

# ENUM Use and Management for the Successful Deployment of ENUM-Enabled Services

Understand ENUM and its deployment to insure success of your VoIP and other ENUM-enabled services

Innovative ENUM management solutions such as Lucent's VitalQIP® ENUM Manager offer huge potential benefits to Service Providers deploying ENUM-enabled services.

**This white paper addresses:**

- ENUM and its operation
- ENUM in IMS networks
- Use of ENUM by VoIP peering partners
- Comprehensive ENUM management with Lucent's VitalQIP® ENUM Manager



## Introduction

With today's increased focus on convergent technologies, such as IP Multimedia Subsystem (IMS) networks, and the increased use of Voice over IP (VoIP) and other IP-based services like Multimedia Messaging Service (MMS), fast, easy, and reliable administration of IP addresses and Domain Name System (DNS) services is quickly becoming a critical management issue.

One technology beginning to be implemented in DNSs for supporting various types of services is ENUM, which is defined in IETF RFC 3761. Different sources define the ENUM acronym differently, and one definition, as per the IETF, is "tElephone NUmber Mapping." In brief, ENUM specifies a method for storing information in DNS servers to map an E.164 number (a.k.a., telephone number) to Uniform Resource Identifiers (URIs) for associated communication services (e.g., VoIP service). Each URI (for VoIP phone, cell phone, e-mail, web page, Session Initiation Protocol [SIP] Proxy Server, Session Border Controller, etc.) is stored in a DNS Naming Authority Pointer (NAPTR) record, which is in an E.164 domain.

One example application of ENUM is to convert a phone number dialed on the Public Switched Telephone Network (PSTN) to an IP address for a VoIP phone on the Internet. For example an E.164 domain name for the phone number (222) 333-4444 is "4.4.4.4.3.3.3.2.2.1.e164.arpa". Note that the digits in the E.164 domain name consist of a phone number in reverse order.

Lucent Technology provides a centralized management solution enabling you to administer ENUM domains (e.g., 1.my-enum.com) and their associated NAPTR records in VitalQIP® and Lucent DNS servers. As part of this solution, ENUM Manager, which is one of the optional modules of VitalQIP®, is used. Using a SOAP interface, an upstream provisioning system can create, update, delete, and search NAPTR records in ENUM Manager. ENUM Manager stores these records in the ENUM database, which is shared with VitalQIP®. VitalQIP® accesses this database, and uses the data in it to update downstream DNS servers, either through Dynamic DNS updates or zone file pushes.

Users can administer NAPTR records via ENUM Manager's Web GUI. To handle the growth of your ENUM domains, the ENUM Manager features the ability to split and merge them in order to manage the size of ENUM zone files used in DNS servers. The GUI also allows an administrator to create, update, delete, and search the NAPTR records. As a result of using VitalQIP® ENUM Manager, Lucent's DNS servers respond to queries for telephone number-to-URI translation for on-net calls and off-net calls to peering partners, and support other ENUM capabilities.

A comprehensive ENUM management application is a necessity to reliably deliver complex next generation services. Many service providers are looking to leverage their existing IPAM, DNS, and DHCP management applications to support ENUM services. As more and more service providers offer ENUM trials and subsequent service deployments, the ENUM management applications will need to keep pace with the needs of the service provider and evolving standards.

## Overview of ENUM and Its Operation

As described in the Introduction, ENUM is defined in IETF RFC 3761. In this RFC, the phrase *E.164 number* frequently appears, and it refers to *Recommendation E.164*, which was written by the International Telecommunication Union (ITU) and specifies the international public telecommunication

numbering plan. In brief, ENUM specifies a method for storing information in DNS servers to map an E.164 number (a.k.a., telephone number) to Uniform Resource Identifiers (URIs) for associated communication services (e.g., VoIP service). Each URI (for VoIP phone, cell phone, e-mail, web page, SIP Proxy Server, Session Border Controller, etc.) is stored in a DNS Naming Authority Pointer (NAPTR) record, which is in an E.164 domain, such as 4.4.4.4.3.3.3.2.2.1.e164.arpa. Note that the digits in the E.164 domain name consist of a phone number in reverse order. As defined in section 4 in RFC 3403, there are six resource data fields in a NAPTR record, and they are as follows:

- Order
- Preference
- Flags
- Services
- Regular Expression
- Replacement

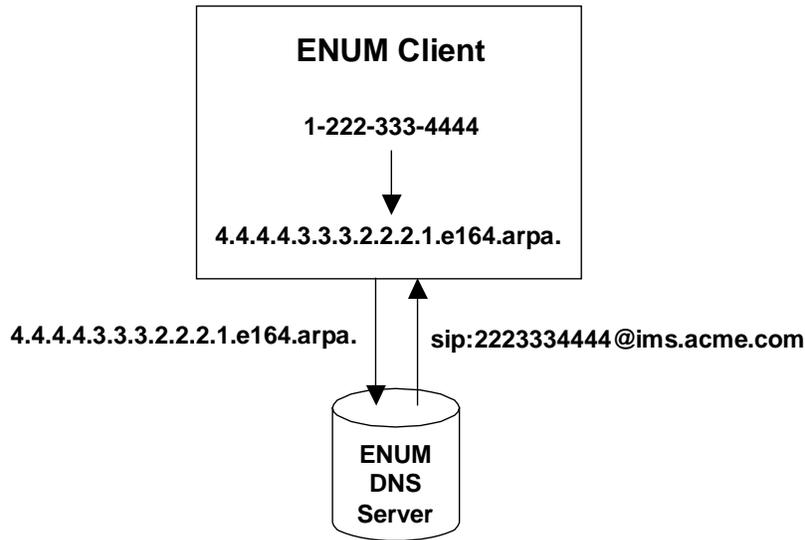
An example NAPTR record is as follows:

```
4.4.4.4.3.3.3.2.2.1.e164.arpa. IN NAPTR 100 10 "u" "E2U+sip" "!^.*$!sip:2223334444@ims.acme.com!" .
```

In this example record, the following values were used (and Replacement was not used).

- Order = 100
- Preference = 10
- Flags = u
- Services = E2U+sip
- Regular Expression = !^.\*\$!sip:2223334444@ims.acme.com!

The figure below provides a brief overview of the typical operation of ENUM.



**Figure 1 - Typical ENUM Operation**

The main steps that occur in this figure are as follows:

1. An ENUM client starts with a called phone number, e.g. 1-222-333-4444.
2. The client turns the number into a domain name, e.g. 4.4.4.4.3.3.3.2.2.2.1.e164.arpa.
3. The client, using a resolver, queries a DNS server with the domain name.
4. The DNS server returns the NAPTR records in the domain to the client.
5. If multiple NAPTR records are returned, the client picks one to use based on the Order, Preference, and Services field values in the records.

If the URI in the selected NAPTR record contains a host name (e.g., ims.acme.com), then the client will do a second non-ENUM DNS query to determine the host's IP address.

## Overview of ENUM in IMS

Below are summaries for two example call flows for VoIP calls made using an IMS network that uses ENUM. In the first scenario, which is depicted in the figure below, one IMS subscriber calls another IMS subscriber.

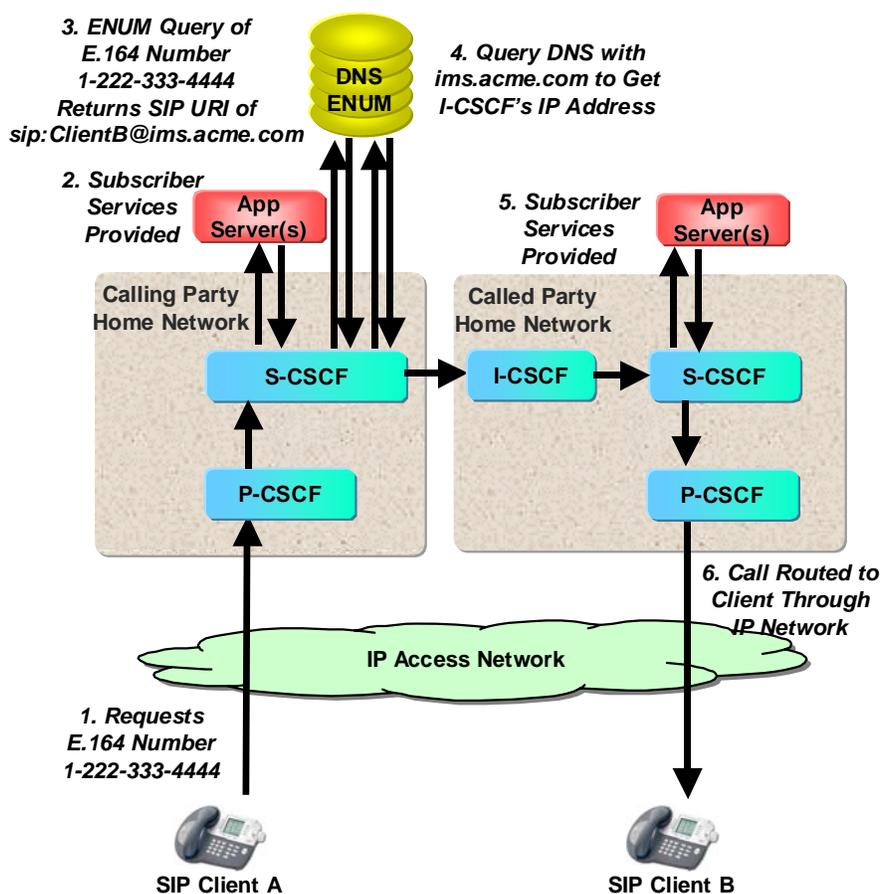


Figure 2 - IMS Subscriber-to-IMS Subscriber Call

In this case, the following steps are carried out to setup and route the call through the IP network.

1. User of SIP Client A calls E.164 number of 1-222-333-4444 in order to reach user of SIP Client B.
2. The Serving - Call Session Control Function (S-CSCF) communicates with the Application Server to provide subscriber services.
3. The S-CSCF queries the DNS/ENUM server with the E.164 number, and it returns the SIP URI of sip:ClientB@ims.acme.com.
4. The S-CSCF queries the DNS/ENUM server again to get the host IP address for ims.acme.com. This IP address is the address of the Interrogating-CSCF (I-CSCF). (Note that in most networks the DNS and ENUM servers are usually separate servers, but are illustrated above as a single server for simplification. Also, although not shown, the following is done: the S-CSCF sends a SIP Invite message to the I-CSCF, and it queries the Home Subscriber Server [not shown] in the Called Party Home Network to determine the S-CSCF currently serving Client B.)
5. The S-CSCF in the Called Party Home Network communicates with the Application Server to provide subscriber services.

- A session is established between the two endpoints, and bearer traffic between them is routed through the IP access and backbone networks.

For the case where an IMS subscriber calls a PSTN subscriber, the main steps to setup and route the call are depicted in the figure below.

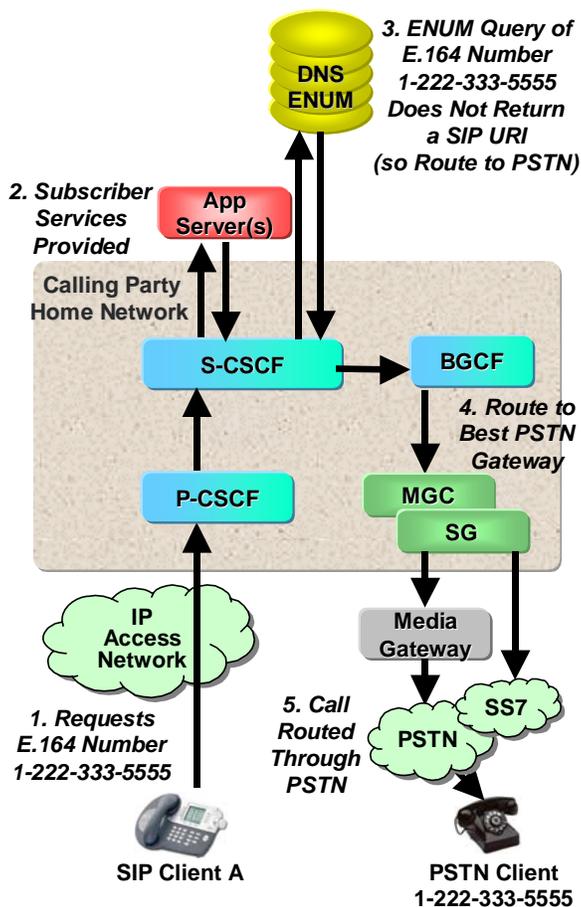


Figure 3 - IMS Subscriber-to-PSTN Subscriber Call

In this case, the following steps are carried out to setup and route the call.

- User of SIP Client A calls E.164 number of 1-222-333-5555, which is on the PSTN.
- The S-CSCF communicates with the Application Server to provide subscriber services.
- The S-CSCF queries the DNS/ENUM server with the E.164 number, and it does not return a SIP URI, since the server does not contain a NAPTR record for this PSTN number.
- The call is routed to a PSTN Gateway.
- The call is routed through the PSTN network to 1-222-333-5555.

## Location of DNS Records for VoIP Peering Partners

Service providers may choose to partner together and interconnect their VoIP networks in order to bypass the PSTN. In this case, peering using ENUM and DNS can be done between partners, and DNS records that will be used by partners can be located in DNS servers in various locations. The main records of interest here are the NAPTR records that map E.164 numbers to SIP addresses of partners' Session Boarder Controllers (SBCs) used to access their networks, and Address records that map the host portion of SIP addresses of partners' SBCs to their IP addresses. Three possible locations for these two types of records are as follows:

Option 1: In DNS servers located in a Centralized VoIP Services Data Center that can be queried by all partners

Option 2: In DNS servers located on the premises of the service provider that owns the SBC, with the centralized DNS servers delegating authority for domains to these servers

Option 3: In centralized Master DNS servers, and in Slave DNS servers located on partners' premises

Since the location of the NAPTR and Address records is independent, nine combinations exist here. A key consideration here is the ability to quickly access the records so as to minimize call/session setup time. With this criterion, Option 3 is the best option, because a DNS server on an partner's premises will be able to resolve client queries from that partner, and will not need to send queries across the partner's network and a backbone network to get to another DNS server. However, this option has the disadvantages of having the most zone update traffic and the longest zone propagation update times during provisioning.

## Possible ENUM DNS Architecture for VoIP Peering Partners

An overview of a possible ENUM DNS architecture for VoIP peering partners using "Option 3" from the previous subsection for the location of the DNS records is presented in the figure below.

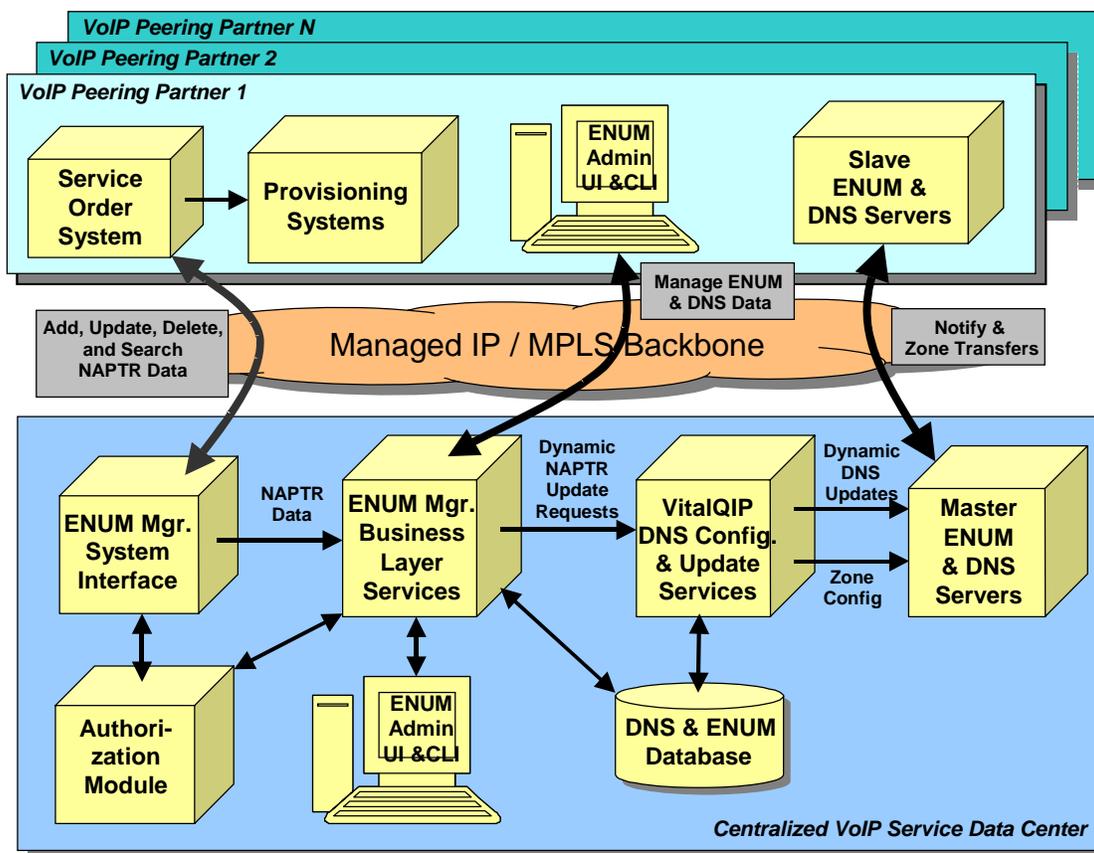


Figure 4 - Possible ENUM DNS Architecture for VoIP Peering Partners

In order to provision NAPTR records for a service provider’s current subscribers in the DNS & ENUM Database and downstream DNS Servers shown in this figure, a service provider would probably need custom or semi-custom software to first retrieve NAPTR data (phone numbers, associated SIP addresses, etc.) from their existing databases. This data could then be loaded by using scriptable command line utilities to bulk load files containing NAPTR data, or by sending the data to the ENUM Manager System Interface.

For subsequent add, update, and delete operations, a service provider’s Service Order System would send NAPTR data (phone numbers, associated SIP addresses, etc.) to the ENUM Manager System Interface, which uses SOAP. (In the future the Extensible Provisioning Protocol described in RFC 3730 or another type of interface may also be available.) Data received would be stored in DNS NAPTR records in the DNS & ENUM Database, which is a centralized relational database.

The ENUM Administrative User Interface depicted consists of ENUM Manager’s browser-based GUI, and a service provider would use it when there is a need to manually operate on ENUM data. This Administrative Interface would also be available in the Centralized VoIP Service Data Center (SDC), and could be used, for example, to perform zone split and merge operations to manage the size of zones.

The VitalQIP DNS Configuration and Update Services component provides scalable replicated services to perform the generation of the configuration and zone files for the downstream Master DNS servers in the VoIP SDC. Also, after a provisioning request is received from an upstream Service Order system, this Configuration component could send out a Dynamic DNS Update (as per RFC 2136) in near real time to the downstream Master DNS server.

Periodic zone transfers could be scheduled to transfer zone data from the Master ENUM and DNS servers located in the VoIP SDC to the Slave ENUM and DNS Servers located in the data centers of the peering partners. Additionally, with VitalQIP's DNS Configuration & Update Services, it is also possible to send zone updates or Dynamic DNS Updates to all downstream Master and Slave DNS servers.

One concern with provisioning NAPTR data is with finding an appropriate authorization mechanism to verify that a service provider has the right to perform a provisioning operation. One option for performing authorization would be to use a DNS mechanism, such as Transaction SIGnature (TSIG). Another possibility would be to perform authorization upstream of the DNS servers in the provisioning process. For example, this could be done by checking permissions in an authorization database, or possibly by having service providers provision a key with each domain name (e.g. 2.1.2.1.5.5.5.2.0.2.1.voippeers.com.). This key could protect existing NAPTR records in that domain from being updated or deleted by another service provider. Further study is needed here to find the best way to perform authorization.

### **Possible Future Capabilities with ENUM**

ENUM was developed to extend an already proven technology, DNS, by enabling translation between not only hostnames and IP Addresses, but translation between E.164 numbers and associated services. With the advances in communications over the last several years most of us have many different contact methods, for example, home number, office number, mobile number, fax number, office email address, home email address, IM address, etc. ENUM enables using a single registered contact number to map to other methods of contact. For instance, an ENUM compliant email application can query the DNS using an E.164 number and what is returned is an associated email address. Once the email address is returned the email application can then send an email message to the end user. Similarly, this same E.164 number can be entered in a web browser in order to retrieve an associated web page. All this can be accomplished through the use of only the end-user phone number, an E.164 number.

In the near future intelligent applications will be emerging allowing potentially multiple methods of contacting someone in the event the primary method is unavailable. An example future scenerio that would extend the use of ENUM even further could be using the E.164 number to place a call to an office based on time of day. In the event a connection could not be established, or during non-office hours, the call can be automatically sent to the users mobile number. Also, if the call is made during the late evening hours, the call might launch an email application instead. The caller would then have the option of sending an email to the user's office email account. In order for the previous scenerio to take place some additional development and applications are needed. However, ENUM provides a mechanism in which Order and Preference values can be assigned to records today. This capability allows the end user to specify, for example, that between 9 AM and 5 PM the primary contact method is the office number. From 5 PM to 10 PM the primary contact method becomes the mobile number, and at all other times an email message should be sent.

## Comprehensive ENUM Management

ENUM extends the existing infrastructure by adding support for additional types of services in the DNS. This is accomplished through supporting NAPTR records in DNS. Support for NAPTR records in DNS is natively supported in BIND. As such, compliant DNS applications using the appropriate BIND version, technically support ENUM. However, in order to effectively and efficiently manage ENUM services, additional functionality is required of the management platform. Any complete ENUM management solution must support the administration of both ENUM domains (e.g., 1.my-enum.com) and the NAPTR records in both the application's database and the corresponding DNS/ENUM servers.

NAPTR records are supported by BIND, but entering and managing the NAPTR records can be cumbersome. Simply entering and formatting the regular expression field can be a cause of major concern. The syntax of the regular expressions lends itself to be error prone if configured manually. In almost every enterprise, and certainly all service providers, a data store of some type exists. In this data store, employees' or subscribers' contact information is stored. A method to extract bulk contact information and populate the ENUM database is required to facilitate rapid service turnout. In addition to the bulk interface, an open interface to existing provisioning applications is needed to properly function in some service providers' networks, such as an IMS network. Once the records are imported into the ENUM application the ability to modify the NAPTR records is needed. In the event neither the bulk interface or provisioning interface are used, NAPTR records must be manually created, deleted, and modified. A user-friendly GUI enables manual configuration of the essential parameters to be quickly accomplished. The GUI should provide the capability to automatically create the regular expressions as required and provide a level of error checking/validation during the process.

Proper management of the ENUM domains is a mission critical function. ENUM services are expected to significantly increase the DNS management burden. When choosing an ENUM management platform, the initial consideration should center around the application's DNS management capabilities. If the vendor's DNS management platform is limited, chances are ENUM management will also be severely limited. The ENUM management platform must contain the capability to split and merge ENUM domains to manage the size of ENUM zone files used in DNS servers. By the very nature of the ENUM domain structures, the ability to split the domains is supported, however not easily. The following NAPTR record, which initially exists in the my-enum.com zone, will be used to illustrate splitting ENUM domains.

```
4.4.4.4.3.3.3.2.2.2.1.my-enum.com. IN NAPTR 100 10 "u" "E2U+sip" "!^.*$!sip:info@tele2.se!"
```

In the above record, starting from the left the first 11 digits represent the primary phone number. The record can be split at any decimal as each decimal represents a level in the DNS/ENUM hierarchy. One logical method to distribute and manage NAPTR records is to split the original my-enum.com zone into individual zones by country code, and then by area code. Consequently, in this example, the following zones would be created:

- 1.my-enum.com. (This zone is used to manage country code 1.)
- 2.2.2.1.my-enum.com. (This zone is used to manage area code 222.)

Records for other area codes could remain in the 1.my-enum.com zone, or, when appropriate, zones could be created for some or all of them.

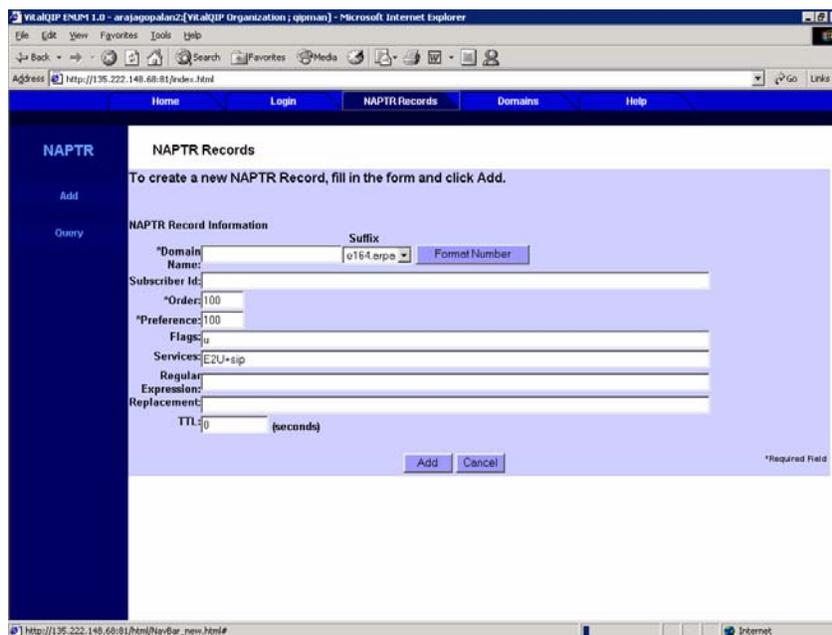
Not only should the ENUM application be able to split ENUM zones, but merging ENUM zones is required. The ability to split and merge ENUM zones provides flexibility to ENUM administrators to manage the size of ENUM zone files for best performance.

## Leverage Lucent VitalQIP® to Manage ENUM

Lucent Technologies provides a centralized management solution enabling administration of ENUM domains (e.g., 1.my-enum.com) and their associated NAPTR records in VitalQIP® and Lucent DNS servers. VitalQIP® ENUM Manager provides the ability to administer NAPTR records in the VitalQIP® database, and manage and update Lucent DNS servers. Lucent's DNS servers use NAPTR records to respond to client queries.

Using an XML/SOAP interface, data for NAPTR records can be loaded from a variety of sources into VitalQIP®. This interface supports dynamic loading of new records from provisioning systems, such as Lucent Technologies' eSM in IMS networks, and bulk loading of records from databases for initial population of NAPTR records. If desired, bulk loading of records can also be done from a file, using a CLI command. ENUM Manager stores the NAPTR records in the ENUM database, which is shared with VitalQIP®. VitalQIP® accesses this database, and uses this data to update downstream DNS servers, either through Dynamic DNS updates or zone file pushes.

When manual administration of NAPTR records is needed, it is done via ENUM Manager's Web GUI. The ENUM Manager GUI allows an administrator to manually create, update, delete, and search the NAPTR records. The administrator simply populates a few fields and, once executed, the record is sent to the VitalQIP® database and, if desired, the appropriate Lucent DNS servers. NAPTR records are created in VitalQIP® ENUM Manager using the screen shown below in Figure 5.



The screenshot displays the VitalQIP ENUM Manager Web GUI in a Microsoft Internet Explorer browser window. The browser title is "VitalQIP ENUM 1.0 - arajagopalansz[VitalQIP Organization : qjpsan] - Microsoft Internet Explorer". The address bar shows "http://135.222.148.68:81/index.html". The page has a blue header with navigation tabs: Home, Login, NAPTR Records, Domains, and Help. The main content area is titled "NAPTR" and "NAPTR Records". It contains a form for creating a new NAPTR record. The form includes the following fields: "Domain" (with a dropdown menu showing "e164.arpa" and a "Format Number" button), "Name", "Subscriber Id", "Order" (set to 100), "Preference" (set to 100), "Flags" (set to "u"), "Services" (set to "E2U+sip"), "Regular Expression", "Replacement", and "TTL" (set to 0 seconds). There are "Add" and "Cancel" buttons at the bottom of the form. A "\*Required Field" label is visible in the bottom right corner of the form area.

Figure 5 - VitalQIP® ENUM Manager NAPTR Record Creation

Once NAPTR records are either manually created or the database is populated through the various interface methods, the administration of the records without an intuitive GUI may quickly become burdensome. Each user may have multiple services associated with their E.164 number, and, consequently, the size of the ENUM database may grow rapidly. The ability for an administrator or troubleshooting technician to search the ENUM database is an essential component of effective NAPTR record management. The VitalQIP® ENUM Manger NAPTR record search screen is shown below in Figure 6.

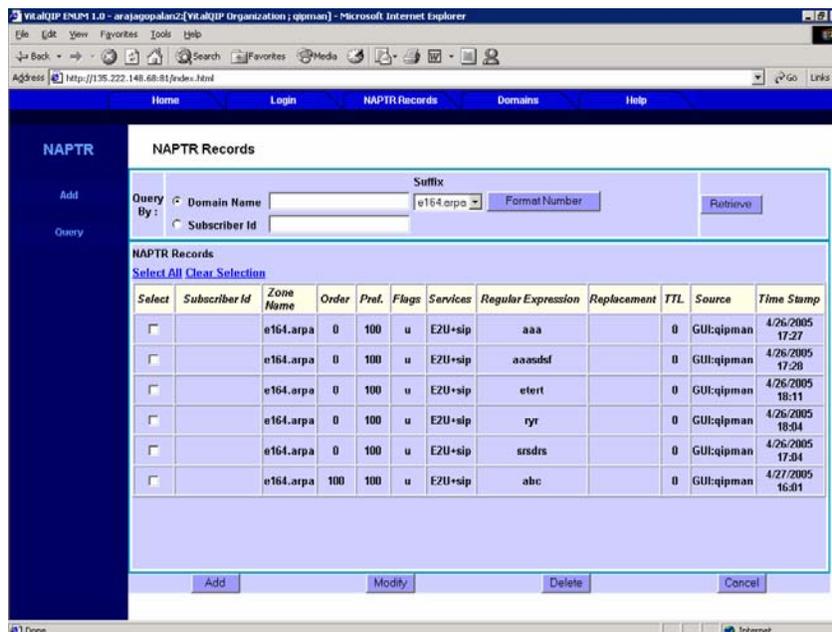


Figure 6 - VitalQIP® ENUM Manager NAPTR Record Search

The ability to quickly locate specific NAPTR records and providing the administrator tools to take the desired action drastically improves ENUM management over stand-alone BIND support. Users can search NAPTR records by either domain or subscriber. Tools provided allow addition, modification, and deletion of NAPTR records.

To handle the growth of your ENUM domains, the ENUM manager features the ability to split and merge ENUM domains to manage the size of ENUM zone files used in DNS servers. ENUM zones can be split at the country code, city code, area code, exchange level, and potentially between any digit in the E.164 number. VitalQIP® ENUM Manager provides broad domain management capabilities to the administrator. Through the user-friendly GUI (see Figure 7 below), domains can be split, merged, and deleted quickly. An administrator simply highlights the desired domains, clicks on the appropriate button, and the appropriate zone files are manipulated as desired. Over time, as needs change, an administrator can easily rearrange the ENUM domains to improve performance.

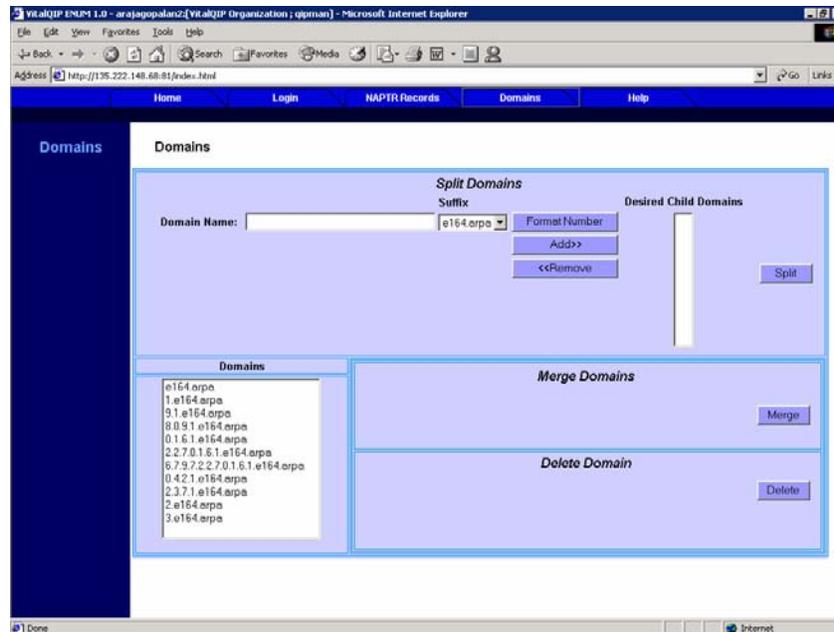


Figure 7 - VitalQIP® ENUM Manager E.164 Domain Management

## VitalQIP® is Your Complete IP Address Management Solution

VitalQIP® Domain Name System/Dynamic Host Configuration Protocol (DNS/DHCP) and IP Management Software is used by hundreds of customers, including Global 1000 companies and top Service Providers around the world, to automate their essential IP name and address services needs. This innovative system has received numerous honors and awards, including the Network World Blue Ribbon Award. VitalQIP® is consistently rated a best-in-class IP management solution by industry analysts and market research firms. Market-leading VitalQIP® software helps you efficiently configure, automate, integrate, and administer IP services across your entire network — locally or globally. This powerful management software centralizes planning and administration, enabling you to rapidly provision address space and reliably deliver critical IP name and services throughout your network. Compatible with multiple technologies and platforms, it helps you streamline management tasks with a comprehensive suite of integrated tools and user interfaces.

VitalQIP® software is widely deployed in high-volume distributed network environments, where it has demonstrated its ability to support demanding environments with millions of individual IP addresses and hundreds of thousands of domains. Built-in support for master and slave DNS servers, as well as Dynamic DNS updates, helps you avoid network outages and automate address and name assignments. VitalQIP® ENUM Manager offers comprehensive administration capabilities to effectively leverage the existing DNS infrastructure, permitting ENUM-enabled services to be deployed in the network.

As your network continues to grow, more IP devices, more traffic, and newer technologies such as VoIP continuously increase your management responsibilities. To keep pace — and to make the most of your existing infrastructure investments — you need the automated, highly scalable management tools that VitalQIP® provides.

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