A Simulation Platform - For Testing and Optimization of ENUM Architecture *

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1. CATEGORIES AND SUBJECT DESCRIPTORS

D.3.3 [Model Validation and Analysis]:

2. GENERAL TERMS

Measurement,Performance,Verification.

3. KEYWORDS

DNS, HMM, Model, ENUM.

4. INTRODUCTION

Electronic NUmber Mapping (ENUM)[1] System, a suite of protocols developed by IETF is one of the simplest approach which permits communicating from the telephony to the Internet Protocol (IP) world and vice versa in a seamless manner. Implementing ENUM is simple because it uses the existing Domain Name System (DNS) to store and serve the information linking PSTN telephone numbers to network addresses and services (email address, SIP phone number etc.). Explanation of how a telephone number is converted to a Fully Qualified Domain Name (FQDN) is shown in fig.1.

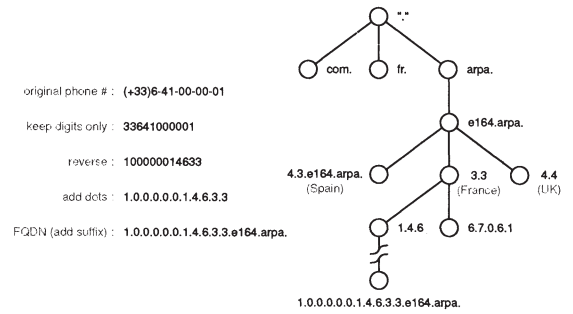

Figure 1: ENUM Tree

ENUM uses a delegation model similar to DNS. The ENUM delegation model is distributed and multiple tiers are responsible for different parts of the ENUM tree (fig.1). In this tree, Tier0 corresponds to the base of the inverted tree that forms the Internet domain name space designated for ENUM, i.e. .e164.arpa (see fig.1). Tier1 is a level below Tier0 which corresponds to the country code for telephone numbers (For France it will be 3.3.e164.arpa.). In France, the next level, Tier2 is managed by telecom operators as they rent chunk of numbers to their clients. (For e.g. numbers from +33-1-60-76-00-00 to +33-1-60-76-99-99 are assigned to one operator and numbers from +33-6-41-00-00-00 to +33-6-41-99-99-99 are assigned to another operator). This level is divided into two parts the Tier2chunk server which handles delegation of chunks of numbers and the Tier2number server which contains the real information (web site address, email, SIP phone number etc.) linked to a phone number.

There are multiple uses of an ENUM simulation platform. For example, the delegation model used by ENUM need not be the same for all countries. To test different delegation models and finalizing an optimized model is difficult, because it involves changing the contents of the databases in the servers that forms the Zone (a part of the domain space). With a simulation platform, the configuration files of the Zone and also all the data relative to the structure of the DNS tree are concentrated in one machine and it becomes quite easy to change the configurations to test different delegation models. A simulation model is built and validated with real world measurements, which are explained in the following sections.

5. METHODOLOGY

In order to build a simulation platform for ENUM, we needed to get metrics like loss rate and response time from a real ENUM platform. To obtain this parameters we made tests on the real platform which is explained in the following subsections.

5.1 Local DNS server measurements

Tests were conducted on a real French ENUM set up. The prototype of this set up was used for our simulation model also (fig.5). Loss rate, standard deviation response time and average response time was calculated (fig.2) locally for the three target servers (Tier1, Tier2chunk and Tier2number server) from the real platform. This results were obtained by stressing the DNS cache server starting from 1000 to 80,000 queries per second. On observing the graph of the results

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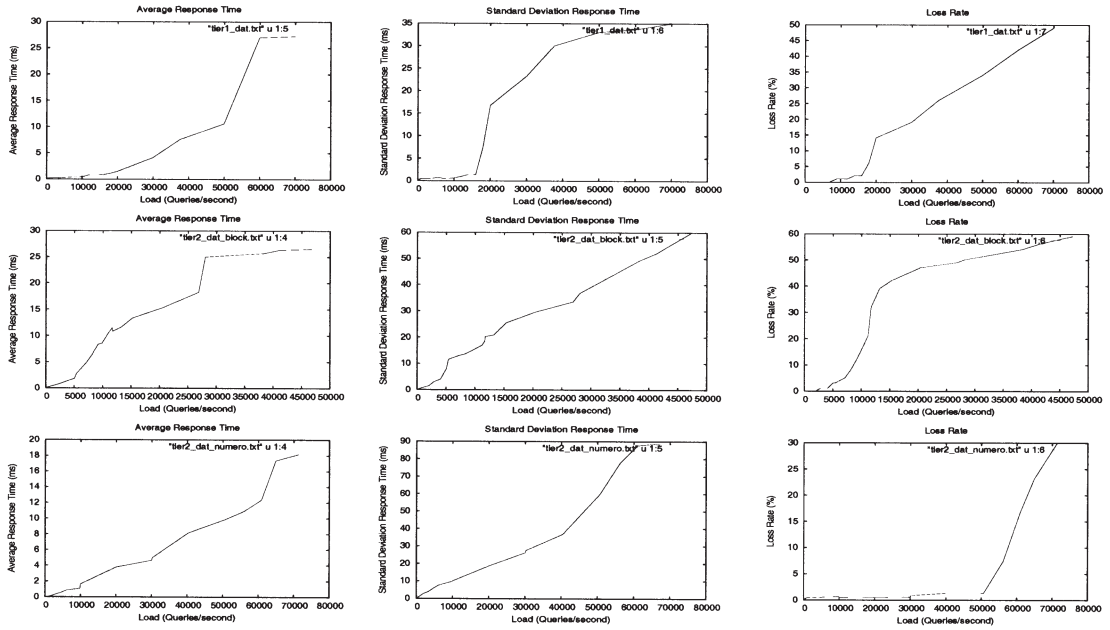

Figure 2: Average Response Time, Standard Deviation and Loss Rate for Tier1, Tier2 chunk and Tier2 Number servers

(fig.2)one notes that in the beginning the loss rate and average response time follows an exponential curve($y = ae^{\alpha x}$) while after a certain threshold it follows a linear pattern($y = ax + b$). This threshold value depends on the technical characteristics of the server (Hardware and DNS Software used on the machine). Censoring techniques were employed to cut the exponential and linear part.Then we proved that our observation is correct by linear and exponential regression techniques. We identified parameters, which when applied into the exponential and linear equations, best fit exponential and linear part of the real world measurements. Thus parameters(α, a, and b) were calculated for all the three target servers to be used in the simulation tool.

5.2 Global DRD measurements

While the stress tests of the previous subsection was proceeding we calculated the global DNS Resolution Delay (DRD). DRD is the time taken by the DNS cache server to obtain a response for a user's request. Global response time cumulative distribution function was obtained for 5000 (fig.3) and 36000 queries, which has been used to compare with the simulated DRD results (fig.6).

5.3 IP Link measurements

Finally, measurement and modeling of the two important metrics (loss and delay) which impact the performance of the IP links connecting the resolver (i.e. the client where the query is generated), the cache server and the authoritative servers (Tier1, Tier2chunk and Tier2number) was done. We wanted the model to reflect the features of an IP link, so an asymmetric Internet model (client-server nature of the internet) was designed, where the delay and loss are not correlated. Hidden Markov Models (HMMs) were used to reflect the dynamic and long-term dependence nature of the

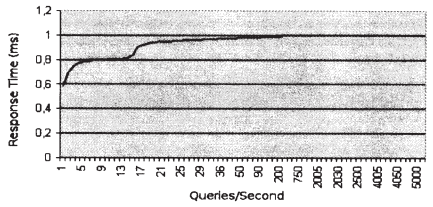

Figure 3: Global Response Time Cumulative Distribution Function(5000 queries)

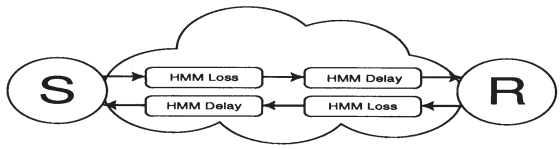

Figure 4: IP links: Two HMMs for both directions

Internet traffic. The model for an IP link has four HMMs one for the delay and one for the loss on both the directions of the IP link (fig.4). The model was validated using simulation[2]. The values (loss and delay) obtained from this experiment was used as input in the simulator to simulate loss and delay for the IP links connecting the different nodes of the simulation topology.

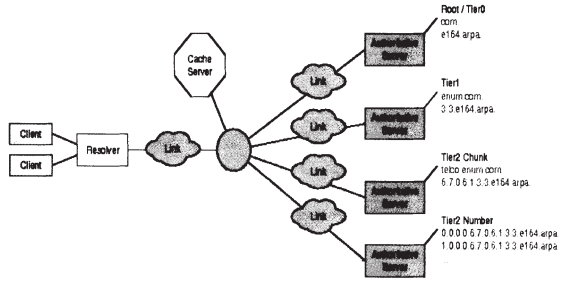

Figure 5: Simulation topology

6. IMPLEMENTATION OF THE SIMULATION TOOL

To the best of the author's knowledge this is the first ENUM simulation model to be developed. The initial topology for the simulation model is shown in fig.5. We used the parameters obtained from the real tests (section 5) into the simulator and validated the simulator with real measurements for both the 5000 first queries and then the 36000 first queries (fig.6).

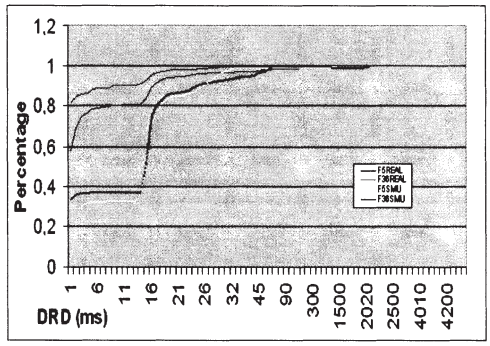

Figure 6: Comparison of real and simulation results

7. CONCLUSION

A new approach is followed to build a simulation tool. The tool is validated with real measurements. The simulator tool that we have developed can be used to study an optimized delegation model for a particular scenario. The tool can also be used to study the feasibility of different ENUM enabled services with minimal modifications. We are convinced that our work could influence different metrics (such as Time to Live for different types of Resource Records in Tiers-(0...2) DNS Servers)) which will lead to recommendations of the new ENUM protocol to achieve better performance.

8. REFERENCES

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