Measurements of DNS Stability

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1. Introduction

The Domain Name System (DNS) maps domain names to IP addresses and vice versa. The Domain Name System consist of two pieces, DNS servers and resolvers. Resolvers are client applications which deliver the IP address(es) of a domain name upon request of a user application or operating system. DNS servers receives queries from resolvers and they return the corresponding IP address(es) of the domain name back to clients. The DNS is one of the core protocols of the Internet.

In this project, we measured the stability of DNS servers based on the most popular 500 domains. In the first part of the project, DNS server replica counts and maximum DNS server separation are found for each domain. In the second part, these domains are queried for a one-month period in order to find their uptime percentages.

2. Measurement Setup

We have developed a number of Java applications for this project. The names and functionalities of main ones are given below.

AlexaParser: Alexa.com is an amazon.com company which provides the most visited 500 domains. Their rankings are based on the information which they collect from the millions of Alexa toolbar users. This Java application parses the HTML files of alexa.com and produce a list of the top 500 domain names.

AuthoritativeDNSServerFinder: This application finds the authoritative DNS servers of a given domain.

MaximumDNSSeperationFinder: This application traceroutes each DNS server of a domain and finds the maximum separation, which is explained in 3.2, between them. It uses the traceroute utility for path discovery.

UptimeProber: This application periodically tries to resolve a domain name via its authoritative DNS servers.

The measurements were done on Unix systems of the Columbia University Department of Computer Science in December 2004.

3. Results

1. DNS Server Replicas

It can be seen from *Table 1* that 3/5 of the domains only have two authoritative DNS servers and most of the others have three or four.

DNS Count	Domain Number
1	4
2	298
3	82
4	68
5	22
6 or more	20

Table 1. Authoritative DNS Server Count

Figure 1 shows the percentage for each DNS replication count. Sixty percent of the domains have two DNS servers, another 30 percent have three or four. The complete list of domain names and their DNS server count can be seen in the Appendix.
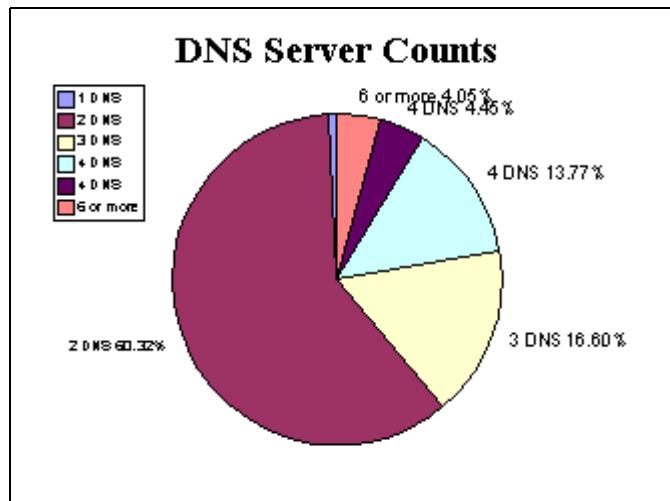

Figure 1. DNS Server Counts

2. Maximum DNS Server Separation

This metric is a good indicator for DNS stability. If the DNS servers of a domain is not separated enough from each other then the users can not access to these servers in case of a link or router failure. The following algorithm is used to calculate the

maximum DNS server separation:

Let us assume that there are 4 DNS servers *ns1, ns2, ns3, ns4* for a given domain. First we perform a traceroute to each DNS server and then calculate the separation between each pair [there are 6 pairs (*ns1,ns2*)(*ns1,ns3*)(*ns1,ns4*)(*ns2,ns3*)(*ns2,ns4*)(*ns3,ns4*)]. The difference for each pair is calculated by counting the different routers on their ways.
For example consider the comparison of *ns1* and *ns2*. Lets assume that their traceroutes are:

ns1 > router1 router2 router6 router9 router7
ns2 > router1 router2 router3 router4 router8

Then their separation difference is 3 because their route differs in last three hops. We define the "maximum DNS server separation" for a given domain as the maximum of these six differences. The maximum DNS server separation for the top 500 domains are given below.
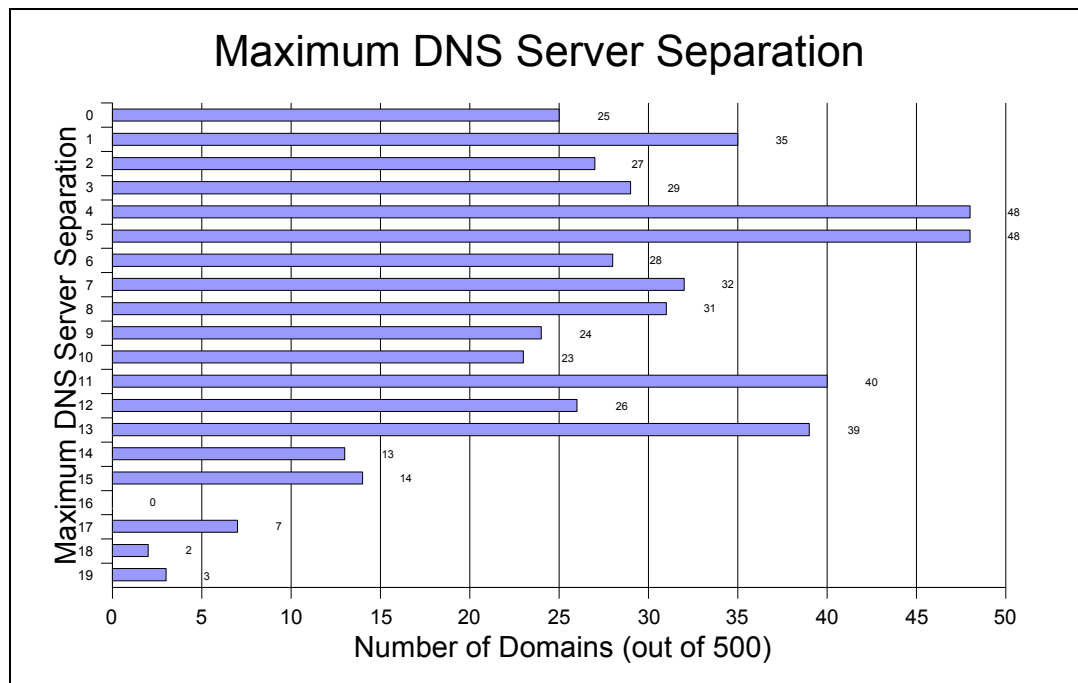

Figure 2. Maximum DNS server separation

More than 75% of the domains have a maximum DNS server separation of at least 4. The complete list of domains and their maximum DNS server separation are given in the Appendix.

3. Uptime Percentages

We measured the uptime percentages by probing each domain 300,000 times over thirty days. We used a customized prober which behaves like a resolver. For each domain it sequentially queries the DNS servers one by one until it receives a response. Each DNS server was queried at most three times with a timeout values of 2, 4 and 8 seconds. If none of the DNS servers responded, we incremented the missed queries counter of this domain. Table 2 shows the DNS query misses of domains. Almost 80% of the domains missed less than 50 packets during the experiment.

Perfect	175	35%
1-5 misses	75	15%
6-10 misses	40	8%
11-20 misses	51	10%
21-50 misses	52	10%
51-100 misses	25	5%
101-500 misses	40	8%
More than 500 misses	42	8%

Table 2. Number of misses

4. Analysis of the results

Table 4 shows the combined results from our two experiments. The values for columns "DNS Replica Count" and "Maximum DNS Separation" are averaged values. It can be seen that when we go from perfect to below 99.99% the *DNS replica count* and *maximum DNS server separation* decrease. This is an indication that *DNS replica count* and *maximum DNS server separation* play an important role achieving stable Domain Name Service.

Uptime Percentages	Number of Domains	Average DNS Replica Count	Maximum DNS Separation
Perfect	170	3.6	9.6
Above 99.99%	180	2.3	6.5
Below 99.99%	120	2.1	4.9

Table 3. Analysis of the results

Appendix

In the table below domains with low uptime percentages are listed. The table is sorted by uptime percentages in an increasing order. The first entry is www.adobe.com because it has the lowest uptime percentage, %94. The rank column shows the place of the domain among top 500 domains. DNS replica count is given in column 3 and maximum DNS server separation is given in column 4. The total number of DNS queries sent to a domain is given in the last column. The number of queries answered by the DNS is given in column titled "Response", where as the number of queries missed by the authoritative DNS servers of a domain is given in column titled "Missed". The uptime percentage is calculated by dividing responses by the total number of queries.

No	Rank	Domain	DNS Replicas	Max DNS Sep	Uptime	Missed	Response	Query
1	128	www.adobe.com	3	10	93.96	20195	314267	334462
2	305	www.blackplanet.com	2	0	97.18	9460	325827	335287
3	53	www.maplestory.com	2	2	97.80	7324	325014	332338
4	327	www.fc2web.com	3	1	99.34	2196	330134	332330
5	28	www.msn.co.il	2	8	99.35	2163	328932	331095
6	308	www.5460.net	2	8	99.48	1712	330626	332338
7	375	www.1stblaze.com	2	1	99.49	1697	328862	330559
8	169	www.domainsponsor.com	2	1	99.52	1615	333671	335286
9	401	www.haohz.com	2	0	99.52	1592	328967	330559
10	290	www.revenue.net	2	2	99.56	1471	329334	330805
11	319	www.incredimail.com	2	2	99.57	1448	333841	335289
12	78	www.sportsline.com	4	2	99.68	1074	330448	331522
13	148	www.17173.com	2	0	99.68	1044	329515	330559
14	459	www.totalvelocity.com	2	0	99.72	918	329640	330558
15	249	www.cjb.net	2	2	99.75	832	333627	334459
16	389	www.online.sh.cn	2	9	99.76	805	331934	332739
17	48	www.cnool.net	2	3	99.76	805	333654	334459
18	60	www.nypost.com	2	7	99.77	762	330333	331095

References

[1] Alexa, http://www.alexa.com
[2] P. Mockapetris, "Domain Names--Implementation and Specification," Request for Comments 1987, Internet Engineering Task Force, Nov. 1987.