



ENGI – 9861 High Performance Computer Architecture

Project Report

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Internet Archives & Reliant's Filers

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The Internet Archive

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Abstract :-

Here are some topics which will be included in the project, The project will start with the history of Internet Archiving how it was started and what was the concept. In the next section there will be a brief discussion about the Architecture of Internet Archives. In this section we will cover these topics Storage Systems, System Requirements, Logical View, Process View, Physical View, Cache, Performance Review, Comparison and Analysis etc. The next section will be about Limitation / Error Detection in Web Archive / Internet Archive. The last topic will cover is on Reliant's Filer. In this section we will talk about NetApp's AFF A200 storage array. At the end there will be concluding remarks, or we can say the Conclusion of the project.

As discussed in previous section the scope of project here are some subtopics that will be cover in project report. In History of Internet Archive, we will cover Introduction of Internet Archive, Brief about archive.org and Way Back Machine. The next section is about Architecture of Internet Archives, System Architecture, What are requirements, Storage, Index and Search, Access, Web Nodes, Storage Nodes, Performance will be discussed, in addition Cache, size of cache and input/output per second will also be discussed. The next section is about Storage System in web archive in this we will discuss again about Way Back Machine's working strategy, system architecture and comparison. Error detection will be next section which will cover content of errors, loading indicators and other parameters. There will be one section about Web Archive Analysis processing. Then there is section related to Review about Reliant's Filer AFF A200. The last section will be about Conclusion.

1.0 Introduction:-

1.1 History of The Internet Archive:-

The word "archive" means to the collection of historical documents or records that provide information about several living or non-living things. The Internet Archive is a digital library that provides a collection of data like websites, articles, software, books, images, and so on. Brewster Kahle founded the Internet Archive in 1996. It has the search engine named as "WAYBACK MACHINE," used to access the historical versions web pages by specified URLs [1].

The Internet Archive is founded by Brewster Kahle in 1996, which is a non-profit organization working as National Digital Library and sharing the knowledge [1]. As mentioned earlier it provides collection of data to their end users. They collect the data in various forms e.g. scanning the books, store the software, games, and movies in forms of torrent, save the web pages and so on.

1.2 Concept of Internet Archive:-

The Internet Archive is a system supporting close to a petabyte of data and delivering an average of 2.3Gb/sec of data to end users. The Internet Archive (www.archive.org) is a petabyte scale public Internet library. The Archive was developing its storage technologies and data collection to store archived data by petabytes. Safely, it designed the Petabox high density, low-cost, and low-power storage system [6]. This system PetaBox was developed by The Internet Archive. The image showed below is the PetaBox.



Figure 1.1 Internet Archive [8]

If we look at some features of the PetaBox here are some specifications [8]:

- It has the high density of 100 TB/track.
- Very low power of 6KW per rack, 60KW for the entire cluster storage.
- The PetaBox supports multiple operation systems.
- As discussed earlier it is developed by the internet archive team, so it has very low maintenance cost.

- Currently the Internet Archive is working on 3rd generation PetaBox which is far better than the previous versions.
- The PetaBox has density of 1.4 Petabytes/rack, which is inexpensive storage system with low cost design.

1.3 The Wayback Machine:-

The name “Wayback Machine” sounds like the concept “The Time Machine”, and this works like the same. It is digital archive of WWW(World Wide Web). It is used as time travel machine but not for the human beings, it is used for the web pages. It has collection of billions of web pages saved every year.

As per current information the Wayback Machine is archiving more than 400 billion of pages every year and it has collection of 500 TBs of web pages [6]. As discussed earlier the data is stored in PetaBox [1], which is the storage device designed and developed by Internet Archive. The Wayback Machine uses 9.6 of PetaBytes of PetaBox [8].



Figure 1.2 Wayback Machine[8]

2.0 The Architecture of Internet Archive:-

2.1 Logical View:-

Logical view refers to the UML diagrams of system. It contains the class diagram, state diagram, flow chart etc. It represents the relationship between the software components. In other words, it shows the functionality of system to users.

The logical can be divided in 3 blocks – Aggregate, Element, Data File. Aggregate is a collection of data same place at same time which does not have any interconnections. A collection might be set of books, movies, games, web pages and any other types of collections. Elements are like web objects or links which is stored in Web Crawls (Web Indexing); every element is references as separate elements [6].

The image showed below will give information about how each block is connected with each other:

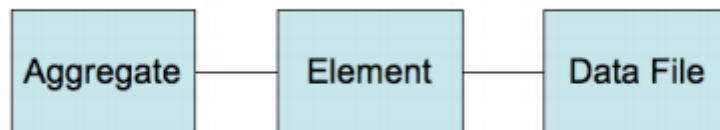


Figure 2.1 Logical View[6]

2.2 Process View:-

Process view helps to understand the communication between system and system processes.

Process view has several elements like Search, Access, Import, Index, Storage. The Internet has exceptionally little involvement in processes Archive. The Storage process preserves the integrity of the Elements fail or are retired from carrier as storage components. The Import manner accepts storage items and accommodates these new objects into the system. The methods of indexing and search create and hold the indexes over items, whilst allowing customers to discover specific items.

Figure shows the internal communication of Internet Archive through the process view. It shows the how a single process works in IA. On later part there is brief detailed discussion about the part of process view i.e. Storage, Import, Access.

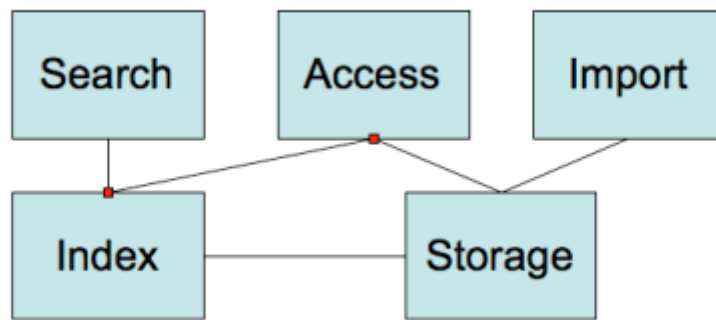


Figure 2.2 Physical View[6]

2.3 Development View:-

The development view illustrates the view from programmer's side which is affected by software management. Before understanding this view, we have to understand the terminology Web Crawl. Web crawling is nothing but web indexing. How web indexing works? It uses the meta keywords used in any website (meta keywords or meta data are at HEAD part of any website).

To understand the whole development view, it is necessary to get knowledge about some terms i.e. Storage, Indexing, Import, Access.

2.4 Storage:-

As it is clearly evident that it is a very high-level system with storage stored in petabytes. So, it is hard to store all data in web indexing elements. All the data of web pages are stored in ARC file. ARC is file format for compression and archive. Thus, it will not take too much space on the Internet Archive Storage. The good thing about ARC file format is that it stores data in the same form of storage nodes.

An automatic framework of recovery will be a simple expansion to current architecture. The sort of device should have handling other challenges including automatic error detection and introducing fresh equipment. The new Internet Archive is distributed through three geographically distant locations, allowing for recovery from each of the remote sites when possible.[6]

One more interesting fact about the IA is, if any software, movie, image, book is listed on the top for downloading and searching the system administration will add some extra node to divert the request loads. In the process of load balancing the PetaBox perform a vital role in it [6].

2.5 Indexing:-

As discussed in the beginning Development View that how Web Indexing is associated with the Internet Archive, it has the record of all meta keywords. With the help of indexing user can find the desired web page from the records of Internet Archive. It stores plethora of web pages received by same type of web indexing. We must know how indexing works... It divides the URLs in multiple groups. e.g. sort them in alphabetical order that would be easy to find. It becomes very difficult when there are large number of pages and their ARC files are stored. These all are stored as separate index number as per the meta keyword of web pages [6].

2.6 Import:-

There are many ways to upload a file, web page to Internet Archive. It may be imported by user, scanning, web indexing. These newly added items are stored parallelly to the web nodes or storage nodes as per specification. When the new web page added to the collection there is not any update in the index or meta keywords, it will be adapted by access automatically.

2.7 Access:-

In this part there is somewhat different process for accessing the web pages. 'When a URL is requested, the Internet Archive uses the file index to check the ARC file for containing the same URL. Then using the broadcast mechanism the web browser redirected to the storage node and then after some process it will open the ARC file to the browser for the user.'[6] This process will take quite longer time than usual, so there a local memory to the storage node to maintain the ARC file in the RAM. That makes this process faster.

2.8 Physical View:-

The physical view tells how the data will be processed and stored in the database.

In the Internet Archive physical view is connected with frontend web nodes and backend storage nodes. The architecture of the web archive is composed of a small number of web frontend nodes and a massive number of storage nodes for backend.

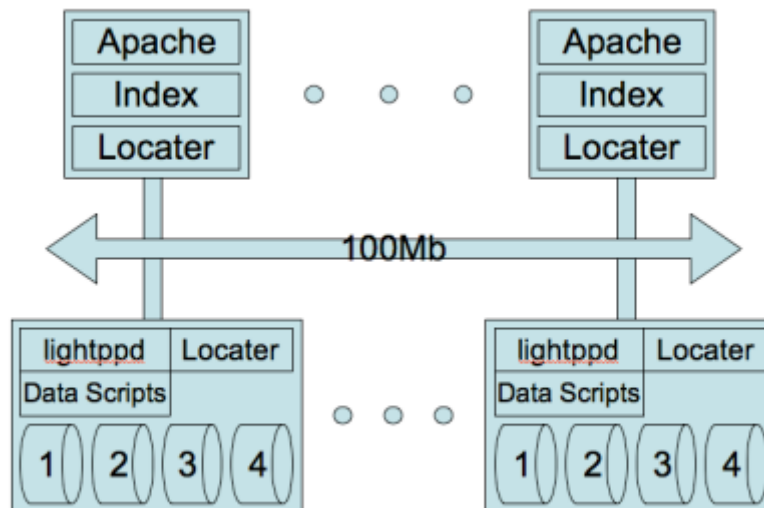


Figure 2.2 Physical View[6]

The image shows the interconnection between web nodes and storage nodes. Here we have to note that web nodes are working at server side to manage the flow of URL requests. While the storage nodes are working at drives as physical server.

2.9 Web Nodes & Storage Nodes:-

Web Node are implemented on the web servers, as they are working as frontend nodes they have higher amount of URL requests. So, Web Nodes are dependent on the requests. At a time, it may be possible that there are more than 5 web nodes are working.

All requested web URLs are stored in the web nodes, as discussed in indexing part all URLs are saved in group of alphabets with 2 web nodes. The reason behind using 2 nodes is due to multiple number of requests are sending to web server. If one node failed to respond the request another node will respond to it [6].

Storage Node is a physical server that is contains of Hard Disk Drive (HDD) or Solid-State Drive (SSD). Storage Nodes have the local files and they are not dependent on any other part of Internet Archive.

The new main data centre comprises more than 2500 storage nodes, enough to hold at least two versions of each data page.[6]

Often, a set of storage nodes is grouped together and operated as a single storage pool by software. One of the key benefits of a network utilising several storage nodes is the availability of data in case of a malfunction of the components. In the case that an HDD or SSD or storage node crashes, the device will proceed to provide data from the operating nodes.

2.10 Performance:-

“ The Internet Archive currently consists of more than 2500 nodes and more than 6000 disks. Outgoing bandwidth is more than 6 Gb/sec. The internal community consists mostly of 100Mb/sec with a 1Gb/sec network connecting the frontend net servers ” [6].

The figure below shows the performance graph of Internet Archive over a period of time. (Load on network).

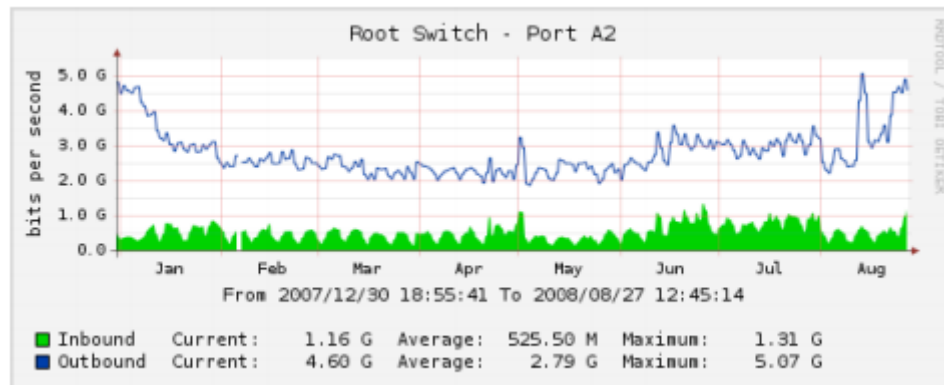


Figure 2.6 Network load [6]

2.11 Cache:-

Cache performs vital role when we are talking about the huge systems like Internet Archives. Such caches are used for lowering load on dynamic web servers, and to accelerate content access [6].

Caches are used to reduce the load on web servers and make it easy to access the data. But fact is cache does not affect the performance of IA because it has the storage nodes that works locally. So, here it requires that kind of cache that will reduce the load – A reverse proxy cache.

A reverse proxy cache works as server between the user and web servers that fetches the data. Here the data is communicating through storage nodes (local server) so this cache will be helpful in IA. [6]

Where the cache ends up costing operationally effective, cost savings could be load balancing to wear and tear on storage nodes, and also save energy on those very same nodes.

Use of the byte hit rate and consider that each download may be for a fraction of the total file only size We see the maximum effective size of the cache is 30 TB [6].

LRU extended stack algorithm to provide the scale of the required items. The algorithm measures the respective objects in an entry trace cache capacity in terms of artefacts and bytes and will be required to get the object processed [6]. In computer storage, a logical unit number, or LUN, is a number used to identify a logical unit. The webtraff kit is a series of scripts used for calculating traditional site trace analyses such as

prevalence, distribution of content, bytes and requests by length, and inter-arrival times [6].

One of the key obstacles of current non-memory caches is the floppy subsystem. We have to consider both the disc transfer rates and the number of I / O operations per second on the disc subsystem.

Usually web caches are implemented using the RAM. In-kernel ram can provide the necessary IOPS quickly, as well as reduce delay with regards to disks [6].

2.12 I/O Per Second:-

Input – Output per second the standard unit of measurement for the maximum number of reads and writes to non-contiguous storage locations. IOPS is frequently referenced by storage vendors to characterize performance in solid-state drives (SSD), hard disk drives (HDD) and storage area networks.

The main issues for the system (IA) are bandwidth and request per second [6].

“ Counting the number of IOPS necessary per second based on the available trace data. Figure shows the results on a log scale. The minimum value was 552 IOPS. The maximum value was 4021411 IOPS. The average value was 7734 per second. As can be seen, there were a significant number of seconds with more than 50000 IOPS [6] .

“

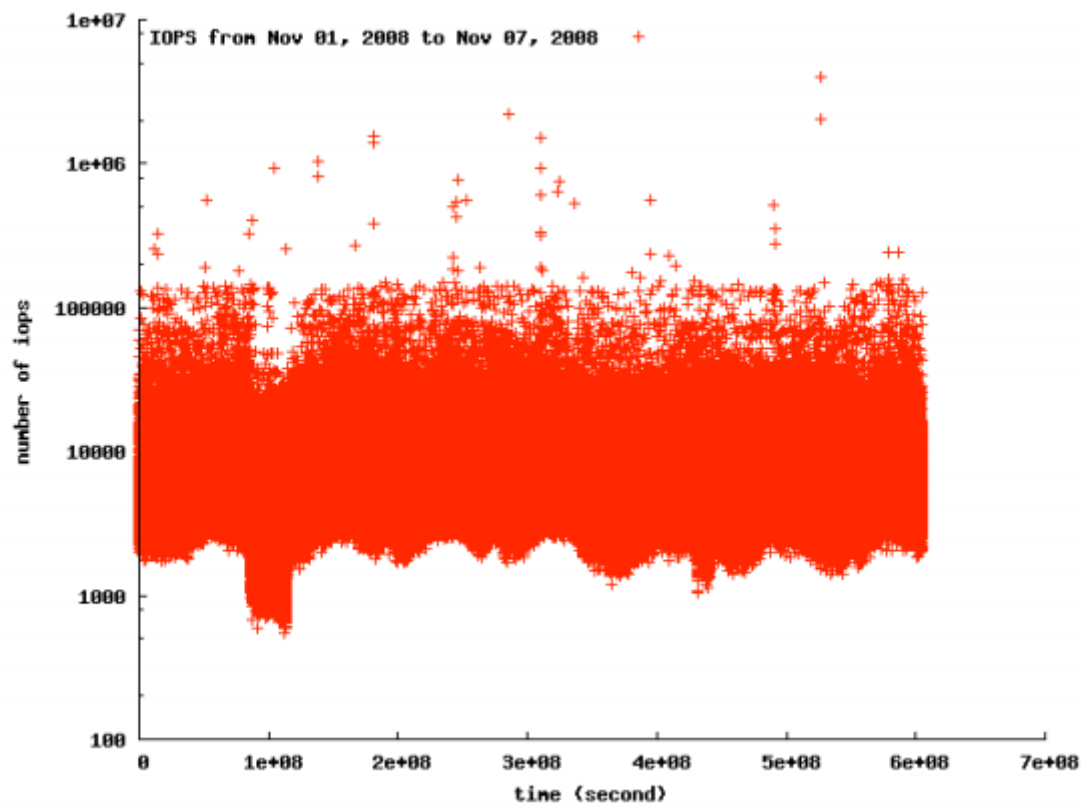


Figure 2.6 IOPS over a time [6]

3.0 Limitation / Error Detection in Web Archive:-

3.1 Error Detection:-

As per April 2019 there were 731 billion active web objects are available on <https://web.archive.org/>. So, ratio of getting error is become very high and there must be high probability of getting wrong data / information.

Provided the huge number of internet sites archived regularly by the following programmes, realization of archiving errors becomes crucial in real time: content errors found later can no longer be remedied as resources for the initial website possibly vanished by then [3].

There are total 5 types / classes of error found when searching on Wayback Machine.

- 1) Error Messages. (4.5%)
- 2) Pop ups. (3.9%)
- 3) Advertisements (1.1%)
- 4) CAPTCHA's (0.8%)
- 5) Content Errors. (10%)

Content error	Agreement	Corrections	Distribution			% Error
			No	Yes		
Ad page	0.65	329	9895	105		1.1
Loading indicators	0.89	48	9950	50		0.5
			Not	A bit	Very	
Pop-ups	0.82	394	9297	315	388	3.9
CAPTCHAs	0.91	124	9865	60	75	0.8
Error messages	0.89	331	9554	83	363	4.5

Figure 3.1 Error Detection[3]

3.2 Comparison:-

The system proposed presents systematic processing methods for internet history pages storage and management. This programme minimises storage house wastage through retaining a page's modified meaning.

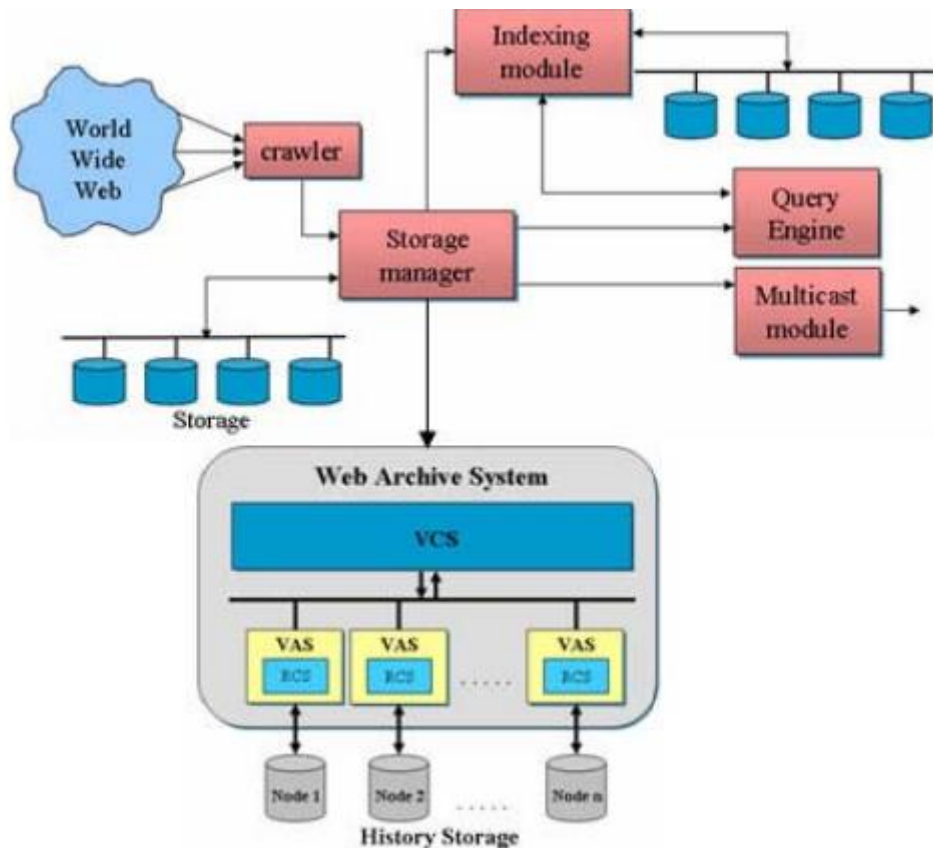


Figure 3.2 Web Archive Architecture [2]

The Web Archive System saves web pages history memory. The VCS classifies history pages and VAS assigns history pages classified to each node [2]. History Storage is scattered to several nodes for efficient storage and search [2]. Here VCS is version control which is responsible for any version changes in a web site. The main functionality of this is, to save the changes of different versions and use that version at the time of URL request. While VAS (Virtual Address Space) is an address space that stores the virtual address for respective operating system.

It is clearly evident from the image that, from the WWW the request passes to the web indexing then it goes to storage controller to find the web pages. After that it will pass request to version control in the web archive architecture and then with the help of address space it will find the web pages. Where each web page is directly connected with the node to respond the web URL request.

How the data is stored in node we can see form the table mentioned below:

Id	Path	TimeStamp	Version
1	Page1/	0308	V1.3
1	Page1/	0306	V1.2
1	Page1/	0304	V1.1
2	Page2/	0311	V1.1
4	Page4/	0309	V1.8
...
9	Page9/
10	Page10/

Figure 3.3 Web Indexing (Node) [2]

A comparison between 3 different internet archive system WebBase, Wayback Machine, Web Archive is given below. It shows that by the time there are plethora of improvements and changes made in the architecture to improve the system. Each phase of internet archive system it has its own advantages and disadvantages. Among all of the system which acquire lest storage space is the best solution for the system.

	WebBase	WayBack Machine	Web Archive System
storage space	Limit storage space	Waste of storage space	Minimization of storage space
additional expense	Need History Storage	Need Crawler	Crawler is unnecessary
extensivity	Search engine dependent	Search engine independent	Search engine dependent

Table 3.2 Comparison of Different Systems[2]

4.0 NetApp's AFF A200 Storage Array – A Reliant's Filer:-

4.1 Introduction to AFF A200:-



Figure 4.1(a) NetApp's AFF A200 [5]

NetApp or Network Appliances is a manufacturer company that makes data storage systems. Here we are talking about NetApp's latest AFF A200 storage system. Generally, it is a storage retrieval system using software and hardware. It is a flash storage array with 15 TB SSD, allowing 367 TB for raw storage.[5] NetApp devices work on ONTAP 9. Currently they are using 9.2 version of this OS.



Figure 4.1(b) NetApp's AFF A200 [5]

Figure shows the physical overview of AFF A200.

4.2 Specifications [5]:-

- Form Factor: 2U
- Memory: 64GB
- NVRAM: 8GB

- Storage
 - o Onboard Bays: 24 2.5" slots
 - o Maximum SSD: 144
 - o Maximum Raw Capacity: 2.2PB
 - o Effective Capacity: 8.8PB (base10)
 - o SSDs Supported: 15.3TB, 7.6TB, 3.8TB, and 960GB. 3.8TB, and 800GB self-encrypting
 - o Supported Storage Shelves: DS224C, DS2246
- SAN Scale-Out: 2-8 nodes
- RAID supported: RAID6, RAID4, RAID 6 + RAID 1 or RAID 4 + RAID 1 (SyncMirror)
 - There are many operation systems are supported by NetApp e.g. Windows Server 2003 – Windows Server 2016.
- Ports:
 - o 8x UTA2 (16Gb FC, 10GbE/FCoE)
 - o 4x 10GbE
 - o 4x 12Gb SAS
- Storage Networking supported: FC FCoE iSCSI NFS pNFS CIFS/SMB
- OS version: ONTAP 9.1 RC2 or later. (Open Network Technology for Appliances Products)

** All data has been taken from the reference [5]

4.3 Performance:-

If we talk about the performance and power consumption of storage devices like AFF A200, Vmmark is tool that will evaluate the system. It gives the reliable and accurate benchmark results of data centre. The Netapp AFF A200 was able to maintain passing scores at a load of 12 tiles operating with RAID-DP in inline compression and dedupe disabled, as well as with compression and dedupe enabled [7]. Tiles To display objects in rows and columns. The Tile command in a graphical interface squares up all open windows and displays them in row and column order.

5.0 Concluding Remarks:-

As it appears this is a very large system with numerous systems and storage system attached, then also this is the best example of a simple methodology with great performance. It is a less expensive system and provide the software and hardware.

It does not require a well-managed cache system then also adding a reverse cache the performance and load can be distributed. By adding storage devices NetApp's AFF A200 we can achieve more fasters retrieval system and that will help to increase the number of delivered request to user.

When we are considering such big system, we have to implement the cache in that way so that we can increase the number of inputs out per second to improve the results. Apart from there supposed to be a cost effective and sufficient bandwidth in the disk we are using in Internet Archive.

6.0 Acknowledgement:-

This project has covered all the topics mentioned above under the guidance of Prof. Ramachandran Venkatesan (Dr. R. Venkatesan). As well as with the help of some IEEE Papers, IEEE Journals, IEEE Conferences, etc.

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