Cloud Computing for Industry 4.0

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Abstract*: The cloud computing paradigm is a never-ending topic of research providing its users with state-of-the-art technological benefits. Its rapid adoption by various companies has paved the way for the Industry 4.0 model. In this paper, we try to consolidate our research on cloud computing to be a part of Industry 4.0. The 4th industrial revolution, after the steam engine, electric power, and electronics being the marker of the first, second, and third revolution, respectively, is referred to as Industry 4.0. Industry 4.0 has a great potential to change the manufacturing sector drastically, and the way factories work by automating the different processes. It transforms the conventional pyramid model to a more rigid and efficient network model of interconnected services, which makes it possible for operational technologies and information technologies to come under a single umbrella and work together with higher utilization of various resources. These interconnected services produce a huge data, which makes its storage and efficient analysis very crucial. Therefore, cloud computing, along with big data become the two most important pillars in the Industry 4.0 model. In this paper, we focus on the cloud computing aspect of the Industry 4.0 model. That is, how we can use the various new advances which are happening in cloud computing and how these new technological advances can be incorporated into the Industry 4.0 model as well as the need, benefits, and difficulties of applying cloud computing technology in Industry 4.0.

Keywords: Cloud Computing, Industry 4.0, XaaS.

I. INTRODUCTION

Cloud computing is now a ubiquitous term used for deploying scalable and highly available web applications for users at a reasonable rate. The National Institute of Standards and Technology(NIST) defines Cloud computing as 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 be rapidly provisioned and released with minimal management effort or service provider interaction.[1]

II. MOVING TO THE CLOUD

A. Factors to be considered before moving to the cloud.

1. Requirements: It is necessary to calculate available resources and further requirements. [2]
2. Disaster Recovery: It should be confirmed with the cloud provider about recovery in case of environmental disasters.
3. Data Location: The location of the data center impacts the speed of data retrieval.
4. Software Licensing and Support: SLAs should be evaluated; budget planning and legal issues are necessary to discuss.[3]
5. Scalability and Automation: We should look for providers who allow scaling in the future without charging now.
6. Training Staff for the Model: Training of staff is must, it's costing should be considered
7. Security: It includes the security of data on cloud from unauthorized access. Analyzing risk and preparing Exit Strategy: Vendor's terms and conditions, features, pricing, usage detection should be appropriately documented.
8. Cloud Adoption can be of two types:
   a. Off-Premises: Hardware and software setup for data-center is done at the provider's premises, and is accessible via the internet.
   b. On-Premises: Hardware and software setup for data-center is done at the client's premises, and is accessible via the intranet, using cables.

B. Important advantages of using a cloud-based structure:

- Data dissemination: Cloud-based storage can offer a great way to store and share data amongst staff.
- Burst capability: Any device which is transmitting data continuously, without going through all the individual steps required to transmit the same data if the transaction were separated individually, then that device is known to be working in burst mode, sometimes also known as burst mode capability. It's a general electronics term. It's used to significantly increase the throughput.
- Super-Scalability: Clouds are designed such that the storage and queues highly scalable. The capability of the cloud to change the quantity of working instances progressively enables to accelerate parallel tasks by increasing hardware resources as per requirement.
- Elasticity: We can dynamically scale resources, thereby paying for what we need.
- Application development and deployment, Machine learning model training. [4]

III. CLOUD SERVICE MODELS

A. Main paradigms of cloud computing

- **Infrastructure as a Service (IaaS):** Cloud issuer provides the foundation and each of its vital services, which can be retrieved and managed by the customer without any restriction [5].

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- **Platform as a Service (PaaS):** PaaS is on a better degree of abstraction; the provider offers to the company an "all-inclusive" platform in which the patron can broaden its packages easily and rapidly, without worrying about the technical implications related to the underlying infrastructure
- **Software as a Service (SaaS):** The first solution came in 1999 via Salesforce.Com. SaaS may be a software distribution version wherein the corporate hosts programs and make them available to customers via the web. It represents the very best degree of abstraction of Cloud Computing [5].

B. XaaS

Anything-as-a-service, or XaaS, refers to all the new terminology for all the various services growing today, which are available via the internet, not locally (on-premise) [6]. Like software-as-a-service (SaaS), infrastructure-as-a-service (IaaS) and platform-as-a-service (PaaS), storage-as-a-service, desktop-as-a-service (DaaS), disaster recovery-as-a-service (DRaaS), network-as-a-service (NaaS), etc. Furthermore, healthcare-as-a-service and marketing-as-a-service belong to XaaS. Figure 1, shows examples of few services offered under XaaS.

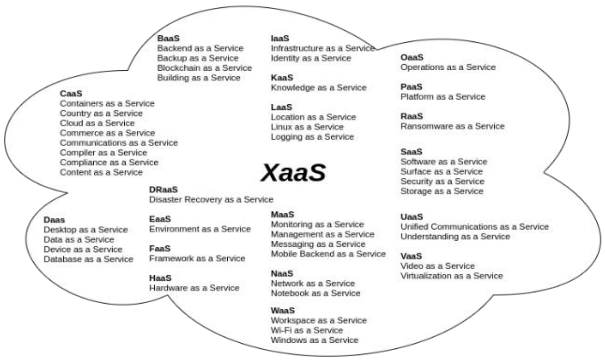

Figure 1: XaaS.

IV. MORE ON CLOUD DEVELOPMENT

Cloud infrastructure can be deployed in 4 ways: Private, Community, Public, and Hybrid. As the name suggests, a private cloud can be used by one organization. Community cloud targets a group of consumers, and Public cloud is meant for open use. Most companies adopt a Hybrid deployment of cloud to support their needs [1].

Mobile Cloud Computing has made it easier to process data remotely, giving rise to cloudlets. Seamless live migration, turnkey databases, continuous integration with pay-as-you-go, etc. are some of the ways industries are enhancing their functions.

V. CLOUD COMPUTING IN INDUSTRY 4.0

According to Constellation Research's 2018 survey, 56% of respondents are developing applications in-house by establishing out data science teams and using frameworks which are open-sourced, 52% are developing applications using cloud-based machine learning and deep learning services, and about 42% picked applications bundled with AI capabilities. Those choices are not mutually exclusive: 20% use a mixture of three modes, and 26% use a combination of two modes [7]. Therefore, this shows that more and more micro, small, medium, and large enterprises are going to the cloud services, which indicates that Industry 4,0 is the new revolution that will significantly enhance production processes. DIT (Department of Information Technology) Manipur became the first state government IT department in India to move its services to the cloud and unlocked significant reductions in capital and operating expenses with substantial time savings. Therefore, there's an enormous scope of using Industry 4.0 techniques in government sectors also [8].

VI. INDUSTRY 4.0

Industry 4.0 is a vision of smart industries/factories built with intelligent cyber-physical systems. Industry 4.0 encourages processes related to manufacturing to use Information and Communication Technologies (ICT), which helps in obtaining products that are customized to satisfy the demands of new and existing customers. It transforms the conventional model of automation into a network model in which different services are interconnected, which combines operational technologies (OT) and information technologies (IT).[9]

In today's world, smaller and affordable electronics with enhanced performance and higher capacity at reduced prices. These help in easy, affordable, and fast incorporation of sensors and other electronically advanced parts in machines, which in turn helps in the production process, products, and business cycle. [10]

Industries have started using the new ICT-enabled production methods, and currently, two famous architectures are present [11]. As an example, the project *Plattform Industri 4.0* published the Reference Architecture Management Industrial 4.0 (RAMI 4.0) in Germany. This project aimed at developing and implementing Industry 4.0 as a scheme promoted by the Federal Government of Germany. The projects in the USA, China, Japan, and France, among other countries, are also associated with this initiative [12]. These changes will help in the growth of the economy, increasing employment, and creating ecosystems that integrate suppliers and customers [13][14].

A. Technology Enablers

The "hyper-connectivity" of a large number of systems that enable the successful completion of any production process generates a lot of data in real-time from a considerable amount of sources and that too in different encoding formats that need to be analyzed and stored using various advanced technologies and algorithms[15]. Cloud Computing allows data warehousing. It makes it possible to store a large amount of data which is produced by various living/non-living players during the whole production process because machines and advanced sensors used generates more data compared to people.[16]

B. Industry 4.0 Reference Architectures

In the entire world, there are various efforts ongoing to implement Industry 4.0 at the practical level. To support this: most prominently, there presently exists two popular reference architectures, namely The Industrial Internet Reference Architecture (IIRA), and the Reference Architecture Model for Industry 4.0 (RAMI 4.0). RAMI 4.0 is used mostly by European countries for their manufacturing and financial development programs. On the other hand, IIRA is predominant because it was originated in the United States of America. Additionally, China also has a model for its "Made in China 2015" program.[9]

- **IIRA**

One of the standards-based open architecture available to Industrial Internet of Things (IIoT) systems at present, is the Industrial Internet Reference Architecture (IIRA), which is multidisciplinary and, is explained as a system, i.e., without describing every ins and outs, which radically increases the interaction of industrial sectors, i.e. healthcare, energy, manufacturing, transportation and public domain[17].

- **RAMI 4.0**

The RAMI 4.0 architecture is a three-dimensional model that shows that a production object must be tracked across its entire lifecycle and thus mapped consistently from end to end on the IT side from components and machines through to networked production plants.[18]

VII. CLOUD COMPUTING SECURITY

Migration to the cloud seems to be very advantageous, but there are specific security issues, a few of which are listed below.

1. **Network Security:** Transfer Security, Firewalling, Security configuration
2. **Interfaces:** API, User interface, Authentication
3. **Data security:** Cryptography, Redundancy, Disposal
4. **Virtualization:** Isolation, Hypervisor vulnerabilities, Data leakage, VM identification, Cross-VM attacks
5. **Governance:** Data control, Security control, Lock-in
6. **Compliance:** Service Level Agreements (SLA), Loss of service, Audit, Service conformity
7. **Legal issues:** Location of data, E-discovery, Legislation, Provider privilege [19]

VIII. RESULT

As per the study, the data is increasing day by day which makes its storage and efficient analysis very crucial. Therefore, cloud computing, along with big data become the two most important pillars in the Industry 4.0 model. Cloud as a Service (XaaS) and the security aspects of cloud computing are also very important key concepts to make complete and safe use of Cloud computing in the present industry (i.e. Industry 4.0). XaaS presents the diversity of applications and services that can be offered by the cloud infrastructure.

IX. CONCLUSION

In this paper, we explained in brief about the growing usage of cloud computing and its importance in Industry 4.0. Cloud as a Service (XaaS), Industry 4.0, and the security aspects of cloud computing is touched in this paper.The diversity of cloud computing applications produce an opportunity to change the way industries respond to the needs of the society. There is a necessity of cloud computing in Industry 4.0, as from small to big industries can use cloud computing for storage, flexible hardware, and system requirements, ar per their needs. So, the presence of cloud computing in Industry 4.0 is of high significance.

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AUTHORS PROFILE

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