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Cloud Computing in Chemical Industry

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ABSTRACT: *Cloud computing is an emerging computing paradigm for delivering computing services over the Internet. Most chemicals companies still are at an early stage in their adoption and usage of cloud computing. Their migration to cloud computing is not a question of "if", but "when." Monitoring assets in remote locations, round-the-clock surveillance, and remote access to data are some of the key factors that are prompting the chemical industry to rethink about the adoption of cloud technology. This paper provides the benefits and challenges of adopting cloud computing in chemical industry.*

KEY WORDS: *cloud computing, chemical industry*

I. INTRODUCTION

The term "cloud" has been used as a metaphor for a network-accessible infrastructure (e.g., CPU, data storage, computing hardware, networks, services, and applications) which is hidden from users. Cloud computing has emerged as a new paradigm for hosting and delivering services over the Internet. It has transitioned from being just a niche IT scheme into a core strategy of businesses. It relies on a number of existing technologies such as the Internet, virtualization, grid computing, Web services, etc. The main objective of cloud computing is to make a better use of distributed resources and solve large scale computation problems. Cloud providers are big companies operating on a massive scale with utility-like characteristics. Common cloud computing providers include Amazon Web Services (AWS), Microsoft Windows Azure, and Google App Engine. The chemical industry is regarded as one of the biggest sectors. All segments of the chemical industry—including basic and intermediate chemicals, polymers, fibers and elastomers, agricultural chemicals, paints and coatings, industrial gases, and others--are well-positioned to leverage significant advantages from emerging technologies, such as industrial Internet of things and cloud computing. To simplify operations, chemical companies are in need of integrating innovative cloud platforms to connect their workforce with operational data.

II. BASICS OF CLOUD COMPUTING

The cloud computing architecture consists of a massive network of interconnected servers, often with a user-friendly front-end interface, which allows users to select services. The cloud model is composed of some essential characteristics, service models, and deployment models.

Characteristics: The National Institute of Standards and Technology (NIST) defines general characteristics of cloud computing [1]:

- *Automated self-service set up*: Users can run and configure their own computing resources without human help.
- *Broad network accessibility*: Computing resources are available through the Internet on various devices.
- *Pool resources*: Users do not have their own dedicated hardware. Multiple users can employ the same hardware and resources.
- *Scalability*: This refers to the ability of a system to perform well under different load sizes. User can easily expand the amount of power available to them. Applications that run within the cloud can be configured to scale automatically. Cloud computing is adoptable for all sizes of businesses.
- *Metered services*: Use of cloud resources is monitored and users are charged for the amount of resources they use. The user pays only for the storage or bandwidth consumed, and not for potential bandwidth.
- *Rapid elasticity*: A user can gain resources from the cloud and rapidly discharge those resources when they are no longer needed.

Service Models: Figure 1 shows the cloud computing architecture [2]. Cloud computing provides different services, not just a single product. The services provided by cloud computing can be divided into three categories:

- *Infrastructure-as-a-Service* (IaaS): This is the simplest of cloud computing offerings. It involves the delivery of huge computing resources such as the capacity of storage, processing, and network. It is the ability to remotely access computing resources. The major advantages of IaaS are pay per use, security, and reliability. IaaS is also known as Hardware-as-a-Service (HaaS).
- *Platform-as-a-Service* (PaaS): This supports a set of application programs interface to cloud applications. It is a delivery of a computing platform over the web, which enables user to create applications quickly. It has emerged due to the suboptimal nature of IaaS for cloud computing and the development of web applications. Many big companies seek to dominate the platform of cloud computing, as Microsoft dominated personal computer (PC).
- *Software-as-a-Service* (SaaS): This provides a service that is directly consumable by the end-user. It is a software deployed over the Internet. This is a pay-as-you-go service. It seeks to replace the applications running on PC. SaaS is the most widely used cloud service model, with more than 92% of employees using SaaS across multiple functions of the chemical industry.

These service models are useful in categorizing not only cloud computing, but specific vendor offerings, products, and services.

Deployment: There are basically two types of clouds: private or public. Private clouds are built within a company's data center, while public clouds extend the data center's capabilities by enabling the provision of IT services from third-party providers over a network. Private cloud is owned, managed, and operated by a single organization. Public cloud infrastructure may be owned, managed, and operated by a business, academic, or government but it is open to the general public. Choosing between private and public clouds is dictated by a trade-off between security and flexibility. These two basic types as well as the hybrid type are illustrated in Figure 2.

III. BENEFITS

While cloud computing has yet to fully penetrate the chemicals industry, other sectors, such as retail and healthcare, have enthusiastically embraced the emerging technology. The chemical industry needs the cloud for the following reasons [3]: (1) Mobile workforce: empowering employees to sift real time data and make decisions on the fly, (2) Minimize disruptions: with the right sort of cloud setup problems can be anticipated and solved quickly, (3) Collaboration: with the right technology, collaboration – as well as transparency and accountability – are easily managed, (4) Innovation: product innovation and process innovation are powerful weapons to survive or thrive in such an environment, (5) Lower cost: No hardware procurement, maintenance, or staff is needed to maintain the systems. Cloud computing services are offered on a pay-as-you-go basis.

The three top benefits of cloud computing most commonly talked about today are low cost, flexible resources, and speed to market. The cloud computing brings agility, speed, instant availability of resources, and tools that enable collaboration and innovation to the chemical sector. Another benefit is that users no longer require to install and host applications since this will be taken care of the by the cloud services. Cloud implementations are rewarding companies with lower costs and increased speed and efficiency. It helps them adapt to the new changes and position them to better meet market demands and grow their businesses.

IV. APPLICATIONS

The research in theoretical chemistry such as Quantum Chemistry, Molecular Modeling, Molecular Dynamics, Theoretical Chemical Kinetics and Cherninformatics, requires extensive computational cost which has been considerably reduced because of cloud computing [4]. Cloud computing is an emerging technology to the scientific community and is used in variety of disciplines. It is used in education, large enterprises, small and medium businesses, manufacturing, industrial automation, life sciences, pharmacy, and medicine. The percentages of cloud usage in different industrial sectors and services are shown in Figure 3 [5].

- *Manufacturing*: Manufacturing is the production of products using raw materials, labors, machines, and tools. Major production facilities of chemical companies run 24/7. Chemical manufacturing facilities mainly involves three phases: design, implementation, and testing. New manufacturing concepts cannot rely

on the lowest manufacturing costs but must take into account also supply chain and operational excellence. The cloud computing has many benefit to apply their technique to the manufacturing system such as efficiency, flexibility, control, and management for the system [6].

- *Pharmaceutical companies*: These companies find cloud computing to be very attractive since it offers them the promise of efficient and cost-effective data analysis and processing as well as multi-layered security. Another factor in favor of cloud computing is its low cost, pay-as-you-grow business model [7]. Early adopters of cloud computing such as Pfizer, Johnson & Johnson, and Eli Lily all used Amazon Web Services (AWS) and Amazon EC2. They were able to perform R&D using the cloud, and process proteomics, bioinformatics, and statistics [8].
- *Oil & Gas*: Cloud computing can be beneficial to the oil and gas industries in many ways: easy viewing of geological survey data of the entire oil field, tracking any fluctuations in the data and auto-correcting them, expand the business to a larger scale, and choose the best available and appropriate technology that will be useful for the explorers. The oil and gas companies around the globe are embracing the benefits provided by the private clouds since they are too great and numerous to ignore [9].
- *Industrial Automation:* Process automation plants can adopt cloud computing to solve business challenges and utilize the rapid spread of Internet-based service models. Applications are suitable with cloud computing technology for industrial automation include condition based maintenance, predictive maintenance, and asset management [10].

V. CHALLENGES

Security and data privacy are prime concerns for cloud implementers in all industry sectors. Leaders fear that their data is "in the cloud and are concerned that their data could be stolen or compromised by hackers. For most chemical companies, the major security concern is usually around their R&D and the intellectual property that it creates [11]. Security concerns may keep those sensitive applications in-house. It has been predicted that competitive success will belong to organizations that are able to cope with rapid external and internal changes in the future trend.

Today's economy trend is compelling chemical industry to address the complex issues in pursuit of higher return-on-investment (ROI). However, finding the perfect cloud computing solutions as well as configuring them can be a daunting task for businesses in the chemical industry. Companies need to prepare for the change by restructuring existing datasets. Before adopting cloud computing, they must take into account the fact that most services offered by cloud providers today are managed and provisioned on a cross-border rather than in-country basis. The issue of "ownership" is critical.

In addition, challenges such as ongoing globalization of manufacturing and research and development (R&D) and industry consolidation are demanding new approaches to operating models of chemical industry. These challenges will require chemical companies to change their operating and business models [12]. Challenges such as ongoing globalization of manufacturing and research are demanding new approaches. Data security in chemical operations has legal, regulatory, and competitive implications, so it must be robust, comprehensive, and reliable. Thus, legal issues are a major concern of cloud computing.

VI. CONCLUSION

Cloud computing provides shared computer resources and data to users through the Internet. It helps companies improve their IT capabilities without investing large amounts in data centers. It is a means of pooling and sharing hardware and software resources on a massive scale. Chemical companies that aspire to be leaders and winners must adopt cloud computing to reimagine their businesses. Companies that fail to embrace cloud computing are likely to miss out on an exciting opportunity for growth in a rapidly changing industry [13]. Even chemical education is moving to the cloud.

This allows every student to have access to all of the resources necessary for the class [14]. It is still too early to predict how cloud computing will change the operation of chemical industry. With time, most of the software applications will be modeled according to cloud computing. Mobile cloud computing is quickly gaining popularity among mobile device users as it is able to offer cloud computing capabilities in a mobile environment. A massive uptake of cloud computing in the developing world is likely to be through mobile devices.

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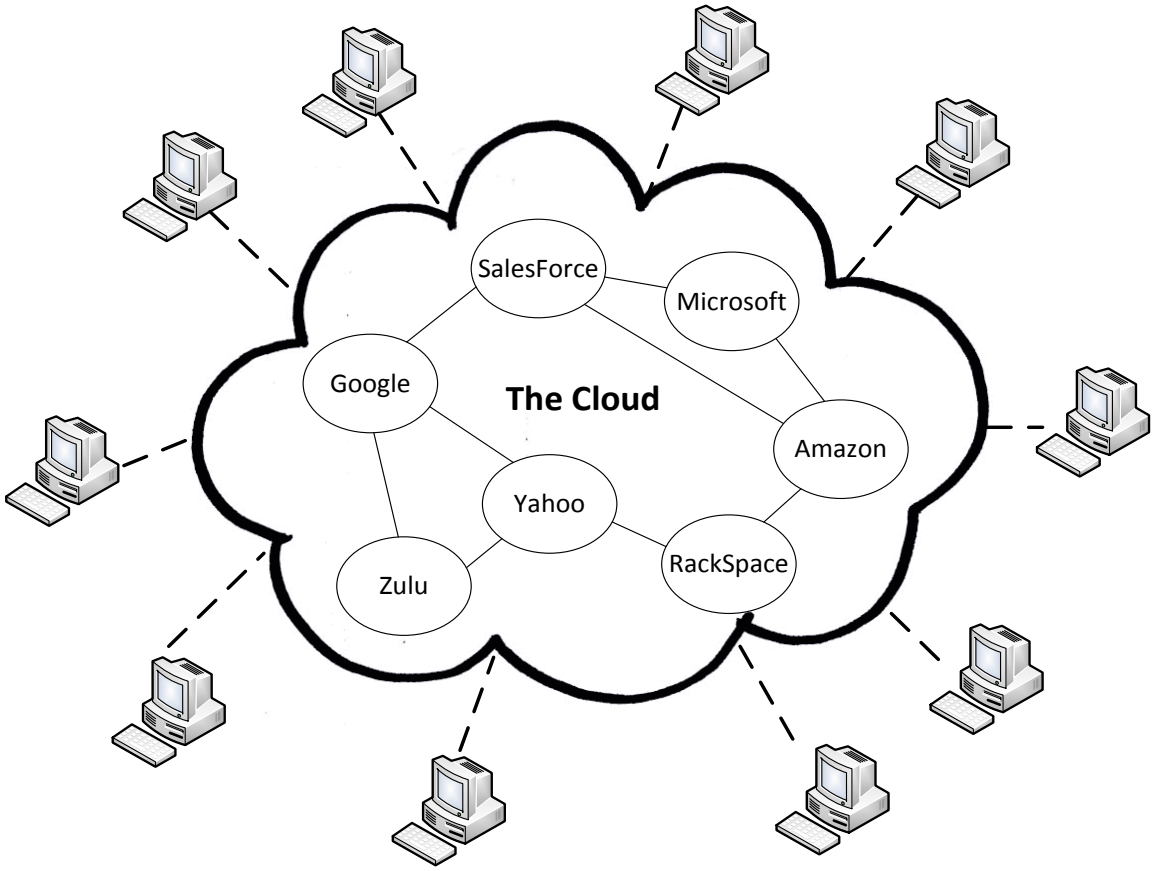

Figure 1. Cloud computing [2].

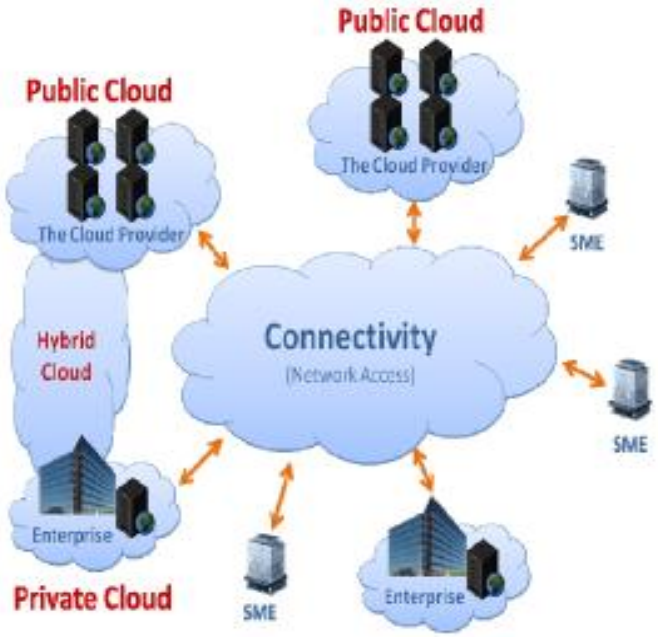

Figure 2. Cloud deployment model types.

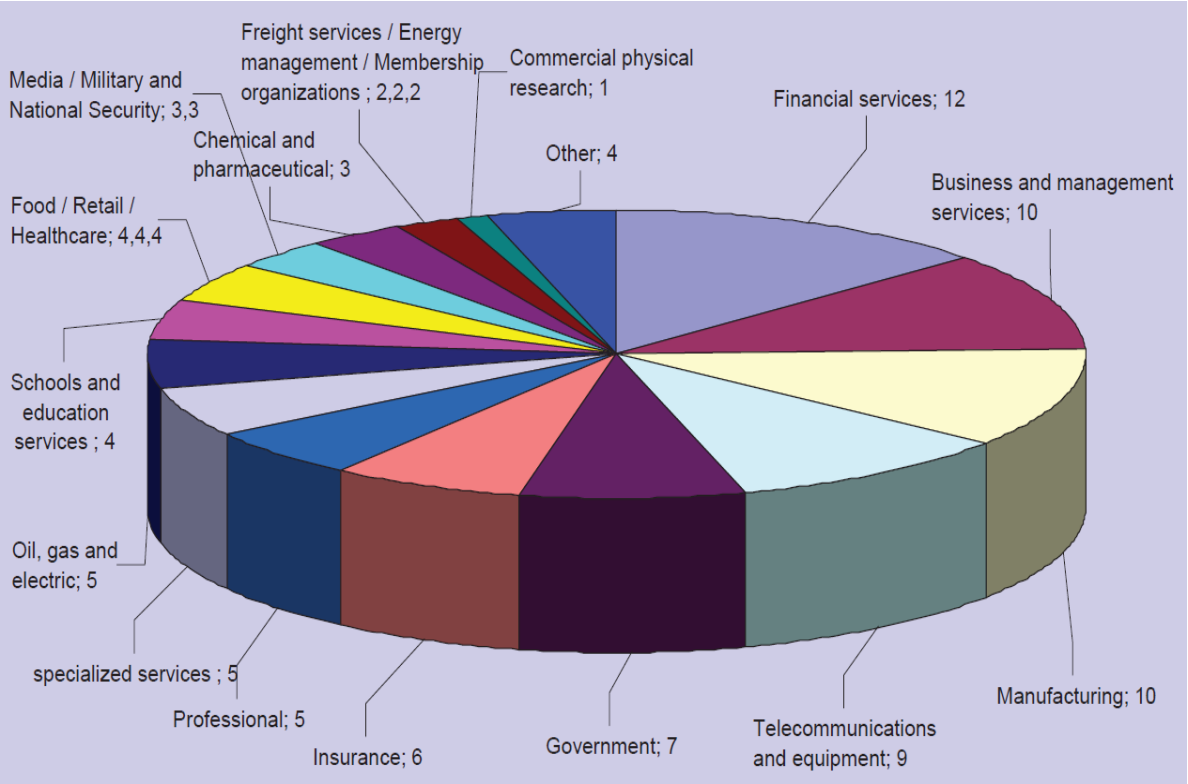

Figure 3. Percentages for cloud usage in different Industrial Sectors and Services [5].