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Adoption of Cloud Computing in Banks: Opportunities and Challenges

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Foreword

As part of ongoing dissemination of BIBM research outputs, this keynote paper presented in a roundtable discussion contains the findings of the roundtable research topic "Adoption of Cloud Computing in Banks: Opportunities and Challenges". The study was conducted in 2022 and the paper was presented in a roundtable discussion on November 29, 2022 at BIBM Auditorium.

The banking industry is undergoing unprecedented changes. Control is now in the hands of the customer, rather than the bank. Customers are driving new business models. Their use of technology—in addition to changes in social and household dynamics—is driving business transformation. Banks need to react to this new customer-driven environment with innovation in business models, operations and IT.

Cloud computing is revolutionizing overall information ecosystems to create seamless sharing of multiple industries, and banking is no exception. Cloud technology offers secure deployment options of IT applications that can help banks develop new customer experiences, enable effective collaboration and ingrain speed to market—all while increasing IT efficiency. Cloud adoption is growing rapidly because it offers diverse type of services for banks.

Bangladesh Government and Bangladesh Bank have taken number of initiatives to promote Cloud Computing for providing secured, faster, cost minimizing and real-time reliable services in the banking sector. As part of the initiatives, Bangladesh Bank has published a guideline on Cloud Computing.

It gives me immense pleasure, on behalf of BIBM, to offer this important resource of academic inputs to the practitioners of the banks and financial institutions, regulatory agencies, policy makers as well as to the academics and common readers. I hope, this keynote paper will be a valuable resource especially for the policy makers and practitioners to understand the opportunities and challenges of cloud adoption in banks.

We do encourage feedback from our esteemed readers on this issue which certainly would help us improve upon our research activities in the coming years.

Md. Akhtaruzzaman, Ph.D.
Director General, BIBM

Acknowledgement

This roundtable discussion keynote paper titled "Adoption of Cloud Computing in Banks: Opportunities and Challenges" has been completed with immense support from numerous individuals and organizations.

We express deep gratitude to Dr. Md. Akhtaruzzaman, honorable Director General of BIBM for his valuable observations and guidance in finalizing the paper. The remarks and insight of Dr. Ashraf Al Mamun, Associate Professor and Director (Research, Development and Consultancy) was significant at different stages of our work.

We are thankful to all of our faculty colleagues for their opinions and positive suggestions to carry out our research. We are also thankful to the chief guest, panelists and participants of the roundtable discussion for their valuable comments that immensely helped us to improve the quality of the paper.

Our honest appreciation goes to the office of Research, Development & Consultancy, BIBM for their continuous assistance in this research. Finally, we would like to thank all of those who extended their support in this research work.

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Md. Foysal Hasan
S. M. Tofayel Ahmed

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List of Abbreviation

AI	Artificial Intelligence
API	Application Programming Interface
AWS	Amazon Web Service
BB	Bangladesh Bank
BCBS	Basel Committee on Banking Supervision
BIBM	Bangladesh Institute of Bank Management
BPaaS	Business Processes as a Service
CBA	Commonwealth Bank of Australia
CBSs	Core Banking Solutions
CC	Cloud Computing
C-DAC	Centre for Development of Advance Computing
CIB	Commercial International Bank
CIO	Chief Information Officer
CRM	Customer Relationship Management
CSP	Cloud Service Provider
CTO	Chief Technology Officer
DR	Disaster Recovery
EC2	Elastic Compute Cloud
e-KYC	Electronic Know Your Customer
ERP	Enterprise Resource Planning
FCB	Foreign Commercial Bank
FGD	Focused Group Discussion
FI	Financial Institution
FSB	Financial Stability Board
GDPR	General Data Protection Regulation
HoIT	Head of IT
IaaS	Infrastructure as a Service

ICT	Information and Communication Technology
IDRBT	Institute for Development and Research in Banking Technology
IP	Internet Protocol
IT	Information Technology
ITD	Information Technology Department
MFS	Mobile Financial Service
NDC	National Data Center
NIST	National Institute of Standards and Technology
P2P	Person to Person
PaaS	Platform as a Service
PCB	Private Commercial Bank
RRB	Regional Rural Bank
SaaS	Software as a Service
SDB	Specialized Bank
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SOCB	State Owned Commercial Bank
UCB	Urban Co-operative Banks, United Commercial Bank
XaaS	Anything as a Service

Executive Summary

Compared to today, banks will undergo tremendous transformation in the future. Banks must take deliberate steps to get ready for the future by adapting the changing consumer expectations, new technology, and new business models. Cloud computing is a key area of interest for CIOs, C-suite executives, and board members. The popularity of cloud computing is growing as a result of its flexibility and efficiency. In order to determine how this technology can help them, certain sizable institutions are actively evaluating it. Before completely embracing technology, some bankers are being cautious because they want adequate responses to their security and regulatory issues.

Organizations, particularly banks, are under enormous pressure to quickly integrate novel components into their current business models in the fiercely competitive business environment of today. In the banking industry, cloud computing is used by two types of users: banks themselves, who incorporate and benefit from cloud services in their current business models, and customers, who use the cloud-based applications offered by banks to carry out their daily financial transactions. Through the use of cloud computing, banks can establish a flexible and responsive banking environment that can promptly adapt to new business requirements. Additionally, cloud technology provides secure deployment options that can aid in the creation of new customer experiences, encourage effective collaboration, improve market accessibility, and enhance IT efficiency. This facilitates the ability of employees to focus more precisely on the bank's mission and vision.

Cloud computing can be defined as more than just a technology; it represents a fundamentally different approach to computing that has the potential to reshape organizations' products, services, and processes. The cloud computing model offers access to a distributed and easily accessible pool of shared computing resources, including networks, servers, storage, applications, and services. These resources can be rapidly provisioned and released as needed, allowing organizations to adjust their workload

dynamically with minimal disruption to operations. Clients typically access these resources through a pay-per-use model, while the service provider commits to delivering certain safeguards as outlined in a Service Level Agreement (SLA).

The study shows that 24 percent of the CTOs/HoITs/CIOs has a very good level of understanding regarding cloud computing. Almost same level of knowledge is seen in case of IT teams of banks. HoITs and the IT teams are the key implementers of cloud technology in banks, so they must have an excellent understanding of the technology. Otherwise, it will bring negative results for the organization. Board Members and Top-Level Management are the ultimate policy and decision maker. So, they need a clear understanding of the technology. It is also seen from figures that Top-Level Management and Board Members have a moderate level of understanding regarding cloud computing.

The survey found that the average number of IT employees attending meetings and vendor-organized cloud computing programs was 2.9 and 2.8, respectively. On the other hand, on an average 0.6 IT employees attended different international programs. Before implementing new technologies, acquiring knowledge from national and international sources is essential. However, IT employees need to catch up in attending various programs in the local and international domains.

The study also reveals that 51.9 percent of banks agree that cloud technology is relevant for them but not a strategic priority. On the other hand, only 11 percent of banks set cloud technology as critical in their top five strategic plan. About 33.3 percent of banks have given importance, but it is not in the top-five strategic priorities. Around 3.7% banks are not sure about the relevance of cloud computing in banks.

It is found that 48 percent of banks adopted some sort of cloud services. The respondent banks that adopted cloud services in hybrid and public clouds. It is seen that 47 and 41 percent of banks used hybrid and public clouds, respectively. However, banks use different cloud service models like SaaS, PaaS and IaaS offered by cloud service providers. The survey shows that

approximately 68.8 percent of banks use SaaS and 31.3 percent use the PaaS model. Very few banks use IaaS and BPaaS as cloud service models.

However, it is seen that 48 percent banks have adopted cloud services partially, rest of the 52 percent banks are planning to move into cloud services by the next two years. Approximately 70 percent of those banks (52% of total) that do not have cloud services are willing to adopt it within the next two years. Table-3 shows that about 62 percent of banks are willing to get IT support services, followed by office automation (38%), human resource management (38%) and CRM (38%). Twenty-four percent of banks expect to adopt call center facilities and 19 percent show eagerness to adopt various application software from cloud service.

Cloud adoption strategy may vary from bank to bank due to the size, human resources, capital base and technological capacity. Based on the opinions by the expert IT executives from banks, the research team suggests the following roadmap that may be followed by the banks in three different phases. Phase-1: Low dependency/Non-Critical Services (Email, Storage, CCTV recording, Data Analytics, CRM, Help Desk Management, Incident Management, etc.). Phase-2: Critical Services (HRMS, Remittance Management, In-House Developed Applications). Phase-3: Most Critical/Advanced Services (CBS including Database, Card System, I-Banking, MFS, Foreign Exchange Transaction Monitoring etc.).

Adoption of Cloud Computing in Banks: Opportunities and Challenges

1.0 Introduction

Banks are using Information Technology (IT) for efficiently serving customers and maintaining seamless banking operations. The importance of IT in the banking sector is widely recognized by industry experts and regulatory bodies. For instance, the Financial Stability Board (FSB) acknowledges the crucial role of technology in the financial industry and regularly monitors its impact on financial stability and risk management. Additionally, regulatory frameworks such as the Basel Committee on Banking Supervision (BCBS) provide guidelines and standards for the effective use of IT systems and cybersecurity practices in banks. However, most banks depend on third-party service providers to avail IT-based services. Outsourcing of IT services is very common in the banking sector. The growth of business and new channels is making the banking job complex. To solve the complex and changing working environment IT is a must. Dependence on new technologies like Artificial Intelligence (AI), Blockchain, Application Programming Interface (API), and Cloud Computing (CC) is increasing every day.

The banks of the future will undergo significant transformations compared to the present. In response to evolving consumer expectations, emerging technologies, and alternative business models, banks must initiate strategic measures to prepare themselves for the future. Cloud computing is emerging as a central focus for chief information officers, executives in the C-suite, and board members. Aggarwal (2022) from 'The Asian Banker' stated that recognizing the agility and cost-effectiveness offered by cloud computing, certain large banks such as Deutsche Bank of Germany, Standard Bank of South Africa, JP Morgan Chase of the USA, Standard Chartered Bank of the UK, and so on are taking proactive steps to test this technology. In India, ICICI Bank, Axis Bank, and Kotak Mahindra Bank are some of the first users of cloud computing in their banking services

(Schou-Zibell and Husar, 2023). However, other bankers are exercising caution as they await satisfactory responses to security and regulatory concerns

Ghule et al. (2014) stated that Cloud Computing (CC) refers to the provision of computing services via the internet, encompassing software applications, storage of data, and processing power. Instead of investing in and managing their own advanced computing infrastructure, banks can utilize cloud computing solutions to supplement or replace their existing data centers. This enables organizations to steer clear of the expenses and intricacies associated with maintaining modern IT infrastructures.

Organizations, particularly banks, are under enormous pressure to quickly integrate novel tech-components (e.g. but not limited to: digital payment systems, Person to Person (p2p) payments, Cloud Computing (CC), blockchain technology, Customer Relationship Management systems (CRM), Artificial Intelligence (AI) applications, etc.) into their current business models in the fiercely competitive business environment of today (Shevlin, 2022). In the banking industry, cloud computing is used by two types of users: banks themselves, who incorporate and benefit from cloud services in their current business models, and customers, who use the cloud-based applications offered by banks to carry out their daily financial transactions. Through the use of cloud computing, banks can establish a flexible and responsive banking environment that can promptly adapt to new business requirements. Additionally, cloud technology provides secure deployment options that can aid in the creation of new customer experiences, encourage effective collaboration, improve market accessibility, and enhance IT efficiency. This facilitates the ability of employees to focus more precisely on the bank's mission and vision.

Cloud computing is not a new concept for large size global organization. However, Bangladesh is far away from cloud computing adoption (Schou-Zibell and Husar, 2023). Banking sector is sensitive to adopt new technology. A very clear direction is required from the Central Bank and Government to move into cloud adoption. In the above context, cloud

computing is a potential sector for industries specially for banking sector. Cloud service needs to be analyzed, assessed and evaluated for identifying its opportunities, scopes and challenges. It is therefore a good opportunity to study how an innovation is perceived and what factors can encourage and prevent its early adoption. With the above background, BIBM has prepared this roundtable discussion paper with the following objectives.

1.1 Objectives

The broad objective of this roundtable discussion paper is to identify the opportunities and challenges of cloud computing adoption in banks. The specific objectives of the paper are to-

a. discuss the conceptual aspects of cloud computing;

b. depict the global scenario of cloud computing adoption in the banking sector;

c. identify the perceptions about cloud services among the IT professionals working in Bangladeshi banks and

d. find out the opportunities and challenges regarding the adoption of cloud computing in banks

1.2 Methodology

This is an exploratory study. The study uses both primary and secondary data. Primary data were collected through semi-structured questionnaire, and Focus Group Discussion (FGD). In this regard, a semi-structured questionnaire (Appendix-1) was sent to the IT department of all banks in Bangladesh. We received 36 questionnaires from banks (Appendix-2). Among the respondent banks, there were 4 State-owned Commercial Banks (SOCBs), 27 Private Commercial Banks (PCBs), 3 Foreign Commercial Banks (FCBs) and 2 Specialized Banks (SBs). Additionally, FGD was conducted among IT professionals of banks (Appendix-3). The secondary data were collected from various research papers, publications, and websites. Extensive literatures were reviewed for developing the conceptual aspects.

1.3 Organization of the Paper

The paper is organized into six sections. The first section describes the introduction, objectives, methodology and the organization of the paper. Section two discusses the conceptual issues on Cloud Computing; section three reviews the literature; section four shares global Cloud Computing Adoption scenario in the financial system; section five, shows the current status, cloud adoption factors, opportunities and challenges of Cloud Computing in the banking and financial sector of Bangladesh, and section six concludes with challenges, recommendations and conclusion.

2.0 Cloud Computing: Conceptual Aspects

A Gartner report listing cloud computing at the top of its strategic technology areas further reaffirmed its prominence as an industry trend by announcing its formal definition as:

"...a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service to external customers using Internet technologies."

This is a slight revision of Gartner's original definition from 2008, in which "massively scalable" was used instead of "scalable and elastic." This acknowledges the importance of scalability in relation to the ability to scale vertically and not just to enormous proportions.

Forrester Research provided its own definition of cloud computing as:

"...a standardized IT capability (services, software, or infrastructure) delivered via Internet technologies in a pay-per-use, self-service way."

The definition that received industry-wide acceptance was composed by the National Institute of Standards and Technology (NIST). NIST published its original definition back in 2009, followed by a revised version after further review and industry input that was published in September of 2011:

"Cloud computing is a model for enabling ubiquitous, 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. This cloud model is composed of five essential characteristics, three service models, and four deployment models."

Cloud computing can be defined as more than just a technology; it represents a fundamentally different approach to computing that has the potential to reshape organizations' products, services, and processes. The cloud computing model offers access to a distributed and easily accessible pool of shared computing resources, including networks, servers, storage, applications, and services. These resources can be rapidly provisioned and released as needed, allowing organizations to adjust their workload dynamically with minimal disruption to operations. Clients typically access these resources through a pay-per-use model, while the service provider commits to delivering certain safeguards as outlined in a Service Level Agreement (SLA).

2.1 Features of Cloud Computing

Cloud computing possesses unique characteristics that distinguish it from other forms of computing, as highlighted by Mahdavisharif et al. (2021). Two essential properties of cloud computing are identified, and several common features are outlined below:

Accessibility of a broad network: Cloud services can be accessed through standardized procedures, enabling users to connect via various platforms and applications. Whether using laptops, mobile phones, or personal computers, users can access cloud resources anytime, anywhere, as long as there is IP network connectivity.

On-demand self-service: This fundamental feature allows users to obtain computing services, including network storage and server time, as per their requirements. Cloud computing services can be provisioned instantly based on user requests, even without human intervention.

Other key features include:

Rapid elasticity: Cloud computing offers elastic and scalable computing capabilities, enabling seamless scaling out and scaling in as needed. Service

capacities can be dynamically adjusted to meet fluctuations in demand, allowing for cost optimization and meeting service quality expectations.

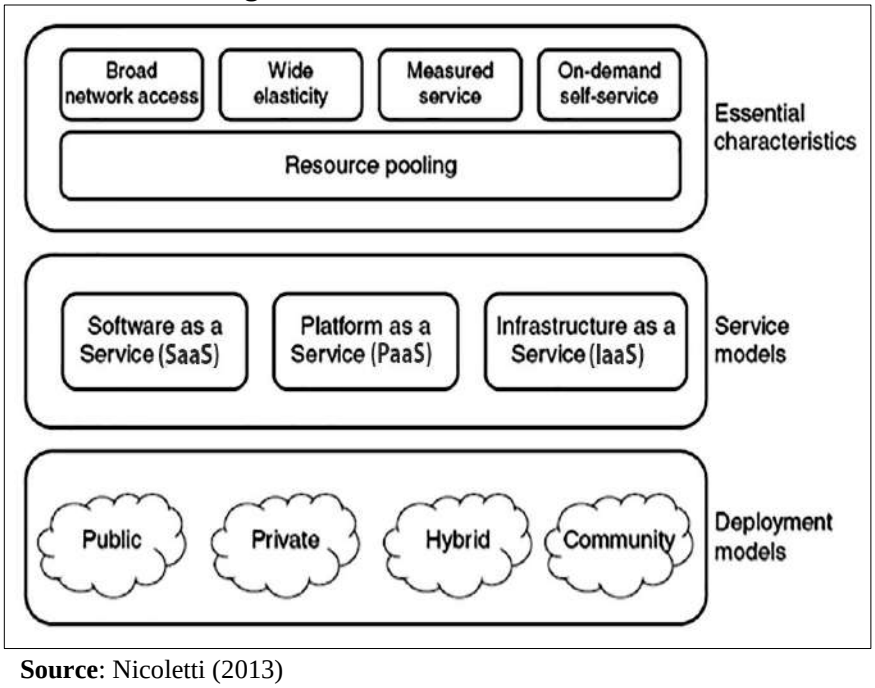
Pooling of resources: Cloud resource providers consolidate computing services from diverse physical and virtual resources to meet the computing needs of multiple users. This resource pooling approach allows for efficient utilization of storage servers and devices. Cloud providers select the most suitable resources from the pool to optimize service quality, enabling cost savings through resource sharing.

Service measurement: Cloud services provide automated monitoring, optimization, and reporting functionalities to ensure efficient resource utilization. Service measurement tools track and manage the utilization of cloud resources, facilitating informed decision-making and resource allocation.

In summary, cloud computing exhibits unique characteristics that enable broad network accessibility, on-demand self-service, rapid elasticity, pooling of resources, and effective service measurement and management.

The Following figure shows three dimensions of cloud computing:

Figure-1: Three Dimensions of Cloud



Source: Nicoletti (2013)

2.2 How does Cloud Computing Work?

Cloud computing is made possible through the utilization of virtualization technology. Virtualization enables the creation of simulated digital "virtual" computers that mimic the behavior of physical computers with their own dedicated hardware. These virtual computers, known as virtual machines, are effectively isolated from one another when implemented correctly. They operate independently, without interacting or sharing files and applications, even if they reside on the same physical machine.

One of the key benefits of virtual machines is their ability to optimize hardware usage. By running multiple virtual machines simultaneously, a single server can effectively function as multiple servers. This scalability allows data centers to serve numerous organizations, transforming into a network of data centers within a single infrastructure. This efficiency enables cloud providers to accommodate a larger number of customers at a lower cost.

Cloud servers are designed to maintain high availability, even if individual servers experience downtime. Cloud vendors typically implement redundancy measures by backing up services across multiple machines and regions. This ensures that cloud services remain online and accessible to users at all times.

Users can access cloud services through web browsers or dedicated applications, connecting to the cloud via the internet. Regardless of the device being used, the connection takes place over interconnected networks, allowing users to utilize cloud services seamlessly.

2.3 Cloud Service Models

Software as a Service (SaaS): SaaS involves vendors delivering applications to end-clients as a service over the cloud. A wide range of SaaS offerings are available today, including general-purpose applications for organizations, specialized applications for specific industries, and client applications. Prominent examples of SaaS applications include Salesforce, MailChimp, and Slack.

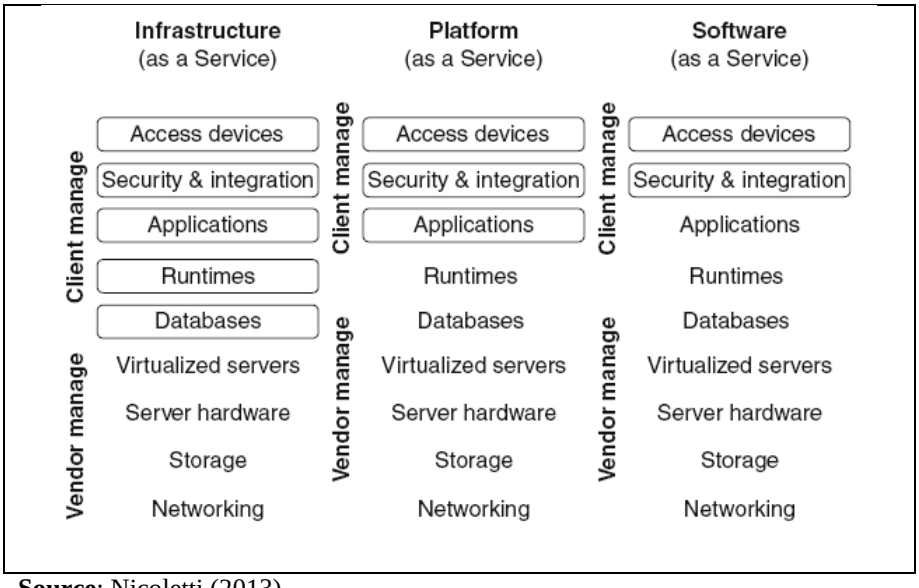
Platform as a Service (PaaS): PaaS provides platforms that enable the development and deployment of applications. Vendors offer these platforms as a service, allowing users to build, deploy, and manage applications in the cloud. A typical PaaS includes databases, middleware, and development tools. The network serves as the medium for delivering hosted applications. PaaS serves as an intermediary between IaaS and SaaS in the context of cloud computing. Notable PaaS examples are Heroku and Microsoft Azure.

Infrastructure as a Service (IaaS): IaaS focuses on providing essential technologies such as storage capabilities, network services, and computing power. It acknowledges the increasing commoditization of ICT infrastructures, often relying on virtualization for hardware resources. IaaS also encompasses virtualization, management, and operating system software components.

Over time, these service models have been enlarged to include other possible modes, indicated in general as XaaS, where X stands for a specific service.

BPaaS is particularly relevant in this regard. It is the provision of business processes as a service. It is a generalization of SaaS where the vendor not only provides the ICT systems but also uses the application to operate a full process on behalf of the client.

Figure-2: Breakdown of IaaS, SaaS and PaaS



Source: Nicoletti (2013)

2.4 Cloud Computing Deployment Approaches

According to Chen and Zhao (2012), cloud computing offers four distinct deployment methods: public, private, hybrid, and community clouds. These models vary in their features and implications for users, and the choice of deployment strategy depends on the specific goals and requirements of a business. To determine the most suitable deployment strategy, companies should conduct evaluations of performance, security, and reliability.

Public Cloud

Public clouds are commonly considered the optimal deployment strategy and are widely recognized as true cloud environments. These clouds are managed by cloud computing resource providers and offer services to the general public. Deployed through data centers and high-speed networks, public clouds are characterized by their multitenant capabilities, where different users have separate data that is not accessible to the public.

Private Cloud

Private clouds can be acquired through leasing or ownership and provide enhanced security standards, unrestricted bandwidth, and no legal obligations. The computing infrastructure in a private cloud is dedicated to a single organization and cannot be shared with other entities. Private clouds are preferred by enterprises that cannot host their data remotely, as they offer optimal infrastructure and security management, leading to improved resource automation and usage.

Community Cloud

Community clouds are distinct from public clouds and serve specific user groups with shared interests. These clouds provide resources to individuals and groups with similar interests, and the computing infrastructure can be located either on-site or off-site. Unlike public clouds where ownership and management are controlled by individual suppliers or owners, community cloud resources are owned and managed by one or more community contributors.

Hybrid Cloud

The hybrid cloud strategy combines elements from the aforementioned deployment methods. It involves a management framework that ensures a unified cloud environment. Organizations are increasingly adopting hybrid cloud approaches to address their evolving needs for flexible pricing, optimized performance, and enhanced security.

3.0 Review of Literature

The term cloud computing emerged in the fourth quarter of 2007 on a collaborative project between IBM and Google (Vouk, 2008). According to Mohamed (2009), in 2002 Amazon provided a suite or cloud-based services including storage, computation and even human intelligence through the Amazon Mechanical Turk. In 2006 Amazon launched Elastic Compute Cloud (EC2) as a commercial web service that allows small companies and individuals to rent computers on which to run their own computer applications.

In 2009, Google began providing enterprise applications through its Google Apps service, which could be accessed via a web browser, a development made possible by the advent of Web 2.0. The most significant impact on cloud computing has been the introduction of "killer apps" by major technology companies such as Microsoft and Google. These services are widely adopted by users when they are dependable and easy to use. This, in turn, has led to greater acceptance of online services throughout the industry as a whole (Taber, 2009).

The most well-known corporation currently adopting the cloud computing approach is Google, which offers a wide range of web-based apps via its cloud architecture. Some of these applications include Google Docs for word processing, Google Presentations for creating presentations, Gmail for email services, and Google Calendar for scheduling and calendar functionality. Other significant companies that have also adopted cloud computing include Microsoft, which offers its Windows Live suite of web-based applications, Amazon with its Elastic Compute Cloud (EC2) providing resizable computing capacity for application development, and

IBM, which has set up a cloud computing center to provide cloud services and research to its clients (Miller, 2009).

Prior to adopting cloud computing, organizations must have knowledge of this technology, its purpose, and its potential applications. A survey conducted by Market Connections in 2008 focused on cloud computing awareness among the U.S. defense/military and federal government sectors. The findings indicated that cloud utilization is set to experience significant growth as awareness of cloud computing increases. The analysis revealed that 34 percent of federal government respondents were unfamiliar with cloud computing. Additionally, three out of five respondents expressed a lack of trust in cloud computing, and 23 percent were unaware of their organizations' activities related to cloud computing. This research clearly highlights the limited knowledge of cloud computing within agencies involved in its implementation.

A survey conducted by Gartner in 2010 aimed to assess the level of awareness of cloud computing in the United States. The results showed that CIOs (Chief Information Officers) now possess a higher level of understanding regarding the cloud business. As a result, they are taking the lead in promoting commitment to the cloud environment. In another survey conducted by Morris in the same year, it was found that CIOs play a vital role as a primary source of awareness within organizations, particularly concerning cloud computing awareness and implementation initiatives.

According to Barnes (2010), there has been a significant growth in cloud adoption and awareness in the region. However, a considerable number of organizations remain hesitant to embrace it. A survey conducted by Ernst & Young in 2009, focusing on the adoption rate of cloud computing in India, found that 81% of Indian C-level executives were familiar with and aware of cloud computing concepts.

The level of cloud computing awareness in the Asia Pacific region (excluding Japan) was investigated in a 2009 study by Springboard. The results showed that there was a dearth of general knowledge about cloud

computing in this area. In the region, only 46% of poll respondents were aware with the idea of cloud computing.

Ellison (2010) states that the introduction of cloud computing has sparked interest among enterprises. However, it is evident that companies are currently exploring different possibilities and evaluating whether or not they should adopt this technology. This behavior raises doubts regarding organizations' willingness to embrace and venture into the realm of cloud computing.

Carolyn (2010) observed a noticeable increase in momentum within the realm of cloud computing, evident through rising adoption rates and a greater level of awareness. According to Carolyn, the adoption of cloud computing is still on the rise, and in the coming years, it will involve evaluation, experimentation, and, crucially, opportunities as the market navigates the involvement of IT channel companies, optimal business models, sales and marketing strategies, and the most relevant technologies.

A survey conducted by the Ponemon Institute in 2010, involving 642 IT executives in the United States and 283 in Europe, discovered that security concerns represent a significant obstacle to adopting cloud technology. Approximately half of the global IT organizations expressed uncertainty about whether anyone within their organization was aware of all the cloud computing services being used by end-users to store data. Larry (May; 2010) highlighted that the current risk associated with cloud computing is substantial due to varying levels of security offered by different cloud computing providers. This factor has contributed to organizations being reluctant to adopt cloud computing.

A survey was done by Harris (2010) with a focus on IT directors at major enterprise companies with 2,500–20,000 workers. The results showed that 77 percent of these businesses used cloud computing in some capacity. The study also probed the exact kinds of cloud computing models—private, public, or a hybrid—that these firms were prepared to use. Of the respondents who were already using cloud services, 50% used a private

model, 34% chose a hybrid strategy combining private and public clouds, and 43% intended to use the combination strategy even more in the future.

According to a survey conducted by LogLogic in 2010, which involved 82 of the world's largest banks, investment houses, and insurance companies, the financial service firms are cautious about adopting popular IT infrastructure investments such as cloud computing. This hesitance is primarily due to concerns regarding data security and transparency.

Although the financial services market has traditionally been at the forefront of adopting cutting-edge information technology, few companies in this sector expressed plans to invest in new technologies like cloud computing. The survey found that 34 percent of respondents did not consider cloud computing as a strategic priority for their company, while 26 percent believed their company was risk-averse towards cloud computing. Consequently, financial firms are apprehensive about embracing cloud computing due to persistent uncertainties regarding data security and transparency in the cloud (Churchward, 2010).

Hayes (2008) highlights the concerns about control and ownership when third-party services are entrusted with personal documents. There are questions regarding data migration if an organization switches service provider, as well as the potential loss of access to documents if the organization fails to pay. This underscores the need for well-defined policies and mutually agreed-upon service-level agreements (SLAs) to address these issues. This raises the question of how prepared organizations are to venture into cloud computing.

A study conducted in India (Tripathi, 2009) aimed to assess the willingness of organizations to adopt cloud computing technology. The findings revealed that cloud computing had not progressed beyond the awareness phase in many decision-makers' understanding. There was a lack of comprehension regarding the terminologies such as IaaS, PaaS, and SaaS, as well as the distinctions among public, private, and hybrid clouds.

Despite the fact that there are many researchers studying the adoption of cloud computing in different contexts, literature reviews show that the

majority of these studies mainly focused on organizational adoption of cloud computing and the technical aspects of its implementation. The table below highlights the areas of these research' concentration and demonstrates their emphasis.

Table-1: Literatures on Factors Affecting Cloud Computing Adoption in Different Areas

Author(s)	Context Area	Factors affecting cloud computing adoption
Lian (2015)	E-government	Effort expectation, social influence, trust, perceived risk, security concerns, behavioral intention
Tehrani and Shirazi (2014)	Small and Medium Enterprises (SMEs)	Relative advantage, complexity, privacy, security, cost, external support, decision maker's innovativeness, decision maker's cloud knowledge, employee's cloud knowledge, information intensity
Rani and Gangal (2012)	Banking	Security, privacy, confidentiality, data integrity, availability, recoverability
Sultan (2010)	Education	Performance, latency, security, privacy, reliability, cost
Benton (2010)	Banking	Cost saving, security, data privacy

According to Radwan et al. (2017), there are distinctions between traditional data centers and cloud data centers in terms of their features. While both types of data centers are responsible for carrying out their respective tasks, they differ in terms of hardware and software configurations required for operation and service delivery.

4.0 Global Cloud Adoption Status by the Banking Sector

According to the British Bankers Association, the primary reasons that banks are turning to cloud-based services can be summarized as follows:

Cost-saving advantages: Traditional banks heavily rely on capital-intensive IT infrastructure. In contrast, cloud services offer cost-saving benefits by providing higher capacity compared to server-based applications. This enables banks to reduce costs while benefiting from the scalability and efficiency of cloud solutions.

Risk reduction: Cloud solutions help banks mitigate risks associated with resiliency, redundancy, and capacity. They have the ability to quickly detect

and address various threats and vulnerabilities. With the cloud's capacity to process a large number of transactions per second, banks can more effectively combat money laundering and fraud compared to previous methods.

Increased flexibility: Migrating to the cloud allows banks to shift resources from IT administration to innovation, resulting in increased productivity and agility in both internal and external processes. Cloud-based solutions offer banks greater flexibility to transform their operations and meet the ever-changing demands of their customers.

Despite the undeniable benefits of cloud computing technology, banks have been slow in fully adopting it. According to sources cited by Forbes in July 2019, including the Financial Times, many financial institutions are falling behind in their goals to embrace innovation. Security concerns are identified as one of the main obstacles to cloud adoption in the banking sector.

Regulatory implications also impact the speed of cloud adoption. Banks must ensure service continuity for their clients during the migration to the cloud and have contingency plans to revert to in-house databases in case of any failures with cloud services. The European Banking Authority has provided recommendations to financial organizations regarding cloud migration, emphasizing the importance of data protection, risk mitigation, and other security concerns.

The adoption of cloud-based technology in the banking industry requires the consideration of the interconnected interests of banks, regulators, and cloud service providers. Collaborative efforts among all stakeholders are essential to accelerate the migration process to the cloud and achieve successful outcomes.

The following section shows some case studies on cloud adoption by banks in global context.

Box-1: ING Bank Builds a Hybrid Cloud

"ING, a global banking and financial services organization with assets in excess of $1.7 trillion, is investing in cloud computing. In 2008, ING had many data centers (16 in the Netherlands alone) which were obsolete, saturated and inefficient, with a fragmented architecture and slow processes. The costs were 24 percent above the market average. A first phase of a project to consider cloud computing brought the elimination of 13 data centers, virtualizing over 6000 servers and 350 applications. It has cut by 35 percent the number of managers and created new teams for the direct support to internal customers and delivery processes. In early 2011, new business pressures triggered another round of interventions; ING created a private cloud going down to six data centers. It has implemented a virtualization of the servers, desktops, and applications. Now the bank is considering becoming a broker of internal and external services on the cloud. ING's investment involves the construction of a large hybrid cloud. It combines the features of public clouds and private data centers. ING hopes that other banking and financial service organizations will use this investment. The hybrid or shared ICT infrastructure helps to bring forth variable costs, scalability, flexibility, and on-demand availability. These benefits should help overcome the concerns of banks and financial services organizations. Those concerns are related to security, compliance, and performance procedures that financial services organizations follow in their internal data centers. With a hybrid approach, ING will start with total control over the physical environment in which servers, storage, and applications reside. As public cloud service level agreements are better understood and as regulations develop, more solutions can shift to cheaper and easily scalable cloud venues."

Source: Alexander, S. (2011)

Box-2: The Commonwealth Bank of Australia (CBA)

"The Commonwealth Bank of Australia (CBA) stated that they would never buy another rack, server, storage, or network device again. It aims not to be locked into proprietary hardware, software, or network solutions. The Sydney-based Commonwealth Bank of Australia is a member of the Tele Management Forum's Enterprise Cloud Leadership Council, which evaluates vendors on the use of their cloud services. CBA's comments encapsulate the two clearest benefits of cloud computing for financial institutions:

- The ability to buy on demand computing capacity, storage, network, bandwidth and so on. In this way, it is possible to pay only for what is used rather than buying hardware or software up front or paying a pre-set annual subscription fee; and
- The speed and ease of provisioning and managing hardware, software and network services when the institution goes into a private or public cloud."

Soruce: Crosman, P. (2010)

Box-3: Cryptomatic the Market's First Cloud Wallet

"Cryptomatic has invented what it claims as the market's first Cloud Wallet. The Cloud Wallet enables a secure payment application to run off a connected trusted platform that is accessible through a network such as Internet. It securely links the user and all their devices – such as smartphones, tablets, or personal computers – to their wallets."

"Visa, the credit-card scheme, used cloud computing to crunch two years of test records, or 73 billion transactions amounting to 36 terabytes of data. The processing time fell from one month with traditional methods to 13 minutes."

Source: (2012) "Cryptomatic invents cloud wallet," Payments Cards/Mobile, March–April

Box-4: La Caixa Achieves Business/ICT Alignment

"La Caixa is Spain's largest savings bank and the country's third largest finance organization. La Caixa follows a multichannel management strategy that leverages advanced technologies and skilled employees to provide high quality and comprehensive banking services to its customers.

To power its 5300-plus locations and network of more than 8000 ATMs (the largest in Spain), La Caixa relies upon a complex technology landscape comprising large mainframes, thousands of servers, and more than 1000 network devices.

La Caixa worked with external consultants to define a multigeneration plan to move in the direction of a private cloud. The first phase was the installation of automation tools. In this way, La Caixa was able to enforce compliance in an automated manner."

"The project is multiphase:

- In phase one, the team carefully mapped the written security policies into rules – ensuring strict adherence going forward. The first phase in the transformation project includes virtual and physical server provisioning and server and network device monitoring;
- Phase two of the project expands the solution to all platforms in La Caixa's infrastructure. It adds further automation and self-service features. This phase also introduces a single, consolidated configuration repository and customized management dashboards. In this way, it sets up the basis for a lower-cost internal cloud computing service delivery model; and
- Phase three offers support and maintenance services. They will keep the bank's ICT services running at peak performance for years to come."

Source: (2011) "La caixa achieves business/IT alignment," Unisys case study, http://www.unisys.com/unisys/inc/pdf/casestudies/11–0055.pdf, Retrieved May 13, 2012.

Box-5: AmBank Places Sourcing Function in the Cloud

"Malaysia-based AmBank Group moved its sourcing function into the cloud after signing a deal with a third-party service vendor. The financial services institution wanted to optimize procurement and spend management, and to drive savings and efficiencies across its operations. AmBank decided to use a cloud services vendor in order to use best practice processes to improve the effectiveness of its operations.

The solutions enable AmBank to identify opportunities for significant savings opportunities across a number of spend categories and to incorporate visibility and rigor into its internal processes"

Source: http://www.procurementleaders.com/news-archive/news-archive/ambank-deposits-sourcing-function-in-the-cloud?highlight=cloud%20banking. Retrieved June 4, 2012.

Box-6: The Spanish Bank Bankinter Uses a Cloud Service as an Integral Part of Their Credit Risk Simulation Application

"Bankinter develops and run complex algorithms to simulate diverse scenarios for evaluating the financial health of its clients. This requires heavy computational power to process at least 400,000 simulations in order to get realistic results. By using the cloud, the bank was able to carry out a simulation reducing the time on the average necessary from 23 hours to 20 minutes."

Soruce: (2012) AWS Case Study: Bankinter, http://aws.amazon.com/solutions/ case studies/bankinter/ Retrieved August 17, 2012.

Box-7: Adoption of Cloud in the Banking Industry – India Success Stories

"There are several early success stories of banks in India adopting cloud computing for optimizing their processes, reducing their costs, and building the capability to scale rapidly. Some of the known/published references are discussed below. It is worth noting that while Urban Co-operative Banks (UCBs) and Regional Rural Banks (RRBs) have been early adopters of cloud computing, as described below, we can expect that larger banks will move towards cloud services as regulatory issues and security challenges are addressed.

Two major software solution providers have provided their Core Banking Solutions (CBSs) to UCBs, RRBs, and district co-operative banks through their own data centers. Some of the major UCBs have also been providing IT support to the small UCBs while leveraging collaborative arrangements among themselves for sharing common IT infrastructures such as data centers and ATM networks. It was observed that these banks were located across India, the geographical proximity or separation was neither a constraint nor a contributory factor, and cloud services were geography-neutral due to availability of good telecommunications networks.

FIs such as Kotak Mahindra Life Insurance, Reliance General Insurance, and IndiaFirst Life Insurance have adopted virtualization solutions to help improve efficiencies of their data centers. Dhanlakshmi Bank has opted to move all of its non-core banking applications to a virtualized solution allowing reuse of old storage boxes. Nawanagar Co-operative Bank has engaged with a cloud service provider to deploy CBS on a hosted cloud services model. ShamRao Vithal Bank partnered with a cloud service provider to offer cloud-based solutions to other co-operative banks in its region.

India is home to a large number of urban and rural co-operative banks. These banks are facing challenges in many aspects and are trying to transform themselves in a complex business environment. Stiff competition is also putting banks under pressure to become more efficient and agile. Four co-operative banks in India – The Co-operative Bank of Rajkot (Gujarat), Shivajirao Bhosale Sahakari Bank (Maharashtra), Goa State Cooperative Bank, and Tumkur Veerashaiva Co-operative Bank (Karnataka) – have adopted hosted solutions to improve their operational efficiency and compete more effectively. As per the company's media release, this solution will enable these banks to set up a cost-effective and energy efficient data center to offer new services like ATM, mobile banking, and online banking to customers. As a customized, pre-packaged data center primarily for small and medium businesses, the solution will also help the banks reduce their energy consumption by 2%.

Pondicherry Co-operative Urban Bank uses a cloud computing solution to offer more customer-centric services and to establish a robust banking operation. By implementing this multi-tenant IaaS on the cloud, the bank will be able to offer state-of-the art financial solutions to its customers including Internet banking, online money transfer, ATM, and mobile banking. This will also help the bank to centralize its mission critical operations such as real-time transaction processing across its six branches in Pondicherry. This is implemented as a shared private cloud for compute and storage with the ability to rapidly provision capacity for additional branches as required.

YES Bank has adopted cloud computing and has been an early adopter of cloud-based services in banking with the first implementation in payments, online account opening, and remittance services. Cloud computing provides the bank flexibility in faster provisioning at a low cost.

Meghdoot is an open cloud initiative of the Centre for Development of Advance Computing (C-DAC), a cloud computing environment completely based on free and open source software. The Indian Banking Community Cloud has been established using Meghdoot in the Institute for Development and Research in Banking Technology (IDRBT), Hyderabad (established by the RBI). The community cloud was inaugurated by the Governor of the RBI and currently six banks have applications ported into the Meghdoot cloud."

Source: The Open Group (2015)

5.0 Findings and Analysis

5.1 Awareness of Cloud Computing in Different Levels of Banks

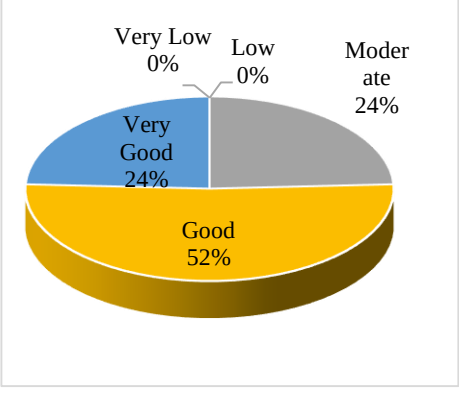
Figure-3 (a and b) illustrates that 24 percent of the CTOs/HoITs/CIOs has a very good level of understanding regarding cloud computing. Almost same level of knowledge is seen in case of IT teams of banks. HoITs and the IT teams are the key implementers of cloud technology in banks, so they must have an excellent understanding of the technology. Otherwise, it will bring negative results for the organization. Board Members and Top-Level Management are the ultimate policy and decision maker. So, they need a clear understanding of the technology. Understanding of Top-Level Management and Board Members regarding cloud computing is shown in figure-3 (c and d).

5.2 Participation of Local and International Programs (CTOs/HoITs/CIOs)

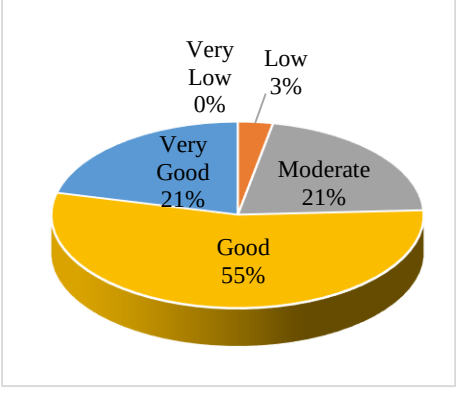
Figures 4(a) and 4(b) depict the percentage of CTOs/HoITs/CIOs who attended different local and international programs in last two years. It is seen that 57.6 percent of the respondents attended local seminars and vendor-programs. The scenario is different in case of international programs. Only 15 percent respondents attended international programs organized by vendors and 12 percent respondents attended cloud computing related international meetings. The graphs also indicate that participation in different programs in home and abroad by CTOs/ HoITs/ CIOs is satisfactory.

Figure-3: Understanding about Cloud Computing

(a) CTOs/HoITs/CIOs



(b) IT Team



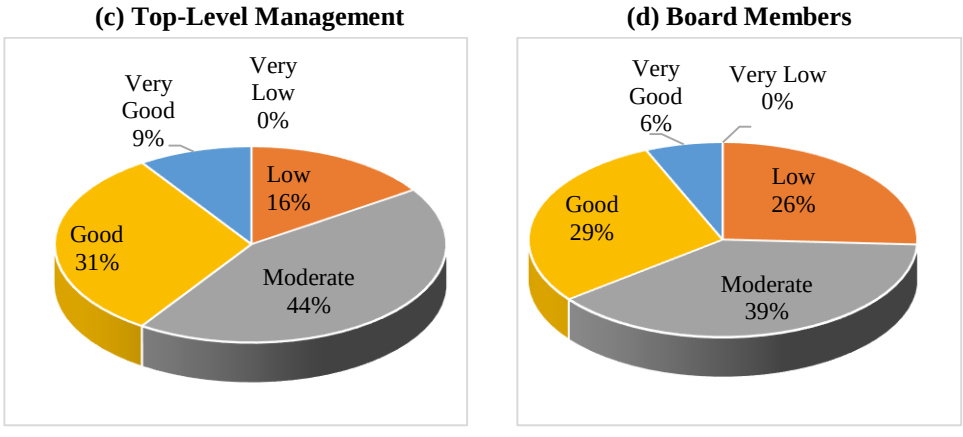
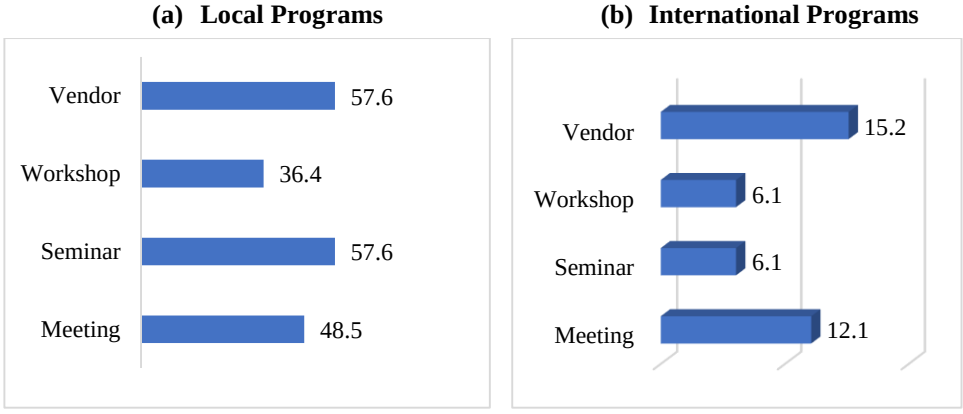


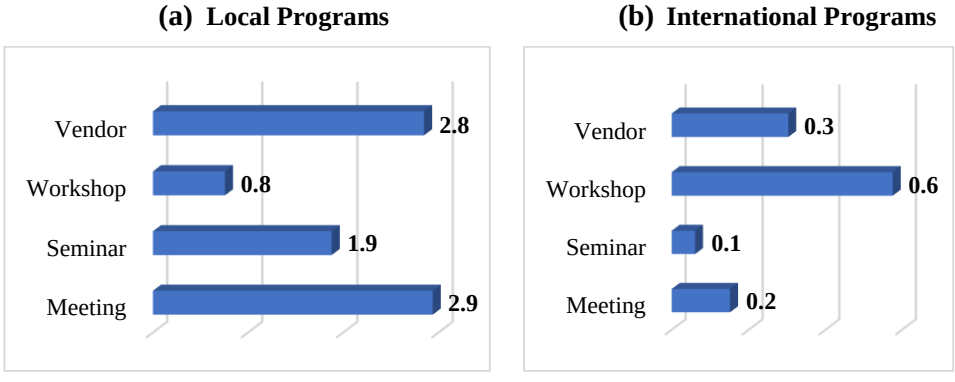
Figure-4: Percentage of CTOs/HOITs/CIOs Attended in Different Programs in last two years



5.3 IT Employees Attended in Different Local and International Programs

IT employees are the critical enablers of implementing new technologies in banks. The survey found that the average number of IT employees attending different meetings on cloud computing programs were 2.9 and 2.8, respectively. On the other hand, average 0.6 IT employees attended different international programs. Before implementing new technologies, acquiring knowledge from national and international sources is essential. However, IT employees need to attend various programs in the local and international domains.

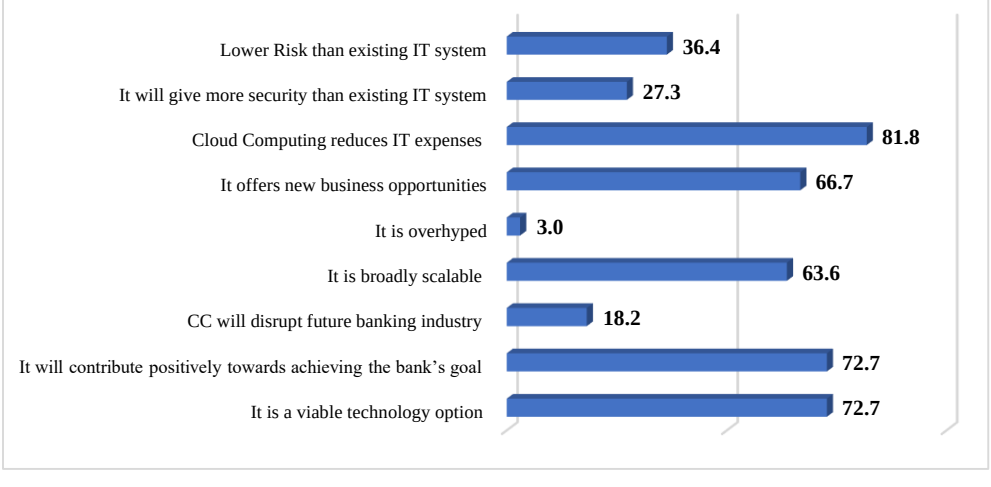
Figure-5: Average No. of IT Employees Attended in Different Programs in last two years



5.4 Perception of HoITs regarding Cloud Computing

The following figure shows the perception of the Heads of Information Technology (HoITs) regarding cloud computing. Approximately 82 percent of the HoITs agrees that cloud computing reduces costs.

Figure-6: Perception of Heads of IT Regarding Cloud Computing (% of HoITs)

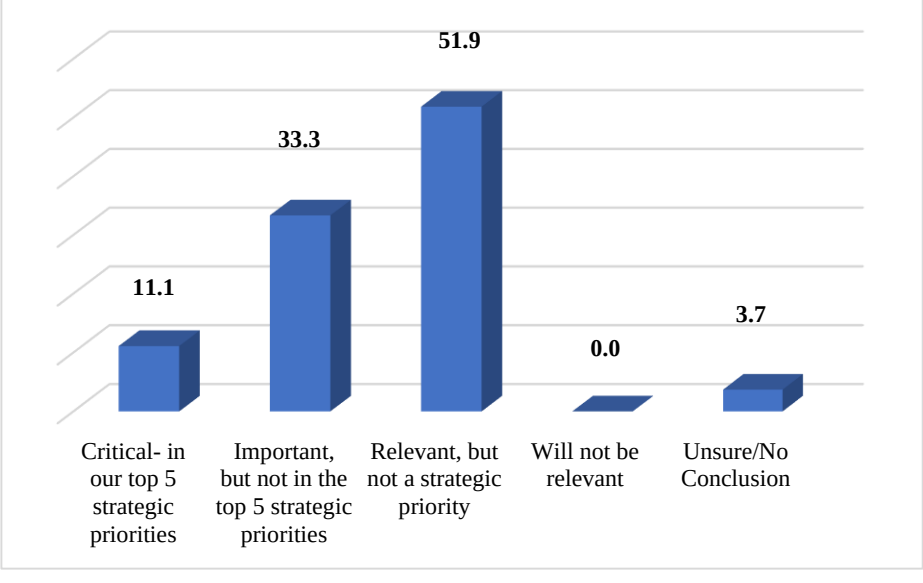


About 72.7 percent believe that cloud computing will contribute positively towards achieving the bank's goal and is a viable technology option for banks. Very few think that the technology is overhyped, which indicates that the future of this technology in banking is constructive. However, many believe the technology will bring new business opportunities for banks.

5.5 Relevance of Cloud Computing in Banks

Figure-7 shows the relevance of cloud computing in banks. It is seen from the survey that 51.9 percent of banks agree that cloud technology is relevant for them but not a strategic priority. On the other hand, only 11 percent of banks set cloud technology as critical in their top five strategic plan. About 33.3 percent of banks have given importance, but it is not in the top-five strategic priorities. Around 3.7% banks are not sure about the relevance of cloud computing in banks.

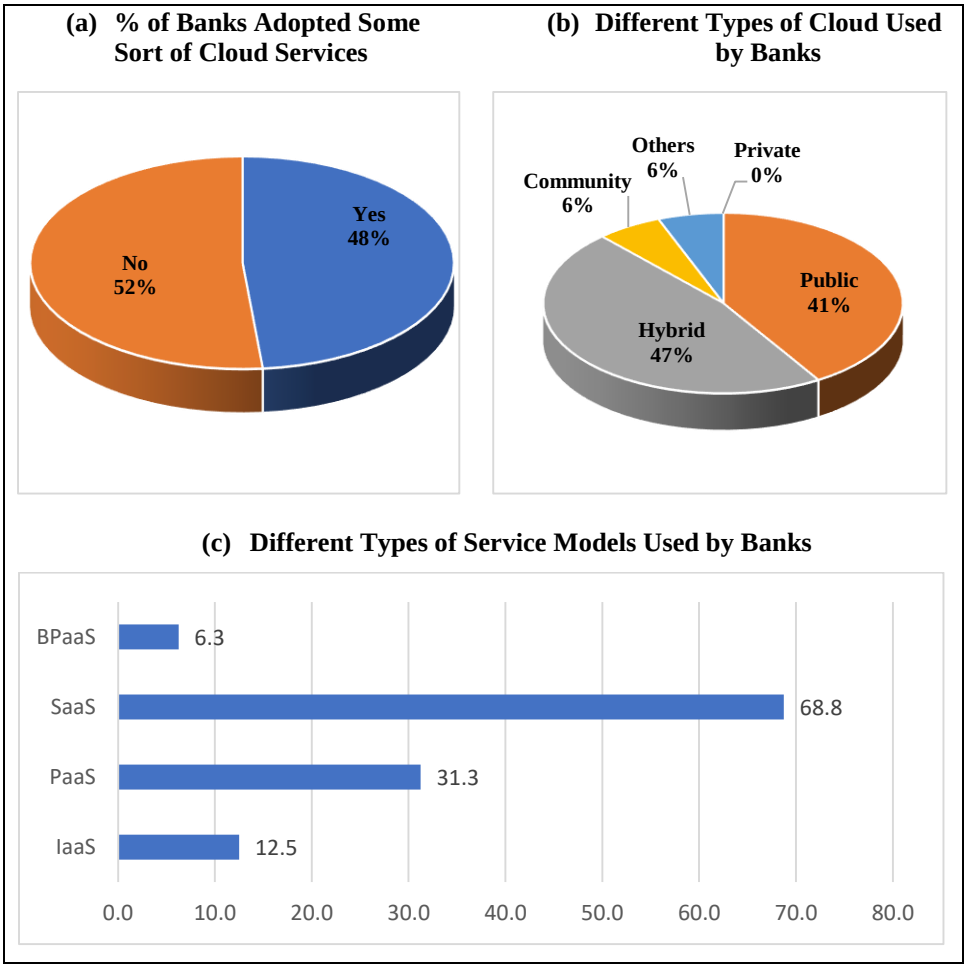
Figure-7: Relevance of CC in Banks (% of Banks)



5.6 Status of Cloud Services Adoption in Banks

Figure-8 illustrates that 48 percent of banks adopted some sort of cloud services. The respondent banks that adopted cloud services in hybrid and public clouds. It is seen that 47 and 41 percent of banks used hybrid and public clouds, respectively. However, banks use different cloud service models like SaaS, PaaS and IaaS offered by cloud service providers. The survey shows that approximately 68.8 percent of banks use SaaS and 31.3 percent use the PaaS model. Very few banks use IaaS and BPaaS as cloud service models.

Figure-8: Cloud Services Adoption in Banks



The services that banks have already adopted from cloud service providers are: Microsoft 365 services, Email security, Web security, Microsoft Exchange Server, Oracle Management Cloud, Video Conferencing System, Zero-day attack prevention, Mobile Device Management, Face Matching Service for e-KYC, End user behavior analysis, Vulnerability assessment, Secure web gateway, Next generation firewall, Project Plus, Adobe PDF Writer, Bulk Mail Service, Helpdesk, Web Hosting, ERP, etc.

5.7 Factors Preventing Cloud Adoption

Table-2 identifies some critical factors based on the rank sum approach that hinder the adoption of cloud services in banks. Legal and regulatory compliance gets the highest ranking among all other factors, followed by data security, loss, and leakage risk. It is also seen that government restrictions and the complexity of moving applications to the cloud are critical factors that are preventing banks to move into cloud services. However, factors like integration with the existing IT environment, fear of vendor lock-in, and expensive/budget constraints have rank sum values greater than 100 that adversely affect banks' cloud adoption.

Table-2: Factors Preventing Cloud Adoption

Sl. No.	Factors	Rank Sum
1.	Legal and regulatory compliance	177
2.	Data security, loss and leakage risks	160
3.	Security concerns	159
4.	Government restrictions	157
5.	Complexity of moving application to cloud	146
6.	Loss of control due to third party management	134
7.	Integration with existing IT environment	122
8.	Fear of vendor lock-in	113
9.	Expensive/Budget constraints	108
10.	Lack of staff resources or expertise	91
11.	Internet speed	87
12.	Decreased flexibility: Special customization not possible	84

5.8 Planning to Migrate into Cloud in Next Two Years

Though 48 percent banks have adopted cloud services partially, rest of the 52 percent banks are planning to move into cloud services by the next two years. Approximately 70 percent of those banks (52% of total) that do not have cloud services are willing to adopt it within the next two years. Table-3 shows the percentage of banks that are planning to adopt various services

from cloud service providers. It is seen that about 62 percent of banks are willing to get IT support services, followed by office automation (38%), human resource management (38%) and CRM (38%). Twenty-four percent of banks expect to adopt call center facilities and 19 percent show eagerness to adopt various application software from cloud service.

Table-3: Expected Services from Cloud Service Providers

Sl. No.	Expected Services	% of Banks
1.	Office Automation	38.1
2.	IT-Services Support	61.9
3.	Human Resource Management	38.1
4.	Enterprise Resource Planning	19.0
5.	Customer Relationship Management	38.1
6.	Governance	14.3
7.	Call Center	23.8
8.	Risk Analysis and Management	19.0
9.	Control and Compliance	14.3
10.	Application software	19.0
11.	Digital Innovations	14.3
12.	Software for overseas exchange house	4.8

5.9 Preference of CSPs and Services by Banks

The following figures (9 and 10) show the preferences of service providers (CSP) by the respondent banks, along with the expected services from the CSPs. It is seen that most banks preferred AWS (61.5%) followed by Microsoft Azure and Oracle Cloud. However, services from local cloud providers are demanded by 23 percent banks. SaaS is preferred (69.2) by Bangladeshi banks followed by PaaS (53.8) and IaaS (46.2).

Figure-9: Preferred Cloud Companies by Banks (% of Banks)

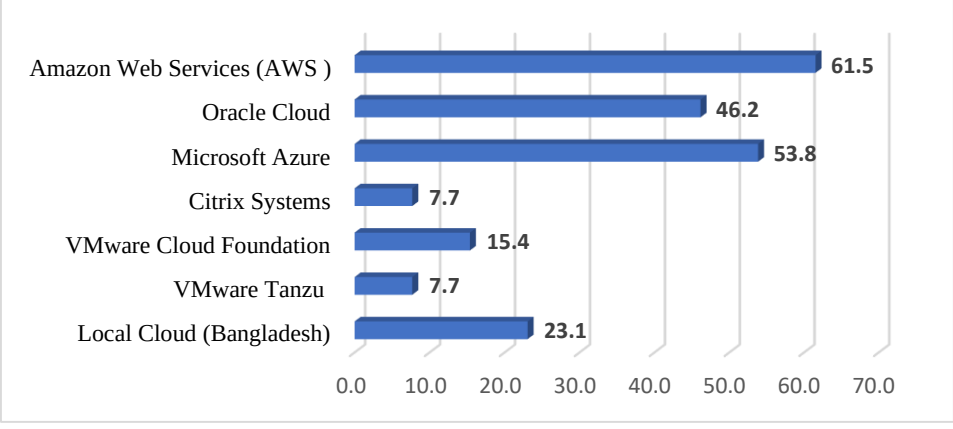
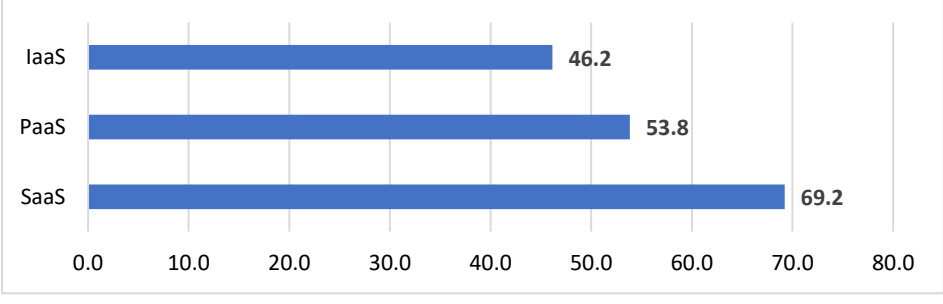


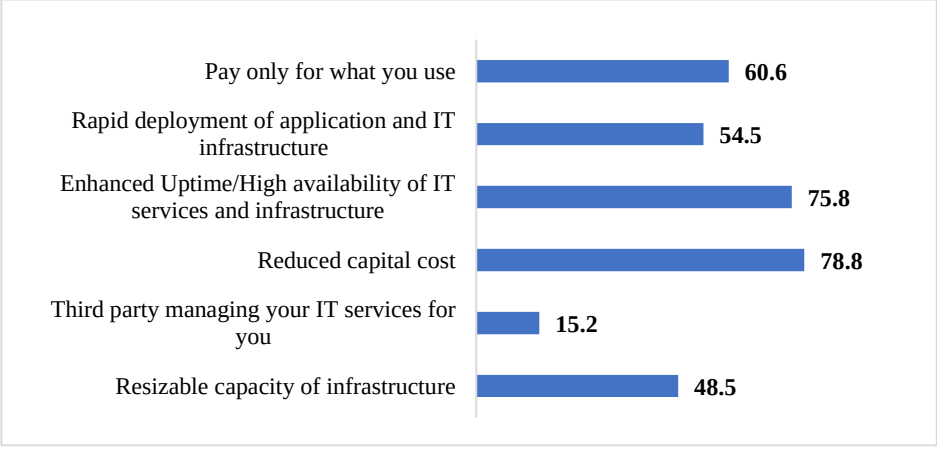
Figure-10: Preferred Services from Clouds (% of Banks)



5.10 Factors that will help the Adoption of Cloud Computing in Banks

Figure-11 portrays the factors driving the banks to adopt cloud computing. 78.8 percent of the respondents believe that cloud computing reduces capital cost, followed by high availability of IT services and infrastructure. Designing, developing, and maintaining a data center, disaster recovery (DR) site and a far DR are becoming complex for banks. So, the two vital factors, reduced capital cost and high service availability, inspire banks to move into cloud service. However, pay-per-use and rapid deployment of applications and IT Infrastructure are other factors that responded by 61 percent and 55 percent, respectively.

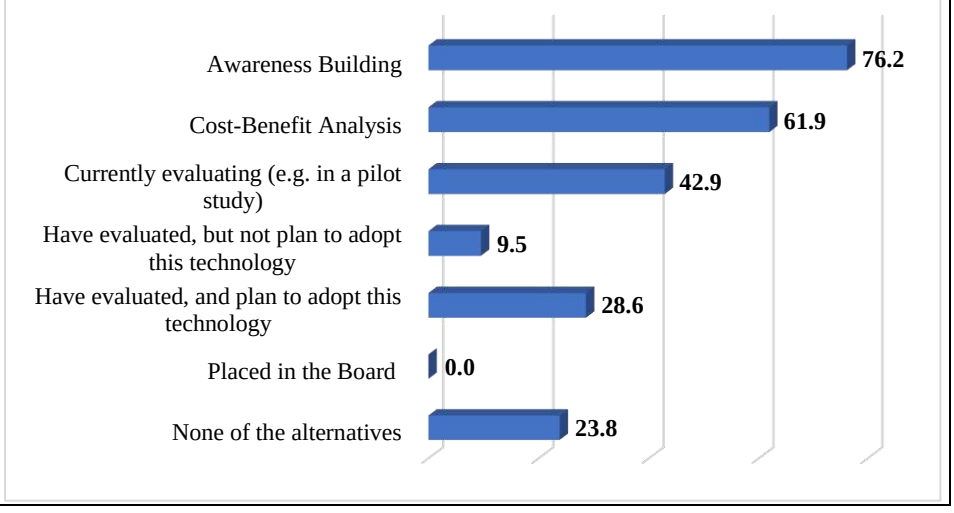
Figure-11: Factors that will Drive Banks into Adopting Cloud Computing



5.11 Current Position of Banks regarding Cloud Adoption

About 52% of banks do not use any cloud services in Bangladesh. The survey shows that approximately 76 percent of the banks who have not adopted any cloud-based services are building awareness regarding Cloud Computing, whereas sixty-two percent of banks have already analyzed the cost and benefits of the services. Some banks are evaluating the service; others have already assessed and plan to adopt cloud technology. It is also seen that 24 percent of the banks do not take any initiatives regarding cloud computing services.

Figure-12: Current Position of Banks regarding Cloud Adoption (% of Banks)



5.12 Cloud Computing Opportunities Identified by Banks

The following table summarizes the opportunities of cloud computing identified by the banks.

Table-4: Cloud Computing Opportunities

Sl. No.	Opportunities	% of Banks
1.	For developing countries like Bangladesh Cloud Computing aims to provide the clients a cost effective and convenient means to manage the huge amount of IT resources (Banks and FIs will not have to invest heavily in dedicated hardware, software, and its implementation) and thus offer strong possibility of accelerating social and economic development, even in this time of limited resources.	74
2.	Cloud computing will unveil the opportunity to deploy service faster. Compared to legacy investments, cloud computing will offer a greater return on investment and the benefits of a contemporary, scalable, and secure infrastructure.	84
3.	Cloud computing will provide a massive level of redundancy and data backup at a low cost. Banks and FIs can achieve greater levels of fault tolerance, data protection and disaster recovery capabilities by adopting Cloud Computing for the business-critical services.	96
4.	Banks and Financial Institutions (FIs) can leverage the processing power of Cloud Computing to analyze customer data real-time using AI and advanced analytics. With analysis available instantly, Bank or FI can understand customer behavior and engage proactively by providing individual customer a sense of personalization.	89
5.	The standardization in Cloud Computing eliminates the complexity of integrating new systems and services with the existing systems, as a result banks and FIs will be able to roll out new products and services much faster.	70
6.	All the major banks run their own data centers, which house computer servers that process vast troves of customer account data, payment records and trading logs. Running the machines is costly because they require a lot of electricity and need to be kept in air-conditioned rooms. So, here is a huge scope of reducing cost and consumption of energy by incorporating cloud computing in Bangladeshi Banks	70

7.	Cloud computing allows employees to be more flexible in their work practices employee can access data from home, on holiday, or via the commute to and from work and it ensure no data loss or leakage of data.	84
8.	Cloud computing or services are usually flexible, and the business can expand or reduce them as needed for organizational changes, market demands and cyclical business models, and to respond to unexpected opportunities/challenges. Cloud computing or services allow the business to focus on its core operations, and enable its IT personnel (if any) to focus on supporting its initiatives.	78

5.13 Expectations of Banks from Bangladesh Bank

Bangladesh Bank has taken numerous actions for smooth e-banking operations in our country. However, bankers are expecting more from the regulator. The following table shows some of the expectations regarding cloud computing from Bangladesh Bank.

Table-5: Expectation from BB

Sl. No.	Expectations	% of Banks
1.	Bangladesh bank may prepare a well-defined guideline for using cloud. A strong policy ensuring security for deployment cloud computing is highly expected.	94
2.	BB may arrange awareness sessions/meetings for senior management regarding cloud computing.	84
3.	Bangladesh Bank may take initiatives to develop a community cloud where all banks will participate. Bangladesh Bank may introduce Cloud friendly software (SaaS) for regulatory and monitoring purpose (Example: CIB, IAS, e-KYC etc.) including APIs.	90
4.	Bangladesh Bank may formulate appropriate polices for cloud service providers serving the banks. BB may publish a list of cloud service providers with ranking regularly (quarterly/half-yearly/yearly) to reflect the support service track record. It will create healthy competition between CC service providers and influence other banks to adopt further services to migrate.	64
5.	Bangladesh Bank may monitor and guide the cloud computing implementation of financial and non-financial institute. BB could	78

Sl. No.	Expectations	% of Banks
	monitor the security and data protection measures banks must ensure to use CC capabilities.	
6.	BB may provide legal and regulatory compliance issues for service providers.	64
7.	Bangladesh Bank could assign a dedicated monitoring and audit team to check all the cloud computing service providers. CC service providers should be audited frequently to check the error logs, customer complaints and resolutions. The audit team may be formed with certified experts on Cloud Computing technology.	78
8.	The regulator (Bangladesh Bank) might assist Bangladesh Government for developing local cloud infrastructure. Central Bank may work with relevant policy makers and the government so that the national cloud policy allows the banks to benefit from expertise and services of the world class International Cloud Service providers while safeguarding sensitive data (as opposed to restricting it altogether).	54

5.14 Expectation from Bangladesh Government

With the vision 2041, Bangladesh Government is proactively taking number of initiatives for ensuring a sustainable digital economy. As part of digital vision of Bangladesh government, the financial sector gets top priorities. Respondent banks have some more expectations from digital friendly government. The following table demonstrations some of the important expectations regarding cloud computing from Bangladesh Government.

Table-6: Expectation from Bangladesh Government

Sl. No.	Expectations	% of Banks
1.	Government may adopt data privacy and security law like GDPR (General Data Protection Regulation) for data security and cross border agreement for data sharing and ensure its executions accurately. As a result, banks in Bangladesh will be inspired and encouraged to procure cloud computing services.	90
2.	Bangladesh Government may make legal agreement with the world's leading cloud service providers regarding Data Privacy and Security.	78

Sl. No.	Expectations	% of Banks
3.	Bangladesh Government may encourage well-known Cloud Platforms Like Oracle, AWS, and Microsoft Azure to invest and setup private cloud within our country. This will build trust for the financial organizations that data will be within Bangladesh and in case of any forgery activity organization can enforce Bangladeshi law. Cloud market player presence in Bangladesh will boost the cloud computing usages.	96
4.	Government may introduce policy and take long term plan to bring out many local Cloud Service Providers (CSPs) to encourage development of local cloud infrastructure limit the foreign dependency.	84
5.	Bangladesh Government may help to develop Information Security Insurance company.	64
6.	Government may have control on overall price cap of cloud related services.	52
7.	Availability of high-speed Internet connections with strong stability and lower cost for organizations may be ensured by the government to adopt CC.	84
8.	Government may plan for developing high quality manpower for cloud market.	72
9.	Bangladesh Government has already introduced cloud service to Government and Non-Government organizations known as National Data Center (NDC). NDC maintains cloud services with global standard and accepted procedures but should enhance the existing connectivity features for cloud computing.	42

5.15 Challenges and Remedies

Cloud Computing has numerous benefits in banks although it has some challenges. Beyond the theoretical concepts, practical challenges are much more complex and difficult to handle. The following challenges with probable solutions of cloud computing in banks have been identified by the respondent banks.

Table-7: Challenges and Remedies

Sl. No.	Challenges	% of Banks	Probable Solutions
1.	Govt./Regulatory Restrictions	96	Government and Central Bank may consider withdrawing restrictions on storing sensitive data in local/international cloud inside/outside Bangladesh with setting up proper control and safeguard of the information with due approval process.
2.	Risk Mitigation/Vendor Lock-in/ Performance/ Availability	84	When business applications move to a cloud or a third-party vendor performance starts to depend on service provider as well. Investing in the right cloud service provider is a challange. Before investment, we should look for providers with innovatory technologies. The performance of cloud-based systems are linked to the provider's systems as well. Be cautious about choosing the provider and investigate that they have protocols to mitigate issues that arise in real-time. Increased application resiliency is needed to ensure continuity by greater range of infrastructure in multiple clouds (data centers) and geographies. Service provider must be available when required. The main focus should be given on sustainability and reputation.
3.	Dependency on Foreign Cloud Infrastructure	64	Establish effective local cloud infrastructure. Data should reside in local clouds of our country to ensure privacy. Bangladesh Bank may take initiatives to develop a community cloud where all banks will participate. Government may review and plan to leverage the service in BD or plan to setup such for all the Bangladeshi Banks.
4.	Data Privacy/ Security	96	The topmost concern in investing in cloud services is security issues in cloud computing. It is because data gets stored and processed by a third-party vendor and we cannot see it. Cloud service user and Cloud Service Providers should ensure all critical data are encrypted and only

Sl. No.	Challenges	% of Banks	Probable Solutions
			authorized users should have access to the data. Enhanced Information & Cyber Security posture is required. Bank can adopt cloud computing technology phase-wise considering the security concerns. Cloud security is different from on premises security; hence we need to ensure security as per cloud security standard. Strong SLA needed containing right to audit, penalty on security breach, arbitration clauses etc. with Cloud Service Providers (CSPs).
5.	Integration with Existing IT Environment/ Complexity of Moving Application to Cloud	84	Compute capacity to meet business needs – scale up or down. Banks need faster integration and development of new business models with clients, business partners and market places. Cloud computing services should have the capacity to integrate smoothly with the on-premise IT. Banks may conduct extensive PoC with OEMs and their partners.
6.	Cost Effectiveness	48	For greater cost transparency and control, reduce spend on procuring hardware & facilities and the associated operations by moving to on-demand usage of IT services on a pay-as-you-go. OEM should offer minimal charges for SLA and AMC. Government may give tolerable price cap.
7.	Legal Framework/ Data Sovereignty Regulations	84	Banks seek legal framework in place for adopting cloud computing. Banks must ensure local and international legal stuffs are aligned in the field of CC to ensure data sovereignty and educate CC users accordingly. Regulatory policy and guidelines is required.
8.	Lack of Expertise and Awareness	96	With the increasing workload on cloud technologies and continuously improving cloud tools, the management has become difficult. There has been a consistent demand for a trained workforce who can deal with cloud computing tools and services**.** Proper training/workshop/

Sl. No.	Challenges	% of Banks	Probable Solutions
			seminar should be arranged by banks/BIBM/BB on regular basis to get aligned with latest technology of CC.
9.	Control/ Governance	64	Maintaining proper control over asset management and maintenance is another issue. There should be a dedicated team to ensure that the assets used to implement cloud services are used according to agreed policies and dedicated procedures. There should be proper maintenance to ensure that the assets are used to meet organization's goals successfully. The team should have the ability to acquire frictionless IT services and automation of software deployment and maintenance processes. Bank's IT team should focus on banking products/process and Cloud Service Provider should focus on IT infrastructure and facilities.
10.	Bandwidth and Availability of Network	84	Network service providers should improve quality and upgrade nationwide existing network with latest technology (4g and 5g). Two or more vendors may be engaged to ensure uninterrupted bandwidth.
11.	Budget Constraints	48	Conduct cost-benefit analysis and justifying the investment. Top level management should be aware about the benefits of cloud adoption.

5.16 Summary of the Focused Group Discussion (FGD)

A number of senior IT professionals (Appendix-3) from Information Technology Department (ITD) of banks participated in the FGD. They gave their opinions regarding CC. Some important issues are summarized in the following box.

Box-8: Summary of the Focused Group Discussion (FGD)

1. Majority of the participants have positive attitudes regarding cloud computing adoption (88%).
2. Most of the participants stated that cloud computing can be cost effective for some services (85%).
3. Many believe that community cloud can be a viable solution for banking sector of Bangladesh (70%). Central bank may take initiative to create one public or community cloud platform for banks and NBFIs.
4. Security is one of the key concerns regarding cloud computing (80%).
5. The retention of employees who have expertise in the field of cloud is also a major concern, as they tend to switch the more when they get better option (65%).
6. Banks will act as an operator if they use Software as Service from the foreign Cloud Service Providers (60%).
7. There may be geopolitical issue when it comes to public cloud (55%).
8. If the banks jointly create a cloud through SDN then renew and extension procedures will be easier (55%).
9. Banking sector has lack of expert human resources in cloud computing (75%).
10. The terms and condition of the cloud are ambiguous and it is difficult to understand without having in-depth understanding of cloud computing (60%).
11. There is no trial and error scope for large size State Owned Commercial Banks, so they need proven business model related to cloud computing (40%).

5.17 Roadmap to Introduce CC in Banks

Cloud adoption strategy may vary from bank to bank due to the size, human resources, capital base and technological capacity. Based on the opinions by the expert IT executives from banks, the research team suggests the following roadmap that may be followed by the banks in three different phases.

Box-9: Roadmap to Introduce CC

1. Awareness Development
2. Convincing the management by putting the visible advantages
3. Aligning the organizational objectives
4. Assessment and Cost Benefit Analysis
5. Planning for Deployment
6. Arrange training for developing skilled workforce
7. Assess security, risk and business impact for every service which is shifting into cloud
8. Choosing the most suitable service delivery model
9. Identifying the right vendor for right service
10. Evaluate the SLA
11. Ensure compliance issues (wait for the guidelines of BB) and make deeds and SLAs carefully
12. Migration to the cloud
13. Configure the services
14. Test the operations
15. Identify the Gaps
16. Optimize, review and make changes
17. Perform UAT and UVT
18. Go for live operation
19. Monitor and evaluate the services continuously
20. Go for immediate mitigations

Phase-1: Low dependency/Non-Critical Services (Email, Storage, CCTV recording, Data Analytics, CRM, Help Desk Management, Incident Management, etc.)

Phase-2: Critical Services (HRMS, Remittance Management, In-House Developed Applications)

Phase-3: Most Critical/Advanced Services (CBS including Database, Card System, I-Banking, MFS, Foreign Exchange Transaction Monitoring etc.)

6.0 Identified Challenges, Recommendations and Conclusion

One, Govt./ Regulatory Restrictions:

A very clear direction is required from the Central Bank and Government to move into cloud adoption. Government may adopt data privacy and security law like GDPR (General Data Protection Regulation) for data security and cross border agreement for data sharing. Government and Central Bank may consider withdrawing restrictions on storing sensitive data in local/international cloud inside/outside Bangladesh with setting up proper control and safeguard of the information with due approval process.

Two, Risk of Cloud Service:

When business applications move to a cloud or a third-party vendor performance starts to depend on service provider as well. The performance of cloud-based systems are linked to the provider's systems also. Service provider must be available when required. The main focus should be given on sustainability and reputation.

Three, Local Setup of International CSPs:

Bangladesh Government may encourage well-known Cloud Platforms like Oracle, AWS, and Microsoft Azure to invest and setup private cloud within our country. This will build trust for the financial organizations that data will be within Bangladesh and in case of any forgery organization can enforce Bangladeshi law. Cloud market player presence in Bangladesh will boost up the cloud computing usages.

Four, Local Cloud Service Development:

It is necessary to establish effective local cloud infrastructure. Data should reside in local clouds of our country to ensure privacy. Bangladesh Bank may take initiatives to develop a community cloud where all banks will participate. Government may review and plan to leverage the service in Bangladesh or plan to setup such for all the Bangladeshi Banks. Government may introduce policy and take long term plan to bring out

many local Cloud Service Providers (CSPs) to encourage development of local cloud infrastructure limiting the foreign dependency.

Five, Data Privacy and Security:

The topmost concern in investing in cloud services is security issues. Because data gets stored and processed by a third-party vendor and we cannot see it. Cloud security is different from on premises security; hence we need to ensure security as per cloud security standard. Strong SLA needed containing right to audit, penalty on security breach, arbitration clauses etc. with Cloud Service Providers (CSPs). Bangladesh Government may make legal agreement with the world's leading cloud service providers regarding Data Privacy and Security.

Six, Legal Framework /Data Sovereignty Regulations:

Banks seek legal framework in place for adopting cloud computing. Banks must ensure local and international legal stuffs are aligned in the field of CC to ensure data sovereignty and educate CC users accordingly. Regulatory policy and guidelines is required.

Seven, Expertise and Awareness Development:

With the increasing workload on cloud technologies and continuously improving cloud tools, the management has become difficult. There has been a consistent demand for a trained workforce who can deal with cloud computing tools and services**.** Proper training/workshop/seminar could be may arranged by banks/BIBM/BB on regular basis to get aligned with latest technology of CC.

Eight, Network Infrastructure Development:

Network service providers should improve quality and upgrade nationwide existing network. Availability of high-speed Internet connections with strong stability and lower cost for organizations may be ensured by the government to adopt CC.

Businesses have faced challenges in fully embracing cloud platforms due to regulatory compliance and security concerns. In order to safeguard cloud

platforms, providers must prioritize the security of virtualized datacenter resources, maintain user privacy, and uphold data integrity. Financial services institutions are gradually adopting cloud computing technologies, especially for mobile applications and innovation testing. It is crucial for banks to understand that this shift represents a "business model transformation" aimed at achieving enhanced business agility for future growth. The essential step is for each bank to commence developing a cloud reference architecture that will establish its successful approach.

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Appendices

Appendix-1: Questionnaire

Adoption of Cloud Computing in Banks: Opportunities and Challenges

Respondent Information (HoIT/CTO/CIO)			
Name		Cell Phone No.	
Designation/Rank			
Name of the Bank			
Bank Type	□ State-owned 1 □ Specialized 2 □ Private 3 □ Foreign 4		

(Please don't change any formatting or numbering of the questionnaire. For questions demanding opinion you may add spaces by entering new lines only.)

Section-A: Awareness of Cloud Computing (CC)						
1.	In which type of programs did you attend regarding CC in last two years (select all that apply)?					
		Meeting	Seminar	Workshop	Vendor Program	Others (Mention)
	Local	□	□	□	□	□
	International	□	□	□	□	□
2.	How many employees of IT department attended the following programs regarding CC in last two years?					
		Meeting	Seminar	Workshop	Vendor Program	Others (Mention)
	Local					
	International					
3.	Please rate your level of understanding about Cloud Computing? □ Very Low 1 □ Low 2 □ Moderate 3 □ Good 4 □ Very Good 5					
4.	Please rate the level of understanding of your IT team regarding cloud computing? □ Very Low 1 □ Low 2 □ Moderate 3 □ Good 4 □ Very Good 5					
5.	Please rate the level of understanding of your top management regarding cloud computing? □ Very Low 1 □ Low 2 □ Moderate 3 □ Good 4 □ Very Good 5					
6.	Please rate the level of understanding of your board members regarding cloud computing? □ Very Low 1 □ Low 2 □ Moderate 3 □ Good 4 □ Very Good 5					

7.	Following which options best match with your thoughts regarding CC (Please select all that apply)? ☐ It is a viable technology option 1 ☐ It will contribute positively towards achieving the bank's goal 2 ☐ CC will disrupt future banking industry 3 ☐ It is broadly scalable and will eventually achieve mainstream adoption 4 ☐ It is overhyped 5
	☐ It offers new business opportunities 6 ☐ Cloud Computing reduces IT expenses (e.g., IT devices, IT maintenances, etc.) 7 ☐ It will give more security than existing IT system 8 ☐ Lower Risk than existing IT system 9
8.	What is the relevance of CC in your bank? ☐ Critical- in our top 5 strategic priorities 1 ☐ Important, but not in the top 5 strategic priorities 2 ☐ Relevant, but not a strategic priority 3 ☐ Will not be relevant 4 ☐ Unsure/no conclusion 6
Section-B: Current Adoption Status	
9.	Did you adopt any services in the cloud? ☐ Yes 1 ☐ No 0
	If Yes, Which type of cloud did you adopt? ☐ Private 1 ☐ Public 2 ☐ Hybrid 3 ☐ Community 4 ☐ …….. Which service model did you adopt? ☐ IaaS 1 ☐ PaaS 2 ☐ SaaS 3 ☐ BPaaS 4 ☐ …….. Mention the name of the services/jobs/business you have adopted. ☐ …….. ☐ …….. ☐ …….. ☐ …….. ☐ …….. ☐ …….. ☐ ……..

If No,
Please select the factors preventing your bank from using the cloud. (Rank from Highest to Lowest by putting 12,12,11,…3,2,1 as needed)

Factors	Rank
Lack of staff resources or expertise	
Security concerns	
Complexity of moving application to cloud	
Loss of control due to third party management	
Not cheap enough/Budget constraints	
Decreased flexibility: Special customization not possible	
Govt. restrictions	
Legal and regulatory compliance	
Fear of vendor lock-in	
Internet speed	
Data security, loss and leakage risks	
Integration with existing IT environment	

Section-C: Future Plan

10 Does your bank have any plan to go to cloud in next two years? ☐ Yes 1 ☐ No 0

If Yes, mention the services you would like to adopt.

- ☐ Office Automation
- ☐ IT-Services Support
- ☐ Human Resource Management
- ☐ Enterprise Resource Planning
- ☐ Customer Relationship Management
- ☐ Governance
- ☐ Call Center
- ☐ RegTech
- ☐ Risk Analysis and Management
- ☐ Control and Compliance
- ☐ ……
- ☐ ……
- ☐ ……

11	Please mention the name, type and services you would like to get from different cloud service providers?		
	Name of the Cloud	**Type (Private, Public, etc.)**	**Service (PaaS, SaaS, etc.)**
12	How much budget do you have for CC for the next year?		Tk. ……
13	Please select the factors that will drive your bank into adopting cloud computing. □ Resizable capacity of infrastructure □ Third party managing your IT services for you □ Reduced capital cost □ Enhanced Uptime/High availability of IT services and infrastructure □ Rapid deployment of application and IT infrastructure □ Pay only for what you use		
14	At what stage of cloud computing adoption is your bank currently engaged in? □ Awareness Building □ Cost-Benefit Analysis □ Currently evaluating (e.g. in a pilot study) □ Have evaluated, but not plan to adopt this technology □ Have evaluated, and plan to adopt this technology □ Placed in the Board □ None of the alternatives		
Section-D: Security Concern			
15	What are your biggest cloud security concerns? (Rank from Highest to Lowest by putting 11,10,9,…3,2,1 as needed)		
	Factors		**Rank**
	Data loss/leakage		

	Data Privacy/ Confidentiality/ Unauthorized Access	
	Accidental exposure of credentials	
	Visibility and Transparency	
	Incident Response	
	Data sovereignty/ residency/ control	
	Insecure interfaces/APIs	
	External sharing of data	
	Hijacking of accounts, services, or traffic	
	Malicious insiders	
	Foreign state-sponsored cyber attacks	

Section-E: Special Thoughts

16 Please put your valuable opinions regarding the opportunities of cloud computing in Bangladeshi Banks?

17 Please mention the major challenges and probable solutions of Cloud Adoption in Bangladeshi Banks?

Challenges	Solutions

18	Would you like to suggest any roadmap to introduce CC in your bank?	
19	Kindly express your expectation from Bangladesh Government regarding Cloud Computing?	
20	Please write your expectation from the regulator (Bangladesh Bank) regarding Cloud Computing?	

Appendix-2: List of Respondent Banks

Sl. No.	Name of Banks	Sl. No.	Name of Banks
1.	Mercantile Bank Limited	19.	Mutual Trust Bank Limited
2.	EXIM Bank Limited	20.	Bank Asia Limited
3.	Global Islamic Bank Limited	21.	The City Bank Limited
4.	Trust Bank Limited	22.	National Bank Limited
5.	Agrani Bank Limited	23.	Midland Bank Limited
6.	Bangladesh Krishi Bank	24.	Habib Bank Limited
7.	Eastern Bank Limited	25.	Dutch-Bangla Bank Limited
8.	IFIC Bank Limited	26.	The Premier Bank Limited
9.	Padma Bank Limited	27.	Community Bank Bangladesh Limited
10.	Shimanto Bank Limited	28.	Al-Arafah Islami Bank Limited
11.	Bangladesh Development Bank Limited	29.	BASIC Bank
12.	Dhaka Bank Limited	30.	Rajshahi Krishi Unnayan Bank
13.	Islami Bank Bangladesh Limited	31.	First Security Islam Bank Limited
14.	Meghna Bank Limited	32.	UNION Bank Limited
15.	Southeast Bank Limited	33.	Standard Chartered Bank
16.	NRBC Bank Limited	34.	HSBC Bank Bangladesh
17.	Union Commercial Bank Limited	35.	Janata Bank Limited
18.	NCC Bank Limited	36.	One Bank Limited

Appendix-3: List of Participants in FGD

Sl. No.	Name of the Participant	Bank Name
1.	Ahmed Zubyerul Huq	Islamic Bank Bangladesh Limited
2.	B M Zahid Ul Haque	BRAC Bank Limited
3.	Mushfiqur Rahman	HSBC
4.	A K M Ahsan Kabir	Dutch-Bangla Bank Limited
5.	Md Farhad Rahman	HSBC Bank
6.	Mohammed Bakhtiar	Sonali Bank Limited
7.	Md. Abul Kalam Azad	Eatern Bank Limited
8.	Md. Shahinur Rahman	Agrani Bank Limited

As a values-based organization, BRAC Bank invests in building the nation with education and development initiatives that contribute to healthy, sustainable and harmonious economic growth.

It gives us immense pleasure to be affiliated with the Bangladesh Institute of Bank Management (BIBM) for publishing a keynote paper of its roundtable discussion. We believe that the new generation of bankers would get access to a pool of knowledge on key functional areas of the banking industry.

We believe that the book will not only empower the professionals with a better understanding of finance but will also broaden their capabilities and help them contribute more to the country's economic prospects.

Our best wishes to BIBM.

Selim R.F. Hussain
Managing Director & CEO
BRAC Bank Limited

BRAC BANK
আস্থা অবিচল

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