

Prepared (also subject responsible if other) EJIAHLU Jiahui Lu		No. 52/155 17-AVA 901 16 Uen		
Approved	Checked	Date 2016-03-29	Rev B	Reference

IPWorks ENUM Function Overview

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1 Introduction

1.1 Document History

Rev	Date	Sign.	Comment
A	2015-06-11	ECIAMAO	New document based on 1/155 17-AVA 901 16 Uen D.
B	2016-01-12	ECIAMAO	Update Section 4.
C	2016-02-02	EJIAHLU	Delete section 4, and split the content into 3 different CPIs. <ul style="list-style-type: none">- Fault Management- License Management- Performance Management

1.2 Purpose

The purpose of this document is to specify the functional design for the ENUM Server in IPWorks.

1.3 Scope

The scope of the document is limited to the specification of the ENUM functions.

1.4 Document Structure

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2 Survey of Included Functions

2.1 Overview

IPWorks supports a number of protocols, including the DNS protocol and the ENUM protocol.

ENUM is a specific usage of the DNS protocol used for mapping telephone numbers to Uniform Resource Identifiers (URIs). More specifically, ENUM is an application of the Dynamic Delegation Discovery System (DDDS), which is built on DNS. See Reference [12] for a list of RFCs specifying DNS and DDDS.

IPWorks provides a monolithically scalable solution for DNS and ENUM services. It can provide for large numbers of ENUM records with high ENUM transaction rates and low latency.

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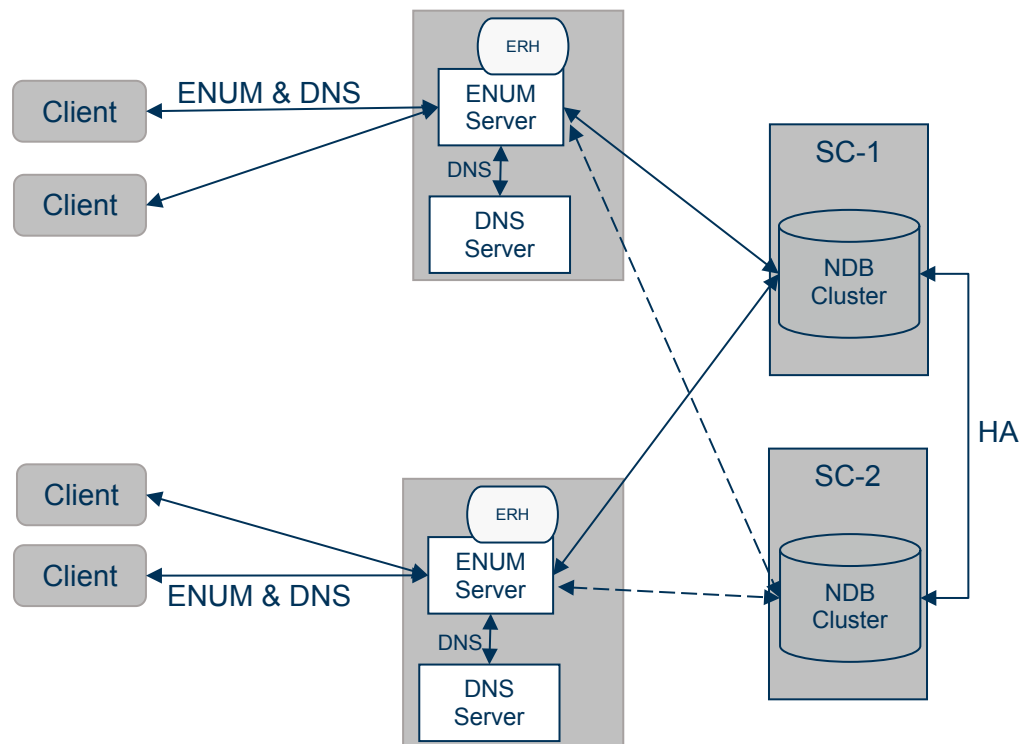


Figure 1 IPWorks ENUM Server Generic Architecture

The ENUM Server receives DNS and ENUM requests from the clients. The ENUM Server handles ENUM queries which fit into the configured ENUM zone itself. It forwards all other requests to the IPWorks DNS Server. Responses from the DNS Server are returned unchanged through the ENUM Server.

For the ENUM queries which fit into the configured ENUM zones, ENUM access view control could be applied. If an ENUM query fails to pass the access control, it will be abandoned silently.

For the queries which have passed the access control and fall into specific ENUM view, the following procedure will be carried out step by step:

1. Try to fetch an entry in the ENUM local database for the query. If succeed, reply to client with the information available, otherwise
2. Check the number series level configuration within this ENUM view. Three kinds of configurations exist:
 - a. Up to 5 wildcard (Asterisk Label and Number Range, See 3.4 for details) NATPTR resource records for this number series.

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b. Forward the query to BIND DNS server.

c. Forward the query to ERH for number portability query processing.

3. If all above steps fail, NXDOMAIN will be replied to the ENUM Client.

For number series level configuration type c: number portability processing, please refer to IPWorks Number Portability Function Overview [16].

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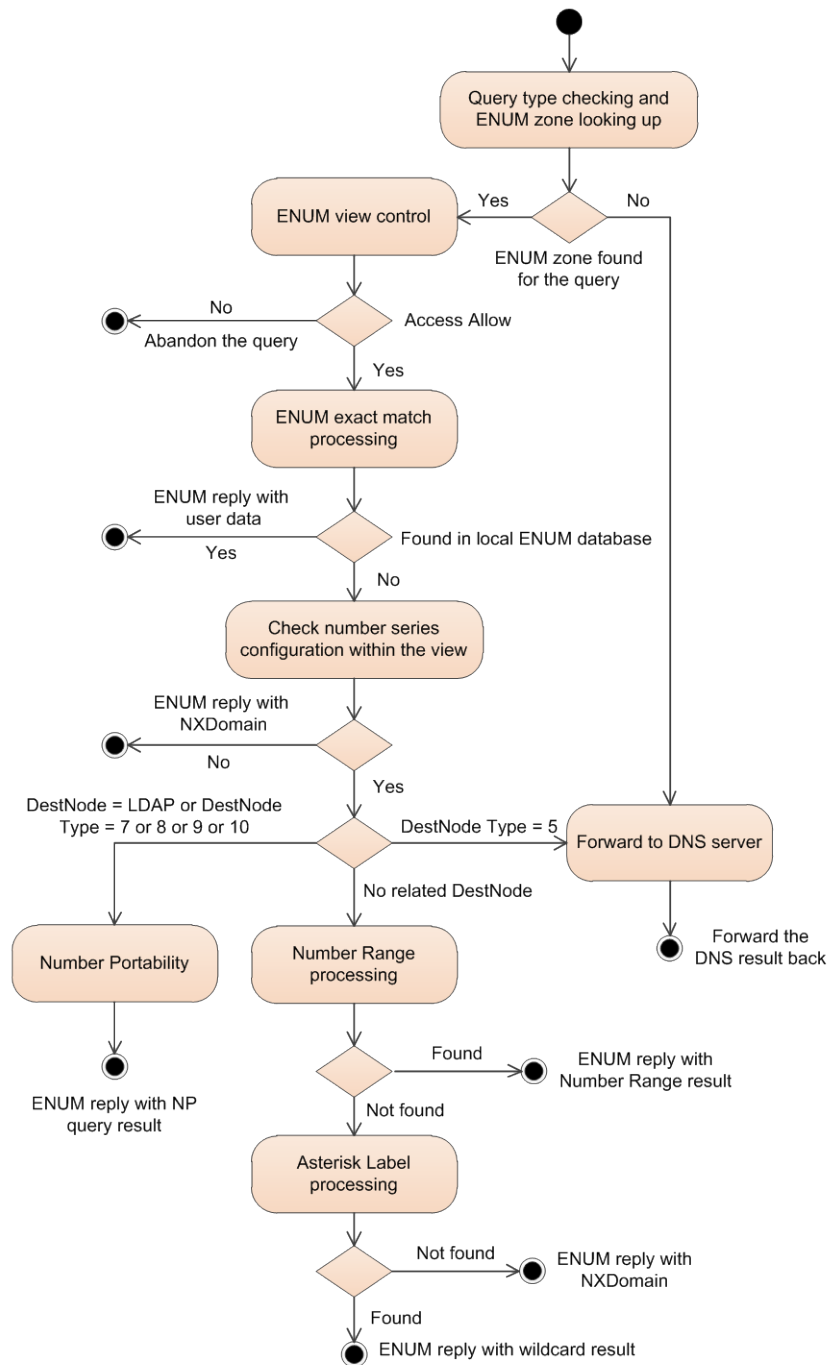


Figure 2 ENUM Server Processing Activity

ENUM Server configuration data is stored in the MySQL NDB database. The Storage Server is responsible for replicating the ENUM Server configuration data on the MySQL NDB data clusters.

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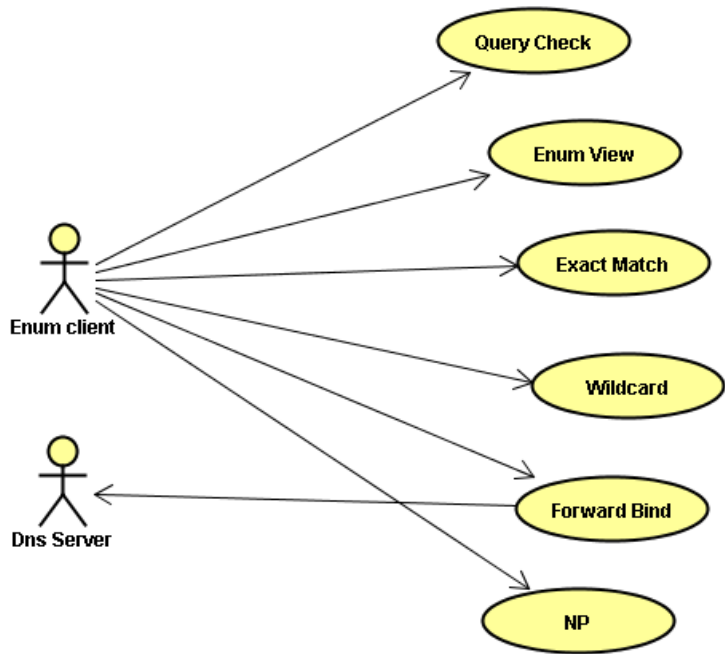


Figure 3 ENUM Server Functions Overview

2.2 List of Actors

2.2.1 Actor: ENUM Client

It is the client performing E.164 number query.

2.2.2 Actor: DNS Server

DNS server locates on the same physical machine with ENUM server and handles the queries from ENUM appropriately, then sends back the processing result to ENUM Server.

2.3 List of Sub-Functions

2.3.1 Query Type Checking and ENUM Zone Looking up

ENUM Server only processes the query which is of NATPTR ENUM type and has a valid ENUM Zone existing. This is preliminary ENUM query selecting function.

2.3.2 ENUM View Control

ENUM View Control comprises two parts, ENUM client access control and split name space for number series level configuration.

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2.3.3 ENUM Exact Match processing

ENUM server always tries to find the exact match for the ENUM query domain name. If an entry found in local database, an ENUM reply will be sent back to ENUM client immediately with the information got, otherwise number series level processing like wildcard or number portability functions will be triggered.

2.3.4 Wildcard Option processing

ENUM wildcard function brings the possibility to synthesize a range of telephone numbers with a common resource record (RR) set. ENUM server provides two kinds of wildcard match. One is asterisk label match. The other is number range match.

2.3.5 Forward to Bind

For non- ENUM queries or ENUM queries which don't have valid ENUM zone configured in ENUM server, they will be forwarded to Bind directly.

For ENUM query which fits into a configured ENUM zone while no entry exists in local database, if it also fits into a number series which is configured to forward the query to Bind DNS server, the forwarding action will be performed.

ENUM reply from Bind DNS server will be forwarded back to ENUM client by ENUM server.

2.3.6 Number Portability

Please refer to IPWorks Number Portability Function Overview [16] for detailed description.

2.3.7 RCS-e interconnect

Rich Communication Suite Enhanced (RCS-e) is a GSMA standard, specifying a service for enriched communications among the subscribers of different operators.

In RCS-e scenario, the DNS/ENUM is designed to use a 2-tier system including eTier0 and eTier2. Compared with the traditional DNS/ENUM architecture, there is no Tier1. The enhanced eTier0 and eTier1 share the Tier1 functionality.

RCS-e uses the existing MNP to get information about national ported-out numbers.

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traditional DNS/ENUM Architecture enhanced eTier 0 and eTier 2

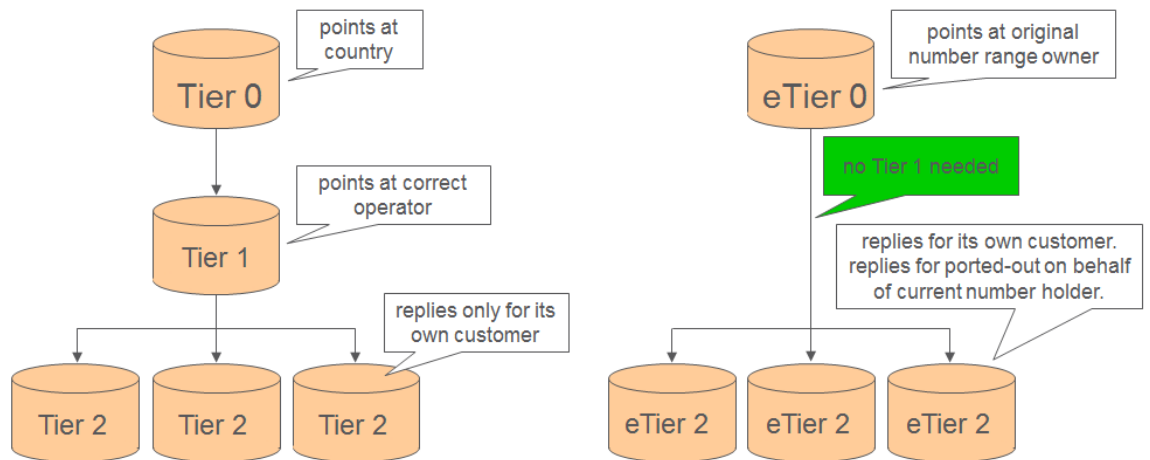


Figure 4 DNS/ENUM Architecture

eTier 0 – Global level

- The eTier0 holds the number plans/ranges for operators (Service Provider).
- The eTier0 points at original number range owner

eTier 2 – Service Provider level

- The eTier2 keeps control of its ENUM data and replies for its own customer.
- For the ported-out number, the eTier2 provides reply on behalf of the current number holder by using the existing MNP.

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2.3.7.1 RCSe Interconnect Handling Query Procedure

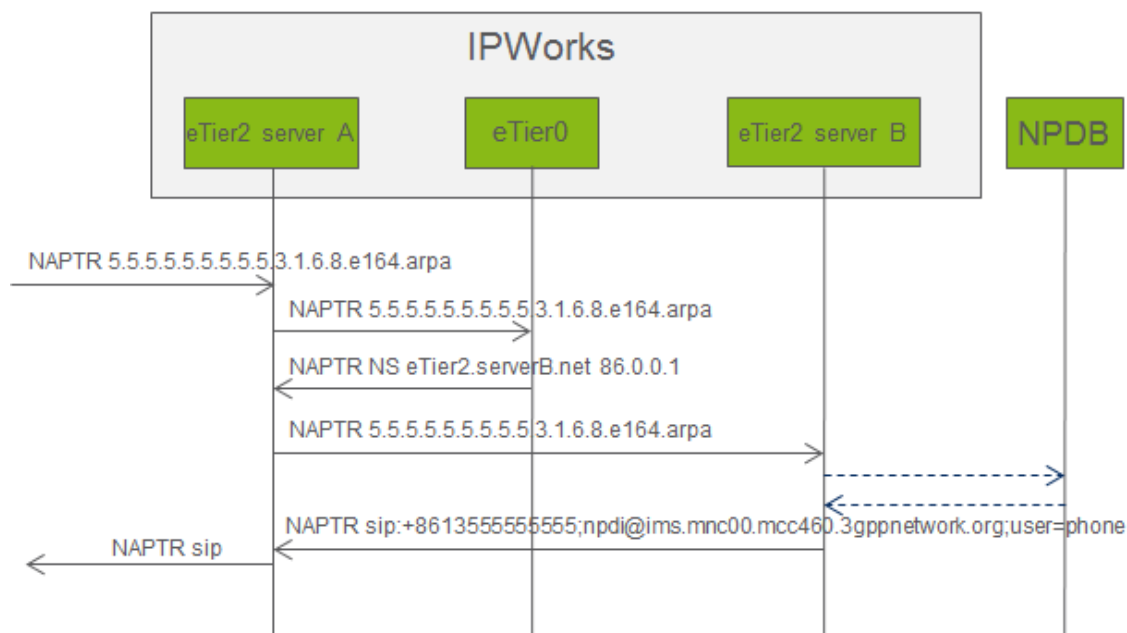


Figure 5 RCSe interconnect Handling Query Procedure

- 1 The eTier2-server-A receives a query from a client.
- 2 If the number of this query is not managed by eTier2-server-A. The eTier2-server-A sends a query to eTier0 for asking for the range owner of this number; and eTier0 returns the range owner as response.
- 3 According to the range holder, the eTier2-server-A forwards the query to the eTier2-server-B who is the owner of this number.
- 4 The eTier2-server-B checks whether this number is ported out by using the existing MNP. If this number is ported out, the eTier2-server-B constructs the response according to query source and current operator.
For details about the corresponding reply format, refer to table 1.
- 5 The eTier2-server-B responds to the eTier2-server-A on behalf of the current number holder.
- 6 Finally, the eTier2-server-A sends response back to client.

Table 1 NP Response Consisting of Specific URI Format

Type of Terminating Operator	Type of ENUM Client	
	Local or National ENUM Clients	International ENUM Clients or Unknown Clients
Local Operators (OP)	The expected NP response example:	NXDOMAIN

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Type of Terminating Operator	Type of ENUM Client	
	Local or National ENUM Clients	International ENUM Clients or Unknown Clients
or unknown OPs	E2U+pstn:tel !^.*\$!tel:+86-123-456-7809;npdi;rn=+86-234-567-8901!! , where the E2U+PSTN:tel is a fixed URI format.	
Other OPs not participating in RCSe interconnect	<p>Two selective NP response:</p> <ul style="list-style-type: none"> If the users apply the attribute ServiceParameter with E2U+PSTN:tel, the expected NP response example is: E2U+pstn:tel !^.*\$!tel:+86-123-456-7809;npdi;rn=+86-234-567-8901!! If the users apply the attribute ServiceParameter with E2U+PSTN:sip, the expected NP response example is: E2U+pstn:sip!^.*\$!sip:+86-123-456-7809;npdi;rn=+86-234-567-8901@ims.mnc004.mcc460.3gppnetwork.org;user=phone!.¹ 	NXDOMAIN
Other OPs participating in RCSe interconnect	The expected NP response is generated by server itself, which means the users cannot make any additional configuration. The NP response contains a fixed URI E2U+SIP.	<ul style="list-style-type: none"> For International ENUM Clients: E2U + SIP For unknow clients: NXDOMAIN

¹ In the NP response, the ims is the Subdomain value that takes effective when ServiceParameter is with value E2U+PSTN:sip.

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3 Detailed Description

3.1 Query Type Checking and ENUM Zone Looking up

Except NAPTR ENUM Query type, all other types of queries will be forwarded to Bind DNS server directly. For NAPTR queries, only those which could find valid zones in ENUM server would be continued with the following ENUM View Control processing.

3.2 ENUM View Control

3.2.1 ENUM View Access Control

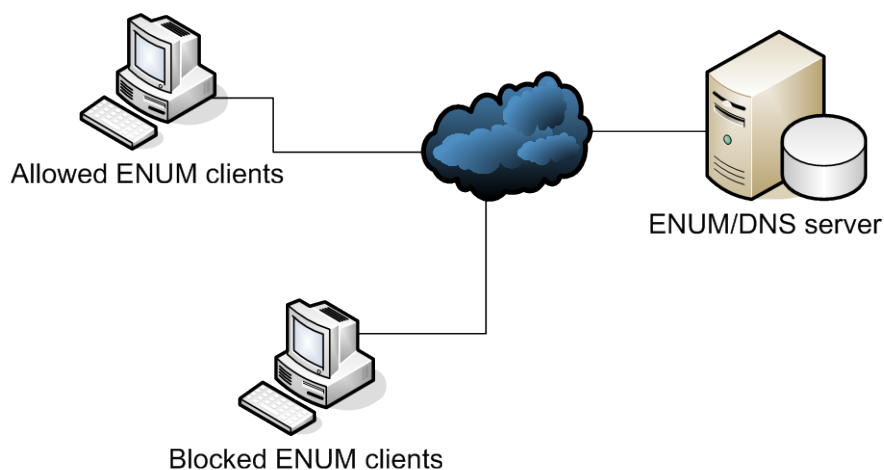


Figure 6 Access Control System Overview

ENUM server has an access control mechanism that will allow or block ENUM queries from clients based on the clients' source IP address.

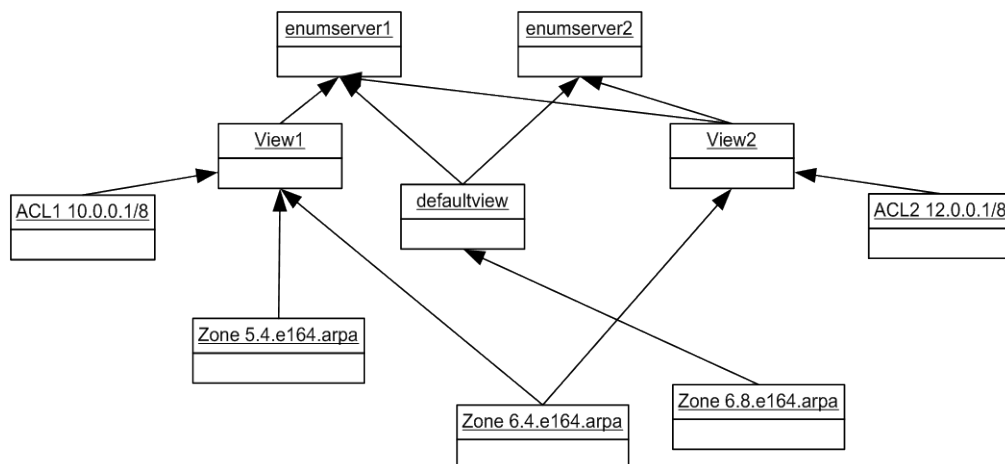


Figure 7 ENUM View for Access Control Example

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ENUM view is an access control mechanism for ENUM data. One ENUM view controls the access for a defined set of ENUM zones. A default ENUM view exists that is not created by the operator. The default view is accessible by any client. If an ENUM zone is controlled by an operator defined ENUM view it will not be part of the default view. When a zone is configured for an ENUM view it will automatically be taken out of the default view. If an ENUM view is deleted and the ENUM zones contained within the deleted ENUM view do not belong to any other ENUM view, the ENUM zones will be released into the default view.

An ENUM view may be applied to multiple ENUM servers. An ENUM view controls the same set of ENUM zones regardless which ENUM server it belongs to. The access to an ENUM view controlled ENUM zone is controlled by means of an enumacl which is a set of allowed client IP addresses. There will be only one enumacl defined per ENUM view. An ENUM view has the same enumacl regardless which ENUM server it belongs to. Each ENUM view is configured with a rank. The rank defines in which priority the operator defined views is be searched by the ENUM server. The rank must be unique otherwise CLI will return an error.

If the operator deletes an ENUM zone, then it will also trigger deletion of the relationship with the ENUM zone from all the ENUM views controlling this ENUM zone.

Please refer to Reference [2] for the configuration of ENUM view, enumacl and related ENUM zones.

3.2.2 Split Name Space for Number Series Level configuration

Split name space here means for same number series in different views, different configurations could exist. Note the data structure of for number series in ENUM server is named as EnumDNRange.

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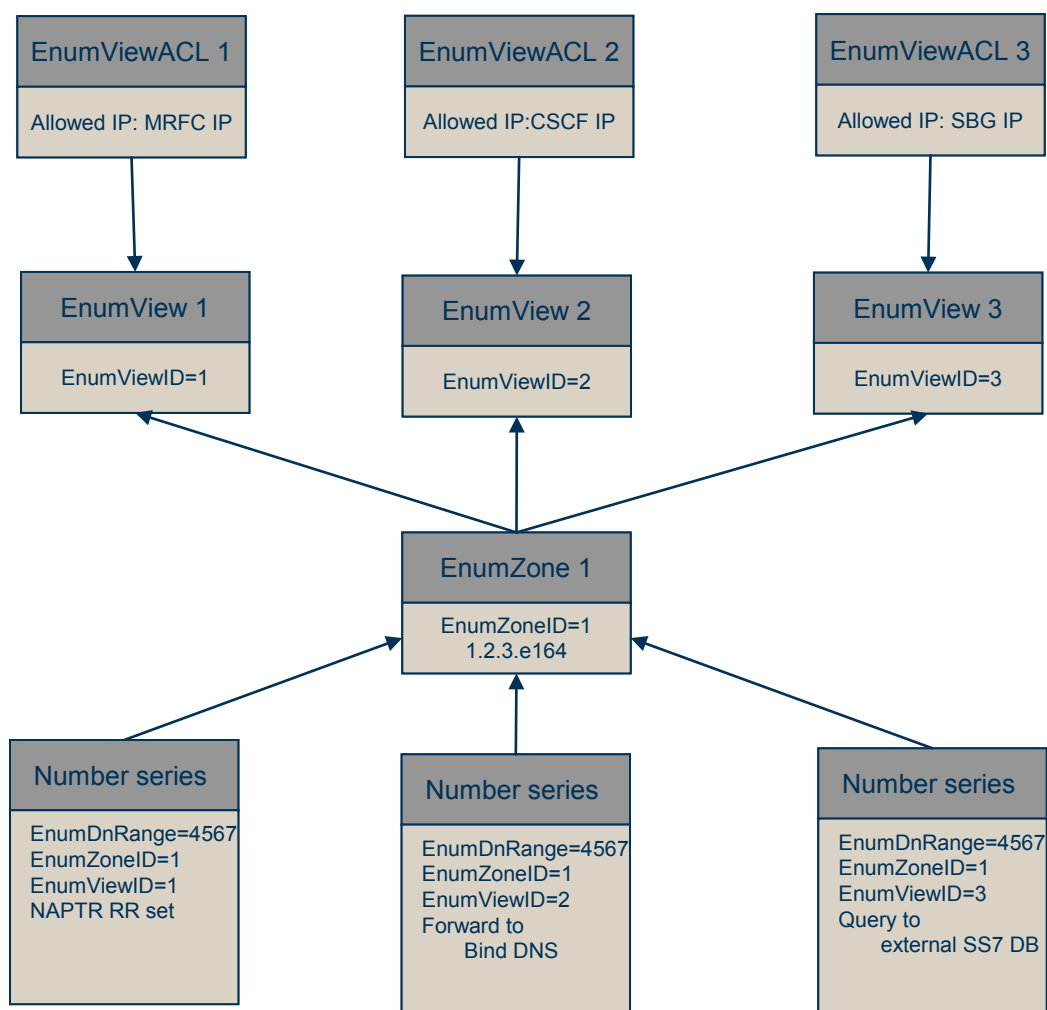


Figure 8 ENUM View for Number Series Level Split Name Space Configuration Example

In **Error! Reference source not found.**, E.164 phone number series 4567.1.2.3.e164 is put into three ENUM views. In ENUM view 1, NAPTR RR set is configured, which is actually wildcard configuration. In ENUM view 2, ENUM queries which reach the number series processing will be forward to Bind DNS server. In ENUM view 3, the configuration instructs ENUM server to forward the queries to external SS7 nodes, the exact protocol used could be MAP, INAP, AIN LNP or AIN Toll Free.

The number series can only be in the views where the ENUM Zone belongs to. It is configurable which view to use for the number series. If the zone is in the default view, the number series will fit into the default view. Otherwise operator needs to specify which view to use.

The split namespaces is not applicable for individual subscriber data EnumDnSched object in ENUM server.

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3.3 ENUM Exact Match processing

The ENUM exact match processing function follows a series of RFC specification.

Standard ENUM is defined by RFC 3761 (Reference [13]). Standard ENUM is based on DNS and uses DNS Naming Authority Pointer (NAPTR) resource records, as defined in RFC 3403 (Reference [12]), to return information to the DNS client. The response to an ENUM query may contain multiple NAPTR resource records.

The ENUM Server supports standard ENUM queries and returns appropriate information in NAPTR resource records in accordance with RFC 3761. The ENUM server supports a maximum of five NAPTR records in the response to a single query.

Standard ENUM supports translation of E.164 telephone numbers containing the decimal digits 0 through 9. The ENUM Server also permits hexadecimal digits 'A' through 'E'. This is because these digits are traditionally used in communication between network operators. The hexadecimal digit 'F' is used to indicate end-of-dialing and therefore never appears as part of a number.

If no local data entry exists for the ENUM query, number series level processing like wildcard or number portability functions will be checked.

3.4 Wildcard option processing

It is possible to configure up to 5 NAPTR RR for an ENUM number series, once NAPTR RR has been configured, no other optional configuration like forward to Bind DNS server or external SS7 database could be configured for this number series.

Number Range Match

With the ENUM server number range setting, operator is able to configure telephone number range with a common RR set.

For example, if the operator wants to name PBX support: 42240000 ~ 42246666 with NAPTR RR set A. It could be configured below:

Number series 4224, scope=0000~6666 with RR set A;

The minimal and maximum number in the scope option shall have the same length. And it is also possible for operator to define a subset of the number range with NAPTR RR set to B. Enum number range match will always return the RR that corresponding to the minimal subnet

Asterisk Label Match

For Asterisk Label Match, the number series will be matched using the best/longest match mechanism. Please refer to RFC 4592 section 2.1.1 for the definition of "Asterisk Label".

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With the ENUM Asterisk Label setting, operator is able to configure many consecutive telephone numbers (number series) with a common RR set. Set specific RR to some telephone number(s) within the range is also no problem.

For example, if the operator wants to name PBX support: 42240000 ~ 42242999 with NAPTR RR set A. But there's a single number 42242888 needs special treatment with NAPTR RR set B. It can be configured as below:

- a. Number series *.0.4.2.2.4, *.1.4.2.2.4, *.2.4.2.2.4 with RR set A;
- b. Single subscriber number 8.8.8.2.4.2.2.4 with RR set B.

Assume ENUM Server first check single subscriber number configuration object EnumDnSched and if the query can't be handled then go for number series configuration object EnumDnRange. By doing so, the operator doesn't need to create EnumDnSched for every telephone number within the given number series.

3.5 Forward to DNS

For non- ENUM queries or ENUM queries which don't have valid ENUM zone configured in ENUM server, they will be forwarded to DNS directly.

For ENUM query which fits into a configured ENUM zone while no entry exists in local database, if it also fits into a number series which is configured to forward the query to Bind DNS server, the forwarding action will be performed.

The reply will send from DNS server to ENUM Server first and then be forwarded to the client.

4 Operational Conditions

4.1 Configurable Parameters

The configurable parameters for the ENUM Server are stored in the IMM Service. The administrator can edit parameters either by the ECLI or NETCONF interface.

There are two types of configurable parameters: static parameter and dynamic parameter. Static parameter takes effect after the ENUM server restarts. Dynamic parameter takes effect immediately when it changes.

Refer to Reference [4] for detailed parameter list and default values.

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4.2 Commands and User Procedures

4.2.1 Configuring the ENUM Server

The IPWorks administrator configures the ENUM Server using the ECLI or NETCONF as described in Reference [5]**Error! Reference source not found.** and [6].

4.2.2 ENUM Data Configuration and Provisioning

The IPWorks administrator configures the ENUM data in the Storage Server using the IPWorks Command Line Interface (CLI) as described in Reference [3]. For detailed CLI parameter list, refer to Reference [20].

For data provisioning via EMA, refer to [17]**Error! Reference source not found.**

4.3 Charging

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4.4 Characteristics

4.4.1 Storage Estimates

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4.4.2 Performance

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5 Statement of Compliance

The ENUM Server supports the ENUM protocol in accordance with RFC 3761 (Reference [13]), with or without the extensions described in this document.

The ENUM Server supports the DNS protocol to the extent necessary to support the ENUM protocol and the extensions to it. The DNS protocol is specified by RFC 1034 (Reference [8]), RFC 1035 (Reference [9]) and a number of subsequent related RFCs. See reference [13] for a fuller list of DNS RFCs that are relevant to the ENUM Server.

The ENUM Server forwards well-formed DNS queries on non-ENUM zones to the IPWorks DNS Server and relays the responses from the IPWorks DNS Server back to the client call server. However, the ENUM Server itself is not a generic DNS server, and so for queries on ENUM zones it only supports aspects of DNS that are required in order to service ENUM queries.

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6 Miscellaneous

6.1 DNS Issues

The ENUM Server is to emulate a DNS server on the client interface. This section summarizes the behavior of ENUM Server and suggested configuration.

6.1.1 ENUM server deployment prerequisite

The following prerequisite shall be met to deploy IPWorks ENUM server:

1. The ENUM Server is authoritative for one or more zones that will be used only for ENUM queries (that is, requests for NAPTR resource records).
2. There is no delegation of parts of the ENUM zones to other servers.
3. DNS queries are always carried over UDP.

6.1.2 SOA and NS Resource Records

Each of the configured ENUM zones is suggested to have a Start of Authority (SOA) resource record and one or more Name Server (NS) resource records configured in DNS server.

The SOA and NS resource records for the zone are supplied by the Bind DNS Server. The SOA resource record indicates the default time-to-live (TTL) to be used for all NAPTR resource records returned from the ENUM Server.

The ENUM Server forwards DNS requests that match the domain name of the zone to the DNS Server. For example, 6.4.e164.iptelco.com may be configured as a zone in ENUM. There will never be any NAPTR resource records equipped for this domain name. A DNS query for this domain name is sent to the DNS Server where the SOA and NS resource records can be retrieved.

There may also be zone boundaries higher in the tree, e.g. at .e164, equipped into the DNS Server. There could be NS resource records pointing to the protocol servers at this node.

ENUM Server does not respond with SOA or NS resource records for any queries that are below the configured zone level in the tree. RFC 1034 (Reference [8]) and RFC 2181 (Reference [10]) make it clear that SOA resource records may be inserted in the Authority section of responses for child nodes, but it is not mandatory.

6.1.3 ENUM Queries

The behavior of the ENUM Server for each of the possible OPCODEs in the DNS query OPCODEs is described in Reference [9].

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6.2 MySQL

The ENUM Server uses MySQL Cluster Version 7.0, or later.

The ENUM Server runs on the SUSE Linux Enterprise 11 SP3, or later.

6.3 Security

6.3.1 Packet Filtering Requirements

There are no specific packet filtering requirements on the ENUM Server. It is assumed these requirements are satisfied by the underlying OS platform.

6.3.2 Access Control Requirements

The interfaces between the ENUM components shall be secured.

ENUM server provides an access control mechanism based on authentication of the client's source IP address. This is realized by means of access control lists which defines the set of allowed clients to access a specific aggregation of ENUM zones. This aggregation of ENUM zones is called an ENUM view..

7 Terminology

7.1 Abbreviations

A	Address – a type of RR
AH	Authentication Header
API	Application Programmers Interface
ASDNS	ActiveSelect DNS
BIND	Berkeley Internet Name Domain
CLI	Command Line Interface (of IPWorks)
DDDS	Dynamic Delegation Discovery System
DHCP	Dynamic Host Configuration Protocol
DN	Directory Number
DNS	Domain Name System
ENUM	The telephone-number-to-URI mapping application defined in RFC 3761 (Reference [13]). ENUM is sometimes said to stand for “E.164 Numbering” or “Electronic Numbering”.
HA	High Availability

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IMM	Information Management Model
IMS	IP Multimedia System
MTU	Maximum Transmission Unit
NAPTR	Naming Authority Pointer – a type of RR
NDB	Network Database (storage engine used by MySQL Cluster)
NS	Name Server – a type of RR
O&M	Operations and Maintenance
OPT	Options – a type of pseudo-RR
OSS-RC	Operational Support System Radio Core
SNMP	Simple Network Management Protocol
SOA	Start of Authority – a type of RR
SQL	Structured Query Language
UDP	User Datagram Protocol
RCS	Rich Communication Suite-Enhanced

7.2 Definitions

IPWorks	An Ericsson product providing DNS and DHCP functions.
MySQL	A third-party relational database management system. MySQL is a trademark of MySQL AB.
Net-SNMP	A suite of open source software used to implement the SNMP protocol.
Resource Record	A piece of information associated with a domain name in the Domain Name System. See Chapter 3.6 of RFC 1034 (Reference [8]) for a full description. DNS defines many types of resource record. The types that are relevant to the ENUM Server are: A (Address), NAPTR (Naming Authority Pointer), NS (Name Server), OPT (Options), SOA (Start of Authority), and TXT (Text String).
UNIX	The UNIX® System. UNIX® is a registered trademark of The Open Group.

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8

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- [6] Ericsson NETCONF Interface [4/155 19-APA 901 44/1 Uen](#)
- [7] Redundancy Overview for IPWorks 54/155 17-AVA 901 16 Uen
- [8] Domain Names – Concepts and Facilities [RFC 1034](#)
- [9] Domain names – implementation and specification [RFC 1035](#)
- [10] Clarifications to the DNS Specification [RFC 2181](#)
- [11] Negative Caching of DNS Queries [RFC 2308](#)
- [12] Dynamic Delegation Discovery System (DDDS) – Part Three: The Domain Name System (DNS) Database [RFC 3403](#)
- [13] The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application (ENUM) [RFC 3761](#)
- [14] IP Authentication Header [RFC 4302](#)
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