Insight into the Utilization of Cloud and Mobile Computing in a service oriented world

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Abstract

Moving, working and storing have become central aspect of the lives of every citizen in business, education, and leisure. While developments in the mobile arena bring many benefits, the bewildering array of new systems and services can be confusing for end users. Already, the average citizen has difficulties in understanding all these new systems, let alone using them effectively. Not only will this slow down the deployment of new services, it will contribute to the digital divide, making it difficult for certain users to benefit from new developments like cloud storage. In addition, network operators have to deal with the complexity of a multi-access networking environment. The enhancement of existing technologies and development of new 4G systems will increase this complexity even more. To make the most of the opportunities offered by new technologies, future mobile services and devices will need to be much easier to use. The success of future mobile communications systems depends on meeting, or exceeding, the needs, requirements and interests of users and society as a whole and that makes paramount for us understand what they mean and how they function in this weird world

Key words: cloud computing, dropbox,

Understanding the cloud concept

You may have heard people using terms like the cloud, cloud computing, or cloud storage very recently. But what exactly is the cloud? Basically, the cloud is the wireless cloud of Internet hovering around you and more specifically, it's all of the things you can access remotely over the Internet. When something is in the cloud, it means it is stored on servers on the Internet rather than on your local computer. It lets you access your calendar, email, files, and more from any computer that has an Internet connection.

The first thing to understand is that “the cloud” is simply a metaphor for various data networks generally located somewhere far away and accessed via the internet. Despite what the name suggests, it has nothing to do with the stratosphere – and so, stormy weather can’t interfere with cloud computing. As a metaphor, “the cloud” simply denotes vast, distant clusters that we may not be able to interact with physically but virtually, yet still affect us. In cloud computing, the clusters of servers, fiber-optic cables, and software engineers may be far away, but we can still interact with them by sending information back and forth.

Fig 1The Cloud

When carry out certain routine activities on your mobile device like checking your web-based email, you are using the cloud. All of the emails in your inbox are stored on servers. However, there are many other services that use the cloud in different ways. Here are just a few examples:

- **Dropbox** is a cloud storage service that lets you easily store and share files with others, and it lets you access your files from a mobile device as well.
- **Evernote** lets you type notes, clip webpages, take photos, and organize all of them from your computer or mobile device.
- **Mozy** and **Carbonite** can automatically back up your data in case your computer is lost, stolen, or damaged.
- **OneDrive** and **iCloud** are also cloud storage that let you store and back your data frequently.

[Ref required] "Cloud storage" is basically defined as data storage that is made available as a service via a network. But that definition can be confusing because it's so broad and can include many different things. Cloud storage is without a doubt one of the biggest catchphrases in recent time. But more than that, cloud storage services are becoming a better option for small- to medium-sized businesses, as well as larger enterprises, as an alternative to expanding and maintaining more storage devices in-house. But before you take plunge and sign up with a cloud storage service provider, there are some things you need to know. Is cloud storage secure? How much will it cost? What services are best for business?

Part of the reason why cloud storage is having difficulty catching on in the data storage world is because it is still a relatively new concept and many people are yet to understand its essence. Also, many users have questions the cost involved and whether or not cloud storage is secure and worthwhile. One of the biggest advantages of using cloud is that the critical technical aspect is handled for you without you having to learn how it works. The idea of cloud computing is based on a very fundamental principal of "reusability of IT capabilities". The difference that cloud computing brings compared to traditional concepts of "grid computing", "distributed computing", "utility computing", or "autonomic computing" is to broaden horizons across organizational boundaries.**[22],[20]**

Cloud Computing Services Models

Cloud Providers offer services that can be grouped into three categories

Software as a Service: In this model, a complete application is offered to the customer, as a service on demand. A single instance of the service runs on the cloud & multiple end users are serviced. On the customers‟ side, there is no need for upfront investment in servers or software licenses, while for the provider, the costs are lowered, since only a single application needs to be hosted & maintained. Google, Microsoft and Apple offer such services today.

Platform as a Service: Here, a layer of software or development environment is encapsulated & offered as a service, upon which other higher levels of service can be built. The customer has the freedom to build his own applications, which run on the provider's infrastructure. To meet manageability and scalability requirements of the applications, the providers offer a predefined combination of OS and application servers, such as LAMP platform (Linux, Apache, MySQL and PHP), restricted J2EE, Ruby etc. Google's App Engine and Force.com offers such services.

Infrastructure as a Service: This provides basic storage and computing capabilities as standardized services over the network. Servers, storage systems, networking equipment, data Centre space etc. are pooled and made available to handle workloads. The customer would typically deploy his own software on the infrastructure. Amazon, GoGrid, and 3 Tera offers such services. [20],[9],[6]

Understanding Public and Private Clouds

Enterprises can choose to deploy applications on Public, Private or Hybrid clouds. Cloud Integrators can play a vital part in determining the right cloud path for each organization.

Public Cloud

Public clouds are owned and operated by third parties; they deliver superior economies of scale to customers, as the infrastructure costs are spread among a mix of users, giving each individual client an attractive low-cost, “Pay-as-you-go” model. All customers share the same infrastructure pool with limited configuration, security protections, and availability variances. These are managed and supported by the cloud provider. One of the advantages of a Public cloud is that they may be larger than an enterprises cloud, thus providing the ability to scale seamlessly, on demand.

Private Cloud

Private clouds are built exclusively for a single enterprise. They aim to address concerns on data security and offer greater control, which is typically lacking in a public cloud. There are two variations to a private cloud:

On-premise Private Cloud: On-premise private clouds, also known as internal clouds are hosted within one’s own data Centre. This model provides a more standardized process and protection, but is limited in aspects of size and scalability. IT departments would also need to incur the capital and operational costs for the physical resources. This is best suited for applications which require complete control and configurability of the infrastructure and security.[1]

Externally hosted Private Cloud*:* This type of private cloud is hosted externally with a cloud provider, where the provider facilitates an exclusive cloud environment with full guarantee of privacy. This is best suited for enterprises that don’t prefer a public cloud due to sharing of physical resources.

Hybrid Cloud

Hybrid Clouds combine both public and private cloud models. With a Hybrid Cloud, service providers can utilize third party Cloud Providers in a full or partial manner thus increasing the flexibility of computing. The Hybrid cloud environment is capable of providing on-demand, externally provisioned scale. The ability to augment a private cloud with the resources of a public cloud can be used to manage any unexpected surges in workload.[25]

Why do we need cloud storage?

Cloud storage is still a pretty new technology, but experts have already developed some best practices for getting the most from moving to cloud storage. One of the more popular use cases for cloud computing is cloud backup. But what should you look for in a cloud backup service? What are the different types of cloud backup services? Which ones are best for business? There are a number of things that must be taken into consideration before you sign up with a cloud data backup service provider. You have to be aware of things like security and privacy, bandwidth issues, and data recovery. [1],[7],[3],[4]

Backup Management

Management isn't the first concern that comes to mind for end users of cloud data backup. One of the reasons that companies outsource their data backups to cloud data backup service providers is to offload the burden of monitoring, maintaining and supporting the infrastructure. But tracking key metrics can be helpful, and users are seeing improving options depending on their cloud backup providers.

Cloud disaster recovery

Many cloud vendors are positioning cloud backup as an ideal disaster recovery solution, allowing users to replicate data offsite and outside of their company's geographic region at a reasonable cost. And, there are even a number of so-called cloud disaster recovery services in the market today. But, do we really understand what “cloud disaster recovery" really mean? Is cloud disaster recovery services really secure?

Cloud security

One of the biggest issues with cloud storage in general is security. Some important tips include making sure that you check your vendor's references, assessing customer service and ensuring that the vendor's procedures align with what your business needs.[15],[13]

Cloud archiving

Cloud archiving can make excellent financial and operational sense, but one thing to keep in mind is that cloud-based data backup is not the same as cloud archiving. Cloud archiving is entirely different from cloud-based backup and recovery. There are four essential reasons to archive. The first two are regulatory compliance and e-discovery, and they are typically lumped together. The next is historical reference, which is rarely discussed but can be very important for some businesses. The fourth is content distribution, which is quickly becoming increasingly important, especially for rich media.

Cloud storage security and the future of the cloud

There are many concerns with cloud storage, which is still a relatively new technology. Does the provider offer public, private or hybrid cloud? How will you integrate your back-end data with cloud services? Data integration, privacy and compliance are some of the top worries for users considering cloud storage services.[1],[2]

There are a lot of security issues to keep in mind when considering cloud backup. Once backup data is removed from your cloud provider -- be it a single file or an entire backup set - is it actually removed or does it linger online forever? This could create data retention and e-discovery liabilities. Is the data encrypted once it's uploaded? This is typically the case and not a big issue you need to be concerned with. Is the data encrypted in transit?

Although adoption of storage clouds is ongoing, many storage administrators still need to be convinced of their value - and point to clear obstacles that still remain with the technology - before they will feel comfortable moving to the cloud. Common questions include: Will my data be available when I need to retrieve it? Who's controlling my data? What is the performance like when retrieving data from the cloud? [6]

The Cloud services are easy to recognize because they:

- Are not installed on your computer, you usually connect to them via a web browser.
- Keep your data with the service and not on your computer, so you don't have to worry about backing it up, losing it, or moving it when you switch computers.
- Are accessible from any device with a web browser, namely laptops, smartphones, tablets and so you can have the service even when you are mobile.[5],[6]

Do we really need cloud services?

We like easy access, not having to worry about our data and the mobility they offer; and bearing in mind that, most of us already use publicly available cloud services like GMail, WhatsApp, Facebook and YouTube, and we expect every service provider to provide tools that deliver a similar experience. Cloud services are appealing for doing business in a fast-paced, resource-constrained and mission-focused world like we live in. The cloud is just a way to rapidly deliver quality IT services, maintain flexibility, reduce expenses, and redirect savings to the core missions of the educational institutions, research and outreach centres. Because IT is integrated in everything we do our business, academic and personal lives demand for IT services will only grow. [22],[30]

The cloud is no longer the buzzword that it was back in 2011, it’s clear that the cloud is here to stay, even though some still find it hard to believe it is secure. However as demand grows for faster, higher-resolution videos and games – especially on smaller and smart devices our dependence on cloud storage and cloud computing will keep growing. The story of cloud storage is in many ways a story of virtualization. So let us start with physical environments, move to virtualization, where virtual and physical models begin to diverge, and finish with the cloud, where the physical is almost completely abstracted by virtual models.[20],[14]

Physical storage Models

At the very root of all storage is some set of physical storage protocols, so let us do a quick recap of physical storage. Three major classes of physical storage models in use today are direct attached storage (DAS), the storage area network (SAN), and network attached storage (NAS).

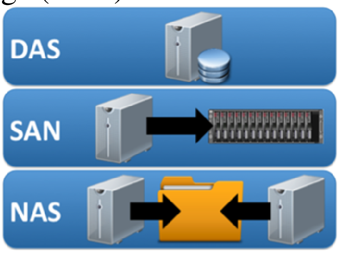

Fig 2 Physical storage models

Direct attached storage (DAS) is the simplest storage model. We are all familiar with DAS; this is the model used by most laptops, phones, and desktop computers. The fundamental unit in DAS is the computer itself; the storage for a server is not separable from the server itself. In the case of a phone it is physically impossible to remove the storage from the device, but even in the case of servers, where it is theoretically possible to pull disk drives, once a drive is separated from the server, it is generally wiped before reuse. SCSI and SATA are examples of DAS protocols.[15],[8]

Storage Area Network (SAN.) came into being when the storage industry recognized the need of separating storage from the device. Rather than attaching disks to each individual computer, we placed all the disks on a single cluster of servers and accessed the disk over the network. This simplifies storage management tasks such as backup and failure repair. This division of storage and device is often called shared storage, since multiple computers will use a single pool of storage. It was most straightforward to communicate between the client and server over the network using the same (or very similar) block protocols that were used to communicate with locally attached disk drives. Storage exposed this way is called a storage area network. Fiber Channel and iSCSI are examples of SAN protocols. In a SAN an administrator will group a set of disks (or a portion of a set of disks) into a logical unit, which then behaves like a single disk drive to outside computers. The logical unit is the fundamental unit used to manage SAN storage.[12],[15]

Network Attached Storage (NAS). While SANs allow us to move logical units between one computer and another, the block protocols they use were not designed to concurrently share data in the same logical unit between computers. To allow this kind of sharing we need a new kind of storage built for concurrent access. In this new kind of storage we communicate with the storage using file system protocols, which closely resemble the file systems run on local computers. This kind of storage is known as network attached storage. NFS and SMB are examples of NAS protocols. The file system abstraction allows multiple servers to access the same data at the same time. Multiple servers can read the same file at the same time, and multiple servers can place new files into the file system at the same time. Thus, NAS is a very convenient model for shared user or application data. NAS storage allows administrators to allocate portions of storage into individual file systems. Each file system is a single namespace, and the file system is the primary unit used to manage NAS.

Virtual storage concept

Virtualization changed the face of the modern data center for storage as it did for computer systems. Just as physical machines were abstracted into virtual machines, physical storage was abstracted into virtual storage. In virtualization, the hypervisor provides an emulated hardware environment for each virtual machine, including computer, memory, and storage. VMware, the initial modern hypervisor, chose to emulate local physical disk drives as a way to provide storage for each Virtual Machine. In other words, VMware chose the local disk drive (DAS) model as the way to expose storage to virtual machines. Just as the fundamental unit of storage in DAS is the physical machine, the fundamental unit in virtual disk storage is the Virtual Machine. [15],[21],[22]

Fig 3 Virtual storage

Virtual disks are not exposed as independent objects, but as a part of a particular virtual machine, exactly as local disks are conceptually part of a physical computer so it is with DAS, a virtual disk lives and dies with the Virtual Machine itself; if the Virtual Machine is deleted, then the virtual disk will be deleted as well. Most conventional virtualization platforms use a virtual disk storage model. For example, storage in VMware vSphere, Microsoft Hyper-V, Red Hat Enterprise Virtualization, and Xen environments are all managed and implemented in a similar way.

Implementing virtual storage

Since VMware wanted to continue to provide the benefits of shared storage to virtual machines, it couldn't rely on a DAS protocol to implement virtual disks. The obvious next choice would be to use SAN, since a SAN logical unit closely resembles a local disk drive. However, physical logical units have limitations that make for a challenging fit for virtual disks. Virtualized environments consolidate a number of logical computers onto a single physical server, which means the number of virtual disks on a given host will be much larger than the number of physical logical units for a host in a physical environment. The maximum number of logical units that could be attached to a given physical server was too low to support the necessary number of virtual disks.

Perhaps even more important, virtual disks, as with virtual CPUs, must be logical objects that can be created, destroyed, and moved programmatically, and these are not operations that SAN storage was designed to perform. For example, VMware needed to dynamically move VMs between physical hosts, which required shared storage access during the migration. For these reasons, VMware chose to implement virtual disks as files in a file system (NFS) or in a distributed file system (VMFS) on SAN, rather than as raw logical units.[8],[9],[10],[30]

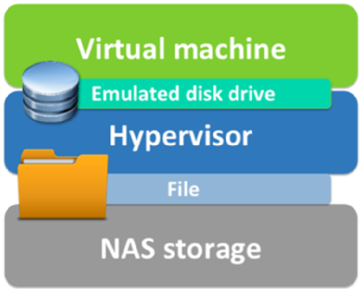

Fig 4: Implementing virtual storage

From storage protocols to storage models

That VMware chose to implement virtual disks, a DAS-style block storage model, on top of NAS or SAN, illustrates one of the interesting characteristics of modern data center storage. Because the IO from a virtual machine is handed off to software in the hypervisor, rather than to hardware on a device bus, the protocol used by the Virtual Machine to communicate with the hypervisor does not need to match the protocol the hypervisor uses to communicate with the storage itself. This leads to a separation between the storage model that is exposed upward to the Virtual Machine and administrator, and the storage protocol that is used by the hypervisor to actually store the data. In the case of virtual disks, VMware designed them according to a DAS storage model, and then used a NAS storage protocol to implement them.

This is a powerful layer of indirection; it gives us the flexibility to mix and match storage models and storage protocols, and even dynamically changes the storage protocol without impacting virtual machines. For example, virtual disks are implemented using files in NFS, files in VMFS stored on Fiber Channel logical units, or even Virtual Volumes directly as iSCSI logical units. The choice of implementation is completely transparent to the application, because eventually all of these protocols will look the same to the Virtual Machine and administrator; they will look like local, physical disk drives attached to Virtual Machines.[15]

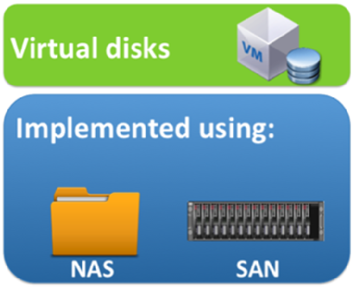

Fig 5 Implementing virtual storage using different models

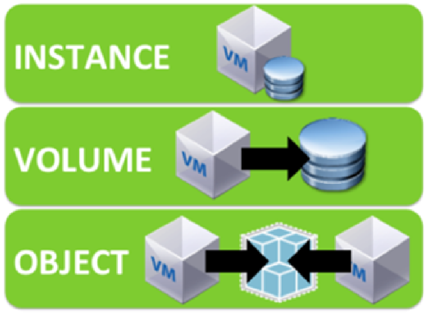

Fig 6 The three cloud storage models.

Thus the application developer in most public cloud infrastructures cannot know what storage protocol is in use; in fact, the protocol may even change dynamically. We don't know what storage protocol Because of the separation between storage model and storage protocol, the storage protocol becomes an infrastructure-facing issue, primarily important for cost and performance, rather than an application-facing decision that dictates functionality.

Storing our Data in the Cloud

The landscape of the data center has shifted once again as virtualized environments transform into cloud environments. Cloud environments embrace the virtual disk model pioneered in virtualization, and they provide additional models to enable a fully virtualized storage stack. Cloud environments attempt to virtualize the entire storage stack so that they can provide self-service and a clean separation between infrastructure and application. Cloud environments come in many forms. They can be implemented by enterprises as private clouds using environments like OpenStack, CloudStack, and the VMware vRealize suite. They can also be implemented by service providers as public clouds such as Amazon Web Services, Microsoft Azure, and Rackspace. Interestingly, the storage models used in cloud environments mirror those in use in physical environments.[15],[10],[12]. However, as with virtual disks, they are storage models abstracted away from the multiple storage protocols that can be used to implement them.

Instance storage: Virtual disks in the cloud

The virtual disk storage model is the primary model for storage in conventional virtualized environments. In cloud environments, however, this model is one of three. Therefore, the model is given a specific name in cloud environments: instance storage, meaning storage consumed like conventional virtual disks. It is important to note that instance storage is a storage model, not a storage protocol, and can be implemented in multiple ways. For example, instance storage is sometimes implemented using DAS on the device nodes themselves. Implemented this way, it is often called ephemeral storage because the storage is usually not highly reliable.[12]

Instance storage can also be implemented as reliable storage using NAS or volume storage, a second storage model described next. For example, OpenStack allows users to implement instance storage as ephemeral storage on the hosts, as files on NFS mount points, or as Cinder volumes using boot-from-volume.

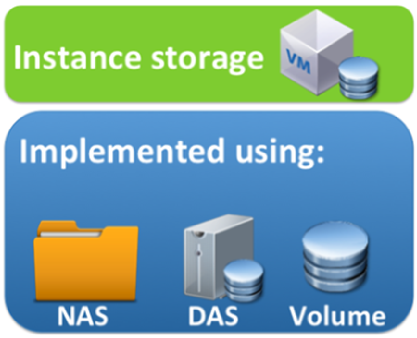

Fig 7 Implementing instance using different models

Implementing volume storage

Instance storage, however, has its limitations. Developers of cloud-native applications often explicitly differentiate configuration data, such as Operating System and application data, from user data, such as database tables or data files. By splitting the two, developers are then able to make configuration transient and re-buildable while still maintaining strong reliability for user data. This distinction, in turn, leads to another type of storage: volume storage, a hybrid of instance storage and SAN. A volume is the primary unit of volume storage rather than a Virtual Machine. A volume can be detached from one Virtual Machine and attached to another. However, like a virtual disk, a volume more closely resembles a file than a logical unit in scale and abstraction. In contrast to instance storage, volume storage is usually assumed to be highly reliable and is often used for user data.[12],[13],[11]

OpenStack's Cinder is an example of a volume store, as is Docker's independent volume abstraction. Note again that volume storage is a storage model, not a storage protocol. Volume storage can be implemented on top of file protocols such as NFS or block protocols such as iSCSI transparently to the application.

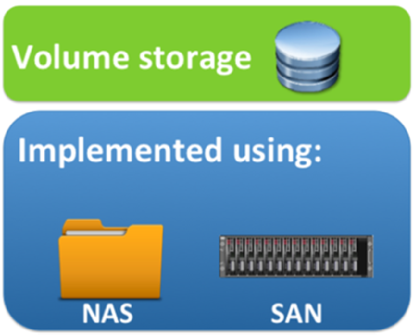

Fig 8 volume storage

Cloud native applications also need a home for data shared between Virtual Machines, but they often need namespaces that can scale to multiple data centers across geographic regions. Object storage provides exactly this kind of storage. For example, Amazon's S3 provides a single logical namespace across an entire region and, arguably, across the entire world. In order to reach this scale, S3 needed to sacrifice the strong consistency and fine-grained updates of conventional NAS.

Object storage provides a file-like abstraction called an object, but it provides eventual consistency. This means that while all clients will eventually get the same answers to their requests, they may temporarily receive different answers. This consistency is similar to the consistency provided by Dropbox between two computers; clients may temporarily drift out of sync, but eventually everything will converge. Traditional object stores also provide a simplified set of data operations tuned for use over high-latency WAN connections: listing the objects in a "bucket," reading an object in its entirety, and replacing the data in an object with entirely new data. This model provides a more basic set of operations than NAS, which allows applications to read and write small blocks within a file, to truncate files to new sizes, to move files between directories, and so on.[12],[13]

This relaxed model allows object storage to provide extremely large namespaces across large distances with low cost and good aggregate performance. Many applications designed for cloud environments are written to use object storage in place of NAS, because of its advantageous scale and cost. For example, cloud-native applications will often use object storage to store images, static Web content, backup data, analytic data sets, and customer files.

It is also important to note that the relaxed consistency and course-grained updates of object storage make it a poor fit for a number of use cases. For example, it is a poor replacement for instance or volume storage (at least in its raw form). Instance and volume storage support strong consistency, small block updates, and write-heavy, random workloads, all of which are challenging to do using object storage. NAS workloads that require strong consistency are also a poor fit for object storage, so NAS will most likely continue to exist in cloud environments alongside objects.

As with NAS, object storage is a software construct, not a hardware construct; object storage is accessed directly from the application itself via REST APIs. There are two major (and similar) object APIs in private cloud: Amazon's S3 API and OpenStack's Swift API. Many vendors provide object storage implementations, such as OpenStack's

Swift, Amazon's S3, Red Hat's Ceph, and Cleversafe. All of these products speak S3, Swift, or both, often in addition to other APIs. Some existing file system vendors provide object interfaces along with their existing file interfaces, such as EMC Isilon.

All together as One Piece

Now we have our complete picture of storage models for the cloud and how they relate to storage models used in more conventional storage environments. Just as DAS, SAN, and NAS provide a set of tools to address a variety of physical and virtual use cases, instance, volume, and object storage together provide a flexible paradigm for the cloud. While all installations may not use all three types of storage, no one type of storage can address all of the necessary use cases on its own.

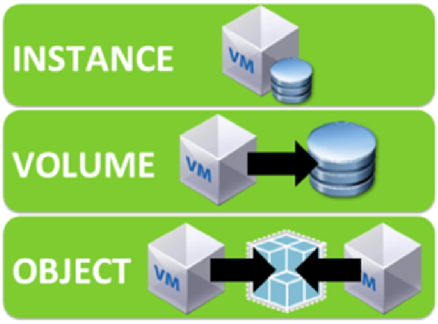

Fig 9 New cloud storage models.

Instance and volume storage serve as a logical abstraction of the existing physical storage models of DAS and SAN. These virtual storage models exist on top of storage protocols in new data center environments. In contrast, object storage provides a new type of storage focused primarily on large scale, which addresses a set of use cases similar to those addressed by NAS in the physical world. While these new abstractions are complicated at first, they provide new freedom to both data center and application administrators. Application administrators are no longer bound to data center infrastructure decisions; they are free to manage their data in the models that make sense to their applications. In turn, data center administrators can manage storage at the abstractions important to their users, while still utilizing best-in-breed storage implementations suited to their data center demands. Just as the DAS, SAN, and NAS models have supported innovation in the physical data center, instance, volume, and object storage will enable continuing innovation in the modern, virtualized data center.

Typical Benefits of Cloud Computing

Enterprises would need to align their applications, so as to exploit the architecture models that Cloud Computing offers. Some of the typical benefits are listed below:

Reduced Cost

There are a number of reasons to attribute Cloud technology with lower costs. The billing model is pay as per usage; the infrastructure is not purchased thus lowering maintenance. Initial expense and recurring expenses are much lower than traditional computing.[21]

Increased Storage

With the massive Infrastructure that is offered by Cloud providers today, storage & maintenance of large volumes of data is a reality. Sudden workload points are also managed effectively & efficiently, since the cloud can scale dynamically.

Flexibility

This is an extremely important characteristic. With enterprises having to adapt, even more rapidly, to changing business conditions, speed to deliver is critical. Cloud computing stresses on getting applications to market very quickly, by using the most appropriate building blocks necessary for deployment.

Cloud Computing Challenges

Despite its growing influence, concerns regarding cloud computing still remain. In our opinion, the benefits outweigh the drawbacks and the model is worth exploring. Some common challenges listed below needed to be improved on.

Data Protection

Data Security is a crucial element that warrants scrutiny. Enterprises are reluctant to buy an assurance of business data security from vendors. They fear losing data to competition and the data confidentiality of consumers. In many instances, the actual storage location is not disclosed, adding onto the security concerns of enterprises. In the existing models, firewalls across data centres (owned by enterprises) protect this sensitive information. In the cloud model, Service providers are responsible for maintaining data security and enterprises would have to rely on them.[32]

Data Recovery and Availability

All business applications have Service level agreements that are stringently followed. Operational teams play a key role in management of service level agreements and runtime governance of applications. In production environments, operational teams support appropriate clustering and Fail over Data Replication System monitoring (Transactions monitoring, logs monitoring and others) Maintenance (Runtime Governance) Disaster recovery Capacity and performance management if, any of the above mentioned services is under-served by a cloud provider, the damage & impact could be severe.

Management Capabilities

Despite there being multiple cloud providers, the management of platform and infrastructure is still in its infancy. Feature like "Auto-scaling" for example, is a crucial requirement for many enterprises. There is huge potential to improve on the scalability and load balancing features provided today.

Regulatory and Compliance Restrictions

In some of the European countries, Government regulations do not allow customer's personal information and other sensitive information to be physically located outside the state or country. In order to meet such requirements, cloud providers need to setup a data centre or a storage site exclusively within the country to comply with regulations. Having such an infrastructure may not always be feasible and is a big challenge for cloud providers.[1],[2],[3]

Understanding Mobile Computing in face of Cloud Storage

Mobile Computing is a technology that allows transmission of data, voice and video via a computer or any other wireless enabled device without having to be connected to a fixed physical link. These are computing systems that may be easily moved physically and whose computing capabilities may be used while they are being moved. Examples are laptops, personal digital assistants (PDAs), and mobile phones. By distinguishing mobile computing systems from other computing systems we can identify the distinctions in the tasks that they are designed to perform, the way that they are designed, and the way in which they are operated. There are many things that a mobile computing system can do that a stationary computing system cannot do; these added functionalities are the reason for separately characterizing mobile computing systems Among the distinguishing aspects of mobile computing systems are their prevalent wireless network connectivity, their small size, the mobile nature of their use, their power sources, and their functionalities that are particularly suited to the mobile user. Because of these features, mobile computing applications are inherently different from other applications written for usage on stationary computing systems

The application development and software engineering disciplines are very young engineering disciplines compare to those such as structural, mechanical, and electrical engineering. Software design and implementation, for the most part, remains part art and part science. Initially the mobile applications were only developed to implement calculator, calendar, alarm and currency converter functionalities. With the advent of 2G and 3G mobile networks, web based *mobile* applications were implemented on a variety of platforms; many of the existing web based applications were ported to platforms on the mobile device. These web-based applications included social networking, blogging, sharing of multimedia such as music, photos, video over the web [31]. Mobile applications can be classified into five major categories [19]: Social Networking, Personal Productivity, Leisure-based, Transaction-Based, and Content Dissemination-Based. Mobile application development has received a boost with two major developments. One development pertains to the availability of increased network bandwidth going from 2G to 3G and now to LTE. The second significant development is on the mobile device side: large screen, increased memory and high speed processing capability [19],[24]. Developers are motivated by these technological advances to create more innovative applications and services.

The differences between PC application and mobile application development

Life Span

The mobile application is developed to implement one or few but limited functionality. Java, Objective-C, .net and similar traditional development frameworks are used. Due to these factors, the number of mobile application developers is large. Given this intense competition in mobile application space, the life span of mobile application is less as compared to that of any desktop application.[24],[16,[17]

Complex Functionalities

Mobile application development involves complex functionality to interface to telephony, camera, GPS etc. When desktop applications are considered the development of the application is much more restricted to the desktop or the laptop device. On the other hand, mobile applications may require the implementation of telephony functionality to send/receive messages or handle voice calls; the application may also require the implementation of GPS functionality to track location by fetching latitude and longitude data.

Fewer physical interfaces

Desktop laptop have different physical interfaces such as keyboard, mouse, touch panel and other external devices but the mobile physical interfaces are strictly restricted to touch panel or the mobile keyboard. The size of the touch panel and keyboard is smaller than that of the laptop. These differences should be considered in the design of mobile applications to make them user friendly despite fewer physical interfaces.

More Number of screens for Interaction

The large screen on a desktop or laptop permits more functionality to be designed in one screen. With a smaller screen size being available, the mobile application requires more number of layered screens to support a similar functionality as a single large screen. Furthermore, the mobile application developer should optimize the functionality design to maximally utilize the screen available for display.

Battery & Memory usage by the application

Optimal usage of the battery and memory is a major design consideration in developing mobile applications: the mobile phone is on all the day round with many applications and services being constantly executed. The mobile applications should be designed to optimally utilize the memory available. The idle processes running on a desktop or laptop would not consume a significant percentage of the available battery or memory in a desktop or laptop as do the telephony applications on the mobile device.

Cross Platform Development

Many mobile operating system platforms share the market rather equally; developing a mobile application on one platform will not suffice in maximizing access to users. A key factor in choosing mobile application features is its portability to all major platforms. For example, the Android platform is open source making it developer-friendly. But other mobile platforms like iOS, Windows, BlackBerry are proprietary: they are closed and restrict developers' access to internals and thereby limiting features that can be implemented on the platform. The limitation does not exist in the same magnitude in desktop and laptop application development.[24],[23]

Updates

With desktop or laptop applications often sold to the user on a CD, the user registration is not tied to the sale and is optional. Mobile applications are more often than not downloaded from the application store; user registration goes hand in hand with the download. Hence, it is easier to provide updates for mobile applications than for desktop or laptop applications.

Services oriented world

[Ref required] "Services" has a very general meaning: it covers everything from communications to computing facilities, from home/building/public-space functionality to security related tasks. Services may be as simple as remote control of an entertainment device (e.g. a television) via a wireless link, or access control to a cloud storage. Conversely, services may be very complex, and may require location awareness, quality-of-service (QoS) support, message exchanges with network databases, structured interaction with remote networking devices (e.g., media gateways), etc. The emergence of new research areas, such as pervasive computing, will further increase the diversity of the devices and services with which users have to deal.[16]. Currently, to exploit such "services", users must frequently use different devices, and configure each of them in different ways. These devices must be recognised and authenticated using different procedures, be charged with different means and must use heterogeneous access technologies and protocols. And this places an enormous burden of complexity on users and, often, implies the physical burden of carrying different devices

Conclusion

Digital mobile communications and Cloud storage have formed the great success stories of recent years, offering people levels of mobility and services never available before. The 4G services and now anticipated 5G services will push the mobile opportunities even further and beyond the realms of our imaginations. This is not the end of the road for mobile or cloud computing, however, on the contrary, we are still only at the beginning of the mobile and cloud revolutions.

Future mobile networks will need to combine different access networks and technologies - satellite as well as terrestrial combinations to get them to work together so as to optimise different services requirements and operational conditions. This brings many new research challenges: in particular solving interoperability issues across multiple networks and a variety of connected devices. We will need new solutions to accommodate a wide range of requirements on data rate, quality of service, quality and security of cloud storage, availability and price according to users' expectations.

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