A Review on Cloud Computing with Smart Grid

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***Abstract*—In Present scenario the Smart Grid is next generation digitally enhanced power system assimilating concepts of modern communications and control technologies which allows much greater robustness, efficiency and flexibility than today's power systems. In this paper we describe the continuous realization of smart grid in electrical power system, the demand of storage and processor resources becomes increasingly higher which can be achieved through cloud computing. It is an emerging technology that enables rapid delivery of computing resources as a utility in a dynamically scalable, virtualized manner. The Objective of this paper is to improvement in robustness, load balancing and storage capacity is obtained by integrating the electrical power system resources through internal network by cloud computing.**

Key words: Cloud computing, Cloud security, Smart grid

I. INTRODUCTION

The power sector across the world is facing numerous challenges including generation, diversification, demand for reliable and sustainable power supply, energy conservation and reduction in carbon emission. Many countries across the world witnessed the energy deficiency which directly impacted development of the state and environment through greenhouse gas emission (GHG). The reason for such an inefficient and unstable electric system is lack of advancement in electrical transmission and distribution system [1]. Thus a technological revamp is required in the practices involving production, management and consumption of electricity along with new grid infrastructure. The smart grid is a modern electric power grid infrastructure for improved efficiency, reliability and safety, with smooth integration of renewable and alternative energy sources, through automated control and modern communications technologies [2]-[3].

Cloud computing is getting popular which is a model for enabling convenient, on demand network access to a shared pool of configurable computing resources(e.g. networks, servers, storage, applications and services) that can rapidly provisioned and released with minimal management effort or service provider interaction[4]. Currently, power grid at all levels has a certain processor and storage resources, the advantage of the realization of cloud computing is that the existing distribution of computers can be kept and maximum utilization of the physical structure of information networks of current electric power system, allocating calculation and storage resources for the current task is possible. With the help of cloud computing, various control algorithms can be developed to improve robustness and load balancing.

Provider of cloud services such as Google, Microsoft owns large data centre's with massive computational and storage capabilities [5]. The relationship between cloud computing, data centre and smart grid is illustrated in Fig 1.

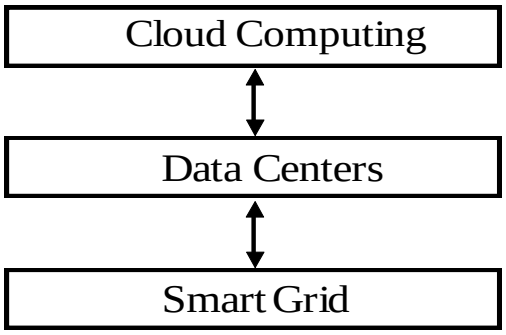

Fig. 1. The interactions between cloud computing systems and smart grid and distributed data centres.

The key constituent of cloud computing is data centre which affects routing and congestion control algorithm [6].It also impact the internet. Secondly, data centre's affected the smart electric grid as it consumes enormous energy and acts as load to the grid.

Grid computing is different from cloud computing as grid computing provides computing resources as a utility that can be used or not. While cloud computing provides on-demand resource provisioning, a step further to grid computing [7].

The paper comprises of five sections. Starting with introduction, next section covers the concept of cloud computing. Similarly, the next section constitutes the implementation of cloud computing in power system followed by need of cloud computing along with security concerns. Last section consists of concluding remarks.

II. CONCEPT OF CLOUD COMPUTING

Cloud computing is an emerging technology. Advances in virtualization, storage and connectivity are combined to create a new environment for cloud computing. Cloud computing has given a new definition to IT industry. In the last few years, cloud computing has grown from fast growing segments in the IT industry. Leading industry sources define cloud computing as a style of computing where massively scalable IT enabled capabilities are delivered as a service to external customers using internet technologies [8]. This leads to industrialization of IT and will alter the way many IT organization deliver the business services that are enabled by IT [9]. By breaking the definition, the first and foremost concept arises of delivering services. Second concept arises of massive scalability. Economies of scale reduce the cost of service. Third, delivery using internet technology implies that specific standard that is pervasive, accessible and visible in global sense are used [10]. Finally these services are provided to multiple external customers leveraging shared resources to increase the economies of scale. There is vast difference between scalability and elasticity. Scalability is an aspect of performance and ability to support customer needs. While elasticity is the ability to support those needs at large or small scale at will [11]. The key issue with scalability is to move in upward or downward direction without disrupting the economics of business model associated with the cloud service. Several flavors are known for the execution of main application available on flexible environment and mainly three systems exist on this which is depicted in the Fig 2.

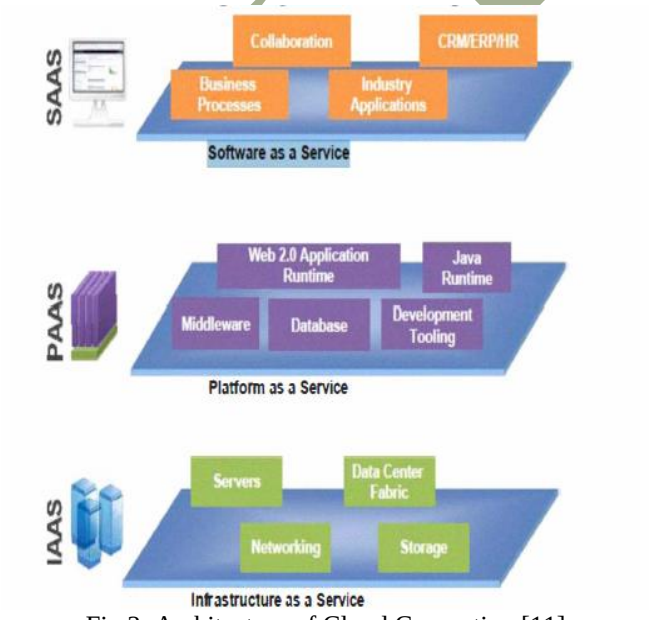

Fig 2. Architecture of Cloud Computing [11]

Infrastructure as a service is a single tenant cloud layer where the cloud computing vendors dedicated resources are shared on the basis of pay per use. Through a client interface such as web browser, various applications are accessible from variant client devices [12]. The advantages associated are that it has a rapid startup along with maintenance and upgrades performed by the vendor. This model incorporate the capability of provision processing, storage networks and other fundamental computing accessories which enable the consumer to examine and run arbitrary software, which consist of operating system and application. The advantages related to this model are that it is scalable with rapid startup sand peak leveling [13]. This model also faces heat from various risks such as Pricing of model, potential lock-in, security and privacy along with proliferation .Examples which defines the above said views are Amazon EC2, Rack space. This model of delivery is called as IaaS. When the software is hosted offsite, the customer does not have to maintain it or support it. On the other hand, it is out of the customer hands when the hosting service decides to change it. The idea is that the use of software out of box as is and do not need to make a lot of changes or require integration to other systems. There are many types of software that lend themselves to this model. This software that performs a simple task without much need to interact with other systems makes them ideal candidate for SaaS. Customers who are not inclined to perform software development but have need of high powered applications can also benefit from SaaS [14]. Some of these applications are Customer resource management, video conferencing, IT service management, Accounting, web analytics, web content management When SaaS is used as a component of another application, this is known as a mash up or a plug-in. There are certain problem which arises during implementation of this service is that an organization that has a very specific computational need might not be able to find the application available through SaaS. Secondly, availability of open source application and cheaper hardware is another problem with this model [15].

CLOUD platform as a service (PaaS) is a model with capability provided to the consumer to avail the cloud infrastructure consumer created or acquired applications created using programming languages and tools supported by the provider [16]. This model provides all the service and application without downloading or installing. The offerings by different vendors include applications such as complete application hosting, development testing and deployment environment as well as extensive integrated services that include scalability, maintenance and versioning. PaaS generally offers some support to help the creation of user interfaces and is normally based on HTML or JavaScript. The advantages related to this model is that it focus on high value not on infrastructure along with leverage economies of scale and provide scalable go to market. PaaS is found on different systems such as Stand-alone environments, add on development facilities and application delivery which only require environments. The hurdle faced by the developers of

this model comprises mainly of higher cost along with the afraid of being locked into a single provider and upgrade issues are very common with this model. Certain examples of this model are force.com, Microsoft Azure, web and e-mail hosting.

III. Implementation of Cloud Computing in Power System

Electric power system involves generation, transmission, distribution and usage of power simultaneously. Secondly, electric power system has a feature that it can't store energy in larger amount [17]. Thus control in the production of the electric power should be real-time, reliable and must comprise of hierarchical management, hierarchical control, and distributed processing [18].

The abovementioned control can be achieved through cloud computing. The cloud computing can divide lengthy calculation into small segments through the intranet. The cloud computing delivers the fragmented information to a system consisting of many servers. These servers, basically, compute and analyze the information and pass it to the end users [19]. So, due to cloud computing, huge information can be handled within a short span of time. The time utilized in this processing is very short which resembles it to the supercomputer's grade service. As distributed computing is finding place in electrical power system which make its operation analogous to internet [20]. The cloud computing platform can be divided in to cloud computing control centre and computing resources integration platform. With cloud computing, electrical power system can make resource allocation as per application and can access to storage resources on demand. The cloud computing enables the running grid nodes or computation on a single computer system. Alternatively, cloud computing avoids to improve the computational ability of the node or computer. It automatically gets enhanced through the clouds at every point in overall system.

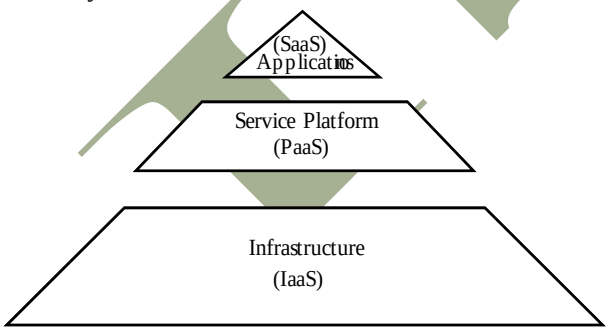

Fig.3 The service architecture model of cloud computing.

Cloud computing is not a single layer service but involves a multi-layer services. The layer which is underlying is called as infrastructure (infrastructure as a service, IaaS) with ability to provide computer or data centre, enabling the execution of arbitrary operating systems and the execution of arbitrary operating systems and software. Next to it is a service platform layer (Platform as a service, PaaS) which consists of infrastructure and the increased custom software stack for a particular application. Upper most layer is the application, (Software as a service, SaaS), a measurement service, a system which implements software on remote computer. The various layers can be depicted in Fig 3.

The cloud computing of electrical power system assimilates all networks with computer application software of inner network of power system to work unitedly with help of cluster application, distributed computer system [21]. It also provides facility for all levels of network of electric power system through software interfaces. Structure of the hierarchical model of the intelligent cloud of power system can be depicted in Fig 4.

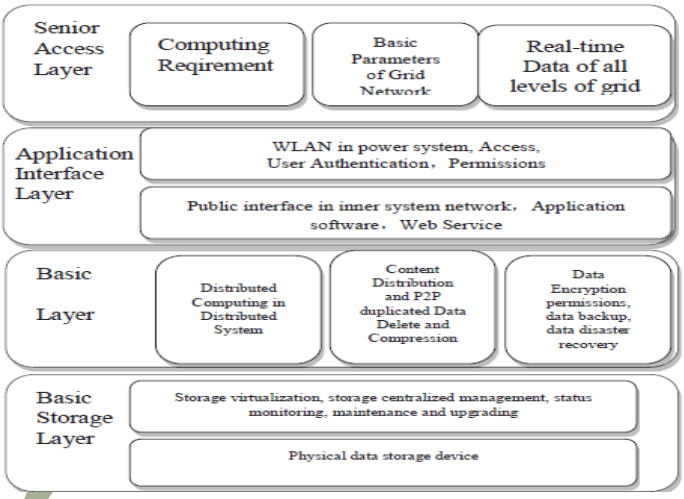

Fig 4 Structural and hierarchical model of intelligent cloud of power system [20].

Basic storage layer is the basis of storage in power system cloud computing .The storage devices are distributed in different geographical locations which are interconnected together by the inner network of the electric power system. Secondly, basic management layer can realize the co-operation of all the devices in the cloud computing, providing strong support.

On the other hand, the most flexible part of cloud computing is application interface which provides different interfaces and services to electric network as per the demand [22].

IV. Need of Cloud Computing in Smart Grid

Various applications require the need of cloud computing in electric power system. The cloud computing helps the system to recover the power system in blackout condition. Secondly, monitoring and scheduling of the power system can be performed with the help of cloud computing. It also enables to have reliability evaluation of the power system. Recovery of power system after blackout proves to be a complicated nonlinear optimization problem. Power restoration process promotes the information sharing and cooperation between different participants [23]. This can be achieved through

distributed computing which also increase calculation efficiency. With the shared computing platforms better sharing and cooperation between information helps to find the optimal complex interconnected recovery plan as shown in Fig 5 as below:

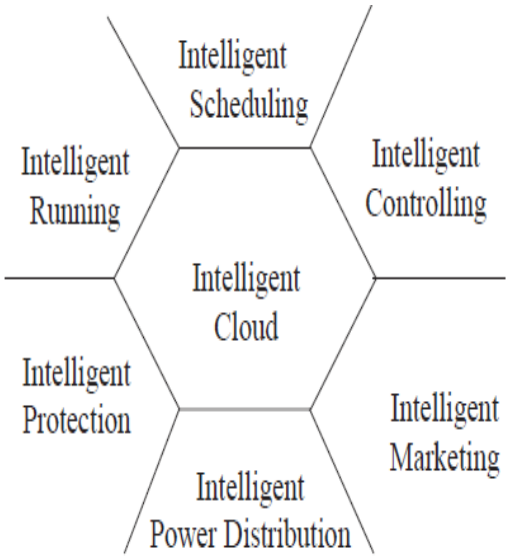

Fig 5 Functions of cloud computing in Power system

Monitoring and scheduling is another application prospect of cloud computing in the power system. Through the unified power system cloud computing platform can promote the distributed control centre of information sharing and collaboration. As the number of the distributed power can be very large system scheduling and operation needs to be maintained. Cloud computing strong scalability helps at any time according to the size of the power system dynamic increase computing power. Using cloud computing information processing power distribution system can help to realize real-time monitoring and information collection.

Using cloud computing, a further improvement in the reliability analysis can be observed. It also provides the unified approach in future power system computing platforms [24].

V.CLOUD SECURITY

Cloud computing belongs to SaaS in cloud computing architecture. With smart grid, heightened security threats must be overcome in order to benefit fully from cloud computing. This new developing computing paradigm faces several security concerns .With the cloud model physical security is lost and storage services provided by one cloud vendor may be incompatible with another vendor services which creates a threat to the system. Another security concern is the ensuring of integrity of the data (transfer, storage and retrieval) [25].

As the information security is changing drastically thus cloud security technologies is adopting these new developments. This protection provides communication with external servers. This communication can provide feedback from online-detection database, reputation systems, black and white lists, managed services. This rapid feedback can give security software the necessary edge it needs to fight threats.

VI. CONCLUSIONS

This paper has reviewed the state of art in Smart grid to provide a clear perspective on various aspects to the researches and engineers working in this area. Cloud computing have emerged as a computing infrastructure that enables rapid delivery of computing resources. Through integration of heterogeneous distributed computing resources, cloud computing platform have powerful computing and storage capacity. Cloud computing provides a new way to achieve power system, online operation analysis and optimal control.

Cloud computing in power system analysis includes various aspects such as power flow calculation, the system restore monitoring, scheduling, reliability analysis. As cloud computing is still growing with smart grid, so future research work needs to focus on its core.

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