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# Cloud Computing for Banking and Investment Services

**Anurag Bejju**

*Department of Computer Science Birla Institute of Technology and Sciences, Pilani*
*E-mail: anuragbejju1995@gmail.com*

**Abstract:** *"The more the things change the more they stay the same." That can be true in some aspects of life, but not in the banking industry. At a global level, the scale of change in this industry since 2008 has been unprecedented. Control is now in the hands of the customer, rather than the bank. Satisfying customer demands has become more complex as they are looking for convenience and control over their banking services. . Technology has become a costly hurdle for financial institutions and developing customized solutions or investing in advanced banking platforms has either been unfeasible or they resulted to too many failures. In today's business and economic climate, financial institutions are looking out for better solutions to cope up with their customer needs as well as get a competitive edge over other banks. Cloud computing is touted as a way to deliver software in the future, can help banking sector react to this new customer-driven environment with innovation in business models, operations and IT. It can offer unconventional business models for delivering innovative client experiences, better data security, high service quality, enhanced IT efficiency and reduced operating cost. Cloud computing is a type of disruptive innovation that is likely to change the demographics of banking industry. Using cloud computing, banks can create a flexible and agile banking environment that can quickly respond to new business needs. Though cloud banking can face few problems like security, data confidentiality and quality of services, they can be sorted by building a good application model. This paper aims to give an overview of cloud computing and proposes a business model to eliminate the negative perception related to cloud based technologies. It also elaborates the defects of current banking systems, and explores the innovative applications of cloud computing in banks.*

**Keywords:** *Financial Cloud Computing, Deployment models, BPaas, IaaS, SaaS, Paas, and Business Agility.*

## 1. INTRODUCTION

Cloud computing is a standardized model and a paradigm shift in computing for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [1] . It has the capabilities and resources which can be delivered as a service to customers using internet technologies. Cloud economics are attractive and increasingly relevant to financial services organizations. It has the potential and ability to change the financial services landscape completely. By making efficient enterprise-level banking systems and high-end technologies available in the cloud on a pay-per-use basis, now any customer can have access to modern core banking systems without the cost and other barriers usually associated with this technology. Banks that take advantage of cloud based technologies are better positioned to provide facilities for users to develop, deploy and manage their applications 'on the cloud' as well as respond to current economic uncertainties, interconnected global financial systems and growing customer demands.

This paper gives a brief outline about the principles, applications and models of cloud computing as well as its implementations in banking and financial sector. Section 2, provides overview and characteristics of cloud computing in banking sector. Section 3 and 4 provides different deployment and service models of cloud computing. Section 5 gives instances of cloud computing in financial institutions including depositary, contractual and investment institutions whereas Section 7, 8 emphasizes on advantages and challenges of using cloud technologies in banking sector. Section 9 provides a solution to implement cloud computing in current financial institutions and section 10 provides conclusion and future advancement of this paper

## 2. OVERVIEW OF CLOUD COMPUTING

Cloud computing provides the facility to access shared resources and common infrastructure, offering services on demand as well as perform operations that meet volatile business needs. Financial institutions can utilize computing capabilities provided by the cloud to control and optimize available resources. Based on current standards, cloud computing can provide banks with vital features like data storage, network computing services, safety, high-speed and convenience . Infrastructures, information and functions required by an information system exist on the network and they are delivered to customers by standardizing and customizing them with the help of service providers. All cloud based bank applications can share resources through network protocols, in accordance with their requirements.

When financial institutions such as banks use cloud based applications and services for improving their current IT standards as well as provide the customers with high end facilities, it can termed as financial cloud computing . The biggest challenge faced by a financial cloud is the perceived notion of banks that the data, costs and security are compromised. Though financial institutions are opting for Open Data Center Alliance and private clouds, a lot more can be done to avail the benefits provided by cloud based computing. Extensive changes are being made in current business computing models like conventional grid computing, virtualization, utility computing, dedicated servers and SOA which offer partial solutions, but are not enough to achieve greater scalability, agility, reliability, fault tolerance, and better management capabilities for banking infrastructure and the applications that run on it.

## 3. DEPLOYMENT MODELS OF CLOUD COMPUTING

Cloud based services can be broadly classified in different ways, depending on their organizational structure and provisioning location. A cloud deployment model represents a specific type of cloud environment, primarily distinguished by its size, location of the cloud services hosted, security requirements, its desire to share cloud services and ability to manage some or all of the services. Four deployment models are usually distinguished by service providers, namely public, private, community and hybrid cloud service usage[2].

*Public Cloud*— A public cloud is available over the internet to everyone and is governed by an organization that trades cloud services. The cloud provider manages and owns everything from operations and facilities to computing resources. The most popular public clouds are Amazon EC2, Google App Engine and Microsoft Azure. Public clouds are widely used in the deployment, development and management of enterprise applications, at low costs. It allows the organizations to deliver highly scalable and reliable applications rapidly and at more affordable cost. Security is a significant concern in public clouds.

*Private Cloud*— A private cloud is accessible only to trusted users of an organization or group. All the information present in a private cloud can be managed either by the organization or the cloud provider. They allow usage of low-cost servers and hardware as well as improve average server utilization providing higher efficiency and cost reduction. The major limitation of a private cloud is that , the IT teams of an organization may have to invest in buying, building and managing the clouds independently.

*Community Cloud*— A community cloud is accessible to the members of a larger community comprised of different organizations or groups, and they are either managed internally or by a third-party. The costs are spread over fewer users than a public cloud and more than a private cloud. Only some of the cost savings potential of cloud computing are utilized.

*Hybrid Cloud*— Hybrid cloud is a mixture of two or more clouds (private, community or public) that remain sole entities but are associated in order to administer services offering the benefits of multiple deployment model. It crosses isolation and provides boundaries so that it can't be classified into one single category of private, public, or community cloud service. Hybrid cloud can run in a private cloud and transform to a public cloud when the demand for computing capacity increases. A primary advantage of a hybrid cloud model is that an organization pays only for extra compute resources when they are needed. This feature overcome limitations like flexibility, scalability and criticality faced by public and private clouds .In hybrid cloud, we can structure our applications as per the requirement of issues depending on their criticality of standards. Critical applications are mainly confined to the private cloud while allowing non- critical applications into the public cloud.

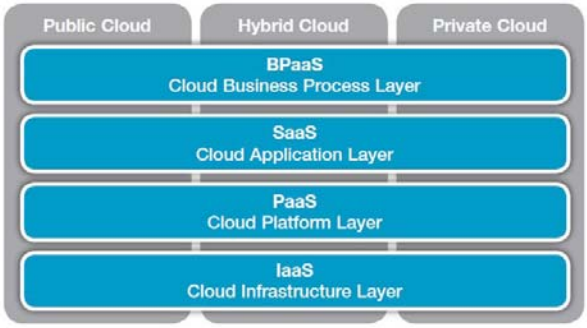


**Fig. 1. Deployment and service models of a cloud.**

## 4. SERVICE MODELS OF CLOUD COMPUTING

Cloud service models offer financial organization the method to move from a capital-intensive way to a more malleable business model that minimize operational wage. The key to achieve maximum utilization of existing resources is in choosing the right cloud services model to meet business goals. There are four basic kinds of cloud service models . Each share similarities but have their own distinct differences as well. (fig 1.)

*Business Process-as-a-Service (BPaaS)* - This service model is used for standard business processes such as billing, payroll, or human resources. BPaaS integrates all the other service models with process expertise. Few examples of BPaas are ADP Employease an online business process service for human resources and AMEX Concur another online business process that connects travel suppliers and mobile solutions all around the world.

*Software-as-a-Service (SaaS )*- In this service model a cloud service provider manages the business software and related data, and end users access the software and data via their web browser. Types of software that can be delivered this way include accounting, customer relationship management, enterprise resource planning, invoicing, human resource management, content management, and service desk management. Organizations that use cloud based technologies release their applications on a hosting environment, which can be accessed through networks from various clients (e.g. web browser, PDA, etc.) by application users. These organizations do not have control over the Cloud infrastructure that often employs multi-tenancy system architecture. Examples of SaaS include SalesForce.com, Google Mail and Google Docs

*Platform-as-a-Service (PaaS)* - A cloud service provider offers a complete platform for application, interface, and database development, storage, and testing. This feature help businesses to streamline the development, maintenance and support of custom applications, lowering IT costs and minimizing the need for hardware, software, and hosting environments. PaaS offers a development platform that hosts both completed and in-progress cloud applications. This requires PaaS, to support application hosting environment, to possess development infrastructure including programming environment, tools, configuration management, and so forth. Examples of PaaS are Microsoft Azure and Google App Engine.

*Infrastructure-as-a-Service (IaaS)*- This service model provided an alternative solution for businesses to buy resources as a fully outsourced service than purchasing servers, software, data center space or network equipment's. Cloud based organization's directly use IT infrastructures (processing, storage, networks, and other fundamental computing resources) provided in the IaaS cloud. Virtualization is vastly used in IaaS cloud in order to integrate/decompose physical resources in an ad-hoc manner to meet increasing or shrinking resource demand from cloud consumers. Examples of IaaS are NYSE Euronext CMCP and Amazon's EC2

## 5. CURRENT ADOPTION OF CLOUD COMPUTING IN FINANCIAL INSTITUTIONS

Cloud computing has been hitting the headlines creating a stir compared to many other recent technological advancements [3]. Regardless, there has been a tremendous rise in its adoption of cloud computing by financial services firms over the last couple of years. Some prominent examples include:

*NYSE Euronext Capital Markets Community Platform*: Recently, NYSE Euronext launched a PaaS community cloud service for the financial services industry, aimed at brokers, dealers, hedge funds, and other market makers. It supports the needs and drives the evolution of the financial services marketplace with a comprehensive range of data, transaction, and infrastructure products and services. User can enjoy high end facilities like raw exchange feeds, historical tick data, consolidated feeds, data administration, ticker plant technology, data publishing, managed services, FIX engine technology, indications of interests, matching engine technology, pre-trade risk and reference data. The infrastructure consists mainly of storage and virtualization tools from EMC and VMware, running on Xeon-powered blade servers.

*NASDAQ OMX Data on-demand*: This SaaS cloud service, built with the support of Xignite, gives customers a way to pick the specific subset of data with pinpoint accuracy. Instead of combing through very large data sets of historical tick data, developers can select very specific data sets and obtain them on-demand for instant processing.

*CME Clearport OTC Data on-demand*: This on-demand SaaS web service is also built on top of the Xignite platform and offers access to end-of- day OTC settlement, volume and open interest data to support markets available through CME Clearport®.

*I-Banks using cloud for risk analysis and non-core processes*: Now a part of Bank of America, Merrill Lynch used IBM iDataPlex servers as part of an IaaS strategy to build and evaluate risk analysis programs. The servers turn many separate computers into a pool of shared resources, i.e., a cloud. Morgan Stanley uses PaaS cloud vendor Force.com for its recruiting applications and has extensive cloud penetration in analytics and strategy.

## 6. ADVANTAGES OF CLOUD COMPUTING IN BANKING AND FINANCIAL SERVICES

A financial services firm that heavily relies on IT enabled services can benefit from cloud computing. Perceived cost savings, ease of scaling-in and scaling-out, faster time-to-market for deploying systems, virtualization of enterprise-wide data as a service, enterprise technology standardization, and the ability to access data and applications on the move are all critical consideration factors that can drive financial services firms to adopt cloud computing [4]. Below are few advantages of cloud computing in banking and financial service sector:

*Customer Satisfaction* - The overarching and most disruptive impact of financial cloud computing will be, its impact on the relationship of banks and their service providers. Cloud computing will make these services more convenient, more accessible, easier to use, and more personalized to the individual's needs and their lifestyle. This is both a threat and an opportunity as it remains to be seen whether it is banks that lead this change or, increasingly, non-banking entrants. With the help rich resources of private cloud, commercial banks can equip customers with client devices. These devices can

provide a series of services, including comprehensive cabinets, bank cards, self-service machines, channel managements, trainings, routine maintenances, upgrade services. We can combine cloud technology with data mining technology to extract valuable information through analyzing and processing by cluster center.

*Data Virtualization* - Data virtualization is the collection of data from multiple and diverse sources across the banks or external sources for the on-demand consumption by a wide range of applications in a virtualized manner. Mostly banks require a data virtualization strategy for better regulations and performance in the market. Larger banks are currently focusing on data virtualization, and may be culturally more obligated to expand their adoption of cloud computing at higher levels [5]. Some large banks are already picking specific task areas and radically cloud-enabling them with SaaS and BPaaS—underscoring the fact that cloud computing adoption is not an all-or-nothing choice.

This paradigm can be used to provide a single source of reference data, such as security master data. Also, risk and analytics calculations rely on many different types and sources of data, including relational and semi-structured XML. Accessing that data from an individual virtual source would drive scores of data consolidation within banks. As confidence grows and more banking cloud products and services emerge, usage of cloud models will continue to advance at all levels of the IT stack. Currently, many banks are focusing on IaaS and/or SaaS, having virtualized their infrastructure and started to use Saas for undifferentiated activities. Data virtualization enable businesses to leverage the right hardware components and manage computing needs as a function of real time usage, rather than design and run with maximum capacity, redundancy and resiliency upfront.

*Pressure built by Non-Banking Cloud-Based Competitors* - Rather than being technologically innovative, the emerging generation of cloud-based, socially-driven money management tools are customer services and experience innovators. Banks are continuously trying to ramp up their efforts to fulfill customer needs. Banks must continue to respond to these competitive pressures in order to avoid disintermediation by investing in cloud-based business models dealing with social media, analytics, and targeted product and service bundling. For banks, the main barrier to winning in the social and mobile environment may be cultural, rather than technological. Customers have become independent in their thinking and online social financial providers have grasped this reality. New entrant Banksimple, is a perfect example as it serves as a platform for its online customers to access mobile and web-based financial services.

*Cost Reduction and Usage-based Billing* - While reduced revenues in financial services are resulting to smaller budgets and cost- management pressures are increasing as a result of regulations and legacy technology systems. The retail banking segment is facing a loss and must now manage costs more effectively. With financial cloud computing paradigms, financial institutions can turn a large up-front capital expenditure into a smaller, ongoing operational cost. There is no need for excess investment on new hardware and software applications. The unique nature of cloud computing permits financial institutions to pick and choose the services required on a pay-as-you-go basis. Billing is a non-core process for banks, and outsourcing it to a cheap and affordable mediator allows them to convert their capital into core technology-based functions efficiently.

*Investment In Cloud-Based Innovation*- Cloud computing can play a vital role in a bank's efforts to reinvent its business and operating models. A cloud computing platform automatically assembles, connects, configures and reconfigures virtualized technology resources to meet business goals. It eliminates constraints like the location of physical IT resources or what specific technologies are employed, which makes it possible to deploy business services rapidly and at a lower cost. Banking innovation in emerging markets is being accelerated by faster economic growth and distinctive social needs. For banks, today's volatile business realities and expanding financial markets infers tremendous growth potential in near future. The financial wealth in emerging markets will reach USD14 trillion by 2015 and 2.7 billion adults in developing nations lack access to financial services. Global financial assets are set to triple by 2020 to USD37 trillion. To increase sustainable shareholder investments and provide better access to customers, banking leaders are looking out for cloud based business models which are flexible as well as streamline operations to create a more innovative customer-focused enterprise. Cloud computing can help transform these aspects of enterprise IT in banking.

*Mobility and Scalability* - If well designed, cloud solutions provide banks with better opportunities to meet customer demands and scale dynamic provisioning of computing resources to save business users and IT experts from engineering the systems for peak loads. Cloud computing can help increase mobility and streamline operations. Banks can drive higher growth and profit margins with improved efficiency ratio and operating leverage and can align business, operations and technology to drive out complexity and cost. Many of today‘s corporate world techno savvy workers want to access risk and analytics reports while they are on the move. They see the benefits of accessing the internet on their smart phones instantly even in remote locations. Cloud allows a bank to scale its business operation by allowing it to allocate resources without scale limitations [6]. Using cloud technology, a company can benefit from economies of scale without needing to add more servers. Solutions are tailored to your current needs, but based on architecture that is flexible enough to evolve as you grow.

*ATMs in the Cloud* - Banks are seeking to grow rapidly in emerging markets and reach unbanked customers, the time and cost of setting up distribution represent major hurdles. Opening a branch or installing a new ATM is expensive and can take several weeks. So third-parties could offer cloud-based services that support rapid growth in a bank's distribution network and infrastructure. For example, a government- driven enterprise in France involving banks, telcos and transportation providers is expanding, and Barclays and Orange are collaborating on contactless payments in the UK. There is also scope in emerging markets for telcos to offer services to banks, such as ATM and POS networks in a cloud.

*Business Agility*–Financial institutions must gain the agility to better respond to business, market, and regulatory changes. The flexibility of cloud-based operating models lets financial institutions experience shorter development cycles for new products. This supports a faster and more efficient response to the needs of banking customers. Since the cloud is available on-demand, less infrastructure investments are required, saving initial set-up time. Agile organizations have an inherent ability to reduce costs. They continually monitor, identify and capture operating improvements in organizational processes, accelerate operational execution of projects and keep costs in line as infrastructure and new services grow. They do much more with less an imperative for the financial sector in the current environment and also identify relevant products and services in a dynamic environment. They can quickly deliver quality financial products and services, open new channels, improve customer engagement, enhance existing revenue and rapidly adapt to new regulations. As a result, firms can focus more on the business of financial services, not IT.

## 7. CHALLENGES OF USING CLOUD TECHNOLOGIES IN BANKING SECTOR

The Cloud computing technologies adoption continues to gain momentum across a wide range of banking services [7]. Aside from all the positive spin around cloud computing technologies, a reliable, trusted, standard model of cloud computing that will enable faster rates and higher levels of adoption is still a long way off, with relatively limited progress being made in that regard in the past year (Fig 2). When a bank moves into cloud computing, there are two prime challenges that must be addressed:

*Security*- The confidentiality and security of financial and personal data and mission-critical applications is paramount. Banks cannot afford the risk of a security breach. The confidentiality and security of commercial and personal data and mission-critical applications is preeminent [8]. With the special requirements of financial service industry, it becomes the major challenge to keep financial data secure, including data leakage, illegal use, loss and authentication. Since financial information is directly related to the economic benefits of many groups and individuals, the importance of information security is self-evident. Currently, the cloud industry lacks comprehensive guidance on security measures relating to personal and financial data. In addition, it is often difficult for potential customers to ascertain whether a cloud vendor meets the current IT security requirements set by regulators in their country (or countries) of operation [9]. These security requirements may include specifications on data transmission, authentication, integrity, availability, location (including security of location), recoverability, consumer privacy and confidentiality. Ultimately, for cloud computing to gain full acceptance within the banking services sector, cloud services must be harmlessly integrated into existing security platforms and processes.

*Regulatory and Compliance* - Many banking regulators require that financial data for banking customers stay in their home country [10]. Certain compliance regulations require that the data does not get intermixed with other data, on shared servers or databases. As a result, banks must have a clear understanding of where their data resides in the cloud. Distributed data storage is a main reason of cloud providers that can cause lack of control and that is risky for customers [11]. Customers are basically responsible for the security and integrity of their own data, even when it is govern by a service provider. Conventional service providers are subjected to external audits and security certifications. A cloud computing provider who ignores to undergo this evaluation is signaling that customers can only use them for the most superficial activities. Many banking mangers require financial data of customers to stay in their native country. Certain compliance arrangements require that data not to be mixed with other data such as on shared servers or databases. Both government and financial firms must determine whether the laws of the country in which the firm operates or the laws of the country in which the data is stored, govern data ownership rights, consumer privacy practices, confidentiality requirements, and other legal consequences. Regulators are additionally concerned about the implication of geographical location on taxes. As a result banks must have a fair understanding of where their data is stored in the cloud.

*Data Segregation and Privileged User Access:* There dwell sensitive data that is processed outside the organization inherent risk of security of data because outsourced services bypass the physical and logical IT controls. As cloud is typically in a shared environment in that data can be shared. So there is the danger for data loss. Is encryption available at all phases, and were these encryption patterns designed and tested by experienced professionals.

*Long-Term Viability and Recovery*: It is very essential to recover the data when some problem occurs and creates failure.so the main question arises here is that can cloud provider restore data completely or not ,this issue can cause a stalemate in security. Ideally, cloud computing provider will

never go broke or get acquired by a larger company with maybe new policies. But clients must be sure their data will remain available even after such an event.

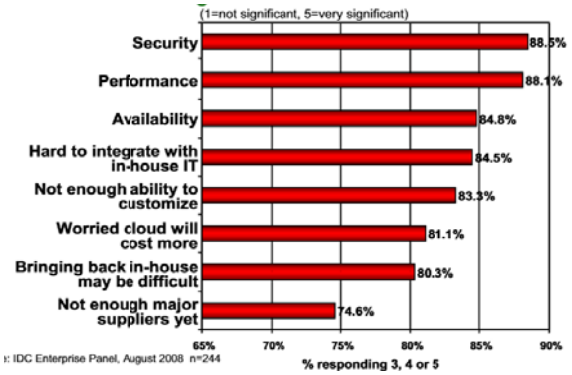


**Fig. 2: Graph representing most significant ( 5) to least significant (1) problems in financial cloud computing.**

## 8. PROPOSED SOLUTION–FINANCIAL CLOUD COMPUTING HIGH-LEVEL ARCHITECTURE

The activity diagram as shown in Fig. 3 can be briefly explained as follows: The lowermost layer includes hardware infrastructure where the data and applications are stored. Above physical infrastructure lies virtual machine which uses several kinds of hypervisors that are supported by the applications and the NCs' that act together with VMs [12]. Above hardware layer is the place for virtual interface management which holds the component Cluster Controller. A cluster is equivalent to an AWS availability zone, and a single Eucalyptus cloud can have multiple clusters. The Cluster Controller (CC) acts as the front end for a cluster within a financial cloud and communicates with the Storage Controller (SC) and Node Controller (NC) [13]. It manages instance (i.e., virtual machines) execution and Service Level Agreements (SLAs) per cluster. If you want to write persistent data to memory outside of the cluster, it would need Storage Controller to write to the backend storage, which is available to any instance in any cluster.

The above next layer consists of several components each with specific functionalities. Provisioning and Configuration is the capability of cloud providers in providing priority services to the customers in terms of virtual machines, data access, infrastructure resources etc. Resource Allocator is a collection of information about the various resources related to the IT Infrastructure within an organization.

It contains data regarding managed resources like computers and application software, process records etc. It is responsible for dynamically allocating data and computing resources to the users as per applications or services requirements Service Level Agreement manager takes care of the service level agreements between the providers and the clients while defining the services.

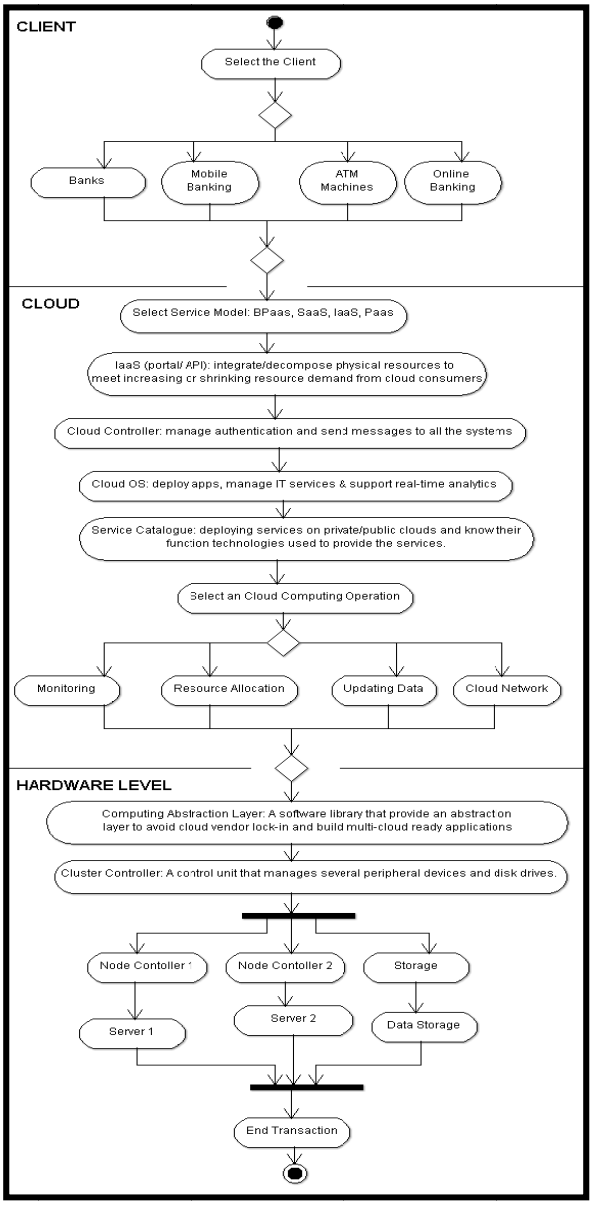


**Fig. 3: Financial Cloud Computing High-Level Architecture.**

Monitoring is a special cloud computing operation used to verify the performances and functionalities of every computing resource in the cloud in order to keep away the risk of failure events. Metering is another important operation for ensuring proper functioning of the vital resources like disk space, network and memory usage in the machines. A well designed metering plan allows cloud providers an advantage to monitor actual usage of resources by the clients and then charge them accordingly. The accurate usage information resulted from metering provides a great opportunity to implement pay per use model to the clients. Service catalog is

the list of services provided by the cloud providers to their customers [14]. It helps the customers deploy services and know their function technologies which can be utilized for their applications.

Above Service Catalog we have Cloud Operating System which is designed to operate within cloud computing and virtualization environments. A Cloud OS manages the operation, execution and processes of virtual machines, virtual servers and virtual infrastructure, as well as the back-end hardware and software resources. Another major component of this business model is Cloud Controller. The Cloud Controller (CLC) is a Java program that offers compatibility and Query interfaces, as well as a Web interface to the outside world, for distribution within the cloud architecture. In addition to handling incoming requests, the CLC acts as the administrative interface for cloud management and performs high-level resource scheduling and system accounting. The CLC accepts user API requests from command-line interfaces like Google, Oracle and manages the underlying compute, storage, and network resources. Only one CLC can exist per cloud.

Above these components level is the level of services provided to the customers like IaaS, PaaS and SaaS. In this model we use IaaS services to the clients to deploy their applications. On top of all these layers is the clients' level, where they can avail cloud services through Web Interface/API like banks, ATM machines, mobiles and web based banking services depending on their requirements.

## 9. CONCLUSION AND FUTURE ADVANCEMENTS

Cloud Computing is a promising paradigm for delivering computing utilities as services. Just as personal computers and servers shook up the world of mainframes and minicomputers or as smartphones and tablets revolutionized the mobile commerce industry, cloud computing is bringing similar far-reaching changes to the licensing and provisioning of infrastructure and to methodologies for application development, deployment and delivery. Continued growth of cloud computing within the financial services industry will require vendors and firms to overcome its challenges together.

Financial Cloud Computing has technical advantages like Capacity on Demand (CoD) , scale up & scale down, fault tolerance and simple architecture as well as economic advantages like no up-Front capital investment and pay as you go business models. Areas where data secrecy is more important than collaboration, hybrid clouds with the appropriate allocation of data and applications are recommended. Cloud Computing will attract Financial Institutions, primarily due the fact that it provides the next generation value in IT with innovative and flexible business models. Some firms have already realized the benefits of cloud computing, which include scalability, cost savings and time to market. Firms that are still looking to leverage the cloud should begin by moving non- revenue generating and non-core systems to the cloud. And, they should consider developing a comprehensive cloud strategy to move core applications to the cloud.

Major shifts in technology can take years to make an impact, the migration of core financial services applications to the cloud might take some time. In near future, scalable and fault-tolerant applications must be made and must be tested for more and better features in shorter time. Deployment of these applications must be easier, faster and reproducible. While the technology foundations of Cloud Computing can be considered as a gradual evolution and must believe that the business models will prove to be potentially disruptive. While the impact is disruptive, the foundation for the mindset needed to adopt this change is already evident within most of the institutions.

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