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**INTRODUCTION:**

The concept of “Cloud Computing” is gaining a lot of attention these days. It is assumed that Cloud Computing is going to be the future which can transform the IT industry. In this paper, let us understand what is the meaning of the word cloud computing and how and why it is gaining so much of importance. Let us understand how Cloud Computing has the potential to transform a large part of the IT industry, making software even more attractive as a service and shaping the way IT hardware is designed and purchased. This paper not only gives a clear understanding about Cloud computing, but it will also discuss why suddenly the concept has emerged and what are the obstacles present which hinders the growth of it. An attempt is made to analyze the obstacles and provide opportunities for the obstacles. Apart from all these, this paper will also throw some light on how the concept of Cloud Computing fits into the three circles of intelligence, communication and computation.

**DEFINITION OF CLOUD COMPUTING:**

Cloud Computing is an emerging computing paradigm where data and services reside in massively scalable data centers and can be ubiquitously accessed from any connected devices over the internet. This data center is referred to as the cloud and is generally represented by using the cloud symbol.

Cloud Computing is a computing technology that uses the internet and central remote servers to maintain data and applications. Cloud computing allows consumers and businesses to use applications without installation and access their personal files at any computer with internet access. This technology allows for much more efficient computing by centralizing storage, memory, processing and bandwidth. The cloud uses software to manage the cloud's computing resources so that it can dynamically scale to meet traffic and computing demands.

In a way the cloud is not really a technology by itself. Rather, it is an approach to building IT services that harnesses the rapidly increasing horsepower of servers as well as virtualization technologies that combine many servers into large computing pools and divide single servers into multiple virtual machines that can be spun up and powered down at will.

Gartner has an important definition for cloud computing in which he defines it as

"a style of computing in which massively scalable IT-related capabilities are provided 'as a service' using Internet technologies to multiple external customers."

The concept of cloud computing has a tremendous affect on the IT industry and is having the potential to transform a large part of the IT industry, making software even more attractive as a service and shaping the way IT hardware is designed and purchased.

Traditional business applications—like those from SAP, Microsoft, and Oracle—have always been too complicated and expensive. They need a data center with office space, power, cooling, bandwidth, networks, servers, storage and a complicated software stack. And a team of experts to install, configure, and run them. They need development, testing, staging, production, and failover environments. When you multiply these headaches across dozens or hundreds of applications, it’s easy to see why the biggest companies with the best IT departments aren’t getting the applications they need.

All these reasons show that Cloud computing is a better approach. Instead of running your applications yourself, they run on a shared data center. When you use any application that runs in the cloud, you just log in, customize it, and start using it. That’s the power of cloud computing.

Hence we can say that Cloud computing is a simple idea, but it has a huge impact.

**CHARACTERISTICS:**

There are a few important defining characteristics of cloud computing. Let us look at each one of them in detail.

* Usage-driven
* Sold on demand
* Elastic
* Service is fully managed by the provider
* Virtual
* Scalable
* Efficient
* Flexible

Characteristic 1: The most important characteristic of cloud computing is that it is usage-driven. Consumers pay for only what resources they use and therefore are charged or billed on a consumption-based model. This explains that the Cloud computing platforms provide mechanisms to capture usage information that enables chargeback reporting and/or integration with billing systems. The value here from a user’s perspective is the ability for them to pay only for the resources they use, ultimately helping them keep their costs down. From a provider’s perspective, it allows them to track usage for charge back and billing purposes.

Characteristic 2: Another important characteristic of cloud computing is that it is sold on demand. Whenever a user requires a resource, it demands from the cloud and only then the user is provided with that resource. This ensures that the users get only those resources which they have asked for.

Characteristic 3: Cloud Computing is said to be elastic. This means that the user can get as much more or as less service that he requires.

Characteristic 4: Another important feature of cloud computing is that the service is fully managed by the provider. A PC and an internet connection is sufficient for the user to access resources from the cloud. The user is freed of the responsibilities of the management of the services.

Characteristic 5: The technology of Cloud Computing is virtual, which means that the physical location and underlying infrastructure details are transparent to users.

Characteristic 6: Cloud Computing is scalable. Scalable means able to break complex workloads into pieces to be served across an incrementally expandable infrastructure.

Characteristic 7: Another important characteristic of cloud computing is that the technology is efficient.

Characteristic 8: It is also very flexible and can serve a variety of workload types ie; both consumer and commercial.

These are all the defining characteristics of the cloud computing technology.

Now let us take a brief look at the characteristics of Cloud computing which differentiates it from traditional hosting.

1. Cloud computing is sold on demand, typically by the minute or the hour which is not the case with traditional hosting
2. It is elastic which means that the user can have as much or as little of a service as they want at any given time
3. And the last important character that differentiates cloud computing from traditional hosting is that the service is fully managed by the provider (the consumer needs nothing but a personal computer and Internet access) unlike the traditional hosting.

**TYPES OF CLOUDS:**

The cloud, which is the data centre that stores all the data and services in it and provides to a user when requested, can actually be divided into two types.

1. Public Cloud
2. Private Cloud

What is a public cloud?

A [public cloud](http://searchCloudComputing.techtarget.com/sDefinition/0,,sid201_gci1356516,00.html) is one that sells services to anyone on the Internet. Anyone can tap into a public cloud with a network connection and a credit card. "Public clouds are shared infrastructures with pay-as-you-go economics," explains Forrester analyst James Staten. "Public clouds are easily accessible, multitenant virtualized infrastructures that are managed via a self-service portal." Currently, Amazon Web Services is the largest public cloud provider.

What is a private cloud?

A [private cloud](http://searchCloudComputing.techtarget.com/sDefinition/0,,sid201_gci1333074,00.html) is a proprietary network or a data center that supplies hosted services to a limited number of people. A [private cloud](http://www.networkworld.com/news/2008/111208-private-cloud-networks.html) attempts to mimic the delivery models of public cloud vendors but does so entirely within the firewall for the benefit of an enterprise's users. A private cloud would be highly virtualized, stringing together mass quantities of IT infrastructure into one or a few easily managed logical resource pools.

Like public clouds, delivery of private cloud services would typically be done through a Web interface with self-service and chargeback attributes. Private clouds give you many of the benefits of cloud computing, but it's privately owned and managed, the access may be limited to your own enterprise or a section of your value chain. It does drive efficiency, it does force standardization and best practices.

The largest enterprises are interested in private clouds because public clouds are not yet scalable and reliable enough to justify transferring all of their IT resources to cloud vendors.

Virtual Private Cloud: There is another type of cloud which is known as the virtual private cloud. When a service provider uses public cloud resources to create their private cloud, the result is called a virtual private cloud. Private or public, the goal of cloud computing is to provide easy, scalable access to computing resources and IT services.

**NEW ASPECTS FROM A HARDWARE POINT OF VIEW:**

When we try to look at the Cloud computing from the hardware point of view we can see three new aspects.

1. The illusion of infinite computing resources available on demand eliminates the need for Cloud Computing users to plan ahead for provisioning.

2. The elimination of an up-front commitment by Cloud users allows companies to start small and increase hardware resources only when there is an increase in their needs.

3. The ability to pay for use of computing resources on a short-term basis as needed and release them as needed and release them as needed, thereby rewarding conservation by letting machines and storage go when they are no longer useful. Generally the processors are taken by the hour and the storage by the day.

**SERVICES PROVIDED BY CLOUD COMPUTING:**

Services provided by cloud computing can be split into three major categories as follows:

### Infrastructure-as-a-Service (IaaS)

Infrastructure-as-a-Service like Amazon Web Services provides virtual server instances with unique IP addresses and blocks of storage on demand. Customers use the provider's application program interface ([API](http://searchExchange.techtarget.com/sDefinition/0,,sid43_gci213778,00.html)) to start, stop, access and configure their virtual servers and storage. In the enterprise, cloud computing allows a company to pay for only as much capacity as is needed, and bring more online as soon as required. Because this pay-for-what-you-use model resembles the way electricity, fuel and water is consumed, it is sometimes referred to as utility computing.

### Platform-as-a-Service (PaaS)

Platform-as-a-service in the cloud is defined as a set of software and product development tools hosted on the provider's infrastructure. Developers create applications on the provider's platform over the Internet. PaaS providers may use APIs, website [portal](http://searchCIO-Midmarket.techtarget.com/sDefinition/0,,sid183_gci212810,00.html)s or [gateway](http://searchNetworking.techtarget.com/sDefinition/0,,sid7_gci212176,00.html) software installed on the customer's computer. Force.com, (an outgrowth of Salesforce.com) and GoogleApps are examples of PaaS. Developers need to know that currently, there are not standards for interoperability or data portability in the cloud. Some providers will not allow software created by their customers to be moved off the provider's platform.

### Software-as-a-Service (SaaS)

In the software-as-a-service cloud model, the vendor supplies the hardware infrastructure, the software product and interacts with the user through a front-end portal. SaaS is a very broad market. Services can be anything from Web-based email to inventory control and database processing. Because the service provider hosts both the application and the data, the end user is free to use the service from anywhere.

**WHY NOW, NOT THEN?**

Even though we consider that the construction and operation of extremely large scale commodity-computer datacenters was the key necessary enabler of Cloud Computing, additional technology trends and new business models also played a key role in making it a reality this time around.

**New Technology Trends and Business Models**

Accompanying the emergence of Web 2.0 was a shift from “high-touch, high-margin, high-commitment” provisioning of service “low-touch, low-margin, low-commitment” self-service. For example, in Web 1.0, accepting credit card payments from strangers required a contractual arrangement with a payment processing service such as VeriSign or Authorize.net; the arrangement was part of a larger business relationship, making it onerous for an individual or a very small business to accept credit cards online. With the emergence of PayPal, however, any individual can accept credit card payments with no contract, no long-term commitment, and only modest pay-as-you-go transaction fees. A second innovation was selling hardware-level virtual machines cycles, allowing customers to choose their own software stack without disrupting each other while sharing the same hardware and thereby lowering costs further.

**New Application Opportunities**

Mobile interactive applications: Tim O’Reilly believes that “the future belongs to services that respond in real time to information provided either by their users or by nonhuman sensors.” Such services will be attracted to the cloud not only because they must be highly available, but also because these services generally rely on large data sets that are most conveniently hosted in large datacenters. This is especially the case for services that combine two or more data sources or other services. While not all mobile devices enjoy connectivity to the cloud 100% of the time, the challenge of disconnected operation has been addressed successfully in specific application domains, so we do not see this as a significant obstacle to the appeal of mobile applications.

Parallel batch processing: Although thus far we have concentrated on using Cloud Computing for interactive SaaS, Cloud Computing presents a unique opportunity for batch-processing and analytics jobs that analyze terabytes of data and can take hours to finish. If there is enough data parallelism in the application, users can take advantage of the cloud’s new “cost associativity”: using hundreds of computers for a short time costs the same as using a few computers for a long time.

The rise of analytics: A special case of compute-intensive batch processing is business analytics. While the large database industry was originally dominated by transaction processing, that demand is leveling off. A growing share of computing resources is now spent on understanding customers, supply chains, buying habits, ranking, and so on. Hence, while online transaction volumes will continue to grow slowly, decision support is growing rapidly, shifting the resource balance in database processing from transactions to business analytics.

Extension of compute-intensive desktop applications: The latest versions of the mathematics software packages Matlab and Mathematica are capable of using Cloud Computing to perform expensive evaluations. Other desktop applications might similarly benefit from seamless extension into the cloud.

**ADVANTAGES OF CLOUD COMPUTING:**

Let us look at the advantages offered by cloud computing, and since there are many advantages I have summarized few of them here:

* **Lower-Cost Computers for Users:**

Here’s a quantitative financial advantage: You don’t need a high-powered (and accordingly high-priced) computer to run cloud computing’s web-based applications. Because the application runs in the cloud, not on the desktop PC, that desktop PC doesn’t need the processing power or hard disk space demanded by traditional desktop software. Hence the client computers in cloud computing can be lower priced, with smaller hard disks, less memory, more efficient processors, and the like. In fact, a client computer in this scenario wouldn’t even need a CD or DVD drive, because no software programs have to be loaded and no document files need to be saved.

* **Improved Performance:**

Let’s look further at what results when a desktop PC doesn’t have to store and run a ton of software-based applications. (The apps are run from the cloud, instead.) With fewer bloated programs hogging the computer’s memory, users will see better performance from their PCs. Put simply, computers in a cloud computing system will boot up faster and run faster, because they’ll have fewer programs and processes loaded into memory.

* **Lower IT Infrastructure Costs:**

In a larger organization, the IT department could also see lower costs from the adoption of the cloud computing paradigm. Instead of investing in larger numbers of more powerful servers, the IT staff can use the computing power of the cloud to supplement or replace internal computing resources. Those companies that have peak needs no longer have to purchase equipment to handle the peaks; peak computing needs are easily handled by computers and servers in the cloud.

* **Fewer Maintenance Issues:**

Speaking of maintenance costs, cloud computing greatly reduces both hardware and software maintenance for organizations of all sizes. First, the hardware. With less hardware (fewer servers) necessary in the organization, maintenance costs are immediately lowered. As to software maintenance, remember that all cloud apps are based elsewhere, so there’s no software on the organization’s computers for the IT staff to maintain. It’s that simple.

* **Lower Software Costs:**

Then there’s the issue of software cost. Instead of purchasing separate software packages for each computer in the organization, only those employees actually using an application need access to that application in the cloud. Even if it costs the same to use web-based applications as it does similar desktop software, IT staffs are saved the cost of installing and maintaining those programs on every desktop in the organization. As to the cost of that software, it’s possible that some cloud computing companies will charge as much to “rent” their apps as traditional software companies charge for software purchases. However, early indications are that cloud services will be priced substantially lower than similar desktop software. In fact, many companies (such as Google) are offering their web-based applications for free—which to both individuals and large organizations is much more attractive than the high costs charged by Microsoft and similar desktop software suppliers.

* **Instant Software Updates:**

Another software-related advantage to cloud computing is that users are no longer faced with the choice between obsolete software and high upgrade costs. When the app is web-based, updates happen automatically and are available the next time the user logs in to the cloud. Whenever you access a web-based application, you’re getting the latest version—without needing to pay for or download an upgrade.

* **Increased Computing Power:**

This is an obvious one. When you’re tied into a cloud computing system, you have the power of the entire cloud at your disposal. You’re no longer limited to what a single desktop PC can do, but can now perform supercomputing-like tasks utilizing the power of thousands of computers and servers. In other words, you can attempt greater tasks in the cloud than you can on your desktop.

* **Unlimited Storage Capacity:**

Similarly, the cloud offers virtually limitless storage capacity. Consider that when your desktop or laptop PC is running out of storage space. Your computer’s 200GB hard drive is peanuts compared to the hundreds of petabytes (a million gigabytes) available in the cloud. Whatever you need to store, you can.

* **Increased Data Safety:**

A big question which arises for most of us is “Is the data that we store in the cloud safe?” It stays in the cloud—somewhere. Unlike desktop computing, where a hard disk crash can destroy all your valuable data, a computer crashing in the cloud doesn’t affect the storage of your data. That’s because data in the cloud is automatically duplicated, so nothing is ever lost. That also means if your personal computer crashes, all your data is still out there in the cloud, still accessible. In a world where few individual desktop PC users back up their data on a regular basis, cloud computing can keep data safe.

* **Improved Compatibility Between Operating Systems:**

If you have tried toget a Windows-based computer to talk to a Mac or a Linux machine to share data with a Windows PC you realize that it is frustrating. But it is not the case with cloud computing. In the cloud, operating systems simply don’t matter. You can connect your Windows computer to the cloud and share documents with computers running Apple’s Mac OS, Linux, or UNIX. In the cloud, the data matters, not the operating system.

* **Improved Document Format Compatibility:**

You also don’t have to worry about the documents you create on your machine being compatible with other users’ applications or operating systems. In a world where Word 2007 documents can’t be opened on a computer running Word 2003, all documents created by web-based applications can be read by any other user accessing that application. There are no format incompatibilities when everyone is sharing docs and apps in the cloud.

* **Easier Group Collaboration:**

Sharing documents leads directly to collaborating on documents. To many users, this is one of the most important advantages of cloud computing—the ability for multiple users to easily collaborate on documents and projects. With cloud computing, anyone anywhere can collaborate in real time. It’s an enabling technology.

* **Universal Access to Documents:**

Ever get home from work and realize you left an important document at the office? Or forget to take a file with you on the road? Or get to a conference and discover you forgot to bring along your presentation? Not a problem when you use cloud computing. With cloud computing, you don’t take your documents with you. Instead, they stay in the cloud, where you can access them from anywhere you have a computer and an Internet connection. All your documents are instantly available from wherever you are. There’s simply no need to take your documents with you—as long as you have an Internet connection, that is.

* **Latest Version Availability:**

And here’s another document-related advantage of cloud computing. When you edit a document at home, that edited version is what you see when you access the document at work. The cloud always hosts the latest version of your documents; you’re never in danger of having an outdated version on the computer you’re working on.

* **Removes the Tether to Specific Devices:**

Finally, here’s the ultimate cloud computing advantage—you’re no longer tethered to a single computer or network. Change computers, and your existing applications and documents follow you through the cloud. Move to a portable device, and your apps and documents are still available. There’s no need to buy a special version of a program for a particular device, or save your document in a device-specific format. Your documents and the programs that created them are the same no matter what computer you’re using.

**USES OF CLOUD COMPUTING:**

Significant innovations in virtualization and distributed computing, as well as improved access to high-speed Internet and a weak economy, have accelerated interest in cloud computing. Cloud computing is used in several areas such as:

* IT management
* Collaboration
* Personal and business applications
* Application development and deployment
* Server and storage capacity

**EXAMPLE OF HOW THE CLOUD DRIVES INNOVATION:**

We have seen the advantages and the uses of cloud computing. One main reason for the Cloud computing to gain so much of importance is due to the reason that the cloud drives innovation. The cloud can drive innovation because it can expand sources of innovation with a network of people who are connected to it. Feedback for the new offerings that are resulted from the ideas of various people can be collected in a short time and then the incubation environment is provided to the prototypes due to the lower barriers to IT.

**WHO WOULD BECOME A CLOUD COMPUTING PROVIDER, AND WHY?**

We have seen the advantages of Cloud Computing and the reasons for which the Cloud Computing users are attracted to it, however who would become a Cloud Computing provider, and why?

There are some reasons that we might have been the attractions for one to become a cloud computing provider. They are:

1. Make a lot of money: Although 10 cents per server-hour seems low, estimations are that very large datacenters (tens of thousands of computers) can purchase hardware, network bandwidth, and power for the prices offered to a medium-sized (hundreds or thousands of computers) datacenter. Further, the fixed costs of software development and deployment can be amortized over many more machines. Thus, a sufficiently large company could leverage these economies of scale to offer a service well below the costs of a medium-sized company and still make a tidy profit.

2. Leverage existing investment: Adding Cloud Computing services on top of existing infrastructure provides a new revenue stream at (ideally) low incremental cost, helping to amortize the large investments of datacenters. This statement is considered true because Amazon’s CTO, Werner Vogels, himself said many Amazon Web Services technologies were initially developed for Amazon’s internal operations.

3. Defend a franchise: As conventional server and enterprise applications embrace Cloud Computing, vendors with an established franchise in those applications would be motivated to provide a cloud option of their own. For example, Microsoft Azure provides an immediate path for migrating existing customers of Microsoft enterprise applications to a cloud environment.

4. Leverage customer relationships: IT service organizations such as IBM Global Services have extensive customer relationships through their service offerings. Providing a branded Cloud Computing offering gives those customers an anxiety-free migration path that preserves both parties’ investments in the customer relationship.

5. Become a platform: Facebook’s initiative to enable plug-in applications is a great fit for cloud computing, and indeed one infrastructure provider for Facebook plug-in applications is Joyent, a cloud provider. Yet Facebook’s motivation was to make their social-networking application a new development platform.

**OBSTACLES AND OPPORTUNITIES:**

There are several obstacles present which are obstructing the growth of Cloud Computing. In this section, I have identified some of these obstacles and have also offered some thought on it which can overcome the obstacle. I consider that making use of these opportunities can actually help in the full growth of Cloud Computing.

Number 1 Obstacle: Availability of a Service

When an organization want to shift to Cloud computing they worry whether Utility Computing services will have adequate availability. Ironically, existing SaaS products have set a high standard in this regard. For example Google Search is effectively the dial tone of the Internet: if people went to Google for search and it wasn’t available, they would think the Internet was down. Users expect similar availability from new services, which is hard to do. However just as large Internet service providers use multiple network providers so that failure by a single company will not take them off the air, the high availability while using Cloud computing can also be assured by making use of multiple Cloud Computing providers. When multiple providers are used there isn’t a single point of failure and even if one provider is not being able to provide the service it can be accessed from another provider.

Another availability obstacle is Distributed Denial of Service (DDoS) attacks. Criminals threaten to cut off the incomes of SaaS providers by making their service unavailable, extorting $10,000 to $50,000 payments to prevent the launch of a DDoS attack. Such attacks typically use large “botnets” that rent bots on the black market for $0.03 per bot (simulated bogus user) per week. Utility Computing offers SaaS providers the opportunity to defend against DDoS attacks by using quick scale-up.

Number 2 Obstacle: Data Lock-In

Software stacks have improved interoperability among platforms, but the APIs for Cloud Computing itself are still essentially proprietary, or at least have not been the subject of active standardization. Thus, customers cannot easily extract their data and programs from one site to run on another. Concern about the difficult of extracting data from the cloud is preventing some organizations from adopting Cloud Computing. Customer lock-in may be attractive to Cloud Computing providers, but Cloud Computing users are vulnerable to price increases, to reliability problems, or even to providers going out of business. The obvious solution is to standardize the APIs so that a SaaS developer could deploy services and data across multiple Cloud Computing providers so that the failure of a single company would not take all copies of customer data with it. The obvious fear is that this would lead to a “race-to-the-bottom” of cloud pricing and flatten the profits of Cloud Computing providers. We offer two arguments to allay this fear. First, the quality of a service matters as well as the price, so customers will not necessarily jump to the lowest cost service. Some Internet Service Providers today cost a factor of ten more than others because they are more dependable and offer extra services to improve usability. Second, in addition to mitigating data lock-in concerns, standardization of APIs enables a new usage model in which the same software infrastructure can be used in a Private Cloud and in a Public Cloud. Such an option could enable “Surge Computing,” in which the public Cloud is used to capture the extra tasks that cannot be easily run in the datacenter (or private cloud) due to temporarily heavy workloads.

Number 3 Obstacle: Data Confidentiality and Auditability

“My sensitive corporate data will never be in the cloud.” Anecdotally we have heard this repeated multiple times. Current cloud offerings are essentially public networks, exposing the system to more attacks. There are also requirements for auditability, that is the regulations that must be provided for corporate data to be moved to the cloud. We believe that there are no fundamental obstacles to making a cloud-computing environment as secure as the vast majority of in-house IT environments, and that many of the obstacles can be overcome immediately with wellunderstood technologies such as encrypted storage, Virtual Local Area Networks, and network middleboxes (e.g. firewalls, packet filters). Similarly, auditability could be added as an additional layer beyond the reach of the virtualized guest OS (or virtualized application environment), providing facilities arguably more secure than those built into the applications themselves and centralizing the software responsibilities related to confidentiality and auditability into a single logical layer. Such a new feature reinforces the Cloud Computing perspective of changing our focus from specific hardware to the virtualized capabilities being provided

Number 4 Obstacle: Data Transfer Bottlenecks

Applications continue to become more data-intensive. If we assume applications may be “pulled apart” across the boundaries of clouds, this may complicate data placement and transport. At $100 to $150 per terabyte transferred, these costs can quickly add up, making data transfer costs an important issue. Cloud users and cloud providers have to think about the implications of placement and traffic at every level of the system if they want to minimize costs. One opportunity to overcome the high cost of Internet transfers is to ship disks. The cheapest way to send a lot of data is to physically send disks or even whole computers via overnight delivery services. A second opportunity is to find other reasons to make it attractive to keep data in the cloud, for once data is in the cloud for any reason it may no longer be a bottleneck and may enable new services that could drive the purchase of Cloud Computing cycles. As another example, consider off-site archival and backup services. Since companies like Amazon, Google, and Microsoft likely send much more data than they receive, the cost of ingress bandwidth could be much less. Therefore, for example, if weekly full backups are moved by shipping physical disks and compressed daily incremental backups are sent over the network, Cloud Computing might be able to offer an affordable off-premise backup service. Once archived data is in the cloud, new services become possible that could result in selling more Cloud Computing cycles, such as creating searchable indices of all your archival data or performing image recognition on all your archived photos to group them according to who appears in each photo. A third, more radical opportunity is to try to reduce the cost of WAN bandwidth more quickly.

Number 5 Obstacle: Performance Unpredictability

From experience it is known that multiple Virtual Machines can share CPUs and main memory surprisingly well in Cloud Computing, but that I/O sharing is more problematic. One opportunity is to improve architectures and operating systems to efficiently virtualize interrupts and I/O channels. One reason to be hopeful is that IBM mainframes and operating systems largely overcame these problems in the 1980s, so we have successful examples from which to learn.

Another possibility is that flash memory will decrease I/O interference. Flash is semiconductor memory that preserves information when powered off like mechanical hard disks, but since it has no moving parts, it is much faster to access (microseconds vs. milliseconds) and uses less energy. Flash memory can sustain many more I/Os per second per gigabyte of storage than disks, so multiple virtual machines with conflicting random I/O workloads could coexist better on the same physical computer without the interference we see with mechanical disks. The lack of interference that we see with semiconductor main memory in Figure 3(a) might extend to semiconductor storage as well, thereby increasing the number of applications that can run well on VMs and thus share a single computer. This advance could lower costs to Cloud Computing providers, and eventually to Cloud Computing consumers.

Another unpredictability obstacle concerns the scheduling of virtual machines for some classes of batch processing programs, specifically for high performance computing.

The obstacle to attracting High Performance Computing is not the use of clusters; most parallel computing today is done in large clusters using the message-passing interface MPI. The problem is that many HPC applications need to ensure that all the threads of a program are running simultaneously, and today’s virtual machines and operating systems do not provide a programmer-visible way to ensure this. Thus, the opportunity to overcome this obstacle is to offer something like “gang scheduling” for Cloud Computing.13

Number 6 Obstacle: Scalable Storage

We know that the three properties whose combination gives Cloud Computing its appeal are short-term usage (which implies scaling down as well as up when resources are no longer needed), no up-front cost, and infinite capacity on-demand. While it’s straightforward what this means when applied to computation, it’s less obvious how to apply it to persistent storage. As Table 4 shows, there have been many attempts to answer this question, varying in the richness of the query and storage API’s, the performance guarantees offered, and the complexity of data structures that are directly supported by the storage system (e.g., schema-less blobs vs. column-oriented storage).14 The opportunity, which is still an open research problem, is to create a storage system would not only meet these needs but combine them with the cloud advantages of scaling arbitrarily up and down on-demand, as well as meeting programmer expectations in regard to resource management for scalability, data durability, and high availability.

Number 7 Obstacle: Bugs in Large-Scale Distributed Systems

One of the difficult challenges in Cloud Computing is removing errors in these very large scale distributed systems. A common occurrence is that these bugs cannot be reproduced in smaller configurations, so the debugging must occur at scale in the production datacenters. One opportunity may be the reliance on virtual machines in Cloud Computing. Many traditional SaaS providers developed their infrastructure without using Virtual Machines, either because they preceded the recent popularity of Virtual Machines or because they felt they could not afford the performance hit of Virtual Machines. Since Virtual Machines are de rigueur in Utility Computing, that level of virtualization may make it possible to capture valuable information in ways that are implausible without Virtual Machines.

**THREE CIRCLES OF COMMUNICATION, COMPUTATION AND INTELLIGENCE:**

Now that we have understood what cloud computing is, can we say that the concept of cloud computing fits into the three circles of communication, computation and intelligence?

Cloud computing definitely fits into all the three circles because there is communication between the connected devices, computation is done in the cloud and also intelligence is present in the cloud. Vijjana is a collaborative, self organizing, domain centric knowledge network. This model which sits on the top layer of the cloud computing architecture, and with its agent activities develops a body of intelligent reasoning system which can semantically connect different dispersed users with their own knowledge nets. Thus we can definitely say that intelligence is present in the cloud computing.

**CONCLUSION:**

The long dreamed vision of computing as a utility is finally emerging. The elasticity of a utility matches the need of businesses providing services directly to customers over the Internet, as workloads can grow far faster than 20 years ago. It used to take years to grow a business to several million customers – now it can happen in months. From the cloud provider’s view, the construction of very large datacenters at low cost sites using commodity computing, storage, and networking uncovered the possibility of selling those resources on a pay-as-you-go model below the costs of many medium-sized datacenters, while making a profit by statistically multiplexing among a large group of customers. From the cloud user’s view, it would be as startling for a new software startup to build its own datacenter as it would for a hardware startup to build its own fabrication line. Cloud Computing users are relieved of dealing with the twin dangers of over-provisioning and under-provisioning our internal datacenters. Thus Cloud Computing with all its advantages is already making its impact on the industry and would completely flourish with the removal of the few obstacles that are present in the path of the growth of Cloud Computing technology. Wonders can be done and life can become much easier when the technology is maximum utilized and more applications are built keeping in mind the three circles.

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