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Global ENUM: The underlying infrastructure for service discovery in the migration to the all-IP communications future

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Overview

The future of communications will converge on the Internet Protocol (IP). Voice is no longer king but 'one of many' channels of communication making it the medium of last resort especially for the younger generation as they contact to their peers through Facebook, Short Message Service (SMS), Twitter and many other channels.[1] To avoid the siphoning of value, operators must focus on the service experience specifically in relation to the communications mechanisms, creating value through connectivity and security of service. Operators need to rapidly build out flexible new services on top of mobile broadband to reduce the risk of becoming a commodity bit pipe for over the top services and remain significant to the communications experience of customers.

Operators need to bolster margins with the introduction of new value-add services such as, presence enhanced phone books, rich media sharing (video, images, other content), interactive multi-user chat blended with traditional SMS, multi-media messaging services (MMS), along with voice and video calling services to create a multi-media telephony paradigm. Each of these new IP-based services has its own interworking and addressing as well as service gateways in the distant network which need to be discovered to enable inter-networking.

Carrier Infrastructure ENUM is the preferred method to interconnect and is critical for IP-based communications and information exchange. However, standardized Carrier Infrastructure ENUM will take time to materialize and adoption will vary by region, country and specific applications as regulatory, technology, and business model hurdles still exist. The adoption of next-generation IP-based services is at serious risk without a globally accessible ENUM solution. Customers expect ubiquitous access to their services from any network and will not settle for less. How can operators take advantage of the benefits provided with ENUM today given the current fragmented ENUM implementations?

Fortunately, an advanced ENUM architecture exists that solves the current authoritative, scale and security limitations of today's fragmented ENUM implementations. Neustar's "Global ENUM" provides an architecture which delivers the global reach for IP-based services with optimal routing for inter-networking between operators, providing for margin management as well as rich routing policy. The Global ENUM architecture also supports a broker relationship permitting operators to interconnect without a direct peering arrangement via third-party transit operators. Operators should look to partner with a trusted third-party who can provide a global interoperable architectural solution which integrates business process and ensures important security controls are retained and integrated into existing operators' Private ENUM infrastructures. Finally, the architecture must provide intra- and inter-networking capabilities as well as global interoperability to ensure the solution suits operators needs wherever they are in the IP interconnect adoption cycle.

Benefits delivered with a Global ENUM architecture:

- Managed migration from Time Division Multiplexed (TDM) to IP networks
- Globally accessible enriched services available today
- Gain cost efficiencies with optimal routing and margin management
- Update routing data in minutes vs. days
- Reduce churn with enhanced user experience
- Increase average revenue per user (ARPU) with additional IP services revenue

Neustar is the selected vendor for the Global Systems for Mobile communications Association's (GSMA) Pathfinder global fixed and mobile ENUM service as well as having deployments of Tier 2 ENUM services with some of the largest operators globally. Neustar's approach to service delivery extends the Internet cloud computing and Software as a Service (SaaS) models into the telecommunications environment, creating a new Communications as a Service (CaaS) paradigm, well suited to the delivery of Global ENUM architectural services.

The Neustar CaaS model provides a trusted enabler for the delivery of next generation multi-media services without the need for significant capital investment, reduces overall operational costs and results in faster revenue generating new service introduction. Benefits of the CaaS model include:

- Deliver new services in hours vs. months
- Reduce the costs associated with technology transformation
- Mitigate risks inherent in technology transformation
- Strengthen position in overall communications experience

This white paper reviews the current state of ENUM deployments, examines the drivers for future service inter-networking using Carrier Infrastructure ENUM services and introduces the concept and benefits of Neustar's "Global ENUM architecture."

Challenges introducing enhanced IP-based services

Limitations of legacy internetworking

Traditionally, telecommunications network interworking (i.e. interconnection or peering) has generally been achieved by a simple bi-lateral arrangement between two parties on a per service basis. These services are predominantly voice centric and supported by Signaling System #7 (SS7/C7) TDM trunks. The network was built for single service one-to-one communications over dedicated circuits.

Mobile networks have increased traffic on the SS7/C7 networks by providing message interworking for SMS passing SMS as signaling between networks. The concept of roaming traffic introduced by mobile networks has resulted in a significant volume of signaling traffic and congestion over TDM trunks.

The services negotiated on a bi-lateral basis between two operators becomes an n-squared problem as the number of interconnects grows to support interworking multiple services with multiple networks. This problem has historically been addressed with a wholesale operator agreement, providing for multi-lateral arrangements. The wholesaler maintains the relationships with a large number of terminating operators and implements the technical and commercial interconnects on behalf of the originating operator. Additionally, the legacy SS7/C7 architecture is not service agnostic and support for new services requires the addition of new service gateways and new technical and commercial interconnect models.

Operators need to add new multi-media services to their arsenals to remain a significant force in this Internet age. The first of these new services was the introduction of MMS. No longer could operators interconnect using the legacy SS7/C7 TDM interconnects. The introduction of MMS created the need for the initial bi-lateral IP interconnects. Enabled by the introduction of mobile broadband the number of new operator services available to users will multiply. New services such as Rich Communications Suite (RCS) enabling presence with enriched calling and messaging and in the future multi-media telephony (MMTel) providing the ability to blend voice, real time video with pictures, text and file transfers, as well as Voice over Long Term Evolution (VoLTE) enabling traditional voice services for the IP Multi-media Subsystem (IMS) drives the need for end-to-end IP both within the operator's network as well as across networks and into social networks for the richness of these services to be preserved. Each service has its own service gateways in the distant network and need to be identified to allow interworking. Establishing simple bi-lateral IP interconnects between operators in the legacy internetworking model is not a sustainable business or technical model. MMS failed to flourish due to limited interconnection compatibility between operators. A new approach that takes advantage of the flexible Internet and IP architectures is needed to ensure ubiquitous service connectivity.

Service enablement for the IP world

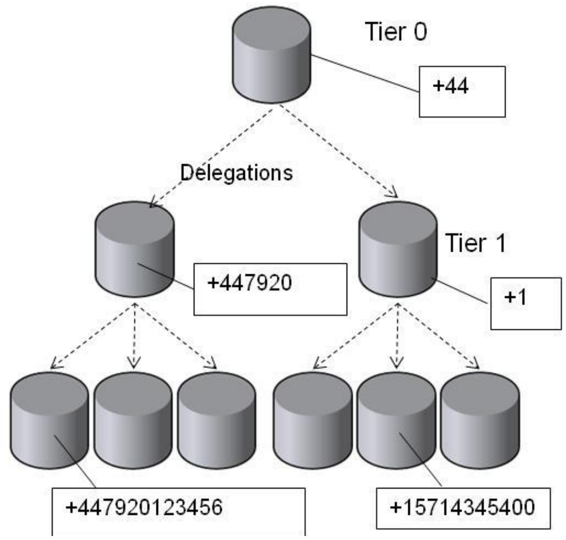
Telephone Number Mapping (ENUM) is the process of unifying the telephone number system of the public switched telephone network, the International Telecom's Union's (ITU's) E.164, with the Internet addressing and identification name spaces.[2] ENUM enables the coexistence of the legacy TDM and IP worlds. ENUM simplifies the interconnectivity of multiple services by affording service discovery to the originating network. This enables ENUM to determine the services available to a given user and the appropriate service gateway to use for access to the services in the destination network.

By design ENUM takes advantages of the Internet working models and provides a single, service agnostic IP-based routing mechanism.

ENUM services include:

- **Multi-media/Voice over IP (MM/VoIP):** H.323, Session Initiation Protocol (SIP) and Extensible Messaging and Presence Protocol (XMPP) based service types for both Multi-media and Voice over Internet Protocol (VoIP) sessions between users
- **Messaging:** mailto with email, MMS and SMS service types
- **Number Portability Correction:** Service provider ID's and number port correction indicators
- **PSTN routing/breakout:** Public switched telephone network (PSTN) service type with Telephony uniform resource identifiers (URI) (E.164 numbers)

The theoretical design provides global reach to any E.164 number enabled by the canonical structure of Domain Name System (DNS). The global Tier 0 root delegates to a regulatory country level authority Tier 1, then to an individual operator level Tier 2 with service addresses and policy for information sharing.



The theoretical design of ENUM relies upon the existence of authorized delegations. The next section illustrates the reality of today's ENUM implementations and lack of authorized delegations which impedes the success of ENUM on an interconnect basis.

Today's fragmented ENUM implementations

Inhibiting service inter-operability

As defined, ENUM provides for efficient use of operator infrastructure, takes advantage of the Internet backbone for efficient routing and provides the foundation for offering enhanced next generation operator services. Despite the potential of ENUM "on paper" the realization of ENUM has yet come to fruition due to fragmented implementations.

Three types of ENUM have been defined and are in various stages of use today:

End User ENUM: The original concept of ENUM provided the ability for users to register their own services against the well known E.164 or telephone numbers within a global database that could be resolved to individual services. End User ENUM, also referred to as Public ENUM, relies on end-user opt-in and provides an open database which relies on the end user to update. The Réseaux IP Européens Network Coordination Centre (RIPE NCC) provides the co-coordinating function for ENUM delegation for e164.arpa, however RIPE will only delegate to regulatory approved Tier 1 Public ENUM services and to date there are only 50 registered delegates and use is very limited. End User ENUM has not been widely adopted and is not appropriate for supporting operator services.

Private Infrastructure ENUM: The most common implementations to date have been implemented at a Tier 2 level within an operator for internal resolution and service discovery. The E.164 ranges are allocated by the ITU to a country and by the regulatory authority within a country to individual telephony operators. Telephony operators who have authoritative control over the E.164 number are the primary users of ENUM. The Tier 2 ENUM servers cache information on operators it regularly passes traffic without communicating to a Tier 1. ENUM has also been used to resolve number portability issues in some domains as in support of mobile number portability with MMS messages between operators. Although Private Infrastructure ENUM brings the advantages of ENUM into the internal network, operators still rely on out-dated, manually intensive bi-lateral like routing arrangements for interconnects.

Carrier Infrastructure ENUM: Provides full benefits of improved routing and interoperability with private interworking ENUM services between operators with peering agreements. It contains the access point for the operator of record, not the final private URI of the subscriber. Carrier Infrastructure ENUM requires authoritative Tier 0 and Tier 1s for appropriate delegations. At the time of this writing no official Tier 1 carrier ENUM registries have been authorized.

A small number of 'Tier 1 like' federations exist where a number of peering partners federate their data to enable interoperability between members of the federation (e.g. XConnect). Recently operator organizations such as GSMA have addressed the lack of Tier 1's by providing proxy Tier 1 capabilities included in its ENUM based services to provide global operator interoperability (e.g. GSMA's Pathfinder fixed and mobile ENUM service). The lack of an authoritative Tier 0 root and Tier 1's along with fractured commercial Tier 1's threatens the use and adoption of Carrier Infrastructure ENUM. This inhibits interoperability, increases costs and places the success of future services at risk.

Placing operator enriched services at risk

New IP-based public communications services such as IMS must use ENUM to resolve interconnect addressing.[3] Operators are actively building out their internal networks to support IMS. Infonetics reports the IMS equipment revenue was up 142% in 2009 (426 million USD) over 2008 driven by mobile networks deployments for RCS, Video, Long Term Evolution (LTE) trials, enhanced mobile instant messaging (IM) and presence services. They forecast growth to remain strong and project IMS equipment revenue of 1.44 billion USD in 2014.[4]

The lack of cohesive ENUM implementations inhibits operator interoperability and increases overall costs.

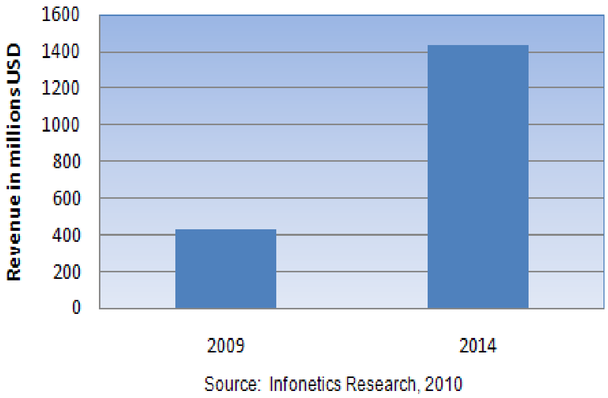


Figure 2: IMS Equipment Revenue Growth Projection

As users migrate to next generation messaging services such as RCS, service discovery is imperative to enabling cross network services. Carrier Infrastructure ENUM is required to provide service discovery for the user and identify the correct service gateway. This includes Interconnect Border Control Function/Interconnect Border Gateway Function (I-BCF/BGF) for packet switch domain messaging and mobile switching center (MSC) softswitch for circuit switch domain VoIP. The adoption of these new services is already underway and expected to grow rapidly. Infonetics forecasts 7.3 million RCS subscribers in 2011 and expects explosive triple-digit percentage annual growth through 2014 as RCS becomes widely available on 3G devices. A critical first step for the success of RCS growth is achieving interoperability among operators.[5]

RCS subscriber base is forecast to experience explosive triple-digit growth through 2014 but the lack of carrier ENUM interoperability places the success of RCS and other services at risk.

Voice services have started to migrate to VoIP and IMS. GSMA's Packet Voice Interworking (PVI) SIP-I voice interconnect service takes advantage of VoIP today. The ability to determine if the destination network subscriber is reachable via VoIP as opposed to TDM based ISDN user part (ISUP) interconnect is important to assure end-to-end quality of service (QoS) by maintaining IP bearer where possible. The ability to identify individuals who have migrated from within a number block and to route to the correct service domain (e.g. circuit switched voice MSC's or packet switched based IMS for VoLTE) during service migration will be a key enabler.

New application environments, such as GSMA's OneAPI, provide the application developer community with access to networks as a service (NaaS) enabled by ENUM which provides the correct gateway address to access the web services for a particular E.164 number.

The success of operator enhanced next generation services hinges on ENUM interoperability between operators. Without Carrier Infrastructure ENUM in place global operator interoperability is unable to address the service discovery and routing decisions required to provide end-to-end connectivity as illustrated in Figure 3.

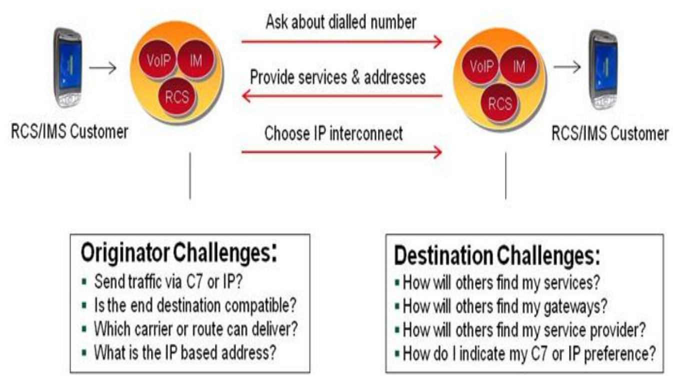


Figure 3: Enhanced operator services fail without interoperability

One additional challenge for interoperable ENUM solutions is the ability to deal with post dial delay sensitivities of certain services such as voice. To be successful an ENUM solution must provide for local caching where possible while also providing for high capacity hosted query services distributed geographically.

The "net" generation brings their Internet experience and expectations of feature rich services and "access from anywhere" to the world of operator services and the old telecom paradigm of bi-lateral agreements for each service will not work. Operator's need to embrace the best of the Internet working models to ensure they capture and retain customers and not become just a bit pipe provider to over the top Internet services. A new route and service discovery architecture is required to handle the growth of new next generation IP-based services and to meet the requirements for interconnects. This new architecture must be evolutionary in nature as it must support both new services and maintain existing business models including the wholesale operator model. The absence of this type of architecture places the success of the next generation operator enhanced services in jeopardy.

Global ENUM: Architectural Solution to Carrier Infrastructure ENUM

Private and Carrier Infrastructure ENUM services are key aspects for the introduction of next generation multi-media services. For enhanced IP-based services to succeed operators need a purpose built ENUM solution that delivers the reliability, scalability and security required to seamlessly and efficiently handle both intra- and inter-network traffic.

An inter-operator carrier ENUM report by management consultancy firm Booz Allen Hamilton Inc., reinforces the need and defines four critical success factors for the widespread success of Carrier Infrastructure ENUM.[6]

Critical success factors for widespread success of Carrier Infrastructure ENUM	
Co-operation	Multiple operators must recognize the benefits and co-operate for carrier ENUM to work.
Technical capabilities	A central carrier ENUM capability with adequate IP interconnects needs be in place and must deliver high performance and reliability.
Simplicity	Implementation must be simple, supported by commonly agreed interoperable business and technical frameworks.
Openness and competition	Carrier ENUM must be open to all operators. Operators should participate in a competitive development environment to ensure innovation in new services.

Source: Booz Allen Hamilton, 2008.

The report goes on to define the two key players who are integral for Carrier Infrastructure ENUM:

- Fixed and mobile operators
- Trusted third-party

The report stresses in the absence of authoritative Tier 1s the trusted third-party must develop services to meet the needs of multiple operators and guide the industry through the development of a common framework.

In absence of authoritative Tier 1s, a trusted third-party must guide the industry through the development of a common framework.

This section introduces the common framework concept of Neustar's "Global ENUM". Global ENUM is an architecture comprising of aspects of both Private and Carrier Infrastructure ENUM that solves the Tier 0 and Tier 1 authoritative and operator security issues.

Operators need to look to a trusted third-party that can deliver Global ENUM services with an architecture having the following distinct functional entities:

- Routing server implementation enabling:
  - Internal routing policies
  - Outbound traffic routing
- Tier 2 delegate for:
  - Externalization of E.164 service discovery
  - Service gateway through external Carrier Infrastructure ENUM services

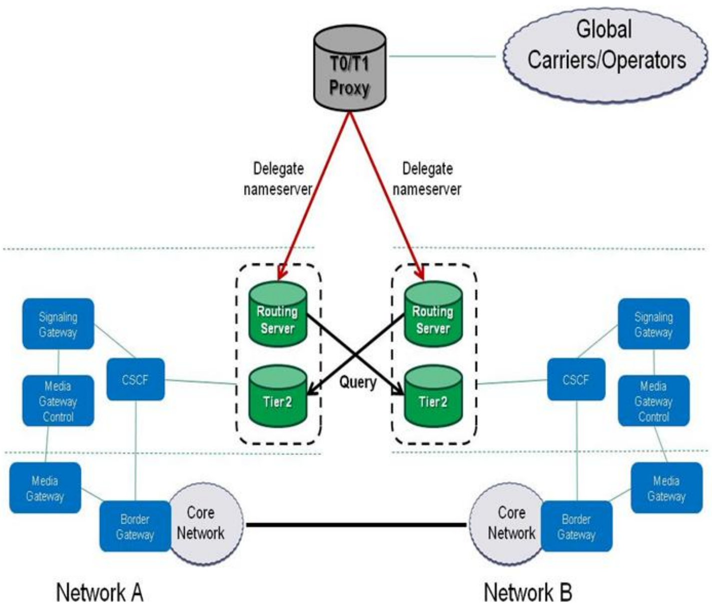


Figure 4: Global ENUM Architecture

Enabling global reach

To succeed, the ENUM architecture must extend beyond the country boundaries of the operator. An operator's Tier 2 servers must be discoverable by other operators from around the globe just as the operator's routing servers must also have the ability to discover other operators without requiring a separate unique infrastructure.

Global ENUM architecture provides a closed network between operators to support the security and policy requirements for operator interconnect. The Tier 0 root of the Global ENUM architecture supports a model where both 'Tier 1 proxy' services can be provided when no national authority provides nameserver records and supports migration to Tier 1 solutions where national Tier 1 ENUM services are provided.

Operators desire to house as much of their peering partners' nameserver addresses in their local cache as possible. When addressing for a global solution operators should query a trusted third-party registry for some nameserver addresses to overcome the difficulty of storing and managing change of global routing information. Queries are directed to a Global ENUM infrastructure in the role of Tier 0 and Tier 1 proxy. The primary role of the Tier 0 and Tier 1 proxy is to provide the mapping of E.164 to a nameserver record of the Tier 2 server. The Global ENUM architecture supports the integration of multiple ENUM registries, enabling operators the flexibility to select its chosen provider with peering between registries for global interoperability.

Benefits of Global ENUM:

- *Managed migration from TDM to IP networks*
- *Globally accessible enriched services available today*
- *Gain cost efficiencies with optimal routing and margin management*
- *Update routing data in minutes vs. days*
- *Reduce churn with enhanced user experience*
- *Increase ARPU with additional IP services revenue*

Rich policy-based routing functionality

The Routing server supports all originating sessions within an operator's network including inter-operator sessions. Routing servers are only accessible to the operator's own network and include all intra-operator routing information as well as data for other operators, including local cached ENUM data such as Tier 2 nameserver addresses. Call session control servers query the Routing server for all sessions to determine session routing. The Routing server also generates external ENUM queries to other operators' Tier 2 and to Global ENUM servers. The Tier 2 functionality of Global ENUM can be provided by the operator or hosted within the Global ENUM infrastructure. Operators have the flexibility of outsourcing service discovery or providing it in-house.

Queries from the session control to the Routing server typically use the DNS protocol. The queries can also use SIP, SS7 or another Internet protocol such as Hypertext Transfer Protocol Secure (HTTPS) or Lightweight Directory Access Protocol (LDAP). DNS is the simplest to deploy given the existing standards work using DNS.

Responses from the Routing server to call control include:

- **Internal address:** RFC3263 address
- **External address:** Point of ingress on peer's network
- **Next hop address:** Point of egress to transit operator, peer or PSTN

The Routing server supports configurable, centralized policy for routing decisions such as time of day, day of week and cost optimized routing (enabling margin management in real time) providing for the operator's business needs; this may be provided by integration with external systems such as Least Cost Routing (LCR) engines and margin analytics. The policy related to determining the appropriate response to the querying entity will be aligned with the operator's commercial and technical agreements for interconnect.

The centralization of data significantly simplifies data management historically distributed across multiple systems resulting in inconsistency, inefficiency and an inability to react to changing business circumstances (e.g. changes in termination rates from one operator to another).

Robust service discovery

The Tier 2 server responds to queries from other service providers. Access to the Tier 2 server can be restricted by a secure network connection such as a virtual private network (VPN), open to the public Internet or both. Operators may use VPNs to identify the querying entity and provide different authorization levels for different entities. Operator A may get one set of URIs while Operator B a different set of URIs. The Tier 2 server will distinguish between the two operators through the VPN and source IP address.

The address of the Tier 2 will be a DNS nameserver record with a DNS query to the Tier 2 Server. The routing servers receive the Tier 2 address from either local cache or from a query to the Global ENUM service.

The response to the Tier 2 query will be one of the following:

- **URI:** Identify a point of ingress to the operators' network. Query is secured by restricting access via VPN or via a secure IP domain such as the Global Roaming eXchange (GRX).
- **E.164 number verification:** Verifies operator provides service for the E.164 number queried (if operator chooses to provide info). Query is typically provided over the Internet.
- **Non-Existent Domain (NXDOMAIN):** Indication that either the operator does not provide service for the E.164 number or is not accessible over IP. The querying operator will default the voice call to the PSTN.

Added level of security

Accurately identifying the originators of a DNS query on the public Internet in order to provide authorization is difficult. Operators may want to provide an address in response to a Tier 2 query of a specific server to provide the authorization. This is the function of the Secure Directory within Global ENUM and is in lieu of providing this functionality in the Tier 2. HTTPS, LDAP and SIP are three examples of protocols that provide the ability to reliably identify the querying party and respond with a rich set of service information. The Secure Directory provides the specific response based on the querying entity.

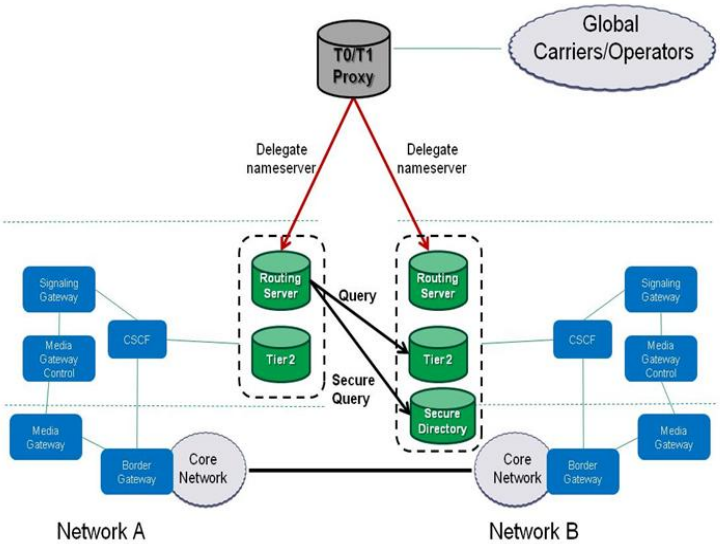


Figure 5: Secure Directory for authentication of querying network.

An example of a Secure Directory address provided by the Tier 2 is https://operatorA.net or sip:TN@operatorA.net. The Secure Directory address can also be used to identify the service provider. The Tier 2 server responses from the Secure Directory include URIs, E.164 number verification and NXDOMAIN.

Support for Transit Networks

ENUM assumes a direct peering relationship between the originating and terminating operators. This assumption does not always hold as in many situations a wholesale transit operator is brokering connectivity between the originating and terminating operators. ENUM assumes that the terminating operator will provide a URI as an ingress point to the network. The originating operator may not have a direct physical interconnect with the terminating operator and may use a third-party wholesale transit operator to terminate traffic to the terminating network.

When using a transit network operators can decide on E.164 number handling and delegate authority for publication of telephone numbers to transit partners. In this scenario transit partners are the authoritative source and publish ENUM records on behalf of the operator such as in the case of federations of interconnect partners. In some instances transit partners provide access to certain world zones/countries and may publish non-authenticated ENUM records for numbers it does not own, but towards those it supports commercial and technical interconnectivity.

The requirement is for non authoritative records to be clearly marked to enable the originating operator to apply its local policy as to whether or not to use the transit operator. A Global ENUM solution must handle these options to meet the needs of operators.

The Global ENUM architecture supports appropriate methods for resolution of transit cases providing the freedom to choose and the ability to extend the architecture as operators needs evolve. Global ENUM allows operators to direct interconnect partners to send traffic via a transit operator interface. In addition, Global ENUM takes advantage of the two Internet Engineering Task Force (IETF) models for solving this issue. The Vandergaast IETF RFC extension to ENUM allows the transit operator to identify the source network if it is relevant to the policy response of the terminating operator.

The IETF's SPEERMINT working group has defined two separate functions for identifying and routing calls between non-peering operators:

- **Look up Function (LUF):** Identifies the terminating operator.
- **Location Routing Function (LRF):** Determines the next hop for routing the call.

The LUF and LRF are functions of the Routing server. Once the Routing server determines the terminating operator it determines how to route the call. The table below shows the multiple methods of performing LUF and LRF.

LUF – Determine identification of operator	LRF – Determine next hop route
Provision the local cache of the Routing server with number assignment and number portability data.	Provision a table which matches destination operator to next hop (e.g. transit operator).
Analyze Tier 2 address either provisioned in local cache or received via a query to Global ENUM.	Resolve a Tier 2 address to a URI.
Analyze response from a Tier 2, Secure Directory or Global ENUM query. Secure Directory address or E.164 number verification.	Access a URI from the Secure Directory.

The Global ENUM architecture's support for transit networks overcomes a critical shortfall in Carrier Infrastructure ENUM design. Global ENUM provides ubiquitous access for operator enhanced services by the permitting operators to interconnect via multilateral hubs rather than a direct peering arrangement.

Take advantage of trusted third-party to reduce cost and mitigate risk

This new era of multi-media interconnect, brings with it significant challenges for operator's used to the traditional worlds of SS7/C7 interconnectivity for roaming and bi-lateral peering services. Simple E.164 number mapping is no longer sufficient to support the variety of services (e.g. IM, Presence, picture messaging, video sharing, music file transfers, etc) and the related gateways that will be enabled by All-IP networks.

Service discovery through Global ENUM is essential to provide for the open distribution of inter-network service and routing data. Outsourcing the deployment and operation of these new technologies to a trusted third-party reduces the overall capital and operating costs while reducing risk.

The benefits of a trusted outsource partner become clear when looking at the development and deployment of next generation session and service layers. The technologies fit well within the Software as a Service (SaaS) and Infrastructure as a Service (IaaS) or cloud computing model. The cloud model reduces the higher risk capital investment through the operationalization of spend, with amortization of cost across multiple networks resulting in lower operational costs. Importantly the cloud model also removes the need for new technology introduction costs. In this way a new Communications as a Service (CaaS) model, achieves the facets of cloud computing and SaaS within the telecommunications environment as it takes advantage of the new distributed models of the next generation telecommunications All-IP networks. The CaaS model provides a trusted enabler for the delivery of next generation multi-media services without the need for significant capital investment, reduces overall operational costs and results in faster revenue generating new service introduction.

Building the interoperability between networks to support global reach has its own new costs for multi-media services. The ability to have one multi-lateral relationship with a trusted partner who provides for multi-media service interoperability will significantly simplify and reduce the costs of introducing new services with ubiquity of reach in a global market.

Interconnects will need to span both the traditional operator communities and new social networks of the Internet, providing interworking between the different standards and supporting new multi-lateral interconnect models. Cross network and cross community interconnectivity will be essential to ensure the ubiquitous access to services and the network effect it creates.

Benefits of CaaS model:

- *Deliver new services in hours vs. months*
- *Reduce the costs associated with technology transformation*
- *Mitigate risks inherent in technology transformation*
- *Strengthen position in overall communications experience*

Realize the full benefits of ENUM today

Private and Carrier Infrastructure ENUM provide many potential benefits to operators that have not been fully realized due to the current fragmented implementation of ENUM services. Global ENUM brings these benefits to fruition with an architecture operators can take advantage of today.

In addition to the inherent benefits of Private and Carrier Infrastructure ENUM, Global ENUM provided by a CaaS model provides the additional benefits operators can realize today:

- Managed migration from TDM to IP networks
- Globally accessible enriched services
- Gain cost efficiencies with optimal routing and margin management
- Update routing data in minutes vs. days
- Reduce churn with enhanced user experience
- Increase ARPU with additional IP services revenue
- Deliver new services in hours vs. months
- Reduce costs associated with technology transformation
- Mitigate risks inherent in technology transformation
- Strengthen position in overall communications experience

Illustrative Global ENUM Use Cases

The following four use cases illustrate session establishment within the Global ENUM architecture. These scenarios cover intra- and inter-networking cases required to provide operators with the global inter-operator reach and optimal routing for delivering enhanced IP-based services. The use cases are not exhaustive in nature, but are provided as an overview of the concepts behind Global ENUM. While certain functions such as Routing server, Tier 2 and Service Management systems are shown within the originating and terminating operator clouds, there is no implication to be inferred that these cannot also be hosted functional components potentially provided by the same provider as the T0/T1 proxy functionality.

While the described Global ENUM use cases show simple information flows that enable the establishment of sessions, these must be taken in the wider business and commercial contexts of an operator's interconnect policy. Operators will apply business rules within both the Routing server and Tier 2 server to determine what they want to expose and make routing decisions based upon the information received from the destination network, any transit networks least cost routing, commercial interconnect agreements, volume commitments or available minute rates.

This implies the service and margin management systems must be integrated with the routing server and the Routing server can support real time routing updates and decisions based upon these key business criteria.

Use Case 1: Intra-network session.

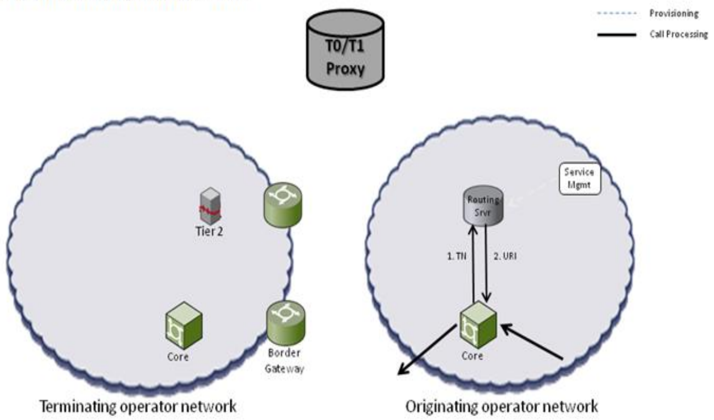


Figure 6: Intra-network routing

Steps 1-2: Operator's own routing server is provisioned with its own internal routing information acting as a private ENUM solution.

Use Case 2: Inter-network peering partner session.

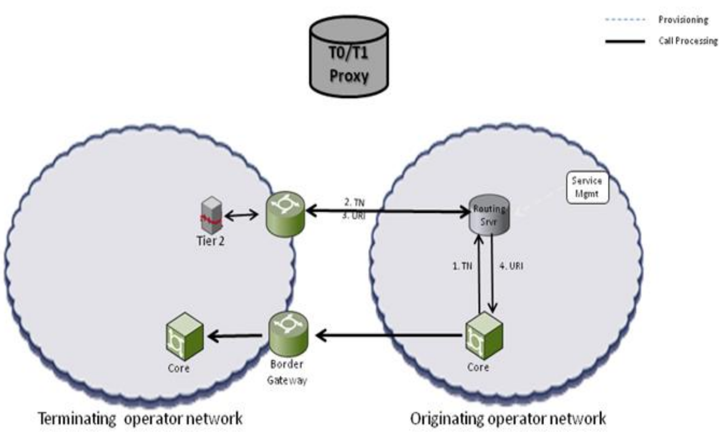


Figure 7: Peering partner

Step 1: Queries for peering partner E.164 numbers get a direct response from the local cache in the operator's Routing Server. Operators service management systems provision well known nameserver records to operator's local cache.

Steps 2-4: Routing server uses the nameserver address to query terminating operator's Tier 2 server and receives the URI for call/service processing.

Use Case 3: External ENUM routing lookup session.

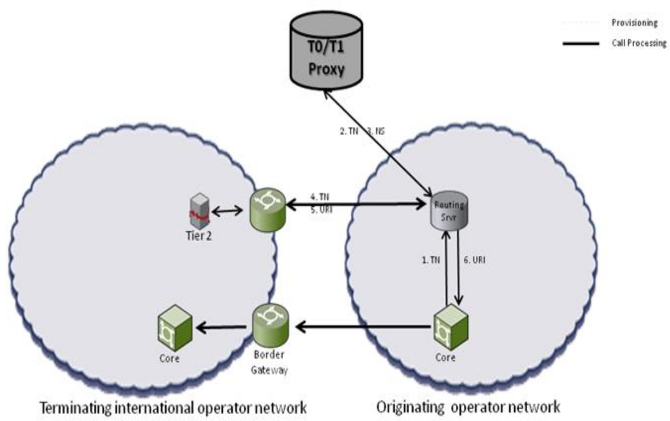


Figure 8: International, non-peering and centralized LNP/MNP scenarios

Steps 1-2: Operator query's to international E.164. Numbers are sent to a Tier 0 root which supports Tier 1 proxy functionality by the operator's Routing server. Operators provision nameserver address in the Tier 1 Proxy.

Step 3: The Tier 1 proxy responds with nameserver address of terminating international operator's Tier 2 server.

Steps 4-6: Routing server uses nameserver address to query terminating operator's Tier 2 server and receives the URI for call/service processing.

Use Case 4: Inter-network, operator to international destination via transit operator session.

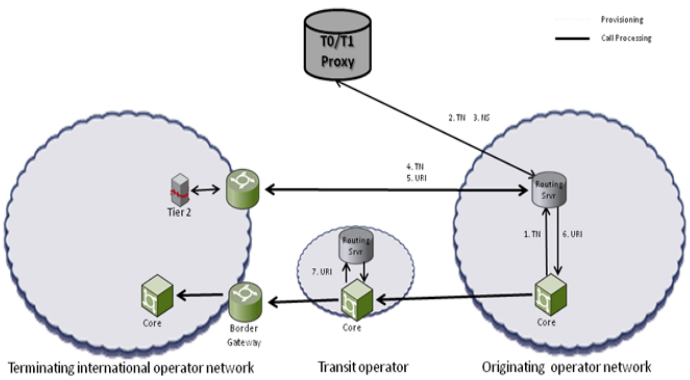


Figure 9: International reach via transit operator

Steps 1-2: Operator query's to international E.164. Numbers are sent to a Tier 0 root which supports Tier 1 proxy functionality by the operator's Routing server. Operators provision nameserver address in the Tier 1 Proxy.

Step 3: The Tier 1 proxy responds with nameserver address of terminating international operator's Tier 2 server.

Steps 4-6: Routing server uses nameserver address to query terminating operator's Tier 2 server and receives the URI for call/service processing. The LUF/LRF functions of the routing server determine that connectivity to this destination network is via a transit operator.

Step 7: A session is established with the transit operator. The transit operator determines the routing to the destination based on routing server policy. In this use case the terminating operator is able to expose its numbers globally to enable discovery of their subscriber's services.

Summary

Private and Carrier Infrastructure ENUM services are pivotal to the success of next generation multi-media communications. The lack of an authoritative Tier 0 root and Tier 1's along with fractured commercial Tier 1's threatens the use and adoption of Carrier Infrastructure ENUM. This inhibits operator interoperability, increases costs and places the success of future operator enhanced IP-based services at great risk.

Neustar is the selected vendor for the GSMA's Pathfinder global fixed and mobile ENUM service. Pathfinder enables the global reach of ENUM as well as the linkage between ENUM registries. The Pathfinder service currently handles over 3.8 billion numbers and 85% of port correction coverage.

Neustar's Global ENUM architecture solves the global reach problem today by transparently supporting Tier 1 proxy functions required to enable reach to Tier 2 operator implementation nameservers where Tier 1 regulatory authority nameservers do not yet exist. Global ENUM also supports the migration to Tier 1 solutions as they become available. Global ENUM provides integrated solutions for ENUM and internal routing, supporting the automated advertising of Tier 2 nameservers within the architecture, as well as rich internal routing policy. The internal 'routing servers' support the extension of services for outbound traffic between operators, with discovery through the Global ENUM solution. The Global ENUM architecture delivers the foundation to enable the successful implementations of the next generation operator enhanced IP-based services.

The unique advantages of a Global ENUM architecture provided by Neustar include:

- Provides a neutral and trusted global architecture for Carrier Infrastructure ENUM
- Successful deployments of Tier 2 ENUM services with several of the largest global operators
- The operator's Tier 2 ENUM services, for the advertising and display of nameserver information for service discovery, fully integrated with and automatically updating the Pathfinder system
- The 'routing server' with rich policy-based routing services for number translation, exception, origin based and least cost routing as well as standards based discovery of services in peering partners and global networks

- Major contributor to the creation of ENUM standards. Co-authored IETF RFC 3482, RFC 3764, RFC 3824, RFC 3953, RFC 4759, and RFC 4769
- Communications as a Service (CaaS) model for service delivery significantly reduces the costs and risks associated with new technology transformations while enabling the delivery of new revenue generating services more quickly than ever before

To speak with a Neustar Solutions Expert to answer your questions or schedule a complimentary webinar demonstration, please contact us at:

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Glossary

ALL-IP Networks – Networks that have migrated their services away from 'legacy' Time Division Multiplexing (TDM) technology to running all services over Internet Protocol (IP) from the access to the core.

ARPU – Average revenue per user. It is the total revenue divided by the number of subscribers.

Bi-lateral peering services – A commercial and technical interconnect for service negotiated directly between two operators.

Bit pipe – The actual transport medium, wired or wireless, for voice and data traffic.

CaaS – Communications as a Service. Similar paradigm to cloud computing and SaaS but within the telecom communications environment. Takes advantage of the new distributed models of the next generation telecommunications All-IP networks.

Cloud Computing (aka IaaS) – Method of running application software and storing related data in central computer systems and providing customers or other users access to them through the Internet. (Source: Encyclopedia Britannica)

CSCF – Call Session Control Function. Central component to signaling and control within IMS.

DNS – Domain Name System. Hierarchical naming system for devices, services or resources connected to the internet. Translates hostnames into IP addresses.

ENUM – A specific service within DNS to allow for the translation of E.164 numbers (aka telephone numbers) to universal resource identifiers as part of service discovery.

GSMA – Global Systems for Mobile communications Association. The GSMA's mission is to create value for operators and the mobile industry in the provision of services for the benefit of end users.

H.323 – Standard defined by the ITU for providing audio-visual communication sessions on any packet network.

I-BCF – Interconnect Border Control Function. Transport level of security within IMS. Identifies what resources are required for the call.

I-BGF – Interconnect Border Gateway Function. Media relay for hiding endpoint address within IMS.

IaaS – Infrastructure as a Service. See definition of Cloud Computing.

IETF – Internet Engineering Task Force. Open standards organization which develops the Internet standards.

IMS – IP Multimedia Subsystem – Defacto standard architectural framework for delivering IP multimedia services.

ISUP – ISDN User Part. Standard defined by the ITU within SS7 for setting up calls in PSTNs.

ITU – International Telecommunications Union. Defines global telecommunication standards, tariffs and accounting principles.

LDAP – Lightweight Directory Access Protocol. An application protocol for querying and modifying data using directory services over IP.

LTE – Long Term Evolution. Project name for a high performance 3G air interface for cellular mobile telephony.

MMS – Multimedia Messaging Service. Standard for sending multimedia content to and from mobile phones.

MMTel – Multimedia Telephony. Global standard which makes use of the IMS architecture to deliver real-time multimedia communication with the characteristics of a telephony service over both fixed and mobile broadband.

MSC – Mobile Switching Center. Responsible for routing voice, SMS and other services for GSM.

Multi-lateral interconnect models – Allows for an intermediary/wholesale operator to provide one commercial and technical interconnect that provides reach to multiple destination networks.

NaaS – Network as a Service. Monetizing network assets by opening the garden gate to the application developer communities, creating the network wide App Store.

NXDOMAIN – Non-Existent Domain. Term used to describe an Internet domain that is unable to be resolved using DNS.

Over the top services – Services carried over the network, delivering value to customers, without any operator service provider involvement.

PSTN – Public Switched Telephone Network. Utilizes standards created by the ITU to permit interconnect.

RCS – Rich communications Services. Defacto standard from the GSMA. Assists in rapid adoption of mobile applications and services to deliver rich communications experience to customers.

RIPE NCC – Independent, not-for-profit membership organization whose primary act is providing global Internet resources and related services to its members who comprise mainly of Internet Service Providers in Europe, the Middle East and parts of Central Asia.

SaaS – Software as a Service. A model of software deployment over the Internet. Allows vendors to develop, host and operate software for customer use.

SPEERMINT – Session PEERing for Multimedia INTerconnect. IETF working group defining the architecture to identify, signal and route delay-sensitive communications sessions using the SIP signaling protocol to enable peering between two or more administrative domains over IP networks.

SIP – Session Initiation Protocol. IETF standard signaling protocol used for controlling multimedia communication sessions over IP.

SMS – Short Message Service. Uses standardized communications protocols that allow exchange of short text messages between mobile devices.

Social networks – Online communities of individuals who exchange messages, share information, and, in some cases, cooperate on joint activities. (source: Encyclopedia Britannica)

SS7/C7 – Signaling System #7. ITU standard set of signaling protocols used to set up and tear down most of the world's PSTN telephone calls.

TDM – Time-division multiplexing. Used in circuit switched networks such as the PSTN where there is a need to transmit multiple subscribers' calls along the same transmission medium.

URI – Uniform Resource Identifier. A string of characters used to identify a name or a resource on the Internet.

VoIP – Voice over Internet Protocol. The delivery of voice communications over IP networks.

VoLTE – Voice over Long Term Evolution. Is an initiative led by a group of mobile operators, infrastructure vendors and handset vendors to define a profile for voice services using IMS in an LTE environment.

XConnect – Independent provider of interconnect services. Operates a global alliance ENUM peering federation.

XMPP – Extensible Messaging and Presence Protocol. IETF standard is a set of open XML technologies for presence and real-time communication.

About Neustar

Neustar, Inc. *(NYSE: NSR) solves complex communications challenges by providing innovative, market-leading solutions and directory services that enable trusted communication across networks, applications and enterprises around the world. Visit Neustar online at* www.neustar.biz*.*