Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

NUMBERING FOR VoIP SERVICES

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EXECUTIVE SUMMARY

Packet switched voice services are starting to gain a part of the voice market. These services are most often referred to as Voice over IP (VoIP) services. Many forms of VoIP services are currently offered as a substitute for traditional voice services (PSTN, ISDN, GSM, etc.). Therefore, the interoperability with traditional voice services is a critical success factor and this means that these services need adequate access to numbers for their subscribers.

This report aims to support European E.164 Numbering Authorities who are member of the European Conference of Posts and Telecommunications (CEPT) in their decisions whether and how to adapt their numbering plan to support VoIP services in their countries.

An extensive exploration is presented of the options for a numbering plan to support VoIP services. It can be concluded that the options that consist of a modified geographic number range and the options for opening a new number range are most likely to meet in a balanced way the interests of VoIP subscribers, calling end-users, VoIP service providers, and National Regulatory Authorities.

This conclusion is based on two important requirements for a number range for VoIP services:

1. it should support the new service features of VoIP services (where “nomadicity” is the most relevant)
2. it should enable competition with traditional voice services.

The geographic number range supports competition best, but the impact of modifying the allocation criteria to support nomadicity needs consideration. A new number range (or new number ranges) is able to support nomadicity best, but the ability to support competition needs consideration.

Numbering Authorities who are member of CEPT are recommended to consider the advantages and disadvantages listed in this report and choose one or several options from this report to achieve a consistent E.164 numbering plan in their country that supports both VoIP services and traditional voice services.

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1 INTRODUCTION

1.1 Background

Packet switched voice services are starting to gain a part of the voice market. These services are most often referred to as Voice over IP (VoIP) services. Many forms of VoIP services are currently offered as a substitute for traditional voice services (PSTN, ISDN, GSM, etc.). Therefore, the interoperability with traditional voice services is a critical success factor and this means that these services need adequate access to numbers for their subscribers. Although many of these services started by offering outgoing calls only, some are now asking for numbers to support incoming calls and so the issue is now high on the agendas of many regulators.

1.2 Aim and approach of the report

This report aims to support European Numbering Authorities in their decisions whether and how to adapt their numbering plan to support VoIP services in their countries. The report contains the results of an extensive exploration of the options that exist for the use of numbers for VoIP services.

Strictly if numbering is to be technology independent the criteria for numbering ranges should not refer to VoIP but to the specific service characteristics. Whilst the report tries to take this approach it is impossible to avoid references to "VoIP services". In most cases the main issue is the possibility of nomadicity, i.e. of calls not being restricted to any specific location.

Because

- the approach to numbering should be technology neutral, and
- the choice of number range interacts with the commercial objectives of the service provider, this report does not aim to select and recommend a single specific numbering solution for VoIP services but instead evaluates a number of options including
- relaxing or re-formulating the allocation criteria for existing number ranges
- introducing new number ranges.

This approach both leaves discretion to national regulatory authorities and allows for VoIP service providers to have a choice of number range, provided that they meet the relevant criteria.

The target audience is the European E.164 Numbering Authorities, both from EU and non-EU countries, who are member of the European Conference of Posts and Telecommunications (CEPT). In other words, all those bodies responsible for the creation, maintenance, or administration of the national E.164 numbering plan in CEPT countries. In addition, the report may be of importance for the European Commission, national policy makers, and national regulators in their work on legal requirements for providers of public available electronic communication services or pubic available telephony services.

1.3 Scope

This report is restricted to E.164 numbering plans. This means that alternative forms of addressing, such as internet addressing (IP addresses), are not included in this report. Also ENUM is not in the scope: from the perspective of an E.164 numbering plan ENUM is just a database mechanism to link E.164 numbers and Internet resources.

The study does not focus on one specific service, but is aimed to be generally applicable to VoIP services that need interoperability with a traditional voice service. Peer-to-peer VoIP services (e.g. Instant Messaging services on PC’s) that do not intend to have such interoperability are therefore outside the scope. The use of IP technology wholly within an existing network for the support of an existing service (e.g. the replacement of a circuit switched transit network with the PSTN by an IP based network) is also outside the scope as it does not affect the existing use of numbers.

The study focuses on number allocation criteria in the numbering plan. The legal requirements that are imposed upon service providers are discussed in some cases, but only with respect to their relation to number allocation criteria.

In VoIP numbering discussions in EU countries, the numbering issue is often related to the concept of publicly available telephone service (PATS)[1]. However, the definition of PATS is not free from discussion and it may be open to review. Therefore, the report is based on basic principles of numbering and not tied to any particular interpretation of the PATS definition.

The study concentrates on national numbering plans. However, for many VoIP services that are based on the Internet national borders are not recognised and calls may be originated and terminated anywhere on the Internet. This situation, which may conflict with the concept of ITU country codes, deserves a broader study and is therefore left out of the scope of this report. Only some issues related to this international aspect are mentioned.[2]

The use of calling card numbers or carrier (pre) selection numbers to access VoIP services is outside the scope of this report, because the numbering aspects are related to calling card or carrier (pre) selection numbering aspects and not to VoIP.

1.4 Outline

Section 2 identifies the relevant existing number ranges in the E.164 numbering plan.

Section 3 presents several viewpoints on VoIP services and their implementation: a classification of different types of VoIP services, a list of examples for commercial service descriptions, a classification into two different types of interfaces to PSTN networks, and a discussion on different numbering plans used for addressing VoIP subscribers.

Section 4 discusses the special service features of VoIP services and how they influence number allocation.

Section 5 addresses the central question of the report by listing several options for an NRA to modify their national E.164 numbering plan to meet the new VoIP service requirements. The implications of every option are identified separately for VoIP subscribers, calling end-users, VoIP service providers, and NRAs.

Section 6 examines to what extent legal requirements affect the use of specific number ranges for VoIP services.

Section 7 discusses some international aspects for VoIP numbering.

Section 8 gives the conclusions.

1.5 Definitions

Numbering plan:	A set of requirements and conditions for the use of E.164 numbers, indicating what number ranges may be used for what types of services.
NRA:	National Regulatory Authority. In this report the acronym NRA is used to refer to a Numbering Authority, a Numbering Administration, or a National Regulatory Authority (in some countries these three entities are not integrated).
Voice over IP (VoIP) service:	A voice service provisioned by using technology that includes packet switching and that has some interoperability with traditional voice services. The voice service may or may not be classified as publicly available telephony and the technology may or may not be part of the public internet. A VoIP service may or may not be capable of supporting fax or modem data transmission.
Traditional voice services:	Telephone voice services supported by PSTN, ISDN, or mobile networks (e.g. GSM).
Nomadicity:	Feature of a service that makes that the service is not linked to a particular physical location and that the service can be provided from potentially any fixed network endpoint in the world for incoming and outgoing communication.

[1] Article 2 of the Universal Service Directive [1].
[2] See Section 7.2.

1.6 References

[1] Universal Service Directive - Directive 2002/22/EC of the European Parliament and of the Council, 7 March 2002

[2] IP Voice and Associated Convergent Services – Final Report for the European Commission, Analysys, 28 January 2004.

1.7 Abbreviations

CLI Calling Line Identification
CEPT Conférence Européenne des Postes et des Telecommunications
(in English: European Conference of Posts and Telecommunications)
CPS Carrier Pre-Selection
DDI Direct Dialling In
ECC Electronic Communications Committee (of the CEPT)
IN Intelligent Network
IP Internet Protocol
ISDN Integrated Services Digital Network
LAN Local Area Network
NNI Network-Network Interface
NRA National Regulatory Authority (or Agency)
PATS Publicly Available Telephone Service
PSTN Public Switched Telephone Network
SMP Significant Market Power
UNI User-Network Interface
UPT Universal Personal Telecommunications
WAN Wide Area Network
WiFi Wireless Fidelity, a wireless Local Area Network
WLL Wireless Local Loop

2 GENERIC TYPES OF NUMBER RANGE

Usually numbering ranges are divided into several generic types. These types indicate the service that may be offered using these numbers. Throughout most participating countries we see the following generic types of numbering ranges:

- Geographic numbers
- Non-geographic numbers
    - Mobile numbers
    - Personal numbers
    - Corporate numbers
    - Shared cost/premium rate/free phone numbers
    - Numbers for special services (e.g. internet dialing in, directory services, etc.)

The last two categories of numbers are not relevant for the scope of this report, because it is not likely that VoIP service providers will apply for these numbers for their VoIP service. For instance, most of these numbers are suitable only for services where the number is translated, and for which numbers it may be prohibited by the regulator to use the number as outgoing CLI (e.g. premium rate services). Or, number range criteria are too specific to be used for VoIP services (e.g. directory service numbers).

Conclusion: For VoIP services the following existing number ranges are relevant: geographic numbers, mobile numbers, personal numbers, and corporate numbers.

3 VIEWPOINTS ON VOIP SERVICES AND THEIR IMPLEMENTATION

3.1 Analysys viewpoint

In a report for the European Commission [2], Analysys distinguishes five different types of voice services over IP networks:

1. Self-provided consumer
   This is a peer-to-peer service, where there is no service provider and end-users use software on their PC to call to other users of the same software. Subscribers of traditional voice services cannot reach these peer-to-peer end-users neither vice versa. Therefore numbering and addressing is not an issue. This type of service is outside the scope of this report as it does not comply with our definition of VoIP service.
2. Independent of internet access
   The service provider provides a voice service on top of a (broadband) internet access connection. The service provider uses a media gateway in the internet to convert circuit switched voice to packet switched voice and vice versa for interoperability with traditional voice services. Furthermore, the service provider uses a call server for naming and addressing purposes. For this type of VoIP service, the interworking with traditional voice services requires the use of E.164 numbers.
3. Provided by broadband access service provider
   Here the VoIP service is part of the broadband access subscription. The advantage is that the service provider can better control the quality of the voice service. For this type of VoIP service, the interworking with traditional voice services requires the use of E.164 numbers.
4. Corporate internal use on Business LAN/WAN
   Companies can use VoIP for internal calls and for interconnection of different premises (IP-VPN). The numbering is equal to the already well-known numbering for multi-site companies, i.e. VoIP does not add specific issues.
5. Carrier internal use
   No numbering issues can be identified.

Conclusion: Not all VoIP related services are relevant for numbering. Only types 2 (Independent of internet access) and 3 (Provided by broadband access service provider) are relevant for this report.

3.2 Network interface viewpoint and number resource viewpoint

Network interface

VoIP service providers can connect their gateways to the PSTN using either of two different types of interface:

- Network-Network Interface (NNI)
  The gateway and the connected packet switched network would be part of the public telephone network and the numbers would normally be allocated by the NRA to the VoIP operator, and sub-allocated by the VoIP operator to the VoIP subscribers. The gateway over which calls to various known number ranges are routed would not be associated with numbers itself. Several gateways could handle traffic to the same numbers. The VoIP operator would be paid a terminating rate for the incoming calls and would pay interconnection rates for outgoing calls.

- User-Network Interface (UNI)
  The gateway and the connected packet switched network would be similar to a private network and be customer of the network from which they take service - similar to a PABX. The numbers would be allocated as DDI blocks by the network that serves the gateway and the gateway/UNI itself would be identified by numbers and any geographic information would relate to the gateway. The numbers could be sub-allocated by the VoIP provider to its customers, either permanently or on a dynamic basis (for outgoing calls only). In this case the public telephone network would end at the gateway. A VoIP customer could be reachable via different gateways but would need one number for each such gateway. The VoIP operator would normally not receive any payment for incoming calls (unless they could negotiate some form of revenue sharing as some ISPs have done) and would pay normal retail rates for outgoing calls. All tariffs would apply to/from the gateway.

Many VoIP operators have started operation with a UNI because it avoids involvement with the regulators. VoIP operators have an incentive to move to the NNI model, however, because it enables them to charge terminating rates and gives them lower outgoing call rates (they pay a termination fee rather than a retail rate).

Figure 1 shows the different cases.

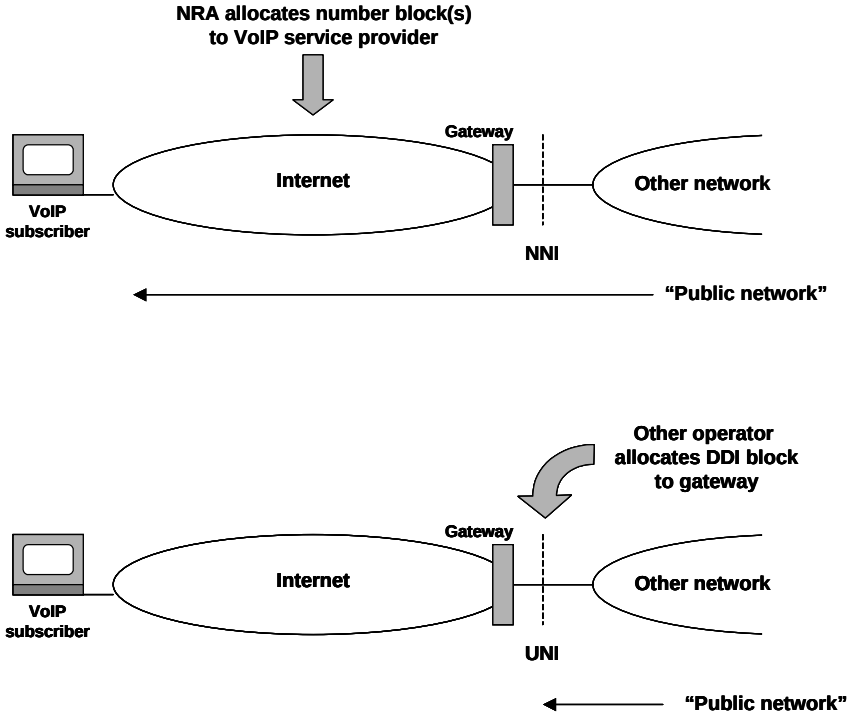

Figure 1: Comparison of NNI and UNI

Whilst the distinctions between NNI and UNI exist in theory for all number ranges, in practice they are most significant for geographic numbers because of the relationship of the number to the location of the subscriber or gateway. The numbering options identified in Section 5 relate to the use of the NNI.

Number resources

In the NNI case with geographic numbers, if the numbers are to relate to the location of the subscriber (whether also nomadic or not) then the VoIP operator may need small quantities of numbers in many different locations for different subscribers. With many different operators this could place a heavy demand on numbers or require allocations in smaller blocks then was previously necessary and hence require greater depth in the number analysis of interconnected networks. Provided that there is some requirement for the subscriber to have a relationship to the location indicated by the number, most individual subscribers will be likely to have only one number each. The possible pressure on number resources will also depend whether there exists a number fee for assignment of numbers or not.

In the UNI case, the numbers relate to the gateways and so DDI blocks will be allocated only where access lines are supplied to gateways and this is likely to be a relatively few locations in a country. One effect may be that gateways may be particularly located in popular geographical areas (capital cities) to provide subscribers with numbers related to such an area even if they are not located there.
Another effect is caused by the fact that the numbers relate to the gateway and the payments for incoming calls relate to the location of the gateway. Therefore, there is an incentive for subscribers to request multiple numbers relating to different gateways close to their correspondents so that their correspondents can call them cheaply. For example Vonage is offering multiple numbers in different US cities to its subscribers.
Both activities could lead to a rapid increase in demand for numbers and exhaustion of numbering plans, but it would not be detected in the early stages by the NRAs because they would not have visibility of the allocations. These activities can be detected by either observing the marketing of the VoIP operators or by requiring the other operators to report instances where the ratio of numbers to access lines is especially high and even placing a limit

on this ratio. Another solution could be the allocation of numbers directly to end-users. Then it could be detected how many numbers from one NRA are assigned to an end-user. Number allocation to end-users will require greater depth in the number analysis of interconnected networks.

Summary

Table 1 summarizes the differences between NNI and UNI

	NNI	UNI
Number allocation	NRA allocates block(s) to VoIP operator independently of interconnection(s)	Other network allocates DDI block in association with provision of access lines
VoIP operator receives for incoming calls	Termination rate	Nothing
VoIP operator pays for outgoing calls	Interconnection rate	Retail rate
Numbers may relate to VoIP subscriber's location	Yes	No – they relate to gateway
Incoming calls to same number may pass through different gateways	Yes	No
Signalling	Inter-operator (e.g. ISUP)	Access (e.g. DSS1)
Number resources (if geographical numbers are used)	NRA has to allocate smaller number blocks to cope with many VoIP service providers (impact on number analysis in existing networks)	Exhausting of (part of) geographical number range due to multiple numbers usage or unilateral number usage

Table 1: Comparison of NNI and UNI

Conclusion: From the perspective of network interfaces there are two distinct implementations for a VoIP service provider to offer his service, NNI and UNI. In case geographic numbers are used, each implementation has different advantages and disadvantages. The NNI leads to requirements for many small block allocations that impose costs on other operators but is capable of providing, but not ensuring, a correct relationship between the number and the location of the subscriber. The UNI is not capable of providing a correct relationship between the number and the location of the subscriber and may lead to rapid exhaustion of numbers because subscribers have some incentive to have multiple numbers. It should be considered by NRAs whether the use of geographical numbers for a UNI implemented VoIP gateway is appropriate in their country and, if not, how such a use could be restricted.

3.3 Commercial viewpoint

There are several ways in which service providers can position their service in the market. They can aim at the consumer market or the business market, a substitute for PSTN or just a secondary service, a fixed location service or a nomadic-type of service, etc.

Below a list of examples for service descriptions is presented. The list is not exhaustive, but is meant to broaden the view on possible service descriptions that could be used by providers of VoIP services when they apply for E.164 numbers.

A. Voice service over narrowband (e.g. PSTN/ISDN dial up connections) as secondary voice service next to PSTN

- usually for private customers,
- low quality.

B. Voice service over broadband connection as substitute for PSTN

- usually for private consumers and small offices and home offices,
- quality requires broadband connection such as cable, WLL, or DSL,
- end-user equipment may be a regular phone in combination with a Voice Adaptor.

C. Nomadic voice service over broadband connection as secondary voice service

- for travelling private consumers and small or home offices as a cheap alternative next to mobile telephony,

- quality requires broadband connection such as cable, WiFi, or DSL,
- end-user equipment may be a laptop, but also a small PDA or WiFi handset.

D. Mobile voice service over a packet switched mobile network
- as a substitute for circuit switch mobile voice service,
- quality requires broadband mobile network such as UMTS,
- end-user equipment may be a mobile phone.

E. Voice service over guaranteed quality broadband connection as fixed line substitute for ISDN/PSTN
- usually for small and medium enterprises, because cost efficiency starts at ca. 4 lines,
- guaranteed quality due to dedicated broadband connection,
- bound to a location due to the use of dedicated broadband (specifically implemented for one user),
- end-user equipment may be a regular phone in combination with a Voice Adaptor.

F. Voice services using a VPN built with IP and similar packet switched techniques
- for large enterprises with multiple locations,
- dedicated network built by means of VPN,
- large part of these networks are non-public,
- end-user systems exist of PBX's, each with their own way of connecting end-user equipment.

G. Voice services with additional multimedia services (e.g. video, instant messaging)
- advanced communication for private customers as well as enterprises.

The boundaries between the categories of services described above may not be distinct in all cases: some services may be characterised by features from more than one of these categories or may seamlessly evolve from one category to another.

Conclusion: When talking about number allocation for VoIP services one should bear in mind that there are a great variety of commercial service descriptions possible. Each service description may end up with a different conclusion for the most appropriate number range to be used.

3.4 Naming and addressing viewpoint

Packet switched voice services and circuit switched voice services differ in the way E.164 numbers are used for naming and addressing. In circuit switched services, the number used as a name and the number used as an address are sometimes the same (e.g. geographic numbers) and sometimes different (e.g. personal numbers, which are currently mainly used for translation). But in both cases, the addressing number space is linked to the naming number space as they are in the same numbering plan.

On the contrary, naming and addressing for packet switched voice services can be completely unrelated. It is e.g. possible to link an IP address dynamically to an E.164 name, which means that the address may change very frequently. Due to the independency of the addressing space and the numbering space, it is easy for a packet switched voice service to change its location (address) without affecting the E.164 name.

In addition, IP addresses are not closely related to geographical areas, which makes it difficult to associate the end-user's IP address with his location. However, work is underway in the Internet Engineering Taskforce DHC (Dynamic Host Configuration) and GEOPRIV (Geographic Location/Privacy) working groups to develop methods for terminal devices using VoIP services to reveal their location in specified circumstances.

Conclusion: In VoIP services the naming and the addressing may use different numbering systems. In IP numbering system, exact location information is technically not supported at this moment.

4 NEW VOICE SERVICE POSSIBILITIES IN PACKET SWITCHED TECHNOLOGY

National numbering plans are organised based on services and number ranges are defined by service descriptions. As a consequence number ranges are technology neutral. Up to now, a new service demand led to the creation of a new number range and in some cases a new service demand led to a change in an existing numbering range.

In a study of the impact of upcoming VoIP services on the numbering plan, it is therefore important to identify what are the differences between traditional voice services and VoIP services.

In principle, a VoIP service can offer the same to the end-user as traditional voice services: outgoing and incoming calls, national and international calling, access to emergency services, real-time speech with a quality at least as good as GSM. However, not all service providers may wish to offer all these service features. In other words, VoIP services might sometimes offer less than traditional circuit switched voice services.

On the other hand, VoIP services may offer advanced service features which are currently not easily incorporated in traditional voice services. For instance, addition of video or instant messaging, or conference calling with the ability to be informed who is talking or who is leaving the conference. Further, IP based services may give more facilities to the end-user to do the provisioning, activation and modification of the service himself. These additional features, however, do not impact the basic characteristic of the service and they are not strictly exclusive to VoIP services.

There seems to be one relevant VoIP service characteristic that is different from a traditional fixed telephony service and that is its inherent nomadic nature. In other words, the service is not linked to a particular physical location and the service can potentially be provided from any network endpoint in the world. However, this capability may be restricted in the case of VoIP services that are provided by the subscriber's broadband access provider. Still the service is not a mobile telephony service, because there is not necessarily a radio access network, an authorisation to use a particular frequency band, or support of hand-overs involved. Nomadicity is close to the UPT concept that is related to personal numbers. The personal number service has already a kind of nomadicity, but this is practically only a service for incoming calls, whereas VoIP allows incoming and outgoing communication.

Conclusion: In studying the impact of VoIP services on the numbering plan and number allocation criteria, it is important to know where VoIP services differ from traditional voices services. VoIP services may offer either less or more features than traditional voice services. In general, there is only one relevant service characteristic in which VoIP services differ from traditional fixed telephony services and that is its inherent potential to be nomadic.

5 NUMBER RANGE OPTIONS FOR VOIP SERVICES

While some VoIP services may fit into existing service descriptions of certain number ranges, others possibly do not. To cover adequately the new possibilities of voice services over packet-switched networks, it is needed to change the numbering plan in most countries. This can be done either by altering criteria of one or more of the existing number ranges, or by creating a new number range with criteria dedicated to the new service characteristics, or by doing both. In general, more than one number range might be available to a VoIP service provider to provide his service.[3]

This chapter is structured in the following way. Every subsection addresses a number range, e.g. the geographic number range or a new number range. A subsection starts with listing the number allocation criteria for the number range of that subsection.[4] These are generic criteria typically used by NRAs in CEPT countries to decide whether or not numbers can be allocated to the number applicant for operation of his service.

In the second place, the arguments to use this number range to support VoIP services are listed. These arguments (or advantages) are described from the viewpoint of four identified stakeholders: VoIP subscribers, calling end-users, VoIP service providers, and NRAs.

Thirdly, the options are described. In this report, an option is defined as a possibility to modify or create number allocation criteria in order to meet the new characteristics of VoIP services. Every option is followed by a list with the points of concern. Sometimes a point of concern is just an effect of the new allocation criteria, but it may also be a serious disadvantage of the option. The options identified in this chapter relate to the use of the NNI[5].

Every subsection ends with a conclusion about the usefulness of the number range for facilitating VoIP services.

5.1 Geographic numbers

Number allocation criteria

In general, the criteria for geographic numbers[6] are:

a. for voice and fax services and some data services related to a fixed location,
b. the fixed location indicates the point where the public network is left and terminal equipment may be connected[7]; this point is located in a specific (geographic) area with an area code[8],
c. in case the geographic number consists of an area code and subscriber number, the area code is related to a well described geographical region,
d. not for paying the number holder (i.e. not for paid content services).

Arguments for using this number range

VoIP subscribers:

- consider geographic numbers as the most familiar type of numbers,
- can keep their number when substituting the traditional PSTN voice service by the VoIP service.

Calling end-users:

- recognise the number as a familiar type of number,

[3] In addition, it is also possible that a VoIP service provider uses for his service a combination of two numbers from different number ranges.
[4] The philosophy behind the several national numbering plans may differ from country to country. Where necessary, these differences are mentioned.
[5] See Section 3.2).
[6] Definition in the Universal Service Directive [1], Article 2d and 2e: 'Geographic number' means a number from the national numbering plan where part of its digit structure contains geographic significance used for routing calls to the physical location of the network termination point. 'Network termination point' means the physical point at which a subscriber is provided with access to a public communications network (…).
[7] Usually referred to as Network Termination Point (NTP).
[8] Exceptions on this principle are already possible in the PSTN/ISDN (e.g. if the call forwarding is activated, the call can terminate in another area).

- associate geographic numbers with a low tariff class.

VoIP service providers (depending on the commercial service description, see Section 3.3):

- consider geographic numbers as the best way to compete against PSTN operators (familiar number, low tariff association, numbers are portable, substitute for traditional voice service),
- will easily establish national interoperability,
- will meet no difficulties with international interoperability, that is, accessing their geographic numbers from outside the country will be easy.

NRA:

- will stimulate competition by enabling innovative service providers to use the most popular number range for VoIP subscribers and calling end-users (commonly used, associated with low tariffs),
- strives for technologically neutral number ranges and considers VoIP as just a technique,
- may consider the nomadic feature in a VoIP service description not distinctive enough to fixed telephony to block the use of this number range.[9]

Option 1 (allow nomadicity in a limited area)

Remove from the definition of geographical location the concept of a fixed location and replace it by a criterion which only indicates the area of the end-user, in order to permit limited use of the nomadic feature of some VoIP services. This leads to the criteria:

a. for voice and fax services and some data services from a certain area,
b. in case the geographic number consists of an area code and subscriber number, the area code is related to a well described geographical region,
c. not for paying the number holder (i.e. not for paid content services).

This will support VoIP services using broadband connections via WLL or WiFi.

Points of concern for this option are:

- (*VoIP service provider*) This option will not be useful for most VoIP service providers not using WLL, because the nomadic aspects of VoIP services cannot easily be restricted to a particular area.
- (*VoIP service provider*) Starting service providers may face high costs because numbers from all geographical areas have to be bought and implemented.
- (*NRA*) The number range may no longer qualify as geographic number.
- (*calling end-user*) VoIP service providers may ask higher terminating tariffs for their VoIP services leading to higher retail tariffs than those of the PSTN service of the incumbent PSTN operator. Tariff transparency becomes more important.
- (*NRA*) Influence on emergency services (see Section 6.1).

Option 2 (allow nomadicity countrywide but require relation with geographical area of the number)

Allocate geographical numbers for a service where the end-user has a street address whose location is indicated by the number but where calls can be made and received at other locations within the same country.[10]In this way, nomadic services can be supported, whereas it can be avoided that popular area codes run short of numbers: the end-user has to prove his geographical connection to the area.

Service providers may do the street address check in a way similar to the way providers of mobile telephony check the address of a new subscriber for fraud prevention.

Points of concern for this option are:

- (*VoIP service provider*) Starting service providers may face high costs because numbers from all geographical areas have to be bought and implemented.
- (*NRA*) It has to be defined what a street address is (also Post Office Boxes?).
- (*NRA*) It has to be checked whether this is legally feasible to include in the allocation an obligation for a service provider to e.g. check street address.
- (*NRA*) The number range may no longer qualify as geographic number.

[9] For instance, a VoIP service provider may have a service where the nomadic aspect is not promoted, but where the use of the service cannot be restricted to one location.

[10] The use of numbers in the national numbering plan outside the country is outside the scope of this study. See also Section 7.2 for more details.

- (*calling end-user*) VoIP service providers may ask higher terminating tariffs for their VoIP services leading to higher retail tariffs for geographic numbers than those of the PSTN service of the incumbent PSTN operator. Tariff transparency becomes more important.
- (*NRA*) Influence on number resources in particular areas (see Section 3.2).
- (*NRA*) Influence on emergency services (see Section 6.1).

Option 3 (remove requirement for relationship to geographical location)

Remove all references to geographical area from the criteria. An end-user can use any geographic number without having a street address in that area. The meaning of area codes is removed. The numbering plan may or may not be closed at the same time.

An argument for doing this is that important historic reasons for geographic numbers no longer hold. There is no technical need to associate call distance to number (tariff) because call tariffs become less dependent on call distance (e.g. international call tariffs have no relation to distance). Further it is no longer technically needed to route calls always digit by digit, because IN-like systems can perform a look up in routing tables using full number length.

Points of concern for this option are:

- (*NRA*) Incumbent operators may in some cases face costs to remove the geographical routing methods in his network.
- (*calling end-user and NRA*) The regulated tariffs of the SMP operator for calling to geographical number may be influenced. For instance, there will probably no longer a difference in local and long distance tariffs for calling to numbers in this number range. Local tariffs may rise, long distance tariffs may decrease.
- (*end-user*) Some end-users may no longer profit from geographic information in a number, e.g. shops who prefer to present themselves as a local shop, at close distance from the customer.
- (*NRA*) The number range may no longer qualify as geographic number.
- (*calling end-user*) VoIP service providers may ask higher terminating tariffs for their VoIP services leading to higher retail tariffs than those of the PSTN service of the incumbent PSTN operator. Tariff transparency becomes more important.
- (*NRA*) Influence on number resources in particular areas (see Section 3.2).
- (*NRA*) Influence on emergency services (see Section 6.1).

Conclusion: There are many arguments in favour for allocation of geographical numbers for VoIP services with a nomadic nature, from all four stakeholders. There are three ways identified to adapt criteria for geographic numbers in order to support VoIP services. Each option removes to some degree the geographic nature of the range, which could have an impact other national regulatory issues (e.g. number shortage, tariff models of SMP operator, business cases of carrier pre-selection providers, the way of handling location information by emergency centres). This impact will have to be weighted against the benefits of using the geographic number range.

5.2 Mobile numbers

Number allocation criteria

The current criteria for mobile numbers are:

a. for voice, fax, messaging, multimedia, and data services from a non-fixed location,
b. service can be used while end-user is moving over long distances,
c. in some countries: service available in whole country,
d. in some countries: service needs an authorisation for use of a radio frequency band,
e. not for paying the number holder (i.e. not for paid content services).

Arguments for using this number range

VoIP subscribers:

- consider mobile numbers as a well known type of numbers.

Calling end-users:

- recognise the number as a familiar type of number.

VoIP service providers (depending on the commercial service description, see Section 3.3):

- will easily establish national interoperability,
- will meet no difficulties with international interoperability, that is, accessing their mobile numbers from outside the country will be easy,
- may wish to promote the (near) mobile characteristics of their VoIP service,
- are able to offer a packaged nomadic-mobile service using one mobile number[11],
- may want the number for a VoIP service which makes use of a mobile broadband network (e.g. UMTS).

NRA:

- may consider the nomadic feature too close to mobile telephony to justify blocking the use of this number range.

Option 4

In order to support the nomadic aspect of VoIP services, the criteria

b. the service can be used while end-user is moving over long distances,
d. in some countries: service needs an authorisation for use of a radio frequency band could be removed from the numbering plan criteria for mobile numbers. Then most services which are not fixed to a certain location may use mobile numbers.

Points of concern for this option are:

- (*calling end-user, VoIP subscriber and VoIP service provider*) End-users associate mobile number ranges with high tariffs, which will make them reluctant to dial the number. For calling within the country, the real retail tariff that will be established for a VoIP service might be even lower than the PSTN tariff, but in some cases foreign operators may not be able to distinguish different tariffs in this number range.
- (*end-user*) It leads to confusion to end-users, because a mobile number may also be associated with SMS, reaching a voicemail system in case of no reply or busy, personal number[12], roaming in other countries[13].
- (*end-user and NRA*) It might lead to a convergence of mobile number ranges and other number ranges.

Conclusion: Except for a VoIP service over a mobile broadband network (e.g. UMTS), the mobile number range does not seem to be appropriate for allocation to VoIP service providers. The mobile number allocation criteria can be broadened to cover nomadic aspects, but there are few arguments to do so. The main point of concern is that a calling end-user will associate the mobile number with a high tariff (independent of the real VoIP service tariff, which is more likely to be comparable to calling a geographical number).

5.3 Personal numbers

Number allocation criteria

The current criteria for personal numbers are:

a. for services related to a person,
b. mainly used as a translation service to all equipment where a person may be reached, set by this very person using variables such as time, date, and location, (i.e. only incoming communication),
c. in some countries used for personal assistant services such as voicemail,
d. number translation leads to the possibility of addressing several types of terminal equipment with one number,
e. not for paying the number holder (i.e. not for paid content services).

[11] Supplement to mobile telephony: the VoIP provider can offer a packaged service: inside the coverage area of a WiFi hotspot the end-user uses cheap VoIP technology, outside the coverage of a hotspot he uses the more expensive mobile telephony.

[12] That is, mobile numbers may be associated with reaching a person, whereas e.g. geographic numbers may be associated with reaching a household or an office.

[13] However, end-users are in many cases able to determine the nature of the service by other means than the number. Both business and social contacts generally provide an indication that the number by which they can be contacted is a mobile number, a fax number, etc.

Arguments for using this number range

VoIP subscribers:

(no arguments).

Calling end-users:

(no arguments).

VoIP service providers (depending on the commercial service description, see Section 3.3):

- can exploit the nomadic aspects of VoIP services within the country. [14]

NRA:

- associates the nomadic aspect of VoIP services with a non-geographic, non-mobile number range and the personal number range is already such a number range.

Option 5

In some countries the criterion

b. mainly used as a translation service to all equipment where a person may be reached, set by this very person using variables such as time, date, and location may need a change to support VoIP services. In other countries the definition of translation service may also be interpreted as a translation from an E.164 number into an IP address, and then the number range is applicable to VoIP services without changing the definition.

Points of concern for this option are:

- (*calling end-user*) End-users may associate the personal number range with a high tariff, which will make them reluctant to dial the number. For calling within the country, the real retail tariff that will be established for a VoIP service might be even lower than the PSTN tariff, but in some cases foreign operators may not be able to distinguish different tariffs in this number range.
- (*calling end-user*) In some countries, personal number ranges are not widely used and therefore the end-user may not recognize the number and be reluctant to dial it.
- (*VoIP subscriber*) The VoIP service will not be considered a real substitute for a traditional voice service as the number must be changed when switching to a VoIP service.
- (*VoIP service provider and NRA*) Competition with traditional voice services is difficult when numbers cannot be ported from a traditional voice service to the VoIP service.
- (*VoIP service provider*) Difficulties are sometimes experienced in accessing personal numbers from outside the country.
- (*VoIP service provider*) For corporate customers another number range has to be used as personal number range is not open to corporate users.
- (*NRA*) Personal numbers will probably no longer be used only as a number translation service, i.e. only for incoming calls, but also for identifying the origin in outgoing calls (CLI).

Conclusion: The personal number range does not seem to be appropriate for allocation for VoIP services. There are too few arguments of stakeholders to do so. The main point of concern is that a calling end-user may associate the personal number with a high tariff (independent of the real VoIP service tariff, which is more likely to be comparable to calling a geographical number).

5.4 Corporate numbers

Number allocation criteria

The current criteria for corporate numbers are:

a. for services related to corporate entities,
b. mainly used as a translation service to all equipment where the corporate entity may be reached, set by this very entity using variables such as time, date, and location,
c. number translation leads to the possibility of addressing several types of terminal equipment with one number,
d. not for paying the number holder (i.e. not for paid content services).

[14] The use of numbers in the national numbering plan outside the country is outside the scope of this study. See also Section 7.2 for more details.

Arguments for using this number range

VoIP subscribers:
(no arguments).

Calling end-users:
(no arguments).

VoIP service providers (depending on the commercial service description, see Section 3.3):

- can exploit the nomadic aspects of VoIP services within the country. [15]

NRA:

- associates the nomadic aspect of VoIP services with a non-geographic, non-mobile number range and the corporate number range is already such a number range.

Option 6

In some countries the criterion

b. mainly used as a translation service to all equipment where the corporate entity may be reached, set by this very entity using variables such as time, date, and location may need a change to support VoIP services. In other countries the definition of translation service may also be interpreted as a translation from an E.164 number into an IP address, and then the number range is applicable to VoIP services without changing the definition.

- (*calling end-user*) End-users may associate the corporate number range with a high tariff, which will make them reluctant to dial the number. This tariff perception is independent of the real retail tariff that will be established for a VoIP service (which might be even lower than tariffs for geographic numbers).
- (*calling end-user*) In most countries, corporate number ranges are not widely used and therefore the end-user may not recognize the number and be reluctant to dial it.
- (*VoIP subscriber*) The VoIP service will not be considered a real substitute for a traditional voice service as the number must be changed when switching to a VoIP service.
- (*VoIP service provider and NRA*) Competition with traditional voice services is difficult when numbers cannot be ported from a traditional voice service to the VoIP service.
- (*VoIP service provider*) Difficulties are sometimes experienced in accessing corporate numbers from outside the country.
- (*VoIP service provider*) For residential customers another number range has to be used as corporate number range is not open to residential users.
- (*NRA*) Corporate numbers will probably no longer be used only as a number translation service, i.e. only for incoming calls, but also for identifying the origin in outgoing calls (CLI).

Conclusion: The corporate number range does not seem to be appropriate for allocation for VoIP services. There are too few arguments of stakeholders to do so. The main points of concern are that a calling end-user may associate the corporate number with a high tariff (independent of the real VoIP service tariff, which is more likely to be comparable to calling a geographical number).

5.5 New number range

The options in this section are not mutually exclusive and a separate new number range may be introduced for each option.

Arguments for using this number range

VoIP subscribers:
(no arguments).

Calling end-users:
(no arguments).

VoIP service providers (depending on the commercial service description, see Section 3.3):

- will have a lot of freedom in their service description.

[15] The use of numbers in the national numbering plan outside the country is outside the scope of this study. See also Section 7.2 for more details.

NRA:

- considers mobile, personal, and corporate number ranges not to be appropriate because these number ranges are associated with high tariffs (independent of the real tariff that would be established for VoIP services) and therefore competition will not be stimulated by using these numbers,
- does not necessarily have to modify the geographic number range allocation criteria when opening a new number range for nomadic type of services,
- does not necessarily have to modify the allocation criteria for mobile, personal or corporate number ranges to cover adequately the demands of VoIP service features (nomadicity).

Option 7 (general purpose number range)

Criteria for a new number range

- numbers are assigned by the service provider to a subscriber for the duration of a subscription (in other words, there is no pool of numbers from which temporary numbers are arbitrarily assigned when a subscriber logs in to the network),
- not for paying the number holder (i.e. not for paid content services).

Points of concern for this option:

- (*VoIP subscriber*) The VoIP service will not be considered a real substitute for PSTN service as the number must be changed when switching to a VoIP service.
- (*VoIP service provider and NRA*) Competition with traditional voice services is difficult when numbers cannot be ported from a traditional voice service to the VoIP service.
- (*end-user*) The meaning of the number range (or in general the structure of the numbering plan) may be understandable to NRAs and service providers, but most end-users may not be able to distinguish yet another number category.
- (*calling end-user*) Some end-users may not recognise the number (or even mistrust it) and may be reluctant to dial it. If the prefix of the new number range resembles a geographic number prefix, then tariff transparency becomes more important as the tariff might settle far from the average tariff for geographic numbers.
- (*VoIP service provider*) National interoperability arrangements for the new number range have to be established, which may delay the entrance of new VoIP services on the market.
- (*VoIP service provider*) International interoperability arrangements would take a very long time to establish, that is, it may take considerable time to achieve that numbers in the new range can be dialled from all networks in other countries.
- (*calling end-user and NRA*) The service providers are just as free as for other number ranges to establish a tariff for VoIP services using this number range. The NRA has probably no legal power to influence interoperability tariffs or terminating access rates (except for an SMP company).
- (*NRA*) The creation of a new number range may be not future proof in the long run. If VoIP services become even more popular than services using existing number ranges, then most end-users will have to change their number to the new number range. Alternatively, the difference in voice services in the new and one of the existing number ranges might decrease and merging of number ranges may be considered.
- (*NRA*) The creation of a new number range has an impact on the number resources because the amount of free number ranges is decreased.

Option 8 (number range for nomadic services)

Criteria for a new number range:

- only for services that have a nomadic feature in the service description,
- numbers are assigned by the service provider to a subscriber for the duration of a subscription (in other words, there is no pool of numbers from which temporary numbers are arbitrarily assigned when a subscriber logs in to the network),
- not for paying the number holder (i.e. not for paid content services).

Points of concern for this option:

- The same as for the previous option.

Option 9 (number range for ENUM-based services)

Criteria for a new number range:

- for services which can be addressed also with the information in the corresponding ENUM domain,

- for services which have some way of achieving interoperability with other traditional communication services that use E.164 numbers, but may not necessarily use E.164 numbers themselves (e.g. an email service may obtain the numbers if it is interoperable with fax),
- numbers are assigned by the service provider to a subscriber for the duration of a subscription (in other words, there is no pool of numbers from which temporary numbers are arbitrarily assigned when a subscriber logs in to the network),
- not for paying the number holder (i.e. not for paid content services).

Points of concern for this option:

- (*VoIP subscriber*) The VoIP service is not a real substitute for PSTN service as the number must be changed when switching to a VoIP service.
- (*VoIP service provider and NRA*) Competition with traditional voice services is difficult when numbers cannot be ported from a traditional voice service to the VoIP service.
- (*calling end-user*) Some end-users may not recognise the number (or even mistrust it) and may be reluctant to dial it. If the prefix of the new number range resembles a geographic number prefix, then tariff transparency becomes more important as the tariff might settle far from the average tariff for geographic numbers.
- (*VoIP service provider*) The VoIP service provider who does not want to make use of ENUM for interoperability cannot use this number range.

Conclusion: A new number range is motivated mainly by (1) avoiding the points of concern related to options for using other number ranges; (2) the aim to keep the existing number ranges intact (especially the geographical number range); and by (3) giving freedom to service providers to create their service description. The points of concern related to the opening of a new number range are primarily related to competition (e.g. late accessibility from other countries, impossibility to port numbers, unknown tariff class).

6 LEGAL REQUIREMENTS FOR A SERVICE AND THEIR RELATION TO NUMBER RANGES

The design of a numbering plan and the set of number allocation criteria for number ranges should not conflict with legal requirements that are imposed on service providers. Therefore, several legal requirements appearing in the Universal Service Directive [2] are considered in this chapter. An assessment is made whether or not these requirements influence the number allocation criteria.

Both the legal requirements in the Universal Service Directive and the number allocation are based on services and service descriptions, but it is important to note that the use of a specific number range does *not* necessarily lead to the obligation to fulfil legal requirements.

6.1 Emergency calls

The provision of calls to emergency services is an important part of the concept of universal service [1]. Such calls receive priority in many circuit switched networks and the CLI may be used for routing, for caller identification, for return calls by emergency services, and is commonly used in conjunction with a database as a source of information on the location of the caller. Telephony access to the emergency services is currently matched to the characteristics of the circuit switched PSTN and the arrangements are not well suited to receiving calls made by VoIP.

The use of VoIP for calls to emergency services creates the following problems:

- The call may be passed to the circuit switched PSTN far from the current location of the caller, even in another country.
- There may not be the information and routing capability to reach the emergency centre appropriate to the current location of the caller, since the current arrangements rely on a single well known emergency number and routings controlled by the circuit switched operators.
- The CLI presented may not be correct when the caller is away from his home location (nomadic) and the caller may not have a home location registered with the VoIP service provider.

The ECC Project Team on Technical Regulation and Interconnection Standards is currently studying these issues and it is outside the scope of this report to recommend how calls to emergency calls should be handled. This report is concerned only with the choice of number range(s) for VoIP, and this issue will affect only the CLI used for an emergency call from VoIP.

The choice of number range does not affect the ability of the emergency service to locate the caller because the emergency service is always dependent on a database for obtaining a street address; analysis of the number alone cannot give sufficiently accurate information. The problems of whether or not such a database is available and whether or not the call is made from home or away cannot be solved by the choice of number range.

It may be useful for the circuit switched network to obtain an indication whether the emergency call originates from a nomadic technology (e.g. VoIP) because this information could result in more appropriate treatment such as routing to a national rather than a local/regional emergency centre. This information could be inferred from the CLI if a number range used specifically for VoIP is used. Conversely, it could be inferred that a call with a geographic CLI is not nomadic. This method of differentiation has some superficial attractions but:

- Nomadic calls made via gateways connected at a UNI may acquire a geographic CLI relating to the gateway rather than the caller, and so the use of the CLI may not be a reliable source of information.
- There are other methods of providing an indication of nomadicity such as adding a specific prefix to the CLI.

Conclusion: The complex issues of calling emergency services are largely or wholly independent of the choice of number range.

6.2 Provision of CLI / CLI presentation restriction

For access to emergency services the provision of CLI is legally required. There may be a legal requirement that obliges service providers to offer their end-users the possibility to hide their identity (privacy). Both legal requirements do not affect the number range.

Conclusion: Legal requirements related to obligations for CLI presentation or presentation restriction have no implications for number allocation.

6.3 Legal interception

Although legal interception is a requirement for a service, in some countries some legal interception regulations may depend on the specific number range used. If a new number range is opened in such countries, this number range should be incorporated in the national regulations for legal interception. Similarly, a change in number range criteria may demand for an update in the national legal interception regulations.

Conclusion: Depending on the country, the opening of a new number range or a change in number allocation criteria of an existing number range may demand an update of the legal interception regulations.

6.4 Number portability

Under Article 30 of the Universal Service Directive [1], the obligation to provide number portability applies only to providers of a certain type of services. It is possible that a provider of a service from which subscribers wish to port their numbers will be under this obligation, whereas a provider of a VoIP service provider may not be subject to the same obligation.

This could result in an anomalous asymmetry if VoIP service providers benefited from a number from an existing number range being ported in, but their subscribers were unable to retain their numbers if they switched back to their former provider or wished to switch to an alternative VoIP service provider.

If a new number range is opened for VoIP services in a country where number portability is related to a number range, the NRA has to decide whether number portability is required for this number range.

Conclusion: Number portability should be imposed in such a way that when a number can be imported for a service, it also can be ported out and vice versa. If this is the case, then number portability has no implication for the choice of number ranges for VoIP services.

6.5 Quality

The voice quality on VoIP may be variable depending on the level of congestion in packet switched networks. It might happen that the quality of VoIP services will be significantly lower than that of circuit switched services.

The question is if numbering should be related to voice quality. In other words, the allocation of a number depends on the intended voice quality of the network or the allocation is associated with a requirement for a certain level of quality to be maintained.

Voice quality should not be associated with numbering for the following reasons:

1. High traffic demands result in call blocking in circuit switched networks but no voice quality reduction, whereas in packet switched networks they do not result in blocking but in voice quality reductions. Numbering in circuit switched networks is not normally associated with the provision of a particular grade of service and the grade of service is normally not regulated, although there are agreed design objectives just as there are for voice quality.
2. Both voice quality and call blocking depend not only on the adequate provisioning of the network but on the adequate provisioning of lines to the called party and the called party's own network. Both are outside the control of the network operator or service provider.
3. Many of the problems of voice quality over packet switched networks arise from the use of inappropriate codecs, i.e. codecs designed for use over circuit switched networks. New codecs designed to be tolerant to packet loss and new forms of adaptive jitter buffers are capable of producing adequate quality in the presence of significant levels of packet loss. Good wideband quality, which many users would prefer to traditional telephony, is possible over packet switched networks and even over the Internet. The industry is starting a learning curve in this area and the results achieved should improve significantly over time.
4. There is little knowledge at present of how the impairments in a network (delay, delay variation and packet loss) affect the voice quality perceived by the user if state-of-the-art integrated adaptive codecs and network equalisation techniques are used. Existing results mostly do not take account of the latest designs of network equalisation and decoder.
5. Quality issues are better judged by users rather than regulators. Users' perceptions and judgements vary greatly and are also dependent on their circumstances and users may prefer to have a call of poor

quality in some circumstances that they would reject in other circumstances. The variation of quality with network congestion as opposed to the variation of call blocking may be a benefit to users.

Conclusion: Voice quality should not be associated with numbering.

6.6 Carrier selection and carrier pre-selection

Under Article 19 of the Universal Service Directive [1], operators with significant market power (SMP) may be obliged to open their network to carrier (pre)selection (CPS). In most countries CPS is regulated in a way that the NRA decides per number range whether or not it is subject to CPS for an SMP operator. In the implementation by the SMP operator the end-user can decide per number range whether or not he wants to deliver his calls by a CPS provider.

This means that if a new number range is opened for VoIP services, the NRA has to decide whether an SMP operator should open this new number range for CPS or not. If these numbers should be routable by CPS providers, the SMP operator has to do investments to change his CPS systems.

Conclusion: If a new number range is created for VoIP services, the NRA has to decide whether an SMP operator should open this new number range for CPS or not.

6.7 Directory services

If an existing numbering range is used for VoIP services, then it seems logical that the corresponding number range obligations to register the numbers in the Directory Service will also hold for VoIP services.

If a new number range is opened for VoIP services, then there has to be made a decision whether or not there will be an obligation for recording the numbers in the Directory Service.

Conclusion: Legal requirements with respect to directory services have no implications for number allocation.

6.8 Tariff related legal requirements

An NRA may influence the tariffs of services, e.g. by price caps or by imposing legally acceptable tariffs. Additionally, the legal requirement of tariff transparency obliges service providers to provide information on tariffs. All these tariff related legal requirements are based on services and not on number ranges. Every VoIP service provider can negotiate wholesale tariffs and set retail tariffs independent of the number range that he uses for his service, provided that the tariff is legally acceptable. Therefore regulatory tariff issues have no influence on number allocation criteria.

The rise of VoIP services with their own tariff structure may have an effect on the end-user's perception of the tariff associated to a specific number range. Although this effect is not caused by VoIP services alone, a good supervision to tariff transparency will become more important.

Conclusion: Tariff related legal requirements have no influence on number allocation criteria. Whatever number range is allocated to a VoIP service provider, the tariff negotiation by a VoIP service provider may lead to any tariff that is legally acceptable. Tariff transparency is not related specifically to VoIP, but the rise of VoIP services may make a good supervision to tariff transparency more important.

7 INTERNATIONAL AND CROSS-BORDER ASPECTS

7.1 ETNS numbers

To support the nomadic aspect of VoIP services across national borders, it can be an option to open a number range in the ETNS numbering space.

Such numbers might be useful for the business market. Whether these numbers will be a success for the consumer market depends on the tariff for the calling end-user. This tariff is influenced by wholesale interconnection agreements. However, because of the packet switched networks, the ETNS routing numbers may not be needed.

Conclusion: Working Group NNA should recognise the possibility of using existing ETNS numbers for VoIP services, or consider the creation of a new ETNS number range for VoIP services.

7.2 Disintegration of national numbering plans

VoIP services have an inherent nomadic nature. In other words, the service is not linked to a particular physical location and the service is potentially available from any network endpoint in the world. If a VoIP service provider uses numbers from a national E.164 numbering plan, the use of these numbers across a national boundary may appear to be inconsistent with the purpose of ITU country codes.

It might be argued whether this cross-border usage of numbers is new. Some freephone numbers from a national numbering plan are used by companies not based in that country. And roaming subscribers to mobile or UPT services do already use their national numbers outside the country.

Comparing the cross-border VoIP service with the cross-border freephone service, the difference seems to be in the scale: Freephone numbers will incidentally be used this way, whereas cross-border VoIP services might in the long term use a considerable percentage of a national numbering plan.

Comparing the mobile and UPT service with the VoIP service, the difference seems to be the home location. The main usage of a mobile service or UPT service will be in the country indicated by the number's country code, which is not necessarily the case with VoIP services. This is caused by the usual tariff structures: for mobile and UPT services roaming tariffs are significantly higher than local tariffs, whereas for VoIP services there is usually no difference in roaming and local tariffs.

Permanent cross-border usage of numbers by VoIP services may be interesting for several types of subscribers. For instance embassies will have a considerable percentage of telephone traffic to their home country. These calls will be cheaper when numbers from their home country are used. VoIP service providers might even choose to assign numbers from two different countries to the same subscriber, to enable the cheapest number to be used for reaching the subscriber.

An effect of cross-border usage possibilities is that VoIP service providers will base themselves and apply for numbers in those countries where their requirements are best met, or with the lowest threshold to get numbers. E.g. international termination rates will be an important aspect, or legal requirements on service providers. This is comparable to shipping under a foreign flag. This phenomenon is already occurring: subscribers of the Free World Dialup VoIP service have the possibility of using numbers from the Liechtenstein numbering plan for interoperability with the traditional voice services (see www.numberdirect.com for more information).

Note that this crossing of borders by VoIP services is not specifically related to geographic numbers. It is possible with all number ranges, but due to low geographical tariffs, this cross-border usage is most profitable for geographic numbers.

The use of numbers of one national numbering plan in another country deserves more study. A lot of questions have to be answered, e.g.:

- What is new in cross-border usage of numbers?
- What are the implications on end-user protection?
- What are the legal implications?
- What are the technical and legal possibilities to restrict the use of VoIP services to one country?
- What is the status of this subject in ITU?

As these questions could not be addressed in the study which was the basis of this report, the subject of cross border usage of numbers remains outside the scope of this report.

Conclusion: The use of numbers of one national numbering plan in another country is an important consequence of the nomadic aspect of VoIP services. However, it is outside the scope of this study. ECC WG NNA should address the specific consequences of this development for the national numbering plans and numbering legislation in a separate study.

8 CONCLUSIONS AND RECOMMENDATIONS

This report presents an extensive exploration of the options for a numbering plan to support VoIP services. It can be concluded that the options that consist of a modified geographic number range and the options for opening a new number range are most likely to meet in a balanced way the interests of VoIP subscribers, calling end-users, VoIP service providers, and NRAs.

This conclusion is based on two important requirements for a number range for VoIP services:

- it should support the new service features of VoIP services (where "nomadicity" is the most relevant),
- it should enable competition with traditional voice services.

The geographic number range supports competition best, but the impact of modifying the allocation criteria to support nomadicity needs consideration by the NRA. A new number range (or new number ranges) is able to support nomadicity best, but the ability to support competition needs consideration by the NRA.

NRAs are recommended to consider the advantages and disadvantages listed in this report and choose one or several options from this report to achieve a consistent E.164 numbering plan in their country that supports both VoIP services and traditional voice services.

ANNEX: OVERVIEW OF CONCLUSIONS PER SECTION

Section 2
For VoIP services the following existing number ranges are relevant: geographic numbers, mobile numbers, personal numbers, and corporate numbers.

Section 3
Not all VoIP related services are relevant for numbering. Only types 2 (Independent of internet access) and 3 (Provided by broadband access service provider) are relevant for this report.

From the perspective of network interfaces there are two distinct implementations for a VoIP service provider to offer his service, NNI and UNI. In case geographic numbers are used, each implementation has different advantages and disadvantages. The NNI leads to requirements for many small block allocations that impose costs on other operators but is capable of providing, but not ensuring, a correct relationship between the number and the location of the subscriber. The UNI is not capable of providing a correct relationship between the number and the location of the subscriber and may lead to rapid exhaustion of numbers because subscribers have some incentive to have multiple numbers. It should be considered by NRAs whether the use of geographical numbers for a UNI implemented VoIP gateway is appropriate in their country and, if not, how such a use could be restricted.

When talking about number allocation for VoIP services one should bear in mind that there are a great variety of commercial service descriptions possible. Each service description may end up with a different conclusion for the most appropriate number range to be used.

In VoIP services the naming and the addressing may use different numbering systems. In IP numbering system, exact location information is technically not supported at this moment.

Section 4
In studying the impact of VoIP services on the numbering plan and number allocation criteria, it is important to know where VoIP services differ from traditional voices services. VoIP services may offer either less or more features than traditional voice services. In general, there is only one relevant service characteristic in which VoIP services differ from traditional fixed telephony services and that is its inherent potential to be nomadic.

Section 5
There are many arguments in favour for allocation of geographical numbers for VoIP services with a nomadic nature, from all four stakeholders. There are three ways identified to adapt criteria for geographic numbers in order to support VoIP services. Each option removes to some degree the geographic nature of the range, which could have an impact other national regulatory issues (e.g. number shortage, tariff models of SMP operator, business cases of carrier pre-selection providers, the way of handling location information by emergency centres). This impact will have to be weighted against the benefits of using the geographic number range.

Except for a VoIP service over a mobile broadband network (e.g. UMTS), the mobile number range does not seem to be appropriate for allocation to VoIP service providers. The mobile number allocation criteria can be broadened to cover nomadic aspects, but there are few arguments to do so. The main point of concern is that a calling end-user will associate the mobile number with a high tariff (independent of the real VoIP service tariff, which is more likely to be comparable to calling a geographical number).

The personal number range does not seem to be appropriate for allocation for VoIP services. There are too few arguments of stakeholders to do so. The main point of concern is that a calling end-user may associate the personal number with a high tariff (independent of the real VoIP service tariff, which is more likely to be comparable to calling a geographical number).

The corporate number range does not seem to be appropriate for allocation for VoIP services. There are too few arguments of stakeholders to do so. The main points of concern are that a calling end-user may associate the corporate number with a high tariff (independent of the real VoIP service tariff, which is more likely to be comparable to calling a geographical number).

A new number range is motivated mainly by (1) avoiding the points of concern related to options for using other number ranges; (2) the aim to keep the existing number ranges intact (especially the geographical number range); and by (3) giving freedom to service providers to create their service description. The points of concern related to the opening of a new number range are primarily related to competition (e.g. late accessibility from other countries, impossibility to port numbers, unknown tariff class).

Section 6
The complex issues of calling emergency services are largely or wholly independent of the choice of number range.

Legal requirements related to obligations for CLI presentation or presentation restriction have no implications for number allocation.

Depending on the country, the opening of a new number range or a change in number allocation criteria of an existing number range may demand an update of the legal interception regulations.

Number portability should be imposed in such a way that when a number can be imported for a service, it also can be ported out and vice versa. If this is the case, then number portability has no implication for the choice of number ranges for VoIP services.

Voice quality should not be associated with numbering.

If a new number range is created for VoIP services, the NRA has to decide whether an SMP operator should open this new number range for CPS or not.

Legal requirements with respect to directory services have no implications for number allocation.

Tariff related legal requirements have no influence on number allocation criteria. Whatever number range is allocated to a VoIP service provider, the tariff negotiation by a VoIP service provider may lead to any tariff that is legally acceptable. Tariff transparency is not related specifically to VoIP, but the rise of VoIP services may make a good supervision to tariff transparency more important.

Section 7
Working Group NNA should recognise the possibility of using existing ETNS numbers for VoIP services, or consider the creation of a new ETNS number range for VoIP services.

The use of numbers of one national numbering plan in another country is an important consequence of the nomadic aspect of VoIP services. However, it is outside the scope of this study. ECC WG NNA should address the specific consequences of this development for the national numbering plans and numbering legislation in a separate study.