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Parameter Selection Schemes for Web Proxy Servers and their Performance Evaluation

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Abstract: Tremendous increase in number of Internet users enforces the study of bandwidth optimization parameters. Analysis of Internet uses, in the specific educational locality, has shown importance of various parameters for satisfying the requirement of users. Results based on the simulation model are presented in this study. With this approach, in present experiment, we have cached 65111 number of web documents at proxy servers so that those can be accessed locally. This leads in the saving of the Internet bandwidth required to fetch 65111 number of web objects bearing average size of 10.87 kb. The total size of these documents is 707.756 Mbytes. Effectively, the bandwidth required to fetch 707.756 Mbytes has been saved whenever there is request for these web documents. Caching web proxy servers, popularity of web objects and their reference of locality, image-storing strategies are shown to be important issues for optimizing the bandwidth utilization.

Key words: Proxy server, bandwidth, web caching, one timers, file popularity

INTRODUCTION

A proxy server is web server that caches Internet resources for re-use by a set of client machines connected to it. Web server implements proxy services based on proxy servers and are in wide use at the enterprise level. The study of web traffic characteristics is a key design technique that saves network bandwidth and improves response time of web access. In web browsing application, a client requests for web document consisting of text, image, audio or executable files. Proxy server stores these documents on local disk or memory. When client sharing the proxy, generates a request, proxy server searches its local memory for requested document. If it is available locally, (Hit), it is sent to the client. In case, if it is not available (Miss), the request is forwarded to the remote server or another proxy server in the network, if proxy servers are in hierarchical structure. the document then made available for the client from remote server. When the ratio of locally available documents to the total number of request made is sufficiently high, caching web objects improve overall performance of the system.

Substantial reduction in Internet workload can be obtained from proxy sharing with a corresponding increase in performance. Better performance comes from a simple implementation model that is non-hierarchical. Proxies access each other using the natural topology of the Internet. Web caching is a rapidly evolving field, which is one of the key factors that motivated for studying web caching. It is difficult to keep up with recent advances as continuous ongoing efforts are resulting in new updates very frequently. Web caching is one of such fields in which a number of researchers are pushing new solutions.

Caching proxies have an important role in the infrastructure of the www. They save network traffic and reduce web latency. Although caching and the creation of cache server hierarchies has become a popular strategy for reducing user waiting time and network traffic[1,2], there is no ultimate recipe for determining the best hierarchy configuration available.

Web proxy caches have been deployed to reduce network traffic and provide better response time for web accesses. Caching document at the proxy can save network bandwidth and reduce network latency for documents access. The first level cache is normally used as browser cache and a second level can be provided by a proxy cache that serves requests from a large community such as customers of ISP. Higher level proxies have also been implemented which have other second level caches as their clients.

SIMULATION MODEL

We give the following working definitions for present model:

One timers on the net: The request that are generated only for once by all clients in the specified time duration.

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Popularity of document: The number of times for which web clients have generated the request of web document defines popularity of web documents in the specified network.

Rank of web document: The popularity of web document in term in access count determines the rank of web document.

We have studied the proxy server setup connected and serving to various clients in the network on behalf of desired web server. A log file of every client system is the target file for study of distinct parameters of the setup. Every request generated by client is first given the attention of proxy server. If desired web object is available with the proxy server, it is served locally to the client by using the bandwidth of intranet (100 Mbps). Availability of this bandwidth influences the effective services offered to clients. In case, if the web object is not available with proxy server, the request is then forwarded to the web server and the object is cached at proxy server first and then served to the respective client. While accessing the web object from web server the instantaneous bandwidth available with Internet setup is used normally this bandwidth is in kilobytes per second.

Every web document is then recorded with information of its Uniform Resource Locator (URL), access time, total number of bytes required for storing, reference count of its access (it is to be incremented with every access of web object), client that is requesting for document, etc. We have created the database with above information of all requests of clients. This database is then analyzed for generating modeling parameters such as total number of requests in the specified time number of unique documents, number of one timers, total bytes required to store unique documents, smallest and biggest size of documents, mean and median size of document, etc.

Figure 1 gives diagrammatic view of proxy server model. The main issues involved in this model are given here:

Modeling of reference of locality/file popularity: In the simulation model, we have presented the relationship of popular web files and reference count of these files. Here, using total number of requests generated, we get information about one timers, information about the reference count of web files, their size, etc. These parameters we refer in the Zipf formula[3] that states the popularity of web objects with their rank. With this popularity and rank of reference of locality, we can make a decision of caching the web object in the local cache of proxy server.

From the record of accessed files, important characteristic observed that is in the Internet there is discrete distribution of references to the files. We

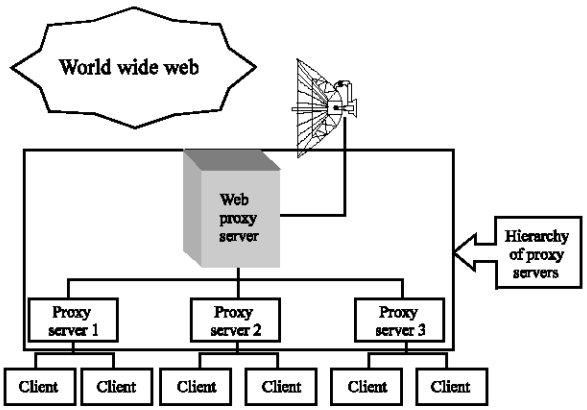

Fig. 1: Proxy server model

model this discrete distribution and ranking of web objects using Zipfs-law. It suggests relationship between the popularity of an item and its ranking. It states that the probability of occurrence of words or other items starts at a higher value and later it reduces. Thus, a few web objects occur very often while many others occur rarely.

Thus, the frequency of occurrence of nth ranked item is given by:

$$Pn = 1/n^a \quad (1)$$

With web proxy server if web files are ranked r according to their popularity P, then the popularity of a file is given by:

$$P = c/r^n \quad \text{(where } 0 < n = 1 \text{ and c is constant)} \quad (2)$$

This distribution is modeled as follows. In order to determine the popularity of remaining distinct files, we estimate the Zipf formula:

$$P = c/r^n \quad (3)$$

Using knownparameters like number of references (N), number of unique files (a) and number of one timers (b) as all one timers have a reference count of 1 the rank r of the first one timers is:

(a-b+1) and the rank of last one timer is a.

The constant c can be estimated using the middle one-timer with rank.

$$r = (a-b)/2 \quad \text{and popularity } p=1$$

Thus, Zipfs formula from Eq. 3 can be modified as:

$$P = c/r^n$$

Table 1: Sample database model

URL name	URL page visited	Request time	Popularity
Welcome to rediff.com	http://im.rediff.com/uim/aids/ ind-home-pop.htm	03/17/00 04:55:26 PM	4
Welcome to rediff.com	http://im.rediff.com/index.html	03/17/00 04:54:07 PM	4
Opera Search	http://protal.opera.com	03/17/00 04:04:53 PM	4
http://www.opera.com/	http://www.opera.com/	03/17/00 01:47:18 PM	3
http://www.operamail.com/ scripts/common...	http://www.operamail.com/scripts/ common/index.main?signin	03/17/00 01:47:18 PM	3

Table 2: Modeling characteristics with results

Proxy server characteristics parameter	Value
Total number of requests	87458
Number of unique documents	22347
Percentage of unique documents (of total requests)	25.55
Number of one- timers	18511
Percentage of one –timers (of unique documents)	82.83
Total bytes of unique documents (GB)	3
Smallest size of web object (bytes)	32
Biggest size of web object (bytes)	21,809,968
Mean size of web object (bytes)	10.878
Median size of web object (bytes)	3.839

$$1 = c/ ((a-b)/2)^n$$

$$c = (a-b/2)^n \quad (4)$$

With this value of c the popularity of remaining distinct files can be generated. We use following algorithm with above assumption for popularity generation using Zipf distribution as.

For given number of distinct files a number of one timers b and Zipf formula exporting n, the popularity constant is:

$$c = (a-b/2)^n$$

Popularity P of each distinct file (other than one timers) as:

$$Pr = c/r^n \text{ (with } r = 1,2,\ldots\ldots \text{ a-b)}$$

Modeling of one time referencing: The study of one timers in the network is important[4] as they are major factor for generating burden on proxy server and web server in term of bandwidth.

In the modeling of one timers we have used straight forward approach. It is determined how many of the distinct web objects are there which are accessed only once. Once determined and specified the one timers, then their reference count can be fixed at 1. If the web object is accessed for more than one time, it is deleted from the list of one timers. The web objects deleted from this list are then considered for finding popularity of web objects along with its size.

Assuming the modeling parameters as:

- N; as total no of requests to be generated
- c; percentage of distinct files relative to N
- d; percentage of one timers relative to c

With N = 500 requests, our simulation generated for 100 distinguishable files with half of them as one timers. Thus,

The number of distinct files:

$$a = c/100.N = 20/100.500 = 100 \quad (5)$$

The number of one timers is:

$$b = d/100.a = 50/100.100 = 50 \quad (6)$$

Assuming that each distinct file has a unique rank based on reference count, with most popular object having rank 1 (Object with highest reference count). Then the ranking rages from 1 to a.

As b is the number of one timers among the a unique files, then all files ranked from a-b+1 to a have reference count of 1.

Proxy server setup methodology: Figure 1 shows the structure for proxy server setup for Internet connectivity through V-sat. The web proxy server performs caching of web documents that are requested by various clients through port 8080 of the server. For each incoming HTTP request it creates a thread to service particular client request. Thus, in case of multiple requests it acts as multi-threaded server handling multiple client requests simultaneously[5-7]. It responds based on the document available in its cache otherwise its forwards the request to higher level proxy server or further web servers. Thus proxy acts both as server and as client depending on the availability of document in its cache.

Using characteristics of Table 1, modeling of file popularity and one time referencing, we studied various parameters for optimization of bandwidth so that as far

as possible requests generated by web clients can be served by means of the cached documents at proxy so that band width of internet (mbps) can be utilized at its maximum extent without reliaing on internet band width (kbps). Internet setup bandwidth will be then utilized only for serving the requests of web objects that are not available with proxy server. Reference count of web object gives information about the popularity and depending on it we can cache the object at proxy server. Internet bandwidth is then deployed for the documents that are being referred in the category of one timers. Also size of the object plays important role in making decision about the caching of document. We have verified it for various cache sizes.

RESULTS AND DISCUSSION

As suggested in the model of file popularity we get history-based information of uniform resource locaters and respective web object size. With this approach we are caching 65111 number of different web objects at proxy servers. The average size of these documents is 10.87 kb and in all 707.756 mb of size corresponding to all web documents (Table 2).

In case of non-caching of web documents, proxy server utilizes total available internet bandwidth of 32 kbps in serving web documents to the clients by accessing them from web servers. It takes 22117.39 sec of time to fetch 707756 mb of documents from web servers by putting all burden on the Internet traffic and with the limitation of 32 kbps bandwidth (Table 2).

Using web caching approach and the results of simulation model, if we separate web documents as per their popularity and reference count, substantial reduction in the time saving has been observed. Specifically proxy server utilizes 32 kbps of bandwidth for serving requests of only one timers that we do not suggest to be cached at proxy server. Thus bandwidth of 32 kbps, is optimally utilized to access only 18511 numbers of one timers and it takes 6287.95 sec to make these documents available from web servers to the web clients. In case of any further reference to the cached document, proxy server serves it locally without putting any burden on internet traffic. We observed the saving of 15829.44 seconds for accessing web documents from proxy server when it refers its local cache, resulting in saving of 71.57% of bandwidth.

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