

Country Code 1 ENUM LLC

Provider ENUM Trial Report

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Introduction

This is a report of the trial of provider ENUM in the United States sponsored by the Country Code 1 ENUM Limited Liability Company ("the LLC") and executed by participating entities ("Participants"). Provider ENUM involves using the technology in RFC 3761 by the Service Provider of Record (SPR) for a specific E.164 telephone number to map that number into a Universal Resource Identifier (URI). This URI identifies a specific point of interconnection to that service provider's network that enables an originating party to establish communication with the party associated with the telephone number.

Background/Introduction

In the course of the LLC's work on the development of ENUM for Country Code 1, members of the LLC came to see the need for a parallel capability to that described in RFC 3761 that would support interconnection of Next Generation Networks. Although this capability has sometimes been referred to as "Carrier ENUM" or "Infrastructure ENUM", the LLC chose the term "Provider ENUM." A Provider ENUM URI is separate from any URIs that the End-user, who registers their E.164 number for End-user ENUM, may wish to associate with that E.164 number. The LLC also concluded that a trial of Provider ENUM would be a useful step in the implementation of such a capability. Accordingly, the LLC developed a framework for such a trial and solicited participation by interested service providers.¹

The Provider ENUM trial (PET) was completely separate activity from the trial of End-user ENUM conducted by the LLC. The trial objectives were:

- To evaluate potential architectures for implementation of Provider ENUM
- To understand interactions, including the provisioning implications of End-user numbering events such as porting and disconnects, between Provider ENUM and End-user ENUM
- To evaluate authorization requirements for Provider ENUM
- To evaluate potential privacy concerns
- To study mechanisms for linking a US implementation of Provider ENUM with other national implementations in both the short and long term to evolve towards a global provider ENUM tree
- To study mechanisms for provider control of resolution and call admission

¹ <http://www.enumllc.com/ProviderTrial.htm>

The LLC developed a Memorandum of Understanding that was agreed to by participants to provide a structure for conduct of the trial and set up a Provider ENUM Trial Participants Committee (PETPAC) to coordinate trial activities. The trial participants included AT&T, Charter Communications, Liberty Communications, Qwest, and Verizon. Robert Schafer of Verizon served as Trial Director for the LLC.

Terms & Definitions

Address of Record	A URI that can be used to determine a point of interconnection with Service Provider of Record of the telephone number
Authentication	The process of verifying that a party, e.g., the Service Provider of Record, is who they claim to be
Authorization	The process of verifying that an (authenticated) party is entitled to perform some action
ENUM	Refers to a protocol developed in the Internet Engineering Task Force (IETF) (RFC 3761) whereby the DNS can be used for identifying available services associated with one E.164 number
Provider ENUM	The use of the technology in RFC 3761 by the Service Provider of Record (SPR) for a specific E.164 telephone number to map that number into a Universal Resource Identifier (URI). This URI identifies a specific point of interconnection to that service provider's network that enables an originating party to establish communication with the party associated with the telephone number
Provider ENUM Tier 0/1 Registry	The repository of ENUM domain name registrations for Provider ENUM
Provider ENUM Tier 0/1 Registry Operator	Organization that processes registration requests for ENUM domains corresponding to E.164 numbers for their Service Providers of Record and hosts the set of pointers to their Tier 2 name servers
Registry Data	Registration Data maintained by the Registry including Zone-File Data, and all other data submitted by SPRs
Service Provider of Record (SPR)	The service provider, recognized by the appropriate regulatory authority, which has been allocated numbering resources, as reflected in the LERG™ and NPAC
Tier 2 Provider	Person/organization that maintains ENUM zone including the NAPTR resource records for that number and is pointed to by the Tier 0/1

Trial Infrastructure

Figure 1 depicts the Trial architecture. In this structure, Service Providers populated DNS Resource Records into the combined Tier 0/1 through the Registry via an agreed interface.² The Registry validated that the service provider populating the number is the SPR using the LERG™ and NPAC data. A separate Registrar entity, as defined in End-user ENUM, is not employed since SPRs are capable of providing the necessary interface to the Registry. Also, Participants either take on the roles of Tier 2 Providers and application service providers or subcontract these to other parties.

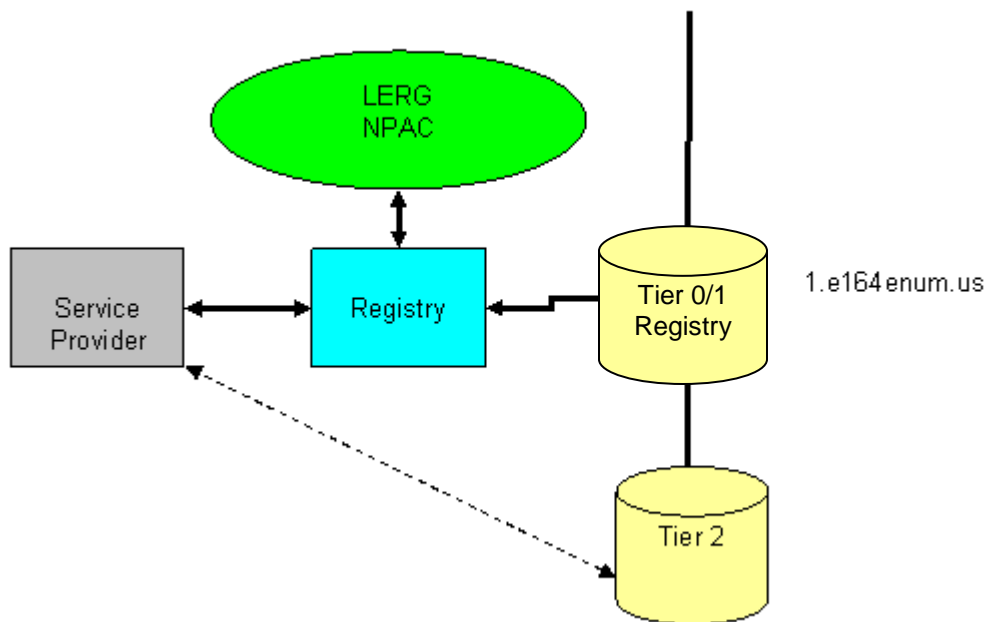


Figure 1 - Provider ENUM Trial Architecture

To support the Registry function for the trial, AT&T set up a test system in San Ramon, California. The test system included PC servers functioning as the Combined Tier 0/1 using Bind9 software. The Registry maintained an authoritative ENUM server accessible via the public Internet.

² More detail on Provider ENUM architecture and the Tier 0/1 concept can be found at http://www.enumllc.com/tac/docs/prov/Provider_Tier_0_1-7.doc.

Trial Phases

Trial activities took place in three phases.

Phase 1 - Registry Infrastructure

The objective of this activity was to establish the combined Tier 0/1 Registry (subsequently referred to as just “Tier 1”) with delegations for individual test numbers. These test numbers were placed in the Tier 1 such that one number pointed to the corresponding Tier 2 nameserver(s) for each service provider in the trial.

Tier 2 Providers were to ensure that queries for the domain name were resolvable to all appropriate Tier 2 name servers and that the data in the Tier 2 name servers could be retrieved successfully (e.g., via a utility such as DIG).

Phase 2 - Provisioning

The objectives of this phase were to implement and test the registration interface between the providers of record and the Tier 1 Registry. This phase included the ability for the Tier 1 Registry to validate that the number being registered had been allocated to the provider of record using information from the LERG/NPAC.

Because an EPP-based automated interface was being tested as part of the End-user ENUM trial, that interface was not tested here. Provisioning of data in the Tier 1 ENUM Server was performed manually, mimicking the proposed logic flow (the detailed procedure is shown in Appendix 1).

Step 1 – The principal representative of each participant company (as designated by the signed MoU) sends an email to Tier 1 administrator (AT&T) providing detail of the authorized parties that can request addition, modification, and deletion of ENUM records.

Step 2 – The authorized party emails a request to Tier 1 to add, modify, or delete ENUM records. This was done using the *CC1 ENUM LLC Provider ENUM Trial Registration Request* found in Appendix 1.

Step 3 – Tier 1 consults NPAC and LERG data to ensure the Service Provider is the SPR for the E.164 number.

Step 4 – Tier 1 fulfills the requests.

The test cases for Phase 2 of the trial were intended to test the following scenarios:

Add new registration

- 1a New service add
- 1b Invalid request – applicant fails authentication
- 1c Invalid request – Telephone Number (TN) not allocated to applicant
- 1d Port from non-participating service provider

Remove registration

- 2a TN disconnect
- 2b Port to non-participating service provider
- 2c Invalid request – applicant fails authentication
- 2d Invalid request – TN not allocated to applicant

Modify registration

- 3a Valid request
- 3b Change name server(s)
- 3c Change contact info
- 3d Invalid request – applicant fails authentication
- 3e Invalid request – TN not allocated to applicant

Detailed test case templates are shown in Appendix 2.

Phase 3 – Network Interconnection

Interconnection between US Service Providers

Interconnection between participating service providers in the trial was by default through existing layer 3 IP peering mechanisms, which, would in some cases be direct and other cases mediated through a third party. In the baseline interconnection scenario, SIP INVITES from all connecting providers to a given number would be directed to the same logical layer 5 entity (e.g., SIP proxy) for any given telephone number.

Participants also wanted to explore the use of techniques such as “split DNS”, “views”, etc. to either selectively control the DNS responses containing URIs that ENUM delivers to different querying entities or the way in which a common URI is resolved, e.g. by distribution of different SRV records to interconnecting partners. These techniques may be ultimately used to restrict information or interconnection to some set of entities based on bi- or multilateral agreements or to direct calls to different points of interconnection (PoIs) based on the identity of the originating carrier. Where ENUM is used to provide internal routing as well as to support interconnection with other carriers, they may also be used to provide different URIs/resolution for interconnection routing to Border Function Elements (e.g., Session Border Controllers) versus routing to ultimate customer end points.³

³ This is much like LNP GTT routing where external parties are provided a gateway address instead of the ultimate network element DPC/SSN serving the number in question.

Differential Resolution

There are a few test cases that involve differential resolution in which ENUM provides different responses for the same E.164 depending on various factors, such as source IP address of the query.

In these test cases, the differential resolution is provided by the Tier 2 ENUM servers so each participant has full control of the entry and exit criteria. For the trial, differential resolution was accomplished using the *view* capability of BIND, which enables a differential response to a query based on the source IP address of the query.

Linkage with other non-US trials

Exploration of linkage with other trials is complicated by the inability to make use of a common domain apex, such as “ie164.arpa”. To get around this difficulty, the trial used DNAME records in each trial’s root domain to point to the roots for other country codes.

Linking a Foreign Tree: DNAME

Verizon still had End-user ENUM records from the country code 353 Ireland trial that were used to provide a link between two trees in different countries. The Provider ENUM trial participants recognized that this was a highly unusual arrangement but would represent a proof-of-concept test case. The Provider ENUM Tier 0/1 Registry contained a DNAME record that directed all DNS inquiries for 3.5.3.e164enum.us to 3.5.3.e164.arpa. As a result, any Ireland-bound phone calls initiated from the LLC’s Provider ENUM trial would be directed to the 3.5.3.e164.arpa tree.

The test cases for Phase 3 of the trial were intended to test the following scenarios:

- 1 Inter-provider routed with Provider ENUM
- 2 Differential Resolution
 - 2a One SP allowed to resolve to a POI; others not
 - 2b Two SPs, each resolve to different POI for same number
- 3a PET SP calls non-NANP number
- 3b Foreign SP calls PET number through foreign ENUM Registry

Detailed test case templates are shown in Appendix 2.

Trial Results

A table summarizing trial results is shown in Appendix 3. Some sample individual test cases are shown in Appendix 4. Because the trial participants used official numbers from their companies, it was not possible to perform tests that involved service discontinuance or porting between service providers. The participants discussed these test cases to analyze where potential issues might exist, but no conclusions were reached.

Lessons Learned

LERG/NPAC validation process

The validation interface, although a manual simulation, worked for the purposes of the trial. Data in the LERG and the NPAC associate either an OCN (Operating Company Number) - LERG or a SPID (Service Provider ID) – NPAC with a telephone number, number block, or central office code (NPA-NXX). A single business entity (e.g., AT&T) may have multiple subsidiaries and, in a commercial implementation, mapping back to a specific provisioning identity for each OCN or SPID would be required.

Capability to protect data from unauthorized access

The trial implementation made use of a Tier 0/1 accessible on the public Internet. Whether such an implementation would be desirable in a production system requires further study. There are several techniques that could be employed including use of access control lists that would limit queries based on source IP address similarly to the views capability discussed under differential resolution.

Differential Resolution

As discussed only the DNS views capability was examined in the trial as a means of differential resolution. There are, however, other techniques that could be considered, including bilateral exchanges of SRV records for use in subsequent stages of resolution, and the “openser” approach developed by the Austrian ENUM registry. Selection of an approach for implementation will ultimately be shaped by SPR plans for interconnection architectures.

Breadth of participation

We invited participation from a variety of industry segments including wireless and cable companies. Although companies from these industry segments did not choose to participate, the LLC believes the results to be representative of the entire industry.

APPENDIX 1

Registration Process

Preconditions

1. Registry identifies e-mail address to receive registration requests.
2. Registry establishes access to LERG™ and NPAC data.
3. Participants provide Registry with authorized e-mail addresses from which registration requests will be sent.
4. Participants establish Tier 2 name servers.
5. Registration request e-mail format specified (PETPAC) (this form can include other cases (change, delete...))

Procedure

1. Applicant provisions Tier 2 name servers, preferably including NAPTR records.
2. Applicant sends e-mail following request format from authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN to be registered
 - iii. Name server host names
 - iv. Contact⁴ information (name, email, contact telephone number)
3. Registry verifies source e-mail address is on authorized list for company [authentication]
4. Registry verifies TN is served by applicant company [authorization]
5. If verification is successful, Registry populates NS records for TN.
6. Registry notifies Applicant of success or reason for rejection.
7. Registrant verifies provisioning via *dig*.

CC1 ENUM LLC Provider ENUM Trial Registration Request Form

Send request to: provreg@enumllc.com

COMPANY NAME	
TELEPHONE NUMBER TO BE REGISTERED	
NAME SERVER HOST NAMES (IF NEW OR CHANGE REQUEST)	
Contact Information	
NAME	
EMAIL ADDRESS	
CONTACT NUMBER	
ACTION (SELECT 1)	ADD NEW REGISTRATION DELETE MODIFY

⁴ Contact is single point of contact expected to work issues regarding numbers and Tier 2 name servers.

APPENDIX 2

Test Case Template Definitions

Phase 2, Test 1a

Test Objective:

Initial ENUM Domain Registration, valid request, new service add

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

ENUM Applicant /Tier 2 Provider	<Enter company name>
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number	
DNS name server host names	
Applicant SPOC information	
Applicant authorized e-mail address	

Test Method:

1. Applicant provisions Tier 2 name servers, preferably including NAPTR records.
2. Applicant sends e-mail following request format from authorized address to Registry. E-Mail includes:
3. Company name
4. TN to be registered
5. Name server host names
6. Contact⁵ information (name, email, contact telephone number)
7. Registry verifies source e-mail address is on authorized list for company [authentication]
8. Registry verifies TN is served by applicant company [authorization]¹
9. If verification is successful, Registry populates NS records for TN.
10. Registry notifies Applicant of success or reason for rejection.
11. Registrant verifies provisioning via *dig*.

Expected Test Outputs:

1. Registration succeeds.
2. TN authorization screen print ?
3. Registry notification e-mail
4. Registrant *dig* output

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

⁵ Contact is single point of contact expected to work issues re numbers and Tier 2 name servers.

Phase 2, Test 1b

Test Objective:

Initial ENUM Domain Registration, new service add, Invalid request – applicant fails authentication

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

ENUM Applicant /Tier 2 Provider	<Enter company name>
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number	
DNS name server host names	
Applicant SPOC information	
Applicant non-authorized e-mail address	

Test Method:

1. Applicant provisions Tier 2 name servers, preferably including NAPTR records.
2. Applicant sends e-mail following request format from non-authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN to be registered
 - iii. Name server host names
 - iv. Contact⁶ information (name, email, contact telephone number)
3. Registry determines source e-mail address is *not* on authorized list for company [authentication]
4. Registry notifies Applicant of reason for rejection.

Expected Test Outputs:

Registration fails.

1. Registry notification e-mail

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

⁶ Contact is single point of contact expected to work issues re numbers and Tier 2 name servers.

Phase 2. Test 1c**Test Objective:**

Initial ENUM Domain Registration, new service add, Invalid request – TN not allocated to applicant

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

ENUM Applicant /Tier 2 Provider	<Enter company name>
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number (not allocated to applicant)	
DNS name server host names	
Applicant SPOC information	
Applicant authorized e-mail address	

Test Method:

1. Applicant provisions Tier 2 name servers, preferably including NAPTR records.
2. Applicant sends e-mail following request format from non-authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN to be registered
 - iii. Name server host names
 - iv. Contact⁷ information (name, email, contact telephone number)
3. Registry determines source e-mail address is on authorized list for company [authentication]
4. Registry determines TN is *not* allocated to applicant company [authorization]
5. Registry notifies Applicant of reason for rejection.

Expected Test Outputs:

Registration fails.

1. TN authorization screen print ?
2. Registry notification e-mail

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

⁷ Contact is single point of contact expected to work issues re numbers and Tier 2 name servers.

Phase 2, Test 1d**Test Objective:**

Port from non-participating service provider

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

ENUM Applicant /Tier 2 Provider	<Enter company name>
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number	
DNS name server host names	
Applicant SPOC information	
Applicant authorized e-mail address	

Test Method:

1. Applicant provisions Tier 2 name servers, preferably including NAPTR records.
2. Applicant ports number from non-participating service provider.
3. Applicant sends e-mail following request format from authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN to be registered
 - iii. Name server host names
 - iv. Contact⁸ information (name, email, contact telephone number)
4. Registry verifies source e-mail address is on authorized list for company [authentication]
5. Registry verifies TN is served by applicant company [authorization]
6. If verification is successful, Registry populates NS records for TN.
7. Registry notifies Applicant of success or reason for rejection.
8. Registrant verifies provisioning via *dig*.

Expected Test Outputs:

Registration succeeds.

1. TN authorization screen print ?
2. Registry notification e-mail
3. Registrant *dig* output

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

⁸ Contact is single point of contact expected to work issues re numbers and Tier 2 name servers.

Phase 2, Test 2a

Test Objective:

TN disconnect

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

ENUM Applicant /Tier 2 Provider	<Enter company name>
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number	
DNS name server host names	
Applicant SPOC information	
Applicant authorized e-mail address	

Test Method:

1. Applicant sends e-mail following request format from authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN to be removed
 - iii. Name server host names
 - iv. Contact⁹ information (name, email, contact telephone number)
2. Registry verifies source e-mail address is on authorized list for company [authentication]
3. Registry verifies TN is served by applicant company [authorization]
4. If verification is successful, Registry deletes NS records for TN.
5. Registry notifies Applicant of deletion.
6. Registrant verifies deletion via *dig* and removes Tier 2 records.

Expected Test Outputs:

Deletion succeeds.

1. TN authorization screen print ?
2. Registry notification e-mail
3. Registrant *dig* output

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

⁹ Contact is single point of contact expected to work issues re numbers and Tier 2 name servers.

Phase 2, Test 2b**Test Objective:**

Port to non-participating service provider

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

ENUM Registrant /Tier 2 Provider	<Enter company name>
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number	
DNS name server host names	
Registrant SPOC information	
Registrant authorized e-mail address	

Test Method:

1. Number is ported to non-participating service provider.
2. On activation of port,¹⁰ Registrant (donor service provider)sends e-mail following request format from authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN to be removed
 - iii. Name server host names
 - iv. Contact¹¹ information (name, email, contact telephone number)
3. Registry verifies source e-mail address is on authorized list for company [authentication]
4. Registry verifies TN is served by applicant company [authorization]
5. If verification is successful, Registry deletes NS records for TN.
6. Registry notifies Applicant of deletion.
7. Registrant verifies deletion via *dig* and removes Tier 2 records.

Expected Test Outputs:

Deletion succeeds.

1. TN authorization screen print ?
2. Registry notification e-mail
3. Registrant *dig* output

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

Note that a PET participant must port one of its numbers to a non-participant.

<Enter comments here.>

¹⁰ The donor should always send a delete request to avoid a dangling registration if the new SP is a non-participant. If the donor request arrives after the port is activated, then it will fail authorization. In this case the registry needs to examine the existing (donor) record and determine that it is no longer valid and so pull it. In commercial implementation it is expected that the Registry would use a feed from the NPAC to remove the donor registration without the need for donor action.

¹¹ Contact is single point of contact expected to work issues re numbers and Tier 2 name servers.

Phase 2 , Test 3a

Test Objective:

Modify registration – name servers

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

ENUM Registrant /Tier 2 Provider	<Enter company name>
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number	
DNS name server host names	
Registrant SPOC information	
Registrant authorized e-mail address	

Test Method:

1. Registrant sends e-mail following request format from authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN
 - iii. New name server host names set¹²
2. Registry verifies source e-mail address is on authorized list for company [authentication]
3. Registry verifies TN is served by applicant company [authorization]
4. If verification is successful, Registry replaces the existing set of NS records with the records based on the name servers listed in the request..
5. Registry notifies Applicant of change.
6. Registrant verifies changes via *dig*.

Expected Test Outputs:

Modification succeeds.

1. TN authorization screen print ?
2. Registry notification e-mail
3. Registrant *dig* output

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

Note that a PET participant must port one of its numbers to a non-participant.
<Enter comments here.>

¹² The Registrant shall provide the complete set of host names to be in the NS records when the request is completed. The Registry will delete existing names not in this set and add names in this set that are not currently provisioned.

Phase 2, Test 3b

Test Objective:

Modify registration - contact info

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

ENUM Registrant /Tier 2 Provider	<Enter company name>
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number	
DNS name server host names	
Registrant SPOC information	
Registrant authorized e-mail address	

Test Method:

1. Registrant sends e-mail following request format from authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN
 - iii. New contact¹³ information (name, email, contact telephone number)
2. Registry verifies source e-mail address is on authorized list for company [authentication]
3. Registry verifies TN is served by applicant company [authorization]
4. If verification is successful, Registry replaces the existing contact info with the with the information in the request..
5. Registry notifies Registrant of change.

Expected Test Outputs:

Modification succeeds.

1. TN authorization screen print ?
2. Registry notification e-mail

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

Note that a PET participant must port one of its numbers to a non-participant.
<Enter comments here.>

¹³ Contact is single point of contact expected to work issues re numbers and Tier 2 name servers.

Phase 2, Test 4a**Test Objective:**

Port service between [participating] providers

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

Old ENUM Registrant /Tier 2 Provider	<Enter company name>
New ENUM Registrant/Tier 2 Provider	<Enter company name>
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number	
DNS name server host names	
Registrant SPOC information	
Registrant authorized e-mail address	

Test Method:

1. At port activation¹⁴, registrant (donor service provider) sends e-mail following request format from authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN to be deleted
2. At port activation, registrant (recipient service provider)sends e-mail following request format from authorized address to Registry. E-Mail includes:
 - i. Company name
 - ii. TN to be registered
 - iii. Name server host names
 - iv. Contact information (name, email, contact telephone number)
3. Registry verifies source e-mail address is on authorized list for company [authentication] (both requests)
4. Registry verifies TN is served by applicant company [authorization]¹⁵
5. If verification is successful, Registry replaces the existing contact info with the with the information in the request..
6. Registry notifies Applicant of change.

Expected Test Outputs:

Replacement of registration succeeds.

1. TN authorization screen print ?
2. Registry notification e-mail

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

Note that a PET participant must port one of its numbers to a non-participant.

<Enter comments here.>

¹⁴ The donor should always send a delete request to avoid a dangling registration if the new SP is a non-participant. If the donor request arrives after the port is activated but before the recipient request, then it will fail authorization. In this case the registry needs to examine the existing (donor) record and determine that it is no longer valid and so pull it. In commercial implementation it is expected that the Registry would use a feed from the NPAC to remove the donor registration without the need for donor action.

Phase 3, Test 1**Test Objective:**

Call from one service provider to another routed using Provider ENUM. The call is assumed to be end-to-end VoIP.

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

Service Provider 1 (originator)	<Enter company name>
Service Provider 2 (termination)	<Enter company name>

Test Inputs:

Input	Value(s)
Telephone Number	

Test Method:

1. Originator and termination SPs define interconnection architecture. This includes physical and logical connectivity (e.g. via Internet vs. dedicated facilities), protocols (e.g., SIP), and other aspects of interconnection (e.g., authentication, codecs, etc.)
2. Originator and termination SPs agree on test numbers and test times (to ensure calls are answered.)
3. Originator dials number, queries Provider ENUM Registry to obtain interconnection URI.
4. Originator resolves interconnection URI per agreement with terminating SP and sends call request (e.g., SIP INVITE).
5. Termination answers

Expected Test Outputs:

1. Interconnection architecture documentation
2. Call completion
3. Call records, if available
4. Protocol analysis trace if needed/available.

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

Phase 3, Test 2a**Test Objective:**

Call from one service provider to another using Provider ENUM with differential resolution. The call is assumed to be end-to-end VoIP. Originating Service Provider (#1) allowed. Originating Service Provider (#2) disallowed.

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

Service Provider 1 (originator)	<Enter company name>
Service Provider 2 (termination - allowed)	<Enter company name>
Service Provider 3 (termination –disallowed)	<Enter company name>

Test Inputs:

Input	Value(s)
Telephone Number	

Test Method:

1. Participating SPs define interconnection architecture. This includes physical and logical connectivity (e.g. via Internet vs. dedicated facilities), protocols (e.g., SIP), and other aspects of interconnection (e.g., authentication, codecs, etc.)
2. Terminating SP provisions Tier 2 for differential resolution. (Methods various, TBD)
3. Originator SPs and termination SP agree on test times to ensure calls are answered.
4. Originator SP 1 Originator dials number, queries Provider ENUM Registry to obtain interconnection URI.
5. Originator SP 1 resolves interconnection URI per agreement with terminating SP and sends call request (e.g., SIP INVITE)..
6. Termination SP 3 answers
7. Originator SP 2 dials number attempts and queries Provider ENUM Registry to obtain interconnection URI. Resolution ultimately fails.
8. SP2 records failure mode

Expected Test Outputs:

1. Interconnection architecture documentation
2. Call completion/Failure
3. Dig trace showing resolution results
4. Call records, if available
5. Protocol analysis trace if needed/available.

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

Phase 3, Test 2b

Test Objective:

Call from one service provider to another using Provider ENUM with differential resolution. The call is assumed to be end-to-end VoIP. Originating Service Provider (#1) allowed. Originating Service Provider (#2) allowed with different point-of-interconnection address.

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

Service Provider 1 (originator POI 1)	<Enter company name>
Service Provider 2 (POI 2)	<Enter company name>
Service Provider 3 (termination)	<Enter company name>

Test Inputs:

Input	Value(s)
Telephone Number	

Test Method:

1. Participating SPs define interconnection architecture. This includes physical and logical connectivity (e.g. via Internet vs. dedicated facilities), protocols (e.g., SIP), and other aspects of interconnection (e.g., authentication, codecs, etc.)
2. Terminating SP provisions Tier 2 for differential resolution. (Methods various, TBD)
3. Originator SPs and termination SP agree on test times to ensure calls are answered.
4. Originator SP 1 Originator dials number, queries Provider ENUM Registry to obtain interconnection URI.
5. Originator SP 1 resolves interconnection URI per agreement with terminating SP and sends call request (e.g., SIP INVITE)..
6. Termination SP 3 answers
7. Originator SP 2 dials number dials number, queries Provider ENUM Registry to obtain interconnection URI.
8. Originator SP 1 resolves interconnection URI per agreement with terminating SP and sends call request (e.g., SIP INVITE)..
9. Termination SP3 answers

Expected Test Outputs:

1. Interconnection architecture documentation
2. Call completion/Failure
3. Dig trace showing resolution results
4. Call records, if available
5. Protocol analysis trace if needed/available.

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

Phase 3, test 3a**Test Objective:**

Call from a PET service provider to a non-NANP number using DNAME records to link to the foreign tree. The call is assumed to be end-to-end VoIP.

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

Service Provider 1 (PET participant)	<Enter company name>
Foreign Correspondent SP	<Enter company name>

Test Inputs:

Input	Value(s)
Telephone Number	

Test Method:

1. Registry provisions linkage to foreign tree via DNAME records.
2. Originator and termination SPs define interconnection architecture. This includes physical and logical connectivity (e.g. via Internet vs. dedicated facilities), protocols (e.g., SIP), and other aspects of interconnection (e.g., authentication, codecs, etc.)
3. Originator SPs and termination SP agree on test times to ensure calls are answered.
4. Originator dials number, queries Provider ENUM Registry to obtain interconnection URI.
5. Originator resolves interconnection URI per agreement with terminating SP and sends call request (e.g., SIP INVITE).
6. Termination SP answers.

Expected Test Outputs:

1. Interconnection architecture documentation
2. Call completion/Failure
3. Dig trace showing resolution results
4. Call records, if available
5. Protocol analysis trace if needed/available.

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

Phase 3, Test 3b**Test Objective:**

Call from an SP using a foreign ENUM tree to a PET service provider number using DNAME records to link to the PET tree. The call is assumed to be end-to-end VoIP.

Test History:

Test Date	<Enter test date>
Test Iteration Number	<Enter test iteration/run number, starting at 1 for the first run>

Test Participants:

Service Provider 1 (PET participant)	<Enter company name>
Foreign Registry	<Enter company name>
Foreign Correspondent SP	<Enter company name>

Test Inputs:

Input	Value(s)
Telephone Number	

Test Method:

1. Foreign Registry provisions linkage to foreign tree via DNAME records.
2. Originator and termination SPs define interconnection architecture. This includes physical and logical connectivity (e.g. via Internet vs. dedicated facilities), protocols (e.g., SIP), and other aspects of interconnection (e.g., authentication, codecs, etc.)
3. Originator SPs and termination SP agree on test times to ensure calls are answered.
4. Originator dials number, queries Provider ENUM Registry to obtain interconnection URI.
5. Originator resolves interconnection URI per agreement with terminating SP and sends call request (e.g., SIP INVITE).
6. Termination SP answers.

Expected Test Outputs:

1. Interconnection architecture documentation
2. Call completion/Failure
3. Dig trace showing resolution results
4. Call records, if available
5. Protocol analysis trace if needed/available.

Test Evaluation:

Pass	<input type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

<Enter comments here.>

APPENDIX 3

Test Case Summary Table

Phase	Test	Title	AT&T	Charter	Qwest	Verizon	Liberty
1	1	Tier 2 Infrastructure established	9/28/2006	5/1/2007	X	1/7/2007	9/28/2006
2	1A	Initial ENUM Domain Registration, valid request, new service add	9/28/2006	10/23/2006	10/5/2006	1/11/2007	9/28/2006
	1B	Initial ENUM Domain Registration, new service add, Invalid request – applicant fails authentication	10/18/2006				
	1C	Initial ENUM Domain Registration, new service add, Invalid request – TN not allocated to applicant	10/5/2006				
	1D	Port from non-participating service provider					
	2A	Removal of Registration, TN disconnect					
	2B	Removal of Registration, Port to non-participating service provider					
	3A	Modify registration – name servers					
	3B	Modify registration - contact info					
	4A	Number Portability Synch, Port service between [participating] providers					
3	1A	Call from one service provider to another routed using Provider ENUM.	1/16/2007	5/15/2007		1/16/2007	2/22/2007
	2A	Call from one service provider to another using Provider ENUM with differential resolution. Originating Service Provider (#1) allowed. Originating Service Provider (#2) disallowed.					
	2B	Call from one service provider to another using Provider ENUM with differential resolution. Originating Service Provider (#2) allowed with different point-of-interconnection address.	5/3/2007				
	3A	Call from a PET service provider to a non-NANP number using DNAME records to link to the foreign tree.	5/10/2007			5/10/2007	5/10/2007
	3B	Call from an SP using a foreign ENUM tree to a PET service provider number using DNAME records to link to the PET tree.	N/A	N/A	N/A	N/A	

APPENDIX 4

Sample Test Cases

Phase 2, Test 1a

Test Objective:

Initial ENUM Domain Registration, valid request, new service add

Test History:

Test Date	9/28/06
Test Iteration Number	1

Test Participants:

ENUM Applicant /Tier 2 Provider	West Liberty
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number	319-627-XXXX
DNS name server host names	ns1.federatedtelephone.com ns2.federatedtelephone.com
Applicant SPOC information	Name: Andrew Gallant Email address: abgallant@xxxx Contact telephone number: +1 301-762-XXXX
Applicant authorized e-mail address	Andrew Gallant [abgallant@xxxx]

Test Method:

1. Applicant provisions Tier 2 name servers, preferably including NAPTR records.
2. Applicant sends e-mail following request format from authorized address to Registry. E-Mail includes:
3. Company name
4. TN to be registered
5. Name server host names
6. Contact¹⁶ information (name, email, contact telephone number)
7. Registry verifies source e-mail address is on authorized list for company [authentication]
8. Registry verifies TN is served by applicant company [authorization]¹
9. If verification is successful, Registry populates NS records for TN.
10. Registry notifies Applicant of success or reason for rejection.
11. Registrant verifies provisioning via *dig*.

Expected Test Outputs:

1. Registration succeeds.
2. TN authorization screen print ?
3. Registry notification e-mail
4. Registrant *dig* output

Test Evaluation:

Pass	<input checked="" type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

¹⁶ Contact is single point of contact expected to work issues re numbers and Tier 2 name servers.

Phase 2, Test 1c

Test Objective:

Initial ENUM Domain Registration, new service add, Invalid request – TN not allocated to applicant

Test History:

Test Date	Thu 10/5/2006 2:41 PM
Test Iteration Number	1

Test Participants:

ENUM Applicant /Tier 2 Provider	AT&T
Tier 1 Registry	AT&T

Test Inputs:

Input	Value(s)
Telephone Number (not allocated to applicant)	+1 908 561 XXXX
DNS name server host names	tier2.no-ip.info
Applicant SPOC information	Name: Steven Lind Email address: sdind@att.com Contact telephone number: +1 973 236 XXXX
Applicant authorized e-mail address	sdind@xxxx

Test Method:

1. Applicant provisions Tier 2 name servers, preferably including NAPTR records.
2. Applicant sends e-mail following request format from non-authorized address to Registry. E-Mail includes:
 - v. Company name
 - vi. TN to be registered
 - vii. Name server host names
 - viii. Contact¹⁷ information (name, email, contact telephone number)
3. Registry determines source e-mail address is on authorized list for company [authentication]
4. Registry determines TN is *not* allocated to applicant company [authorization]
5. Registry notifies Applicant of reason for rejection.

Expected Test Outputs:

Registration fails.

1. TN authorization screen print ?
2. Registry notification e-mail

Test Evaluation:

Pass	<input checked="" type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

Registry Email to Applicant Wed 10/18/2006 4:46 PM

Steve,

I am unable to register 908-561-XXXX into Tier 1 because it is a VZ phone number. Please see the attached Exchange Info for your reference.

---Armstrong Soo

¹⁷ Contact is single point of contact expected to work issues re numbers and Tier 2 name servers.

Detailed Exchange Information about (908) 561

(908) 561-0000 to 9999

- LATA = 224, NORTH JERSEY NJ
- VERIZON NEW JERSEY, INC. (RBOC), OCN=9206
- VERIZON COMMUNICATION (GENERAL), AOCN=9200 - *Administrative*

From: sdlind@xxxx

Sent: Thursday, October 05, 2006 11:41 AM

To: Soo, Armstrong

Cc: PFAUTZ, PENN L (TCORP)

Subject: Registration of number into Provider ENUM

Armstrong,

Please attempt to register this number. It should fail because it is not (technically) presubscribed to AT&T.
Steve

Phase 3, Test 1**Test Objective:**

Call from one service provider to another routed using Provider ENUM. The call is assumed to be end-to-end VoIP

Test History:

Test Date	January 16 th , 2007
Test Iteration Number	1

Test Participants:

Service Provider 1 (originator)	AT&T
Service Provider 2 (termination)	Verizon

Test Inputs:

Input	Value(s)
Telephone Number	1925824XXXX
	1972729XXXX

Test Method:

1. Originator and termination SPs define interconnection architecture. This includes physical and logical connectivity (e.g. via Internet vs. dedicated facilities), protocols (e.g., SIP), and other aspects of interconnection (e.g., authentication, codecs, etc.)
2. Originator and termination SPs agree on test numbers and test times (to ensure calls are answered.)
3. Originator dials number, queries Provider ENUM Registry to obtain interconnection URI.
4. Originator resolves interconnection URI per agreement with terminating SP and ends INVITE.
5. Termination answers

Expected Test Outputs:

3. Interconnection architecture documentation
4. Call completion
5. Call records, if available
6. Protocol analysis trace if needed/available.

Test Evaluation:

Pass	<input checked="" type="checkbox"/>
Fail	<input type="checkbox"/>

Test Comments:

All ENUM queries went through Tier 1 and Tier 2 server as expected. Both AT&T and VZ end-user softphones (X-Lite) were connected to their respective Softswitch via SprintNextel's cellular Internet connections.