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A Parallel Architecture for Inline Data De-duplication Using SHA-2 Hash

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Abstract— In this digital world of internet, data storage and server storage use is often and every home user, enterprises, several organizations are using email and online storage as a storing node. Online backup storage is an easy option for everyone to store digital data, files and other multimedia files. This makes the storage servers loaded as well as more disk storage is required to save a large amount of same data. Due to the same reason the search operation takes more time to found a specific file and time taken to send acknowledgement is increased. This problem was overcome with a mechanism known as Data de-duplication. This process is used for removing duplicate data and to reduce redundancy at server node. In this paper we have studied previous and recent work on de-duplication and proposed a solution which is a Parallel architecture for inline data de-duplication which uses the secure hash algorithm 256 for performing data de-duplication task in order to overcome the issues of time and to reduce hash collision. In this architecture write and delete operations are performed for efficiency and time evaluation. This architecture is useful for storage servers where a huge amount is stored every day and software industries always looks for new developments so that they can keep their storage systems up to date and free for efficient utilization of the server nodes.

Keywords— De-duplication, block level de-duplication, hash, Inline parallel de-duplication.

I. INTRODUCTION

Nowadays, online backup storage, content delivery networks, blog sharing, news broadcasting and social networks as an ascendant part of Internet services are data centric. Hundreds of millions of users of these services generate petabytes of new data every day. For instance, as of April 2011, an online file-sharing and backup services called drop boxes, has more than 25 million 2GB drop boxes (total of 50 peta bytes). A large portion of internet service data is redundant for the following reasons. One is, now a day's people tend to save data at multiple times for data safety reasons and avoids purchasing storage for high cost; this leads to more redundant data. One another reason is, while incremental (or differential)data backups or disk image files for virtual desktop tend not to have duplicated whole-file copies, but still there is large ratio of duplicated data portion from the modifications and revisions of the files.

Rapidly increasing data arises many challenges to the existing storage medium to be used [1]. As the data increases, more data is for backup cite. Due to increment in storage data it is found that it brings some difficulties in backup systems. The cost of the storage media has decreased, but the main problem is to manage number of disks in the back-up systems. In fact, in storage archives a large amount of data is redundant and slight changed to another chunk of data. The identification of these duplicate chunks is fundamental to improve the quality of information retrieval [2].

In de-duplication the redundant data is deleted by using the cryptographic hash concept. In backup servers hash is used for finding the duplicate data. Hash is a fixed length representation of any arbitrary length message. The complexity of comparisons can be reduced by using hash as the original length of data is much more than the hash size. In de-duplication process whenever any record comes for server, it calculates the hash signature for the record using secure hash algorithm (SHA). Once hash signature is generated server checks this signature in hash index, which is already maintained in the system. While searching for the signature in hash index if the server finds its entry in the hash index (record already exists) then rather storing it again server creates a reference for this. This reference will point to the location of block on the disk. In second case if server does not find the entry of record in hash index table it will store the record on the disk and adds an entry for its hash signature in hash index [2] [3].

In this paper we have studied different data de-duplication methods and issues related to them. To overcome the draw-backs of previous work many researchers have worked and gave methods with increased efficiency. In next sections, we will discuss some previous methods and there major elements. After that our proposed architecture is described which is designed for inline parallel data de-duplication using Secure hash algorithm 256 and rest section is followed by experiments and results. A comparison among previous hash algorithms is then given with future possibilities in the research area.

II. CLASSIFICATION OF DATA DE-DUPLICATION

Generally de-duplication methods consist of two main approaches for data de-duplication storage systems: finger- printing based and delta-based data de-duplication. Nowadays fingerprinting-based de-duplication is prevalent in practice and research and this thesis deals exclusively with this type.

A. De-duplication based on processing position

De-duplication can occur where data is created, which is referred as “source de-duplication”. De-duplication performed at the place where data is saved or stored is called “target de-duplication” [3]. Source de-duplication ensures that data on the data source is de-duplicated. It takes place directly within a file-system. The file system will periodically scan new files creating hashes and compare them to hashes of existing files. The de-duplication process is transparent to the users and backup applications. Backing up a de-duplicated file system will often cause duplication to occur resulting in the backups being bigger than the source data. Target de-duplication (De-duplication Appliance-based) is the process of removing duplicates of data in the secondary storage. Generally this will be a backup store such as a data repository or a virtual tape library. In the target de-duplication, when the data is coming to store, we apply post process or in-line data de-duplication depends on our needs at the target side [2].

B. De-duplication based on time of processing

With post-process de-duplication, de-duplication analysis and calculations are made after the data is stored in storage device. Once the data is stored then only the process will be applicable. A benefit of using post process is no one needs to wait for hash based calculations. The lookup is completed before storing the data also ensuring about performance degradation not achieved. On the negative side of this process, one may unnecessarily save redundant data for a small time which could be an important issue if the system is near to full capacity [3] [2].

Inline de-duplication is the process where the de-duplication hash calculations are created on the target device. When the data enters the in the device, if the device spots a block that is already stored on the system. It does not store the new data block. The benefit of in-line de-duplication is that it requires less amount of storage. On the other side, because of hash calculations as well as lookups takes long time, the data ingestion may be slower; this leads to which throughput of the device is reduced [3].

C. Hash Based De-duplication

In hash based data de-duplication process we use cryptographic hash to detect redundant copy of any record. In the general process storage server maintains a hash table, which contains two fields. One is hash signature and other is its real address. It calculates the hash signature for each record requesting for backup by using secure hash algorithm. Now it searches for this hash signature in hash table. If signature not found, that means record is unique, and do an entry for this in hash table.

III. LEVELS OF DE-DUPLICATION

In the file level de-duplication (whole file hashing), entire file is assumed as a record. When a file comes to backup, hash signature of incoming file is compared with already stored file’s hash signatures. If the file is already stored, it stores a reference to it otherwise store entire file and make an entry for hash signature of this file in the hash table.

In the block-level data de-duplication(sub file hashing) method, incoming data stream is divided into various data blocks and compared with the hash of data block. Then it determines whether it is same as with the previously stored data block. If the hash of the data block is unique, then store this block to disk, and store its identifier in the hash index; otherwise, only store the reference to the same data block’s original location. It stores a reference of a comparatively small size in place of the data block, rather than storing duplicate data locks again, hence a significant saving of disk storage space. Hash algorithm used to judge duplicate data, may lead to conflict between the hash signatures. There are two types of Block Level de-duplication.

- Fixed Block de-duplication involves determining a block size and segmenting files/data into those block sizes. Then, those blocks are what are stored in the storage subsystem. For example suppose we take a fixed size 1 byte to divide an incoming file.
- Variable Block de-duplication involves using algorithms to determine a variable block size. The data is split based on the algorithm’s determination. Then, those blocks are stored in the subsystem.

In byte stream level de-duplication the incoming data stream is divide into the number of bytes and then the hash signature of each incoming bytes are compared with the stored bytes on the disk and take appropriate action. Byte level de-duplication gives highest accuracy as compared to file level de-duplication and block level de-duplication. But byte level de-duplication lead to some problems like size of the hash table will become very large and sometimes leads to large file fragmentation.

IV. BACKGROUND AND RELATED WORK

While surveying the recent methods and advancements we can see that most available backup systems uses file-level de-duplication [4] traditionally. But the data de-duplication technology can exploit inter-file and intra-file information redundancy to eliminate duplicate or similarity data at the granularity of file, block or byte. Some of the available architecture follows the source de-duplication approach and provide the de-duplication technology in the available users file system [5]. Because of this file system de-duplication, user faces delay in sending data to backup store, and the rest of the available architectures which support target de-duplication strategy provide single system de-duplication which means at the target side only single system or Server handles all the user requests to store data and maintains the hash index for the number of disks attached to it [2].

Name of some previously proposed architectures are VENTI [6], lower bandwidth file system (LBFS) [5], MAD2 [7], SIS (single instance store) [8], CDC (Content defined chunking) [9], INS(Index Name Server) and PASTICHE. VENTI and Single Instance S adopt fixed-size file dividing method to partition the file into blocks [6] [8]. LBFS and PASTICHE divide each file into variable sized blocks [5] [10]. Fixed-size file dividing method is simple and easy, but the salient disadvantage is that all the blocks after the change point will be affected, and then misjudged as non-duplicate blocks.

Summary Vector, an in-memory, conservative summary of the segment index, to reduce the number of times that the system goes to disk to look for a duplicate segment only to find that none exists. Then they use Stream-Informed Segment Layout (SISL) to create spatial locality and to enable Locality Preserved Caching (LPC) to prefetch hash codes of adjacent segments into cache. LPC method avoids disk operation and accelerates the process of identifying duplicate segments [11] [2]. Some researchers worked in the field of cloud storage and worked with using both fixed size block and variable size blocks. As there are a lot of de-duplication techniques depending on the algorithms chunking of the data blocks. They chosen Fixed Block [3]and Rabins Fingerprint [12] which are the most well known algorithms as the representatives. Fixed Block algorithm uses fixed size block as a unit of the de-duplication while Rabins Fingerprint uses variable block size. A new data management structure named Index Name Server (INS), which integrates data de-duplication with nodes optimization mechanisms for cloud storage performance enhancement. INS manages and optimizes the nodes according to the client-side transmission conditions.

Sengar and Mishra [2] proposed a very scalable and efficient in-line data de-duplication using SHA-160. This algorithm supports bloom filter to reduce the disk access time for segments which are not present in the Disk. It support load balancing in storage nodes. Content-Defined Chunking is latest work in which provides basis in the field of Cloud Storage and Cloud Synchronization through mobile devices. In this way, a file is divided into chunks of different sizes instead of a pre-fixed size based on file contents. Required steps of Data De-duplication algorithm were optimized to make this method accommodate to mobile devices [9]. A problem with the available architectures is that the hash algorithm may lead to hash collision, that is, different blocks produce the same hash codes, which will result in discarding unique block mistakenly. However, LBFS [5], finger diff used hash algorithm (SHA-1 or MD5), and most of them considered that the probability of hash collision is extremely lower than the probability of hardware errors. In our architecture we selected SHA-256 hash algorithm because of its strong collision resistant and encryption function. “A Parallel Architecture for In-Line Data De-Duplication Using SHA-256 Hash” is our goal. The proposed architecture uses the hash index for redundancy identification between files so it should fulfill some other features-

1. Use of upgraded hash algorithm leads to lesser probability of hash collision as SHA-256 Provide hash signature up to 2^{128} bytes.
2. Parallel implementation helps reducing time consumption and shows better performance for larger file sizes.
3. Space reclaiming with use of reference count mechanism.
4. To decrease the communication overhead it should support better interaction between storage node and server.

V. PROPOSED DE-DUPLICATION ARCHITECTURE

Our proposed parallel architecture with SHA-256 algorithm is using following components given below-

A. Client-The node that contains or need back up for data is client. When client require to store any data , it sends that data to server node.

B. Server-After a client request a file to backup, server first receives that file at backup store and after accepting the file, server divides it in fixed size blocks (example 1024 KB) and group these divided blocks into super block and these super blocks are distributed among nodes of available storage using strategies of data distribution. Now storage nodes and server create hash signature of distributed parts and a sequential search of hash signature is performed. This search is performed in parallel way at the maintained hash table.

C. Meta Server-All the database tables are collected at meta data server. The meta data tables contain the file name, number of parts in each file, parts path information, number of references to each file part, hash signature of each files part and storage utilization of each storage node information.

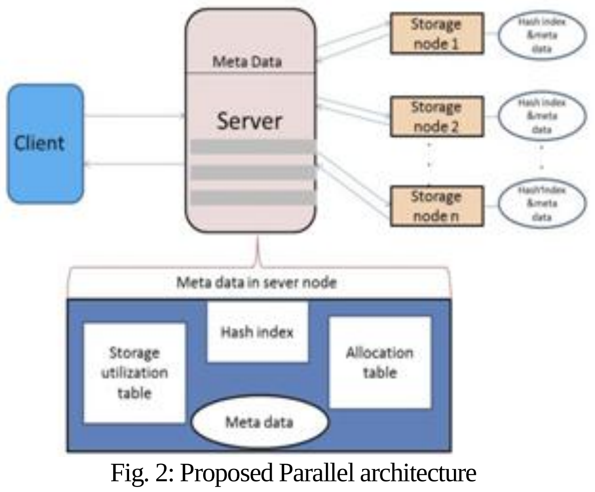


Fig. 2: Proposed Parallel architecture

D. Storage Server-Every storage server has its hash table and information related to it. Storage node first receives data for backup and performs hash calculation of data block and compares this with its hash table which is maintained by server itself. The details stored in disk storage if hash signature found unique. If its signature is found similar then it only stores the reference. Our proposed architecture for inline data de-duplication is given in (Refer fig 2).

VI. PROCESS

Our proposed architecture is executed with some module and nodes are taken as components. Important components of this architecture are client node and server nodes. By using these nodes such parallel architecture is implemented and performance study is obtained using the operations as write, delete and read The main components of this architecture are client, server, and storage nodes. The operations which we have implemented in this architecture are read, write and delete. Fourth operation is nothing which leads to exiting from system. An schema for these operations are discussed in following sections.

A. Descriptions of operations

Write operation algorithm

At the server

1) Client sends the file or record to backup.
2) Server receives this requested file and numbers of blocks are calculated by server itself.
3) These number of blocks are divided depends on the block size allotted. For an example if a file of 7 KB is requested for backup and block size is decided as 1 KB, then the number of blocks for the file will be 7.
4) In allocation table these blocks are entered.
5) Adds an entry in allocation table.

At the storage client

1) Storage client receives the super block from server and proceed to step 2.
2) Calculate hash signature for all available blocks in the super block.
3) Determine if any of these or all of those blocks are already stored or not. In case if already stored, then go for referencing it; otherwise entire block should be stored in disk.

Delete operation algorithm

At the server

1) Client sends the file or record it wants to delete.
2) Server takes this request and send the name of the File requested to module of meta data and to all storage nodes. This both sending process are done simultaneously.
3) Meta data module on server now decrease the number of references and every storage node also Decreases the number of references, corresponding to that file.
4) Data block is deleted if the number of reference value is zero for that data block.
5) Once deletion is performed, server acknowledged to client with a message of success.

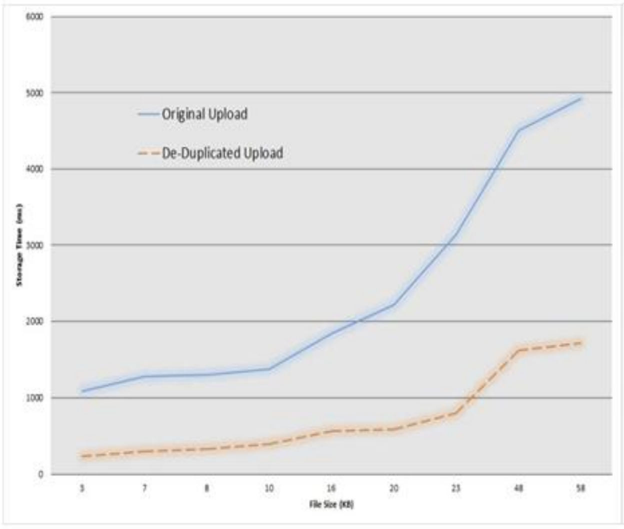
B. Technologies used

Java programming language is used for the implementation of this architecture. Java sockets are used for connection of network. for implementing the above mentioned architecture. We are using java sockets for implementing connection of network. This implementation of connection network is between client and server. Java programming database is used for establishment of connection between mysql server and java. Different java classes are also used for different modules. Mysql server is used for maintaining the metadata and their tables. These tables contains the data about hash index, number of references, allocation, file part meta data.

VII. RESULTS AND DISCUSSION

The main aim of our proposed architecture is to provide a system or platform by which can remove duplicate data from the data centres in parallel and allow load sharing. Proper distribution of all incoming load is done using storage balancing technique. This architecture also uses distribution of requested data and server using different storage nodes. Our implemented architecture provides inline data de-duplication mechanism. Such method of de-duplication takes place before storing data. It means the system checks for redundancy when data is not stored. For experimental purpose, we performed our experiments with different Block Size i.e. 1 KB, 2 KB, 3 KB and 4 KB and studied their effect on different file size. For experiment we used two core 2 Duo work stations with 4 GB RAM with memory specification as 160 GB Hard drives and network connection of 1GBPS LAN.
For experimental purpose, we performed our experiments with different Block Size i.e. 1 KB , 2 KB , 3 KB and 4 KB and studied their effect on different file size. All the graphs are representing two parameters as file size and storage time taken for different files during write process and delete process.

- Using block size of 1 KB the performance graph for write process different file sizes is given below- (Refer fig 3).
- Using block size of 1 KB the performance graph for deleting different file sizes is given below- (Refer fig 4).



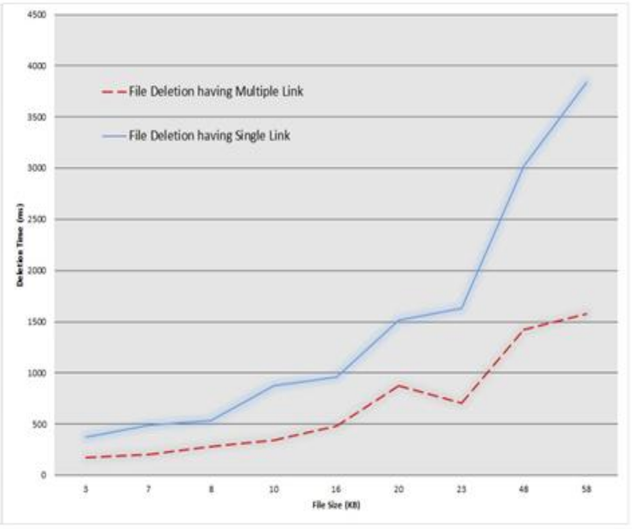
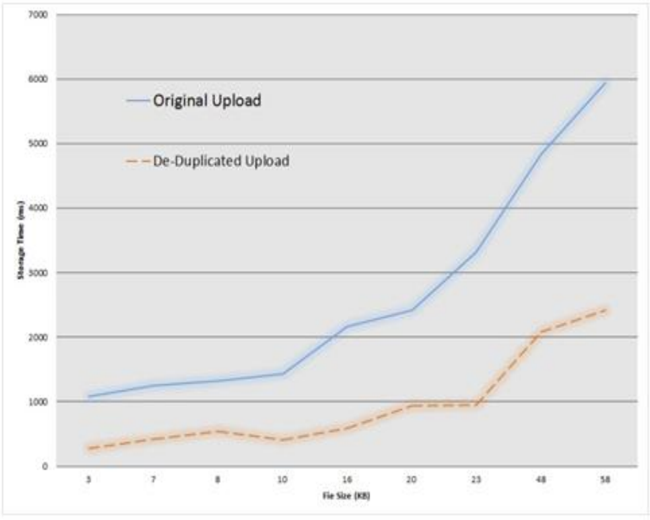


Fig. 3: Write process with 1 KB block size

Fig. 4: Delete process with 1 KB block size

- Using block size of 2 KB the performance graph for write process different file sizes is given (Refer fig 5).
- Using block size of 2 KB the performance graph for deleting different file sizes is given (Refer fig 6).



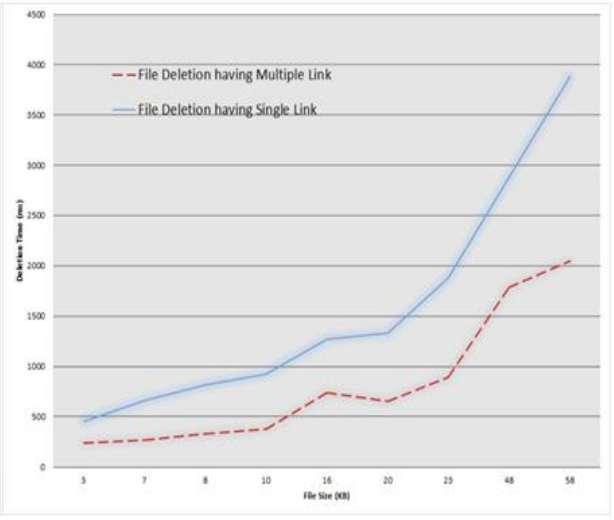
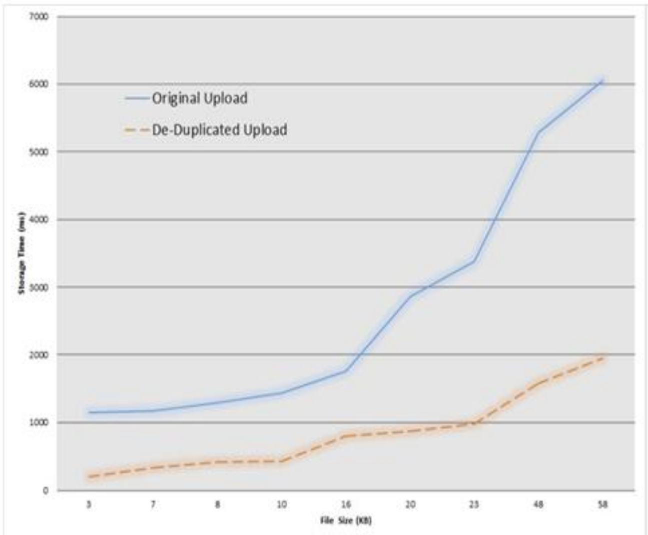


Fig. 5: Write process with 2 KB block size

Fig. 6: Delete process with 2 KB block size

- Using block size of 3 KB the performance graph for write process different file sizes is given (Refer fig 7).
- Using block size of 3 KB the performance graph for deleting different file sizes is given (Refer fig 8).



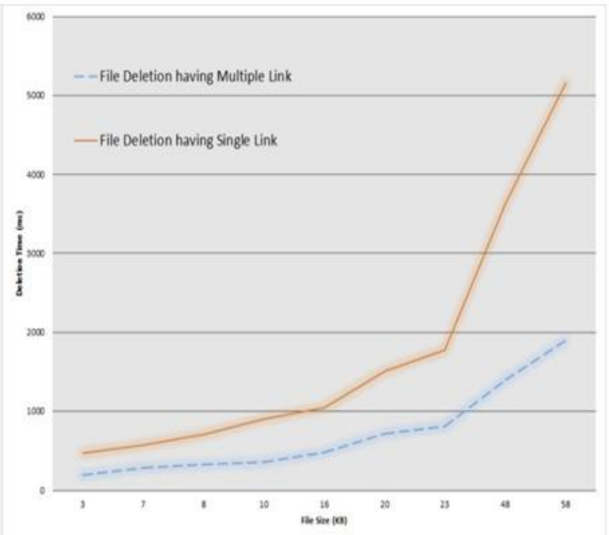
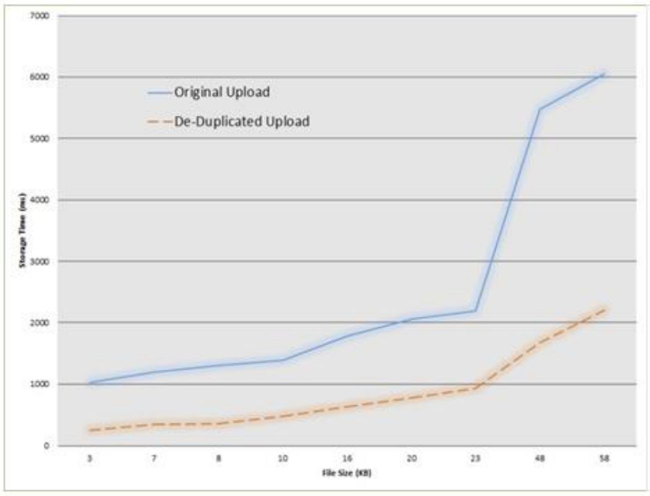


Fig. 7: Write process with 3 KB block size

Fig. 8: Delete process with 3 KB block size

- Using block size of 4 KB the performance graph for write process different file sizes is given (Refer fig 9).
- Using block size of 4 KB the performance graph for deleting different file sizes is given (Refer fig 10).



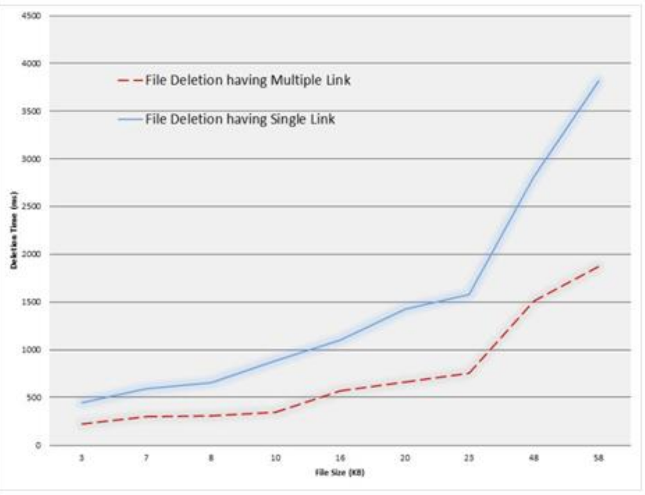


Fig. 9: Write process with 4 KB block size

Fig. 10: Delete process with 4 KB block size

While applying write process on different files sizes using inline parallel architecture, on storing a file having multiple references the time for write process will be less than the time, when there was no references. When we applied delete process on different file sizes using inline parallel architecture , we found that; if we are deleting a fie having multiple references at first time deletion will take very less time, because it only delete the data base entries, and if we are finally deleting the data having 1 reference count the deletion time will increase. Our implementation is showing a same trend with varying Block size. So it can be used with varied block sized file system and it will give same results. The overall performance on parameter time is given in the graph given below-(Refer fig 11)

Results

The results we get with this implementation and experiment are

- Hash collision probability is much lesser due to use of SHA-256 hash signature. It provides a message digest of size $2^{128}-1$, which means the probability is much lesser then SHA-1 algorithm.
- For different block sizes the parallel architecture is running successfully and the time taken (in milliseconds) by

The system to perform write operation for redundant data is less than the time taken to store that data at first time. One important fact we get during implementation is that this architecture is more efficient for files with larger size. The overall time taken to store redundant large files is lesser then the time taken for small file size.

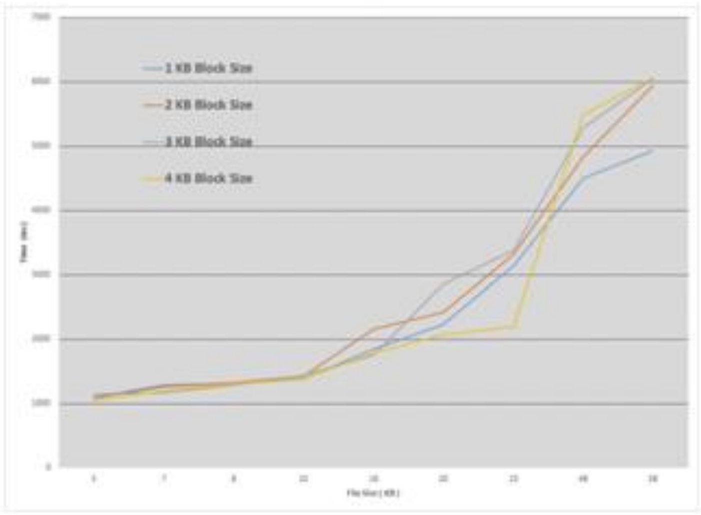


Fig. 11: File Storage time Variation with Varying Block Size

- For performing the delete operation for block size of 1 KB, 2 KB, 3 KB and 4 KB, we get a fact that for deletion Of a single link the time taken by system is lesser; where for deletion of actual data takes more time. This depends on the reference count information. If the reference count is greater than one then only the entries in database are remove and leads to lesser time but if the reference count is one, in that case it has to go to the actual data storage and will perform delete operation; that leads to more time taking process.
- Parallel architecture supports for better time efficiency and load sharing. By using various storage nodes parallel with server node, the incoming data is properly shared with all storage nodes and hash is created for each node

individually. For reading, writing or deleting these file it is also easier for server to assemble all parts together and sending the data to client.

- It creates unique names of file if duplicates are present. If a data is already stored then it fetches that particular part of data and never writes a duplicate name.

Comparison with previous Hash algorithms

- The probability of collision is very less in the case of SHA-256 algorithm with 2^{128}. In the case of MD5 and SHA-1 the collision chances are 2^{64} and 2^{80} respectively, which have more probability of having collision.
- The maximum message size for SHA-256 is $2^{128} - 1$.It is higher than SHA-1 and MD5, those have maximum message size as $2^{64} - 1$.
- These properties of SHA-256 made it robust to use and gives better results at higher speed.

VIII. CONCLUSION AND FUTURE WORK

In this paper a parallel architecture for inline data de-duplication is presented, in this we used SHA-256 algorithm for less collision probability. The main advantage of using SHA- 256 algorithm is that, it provides 128 bit hash by which the collision probability is much more lesser than previous de-duplication methods. We have implemented an inline parallel architecture for data de duplication by experimenting write and delete operations with different size of data blocks. Finally we got the positive results for storing operations as well as for delete operations. In our architecture we have implemented in-line parallel architecture using server and client storage based de-duplication of data. Further modification can be done using different hash algorithms with variable block size concept. Implementation of such architecture can be done possibly on Linux kernel. Study is going on to check our algorithm with varying Hashing methods and it will be very interesting to check its performance compared to other algorithms.

REFERENCES

[1] D. Bhagwat, K. Eshghi, D. D. Long, and M. Lillibridge, "Extreme binning: Scalable, parallel deduplication for chunk-based file backup," in Modeling, Analysis & Simulation of Computer and telecommunication Systems, 2009. MASCOTS'09. IEEE International Symposium on. IEEE, 2009, pp. 1-9.

[2] S. S. Sengar and M. Mishra, "A parallel architecture for in-line data de- duplication," in Advanced Computing & Communication Technologies (ACCT), 2012 Second International Conference on. IEEE, 2012, pp. 399-403.

[3] Q. He, Z. Li, and X. Zhang, "Data deduplication techniques," in Future Information Technology and Management Engineering (FITME), 2010 International Conference on, vol. 1. IEEE, 2010, pp. 430-433.

[4] G. Wang, Y. Zhao, X. Xie, and L. Liu, "Research on a clustering data de-duplication mechanism based on bloom filter," in Multimedia Technology (ICMT), 2010 International Conference on. IEEE, 2010, pp. 1-5.

[5] A. Muthitacharoen, B. Chen, and D. Mazieres, "A low-bandwidth network file system," in ACM SIGOPS operating Systems Review, vol. 35, no. 5. ACM, 2001, pp. 174-187.

[6] S. Quinlan and S. Dorward, "Venti: A new approach to archival storage." in FAST, vol. 2, 2002, pp. 89-101.

[7] J. Wei, H. Jiang, K. Zhou, and D. Feng, "Mad2: A scalable high- throughput exact deduplication approach for network backup services," in Mass Storage Systems and Technologies (MSST), 2010 IEEE 26th Symposium on. IEEE, 2010, pp. 1-14.

[8] W. J. Bolosky, S. Corbin, D. Goebel, and J. R. Douceur, "Single instance storage in windows 2000," in Proceedings of the 4th USENIX Windows Systems Symposium. Seattle, WA, 2000, pp. 13-24.

[9] X. Ge, N. Deng, and J. Yin, "Application for data de-duplication algorithm based on mobile devices," Journal of Networks, vol. 8, no. 11, pp. 2498-2505, 2013.

[10] L. P. Cox, C. D. Murray, and B. D. Noble, "Pastiche: Making backup cheap and easy," ACM SIGOPS Operating Systems Review, vol. 36, no. SI, pp. 285-298, 2002.

[11] B. Zhu, K. Li, and R. H. Patterson, "Avoiding the disk bottleneck in the data domain deduplication file system." in Fast, vol. 8, 2008, pp. 1-14.

[12] D. R. Bobbarjung, S. Jagannathan, and C. Dubnicki, "Improving du-plicate elimination in storage systems," ACM Transactions on Storage (TOS), vol. 2, no. 4, pp. 424-448, 2006.