DNS Performance and the Effectiveness of Caching

Authors: Jaeyeon Jung, Emil Sit, Hari Balakrishnan, Robert Morris

The paper presents a detailed analysis of traces of DNS and associated TCP traffic. In the first part of the paper authors make an analysis of how clients interact with the wide-area domain system and in the second part they try to evaluate the effectiveness of DNS caching. Moreover, authors conclude that two factors contribute to the scalability of DNS (i) the hierarchical design around deleted name spaces and (ii) the aggressive use of caching.

They used for their analysis three different datasets. The first two datasets were collected in January and December 2000 respectively, at the link that connects the MIT LCS and AI labs to the Internet. (Includes 24 internal subnetworks with over than 500 users and 1200 hosts) The third one dataset were collected at May 2001 at one of two links connecting KAIST to the rest of the Internet. (Includes over than 1000 users and 5000 hosts). They collected the outgoing DNS queries and incoming responses and outgoing TCP connection start (SYN) and end (FIN and RST) packets for connections originating inside the traced networks.

Before describing the key results and methodology they used its important to present the terminology they used.

• A lookup refers to the entire process of translating a domain name.
• A query refers to a DNS request packet sent to a DNS server.
• A response refers to a packet sent by DNS server in reply to query packet.
• An answer is a response from a DNS server that terminates the lookup (either successfully or unsuccessfully.)
In this study authors surprisingly found that over a quarter of all lookups are not successfully answered. More specifically, they found that 23% of all client lookups in the MIT December trace fail to elicit any answer. Another interesting finding was the DNS queries per lookup. Every unanswered lookup produces about 10 query packets and every answered about 1.3 query packets. Also, they found that the percentage of TCP connections made to names with low TTL increased from 12% to 25% in 2000 and by setting all A-record TTL’s to a value as small as 10 minutes is not likely to degrade the scalability of DNS. Finally, they found that 13% of lookups result in an answer that indicates an error.

The authors analyse the datasets using the following methodology. To measure the latency in resolving lookup they maintained a sliding window of the lookups seen in the last 60 seconds.

In the above example we have a lookup for www.mit.edu.

As we can see at first (Time t1) the a.root-servers.net is being contacted using a DNS query for (www.mit.edu).

Next (Time t2) the a.root-servers.net send back the address of the .edu NS (referral 1)

Then two new queries are sent to the .edu root servers. (Time t3 & Time t4) *There is one retransmission

A response from .edu NS is coming with the address of the NS of mit.edu. (Time t5) (referral 2)

A new query is sent for the www.mit.edu to the mit.edu NS (Time t6)

Finally, an answer A type for www.mit.edu is delivered. (Time t7)

So the final latency of the lookup is calculated as t7-t1.
A shortcoming that discovered is that Many DNS name servers are too persistent in their retry strategies. Results show that it is better for them to give up after 2 or 3 retransmissions. Authors also study the relationship between the number of TCP connections and the number of DNS lookups in the MIT traces. The ratio suggest that the hit rate of DNS caches inside MIT is about 80%. A very interesting key finding is that 10% of the total domain names account for more than 65% ot total lookups and also due to the Zipf-like distribution of domain names the theoretical effectiveness of caching is limited. Authors conduct some trace driven simulations to investigate the affect of caching of two factors. First, the TTL values on name bindings and the degree of aggregation due to shared client caching. Simulations results show that the most benefit of caching is achieved with TTLs less than about 1000 seconds for A-records and NS record caching is critical. Also, they discover that the benefit of sharing a cache is obtained with at few as 10 or 20 clients per cache.

Conclusion, about a quarter of all DNS lookups never get an answer, which corresponds over 50% of DNS packets in the wide-area Internet. DNS retransmission protocol appears to be overlay persistent. Furthermore, setting all A-record TTL’s to a value as small as 10 minutes is not likely to degrade the scalability of DNS in any noticeable way. Finally, the cache ability of NS records enhances scalability by reducing load on the root and top-level name servers and little bene fit is obtained from sharing a forwarding DNS cache among than 10-20 clients.