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Review Article

Roadmap for Access and Adaptation of Cloud Computing in Bangladesh

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Abstract *- In the field of information technology (IT), a new popular method is introduced by cloud computing in the present digital world, which no one can escape. Cloud computing offers more advantages to infrastructures, is cost-effective, and gives liabilities to an organization from third-party providers. It has become an integral part of technology and business models and has evoked interest in the organization to adopt new technology strategies. In order to give a general overview of how to use cloud computing successfully, this paper discusses its foundations, commercial achievements, and how they interact. The fundamentals of cloud computing section includes the definition of cloud computing, several levels of architecture, cloud types, and the advantages and drawbacks of the cloud. The commercial achievements section includes the management of business operations and their activities. How cloud infrastructure is connected with corporate innovations and how cloud computing is accessible to enterprises are also described. The final theme of this study is finding an efficient approach to access and utilize cloud computing in a developing country like Bangladesh. This will also guarantee that any data kept in the cloud is protected, readily available, affordable and more beneficial for the entire organization as well.*

Keywords *- Cloud Computing, Information Technology, Networking, Resource Management.*

1. Introduction

The term "cloud" is widely used, represented by software applications, networking, storage, management tools and cloud computing that facilitate a new wave of information technology and consumer services delivered based on the internet. These services are delivered quickly and reasonably priced without compromising performance and security. In the system diagrams, an abstract representation of the intricate cloud computing architecture is provided by a cloud-shaped symbol. Cloud technologies provide remote services to access vast amounts of data, software, and computation [1].

A significant group of virtualized resources that are easily accessible and usable through an internet browser is referred to as the "cloud". These adaptive resources enable dynamic reconfiguration for the best possible resource depletion. In a payment-based paradigm, this resource pool is often used, and the infrastructure provider offers assurances through customized service-level agreements [2].

According to the National Institute of Standards and Technology (NIST) of the United States (US), "cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (such as applications, networks, servers, storage, and services) that can be rapidly provisioned and released with little management effort or service provider interaction". So, Enterprises are relieved of managing database administration since cloud-based computing uses remote servers housed in exceptionally secure data centers for data storage and management [3]

There are eight sections in this paper. Introductions to cloud computing and associated services are provided in Section 1. Section two provided information about the historical background of cloud computing. The third section gives an overview of cloud computing and details the different types of cloud computing models and their architecture layers. The benefits of the cloud are covered in part four. In section five, challenges in cloud computing's problems are discussed. Information regarding Bangladesh's existing cloud computing infrastructure is provided in section six. In section 7, suggestions and recommendations are included based on a few reviews. The summary of the key findings appears in the last conclusion section.

2. Historical Background

In the 1960s, the concept of centralized computing services, which make use of a mainframe time-sharing technology network, was first introduced. The idea of computers as a public utility with a centralized computing facility where many remote users connect through a network, is described in "The Challenge of the Computer Utility" book in 1966[4].

There are distinct categories and concepts of cloud computing, including public cloud, private cloud, hybrid cloud and community cloud. The existing features and architecture of cloud computing have both been explained. Finally, a cloud computing infrastructure was implemented and demonstrated the characteristics that make it different from how cloud computing is currently processed [5].

Cloud computing is used for educational systems and public cloud security issues and additionally, suggested a few themes for constructing an educational cloud computing system, including the system's operational principles, the significance of its development and evolution, and the implications for education. Finally, a guideline for establishing cloud computing for education systems is presented [6].

Research was done on cloud computing systems for Geographical Information Systems (GIS), and a detailed analysis of the cloud computing strategy for GIS was carried out. Finally, a multi-tiered architecture for the GIS Cloud System was suggested, with the GIS cloud web interface and GIS server serving as the two main components. The GIS server is divided into five sub-layers in order to optimize the efficiency of resource sharing, databases, configuration, server-side utilities, communication interfaces, and high-powered processing [8].

Noticed that the existing framework for e-government is unable to map all user requirements. A new, effective cloud computing-based e-government framework that is more intelligent and capable of meeting all user requirements has been recommended [10].

The study focused on cloud service providers and software as a service (SaaS). Characterized the cloud as a combination of software and hardware found in data centers. Additionally, provides a definition of a public cloud that has been set up and offers pay-as-you-go utility computing services to the general public. The rapid expected growth of the cloud computing industry is something that developers should take into consideration while designing and developing applications. Three additional points: that application software should be saleable up and down; the infrastructure software and hardware should be updated; the idle memory, disk, and network resources should be switched to low power mode. The memory hierarchy should include flash memory, and the processors should work nicely with Virtual Machines (VMs), and the bandwidth and operating costs of the Wide Area Network (WAN) routers and Local Area Network (LAN) switches should have improved [13].

At first gave the definition of cloud computing. Three observations about hardware-related, incorporating the idea of limitless computing resources that are accessible whenever needed, the elimination of an upfront commitment for cloud users, and the option to pay for the usage of resources only when necessary. Outlined the economics of cloud computing and provided evidence of its benefits over traditional data centers. Discover the top ten problems and advantages facing the growth of cloud computing [16].

Emphasizes cloud computing as a result of the relocation of software systems to distant servers that are manageable from a distance. Demonstrations were given regarding the evolution of cloud computing and its future prospects, along with a few examples that served as directions. The website that first drew attention to cloud computing was WordStar, which made cloud computing popular. Mentioned about Google Docks for a WordStar program that had previously been developed [14].

The benefits and advantages of cloud computing for web applications have been described. Provided comments on a range of difficulties online applications face while using cloud computing, including affordability, usability, adaptability, teamwork, privacy, flexibility and security. Besides, it covered how power loss happened inside computer components and how power loss could be minimized by delivering high voltage Direct Current (DC) electricity throughout the data center [9].

Utilizing cloud computing with a marketing focus, a mathematical model was put into practice. The mathematical model was also used to create an algorithm. The proposed system has been put to the test by setting up a private cloud, and the results show that the proposed objective function increases gradually with increasing stochastic demand and provides more optimized value when the demand is within a moderate and maximum range; nevertheless, optimal performance was not found when the demand was at its highest [12].

Presented and built an environmentally friendly cloud computing solution using an algorithmic technique. It focuses on green cloud computing, where the green cloud was empathized by how much energy cloud computing techniques consume—recommendations for upcoming future initiatives and the appropriate security management system for cloud computing techniques [11].

The study used remote and wide-area network resource access to evaluate the effectiveness of cloud computing systems operation in a virtual environment. According to the study's findings, systems operation in a virtual environment with short job runtime for workflows had great computation time scales, albeit wide-area connections and resource scheduling delays can have an effect [7].

3. Cloud Computing

The main components of cloud computing are architecture, model type, and services, which cover the full processing stack of a system.

3.1. Architecture

The cloud computing architectural paradigm can be characterized by the four-layer pyramid structure shown in Figure 1.

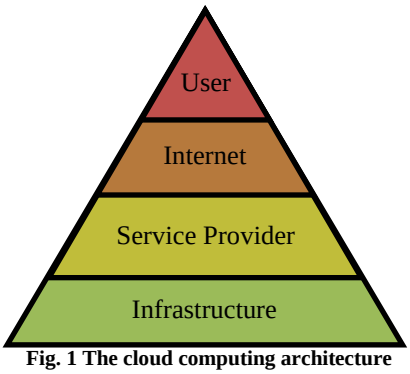

Fig. 1 The cloud computing architecture

The application is run by the end user. The end users have a computer that can be used to access the internet. The application does not need to be purchased by the end user. Only have to cover the subscription fees. The application does not have to be installed on individual end-user Personal Computers (PCs). They are not responsible for maintaining or updating the software. The Service Provider is the intermediary layer. That refers to the interaction between the infrastructure and the end user. Customers' needs are taken into account when providing services. Infrastructure serves as the framework for this design. Hard drives, RAM, and the Central Processing Unit (CPU) are only a few of its hardware elements. The server and networking components are also included.

3.2. Models for Cloud

As the use of cloud computing grows across numerous organizations. “Which cloud model should the organization take into account?” is the ensuing query. The four most popular cloud model types for cloud computing adoption are public, private, communal, and hybrid [19].

3.2.1. Public cloud

This type of cloud can be shared by anyone using the internet. Typically, a large investment was needed to set up the public cloud. Large firms, such as Microsoft, Amazon, and Google, practically own them, and their services are publicly available. Applications are used by numerous organizations simultaneously at the same time, stored on a cloud server with a mixed storage system and network.

3.2.2. Private Cloud

This kind of cloud was managed by the organization itself and utilized the organization’s own server infrastructure. It is not accessible to the general public.

3.2.3. Community Cloud

In most cases, a group or an organization will establish this kind of cloud to facilitate information sharing among its members. Anyone who is not a member of the group cannot access the information saved in the cloud. It is comparable to a private cloud, but the infrastructure and computational resources are restricted to two or more organizations rather than a single organization. These organizations share similar concerns regarding privacy, security, and regulatory requirements.

3.2.4. Hybrid Cloud

It is sometimes referred to as a virtual private cloud. This is an amalgamation of multiple different public and private clouds.

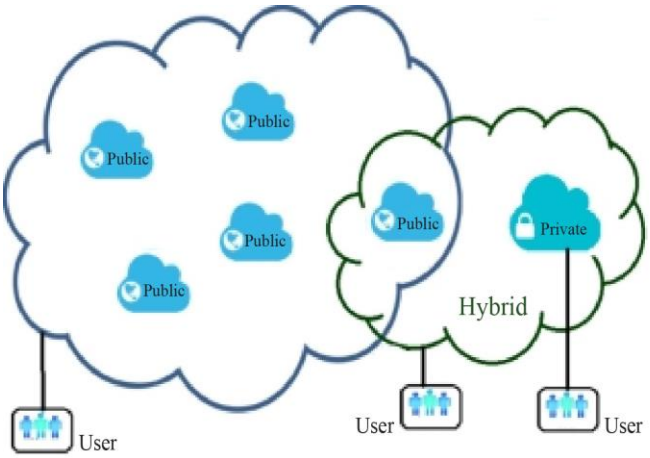

Fig. 2 Models of Cloud Computing

The cloud server may be operated independently. Though it is located inside an organization, there is an option to replicate data to a public cloud. Most often, research-based organizations constructed this kind of cloud architecture.

3.3. Service Offered by Clouds

Based on the services offered, clouds are categorized as Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS), which are well-accepted in the industry. Figure 3 illustrates the hierarchical arrangement of services, SaaS, PaaS, and IaaS services according to the perspective of a cloud end-user [19].

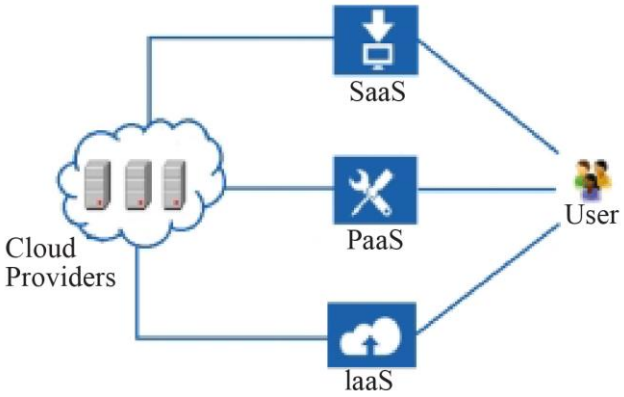

Fig. 3 Cloud service hierarchy

3.3.1. Software as a Service (SaaS)

The most widely used cloud service is called Software as a Service (SaaS). A cloud provider develops and offers the consumer complete software solutions through an Internet browser. End users can modify the configuration of the software to meet their needs without having to install or run it on a local PC. When using SaaS, the software is sent through a browser, and client computers temporarily cache data permanently stored on distant cloud computer systems. Because the data is stored in the cloud rather than on a local computer, the user can access the software through the internet from any location. The user cannot alter the software or hardware used in the cloud according to the need.

Fig. 4 SaaS services

The pioneer vendor in this area. Salesforce.com offers online customer relationship management (CRM) services. As an example of SaaS, Mozy offers a backup service that provides software to assist users in backing up their data. Google Docs and Microsoft's online version of office is called Business Productivity Online Standard Suite (BPOS), and online email services like Google's Gmail, Yahoo! Mail, and Hotmail are a few examples of SaaS. Google Drive is an additional SaaS that lets users store data on their servers, synchronize files across devices, and share information.

3.3.2. Platform as a Service (PaaS)

A platform with all the tools required to develop and distribute web applications is provided by the Platform as a Service (PaaS) approach. Applications have the option of using vendor infrastructure automatically. Resources used at any given time is determined by the number of people actively utilizing the program. The platform automatically monitors and analyses its workload to track and evaluate before activating or deactivating resources. Giving users maximum control over the various aspects of safeguarding sensitive data privacy is the primary goal of PaaS design. This is accomplished through the use of user-configurable data privacy and software protection methods. Google's Application Engine, Microsoft Azure and Salesforce.com are examples of common Pass providers.

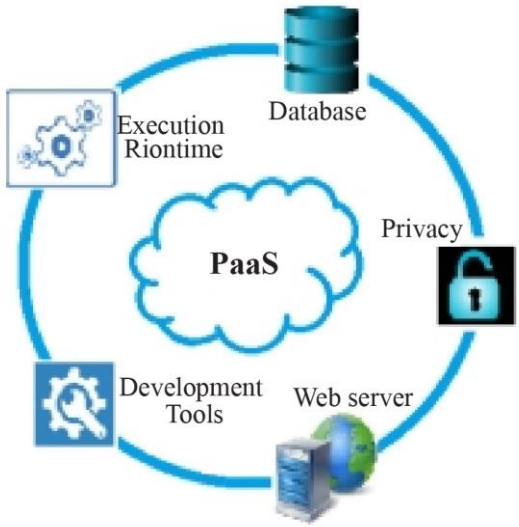

Fig. 5 The PaaS services [17-18]

Creating and hosting web apps using the Google Application Engine is possible without having to purchase servers. Database services, web hosting, and backup options are more examples of common platform cloud features. The Microsoft Azure platform gives end users a place to create, test, and host applications. Depending on the requirements of the applications, the storage capacity for user data may be increased or decreased. There is no need to construct the platform. Just pay a modest fee to make use of these services.

3.3.3. Infrastructure as a Service (IaaS)

IaaS provides the infrastructure based on customer demand. Everything, including storage servers, applications, and operating systems, is on the IaaS infrastructure. As a result, it is substantially less expensive, time-consuming, and labor-intensive to set up and maintain the user's infrastructure. The cloud service provider configures and maintains the infrastructure. Only a small fee is required to use it as the user requirements. IaaS is the foundation of a cloud computing system. On top of this IaaS layer, the SaaS and PaaS layers are constructed.

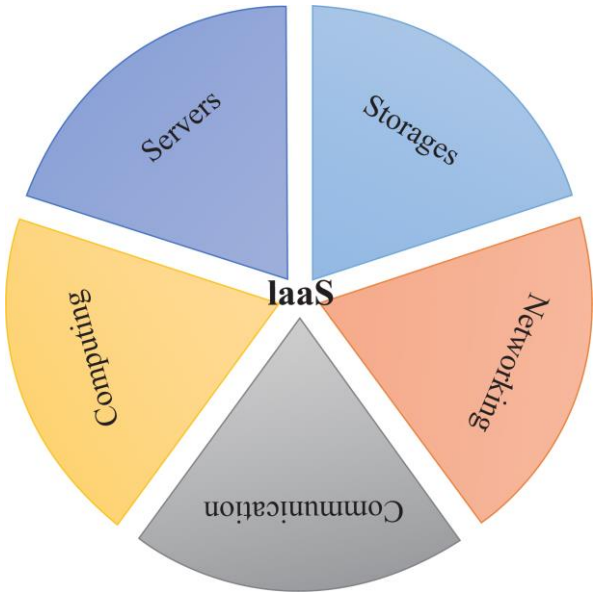

Fig. 6 IaaS services

The top four providers of IaaS services are Flexi-scale, Rackspace, Terre-mark, and Amazon. The end-user has full access to and control over these instances. The majority of instances in the infrastructure cloud are virtualized platforms. Since physical instances share their resources, such as the CPU and main memory, with numerous separated and encapsulated virtual instances (such as servers, databases, disk storage, etc.), they are referred to as virtualized.

This inevitably results in hardware, maintenance, and administrative costs being obviously reduced. To carry out computationally intensive activities, the customer has the option to buy many instances at once and designate a cluster architecture between the instances. A cluster is a connection between numerous computer instances where a particular piece of work is dispersed. When implementing IaaS, a number of factors and considerations must be made for things like data security, scalability, data transport, and the usability of existing technologies.

4. Benefits of Cloud Computing

The advantages of cloud computing technologies are numerous and are not limited to going beyond the topics covered in this section.

4.1. Scalability and Feasibility

One of the core features of cloud computing is its capacity to offer services with infinite scalability [21]. Customers have access to a vast number of virtual resources, enabling them to respond to erratic moments of peak load in a way that is effective, flexible, and economical [22]. As a result, performance and economic stability are balanced. Furthermore, cloud computing resources can be automatically purchased at any time and in any amount [23].

4.2 Quality Assurance for Technical Support

Providers of cloud computing services purchase servers and host the applications. Additionally, they are in charge of software updates and technical assistance. In order to handle e-government difficulties, the beauty of cloud computing is rising, especially for small government offices on the outskirts of cities where hiring qualified staff is not cost-effective and where specialists also prefer not to work [24]. Moreover, with cloud computing, it is not essential to update software on a single-user computer [21]–[25]. This work will reduce time and costs, increase system efficacy and efficiency, and reduce the need for highly trained workers by reducing maintenance errors.

4.3. User Friendly Interface

Location-independent cloud interfaces are accessible through well-known interfaces like web services and internet browsers.

4.4. Auditing and Security

E-government services require the ability to recognize any changes to information content. By utilizing information technology services and holding service providers accountable, corruption in governmental organizations can be controlled and reduced. Routine auditing procedures and security audits should be carried out to maintain system security. The cloud can assist in gathering a large amount of data, detecting fraud, and analysing it. This can help with the development of security defenses, enhancing security and enhancing the availability and dependability of applications [24].

4.5. Disaster Recovery

Many businesses must address this critical issue to evaluate whether they will be able to withstand catastrophes caused by their IT infrastructure. Clouds offer additional options than the standard disaster recovery paradigm for businesses to quickly and effectively restore information [19]. Costs and turnaround times for this kind of catastrophe recovery are decreased [23]. Governments have the alternative of saving daily server backups in the cloud for disaster recovery as well as off-site with the ability to save in a different location through the use of a third-party storage service provider.

4.6. Reporting and Intelligently

Monitoring and reporting on aspects like peak load, consumption level, energy use, and time spent in the data center (CPU, storage, network, etc.) are important for improved resource usage. This reduces expenses and scheduling. Profiling information makes the many government services available visible. In terms of scope and functionality, the cloud offers the Best Smart Business Infrastructure as compared to earlier techniques. Applications may extract a lot of current, accurate data to help users make the best choices for improved service [24].

4.7. Policies Management

E-government applications must be implemented in accordance with government policies created for the citizens. These policies should be implemented along with the infrastructure and data centers to enhance daily performance. An extreme data center can adopt this strategy with the use of cloud architecture. The data center, hardware systems integration, and legacy software will be used to build and implement security-related policies integrated into the applications. Additionally, it interfaces with cloud-based software. IT's abilities include message transmission in other systems and data correlation across apps to provide end customers with speedier services. The cloud is built using SOA principles and can offer great ways to quickly combine different apps and transfer them into the cloud [24].

4.8. Migration to New Technologies

It can be challenging to switch from an obsolete technology to a current, new one. Using various updated versions of software, apps, and security packages is one of the safeguards included in each data center's security maintenance for e-government. It is now possible to administer the suggested policies in the cloud system by simply integrating multiple e-government apps because safe and adaptable e-government apps are readily available. Multiple software versions can be used simultaneously thanks to the cloud architecture. Following testing, these apps will move onto the servicing phase [25].

4.9. Green Technology

ICT systems negatively influence the environment, increasing the greenhouse effect's rate and necessitating higher power usage [23]–[26]. Cloud computing offers ecosystems through virtual services with relatively low energy consumption. A common personal computer's power consumption is decreased to 90% by using virtual services [26],[27]. Data centers are receiving a lot of attention these days due to their high power consumption and the potential environmental concerns posed by e-waste in the air [25]. This may be one of the factors driving the government's shift to the cloud. Cloud offers existing facilities for centralization from rather than developing new ones.

4.10. Cost and Efficiency

The cloud computing service models have concentrated on providing affordable services to businesses, educational institutions, and governmental organizations. Lowering the expense of purchasing extremely expensive systems and hiring new qualified workers to administer and maintain the system creates a chance to lower the investment costs of starting and operating a system [23]. As a result, the fundamental obstacles to acquiring a substantial and expensive technology infrastructure are diminished, and new chances for cloud system investment are opening up daily in emerging nations.

5. Challenges in Cloud Computing

Cloud computing presents a number of challenges. Cloud computing necessitates a steady Internet connection, performs poorly over slow connections, and has other drawbacks. Features may be restricted, stored data may not be safe, stored data may be lost, and moving a large amount of data, even on a fast connection, may be challenging. The literature review revealed the following problem areas:

5.1. Data Transfer

When performing computations that demand a large of time and data, IaaS can be quite beneficial. One of the biggest problems is figuring out how to move all the relevant data to the cloud. The use of public clouds requires uploading files over the internet. It can take a while to upload files containing terabytes of data because the upload speed of many Internet connections is often ten times slower than the download speed. For representation, uploading 1 gigabyte (GB) of data takes 4 hours on average at a speed of 70 kB/s. One terabyte (1 TB) of data may be uploaded in 166 days, nearly half a year. As a result, several IaaS providers give customers the option of receiving data on hard drives. Only necessary data should be uploaded in order to save money on storage. Another important obligation that must be considered is data compression. For instance, files that are mostly text-based can be compressed by a factor of roughly 20, which speeds up uploading and lowers costs. Bringing the cloud to the data is one approach if transporting data to the cloud is not feasible. Building one's own private cloud requires additional upfront costs because each cluster needs to be purchased and maintained. As shown, the optimal course of action is always contingent on the specific situation.

The use of the cloud may potentially present chances for researchers. Everyone has access to data on a public cloud, giving them the chance to share and duplicate results. A cloud solution is frequently more secure than using a local computer since cloud instances are managed and physically secured by experts [34]. In 2008, two million laptops were stolen in the United States, along with misplaced USB keys containing private company's confidential data. These stolen computers frequently have extremely sensitive data on them. A National Health Service computer from Liverpool was stolen in June 2011 and contained highly private, unencrypted information on 8.63 million people [35].

Vendors enhance the security of cloud systems, and the information is redundantly kept. Moreover, cloud computing cannot succeed without encryption technologies. Only communications that are encrypted can guarantee the security of data transmission. This problem can be solved in a number of ways, and software tools such as the open-source, free OpenAM10 authentication and authorization application provide solutions.

5.2. Security and Privacy

Along with delivering these technologies' benefits, newer developments like service-oriented architecture in cloud computing also aim to address their drawbacks. Establishing e-governments in one place is the major obstacle to cloud computing. The usage of cloud computing integrates cutting-edge security methods to secure the environment despite the fact that there are many concerns, such as downtime for servers or data centers and the inability to utilize some services at specific periods of the year, such as voting and election days for voters. Concentrated security resources, automation, and the cloud combine to provide advanced security measures. But as of right moment, no technology can totally ensure security and privacy.

One of the biggest challenges the information technology sector faces in order to increase user confidence is securing public clouds. The survey found that the majority of consumers base their decisions on the lack of security [36]. Thus, it must be ensured that data is stored safely and that only authorized people may access it. As personal data usage rises, data security becomes more and more important. For example, many users are reluctant to save such data on machines controlled by other persons because it is regularly used in unpublished research findings. In addition, special security standards and guidelines must be provided if the data is governed by legal requirements [37].

5.3. Scalability

Scalability refers to the ability of software or hardware systems to scale up to meet growing demands. For example, if an algorithm scales linearly, the calculation uses twice the processing power but takes half the time. People frequently believe that scalability in the cloud is automatic and that shifting an application to the cloud instantly scales it.

However, it is evident that this is a myth. To be scalable, algorithms must be parallelized. Parallelization is the computational technique of breaking down a large problem into smaller problems tackled simultaneously (or "in parallel") by several computers. The multicore paradigm of modern CPU architecture highlights the need for parallelization, which is required for high-performance computing.

MapReduce is a parallelization-enabled programming paradigm [38]. MapReduce is a Google framework for distributing data chunks, also known as nodes, to several machines in a cluster. In this paradigm, each problem instance is solved by each partial, and all partial solutions are combined at the conclusion. The execution time is thereby greatly decreased. The Apache Hadoop framework11, in conjunction with its distributed file system, provides a robust open-source version of MapReduce Hadoop Distributed File System (HDFS).

Furthermore, projects like the Apache Whirr12 project aim to simplify cluster architecture configuration and provide user help. Finally, whether MapReduce is suited for a particular use case and achieves the desired results always relies on the program or algorithm itself. Frequently, problems escalate to the point where it makes no sense to use additional resources. It would also be a financial waste because the materials would have to be compensated.

5.4. Usability

Usability issues are not limited to cloud computing. It is also frequently absent in conventional software systems. In bio-informatics, a script pipeline and a command line interface are often left to one's own devices. Moreover, configuring cloud nodes necessitates a plethora of command-line commands as well as some in-depth knowledge. Promising research approaches aim to increase usability for end users without a strong computer science background. Because a sensitive application's graphical user interface could be compromised, usability and security are directly related.

6. Cloud Computing in Bangladesh

A recent study predicts that cloud computing will change over the next 20 years, impacting economies, markets, society, and education. By 2025, the majority of IT and web application services might be available or enabled in the cloud. Bangladesh can no longer afford to stay cut off from the global communication network since cloud computing affects not only information technology but also the entire economic system.

6.1. Present Situation of Bangladesh

Bangladesh is currently using internet access from a local operator. The local service providers do not offer cloud computing or other services like software applications, data access and storage. So, end users do not need to know where the system is physically located or how it is configured.

Bangladesh already exports software services, and cloud computing will dramatically expand this possibility. On the other side, the government's digital Bangladesh vision has made steps to provide public services at the grassroots level through the use of technology, intending to establish a Union Information and Service Center on the council of the 4500 unions. In addition, the government has built one of the world's most impressive national web portals. Around 24000 Upazilas have been connected to the internet from the central level to the portal's union. In the telecommunications sector in Bangladesh, mobile subscriber numbers have climbed to 9 million, and 3 million internet users to e-payments and mobile banking. The issue of the government performing internet shopping has become institutionalized. The commercialization of 4-G technologies and mobile networks has begun.

6.2. Empowering Digital Bangladesh

Bangladesh has significantly changed its approach by adopting a "Digital Bangladesh" instead of concentrating on real economic development centered around low-cost labor. Utilizing cloud computing for the economy is a smart idea. Cloud computing is being used in many different countries worldwide as well. The system software and hardware found in data centers of the cloud are also used to provide applications as online services. Cloud computing provides a variety of new chances for developing countries to undertake and accomplish things that they were not able to do previously with computers and the internet.

Users with mobile phones, tablets, personal computers, and other mobile devices can interface with cloud computing applications and infrastructure. Combining cloud computing and mobile device infrastructure opens up new potential for developing countries. Because the mobile phone and device user market is simply too large to ignore, cloud service providers have launched many cloud-enabled applications in collaboration with mobile service providers. They are continuing in their efforts to deliver an infinite choice of products. Mobile banking, m-education, m-health, and m-agriculture are a few well-known applications that development initiative projects. Other apps are already accessible and frequently utilized in developing countries. Cloud computing allows small firms to provide some IT services through outsourcing; otherwise, they must provide services internally. Businesses benefited from increased processing and storage capacity and the expertise of reliable service providers in fields like IT management and security.

Most cloud service providers are found in the United States. In developing countries, there is not a single cloud provider. Japan and Singapore, located in the heart of Asia, each have their own data center that provides cloud services. Bangladesh should now start planning to establish its own cloud service providers in the near future. Japan has built cloud systems for national and local administrations, dubbed Kasumigaseki Cloud and Jichitai Cloud, respectively. Kasumigaseki Cloud delivers nationwide local-level service from multiple ministries working together. Jichitai Cloud, on the other hand, was created to provide services to municipal governments.

Even Nevertheless, the global privacy framework that governs the transit of data is not uniform. Emerging nations may benefit from the establishment of robust domestic privacy policies. Until 2013, over 89 nations in the world had data privacy legislation. Mexico has the most up-to-date cloud-specific data protection provisions. Developed countries such as Bangladesh may consider introducing new legislation or revising the current ICT act to guarantee security in knowledge processing and cloud computing services. Information security, privacy, data protection, and cybercrime are the key topics that require improvement.

6.3. Road Map and Safety Factor for Cloud Adoption in Bangladesh

Because of its multiple benefits, cloud computing is largely used by Small and Medium-sized Businesses (SMEs). By leveraging the great capabilities of cloud computing, SMEs can deploy apps faster and at a lower cost than the cost of the owner's entire IT infrastructure setup and services. Furthermore, cloud computing does not impose software license restrictions, and both small and large numbers of users benefit [1,13].

An enterprise must examine several things before moving to a cloud-based solution. First, the consumer must comprehend and be technically satisfied with the present cloud infrastructure. Second, transferring data to the cloud should not violate any laws pertaining to government security or consumer data privacy policy. Third, the cloud environment should be capable and user-friendly regarding workload execution. Finally, organizations must arrange their business processes such that any product requirement may be met by a cloud system [9].

Cloud computing has enormous potential in Bangladesh, ranging from lower computation costs to developing world-class applications for the global market. However, before the widespread adoption of cloud computing technology, we must address security concerns and educate researchers and students about the challenges and unresolved issues.

In recent times, cloud computing has become the predominant paradigm for computing. Many firms are going to adopt cloud migration because of its flexibility and cost-effectiveness when it comes to important critical applications. Regrettably, serious security problems with today's cloud affect the availability, confidentiality, integrity, and privacy of data and apps transferred from the cloud. Multitenancy, one of the intrinsic aspects of cloud computing, has created new attack vectors and security risks. New kinds of attacks are also being launched against cloud services and their clients, endangering their dependability, credibility, and long-term viability financially. Until these problems are fixed, sensitive data, such as financial transactions or medical records, cannot be stored on the cloud.

Any computerization initiative should not result in job losses in a country with a high unemployment rate. A computerized system's power lies not in replacing human labor but in re-engineering processes and data analysis to optimize the system. Quarter-century of computerization experience has yet to prove the importance of data. A significant amount of financial, educational, and other sectors are now under control. To be able to extract knowledge from data mining tools and apply it to field enrichment. A massive amount of digital data has been generated by distributing approximately 100 million mobile

phones across the country. These data should be analyzed and utilized.

7. Suggestion and Recommendations

Cloud computing is a rapidly growing IT field in developed countries that immediately impacts our daily lives. As a result, it is critical that every organization, including universities, schools, and colleges, as well as government and non-government organizations, adopt it as soon as possible. As per the US National Institute of Standards and Technology (NIST), cloud computing possesses the following five fundamental characteristics:

7.1. On-demand Self-Service

Customers can adapt computing resources to their specific needs without other human interaction.

7.2. Broad Network Access

Personal computers, PDAs, smartphones, and other mobile devices should be able to connect to the network and use the cloud program.

7.3. Multi-Tenancy

Multiple users should be able to access the cloud computing system concurrently, and users ought to be able to exchange resources with one another via the cloud service provider's pool.

7.4. Rapid Elasticity

The resource will be free after any user obtains or uses it. Any user can obtain any resource quickly and without interruption at any time.

7.5. Measured Service

Should use a standard meter to measure services such as the user's bandwidth, storage space, server, and so on.

Many researchers worldwide are also working to address the following cloud computing issues.

7.6. Privacy and Security

The two main barriers to adopting cloud computing are privacy and security concerns. Many studies are being conducted to develop complex encryption methods for increased privacy and security, in which users can send their data in encrypted form, from which data can be searched and calculated by the cloud provider. However, they cannot see the actual data. This type of method does exist in theory. However, it necessitates a high bandwidth and processing speed, which raises the cost.

On the other hand, hardware-based security is possibly more efficient in terms of processing speed and bandwidth. But the price was higher for it [5], [10]. The European Union increased privacy and security, making the region more trustworthy to customers [1],[11].

Vendor lock-in problem: If all vendors are required to use a unified Application Programming Interface (API), cloud vendors' profits will be reduced, but this opportunity will pique the interest of more customers in adopting cloud systems [2].

7.7. Service Level Agreement

Service Level Agreements (SLAs) between a cloud service provider and a client are still working. Many changes occur on a daily basis because a single integrated SLA is not currently supported by cloud computing due to its immaturity. Rather than developing their own SLA and convincing others to accept it, all cloud service providers and standardization organizations have agreed to develop a unified SLA and work in stages [8].

7.8. Performance Instability

The problem of performance instability is being researched. This problem can be solved with proper scheduling techniques [2].

7.9. Scalable Database

According to current research, one potential option could be to install a new storage system with a unified interface for all cloud providers to address the problem of scalable databases [2]. To address the Scalable database issue, a SQL-API is being developed [3].

7.10. Hybrid Solutions

A hybrid solution could be part of the problem solution described above. In this hybrid solution, an organization will only move a portion of its IT infrastructure into the cloud system without affecting ongoing issues. The organization will own the remaining components of the IT infrastructure [7].

7.11. Recommendations Feature of Cloud Based

The cloud has cloud servers that are unique to each organization. Specific organizations implement infrastructure, and clients share those infrastructures to reduce implementation costs, support costs, maintenance costs, and time. Because the cloud server is managed centrally, updating and modifying it is less expensive. Because it is centrally controlled, it can support multiple organizations simultaneously and customize software based on organizational needs.

Given the topic and benefits of cloud computing technology, it is currently the best option for e-government and will lead to implementing the current digital Bangladesh concept. Cloud computing will save money while improving efficiency and user satisfaction. The government faces numerous other challenges, such as data integrity, process acceleration, and flexibility, which can be addressed through cloud computing in e-government, and the government should not overlook these benefits.

It is necessary to develop new laws and regulations between countries in the field of data transfer in order for governments all over the world to be able to use services provided by service providers.

Special consideration should be given to providing infrastructure, telecommunications, and communication equipment to increase internet bandwidth to realize e-government through cloud computing.

Cloud infrastructure may be more advantageous for those who are new to the IT field. All new entrepreneurs (Private Businesses, Organizations, Institutions, Research and Services) would be successful in this trend and would profit greatly from this ideal race.

The purpose of Enterprise Resource Planning (ERP) software is to enhance and mechanize business operations. Consequently, this software depends greatly on databases, software platforms, intelligence, security, and other third-party programs. Not every feature and dependency may be supported in the same manner by a single software development company [26]-[27]. Cloud architecture can ensure ERP development and support for both vendors and users. In contrast to traditional software development and maintenance, Microsoft Corporation wishes to place a greater emphasis on cloud computing rather than traditional personal computing. Benefit more from cloud computing, and its growth rate is faster than the previous year. More cloud computing support is provided by the organization. Also want to improve AI in cloud computing, which will be more profitable in the near future [28].

8. Conclusion

The biggest IT revolution in history was initiated by cloud computing, and all sizes of organizations now take advantage of a wide range of new business opportunities. The percentage of businesses using a public cloud is increasing day by day. Public clouds will be the primary source of opportunities for cloud service providers. This study presents a number of cloud computing problems, along with some current prospective solutions.

Data privacy, security, vendor lock-in, interoperability, service availability, lack of uniform SLA, performance instability, network bottleneck, lack of scalable storage, and reputation fate sharing are among the core difficulties that the majority of current research has found. Cloud computing solutions have cheap infrastructure and maintenance expenses; because of this, small and medium-sized organizations frequently use them. However, large business organizations depend on their own infrastructure rather than services provided by cloud providers. Researchers are trying to remove the obstacles preventing the widespread adoption of cloud computing. Most cloud computing issues are resolved, or the threat can be modified to be accepted.

According to the literature, a great deal of work has to be done in order to discover solutions for cloud computing. This is often the most important concern regarding the future of cloud computing since many businesses may want to move their IT systems to the cloud after careful consideration.

It is possible to conclude from this study that a developing country such as Bangladesh has a critical need to create e-government as a vision of Digital Bangladesh. In times of economic difficulty and challenges, cutting expenses and promoting sustainable growth can be achieved by utilizing affordable, environmentally friendly technology, which is feasible when using cloud computing. Therefore, it is safe to say that the cloud will soon exert a disruptive influence on both the computer and mobile industries for resolving and mitigating current issues, and a significant number of individuals will use its services as well.

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