**Contribution**

**TITLE:** IP Interconnection Routing Report

**SOURCE\*:** AT&T

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**ABSTRACT**

This document provides updates to the current draft routing report.

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**ATIS-0x0000x.YYYY**

American National Standard for Telecommunications

**IP Interconnection Routing**

**Alliance for Telecommunications Industry Solutions**

Approved Month DD, YYYY

**American National Standards Institute, Inc.**

**Abstract**

As Service Providers introduce and expand IP-based service offerings, there is increasing interest in identifying the opportunities for the industry to facilitate IP routing of VoIP traffic using E.164 addresses. The ATIS/SIP Forum Task Force has taken on the initiative to develop the necessary standards and is publishing this first report to describe the candidate proposals for circulation and comment. Recognizing that IP traffic exchange is developing as an overlay to existing TDM interconnection and will be implemented by different service providers with varying timelines,

The purpose of this first report is to:

1. Document already in use routing methods for IP-based services using existing industry data in the LERG and NPAC supplemented with the bilateral exchange of information to map LERG and/or NPAC identifiers to specific IP connection information.
2. Detail a simple registry approach that provides the ability to exchange routing information on a per-TN basis without aggregation based on NANP data structures. This approach also requires some bilateral exchange of specific IP connection information.
3. Discuss methods for interworking between service providers that choose differing approaches.

**Foreword**

The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI’s requirements for an ANS. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Standard.

The Alliance for Telecommunications Industry Solutions (ATIS) serves the public through improved understanding between carriers, customers, and manufacturers. The [**COMMITTEE NAME**] Committee [**INSERT MISSION**]. [**INSERT SCOPE**].

ANSI guidelines specify two categories of requirements: mandatory and recommendation. The mandatory requirements are designated by the word *shall* and recommendations by the word *should*. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identifiable as having distinct compatibility or performance advantages.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, [**COMMITTEE NAME**], 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time of consensus on this document, [**COMMITTEE NAME**], which was responsible for its development, had the following leadership:

[**LEADERSHIP LIST**]

The **[SUBCOMMITTEE NAME]** Subcommittee was responsible for the development of this document.

**Table of Contents**

[INSERT]

Contents

[ATIS-0x0000x.YYYY ii](#_Toc393882495)

[American National Standard for Telecommunications ii](#_Toc393882496)

[IP Interconnection Routing ii](#_Toc393882497)

[Alliance for Telecommunications Industry Solutions ii](#_Toc393882498)

[Abstract ii](#_Toc393882499)

[1. Scope, Purpose, & Application v](#_Toc393882500)

[1.1 Scope v](#_Toc393882501)

[1.2 Purpose v](#_Toc393882502)

[1.3 Application vi](#_Toc393882503)

[2. Informative References vi](#_Toc393882504)

[3. Definitions, Acronyms, & Abbreviations vi](#_Toc393882505)

[3.1 Definitions vi](#_Toc393882506)

[3.2 Acronyms & Abbreviations vi](#_Toc393882507)

[4. Reference Model for IP NNI Routing viii](#_Toc393882508)

[4.1 Network Connections viii](#_Toc393882509)

[4.2 Routing ix](#_Toc393882510)

[5. Aggregate Approach Based on Existing NANP Data Structures x](#_Toc393882511)

[6. Telephone Number Registry (per-TN) Approach xiii](#_Toc393882512)

[6.1 Per-TN Use Case xiii](#_Toc393882513)

[6.2 Per-TN Routing Implementation xiv](#_Toc393882514)

[7. Interworking between Current and Registry based approaches xvii](#_Toc393882515)

[7.1 Data from an Aggregate SP to a per-TN SP xvii](#_Toc393882516)

[7.2 Data from an per-TN SP to an Aggregate SP xviii](#_Toc393882517)

[7.3 A Registry could provide both aggregate and expanded per-TN data based on aggregate input xviii](#_Toc393882518)

[7. Next Steps xviii](#_Toc393882519)

[Appendix A – Other Solution Proposals xviii](#_Toc393882520)

[1. Utilization of Existing BIRRDS/LERG Industry Database xviii](#_Toc393882521)

[2. Utilizing the NPAC as an ENUM Registry xviii](#_Toc393882522)

[1. Call Flow xix](#_Toc393882523)

[2. Provisioning xxi](#_Toc393882524)

[3. SUMMARY xxii](#_Toc393882525)

[3. Utilizing LERG as an ENUM Registry xxiii](#_Toc393882526)

[4. Independent ENUM Registry xxiii](#_Toc393882527)

[Appendix B - Routing Criteria Tables xxiii](#_Toc393882528)

[Appendix C – Data Exchange Worksheet Example xxiii](#_Toc393882529)

**Table of Figures**

[INSERT]

**Table of Tables**

[INSERT]

# Scope, Purpose, & Application

## Scope

This document was developed under a joint ATIS/SIP Forum collaboration. The document discusses the existing in-use and proposed routing solutions to facilitate the exchange of traffic associated with IP-based services between North American service providers.

Many options and issues were previously investigated by an ATIS Inter-Carrier VoIP Call Routing Focus Group (IVCR-FG), which issued its final report in February 2008. At that time, the IVCR-FG report noted that a number of vendor proposals have been made, but no initiative exists to develop the necessary standards needed to enable VoIP call interconnectivity [1].

Subsequent to the formation of the ATIS/SIP Forum collaboration, the Federal Communications Commission authorized the creation of a Numbering Testbed to “spur the research and development of the next generation standards and protocols for number allocation, verification, and call routing.”[[1]](#endnote-1) The Commission also held a workshop to initiate a Numbering Testbed on March 25, 2014. Discussion at the Workshop focused on ideas for a “future integrated registry” that would support number allocation, verification, and call routing across all types of NANP numbers in a post TDM environment.

It should be noted that this initial report of the ATIS/SIP Forum NNI Task Force report does not address the development of such an integrated registry, but instead focuses on the identification of existing in-use and proposed “interim” solutions to facilitate call routing across IP interconnections between now and the deployment of the future integrated registry envisioned at the Workshop.

## Purpose

As Service Providers introduce and expand IP-based service offerings, there is increasing interest in identifying the opportunities for the industry to facilitate IP routing of VoIP traffic using E.164 addresses. The ATIS/SIP Forum Task Force has taken on the initiative to develop the necessary standards and is publishing this first report to describe the candidate proposals for circulation and comment. Recognizing that IP traffic exchange is developing as an overlay to existing TDM interconnection and will be implemented by different service providers with varying timelines,the purpose of this first report is to:

1. Document already in use routing methods for IP-based services using existing industry data in the LERG and NPAC supplemented with the bilateral exchange of information to map LERG and/or NPAC identifiers to specific IP connection information.
2. Detail a simple registry approach that provides the ability to exchange routing information on a per-TN basis without aggregation based on NANP data structures. This approach also requires some bilateral exchange of specific IP connection information.
3. Discuss methods for interworking between service providers that choose differing approaches.

An appendix also provides information on other proposals reviewed by the Task Force.

## Application

This standard is defined for North America deployments, but may be applicable for deployments outside North America.

# Informative References

[1] ATIS-I-0000017, ATIS Inter-Carrier VoIP Call Routing (IVCR) Assessment and Work Plan, February 2008

[2] ATIS-0x0000x, *Technical Report*.

[3] ATIS-0x0000x.201x, *American National Standard*.

[4] ATIS-1000039

[5] RFC 4904

[6] RFC 4694

[7] RFC 6116

[8] RFC 5067

# Definitions, Acronyms, & Abbreviations

For a list of common communications terms and definitions, please visit the *ATIS Telecom Glossary*, which is located at < <http://www.atis.org/glossary> >.

## Definitions

**AAA**: xxxx.

**Bbbb**: xxxx.

## Acronyms & Abbreviations

3GPP 3rd Generation Partnership Project

ALG Application Level Gateway

ATCF Access Transfer Control Function

B2BUA Back to Back user agent

BGCF Border Gateway Control Function

CSCF Call Session Control Function

IBCF Interconnection Border Control Function

I-BGF Interconnection Border Gateway Function

I-CSCF Interrogating-Call Session Control Function

ICSS IMS Centralized Services

II-NNI Inter-IMS Network to Network Interface

IM-CN IP Multimedia Core Networks

IMS IP Multimedia Subsystem

IMS-ALG Multimedia Subsystem Application Level Gateway

IP Internet Protocol

IPSec IP Security

IPv4 Internet Protocol Version 4

IPv6 Internet Protocol Version 6

LERG Local Exchange Routing Guide

MGCF Media Gateway Control Function

MGF Media Gateway Function

MIME Multipurpose Internet Mail Extensions

MSC Mobile Switching Center

NAT Network Address Translation

NAT-PT Network Address Translation—Protocol Translation

NNI Network to Network Interface

NPAC Number Portability Administration Center

OCN Operating Company Number

P-CSCF Proxy Call Session Control Function

PE Provider Edge

RTP Real-Time Protocol

SBC Session Border Controller

S-CSCF Serving-Call Session Control Function

SCTP Stream Control Transmission Protocol

SDP Session Description Protocol

SGF Signalling Gateway Function

SIP Session Initiation Protocol

SIP URI SIP protocol Uniform Resource Identifier

SIP-I SIP with encapsulated ISUP

SIP-T SIP for Telephones

SLA Service Level Agreement

SPID Service Provider ID

SRVCC Single Radio Voice Call Continuity

TCP Transmission Control Protocol

tel-URI Telephone Uniform Resource Identifier

TRF Transit and Roaming Function

TrGw Transition Gateway

TLS Transport Layer Security

UA User Agent

UDP User Datagram Protocol

URI Uniform Resource Identifier

VoIP Voice over IP

# Reference Model for IP NNI Routing

There are two broad steps to establishing IP interconnection between service providers:

• Establishing the network connections between the service providers

• Setting up service provider specific routing to use those connections

## Network Connections

In order to examine what is needed for routing SIP sessions across the IP NNI, it is helpful to consider first the implementation of network interconnections in more detail. What follows expands on the model presented in, for example, ATIS-1000039.

Figure 1 below shows three types of transport arrangements: through the public Internet on the top, via direct physical connection of the partner service providers in the middle, and using an intermediary service provider (e.g., as an IPX) on the bottom.



Note that interconnection may involve multiple egress and ingress Session Border Controllers (SBCs) each connected through multiple Provider Edge (PE) Routers in turn linked by multiple physical facilities[[2]](#footnote-1). The SBCs may in turn host multiple signaling and media IP addresses and associated port numbers. For a given telephone number in the terminating SP network the set of PE Routers, ingress SBCs, IP addresses may not be the same for different interconnecting SPs.



## Routing

. A route from Service Provider A to Service Provider B will ultimate involve a path from an SP A egress SBC through na SP A PE Router over an interconnection facility to an SP B PE Router and thence an SP B ingress SBC as shown in Figure 2. There will generally be multiple routes for exchange of traffic between two service providers to ensure reliability and to optimize network resources.

Routing across the NNI will involve selecting one of the available paths based on the destination number and the routing discipline agreed to by the service providers in their traffic exchange agreement.For example, Carrier b in Figure 2 may have indicated that it prefers to receive traffic for some subset of its TNs over the location a exchange point directed first toLaSBC1 and thenLa SBC2 with the understanding that if this path is unavailable the traffic may be re-routed over exchange point b at layer 3 and if the SBCs at La are unavailable the traffic may be sent to LbSBC1 or LbSBC2 over either of the exchange points.

Setting up routing involves associating TN identifiers provided by the terminating network with the appropriate route. There are many choices for what TN identifiers can be used including; AOCN/OCN, NPAC SPID, CO code, or, in the limiting case, individual 10-digit telephone numbers. Current methods generally employ TN identifiers that aggregate a set of telephone numbers, usually based on some LERG or NPAC construct as discussed in Section 5.

To begin with, the terminating carrier provides a list of TN identifiers to the originating carrier and the network entry-point(s) to be used for routing calls to each identifier. The entry points will be defined by the corresponding Session Border Controller IP addresses.[[3]](#footnote-2) The originating carrier then builds the corresponding routing in its network. The manner in which this is accomplished is an internal matter though some examples of how such routing may be implemented will be provided in the following sections.

# Aggregate Approach Based on Existing NANP Data Structures

Some service providers are already exchanging voice traffic over IP facilities. This section details how routing for such exchanges has been implemented based on existing industry data in the LERG and NPAC supplemented with the bilateral exchange of information to map LERG and/or NPAC identifiers to IP connection information.

Existing approaches to IP interconnection routing rely on NANP constructs for aggregating telephone numbers into groups and then associating a route (SBC URI or IP address) with the TN group. Common methods of aggregation are Location Routing Number (LRN) in the NPAC, OCNs, CLLIs, and central office codes (NPA-NXXs).

## Introduction

This section describes how some SPs have already implemented an internal IP routing service using data available from the LERG and NPAC. This is possible because when SPs obtain numbering resources they are associated with the SP’s OCN, the serving switch’s CLLI code, an NPA-NXX, as well as a 10-digit LRN for those TNs which are ported or pooled. These “identifiers” are shared among SPs through existing NPAC and LERG feeds and no new industry systems development or standards were required to implement this solution. Sometimes referred to as the “aggregation method,” the use of these existing identifiers to efficiently represent (or aggregate) large groups of TNs significantly reduces the quantity of routing records, and avoids the need for SPs to provision multiple instances of the same routing data for each of its customers’ TNs. During the development of the interconnection agreement, SPs exchange these “identifiers” (aka “TN group identifiers”) and ingress SBC IP addresses to establish routes between their networks via an IP interconnection.

## - Use Cases

The makeup of an SP’s switching infrastructure and the degree to which customer TNs are served via IP will influence which identifier(s) may be used to represent the groups of TNs to which traffic should be sent via an IP interconnect. The following use case examples are not intended to serve as an exhaustive list of possible scenarios:

An SP may specify calls to all of their customers’ TNs on all of their switches should be sent over an IP interconnection. Here, the SP can simply specify their Operating Company Number (OCN) as the identifier since all the TNs associated in the LERG and NPAC with their switches are related to their OCN. This is likely attractive if the SP is an OTT VoIP provider or a cable company if all of their customers are served via IP.

If an SP has specific switches to which calls should be sent via IP, they could simply identify those switches by their switch CLLI code. This is likely attractive for SPs with a mixed TDM and IP switching infrastructure that prefer traffic associated with certain or all of their IP switches be sent via an IP interconnect. Also, SPs transitioning their TDM interconnects to IP can manage the rate of transition by adding switch CLLI codes to the list of identifiers as it grows its IP interconnection capacity.

The 10-digit LRN is a flexible vehicle for identifying a subset of TNs associated with a particular switch that, for example, serves both TDM and IP customer endpoints. Although SPs are required to establish at least one LRN per switch per LATA, they can create additional 10-digit LRNs to uniquely identify those TNs to which calls should be sent over an IP interconnection. This is likely attractive where one IP switch is used to serve both TDM and IP customer endpoints where the SP establishes second unique LRN to identify those TNs served via IP for which traffic should be sent over the IP interconnection. For example, an LTE wireless carrier may choose to establish unique LRNs to identify TNs belonging to VoLTE customers. Another example is where a CLEC provides TNs to an OTT VoIP provider and creates a unique LRN to identify those TNs assigned to customers of the OTT VoIP provider (that should be sent via and IP interconnection).

Below is a table summarizing the group of TNs represented by a “group identifier” as described in the above examples:

|  |  |
| --- | --- |
| **Group Identifier** | **Group of TNs Represented By the Identifier** |
| OCN | All TNs associated with all SP switches |
| Switch CLLI | All TNs associated with an single SP’s switch |
| LRN | A subset of TNs associated with a single switch |
| NPA-NXX | A subset of TNs associated with a single switch  |

## Implementation

Many SP core networks are IP based and utilize an internal “routing service” to determine how to forward service requests. SIP redirect and DNS capabilities common in IP core networks provide the basic building blocks to implement real-time call processing for external NNI routing applications using “group identifiers.” This solution can be accommodated by commercially available routing (DNS and ENUM) infrastructure and each SP is free to determine when and how to implement a "routing service” solution appropriate for their business and operational needs. SPs have options given vendors are actively engaged in providing solutions of this nature and the following general description is provided for illustrative purposes only.

### - Provisioning

A Provisioning diagram is shown below in Figure 3:

In this provisioning example, SP1 provisions its Routing Service and DNS based upon information provided by SP2. In this example, group identifiers (LRNs) are correlated with SBC interconnect IP addresses and domain names provided by SP2.

**NPAC**

**LERG**

Service Bureau

SP1

SP2

**Routing
Service**

Provisioning

**DNS**

Figure 3

### - Call Flow

One example of the Call Flow is shown below in Figure 4. Other methods of implementation are also consistent with this approach:

1. Pat (non-roaming subscriber of SP1) makes a session request (e.g., places a call) to Mike (subscriber of SP2). SP1’s network provides originating services based on Pat’s subscription.
2. SP1’s application server queries its routing service in real time using the called number to determine how to forward the request. The routing service first portability corrects the called number, and then determines that it is not subscribed to SP1. It then checks to see whether a group identifier is associated with the telephone number and covered by an IP interconnection agreement. If so, the SP1 routing service supplies[[4]](#footnote-3) the application server with the ingress point through which SP2 has requested that session requests directed to members of this group enter its network.
3. The application server identifies SBC-2 and (if applicable) SBC-1 in SIP ROUTE headers, and forwards the resulting session request onward. SP1’s L3 processing resolves the host portion of the topmost ROUTE header (using DNS) to the IP address of SBC-1.
4. SBC-1 removes the topmost ROUTE header (which identifies itself) and forwards the session request based on the next one (which identifies SBC-2). To do so it resolves (using DNS) the host portion of that header, yielding the IP address of SBC-2.
5. SBC-2 removes the topmost ROUTE header (which identifies itself) and admits the message to SP2’s network, forwarding it to an application server, and eventually to Mike. How SP2 performs these functions is SP specific.

SP1

Pat

SP2

SIP

SIP

Mike

SBC-2

SBC-1

**Routing
Service**

**Call Flow**

SP1 customer (Pat) calls
SP2 customer (Mike)

**DNS**

**DNS**

Figure 4

# Telephone Number Registry (per-TN) Approach

## Per-TN Use Case

A number of service providers have identified that they have a need for more molecular routing than that based on NANP aggregation elements as discussed in the previous section.

In general these needs arise where TNs may share common point of interconnection (PoI) for TDM interconnection (and are thus associated with the same LRN or CLLLI) but need to be treated differently for IP interconnection.

For example, wireless SPs are migrating their existing 2G/3G subscribers to VoLTE – from TDM to IP based user equipment (UE). For VoLTE to VoLTE calls, IP interconnection makes sense for a number of reasons – support for high definition (HD) voice and other Rich Communication Services (RCS) features and elimination of needless IP-TDM and TDM-IP conversions as would be required for TDM interconnection. SPs must still offer TDM interconnection for VoLTE TNs since not all SPs are capable or willing to provide IP interconnection. And because the migration will be gated by customer adoption of VoLTE capable UE, SPs may want to maintain existing TDM PoIs for both 2G/3G and VoLTE TNs and maintain existing TDM routing to those PoIs. Moreover, it may be desirable not to use the IP interconnection serving VoLTE TNs for 2G/3G TNs. First, additional network equipment must be deployed sooner than if IP interconnection scales with VoLTE adoption and, second, 2G/3G calls will be forced to go through unnecessary TDM/IP and IP/TDM conversions. These issues can be avoided if an SP can specify IP interconnection routing for VoLTE TNs separately from the associated LRNs.

A related case cited during Task Force discussions occurs in the deployment of RCSe capabilities outside North America in situations where voice calls and sessions using other RCS features need to be routed differently. This may be particularly the case where number portability methods may not support aggregation via methods like porting to different LRNs.

There may be other use cases for TN routing as well. It has been suggested that per-TN routing could be used to either avoid routing calls to fax numbers over IP interconnections using incompatible compression or taking other measures to insure adequate transmission quality.

## Per-TN Routing Implementation

Service providers wishing to provide per-TN routing perform the following provisioning activities:

1. As part of bilateral interconnect negotiations provide mappings for SIP URI hostnames to SBC IP addresses.
2. Populate registry records for TNs available for IP interconnection with the appropriate SIP URI. The URI will be a full SIP URI (e.g., sip:+13036614567@example.mso-a.com;user=phone ) but without the tel URI number portability parameters as defined in RFC 4694..

The registry must insure that only the provider of record for the number as defined by LERG/NPAC can populate a corresponding record and service providers must ensure that their routing servers are updated when information in the Registry changes.

Service providers electing to use the per-TN routing information will:

1. Provision the hostname – IP address mappings into their internal DNS (A or AA records).
2. Provision TN-URI mappings from the Registry into their internal routing servers. If the routing server is accessed via a SIP query, the SIP URI may be directly populated. If the routing server is accessed via an ENUM query, the SIP URI is encapsulated into a NAPTR record.

This provisioning process is illustrated in Figure 1 below. The Figure shows the registry instantiated in the NPAC but alternate registry implementations (using different provisioning mechanisms than the SOA/LSMS) are possible.



Figure 1

On call origination, the originating service provider will query their routing server and obtain the corresponding SIP URI for numbers available for IP interconnect. They will resolve the hostname from the URI in their internal DNS to obtain the IP address of the terminating provider’s ingress SBC.[[5]](#footnote-4) The call flow is shown in Figure 2 below:



1. SP2 Caller dials destination number
2. SP2 S-CSCF queries internal route server and SP2 route server responds with a URI passed back to S-CSCF
3. SP2 S-CSCF resolves the hostname in the SIP URI to obtain the IP address of an agreed upon SP1 ingress SBC
4. A SIP INVITE is sent to egress SBC of SP2 that has layer 3 connectivity to the ingress SBC of SP1
5. The SIP INVITE is forwarded to the SP1 ingress SBC.
6. and 7. SP1 terminates the call to its end user.

# Interworking between Current and Registry based approaches

This section discusses how interworking may take place between service providers using different routing approaches.

When considering interworking between carriers it is important to recognize that the interconnection process has a number of steps that are common to all the approaches.

1. Interconnection agreements are formally negotiated between carriers on a bilateral basis. This negotiation process will lead to a formal agreement between the carriers on a number of key points related to the interconnection, including an agreed mechanism for exchanging routing data. As a result, thereis no a need to define an approach where two carriers with arbitrary preferences interconnect and exchange data without first agreeing on the approach they will use.
2. Under all scenarios being considered, carriers will use data from a variety of sources (LERG, NPAC, etc.) as input into their internal OSS/BSS to build and maintain an internal database for routing calls. Each carrier uses their own system, with their own algorithm, for this, and it is therefore out of scope for the NNI. The routing data defined in this document is an important enabler for interconnection, but it is just one of the sources of data used by the carrier to construct their routing tables.

One thing that differs between the solutions is what data is being uploaded to a registry, or exchanged between carriers as part of interconnection negotiation. This is an important aspect that is specified in this document.

Previous sections of this document cover the cases where carriers agree on the use of aggregate or per-TN routing data. This section covers the case where they prefer different approaches, and outlines a series of intermediate options that would allow them to meet somewhere in the middle.

## Data from an Aggregate SP to a per-TN SP

There are several possibilities for how the per-TN SP may arrange to route to the Aggregate SP”

First, the Per-TN provider may simply agree to implement aggregate-based routing as described in Section 5.

The second alternative is to transform the aggregate data into a per-TN representation. In the basic case, the per-TN SP receives the aggregate data and then creates individual TN records in its routing server based on that data. For example, if an AOCN to SBC IP address mapping is provided, the per-TN SP uses LERG and NPAC data to map the AOCN into the set of TNs the aggregate SP is offering for IP traffic exchange. This involces determining from the LERG the set of NPA-NXXs and/or thousands blocks under the AOCN, creating a record for each TN, then removing records for numbers that have ported or pooled away from the aggregate SP and adding records for numbers ported or pooled into an LRN that is associated (has an NPA-NXX with the code holder AOCN of the aggregate SP). It is the responsibility of the Per-TN SP to update the record set based on changes in the LERG or NPAC. Note that the expanded data set may include records for unallocated numbers. Except for misdials, these records would not be accessed.

The expansion described above could also be performed by a third party, either on behalf of the per-TN SP or the aggregate SP depending on business arrangements.

In a special case the third party could be the registry operator and the aggregate data could be delivered to the registry by the aggregate provider. Because the registry could distribute date to multiple per-TN providers records would not include IP addresses, which would be target provider specific, but would map TNs to a SIP URI with a generic host name keyed to the aggregation element provided in the bilateral exchange. For example, a SIP URI containing the hostname aocn <aocn>.<spname>.net might be used in the registry records. The recipient provider could then populate the TN records in its routing server as described in Section 6 and resolve the host name in its internal DNS, having built address records that matched the host name to the IP address associated with the corresponding AOCN in the bilateral data exchange.

## Data from an per-TN SP to an Aggregate SP

There are likewise several possibilities for how an aggregate SP may route to a per-TN SP.

First, the per-TN provider may agree to provide aggregate data. Aggregate data may include TNs beyond those for which the per-TN provider prefers to prefer IP interconnection. For example, a wireless SP that has both VoLTE (IP served) and GSM/UMTS (non-IP) subscribers that are not distinguished from a NANP data point of view may simply provide mappings from, for example, its AOCNs to it SBC IP addresses. This will result in some VoLTE originated calls transiting the IP interconnection even though destined for GSM/UMTS users.

A second possibility is that the aggregate SP will accept per-TN information to populate its routing server even though it prefers to provide routing information for its own TNs on an aggregate basis The per-TN data could be provided via the registry.

## A Registry could provide both aggregate and expanded per-TN data based on aggregate input

In this hybrid case, as discussed as part of Section 7.1 above, the aggregate input would map a NANP construct to a SIP URI rather than a set of IP addresses. Bilateral negotiation would then provide URI to IP address mapping. The Registry would retain the aggregate input, however, and make it available to SPs that prefer aggregate input via an interface to be defined.

# 8 Next Steps

# Appendix A – Other Solution Proposals

# Utilization of Existing BIRRDS/LERG Industry Database

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Placeholder:

This section describes the exchange of data for IP routing and interconnection using existing industry database systems, architectures and processes for routing of E.164 Addressed Communications over IP Network-to-Network Interconnection (NNI). See IPNNI-2014-044R1.

# Utilizing the NPAC as an ENUM Registry

Consistent with 3GPP IMS recommendations for inter-carrier routing, an ENUM-based architecture is proposed for routing across the IP NNI. The essence of this architecture is a query using the protocol described in RFC 6116. 3GPP recommendations do not specify, however, the details of the ENUM data repository to be queried nor the source of the data in that repository. This proposal includes recommendations for these matters, the corresponding data formats, and the manner in which the results of ENUM queries are processed to resolve responses to the IP address(es) toward which a SIP INVITE to the destination network Session Border Controller are to be directed.

The classic ENUM “golden tree” architecture assumed a tiered structure in which a Tier 0 registry (such as the one currently managed by RIPE for the e164.arpa *user* ENUM domain) contains name server (NS) records pointing to the Tier 1 name servers authoritative for individual E.164 country codes. The Tier 1 registries in turn consist of NS records pointing to the authoritative Tier 2 server for a specific E.164 number. The Tier 2 servers, maintained by or for the assignee of the number, contained NAPTR records that resolved to the URIs needed to establish communication to the number in question.

As the industry has yet to establish a universally recognized Tier 0 for *infrastructure* ENUM (RFC 5067) as opposed to *user* ENUM, a combined Tier 0/1 registry is proposed for the US portion of Country Code 1.[[6]](#footnote-5) This Tier 0/1 registry is in principle extensible to other portions of Country Code 1 if desired by the competent authorities and may eventually be linked to registries for other country codes or to a global Tier 0 when and if consensus on such a Tier 0 emerges. In the interim the registry simply contains NS records for individual numbers in the US portion of CC1.

To speed deployment and leverage existing infrastructure it is proposed that the Number Portability Administration Center (NPAC), the local number portability database of record, serve as the Tier 0/1 registry. Unlike the Tier 0 and Tier 1 registries in the classic ENUM architecture, the NPAC is not a DNS name server and is not queried during call processing. It can however download data for NS records to service providers or service bureaus for them to provision in their name servers to be queried on call origination.

As in the classic ENUM model, the NS records will point to Tier 2 name servers that respond with NAPTR records containing the actual routing data. Service Providers will maintain themselves or have service bureaus provide for Tier 2 name servers for the numbers they serve. Based on the NS records obtained from the Tier 0/1 query, the originating service provider will query the Tier 2 name server to obtain the NAPTR record for call routing.

1. **Call Flow**

The following is the inter-service provider call flow as shown in the Figure below:



1. SP2 Caller dials destination number
2. SP2 S-CSCF queries internal ENUM server
3. SP2 ENUM server finds an NS record
4. SP2 internal ENUM server resolves the FQDN in the NS record to the IP address of SP1’s Tier 2 ENUM server.[[7]](#footnote-6)
5. An ENUM query is forwarded to SP1’s Tier 2 ENUM server.[[8]](#footnote-7)
6. SP1’s Tier 2 ENUM server responds with a NAPTR record(s) passed back to S-CSCF
7. SP2 S-CSCF processes the NAPTR record set returned resulting in a SIP URI
8. SP2 S-CSCF resolves the hostname in the SIP URI to obtain the IP address of an agreed upon SP1 ingress SBC
9. A SIP INVITE is sent to egress SBC of SP2 that has layer 3 connectivity to the ingress SBC of SP1
10. The SIP INVITE is forwarded to the SP1 ingress SBC.
11. SP1 terminates the call to its end user.
12. **Provisioning**

Provisioning is shown in the Figure below:



1. Service providers negotiate interconnection and exchange, as part of the interconnect technical negotiation process,
	1. Address (A or AA) records for their Tier 2 name servers
	2. Address (A or AA) records for the hostname FQDNs in URIs derived from the NAPTR records that will provided in the responses from their Tier 2 name servers. These IP addresses correspond to the destination service provider’s I-SBCs that constitute the application layer POIs.[[9]](#footnote-8)

Each service provider provisions the records received from the other carrier in its internal DNS.

1. When new numbers are provisioned or existing numbers made available for IP interconnection by an SP, the SP
	1. Provisions NS record information for the number into the NPAC Voice URI field of the subscription version (SV) of the number through its SOA. (If there is no existing subscription version one is added.)[[10]](#footnote-9)
	2. Provisions NAPTR records for number in its Tier 2 name server[[11]](#footnote-10).
	3. Provisions internal NAPTR records in its internal ENUM server for use within network calls.
2. Service providers download SVs from the NPAC, extract the NS information from the Voice URI field and provision it as NS records into their internal ENUM server. Note that a record is provisioned for each TN.
3. **SUMMARY**

A Tiered ENUM approach using the NPAC as the Tier 0/1 registry populates NS records into existing fields in the subscription version that already contains TDM routing elements. SVs are populated in the NPAC for each TN for which IP interconnection is offered. (If a TN is not otherwise ported or pooled an SV with a pseudo LRN is created). This approach simply enhances the existing interfaces (direct or via service bureaus) that all SPs have with the NPAC, requiring no new governance structures.

# Utilizing LERG as an ENUM Registry

Placeholder:

This section describes provides utilizing the LERG as part of a Tiered ENUM Registry, for the exchange of data for IP routing and interconnection for routing of E.164 Addressed Communications over IP Network-to-Network Interconnection (NNI). See IPNNI-2014-042R1.

# Independent ENUM Registry

Placeholder:

This section describes an independent ENUM Registry, for the exchange of data for IP routing and interconnection for routing of E.164 Addressed Communications over IP Network-to-Network Interconnection (NNI). See IPNNI-2014-043R1.

# Appendix B - Routing Criteria Tables

# Appendix C – Data Exchange Worksheet Example

1. FCC 14-5, released January 31, 2014. [↑](#endnote-ref-1)
2. Recall that SBCs may not be co-located with the PE routers connected at the exchange point and the layer 3 path between them may involve other routers. [↑](#footnote-ref-1)
3. Layer 3 routes for these IP addresses will generally be exchanged between the PE routers via BGP. [↑](#footnote-ref-2)
4. How this is accomplished is implementation specific. Messages from an application server to a routing service is typically an ENUM query, but in some networks a SIP message is sent to a proxy collocated with the ENUM service, which sends back a 302 “redirect” response. [↑](#footnote-ref-3)
5. There may be alternate approaches to combining the bilaterally exchanged URI-IP address mappings and the TN-URI mappings obtained from the Registry and combining them in a routing server for session establishment. [↑](#footnote-ref-4)
6. In infrastructure ENUM, the Tier 1 servers point to Tier 2 servers maintained by or for the service provider of record for the number. [↑](#footnote-ref-5)
7. Resolution is shown in recursive mode. It could also take place in iterative mode with the NS record being returned to the S-CSCF for the S-CSCF to resolve the FQDN in the NS record and then issue a query to the SP1 Tier 2. [↑](#footnote-ref-6)
8. Use of separate Data Border Element is shown. [↑](#footnote-ref-7)
9. There are alternate approaches to the resolution of Tier 2 name servers and interconnection URI FQDNs. These include a) exchange of SRV instead of A/AA records, b) resolution in the internet DNS, c) sharing through some controlled access industry system including but not necessarily limited to a private DNS. [↑](#footnote-ref-8)
10. The VOICE URI field was originally defined to contain a URI that would be used to provide for IP routing of voice calls, but it is currently little used and has no explicit typing. It simply allows up to 255 characters.

It is proposed that NS record information be populated in the VOICEURI field in the form

 *tier2enum.serviceprovider.com*

 (i.e., just the nameserver name as an FQDN) as opposed to the full NS form:

*3.8.0.0.6.9.2.3.6.4.1.e164enum.net IN NS tier2enum.serviceprovider.net*

The full record form would be reconstituted by the service provider for provisioning in its ENUM server. Note that an NS record or records are generally provisioned for each individual number.

Multiple NS records could be populated in the NPAC VOICEURI field through the use of some agreed upon separator character. This would allow for redundancy as it is expected that carriers would want to have multiple name server instances.

Note that an apex domain, for example, *e164enum.net*, needs to be agreed upon. [↑](#footnote-ref-9)
11. The ENUM query may return multiple NAPTR records with different order, preference, and enumservice fields as defined in RFC 6116. Thus multiple options for interconnection can be provided including different gateways for different service types (e.g., voice versus video) where appropriate. A NAPTR for general SIP interconnection might look like

 *NAPTR 10 100 "u" "E2U+sip" "!^.\*$!sip:\1@gw02.serviceprovider.net; user=phone!" .*

its resolution would result in the URI

*sip:+14632963800@gw02. serviceprovider.net**; user=phone*

The querying service provider would then resolve the hostname

*gw02.serviceprovider.net* to obtain an IP address for the terminating provider’s ingress SBC. [↑](#footnote-ref-10)