

# Ready Reckoner for Quick Cloud Adoption

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**Abstract**—in the effervescent field of cloud computing, organizations are finding it quite difficult to adopt cloud for their existing on-premise deployments in terms of business viability. Organizations are not sure whether “moving to cloud” would be beneficial for them in terms of ease of services, better scalability, security, good pricing model etc. There are so many cloud service providers offering many diverse infrastructure-platform-software services which may be suitable for one industry vertical and may not be at all good for some other industry vertical. Therefore, there is a need of a cloud ready reckoner which may help organizations to take appropriate decisions during their cloud adoption phase. In this paper, we have provided a detailed cloud ready reckoner which will help different industry verticals like banking, finance, media, education and IT sectors during cloud adoption phase to take appropriate call on various cloud parameters like security, SLA (Service level Agreement), monitoring, APIs, and pricing plan. A comparison of these parameters offered by different cloud vendors like AWS, Microsoft, IBM, HP, Rackspace etc. is also done towards the end of the paper.

**Keywords**— Cloud Computing, Public Cloud, IaaS, PaaS, SaaS, Private Cloud, CDN, Cloud Storage, Cloud servers

## I. INTRODUCTION

No more a buzz word these days, cloud computing has revolutionized the way business verticals of various industries function. With computing power available as a service, many organizations are exploring cloud as a suitable alternative to all their computing needs, be it infrastructure in terms of hardware, storage and network or a platform for any business usage or hosting a software application [1],[3],[11],[13],[27]. Cloud computing can be easily defined as “a large pool of computing resources connected to each other over cloud (internet)” [1],[3]. The term is not something that appeared suddenly overnight, the roots of the term can be traced back to the time when computing systems used to remotely time-share computing resources, software’s and other applications. In the modern times the term is best described as a model on which many different types of services, applications are delivered across the world over internet which is simply termed as Cloud [3],[11],[27].

Carrying a lot of benefits for the organizations like accelerated deployment, rapid provisioning of resources, almost zero CAPEX (capital expenditure) and very less OPEX (operational expenditure), it brings a few challenges also in terms of data privacy and confidentiality, security, performance, QoS etc. Many a times, business organizations are not sure whether they need to go for cloud or not. If they decide to go for cloud, they are not sure which service or deployment model will suit their business needs. They are not able to decide which vendor they should go for as almost all vendors have some USP (unique selling point) associated with their cloud offering. The organizations are in nut shell not able to take appropriate decisions on the following queries:

- Which security model will suit their business vertical?
- Which pricing plan will be most economical for their usage?
- Does the offered SLAs (Service Level Agreements) by the cloud vendors fine in line with their business requirements?
- Do they need monitoring option for their infrastructure, platform or software?
- Will it be beneficial for the business to utilize available out-of-box APIs from cloud vendors?
- Can the organization utilize the free tier option in some use-cases?
- What is the data transfer cost? Is it relevant for the organization to consider it while deciding on cloud?
- Do the offered instance types suit business needs in terms of infrastructure?

These are a few concerns which cause delayed decisions for the organizations who want to migrate to cloud computing. There are no ready reckoners available which can provide a basic framework to the organizations helping them to take quick decisions while deciding on moving to cloud. Through this paper, we have tried to provide a broad outlining of a framework which may help the novice organizations to take a quick decision while opting for cloud vis-à-vis on-premise deployments. Section 2 provides preliminaries covering basics of cloud service models and deployment models, benefits and challenges faced during cloud adoption. Section 3 highlights various business verticals and their concerns. Section 4 gives an elaboration of various parameters being considered during cloud adoption. Section 5 touches upon various enterprise grade parameters, with section 6 provides a detailed discussion on various scenarios focused on different industry verticals followed by cloud vendor comparison. Section 7 concludes the article.

## II. PRELIMINARIES

As per NIST “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” [5].

### A. Service Models

There are several cloud service providers in the market

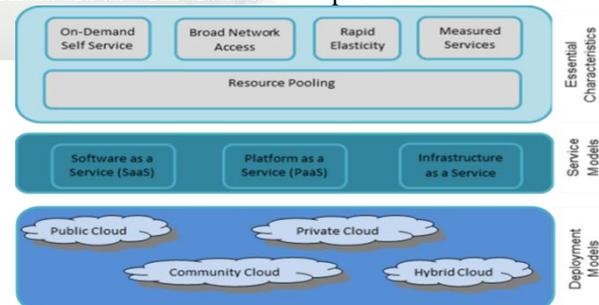


Fig. 1. Cloud Computing models and features

[3],[5],[9],[11],[22] which provide services based on few fundamental models also known as Service Models, hereby naming the most common service models as shown in figure 1.

#### 1) *Infrastructure as a Service (IaaS):*

IaaS is the base service model offered by cloud providers that includes mainly servers, storage, memory etc. [1],[15],[47] as a service over internet and charge the users based on several pricing plans. Other services that fall in the paradigm of IaaS include Load balancers, firewalls, and IP addresses to name a few. All the maintenance work related to the infrastructure is taken care by the service provider, thus enabling the customer to focus more on the core business idea not on infrastructure management.

#### 2) *Platform as a Service (PaaS):*

In PaaS [15], service provider provides a computing platform and a solution-stack as a service to the consumers, on which they can deploy, configure and manage their applications. PaaS inherits some details from its parent model (IaaS) like servers, network, load balancing, operating system, storage etc. All these underlying cloud resources are managed by the service provider thus facilitating rapid deployment of application.

#### 3) *Software as a Service (SaaS):*

SaaS is a software delivery model providing access to various types of software as a web based service and is paid on subscription basis (monthly or yearly). SaaS inherits some details from its parent model i.e. PaaS, thus allowing organizations to access business functionality at very less cost as compared to buying licensed model of the software and as the software is hosted remotely at the providers end thus consumers don't even need to invest in additional hardware.

### B. *Deployment Models*

Depending on the requirements deploying cloud computing can differ broadly into these four types [5],[9],[15],[22]:

#### 1) *Public Cloud:*

A public cloud is one in which the infrastructure and computational resources that it comprises are made available to the general public over the Internet on commercial basis. It is owned and operated by a service provider delivering cloud services to its customers.

Eliminating the hassle of purchasing and managing the infrastructure greatly reduces the CAPEX and OPEX of the consumer. Data control might be an issue depending on number of factors including the type and sensitivity of the data as well as the industry and local laws concerning the data.

#### 2) *Private Cloud:*

Contrary to Public Cloud model, where the infrastructure is owned by a particular service provider and services are available for public usage, in private cloud the infrastructure and services are available with the boundary of a particular organization, although the model is not as cost-effective as compared to Public Cloud model, but it brings in tremendous value from a security and customization point of view.

#### 3) *Hybrid Cloud:*

The hybrid cloud infrastructure is a perfect combination of one or many types of cloud infrastructure, and has the ability

to interact with each other with the help of their interfaces thus leveraging the benefits of all the types of deployment models, hence, the cloud migrates workloads between public and private hosting without any inconvenience to the users.. Because of the versatility offered by Hybrid Cloud, it is also considered as the future of cloud computing by many cloud experts.

#### 4) *Community Cloud:*

Community cloud can be considered as a perfect blend of the pros of both public and private cloud.

The infrastructure in community cloud is provisioned for usage by a particular set of organizations that share similar interest, policy and compliance interest. The cloud can be managed by a single organization or a group of organizations, and it greatly reduces the cost as compared with private cloud as cost is shared by a group of organizations.

### C. *Benefits of Cloud Computing*

As compared to traditional on-premise model of computing, cloud computing has a lot of benefits some of them being

#### 1) *Accelerated deployment / Rapid Provisioning*

With the help of public cloud IaaS service model, a user can easily scale up and provision as many computing resources as required within very less time as compared to traditional deployment model.

#### 2) *Pay-as-you-go model with lower cost barriers*

The most adopted pay-as-you-go pricing model assists consumers to reduce their OPEX significantly, as now consumer only pay for the time and amount of the resources they have used.

#### 3) *Scalability (& Elasticity) without upfront CAPEX*

Cloud Computing model helps user to easily scale up or down the required resources with minimal friction, and in addition provides considerable elasticity while dealing with computing resources, like customization of servers, software and platforms etc. without any upfront capital expenditure.

#### 4) *Support cost and hassles transferred to service provider*

Once shifted to cloud model, the hassles like managing infrastructure, applying patches etc. are all transferred to the service provider and thus users can pay more attention on their business idea.

#### 5) *Enables / helps business get things done with minimal IT support*

As all the excessive burdens like security concerns, managing the infrastructure, upgrading the software etc. are now managed by the service provider thus businesses need to maintain a very small team to provide IT support.

### D. *Challenges of Cloud Computing*

Although there are many benefits of cloud adoption for the organizations, it also brings a few challenges [4],[9],[13],[14],[15],[22]. These challenges can be categorized in two broad categories like technology related and business related challenges as discussed below:

#### E. *Technology challenges:*

##### 1) *Data Security and Privacy*

One of the biggest challenges faces by companies while shifting their on-premise deployments to cloud is the privacy of their data on cloud, this concern is more profound in public cloud deployment model as the data is not residing at consumer's location but on provider's location.

## 2) Availability of service

Other major concern faced by consumers is how readily the service is available, how often there is a service outage and how does the provider deal with the outages.

## 3) Quality of Service (QoS)

QoS is another factor that has to be given consideration while shifting to cloud which primarily touches upon key issues like the quality of server and network performance.

## 4) Reliability and Performance

Reliability of the provider is an important parameter during the process of cloud adoption. These parameters give a holistic indication to the users how often a given provider faced network or service outages.

### F. Business Challenges:

#### Less or minimal data ownership and control options

The end-users have very less ownership on their data residing on the cloud, which may be a concern for many industries, especially Banking and Finance industries.

#### 1) Vendor lock-in

While shifting to cloud, consumers may get bound to a particular service provider called vendor lock-in, this may prove to be a concern as depending on the changing requirements consumers may want to shift the services to a more suitable provider.

#### 2) Compliance to Legal standards

There are set of legal standards being defined which if followed by service providers ensures data security to customers like undergoing Service Organization Controls 1(SOC 1), SOC 2, SOC 3 audits, ISO 270001 etc.

### III. BUSINESS VERTICALS AND THEIR CONCERNS

Many industries now are trying to shift their traditional model of computing to cloud computing, some in entirety and some partially, thus trying to leverage the borrowing aspect over the buying one. To help their cause there are many cloud vendors available in the market that can assist the shift.

Specifically talking about public cloud which as per Gartner is forecasted to grow 18.5 percent in 2013 to total \$131 billion worldwide, up from \$111 billion in 2012, especially Infrastructure as a service (IaaS), including cloud compute, storage and print services, which is continued as the fastest-growing segment of the market, growing 42.4 percent in 2012 to \$6.1 billion and expected to grow 47.3 percent in 2013 to \$9 billion.

Now the vendors that contribute to this exponential growth of public cloud has also grown quite in number, each having their own USP. The unavailability of a ready reckoner with the customers to choose the most appropriate vendor as per their requirements adds to the complexity of shifting their model to cloud, we hereby present some industry verticals and their concerns while migrating to cloud:

#### A. Banking Sector

Modern banking is now adopting to the internet boom into its services and thus provides all the traditional banking services to its customer on the go, shifting the traditional banking model to cloud is considered to a good option as it will help the banks to balance the load on the websites imposed due to enormous amount of transactions taking

place, shifting to cloud will also help to automate disaster recovery, multi cluster and multi-site management.[43],[44]

#### 1) The Concern

The proposal of shifting banking services to cloud has its own part of concerns like

- The confidentiality of customer's data in the cloud which is a cornerstone in successful cloud migration.
- Money is not always the primary concern of a cyber-attack on a banking service provider, even a data breach incident can lead to significant negative impact on the reputation amongst customers and industry
- Banks thus need a highly secure environment where they have control on every single bit of information that is stored on cloud.

#### B. Financial Sector

Financial sector has witnessed a considerable change with the increase in the popularity of e-money.

As majority of the customers now avail the benefits of e-money and with the increase in the popularity of e-commerce companies like eBay, amazon there are thousands of transactions taking place per second all over the world, thus shifting the financial sector model to cloud can help companies to make their services available to its customers 24x7.

The shift will also help the companies to cater the exponentially growing transactions by helping them scale up on computing resources in very less time

Similarly other sub-verticals like brokerage, banking, investment banking, and insurance can also be benefitted by adopting cloud computing as their computational model.

#### 1) The Concern:

The shift has its own concerns that requirements due attention, the very first being maintaining the confidentiality of the customer as the data resides on cloud, secondly securing thousands of transactions taking place per second, The third being keeping the service available 24x7 to the customers and dealing with service outages.

Thus in a nutshell picking up the best Load balancer, security model (Sec 4.1) and best Service Level Agreement (Sec 4.3) as per their requirements would be the top most concern.

#### C. Media Sector

Media Sector today is forced to adapt their business models at an unprecedented rate, when there was a scarcity of content to be delivered, now there is a seemingly unlimited supply coming from traditional media sources as well as new media and social network Internet sites via more and more portable consumer devices. Shifting to cloud model can help media sector overcome these challenges by providing

- Increased sales by increasing exposure to content
- A richer flow of information to adapt quickly to changing consumer interests and demand
- Decreased labor, inventory, and working capital costs
- Faster, fresher content packaged, identified, and available to the right consumer anywhere, anytime

#### 1) The Concern:

Media sector is looking for ways to innovate without compromising their content ownership and digital rights.

Thus Cloud Providers must take care of these issues that media executives care about

The other concern while deploying traditional media model to cloud would be consistency and availability i.e. how quickly is the right content streamed to its customers irrespective of their location.

The online version of the media sector deployed on cloud should be able to handle predicted and unpredicted spikes encountered.

#### D. Education Sector

The constantly expanding education sector with the addition of latest technology-assisted-learning techniques has made MOOCs (Mass Open Online Courses) a reality in today world. Many renowned universities have started offering online courses to global students using cloud as CDN.

##### 1) The Concern

As a new form of instructional delivery, MOOCs could take some of the heat off of higher education, with its ever rising tuition fees but along with it comes its part of concerns like

To bridge the gap between classroom delivery and cloud based delivery majority of MOOC courses provides interactive audio and video tutorials and other media content are also streamed to aid the learning process, As the courses are available over the globe thus constant availability of the course artifacts in all parts of the world is a major concern, i.e. irrespective of the location courseware should be readily accessible to the student.

#### E. Information and Technology Sector

IT sector can be considered as the most dynamic sector in terms of the changes that takes place. Latest finding in the technology keeps on complimenting the growth of IT sector, the latest being BIG DATA. The combination of Big Data analytics and Cloud is a very well-known duo, both complimenting each other very well, the availability of cloud and volume, diversity of Big Data has worked very well to extract the relevant information for its customers thus helping them to focus on future trends and thus leading to growth of the organization.

##### 1) The Concern:

Although the data analytics model works very well on cloud, be it batch processing for a particular interval of time or a continuous process to extract relevant information from social network, there are few concerns that need to be sorted out like,

- Which cloud provider will be able to scale up and scale out if the data being analyzed grew exponentially,
- What would be the most appropriate pricing plan suited for various verticals of IT sector.
- Which security model would suit best while dealing with sensitive data analytics

The unavailability of such a reckoner does result as a jam in the model shifting. We must have a structured way of evaluating our business needs so that right service model, right deployment model with right parameters is chosen.

#### IV. PARAMETERS FOR CLOUD ADOPTION

In this section, we have discussed some critical parameters [8],[26] which may be evaluated before deciding on a specific cloud vendor.

#### A. Security:

Despite the clear economic benefits of using cloud services, concerns about security, compliance and data privacy have slowed enterprise adoption [9],[15],[22],[24],[25],[28]. An IDC survey of IT executives reveals that security is the #1 challenge facing IT cloud services. Gartner Research has identified six specific areas of security risk associated with enterprise cloud computing, and recommends that organizations address several key issues when selecting a cloud hosting provider:

Thus here are some parameters that should be taken care while evaluating the security aspect of Public Cloud Vendors

1) *Access privileges*: Cloud service providers should be able to demonstrate they enforce adequate hiring, oversight and access controls to enforce administrative delegation[9],[22],[25].

2) *Regulatory compliance* – Enterprises are accountable for their own data residing in the cloud, thus they should ensure their providers are ready and willing to undergo audits [24] like SOC1, SOC2, SOC3 and they are also available for public view.

3) *Data provenance* – The provider must disclose their data center location to the customer, and should allow the user to store, borrow a server from its own choice of datacenter.

4) *Data segregation* – Most public clouds are shared environments, and it is critical to make sure hosting providers can guarantee complete data segregation for secure multi-tenancy.

5) *Data recovery* – Enterprises must make sure their hosting provider has the ability to do a complete restoration of data in the event of a disaster [22].

6) *Business continuity* – Businesses come and go, and enterprises should ask hard questions about the portability of their data to avoid lock-in or potential loss if the business fails [22].

#### B. Pricing Plan and Cost

Cloud Computing is growing at a rapid pace in spite of its security concerns because of its economical model, thus making pricing plan an important parameter to be considered.[15] on a broader scale there are two types of pricing plans being offered [4]:

##### 1) Price unbundling

Price unbundling, as exemplified by Google, charges for each computing characteristic separately and has similarities to pay-per-use pricing plans. Customers decide on the required computing characteristics (e.g., the number of CPUs and storage capacity) and are charged a specific price per unit (e.g., \$50 per CPU or \$15 per 100 GB of storage)

##### 2) Price Bundling

Price bundling as offered by IBM, Amazon, and Microsoft uses a discrete set of predefined templates (e.g., a "Silver Instance" with 4 GB of memory, 400 GB of storage, and 2 CPUs for \$140 per month or a "Gold Instance" with 16 GB of memory, 1 TB storage, and 4 CPUs for \$280 per month). Therefore, customers with specific computing requirements can only choose the next available template which may not fully suit their requirements.

##### 3) Other Plans

There are other plans that are provided by the service providers like pay-as-you-go, monthly pricing plans, weekly

pricing plans [4], but pay-as-you-go stands as the most adopted across various users.

### C. Service Level Agreement

The cloud service level agreement establishes the legal relationship between the cloud provider and the client [9]. It highlights the responsibilities and expectations of each party, touching upon security, expected uptime of the cloud service and any compensation arrangements should the vendor fail to meet its obligations [15],[21],[23]. Thus it is highly recommended to go through the SLA of the service provider. Below are some of the highlights of SLAs offered by major cloud service providers.

#### 1) Customized SLA

There are vendors that allow its customers to customize its SLA as per their requirements and not offer a rigid SLA [21],[23]. This provides a greater flexibility to the users to define their own convenient SLAs in line with their business needs.

#### 2) Uptime[21]

Uptime is an important factor to be considered while going through the SLA of a service provider as it states how often cloud provider undergoes service outage and steps to deal with such scenarios.

- Support response time for the queries  
Parameter describes minimum response time guaranteed by the provider to resolve the technical or service queries of customer
- Service Credit Calculation  
This parameter defines what percentage of the bill shall be refunded to customer in case of a SLA defilement by the provider
- SLA Exemptions  
Clear mentioning of the scenarios where SLA will be considered as null and void.  
Thus based on all the parameters service providers can be categorized in 2 different categories:

#### Type 1:

- SLA provided defines uptime yearly not monthly,
- downtime is considered in terms of regions not in terms of instances
- Lots of details required in order to confirm a instance downtime
- Less than 10% giveback on customer's monthly bill

#### Type 2:

- SLA provided defines uptime monthly
- Downtime is considered in terms of availability zones or instances
- Less amount of details required in order to confirm a instance downtime
- More than 10% giveback on customer's monthly bill

### D. Scale up

- If it is possible to scale up individual cloud server instances by adding more memory, extra CPUs or more storage space as per the requirements of the customer.
- The level of service providers interference required in such activity

### E. Scale out

- Does the service provider enables its customer to quickly deploy new server instances to meet the

requirements

- The level of service providers interference required in such activity

### F. Customer Support

The level of technical and sales support offered by the service provider can be categorized in 3 types

- Type 1 :  
Companies that offer on-line forums for free, other services like online chat with expert, phone-based support etc. are paid
- Type 2 :  
Companies that offer a single type of 24x7 support for free (either phone-based or on-line chat), in addition to forums
- Type 3 :  
Companies that offer multiple support offering included even in the base price.  
Minimum time guaranteed by the provider to resolve the issue or concern

### G. Monitoring

Monitoring services help the customer to track the performance, billing and load on the servers borrowed from the provider

Monitoring service also allows the customers to set up alarms for their resources which will provide timely notification about the health of resources.

Monitoring services for borrowed can also be categorized in 3 types

- Type 1 :  
Companies that have no monitoring/alert solutions integrated, requiring the deployment of third-party tools or that extra services be purchased
- Type 2 :  
Companies with very simple integrated monitoring tools (few indicators or no alerting)
- Type 3 :  
Companies with very complete integrated monitoring tools offered for no additional cost (covering all the alerts and status checks)

### H. Application Program Interfaces (API's)

Apart from providing a console from where the customers can manage their resources, some providers also provide API's that enables a user to access the services offered by the provider programmatically, thus making it simpler for the user to integrate the services with its own application.

Broadly these services can also be categorized in 3 types

- Type 1 :  
Companies that offer no API's to interact with the services offered
- Type 2 :  
Companies that offer CLI tools and basic API like REST to interact with the services
- Type 3 :  
Companies that offer extensive API's like Java SDK's and toolkits to be integrated with several IDE's for easier development works

### I. Free Tier

Many providers also offer a free-tier to its customers to test

their services before actually buying them

Free tier offered can be categorized in three different types

- Type 1:  
Any type of free tier is not provided by the company
- Type 2:  
Free tier provided by the company is restricted to a particular instance type and only restricted to some services, free tier time range is up to 1 month
- Type 3:  
Free tier is open to all the services offered by the provider to a particular time interval, company also provides some credit amount to test all the services

#### J. Number of instance types

The flexibility offered by the provider in terms of instance types covers

- Number of instance types that are available with the provider
- Customized instance types
- Level of customization that can be achieved

Thus based on the above parameters companies are categorized in 3 different categories

- Type 1:  
Less than 3 instance types, instance types are rigid and cannot be configured as per the requirements of customer
- Type 2:  
More than 3 instance types are available, but instances are configurable to some extent like only hard-disk space can be customized and not CPU or memory
- Type 3:  
Instances can be configured as per the requirements, the level of customization include CPU, memory and Disk space

#### K. Cost of data transfer

Computing and storage resources borrowed from a service provider involves a lot of data transfer both inbound and outbound over the internet and also within the intranet of the service provider [4]. The parameter states the cost incurred by the customer as per size of the data transferred

- Type 1:  
Company charges for all the transfer taking place including inbound and outbound data transfer, Charged also include data transfer between intranet and internet
- Type 2:  
Company offers a free tier for data transfer occurring including inbound and outbound data
- Type 3:  
Company doesn't charge at all for the data transfer, or offers at least free inbound data transfer

#### V. ENTERPRISE GRADE PARAMETERS

Apart From providing services to SMB's Public Cloud IaaS model is proving very effective for Enterprise grade organizations as well, which results in its own niche parameters to compare, although all the below mentioned parameters are applicable to SMB's as well

##### A. Custom instance borrowing location

Enabling customer to choose its own data center to

provision resources can greatly help the company to minimize the latency and thus resulting in faster performance.

##### B. Audits Transparency and Certification[46]

A compliance audit is a comprehensive review of an organization's adherence to regulatory guidelines like

- Sarbanes-Oxley Act (SOX) which requirements mean that any electronic communication must be backed up and secured with reasonable disaster recovery infrastructure.
- HIPAA (Health Insurance Portability and Accountability Act)
- PCI DSS (Payment Card Industry Data Security Standard )
- Service Organization Controls (SOC), Type II report

The customer should check whether its provider undergoes various compliance audits and publish the audits publicly to be viewed by the customers

##### C. Deployment models

The flexibility in terms of deployment models offered by the provider enables customer to flex its application's scope on different cloud deployment models like private, hybrid or community cloud as per the requirements.

##### D. Number of Datacenters

The number of datacenters available with the service provider from where customers can provision their resources

Also covers the number of data centers where customer's data shall be replicated for backup purpose.

##### E. Load Balancing

Load balancing is a service that enables a customer to effectively balance the load on his application on various ports automatically with no or very little interaction from the customer.

#### VI. DISCUSSION

After having a look at the parameters for evaluating a public cloud service provider for the SMB's and enterprise grade organizations we shall now move forward to the conclusion part, Here we shall discuss in brief about the gravity of the parameters and which provider suits best as per the scenario's.

##### A. Security

As already discussed when it comes to deploying information on cloud, security is the biggest concern for SMB's as well as for the enterprise.

While opting for a cloud provider one should make sure that

- Provider meets all the compliance, security-related certifications and undergo audits like PCI and SAS 1 , SOC 2,SOC 3.
- Provider offers built in firewalls for the instances and does not depend on the firewall applied by customer
- Provider supports encrypted key pair for instance login
- Provider supports different level of access privileges to the customer
- Provider supports adequate measures to save customer's data in case of a service outage or disaster
- While dealing with the API's provider offers secured token to the customer from where he can interact with

the services

1) Scenario 1

Consider a company hosting an on-line gaming website, the requirements of the company is to host front end of the website on a public cloud IaaS provider and make use of a content delivery network (CDN) to minimize the latency for the customers.

The security concerns for such an organization cover

- A Virtual Private Cloud security as website is hosted on Public Cloud and on-premise location
- Security for Content Delivery network
- Considering the above parameters as per the priorities, Amazon Web Services is the best suited vendor for the organization as AWS provides
- Highly secured VPC (Virtual Private Cloud) and highly secured VPN connection between customer's network and AWS
- AWS provides CloudFront which is highly available and secure content delivery network

2) Scenario 2

Consider a banking organization that deals with regular banking related transactions and e-commerce activities, the requirement of the company is to shift a part of its regular activities to public cloud IaaS service to manage on-premise workload.

The security concerns for such an organization covers

- Being a banking organization, biggest security concern is the authentication of users
- Second most important security threat covers identity management, encryption and isolation of critical data
- Third most important security concern is the availability of data in case of a failover or service outage

Considering the above parameters as per the priorities, Windows Azure is the best suited vendor for the organization as Azure provides

- Windows LiveID authentication mechanism, as Live ID is one of the longest-running Internet authentication services available, and thus provides a rigorously tested gatekeeper for Windows Azure.
- Azure handles Identity management very well by its SMAPI Authentication
- Isolation of Hypervisor, Root OS, and Guest VMs
- Encryption algorithms like AES, A full array of cryptographic hash functionality including MD5 and SHA-2 etc.

VII. SERVICE LEVEL AGREEMENT (SLA)

As already discussed in Sec4.3, Service level agreement is considered as a deal between customer and provider, thus before opting for a cloud provider one should always pay considerable amount of attention to the SLA's [21]

There are few important points that should be considered while going through a SLA

- Availability time

It accounts for the percentage of up-time (weekly/monthly/yearly) offered by the provider to customer; it also covers the unscheduled downtime acceptable Best practice is to calculate the Availability time monthly, but many providers also calculate it as weekly and yearly, the acceptable unscheduled downtime as per different scenarios are

Availability %	Downtime Per Year	Downtime Per Month	Downtime Per Week
99 %	3.65 Days	7.20 Hours	1.68 Hours
99.5 %	1.83 Days	3.60 Hours	50.4 Minutes
99.90 %	8.76 Hours	43.8 Minutes	10.1 Minutes
99.95 %	4.38 Hours	21.56 Minutes	5.04 Minutes
99.99 %	52.56 Minutes	4.32 Minutes	1.01 Minutes

- Parameters for outage consideration

It defines the minimum parameters that should be satisfied to term an incident as SLA Violation like

- Many providers mandates service zones and availability zones to fail to consider the event as an SLA violation
- Many providers mandates instance to be replicated at least twice in different availability zone, and only if both the instances fail the incident will be considered as a SLA Violation

Although the best practice is to consider failure of a single instance as a SLA Violation.

- Penalties for SLA Violation

It defines in case of a SLA violation i.e. after reaching the contractual threshold of downtime, how is the provider going to compensate for the loss to customer.

Many providers will agree to pay a percentage refund to customer depending on the downtime, but the commitments from vendors can vary and customer should pay due attention while going through this part of the SLA

- Credit amount to be refunded based on percentage of downtime
- What portion of the services downtime is refunded
- Is the provider going to refund only for the compute instances that have failed and exclude CDN, network and database downtime
- If a server fails, is the provider going to refund the customer for all the servers that were dependent on the failed server
- SLA Exclusions:

This part of SLA can give indication to customer about how often the provider expects his services to fail [21]

- If the provider expects customer to borrow instances from at least 2 availability zones and the failure of both the availability zones will be treated as SLA Violation, than the provider expects single availability zone failures
- If provider expects customer to build a new instance in case of failure of a single instance before considering it as a SLA Violation, than provider expects single servers to fail
- If provider provides Server SLA but not Network SLA than provider expects network downtime

1) Scenario

Considering a company that is hosting a brokerage website (like moneycontrol.com), and as a result of the tremendous amount of load being incurred by the website, company wants to shift its model to public cloud to effectively balance the load

The SLA requirements for such an organization

- The topmost requirement for such an organization would be availability, as even a small amount of downtime can lead to a tremendous loss for the customers
- Second most important requirement shall be service granularity guarantee, as even a single instance failure can lead to degrade in the performance.
- The third most important parameter would be network performance, as even a slight degradation in the network performance can lead delayed updates to customer which will lead to customer discontent

Considering the above scenario the best provider for such an organization is Rackspace as

- Rackspace guarantees 100% uptime for the servers borrowed
- Rackspace guarantees up to 100% of credit in case of SLA Violation
- Rackspace's level for considering a SLA Violation is "instance" and not availability zone
- Rackspace also provides **100% network uptime** guarantee

#### B. Pricing Plan and Cost

As already discussed there are many types of pricing plans being offered by public cloud vendors to suit the need of customers like

- **Monthly**  
Vendor charges the customer on monthly basis rather than pay-as-you-go basis, even if the customer is not using the services for some period of time of the month he is still liable to pay for the service, this type of plan suits to the customer who is going to use the services continuously for the entire month.
- **Pay-as-you-go**  
Probably the best type of pricing plan offered by vendors, the customer is charged for the services he has used over a particular interval of time, there is no upfront investment and no long term commitments involved. Cost is calculated on hourly basis.

Hereby comparing the **32-bit smallest (least resourceful) Linux instances** from 5 top vendors as on 5-Sept-2013 (Table 6.3)

Vendor	Price (in \$ per hour)
IBM SmartCloud	0.120
Rackspace	0.022
HP Cloud	0.035
Amazon EC2	0.060
Windows Azure	0.020

Table 6.3

##### 1) Scenario 1

Consider a IT company that deals in big-data analytics and runs batch data processing for a short interval of time, the requirement of running Big data analysis on batch data consists of highly resourceful infrastructure resources, the company doesn't want to manage all the clusters thus want to run the job on public cloud vendors

The Pricing Plan and Cost requirements for such a company

- The company requires **high end computing instances** for running data-analytics jobs
- As the company performs batch analytics, thus there is

no need for long term commitments with cloud provider

Considering the above scenario and problem set Rackspace and Windows Azure would be recommended

- As both Rackspace and Azure incur least cost (0.022\$ and 0.020\$ per hour) which is ideal for batch processing

##### 2) Scenario 2

Consider a University, which wants to deploy a MOOC for its students located worldwide  
The Pricing Plan and Cost requirements

- The university website is going to be functional for the entire year and not limited to a particular interval of time
- The CDN requirements for such a university shall include a provider that has edge-locations to provide CDN at all the major parts of the globe that effectively covers its spread of students

As per the requirements of the university Amazon Web Services would be the recommended option because

- AWS provides 1 year, 3 year long term commitments by the help of which the university can save up to 56% of their total cost(considering 3 year heavy reserved plan for t1.micro instance)
- AWS provides CloudFront which is highly available and secure content delivery network

##### 3) Scenario 3

Consider a company that develops various software's for its customers, before actually rolling out the software to the customer company wants to test the software with the help of public cloud servers  
The Pricing Plan and Cost requirements

- The company only want to use the public cloud servers for testing purposes and for a small interval of time

As per the requirements of the company Windows Azure would be the recommended option because

- Azure provides an unrestricted free tier of up to \$200 of usage
- The free tier includes all the major services from Azure

#### C. Compute capacity, scale up and OS's

- Compute Capacity provides the width of computing resources available with the provider
- Scale Up is the feature by which a customer can increase the resources for the instance he borrowed either on predefined instance templates or customizing the instance as per his requirements
- OS's covers the aspect of Operating System and software that are available with the vendor

##### 1) Scenario 1

Consider a startup company hosting an online gaming website, the company is not sure about the number of hits it might experience at the beginning and number of hits it might after a particular interval of time, thus the company wants to deploy the website on public cloud.

The compute capacity, scale up requirements for such a company

- The company would like to start from a small instance to manage the load in the beginning
- As the load increases the company would like to scale up on the instance as per their requirements, not scaling up by predefined templates set by provider

Considering all the requirements set up by the company Rackspace is the recommended option because

- Rackspace provides a smaller instance with 1CPU core, 1GB RAM for the initial use.
- Company can customize the processor, memory and disk space of the instance as per their requirements after a particular interval of time

### 2) Scenario 2

Consider a company that deals with Business Intelligence tools and mainly in unstructured and semi-structured data (mainly from social networking web-sites), to analyze such a exponentially growing diverse data the company has create a tool which requires high end processors, for testing purpose company doesn't want to invest in the servers and wants to check the performance of the tool by the help of public cloud servers.

The compute capacity, scale up requirements for such a company

- The company requires high end servers to analyze varied data
- The company would like to scale up on instances as per the requirement and the volume of the data

Considering all the requirements set up by the company Amazon Web Services is the recommended option because

- AWS provides the highest core and memory servers with 32 CPU cores and 244 GB RAM
- Company can scale up as per the requirements from by the predefined templates.

### 3) Scenario 3

Consider a company that has just moved in consultancy business and wants to develop an enterprise grade business website, apart from building the website company also would like to monitor the website, the company wants to build and monitor the website with the help of public cloud servers

The compute capacity, OS's requirements for such a company

- Company would like to use a software that will help it in building the website
- Company would also like to use a tool to monitor the performance of the website

Considering all the requirements set up by the company IBM SmartCloud is the recommended option because

- For developing business website IBM provides IBM WebSphere Image on pay-as-you-go basis
- For monitoring the website IBM provides IBM Tivoli Image on pay-as-you-go basis

detailed comparison of these parameters is shown in Table – 3.

## D. Application Programming Interface (API)

API's are the availability of the customer to interact with the services programmatically

There are many types of API's that are provided by the vendors like

- Java SDK

With the help on Software development kit provided by the vendor, customer can easily embed code to initialize, stop, and terminate servers from his java program

- REST API's

This is the most common type of API that is provided by the vendors, with the help of REST, customer can do all the operations on the services with the help of HTTP protocol

- IDE Support

Some vendors also provide IDE support by providing plugins

### 1) Scenario

Consider a company that wants to develop a software that requires various services from public cloud like DNS, Storage, load balancer, compute etc. As there are various services being used company wants a single point of contact from which it can manage all the services programmatically

The API requirement for the company

- The company wants a single Software Development Kit for all the services provided by the vendor

- An IDE plugin is also required for ease of programming

Considering all the requirements set up by the company Amazon AWS is the recommended option because

- AWS provides a Software Development Kit with all the required libraries, sample codes and documentation
- AWS also provides Eclipse IDE plugin for ease of programming

## E. Other Parameters

Other parameters like

- Scale out: Ability to add more servers
- Monitoring: Ability to monitor the instance, add alarms and health checks
- Custom Instance borrow location: Ability to allow customer to borrow instances from data center location of his choice

These all parameters are more or less same in all the top vendors and comparison between these parameters won't make much of a difference

Parameters	Sub-Parameters	Cloud Vendors					
		Amazon EC2[16]	Windows Azure[20]	IBM Smart Cloud[17]	Rackspace[18],[19],[31]	HP Cloud	OpSource
Security	Access Privileges	AWS IAM	Windows Azure Identity	Yes	Expected by Sep-2013	Identity Management	
	Compliance	Yes	Yes	Yes	Yes	Yes	Yes
	Data Provenance	Yes	Yes	Yes	Yes	Yes	Yes

	<b>Data Backup</b>	Customer responsible for backup,	Customer has to create snapshots, which further are backed up the Azure	Data backup responsibility of customer, aided by IBM SmartCloud Managed Backup	Backup has to be initiated by customer, aided by Unmetered Managed Backup	Customer responsible for data backups	Customer responsible for backup, aided by built in tools
	<b>Additional Features</b>	Security includes MFA, Built in firewalls, VPN, Encryption of data	Security includes Identity management, Isolation, Encryption,	Security include built-in firewall, IP-filtering technology, VPN, Encrypted connections	Best in class security services by 4 levels of security	Security includes MFA, Stronger token protection	NA
<b>SLA</b>	<b>Uptime</b>	99.95% monthly	99.95% monthly	99.90% monthly	100 % monthly	99.95% monthly	100% monthly
	<b>credit level</b>	Up to 30%	up to 25%	up to 10%	up to 100%	Up to 30%	NA
	<b>Failure Level Recognition</b>	Region	2 instances	data center	Instance	Instance	NA
<b>Compute Capacity</b>	<b>CPU - RAM capacity</b>	Ranges from 1 CPU, 615MB RAM - 32CPU cores, 244GB RAM	Ranges from 1CPU, 1.75GB Ram - 8CPU, 56GB RAM	Ranges from 1CPU, 2GB Ram - 16CPU, 16GB RAM	Ranges from 1CPU, 512MB RAM - 8 CPU, 30GB	Ranges from 1 CPU, 1GB RAM - 8CPU, 32GB RAM	Range s from 1CPU, 1GB RAM - 16 CPU cores, 128GB RAM
<b>APIs</b>		REST API, Java SDK, IDE plugin, Command Line tools	REST API, Java SDK, IDE plugin, Command Line tools	REST API	REST API	REST API	REST API
<b>Free Tier</b>		Yes, Free tier restricted to particular instance	Yes	Yes, free tier restricted to particular instance and software	No	Yes	Yes
<b>Instance Types</b>		12	7	4	8 and configurable	6	Configurable
<b>Data Transfer out (\$/GB)</b>		0.12	0.12	0.15	0.18	0.12	0.15
<b>Support</b>	<b>Response time</b>	Depends on the Plan	Depends on the Plan	Instantly	Instantly	Within a day	Instantly
	<b>Phone Call based Support</b>	Depends on the Plan	Yes	Yes	Yes	Yes	Yes
	<b>Online chat</b>	No	Yes	Yes	Yes	Yes	Yes
	<b>Charges</b>	Yes	Yes	Yes	Yes	No	No

### VIII. CONCLUSION

The paper suggests a point-by-point ready reckoner for the cloud adoption in major industry verticals across the business. Highlighted concerns from a few important

industry verticals like banking, finance, education, media and IT sector highlight a broad outline of the business requirements for the cloud adoption in these domains. Key cloud adoption parameters provide a spectrum of services a given industry vertical may look for while migrating from on-premise to cloud based deployments. Various scenarios

contribute towards a very crisp ready reckoner that will be very useful for the business people to decide cloud adoption quickly and precisely in line with their domain specific requirements. Currently, Cloud Computing is fast evolving technology area, therefore, the use cases discussed in the paper may need some feature based tweaking while using the suggested cloud ready reckoner in future.

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