A

SEMINAR REPORT
on
APPLICATIONS OF CLOUD COMPUTING FOR POWER SYSTEMS
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1.INTRODUCTION

To increase the utilization of green energy, considering carbon emission and energy mix several changes has been taking place in power system. In order to satisfy these requirements, additional energy generation resources are placed in the power system in addition to the traditional energy generation systems. These energy generations can be owned either by utilities or customers. In this case energy and information are exchanged in both ways to enable smooth operation and reliable energy delivery system. The electric network that can support these additions which are improved in a reliable, sustainable and low-cost method. Smart grid will provide a solution to this effort in increasing reliability, quality of power supplies and energy efficiency. Different players such as utilities, network operators, demand response providers and customers are involved in smart grid to ensure the efficient delivery of energy where it is needed most. Huge amount of online and offline information needs to be exchanged among them and enormous data are collected by these players for different uses. Processing and computing these data in time enables efficient monitoring and controlling of resources, directing energy to where it is most needed to make technical or administrative decisions and smooth operation of the energy delivery network. The coordinated information exchange and active participation of all the players who have roles in the power system operation is vital in minimizing down time and satisfy the customers need in terms of energy consumption management, predictions and quality energy delivery.

According to National institute of standards and technology (NIST) cloud computing is defined as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction." The computing resources can be networks, servers, storage, applications, and services. Cloud based systems are a sharing of an enormous amount of Information Technology (IT) infrastructures, such as computational and database resources in the form of service, which focus on maximization the efficiency of operation, scalability, maintainability and reliability by decreasing cost. These resources are provided in three service models: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). A single cloud computing data center might have storage and computing capabilities tens or hundreds of times greater than all of the world's supercomputing facilities combined.

Cloud providers own a large number of networked servers with low expenses. This infrastructure consists of massive pooled systems that are linked together and works with virtualization techniques to provide a high performance of data storages and runs along-side with a local network connection that can runs from a few to trillions of computations per second depending on the demand.

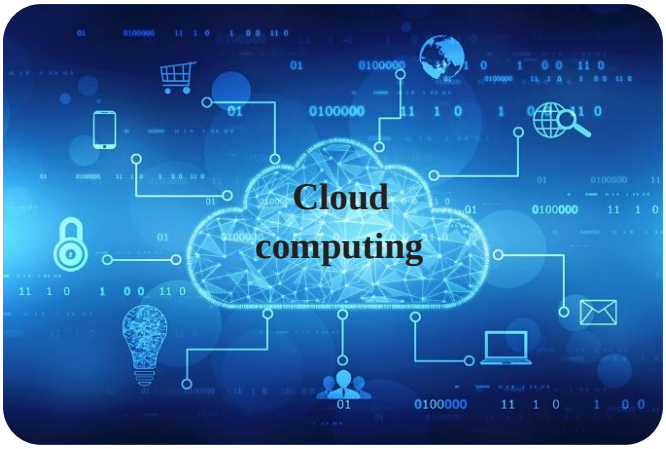


Fig (1): cloud computing

2. TYPES OF CLOUD COMPUTING

The deployment models differ on the basis of implementation type, hosting type and who has access to it. All Cloud deployment models are based on the same principle of Virtualization (abstraction of resources from bare metal hardware) but differ in terms of location, storage capacity, accessibility, and more. Depending on the type of data you are working with, you will want to compare Public, Private, Hybrid, and Community Clouds in terms of different levels of security they offer and the management required.

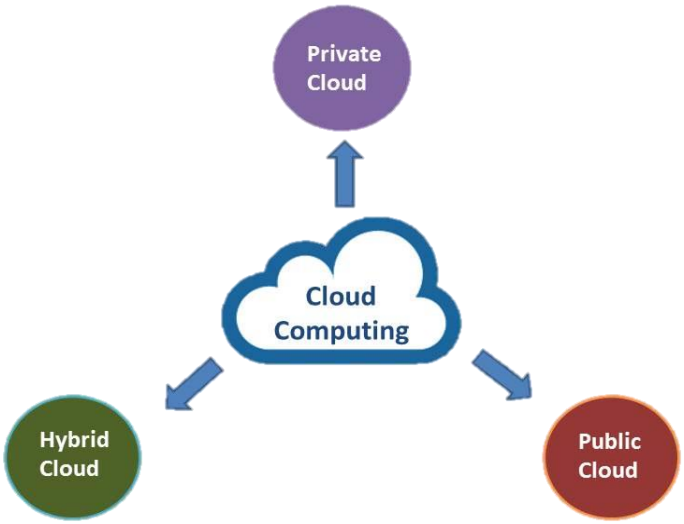


Fig (2): Types of cloud computing

2.1 PUBLIC CLOUD

- Public Cloud provides a shared platform that is accessible to the general public through an Internet connection.
- Public cloud operated on the pay-as-per-use model and administrated by the third party**,** i.e., Cloud service provider.
- In the Public cloud, the same storage is being used by multiple users at the same time.
- Public cloud is owned**,** managed**,** and operated by businesses, universities, government organizations, or a combination of them.
- Amazon Elastic Compute Cloud (EC2), Microsoft Azure, IBM's Blue Cloud, Sun Cloud, and Google Cloud are examples of the public cloud.

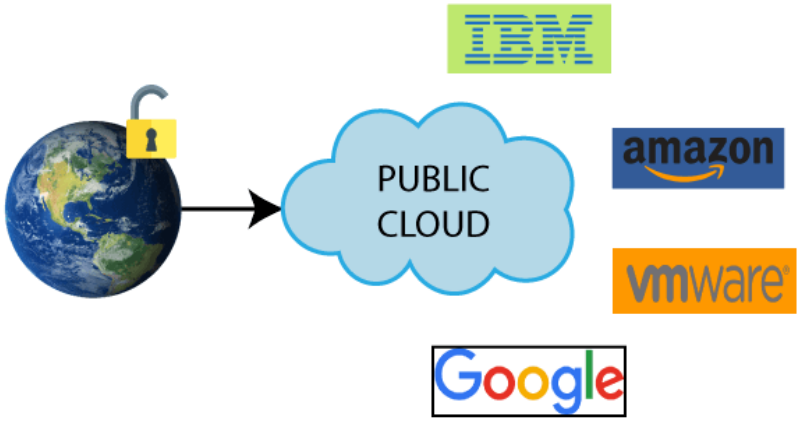


Fig (2.1): Public cloud

Advantages of Public Cloud

There are the following advantages of public cloud

1) Low Cost

Public cloud has a lower cost than private, or hybrid cloud, as it shares the same resources with a large number of consumers.

2) Location Independent

Public cloud is location independent because its services are offered through the internet.

3) Save Time

In Public cloud, the cloud service provider is responsible for the manage and maintain data centres in which data is stored, so the cloud user can save their time to establish connectivity, deploying new products, release product updates, configure, and assemble servers.

4) Quickly and easily set up

Organizations can easily buy public cloud on the internet and deployed and configured it remotely through the cloud service provider within a few hours.

5) Business Agility

Public cloud provides an ability to elastically re-size computer resources based on the organization's requirements.

6) Scalability and reliability

Public cloud offers scalable (easy to add and remove) and reliable (24*7 available) services to the users at an affordable cost.

Disadvantages of Public Cloud

1) Low Security

Public Cloud is less secure because resources are shared publicly.

2) Performance

In the public cloud, performance depends upon the speed of internet connectivity.

3) Less customizable

Public cloud is less customizable than the private cloud.

2.2 PRIVATE CLOUD

- Private cloud is also known as an internal cloud or corporate cloud.
- Private cloud provides computing services to a private internal network **(**within the organization**)** and selected users instead of the general public.
- Private cloud provides a high level of security and privacy to data through firewalls and internal hosting. It also ensures that operational and sensitive data are not accessible to third-party providers.
- HP Data Centers, Microsoft, Elantra-private cloud, and Ubuntu are the example of a private cloud.

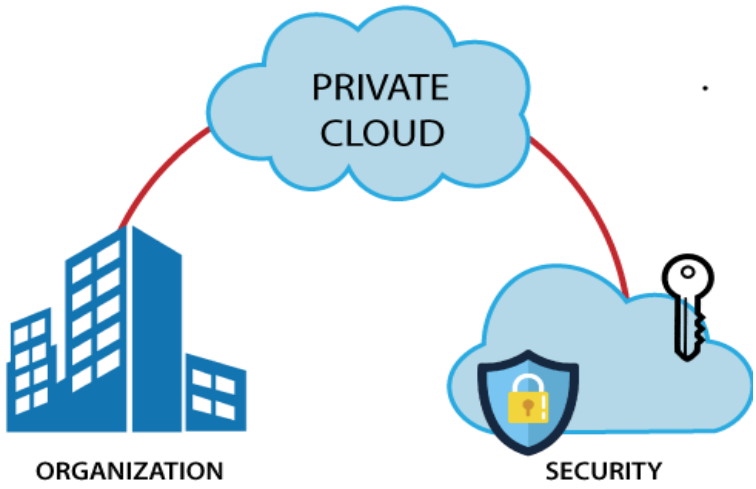


Fig (2.2): Private cloud

Advantages of Private cloud

There are the following advantages of Private Cloud -

1) More Control

Private clouds have more control over their resources and hardware than public clouds because it is only accessed by selected users.

2) Security & privacy

Security & privacy are one of the big advantages of cloud computing. Private cloud improved the security level as compared to the public cloud.

3) Improved performance

Private cloud offers better performance with improved speed and space capacity.

Disadvantages of Private Cloud

1) High cost

The cost is higher than a public cloud because set up and maintain hardware resources are costly.

2) Restricted area of operations

As we know, private cloud is accessible within the organization, so the area of operations is limited.

3) Limited scalability

Private clouds are scaled only within the capacity of internal hosted resources.

4) Skilled people

Skilled people are required to manage and operate cloud services.

2.3 HYBRID CLOUD

- Hybrid cloud is a combination of public and private clouds.

Hybrid cloud = public cloud + private cloud

- The main aim to combine this cloud (Public and Private) is to create a unified, automated, and well-managed computing environment.
- In the Hybrid cloud, non-critical activities are performed by the public cloud and critical activities are performed by the private cloud.
- Mainly, a hybrid cloud is used in finance, healthcare, and Universities.
- The best hybrid cloud provider companies are Amazon**,** Microsoft**,** Google**,** Cisco**,** and NetApp.

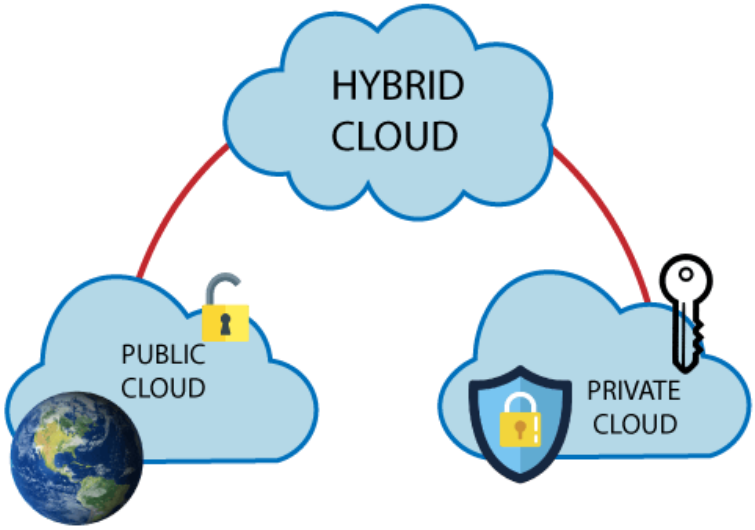


Fig (2.3): Hybrid cloud

Advantages of Hybrid Cloud

There are the following advantages of Hybrid Cloud -

1) Flexible and secure

It provides flexible resources because of the public cloud and secure resources because of the private cloud.

2) Cost effective

Hybrid cloud costs less than the private cloud. It helps organizations to save costs for both infrastructure and application support.

3) Cost effective

It offers the features of both the public as well as the private cloud. A hybrid cloud is capable of adapting to the demands that each company needs for space, memory, and system.

4) Security

Hybrid cloud is secure because critical activities are performed by the private cloud.

5) Risk Management

Hybrid cloud provides an excellent way for companies to manage the risk.

Disadvantages of Hybrid Cloud

1) Networking issues

In the Hybrid Cloud, networking becomes complex because of the private and the public cloud.

2) Infrastructure Compatibility

Infrastructure compatibility is the major issue in a hybrid cloud. With dual-levels of infrastructure, a private cloud controls the company, and a public cloud does not, so there is a possibility that they are running in separate stacks.

3) Reliability

The reliability of the services depends on cloud service providers.

3.CLOUD SERVICE MODELS

There are the following three types of cloud service models

Fig (3): Cloud service models

INFRASTRUCTURE AS A SERVICE(IAAS)

Infrastructure as a Service (IAAS) is a form of cloud computing that provides virtualized computing resources over the internet. In an IAAS model, a third-party provider hosts hardware, software, servers, storage and other infrastructure components on the behalf of its users. IAAS providers also host users' applications and handle tasks including system maintenance backup and resiliency planning. IAAS platforms offer highly scalable resources that can be adjusted on-demand which makes it a well-suited for workloads that are temporary, experimental or change unexpectedly. Other characteristics of IAAS environments include the automation of administrative tasks, dynamic scaling, desktop virtualization and policy-based services. Other characteristics of IAAS include the automation of administrative tasks, dynamic scaling, desktop virtualization and policy-based services. Technically, the IaaS market has a relatively low barrier of entry, but it may require substantial financial investment in order to build and support the cloud infrastructure. Mature open-source cloud management frameworks like OpenStack are available to everyone and provide strong a software foundation for companies that want to build their private cloud or become a public cloud provider.

There are two major network services offered by public cloud service providers: load balancing and DNS (domain name systems). Load balancing provides a single point of access to multiple servers that run behind it. A load balancer is a network device that distributes network traffic among servers using specific load balancing algorithms. DNS is a hierarchical naming

system for computers, or any other gaming devices that use IP addressing for network identification – a DNS system associates domain names with IP addresses.

3.1 PLATFORM AS A SERVICE(PAAS)

Platform as a Service (PAAS) is a cloud computing model that delivers applications over the internet. In a PAAS model, a cloud provider delivers hardware and software tools, usually those needed for application development, to its users as a service. A PAAS provider hosts the hardware and software on its own infrastructure. As a result, PAAS frees users from having to install in-house hardware and software to develop or run a new application.

PAAS doesn't replace a business' entire infrastructure but instead, a business relies on PAAS providers for key services, such as Java development or application hosting. A PAAS provider, however, supports all the underlying computing and software; users only need to log in and start using the platform-usually through a Web browser interface. PAAS providers then charge for that access on a per-user basis or on a monthly basis.

Some of the main characteristics of PAAS are

- Scalability and auto-provisioning of the underlying infrastructure.
- Security and redundancy.
- Build and deployment tools for rapid application management and deployment.
- Integration with other infrastructure components such as web services, databases, and LDAP.
- Multi-tenancy, platform service that can be used by many concurrent users.
- Logging, reporting, and code instrumentation.
- Management interfaces and/or API.

3.2 SOFTWARE AS A SERVICE(SAAS)

Software as a Service (SAAS) is a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over a network, typically the Internet. SAAS has become an increasingly prevalent delivery model as underlying technologies that support Web services and service-oriented architecture (SOA) mature and new development approaches, such as Ajax, become popular. SAAS is closely related to the ASP (Application service provider) and on-demand computing software delivery models. IDC identifies two slightly different delivery models for SAAS namely the hosted application model and the software development model.

Some of the core benefits of using SAAS model are:

- Easier administration.
- automatic updates and patch management.
- compatibility: all users will have the same version of software.
- easier collaboration, for the same reason.
- global accessibility.

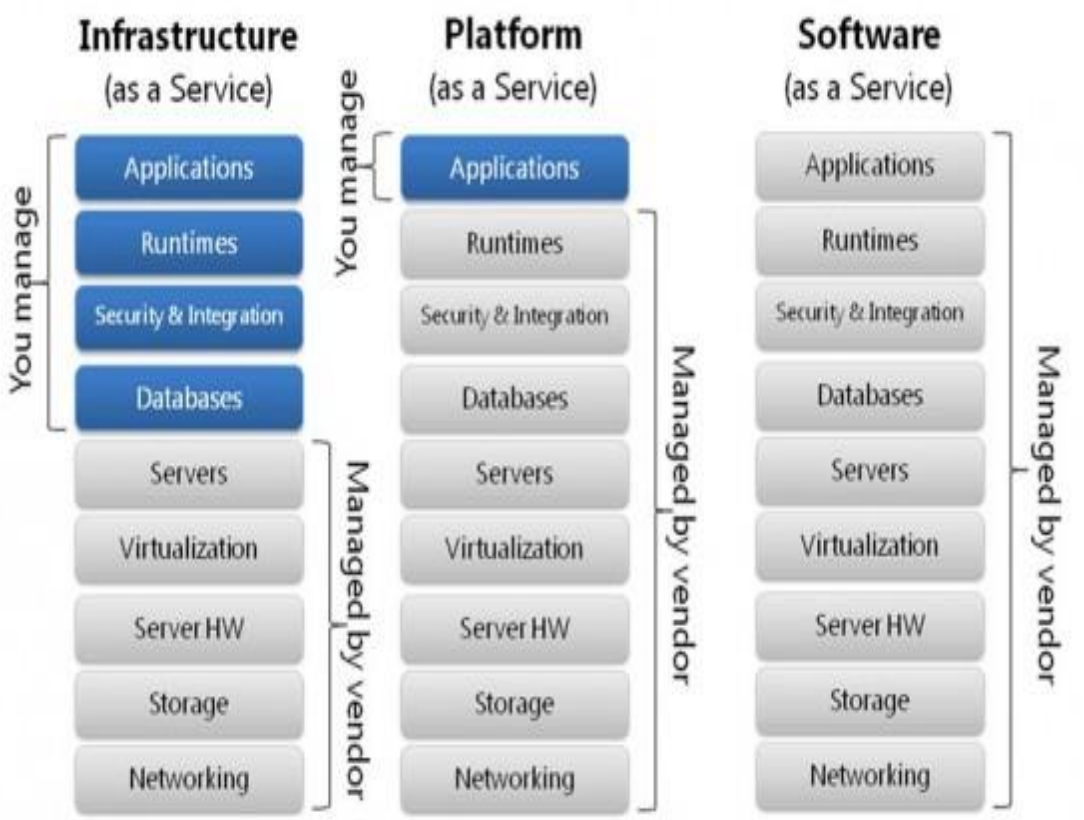


Fig (3.1): Differentiating with various cloud service models

4.CLOUD BASED POWER SYSTEMS PROGRAMMING ARCHITECTURE

The Cloud-based power systems programming architecture normally comprises of 3 levels as appeared in Figure (4.1); One level comprises of the remote simulation server which runs a software that simulates a model of the power system network and performs estimations, the second level is the web server that handles communication between alternate levels, and the web browser is the third level for parameters of input and displaying results.

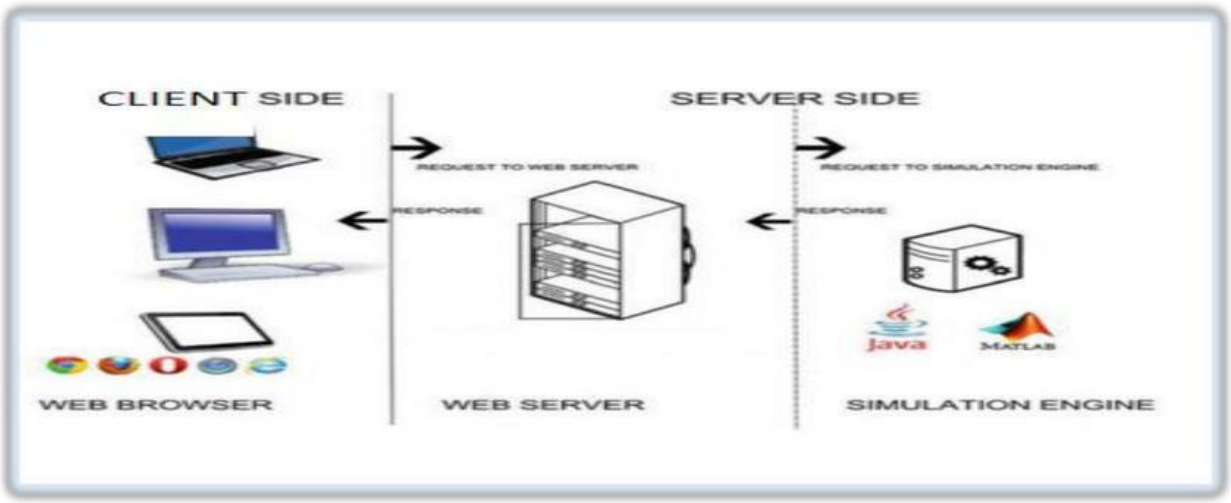


Fig (4.1): 3-level architecture for web-based power systems analysis

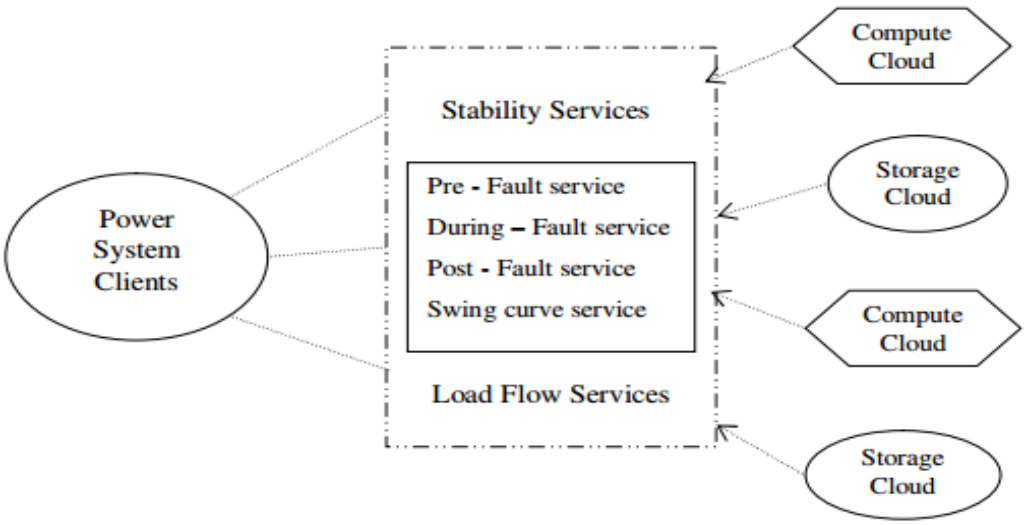


Fig (4.2): Communications with Power System Service Provider –Cloud Environment

MATLAB power systems solvers, for example, MATPOWER may likewise be gotten to on the web by running them on an application server with MATLAB introduced and afterward utilizing a intermediate scripting language, for example, ASP.NET to communicate with the web browser. Another online cloud application is InterPSS which depends on Google Drive spread sheets for data and results yield, and a Google App script communicate with a Java based simulation engine. The 3-level design is executed for practical reasons that simulation of software packages which are not prepared for web demonstrating use a web server as an interface. The main necessity for web access is to upgrade of communication and data transfer. Another practical explanation is that the programming dialects utilized for building sites are not as intense or as deliberate for computation as those used for building simulation software. Additionally, the power system customer applications (MATLAB, JAVA) are to get to the stability services in a cloud computing environment. The power system services in a cloud environment as shown in Figure (4.2).

The power system customers can access their required services by paying for what they use with minimal investment costs in cloud environment. This environment can adopt by power sectors for running their power system applications keeping in mind to enhance the effectiveness of their operations demands.

5.ENERGY MONITORING SYSTEM

This system developed to optimize energy usage, to achieve continuous storage and procession of even more than ten million smart meter's data, as well as serving millions of users. The high safety-storage of such amount of data and the large availability of service for numerous users can optimally be ensured by the computing power and data storage capability of cloud technologies.

Fig (5): Energy monitoring system using Cloud Computing

In case of cloud-based solutions, users are served by information technology services available on the web. These services are divided on the servers of the service providers and the operational details of the services are hidden from the user.
The computing power and the data storage capability of cloud technology can be scalable according to the number of smart meters and users connected to the system, and the required computing resources of the management application. These cloud-based systems can also ensure the cost-effective service for millions of users.

The following main functions are required for cloud based energy management service implementations:

- Collecting, storing, displaying real-time data of the smart meters.
- Ensuring adaptability of newly developed smart meters to the system.
- Determining consumption and costs for different periods.
- Near real-time energy management, and control of energy using devices.
- Simple and rapid addition of smart meters, users, built-in functions.
- The manual remote control of energy consumption devices.
- Safe and reliable realization of the above functions.

6.CLOUD BASED SCADA CONFIGURATION

The power organizations to exchange data and information between various nodes in the power systems network using Supervisory Control and Data Acquisition systems (SCADA) technology.

The architecture to implement smart grid application into cloud computing is shown as in Fig (11). It has multiple layers which consider and describe both the cloud computing and the smart grid domain. This configuration can be modified for different application depending on the algorithm, type of data or information required to access, computation needs, whether it is a real-time or an offline application. The type of additional software tools used to realize the specific application may also define the needs.

As shown in Fig (11), the above layer, web-based monitoring and controlling application layer is an application layer to visualize, monitor and control the readings of different sensors installed across the network and send control signal to the actuators when it is necessary. The middle layer is a cloud computing platform which provides server, database system, different operating systems and computing tools. The virtual servers and operating systems used as a local computer to provide unlimited storage to accommodate the vast amount of data collected from the smart grid, it is also possible to run applications in different instances in parallel to increase the speed of the computation and decrease execution time. The lower layer is the smart grid where the actual grid data is collected. The data can be, the reading of current sensor, network voltage, phase angle, frequency, energy meter readings, the status of a relay or circuit breaker or insulator, and so on.

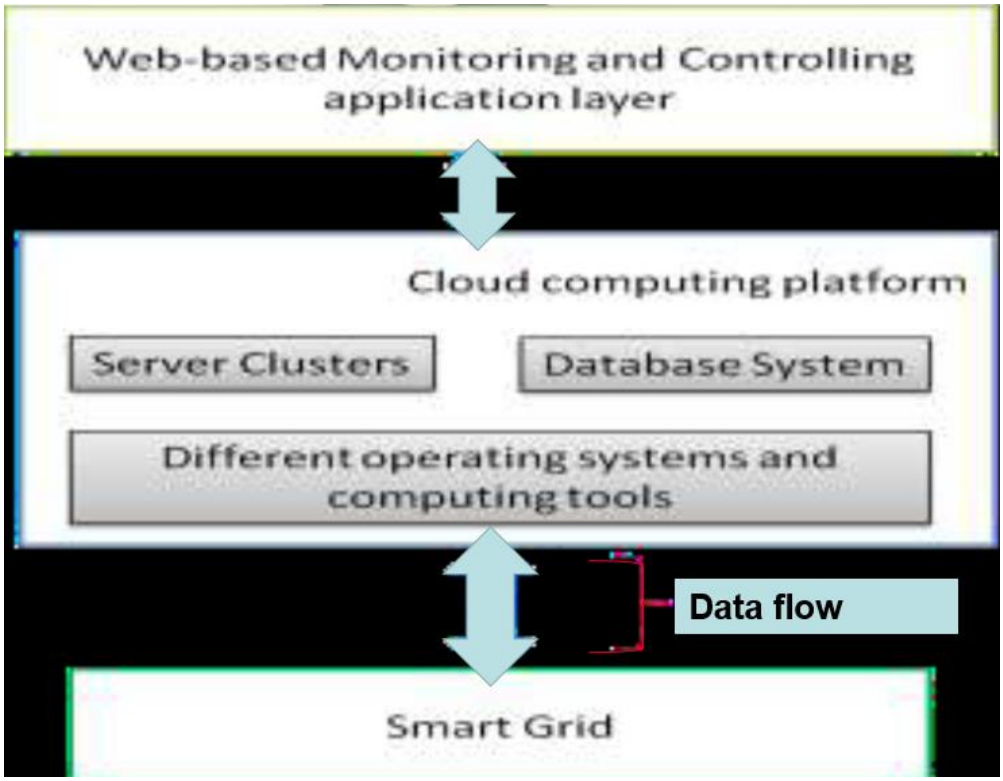


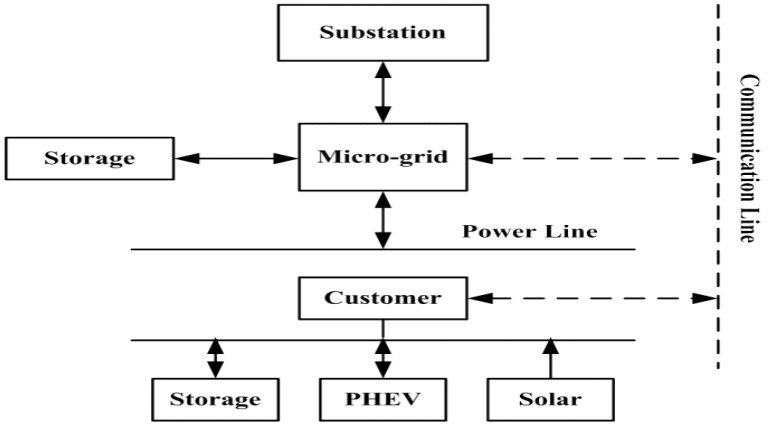
Fig (6): Cloud-based SCADA configuration

7.A SMART GRID WITH AND WITHOUT CLOUD APPLICATION

The cloud applications can be served as virtual energy storage, and data storage devices. In such a scenario, smart grid components communicate with the cloud instead of doing so with one another directly, and taking necessary decisions for energy management. In the conventional smart grid architecture (without cloud), several problems, as detailed below, are addressed by researchers

- The master-slave architecture causes extensive exposure to cyber-attacks such as the distributed denial of- service (DDoS) attack from the compromised nodes in the demand response model. In such master-slave architecture, the utility provider acts as a master and the customers act as slaves.
- Single failure in master-slave architecture is one of the biggest concerns in the existing approaches in which cloud is not used.
- The maximum number of customers that can be served is limited due to the limited server capacity.

- Demand response is performed in a utility's energy management systems (EMS). As limited memory and storage are available, it will be a challenging problem for energy management when the number of customers increases.
- Adequate management and control are necessary, while a micro-grid provides services in islanded mode, as different issues (such as stability and voltage regulation) are to be met by the micro-grid itself.
- In the conventional approaches (without cloud), using sensor nodes and intelligent devices, an early warning system can be integrated with the grid.



(a) A smart grid without cloud application

Fig (7.1)

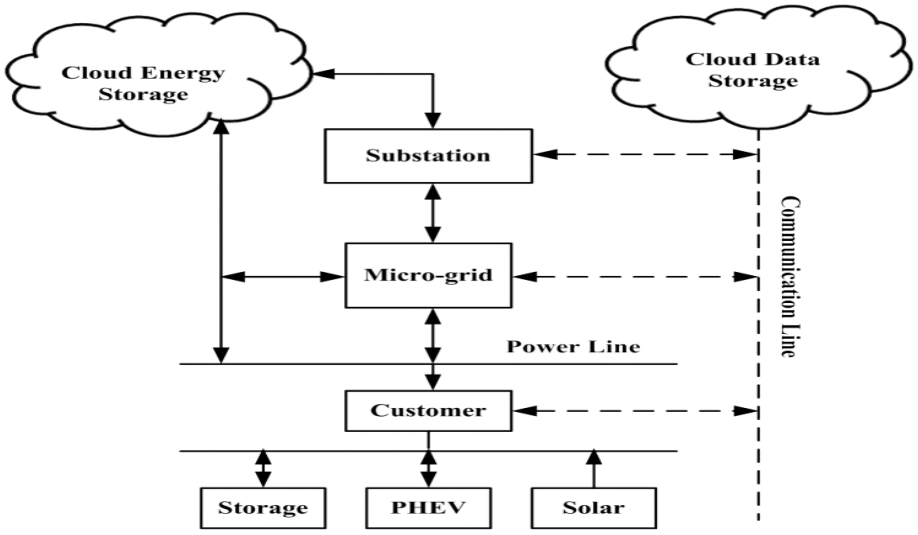
cloud applications to build a software infrastructure to support such dynamic and always-on applications. In these environments, cloud platforms work as intrinsic components due to the diverse benefits they offer, as mentioned below:

1) Cloud acts elastically to avoid costly capital investment by the utility during the peak hours.
2) Real-time energy usage and pricing information can be shared, so that the customers can get benefited from the real-time information.
3) Some data can be shared with a third party by using cloud services, after meeting the data privacy policies for developing intelligent applications to customize consumer needs.

The implementation of specialized data abstraction for data streams generated from the different components is one of the key technologies for real-time monitoring to take decisions at different instances. On the other hand, third-party vendors are allowed to participate in such real-time monitoring system. So, defining an effective privacy-policy is perceived to be a secure mechanism, while allowing the third-party vendors for the real-time monitoring process.

Cloud-based services are used for communication and management schemes in the smart grid by Ji et al, while providing the facility of power monitoring and early-warning system as well. In such a scenario, service-oriented architecture (SOA) and enterprise service bus (ESB) are used for providing the real-time support. In this approach, flexible, efficient, on-demand, and

scalable smart grid power monitoring system can be built. The authors proposed that SOA relies on publishing applications as a service.



(b) A smart grid with cloud application

Fig (13)

8.ADVANTAGES AND DISADVANTAGES OF CLOUD COMPUTING

Advantages

1) Back-up and restore data:

   Once the data is stored in the cloud, it is easier to get back-up and restore that data using the cloud.

2) Improved collaboration

   Cloud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage.

3) Excellent accessibility

   Cloud allows us to quickly and easily access store information anywhere, anytime in the whole world, using an internet connection. An internet cloud infrastructure increases organization productivity and efficiency by ensuring that our data is always accessible.

4) Low maintenance cost

   Cloud computing reduces both hardware and software maintenance costs for organizations.

5) Mobility

Cloud computing allows us to easily access all cloud data via mobile.

6) Services in pay-per-use

Cloud computing offers Application Programming Interfaces (APIs) to the users for access services on the cloud and pays the charges as per the usage of service.

7) Unlimited storage capacity

Cloud offers us a huge amount of storing capacity for storing our important data such as documents, images, audio, video, etc. in one place.

8) Data security

Data security is one of the biggest advantages of cloud computing. Cloud offers many advanced features related to security and ensures that data is securely stored and handled.

Disadvantages

1) Internet connectivity

In cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection. If you do not have good internet connectivity, you cannot access these data. However, we have no any other way to access data from the cloud.

2) Vendor lock-in

Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.

3) Limited control

As we know, cloud infrastructure is completely owned, managed, and monitored by the service provider, so the cloud users have less control over the function and execution of services within a cloud infrastructure.

4) Security

Although cloud service providers implement the best security standards to store important information. But, before adopting cloud technology, you should be aware that you will be sending all your organization's sensitive information to a third party, i.e., a

cloud computing service provider. While sending the data on the cloud, there may be a chance that your organization's information is hacked by Hackers.

9.APPLICATIONS

- Art
- Business
- Data Storage and Backup
- Education
- Entertainment
- Management
- Social

10.CLOUD COMPUTING SERVICE PROVIDERS

Cloud Service providers are vendors which provide Information Technology (IT) as a service over the Internet. Cloud computing is a term which is used for storing and accessing data over the internet. It doesn't store any data on the hard disk of your PC. Cloud companies helps you to access your data from a remote server.

Cloud computing companies' services range from full application development platforms to servers, storage, and virtual desktops. Here is a handpicked cloud service providers list. This cloud provider list contains various types of cloud computing services that are available in the market.

Fig (10): Different types of cloud computing service providers

10. 1 Amazon Web Services (AWS)

Fig (10.1): Amazon Web Services

AWS is Amazon's cloud web hosting platform which offers fast, flexible, reliable and cost-effective solutions. It is one of the top cloud service providers which offers a service in the form of building block which can be used to create and deploy any kind of application in the cloud. It is the most popular as it was the first to enter the cloud computing space.

Features:

- Easy sign-up process
- Fast Deployments
- Allows easy management of add or remove capacity
- Access to effectively limitless capacity
- Centralized Billing and management
- It is one of the cloud companies that offers Hybrid Capabilities and per hour billing

10.2 IBM Cloud

Fig (10.2): IBM cloud service

IBM cloud is a full stack cloud platform which spans public, private and hybrid environments. It is one of the best cloud providers which is built with a robust suite of advanced and AI tools.

Features:

- IBM cloud offers infrastructure as a service (IaaS), software as a service (SaaS) and platform as a service (PaaS)
- IBM Cloud is used to build pioneering which helps you to gain value for your businesses
- It offers high performing cloud communications and services into your IT environment.

10.3 Google Cloud Platform

Fig (10.3): Google cloud platform service

Google Cloud is a set of solution and products which includes GCP & G suite. It is one of the top cloud service providers which helps you to solve all kind of business challenges with ease.

Features:

- It is one of the cloud companies that allows you to scale with open, flexible technology
- Solve issues with accessible AI & data analytics
- Eliminate the need for installing costly servers
- Allows you to transform your business with a full suite of cloud-based services

10.4 Microsoft Azure

Fig (10.4): Microsoft Azure cloud service

Microsoft Azure is a cloud platform which is launched by Microsoft in February 2010. This open source and flexible cloud platform which helps in development, data storage, service management & hosting solutions.

Features:

- Windows Azure offers the most effective solution for your data needs
- Provides scalability, flexibility, and cost-effectiveness
- Offers consistency across clouds with familiar tools and resources
- Allow you to scale your IT resources up and down according to your business needs

10.5 VMware

Fig (10.5): VMware cloud service

VMware is a comprehensive cloud management platform. It helps you to manage a hybrid environment running anything from traditional to container workloads. The tools also allow you to maximize the profits of your organization.

Features:

- Enterprise-ready Hybrid Cloud Management Platform
- Offers Private & Public Clouds

- Comprehensive reporting and analytics which improve the capacity of forecasting & planning
- Offers additional integrations with 3rd parties and custom applications, and tools.
- Provides flexible, Agile services

10.6 Digital Ocean

Digital ocean's droplet is a scalable computer service. It is more than just virtual machines. This cloud platform offers add-on storage, security, and monitoring capabilities to run production applications easily.

Fig (10.6): Digital Ocean cloud service

Features:

- Allows you to deploy your custom image, one-click app, or standard distribution
- You can deploy Droplets and get a reliable connection and flat pricing across 8 data center regions
- Option to select Standard Plans or Performance Plans according to your business needs

11.CONCLUSION

- Thus, cloud computing provides a super-computing power
- This cloud of computers extends beyond a single company or enterprise.
- This applications and data served by the cloud are available to broad group of users, cross-enterprise and cross platform.
- Cloud service, describing scalability and pay-as-you-go demonstrate based service, gives
- a cost-effective and flexible approach to utilize vast scale computing resources. In this paper, the inspiration driving this pattern is talked about and a short presentation of Cloud Computing is given. In the blink of an eye, it gives Load flow, contingency analysis and data format transformation service and it gives clients the capacity to run their analysis anywhere, 24 x 7, by means of the web. Likewise, it ought to be noticed that more and further looks into will be required for better application of cloud computing in power system.

Fig (11): Conclusion

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