

3. Data Security

Security is the key concern for all customers - since the applications and the data is residing in the public cloud; it is the responsibility of the service provider for providing adequate security. In my opinion security for customer data/applications becomes a key differentiator when it comes to selecting the cloud service provider. When it comes to IT security, customers tend to view the cloud service providers like they view banks. The service provider is totally responsible for user security, but there are certain responsibilities that the customer also needs to take.

The service provider must a robust Information Security Risk Management process - which is well understood by the customer, and customer must clearly know his responsibilities as well. As there are several types of cloud offerings (SaaS, PaaS, IaaS etc), there will be different sets of responsibility for the customer and the service provider depending on the cloud service offering.

When it comes to security, the cloud service providers offer better security than what the customer's own data center security. This is a kin to banks - where banks can offer far greater security than any individual or company. The security in cloud is much higher due to: Centralized monitoring, enhanced incidence detection/forensics, logging of all activity, greater security/venerability testing, centralized authentication testing (aka password protection), secure builds & testing patches before deployment and lastly better security software/systems.

4. Manageability

Managing the cloud infrastructure from the customer perspective must be under the control of the customer admin. Customers of Cloud services must be able to create new accounts, must be able to provision various services, do all the user account monitoring - monitoring for end user usage, SLA breaches, data usage monitoring etc. The end users would like to see the availability, performance and configuration/provisioning data for the set of infrastructure they are using in the cloud.

Cloud service provider will have various management tools for Availability management, performance management, configuration management and security management of applications and infrastructure (storage, servers, and network). Customers want to know how the entire infrastructure is being managed - and if possible can that management information be shared with them, and alert the customer on any outage, slow service, or breach of SLA as it happens. This allows customer to take corrective actions - either move the applications to another cloud or enable their contingency plans.

Sharing the application performance and resource management information will help improve utilization and consequently optimize usage by customers. This will result in improving ROI for the customers and encourage customers to adapt cloud services.

As customers buy cloud services from multiple vendors, it will become a necessity to have a unified

management system to manage all the cloud services they have. This implies that cloud service providers must embrace an XML based reporting formats to provide management information to customers and customers then can build their own management dashboards.

5. Elasticity

Customer on Cloud computing have a dynamic computing loads. At times of high load, they need greater amount of computing resources available to them on demand, and when the work loads are low, the computing resources are released back to the cloud pool. Customer expects the service provider to charge them for what they have actually used in the process.

Customers also want a self service on-demand resource provisioning capability from the service provider. This feature enables users to directly obtain services from clouds, such as spawning the creation of a server and tailoring its software, configurations, and security policies, without interacting with a human system administrator. This eliminates the need for more time-consuming, labour-intensive, human driven procurement processes familiar to many in IT.

6. Federated System

There are several reasons as to why customers will need a Federated cloud system. Customers may have to buy services from several cloud service providers for various services - email from Google, online sales transaction services from Amazon and ERP from another vendor etc. In such cases customer want their cloud applications to interact with other services from several vendors to provide a seamless end to end IT services.

CLOUD MODELS

Cloud models come in three types: SaaS (Software as a Service), IaaS (Infrastructure as a Service) and PaaS (Platform as a Service). Each of the cloud models has their own set of benefits that could serve the needs of various businesses.

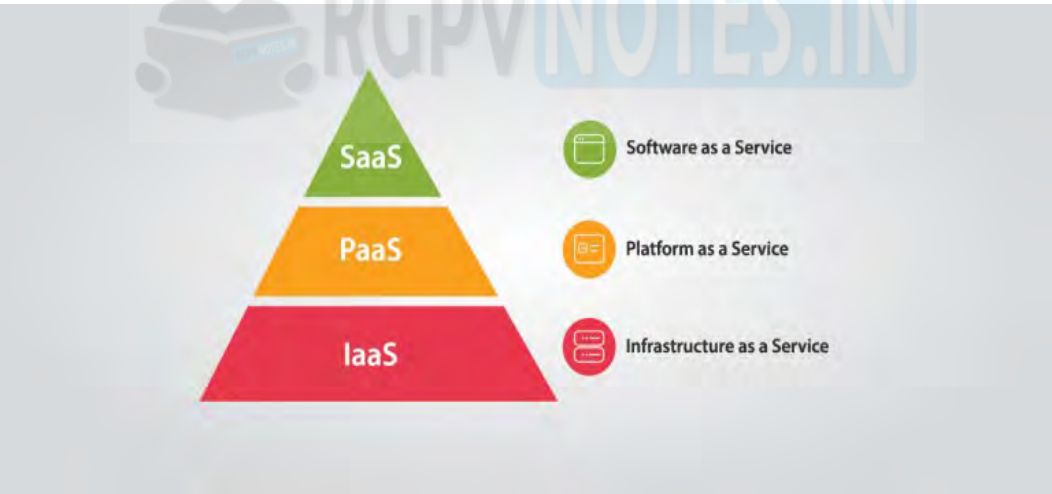

Figure 1.4: Cloud Models

SaaS

SaaS or Software as a Service is a model that gives quick access to cloud-based web applications. The vendor controls the entire computing stack, which you can access using a web browser. These applications run on the cloud and you can use them by a paid licensed subscription or for free with limited access.

SaaS does not require any installations or downloads in your existing computing infrastructure. This eliminates the need for installing applications on each of your computers with the maintenance and support taken over by the vendor. Some known example of SaaS includes Google G Suite, Microsoft Office 365, and Dropbox etc.

IaaS

IaaS or Infrastructure as a Service is basically a virtual provision of computing resources over the cloud. An IaaS cloud provider can give you the entire range of computing infrastructures such as storage, servers,

networking hardware alongside maintenance and support.
Businesses can opt for computing resources of their requirement without the need to install hardware on their premises. Amazon Web Services, Microsoft Azure, and Google Compute Engine are some of the leading IaaS cloud service providers.

PaaS
Platform as a Service or PaaS is essentially a cloud base where you can develop, test and organize the different applications for your business. Implementing PaaS simplifies the process of enterprise software development. The virtual runtime environment provided by PaaS gives a favourable space for developing and testing applications.
The entire resources offered in the form of servers, storage and networking are manageable either by the company or a platform provider. Google App Engine and AWS Elastic Beanstalk are two typical examples of PaaS. PaaS is also subscription based that gives you flexible pricing options depending on your business requirements.

SECURITY IN PUBLIC MODEL
Opting for a public model means that you're enlisting a third party provider to deliver a set of services over the internet. These services can range from processing power to storage capacity. Now, contrary to how it may seem, a public cloud doesn't lack major security precautions. Over the years, public cloud providers have adapted and improved upon their security measures, enabling them to manage attacks that have only grown in terms of sophistication.
There are limitations to the level of security available.

1. **Identification and allowance:** In a cloud, there is a risk that the data can access by the unauthorized user as it can access from anywhere it is a need to establish it with certainty the identity of a user. A strong authentication and authorization should be a critical concern.
2. **Management interface vulnerability**: The cloud can access from anywhere and thus it leads to an increment in the risk. As there is a large number of users who are accessing the cloud the risk is quite high. So, interfaces which use to manage the public cloud resources should secure as their combination with remote access and web browser vulnerabilities.
3. **Management of security incidents**: The customer should inform with the delay which causes due to any detection reporting and subsequent management of security incidents. So there should be a proper management and the customer should be familiar with the fact.
4. **Security of application**: The applications on the cloud protect with a great security solution which based on physical and virtual resources. The level of security is high and the same level of security must provide to workloads which deploy in cloud services. There should centralize management across distributed workload instances
5. **Securing the data**: The personal data of the customer should secure as it is one of the important parts. Unavailability of the data can cause a major issue for both the customer and the provider. This problem can rapidly grow in case of multiple data transfer which will result in a lack of ownership transparency and will lead to a great loss.

PUBLIC VERSES PRIVATE CLOUDS
Private clouds are owned and operated by a single organization. In a private cloud environment, the hardware, the software, and the related infrastructure is either located at the data-centre of the organization or is provided by a service provider. Private cloud is thus, not provided as a service.

Public cloud is a service offered by a third-party provider over the internet. Thus, offering higher penetration in comparison to private cloud. Ideally used by small and mid-sized companies, the public cloud offers ease operation as the maintenance and set up is borne by the provider. On the other hand, the private clouds which are servers owned and operated by a single organization, are ideally used by organisations dealing with sensitive data, one where a data breach is not an option. Private clouds are thus, comparatively expensive.

S. No.	Public Cloud	Private Cloud
1.	Services owned and provided by third party provider	Service used by single organization
2.	The maintenance cost borne by service provider	Higher security as the resources are not shared
3.	Pay as you go Model. Thus setting and operating cost is less	Greater flexibility to control the cloud environment.
4.	Shared responsibility for security-provider and consumer	Opportunity to control entire cloud infra stack
5.	All resources are hosted on cloud providers infra.	Complex than using a public cloud.

Table 1.1: Difference between Public and Private Cloud

CLOUD COMPUTING PLATFORMS: AMAZON EC2,

Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides secure, resizable compute capacity in the cloud. It is designed to make web-scale cloud computing easier for developers. Amazon EC2's simple web service interface allows obtaining and configuring capacity with minimal friction.

Elastic Compute Cloud (EC2) is one of the integral parts of the AWS ecosystem. EC2 enables on-demand, scalable computing capacity in the AWS cloud.

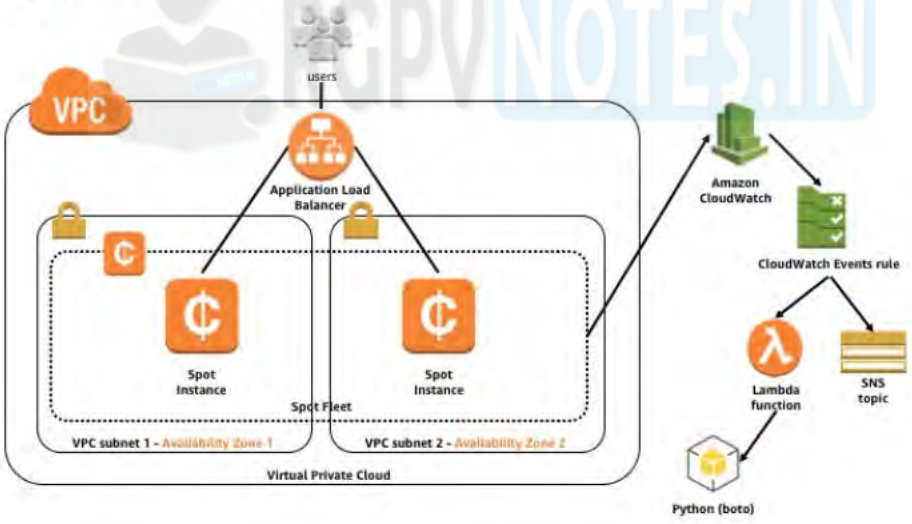

Figure 1.5: Basic architecture of AWS EC2

Amazon EC2 instances eliminate the up-front investment for hardware, and there is no need to maintain any rented hardware. It enables you to build and run applications faster. You can use EC2 in AWS to launch as many virtual servers as you need. Also, you can scale up or down when there is an increase or decrease in the website traffic.

AWS Elastic Compute Cloud provides a lot of benefits:

- **Auto-scaling:** This is the benefit which makes most businesses opt for AWS EC2. It is already explained earlier how Netflix uses auto-scaling to its advantage and provides a crash-free experience. Auto-scaling is basically providing resources according to the demand. They either scale up or scale down corresponding to the increase or decrease in demand.

- **Pay-as-you-go**: User will be charged by the hour, and you have to pay only for what you have used. A company, XYZ might be using 100 servers normally, and on Mondays it scales down to 50 servers. So, it only has to pay for 50 servers those days, not the usual fee for the usage of 100 servers.
- **Increased Reliability**: AWS is spread across 20 worldwide regions with 61 availability zones (AZs) which helps your business when it is expanding. Also, this will increase the load speed of your application around the world. User can always store multiple copies of your application in multiple AZs so that when one data center fails or loses data, the application will not fail completely.
- **Elasticity:** Instead of 10 low-configuration machines, you could rent a single high-configuration machine with an OS of your preferred choice for your application. Elasticity is the feature from which Elastic Compute Cloud got its name.

PLATFORM AS SERVICE: GOOGLE APP ENGINE, MICROSOFT AZURE

Google App Engine

Google App Engine can be used for content distribution of digital publishing assets as well as analytics and authentication services for a wide array of platforms. The whole organization uses Google App Engine in some capacity or another. The business problems it addresses are virtualizing services and abstracting away server configuration, load balancing, software updates and everything else one have to do to set up the infrastructure on a classic web server stack.

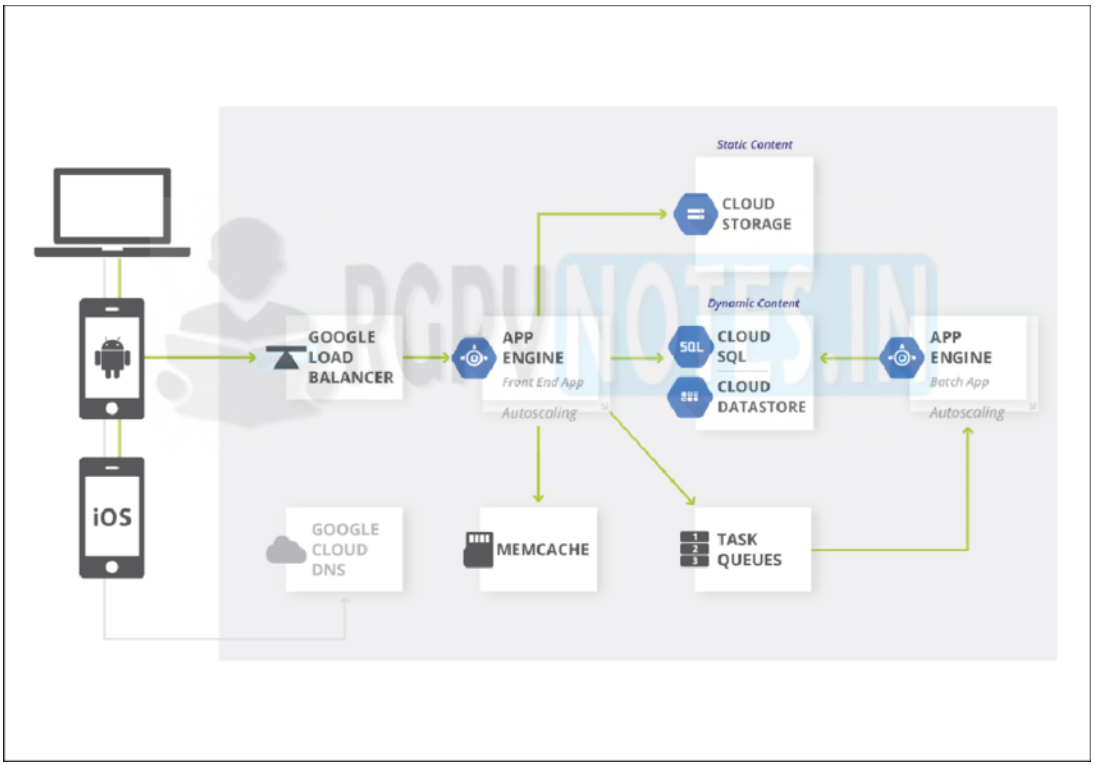

Figure 1.6: Basic architecture of Google App Engine

Pros of Google App Engine

1. Quick to develop, quickly to deploy. You can be up and running on Google App Engine in no time.
2. Flexible. We use Java for some services and Node.js for others.
3. Great security features. We have been consistently impressed with the security and authentication features of Google App Engine.

Cons of Google App Engine

1. Documentation does not always keep up with the latest changes to the service. Google App Engine has undergone a lot of changes these past couple of years. At times, we were surprised to find out that something we didn't think was possible was, or, conversely, something that was supposed to work fine which had been deprecated. We also ended up using some undocumented features and weren't sure whether they would keep working or not.

2. Price. Google App Engine isn't cheap. But, you get what you pay for. Rock solid service, great tools, at a hefty price.
3. Difficult to tell how to optimize costs. We racked up the expenses and it is still a mystery where all the costs are being incurred.
4. Some intimidating or arcane aspects of configuration. Most of it was a breeze but every now and then something would be pretty far out and require a few of us developers putting our heads together to figure it out.
5. Sometimes required reading source code to figure out how to do something. Not a ton of examples of how to do various things, nor Stack Overflow posts, at least in the beginning.

Microsoft Azure

Microsoft Azure is used by departments to manage larger data sets across entities. The software addresses the need for multiple users to have access to multiple different data sets simultaneously. The software makes this relatively easy by making Microsoft Azure similar to the user-friendliness of other Microsoft products. Users point their analytical tools at Azure for data visualization and analytics. Some analytics is also done in Azure itself**.**

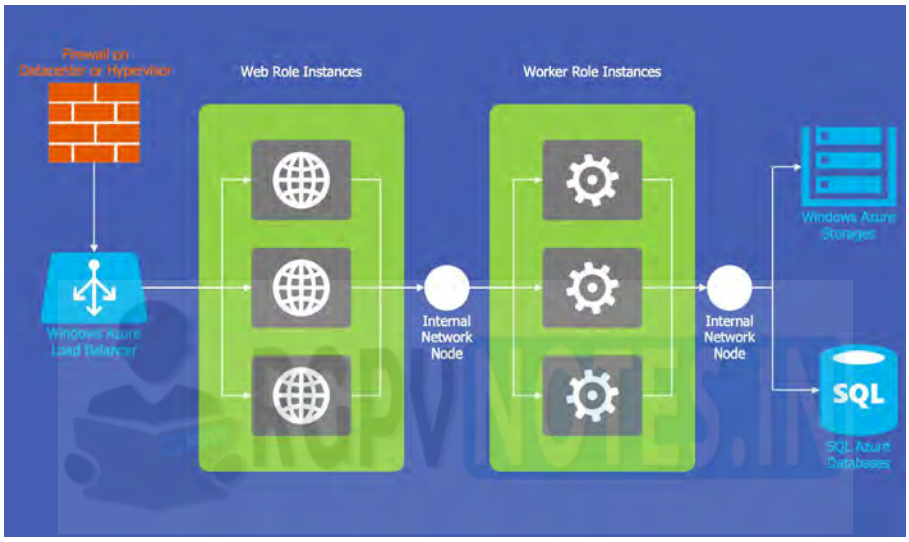

Figure 1.7: Reference architecture of MS Azure

Pros of Microsoft Azure

1. Perhaps the biggest advantage of Microsoft Azure is its ease of integration with other Microsoft products. If you're used to using Excel, Access, SQL Server, and other Microsoft products, Azure will fit in nicely.
2. Azure does a good job at pointing the user into user-friendly methods for data capture and analysis. In fact, Azure does the best job at this compared to competing tools.
3. Microsoft Azure has recently made strides in implementing advanced analytics, such as machine learning. Their advances are great and integrate nicely with the tool.

Cons of Microsoft Azure

1. Microsoft Azure's movement into machine learning and other advanced analytics are somewhat behind the curve. Other tools that have been doing this for a long time have set up easier user interfaces.
2. Azure seems to run slower than other big data housing tools. I think this might be because of Microsoft's attempt to make Azure more user-friendly.
3. Azure could improve its product by making it even more like Microsoft Excel.

UTILITY COMPUTING

Utility computing is a service provisioning model in which a service provider makes computing resources

and infrastructure management available to the customer as needed, and charges them for specific usage rather than a flat rate. Like other types of on-demand computing (such as grid computing), the utility model seeks to maximize the efficient use of resources and/or minimize associated costs.

The word utility is used to make an analogy to other services, such as electrical power, that seek to meet fluctuating customer needs, and charge for the resources based on usage rather than on a flat-rate basis. This approach, sometimes known as pay-per-use or metered services is becoming increasingly common in enterprise computing and is sometimes used for the consumer market as well, for Internet service, Web site access, file sharing, and other applications.

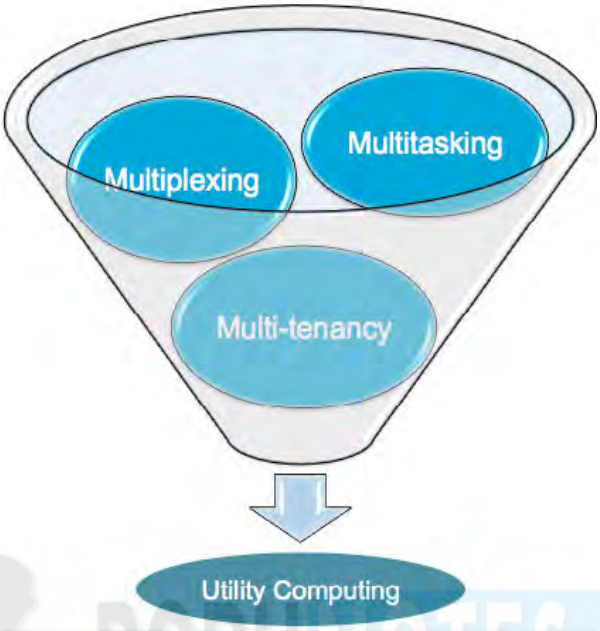

Figure 1.8: Utility computing

Another version of utility computing is carried out within an enterprise. In a shared pool utility model, an enterprise centralizes its computing resources to serve a larger number of users without unnecessary redundancy.

Properties of utility computing

These following are five characteristics of utility computing.

1. Scalability: The utility computing must be ensured that under all conditions sufficient IT resources are available. Increasing the demand for a service may, its quality (e.g., response time) does not suffer.
2. Demand pricing: So far, companies have to buy his own hardware and software when they need computing power. This IT infrastructure must be paid in advance of the rule, regardless of the intensity with which the company uses them later. Technology vendors to achieve this link, for example, the fact that the lease rate for their servers depends on how many CPUs has enabled the customer. If it can be measured in a company as much computing power to claim the individual sections in fact, may be the IT costs in internal cost directly attributable to the individual departments. Other forms of connection with the use of IT costs are possible.
3. Standardized Utility Computing Services: The utility computing service provider offers its customers a catalogue of standardized services. These may have different service level agreements (Agreement on the quality and the price of an IT) services. The customer has no influence on the underlying technologies such as the server platform.
4. Utility Computing and Virtualization: To share the web and other resources in the shared pool of machines can be used virtualization technologies. This will divide the network into logical resource instead of the physical resources available. An application is assigned no specific pre-determined servers or storage of any but a free server runtime or memory from the pool.

5. Automation: Repetitive management tasks such as setting up a new server or the installation of updates can be automated. Moreover, automatically allocate resources to services and the management of IT services to be optimized, with service level agreements and operating costs of IT resources must be considered.

Advantages of Utility Computing

Utility computing reduces the cost of IT, given that existing resources can be used more effectively. Moreover, the costs are transparent and the various departments of a company can be directly assigned. In the IT departments will be fewer people needed for operational activities.

The companies achieve greater flexibility, because their IT resources more quickly and easily adapt to fluctuating demand. Overall, it is easier to manage the entire IT structure, as there will no longer be made for each application, which is a benefit for specific IT infrastructure.

ELASTIC COMPUTING

Elastic computing is the ability to quickly expand or decrease computer processing, memory and storage resources to meet changing demands without worrying about capacity planning and engineering for peak usage.

Elastic computing is a concept in cloud computing in which computing resources can be scaled up and down easily by the cloud service provider. Elastic computing is the ability of a cloud service provider to provision flexible computing power when and wherever required. The elasticity of these resources can be in terms of processing power, storage, bandwidth, etc.

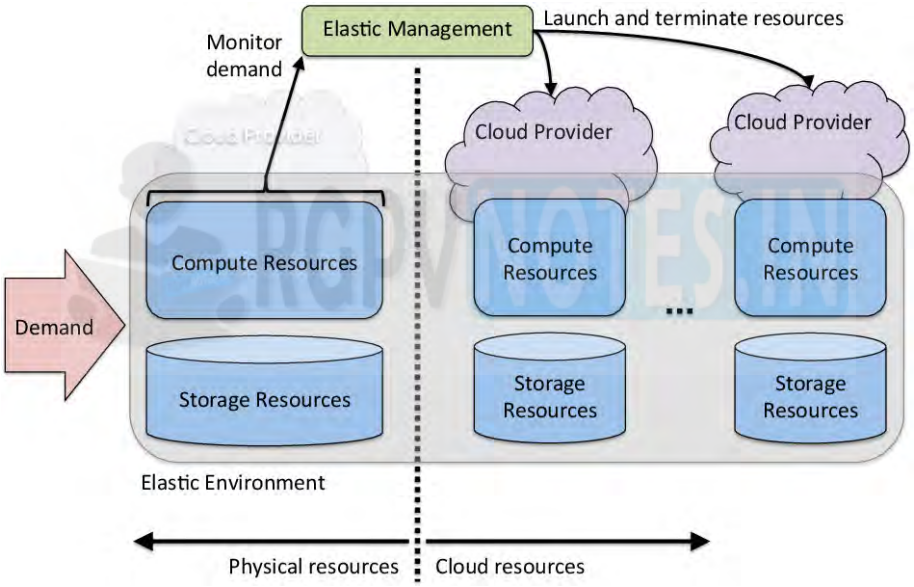

Figure 1.9: Elastic computing model

Cloud computing is about provisioning on-demand computing resources with the simplicity of a mouse click. The amount of resources which can be sourced through cloud computing incorporates almost all the facets of computing from raw processing power to massive storage space.

Besides providing these services on demand basis, the resources are elastic in nature, i.e. they can be easily scaled depending upon the underlying resource requirements on run time without even disrupting the operations and this ability is known as elastic computing. On a small scale this is done manually, but for larger installations, the scaling is automatic. For example, a larger provider of online video could setup a system so that the number of web-servers online scaled during peak viewing hours.

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