Modified LRU Algorithm To Implement Proxy Server With Caching Policies

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Abstract

In order to produce and develop a software system, it is necessary to have a method of choosing a suitable algorithm which satisfies the required quality attributes and maintains a trade-off between sometimes conflicting ones. Proxy server is placed between the real server and clients. Proxy server uses caching policies to store web documents using algorithms. For this, different algorithms are used but drawbacks of these algorithms are that it is applicable only for the video files not for other resource types. Second drawback is that it does not tell any thing about organizing the data on the disk storage of the proxy server. Third drawback is that it is difficult to implement. Fourth drawback is that they require the knowledge about the workloads on the proxy server. Major problems in previous described algorithms is that "Cold Cache Pollution".
As described in the previous description all the existing algorithms used for caching suffers from various disadvantages. This paper is proposing a technique to remove the problem of cold cache pollution which is proved mathematically that it is better than the existing LRU-Distance algorithm.
Keywords: LRU, Proxy Server, Cold Cache Pollution, Web Documents,

1. Introduction

Proxy server is placed between a client application such as a web browser, and a real server the request to the real server. Different key features are improving performance of proxy server like caching the documents and thread polling etc. It provides security like firewall and protection of local Area Network (LAN) from accessing of unauthorized users. Most important feature is caching the web documents. Caching refers to store copies of the popular documents in proxy memory and thus used it for future references and reduces the bandwidth requirement. There are different available techniques but this paper is proposing the new and better technique. It intercepts all requests to the real server to see if it can fulfill the requests itself. If not, it forwards unique to improve the performance of Least Recently Used- Distance (LRU-D) of caching the web document in the proxy server. proxy server is a server (a computer system or an application program) that acts as an intermediary for requests from clients seeking resources from other servers. A client connects to the proxy server, requesting some service, such as a file, connection, web page, or other resource, available from a different server. The proxy server evaluates the request according to its filtering rules. For example, it may filter traffic by IP address or protocol If the request is validated by the filter, the proxy provides the resource by connecting to the relevant server and requesting the service on behalf of the client. A proxy server may optionally alter the client's request or the server's response, and sometimes it may serve the request without contacting the specified server. In this case, it caches responses from the remote server, and returns subsequent requests for the same content directly.
A proxy server has many potential purposes, including:

- To keep machines behind it anonymous (mainly for security)
- To speed up access to resources (using caching). Web proxies are commonly used to cache web pages from a web server
- To apply access policy to network services or content, e.g. to block undesired sites.
- To log / audit usage, i.e. to provide company employee Internet usage reporting.
- To bypass security/ parental controls.
- To scan transmitted content before delivery.
- To scan outbound content, e.g., for data leak protection.
- To circumvent regional restrictions.

A proxy server that passes requests and replies unmodified is usually called gateway sometimes tunneling proxy.

A proxy server can be placed in the user's local computer or at various points between the user and the destination servers on the Internet.

A revisers proxy is (usually) an Internet-facing proxy used as a front-end to control and protect access to a server on a private network, commonly also performing tasks such as load-balancing, authentication, decryption or caching.

2. Types and functions

Proxy servers implement one or more of the following functions:

2.1 Caching proxy server

A caching proxy server accelerates service requests by retrieving content saved from a previous request made by the same client or even other clients. Caching proxies keep local copies of frequently requested resources, allowing large organizations to significantly reduce their upstream bandwidth usage and cost, while significantly increasing performance. Most ISPs and large businesses have a caching proxy. These machines are built to deliver superb file system performance (often with RAID and journaling) and also contain hot-rod versions of TCP. Caching proxies were the first kind of proxy server.

2.2 Web proxy

A proxy that focuses on world wide wave traffic is called a "web proxy". The most common use of a web proxy is to serve as a web cache . Most proxy programs provide a means to deny access to URLs specified in a blacklist, thus providing content filtering. This is often used in a corporate, educational or library environment, and anywhere else where content filtering is desired. Some web proxies reformat web pages for a specific purpose or audience, such as for cell phones and PDAs.

2.3 Content-filtering web proxy

A content-filtering web proxy server provides administrative control over the content that may be relayed through the proxy. It is commonly used in both commercial and non-commercial organizations (especially schools) to ensure that Internet usage conforms to acceptable use policy. In some cases users can circumvent the proxy, since there are services designed to proxy information from a filtered website through a non filtered site to allow it through the user's proxy.

2.4 Anonymous proxy server

An anonymous proxy server (sometimes called a web proxy) generally attempts to anonymize web surfing. There are different varieties of anonymizers. One of the more common variations is the open proxy. Because they are typically difficult to track, open proxies are especially useful to those seeking online anonymity, from political dissidents to computer criminals.

2.5 Hostile proxy

Proxies can also be installed in order to eavesdrop upon the dataflow between client machines and the web. All accessed pages, as well as all forms submitted, can be captured and analyzed by the proxy operator.

2.6 Intercepting proxy server

An intercepting proxy combines a proxy server with a gateway or router (commonly with NAT capabilities). Connections made by client browsers through the gateway are diverted to the proxy without client-side configuration (or often knowledge).

2.7 Transparent and non-transparent proxy server

The term "transparent proxy" is most often used incorrectly to mean "intercepting proxy" (because the client does not need to configure a proxy and cannot directly detect that its requests are being proxied). Transparent proxies can be implemented using Cisco's WCCP (Web Cache Control Protocol). A 'non-transparent proxy' is a proxy that modifies the request or response in order to provide some added service to the user agent, such as group annotation services, media type transformation, protocol reduction, or anonymity filtering".

2.8 Forced proxy

The term "forced proxy" is ambiguous. It means both "intercepting proxy" (because it filters all traffic on the only available gateway to the Internet) and its exact opposite, "non-intercepting proxy" (because the user is forced to configure a proxy in order to access the Internet).

2.9. Open proxy server

Because proxies might be used to abuse, system administrators have developed a number of ways to refuse service to open proxies. Many IRC networks automatically test client systems for known types of open proxy. Likewise, an email server may be configured to automatically test e-mail senders for open proxies.

2.10 Reverse proxy server

IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 6, No 1, November 2011
ISSN (Online): 1694-0814
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A reverse proxy is a proxy server that is installed in the neighborhood of one or more web servers. All traffic coming from the Internet and with a destination of one of the web servers goes through the proxy server.

3. Working of Proxy server

Proxy server is placed between the real server and clients. Clients sends the request to the proxy server, if proxy server is able to fulfill the request of the clients by its stored web pages then it forwards the data from its cache to the clients. If proxy server is not able to fulfill the request of the clients, then it forwards all such request to the real server in World Wide Web take the response of such request and sends the request to the clients. It also protects the internal networks from accessing of unauthorized users. Caching the web document is its main works. Caching refers to store copies of the popular documents in proxy memory and thus used it for future references and reduces the bandwidth requirement.

4. Characteristics of Proxy Server

As such there is no RFC that describes the characteristics of the proxy server. It is up to the designer that how much facility designer is going to provide for the users. Some of most important features are as follows:
- Caching
- Security
- Content filtering
- Does port redirection or forwarding

5. Caching Policies

There are different types of caching policies [7] used today's in proxy server for caching the web documents. Each caching algorithm has its own advantage and disadvantage. Some caching algorithms are based on the some value of the web documents. Some algorithms are used for caching the audio and large video files. Some algorithms are used for caching the partial video files to efficiently utilize the disk bandwidth, disk space of proxy server and internet bandwidth provided to the network. But still these caching policies are not perfect for caching the all types of the web document. Some algorithm suits well for some types of web documents and some suited well for some other type of web documents. a cache (pronounced) is a component that improves performance by transparently storing data such that future requests for that data can be served faster. The data that is stored within a cache might be values that have been computed earlier or duplicates of original values that are stored elsewhere. If requested data is contained in the cache (cache hit), this request can be served by simply reading the cache, which is comparably faster. Otherwise (cache miss), the data has to be recomputed or fetched from its original storage location, which is comparably slower.

Hence, the more requests can be served from the cache the better the overall system performance is.

6. Literature Survey

Related work in the area of caching of proxy server is described in this paper. There are many techniques designed for caching the web objects. All the caching policies are categorized depending on there features. Different categories are described in following section.

6.1 Value-Based Caching

These policies are based on some value that these algorithms decide for the selected objects to be cached. These values are like frequency, recency, expires date etc. Some algorithms combined two or more approaches and make new one. These policies are least recently used (LRU), least frequently used (LFU), LRU-threshold, and LRU-min, Day and first in first out (FIFO).
Drawbacks of these algorithms are, they never does the caching on resource basis means They always considered all objects same. For example it does same things for image, text, html, jpg and video or audio files. Second drawback is that these algorithms never consider the I/O bandwidth and network bandwidth into consideration, it considers only disk space. Third drawback is that it does not tell any thing about organizing the data on the disk storage of the proxy server.

6.2 On disk Caching

These caching algorithms are used for caching the document on disk storage of the proxy Server. On disk caching of web objects give the techniques for caching web objects on secondary storage. There are several difficulties created by the non-uniformity of document sizes when placing them on disk.
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6.3 LRU-Distance and LRU-Segmentation Caching

These are the modified form of LRU that describes a problem Cache Pollution [4] means that a cache contains objects that are not frequently used in the near future. One of the main weaknesses of LRU in WWW applications is that it suffers from "cold cache pollution". The term "cold cache pollution" refers to the unpopular objects that remain in the cache.
The LRU-Distance algorithm places a new object at a distance D from the bottom of the cache stack (as opposed to the traditional LRU that places the new objects on top

of the stack). The LRU-Distance algorithm reduces the cold cache pollution since it takes a shorter time to drop out a new object if it is not accessed again. In the SLRU algorithm, he cache is partitioned into a lower and an upper partition. An object is first placed in the Lower partition, but it is promoted to the upper partition when it is qualified (e.g., when it is accessed k times). We have used trace-driven simulation to evaluate the effectiveness of these two algorithms in relieving cold cache pollution.
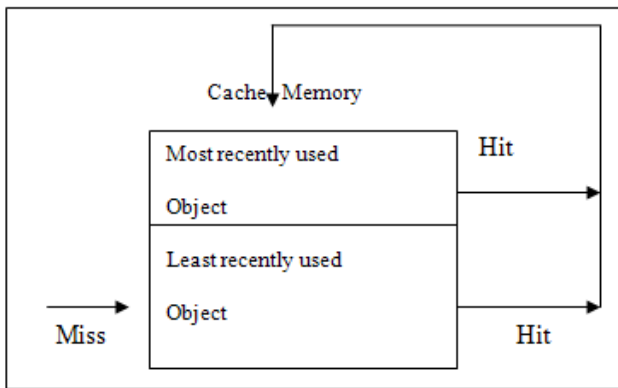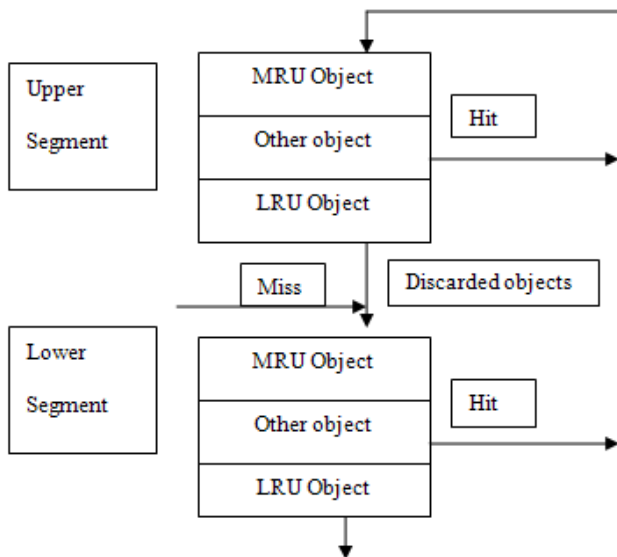

Fig 1: Logical Flow of LRU Distance

Fig 2: Logical flow of Segmented- LRU

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pollution is not completely removed although it is used for removing the cold cache pollution.

6.4 Cooperative Caching

A group of proxy server is used for cooperative caching in which mesh structure of proxy server is used where each server is cooperating with other server just like the distributed caching.

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6.5 Progressive Caching

Progressive Caching means caching the more part of the document as requirement increases. There are good reasons to allow the proxy server caching partial video instead of the entire video.

Drawbacks of these algorithms are that it is applicable only for the video files not for other resource types. Second drawback is that it does not tell any thing about organizing the data on the disk storage of the proxy server. Third drawback is that it is difficult to implement. Fourth drawback is that they require the knowledge about the workloads on the proxy server.

7. Problem Identification & Methodology

Efficient utilization of proxy resources such as I/O bandwidth and disk space as well as saving the network bandwidth are very important issues to be considered so that proxy server can provides the best facility to the local area network users.

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7.2 Drawbacks of On disk Caching

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IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 6, No 1, November 2011
ISSN (Online): 1694-0814
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web objects on secondary storage. These algorithms tell about how to organize the data on the disk storage of the proxy server.

Drawbacks of these algorithms are, they never does the caching on resource basis means they always considered all objects same.

7.3 Drawbacks of Resource-Based Caching

The resource based caching algorithm characterizes each object by the bandwidth and space requirement pair and a caching gain. The cache is modeled as a two constraint Knapsack. The algorithm describes heuristics to convert the two constraints knapsack model to multiple single constraint models.

Drawback is that it does not tell any thing about organizing the data on the disk storage of the proxy server.

7.4 Drawbacks of Cooperative Caching

A group of proxy server is used for cooperative caching in which mesh structure of proxy server is used where each server is cooperating with other server just like the distributed caching.

Drawbacks of these algorithms are, they never does the caching on resource basis means they always considered all objects same.

7.5 Drawbacks of LRU-Distance and LRU-Segmentation Caching

The LRU-Distance algorithm places a new object at a distance D from the bottom of the cache stack (as opposed to the traditional LRU that places the new objects on top of the stack). The LRU-Distance algorithm reduces the cold cache pollution since it takes a shorter time to drop out a new object if it is not accessed again. In the SLRU algorithm, the cache is partitioned into a lower and an upper partition. An object is first placed in the Lower partition, but it is promoted to the upper partition when it is qualified (e.g., when it is accessed k times). We have used trace-driven simulation to evaluate the effectiveness of these two algorithms in relieving cold cache pollution.

Drawback of these algorithms is that cold pollution is not completely removed although it is used for removing the cold cache pollution.

Problem Definition: To remove the cold cache pollution LRU-Distance places the recently accessed web pages at a distance d from the bottom of the stack. If this web page doesn't access again by any client then it takes D - time to remove the cache. But if accessed again then it is placed on the top of the stack. If it is not accessed again then it takes time equal to the length of the cache, so again causing cold cache pollution. So this existing mechanism doesn't remove cold cache pollution fully. This paper is proposes a new improved technique to deal with this cold cache pollution.

8. Proposed Solution

As described in the previous description all the existing algorithms used for caching suffers from various disadvantages. This paper is proposing a technique to remove the problem of cold cache pollution which is proved mathematically that it is better than the existing LRU-Distance algorithm. The proposed technique along with its associated advantages and disadvantages is described here.

Main cause of cold cache pollution is due the objects present in the cache that are once accessed and not accessed again. These objects take time equal to the length of the stack. So, when object is first accessed it is placed at a distance D from the bottom of the stack. If it is not accessed again then it takes D time to remove from the cache. If it is accessed again then in spite putting the object on the top of the stack as in case of LRU-Distance algorithm, it is placed in mid of top of the stack and distance D. If it is accessed third time then it is placed in mid of top and previous position the stack. If it accessed again then same process goes on until object reached at the top position. If objects are not popular at any stage then it takes less time to drop from the cache.

An important issue in LRU- Distance is how to determine the value of D. Initially its value is taken as total no of objects divided by two, means middle of the stack. It can be changed time to time if performance is decreased. Generally its value is increased because as value is increased, it is proceeding towards traditional LRU. If D is as big as Cache size then it is equivalent to the traditional LRU.

Suppose total 20 pages can be inserting in cache stack, then size of D will be 10 because

$$D = \text{Total No Of Object Present In Cache Stack} / 2$$

When first object will be inserting in cache stack then it will go to the D distance from the bottom of the cache stack. When Second object will be inserting in cache stack then it will go to the Mid. When third Object comes then it will insert between previous object and top of the cache stack.

$$Mid = \lceil \text{Top Of Stack(Index No.)} + \text{Distance D from Bottom of the stack (index of where previous object placed)} / 2 \rceil$$
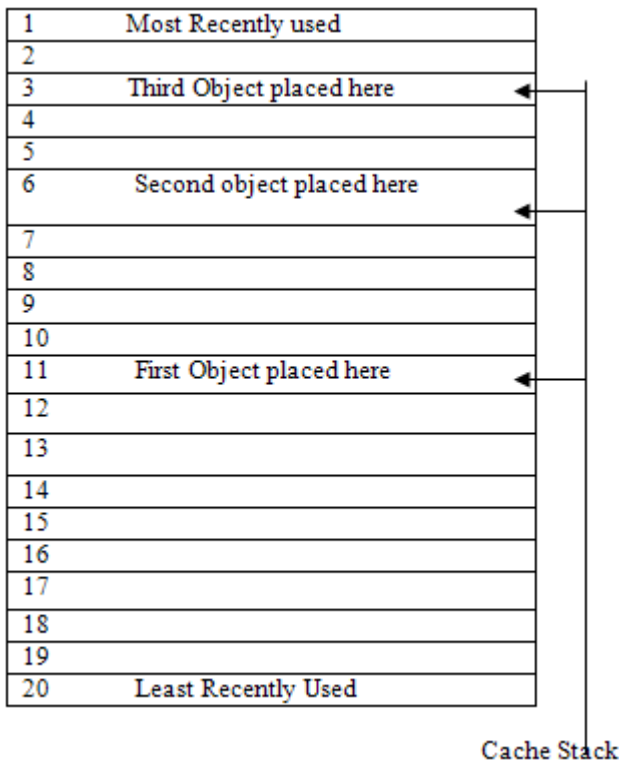
This process will be continuing such type.

IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 6, No 1, November 2011
ISSN (Online): 1694-0814
www.IJCSI.org

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Fig 3: Page Insertion by Modified LRU Distance Algorithm.

9. Proposed Algorithm

Proposed algorithms with the assumptions are described here:
Total size allocated for caching of document is CS.
Size of total information stored at any time is IS.
Total number of web objects stored at any time is TNO.
Size of object to be inserted is OS.
Top of stack is represented by TOS.
Jumping of web document is represented by JB.
Position of web document returned by linear search function is Index.
Significance of D is described in section 4.

Algorithm for storing the new web document:

Step 1. If (OS>(CS-IS)) then do the following
(a). "Delete one or more web documents from bottom of stack, sum of whose size is just greater than or equal to object to be inserted.
(b). Goto step 2.
Step 2. Do the following
(a). "Insert the document at the distance D from bottom of stack".
(b). IS = IS + OS.
Step 3. If (D != TOS)
JB=1;
Step 4. Exit.

Modified LRU-Distance Algorithm:

Step 1. If (JB == 0) then do the following
"Put the accessed object at the top of Stack", and go to step 3.
else
pos = Index / 2.
"Put the object at the position pos in the stack".
Step 2. If (pos == TOS) then do
JB = 0.
Step 3. Exit.

Advantages of Proposed Algorithm:

1. Better than the LRU-Distance algorithm for removing cold cache pollution.
2. Doesn't require previous knowledge about workloads.
3 .Easier to implement than other advanced algorithms.
4. Can handle all types of data type.

Disadvantages of Proposed Algorithm:

1. Not efficiently works for Video data types.
2. Doesn't consider Network bandwidth and disk I/O bandwidth of proxy server.
   It considers only disk space of the proxy server.
3. Doesn't tell any thing about the organization of data on the disk space.
4. It considers all the data of same types.

10. Conclusions and Future Work

10.1 Conclusions

LRU is a very simple and widely used cache replacement algorithm that suffers from cache pollution in proxy caching. In the recent years, several more efficient replacement algorithms have been suggested. But, these advanced algorithms require more knowledge about the workloads and are generally more difficult to implement. The main attraction of LRU is its simplicity. Then two modified LRU algorithms, LRU-Distance and SLRU proposed, to reduce cold cache pollution. These two algorithms are also simple to implement. But cold cache pollution is partially removed by these two modified form of the LRU. This paper is proposing a new and better technique by modifying the LRU- Distance algorithm, to reduce the cache pollution further.

10. 2 Future Work

No strategy can be hundred percent perfect and this proposed algorithm also suffers from some inherent disadvantages. The proposed technique doesn't considered I/O bandwidth and network bandwidth in storing or replacing the web pages. This technique doesn't tells any thing that how to organize the data on the secondary storage, what should be the file structure. It does consider all the resources of same types.

IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 6, No 1, November 2011
ISSN (Online): 1694-0814
www.IJCSI.org

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Acknowledgement

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