

# Data Storage and Computation In Cloud: A Review

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## Abstract

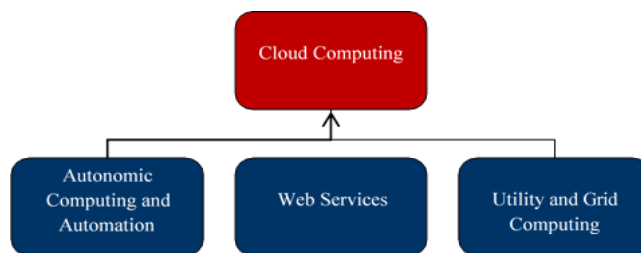
This section addresses the evolution of cloud computing and its models of implementation which includes Private Cloud, Public Cloud, Hybrid Cloud and Community Cloud and in addition various service models which includes IaaS, PaaS, SaaS, XaaS has been discussed.

In later section of this paper, various offerings of Cloud Computing and concerns of IT Community has been discussed. This Chapter also gives insight into types of information stored in Cloud and security concerns of data owners.

**Keywords:** Cloud Computing, IaaS, PaaS, SaaS, XaaS, Hybrid Computing.

## Introduction

The boom of "Cloud Computing" is the result of advancements in Network Technologies that led to development of three computing models namely Grid Computing, Processing the utility and now processing the internet. "Cloud Computing" is a model for enabling omnipresent computing, according to NIST. It provides access to a shared pool of configurable computing resources on demand with minimal management effort or interaction between service providers. Cloud Computing Framework has changed everyone's perception about the Software Delivery, Infrastructure Architectures and Development Models. The evolution of Cloud Computing is the result of improvement in Technologies as shown in Figure 1[1, 2]. The users of IT Companies have started migrating to Cloud Platform because of its feature like rental-based services; need based services and easy release of the resources, when there is no requirement.



*Figure 1: Evolution of Cloud Computing*

**Models and Services of Cloud Computing**

The United Nation’s National Institute of Standards and Technology (NIST) has a set of working definition, separating Cloud Computing into services and deployment model. It can be inferred that Cloud Computing categories are based on strategies of deployment and service usage [3, 4].

There are five essential characteristics and three Service Models (based on service of Software, Platform and Infrastructure), and four Deployment Models (Private, Community, Public and Hybrid Cloud). It has five characteristics of On Demand Self-Service (ODSS), Broad Network Access (BNA), Resource Pooling (RP), Rapid Elasticity (RE) and Measured Service (MS).

**Cloud Service Delivery Models**

Cisco and other IT Industries are moving to an Internet of Everything (IoE). Apart from this, in literature, Several studies reveal three basic models of services in Cloud Computing

(i) Software as a Service (SaaS) (ii) Platform as a Service (PaaS) (iii) Infrastructure as a Service (IaaS). Recently, anything as a Service (XaaS) has been accepted as a new member [5].

The brief description has given in subsequent subsections:

**Infrastructure as a Service (IaaS)**

IaaS has intended to offer virtualized resources like High Computational and Scalable Storage. It provides users to get on demand availability of various resources like Storage Servers, Networking Components. (for example, Amazon Web Services offering VM Ware with Customized Software Stacks).

The IaaS Service providers manage the entire infrastructure whereas client is responsible for Deployment Services, which includes Operating System and Applications. IaaS finds suitability in IT investment for business. Elastic Cloud Compute (ECC) is offering services (Virtual Private Servers) on minute mode by paying only as per the requirement [6].

**Platform as a Service (PaaS)**

PaaS is for developers to create, deploy their applications without knowing or bothering about the Architecture or Configurations of Platforms. For example, Google APP Engine acts as Middleware for Cloud users to build their own

application by supplying Development Tools, Platforms and Frameworks that enable users to run their apps[6].PaaS Model has been in much demand than SaaS because of providing more user ready features. Even for upgrades, users need not worry as PaaS service providers manage upgradation. Examples of PaaS are Google App Engine, Amazon Web Services, and Microsoft Azure [6].

### Software as a Service (SaaS)

The SaaS has reduced the burden of Software Maintenances for various users .It uses applications residing on the top of stack and users can access this layer through Web Portals, say Social Network, CRM and Video Processing. Examples of SaaS are Google Docs, Cloud Drive, Salesforce.com and CRM application [6].

### Anything as a Service (XaaS)

Anything as a Service (XaaS) supports clients to offer and support anything in the form of services ranging from specific requirements to large requirement of Storage, Computing Power, etc [6].

## Cloud Deployment Models

Cloud Service users look into various Deployment Models to examine their merits and demerits in terms of Elasticity, Migration, Pricing, Security etc. In the literature, five models have been described namely Public Cloud, Private Cloud, Hybrid Cloud, Community Cloud and Virtual Private Cloud [7].

### Private Cloud (PC)

Private Cloud has a proprietary infrastructure usually kept in Data Centres of an organization managed under Firewall. Therefore, management and security responsibilities in case of Private Cloud are much easier to carry out.

In other words, Private Cloud is like an Internal Data Centre of an organization that is not available to Public like Bank Data Centre. It is managed by the organization or a third party and may exist on premise or off premises [7].

### Hybrid Cloud (HC)

When Private Cloud is supplemented with computing capacity from Public Clouds, it shapes to new Cloud known as Hybrid Cloud. This cloud technology consists of two or even more clouds (private, community or public) that stay unique entities but are linked together by uniform or proprietary technology that enables the portability of data and applications (e.g. cloud bursting to flow-balance clouds).Hybrid Clouds are, in most situations, a combination of public and private clouds, putting together their strengths and overcoming their obstacles.

Hybrid Models have managed by both organisation and third party and placed in both offsite and onsite locations [7].

### Com Cloud (ComC)

Cloud services are distributed among many organizations and serve the common concern of a specific community. The organizations or a third party can manage it and may exist on premise or off premise.This Clouds eliminate security risks of Public Cloud [7].

### Public Cloud (PC)

The cloud software is made available to the general public or to a large industry and managed by a cloud service distribution company. Through various locations, multiple tenants can access a Government Cloud. The strategy is based on a pay-per-use approach and provides Efficient Services [8].

Since, resources and infrastructure providing services to customers can reside at Geographically Separated Places within or outside the Country, it makes it system less stable and more vulnerable than any other Deployment System.

This Model has highlighted issues of designing Service Level Agreements between Cloud Service Providers and Service Seekers [7].

### Virtual Private Cloud (VPC)

Virtual Private Cloud is mentioned in very less sources of Literature. Using Virtual Private Network (VPN) communication, it is created between different devices. VPC is a specific Private Cloud event. This design allows customers to use cloud services in a private or public environment without worrying about operating [7]. Offerings of Cloud Computing

The Cloud Computing has changed the way IT companies invest on Hardware, Software etc. It has reduced the cost of Computing, Marketing and Investment etc. Some of the offerings of Cloud Computing are:

#### Automatic Elasticity

Elasticity permits the automatic assignment of dynamic number of resources to a task. This feature gives illusion to clients about unlimited availability of resources irrespective of task or service. This is typically employed to ensure that availability criteria of a service or resource are always granted with best resource utilization. As the applications on Cloud need to scale up or scale down according the varying requirements as per the conditions. Therefore, elastic behavior is the Key features under IaaS category [8].

When the number of Servers are increased by automatic scaling, incoming load i.e., traffic is also distributed accordingly. Optimally, cloud computing gives the illusion of on-demand unlimited computing resources [8].

#### Reduced IT Costs and Access to Automatic Updates

Migration of various companies to the Cloud has reduced the cost of Computing, Managing and Maintaining IT Systems of the companies. The various companies and customers expected to purchase expensive systems and equipment for their company, increasing their budget by using Cloud Service Provider's unrestricted and versatile assets on a need-based basis [9].

The cost may be reduced because of the following reasons:

The Cloud Users need not to pay for system upgrades, new Hardware and Software and this could include up-to-date versions of Software, as well as upgrade servers and Computer Processing Power. It has been found that in UK alone,

companies are spending 18-20 working days per month managing on-site security alone but the Cloud has reduced the same.

The Cloud users need not to employ experts for their companies as Cloud manages most of the things.

Less Hardware at user's level reduces electricity consumption and cost [9].

### Scalability

One of the biggest advantages of Cloud Computing is scalability because enterprises can scale up or scale down depending upon requirement, operation and storage needs to suit situation, allowing flexibility as per the needs.

### Securing and Making Data Available All the Time

For a competitive environment, protection of data and systems is an important part of business. Migrating data into Cloud and using other resources like Computing Power, infrastructure is safe as Cloud Service Providers ensures secure and safe location. Even in case of Natural Disaster, Power Failure or other crisis, data stored in the Cloud is secure because of Encryption and Backup [10].

### Collaboration Efficiency and Flexibility of Work Practices

Collaboration is another useful aspect in any business. Therefore, Cloud Environment provides ways to communicate and share more easily outside of the traditional methods for business purpose.

Because workers from different companies work in different locations on a project, businesses can use Cloud Computing to provide access to the same data for their staff, suppliers and third parties. Firms should choose a cloud computing model that makes sharing their records simple for them. Cloud Computing allows flexible work practices and concept of Virtual Office has been started where employees have the ability to perform official work from home using Internet [11].

### A Green Choice and Environment Friendly

No doubt, Cloud Computing Model encourages SME's to move into Cloud by providing High Computing Resources, Infrastructure and Platforms which cuts in energy use and carbon emissions (small companies) likely to be 80-90%.

## Issues in Adoption of Cloud Computing

Cloud Computing offers a great deal of attractive benefits but infact it can deviate from the ideals mentioned above in many ways:

### Data Security and Privacy

When we move our data into Cloud Storage, we are isolated from our data, we do not know about Geographic Location of our data, and relying on CSP is very tough. It is one of the major concerns in adoption of the Cloud Computing which discourages enterprises from moving to Cloud. To ensure data privacy and security in Cloud, various

CSP are adopting Private Encryption, Firewall methods. Cryptographic perspective and analysis is rarely available in the Literature. This Proposed research work is in this direction [12, 13].

### Bandwidth Cost, Time and Complexity of Moving Data into Cloud

It seems obvious that the economic value will be there through sharing resources at smooth peaks, charging only for what is used, and reducing upfront capital expenditure on IT solutions [14].

Although adoption of Cloud involves cost earlier which includes internet speed and approx 42% of the enterprises feel the same as a concern. It will be necessary to balance all the short- and long-term costs and benefits associated with cloud computing.

Network bottlenecks occur when an enterprises transfers bulk data onto the Cloud premises.

### Customization and No Control on Service Level Agreement

Losing control over data and resources is a big concern of an enterprises. When the system is down, the IT Peoples are always blamed, so it's no wonder they're worried about turning over network responsibility to someone they don't even know and according to survey 18% of enterprises believes the same is an issues which prevents them to adopt Cloud.

Moreover, Laws and Policies vary by Geographical Locations and location of data or Cloud Service Providers may be at different nations or continent. So, any dispute if occurs may not be easy to resolve because of different laws. Service Level Agreements are in infancy still need to be standardized in order to appeal to majority of customers [15].

### Reliability of Cloud Storage

Data interchangeability and portability between Private Clouds and Public Clouds are essential enablers for enterprise-wide adoption of cloud computing. Reliability of Cloud Storage is still a serious concern [15, 16].

### Issues in Migration into the Cloud

A customer running his application in his premises may need to move to Cloud for some of its applications and Therefore, switching cost does not only arises from the portability or interoperability restrictions of the different Cloud Environments, but also from the fact that most of the applications are not Cloud ready. It has been seen that the most of the applications exhibit properties of multiple modalities of scale, which are however difficult to identify. Therefore, it should be always being kept in mind that all applications are not equally fit for Cloud Environment. The architectural choices of the infrastructure thereby influence immensely what kind of qualities can be expected for the different application is not yet fully understood [17, 18, 19].

### Vendor Lock-In

Since there is strong divergence among different Cloud Service Providers due to the lacking generality in the approaches of Cloud interfaces. It has experienced that applications developed for one Cloud Platform are not portable for other Clouds, which prevents Cloud users form changing their vendors.

In case of Cloud Service Provider, Vendor Lock in increases moving from IaaS to SaaS and then to PaaS Computing Platform [20].

**Shared Technology Vulnerabilities**

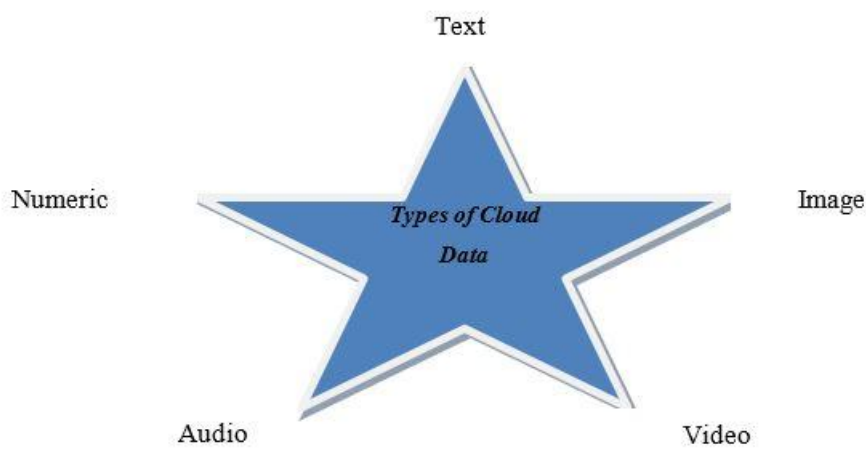
Since multi-tenancy feature of Cloud Computing allows multiple users to share various resources in the IaaS Model. Nevertheless, elements such as Disk Partitions, CPU Cache Memory, Graphics Processing Units (GPUs) were not originally intended for multi-tenant architecture sharing.

Cloud service providers have to monitor and enforce computing, storage and network security techniques to avoid this threat. CSP must isolate the boundary of tenant’s Data, Network and so on [21].

**Information Types over Cloud**

In Cloud based Environment, various types of data is stored, processed, organized and distributed according to the need of specific Clients and Service Providers. The Cloud information is infact, processed client’s data, which improves the knowledge and support in Decision Making Process.

The versatility of Cloud Computing makes it usable to manage variety of data types as shown in Figure 2.



*Figure 2: Types of Clients Data Stored on Cloud Platform*

**Text**

Article, Blog, Codes, e-books, Research Manuscripts etc. are part of Text Data. In Google Docs or online word processing applications, rough draft of Text is typed using the Keyboard and can be formatted with option of justify, center alignment, italic or bold, inserting hyperlinks and spell checking etc. These are string of characters or simply Text. The output is well-formatted online Text with neat appearance. Using Cloud based Text- Processing Tools, detection of grammar checking and suggestion of better alternative statement can be achieved. In Figure 3, the usage of Cloud Based Text Information Storage in presented for Cloud Based Platform [22].

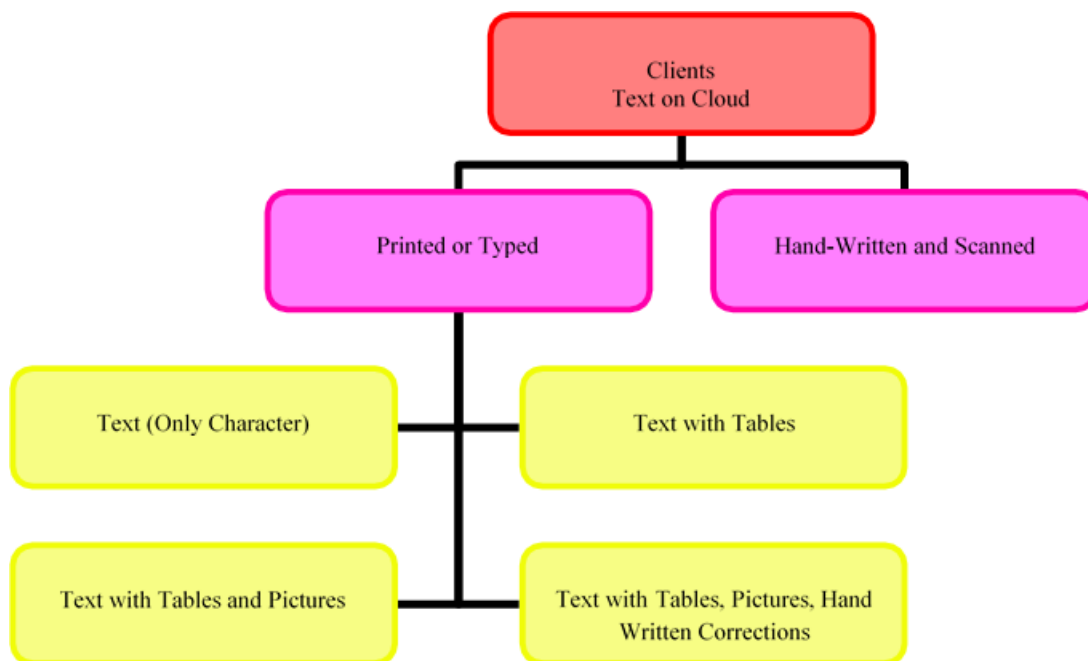


Figure 3: Variants of Clients Text Information Stored on Cloud Platform

### Image/Photos/Pictures

Clients Capture Photographs (black & white and color), Maps, Fingerprint, Images, Medical Scanned Documents including X-ray. In thesis the term Picture, Photo and Image has been used interchangeably. Images are now integral component of Blogs, Websites, News and Social Media Communications [23].

### Representation of a Typical Image

The format of Image is depicted below in Figure 4.

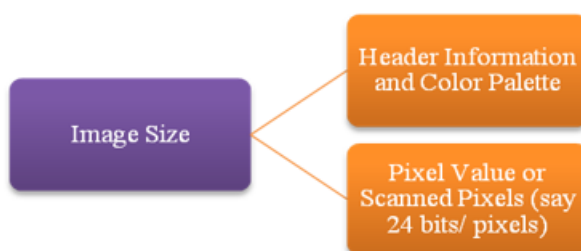


Figure 4: An Image Format in Cloud

An Image is collection of pixels. For an Image /Picture, pixels are represented with different encoding schemes depicted in Table 1.



*Table 1: Image Encoding Schemes and Bit Size*

S. No.	Bit-Size	Description
1	1-bit	B&W Image
2	8-bit	Monochrome picture with 256 grey level
3	24-bit	Color picture

On Cloud Environment, varieties of Image information is supported as per the need of clients. Some popular Image files formats are described in the Table 2.

*Table2: Various Image File Formats in Cloud*

Image File Type	Extension File	Applications	Benefits	Features
Bit Map	.bmp	Uncompressed output of scanners	All information in	High storage requirements need to be compressed
Tagged Image	.tiff	Exchange Image files.	Widely used Image format	Not usually compressed but may be compressed
Graphical Interchange	.gif	Exchanging compressed files. Used for transmitting medical, animation	Reasonable compression, High compression speed , Lossless compression of 1:6 to 1:10	Limited color palette
JPEG	.jpg and	For Compression of color picture with high details Mostly useful for WWW	High compression with low quality and low compression for high quality	Uses complex compression algorithm, for generative and cognitive Images with lossy compression
Compression	.jpeg	transmission of Image		

**Optimized Image Files for Cloud**

The storage of Image information with varied types and extension are processed for Cloud Storage is presented in Figure 5.

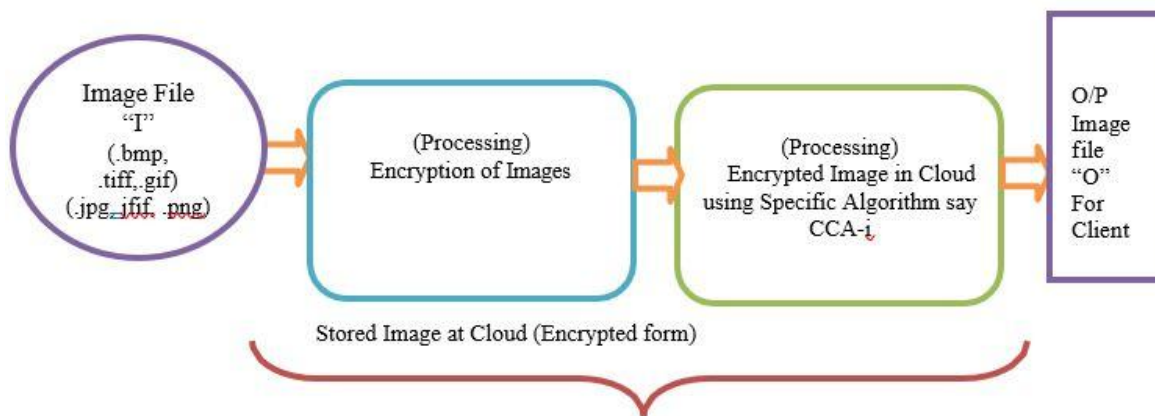


Figure 5: Clients Image Information Stored in Cloud

Algorithm “CCA-i” represents any Cryptic Algorithm applied at the Image to store Images economically with faster rate. They will exploit the redundancy and irrelevancy of information. Some of the issues associated with CCA-i algorithm.

- How to estimate of best cryptic algorithm?
- Estimation of time for Encryption and Decryption.
- Which “CCA-i” is suitable for which type of file?
- What is the O/P of “C” is universally accepted for exchange?

### Audio/Sound

The term Audio represents “Sound”. It may be taken from anyone component from Figure

6. It may be taken from any one of the sources specified in the figure. Any Audio “A” is a continuous function of time

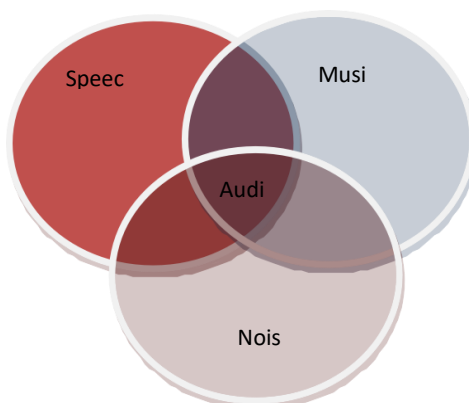


Figure 6: Various Sources of Audio Data

“t” i.e.  $A = f(t)$ .

Speech, songs, conversations, noise as and when recorded for usage of clients. Usually they are waveform with Time Varying Amplitude. Some common type of clients input files may be from output of Voice Recorder, Music etc [24].

Representation of Audio

The scheme of storing Audio files in secure way is presented in Figure 7. The processing of Audio input “A” is done at

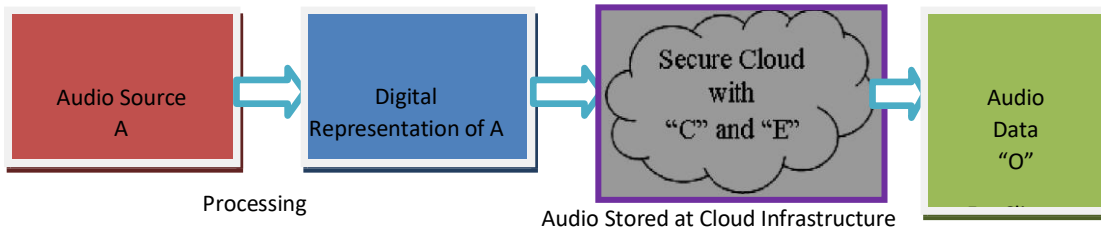


Figure 7: Storage of Audio data at Cloud

client device with the binary representation is explained in next section. Where C stands for Cryptic Algorithm and E stands for Encryption Process.

Audio Files Accessing in Cloud Infrastructure

Cloud user may access the stored files in the flow described below with processing Audio files from Cloud infrastructure as shown in figure 8.

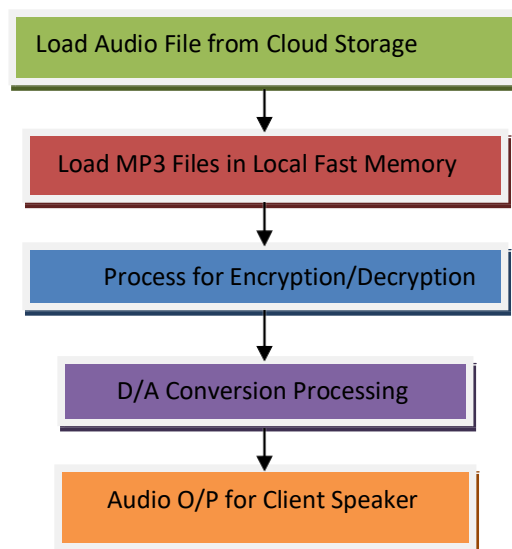


Figure 7: Accessing of Audio Data from Cloud

Video/Moving Pictures/Animation

A Video represents collection of pictures displayed with high speed Several times per second to give illusion of movement (Greater than persistence of vision of human eye).In other words, slightly different pictures shown with speed greater than persistence of vision of human eyes provides view of real-time scene. Animation Based Lectures,

Tutorials and Web based Image Morphing Repository are one of the sources of client’s Video. Recently 360-degree Videos and VR Videos are part of YouTube Web Channel [25].

**Storage and Optimization of Video Storage at Cloud**

Figure 9 and Figure 10 presents captured Video from client’s devices and it is stored at Cloud infrastructure. The conventional compression algorithm is used to compress the file.

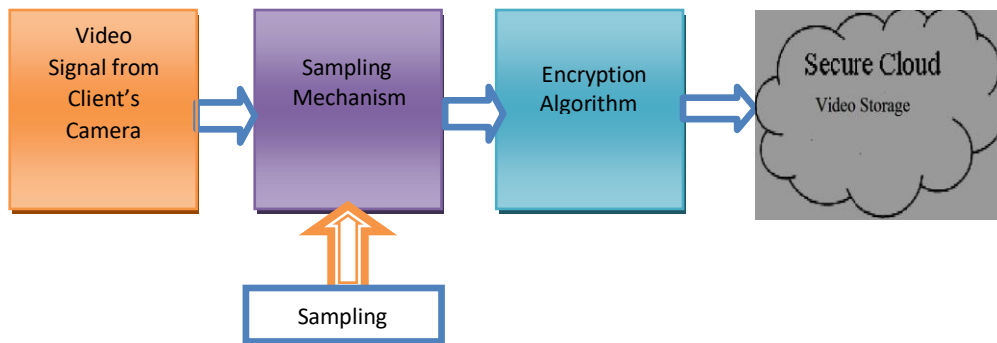


Figure 8: Storage of Video Data in Cloud

The suitable samples of input Video signals supplied by sampler is encoded and compressed before storage at Cloud. This is depicted in figure 10.

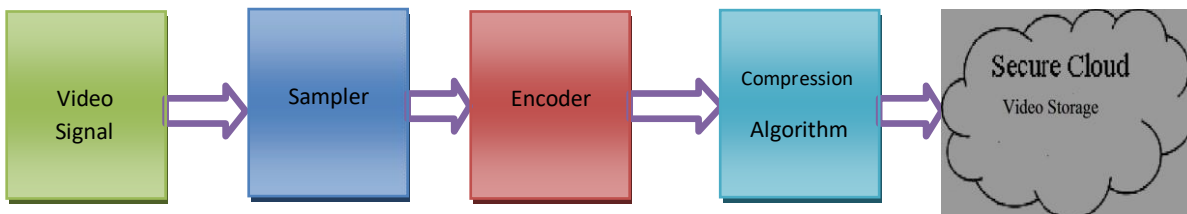


Figure 9: Optimization by Compression of Video Storage at Cloud

**Cryptography Algorithms for Secure Information overCloud**

The procedure that transforms Client’s input (Plain Text) into Cipher Text and vice-versa is popularly known as Cryptographic Algorithms. There are mainly two categories of cryptic procedures based on the type of security Keys exists, Symmetric Key Encryption and Asymmetric Key Encryption procedure. Out of these two Symmetric Key, based algorithms are primarily used in Cloud for exchanging huge files. These Cryptic Algorithms/Techniques are discussed in subsequent sections.

**Symmetric Key Based Cryptic Algorithm in Cloud**

In this type of Cryptic Algorithms, Client and Cloud/Server both uses a shared secret Key to encrypt and decrypt the data respectively, Figure 11 shows working of Symmetric Key based Cryptic Algorithms.

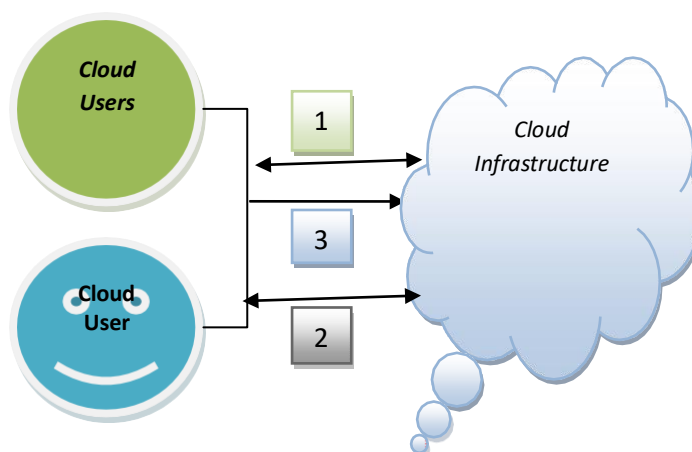


Figure 10: Symmetric Key Encryption Process

Steps of Symmetric Key Encryption:

Communicating node X and Y agree on a common cryptosystem

- Client X and Cloud Y agree on a Key to be used for Encryption/Decryption.
- Client X encrypts data using the shared Key.
- Algorithm at Cloud Y decrypts the ciphered data using the shared Key.

Major issues behind this type of Encryption is the sharing of Secret Keys between two devices. If the Secret Key is revealed by any mean then the entire system may get fail [26, 27, 28, 29].

### DES Symmetric Key Cryptic Algorithm

Data Encryption Standard (DES) is designed by Horst Festal (1970) for input 64-bit block size, 64-bit Key; it transforms plain Text into cipher Text. Out of 64 bits Key only 56 bits are used by the algorithm. Remaining 8 bits are used for parity checking and are thereafter discarded. Thus, effective Key length is 56 bits. The Key is transmitted or stored in 8 bytes, each with odd parity. DES has been one of the most widely used encryption algorithm in the world [31].

### Triple DES Symmetric Key Cryptic Algorithm

Triple DES (3DES) applies three times the DES algorithm to each block of data. Since DES has only 56 bits Key size and DES cipher was vulnerable to attack due to increased Computational Power of resources. Therefore, 3DES has been designed to remove the drawbacks of DES. 3DES gives a way to increase the Key size of DES for protection without making it necessary to design an entirely new encryption algorithm. It uses a key bundle containing three DES keys, such as K1 -Key1, K2-Key2 and K3 -Key3. Each key is about 56 bits, excluding additional bits of parity. Ciphertext =  $E_{K3}(D_{K2}(E_{K1}(\text{plaintext})))$  is the encryption algorithm.

DES encrypts plaintext with K1, then DES decrypt it with K2, and after that DES encrypts it with K3. The decryption process is just opposite to the Encryption. The plaintext =  $D_{K1}(E_{K2}(D_{K3}(\text{chiphertext})))$  is the flow to recover

plaintext. That is, first decrypt cipher Text with K3, encrypt it with K2, and at last decrypt it with K1. One block of 64 bits of data is Encrypted by 3DES. In all cases, the middle operation is the reverse of the first and last operation. 3DES is sensitive to differential and related Key attacks [32].

### Blowfish Algorithm

Blowfish (16-round Festal cipher) is a Symmetric Key Algorithm, which works on 64-bit block size and variable Key length between 32-448 bits. Generally, it is a fast block cipher except when changing Keys. With weak Keys in four rounds, it is exposed to differential attack with large number of weak Keys [33].

### Twofish Algorithm

It is a Symmetric Key block cipher (128 bits) with Key sizes up to 256 bits. The main encryption key is one-half of the n-bit key and the other half of the n-bit key can be used to adjust the encryption algorithm. On most software platforms, Twofish was slightly slower than AES (128-bit Keys), but it's a little faster for 256-bit Keys. It is sensitive to chosen Key attacks that affect reduction in security, when applied to Hash Function [34].

### AES

AES was developed by two Belgian Cryptographers Joan Diemen and Vince Ragmen to overcome issues of DES. For the respective Key lengths, there exist three versions of AES namely AES-128, AES-192 and AES-256. There are 10, 12 and 14 rounds of algorithm executed for respective AES. More the length of Key more will be the security. Both, plain Text and Key is represented as a matrix in AES. The algorithm works on hexadecimal values, so both, plain Text and Key are either inserted or converted within a block in hexadecimal form. Four major transformations are performed in rounds of AES- Sub Bytes, Shift Rows, Mix Columns, and Add Round Key. The plain Text represented in hexadecimal form is known as 'state' in AES. Most of the work is done on this only [35, 36].

## Conclusion

Algorithms DES and 3DES have their own features. Blowfish is a fast block cipher except when changing Keys. With weak Keys in four rounds, it is exposed to differential attack with large number of weak Keys. Twofish was slightly slower AES (128-bit Keys) on most software platforms, But for 256-bit buttons, it's a little quicker. It is sensitive to chosen Key attacks that affect reduction in security, when applied to Hash Function. For efficient usage of Cryptic Algorithms for Cloud Environment and suitability of these algorithms for specific file types with respect to client's need is the problem domain for proposed research work.

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