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An Approach for Video Compression Technique for Efficient Data Backup and Recovery in Public Cloud

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Abstract: ***With the rapid popularity of cloud computing paradigm,data recovery using cloud resourcesbecomes an attractive approach. Research work is carried out to design and optimise data recovery through cloud with efficient video compression . In this work, we propose real time data backup and recovery system integrated with public cloud.An effort is made toimprove the storage and data access cost by identifying the video files and compressing them using H.264lossy compression technique at the background before backup and recovery process. The objective also is to reduce the backup and recovery time. Therefore we implement a dual backup system that backup the files in both cloud storage and in local storage.***

Keywords: Backup and Recovery,Public Cloud, Video Compression, Skydrive, Cloud Computing

1. Introduction

Data backup and recovery holds significant importance in today's information technology age. Need for data backup ranges from possibility of data being corrupted by malicious programs in the computer to ease of distribution in a channel (for example sharing photos and videos). This data backup mainly depends on the size of data to be stored and available space. One of the conventional methods for space reduction is data compression and for recovery is a local backup system which is essentially a part of file system which is indexed so that in the event of data disasters, such backup can be easily recovered by recovery software. However local data backup is not reliable as the efficiency of the backup depends upon the integrity of the local storage system.

One of the common policies adopted for data backup is remote backup. However not every individual or organization is capable of maintaining it's own data centre of data storage infrastructure.

The growth of Cloud based data solutions and players like Dropbox, Skydrive, Googledrive have made it easy to keep the data in the cloud and access it at any time from anywhere. However none of these cloud storage providers offers compression backup and recovery services. On the other hand there are data recovery and backup managers like HP, Dell, Oracle which offers data backup and recovery through their company cloud with access based transaction and billing.

However no work has yet been proposed that leverages the power of public cloud and integrates that with compression technique, back up and recovery system.

Another drawback of almost all data backup solutions of today is that it interprets every data as a set of binary stream and treats them with equal priority. However Videos consumes a lot of space in cloud and leads to higher cost in accessing cloud based storage services. In order to overcome this limitation we propose a unique technique of compressing uncompressed videos as a background process in order to minimize the bandwidth and cost.Further we demonstrate through our real time system that performance gain in terms of bandwidth and gain is significant for the proposed system. We also show that the recovery time for the files in optimally low even for video Files.

This paper is organized as follows, section 1 discusses the introduction, and section 2 describes related work. Section 3 problem definition.Section 4, presents methodology.Section 5 Results and discussion, section 6 conclusion Finally, section 7 presents Future scope.

2. Related Work

To address the above problem state of technology, the literature survey of previous work is given as follows

"MapReduce: Simplified Data Processing on Large Clusters",Dean J. and Ghemawat S [2] has considered the map reduce model to process large dataset on cluster, a system where map function that processes a key/value pair to generate a set of intermediate key/value pairs, and a reduce function that merges all intermediate values associated with the same intermediate key.**"A Novel Way of De-duplication Approach for Cloud Backup Services Using Block Index Caching Technique",JyotiMalhotra and G.Priya[4]** has proposed data de-duplication approach that reduces the storage capacity needed to store data or data has to transfer on network and also saves network bandwidth and reduces network space.The problem is that these schemes traditionally require a full chunk index, which indexes every chunk, in order to determine which chunks have already been stored unfortunately.**"HAVS: Hadoop Based Adaptive**

Video Streaming by the Integration of Cloudlets and Stratus",KeerthikaJanani.M and Sudhakar.G[5]has discussed a HAVS[Hadoop based Adaptive Video Streaming]. They proposed a platform to enhance dynamic adaption and optimization of video by reducing energy consumption by leveraging cloud resources to make the data communication on Smartphone's more efficient.**"Disaster Recovery in Cloud Computing: A Survey", Mohammad Ali Khoshkholghi, Azizol Abdullah [7]**hasproposed different disaster recovery approaches to develop a recovery plan in cloud system. They are based on the nature of the system, where these approaches are uses redundancy and backup strategies for recovery process. The redundancy strategy uses separated parallel sites which have the ability to start up the applications after a disaster. Where backup strategy uses replication technology. The speed and protection degree of these approaches depend on the level of recovery service.**"A Comparative Study for Optimization of Video File Compression in Cloud environment",Navdeep S. Chahal and Baljit S. Khehra[8]** has proposed design to implement and optimize the performance of Digital Video to MPEG4 transcoding in the Cloud environment using Megh-dooth .They used Map-Reduce approach to rationalize the use of resources by exploring on demand computing and performs parallel video conversion thereby reducing the video encoding times."**An Architecture for Distributed High Performance Video Processing in Cloud,"Rafael Pereira, Marcello Azambuja, Markus Endler[9]**has proposed the Split & Merge architecture for high performance video processing, a generalization of the Map-Reduce paradigm that rationalizes the use of resources by exploring on demand computing. To illustrate the approach, they implemented the Split & Merge architecture, that reduces video encoding times to fixed duration, independently of the input size of the video file, by using dynamic resource provisioning in the Cloud. **"Dynamic Resource Allocation And Distributed Video Transcoding Using Hadoop Cloud Computing", Shanthi.B.R andPrakashNarayanan.C[10]** has proposed the solution that how video transcoding becomes smart and speeds-up due to the efficiency of cloud computing and allocate resources dynamically in cloud storage.**"Enterprise-Ready Virtual Cloud Pools: Vision, Opportunities and Challenges", Timothy Wood, K. K. Ramakrishnan[12]** has proposed about a Virtual Cloud Pool abstraction to logically unify cloud and enterprise data centre resources, and present the vision behind Cloud Net, a cloud platform architecture which utilizes virtual private networks to securely and seamlessly link cloud and enterprise sites. Authors also says that it also enables the pooling of resources across data centre to provide enterprises the capability to have cloud resources that are dynamic and adaptive to their needs, **"Differentiated Reflication in Data Center," Tung Nguyen, Antony Cut way[13]**has proposed Differential Replication (DiR) which allows user to choose different replication strategies by considering both user requirement and system capabilities.They implemented system that offers four differential storage services with DiR. Their experimental result showed that services provides different availability and execution time for different service types with same request trace, failure trace, workload.
"Cloud Computing – Issues, Research and Implementations,"Vouk M.A[15]has discussed about concept of cloud computing and the issues it tries to address, related research topics, and a "cloud" implementation based on VCL technology.**"DR-Cloud: Multi-Cloud Based Disaster Recovery Service," Yu Gu, Dongsheng Wang, and Chuanyi Liu [16]has** proposed a practical system model for multi-cloud based disaster recovery service(DR-Cloud), which utilizes resources of multiple cloud service providers cooperatively, where Customers only need to deal with the DR-Cloud, using very common and unified service interface that leverages the virtual platforms in cloud computing to provide data disaster recovery service.

From above literature survey, it is found that Video Compression and Data Recovery has been covered. But no work has been carried out for public cloud that integrates with video compression technique, backup and recovery system. Hence the following approach is proposed.

3. Problem Definition

Many cloud based data service providers provides easy file backup and storage. Few automatic backup and recovery managers provide a file backup and recovery system through their own cloud. But no service providers provide a system for automated backup and recovery through public Cloud like skydrive. None of the solution providers also provide a solution for background compression based Cloud integration for video services. Also current state of art do not offer duel backup through Cloud and system workspace integration.This leads to three particular problems: Inability of the users to configure public cloud with their own recovery manager and also increase in storage and communication cost for video data.Increased communication cost for every recovery bit as all the files need to be retrieved from the cloud space.The work attempts to solve the afore mentioned problem with the help of video compressor integrated Cloud based dual backup and recovery manager system.

The objective of the work is to implement a real time data backup and recovery system integrated with public cloud (Skydrive). The system also contributes towards improving the storage and data access cost by identifying the video files and compressing them at the background before recovery. The objective also is to reduce the backup and recovery time. Therefore we implement a dual backup system that backup the files in both skydrive and in local storage. Data from skydrive is retrieved only when the data in the local backup is corrupted or inaccessible. The objective also is to show that the proposed system helps in achieving significant performance improvement over current non-compression based backup manager.

4. Methodology

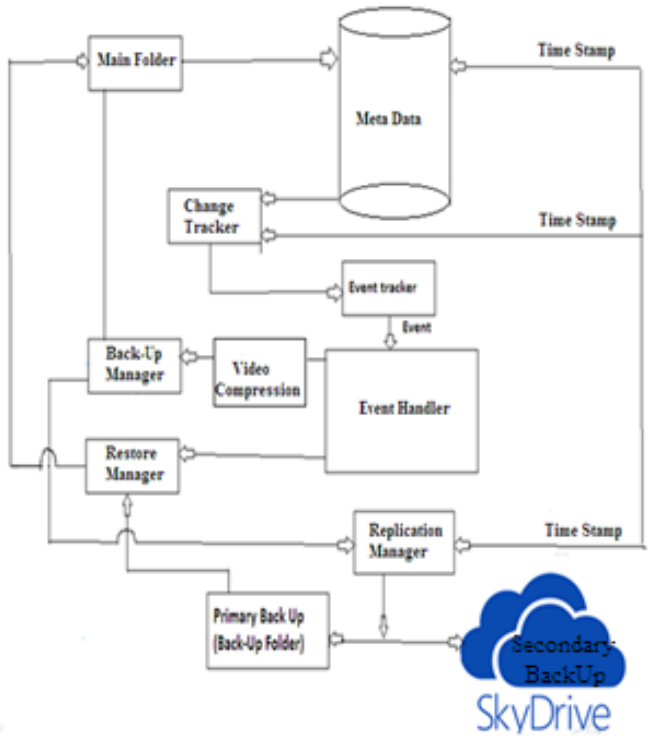

Figure 1: Architecture of proposed system

In this work we propose a unique design to address the drawback of current cloud based data backup and recovery solutions. The proposed work mainly comprises of : File system watcher, Backup manager, Recovery Manager, Cloud Manager, Local Recovery Manager and Video Compressor. Most of the present solutions offers either local file manager or Cloud based managers for data backup. Proposed system by integrating both of them seamlessly ensures that the files that can be recovered through the local backup are not needed to be fetched from remote cloud. No system presently supports video compression as background service with backup or recovery manager. One of the major contribution of the proposed work is to offer Video Compression as an integrated service with the backup manager. Files are compressed before backup. Only the compressed version of the videos are backup both in Cloud as well as in local drives.

However both the original as well as the compressed videos are retained in the original user folder which we call the workspace. Hence data loss is minimum. The proposed system by compressing videos to significantly lower sizes ensures that total communication and storage cost is reduced significantly. Dual backup system also ensures that under unintended service failure or in the absence of network connectivity also the files can be recovered.

4.1Algorithm

Step 1: Start Tracking
Step 2: Set up main working directory and local backup directory
If directories exist
Then
go to step 3
Step 3: Extract video files from working directory
If video is uncompressed type
Then
Compress
else
go to step 4
Step 4: Back up Compressed video to local backup
Step 5: Activate Skydrive
check for user authentication
If user Authentication is successful
Then
User to approve the application to access the resources
If user approval successful
Then
access cloud environment
Step 6: Back up Compressed video to Skydrive
Step 7: Continue file scanning
If video deleted or modified
Then
Recover lost video from Local backup
If video file not exist
Then
Recover lost video file from skydrive
Step 8: Stop

4.2 Components of the Proposed system

- **Main Folder**

Main folder is a working folder, which comprises video data (news data) and kept on Users computer or personal computer. It is synchronized with another folder called Backup folder. Data in main folder are reflected into backup folder before backing up to actual cloud via the internet.

- **Meta data**

Meta data are data, which describe the properties of data and the relationships between these data. It provides the details of the current files in the working directory along with their type and size. By watching Meta Data context one can observe what changes (new, updated, deleted) happened in the directory in main folder last check up.

- **File change notifier**

Main objective of file notifier system is, whenever change in folder or file such as new file is created, existing file is edited, renamed, or file is deleted, during these events user should get notifications. According to the notification Backup or Recovery process is done. It is also called as synchronization model.

It comprises two process

1. **Change Tracker:**
   It periodically monitors file system, Change tracking is a lightweight solution that provides an efficient tracking mechanism when contents of file changed for applications.

2. **Event Handler:**
   It takes particular action for specific event that tracked, for example when file is modified it might be saved. When file is deleted or renamed, it is automatically recovered from its backup location.

• Video Compression

Video compression is a technology used to reduce and remove the redundant video data so that a digital video file can be effectively sent over a network and stored on computer disks or cloud. With efficient compression techniques, a significant reduction in file size can be achieved with little or no adverse effect on the visual quality.

Proposed system looks for video files. Once the video files are located, it checks if the files are compressed or not. If the files are compressed, the system directly uploads them in Skydrive. Else the files are compressed with lossy compression followed by backing up in backup storage. There are several open source tools for video compression, among the most popular ffmpeg which is compatible with various implementation of audio and video codecs, used for video compression in this proposed system.

FFmpeg [1],[3] is a free software project that produces libraries and programs for handling multimedia data for doing stuff like video compression, video transcoding, video trimming, adding into or extracting images from video etc.FFmpeg is developed under Linux, but it can be compiled under most operating systems, including Mac OS X, Microsoft Windows. In this work FFmpeg compiled under Microsoft Windows software.

FFmpeg uses standard H.264 for video compression. The process of compression involves applying an algorithm to the source video to create a compressed file that is ready for transmission or storage.Video compression algorithms H.264 uses inter frame prediction to reduce video data between a series of frames. This involves techniques such as difference coding, where one frame is compared with a reference frame and only pixels that have changed with respect to the reference frame are coded. In this way, the number of pixel values that is coded and sent is reduced. When such an encoded sequence is displayed, the images appear as in the original video sequence.

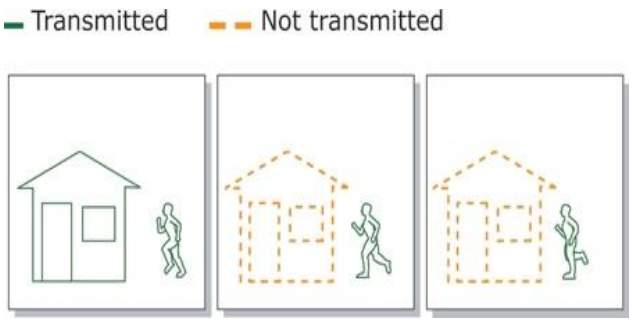

Figure 2: Inter frame prediction method for video compression

With difference coding, only the first image (I-frame) is coded in its entirety. In the two following images (P-frames), references are made to the first picture for the static elements, i.e. the house. Only the moving parts, i.e. the running man, are coded using motion vectors, thus reducing the amount of information that is sent and stored. This is where the economies of reduced bandwidth and storage needs will deliver the biggest savings. much higher video quality can be achieved for a given bit rate.

H.264 will most likely find the quickest traction in applications where there are demands for high frame rates and high resolution. H.264 is also expected to accelerate the adoption of megapixel cameras since the highly efficient compression technology can reduce the large file sizes and bit rates generated without compromising image quality. H.264 provides savings in network bandwidth and storage costs With inter frame prediction, each frame in a sequence of images is classified as a certain type of frame, such as an I-frame, P-frame or B-frame.

An I-frame, or intra frame, is a self-contained frame that can be independently decoded without any reference to other images. The first image in a video sequence is always an I-frame. I-frames are needed as starting points for new viewers or resynchronization points if the transmitted bit stream is damaged. I-frames can be used to implement fast-forward, rewind and other random access functions. An encoder will automatically insert I-frames at regular intervals or on demand if new clients are expected to join in viewing a stream. The drawback of I-frames is that they consume much more bits, but on the other hand, they do not generate many artefacts, which are caused by missing data.

A P-frame, which stands for predictive inter frame, makes references to parts of earlier I and/or P frame(s) to code the frame. P-frames usually require fewer bits than I-frames, but a drawback is that they are very sensitive to transmission errors because of the complex dependency on earlier P and/or I frames.A B-frame, or bi-predictive inter frame, is a frame that makes references to both an earlier reference frame and a future frame. Using B-frames increases latency.

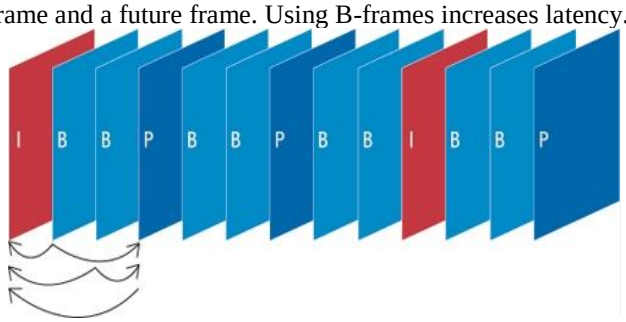

Figure 3: A typical frame sequence with I-, B- and P-frame A P-frame may only reference preceding I- or P-frames, while a B-frame may reference both preceding and succeeding I- or P-frames.

Command line option of FFmpeg used for video Compression

```
var program = Directory.GetCurrentDirectory()+
 "\\ffmpeg\\bin\\ffmpeg.exe";
var input = "-y -i \"" + fi.FullName + "\"";
var options = " -c:v libx264 -crf 19 -preset slow -c:aaac -
strict experimental -b:a 192k -ac 2 ";
```

Parameters of compression

- -i – input file
- -y – overwrite the input
- -c:v – video channel
- libx264 - library contains necessary tools for compression
- -crf – Constant rate factor
- -c:a – audio channel
- aac – advance audio codec
- -b:a – audio bitrate

The proposed work uses news video as input and compression using FFmpeg technology. The next task for efficient news data transmission is data backup and reliable recoverys approach.

- **Backup manager**

Backup manager is triggered in every 10 seconds with a timer click event. The role of the module is to check if a file present in mainfolder is also present in backup folder or not. If not, it is copied to the backup folder.Backup Manager generate overall backup schema in two forms
a)local backup (backup folder)and
b)cloud backup (skydrive)

- **Replication Manager** makes replicas for each video data present in mainfolder and intelligently determines storage location of each replica.

- **Primary Backup**

Primary Backupis a local backup system which provides backup facility for data present in main folder.All the video data presented in mainfolder are get reflected to backupfolder which is primary backup method to keep the data on the user's system at any different location other than mainfolder.

- **Secondary backup**

Secondary backup is actual cloud storage that used for backing up the data via internet and typically hosted by a third-party vendor. Proposed system uses skydrive cloud as a secondary backup. SkyDrive is a file hosting service that allows users to upload and sync files to a cloud storage and then access them from a Web browser or their local device.

- **Restore Manager(Recovery manager)**

It manages recovery process in two methods

1. Local Recovery:

When the background file scanner finds that any file from the workspace (main folder) is deleted, it automatically recovers the lost file from the local backup

2. Cloud Recovery:

System tries to recover the lost file from cloud when a file neither presented in mainfolder nor in backupfolder to avoid permanent data loss.

5. Results and Discussion

Proposed work is a single window application that provides in-app analysis tools for comparing the present state of art with the proposed system. Individual components are marked in the UI figure 4. Following are the details of these components.

1) **Directory Details:** This section provides the details about current working directory (main folder) and backup directory (backup folder). User can change these folders based on his preferences. Once changed, the system remembers the changes through a setting file linking.
2) **File Details:** The data gridview component provides the details of the current files in the working directory along with their type and total memory in Mb.

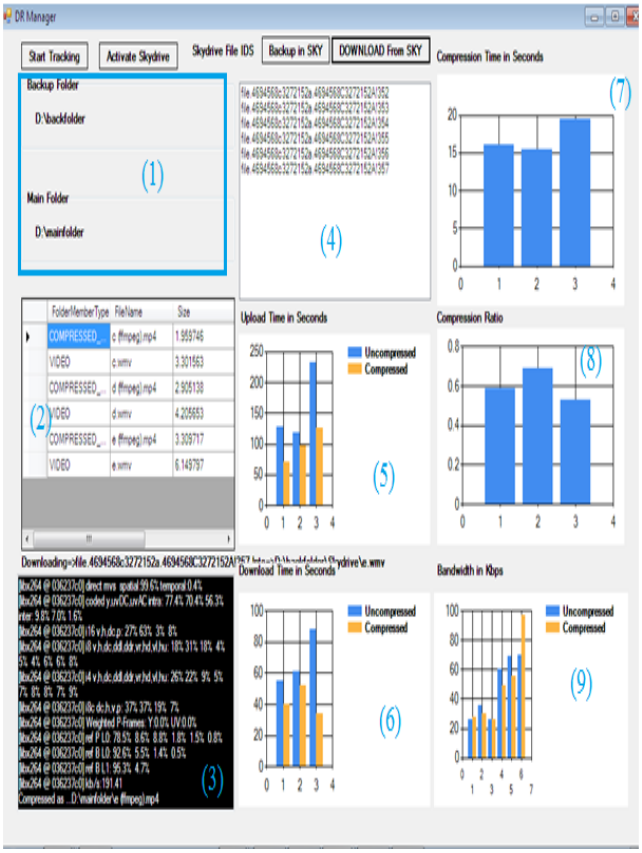

Figure 4:Overall result of the proposed work

3) **Compression Console:** Compression console provides the details of FFMPEG result whenever a video compression is triggered.
4) **Skydrive File Details:** Soon a file is uploaded in Skydrive, a file ID is generated which is essential for recovery. The file can be downloaded by supplying this ID to cloud manager. These file Ids are shown in Skydrive file details section.
5) **Upload Time Analysis:** This graph provides the details about time taken for uploading compressed file and it's uncompressed peer.
6) **Download time Analysis:** This is recovery time analysis. The graph presents the details about total time taken for downloading a file. Here too, compressed and uncompressed files are compared.
7) **Compression Time Analysis:** This graph presents the overview of total time taken by a video to get compressed.
8) **Compression Ratio Analysis:** This graph depicts the ratio of current size of the compressed video to the size of uncompressed video.
9) **Bandwidth Analysis:** Bandwidth graph shows the total bandwidth being consumed by compressed files (for both uploading and downloading) and time consumed by uncompressed files.

5.1 Experimental Setup

Table 1: UncompressedVideo Data

Sl.No.	File Name	File Size (in MB)
1)	Video a	3.3
2)	Video b	4.2
3)	Video c	6.14

Table 1 presents Input (Uncompressed) video files in the working directory along with their size.

We perform the experiment by taking three uncompressed videos(.wmv) of news data as shown in table 1 . The videos are placed in the main folder. When file notifier triggers the presence of videos, video compression module is triggered. We measure the time between start of compression to end of compression. This time is called compression time. Once the files are compressed, the compressed file is saved with ffmpeg name extension. System now calculates the size of a video file and their corresponding _ffmpeg name extension. The ratio of these two is referred as compression ratio.Table 2 presents compressed video.

Table 2: Compressed Video Data

Sl.No.	File Name	File Size(in MB)
1)	Video a_ffmpeg	1.95
2)	Video b_ffmpeg	2.90
3)	Video c_ffmpeg	3.30

In the experimental setup we upload both compressed(.mp4) as well as uncompressed(.wmv) files. However the proposed system only suggests uploading and downloading only compressed variants of the video. But for comparing the performance it is essential that the behaviour of both are analysed.Uploading and downloading time for both compressed as well as uncompressed videos are logged. These comparisons are presented as uploading time and downloading time analysis. We also log the bandwidth of the files which is presented as bandwidth analysis graphs.

5.2 Performance of Video Compression

Compression time is a measure of time complexity of the video. Generally time complexity of compression is O(n) where n is number of frames. As FFMPEG adopts lossy compression which includes both intra-frame and inter-frame compression the complexity in O(log(n)). Therefore the time increases slightly with increase in large video file size. This is shown in figure 5.

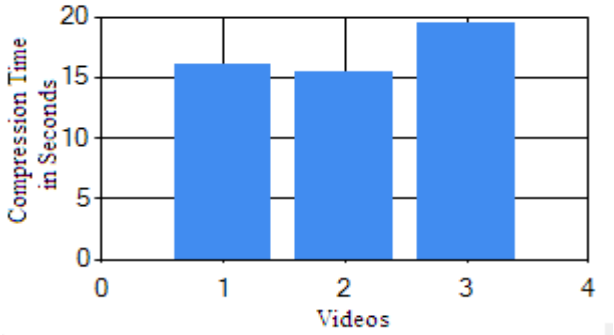

Figure 5: Compression Time Graph

5.3 Compression Ratio

Compression ratio is a measure of performance of video compression module. Figure 6 shows that the system produces almost linear performance irrespective of the size of the files. The variations are observed due to frame content of the files. We can see that the proposed system achieves almost 50-60% compression which leads to faster backup and recovery.

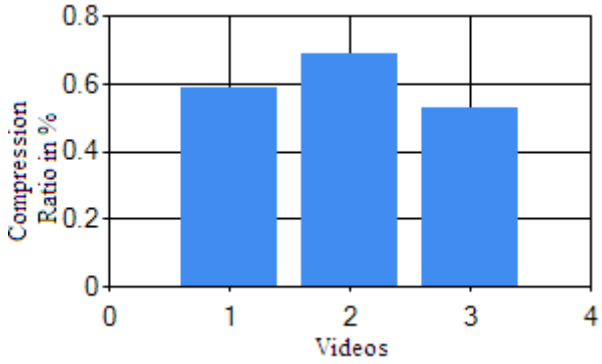

Figure 6: Compression Ratio Graph

5.4 Time Analysis

Both uploading and downloading times are specified in seconds and is a measure of uploading and downloading of entire file.

5.4.1 Backup Process

Figure 7 presents the comparison between compressed and uncompressed files for Skydrive uploading. We can clearly see that as video file size increases the time gain for proposed method becomes significantly distinguishable from uncompressed backup. This is because as the size of the video increases the traffic becomes more throttle traffic which demands better scheduling and load balancing technique and packet rate to server stars varying. This leads to high uploading time. However as compressed video effectively reduces number of frames through frame interleaving, it takes less time.

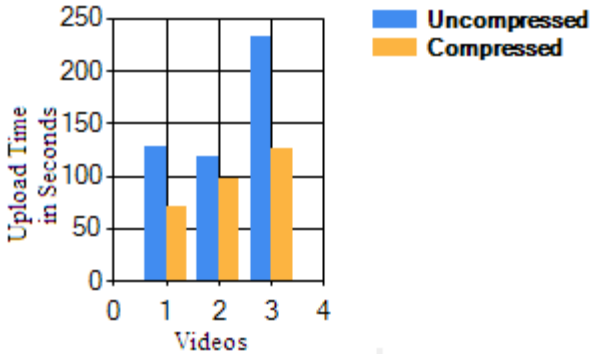

Figure 7: Backup**(**Uploading) time Graph

5.4.2 Recovering time

Recovery time interpretation is similar to that of backup interpretation. But we observe that for larger files the proposed system performance is better than uploading time performance. Compressed file headers gives an information about type of files. At the receiver lost frames can be reconstructed by motion vector differential technique. Therefore the receiver can obtain files at a higher speed.

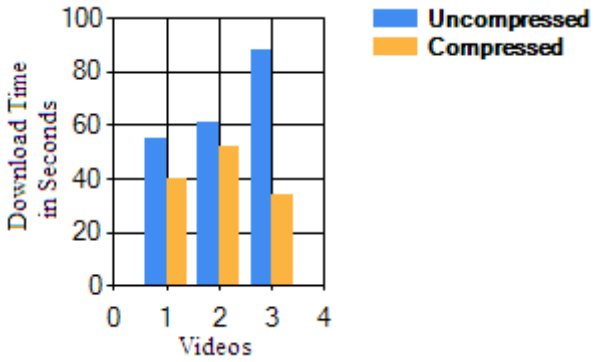

Figure 8: Recovering (Downloading) time Graph

5.4.3 Bandwidth Utilization

Bandwidth is calculated as the ratio of total size of the file divided by the time to upload or download. For uncompressed video the size is more and thus time is also more. For compressed videos size and time is low. So theoretically both the bandwidth must be almost same as the ratio does remains same. For lower file sizes, it is clearly justified. However as we discussed, high file size converts CBR traffic to throttle traffic which increases network latency as bandwidth allocation fails at inner nodes. Thus for high file size in case of uncompressed videos, time increases non linearly resulting in more bytes par seconds (throttle). Therefore required bandwidth significantly increases for uncompressed videos. The bandwidth is logged through Microsoft virtual adapter and is measured in Kbps.

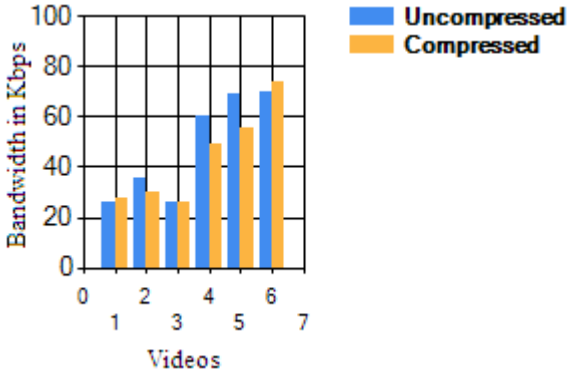

Figure 9: Bandwidth Utilization Graph

6. Conclusion

The concept of data backup and recovery is as old as the history of computation. However the complexity of data usage, demand for sharing more volume of data and increase in OTG(on the go) data access have made remote data storage of extreme importance. Cloud based data services have been growing to meet this new challenges. Several public cloud like Skydrive and DropBox offers state of the art Cloud based data storage services. Few hardware service providers like Dell has comeup with it's own integrated cloud for automatic storage of data from user devices. However one of the major drawback of all the current state of art (be it commercial or research) is that it treats data as binary chunk. Therefore storage and communication cost rises significantly for large sized data like video.

Therefore in this work we address this problem by proposing a unique system of video compression integrated cloud based backup and recovery solution. We show through the experimental setup that the proposed system can improve the storage and communication cost significantly by a background video compression process.

Our work scans user's workspace in background and notifies the backup manager, whenever new files are added or existing files are edited. Backup manager accordingly updates the backup files in both local as well as in cloud storage. When the background file scanner finds that any file from the workspace is deleted, it automatically recovers the last backup file from the local backup. If in case the file is absent in the local backup, it is being fetched from the skydrive and is recovered in the workspace. The dual backup system reduces communication cost in case the local backup is accessible.

7. Future Work

Proposed work failed to achieve update services. For instance even when only part of a file is modified, entire file needs to be backup up once again. Though this is not significant in terms of videos as they are rarely modified, for other files it may present communication overhead. Overcoming this shortfall could be considered as future work for the proposed system.

References

[1] Converting video formats with FFMpeg,LinuxJournalarchive – Issue 146, June 2006.
[2] Dean J and Ghemawat S,MapReduce: "Simplified Data Processing on Large Clusters",InOSDI, 2004.
[3] FFMpeg – http://ffmpeg.org.
[4] JyotiMalhotra,PriyaGhyare,"A Novel Way of Deduplication Approach for Cloud Backup Services Using Block Index Caching Technique", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 7, July 2014.
[5] KeerthikaJanani.M and Sudhakar.G Anna University, Chennai,HAVS: "HadoopBased Adaptive Video Streaming by the Integration of Cloudlets and Stratus",Volume 3, Issue 2, February 2014.
[6] Michael Vrable, Stefan Savage, and Geoffrey, Department of Computer Science and Engineering University of California, San Diego , Cumulus: "Filesystem Backup to the Cloud".
[7] Mohammad Ali Khoshkholghi, Azizol Abdullah,"disaster recovery cloud computing survey". http://con nection.ebscohost.com/c/articles/99420602/disaster-recovery-cloud-computing-survey
[8] Navdeep S. ChahalBaljit S. Khehra,"A Comparative Study for Optimization of Video File Compression in Cloud Environment",Volume 60 - Number 13.
[9] Rafael Pereira, Marcello Azambuja,KarinBreitman and Markus Endler, "An Architecture for Distributed High Performance Video Processing in the Clouds".
[10] Shanthi.B.R, PrakashNarayanan.C,"Dynamic Resource Allocation And Distributed Video Transcoding Using

HadoopCloudComputing", Vol.2, Special Issue 1, March 2014.
[11] Sudhir, Dhage; Akassh, Mishra A,Security in Inter-Cloud Communication,2012.
[12] http://theses.Covenant university.edu.ng/
[13] T.Wood, E. Cecchet, K. K. Ramakrishnan, P. Shenoy, J. Van der Merwe, and A. Venkataramani, "Disaster recovery as a cloud service: Economic benefits &deployment challenges", in 2nd USENIX Workshop on Hot Topics in Cloud Computing, Boston, USA, 2010.
[14] Tung Nguyen, Anthony Cutway, Weisong Shi, "Differentiated Replication Strategy in Data Centers",2014.https://hal.inria.fr/hal-01054977
[15] Vince Paul, Anumol Johnson, ,"Big Data Processing Using HadoopMapReduce Programming Model", Vol. 6 (1) , 2015.
[16] Vouk, M.A., Cloud Computing – Issues, Research andImplementations, 30th International Conference onInformation Technology Interfaces, June, 2008, pp. 31-40.
[17] Yu Gu, Dongsheng Wang_, and ChuanyiLiu ,"DR-Cloud: Multi-Cloud Based Disaster Recovery Service" , Volume 19, Number 1, February 2014.