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Supplement 3
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SERIES E: OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

International operation – Numbering plan of the international telephone service

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The international public telecommunication numbering plan

Supplement 3: Operational and administrative issues associated with national implementations of the ENUM functions

ITU-T Recommendation E.164 – Supplement 3

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ITU-T Recommendation E.164

The international public telecommunication numbering plan

Supplement 3

Operational and administrative issues associated with national implementations of the ENUM functions

Summary

This Supplement provides background, tutorial and guidance information on a broad range of operational and administrative issues associated with the inclusion of E.164 numbers into the DNS (i.e., the inclusion of ENUM domain names based on E.164 numbers). It contains considerations of and potential consequences arising from such issues. This Supplement does not attempt to provide solutions for these issues; such solutions are left to the prerogative of Administrations for whom a range of oversight responsibilities is proposed in this Supplement. This Supplement describes the various issues and provides some guidance considering various ways to address each issue. Please refer to the Recommendation(s) in which TSB processes and procedures relating to requests for delegations of domain names corresponding to E.164 country codes are specified.

Source

Supplement 3 to ITU-T Recommendation E.164 (1997) was agreed on 28 May 2004 by ITU-T Study Group 2 (2001-2004).

NOTE – As of the date of publication of this Supplement, the insertion of E.164 numbers in a particular Top Level Domain (TLD) (e.g., in .e164.arpa as described in RFC 2916) and the designation of an ENUM Tier 0 Registry (presently RIPE-NCC) remained open issues within the ITU-T. The approach followed in this Supplement is to refer to the domain in which is the ENUM Root Level as ".e164.TLD", and to refer generically to the entity that is the Registry at this level.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this publication, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Operational and administrative issues associated with national implementations of the ENUM functions

Introduction

The Internet Engineering Task Force (IETF) has developed the Telephone Number Mapping (ENUM) protocol (see RFC 2916) as a mechanism for mapping E.164 numbers onto Uniform Resource Identifiers (URIs; see RFC 2396). The E.164 number might also be used as the "key" within the ENUM protocol to produce a listing of the various applications (e.g., e-mail, fax, telephony) that could be used to communicate with a specific subscriber. This Supplement provides an overview of the ENUM concept and describes various issues that are national matters and that need to be addressed by Administrations as they consider the inclusion of the portion of the E.164 numbering plan under their jurisdiction within the Domain Name System (DNS; see RFC 1591) as part of the one such envisaged implementation described by RFC 2916. This Supplement also describes various issues that are of interest to and that need to be addressed by assignees of E.164 Country Codes for geographic areas (also CCs for trials). Please refer to the Recommendation(s) in which TSB processes and procedures relating to requests for delegations of domain names corresponding to E.164 country codes are specified. Information about the early understandings between the ITU and the IETF concerning ENUM can be found in RFC 3026, "Liaison to IETF/ISOC on ENUM".

There are potentially multiple competitive implementations of the ENUM protocol not covered in this Supplement. As competition is a national matter, this Supplement is not intended to preclude such implementations.

1 Scope

This Supplement provides background, tutorial and guidance information on a broad range of operational and administrative issues associated with the inclusion of E.164 numbers into the DNS (i.e., the inclusion of ENUM domain names based on E.164 numbers). It contains considerations of and potential consequences arising from such issues. It does not attempt to provide solutions for these issues; such solutions are left to the prerogative of Administrations for whom a range of oversight responsibilities is proposed in this Supplement. This Supplement describes the various issues and provides some guidance considering various ways to address each issue. Please refer to the Recommendation(s) in which TSB processes and procedures relating to requests for delegations of domain names corresponding to E.164 country codes are specified.

2 References

2.1 IETF

– RFC 1034 (1987), *Domain Names – concepts and facilities* – http://www.ietf.org/rfc/rfc1034.txt.

– RFC 1591 (1994), *Domain Name System Structure and Delegation* – http://www.ietf.org/rfc/rfc1591.txt.

– RFC 2396 (1998), *Uniform Resource Identifiers (URI): Generic Syntax* – http://www.ietf.org/rfc/rfc2396.

– RFC 2826 (2000), *IAB Technical Comment on the Unique DNS Root* – http://www.ietf.org/rfc/rfc2826.txt.

– RFC 2915 (2000), *The Naming Authority Pointer (NAPTR) DNS Resource Record* – http://www.ietf.org/rfc/rfc2915.txt.

– RFC 2916 (2000), *E.164 Number and DNS* – http://www.ietf.org/rfc/rfc2916.txt.

– RFC 3026 (2001), *Liaison to IETF/ISOC on ENUM* – http://www.ietf.org/rfc/rfc3026.txt.

2.2 ITU-T

– Recommendation E.164 (1997), *The international public telecommunication numbering plan*.

– Recommendation E.164.1 (2003), *Criteria and procedures for the reservation, assignment and reclamation of E.164 country codes and associated identification codes (ICs)*.

– Recommendation E.164.3 (2001), *Principles, criteria and procedures for the assignment and reclamation of E.164 country codes and associated identification codes for groups of countries*.

– Recommendation E.190 (1997), *Principles and responsibilities for the management, assignment and reclamation of E-series international numbering resources*.

– Recommendation E.195 (2000), *ITU-T International numbering resource administration*.

– Recommendation H.323 (2003), *Packet-based multimedia communications systems*.

3 Definitions

3.1 General terms

3.1.1 address: A string or combination of digits and symbols which identifies the specific network termination points of a connection and is used for routing.

3.1.2 name: A combination of characters (e.g., numbers, letters and symbols) which is used to identify end users.

3.1.3 telephony: A form of telecommunication primarily intended for the exchange of information in the form of speech.

3.2 E.164-specific terms

3.2.1 administrator: The organization entrusted with the administration of a resource derived from an international numbering plan.

3.2.2 assignee: The applicant to whom E-series international numbering resources have been assigned.

3.2.3 assignment: The process for providing an international numbering resource to an eligible applicant.

3.2.4 country: A specific country, a group of countries in an integrated numbering plan or a specific geographical area.

3.2.5 E.164 number: A string of decimal digits that satisfies the three characteristics of structure, number length and uniqueness specified in Annex A/E.164. The number contains the information necessary to route the call to a specific termination point associated with this number.

3.2.6 subscriber: A person or entity (i.e., a Registrant) that is assigned an E.164 number.

3.2.7 telephone service provider: The provider of the telephone services associated with an E.164 number in the PSTN, ISDN or PLMN. The service provider often assigns E.164 numbers to subscribers.

3.3 ITU-T non-numbering terms

3.3.1 Administration: Any governmental department or service responsible for discharging the obligations undertaken in the Constitution of the International Telecommunication Union, in the Convention of the International Telecommunication Union and in the Administrative Regulations.

3.3.2 Member State: A State that is considered to be a Member of the International Telecommunication Union in application of Article 2 of the Constitution.

3.4 DNS-specific terms

3.4.1 .arpa: The Address and Routing Parameters Area top level domain (TLD), used for network infrastructure.

3.4.2 delegation of a domain: The process of separating a sub-domain, which was contained in a zone, into its own zone.

3.4.3 DNS root level: The base of the inverted tree that forms the Internet domain name space. Sometimes represented as ".".

3.4.4 domain: A set of host names consisting of a single domain name and all the domain names below it.

3.4.5 domain name: A set of labels delimited by "."s.

3.4.6 name server: A DNS component that stores information about one zone (or more) of the DNS name space.

3.4.7 name space: The structure of the domain names in the DNS.

3.4.8 naming authority pointer: A standard record used within the DNS (see RFC 2915). Within RFC 2916, a naming authority pointer identifies possible URIs and numbers that can be returned from an ENUM query.

3.4.9 registrant: A subscriber who wants to register a domain name in the DNS. This is normally done via a Registrar and after the registration is done, the Registrant becomes the domain name holder.

3.4.10 registrar: An organization that provides direct services to domain name Registrants by processing name registrations to the Registry.

3.4.11 registry: The organization that maintains the authoritative DNS Registry database, is responsible for master and slave servers, and also creates the zone file for this domain. There is only one Registry per DNS zone.

3.4.12 zone: A domain (sometimes called the *child zone*) that has been delegated from another domain (sometimes called the *parent zone*). A zone includes all sub-domains below it except for those sub-domains that have themselves been delegated. A domain name belongs to exactly one zone.

3.5 ENUM-related terms

3.5.1 application service provider: An entity that provides specific application(s) (e.g., e-mail or voice messaging) direct to the ENUM subscriber.

3.5.2 e164.TLD: The second level domain used as the ENUM root level for ENUM domain names corresponding to E.164 numbers.

3.5.3 end user: A person who initiates some form of electronic communication (i.e., calling end user).

3.5.4 ENUM function: The capability to map E.164 numbers into Uniform Resource Identifiers (URIs) as described in RFC 2916.

3.5.5 ENUM CC level: A level in the tiered architecture (Tier 1) for ENUM that corresponds to the E.164 Country Code (CC).

3.5.6 ENUM domain name: The domain name for an E.164 number, the primary point of reference in ENUM.

3.5.7 ENUM E.164 number level: A level in the tiered architecture (Tier 2) for ENUM that corresponds to an E.164 number (i.e., of the international public telecommunication numbering plan).

3.5.8 ENUM registrant: The subscriber to an E.164 number who has chosen to subscribe to ENUM functions.

3.5.9 ENUM registrar: An organization that interacts with subscribers or their agents to establish ENUM registration for the subscriber's assigned E.164 numbers.

3.5.10 ENUM root level: A level in the tiered architecture (Tier 0) for ENUM that corresponds to the base of the inverted tree that forms the Internet domain name space designated for ENUM, i.e., .e164.TLD.

3.5.11 ENUM tier 0 manager: The entity responsible for the management of the domain for the ENUM Root Level.

3.5.12 ENUM tier 0 registry: The entity, under the administrative direction of the ITU-TSB, which acts as the Registry for the ENUM root level, in accordance with draft ITU-T Rec. E.A-ENUM.

3.5.13 ENUM tier 0 registrar: The entity (TSB) acting as the Registrar for the ENUM Root Level.

3.5.14 ENUM tier 1 manager: The entity (ITU Member State(s) or Administration(s)) responsible for the management of the domain for the ENUM CC level.

3.5.15 ENUM tier 1 registry: The entity acting as the registry for the ENUM CC level.

3.5.16 ENUM tier 2 manager: The entity (i.e., ENUM Subscriber) responsible for the management of the domain for the ENUM E.164 number level.

3.5.17 ENUM tier 2 name server provider: The entity that holds NAPTR resource records at the ENUM E.164 number level.

3.5.18 RIPE-NCC: The organization that presently acts as the ENUM tier 0 registry for the ENUM root level.

3.5.19 tier 0: ENUM level in the tiered architecture corresponding to the root, i.e., .e164.TLD. Records at this level contain pointers to Tier 1 for an E.164 Country Code or portion thereof.

3.5.20 tier 1: ENUM level in the tiered architecture corresponding to the E.164 Country Code (CC), i.e., .<CC>.e164.TLD. Records at this level contain pointers to Tier 2 for an E.164 number.

3.5.21 tier 2: ENUM level in the tiered architecture corresponding to the E.164 number, i.e., .<N(S)N>.<CC>.e164.TLD. Records at this level contain NAPTR pointers for an E.164 Country Code number.

4 Abbreviations

ASP	Application Service Provider
CC	(E.164) Country Code (as specified in ITU-T Rec. E.164)
DNS	Domain Name System
ENUM	TElephone NUmber Mapping (both a protocol and an IETF Working Group)
IAB	Internet Architecture Board
IANA	Internet Assigned Numbers Authority
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISOC	Internet Society
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
NAPTR	Naming Authority Pointer
NDC	National Destination Code
NPA	Numbering Plan Area – a national destination code in the North American Numbering Plan Area
NS	Name Server
PLMN	Public Land Mobile Network
PSTN	Public Switched Telephone Network
RFC	Request For Comments (the name for an Internet standards-related specification)
RIPE-NCC	Réseaux IP Européens Network Coordination Centre
SCN	Switched Circuit Network
SIP	Session Initiation Protocol
SOA	Start of Authority
TLD	Top Level Domain
TSB	Telecommunication Standardization Bureau (of the ITU)
URI	Uniform Resource Identifier (a Uniform Resource Locator is one type of URI)

5 Background

5.1 What is ENUM

ENUM is a function for mapping E.164 numbers into Uniform Resource Identifiers (URIs) corresponding to communication applications associated with those numbers. ENUM utilizes the protocol developed by the Internet Engineering Task Force (IETF), specified in RFC 2916 that first transforms E.164 numbers into ENUM domain names and then uses the DNS-based architecture to

access records from which the URIs are derived. ITU-T Rec. E.164, titled "*The international public telecommunication numbering plan*", describes the format and types of use of public E.164 numbers.

Through the ENUM function, E.164 numbers can be used to provide calling users with a variety of addresses, including those used for phone, fax and e-mail, by which the called user can be contacted. This enables the called user to tailor the manner in which they are contacted through a single number. Contact information can also be easily amended, added to, or updated without changing the number used for access.

Figure 1 shows some of the applications that can be associated with an E.164 number.

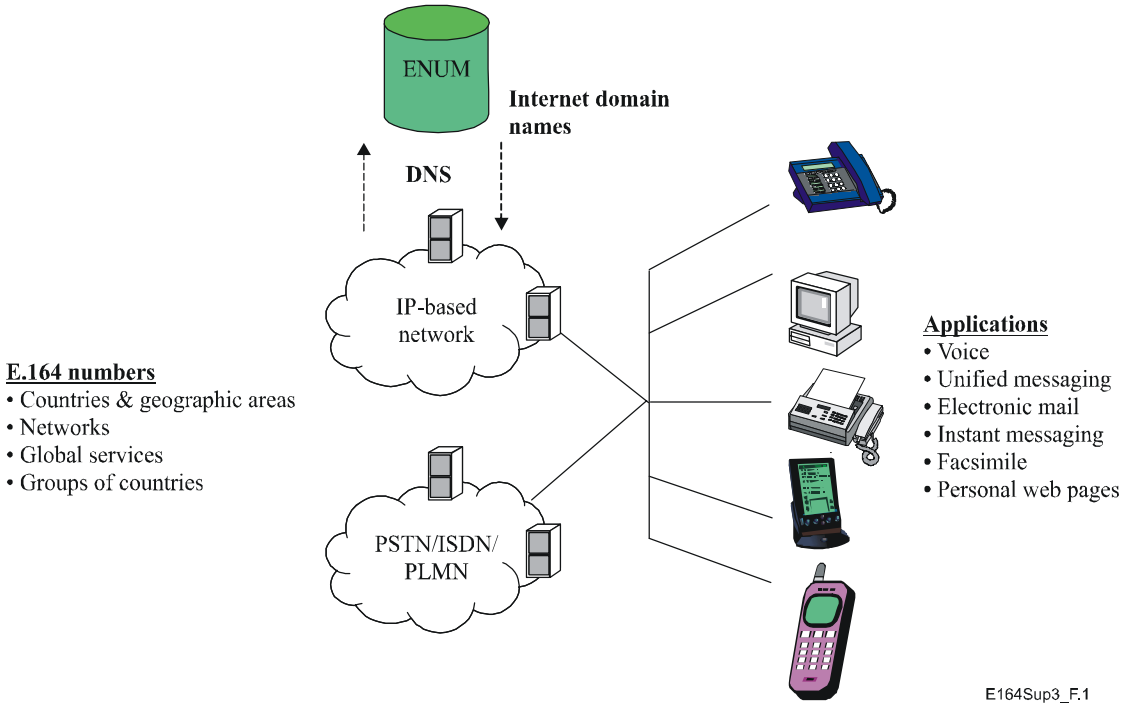


Figure 1 – Possible applications associated with E.164 numbers

When using ENUM in the specific implementation proposed in this Supplement, E.164 numbers are inserted within a single, carefully defined and structured domain of the DNS system. In a purely IP environment, ENUM will allow end users to use their E.164 number as a commonly used ENUM domain name for a variety of applications. It does not change the E.164 numbering plan in anyway.

This initiative can also facilitate both-way interworking between the SCN and IP-based networks. Sample call flows from an SCN to an IP-based network, and from an IP-based network to an SCN, are shown in the following figures.

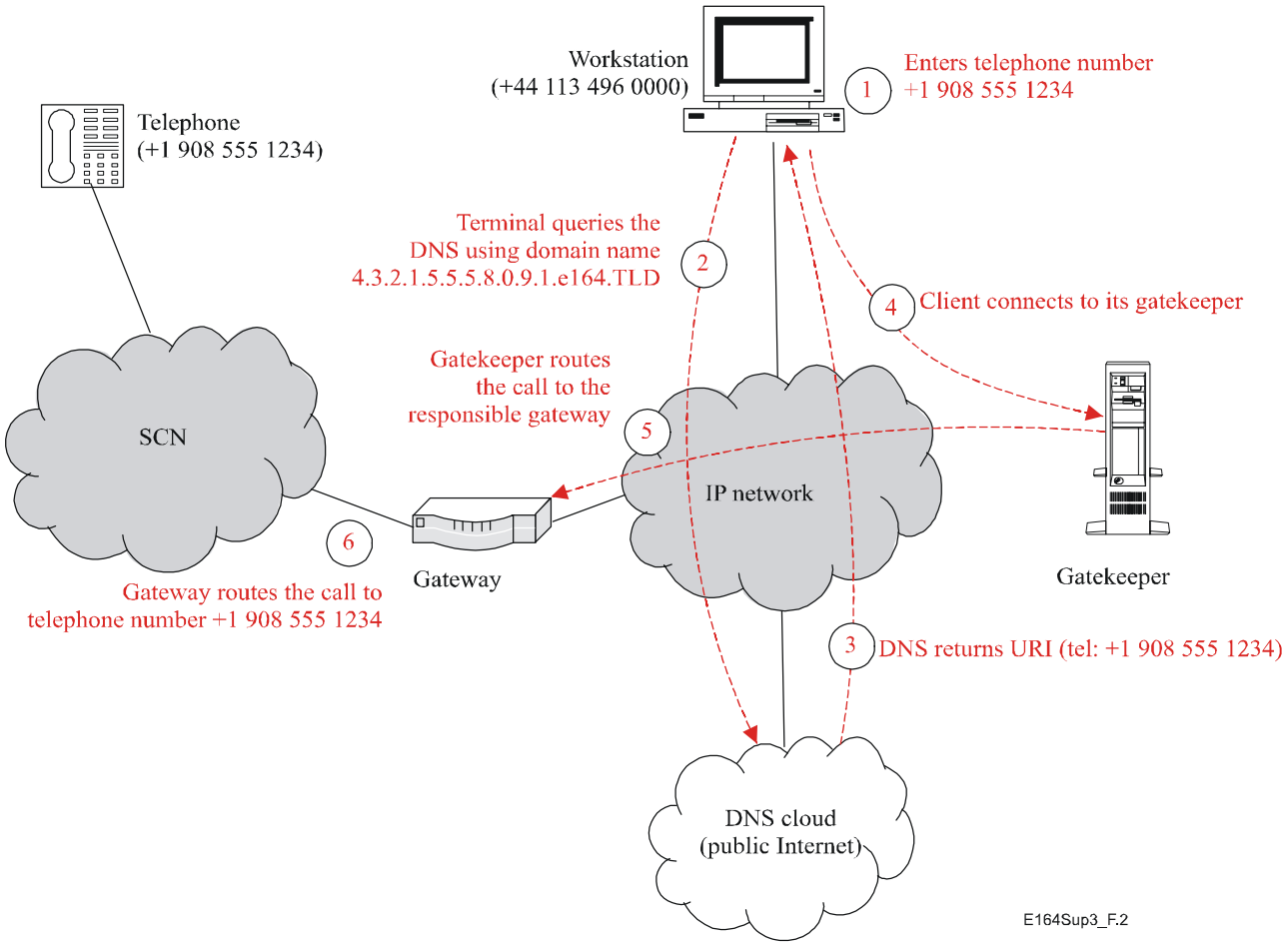


Figure 2 – Sample call flow from switched circuit network to IP-based network

Although use of ENUM is not required for IP to SCN interworking, ENUM records can be established for E.164 numbers without IP connectivity. In Figure 2, the call set up is shown from an IP-based terminal to the SCN. The IP-based terminal related to the E.164 number (44 113 496 0000) formats the called user's E.164 number (1 908 555 1234) into an ENUM domain name (4.3.2.1.5.5.5.8.0.9.1.e164.TLD) and forwards this to the DNS. This returns the URI (tel: +1 908 555 1234), which initiates the call set-up to the gatekeeper using the 'tel' URI. The gatekeeper then routes the call to the responsible gateway. The call is then routed through that gateway and delivered via the SCN.

An example of this call type in the SIP environment is contained in Annex A.'

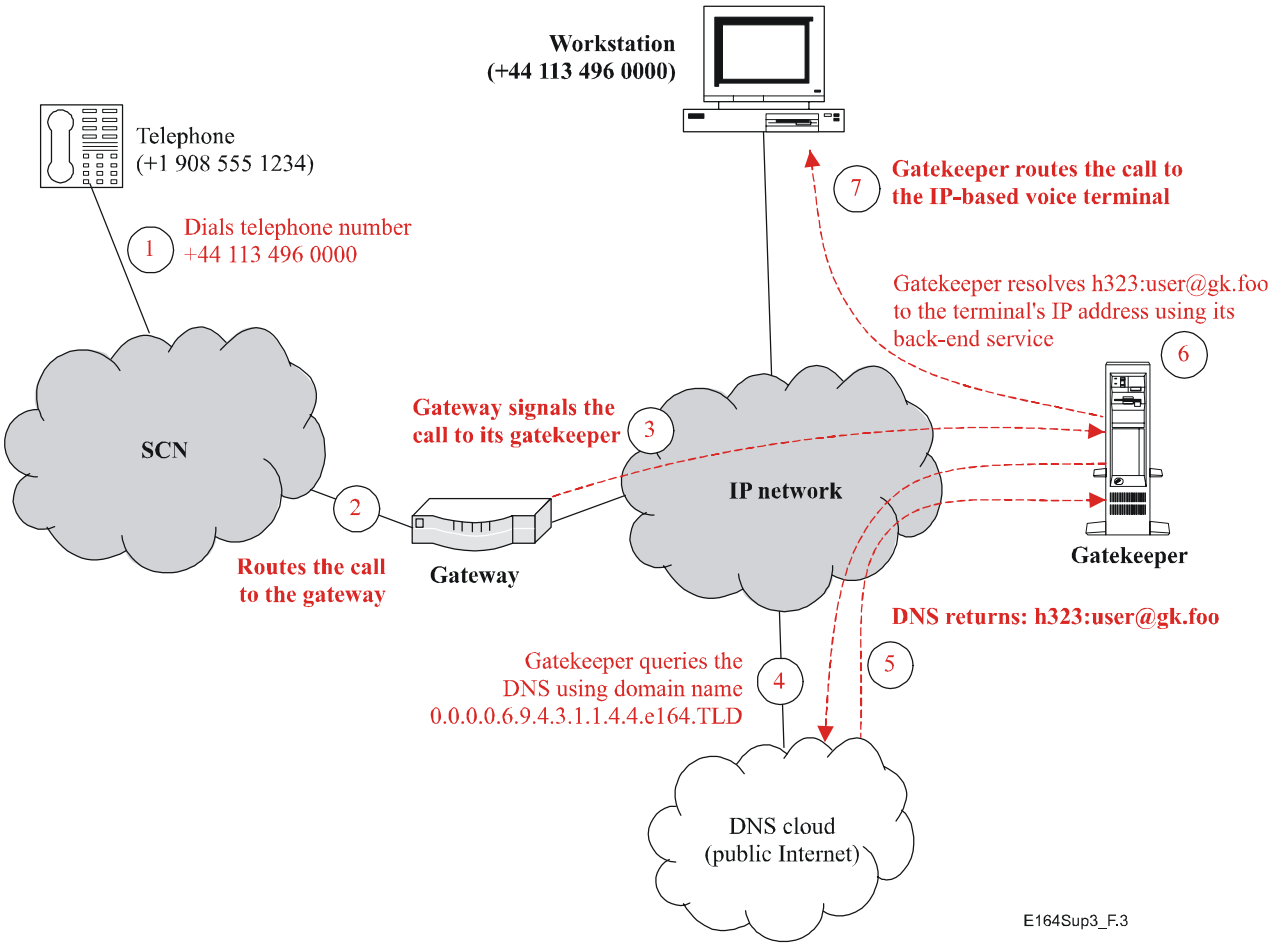


Figure 3 – Sample call flow from IP-based network to switched circuit network

It can be seen from Figure 3 that an SCN-based user (E.164 number: 1 908 555 1234) can contact a customer on an IP-based network through the use of the called user's E.164 number (44 113 496 0000). When the SCN initiated call reaches an ENUM enabled gatekeeper, it formats the number into the ENUM domain name 0.0.0.0.6.9.4.3.1.1.4.4.e164.TLD and the DNS returns the URI related to the required H.323 user (h323:user@gk.foo). Another look-up in the Back-End service is then required to look up the IP address for the subscriber's terminal. The call can then be completed to the H.323 client (terminal) related to the E.164 number (44 113 496 0000). In the H.323 environment, a gatekeeper is the controlling element within a specific H.323 environment and it controls a number of gateways in this H.323 domain.

An example of this call type in the SIP environment is contained in Annex A.

5.2 DNS zones and delegation

The basic administrative unit of DNS authority is the zone. Essentially, the important aspects are the following:

- a zone has a domain name;
- a domain name belongs to exactly one zone, nothing more, nothing less; and
- a zone's contents is theoretically the same on any authoritative name server for the zone.

For example, consider the fictitious domain "comp-sci.old-ivy.edu", where the Computer Science Department runs its own zone. The *domain* "old-ivy.edu" contains all the domain names that end with "old-ivy.edu". However, the *zone* "old-ivy.edu" contains all domain names that end with

"old-ivy.edu" *except* for all the domain names ending with "comp-sci.old-ivy.edu", because the "comp-sci" names are in the delegated "comp-sci" zone.

Therefore, in this example, "finance.comp-sci.old-ivy.edu" and "finance.old-ivy.edu" are different host names in different zones: the former belongs to "comp-sci" but not the latter. A domain name ending in "old-ivy.edu" belongs to either the zone of the Computer Science Department or else to the zone of the whole university. It can belong to only one zone.

Another way to describe this difference between the domain and the zone that have the same domain name, which is "old-ivy.edu" in this example, is to look at what is delegated:

- the *domain* is the set of all domain names under the delegated domain name; but
- the *zone* is that domain **minus** all the delegated domain names below that zone's name.

In other words, "comp-sci.old-ivy.edu" is in the domain "old-ivy.edu" but not in the zone "old-ivy.edu", because it is in the zone "comp.sci.old-ivy.edu" that was delegated from above.

5.3 Tiered architecture

The ENUM implementation will employ a DNS-based tiered architecture that is shown in Figure 4.

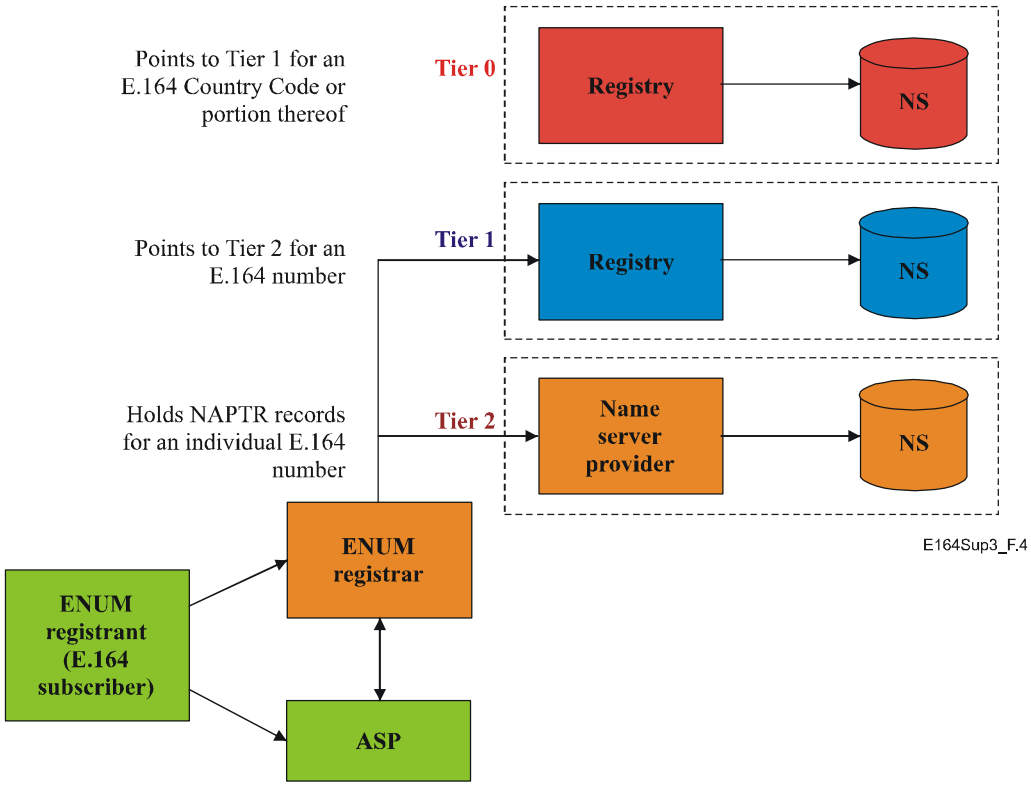


Figure 4 – Inserting E.164 numbers in DNS

Tier 0 corresponds to the ENUM root level. At this level, the ENUM architecture contains only one domain (the ENUM root). The TSB is the ENUM Tier 0 registrar for that domain. The ENUM Tier 0 registry should be designated by the ENUM Tier 0 manager. The Tier 0 name servers contain records that point to ENUM Tier 1 name servers.

Tier 1 corresponds to the E.164 Country Code, or a portion of an integrated numbering plan that is assigned to an individual country. Delegations of the sub-domains are made by the TSB to the entities designated by each country as administratively responsible for the domain corresponding to their country code.

The ENUM Tier 1 manager for a domain corresponding to a country code is the entity responsible for the management of the numbering plan in this country. The registry of the domain may be chosen by this entity. The name servers of the domain contain records that indicate the authoritative name servers for individual E.164 numbers or blocks of numbers in the country code or portion thereof.

Tier 2 corresponds to the E.164 number. Which entity will act as the ENUM Tier 2 manager for domains at the Tier 2 level is a national matter and is for further study. The name servers will contain domain names corresponding to E.164 numbers and NAPTR resource records with information for specific communication services.

Some entity must interact with E.164 number subscribers (i.e., the ENUM registrant) to have records for their numbers provisioned into the ENUM DNS-based architecture. This entity, the *ENUM registrar*, might in some implementations be the same as the ENUM Tier 2 name server provider of the corresponding E.164 number, which maintains the subscriber's NAPTR resource records. The ENUM registrar (and potentially other entities) may also have to interact with other parties, not depicted in Figure 4, having knowledge of number assignments including telephone service providers and, in some cases, number portability administrators of central reference databases.

It should be noted that not all of the potential interactions between entities are shown in Figure 4, nor, as will be discussed, all of the potential variants of the general tiered architecture.

5.4 Overview of ENUM functions and entities

The following tables describe the roles of functional entities involved in ENUM, and contain additional information on relationships between these entities. These tables are illustrative, and the remainder of this Supplement should be consulted for more definitive discussion of the concepts that appear in them.

Table 1 looks at the four types, or levels, of ENUM tiers in the context of the DNS hierarchy. Users and service providers are described in Tables 2 and 3, respectively. These groupings help to clarify how the different roles need to interact in order to provide ENUM services.

Table 1 – ENUM entities: Functions and responsibilities

Domain	Responsible organization for management of the domain (*Designated manager*)	Responsible organization for technical operation of the domain (*Registry*)	Registrar(s)	Note
"." (DNS root level)	**DNS root manager** ICANN through agreement[1] with United States Department of Commerce	**DNS root registry** IANA, which is part of ICANN	**DNS root registrar** N/A	
.TLD (TLD level)	**TLD manager** Entity responsible for managing the TLD level	**TLD registry** Entity designated by the TLD Manager	**TLD registrar**	
.e164.TLD (ENUM root level)	**ENUM Tier 0 manager** Entity (see Note) responsible for managing the ENUM root level. NOTE – At present, the IAB, which, will instruct the registry to obtain approval from the TSB for any delegations.	**ENUM Tier 0 registry** Entity designated by the ENUM Tier 0 manager.	**ENUM Tier 0 registrar** TSB	The registrant will be the ITU Member states or the Administration

[1] According to section III B (i-v) in the Memorandum of Understanding between the United States Department of Commerce and ICANN (http://www.icann.org/general/icann-mou-25nov98.htm) and according to section 1 in the agreement between the University of Southern California and ICANN (http://www.icann.org/general/usc-icann-transition-agreement.htm).

Table 1 – ENUM entities: Functions and responsibilities

Domain	Responsible organization for management of the domain (*Designated manager*)	Responsible organization for technical operation of the domain (*Registry*)	Registrar(s)	Note
.<CC>.e164.TLD (ENUM CC level)	**ENUM Tier 1 manager** The ITU Member State[2] that has been assigned the CC	**ENUM Tier 1 registry** The ITU Member State/Administration can manage this in their own activities or designate someone else to act as the ENUM Tier 1 registry	**ENUM registrar** ENUM registrars provide direct registration services to ENUM subscribers involving: – verifying subscriber identity and authorization to use E.164 number; – interacting with ENUM Tier 2 name server provider and ASP to establish records for the applications desired by the ENUM subscriber; could be public telecommunication operators (PTO) or other ENUM service providers – i.e., *national matter*	
.<N(S)N>.<CC> .e164.TLD (ENUM E.164 number level)	**ENUM Tier 2 manager** A *national* matter ensuring that the desires of the ENUM subscriber, as far as possible, are properly reflected in the choices available	**ENUM Tier 2 name server provider** ENUM Tier 2 name server provider stores NAPTR resource records in the DNS – i.e., *national matter*		The registrant will be the ENUM subscriber

2 For integrated numbering plans, other procedures might apply.

Table 2 – Functional entities: Subscribers and calling users for ENUM

Functional entity	ENUM/DNS role	Information	Comments
ENUM subscriber/ called user	• The DNS registrant of an assigned E.164 number for ENUM • Is the authority for using ENUM to associate information for that specific service with the E.164 number	• Provides information on an E.164 number assignment and on specific services • Specifies preferences for the association of specific services with the E.164 number • Intends that calling users could contact the end user by using ENUM information	A subscriber has three types of subscription: – as assignee of an E.164 number for a telephony service; – as subscriber to one or more (IP-based) specific services; – as party responsible for specifying how ENUM associates the number with service-specific URIs.
Calling user/caller/ originator	• Is a calling user who queries DNS to retrieve service-specific information associated with the E.164 number of an ENUM subscriber • May or may not use the service-specific addressing information to "call" the ENUM subscriber	• Intends to contact an ENUM subscriber via a specific service but addressed with an E.164 number • Uses ENUM-enabled client software to discover subscriber's chosen services • May or may not choose a specific service to contact the subscriber	• A calling user chooses to contact an ENUM subscriber • ENUM-enabled software performs the ENUM query • Service-specific software makes the "call" using service-specific address information resulting from an ENUM query of a number

Table 3 – Functional entities: Service providers for ENUM

Functional entity	ENUM/DNS role	Information	Comments
Telephone service provider	• The provider of telephony service to an end user (subscriber) of that service	• May be authorized by the subscriber to provide current information about the assigned E.164 number to the ENUM Tier 2 name server provider	• The E.164 number is assigned to an end user for the subscribed telephony service
Application service provider	• The provider of a specific IP-based service to an end user (subscriber) of that service	• May be authorized by the subscriber to provide current information about the service-specific URI to the ENUM registrar	• The ASP may be authorized by the subscriber to add, change, or delete the service-specific NAPTR resource records held by the ENUM Tier 2 name server provider

6 General administrative issues and options

Some of the issues that would be appropriate for a Member State that chooses to have all or a part of its numbering resources included in the e164.TLD domain and participate in ENUM are listed below. While the decision on how to resolve them is the responsibility of Member States, this clause attempts to outline, where possible, some of the potential options.

6.1 Identification of ENUM Tier 1 registry or registries

Each Member State (i.e., ENUM Tier 1 manager) that wants its numbering resources included in the ENUM DNS-based tree may identify the ENUM Tier 1 registry or registries associated with these resources.

The Member State may choose a single registry or may choose to have different number ranges of its country code(s) represented in different registries, each of them maintaining name servers. For example, if the numbering within the Member State used NDCs, there could be different registries for the numbers within each NDC. The overall hierarchy of possible registries would reflect the hierarchical structure of E.164 numbers. The chosen structure of the ENUM Tier 1 registry or registries for a Member State is a national matter.

Recall, however, that any given E.164 number can have only a single registry and that partitions of a country code should not be so small as to burden the ENUM Tier 0 registry name servers.

A CC may be divided among registries where the CC represents an integrated numbering plan (e.g., CC 1) and the Member States wish to individually control ENUM arrangements for their respective resources.

6.2 Delegation of names from the ENUM Tier 1 registry

It would be appropriate for Member States to select a process for population of numbers in the ENUM Tier 1 registry name servers. Depending on the role of telephone service providers in arranging for population of numbers in the ENUM Tier 1 registry, population of numbers may be on the basis of either individual numbers or blocks of numbers. Irrespective of the role of telephone service providers, however, implementation of number portability may make it necessary for population of numbers to be on an individual number basis. This is because not all numbers in a block, for example a national destination code, are necessarily associated with a single service provider.

6.3 Determination of ENUM Tier 2 name server provider and ENUM registrars

It would be appropriate for Member States to determine the rules for who may serve as ENUM Tier 2 name server providers and ENUM registrars for E.164 numbers.

Any entity may serve as an ENUM Tier 2 name server provider and/or ENUM registrar subject to whatever general qualifications the Member State may choose to impose. The level of qualification will need to balance the desire to promote user choice of entities on the ENUM E.164 Number Level versus any needs for consumer protection.

It will be necessary for ENUM registrars to validate a subscriber's right to have ENUM records for a particular E.164 number, and it would be desirable for alternative means for the verification of number assignments to be evaluated. In certain implementations, it may be considered appropriate for ENUM registrars to validate an E.164 number assignment with the relevant telephone service provider. Also, the telephone service provider will need to notify the ENUM registrar, the ENUM Tier 2 name server provider and ASPs when service is terminated or service changed (e.g., number portability). Exactly how the chain of notifications is performed is a national matter.

6.4 Validation of ENUM requests and records

As noted above, a major issue in devising an administrative model for the ENUM is ensuring that only assignees of numbers can have records for the corresponding numbers populated. It would be appropriate for Member States to consider what arrangements are necessary to facilitate validation of number assignments and the identity of those requesting ENUM records.

Since it is expected that subscribers may choose from among various ASPs to deliver the services that are built using ENUM records, procedures may also be needed that allow such ASPs to work with the ENUM registrar to populate the appropriate NAPTR resource records for (and only for) services that the number assignee has authorized. This is important because NAPTR resource records may be too complicated for most users to provision directly. These procedures need to support verification of both the identity of an ASP and that it is authorized by the assignee of an E.164 number.

6.5 Relationships of administrative structures with ENUM zone structures

The structure of the entities in the administrative process that provisions the ENUM function is not necessarily mirrored by the operational ENUM zone structure. For example, Figure 5 shows two different versions of the ENUM zone structure that might be used by the same set of administrative entities and processes.

In this figure, entities *a*, *b* and *d* are responsible administrative organizations for one or more domains; i.e., acting as managers for the different ENUM Tier levels, as described in Table 1. Entities *a*, *b* and *d* therefore interact with entities that operate name servers (NS). Entity *c* is an arbitrary entity that is involved in the overall administrative process needed for ENUM, but is not responsible for a domain. Entity *c* does not, therefore, interact with name servers.

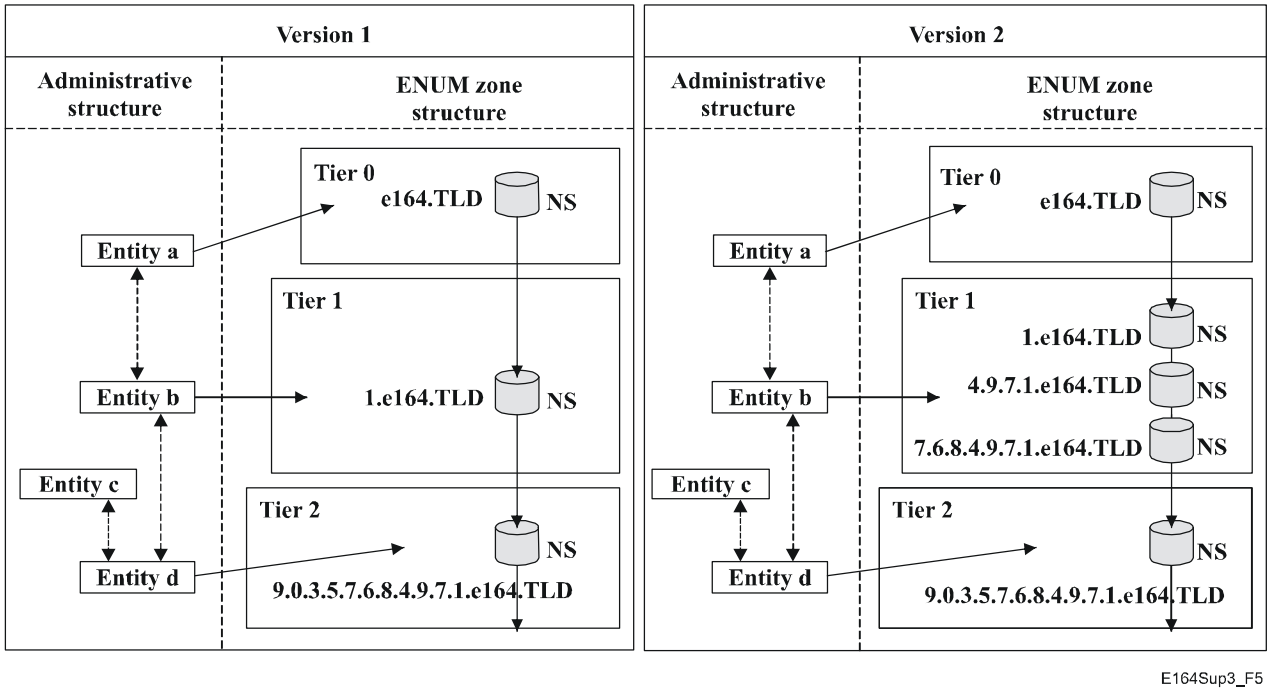


Figure 5 – Examples of possible relationships of administrative structure with ENUM zone structures

6.6 Additional considerations

6.6.1 Security

Due consideration of the following issues is also essential when the introduction of an ENUM function is planned:

- DNS and information security – Readers of the public DNS data stored in the ENUM function should be assured that they will receive valid information. Therefore, there is a core requirement to consider security aspects related to DNS functions used for provisioning this service.

It is also considered essential that clients that have the authority to add, change, and delete entries in the ENUM function should be assured they:

– Are updating data in the correct records;

– Have uninterrupted access to the data;

– Are only allowed to update data following presentation of valid credentials.

Entities involved in the ENUM functions have the responsibility to protect their physical and network resource as well as ensuring the validity of the DNS data entered into the system.

- Impersonation – Spoofing or misrepresentation of the identity of the originator of the information could allow unauthorized updates to the database. Invalid or missing data could, in turn, cause malicious redirection and denial of service. Therefore, clients attempting to add and update entries in an ENUM function should be able to unequivocally prove their identity to the DNS.
- Data Tampering – During the transmission of ENUM records, invalid URIs could replace valid URIs, thereby causing malicious redirection. This should be prevented by adequately provided network security features.

6.6.2 Privacy

For ENUM to be successfully implemented, registrants must be comfortable that operation of the ENUM system will not compromise the privacy of their personal information. Registrant choice is central to the operation of ENUM and, as such, functions in ENUM in a number of ways.

First of all, participation in ENUM is optional. Simply put, an ENUM user chooses to have his or her telephone number loaded into the authoritative ENUM Tree. No telephone numbers should be registered absent the consent of the authorized assignee of that number.

Second, registrants control what information will be included in their Naming Authority Pointer (NAPTR) records and what preferences will be set regarding how such information should be used. Thus, the registrant controls what information will be associated with his or her telephone number.

Third, when registrants choose to take advantage of ENUM, they should be fully informed about how the information they will be disclosing will be used. It seems logical that in order to take advantage of any number of advanced communication services in the electronic world, one may have to disclose some amount of personal information. E-mail, for example, is not useful unless the sender actually has the intended recipient's e-mail address. Similarly, one cannot make a telephone call unless one knows the telephone number of the person one intends to call. Thus, in order to take advantage of communication services, a registrant typically must be willing to disclose certain personally identifiable information. Beyond the information that will be publicly accessible in the DNS resource records, other personal information will generally be collected and maintained by the registrar as part of the application, authentication, authorization, and registration process. This registrant data must be kept confidential. Only the minimal information, necessary for technical management and troubleshooting of ENUM and the DNS, might be disclosed in a controlled manner.

In any case, national ENUM implementations should acknowledge and comply with the data privacy regulations of the country in which they operate. There may be several different ways to implement and use ENUM that will minimize the privacy risks, such as using a called-party-control model or mandating that only the registrar's contact information be stored in any accessible troubleshooting database.

7 Implications of ENUM for country codes assigned to geographic areas

Under terms defined in ITU-T Recs E.164 and E.164.1, the ITU-T has allocated a combination of one-, two- or three-digit country codes to identify a specific country, countries in an integrated numbering plan, or a specific geographic area.

It can be expected that the optimal implementation for the operational and administrative processes needed for ENUM depend strongly on the national telecommunications environment. The optimal implementation will, therefore, vary from country to country and possibly even from geographic area to geographic area.

7.1 Administration aspects, options and interfaces

There are a variety of issues that the TSB and the Member States/Administrations (including the national numbering plan administrators) need to address in implementing an ENUM DNS for their part of the E.164 numbering plan. This clause lays out those issues.

There are issues about inserting E.164 numbers into a DNS-based architecture for numbers that are within a Country Code for a country (or integrated numbering plan). These issues include how to determine the most appropriate arrangement for adding, updating, and deleting the ENUM records related to an E.164 number, who runs the ENUM Tier 1 servers (from an operational perspective), and an agreed process between participating Member States within an integrated numbering plan, as appropriate.

Member States may also decide who qualifies to be an ENUM registrar and an ENUM Tier 2 name server provider. In some cases, Member States may want to solely rely on telephone service providers to serve as a ENUM registrar and/or ENUM Tier 2 name server provider for maintaining ENUM records on behalf of end users. In other cases, the level of competition may call for allowing a variety of entities to be ENUM registrars for end users. In other cases, subscribers, themselves, may be allowed to function as the ENUM Tier 2 name server provider for their own ENUM records.

In all aspects, it would be appropriate for the procedures established by Member States to ensure the integrity of their portion of the E.164 numbering plan. It would be appropriate for the validity of subscriber identity, data and service specific ENUM records in the NAPTR resource records to be addressed. Important issues include the incorporation of number plan changes within the DNS, the natural churn of numbers, and procedures for addressing ceased numbers and recovering those records within the DNS. Number and name hijacking and fraud needs to be addressed within the defined procedures. It would be appropriate for Member States to study whether, and how, such procedures can be enforced with carriers and third parties. It is important to note that a breakdown in the management of and, therefore, the integrity of, this information will cause call-processing failures in the future.

It would be appropriate for Member States to ensure compliance with, and take into account, the impact of the national deployment of number portability (service provider, geographic, and/or service) prior to the implementation of ENUM. In some cases, the ENUM Tier 1 registry name servers should point to ENUM Tier 2 name servers on an individual E.164 number basis and not on a number block basis.

It would be appropriate for Member States to consider the types of national numbers (e.g., geographic, mobile, service types, etc.) allowed within the DNS. The inclusion of prepaid

mobile or pager numbers may provide unique challenges. Changes to ownership, loss/theft of terminals and ceased service need to be addressed in this decision.

7.2 Review of consequences

The development of implementations for the operational and administrative processes for ENUM, and the assessment of implementation options, is a matter for the Member States and the national parties they wish to involve. However, there are a number of generic points that are expected to be useful in the development and discussion of implementation options, irrespective of the specific implementations considered and the country or geographic area involved.

7.2.1 Ease of validation of relation between E.164 number and telephony subscriber

The validation of the relation between the E.164 number and the telephony subscriber, as well as the status of an E.164 number (in service or not), is crucial in ENUM. An ENUM registrar will need to perform this validation when requested to provide the ENUM function for a given E.164 number. Several means of validating the E.164 number – telephony subscriber relationship will be available. One option may be for the ENUM registrar to interact with an entity that has information on the E.164 number – telephony subscriber relation. This entity may be the telephone service provider that provides the telephony service for the number involved. A second option may be for the ENUM registrar to require documentary evidence from an ENUM registrant demonstrating that a telephony subscriber has been assigned the E.164 number.

Both of these and other options deserve careful consideration as to how effective they will be, given the particular operational and legal environment in each country. For example, the first option may be complicated in environments with number portability. If a central reference database is used for number portability, the administrator of this may need to be consulted to carry out the E.164 number – telephony subscriber validation. If no central database is used (i.e., onward routing of calls via a donor network), it may be necessary to consult the donor telephone service provider to obtain the identity of the recipient telephone service provider, who in turn can finally carry out the validation. The second option mentioned above may suffer from the perishable nature of most forms of documentary evidence, and would require the support of effective fraud laws.

Among the goals in the development of an implementation for the administrative processes in ENUM may be to have a validation process that is simple while, at the same time, discouraging fraud and the unauthorized creation or transfer of services. Depending on the national telecommunication environment, the simplicity or complexity of the validation process may be an important criterion in the assessment of different implementation options.

7.2.2 Analysis of complexity and effort associated with provisioning

In selecting the administrative structures and processes for provisioning the ENUM function, Member States/Administrations may want to take into account the types and amounts of interactions between the several entities. For example, it may be useful to distinguish one-time from continuous interactions. One-time interactions are carried out only once or, at most, only a few times, and involve many E.164 numbers at the same time. An example of a one-time interaction is the DNS delegation from ENUM Tier 0 registry to ENUM Tier 1 registry for the ENUM CC level (see Table 1). Continuous interactions, on the other hand, relate to individual E.164 numbers and are expected to occur many orders of magnitude more frequently.

8 Summary and conclusion

ENUM is an opt-in capability developed to take advantage of the hierarchical nature of E.164 numbers and to use that structure to discover IP-based applications that can be used to communicate with end users. This opt-in characteristic is exhibited at two levels:

– The Member State; and

– The end user.

Once a Member State decides to opt-in to ENUM, a set of implementation and provisioning processes should be developed. Many of the issues that may be considered in this development have been addressed in the preceding sections. Member States may also want to learn from the development activities taking place in other countries and the sharing of such information is encouraged. The national architecture and requirement documents produced by a Member State may provide valuable insight into how the various issues are addressed and other Member States may want to consider these documents in their own development process.

Secondly, end users can decide whether to opt-in to ENUM and provision their contact information within the DNS. These users will want to feel that their contact information is both safe and secure before they will want to participate in ENUM. The security and privacy issues, discussed in previous sections, are probably the most important aspects of ENUM to end users.

In addition, ENUM relies on applications and services. Application software must become ENUM-enabled for users to be able to access the capability. In some cases, software (e.g., e-mail programs) must be changed to use the ENUM capability when an end user supplies an E.164 number to be translated into the appropriate URI (e.g., mailto:user@host) for the application. In other cases, service providers will need to update software or add new equipment (e.g., IP gateways) to access the DNS for ENUM. Market forces may influence the speed and penetration of such changes within the industry.

It is only after all three pieces of the ENUM puzzle fall into place that the capabilities of ENUM can be realized.

Annex A

Typical PSTN-IP call flows using SIP

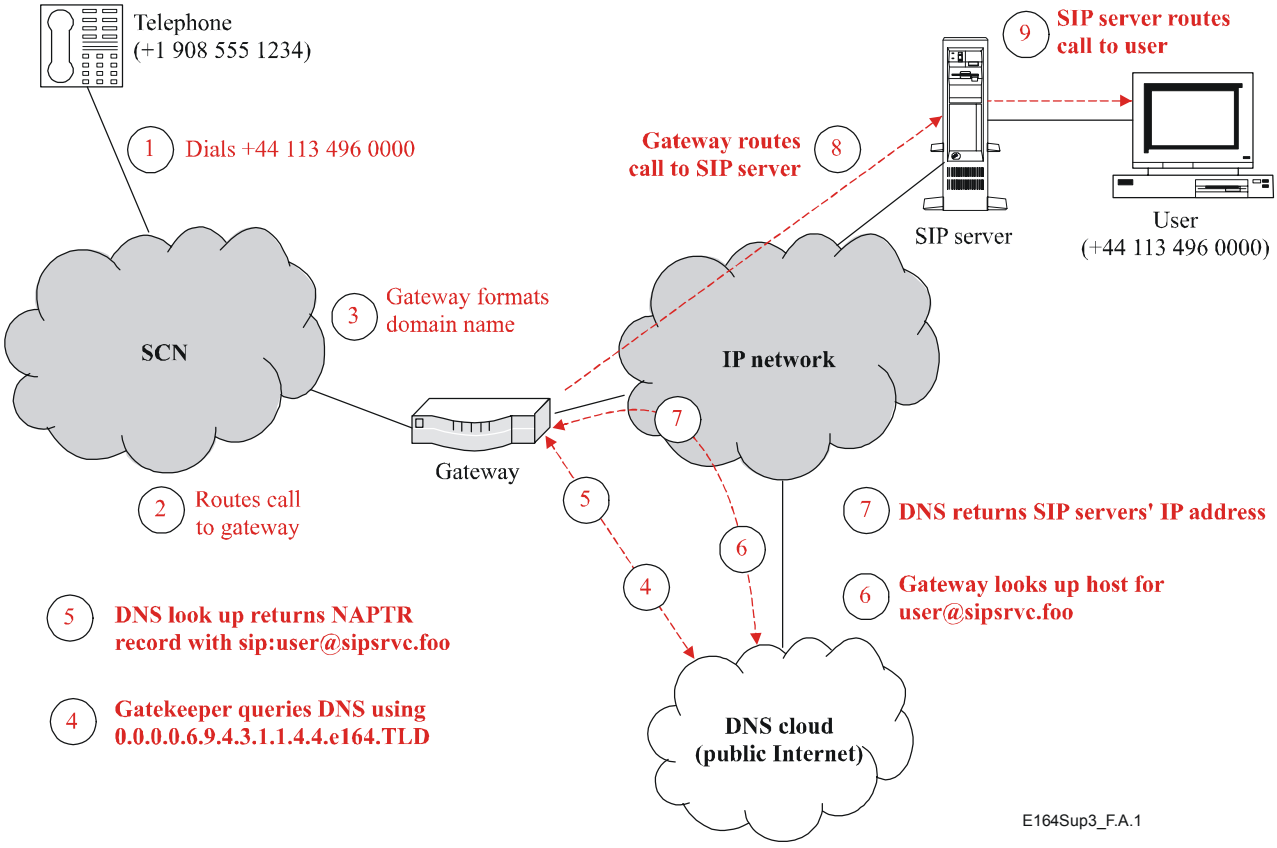


Figure A.1 – Typical call flows: PSTN to IP

It can be seen from Figure A.1 that a PSTN-based user (number +1 908 555 1234) can contact a customer on an IP-based network through the use of the called user's E.164 number (+44 113 496 0000). When the PSTN initiated call reaches an ENUM-enabled gateway, it formats the number into the ENUM domain name 0.0.0.0.6.9.4.3.1.1.4.4.e164.TLD and the DNS returns the URI related to the required SIP user (sip:user@sipsrvc.foo). Another DNS look-up is then required to look up the host for user@sipsrvc.foo and the SIP server IP address is returned. The call can then be completed to the SIP client (terminal) related to the E.164 number +44 113 496 0000.

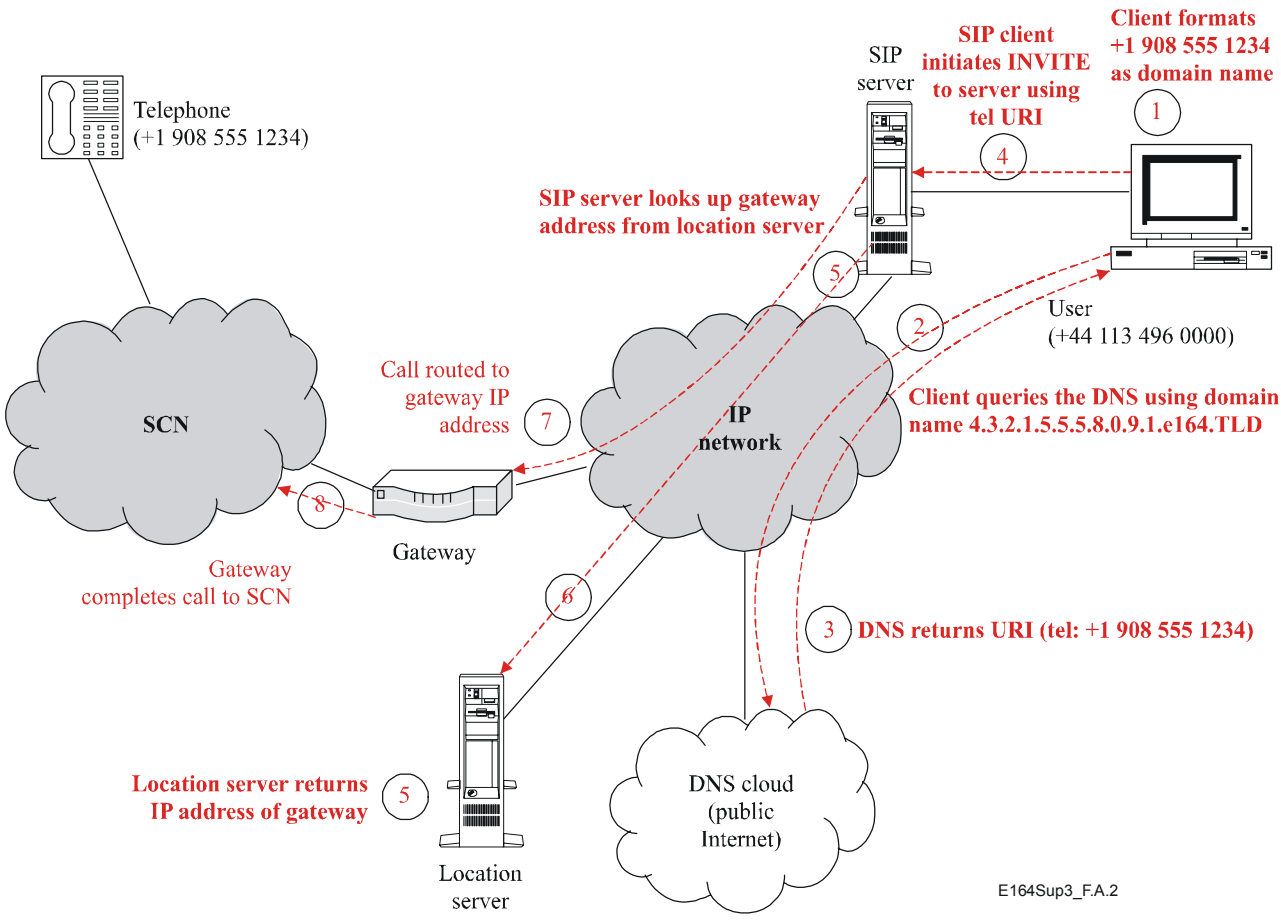


Figure A.2 – Typical call flows: IP to PSTN

Although use of ENUM is not required for IP to PSTN interworking, ENUM records can be established for E.164 numbers without IP connectivity. In Figure A.2, call set up is shown from an IP-based terminal to the PSTN. The IP-based terminal related to the E.164 number formats the called user's E.164 number into an ENUM domain name and forwards this to the DNS. This returns the URI (tel: +1 908 555 1234) which initiates the command INVITE to the server using the 'tel' URI. The SIP server will then look up the gateway address from a location server which returns the address of the gateway. The call is then routed through that gateway and delivered via the PSTN.

Annex B

Integrated numbering plans

This annex describes how different geopolitical regions can be differentiated within an integrated numbering plan based on sets, or unions, of zones.

An integrated numbering plan refers to E.164 numbering resources, under a single E.164 resource, that are used by the countries participating in that plan. For example, the E.164 Country Code "1" is assigned to the integrated numbering plan know as the North American Numbering Plan (NANP – see, for example, http://www.nanpa.com).

A major constraint comes from the requirement that a DNS zone has a single domain name. A DNS zone is the set of all domains that fall within the domain name corresponding to the zone except for

those that have been delegated. For example, hypothetically, ENUM Domain Names for all E.164 numbers in Numbering Plan Area (NPA) = 301 would form a zone. The name of the zone would be "1.0.3.1.e164.TLD". In this case, the DNS and numbering administrative structures would match.

However, NPA = 301 is not the only NPA in the State of Maryland in the United States. For example, NPA = 410 is also in Maryland. The ENUM domain name for this NPA is "0.1.4.1.e164.TLD". This gives a hypothetical example of a numbering administrative structure (i.e., Maryland) that *cannot* be matched by a single DNS zone.

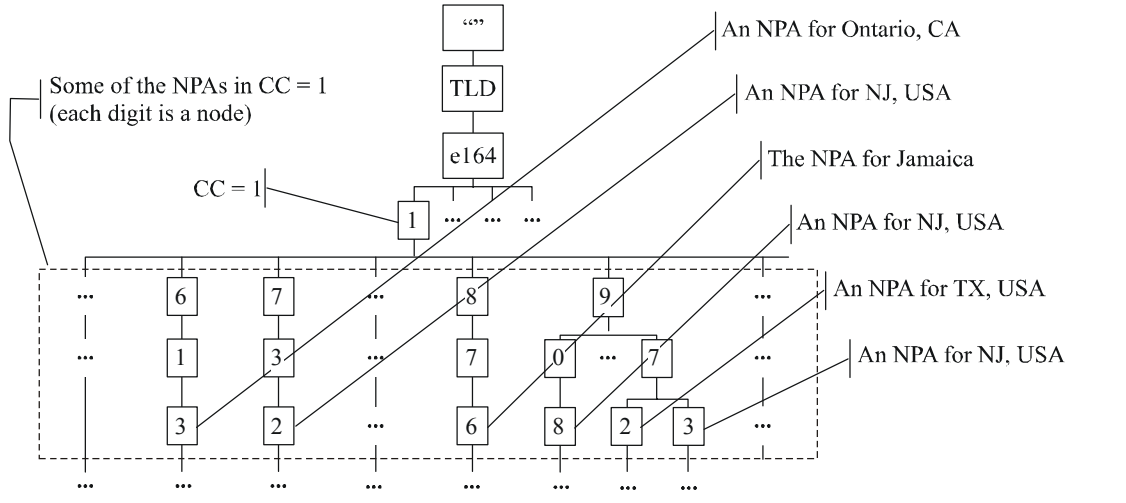
Suppose that all E.164 numbers in Maryland would come under a particular numbering administrative structure. There is no single ENUM domain name that can exactly match this. The smallest domain containing names for both NPA = 301 and NPA = 410 is the ENUM domain name "1.e164.TLD". Unfortunately, this ENUM domain name is not available for Maryland, since it would actually apply to all numbering resources inside the E.164 Country Code = 1.

One way to reconcile the problems caused by zones having single names is to look at ENUM administration based on sets, or unions, of zones. Hypothetically, the example for Maryland NPAs could consider an appropriate ENUM administrative unit as the union of the zone for 301, the zone for 410, and the zones for the other numbering resources in Maryland.

An example of ENUM administration for numbering resources within an E.164 Country Code can be described using this concept of the union of zones. Hypothetically speaking, consider some possible ENUM administrative units within E.164 Country Code = 1.

A country (e.g., Canada or the United States), or a state (e.g., New Jersey or Texas) typically has numbers from more than one NPA. Figure B.1 shows how some ENUM domain names in E.164 CC = 1 would fit into the DNS name space.

It also illustrates how sets of numbers under numbering administrative entities would not match any single DNS zone. For example, no single DNS zone could match the set of NPAs in New Jersey. However, the set of NPAs in New Jersey is hypothetically also an example of a numbering administrative entity that could be matched by a union of DNS zones.



The set of (ENUM domain names for) E.164 numbers in an NPA is a DNS zone.

Names for the numbers in a country or a state typically are a *union* of more than one zone.

Figure B.1 – Some NPAs in E.164 CC = 1 in DNS name space for ENUM

The concept of unions of zones is, therefore, one useful way to describe ENUM administration in terms of both DNS and numbering administration. It could, for example, help make the discussion of options for registries and registrars within "Tiers" simpler and more consistent.

Theoretically speaking, there are several different options for delegations of domains for Tier 1.

Note also that similar options would apply in any Tier, or zone, where different partitions might be considered. The following discussion is intended to be illustrative only.

Tier 0 may contain a single delegation to an E.164 Country Code, or it may contain multiple delegations within an E.164 Country Code. In either case, there are two options to consider.

Options for a single delegation from Tier 0 to an E.164 country code

– Option 1: Tier 1 is a single zone and delegates to Tier 2 zones.

– Option 2: Tier 1 has an upper layer with a single zone and delegates to one or more zones in a lower layer of Tier 1; these lower layer zones then delegate to Tier 2 zones. It is possible to construct options with more than two layers in Tier 1.

Options for multiple delegations from Tier 0 within an E.164 country code

– Option 3: Tier 1 has one layer with multiple zones; each zone then delegates to Tier 2 zones. It is possible to construct options with more than two layers in Tier 1.

– Option 4: Tier 0 delegates to Tier 2 zones; Tier 1 is null. It is possible to construct options with more than two layers in Tier 1 with the top sub-layer being null.

Figure B.2 shows some theoretical examples of Tier 1 options for ENUM.

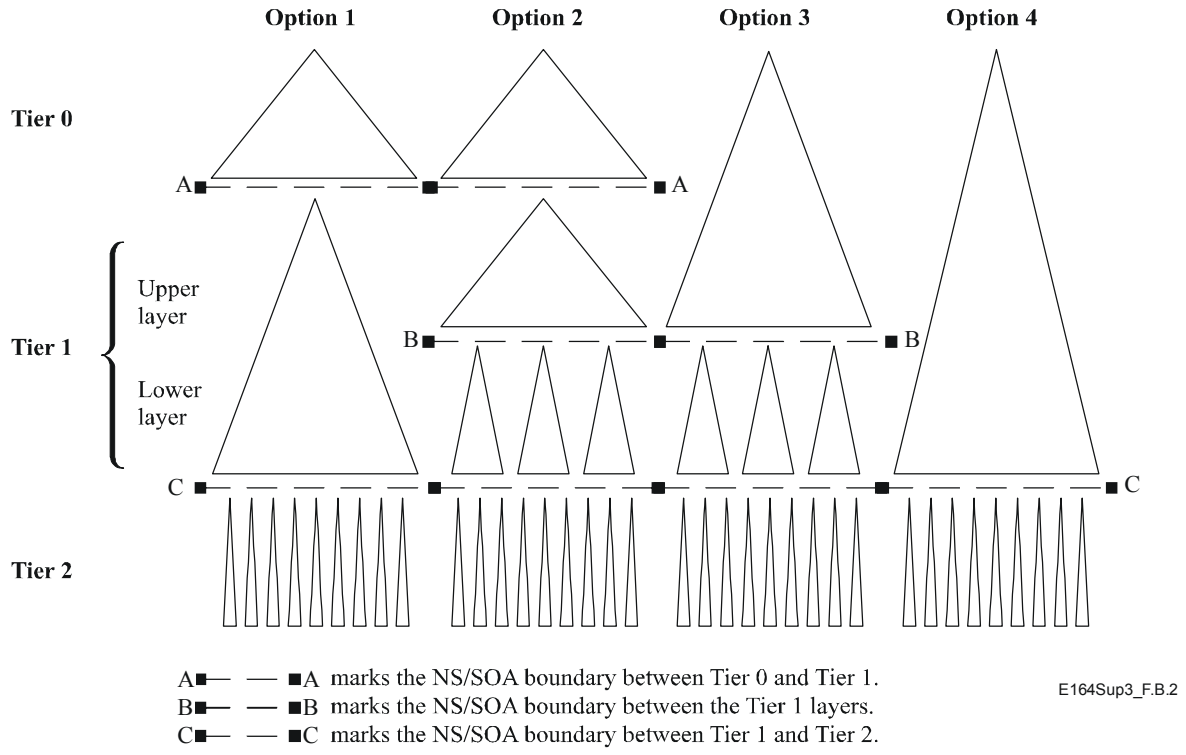


Figure B.2 – Some examples of options for zone delegations involving ENUM Tier 1

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series B	Means of expression: definitions, symbols, classification
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	**Overall network operation, telephone service, service operation and human factors**
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
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