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An Improved Content Search Engine

— Usage of Network Configuration Information —

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ABSTRACT

In today's Internet environment, the same service is generally available in many places and the redundancy is increasing with Web and FTP-server mirroring. Retrieving information from the closest server is desirable. Otherwise, it is inefficient for users as it will take more time to fetch the desired information. It is also common today for users to use search engines as their starting point to find information they want. In this paper, we propose a content search engine which uses network configuration and/or application log information to locate the nearest server for a given content.

1. Introduction

Among the various categories of network services, the category of Web and FTP-servers is special as they involve a lot of redundancy. The same piece of information may potentially be serviced by several servers. This poses a difficult problem for the user. While it is clear that a user would in general like to have the information from the closest server - the user does not have any means of ascertaining which server is near and which is far, in the network sense.

In this paper, we propose a content search engine which uses network configuration and application log information to locate the nearest server for a given content. We show to effectiveness of the proposal by experimenting under actual operational network conditions.

2. Current condition and other works

There has been some work on choosing the closest server. Users generally utilities like *ping, traceroute* etc to measure RTT and/or packet loss rate for each server. By comparing these network parameters one can decide which server is closer and which is not. But this method generates massive measurement traffic and some networks don't allow measurement traffic. Distributed Director[1] and Host Anycasting Service[2] and other works attempt to locate the most preferable server from among several candidates which offer identical services. But, for cases with potentially massive redundancy, these approaches do not scale well because they require manual configuration and/or extra instrumentation or entries in every routing table. For ftp-retrievals[3], the number of router hops to each server was measured , and by comparing this hop count, a decision was made on the proximity of a server. This method showed some improvement on the choice of the closest server. But in that work, the potential and role of a search engine had not been considered. In today's Internet environment, search engines play an important role as invariably users use it as their starting point to look for information.

To improve the performance and accuracy of the network distance computation algorithm and to utilize effectively the potential role of the search engine, we propose a new content search engine which uses network configuration and/or application log information to locate the nearest server for a given content. In Section 3 and Section 4, we explain how network configuration information or application log information can be taken and applied to content search engine.

3. Network Configuration Information

Network configuration information can be obtained from various sources and in many forms viz. network management information in the form of MIBs (Management Information Base), the public databases of Network Information Centers (NICs), the IRR(Internet Routing Registry) etc[4][5]. Further, there are several means to find the dynamic characteristics like network packet loss rate, Round Trip Time (RTT) etc.

We have proposed a Network Definition Language (NDL) that can be effectively used to describe a network's configuration and its characteristics[6]. Configuration information can be used to compare the closeness or distance of two destinations from a source. The measure used in the comparison could be based on some or all of the following: 1. number of Autonomous System (AS) hops, 2. number of router hops 3. bandwidth of the links 4. RTT 5. geographical location and time of day.

4. Application Log information

In addition to network configuration information, we propose that search engines complement the search result with predicted transfer

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rate for each server. This prediction can be done by using historical information present in network application logs. For example, one can learn transfer rate for servers(networks) by analyzing the logs of a proxy server(Figure 1). The detailed algorithm to predict transfer rate from application logs is described in [7].

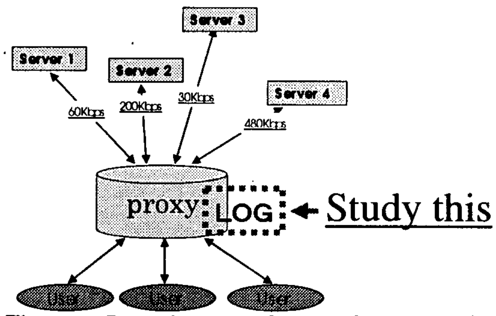


Figure 1: Learning transfer rate from proxy log.

5. An Improved Content Search Engine

5.1 Using configuration information

Content Search Engines (CSE) respond to a user's query. The response is generally in the form of a list of URLs, potentially on various servers. Sometimes the list is graded by popularity and/or appropriateness. In this paper we propose that search engines complement the search result with network configuration information so that the list can also be graded according to the proximity of the URL. Then users can choose the source that is the nearest. Figure 2 shows the architecture of the improved CSE. Users query the CSE with a keyword, the CSE then searches its content database with the given keyword and shows the result in a graphical form as a tree with the user's host as root. This graphical tree is generated from the information described in Section 3 using the client and target IP addresses as parameters.

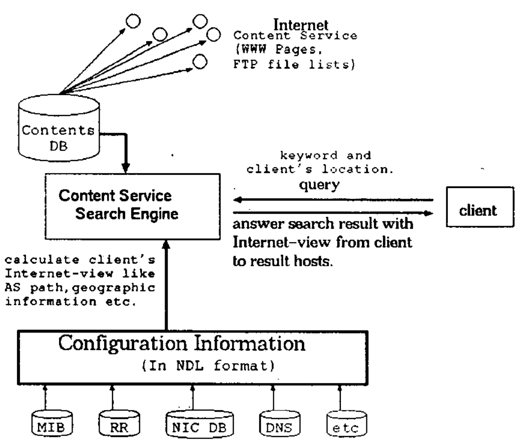


Figure 2: Architecture of Search Engine with configuration information.

A sample response of the CSE is shown in Figure 3. The AS level configuration information which is used by the CSE is computed from the information in the IRR. The search engine shows the AS path from the client's host to potential sources of the information sought by the user.

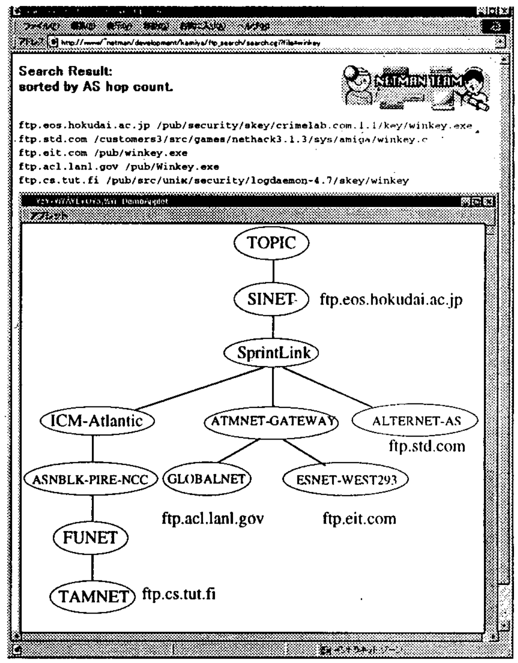


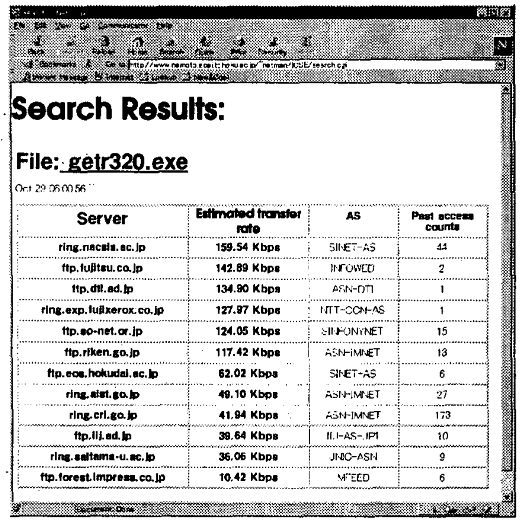
Figure 3: Search Engine with configuration information.

The TOP circle (TOPIC) is the AS to which the users node is connected. In the example, the user searched for a file with key 'winkey'. The response from the CSE shows five ftp-servers that have the desired file. Further the CSE graphically shows the user that to reach the information source at ftp.std.com, 4 AS hops are required. In other words, four ASes will need to be traversed. The paths to the other ftp-servers are shown too.

5.2 Using transfer rate estimated from application logs

Figure 4 shows the Search Engine with estimates transfer rates for each server. In the exmple the user has asked for a file, named 'getr320.exe'. The result is sorted by estimated transfer rate so that users may have an idea about the relative retrieval speeds from each server. Figure 5 shows the architecture of the improved CSE with estimated transfer rate information. The difference from Figure 2 is that there is a proxy between the user and the CSE.

The proxy adds the estimated transfer rate information for each server, which it learns by analyzing the application logs described in Section 4.


Search Results:

File: getr320.exe

Oct 29 06:00:56

Server	Estimated transfer rate	AS	Past access counts
ring.nacsis.ac.jp	159.54 Kbps	SINET-AS	44
ftp.fujitsu.co.jp	142.89 Kbps	INFOWEB	2
ftp.dti.ad.jp	134.90 Kbps	ASN-DTI	1
ring.exp.fujixerox.co.jp	127.97 Kbps	NTT-OCN-AS	1
ftp.so-net.or.jp	124.05 Kbps	SINFONYNET	15
ftp.riken.go.jp	117.42 Kbps	ASN-IMNET	13
ftp.eos.hokudai.ac.jp	62.02 Kbps	SINET-AS	6
ring.aist.go.jp	49.10 Kbps	ASN-IMNET	27
ring.crl.go.jp	41.94 Kbps	ASN-IMNET	173
ftp.iij.ad.jp	39.64 Kbps	IIJ-AS-JP1	10
ring.saitama-u.ac.jp	36.06 Kbps	JNIC-ASN	9
ftp.forest.impress.co.jp	10.42 Kbps	MFEED	6

Figure 4: Search Engine with estimated transfer rates

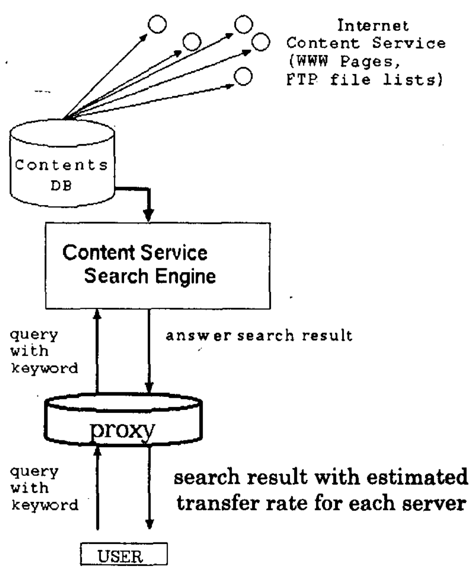


Figure 5:Architecture of Search Engine with estimated transfer rate information.

6. Evaluation and Experimentation

We have carried out experiments to evaluate the impact of the improved CSE. We chose 72 sets of mirror servers and measured the actual time required for transfers of every file. We predicted the fastest server in each set by the two selection methods, using network configuration information (AS-hops) and estimated transfer rate learned from application logs. For example, 'cc32e406.exe' has been retrieved from nine servers appearing in Table 1. We assume that these servers are mirrors of each. Then we get the file from those places and measure the actual elapsed time. By dividing file size by the elapsed time, we can know the actual transfer rate that can be seen in the fourth column of Table 1. We also graded the servers by measuring the number of AS hops to each server using *traceroute* command, and by estimating the transfer rate from application log information. These results are shown in the column 2 and 3, respectively. If we choose servers by number of AS hops, server C that involves the smallest number of AS hops, is chosen. And if we go by estimated transfer rate, server B is expected to offer the best performance. But, the actual transfer rate ranking is B (1st), A(2nd), C(3rd). So, the number of AS hops method, actually gives us the 3rd fastest server and the estimated transfer rate gives us the fastest server.

Table 1 Sample of server selection by each method

Server	Number of AS hops	Estimated Transfer Rate	Actual Transfer Rate
A	4	392.6	1767.6
B	2	1202.8*	2545.4*
C	1*	879.6	1414.1
D	5	63.6	303.0
E	2	185.5	1339.6
F	5	72.0	293.9
G	4	263.2	831.8

Servers: A – ftp.netscape.com、 B – sunsite.sut.ac.jp、 C – ftp.eos.hokudai.ac.jp、 D – ftp.nus.sg、 E – ftp.kyushu-u.ac.jp、 F – ftp.cs.hku.hk、 G – ftp.meisei-u.ac.jp、 H – ftp.pu-toyama.ac.jp、 I -- ftp.jaist.ac.jp

In this manner, we compared the performance of the server selection algorithms, for all 72 sets. Table 2 shows the result. By seeing this, we can see that in each method, we can often select the fastest server or the second.

Table 2 Comparison of selected server with actual server ranking

Ranking	AS Hop number	Predicted Transfer Rate
1	34	35
2	27	25
3	5	6
4	3	5
5	2	1
6	2	1
7	0	0
8	0	0
9	1	1

Since, finding the 2nd best performer from amongst 10 servers and the 2nd best performer from among 2 servers are significantly different, we have defined score as below.

score = 100 – 100×(m-1/n-1)

n: number of candidate servers in set

m: ranking of the selected server

In case, number of candidate servers is 5, if the best performer is selected correctly the score is 100. If the 2nd best performer is selected the score is 75, if the 3rd server is selected the score is 50, and so on. The Average scores of all 72 sets are shown in Table 3. A score of 50 generally indicates random selection.

Table 3 The score of each method

	AS Hop number	Predicted Transfer Rate
score	60.6	62.8

From Table 3 we can see that if the CSE follows the number of AS hops or the estimated transfer rate, users can obtain better performance than users who select servers without any knowledge. Table 3 also shows that there will be cases where a smaller number of hops or larger estimated transfer rate will not necessarily mean a shorter distance. Other means and information components will be needed to tackle these exceptional cases. Also, other pieces of information like geographical location of an AS and time of day is expected to play a role in helping users make a better informed choice. The bandwidth of the links also will have an important bearing on a users decision. Though bandwidth information is generally not published, some work is being done to determine the bandwidth[8].

7. Conclusion

The content service on the Internet is characterized by its massive redundancy. CSEs are used to search the network for contents. In this paper, we have discussed how the results of the queries may be supplemented with network configuration information or estimates of transfer rates from application log analysis, by the CSE to enable users to make a more intelligent choice from among the servers. We have evaluated the effectiveness of the algorithms in an operational network. The results show that users of CSE can get faster response than users who choose servers without any knowledge. We have built a pilot that is accessible at http://www.nemoto.ecei.tohoku.ac.jp/research/netman/ICSE/ .

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