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Cloud Computing- A Study of its Characteristics, Platforms and Models Deployed in Enterprises of Delhi-NCR Region

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Abstract: Cloud computing is a booming technology that utilizes internet and central remote servers for applications and data maintenance. It enables businesses and consumers to use applications without installation and access their personal files at any computer with proper Internet access. It allows highly efficient computing by centralizing memory, storage, processing and bandwidth. It implies research in virtualization, distributed computing, networking, utility computing, web and software services. This paper focuses on the technological details, characteristics, deployment models, architecture, services and applications of cloud computing. A detailed study of cloud segments namely, applications, storage and connectivity will be done so as to predict the benefits in shifting from on-premises platforms to cloud platforms thus generating snowball effect and cloud pyramid. . It also involves empirical research using percentage analysis and factor analysis to study the use, impact and need of cloud computing in organizations so as to enhance their competitive intelligence.

Keywords- cloud computing, central remote servers, deployment models, on-premises platforms, virtualization, snowball effect, cloud pyramid.

I. INTRODUCTION

Cloud computing is a style of computing where massive, scalable and elastic information technology related to capabilities are provided "as a service" to external consumers using internet technologies. It became popular in October 2007 when Google and IBM announced their collaboration with respect to cloud computing [1] [2]. Clouds provide data access, storage resources and software without letting users to bother about the location and other technical details of computing infrastructure.

It implies a service oriented architecture, great flexibility, reduced information technology overhead for the end-user, on-demand services and reduced total cost of ownership. It lets developers write applications that run in the cloud, or use services provide from the cloud, or both. It is now referred by different names as on-demand platform or platform as a service (PaaS).

It allows easy working environment for both end users and software developers as end users access cloud based applications through a web browser or mobile application while the business software and data are stored on servers at a remote location which ultimately give the same performance as of installed locally on end-user computers. Cloud technology has the potential to dramatically reduce the overall cost of computing and enhance corporate productivity. Cloud computing embraces cyber infrastructure which makes applications easy to develop and deploy and allows expansion of scope of applications within budget and organizational constraints. A simple example of cloud computing is Gmail, Hotmail and Yahoo email which allows consumers to use internet connection and send emails without requiring a software or a server on their systems as it is managed automatically on the cloud by the cloud service provider Yahoo, Google etc.

According to Forrester research cloud computing is "a pool of abstracted, highly scalable and managed computer infrastructure capable of hosting end-customer applications and billed by consumption". It has all the earmarks of being a potential innovation which professionals and enterprise need. It is fully virtualized, paid by consumption, dynamic in infrastructure, application and operating system independent, free of long term contracts and free of software or hardware installation.

According to IBM Press Releases on Blue cloud "Cloud computing is an emerging approach to share infrastructure in which large pools of systems are linked together to provide information technology services". It describes a hosted infrastructure model that assumes nothing about the physical location, ownership of its component parts or internal composition and deliver abstracted IT resources over the internet.

II. LITERATURE REVIEW

A lot of literature has been done in past years about the role, relevance and usage level of cloud computing. It is the next natural step in the evolution of on-demand information technology services and products using virtualized resources [3]. It is the delivery of computing as a service rather than a product, where software, shared resources and information are provided to computers and other devices as a metered service over internet. It allows Converged Infrastructure and shared services which allow enterprises in getting their applications up and run faster with less maintenance and easier manageability, thus enabling more rapid adjustment of IT resources as servers, networking etc. to meet varying and unpredictable business demands [4]. Through cloud adoption, employees can accomplish more tasks over any device from any location [5]. It increases quality, reliability and efficiency of applications and provides efficient sharing of equipment and services [6].

III. CHARACTERISTICS OF CLOUD COMPUTING

The following are the main characteristics of cloud computing-

a. Ease of use- cloud computing deploys infrastructure with a Application Programming Interface (API) so does not requires cabling, racking, buying and unboxing as it does its work remotely from anywhere anytime. End users are empowered to use resources in their own control in contrast to the control of a centralized IT service.
b. Scalability- cloud computing controls the infrastructure with the application so allows delivery on instant and no purchase.
c. Reduced Risk- cloud computing avoids risk and uncertainties as there is nothing to buy and allows instant change and rebuilding.
d. Reliability- cloud computing is designed to combat failures by automatically spinning up replacements and using multiple clouds as it is based on enterprise grade hardware. If multiple redundant sites are used it is most suitable for business continuity and disaster recovery [7].
e. Low cost- cloud computing does not involve too much costs as of applications, operating system and infrastructure as user pays only what he uses. There are no contracts to be made and no purchase in advance. It provides zero capital outlay and no annual maintenance fees by converting capital expenditure to operational expenditure [8].
f. Device and location independence- cloud computing enables users to access systems over internet irrespective of their physical location or device [9].
g. Increased speed- cloud computing provides 24 hour online self service.
h. Multi-tenancy- it enables sharing of resources and costs across multiple users allowing centralization of infrastructure in locations with lower costs. It also provides for utilization and efficiency improvements and increased peak load capacity.
i. Maintenance- cloud computing applications have easy maintenance as they do not need to be installed on each user's site.

IV. CLOUD PLATFORMS

Cloud platform lets developers write applications that use services provided from the cloud or run in the cloud or both. It is also called as on-demand platform and platform as a service(PaaS). If every development team wishes to create a cloud application, it must first build its own cloud platform using three types of cloud services as given in diagram below-

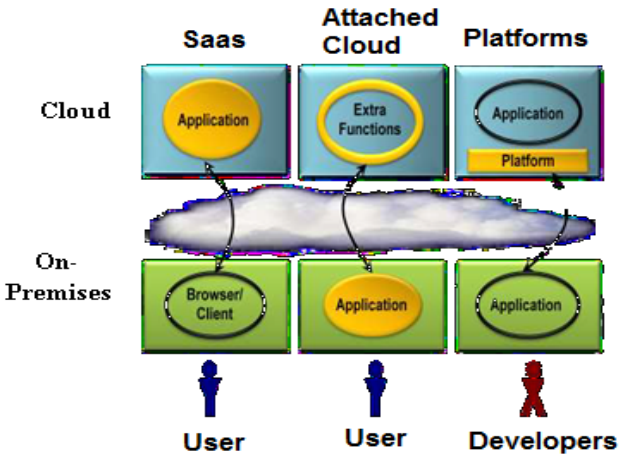

Figure1 Cloud Platforms in context of three types of cloud services (Source David Chappell, 2008)

A. *Software as a Service (SaaS):*

SaaS application runs entirely on the servers at an Internet- accessible service provider). It manages software on "usage basis" at established negotiated prices and provides maintenance and patches. SaaS Providers include future versions and releases examples- Enterprise email, back-up and recovery and host based security solution.

B. *Attached Services:*

Every on-premises application provides a number of attached services which can be enhanced by accessing application-specific services of the cloud. For example- Apple's iTunes in which desktop application is useful for playing music while an attached service allows buying new video and audio content. Microsoft's Exchange Hosted Services is another example of attached services which provides archiving, cloud based spam filtering and other services to an on-premises Exchange server.

C. *Cloud Platforms:*

It provides cloud-based services for creating applications rather than creating its own. For example- the creators of a new SaaS application could instead build on a cloud platform as shown in the above figure where direct users of a cloud platform are developers, not end users.

V. THE CLOUD PYRAMID

Cloud computing allows sharing of services within any one of the following layers, once an internet protocol connection is established-

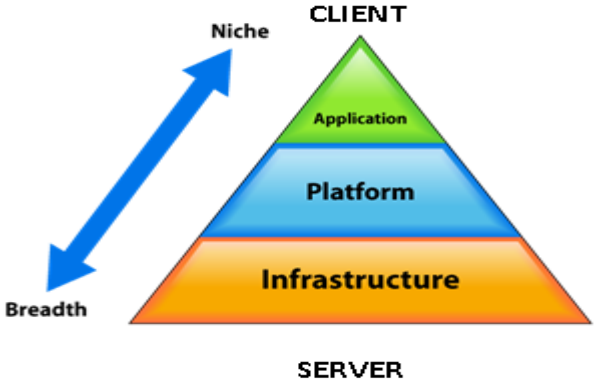

Figure 2- The Cloud Pyramid (Source http://milinic.blogspot.in/)

A. Client:

Cloud computing is accessed by users through networked client devices like laptops, tablets, desktop computers and smartphones. Some cloud applications do not require software on the client instead allow its access to clients using a web browser such as HTML5 and AJAX whereas some cloud applications require dedicated software on the client such as email clients and virtual desktop clients.

B. Application:

Software as a Service (SaaS) is a cloud application service that allows software usage on the Internet rather than on the clients machine thus simplifying maintenance and support. It consists of a package of tasks, their definition, configuration files which provide storage, computation, communication and management capabilities. Cloud applications provide utility computing and have a pricing model based on the storage usage and tenancy metrics [10]. Cloud applications are elastic and can be scaled into multiple virtual machines at run time to meet increasing run time demands.

C. Platform:

It is also known as Platform as a Service (PaaS) that provides solution stack and /or computing platform to the developers in writing applications for cloud or using services of cloud. It allows applications deployment without cost and buying complexity and managing underlying hardware and software layers [11].

D. Infrastructure:

It is also known as Infrastructure as a Service (IaaS) that delivers platform virtualization environment as a service along with storage and networking. Clients purchase resources as an outsourced service rather than purchasing them for which suppliers charge bill on utility computing basis and amount of resources used for example, virtual desktops and grid computing [12].

E. Server:

It supports the layers containing hardware and software, products delivering cloud services, multi core processors and their operating systems. Devices that use cloud computing use programs that reside on a remote server rather than on the device itself. The servers, in the so called cloud, deliver web services varying from customer relationship software to a facebook game.[13].

Thus, cloud delivery models which are deployed on the top of cloud infrastructure are as follows-

a. Cloud Software as a Service (SaaS)- it uses provider's applications over a network
b. Cloud Platform as a Service (PaaS)- it deploys customer created applications to a cloud
c. Cloud Infrastructure as a Service (IaaS)- it provides fundamental cloud computing services as storage, rent processing and network capacity.

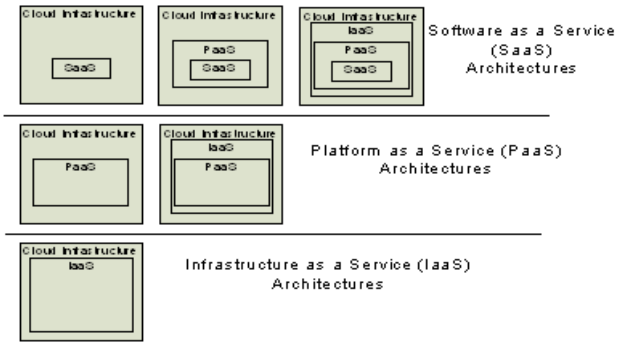

Figure 3- Cloud Delivery Models

VI. CLOUD COMPUTING DEPLOYMENT MODELS

The deployment models for cloud computing are community, private, public and hybrid which are explained as following-

A. Community Cloud:

It shares infrastructure between various organizations with similar concerns for compliance and security and either managed or hosted internally or externally by a third party. The cost incurred here are more than a private cloud but less than a public cloud allowing realization of cost saving potential [14].

B. Private Cloud:

This infrastructure is operated only for single organization and is either managed internally or by an external third party. It lacks the feature of reduced cost of cloud as users still have to buy, build and manage software's and applications.[15]. A "private cloud" lacks the economic model that makes cloud computing such an intriguing concept in the first place.

C. Public Cloud:

This model is a standard cloud model in which public over the internet are provided with applications and storage by a service provider. These services may be free or offered on pay-per-usage model.

D. Hybrid Cloud:

It is a combination of two or more private, public or community clouds that offer benefits of cloud in common by being unique but bounded together.

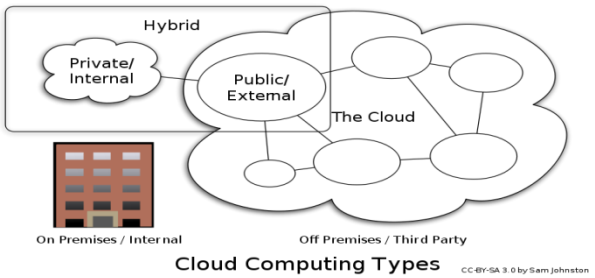

Figure 4 Cloud Computing Deployment Models (Source-Sam, 2009)

VII. A GENERAL MODEL FOR APPLICATION PLATFORMS

Cloud platforms allow seeing how the services an application developer relies on in the on-premises environment. It comprises of following three parts-

A. *Foundation:*

It includes support functions as standard libraries, storage and operating system. The on-premises foundation include the following-

a. ***Operating System***- Windows, UNIX, Linux etc.
b. ***Local Support***- .NET framework and advanced JAVA (J2EE) application servers provide local support for web applications while other technologies target specific applications such as Microsoft Dynamics CRM product includes support for specific business application. Same is the case for storage varying from raw byte storage by file systems to systems in Windows and Linux offering structured database storage in Oracle, Microsoft SQL Server, IBM, DB2 etc.

B. *Infrastructure Services:*

Applications use these basic services on other computer providing remote storage. For example, remote storage, integration services and identity services. The on-premises infrastructure services include the following-

a. ***Storage***- It varies from simple byte oriented storage on a remote file system to a structured remote storage service of a Microsoft Share Point document library.
b. ***Identity***- this information is the basic requirement for most distributed applications such as LDAP servers and Microsoft Active Directory.
c. ***Integration***- it provides connection of applications within an organization using a remote service. For example, a message queues, Microsoft's Biztalk Server, IBM's WebSphere Process Server etc.

C. *Application Services:*

They maximize towards service orientation to new applications which already exist to provide services to end users. The on-premises application services vary across different organizations as each use different application exposing diverse services. It includes two categories-

a. ***Packaged applications***- they expose services to other applications as SAP, Oracle and Microsoft Dynamics.
b. ***Custom applications***- they increasingly expose services and become a part of on-premises application platforms.

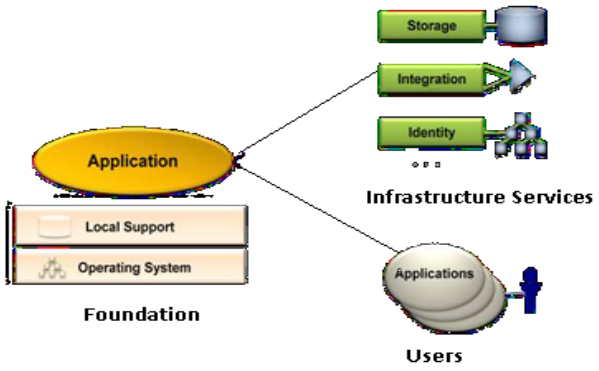

Figure 5- A General Model for Application Platforms (Source David Chappell, 2008)

VIII. CLOUD ARCHITECTURE

It is the systems architecture of the software systems involved in the delivery of cloud computing. It involves multiple cloud components communicating with each other over a loose coupling mechanism such as a messaging queue thus providing elasticity and scalability in cloud computation [16].

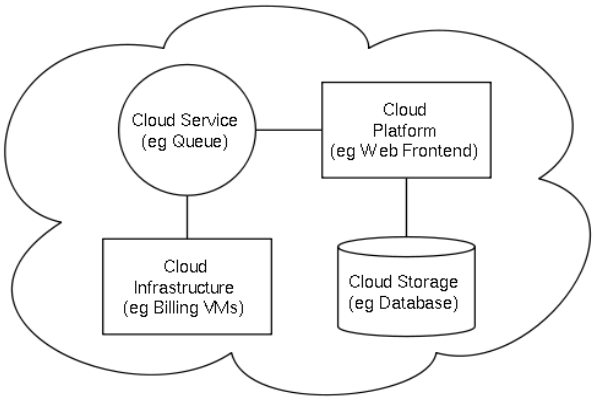

Figure 6 Cloud Computing architecture (Source- Sam, 2008)

IX. SHIFT FROM ON-PREMISES PLATFORM TO CLOUD PLATFORMS

The traditional hosting poses a number of problems with respect to low facility asset utilization, high depreciation (42-50%), higher power costs than server costs (55%), hardware obsolescence (30%) [17]. Thus, these problems are now resolved by collocation, managed hosting in which dedicated servers are managed by third party and cloud hosting which provides lower cost, easy usage and scaling, lower risk and increased reliability.

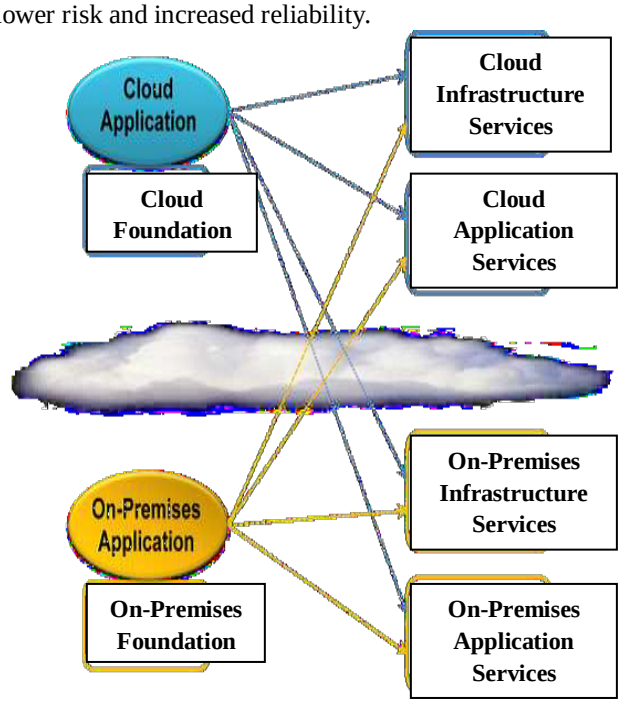

Figure 7 On-Premises Platforms and Cloud Platforms (Source David Chappell, 2008)

The above figure shows that a cloud application can be built on a cloud foundation similar to an on-premises application built on an on-premises foundation. Both types of applications can access application and infrastructure services of both platforms. On-premises platform support today's applications whereas cloud platforms provide services for applications to be built tomorrow.

X. VIRTUALIZATION IN THE CLOUD

It allows isolation and abstraction of lower level functionalities and underlying hardware, enabling profitability of higher level functions and aggregation and/or sharing of physical resources. It enables multiple users to share the same hardware but maintain distance based on data or application owner. Virtualization provides abstraction of computing resources by providing rapid deployment of new servers, flexible use of resources, virtual network connections and simplified recovery. Due to its economy and ability to offer complex and advanced IT services, it is used along with wireless and highly distributed computing devices like sensors [18]. Despite of having so many advantages and providing hardware assisted and operating system level virtualization, virtual computing environment faces problems of hypervisor security issues, virtual network connections, single component failure, risky impacts, keeping virtual machine images current and complexity.

XI. CLOUD SNOWBALL EFFECT

Snowball effect is the maturation of virtualization technology which creates demand for storage clouds. Storage and compute clouds create cloud infrastructure which enables cloud platforms and applications to be tightly configured and prove good for developers but are still restricted to dependencies and availability. For example- Google Application Engine, Force.com (Sales Force Development Platform). Multiple cloud types generate cloud aggregators which provide more options for cloud environments. Cloud snowball effect provides extension to cloud platforms and infrastructure through cloud extenders which extend functionality of computer and storage with legacy systems or other clouds. For example- Amazon SimpleDB, Google BigTable.

XII. APPLICATIONS OF CLOUD COMPUTING

A. In internet based companies as Amazon.com (AMZN), Google (GOOG)
B. By healthcare providers as eKlinik Healthcare Cloud Computing
C. Software as a Service used by Gmail, Yahoo mail for free and easy consumer adoption.
D. At Enterprise level for-
   a. Data Storage like Oracle, SQL Server, DB2
   b. Backup & Recovery
   c. Security solutions
   d. Spam Filtering
   e. Customer relationship software
   f. Online games
   g. Video Chat

XIII. RESEARCH METHODOLOGY

A survey of 100 people was conducted to know the impact and use of cloud computing in enterprises. Simple percentage analysis, factor analysis and pie chart were used as a tool to explain the questionnaire which is mostly a close ended one.

XIV. OBJECTIVES OF STUDY

a. Main Objective of the research is to study the characteristics, impact and need of cloud computing amongst the enterprise of Delhi NCR area.
b. To know the process and services mostly seeked by enterprises from cloud computing.
c. To know the type of servers, framework and technology used by enterprises for making use of cloud computing services.
d. To know the type of cloud models deployed in maximum enterprises of Delhi-NCR region.
e. To study the benefits of having cloud computing platform in enterprises.

XV. HYPOTHESIS

a. Many enterprises of Delhi-NCR region are in favour of cloud computing
b. Cloud platforms are more used for services than applications and infrastructure.
c. Cloud services provide zero-capital outlay and no annual maintenance fees.
d. Data Storage and Backup & Recovery are maximum used services on cloud platforms.
e. Cloud applications are popular and easy to access through web server than email and virtual desktop clients.
f. Hybrid cloud model is mostly deployed in enterprises and private model the least.
g. Cloud platform are more popular for todays and future applications than On-premises platform.

XVI. FINDINGS AND RESULTS OF ANALYSIS

Table 1. Use of cloud computing

Response	Yes	No
No. of Respondents	84	16

84 percent of the total respondent answered that they are aware and use cloud computing in their personal and enterprise operations whereas 16 percent responded that they are not using it.

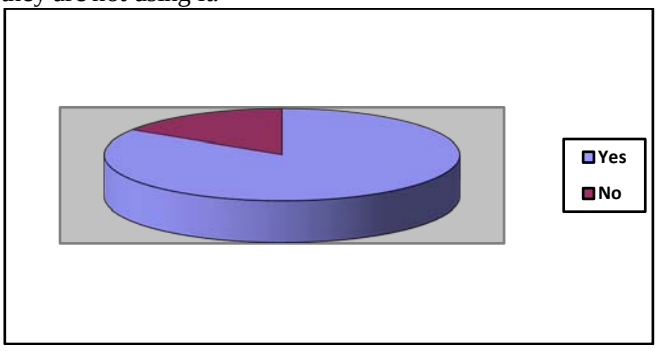

Figure 8 Cloud computing awareness in respondents

Table 2. Email Cloud server mostly used

Cloud server	**No. of respondents**	**Percentage of the response (Total=84)**
Yahoo	22	26.19
Google	44	52.38
Rediff	18	21.43

The analysis reveals that 52.38 percent of the respondents use gmail for emailing and rediff the least having only 21.43 percent respondents thus, showing that google server is more successful cloud platform providing its users ease, security and unlimited data storage.

Table 3.Cloud server usage

Cloud Usage	**No. of respondents**	**Percentage of the response (Total=84)**
Services	40	47.62
Applications	28	33.33
Infrastructure	16	19.05

Almost 48 percent of the respondents use cloud platforms and environments for services, 33 percent for applications and only 19 percent use cloud for its infrastructure.

Table 4. Are Cloud services cheaper

Response	Yes	No
No. of Respondents	81	3

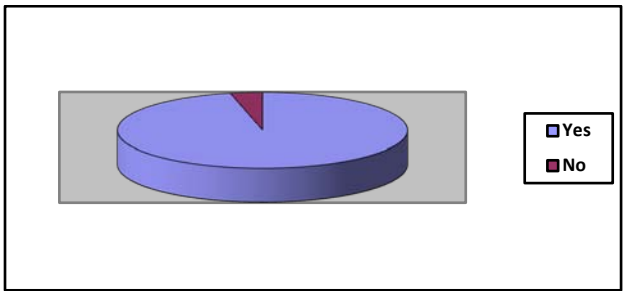

Figure 9 Cloud service cost

Out of 84 respondents who use cloud computing, 81 that is, 96.43 percent agreed that cloud services provide zero-capital outlay and no annual maintenance fees

Table 5. Empirical and Factor Analysis of Cloud services usage in Enterprises

KMO and Bartlett's Test[a]

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.571
Bartlett's Test of Sphericity	Approx. Chi-Square	866.586
	Df	55
	Sig.	.000

a. Based on Correlations:

KMO values is more than 0.571, which clarifies that factor analysis is suitable in this sample. Kaiser Meyer-Olkin test is adopted during the factor analysis to know the adequacy of the sample whether the sample is suitable for factor analysis or not.

Rotated Component Matrix[a]

	Raw Component		Rescaled Component	
	1	2	1	2
D_strorage	1.364	.814	.844	.499
Backup	.814	.523	.776	.504
Security	.593	.460	.563	.437
SF	-.275	-.383	-.245	-.343
CRS	.986	.401	.789	.321
OG	.559	.034	.492	.030
VC	.137	.013	.166	.016
DC	-.151	-.454	-.097	-.291
NWT	.301	.245	.321	.261
Virtu	3.152	-4.446	.578	-.815
CI	.547	.065	.550	.065

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

D_strorage-Data Storage
Backup-Backup & Recovery
Security-Security Solutions
SF-Spam Filtering
CRS-Customer Relationship Software
OG-Online Games
VC-Video Chat
DC-Distributed Computing
NWT-Networking
Virtu-Virtualization
CI-Converged Infrastructure

By looking into the rotated component matrix it is clearly evaluated that the two factors are Data storage like oracle, SQL server, DB2 etc. and other is Backup and recovery, which were used as primary cloud services. **(See Annexure 1 for Factor Analysis of usage of cloud services in Enterprises of Delhi-NCR Region)**

Table 6. Is Cloud usage through web server better than virtual desktop clients

Response	Yes	No
No. of Respondents	70	14

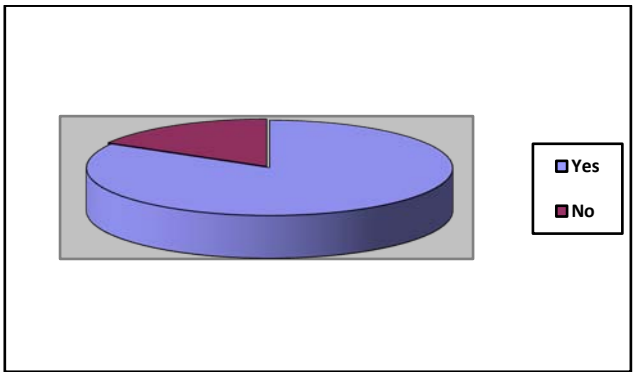

Figure 10 Cloud services are better used through web servers

Out of 84 respondents who use cloud computing, 70 respondents that is, 83.33 percent agreed that they use cloud applications through web server like AJAX, HTML5 whereas only 16.67 percent use through email and virtual desktop clients.

Table 7. Data model deployed in Enterprises for cloud services

Data Models	No. of respondents	Percentage of responses (Total=84)
Community	10	11.90
Private	9	10.71
Public	27	32.14
Hybrid	38	45.24

Most of the enterprises preferred the Hybrid model most for cloud computing followed by public and community model. Private model is the costliest amongst all so is least used.

Table 8. Framework adapted for local support to cloud computing

Framework	No. of respondents	Percentage of responses (Total=84)
.Net	48	57.14
J2EE	36	42.86

Out of 84 respondents who use cloud computing, 48 respondents that is, 57.14 percent agreed that they use .Net

framework for local support, whereas 42.86 percent use J2EE platform. The analysis reveals that both frameworks are equally good and can be used successfully as shown in the pie chart below.

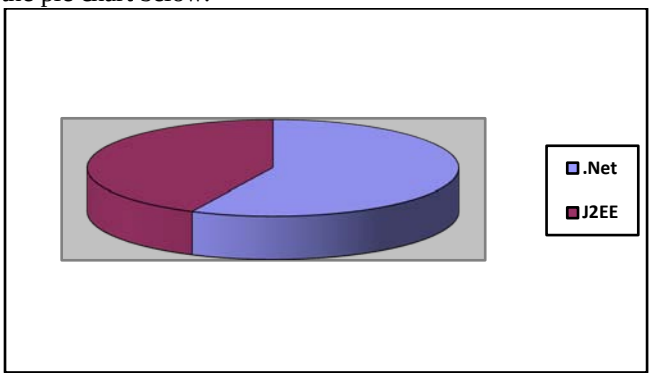

Figure 11 Framework for cloud computing

Table 9. Platform Preferred for future

Platform	No. of respondents	Percentage of responses (Total=84)
On-premises	10	11.90
Cloud Platform	74	88.09

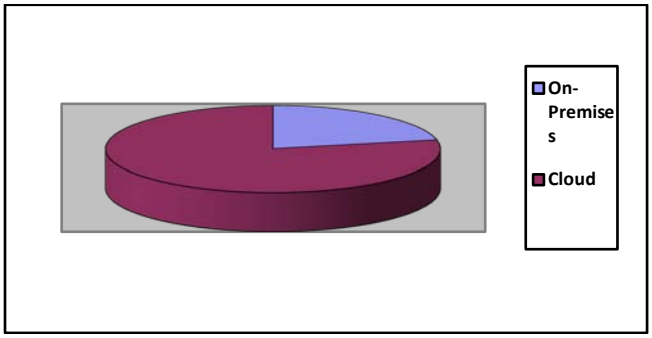

Figure 12 Platform used for future

74 respondents that is, 88.09 percent agreed that they are and would use Cloud platform for today's and future applications whereas, only 11.9 percent prefer On-premises for today's applications and are not that bothered of future.

XVII. PRIVACY AND SECURITY ISSUES

Cloud computing despite of its ability to allow resources and applications on the internet at a faster rate, faces a number of problems like-

a. Encryption needs
b. Data ownership
c. Conflicts with existing data dispersal and international privacy laws
d. Moving personal and sensitive information to the cloud without user validation and security
e. Accidental or deliberate alteration or deletion of information in the cloud
f. Data segregation
g. Bug exploitation and malicious intrusion
h. Management console security

XVIII. SUGGESTIONS AND RECOMMENDATIONS

Cloud computing promotes external management of services and so opens up private and public security issues but these can be resolved by security optimization, validations, shared accreditation, contingency planning, disaster recovery, cryptography like Public Key Infrastructure (PKI), abiding legal policies, improving virtual machine support and business streamlining. So, a new cloud pyramid could be used now with extenders and aggregators.

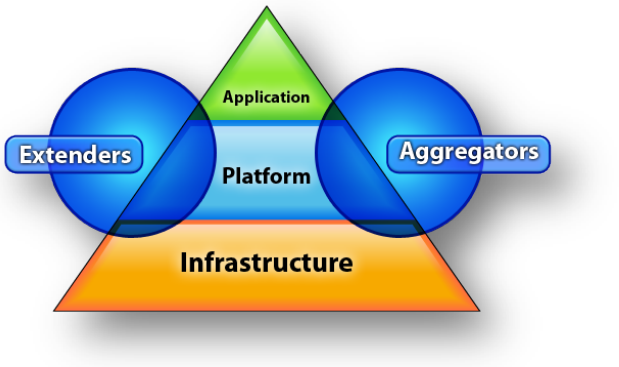

Figure 13 New Cloud Pyramid (Source http://milinic.blogspot.in/)

XIX. CONCLUSION

Cloud computing is thus, a unique research in virtualization, utility computing, distributed computing, networking, web and software services. It pertains to all the files or documents kept by servers from remote systems that can be accessed through the internet. These files can be used either for personal use or for other user purposes. Cloud platforms don't yet offer full environment for on-premises services but is still gaining popularity and reach due to its lower costs, scalability, flexibility and quick on-demand services. In future, it is going to play a vital role whether for a software vendor or for an end-user as it provides next generation application platforms.

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Annexure 1

Factor Analysis of Usage of Cloud Services in Enterprises of Delhi-NCR Region

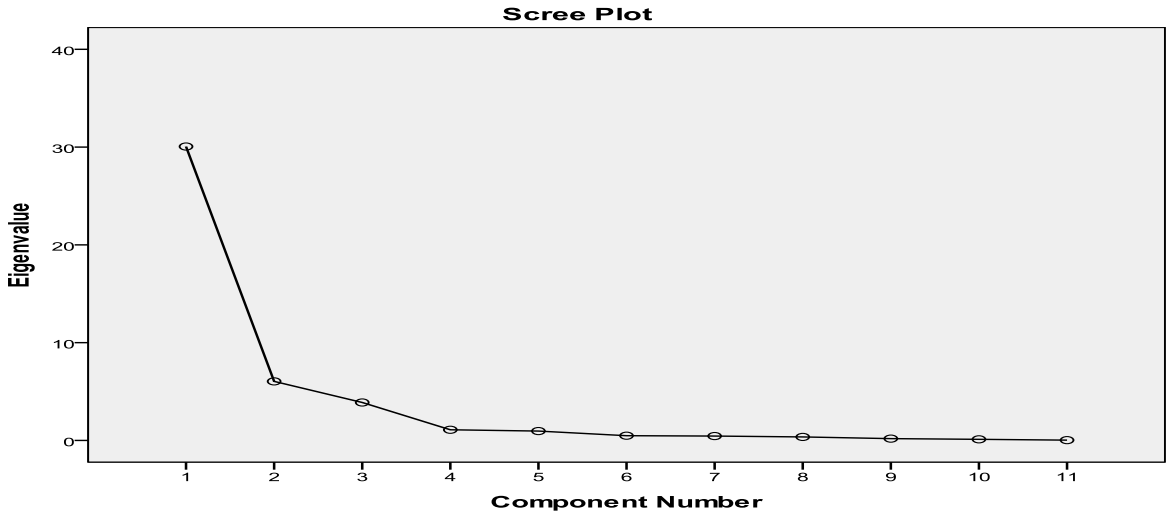
Total Variance Explained

	Component	Initial Eigenvalues[a]			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
		Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Rescaled	1	30.058	68.875	68.875	1.262	11.475	11.475	3.332	30.289	30.289
	2	6.039	13.837	82.712	3.806	34.601	46.076	1.737	15.787	46.076
	3	3.881	8.893	91.605						
	4	1.090	2.498	94.103						
	5	.957	2.194	96.297						
	6	.484	1.109	97.406						
	7	.447	1.024	98.430						
	8	.358	.820	99.250						
	9	.184	.423	99.672						
	10	.113	.258	99.931						
	11	.030	.069	100.000						

Extraction Method: Principal Component Analysis.

a. When analyzing a covariance matrix, the initial eigenvalues are the same across the raw and rescaled solution.

Total variance table provide the information that their exists two factors in the question whose total variance is more than any other factor. Here in this problem their exists one factor whose total variance is 68.875 percent of 100 percent variance. Similarly second factor affect by 13.837 percent as total variance including first factor covers 82.712 percent of the total variance, which means that there exist two factors which affects more than any other 9 factors.



Scree plot is the representations of the total variance table.

