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Proxy Server and the Changing Nature of the Web

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Abstract—**The use of proxy server could help provide adequate access and response time to large numbers of World Wide Web (WWW) users requesting previously accessed page. While some studies have reported performance increase due to the use of proxy servers, a study reported performance decrease associated with the use of proxy server. Due to lack of recently published scholarly article that test the performance of proxy server, we carry out an in-depth study of the behavior of a proxy server over a six month period. The result of the study showed that hit ratios of the proxy servers range between 21% to 39% and over 70% of web pages are dynamic. The study indicates the effectiveness of the proxy server and helps evaluate the tradeoff between money spent on higher bandwidth lower latency connections, versus the cost/performance of using a caching intermediary.**

Index Terms— **caching, hit ratios, Proxy performance, workload characterization.**

I. Introduction

The WWW has witnessed significant growth in the last few decades; this is due partly to the large numbers of users and the type of traffic generated. A typical solution which is not scalable is to increase the bandwidth. Since increasing the bandwidth can be achieved with associated monthly cost, many organizations are using proxy server to provide adequate access and response time to their ever growing number of users requesting internet connectivity.

The performance increase due to proxy servers has been widely reported, however a study reported that proxy servers actually decrease performance [1]. Since we could not locate any recently published scholarly article that performed experiment to test proxy server performance, a pertinent question we need to answer is, as the web evolves from static to dynamic information repository, will there be a future for the caching proxy server?

In order to further understand the nature of proxy server and how it can be used to provide adequate access and response time to large numbers of users requesting same object from the Internet, we carried out an in-depth study of the behavior of a proxy server over a six month period. In our earlier work, a non-intrusive network traffic monitoring system was developed to monitor and analyze network traffic [2]. This setup was used to collect and analyze access logs from three proxy servers for a period of six months. The three proxy servers are institutional web proxy cache, two of the proxy servers are on the academic network of the Obafemi Awolowo University, Ile-Ife, Nigeria (OAU), while the third proxy is on the Wide Area Network of the International Centre for Theoretical Physics, Trieste, Italy (ICTP). A major contribution of this work is to show the effectiveness of the proxy server and help evaluate the tradeoff between money spent on higher bandwidth lower latency connections, versus the cost/performance of using a caching intermediary.

The rest of the paper is organized as follows: in section II, we review related work, followed by data collection in section III. In section IV, we perform access log analysis on raw data and reduced data. In section V, we present the results of our analysis for each caching proxy server and finally, in section VI, we conclude the paper.

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II. Related Work

Caching can be applied at several locations namely; the web client, web server and within the network (proxy servers) [3]–[5]. Several studies have reported performance increase due to proxy servers. The result of a study in [3] showed that the average response time of a hit may be five times smaller than a miss. A 20% to 25% improvement in user perceived response time was reported in [6], [7]. Research on the effectiveness of proxy caching is very active. A study at Virginia Tech has shown that hit rates of 30% to 50% can be achieved by a caching proxy [8]. Other studies gave a range from between 20% to 60% hit rate [3],[4], [9], [10] reported hit rates of between 10% to 40% for a three level caching hierarchy, and about 35% to 40% for a university-level web proxy cache.

However, a study conducted in [1] reported a hit rate of 4%, which shows a decrease in performance. The reason for this decrease in performance was traced to the changing nature of the web, i.e. the web is evolving from static nature to dynamic repository. Furthermore, research into the ability of proxy servers to cache video was reported in [1]. Research efforts in the last few years address performance of multi-level proxy cache configuration [11]. Other factors that may improve proxy cache performance are the replacement policies used by the cache and the workload characteristics.

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The results of [10] showed that combining different replacement policies at different levels of the cache can improve the performance of a caching hierarchy. Finally the results of [12] showed that the cache replacement policies are sensitive to Zipf slope, temporal locality, and correlation between file size and popularity but relatively insensitive to one-timers, and heavy tail index.

III. Data Collection

The access logs for our study were collected from three different proxy servers. Two of the proxy servers are located at the Obafemi Awolowo University, Ile-Ife, Nigeria and the third proxy server at the International Center for theoretical Physics, Trieste, Italy; we refer to the proxies as:

- ASOJU used by the academic network
- CAFÉ used by the campus cyber cafes and
- ICTP used by the ICTP network.

ASOJU and CAFÉ continuously recorded access log on a daily basis for six months, details can be found in [2], while we only had one month of access log for ICTP. All proxies are institutional-level proxy servers.

IV. Proxy Server Access Log Analysis

A. Raw Data Analysis

Webalizer [13] is capable of generating reports on a monthly basis and also a summary report for the entire period. Table I provides a summary of the access logs for the three proxy servers. From Table I, ASOJU has the highest activity in terms of number of requests per day and also the highest average volume of bytes transferred per day.

In this study, we are interested in requests for the transfer of web documents. Hence we studied the response code in the access logs for all web requests. Table II shows the breakdown of the HTTP reply code as a percentage of the total request. Web proxy server can provide many possible responses to web client [14]. The 200 series response code means a valid document was made available to the client, 300 series means redirection, 400 series means client error and 500 series means server error.

TABLE I
Summary of Proxy Access logs (Raw Data)

Item	ASOJU	CAFE	ICTP
Access log Duration	107 days	178 days	8 days
Start Date	Sept 30 2006	May 1 2006	Feb 11 2007
End Date	Feb 28 2007	Oct 31 2007	Feb 18 2007
Total Request	153,129,674	92,445,888	5,458,868
Avg Request/Day	1,431,118	519,359	682,359
Total Bytes Transferred (GB)	1637.4	895.9	86.3
Avg Bytes/Day (GB)	15.30	5.03	10.79

TABLE II
Breakdown of HTTP Response Code

Response Code	ASOJU	CAFE	ICTP
200 Series	38.34	76.00	45.20
300 Series	12.30	21.00	28.00
400 Series	46.00	2.00	2.70
500 Series	2.16	1.00	0.90
Undefined	1.20	1.00	23.20
Total	100	100	100

B. Data Reduction Analysis

The access log recorded the amount of data transferred regardless of the source (i.e. from proxy cache, another cache or origin server). To know the actual workload of a proxy server, we considered all requests resulting in the documents being accessed from the origin server without an intermediate proxy. The objective is to evaluate the effectiveness of proxy caching.

Suppose a client using a proxy makes requests r_1, r_2...r_n to pages, if a page has F objects out of which C can be obtained from the cache and W from the origin server. Total request R will be:

$$R = \sum_{i=1}^{n} r_i$$

But not all requests will bring back data. Hence, all requests that will result in data transfer will be:

$$F = \sum_{i=1}^{n} W_i + \sum_{i=1}^{n} C_i$$

So we can compute the Document hit ratio (DHR) and Byte Hit Ratio (BHR) as;

$$DHR = \frac{\sum_{i=1}^{n} C_i}{\sum_{i=1}^{n} W_i + \sum_{i=1}^{n} C_i}, \quad BHR = \frac{\text{Cachebyte}}{\text{Totalbyte}}$$

Cachebyte = the no of bytes transferred from the cache.
Totalbyte = the total no of bytes transferred.

For DHR and BHR we considered only 200 and 300 series of response, in order to consider only successful transfer of documents to requesting clients. Table III summarizes the reduced access logs for the three proxies. Based on the average number of request seen by each proxy server per day, ASOJU has the highest activity while CAFÉ and ICTP have about the same activity. The successful transfer accounted for 50% to 97%, while the total bytes transferred accounted for 54% to 98%, similar to the observation in [11]. Other values on the table were calculated. The two performance metrics used in this study to evaluate the performance of the proxy servers are DHR and BHR.

V. Proxy Server Performance Evaluation

We observe that the total requests in the reduced data for ASOJU is smaller, this is expected since about 46% of the total request are errors due to client authentication, see Table II. This is possible since ASOJU runs proxy authentication.

TABLE III
SUMMARY OF PROXY ACCESS LOGS (REDUCED DATA)

Item	ASOJU	CAFE	ICTP
Total Request	77,580,469	88,922,534	3,998,971
Avg Request/Day	725,051	499,565	499,871
Total Bytes Transferred (GB)	884.2	878.0	84.0
Avg Bytes/Day (GB)	8.26	4.93	10.5
Total Internet Requests	58,707,185	69,945,197	2,469,348
Total Cache Requests	18,873,284	18,977,337	1,529,623
Total Cache Byte (GB)	108.7	184.4	23.5
DHR (%)	24.3	21.7	38.3
Cache Miss Rate (%)	75.7	78.3	61.7
BHR (%)	22.8	21.4	28.8

Again about 60% to 78% of the requests are for dynamic pages that cannot be serviced by the proxy server. This observation supports the fact that the web is fast changing from static nature to dynamic information repository [1]. However, the DHR ranges from 21% to over 38% for the three proxy servers analyzed in this study, these results are similar to the results obtained in [3], [4], [8], [9]. Similarly, the BHR ranges from 21% to 29% for the three proxy servers. This result is also comparable with [3]. Since The ICTP data was only collected for 8 days in the month, we can only plot the graphs of the hit ratios for ASOJU and CAFÉ using the reduced data for six months. Figures 1 and 2 shows that both hit ratios for ASOJU and CAFÉ are not affected by the volume of the workloads across the months. We further studied this observation on monthly hourly raw data.

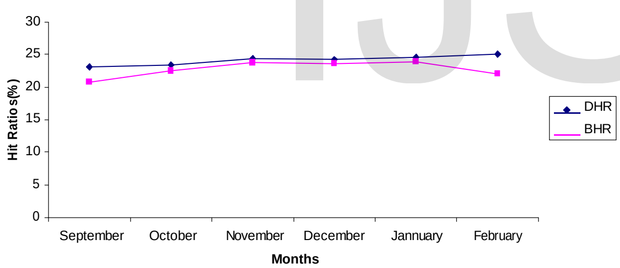

Fig 1. ASOJU hit ratios (reduced data)

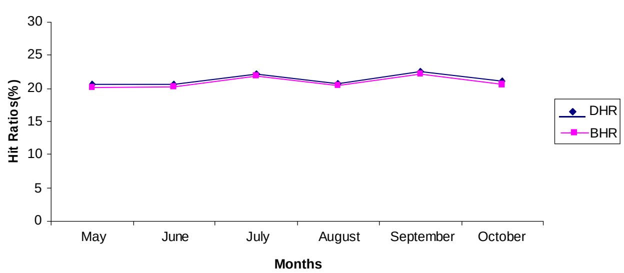

Fig 2. CAFÉ hit ratios (reduced data)

Figures 3 and 4 shows the variations in the monthly average hit ratios for ASOJU. Both hit ratios follow a similar trend, the standard deviation of the y-error bar graph shows a high dispersion for both ratios during the peak periods. This is expected since the traffic intensity increases during the peak periods. The variation of the DHR is higher; this is a reflection of the replacement algorithm and size of objects cached by the proxy server. This particular proxy is configured to cache small objects. Hence, higher values of DHR will result in faster response time for the users.

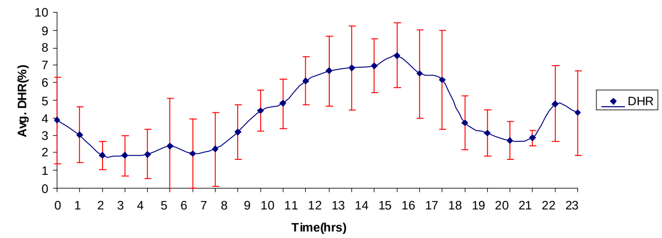

Fig 3. ASOJU monthly variation in DHR (six months)

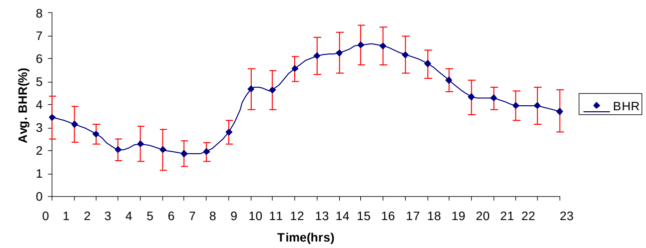

Fig 4. ASOJU Monthly variation in BHR (six months)

Figure 5 shows the coefficient of variation (COV) for ASOJU hit ratios. The hit ratios show low variations during the peak periods (9hrs to 15hrs). This shows that neither ratios depend on traffic intensity.

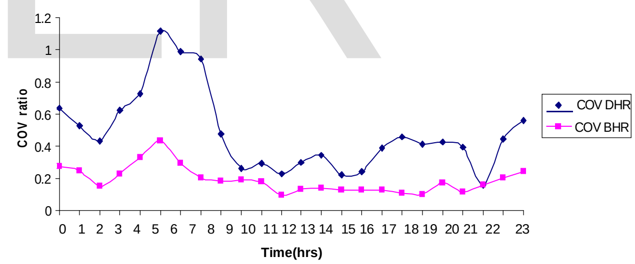

Fig 5. COV for ASOJU Hit Ratios (six months)

Figures 6 and 7 show the variations in the monthly average hit ratios for CAFÉ. Again, both hit ratios follow a similar trend, the standard deviation of the y-error bar graph indicates a high dispersion for both ratios during the peak periods.

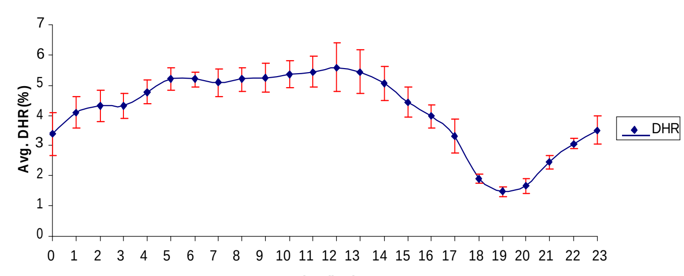

Fig 6. CAFÉ monthly variation in DHR (six months)

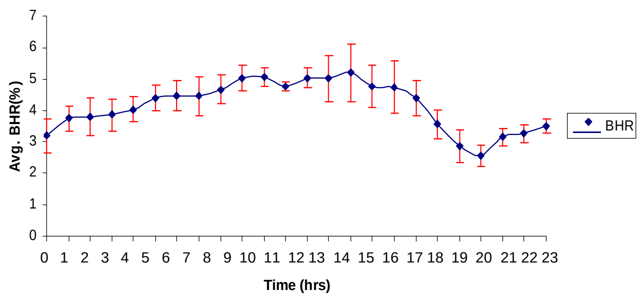

Fig 7. CAFÉ monthly variation inBHR (six months)

Figure 8 shows the COV for CAFÉ hit ratios. Similarly, the hit ratios show low variations during the peak periods (0hrs to 17hrs). Again, we observe that neither ratio depend on traffic intensity.

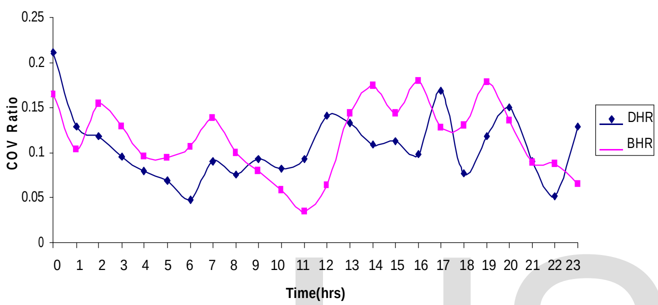

Fig 8. COV for CAFÉ hit ratios (six months)

Figure 9 shows the effect of traffic intensity on the ICTP hit ratios. From the graph, the hit ratios show low variations during the peak periods (8hrs to 23hrs). Again, we observe that neither ratio depend on traffic intensity.

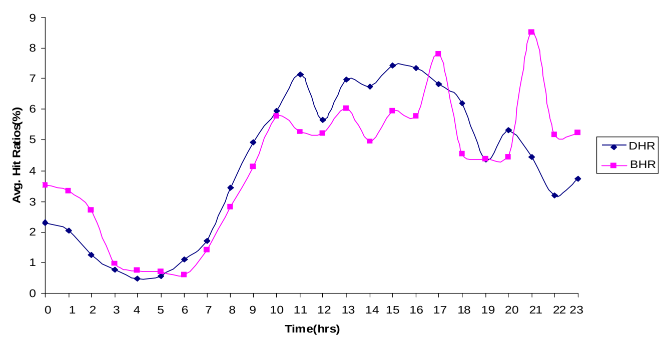

Fig 9. ICTP daily hit ratios (eight days)

VI. Conclusion

This paper focuses on testing the performance of proxy servers experimentally and investigates the effect of the changing nature of the web on proxy server performance. We carry out an in-depth study of the behavior of a proxy server over a six month period. Access logs of varying durations were collected, from three different proxy servers. We analyzed the logs using Webalizer. Two performance parameters, DHR and BHR were used to evaluate the performance of the proxy servers. We computed DHR and BHR for the entire period, and on a monthly and hourly basis to see if there will be drastic variations. Our result shows a hit rate of about 21% to 38% and a byte rate of 21% to 28%, furthermore, a high variation was observed during the peak periods from the y-error bar graphs. The COV graph shows a low or constant variation during the peak periods indicating that neither hit ratios depend on traffic load. About 60 to 78% of requests to the proxy servers are for dynamic content, this indicates that the web is changing from the static nature to dynamic information repository. The results of our experiment show the effectiveness of the proxy server and helps evaluate the tradeoff between money spent on higher bandwidth lower latency connections, versus the cost/performance of using a caching intermediary. Future work will focus on other techniques that can be used to improve proxy performance, this include multicast delivery of pages and the use of cyclic multicast engine.

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