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Numbering for VoIP and other IP Communications

Status of this Memo

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Abstract

This document gives advice in setting up E.164 compatible numbering and dialing plans in administrative domains set up for IP Communications in general and VoIP applications in detail. After explaining numbering and dialing plans in principle, it discusses which types of E.164 numbers should be used for IP based terminals, to achieve proper routing of calls and other communications on the PSTN/ISDN and also on the Internet, using ENUM technology.

Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119 [2].

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1. Introduction and Overview

Currently a number of Administrative Domains for IP communications are implemented allowing users to register IP phones or soft clients and place VoIP calls or establish other types of IP communications via broadband connections to other users registered in the same or in other administrative domains by using Internet Naming and Addressing schemes.

As a courtesy to users having only IP phones with numeric keypads or terminal adaptors for steam phones, numeric aliases are used exclusively or in addition. This allows users placing calls using dialing strings. For "cross trunks" or "cross connections" to other...
administrative domains and to the PSTN/ISDN different combinations of access codes are implemented in an ad-hoc uncoordinated manner.

The advantage of this approach is that registered users may be reached also from the PSTN/ISDN and other administrative domains if a proper mapping of E.164 numbers to these numeric aliases as partial numbers is achieved.

This situation is similar to the mess existing in the PSTN with automatic trunk dialing in the ‘50s of the last century and with international automatic dialing in the ‘60s, before the International Public Telecommunication Numbering Plan (E.164 numbers) [3] was introduced by ITU-T (CCITT). Traces of this messy situation can still be recognized in the existing national dialing and numbering plans. To prevent this from happening again on the Internet, the purpose of this document is to give guidance to the definition of numbering and dialing plans and the provision E.164 numbers in IP based administrative domains.

After stating the problem, the terminology used is defined, especially the definitions of numbering and dialing plans are given and their differences are explained.

The types of number ranges used in existing numbering plans are explained and a new grouping of the type of number ranges is proposed:

- Pure geographic numbers
- Non-geographic numbers for private networks
- Non-geographic numbers for networks and personal numbers
  (including mobile networks and personal services using VoIP networks)
- Non-geographic numbers for tariff related services

The types of number ranges usable for VoIP and IP Communications are analyzed and discussed. In principle any number range could be used for VoIP, but for the direct mapping of administrative domains using partial numbers the usage of national geographic numbers, national non-geographic numbers for private and mobile networks and global numbers for networks is recommended.

The document explains the routing of calls to these number ranges on the PSTN/ISDN to the appropriate VoIP gateways. It is also proposed to use ENUM for routing of calls on the Internet from the VoIP gateways used or from other administrative domains to the E.164 numbers hosted by these administrative domains.

To map administrative domains with partial numbers to E.164 numbers it is necessary to set up the administrative domains with numeric
userinfo (aliases). It is therefore required to set up numbering and dialing plans within these administrative domains.

These numbering and dialing plans should allow to access the own users, users in other administrative domains and users on the PSTN/ISDN in a consistent manner and also allow the mapping of this numbering plan to the International Public Telecommunication Numbering Plan E.164 as partial numbers.

The basic requirements and rules to achieve this are proposed in this document.

2. The Problem

2.1 IP Communications as Applications on the Internet

IP Communications (VoIP, IP Telephony, Internet Telephony, Voice over the Net, Instant Messaging, Presence, Video, etc.) are applications based on the Internet (IP) protocols, and are therefore like any other applications on the Internet basically using the IP addressing scheme.

For various reasons the direct usage of the IP addressing scheme has many drawbacks, most applications on the Internet use in addition a more user-friendly and comfortable naming scheme. This naming scheme is based on the Domain Name System (DNS) and Universal Resource Locators and Identifiers (URLs, URIs). The usage of a naming scheme has also an important advantage. IP addresses may dynamically change and are also related to a network endpoint (device). Since a user may attach to different and multiple devices, the usage of a naming scheme is adding one level of indirection and therefore allows addressing the user independently of the device currently used.

For VoIP, the most commonly used URLs and URIs are sip:, h323: and tel:. These URIs are called contact addresses, if used for a specific device, or Address-of-Records, if used to address a user or a generic service via a location service (see RFC3261). Address-of-records allow VoIP users to reach each other on the Internet and also to reach users on the PSTN/ISDN, if a proper gateway is provided. This can e.g. be done with the tel: URI, which contains a phone number (see RFC2806bis [4]).

2.2 How to reach VoIP users from the PSTN/ISDN

On the other hand it is in most cases not possible for users on the PSTN/ISDN to reach users on the Internet, because URIs cannot be entered on most telephone devices and also the signaling systems are not able to deal with URIs. The PSTN/ISDN is using "phone numbers",

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mainly the numbering scheme defined in ITU-T Rec. E.164 or compatible national variants. These phone numbers are called International Public Telecommunication Numbers, or E.164 numbers.

It is therefore necessary to provide a translation service between the naming and addressing (numbering) scheme used on the PSTN/ISDN and the naming scheme used on the Internet. This can be done in different ways; one of these translation services is ENUM (see RFC2916bis [5]).

2.3 The Global Public Telephony Service

This implies that an E.164 number is attached in addition to the existing Address-of-Record of a VoIP user. If a user on the PSTN/ISDN is now dialing such an E.164 number the call needs to be routed to a VoIP-gateway located on the boundary between the PSTN/ISDN and the Internet.

The VoIP-gateway is translating the E.164 Number to the Address-of-Record (e.g. a sip: URI) assigned to the user. The call is then routed on the Internet to the VoIP user, or more precisely to the VoIP server pointed to by the host part of the Address-of-Record. This implies also that the VoIP application is part of the global public telephony service as defined in ITU-T Rec. E.105 [6], and therefore has to fulfill a minimum of basic requirements to be compliant.

Within this document, some of these basic requirements will be discussed.

2.4 ENUM

One possibility to translate E.164 numbers to URIs is ENUM.

ENUM is based technically on the Domain Name System and allows a mapping or translation from an E.164 number to one or more URIs. ENUM is achieving this by providing a distinct domain (e164.arpa) for a unique and 1:1 mapping of E.164 numbers to a specific and unique domain name. Within this domain name the user may store pointers to URIs. This may be any URI (e.g. an e-mail address or a pointer to a web-page), but specifically also a VoIP URI. Only these mappings will be discussed within this document.

ENUM raises two questions:

1. Which type of E.164 numbers may be entered in ENUM?

The type of numbers available will be discussed later in this document.
The current status of discussion is that geographic numbers, numbers for private networks, mobile numbers and personal numbers may be used in ENUM. The usage of the other numbers, especially service numbers like freephone and premium rate services are under discussion.

2. Are E.164 numbers entered in ENUM only or additionally to existing phone services?

The more important question is if the ENUM entries are made IN ADDITION to existing phone services if the subscriber requests it (opt-in) or is it required to have an ENUM entry to get a phone service (infrastructure ENUM)

2.4.1 ENUM as additional service with opt-in (User ENUM)

In this case ENUM domain names are entered in ADDITION to existing phone services available on the PSTN/ISDN. Therefore any call originating on the PSTN/ISDN will be routed normally on the PSTN/ISDN to the existing termination as usual. Only calls originating on the Internet MAY query ENUM and MAY route the call to the termination on the Internet given by the ENUM entry. This is called the opt-in principle.

The called user is opting-in in ENUM, because the entry in ENUM is optional. The calling user is also opting-in, because he may query ENUM or not, and even if he is querying ENUM, he still may decide to terminate the call on the PSTN via a gateway.

In this case the VoIP application is a second line service in addition to the primary line on the PSTN. This approach may be feasible in conjunction with other services and applications on the Internet (e.g. e-mail), but it has one serious drawback for VoIP: it suffers from Metcalfe’s Law.

Metcalfe’s Law states that "the usefulness, or utility, of a network equals the square of the number of users", which may translate to: "a new communication application will probably be stillborn anyway, because the initial value will be so small that no one will have sufficient incentive for purchase".

Is there a way to overcome this problem? Eventually by using ENUM also as infrastructure service. Here users rely on ENUM regarding VoIP and get used to it, so User ENUM maybe introduced later additionally for other services.

There is another disadvantage with User ENUM: Since the E.164 assignments to the phone services on the PSTN/ISDN and the delegations of the corresponding e164.arpa domains have to be kept in
sync, it has to be validated that only the proper number assignee may request the corresponding ENUM domain. This requires complicated validation procedures to be established.

2.4.2 ENUM as infrastructure service (Infrastructure ENUM)

If the E.164 number is entered only in ENUM, there is no synchronization with PSTN/ISDN services and therefore no validation necessary, which simplifies matters. The E.164 number is then used natively on the Internet.

In this case ENUM is implemented as a kind of IN-Service on the Internet to route voice and other multimedia real-time applications (IP Communications) using E.164 numbers to destinations primarily on the Internet.

The problem to be solved here is how a call originating on the PSTN/ISDN may be routed to such destinations. Routing on the PSTN/ISDN is still done primarily by digit analysis of the dialed destination number. IN services e.g. for Number Portability (NP) are available only on a local or national scale.

This immediately raises the question: which E.164 numbering resources could be used for such destinations?

A simple solution is to use specific numbering resources for this purpose. This would allow to route (and also bill) any call to this number from the PSTN/ISDN to the nearest ENUM-enabled gateway (Point-of-Interconnect). Note: this can be done even on a global scale, if the first 6 to 7 digits of an E.164 number are used (e.g. CC + NDC). End Note.

This has a severe drawback insofar that most numbering plans established by the national authorities (NRA) responsible claim to be technology independent (which is not completely true in all cases anyway), so specific number ranges for "VoIP-only" are currently not possible in some countries and also not on a global scale. Although this may change, other possibilities need to be considered. This document will try to propose different solutions for this problem.

2.5 Why using E.164 numbers natively on the Internet?

It was stated above that users on the Internet may use URIs to communicate with each other. Although this is true in principle, the usage of phone numbers also has advantages.

Some existing Administrative Domains implementing VoIP and other IP Communications use numbers to identify their user agents (subscribers). This may be done either directly by giving the user agents a numeric user(info) to be used in the sip: URI or h323: URI
Address-of-Record, or by providing them in addition with an alias tel: URI Address-of-Record of a global E.164 number, or both.

It is proposed to provide the numeric userinfo in such a way that it maps as partial number to the global E.164 number as defined in ITU-Rec. E.164 Annex B.

There are two main reasons to do this:

1. Most VoIP terminals in use are similar to normal phone terminals (or even use POTS Phones with a terminal adaptor) and provide only a numeric keypad, and

2. if VoIP Applications are migrating from existing PBX or Centrex Systems, they want to provide their users with the same environment as before.

The task of a system administrator of such an administrative domain is to set up a consistent numbering and dialing plans, leaving room for future extensions and also for access codes to reach other numbering plans.

This document tries to give advice in setting up consistent global and local (private) numbering and dialing plans including access codes to be used within and across administrative domains.

The proposed numbering and dialing plans are also compatible with existing numbering and dialing plans on the PSTN/ISDN and especially with the global numbering plan as defined in ITU-T Rec. E.164. The proposed numbering plans can also easily implemented in ENUM for routing within and between administrative domains.

3. Numbering and Dialing plans

This section explains existing numbering and dialing plans in general and also some basic definitions.

3.1 Numbering Plans

A numbering plan defines the structure of a namespace consisting only of strings of decimal digits. It is an inverted tree, consisting of nodes, called number blocks or number ranges and of leaves, called numbers. In a telecommunication numbering plan the numbers are called phone numbers and uniquely identify either directly end-points in a telecommunication network (e.g. a subscriber line), or indirectly temporarily connected users (e.g. mobile or personal devices), or also indirectly specific services (e.g. a freephone service).
Note for net-heads: A numbering plan is very similar to the structure of the DNS. If you take an E.164 number e.g. +436644204100, the ‘+’ can be considered as the root and each single digit can be considered as a label. There are only two minor and one big difference:

1. the root and the "top level domain" is on the left side
2. a label can be only be a single decimal digit

Therefore a mapping from a phone number to DNS is very easy: if one swaps the order of the digits, places dots between the digits and replaces ‘+’ with ‘e164.arpa’, you get exactly a domain name as specified in ENUM.

Now to the big difference: in the DNS each node may contain data, e.g. it is possible to have the following e-mail addresses: user@acme.com and user@dept.acme.com, because there are different MX records in acme.com and dept.acme.com.

In a numbering plan only the leaves of the tree are phone numbers, that is, they define end-points, users or services. The +43664 part of a number is called a number block, or if dialed (see below), it is called an incomplete number (not a partial number) and (almost) never leads to a destination (with the exception of pilot numbers for PBX with direct-dialing-in (DDI or DID), see below).

In some numbering plans also hexadecimal digits are allowed, but only for internal network specific purposes and not for the normal user. These digits are not considered any further here. E.164 numbers consist only of decimal digits (and so do the labels in ENUM, except e164.arpa)

End Note for net-heads.

As stated above, a numbering plan specifies the format and structure of the numbers used within that plan. It typically consists of decimal digits segmented into groups in order to identify specific elements used for identification, routing and charging capabilities, e.g. within the E.164 global numbering plan to identify countries, national destinations, and subscribers.

A numbering plan does NOT include the prefixes to be dialed by the calling user (this is part of the dialing plan), and it also does not include suffixes and additional information required to complete a call.

3.2 Types of Numbering Plans

The following types of numbering plans exist in principle:
The global E.164 Numbering Plan
National numbering plans
Local or network specific numbering plans
Private numbering plans.

They will be discussed below. Some additional useful terminology in advance:

Closed and open numbering plans

Only the leaves of the inverted tree are phone numbers. To allow the users and also the phone systems to find out if a number is complete, some numbering plans define a fixed length for all numbers or at least for certain numbering blocks (ranges).

A closed numbering plan refers to a telephone numbering scheme that has a fixed number of digits, not counting special service codes. The North American Numbering Plan +1 is an example for a closed numbering plan, because there are always ten digits (10D) associated with each national number: 3 digits area code (NPA) followed by the 7 digits of the subscriber number. Australia +61 is another example of a closed numbering plan.

Note: this term is sometimes confused with a closed dialing plan: A closed dialing plan refers to a national requirement to use all digits of a national number (often including a trunk prefix) to place a call, whether local or long distance. End Note.

There are other numbering plans which have variable number length, only defining the minimum and maximum length of digits, e.g. in Austria the area codes may be 1 to 4 digits and the local numbers may be 3 to 8 digits. This is an open numbering plan.

3.2.1 The Global E.164 Numbering Plan

This is also called the International Public Telecommunication Numbering Plan according to ITU-T Rec. E.164. The numbers are called International Public Telecommunications Numbers (IPTN) in the international format (or E.164 numbers).

A number according to ITU-T Rec. E.164 is a string of decimal digits that uniquely identifies a user-network interface, e.g. PSTN/ISDN or mobile terminals and individuals utilizing specific global services, e.g. Universal International Freephone Numbers (UIFNs). Most of the services/subscribers can be addressed directly, but in cases where indirect addressing is used number translation is required, e.g. for UIFNs. The number contains directly or leads to the information necessary to route the call to the termination point.
A number can be in a format determined nationally or in an international format. The international format is known as the International Public Telecommunication Number (often also known as E.164 Number) which includes the country code and subsequent digits, but not the international prefix.

The global E.164 Numbering Plan defines the International Public Telecommunication Numbers and their structure (e.g. Country Code <CC> and National (Significant) Number <N(S)N> or Global Subscriber Number <GSN>).

### 3.2.2 National Numbering Plans

A national numbering plan is the national implementation of the E.164 global numbering plan (e.g. N(S)N = National Destination Code <NDC> and Subscriber Number <SN>.

### 3.2.3 Local or network specific Numbering Plans

A local or network specific numbering plan is a local or network specific implementation of a national numbering plan and therefore part of the E.164 numbering plan. It may not exist in some national numbering plans (e.g. in closed dialing plans).

### 3.2.4 Private Numbering Plans

A private numbering plan is an implementation of a numbering in a private telephone network. It may or may not be part of the national or local numbering plan.

If a private numbering plan maps to the global E.164 Numbering Plan the private numbers are part of the International Public Telecommunication Number as partial numbers, as defined in ITU-T Rec. E.164 Annex B. Only these private numbering plans are considered within this document.

Note: The tel: URI as defined in RFC2806bis uses the terms global and local number. Within RFC2806bis the term global number is used only for IPTN (E.164 numbers) in the format ’tel:+43179780′. All other numbers e.g. in the format ’tel:32;phone-context=+43179780′ or ’tel:7978032;phone-context=+431′ are called local numbers. Therefore local numbers may be numbers from national, local or private numbering plans. End Note.

### 3.2.5 Non-E.164 numbers

Any international number which does not conform to the structure, length and uniqueness as defined ITU-T Rec. E.164 is not an E.164 number.
number. Non-E.164 numbers may not be passed across any Network boundaries without a specific bilateral agreement.

Some examples are local special numbers, network specific numbers, etc. For more information see ITU-T Rec. E.164 Annex A.

‘911’ and other emergency numbers (e.g. ‘112’ in Europe) are a typical examples of non E.164 numbers. Even if they may be dialed from another country in principle, they lack the uniqueness.

3.3 Dialing Plans

A numbering plan is a name space and defines the end-points from the point of the called user. Phone numbers are assigned to network-end points, users or services.

A user normally does not enter in most cases a number in his device. The user is entering a "dialing string", depending on his local context.

A dialing plan is a string or combination of decimal digits, symbols, and additional information that defines the method by which a defined numbering plan is used by the calling user. A dialing plan includes the use of prefixes, suffixes, and additional information, supplemental to the numbering plan, required to complete the call. It is therefore the method to access the given name space.

Depending on the mapping of the dialing plan to the numbering plan, it may be necessary to leave certain number blocks of the namespace of the numbering plan unused for use of prefixes (access codes) to access other numbering plans or network specific services.

Prefix

A prefix is an indicator consisting of one or more digits that allow the selection of different types of number formats or numbering plans to be used.

Another type of a prefix is a Carrier Access Code (CAC) followed by a Carrier Identification Code (CIC) and then the requested number (eventually including again a prefix). This is used to select within the originating network the carrier network to be used to route the call to the destination network. This is a different type of prefix and should NOT be confused with the access code to select the dialing plan.

International Prefix
A digit or combination of digits used to indicate that the number following is a full E.164 Number.

Note: A numbering plan consists only of decimal digits (with the above mentioned exception of network specific hexadecimal digits). A dialing plan may also consist of symbols (e.g. ‘*’) and hexadecimal digits (e.g. ‘A’, ‘F’). Their use is up to the administrator of the dialing plan. A normal user may not be able to dial all of these ‘digits’. End Note.

The symbol ‘*’ has a special predefined meaning, originating from mobile networks: If a number is preceded by a ‘*’, the ‘*’ has to be replaced by the digits equivalent to the international prefix valid within this dialing plan, e.g. ‘00’ in most European national dialing plans or ‘011’ in the North American dialing plan.

Important note: The hexadecimal digits may be used ‘*’ and ‘#’ to manipulate supplementary services and are always network-specific. They should therefore only be used as prefixes to access other numbering plans if it is not planned to use them for supplementary services in the future. End of important note.

3.3.1 Types of Dialing Plans

A user on the PSTN/ISDN is always in one defined dialing plan at a given time. That means, if he is going off-hook and starting dialing digits, or if he enters the digits in his device and submits them in one block, there is always ONE defined dialing plan assumed by the system receiving the dialed digits (dialing string). The user has to know the dialing plan in use, e.g. by reading the manual (phone book). The dialing plan does never change on a device connected to a phone system via a fixed line; it may change in case of a mobile phone while roaming.

Basically the dialing plan can be

- private,
- local,
- network-specific or
- national.

Note that there is no global dialing plan.

3.3.2 Access to numbering and dialing plans

The basic principle of a dialing plan is a follows (although there are exceptions):

- If you dial a number without any prefix, you are accessing a number of the associated numbering plan.
If you dial a prefix (access code), you are accessing another numbering or dialing plan.

Normally the dialing plans are hierarchically, especially if the numbering plans are compatible, as it is in the case of E.164 numbers. It is recommended by ITU to use ‘0’ as access code for going up the hierarchy, but this is not implemented in all countries (mostly because for historical reasons the number range is not available).

1. If your phone is connected to a PBX line, you dial either the extension directly or an access code (e.g. ‘0’ or ‘9’) to access the local dialing plan. If your phone is directly connected to the PSTN/ISDN, goto step 2.

2. Now you may dial either a local number or again an access code (e.g. ‘0’) to access the national numbering or dialing plan.

3. There you may dial a national number or again an access code (e.g. ‘0’) to access the international numbering plan.

There is normally no way to go to another numbering or dialing plan directly on the same hierarchy level or to go down the hierarchy. The only way to access another numbering or dialing plan normally is to go via the lowest common hierarchy. This requires that the other numbering plan is mapped into the next higher hierarchy. To reach another local numbering plan in the same country requires going via the national dialing plan, to reach a local numbering plan in another country requires dialing the international access code and the E.164 number including the country code.

3.3.3 Mapping of private numbering plans as partial numbers

To reach another private numbering plan with DDI via the PSTN/ISDN requires a mapping of the private numbering plan to the E.164 numbering plan as partial numbers. In some cases a given private number may even be reached with two or three different E.164 numbers (e.g. from one or more local numbering plans, from one or more national numbering plans, and here either from a mobile number or a number for corporate networks.

The extension 3184 of a Vienna company may be reached via +43 1 60501 3184 (Vienna), +43 664 67070 3184 (mobile) or +43 50811 3184 (corporate networks).

3.3.4 Cross trunks or cross connections
In some cases there may exist additional access codes to directly access other numbering plans as a shortcut. These access codes are called cross trunks or cross connections. For technical reasons these cross connections have been implemented also in the public PSTN/ISDN in the past when the E.164 numbering plan was not fully implemented yet. They still exist and are widely used between private networks with heavy traffic relations. These cross trunks may be implemented also with physical trunks or only virtually as cross connections. Often numbers out of the number range ‘9’ are used for this purpose.

It is depending on the system administrator of the destination network if the dialing plan or only the numbering plan can be accessed via these cross connections. Normally only the numbering plan may be accessed and sometimes the access is even more restricted to certain number ranges. The reason for the blocking of the dialing plan (especially the access code to the next hierarchy) is to prevent transit calls (for billing reasons).

Of course the number ranges (blocks) used for these access numbers cannot be used within the numbering plan. Since often the number range ‘1’ is used for network-specific services, it is quite common to use only the number ranges from ‘2’ to ‘8’ for subscriber numbers.

3.3.5 Closed Dialing Plans

In some countries and networks closed dialing plans are used. A closed dialing plan refers to a national requirement to use all digits of a national number (often including a trunk prefix) to place a call, whether local or long distance. The current systems in France (as of October 1996) and Belgium (as of January 2000) are examples of closed dialing plans.

The issue of closed dialing plans can be somewhat confusing. Not only that the terms closed dialing plan and closed numbering plan are used ambiguously in literature, there are two types of closed dialing plans.

Type I is derived by canceling the direct access to the local numbering plan, but leaving the rest of the local dialing plan as is: one always has to dial the national access code (e.g. ‘0’) to reach national E.164 numbers. Only network-specific numbers and service code may be dialed without prefix. Examples are Switzerland and France. Also many mobile networks use this type. This is less logical, but easier to tell the customers: “You have to dial now the area code for local numbers also.” People are also used to this approach from mobile phones anyway.

Type II is derived by canceling both the local numbering plan and dialing plan: one may dial national numbers directly without a
prefix. One example is Portugal. This approach seems more logical and also saves one digit to dial, but is harder to explain: "You have to dial now the area code for local numbers also, but you must not dial the national access code". To confuse things even further from a logical point, but to make things easier for customers, the international access code in Portugal is still '00'.

In the North American Numbering plan all variants exist, normally you may dial 7 digits xxx-xxxx to access the local dialing plan, and 1-xxx-xxx-xxxx (1+10D) to access the national dialing plan, but in some NPAs you also may dial only the 10 digits. In some NPA the dialing plan is closed, so you may only use 1-10D. With mobile phones you also must use 1+10D always.

In general, the NANP is moving to 1+10D in all NPAs (for more information see www.nanpa.com).

4. Types of numbers in existing numbering plans

Phone numbers in the PSTN/ISDN serve two main purposes: to route calls properly to their destination and to be able to tariff the call. Before the introduction of IN-services and all-call-query (ACQ) for all numbers dialed (also still today), a switching system must be able to analyze the first digits dialed and deduce the routing information and the tariff information. For E.164 numbers in the international format this is limited to the first 7 digits.

It is therefore necessary to group the numbers in certain number blocks to be able to derive routing and/or billing information. This is also required to enable the customers to derive especially the expected cost and/or service of the call by looking at the number.

4.1 International Public Telecommunication Numbers (E.164 Numbers)

The ITU-T Rec. E.164 defines the following types of International Public Telecommunication Numbers (IPTN). A distinction between the types of numbers can be made within the first three digits.

\[ \text{\text{IPTN for Geographic Areas} \text{\!}} \]

These are the "real" Country Codes (CC) and are one to three digits in length. The maximum length of an IPTN is 15 digits in principle, but nationally shorter length may be required (e.g. a number of the NANPA has a maximum length of 11 digits). The further structure is a national matter and will be discussed in the next section.

In order to determine the country of destination, the most appropriate network routing and the proper charging, the originating country must analyze a number of digits of the E.164 international
number (maximum of 7). The length of the National Destination Code (NDC) increases the potential requirement for number analysis because it provides for a combination of either a Trunk Code (TC) and/or a network identification function. Careful consideration should be given to the preparation of the National Destination Code (NDC) assignments.

**IPTN for Global Services**

The numbering plan for global services is service specific. Each use of an E.164 country code for a global service needs to comply with numbering assignment principles, as specified in Recommendation E.190, as identified for the specific service, and the criteria and procedures as specified in Recommendation E.164.1. Refer to the appropriate numbering Recommendation for documentation regarding the numbering scheme and any service specific principles, e.g. Recommendation E.168 Application of E.164 numbering plan for UPT.

The international public telecommunication number for global services is composed of the 3-digit country code applied for the global service and the Global Subscriber Number (GSN). The maximum length is 15 digits.

Digit analysis for global services is service specific. In order to determine the specific global service, and the call routing and charging, the digit analysis should not exceed 7 digits, e.g. 3-digit CC + 4 digits of N(S)N. Refer to the appropriate ITU-T numbering Recommendation for documentation regarding the number analysis requirements for the specific global service.

Currently the following Global Services are defined:

- ITU-T Recommendation E.168 (1999), Application of E.164 numbering plan for UPT.

**IPTN for Networks**
International public telecommunication numbers used by Networks consist of three parts: a shared 3 digit E.164 country code; an identification code; and a subscriber number. The maximum length of international public telecommunication numbers used by Networks is fifteen (15) digits.

For calls utilizing the international public telecommunication number for Networks, the maximum number of digits to be analyzed is seven, which includes the three digits of the E.164 country code, the identification code, and the initial significant digits (if any) of the subscriber number. A minimum of the 3-digit country code and IC must always be analyzed to determine the appropriate routing and charging.

**Å² IPTN for Groups of Countries**

International public telecommunication numbers used by Groups of Countries consist of three fields: a shared three digit Rec. E.164 Country Code; a one digit Group Identification Code; and a Subscriber Number to a maximum length of eleven digits. The maximum length of international public telecommunication number used by Groups of Countries is fifteen digits.

These are the first three digits of international public telecommunication number for Groups of Countries. A country code for Groups of Countries is a shared (i.e., shared between GoC’s) three digit CC used in combination with a single digit GIC to uniquely identify a Group of Countries.

The maximum number of digits to be analyzed for the processing of calls to international public telecommunication numbers for Groups of Countries is seven. This includes the CC field (three digits) plus the GIC field (one digit) plus the first three digits of the Subscriber Number (SN). A minimum of four digits (i.e., CC + GIC) must always be analyzed to determine the appropriate routing and charging.

**4.2 National E.164 Numbers**

Since the structure and also the types of numbers and services provided are a national matter, there exists a big variety of implementations, although there are some recommendations from ITU and also some common international and regional approaches.

Note: One should consider that national numbering plans have historically evolved and a complete alignment of these numbering plans would cause major changes to the existing numbering plans. Since these changes are very costly and causing major resistance by the public, they are either avoided at all or are long term projects.
Even such a simple change to introduce the recommended access code ‘0’ for international calls has not been implemented globally yet. The introduction of a new globally unique access code in all national dialing plans (e.g. for VoIP) is absolutely impossible – don’t even think of it. End Note.

In most countries the following types of numbers have been introduced. In most cases a distinction between the types of numbers can be made within the first three or four digits. Since the grouping or categorization differs in most countries, a new and simplified grouping is proposed:

4.2.1 ‘Pure’ Geographic numbers

These are the "original" phone numbers for fixed line end-points. In open numbering plans they consist of a "trunk code û TC" or "area code", giving the geographic area or region and the "subscriber number û SN". The SN may be dialed in open dialing plans directly out of the local dialing plan. Customers may derive the TC (and also the tariff for distance) by knowing the address of the called user.

The TC is used to route the call to the switching system(s) serving the geographic region and also to derive the tariff from the distance between the originating and termination end-point.

In many countries local number portability is possible if the customer is moving to another location within the same TC range. A customer may also port these numbers to another service provider without changing his location; this is called service provider portability.

In most countries also databases are available giving the exact location of the end-point e.g. for emergency services.

These geographic numbers are using up most of the numbering space and have been the reason for earlier discussions on numbering exhaust. For historic technical reasons the numbering space is not used economically. Since some years the number of fixed lines using mostly these geographic numbers is decreasing.

For this type of numbers number ranges out of each TC are assigned to network operators or service providers, which in turn assign the numbers to the end-users.

4.2.2 Non-geographic numbers for private networks

A range of non-geographic numbers may be used for networks private networks with more then one connection to the PSTN/ISDN. These connections normally have also geographic numbers assigned. These
numbers consist of a "national subscriber number" and can only be
dialed locally by accessing the national dialing plan and by
prefixing the national access code. The "national subscriber number"
consists of a pilot number for the private network (company) and a
mapping of the private numbering plan as partial number.

The "pilot" number is translated to the nearest geographic number
providing access to the private network and also to derive the
tariff. This tariff is in the most cases only dependent on the type
of number (the number ranges assigned for private networks), and not
on the pilot number.

For this type of numbers service provider portability is available.

For this type of numbers the pilot numbers are assigned to the
private networks, which in turn assign the partial numbers to the
end-users.

4.2.3 Non-geographic numbers for networks

Non-geographic number ranges may also be used for networks (e.g.
mobile networks). They consist in open numbering plans of a "network
destination code û NDC" and also a "subscriber number ûSN".

The NDC is used to route the call to the nearest Point-of-
Interconnect of the network given by the NDC and also to derive the
tariff. The tariff may either be dependant on the type of network or
dependant on the specific network.

Between the same types of networks (e.g. mobile networks) service
provider portability may be available in some countries.

For this type of numbers NDCs are assigned to network operators or
service providers, which in turn assign the numbers to the end-users.

Note that in some countries also geographic numbers may be used for
mobile subscribers. End Note.

4.2.4 Non-geographic numbers for personal services

Non-geographic numbers may also be used for personal services. They
consist in open numbering plans of a "network destination code û NDC"
and also a "subscriber number ûSN".

Depending on the implementation of the personal services, either the
NDC is used to route the call to the nearest Point-of-Interconnect of
the network providing the personal service, or the full number is
translated to route the call again the a PoI, or directly to the
geographic number where the user is currently connected to. The number range is also used to derive the tariff.

Personal numbers are normally service provider portable by definition, especially if the number is assigned directly to the end-user. Number ranges may also be assigned to service providers, which in turn assign the numbers to the end-users.

4.2.5 Non-geographic numbers for services (tariff related)
Non-geographic number ranges are used for services. They consist in open numbering plans of a "network destination code \text{NDC}" and also a "subscriber number \text{SN}". The NDC defines the type of service.

Since most of these services are related to billing, the NDC is primarily used to derive the tariff. This becomes clear if we look at the services in question: these are freephone, shared cost and premium rate or other value added services.

Services may be hosted with different service providers and are also translated finally to a geographic number for termination. These services are normally implemented as IN-services and two IN-dips are required for completion: the first to find out the network or service provider hosting the service and a second to translate the service number to the final destination number. This second translation may be dependant on date, time and origination of the call.

In most case service provider portability is available, but only between the same types of service.

This type of numbers is in most cases directly assigned to the end user and then hosted by a service provider.

It should be noted that even if some of this services may be reached uniquely by e.164 numbers, but are blocked for international incoming calls because they cannot be billed properly.

4.2.6 Discussion of the existing schemes for types of numbers

The boundaries between the classifications of the types of numbers are already blurred in the existing schemes and may differ in the various national implementations.

Some examples (not exhaustive):

Some countries assign numbers out of geographic numbering blocks for access to mobile wireless terminals e.g. in the NANP. Therefore the same tariffs are charged to calling users regardless of destination in the fixed or mobile networks and also regardless of mobile
network. The mobile networks therefore may charge air-time to the called subscriber.

Personal services are currently classified as non-geographic numbers in most countries and also within the global international E.164 numbers. The reason for this is that existing number ranges for personal numbers are implemented as Personal Services along the service description of for Universal Personal Telecommunications (UPT) as specified in ITU-T Rec. F.85x series. The basic assumption of UPT is that an UPT user may register on any other fixed or mobile terminal and receive calls to the personal number and also may make calls from this terminal in his/her account. This requires an IN-type service with All Call Query (ACQ) to translate the dialed UPT number to the number of the line where the user is currently registered. This service is currently implemented rarely and if, only on a national scale, because there is no global interworking of IN-services available. For this reason and also because of the pricing of the service it was not very successful on the market.

A global implementation using the assigned CC for UPT +878 and IP technology is under development. Although here the users may also attach to PSTN/ISDN lines, the prime intention of the service is for "mobile" users on the Internet.

On the other hand, one may consider mobile numbers also as "personal" numbers and mobile services as "personal" services, because a mobile numbers are (at least in GSM and UMTS) linked to Subscriber Identity Modules (SIM). These SIMs are attached temporarily to a device (the mobile phone). The device also gets a (temporary) number (MSRN) and the routing of the call is done by this numbers. This also requires a translation of the number dialed (the mobile number) to the number assigned currently to the device, the mobile subscriber roaming number (MSRN). The MSRN is also a E.164 number but used only within or between mobile networks to route the call properly to the destination mobile switching center (MSC) of the roaming subscriber (user). The translation is also done by an IN-type service with ACQ via the home location register (HLR) of the subscriber.

The technical implementations of personal and mobile numbers are very similar, with one exception: there is a globally interworking IN-service available, but only within and between the GSM/UMTS networks.

Therefore one may question the classification of mobile numbers in the existing categories Âgeographic or non-geographic for networks (they may also be classified as type non-geographic for services) and one may also question the statement that numbering resources are allocated technology independent.
It is therefore proposed to classify both personal and mobile numbers as equivalent and also as non-geographic number for networks.

4.2.7 Proposed new scheme for types of numbers

It is therefore proposed to use a new classification scheme:
- Pure geographic numbers
- Non-geographic numbers for private networks
- Non-geographic numbers for networks and personal numbers (including mobile networks and personal services using VoIP networks)
- or better: mobile personal services.
- Non-geographic numbers for tariff related services

Even if mobile (wireless) and mobile (VoIP) networks (or services) are keep distinct for some time, they may merge into one group of services, namely mobile personal services very soon, especially with so-called dual mode devices.

Note: These devices are announced for the 4Q2003 and will have both GSM and WiFi (VoIP) capabilities and may even use the same SIM card for identification and authentication. End Note.

4.3 Partial Numbers

Private numbering plans may map part or all of their numbers to an E.164 Number in such a manner that destinations (extensions) within the private network may be reached from the public PSTN/ISDN by direct-dialing-in (DDI). This is described in more detail in ITU-T Rec. E.164Annex B "Application of international public telecommunication numbers for ISDN".

This is done currently in the following way: a number block of an E.164 number is assigned to a company or provider. This numbering block is called pilot number. Then the numbering plan of the private network is attached as partial number.

Pilot number and partial number together are a full E.164 number. The full E.164 number MUST fit into the national or international numbering plan, especially concerning digit length.
Types of numbers used for this purpose are:

- National Geographic numbers
- National non-geographic numbers for private networks
- National non-geographic numbers for mobile networks
- Global numbers for networks

Note: If a pilot number is in a numbering range supporting number portability, only the pilot number (at the endpoint of the PSTN/ISDN) is portable. End Note.

This is the reason why personal numbers should not be used for this purpose, or a distinction must be made between single portable numbers and pilot numbers. This is already the case for mobile (personal) numbers.

Note: I received a comment to this section from John Elwell, stating that

"In 4.3 the term "pilot number" is possibly misleading. The fact is that two private networks could have the same pilot number, e.g., one network has nnnnnn1xxx and another has nnnnnn2xxx, where pilot number nnnnnn is the same in each case. The term pilot number implies it is a kind of lead-in to a private network, but in fact it is (in such cases) insufficient to identify a particular network."

To which I replied:

This is a very crucial point.
As you see, I copied out the picture from E.164 Annex B, which defines everything EXCEPT the pilot number (I suspect on purpose, because there seems to be no clear definition).

According to your explanation, the term pilot number defines the endpoint in the public network, and I know, there may be split PRI connecting more than one PBX with different ranges.
Here I have now the problem that on IP there is not really a clear definition of an "endpoint".

The next problem I have is that in your example in ENUM (DNS) I could define the "endpoint" or pilot number (delegation-wise) to be nnnnnn1 and nnnnnn2. The "endpoint" in the case is a change of authority and this can be in DNS only at a "point" or in numbering speak only with a full digit. If you have the case (and such cases exist) that one private network (PBX) has number ranges nnnnnn1 and 2 and the other has nnnnnn3 and 4, you could solve this in DNS only with four separate delegations, two for one network and two for the other.

So if one hand the term pilot number is defined as network endpoint and this is meaningless on IP, I need another term for a point of delegation of authority in DNS. So either I come up with another term or I explicitly define in my document "pilot" number as boundary of authority to the number range holder. End of Note.

4.4 Calling line identification (CLI)

Phone numbers are also used to identify the identity of the calling user. For this reason the number of the calling user is transmitted as CLI to the called user.

The CLI serves many different purposes:

- Call-back information to the called user.
- Identification of the user and his location to emergency services and legal intercept
- Identification of the user for malicious call identification (MCI)
- Identification of the user for accounting purposes

These purposes have different requirements on the trustworthiness of the CLI. In some signaling systems two numbers may be transmitted, one un-trusted (user provided) for call back and a trusted (network provided and screened) for the other thee items.

Regarding the types of numbers, in case of geo-graphic and non-geographic numbers the CLI of the user should be displayed if this user is making an originating call using this number. In case on non-geographic numbers for private networks, both numbers may be displayed if a translation is used.

In case of non-geographic numbers for services either only the number of the terminating line is displayed, or also both numbers if available.
The usage of CLI with VoIP and the possibility to provide secure signaling of this information via the Internet will be discussed in detail in a separate document.

5. E.164 Numbers for VoIP

5.1 E.164 Numbers for VoIP-only

In principle any E.164 number may already terminate on IP-based networks or the Internet using VoIP technology. Numbering Plans claim to be technology independent. A telecommunication network provider may claim a number range out of an area code reserved for geographic numbers or a number range out of a network destination code for (mobile) networks. Since he may use any technology within his network, he may also use VoIP technology.

There are already network providers using IP technology internally (e.g. cable network providers), mobile operators are planning to use VoIP technology for UMTS.

Currently these networks are mainly ‘private’ IP networks with no direct connection to the Internet. All interconnections with the public telephony network and to other networks are done via circuit-switched Points-of-Interconnect. All calls are routed via the PSTN, even if they originate and terminate on IP terminals. This is not efficient for various reasons, the two most important being the unnecessary double use of expensive equipment (gateways) and the reduction in Quality of Service (QoS) (delays) also caused by the unnecessary double use of gateways.

Another drawback of these closed networks is that the VoIP service may only be accessed from within the networks. If users want to be mobile and use their terminal equipment anywhere on the public Internet they need to be able to connect and register on any (broadband) Internet access (e.g. via a WiFi hotspot or in a hotel or meeting broadband connection).

So we have two basic requirements for VoIP:

1. Calls originating on the Internet and terminating on the Internet must stay on the Internet or terminals using IP technology should be reachable via the public Internet.

2. Users want to have an E.164 number independent of the PSTN, want to connect to the Internet anywhere and want to be reached via this E.164 number from anywhere, including the PSTN/ISDN.
In this section the possible types of numbers for VoIP-only usage are discussed.

5.2 Potential E.164 Number types for VoIP-only

5.2.1 National Geographic Numbers

Geographic numbers have a geographic significance. A caller may determine by looking at the number the geographic region, in some countries, depending on the numbering plan even the town or village. What is even more important is that emergency services in most countries may derive from the displayed number not only the identity but also the exact location of the caller.

This is considered an important feature and should therefore be implemented also for VoIP.

So if geographic numbers are allocated to VoIP terminals, it should be required that the terminal can only be used at the given location. This is no technical problem e.g. with cable or xDSL access.

To be more precise: it is required that the user may only register (any terminal) via the given access and make outgoing call using the geographic number in CLI from this location.

This does not imply that he may not receive calls to this number anywhere in the world. This can easily be achieved via simple call forwarding to another number.

Geographic numbers may either be used for residential subscribers or for private networks. In case of private networks the same is valid as stated in the next section.

5.2.2 National non-geographic numbers for private networks

Private networks may migrate to VoIP on their own discretion anyway. So a private network may use VoIP internally anyway. The question here is the access to the private network itself, which is done normally via the pilot number and a translation of the national non-geographic number to one or more geographic numbers. It is also up to the private network if may be reached from the Internet directly.

5.2.3 National non-geographic numbers for mobile networks

This is a question of definition if VoIP networks are also considered as mobile networks.
One could imagine that the definition for mobile networks is extended or that there is no distinction between numbers for mobile networks and personal numbers.

5.2.4 National non-geographic personal numbers

This is the most convenient number range candidate to be used for mobile VoIP, because it fits the purpose best. Furthermore number range(s) for personal numbers are already reserved in most countries, but in most cases not or not extensively used.

5.2.5 Global numbers for networks

These numbers may be considered equivalent to national non-geographic numbers for private networks. It is up to the customer and his business if he prefers a national or global numbering resource or both.

5.2.6 Global personal numbers

These numbers are equivalent to national non-geographic personal numbers. It is up to the subscriber if he prefers a national or global numbering resource or both.

6. How to set up numbering and dialing plans for VoIP domains

6.1 Basic Requirements

Note: the requirements in this section are only valid for numbering plans if the administrative domain wants to map its numbering plan to the global numbering plan and/or to a national numbering plan, to be reachable by E-164 numbers from the outside, either from the PSTN, from the Internet or both. End Note.

They are only valid for dialing plans if the administrative domain wants to access the global numbering plan and/or national dialing plans to reach other administrative domains or the PSTN/ISDN via E.164 numbers.

These requirements are not valid for administrative domains hosting single E.164 numbers, e.g. local numbers, mobile numbers or personal numbers requiring number portability. In this case a mapping of an own numbering plan is not required, although a dialing plan may exist.

Recommendation 1:

If existing numbering and dialing plans are used, e.g. if an administrative domain is migrating an existing private, local or
national network to IP-technology, the numbering and dialing plans MUST be compliant to these existing numbering and dialing plans.

Recommendation 2:

The global numbering plan as defined in ITU-T recommendation SHALL be accessible directly and in the same way from all numbering and dialing plans defined in this document (e.g. with an international prefix).

Recommendation 3:

The numbering and dialing plans defined in this document SHALL be compatible with the global numbering plan as defined in ITU-T Recommendation E.164 Annex B.

Recommendation 4:

It SHALL be possible to address private numbers (extensions) within an administrative as defined in ITU-T Rec. E.164 Annex B.3.2 by an ISDN Number to be reached either with Direct-Dialing-In (DDI) (Overdialing) or via MSN. This implies that the private numbering plan maps to the E.164 numbers as partial numbers. Sub-addressing (network address extensions) SHALL not be used.

Recommendation 5:

All private numbering plans according to this document SHOULD use a fixed length of numbers. This is to allow also for fixed length E.164 numbers and a defined end-of dialing for terminals.

But: Note A private numbering plan could have variable number length, but the corresponding E.164 numbers are fixed length. For example: Site 1 has private numbers 77xxxx mapping to E.164 numbers +44 123 4567 xxxx and site 2 has private numbers 666 xxxx mapping to E.164 numbers +44 234 5678 xxxx. End Note:

Recommendation 6:

If the administrative domain has to be reachable from the outside, it is recommended to start setting up numbering and dialing plans first with the selection of the E.164 number range (pilot number) where the numbering plan will be mapped into as partial number.

After the selection of the number range assigned to the administrative domain the according dialing plan has to be selected and defined.
After the definition of the dialing plan it is known which number ranges are used up eventually for access codes, allowing defining the available numbering ranges for local numbers.

6.2 Which E.164 Numbers to use for mapping of partial numbers?

As stated above all types of numbers may be used for VoIP, but only certain E.164 number types are recommended for partial number mapping to administrative domains and therefore require the creation of an own numbering and dialing plan. With all other options the numbering and dialing plans are already predefined.

Global Numbers for Networks

These types of numbers are recommended for administrative domains hosting subscribers from many different countries. In this case a dialing plan for global access is recommended.

National non-geographic numbers for private networks

These types of numbers are recommended for administrative domains hosting subscribers from mainly this specific country. The selection is also dependent on national regulations. In this case a dialing plan for national access is recommended.

National non-geographic numbers for mobile networks

These types of numbers are also recommended for administrative domains hosting subscribers from mainly this specific country. The selection is also dependent on national regulations. In this case also a dialing plan for national access is recommended.

Note: this is only possible if the mobile network allows partial numbers and DDI. If the administrative domain is also mapped to another number range, it is recommended to use the dialing plan of the other numbering range and let the system convert the digits to access the mobile network. End Note.

Geographic numbers

These types of numbers are recommended for administrative domains hosting subscribers from mainly this specific location (city). In this case a dialing plan for local access is recommended.

Note on number assignment to administrative domains

E.164 numbers may be assigned to an administrative domain in two different ways, depending on policy.
1. The administrative domain is the End User
2. The administrative domain is the number range holder

This has implications on ENUM and Number Portability.

The administrative domain is the End User

In this case the administrative is equivalent to a private company implementing an IP PBX or IP Centrex. The company is the End User holding the E.164 Number minus the partial number range (also called pilot number) and has the right to opt-in into ENUM with this number. The full E.164 numbers may or may not be entered in ENUM. If the numbers are entered in ENUM, the company may in addition decide to provision the entries as a whole or give the provisioning of the single entries to the employees using the number.

Number Portability never applies.

Examples are administrative domains (companies) with national geographic numbers or national non-geographic numbers for private networks.

The administrative domain is the number range holder

This is the case the administrative domain is equivalent to a Telephony Service Provider (TSP) in the PSTN/ISDN sense. The administrative domain may now assign in turn E.164 Numbers out of the number range to End Users.

In this case the End User is the holder of the E.164 Number and has the right to opt-in to ENUM on his own.

If Number Portability also applies within the number range, the administrative domain must be aware of this fact and allow for porting in and out of numbers.

Examples are administrative domains implementing local numbering plans as Local Exchange Carriers or administrative domains implementing service numbers e.g. personal numbers.

6.3 Dialing Plans for administrative domains

6.3.1 General Recommendations for all Dialing Plans

These recommendations concern dialing strings and are proposals for discussion.

Recommendation 7:
Any dialing plan of an administrative domain SHALL recognize a global (E.164) number in the format as defined in rfc2806bis and E.123 with a leading ‘+’. The server of the administrative domain SHALL translate the ‘+’ to the international access code used within this administrative domain. This is also necessary for a potential interworking with dual-mode mobile devices (e.g. GSM and WiFi), because it is common to store numbers in this format.

Note: these numbers may be transmitted to the administrative domain from the user device (User agent) either in the format tel:+43179780, sip:+43179780@acme.com or h323:+43179780@acme.com. If a server receives such a request, he may either forward the call to the PSTN or launch an ENUM-query. If the result is a NAPTR with a (different) tel:+xxxx, he may launch another ENUM query. If the result of an ENUM query is the same number as the previous number queried or no NAPTR is found for this number, the call shall be forwarded to the PSTN or forwarded to another proxy with tel:+xxxx;edi (ENUM dip indicator).

Recommendation 8:
Any dialing plan of an administrative domain SHALL recognize the international access code either in the format ‘00’ or ‘011’, e.g. 0043179780 or 01143179780. Only administrative domains with global access SHALL recognize both access codes.

Recommendation 9:
For customer convenience, the ‘+’ character MAY be replaced by the ‘*’ symbol, e.g. international calls MAY also be dialed *43197980.

Recommendation 10:
The administrative domain MAY decide to use ‘***’ for the selection of a cross trunk or cross connection. In this case the format of the dialing string is ‘***yyyxxxxx’ where yyy is the selection of the cross trunk to another numbering plan and xxxxx is a number of the other numbering plan selected. It is suggested to use not more then 3 digits for cross trunk selection.

In addition or instead of ‘***’ also a digit MAY be used as access code for cross trunking. It is recommended to use the digit ‘9’ for this purpose.

Recommendation 11:
The character ‘#’ may be used as end-of-dial signal.
The further selection of the variant of dialing plan used within an administrative domain is an internal matter, but the choice has to be communicated to the users (subscribers).

6.3.2 Types of dialing plans

The dialing plans for domains come in four variants:

1. Dialing Plan for domains with global access
2. Dialing Plans for domains with national access
3. ITADs within Local Dialing plans
4. Dialing Plans for domains with local access

6.3.3 Dialing Plans for domains with global access

This dialing plan is for administrative domains with no specifically defined local or national access. This is intended for administrative domains hosting users (subscribers) from various nationalities or countries.

1. All generic recommendations from above may apply.
2. All other numbers dialed are treated like private (local) numbers out of the selected numbering plan (see numbering plans below).
3. Network specific numbers may be introduced in the number ranges 1 and 9 (see below).

As long as the problems of user location and the routing of emergency calls is not solved, it is not recommended to provide routing to national emergency services, but this may be implemented later if the numbers 112 and 911 are reserved from the beginning.

6.3.4 Dialing Plans for domains with national access

Administrative domains with national access will be domains using national mobile or personal ENUM numbers, where most of the users (subscribers) may come out of this country. Nevertheless, a domain may also decide to use only global access.

1. All generic recommendations from above may apply, with the exception of '00' or '011'. The reason is that in this case either '00' or '011' may be valid, depending on the national dialing plan.
2. Only one national access SHALL be provided. It MUST be made clear to all subscribers which national dialing plan is accessed. Example: If the Austrian national dialing plan is accessed, a number dialed as 019793321 or 004319793321 is equivalent to +4319793321.
3. It is up to the dialing plan administrator of the ITAD if a Type I or Type II dialing plan is selected.

4. The access code to the national dialing plan depends on the national dialing plan itself, e.g. in Europe ‘0’ is recommended, in the NANPA ‘1’ is recommended.

5. Network specific numbers may be implemented depending on the Type of dialing plan selected

ITADS with national access may provide routing to national emergency services, e.g. to the European Emergency Number 112.

6.3.5 Domains within Local Dialing Plans

If a local dialing plan has to be implemented, the administrator has no choice. He has to implement the local dialing plan in question and also use local numbers as assigned by the numbering authority.

6.3.6 Dialing Plans for domains with local access

Administrative domains with local access will be domains created by migration from enterprise PBX or Centrex and therefore may already have implemented a dialing plan. In this case this dialing plan may be migrated as is to the ITAD and in most cases this means that the users are used to dial out to a local dialing plan.

1. All numbers dialed starting with 0 SHALL be treated as access to ONE specific well defined local dialing plan. The numbers dialed after the 0 belong always to the local dialing plan selected.

2. Only ONE local access SHALL be provided. It MUST be made clear to all subscribers which local dialing plan is accessed. Example: If the Vienna local dialing plan is accessed, a number dialed as 09793321 or 0004319793321 is equivalent to +4319793321.

3. Since with 0 the local dialing plan is reached, further prefixes to be used within this local dialing plan are already defined.

4. All other numbers are treated like private (local) numbers.

5. Network specific numbers may be introduced in the number ranges 1 and 9 (see below).

Domains with local access may provide routing to local emergency services, e.g. to 911, 112 or 133 in Vienna.

6.4

Numbering Plans for administrative domains

6.4.1 General
The private numbering plan is either taken over from an existing numbering plan, in case of a PBX or Centrex migration to VoIP (IP PBX or IP Centrex), or defined from scratch. It the first case it is assumed that the numbering and dialing plan is already compatible with ITU-T Rec. E.164 and proper access codes to the local or national E.164 numbering plan exists.

In the second case, the following is recommended:

1. Define the number of digits N of the local number. The possible number length is dependent on the E.164 number range where the local number is mapped as partial number. The minimum number of digits is the maximum will be dependant on expected final number of users and the type of E.164 number to be used to address the domain from E.164 (4, 5 or even 6 digits).

   It should be noted that the possible flexibility may be very restricted here, especially in closed numbering plans. Example: If the number should be mapped to an E.164 number of the NANP, and only number ranges smaller then 1-xxx-xxx are assignable, the choice is between 2 to 4 digits.

2. The E.164 number requested to address the administrative domain as a whole SHALL be according to ITU-T Rec E.164 Annex B.3.2 in such a way that the CC N(S)N SN or CC GSN including the private number as partial number gives a full E.164 number and does not exceed 15 digits (in national numbering plans additional restrictions may apply)

3. No private number SHALL start with digit 0.

4. It is also recommended that no number related to a user starts with 1 and 9, so it is recommended to use the digits from 2 to 8. Therefore private numbers MAY start from e.g. 2000 to 8999.

5. There is one exception from this rule. if the dialing plan is closed and of type I (which means that always an access code has to be used to dial a local number), then, depending on the access code also the ranges x0, x1 or x9 may be used for local numbers, where x is the access code. In this case all other number ranges can be used for network specific numbers.

6.4.2 Network specific numbers and access numbers

   Administrative domains may provide network specific numbers for internal use only. This numbers SHALL not be reachable from the outside, since they are NOT E.164 numbers.
A domain may decide on the use network specific numbers on its own discretion, but the following principles are recommended to be common for user convenience.

Network specific numbers may be used for the following main purposes: providing internal services specific for this administrative domain and providing access to emergency services.

Network specific service numbers SHALL start with digit 1 (or 9).

Numbers starting with 9 may also be used as access numbers to cross connections to other domains, e.g. if an AD1 has cross connections to an AD2 and an AD3, it may decide to use access code 99 to access directly the private numbers of AD2 and 98 to access directly the private numbers to AD3.

6.4.3 Emergency Numbers

As long as the problems of user location and the routing of emergency calls is not solved, it is not recommended to provide routing to national emergency services from domains with global access, but this may be implemented later if the numbers 112 and 911 are reserved from the beginning.

Domains with national access may provide routing to national emergency services, e.g. to the European Emergency Number 112.

Domains with local access may provide routing to local emergency services, e.g. to 911 or 133 in Vienna, but only if they map to geographic numbers.

6.4.4 Adress-of-Records and userinfo

Subscribers of these administrative domains may be provided with the following types of Address-of-Records and alias userinfo:

sip:private number@acme.com (or h323:)
sip:+e164 number@acme.com (or h323:)
tel:+e164 number

In addition, the following types may be used within the domain:

tel:<private number>;phone-context=acme.com
tel:<private number>;phone-context=+e164number - partial number but these are not recommended.

7. Routing of calls to E.164 numbers terminating on VoIP
7.1 Routing on the PSTN

In principle routing on the PSTN/ISDN is done via digit analysis. Up to seven digits may be used in a given network for this purpose. Normally the originating network (a local network e.g. a LEC) is analyzing the first digits to determine if the call is local or long distance. If it is long distance, the call is forwarded to a long-distance carrier. The long-distance carrier is again analyzing the digits, and routing the call either to the destination network (nationally) or routing the call to the country in question internationally. This is done either to another long-distance carrier or to the destination network.

If a number is ported, an intermediate step may be necessary to determine the final destination network. How this is done depends on the method of NP implemented and is not discussed detail here. The primary aim should be to allow for a number terminating on VoIP to be recognized via digit analysis as soon as possible. This requires the information to be in the first 7 digits maximum.

In this case the call could be routed immediately within the LEC or by the IXC to the nearest VoIP gateway. In case of E.164 numbers contained in ENUM, all such calls should be routed to the same type of gateway, namely to a gateway capable of querying ENUM (an ENUM-enabled gateway).

7.1.1 National Geographic Numbers

National geographic numbers will always be routed on the PSTN/ISDN network to the destination network. There is currently no way to find out on the PSTN (e.g. in the originating network) if the number terminates on VoIP (except with ACQ).

7.1.2 National non-geographic numbers for private networks

National non-geographic numbers for private networks will always be routed internationally to the country hosting the number. Nationally there are three options.

1. The private network has a direct connection(s) to the PSTN/ISDN which is assigned a geographic number. In this case the call will be routed (e.g. via IN-translation) to the nearest connection.

2. The private network has no direct connection, but has a geographic number terminating on VoIP assigned. In this case the number is translated like in option 1 and then routed like a geographic number terminating on VoIP.
3. The private network has no direct connection to the PSTN/ISDN, but has a routing number to a gateway assigned. In this case the call will be routed to the nearest VoIP-gateway capable of routing the call further on the Internet (e.g. with ENUM).

7.1.3 National non-geographic numbers for mobile networks

These numbers will always be routed to the mobile network defined by the number as defined in the national network. If the "mobile" network is using VoIP technology and is assigned a separate national destination code, the call may be routed by digit analysis directly to a VoIP gateway.

7.1.4 National non-geographic personal numbers

If number ranges assigned for personal numbers can be assumed to terminate on VoIP, the same applies as for mobile numbers. The number range may be analyzed in the originating network and routed directly to the nearest VoIP gateway.

7.1.5 Global numbers for networks

In this case the routing will be very easy, because the originating network may determine the VoIP and ENUM-enabled number by the first 5 digits (e.g. +882xx)

7.1.6 Global personal numbers

In this case the routing will be very easy, because the originating network may determine the VoIP and ENUM-enabled number by the first 5 digits (e.g. +87810)

7.1.7 User-ENUM and access codes

In case of User ENUM (see also section Å ) any geographic and non-geographic number for networks could in principle terminate also on the Internet as second line service, providing the national regulation authority has opted into e164.arpa.

The only question here is how a user on the PSTN may force the PSTN to make an ENUM lookup to terminate the call not on the PSTN by default.

This may be done by various ways, one could be to provide a specific access code similar to a carrier selection code to route the call to a VoIP gateway. This will be a matter of the originating PSTN network and is not discussed here any further.
7.2 ENUM Support for Routing of E.164 numbers on the Internet

On the Internet, E.164 numbers may be routed by different means. Administrative domains may have e.g. their own translation and routing tables, but in this case the calls need to be routed on the PSTN/ISDN directly to a gateway operated by this administrative domain. Examples may be PBXes connected to the PSTN or local networks based on IP technology.

To be reachable from anywhere on the Internet, a global mapping is necessary. This is provided by ENUM using the DNS. ENUM maps E.164 numbers to URIs. If a domain provides URIs for its users, a mapping from any E.164 number to the given URIs is possible.

For calls originating on the Internet it is of no difference if the E.164 number is also used on the PSTN or only on the Internet. The call is normally routed to the URI given in ENUM first.

Only if for a given number no ENUM entry or no URI pointing to a VoIP application is found, the call may be routed to the PSTN, proper connectivity provided.

7.3 Routing from Gateways and between domains with ENUM

This section needs work Â– feedback requested.

This section deals with the routing between administrative domains and also with the routing from Gateways to the destination domain.

As stated above, a subscriber may have the following types of address-of-records within his domain:

- sip:partial-number@acme.com
- sip:+e164-number@acme.com
- tel:+e164-number

Additionally he may also have as an alias an alphanumeric user(info), but this is of no concern within this document (e.g. sip:firstname.lastname@acme.com).

Another user may enter either the full sip URI to access the user or dial within the domain by entering the private (partial) number directly. Outside the domain this private (partial) number alone is not meaningful and cannot be used, except with cross connections using access codes.

Therefore to access a user in another domain from a given domain a sip: or h323 Address-of-Record must be used. If the user does not
know Address-of-Record, or is using an IP Phone with a numeric keypad he may want to use the E.164 number instead.

If the call is coming in via a Gateway, only the E.164 number is available.

ENUM is providing a mapping from E.164 Numbers to sip: or h323: Address-of-Records, it is therefore proposed to use ENUM for the routing of these calls.

7.3.1 The administrative domain is the End User

In this case the domain has the full control over the ENUM entries. He may decide to enter only the domain of the pilot number into ENUM or to enter domains for every extension. In the latter case he may also decide to control the entries centrally by a system administrator or delegate the rights to his employees.

One ENUM entry within domain of the pilot number

There is a very simple way to implement a default routing to domains with ENUM: since all partial numbers are mapped in the same way to the domains main (pilot) E.164 number, one ENUM domain with the pilot E.164 number containing one wildcard NAPTR is sufficient.

If e.g. OeFEG has an ENUM entry for +43 1 79780, the following entry is sufficient:

```
$ORIGIN 0.8.7.9.7.1.3.4.e164.arpa.
IN NAPTR 10 10 "u" "E2U+voice:sip" 
"!^\+4379780(.*$)!sip:\\1@sip.oefeg.at!" .
to route all calls dialed including the partial numbers to this domain.
```

ENUM entry with centralized administration

If there is a centralized administration by a system administrator there could also be only one ENUM domain for the pilot number with the following entries:

```
$ORIGIN 0.8.7.9.7.1.3.4.e164.arpa.
IN NAPTR 10 10 "u" "E2U+voice:sip" "!^.*$!sip:operator@sip.oefeg.at!" .
IN NAPTR 10 10 "u" "E2U+email:mailto" "!^.*$!mailto:office@oefeg.at!" .
IN NAPTR 10 10 "u" "E2U+web:http" "!^.*$!http://www.oefeg.at!" .
0 IN NAPTR 10 10 "u" "E2U+voice:sip" "!^.*$!sip:operator@sip.oefeg.at!" .
```
ENUM entries with per user administration

If there is a separate administration of each partial number by the employees of the company a sub-delegation to an ENUM Tier 3 Name Server operated by the company could be done. There could either be a wildcard NS Resource Record for all sub-delegations or separate NS RR for each partial number visible from the outside.

$ORIGIN 0.8.7.9.7.1.3.4.e164.arpa.
IN NAPTR 10 10 "u" "E2U+voice:sip" "!*.*$!sip:operator@sip.oefeg.at!" .
IN NAPTR 10 10 "u" "E2U+email:mailto" "!*.*$!mailto:office@oefeg.at!" .
IN NAPTR 10 10 "u" "E2U+web:http" "!*.*$!http://www.oefeg.at!" .
* IN NS enumns1.oefeg.at.
* IN NS enumns2.oefeg.at.
or
0 IN NS enumns1.oefeg.at.
0 IN NS enumns2.oefeg.at.
2.3 IN NS enumns1.oefeg.at.
2.3 IN NS enumns2.oefeg.at .
extc.

7.3.2 The administrative domain is the number range holder

If the domain is hosting full E.164 numbers, the user has the right to opt-into ENUM on his own behalf and also he may have the right to port his number out of the domain regarding the telecommunication service.

In this case all full E.164 numbers MUST be delegated directly from the ENUM Tier 1.

But consider the following example:

All numbers from the number range +8781012345 are hosted by the domain sip.nic.at

All users originally are not interested in own ENUM entries and also happy with the nic.at sip service. For all this users the first NAPTR is sufficient.
Now the user with the number +8781012345543210 wants to have an ENUM service but still provided by the ENUM Tier 2 Name Sever of nic.at. He gets the second NS RR. He may or may not leave his sip service within sip.nic.at.

The user with the E.164 number +8781012345543211 wants to have an ENUM service, but with another ENUM Tier 2 Nameserver Provider. He gets the third NS RR. He may or may not leave his sip service within nic.at.

$ORIGIN 5.4.3.2.1.0.1.8.7.8.e164.arpa.
* IN NAPTR 10 10 "u" "E2U+voice:sip"
"!^\+8781012345(.*)$!sip:\1@sip.nic.at!" .
0.1.2.3.4.5 IN NS enumns1.nic.at.
1.1.2.3.4.5 IN NS enumns1.otherprovider.net.

8. Security Considerations

This document deals primarily with routing of VoIP calls and other communications on the Internet using ENUM. Regarding the usage of ENUM and DNS technology see the security considerations in RFC2916bis. For more general aspects of privacy and security in the context of ENUM, see [7].

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