



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

THE FUTURE OF E.164 NUMBERING PLANS AND ALLOCATION ARRANGEMENTS

Lisbon, September 2006

EXECUTIVE SUMMARY

This Report explores the underlying trends in the technology and market and analyses how they affect traditional numbering arrangements and makes some 15 recommendations about how NRAs should adapt their national numbering plans and number allocation methods.

The trends discussed are:

- Changes to cost structures
- Changes to the retail market
- Changes to technology and layering
- Service substitutions
- Customisation of identifiers

The issues explored include:

- Convergence
- Network structures
- ENUM
- Voice over Internet based services
- Next generation networks
- New services

The consequence for numbering and the factors for consideration include;

- Consumer protection
- Geographic structuring
- The scope of services for given ranges of numbers
- Number portability
- Tariff transparency
- Individual number allocation
- Connectivity
- Sub-allocation

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1 INTRODUCTION

Telecommunications is at a watershed with technological and economic developments changing the whole industry and many operators starting to use new network designs for the provision of existing and new services.

Numbering, or more generically naming and addressing is pervasive to the design of a network as it provides the identification system for linking users together and has to be supported across all the various technologies and systems that make up the network. E.164 numbering has developed gradually over the last 40 years with well-established practices and expectations for various different number ranges. Nearly all¹ National Numbering Authorities have produced written numbering plans that describe their numbering arrangements and the different uses of different ranges.

The purpose of this report is to analyse the changes that are taking place at present and to identify the ways in which national and international numbering arrangements need to change. The report is focussed on E.164 numbers and does not attempt specifically to cover other forms of identifiers. The report is taking a reasonably long term view of developments and looking beyond the boundaries of the current EU regulatory framework.

2 DEFINITIONS

GRX backbone: The GPRS Roaming eXchange, which is an international shared transit or backbone network that is run by the GSM Association for the support of GPRS roaming traffic and which may be extended for the support of IMS. The GRX has a form and structure that is similar to that of the public Internet and it uses public IP addresses but is not connected to the public Internet.

Next Generation Networks (NGN): A general term used for networks with a packet-based architecture that will replace the ISDN/GSM2+ generation of networks. In this report the term is used for networks run and controlled by the telcos in contrast to the public Internet.

IP Multimedia subsystem (IMS): The IP-based network planned for the support of both voice and data services within the third generation mobile networks based on the 3GPP standards.

Operator: Any party other than the end user who may be assigned a number. This report does not attempt to make distinctions between a network operator, a service provider or a reseller when considering the allocation of numbers.

3 NUMBERING ARRANGEMENTS

3.1 Introduction

There are three aspects or dimensions to numbering:

- The numbering plan or framework - the division into ranges for different services or applications
- The number-related requirements associated with each numbering range or service
- The number allocation process for each range, which may be accompanied by number charging.

The changes taking place affect all three aspects, but before explaining the changes it is worth explaining these aspects in more detail.

¹ See <http://www.itu.int/ITU-T/inr/nnp/index.html>

3.2 *The international framework*

Traditional telecommunications numbering is organised in accordance with ITU-T Recommendation E.164 "The international public telecommunication numbering plan". This Recommendation provides the number structure and functionality for the four categories of numbers used for international public telecommunication:

- geographic areas,
- global services,
- Networks and
- Groups of Countries (GoC).

For each of the categories, it details the components of the numbering structure and the digit analysis required to successfully route the calls. Thus ITU-T Recommendation E.164 establishes an international framework within which each individual country has freedom to organise its own national numbering plan.

This report primarily concerns changes that will affect national numbering plans (i.e. the part of the worldwide E.164 numbering plan identified by a given geographic country code²).

ITU-T Recommendation E.164 recommends the following for national numbering plans (geographic areas):

"Each national numbering plan administrator should give the most careful consideration to the preparation of a national numbering plan for its own network. This plan should be designed:

- a) to allow generous provision for future growth in the number of subscribers and services to the national system;*
- b) with the consideration that the national network will ultimately be accessible to subscribers in other countries by means of international dialling procedures;*
- c) so that subscribers would always be called by either the same N(S)N or SN, a national matter, regardless of where the call originated from within the national numbering plan."*

The only real constraints recommended for the structure of the national numbering plan are:

"7.5.2 On international calls the number analysis performed at the originating country need not be more than the country code and:

- four digits of the N(S)N in the case of a country with a three-digit country code;*
- five digits of the N(S)N in the case of a country with a two-digit country code;*
- six digits of the N(S)N in the case of a country with a one-digit country code.*

7.5.3 The national numbering plan of a country should be such that digit analysis for incoming international calls need not exceed established limits applicable to the N(S)N but allows:

- a) determination of routing that reflects economic and other appropriate network factors;*
- b) distinctions for charging in those countries where distinctions are applicable."*

3.3 *National numbering plans and their objectives*

National numbering plans are normally organised today to achieve the following objectives for callers:

- Tariff transparency for callers, ie enabling callers to obtain an indication of the tariff level from the first 1-3 digits of the national number
- An indication of the location of the called party for fixed services, although this conflicts with nationwide location portability and some countries prefer to remove or reduce location information.
- Grouping of similar services that some subscribers may wish to bar, eg adult services, gambling, services with very high tariffs.

² some countries have been given several country codes, each of them identifying a particular geographic area (e.g France whose 33 identifies the Metropolitan territory and other CCs like 262 for Réunion, identify the overseas Departments DOM)

- Grouping of similar services for which the caller may have particular special expectations, eg grouping of mobile services where calls may be intrusive, grouping of paging services, or grouping of services which may support nomadicity.
- Continuity of numbering for users of essentially the same service, ie avoiding the need to change number when new features are added to a service. An example is the addition of nomadicity to existing fixed numbers.

The following objectives also assist the telecommunications operators and regulators:

- Grouping of similar services that require similar call handling, eg number translation or number portability
- Grouping of similar services that are subject to similar regulatory requirements eg number portability or the ability to support calls to emergency services.

In other words the numbering plan needs wherever possible to simplify and facilitate the analysis of numbers by callers, operators and regulators.

Consequently national numbering plans divide up the national numbering space into ranges and assign a set of criteria and obligations for the use of each range.

There has been much discussion of the distinction in the EU Framework between Publicly Available Telephone Service (PATS) and non-PATS. The definitions used in the Framework relate out-going call capabilities such as international calls and calls to emergency services to requirements to provide number portability, but the wording of the definitions is circular and has given rise to many inconclusive policy discussions. This report therefore does not use the term PATS but instead considers the elements such as number portability, referred to in the definition of PATS. This approach means that the report will not become out of date if the concept of PATS is changed or refined.

Generally most regulators aim to make their numbering plans "technology neutral" and to treat different technical solutions for providing similar services in a similar way. The reason for this is to enable operators to adopt newer and different technologies in their networks and users to upgrade their terminals without disturbing the numbering arrangements. Another reason is numbering portability, which allows a user of a given service going from one provider to another provider of the same service (with or without the same technology) and keeping his/her number. In practice though, some of the conditions and concepts that have become embedded in numbering plans relate to the characteristics of particular technologies and therefore plans may only be "technology neutral" in terms of the technologies available when the plans were established and they may need to be modified to remain "technology neutral" in terms of new technologies. An example here is the support of nomadicity and location portability inherent in most uses of IP technology.

The definition of the scope of the services that may use each number range is seldom addressed with great precision but is now becoming more of an issue as a result of the greater diversity that results from the use of IP technology and from the introduction of new access technologies.

3.4 Number-related requirements associated with each number range

The following are the main number related charges associated with different number ranges.

3.4.1 Geographic location for allocation

Fixed numbers are commonly allocated according to a geographic plan with the early digits of the number indicating an area within the country. The number of digits used to indicate the area in the country may vary from one to four (eg UK). To obtain a number in a particular area it may be necessary for the subscriber to have a network termination point in that area. This geographic information may be used:

- by callers for example when responding to advertisements to gain an approximate idea of the location of the called party
- by callers to see if local dialling may be used
- by callers to see if a local or long distance tariff will be payable if such tariffs are different
- by operators to determine which interconnection point to use
- by operators to determine the routing of the call.

If the number of digits that are used for geographic location exceeds the level where each operator that is allocated a block of numbers is likely to have sufficient subscribers to use the whole block, then the overall efficiency of use of the

numbers will decrease quite rapidly. For example a country with a finely divided geographic numbering scheme and many different competing operators with their own local loops will tend to have a low average use of numbers.

3.4.2 Geographic location for usage, ie restrictions on nomadicity

Where there is a requirement on geographic location for allocation, there may be a requirement to use the number only in the area for which it was allocated. This is in effect a restriction on nomadicity.

3.4.3 Tariff level and transparency

Tariff transparency is very important for the general public (i.e. users and subscribers); probably the most important aspect of numbering plans for these people.

Tariffs are increasingly set by competition rather than by regulation and therefore will differ from operator to operator. The operators however have to take account of their cost base and in most cases this will include the interconnection terminating rate of the terminating operator. Thus tariffs are linked to a large extent to termination rates.

Regulators tend to assume that subscribers:

- Expect a reasonable degree of tariff transparency from the early digits of a number
- Are not concerned if there is no distinction between the price of calls to numbers where the price differences do not exceed a threshold that is say 5% - 15%.
- Are not concerned to distinguish the price of calls that are below a certain threshold such that they are not expensive enough to bother about.

It is worthwhile distinguishing different aspects of tariff transparency:

- An indication of the level of the tariff is normally what can be achieved by a numbering plan, ie a distinction between a number that is inexpensive to call and one that is more expensive. An example is the distinction between fixed and mobile numbers.
- An indication of the exact tariff of the call would normally be possible only for special tariff numbers where a fixed tariff applies to the whole range.

Regulators may achieve tariff transparency to greater or lesser extents by:

- Grouping similar services for which the terminating rates would tend to be similar. However some operators, especially some new entrants, set relatively high termination rates as a means of raising additional revenue from parties who are not their own subscribers. Note: We refer here to termination rates because these rates are commonly regulated and are linked indirectly to the rates charges to callers, which are commonly unregulated.
- Regulating all termination rates on the grounds that call termination is a monopoly. Some regulators regulate only the rates of operators who have significant market power in out-going calls leaving smaller operators free to set much higher termination rates.
- Setting an upper limit on termination rates. This is rare.
- Requiring operators of similar services to charge the same termination rate. This is relatively rare in Europe but is in effect part of the approach to mobile operators in the USA where the called party pays for the mobile termination, ie the terminating rate is effectively zero for all mobile operators.
- Setting a maximum price limit for calls to a number range. This would provide an effective protection against extreme abuses especially by some niche market players but is rare. The price limit would need to be set well above the level set by competition to avoid interference with competition.

In general the current level of tariff transparency in some countries could be improved to the benefit of users. Areas where tariff transparency is poor are:

- Calls to mobiles where some operators use much higher termination rates than others yet numbers are portable between the operators.
- Calls between mobiles where there are high on-net discounts because number portability makes it impossible to see easily if the called party is on the same network
- Calls to special tariff services, especially from mobiles

- Calls made from roaming mobiles
- Calls received by roaming mobiles.

The means for regulators to address these problems are not necessarily available under the current EU regulatory framework

3.4.4 Number portability

Under the European Framework (Universal Services Directive), all Publicly Available Telephone Services are required to provide number portability. This requirement is caught up in the problem of the circularity in the definition of Publicly Available Telephone Services but national regulatory authorities are free to require number portability where the services do not fit into the definition.

The current situation is that most regulators regard traditional services that use geographic and mobile numbers as subject to portability but practices differ concerning new IP-based services, which may have access to geographic numbers in some countries. This may create asymmetries where there may be a requirement for a given geographic number to be exported from one operator, regarded as offering a PATS, but not from another that is not regarded as offering a PATS. Arguably most non-geographic numbers are used for services that are not PATS because the non-geographic number is translated into a geographic number and is not itself used for out-going calls. Nevertheless most regulators require non-geographic numbers to be portable.

For clarity it is advisable to associate a requirement for number portability with a number range.

The issues around number portability have changed over the last decade in a paradoxical manner:

- Number portability requirements have become much more common and are regarded in the European Framework as a user right irrespective of the cost, yet the set-up cost in some smaller countries (eg of less than 1 million subscribers) may be as high as 30 Euros per subscriber (over all subscribers, not per just porting subscribers).
- The problems of changing number have reduced especially for individual subscribers, and so the net benefit of number portability has reduced, because most subscribers can easily inform their correspondents of a change in number via a broadcast email at zero marginal cost.

3.4.5 Other issues

Questions are asked from time to time whether numbering should be:

- linked to Quality of Service, especially voice quality during calls
- related to requirements to provide the capability to call emergency services and provide location information, or
- related to requirements for law enforcement.

Linking numbering to quality of service is not advisable because quality of service depends on a combination of the technology used and the way in which the networks are designed and operated. The first issue is technology specific and conflicts to some extent with the objective of being technology neutral. The second issue results in the QoS being variable (for IP based technologies it is variable within the daily cycle of traffic loadings) and so is not stable and numbering needs to be as stable and future proof as possible. A linkage to levels of quality would imply that numbering should change when quality changes, which is neither reasonable nor practicable.

The issue of emergency calls from IP-based technologies is attracting much attention. The issues include:

- How to route a call to an emergency response centre in a different country - this will almost certainly require the use of geographic numbers for the calls from the gateways to the emergency response centres.
- What to do to with Calling Line Identity - this information may not be correct or may be misleading and could result in the call being rejected incorrectly.
- How to provide location information - the main options are databases that relate to network access and the long term use of GPS or Galileo position fixing in mobile terminals.

Again these issues are important but do not affect the organisation of numbering. ECC Report 74 contains some relevant information in these issues.

There are two main aspects to law enforcement:

- Lawful interception of calls and other communications
- Data retention where service providers hold data on a subscriber's usage in case it is needed later for law enforcement

Both activities require the appropriate legal processes to be followed and are supported traditionally by service providers. The effects of the new technologies is expected to be that:

- Lawful interception has to be based on access rather than service provision
- There will be difficult legal issues with access to data under data retention if the service provider and the data are under different jurisdictions.
- Data retention will not work so readily with self provision of services.

These issues are also important but do not affect the organisation of numbering.

3.5 Number allocation methods

Numbers are normally allocated in blocks (commonly 10 000 numbers) by the National Numbering Authority to operators or service providers and then sub-allocated to subscribers.

Operators and service providers may or may not be allowed to sub-allocate numbers to other operators and service providers. In many cases regulators have not made this issue explicit. In any case, the entity responsible for the assigned numbers (e.g. responsible to make possible the lawful interceptions) needs to be known.

In a few countries, some ranges of numbers are allocated on an individual basis direct to end users who then arrange for an operator or service provider to serve the number. This arrangement normally means that operators need to use an all call query routing solution and a national reference database, as there is no operator related information in the number.

Some authorities charge for subscriber numbers. Different forms of charging are used such as:

- a one-time charge per block allocation
- an annual charge per block
- an annual charge per active number

or a combination of the above.

3.6 A typical current numbering plan

Figure 1 shows a typical current numbering plan.

Range	Application/service	Geographic structure	Tariff	Nomadcity	Portability	Allocation
A	Fixed	Yes	Low	No	Yes	Blocks, no sub-allocation
B	Fixed	No	Low	Possibly	Yes	Blocks, no sub-allocation
C	Mobile cellular	No	Medium-high	No but roaming may be supported	Yes	Blocks, no sub-allocation
D	New wireless technologies	No	Low-medium	?	?	Blocks, no sub-allocation
E	Personal numbers	No	Varies greatly	Yes through number translation	Varies	Block or individual
F	Nomadic (VoIP)	No	Low	Yes	No	Blocks, no sub-allocation
G	Freephone	No	Zero	Yes through number translation	Yes	Block or individual
H	Shared cost	No	Low	Yes through number translation	Yes	Block or individual
I	Premium rate	No	High	Yes through number translation	Yes	Block or individual
J	Other specialist radio services eg paging	No	Varies	No but roaming may be supported	No	Block

Figure 1: Typical current numbering plan

3.7 Requirements on other networks

The requirements discussed above apply to the operators and service providers to whom numbers are allocated. Two other issues need to be considered that apply to other operators:

- The price for calling the numbers
- The connectivity to the numbers (the ability to call them)

For specially tariffed numbers regulators take different approaches between fixing the price for all calls to the numbers and fixing the price only for calls from operators with significant market power. For "normal" numbers there is the question about whether a price ceiling should be set as a consumer protection measure. Generally these aspects of price do not influence the basis planning of numbering and the allocation procedures.

Connectivity does have an influence on introduction of new number ranges and the scope specified for each different number range. If there is any risk that operators will fail to offer connectivity to new number ranges then unless regulators are willing to enforce connectivity it would be advisable to adopt an alternative policy of widening the scope of existing ranges where there is connectivity. Under the Universal Services Directive Article 4.2, Member States are required to ensure that at least one undertaking provides the ability to make local and national calls, but the application of this to new services such as nomadic services provided by VoIP is not totally clear. Furthermore, even if this requirement is met by the incumbent, if other operators decide not to connect calls to VoIP services in a new number range for nomadic services, then the VoIP operators are disadvantaged significantly. This situation could easily arise if, say, 6 operators have 60% of the market between them yet none qualifies for significant market power.

Connectivity problems also occur where operators in foreign countries analyse the called number beyond the country code and may not connect calls to new number ranges.

4 THE MAIN CHANGES TAKING PLACE

4.1 The underlying trends

The underlying changes and trends behind the fundamental changes in telecommunications are:

Digitalisation, which is enabling all communications content to be characterised in a single common form. The effects of digitalisation are enhanced by the development of the Internet Protocol that enables all digital forms of communications to be carried on a common network structure. Together these developments enable all forms of communications and services to be carried on a single network - the multi-service network.

Liberalisation, which has created a dynamic market of network and service providers. This has radically changed the structure of the industry as has broken the control that the established telcos have enjoyed for the past decades. No longer do the telcos decide or control which services will be available to users and how they will be provided. New companies such as Skype and other VOIP operators are now able to provide new services over the Internet in competition with the existing telco services. The significance of this is that users are beginning to have greatly enhanced choice and that technological developments and cost reductions can no longer be withheld from users. Furthermore the Internet provides a totally alternative platform and so there is much greater scope for competition in services and features whereas hitherto competition has been limited in practice to price.

Technology advances, which are greatly reducing the costs of telecommunications especially in the higher capacity links that are provided over optical fibre. Costs are falling as fast and faster in some areas than demand is rising with the result that whilst the industry expands in terms of volume its revenue base is reducing or static. This is leading to new price structures at the retail level such as unlimited call plans, although these new structures are not yet implemented at the interconnect level. Charges for distance are disappearing in the more developed countries.

4.2 Changes to cost structures

Developments in technology and huge economies of scale from the customer premises market have resulted in the costs of core or backbone networks dropping substantially. The existing regulatory and commercial models are built on the assumption of an expensive core or backbone network hence the focus on competition in long distance and international calls through carrier selection and the development of services such as freephone. Figure 2 shows the existing cost model in simplified form. In practice the backbone may be composed of several separate interconnected transit networks.

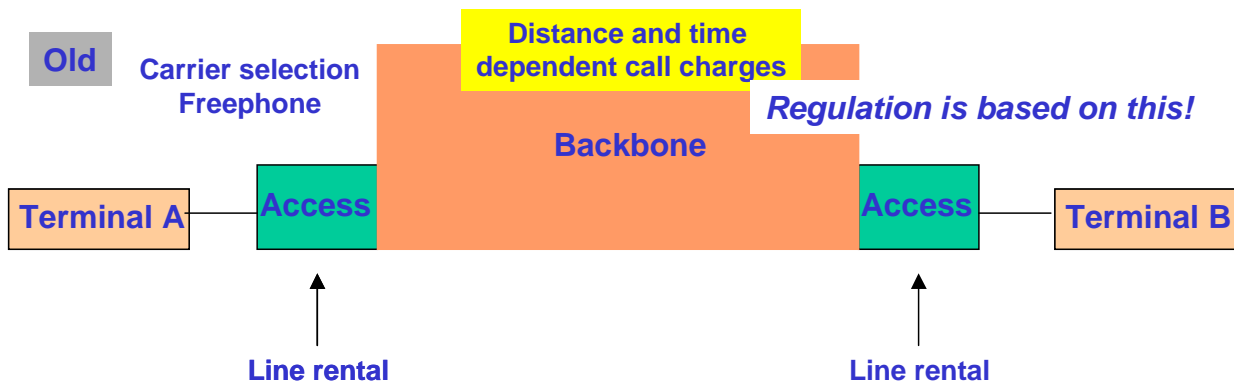


Figure 2: Existing cost model

Figure 3 shows the new cost model.

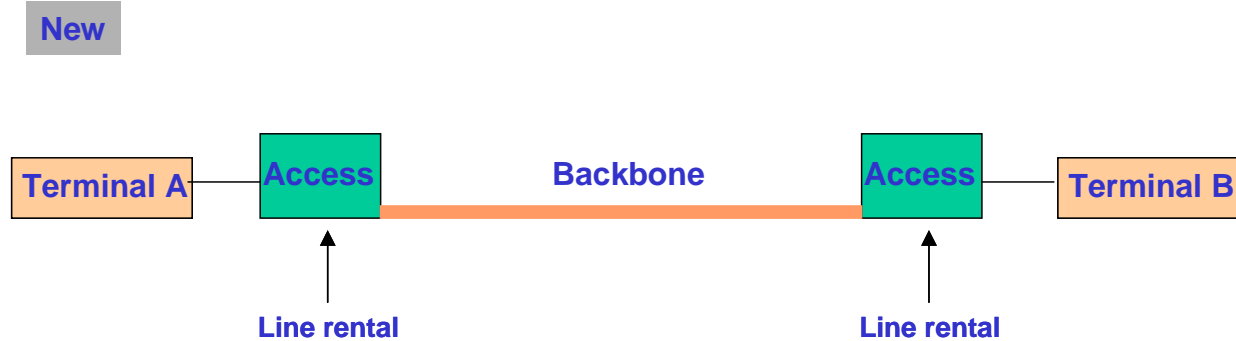


Figure 3: New cost model

The new cost model has applied to mobile networks for some time because of the high costs of radio access and the mobile operators have initially adopted a charging model similar to that proposed here for services on GPRS. The reduction in costs means that a complex interconnection charging model is no longer justified and that a simpler approach should be sought. Notwithstanding these changes the operators are exploring some new service-specific charging models for IMS and so simplification will not necessarily be achieved.

It is not yet clear to what extent the cost models will change under competitive pressure from the Internet and to what extent distance elements will remain. Even if distance is eliminated from charging at the retail level its elimination at the interconnection level would have some wide-reaching implications and change the incentive to carry calls as far as possible on ones own network to an incentive to hand over the calls as early as possible. Any charge for the carriage of a call across a network is in effect an element of distance related charging.

4.3 Changes to the retail market

The existing retail market is changing with call prices dropping and many operators starting to offer flat rate tariffs where unlimited call volumes are offered for a fixed subscription. This generates the risk of arbitrage and the operators would benefit from having interconnection arrangements that better match the structure of the retail charges. This change is causing many commentators to say that the days of call charges are disappearing.

There is however a small number of high price calls remaining including calls to some countries, calls to satellite services, calls to mobiles, calls from mobiles when roaming and calls to premium rate services.

4.4 Changes to technology and layering

Network technology is migrating from circuit switched technologies to IP-based technologies where the IP layer is shared by all services and applications but may be supported on a variety of different transmission technologies. The Internet Protocol is a product of the data communications design philosophy where different functions are separated into different independent layers so that changes can be made and one layer and not affect others. The Internet is structured along this layered approach so that there is a separation between services and transport. This means that the transport layer is unaware of the services that it is carrying.

Layering provides great flexibility and enables full competition at the services layer independent of the provision of the transport. This approach is incompatible with the traditional "telco" approach to telecommunications where access to and use of the transport is lined to the provision of specific services with charges related to the type of services the duration of use and the distances between the end points. One of the controversial design issues for the NGN is the extent to which it will be a platform for open service provision and the extent to which the telcos will manage to continue linkages between layers to continue usage based charging.

Another consequence of the changes in technology is that calls can cross borders without passing via a specific international gateway switch.

4.5 Service substitutions

The usage of services is changing and some newer services are substituting for older services. Some of the main substitutions are:

- Internet transactions replace calls
- Emails replace calls
- Texts (SMS) replace calls
- Mobile calls replace fixed calls
- Voice over Internet (PC-PSTN and PC-PC) calls replace both fixed and mobile (roaming)
- Internet based Instant Messenger services replace fixed and mobile calls, and texts (SMS).

4.6 Customisation of identifiers

The increased capability of terminals especially mobile terminals and software on PCs means that users can create their own customised set of commonly used names and uses these names instead of using E.164 numbers, SIP addresses or other identifiers directly. The best example is the phonebook in mobile phones where an E.164 number is stored under a name of the user's choosing. The users then seldom see the E.164 number.

5 CONVERGENCE

Convergence is not, or is not yet, the simple process of all different systems converging into a single solution. The process is more complex and has different dimensions:

- In the markets, there is convergence in that different organizations, eg telcos, Internet access and service providers, and broadcasters who used to address different market sectors are increasingly providing overlapping services and competing with each other.
- In the technology, the different purpose networks are being replaced by a single multi-purpose network based on the Internet Protocol.

However in the commercial area, there is increasing competition between what can be characterized as the telco commercial model and the Internet commercial model. This is illustrated in figure 4.

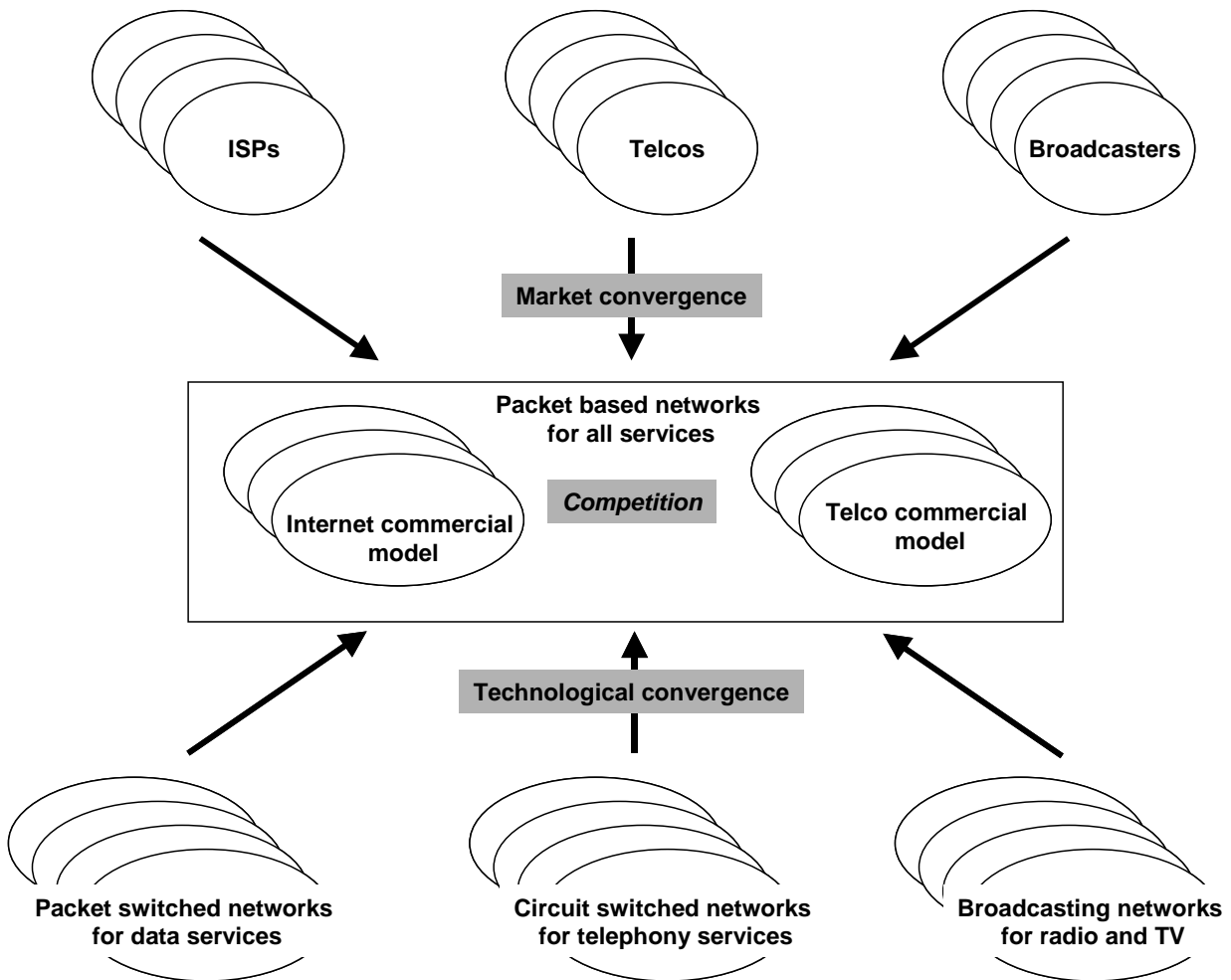


Figure 4: Convergence

It is not clear how this competition will develop. The Internet as an "open" network is architecturally much better suited to the provision of innovative and third party services, but there are concerns that its quality may deteriorate because at present there is over capacity in the backbone as a result of over investment during the dot com boom in 1999-2000. Equally if telcos continue their current approach to NGN developments they may not be well suited to flexible service provision. Nevertheless there are commercial changes starting in the telco world to make their retail tariffs more like the Internet, ie subscription rather than usage based. Thus the process of convergence is not simple and it is not clear whether both the telco and Internet models will continue in parallel indefinitely or will eventually merge into a single solution.

6 NETWORK STRUCTURES

Future networks are expected to be all based on the Internet Protocol (IP). The Internet Protocol provides the foundation for the separation of services and connectivity. This separation is achieved in the Internet and is a principle characteristic of the Internet but the telcos do not intend to allow this separation in the NGN.

A consequence of the separation of services and connectivity is the characteristic of nomadism where a user may be located anywhere relative to their service provider and relative to a gateway to another network type such as the PSTN. With the Internet, nomadism is worldwide but with the NGN it is limited to the network that the user is subscribed to. Use of services beyond that network is treated as roaming and a much higher tariff is charged.

Nomadism means that, unless special measures are taken, there can be no control or effective restriction on the location where a number anywhere is within the nomadism area, and this is worldwide for the Internet.

The Internet uses names instead of numbers and the Domain Name System converts names into IP addresses, which are used for the end-to-end routing of packets through the Internet. NGNs will also need their own DNS but it is not yet decided whether this will be:

- The same public DNS that is used by the Internet
- A common DNS available only to NGN operators (eg a DNS serving the GRX)
- Individual DNSs provided by each operator for their own use

DNS technologies may be used for handling numbers, which may be stored in ENUM or a system similar to ENUM. Storage in a different form does not necessarily affect how a number is used or how numbers should be arranged, but the methods of using numbers may affect how numbers should be arranged. For example, where networks analyse numbers partially in blocks, eg analyse the first X digits and later analyse deeper into the number, then all the numbers in a block may need to retain certain characteristics. In contrast if the analysis system always treats each number individually, as DNS does with names, then there is no requirement for all the numbers in a block to retain the same characteristics.

E.164 numbers function as an un-planned mixture of names and addresses as they contain more or less network specific information. The trends in the network structure mean that the amount of network specific information will reduce and could reduce to zero in the longer term. For example, in an IP-based network each time a E.164 number is dialled, before using it for routing, the network must resolve it into an address by means of a database translation (eg using ENUM)

7 ENUM

ENUM is a system for mapping E.164 numbers stored in DNS under <cc>.e164.arpa into Uniform Resource Identifiers such as SIP addresses or other identifiers. In "User ENUM" each number is loaded into DNS by its authorized user with user opt-in. In practice user ENUM may be used only for blocks of DDI numbers as there is insufficient incentive for individual users to load numbers into ENUM.

The IETF is starting to prepare an extension to ENUM to provide carrier ENUM which will probably be under the same tree as user ENUM but link the number only to a SIP address for the SIP server that is serving the number and numbers will be entered by the serving operator "en block" rather than individually.

The significance of user ENUM in particular is that numbers that were allocated for use with a given operator will start to be used also for services that are provided by another operator or are self provided; this may even happen when the number is stored in a ENUM database for the first time if the Tier 2 provider is different from the telephone service provider. At some stage the user may wish to discontinue the original service but keep the number to continue it newer use. Thus numbers may gradually become detached from the service providers that they were originally associated with and be associated with different or multiple service providers. We call this effect and the pressure for it "number detachment".

8 VOICE OVER INTERNET

Voice over Internet services use various identification methods including E.164 numbers, SIP addresses and proprietary names such as Skype names. E.164 numbers are needed in particular for incoming calls from the PSTN.

Within a country there are normally up to four options for numbers for voice over Internet services:

- Geographic numbers under the existing geographic plan
- Numbers in a new non-geographic range created for nomadic services
- Existing special tariff numbers, such as relatively non-geographic/low price premium rate numbers
- Personal numbers.

The use of new number ranges can lead to the following problems:

- Existing operators refuse to open connectivity to the new ranges because they do not want to encourage competition from voice over Internet services
- Existing operators charge higher tariffs for calls

- Call to these numbers are not included in flat rate tariff arrangements and/or are not included in call package offers.

Another option favoured by some providers of voice over Internet services is the use of sub-ranges within the main geographical range as a means of making it more difficult to discriminate against the new numbers. This would be like a virtual region for new services and this solution would work best if there is no distinction between local and long distance calls in the country concerned.

In practice many voice over Internet providers operate "behind" new entrant telco operators and use the existing interconnection arrangements of these operators for their services. This may include number portability for the importing of numbers and use of subsets of the geographic number blocks assigned to these operators. These arrangements may be used especially in countries where the regulatory framework makes the commercial operation of voice over Internet services especially difficult as they may overcome some of the disadvantages such as the unavailability of geographic numbers and the set-up costs of handling number portability processes.

Some service providers operate PSTN gateways in many different countries and offer their subscribers numbers in distant countries so that their correspondents may call them cheaply using a local or national number. This arrangement gives the benefit of VoIP such as avoiding higher tariffs to the less technically aware or poorer people and is the inverse of the normal arrangement for VoIP where the person with the PC and broadband access has the benefit. The arrangement is similar in some respects to the sale of mobile accounts to visitors to a country as a means of avoiding high roaming charges. If the call is routed through a service point in the country concerned then this is still in accordance with E.164 and this would normally be the case for calls from the PSTN. If, however, calls are routed wholly over the Internet using an E.164 number plus an ENUM-like translation capability then this is a situation that was not envisaged when the current version of E.164 was drafted. If such arrangements become much more common in the near future, this might lead the ITU-T to update E.164, but the guidelines for the updating are not easy to define.

The result of these practices is increased demand for numbers for the purpose of avoiding high charges.

9 USER PERSPECTIVES AND NEW SERVICES

9.1 Users and identifiers

Users are collecting more and more identifiers as new services multiply. This creates a problem of identity management that User ENUM hoped originally to solve.

Personal numbering services have been introduced in some countries but have not proved greatly popular. In most cases the services use distinct number ranges and have not benefited from the tariff reductions that have applied to fixed network services.

Generally there will be pressure from users to minimise the introduction of additional numbers for additional services and this will mean increasing pressure for:

- multiple uses for existing numbers and number detachment
- portability of numbers between services

Even though users may see numbers less frequently as a result of customised address books, E.164 numbers are likely to remain important as globally understood identifiers that unambiguous and transcend language and alphabet differences. Another great advantage of E.164 is that it can be used on any type of terminal to set up a call: even the oldest ones like rotating diallers can support E.164 decimal digits. In contrast the benefits of character string names are limited to the same language and alphabet and to more recent terminals

9.2 New forms of communication

With the growth of high speed access systems, video telephony may gradually replace audio telephony. This raises the question whether new numbers are needed. During the service migration, users will wish to continue to use their existing numbers. This may be possible but the provision of video telephony has not been studied yet under NGN. Provided that the person who is paying invokes the use of the video channel or is able to refuse it then there should be not tariff transparency issues.

9.3 Fixed - mobile convergence

Some operators are introducing services that combine fixed and mobile access under the same number. These services are at an early stage and the use of numbers for incoming calls and the tariffs to be applied may change. They may create a demand for a number range with a tariff level somewhere between the levels for fixed and mobile. An alternative that is attractive for users, especially for a calling party, is to use an existing fixed number and for the called party to pay for any extension of the call to their mobile.

In general terms the increasing use of a mobile handset as a substitute for a fixed telephone will lead to increased pressure for number portability between services.

10 SUMMARY OF FACTORS THAT WILL AFFECT NUMBERING PLANS

The following is the list of factors for change that arise out of the sections above:

- Geographic numbers no longer need to support distance related tariffs so geographic boundaries can enlarge with the result that geographic numbers become more “non-geographic”
- Tariffs fall leaving fewer services with high tariffs
- Flat rate calling plans become more common place and inclusion in flat rate tariffs becomes an important issue
- Flat rate reduced tariffs reduce demand for freephone
- Nomadicity spreads to existing services as IP technology is adopted so that it becomes impossible to restrict where numbers are used within the region of nomadicity
- Voice over the Internet and high roaming charges lead to increased demand for additional numbers for the purpose of reducing charges
- Numbers are increasingly associated with services for which they were not originally allocated. Thus as ENUM increases pressure for number detachment, the linkage with the service provider through which the number was allocated will be broken and the number will become more personal.
- Secondary allocation between operators increases as new operators wish to work behind existing operators (normally non-incumbent ones) both to share facilities such as number portability ordering systems and to gain improved connectivity
- New ranges may be needed for fixed mobile convergence services
- Pressure for number portability between different services increases subject to the tariffs not being too different.
- Numbers can be used outside the country where they were allocated. This has many consequences on issues like E.164 worldwide management, lawful interception responsibilities, etc.

11 CONSEQUENCES FOR NUMBERING PLANS

The following consequences are written especially from the perspective of the numbering plan.

11.1 Scope of services and portability between services

The pressure for number portability between services would both:

- increase the scope of number portability requirements - for example functional specifications would need to be revised.
- create pressure for the definitions of the scope of different services to be widened so that they can overlap. Overlapping between service definitions means for example that a number from the fixed range may be used for a mobile service and that a fixed number can be ported to a mobile service accordingly.

Portability between services is desirable provided that the benefits outweigh the costs. This is likely to be the case where the services concerned already support number portability, but would be unlikely in small countries that do not yet have number portability between providers of similar services as the set-up costs would be relatively too high.

Relaxations on the scope of services and requirements for inter-service portability should be introduced only where they will not introduce a problem of tariff transparency. In practice this could be achieved by the termination rates becoming similar.

Recommendation 1: When the terminating rates for different services are within, say, 20% of each other, NRAs should consider changing the definitions of the scope of services in the numbering plan, in such a way that number portability between all the services concerned can be required.

The introduction of new technology and features such as nomadcity will lead to pressure for new number ranges to be introduced. The introduction of new number ranges can cause problems for the operators who use the new ranges because the new ranges may be excluded from flat rate tariff plans and so be more expensive to call than existing ranges, and some operators may be slow in establishing connectivity to the new ranges. Indeed some may refuse to do so if the services are seen as competitive threats. NRAs should therefore introduce new number ranges for new services only when really needed and only if it is quite inappropriate to accommodate the new services in existing ranges.

Some operators may offer enhanced services as a supplement to existing services, eg they may offer video-telephony as an enhancement to telephony with the video component being usable where both the calling and called parties have the necessary terminal equipment. In this case subscribers will want to retain their existing numbers and issues may arise about more than one tariff being associated with the same number. These issues will not be soluble through numbering, and wherever possible subscribers should be allowed to retain their existing numbers for enhancements to existing services and new services that retain compatibility with existing services. The scopes of services allowed for the number ranges concerned should be correspondingly widened.

Recommendation 2: NRAs should introduce new number ranges for new services only when really needed and only if it is quite inappropriate to accommodate the new services in existing ranges. Subscribers should be allowed to retain their existing numbers for enhancements to existing services and new services that retain compatibility with existing services. The scopes of services allowed for the number ranges concerned should be correspondingly widened.

11.2 Geographic location for allocation

The changes foreseen in the costs and economics of networks as well as in the retail tariff trends imply that the geographic information in numbers will gradually be diluted and does not need to be retained rigidly as the distinctions between local and long distance tariffs disappear. This change is being led at the retail level. Interconnection rates need to be reviewed and kept broadly in line with retail rates otherwise geographic information may need to be retained solely for interconnection purposes, however the implications for interconnection of changing from a geographic to a non-geographic structure need to be studied further. Replacement of the current PSTN by NGN technology could be a trigger for reviewing and simplifying the numbering, as changes where the technology remains circuit switched would be more difficult.

The change would mean that:

- Numbers already allocated would cease to have geographical significance (at least within a country, as regards geographical significance as solely recognition of a country, the issue is more complex.)
- Unused numbers within existing allocations could be allocated to subscribers at any location and so many unused numbers would become usable and the efficiency or use of numbers would increase
- The location portability of existing numbers would increase and so subscribers would be faced with fewer number changes if they move location, but correspondingly callers would no longer be able to derive the approximate location of the called party from the called number (and vice versa for the called party examining the CLI)
- New number blocks would be allocated without any geographical reference
- Interconnection practices would be forced to change as distinctions between different termination arrangements such as local, single and double transit are based on partial number analysis
- Dialling plans would change to full length dialling for all numbers as short dialling would no longer be possible since the caller would no longer have a numbering relationship to a location
- Lawful interception arrangements might need to be reviewed.

The advantage of location portability for subscribers would need to be weighed against the disadvantage of the loss of geographic information. This information can be useful when calls are considered to destinations where the calls has only the number, eg answering advertisements where callers can sometimes deduce if the called party is in the same

area. Also in some countries the CLI is used to select which emergency centre to route the call to if there is more than one such centre. These aspects are also affected by nomadicity.

Recommendation 3: NRAs should study further the implications of removing the geographic significance of numbers within their own country, especially for interconnection and should consider taking this step when the operators start to adopt IP-technology widely.

11.3 Geographic location for usage, ie restrictions on nomadicity

The change to IP technology with its inherent layering means that nomadicity will become more commonplace. It may be universal, eg on the Internet calls can be made and received with a given number at any location, or limited in NGN architectures to a certain area. NRAs should recognise that nomadicity is a user benefit and should not apply usage conditions that restrict the user benefit of nomadicity. Such restrictions would not be enforceable in practice anyway.

Nomadicity may extend beyond national boundaries so that the originating and terminating network termination points are no longer necessarily located in the counter identified by the country code. Thus the significance of the E.164 country code will reduce and it will become more like an Internet ccTLD.

Concerning the Country Code E.164, Clause 7.1 states: *"The Country Code is used to select the destination country (i.e., the country where the identified subscriber is registered or the country containing a point where the service is provided) and varies in length from 1 to 3 digits"*

Provided that allocations are made only to service providers with an agency or a legal entity or a call routing capability in the country concerned, so that calls can be routed through that country, then the use of nomadicity is compatible with the statements about the Country Code in E.164. Thus there is no need to revise E.164 to take account of nomadicity in the short term.

However if cross border nomadicity develops to be used extensively in practice then it will be advisable to revise E.164 to address this practice more explicitly and to take account of new forms of routing such as carrier ENUM implemented in a coordinated global manner. But it is premature to take these steps yet.

The issues affecting E.164 will be relatively minor compared to the general legal issues that will result as telecommunications becomes trans-national while the legal frameworks remain still national.

Recommendation 4: NRAs should recognise that nomadicity is a user benefit and should not apply usage conditions that restrict the user benefit of nomadicity. Such restrictions would not be enforceable in practice anyway. In the longer term, NRAs and ECC NNA should consider proposing revisions to E.164 if the use of cross border nomadicity grows substantially.

11.4 Tariff level and transparency

NRAs need to recognize the importance of tariff issues to subscribers and to seek to reduce the number of occasions when calls cost more than expected. Because competition is leading to a diversity of tariff and call plans and to a migration from usage based charging to subscription based charging, NRAs should focus on maintaining transparent information on the maximum that a call to a number is likely to cost.

One of the main causes of tariff confusion is the existence widely varying termination rates for services that are essentially similar and share the same number range. Another cause is the existence of deep on-net discounts, but these discounts are related to some extent to the need to pay high termination rates for off-net calls.

Termination rates of operators with significant market power are commonly regulated to be cost based. Yet the concept of cost-based termination is not absolute. It has been justified by the view that all the benefits of a call accrue to the caller but in practice the benefits of a call may accrue to either end or most commonly be shared between the ends. Cost based termination means that regulators control a substantial part of the market and so long as this approach continues there is little hope of regulators withdrawing further from the market. NRAs should explore the scope for other arrangements that would and reduce termination rates and equalize them between similar services. The simplest arrangement would be to move towards low or zero termination rates.

This would give the following advantages:

- All revenue for termination would have to come from the subscribers of the terminating network and so be fully competitive
- Regulators would no longer have to determine rates and could withdraw from the market
- Interconnection payments would simplify greatly

Revenue loss would be offset to some extent by cost savings, and either:

- Called parties paying to receive calls on a per call or per minute basis
- Operators bundling the cost of incoming calls with outgoing calls.

For fixed networks the access is paid for normally by a line rental. The switching and transmission costs of the "core" part of the network are low and decreasing with technology advances and flat rate retail tariffs are becoming popular. This change would not be a major issue, especially as the fixed operators would benefit from becoming able to bundle calls to mobile in flat rate packages.

For mobile networks all the termination is normally paid for by termination charges and the changes would be more disruptive. A glide path rather than an abrupt change would be needed.

There would be further consequences most of which would be beneficial:

- The trend to have only a mobile phone would reduce if users had to bear the full costs of their own decisions, and this would mean retention of more fixed lines. The economic distortions that exist at present would disappear.
- Prices for calls to fixed and mobile would converge so number portability between fixed and mobile networks would become practicable and would no longer be prevented by the need for tariff transparency.

Thus addressing termination rates would resolve or alleviate many of the problems of tariff transparency and increase the scope for number portability and convergence.

Recommendation 5: NRAs should explore the possibility of improving tariff transparency and increasing the scope for convergence and number portability by equalizing termination rates between similar services for example by moving on a glide path towards low or zero termination rates. Further discussion of this is a wider issue than numbering but there is a strong linkage with numbering.

Some consumer protection issues would however remain and could be addressed by setting maximum levels for calls from any operators to each number range. It may not be possible to do this under the existing EU Framework but should be considered in the review that is starting.

Recommendation 6: The review of the EU Framework should consider enabling NRAs to link maximum retail price limits for calls to each number range as a consumer protection measure (if this is not possible under the current regime) These limits would be well above the level set by competition and protect users in "micro-monopoly situations" where they are unable to benefit from competition.

As the main market trend is towards lower costs and lower tariffs, NRAs should be cautious about promoting new services with high tariffs and about introducing new number ranges with high tariffs or allowing new applications into high tariff ranges (eg fixed information services being allowed into mobile ranges) as high tariffs will increasingly become an anomaly and may allow scope for abuse or require special measures for user protection.

Recommendation 7: NRAs should be cautious about introducing new number ranges with high retail tariffs as they will increasingly become anomalous as the tariffs for other calls reduce.

11.5 Number portability

Where number portability has not yet been introduced, NRAs should ensure that the prospective benefits outweigh the costs and that the problems of changing operator cannot be alleviated adequately by other cheaper solutions.

Where number portability has been introduced, NRAs should consider extending number portability between operators of dissimilar services provided that any tariff differences between calling the different operators are less than a threshold of sensitivity, perhaps < 20%. However once tariffs reduce to a very low level portability can be introduced

irrespective of any differences as the sums will be minimal. Recommendation 1 has addressed the need to widen the scope of the services allowed in different bands when number portability is required between services that are currently dissimilar. The requirements for number portability themselves may, however, be linked to number ranges or descriptions of operators and may need to be updated and broadened.

Recommendation 8: NRAs should consider updating and broadening number portability requirements between operators of dissimilar services in accordance with the broadening of the scope of number ranges in the numbering plan.

12 CONSEQUENCES FOR NUMBER ALLOCATION

12.1 The allocation framework

The allocation framework is set out in ITU-T Recommendation E.164 and has been described in section 3.2. There appears to be no need to change this framework for allocation. Delegating the majority of allocations to national regulatory authorities makes it easier for operators to apply for numbers and these delegations should remain.

Recommendation 9: There is no need to change the existing country based structure for number allocations.

12.2 Number Sub allocation

The approach to sub-allocation of numbers is not explicit in many countries. Sub-allocation may provide benefits in cases where operators wish to share facilities such as gateways/interconnections to other operators and inter operators systems such as number portability and carrier selection. It may also allow operators to use unused parts of number blocks. Some regulators are afraid of sub-allocation as it may imply a loss of control and visibility. However it is difficult to see that sub allocation would lead to any serious problems provided that:

- the operator who makes the sub-allocation informs the NRA of the operator who receives the allocation
- the operator who receives the allocation continues to meet the requirements that apply to the number range in question.

In order to minimise possible confusion and loss of control, however, sub-allocation could be limited to one level of sub-allocation.

Recommendation 10: Regulators should consider allowing one level of sub-allocation but require any operator who makes the sub-allocation to inform the NRA of the sub-allocation. NRAs should ensure that the party that receives the sub-allocation meets the requirements associated with the original allocation. The means to achieve, including the exact responsibilities of the parties concerned in order to prevent mis-use, will need further study.

12.3 Criteria for receiving allocations

Where there is geographic numbering, ie at the country level from the perspective of the ITU or at the regional or city level from the perspective of a national regulator, other operators have a reasonable expectation that they should be able to hand over calls to the geographic number range concerned in the area concerned. A condition of allocation should therefore be that an interconnection point is provided in or near the area concerned so that other operators in the same area can hand-over calls without incurring long distance termination rates or additional costs to convey the calls to a distant interconnection point. For example if a city X has a particular number sub-range with a local rate for all calls in that city then an operator must offer an interconnection point within the boundary of the city's numbering area with termination to the city's numbers at the rate for termination inside the city.

At the country level it means that an operator must offer interconnection within the country at the national rate to qualify for numbers within the country.

Recommendation 11: To qualify for an allocation of geographic numbers, an operator should offer interconnection arrangements so that other operators in the same area can hand-over calls without incurring long distance termination rates or additional costs to convey the calls to a distant interconnection point. The best way to achieve this would depend on the national regulatory framework.

12.4 Individual allocation, increasing personal rights and number detachment

NRAs should recognise that existing numbers may gradually become more personal, ie the rights of users increase and the rights of service providers decrease. This could imply a migration towards individual number allocation direct to end users in the longer term. There does not, however, appear to be a great deal to gain from personal allocation. It may seem attractive for numbers that people would like to be memorable, but increasingly callers will not see numbers but see instead the customised names that they have assigned themselves to correspondents in electronic address books.

One aspect of the increasing personal rights of users over numbers would be the use of existing numbers for separate additional services provided by operators other than the one through which the number was allocated. An example would be the use of an existing geographic number for Voice over Internet incoming calls based on ENUM. This is what can be termed "number detachment" because the use of the number becomes detached from the allocating operator.

A move to personal allocation would require a change to any arrangements for number charging.

Recommendation 12: There does not appear to be a great deal to gain from moving to a system of individual number allocation although there is gradual trend for the rights of users over numbers to increase. Developments around "user" ENUM should however be monitored as they could lead to the need to move to personal allocation.

12.5 Allocations to users who are not resident in a country

Nomadcity allows users who are not resident in a country or area to have a virtual presence there for example to enable correspondents to call them more easily or cheaply. This gives benefits to both calling and called users and coupled with the distance independent nature of the communications over the Internet brings extra competitive pressure on tariffs. The practice should be allowed subject to reasonable measures to ensure that adequate numbers remain available for residents and that numbers do not have to be lengthened to meet demand. The operators who provide services using such numbers would be required to provide an interconnection point in the area concerned in accordance with the recommendation above. This would be in accordance with E.164 Clause 7.1, which states: "*The Country Code is used to select the destination country (i.e., the country where the identified subscriber is registered or the country containing a point where the service is provided)...*", since the subscriber would be registered in the country concerned and there would be an interconnection point there.

This practice occurs commonly in mobile networks where non-residents have local accounts to avoid high roaming charges for both incoming and outgoing calls.

Recommendation 13: NRAs could consider exploring the advantages and disadvantages of allowing numbers to be made available to users with or without a link to the country concerned and who are not resident in that country or area to have a virtual presence there, subject to reasonable measures including the need to ensure that adequate numbers remain available for residents and that numbers do not have to be lengthened to meet demand

12.6 Number charging

The changes identified are not expected to affect existing number charging arrangements unless there is a move to personal number allocation.

13 OTHER CONSEQUENCES

13.1 Connectivity

Connectivity - the ability to reach any other subscriber - is important for users. The proliferation of service providers and the introduction of new number ranges threaten connectivity. It may be difficult and time consuming for new service providers with numbers in a new number range to ensure that their subscribers are reachable from all other subscribers and this problem may lead to increasing demands for sub-allocation.

The market based approach does not appear to cater adequately for ensuring connectivity because service providers without market power may collectively hold a significant share of the market and have a joint interest in denying connectivity to newer service providers with technologies that they consider to be threatening such as Voice over Internet.

The growth in popularity of flat rate tariffs resulting from the reduction in costs has created another potential method of discrimination against new number ranges by excluding them from flat rate tariffs.

Recommendation 14: NRAs should monitor carefully the development of connectivity to new operators, and to operators with allocations in new number ranges. They should ensure that existing operators are required to provide connectivity and that new ranges are not excluded unreasonably from flat rate tariff offers.

13.2 Drift to revenue sharing and non-geographic numbers

Many companies prefer to have non-geographic numbers because this provides location portability. In some countries the tariffs to non-geographic numbers have not reduced whilst tariffs to geographic numbers have. This has resulted in scope for revenue sharing with companies who use such numbers, and many companies have changed to use such numbers. This is to some extent an exercise of micro-monopoly power by the called party to the detriment of the caller. When coupled with the ability to exclude numbers from flat rate tariffs it gives incumbents a strong incentive to market such revenue sharing services whilst at the same time excluding the numbers from flat rate calling plans - thus increasing the operators revenue. Regulators need to monitor such trends carefully and take steps to prevent abuse micro-monopoly power by called parties. Such practices have led to many complaints especially when practised by bodies with a public interest role.

Recommendation 15: NRAs should monitor carefully the tariffs for calling non-geographic numbers and the inclusion or exclusion of such numbers in flat rate calling plans and take steps if necessary to prevent abuse of micro-monopoly power by called parties.

14 SAMPLE LONG TERM NUMBERING PLAN

Figure 5 shows how a numbering plan might look in the long term.

Range	Application/service	Geographic structure	Tariff	Nomadacity	Portability	Allocation
A	Fixed, mobile and most other technologies	No	Low	Yes	Yes	Blocks, sub-allocation allowed
E	Personal numbers	No	Low	Yes through number translation	Yes	Block or individual
G	Freephone	No	Zero	Yes through number translation	Yes	Block or individual
I	Premium rate	No	High	Yes through number translation	Yes	Block or individual

Ranges A and E could possibly be merged but are probably best kept separate because personal numbers require mapping to numbers in range A for call delivery and one personal number may map to several numbers in range A. Maintaining the distinction may help to reduce costs although this could be reviewed further in future.

Figure 5: Possible long term numbering plan

15 SUMMARY OF RECOMMENDATIONS¹

Recommendation 1: When the terminating rates for different services are within, say, 20% of each other, NRAs should consider changing the definitions of the scope of services in the numbering plan, in such a way that number portability between all the services concerned can be required.

Recommendation 2: NRAs should introduce new number ranges for new services only when really needed and only if it is quite inappropriate to accommodate the new services in existing ranges. Subscribers should be allowed to retain

their existing numbers for enhancements to existing services and new services that retain compatibility with existing services. The scopes of services allowed for the number ranges concerned should be correspondingly widened.

Recommendation 3: NRAs should study further the implications of removing the geographic significance of numbers within their own country, especially for interconnection and should consider taking this step when the operators start to adopt IP-technology widely.

Recommendation 4: NRAs should recognise that nomadicity is a user benefit and should not apply usage conditions that restrict the user benefit of nomadicity. Such restrictions would not be enforceable in practice anyway. In the longer term, NRAs and ECC NNA should consider proposing revisions to E.164 if the use of cross border nomadicity grows substantially.

Recommendation 5: NRAs should explore the possibility of improving tariff transparency and increasing the scope for convergence and number portability by equalizing termination rates between similar services for example by moving on a glide path towards low or zero termination rates. Further discussion of this is a wider issue than numbering but there is a strong linkage with numbering.

Recommendation 6: The review of the EU Framework should consider enabling NRAs to link maximum retail price limits for calls to each number range as a consumer protection measure (if this is not possible under the current regime) These limits would be well above the level set by competition and protect users in "micro-monopoly situations" where they are unable to benefit from competition.

Recommendation 7: NRAs should be cautious about introducing new number ranges with high retail tariffs as they will increasingly become anomalous as the tariffs for other calls reduce.

Recommendation 8: NRAs should consider updating and broadening number portability requirements between operators of dissimilar services in accordance with the broadening of the scope of number ranges in the numbering plan.

Recommendation 9: There is no need to change the country based structure for most number allocations.

Recommendation 10: Regulators should consider allowing one level of sub-allocation but require any operator who makes the sub-allocation to inform the NRA of the sub-allocation. NRAs should ensure that the party that receives the sub-allocation meets the requirements associated with the original allocation. The means to achieve, including the exact responsibilities of the parties concerned in order to prevent misuse, will need further study.

Recommendation 11: To qualify for an allocation of geographic numbers, an operator should offer interconnection arrangements so that other operators in the same area can hand-over calls without incurring long distance termination rates or additional costs to convey the calls to a distant interconnection point.

Recommendation 12: There does not appear to be a great deal to gain from moving to a system of individual number allocation although there is gradual trend for the rights of users over numbers to increase. Developments around "user" ENUM should however be monitored as they could lead to the need to move to personal allocation.

Recommendation 13: NRAs could consider exploring the advantages and disadvantages of allowing numbers to be made available to users with or without a link to the country concerned and who are not resident in that country or area to have a virtual presence there, subject to reasonable measures including the need to ensure that adequate numbers remain available for residents and that numbers do not have to be lengthened to meet demand.

Recommendation 14: NRAs should monitor carefully the development of connectivity to new operators, and to operators with allocations in new number ranges. They should ensure that existing operators are required to provide connectivity and that new ranges are not excluded unreasonably from flat rate tariff offers.

Recommendation 15: NRAs should monitor carefully the tariffs for calling non-geographic numbers and the inclusion or exclusion of such numbers in flat rate calling plans and take steps if necessary to prevent abuse of micro-monopoly power by called parties.

¹ The Recommendations in this ECC Report should not be mixed with ECC Recommendations.