ENUM 디렉터리 서비스 설계 및 성능 평가
(Design and Performance Analysis of ENUM Directory Service)

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요 약 PSTN(Public Switched Telephone Network)과 IP Network의 연동을 제공하는 새로운 프로토콜 ENUM(tElephone NUmbering Mapping)은 전 세계적으로 유일성을 가지는 전화번호를 DNS 기반의 구조에서 사용되는 F.Q.D.N.(Fully Qualified Domain Name)으로 변환함으로써 E.164 번호를 사용하여 PSTN에서 제공하는 서비스와 IP 네트워크에서 제공하는 서비스를 동시에 사용 가능케 하는 새로운 인터넷 주소체계이다.

본 논문에서는 미국과 유럽에서 활발히 진행중인 ENUM 모델 표준화 연구 및 개발에 발맞추어 ENUM 기반의 서비스를 사용할 때 ENUM resolution 성능 향상을 위한 Tier 2 네임서버 관리기법을 제시한다. ENUM 위임구조에서 Tier 2 네임서버 제공업자가 지역번호 별로 ENUM 등록 대행업 및 NAPTR RR(Naming Authority PoinTeR 리소스 레코드)을 제공함으로써 ENUM resolution의 성능이 향상됨을 증명하기 위해 ENUM 기반의 네트워크 모델링을 사용하였다.

ENUM 프로토콜이 IP 네트워크 사용자와 PSTN 사용자에게 유연성 및 편의성을 제공하는 반면 사용자가 ENUM을 사용할 때 지불해야할 인내력을 측정할 척도가 없는 현재 이 논문에서 제안하는 방법은 사용자의 ENUM 서비스 선택 결정에 긍정적인 영향을 미치고, ENUM Tier 2 네임서버 관리를 위한 정책에 도움이 될 것으로 기대된다.

키워드 : DNS, ENUM, resolution, 성능, 응답시간, NAPTR RR

Abstract ENUM(tElephone NUmbering Mapping) is a protocol that brings convergence between PSTN Networks and IP Networks using a unique worldwide E.164 telephone number as an identifier between different communication infrastructures. The mechanism provides a bridge between two completely different environments with E.164 number; IP based application services used in PSTN networks, and PSTN based application services used in IP networks.

We propose a new way to organize and handle ENUM Tier 2 name servers to improve performance at the name resolution process in ENUM based application service. We build an ENUM based network model when NAPTR(Naming Authority PoinTeR) resource record is registered and managed by area code at the initial registration step.

ENUM promises convenience and flexibility to both PSTN and IP users, yet there is no evidence how much patience is required when users decide to use ENUM instead of non ENUM based applications. We have estimated ENUM response time, and proved how to improve performance up to 3 times when resources are managed by the proposed mechanism. The proposition of this thesis favorably influences users and helps to establish the policy for Tier 2 name server management.

Key words : DNS, ENUM, resolution, performance, response time, NAPTR RR

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1. Introduction

1.1 Research Background and Motivation

ENUM, a protocol defined in RFC 2916[1], maps telephone numbers into domain name, and provides a connection between IP network based services and PSTN based services. This mechanism enables end-users to access web-sites, e-mail, fax, mobile-phone and instant message services with a single telephone number. ENUM protocol is shown in Figure 1. ENUM protocol promises uniqueness, flexibility and convenience to both IP network and PSTN users; however, there is no sufficient proof as to how long users must wait to use ENUM service instead of conventional DNS lookup service. As ENUM Tier 2 name server responds to query, it only sends an application-specific NAPTR Resource Record(RR), not all of NAPTR RRs according to [1], and the availability of cached NAPTR RR should be lower than the availability of cached conventional RR in local name server. Thus, we suspect that people would have more a relatively long wait to get an appropriate response with ENUM service. This thesis discusses lookup service performance with ENUM service, estimates response time, and presents some techniques to improve its performance.

2. Related Works

2.1 DNS and Lookup Process

IP based application and services are indispensable to *Domain Name System*[3, 4], so the correct operation of DNS is the primary element in IP based networks. Domain name is preferred to IP address because of its readability and writability; however, physical hardware cannot understand this, so DNS translates domain name into IP address, logical address of device, providing information to most IP based applications and services. DNS offers the other service, *opposite mapping* from IP address to domain name. Whenever client application needs to connect with another party in the network with no knowledge about logical address, it queries one of the nearest name servers and receives a response from it. Figure 2 describes the general hierarchical organization of DNS[6]. The design of DNS is well specified in [3, 4, 5]. We sum up the important terminologies and basic concepts here.

The whole picture of DNS structure is described as a "genealogical table" with only one parent. Each parent would have several children and each child would become a parent, who in turn has his own children. From this analogy, a genealogical

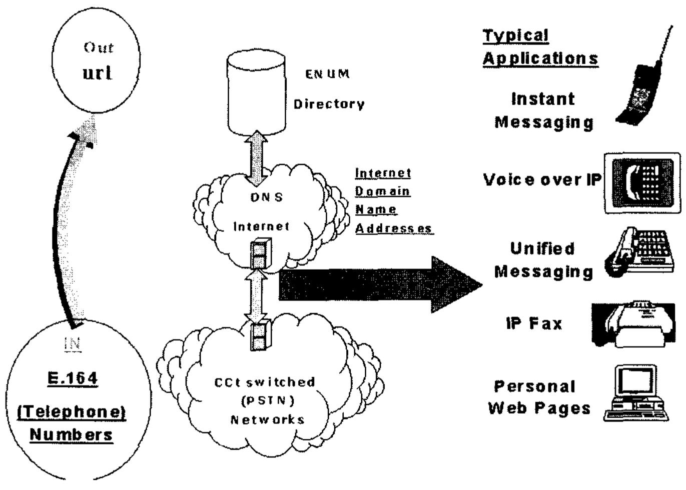


Figure 1 ENUM provides a bridge between PSTN and IP Network

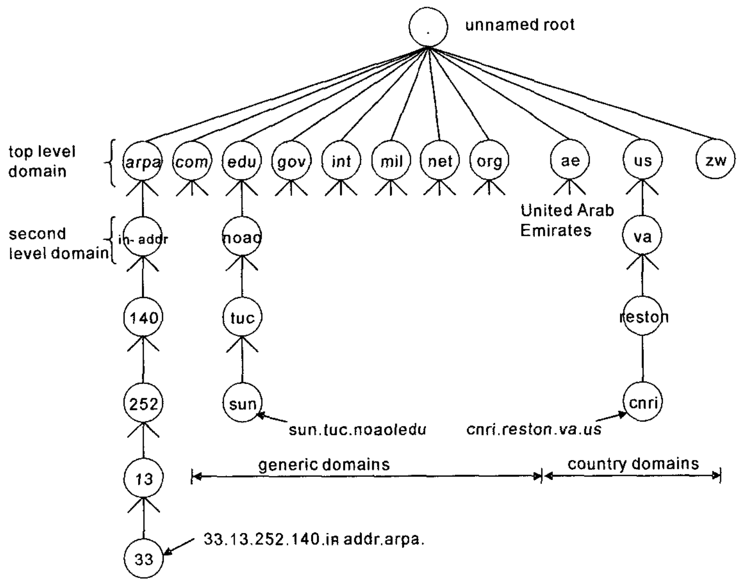


Figure 2 Hierarchical organization of the DNS

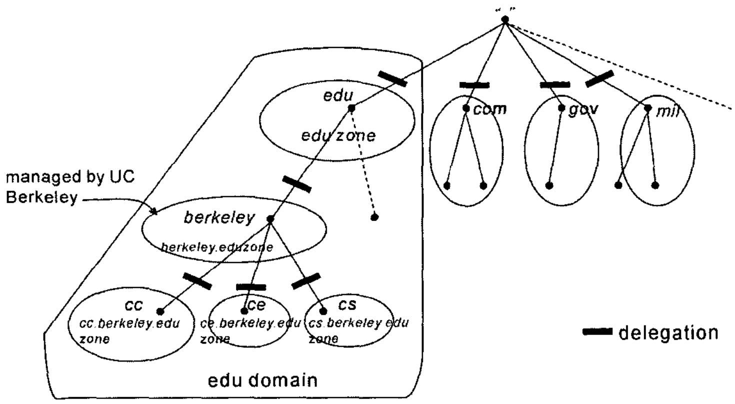


Figure 3 Domain is broken into zones

table is called *domain*. Each family member should have its own name, called *domain name* in DNS, and this domain name expresses the relative relationship with its parent. Each child becomes the parent in a new family, and this family represents *subdomain*. Each parent must assume responsibility for his family members, and this should not be handed over to another family or higher parent. This responsibility in DNS is called *delegation*. Figure 3 shows domain, domain name, subdomain, delegation and zones[5].

Top level domains are divided into three groups: arpa domain, generic domains, and geographical domains. Arpa is a special domain used with address to name mappings, generic domains(com, edu, gov, int, mil, net, org) are organizational domains, and geographical domains are based on the country codes found in ISO3166[6].

Zone has a different meaning from domain. Domain is the set of all domain names under the delegated domain, while zone refers to that domain except all the delegated domain names below that zone's name[16]. From Figure 3, edu domain is grouped into several zones, and berkeley domain in the edu domain is grouped into 3 zones again: cc, ce and cs. Each of the three domains will be delegated responsibility for its zone from the upper domain, berkeley.

The active components of DNS can be classified into two major types: *name servers* and *resolvers*. Name server is a database of domain names, and resolver is a user-side application to embody the algorithms necessary to find a name server that has the information requested by the client[3,7,8]. When client software queries the name server about IP address, the name server responds with whatever the information it holds(Figure 4).

When the name server is queried, it responds with *resource records*. There are several kinds of resource record types, yet only two common types are used: address record(A record), and pointer record(PTR record)(Table 3). An A recordspecifies an IP address of domain or host name, and a PTR record specifies the domain name of the IP address, so PTR record is used to address to náme mapping(Figure 2).

A name server has authority for one zone or multiple zones, and the administrator for zone must provide *primary name server* and one or more *secondary name servers*. The primary and secondary servers must be located in other places, so excessive loads to name server are precluded, load balancing is feasible, and eventually a single point of failure does not affect the availability of name service[6,16].

A name server can provide data from zones for which it is authoritative, as well as search through the domain name space to find data for which it is not authoritative. When a name server which does not possess proper information corresponding to query is requested, it must contact another server. To contact every other name server is almost impossible, so instead, every name server knows how to contact the root name servers. All primary servers know the IP address of the nearest root server, and the root servers then know the IP address of each authoritative name server for all the second level domains(Figure 2). This process is called *name resolution*, or simply *resolution*. Name resolution adopts iterative mechanism according to DNS specification[3]. At first, stub resolvers queries to the nearest name server *recursively*, then the name server contacts a root server. Finally, root server tells the requesting server to contact another

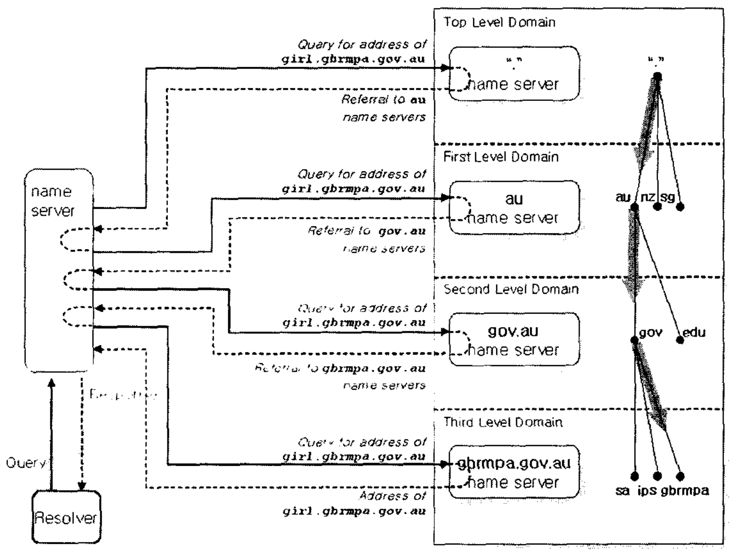


Figure 4 Resolution of *girl.gbrmpa.gov.au* on the Internet

server, and so on. Figure 4 shows the DNS resolution process[5]. When client application queries a *local name server for hostname*, girl.gbrmpa.gov.au, provided this local name server does not know, it follows the steps as in Figure 4 to arrive at the authoritative name server for queried hostname.

When a name server receives information about a mapping(e.g., the IP address of a hostname), it *caches* that information. Later, a query for the same domain name can be answered by the cached result without any additional query to other servers. Usually cache in DNS is not size limited since the cached records are small, and commonly consist of no more than a hundred bytes. Each resource record expires according to the time(TTL, Time To Live) set by the authoritative name server managing how long each domain record is cached, and how long changes will be deferred by handling TTL. Expired records must be replaced by fresh ones from the authoritative name server. A rapidly changing record will have a short TTL, trading latency, server load and DNS traffic for fresh data[6,7].

Since achieving good performance is the most important aspect of DNS, it makes extensive use of caching to reduce server load, client latency and ultimately DNS traffic on the Internet. It is generally credited that cache is very efficacious even in changable and variable IP environment, because information in DNS database varies slowly, and small quantities of staleness are tolerable. Simply the DNS caching design prefers availability above freshness. On this premise, most name servers respond to query with unauthoritative data they have, and use cache mechanism aggressively. It is widely believed that aggressive use of caching has a major influence on the *scalability* of DNS[7,8].

2.2 ENUM Lookup Service and Delegation Model

ENUM is a protocol to map E.164 numbers recommended by ITU-T[2] into Uniform Resource Identifiers(URIs) corresponding to communication applications associated with those numbers. ENUM first transforms E.164 numbers into ENUM domain names and then uses the DNS-based architecture to access records from which URIs are derived. With the ENUM function, E.164 numbers can be used to provide users with a number of addresses, including those used for phone, fax and email, at which the called party can be contacted. This enables the called party to tailor the manner in which they are contacted through a single number[16]. Figure 1 shows the basic ENUM protocol used in the

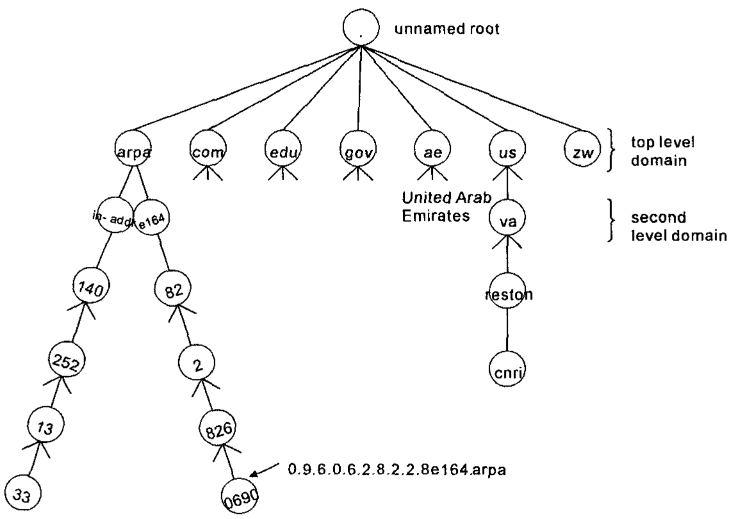


Figure 5 Single Common ENUM Domain

communication world. Basically, ENUM adopts contemporary DNS's philosophy and design. The design of ENUM is specified in [1, 9, 12]. We summarize the important terminologies and basic concepts here.

E.164 number was chosen as a "representative identifier" in the ENUM environment connecting IP network and PSTN because it guarantees uniqueness in the world, and it is easy for people to memorize and understand. When ENUM is used in a specific implementation, E.164 numbers are inserted into a single, carefully defined and structured domain of the DNS system. Figure 5 shows the single ENUM domain applied to a conventional DNS domain tree. In a purely IP environment, ENUM will allow users to use their E.164 number as a commonly used ENUM domain name for a number of applications, while having no effect on E.164 numbering plan.

Through the transformation of E.164 numbers into DNS names[1], the use of existing DNS services like delegation through NS records, and use of NAPTR[13] records in DNS, users can find what services are available for a specific domain name in a decentralized way with distributed management of the different levels in the domain name lookup process.

Communication between ENUM clients requires a query and response process to find appropriate URLs[1]. This query will pass through each tier in the hierarchical DNS tree architecture, such as local name server, root server and several intermediate DNS name servers[16]. Figure 6 shows query and response process for ENUM protocol[11, 12]. After the ENUM lookup process, the DNS lookup process should be followed, and the connection between devices(e.g., e-mail, cell-phone, telephone, etc) and services[20] can be made. ENUM is a directory service, so it is independent of the communication service selected by users. SIP, H.323, e-mail or other specific protocol would be used according to the responded service type among NAPTR RRs corresponding to E.164 number.

3. Design of ENUM Directory Service

3.1 Proposed ENUM Delegation Model

The ENUM implementation will employ a DNS based tiered architecture as shown in Figure 5. In this section we analyze the function, requirement, and restriction of each tier, and we propose how to manage resources in name servers for each country code in order to improve ENUM performance[11,12,15].

The ENUM delegation model is made up three tiers: Tier 0 registry, Tier 1 registry, and Tier 2 name server provider. First, Tier 0 corresponds to the ENUM root level. At this level, the ENUM architecture contains only one domain(the ENUM root). The Tier 0 name servers contain records that point to ENUM Tier 1 name servers. There is no

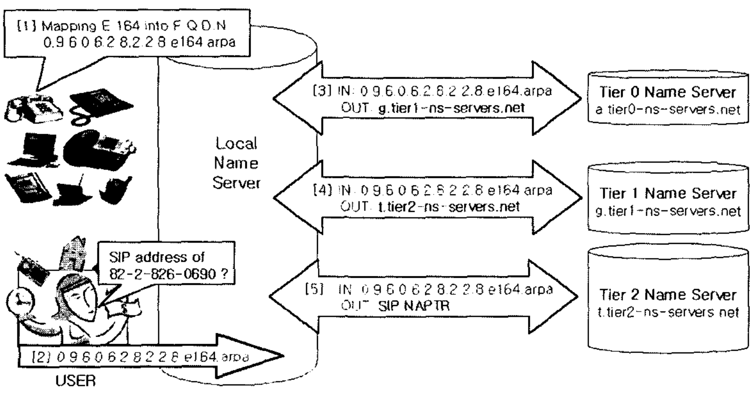


Figure 6 ENUM resolution process

service-specific information associated with individual ENUM numbers. Secondly, Tier 1 registry is an entity responsible for the whole management of the E.164 country code for ENUM in each country. Tier 1's name servers contain records that point authoritative name servers for individual E.164 number or blocks of numbers in the country code, but it would not have any direct interaction with end users. Tier 1 registry guarantees security, availability, reliability, and performance for ENUM directory service. Finally, Tier 2 name server provider is an entity that creates, authenticates, and possesses the NAPTR records. Tier 2's name servers contain domain names corresponding to E.164 numbers, NAPTR resource records with information for specific communication services, and responses to a query about E.164 number from ENUM resolver. Tier 2 name server provider is comprised of competitive entities which interact with ENUM registrants directly. Tier 2 name server provider guarantees of identification, authentication, and authorization at initial ENUM registration step. Besides these factors, it should guarantee of transparent management and integrity of database.

Hierarchical design around administratively delegated name spaces and aggressive use of caching are indispensable to the scalability of DNS[7, 8]. Contemporary DNS resolution process makes use of caching, and the cache hit rate is up to 90% depending on the starting state of database: cold or warm start[8]. The response time of DNS query is independent with hop count between source and root server or administrative name server, no matter what the destination is so far. However, the response time of ENUM query is dependent on hop count, because it is impossible to cache every NAPTR RR pursuant E.164, so we suspect the ENUM resolution would have excessively low cache hit rate.

The successful cache hit rate is indispensable to scalability; so alternatively, we propose to separate Tier 2 name server's role to make ENUM performance better. If Tier 2 name server represents one area code, each local name server can pre-learn and cache Tier 2 name server's addresses per area code. More than two Tier 2 name server providers can represent a specific area; and moreover, one Tier 2 name server provider can represent more than one area, but their information must be mutually exclusive. This idea guarantees that a local name server knows every Tier 2 name server's address per area code, so a query does not have to be forwarded to root name server or Tier 1 name server(Figure 7). We can thus shorten query response time, and reduce falloff in performance.

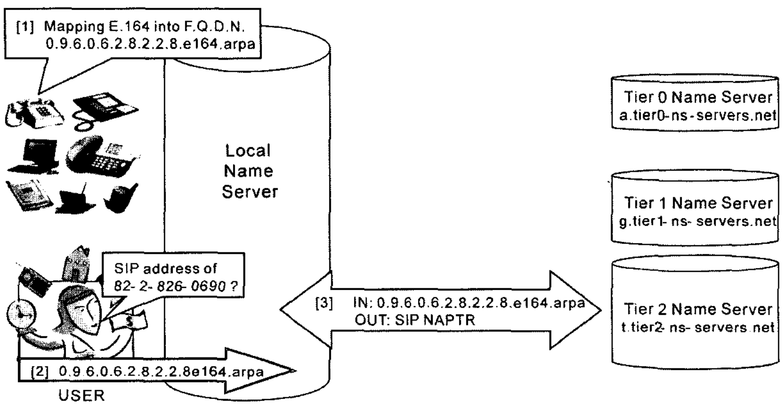


Figure 7 Expected ENUM resolution process

4. Evaluation of Resolution

4.1 Modeling

4.1.1 Experiment environment

The base assumptions for this experiment are that:

- Domain name to query is restricted only to the *.kr* domain, so any query which the local name server does not know is forwarded to the *.kr* root name server.
- A query always starts from the SSU network, and the local name server is *ns.ssu.ac.kr*.
- There are five *.kr* root name servers in Korea, and they have the same data in their zone files for data consistency.
- The Name server administrator can designate the nearest *.kr* root name server.
- The administrative name server does not have any sub name server. This name server can have more than one secondary name server, but cannot have delegation.
- Any current DNS name server can be the ENUM Tier 2 name server.
- There is no query for non-existant domain names, and no failed DNS query in entire networks.
- All name servers have the same name server processing time:
  e.g., searching, caching, transmission time.
- The processing time for ENUM is assumed to be the same as the processing time for DNS.
- All intermediate routers between a host and name server have same router processing time.

4.1.2 Scenario

When a local name server receives a query about NAPTR RR from a host, it first searches its cache memory. If the local name server finds an appropriate NAPTR RR corresponding to the query, it responds to the host, and the ENUM resolution is over. Otherwise, the local name server forwards the query to the Tier 1 name server, which then returns a referral response composed of addresses of administrative Tier 2 name servers which store NAPTR RRs corresponding to E.164 number. The local name server then forwards the query to the Tier 2 name server again, and it responds to the local name server with an appropriate NAPTR RR. As the local name server receives a response from administrative Tier 2 name server, it caches and forwards the response to the host. Now, the ENUM client of the host receives NAPTR RR, and starts DNS name lookup process again to find IP address correspondent to NAPTR RR.

When the local name server receives a query about IP address from a host, it searches its cache memory. If the local name server knows the appropriate IP address corresponding to the query, it responses to the host, and the resolution is completed. Otherwise, the local name server forwards the query to the root name server. The root name server returns a referral response; the address of administrative name server. The local name server forwards the query to the administrative name server again, and administrative name

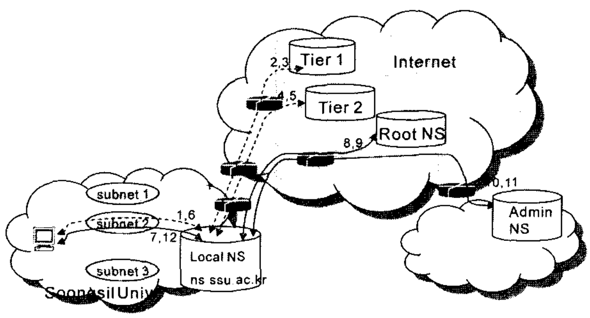


Figure 8 Schematic topology of the traced networks

server responds to the local name server. Finally, the local name server forwards the response to host.

Figure 8 illustrates the name lookup process from ENUM resolution to DNS resolution. The dotted line indicates the ENUM query process, while the solid line indicates the conventional DNS query process.

The appropriate mathematical model for the response time of each step in the name lookup process is as follows:

$$x_i = 2\alpha \sum_{j=1}^{m}(n_j - 1) + m\beta + \gamma(i-1) + 2\sum_{j=1}^{m} n_j\delta_j,$$
$$\text{if } i \le 1 \text{ then } m = i, \text{ else } m = i+1 \quad (1)$$

where

1. x_i : response time of each step in name lookup process,
2. n_i : hop count in i^{th} trace,
3. p_λ : probability related ENUM resolution,
   - p_{λ_1} : probability which local name server has NAPTR RR corresponding to a query,
   - p_{λ_2} : probability which Tier 1 registry's name server will give address of Tier 2 name server corresponding to a query,
4. p_μ : probability related to original DNS reso lution,
   - p_{μ_1} : probability which local name server can response to a query,
   - p_{μ_2} : probability which root name server will give the address of administr ative name server corresponding to a query,
5. α : router processing time,
6. β : DNS name server table searching time,
7. γ : DNS name server table caching time,
8. δ : query propagation delay time between two hops.

Assume that x_λ is the response time of the ENUM resolution process, and x_μ is the response time of the DNS resolution process. The expectation of the response time for the whole resolution process using ENUM is the sum of each expectation, follows:

$$E(X) = E(X_\lambda) + E(X_\mu) \quad (2)$$

4.1.3 The data-statistical analysis

To evaluate the response time of ENUM query and original DNS query, we used some real physical data. For name server processing time, 5,000,000 virtual A records were used to get DNS query processing time of *.kr* root server on July 2002. Table 1 shows that DNS query processing time is 0.008*ms*.

An approximately one-day aged name server statistics from Soongsil University (ns.ssu.ac.kr) was used to get the response rate of the name server. The response rate(or cache hit rate) has a deep connection with how long name the server has been turned on, and should be varied with other simulation results, so we turned off and restarted the name server for the test. In this thesis the name server's response rate is defined as the total of query responded by the name server to total queries from remote hosts. Table 2 and Table 3 summarize DNS basic traced statistics of ns.ssu.ac.kr. Table 2 shows that response rate of name server is 88.48%. For further details of Table 2, see, in particular, [5]. The percentage of DNS lookups across the most popular query types

Table 1 Throughput of .kr root name server

Date		Place	
22:09:39 KST July 29, 2002		.kr Root Server	
DNS program	Zone file data	Query data	Check program
BIND 9.2.0	Virtual 5,000,000 A records	500,000 A records in zone file	queryperf tool
Queries sent	Queries completed	Queries lost	Percentage completed
500,000	500,000	0	100%
Percentage lost	Started at	Finished at	Range for
0.00%	22:09:39	22:10:21	41.364978 sec

Table 2 Name server (ns.ssu.ac.kr) statistics

Date	Place	DNS Program	Time since boot	Time since reset
Oct 2 2002	Soongsil Univ.	BIND 8.2.2-P5	150269 (sec)	150269 (sec)
RR	RNXD	RFwdR	RDupR	RFail
823,370	439,968	710,946	1,334	1,875
RFErr	RErr	RAXFR	RLame	ROPTs
0	237	0	18,549	0
SSysQ	SAns	SFwdQ	SDupQ	SErr
436,914	2,402,330	316,407	81,456	0
RQ	RIQ	RFwdQ	RDupQ	RTCP
2,745,590	0	0	22,794	39,866
SFwdR	SFail	SFErr	SNaAns	SNXD
710,946	13	0	131,547	797,155

Table 3 Percentage of DNS lookups across the most popular query types

A	PTR	MX	ANY
64.41%	24.83%	5.35%	5.41%

Table 4 Performance Cisco Internet routers

Platform	Cisco 12416 Internet Router	Cisco 12410 Internet Router	Cisco 12406 Internet Router	Cisco 12406 Internet Router	Cisco 7600 Internet Router
Throughput (Packets per sec)	375 million	225 million	125 million	30 million	350 thousand

appears in Table 3.

For router processing time, benchmark from Cisco was used, and it is reciprocal of throughput. Table 4 shows the results of the benchmark.

The propagation time between hops is measured using 60,000 packets 40 bytes long between one host and the first external router from SSU network on September 28, 2002(Figure 9). The half value of RTT (Round Trip time) from this host to the first external router is assumed as one unit of propagation time between two hops. Average value of propagation time, $\overline{X}$ is 43.30ms and σ is 48.98ms. It is possible to say that propagation time between two hops will be laid between 42.91*ms* and 43.70*ms* with 95% confidence level. Average propagation delay time between two hops is assumed to be 43.2*ms*, propagation delay between hops follows an exponential distribution, and it is as follows:

$$\delta_i = -\frac{\ln R}{\lambda} \tag{3}$$

where R is random number between 0 and 1, and average propagation delay time, $\frac{1}{\lambda}$ is 43.2*ms*.

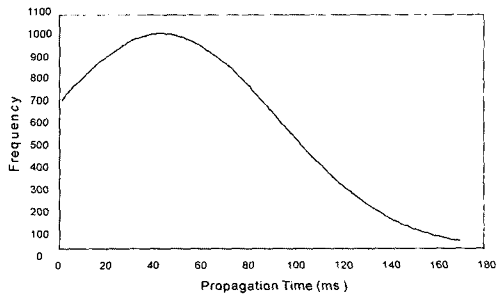


Figure 9 Propagation time between a host in SSU network and the first external network router

Let us now return to formula (1). β and γ are the same, because searching and caching process are jobs of the name server, and all name servers have same name server processing time. These values and router processing time, α, are negligible compared with other variables: hot count, and propagation delay time.

Now we can revise formula (1) and (2) as follows:

$$x_i = 2\sum_{j=1}^{m} n_j \delta_j,$$

if $i \le 1$ *then* $m = i$, *else* $m = i+1$ (4)

$$E(X) = 2\sum \sum_{j=1}^{m} (n_{\lambda_j} p_{\lambda_j} + n_{\mu_j} p_{\mu_j})\delta_j,$$

if $i \le 1$ *then* $m = i$, *else* $m = i+1$ (5)

4.2 Numerical Results[1)]

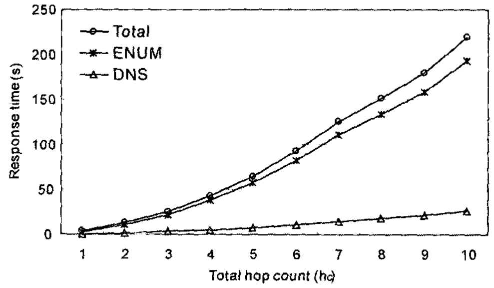
Table 2 tells us that the response rate for original DNS query of local name server is 88.48%, so we can assume the value of p_{μ}, as $p_{\mu_1} = 0.88$, and $p_{\mu_2} = 0.12$. The cache hit rate of local name server for ENUM query is supposed to be very low relatively to DNS query. It will never get ahead of DNS's cache hit rate, because the number and size of NAPTR RR per E.164 number should be more and bigger than RR per IP, so we suspect that $p_{\lambda_1} \ll p_{\lambda_2}$. n_1 is always 1. Here is a figure which shows expected response time with followed assumption:

$n_{\lambda_1} + n_{\lambda_2} + n_{\lambda_3} = n_{\mu_1} + n_{\mu_2} + n_{\mu_3} = h_c$, and h_c is the unit of hop count.

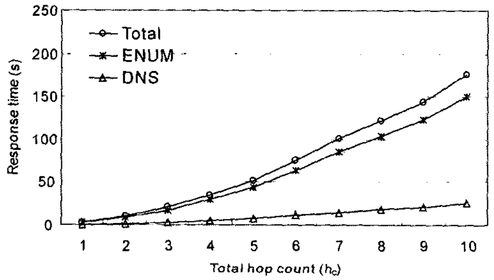
As the Figure 10(a) and 10(b) indicate, DNS response time is insensitive to the increment of hop count, and has no relevance at all to cache hit rate for ENUM. On the other hand, ENUM response time is very susceptible with increment of hop count and cache hit rate. As hop count increases from $2h_c$ to $5h_c$, ENUM response time at $p_{\lambda_1} = 0.3$ rapidly jumped from 8*sec* to 44*sec* approximately. As p_{λ_1} increases from 0.1 to 0.3, ENUM response time at $5h_c$ falls approximately from 57*sec* to 44*sec*. Figure 10 proves clearly that ENUM response time has a big influence upon total hop count(h_c), and total response time is no doubt to be decided by ENUM response time, not by DNS response time.

4.3 Analysis

To improve the total response time, it is essential to reduce the ENUM response time, and to reduce ENUM response time, it is inevitable to lessen total hop count. A name servers for ENUM is bound with geographical location similar to DNS generic



(a) $P_{\lambda 1} = 0.1$, $P_{\lambda 2} = 0.9$



(b) $P_{\lambda 1} = 0.3$, $P_{\lambda 2} = 0.7$

Figure 10 DNS, ENUM and total response time

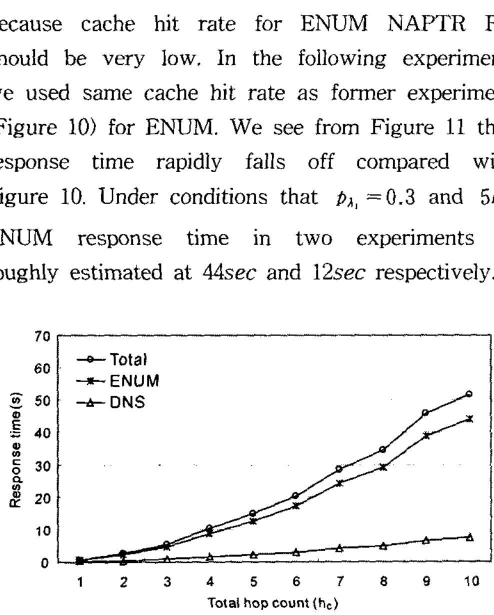
domain, so it is difficult to lesson total hop count. If we run name server to represent each local area as proposed section 3, then there is a fair possibility that name server knows the logical address of Tier 2 name servers corresponding to area code of E.164 numbers.

Whenever local resolver queries about E.164 number, which name server does not know, the query from local resolver does not have to be forwarded to root name server, not to Tier 1 name server either. This query would be forwarded to directly appropriate administrative Tier 2 name server which possess NAPTR RRs corresponding E.164 number. In other words, given that name server knows all of Tier 2 name servers' addresses corresponding to country area code, the key to an understanding of question as shown above from line 1 to line 4 is offered.

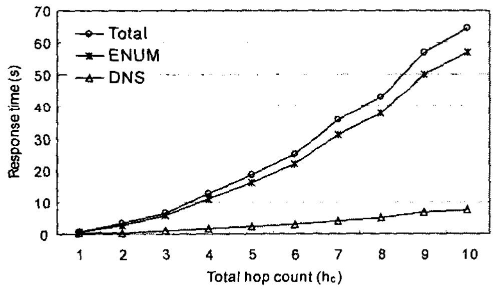
Whether name server caches NAPTR RR responded from Tier 2 name server, and how long name server will cache it are out of the questions

1) The definition of variables, p_{λ}, p_{μ}, and n is given formula (4) and (5).

because cache hit rate for ENUM NAPTR RR should be very low. In the following experiment, we used same cache hit rate as former experiment (Figure 10) for ENUM. We see from Figure 11 that response time rapidly falls off compared with Figure 10. Under conditions that $p_{\lambda_1}=0.3$ and $5h_c$, ENUM response time in two experiments is roughly estimated at 44*sec* and 12*sec* respectively.



(a) $P_{\lambda 1}=0.1$, $P_{\lambda 2}=0.9$



(b) $P_{\lambda 1}=0.3$, $P_{\lambda 2}=0.7$

Figure 11 DNS, ENUM and total response time when NAPTR RRs are managed by area code

5. Conclusions

ENUM supports connectivity between applications based on completely different communication infrastructures, with contemporary Domain Name System. Simply, this mechanism has PSTN users communicate to other parties in no matter what environment they belong to, and access to resources on Internet. In ENUM based environment, when we need to connect with another party in PSTN or IP network, we will use E.164 telephone number as an unified identifier. ENUM protocol requires to send query twice: one for E.164 number, and the other for URL. Resolution process for the first query is to get appropriate NAPTR RR from administrative Tier 2 name server, and it requires quite much time, compared to original DNS response time.

In this thesis, at first, we analyzed original DNS query response time with priority given to the hop counts from source terminal in the Soongsil University to a destination within Korea. Secondly, we estimated ENUM query response time with the same condition of the first analysis. These results from two experiments lead us to the conclusion that total response time is very correlated with ENUM response time. We proposed representative Tier 2 name server, so queries from local resolvers are seldom, if ever, forwarded to root name server or Tier 1 name server when local name server does not know the answer. For the most part, queries are directly forwarded to an appropriate administrative Tier 2 name server which possesses application-specific NAPTR RRs for each query, and we have seen this idea promises better performance in ENUM resolution process.

Further researches how to manage Tier 1 name server and Tier 2 name servers, how to advertise its address according to local area code with country code, how long information about name server can be reliable to use, and how to guarantee data coherence and security on all processes will be needed. In addition, a challengeable direction of this study will be to lower the ratio of cache hit rate radically and also to provide more dynamic caching technique, not limited to area code of telephone number.

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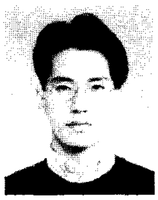

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