DNS Performance and Effectiveness of Caching

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This paper has two goals. First, it seeks to understand the performance and behavior of DNS from the point of view of clients and, second, it evaluates the effectiveness of caching.

The study is based on three separate traces. The first two were collected in January and December 2000 respectively, at the link that connects the MIT LCS and AI labs to the rest of the Internet, the third trace was collected in May 2001 at one of two links connecting KAIST (Korea Advanced Institute of Science and Technology) to the rest of the Internet. Through analysis of these data they found the latency for a DNS query.

One surprising result is that over a third of all lookups are not successfully answered. 23% of all client lookups in the most recent MIT trace fail to elicit any answer. In the same trace, 13% of lookups result in an answer that indicates an error. Many of these responses appear to be caused by missing inverse (IP-to-name) mappings or NS records¹ that point to non-existent or inappropriate hosts.

DNS servers also appear to retransmit overly aggressively. While most successful answers are received in at most 2–3 retransmissions, failures cause a much larger number of retransmissions and thus packets that traverse the wide-area. The query packets for these unanswered lookups, including retransmissions, account for more than half of all DNS query packets in the trace. Loops in name server resolution are particularly bad, causing an average of 10 query packets sent to the wide area for each (unanswered) lookup. In contrast, the average answered lookup sends about 1.3 query packets. Loops account for 3% of all unanswered lookups.

There were observations on changes in DNS usage patterns and performance. For example, the percentage of TCP connections made to names with low TTL values increased from 12% to 25% between January and December 2000, probably due to the increased deployment of DNS-based server selection for popular sites. Also, while median name resolution latency was less than 100 ms, the latency of the worst 10% grew substantially between January and December 2000.

The relationship between numbers of TCP connections and numbers of DNS lookups in the MIT traces suggests that the hit rate of DNS caches inside MIT is between 80% and 86%. Since this estimate includes the effects of web browsers opening multiple TCP connections to the same server, DNS A-record² caching does not seem particularly effective; the observed cache hit rate could easily decrease should fewer

¹ An NS record specifies the name of a DNS server that is authoritative for a name.
² An A record specifies a name’s IP address.
parallel TCP connections be used, for example. Moreover, the distribution of names is Zipf-like, which immediately limits even the theoretical effectiveness of caching. Based on the captured TCP traffic a trace driven simulation was performed to investigate two important factors that affect caching effectiveness: (i) the TTL values on name bindings, and (ii) the degree of aggregation due to shared client caching. The simulations show that A-records with 10-minute TTLs yield almost the same hit rates as substantially longer TTLs. Furthermore, we find that a cache shared by as few as ten clients has essentially the same hit rate as a cache shared by the full traced population of over 1000 clients. This is consistent with the Zipf-like distribution of names. These results suggest that DNS works as well as it does despite ineffective A-record caching. On the other hand, the NS-record caching is critical to DNS scalability by reducing load on the root and gTLD\(^3\) servers. The reasons for the scalability of DNS are due less to the hierarchical design of its name space or good A-record caching (as seems to be widely believed); rather, the cacheability of NS-records efficiently partition the name space and avoid overloading any single name server in the Internet.

\(^3\) Generic Top Level Domain