

ENUM Scalability and Performance Testing

A comparative study of DNS engines for VoIP



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Executive Summary

DNS scalability and performance are of critical importance for any telco or service provider deploying ENUM for their VoIP service. Whereas the DNS *architecture* is indeed highly scalable across the Internet, ENUM changes the rules of the game by requiring individual DNS servers to store several orders of magnitude more records, respond with reduced latency, and guarantee 99.999% availability.

To determine which DNS servers could sustain production level ENUM load, Nominum performed side-by-side tests of Nominum's Authoritative Name Server (ANS) versus DNS servers BIND, DJBDNS, and PowerDNS. These software products were selected because, combined, they represent over 95% of the DNS Servers used by telcos and service providers. They are also the DNS component of many commercial DNS servers included in IP address management offerings.

The tests were designed to simulate a telephony service provider VoIP environment with a medium to large subscriber base. The goal was to compare load times, queries per second, latency, and update rates. The initial dataset chosen was 200 million NAPTR records in 10 zones. In this scenario, only Nominum ANS was able to load the data and start successfully. Since none of the other servers could start with that amount of data, the number of records was reduced to 50 million so that the other servers could be tested. Even with the four times smaller dataset all the other servers failed to load. The dataset was reduced again to 10M records. At this level, two of the three servers started but their performance was low.

With 200M records loaded, ANS started in less than 1 second, answered 45,135 queries per second with an average latency of 0.0016 seconds. In addition, Nominum ANS was able to process 467 dynamic DNS updates per second.

Lab Environment

The test lab environment consisted of six servers, all of which were running Red Hat Enterprise Linux 3.0. One machine was used to run the different DNS servers one at a time. The other five machines were used to generate DNS related traffic. This setup ensured that the test hardware and network remained constant through all tests.

A total of ten DNS zones were created using a Perl script that is included at the end of this document. Each zone consisted of approximately twenty million NAPTR records for a total of 200 million records. This number of records per zone was reduced to 5 million and then to 1 million to allow for non ANS servers to start.

The five traffic generator machines were loaded with queryperf, an open source DNS traffic generator included in the BIND 9 distribution. Nominum updated queryperf to support NAPTR records, capture the average latency of responses to DNS queries, and improve performance. This enhanced version of queryperf is available on Nominum's web site and in open source.

A query file was created which listed the first 15,000 NAPTR records in each of the ten zones. This resulted in a query file of 150,000 NAPTR records. The same query file was used for each test. For each test, queryperf was run simultaneously on all five traffic generator machines.

In order to test dynamic DNS (DDNS) update performance, a Nominum developed, Java based, tool was used to generate DDNS requests to both ANS and BIND 9.3.0. DJBDNS and PowerDNS do not support DDNS. This tool was run on each of the five traffic generating machines simultaneously.

The hardware used was as follows:

DNS Server machine:

- Red Hat Enterprise Linux 3.0
- Intel XEON 2.4 GHz processor
- 2 GB RAM
- 160 GB Raid 5 Hard disk
- Gigabit Ethernet Interface

Load Generator machines:

- Red Hat Enterprise Linux 3.0
- Intel Pentium 4 2.4 GHz Processor
- 1 GB RAM
- 80 GB SCSI Hard Drive
- 100 MB Ethernet Interface

Network Switch:

- Foundry FastIron 4802 Layer 2/3 Switch

Server Configurations

Nominum ANS (www.nominum.com)

The DNS zone data, in BIND compatible format, was imported into ANS using the `ans_import` command. This tool parses the data files and inserts the records into the ANS database. The configuration file(s) contained both the zone configuration information and the directives to allow for dynamic DNS updates. Once the 200 million NAPTR records were loaded, ANS was able to start in less than one second.

BIND 9.3.0 (www.isc.org)

The DNS zone data, in BIND compatible format, was loaded by BIND at start time and loaded into memory. BIND failed to load 200 million and 50 million NAPTR records. When the number of records was reduced to 10 million records, then BIND 9.3.0 took 150 seconds to load the data into memory before it was ready to answer queries.

DJBDNS (cr.yyp.to/djbdns.html)

The authoritative portion of DJBDNS, TinyDNS, was used. In order to configure TinyDNS, the DNS data needed to be loaded into another DNS server (Nominum ANS in this case). A command line tool that ships with TinyDNS was then used to do a zone transfer of the data. The load took several minutes to accomplish. Once the data was transferred, the data file was compiled using the make command. TinyDNS failed to compile either 200 million or 50 million records. When the number of records was reduced to 10 million records, then the server could be started. TinyDNS does not load all of its data into memory. It reads data from the compiled database for each request. It should be noted that in order to install TinyDNS on a version of Red Hat Linux more recent than Red Hat 8, it was necessary to edit the source code before compilation.

PowerDNS (www.powerdns.com)

PowerDNS normally operates by loading all DNS data into a MySQL database. When PowerDNS is started, it reads the data out of the database and loads it into memory. PowerDNS also has the ability to read this data directly from BIND-compliant DNS zone files. The PowerDNS web site states that using BIND-compliant zone files is faster than using MySQL so the zone files were used for this test. PowerDNS failed to load even the smaller set of ten million resource records into memory.

Test Procedures

To properly evaluate each DNS server, care was taken to make the environments as similar as possible. All DNS servers were configured in accordance with the available documentation for each product. All DNS server software was installed on the same machine with care taken to ensure that no installation conflicted with any of the others. The test procedure was as follows:

1. Start DNS Server
2. Start queryperf simultaneously on each of the five traffic generating servers. The first data set was not collected to allow the DNS server to perform any caching it might need to do with the first run of the data. This allowed each server to display its best possible performance.
3. Run queryperf again on all five servers.
4. Collect the number of queries per second and add them.
5. Collect the average latency for each machine and average the numbers.
6. For the servers that support it, run the Dynamic Update test and add the number of updates from each server.

Test Results

Below are the results of the tests that were run in the above environment

| | Nominum ANS | BIND 9.3.0 | DJBDNS | PowerDNS |
|--|----------------|--------------------------|--------------------------|----------------------|
| 200M Records Load | Pass | Fail | Fail | Fail |
| 50 M Records Load | Pass | Fail | Fail | Fail |
| 10 M Records Load | Pass | Pass | Pass | Fail |
| Queries per Second | 45,135* | 143[†] | 6,992[†] | N/A |
| Average Latency (Secs) | 0.0016* | 0.618[†] | 0.014[†] | N/A |
| Dynamic Updates (DDNS) per Second | 467* | 69[†] | Not Supported | Not Supported |
| DNS Security (DNSSEC) | Yes | Yes | Not Supported | Not Supported |

The next table shows the ANS performance advantages to the best alternative in each category:

| | ANS Advantage | Calculation |
|---------------------------|----------------------|--------------------|
| Scalability | 20X | 200M/10M |
| Queries per second | 6.4X | 45,135/6,992 |
| Latency | 9X | 0.014/0.0016 |
| Updates per second | 6.7X | 467/69 |

Neither DJBDNS nor PowerDNS support either dynamic DNS or DNS Security (DNSSEC). This will make the use of these servers in an ENUM environment problematic. In order for a DNS server to be flexible to allow modifications of DNS data on an as-needed basis, it must support dynamic DNS. Given the anticipated nature of changes to DNS in an ENUM environment, the DNS server must be able to handle a high load of dynamic DNS updates. Additionally, the IETF RFC 3761 that specifies ENUM recommends the use of DNSSEC.

* ANS tests on 200M records

† BIND and DJBDNS tests on 10M records

Summary

The above tests clearly show that Nominum ANS is the only viable choice for ENUM deployment. ANS is the only server that is able to scale to the number of NAPTR records required for a real-world ENUM deployment. ANS loaded and delivered high performance results with 200 million NAPTR records. On the same hardware, none of the other servers were able to load much more than 10 million NAPTR records and performance was weak. While multiple DNS servers will no doubt be deployed in any production environment, it is vital that DNS Servers in an ENUM environment be able to scale to large data sets, with low latency and guaranteed uptime and manageability.

About Nominum

Nominum is the leading provider of IP address infrastructure solutions for Global 2000 companies. Nominum provides the industry's only high scalability and high availability Internet name and address solutions for the always-on network. Nominum's Foundation product family includes scalable, reliable and secure DNS and DHCP servers and IP address management (IPAM) systems. These solutions allow service providers to deliver a carrier-grade telecommunications infrastructure that supports the rapidly growing demand for new services, and enterprises to create resilient and reliable networks that are responsive to changing business conditions. For more information about Nominum, go to www.nominum.com.

