ECC REPORT 154

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

EVOLUTION OF
GEOGRAPHIC NUMBERS

Luxembourg, November 2010

EXECUTIVE SUMMARY

Geographic line telecommunications services have traditionally used geographic numbering. The development of competition in geographic services has led to a rapid increase in the demand for number blocks and this has created shortages of numbers in some areas and regulators have had to decide on the changes needed to ensure sufficient supply of numbers. At the same time network technology has advance and network costs have changed so that retail tariffs in many countries have become distance independent.

All these changes are causing NRAs to revise their numbering plans and some are removing the geographic significance of numbers from their numbering plans.

This report:

- provides a brief history of geographic numbering explaining its structure and current limitations
- describes and discusses in detail the possible removal of geographic significance from numbers as a means to increase the efficiency of the use of numbering schemes and to permit the introduction of wide area or country-wide location portability.

The report shows that:

- The removal or reduction of geographic requirements for the use of numbers makes the use of numbering blocks much more efficient.
- The removal or reduction of geographic requirements for the use of numbers also makes possible wider area location portability, but it is normally an optional commercial decision by operators whether or not to offer such portability within their own networks. The technology needed, though is the same as for service provider portability. In this context it may be appropriate to introduce a common service provider portability and location reference database containing all numbers.
- There are alternatives for removing geographic information from the numbering plan when a solution is needed for a situation of scarcity in numbers, such as reducing the size of the number block allocations or closing the dialing plan.
- There are different ways of reducing or removing requirements for geographic information. Considering that the main target of a numbering plan is to facilitate technological and commercial developments, different steps in time can be taken as appropriate. This would meet new users' and operators' requirements or could solve number scarcity, but limit negative effects for end-users and operator.
- The process in which geographic information is (gradually) removed from the numbering plan depends on the country-specific market situation and situation with regard to levels of capacity use within the existing numbering plan.
- The dialling plan is unrelated to removal of geographic significance of numbers, although the impact of the removal of geographic significance of numbers might depend on whether the dialling plan is open or closed.

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Evolution of Geographic Numbers

1 INTRODUCTION

Geographic line telecommunications services have traditionally used geographic numbering. The development of competition in geographic services has led to a rapid increase in the demand for geographic subscriber number blocks and this has created shortages of numbers in some countries or areas and regulators have had to decide on the changes needed to ensure sufficient supply of numbers.

Even though many subscribers have terminated their geographic voice service subscriptions as mobile phones have become their only communications means, this trend has not compensated for the increasing demand for number blocks because the numbers released are scattered and not organised in neat blocks that can be re-assigned. Thus the use of geographic numbers is becoming increasingly inefficient.

At the same time network technology has advanced making location portability possible and network costs have changed so that retail tariffs in many countries have for the most part become distance independent.

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

Traditionally numbering plans distinguish between geographic and non-geographic (mobile telephone number ranges, freephone, shared cost, etc). Different termination rates which result in different retail tariffs are the major reason for this distinction. The majority of numbers traditionally belonged to geographic telephony but this is now rapidly changing. Although it is possible to use modern smart phones for different applications with a single number, some users demand a 2^{nd} or 3^{rd} mobile number for their portable equipment, such as for mobile broadband for laptops. Furthermore, since services such as machine-to-machine communications typically require mobile numbers, some NRA’s may need to find new numbering resources for mobile applications. Even if there would be spare capacity in geographic numbering ranges, it is difficult or impossible to move it fluently to mobile usage. Therefore, some countries are considering rearranging their numbering plans in order to free capacity for increased demand of mobile numbers.

This report:

- provides a brief history of geographic numbering explaining its structure and current limitations
- describes and discusses in detail the possible removal of geographic significance from numbers as a means to increase the efficiency of the use of numbering schemes and to permit the introduction of wide area or country-wide location portability.

2 SCOPE

The main purpose of this report is to assess the implications of removing or reducing the geographic significance from geographic numbers, which both increase the potential efficiency of the use of geographic numbering schemes and permits the introduction of wide area or country wide location portability. The full implications of closing the dialling plan, which might be done alongside the reduction or removal of geographic significance, are outside the scope of this Report As in some cases the difference between an open and a closed dialling plan is relevant for describing the impact of reducing geographic significance from numbers, in some cases a reference is made to such situation. This issue may be part of further studies of the Working Group Numbering and Networks (WG NaN). The implications that are discussed in this Report include those for users and those for network operators.

The report also provides a brief history of geographic numbering explaining its geographic structure and current limitations.

Mobile numbers and services with non-geographic numbers (e.g. freephone, shared cost and premium rate) numbers are outside the scope.

This report is compatible with the Recommendations of ECC Report 87: The Future of E.164 Numbering Plans and Allocation Arrangements.

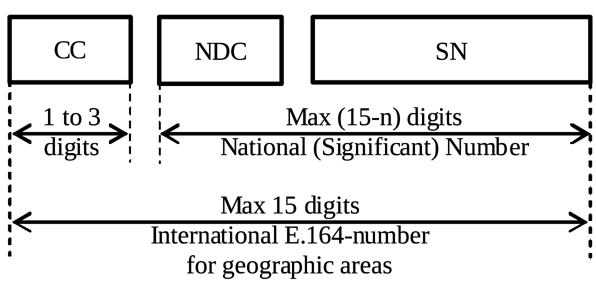
3 REFERENCES

[1]	ECTRA Report 48381 A Long Term Strategic Plan for the Numbering and Addressing of Telecommunications Services in Europe 6 December 1999
[2]	ITU-T Recommendation E.101 Definitions of terms used for identifiers (names, numbers, addresses and other identifiers) for public telecommunication services and networks in the E-series Recommendations Geneva, 11/2009
[3]	ITU-T Recommendation E.164 The international public telecommunication numbering plan 02/2005
[4]	ECC Report 126 Fixed-Mobile Convergence with Survey of Numbering Related Issues Ljubljana, October 2008
[5]	ECC Report 87 The Future of E.164 Numbering Plans and Allocation Arrangements Lisbon, September 2006

4 BACKGROUND OF GEOGRAPHIC NUMBERS

4.1 Introduction to Geographic Meaning of Numbers

Country codes[1] assigned by the ITU TSB Director have a geographic significance covering the whole world. Consequently, dialling an international prefix, typically ‘00’, indicates that the following 1-3 digits represent the country code. Therefore the country code defines a destination country or a geographic area in the world. The digits following the country code may have geographic significance within this country or geographic area defined in the national numbering plan but also other numbers such as mobile numbers apply. Figure 1 shows the structure of an (ITU defined) international E.164 number.



CC   Country Code for geographic area
NDC   National Destination Code
SN   Subscriber Number
n   Number of digits in the country code

NOTE – National and international prefixes are not part of the international E.164-number for geographic areas.

Figure 1: The structure of an E.164 number for geographic areas

[1] In this chapter, a country code represents a country code for a geographic area (one country or a group of countries in case of a shared CC, e.g. ‘1’ for North American Numbering Plan).

Traditionally, the above mentioned factors had an impact on an operator's network architecture, which was historically based on geographic division (meaning) of numbers. Figure 2 illustrates a simplified example of a geographic network hierarchy.

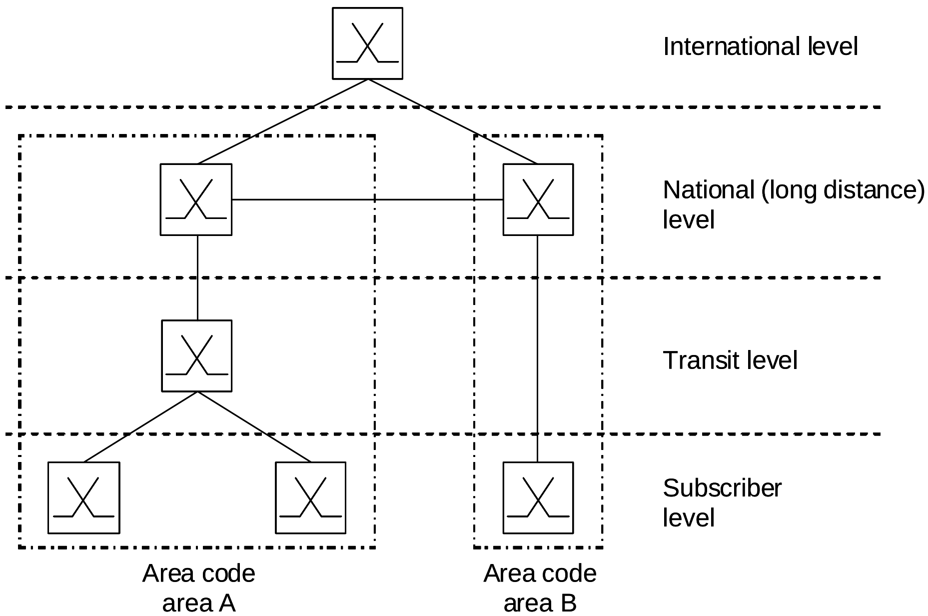


Figure 2: An example of a geographic network hierarchy

4.2 A Brief History of Geographic Numbers

The oldest and best known telephone numbers are the geographic numbers. Typically, the most significant digits of these numbers (area code or national destination code, NDC) indicate a geographic area (i.e. a numbering area) in a country in which a geographic telephone access point is situated physically. In most countries the numbering plans or associated regulations state that the physical network termination point associated with a geographic number has to stay within the geographic area as defined by the numbering plan. There was a strict relationship between the network architecture of the geographic telephone network and the geographic subdivision into numbering areas (figure 2)

In addition, the end-user's calling tariff depended greatly on the distance. Consequently, it was possible for the caller to estimate the tariff based on the geographic telephone number dialled: dialling a national (trunk) prefix (typically 0) and a NDC indicated a long distance call, which typically was more expensive than a local call dialled just with a subscriber number without NDC. For users in countries with distance dependent tariffs this "tariff transparency" has been very important.

Development of switching and transmission technology allowed a larger number of subscribers to be connected to the same switch. Furthermore, it became possible to build semi-automated telecommunication networks with larger numbering areas as technical limitations were gradually removed. In many countries this development resulted also in larger areas with a single charge for calls, meaning, for example, that locally charged calls to geographic numbers were possible within the whole numbering area. Dialling between numbering areas required a national (trunk) prefix and these calls were recognised as long distance calls charged more expensively than a local call, as mentioned above.

These developments allow possible changes to be made to the numbering plans that would previously have been impossible or extremely expensive.

4.3 Characteristics of Geographic Numbering

4.3.1 Name, Address and Tariff Indicator

In the past, geographic telephone numbers combined several characteristics. The number not only represented a subscription or 'name', but also indicated the location or 'address' of the network termination point both in real geographic terms and in terms of network topology because the two were strongly linked by the limitations of the technology. Furthermore, where there was distance dependent charging the "address" or geographic information in the leading digits of the number (NDC) enabled the caller to estimate the cost for a call.

4.3.2 Number Structure and Length

The structure of an E.164 number was given in Figure 1. For a geographic number, the National Destination Code (NDC) is a code with geographic significance and is called the "area code". The term National Destination Code is also used for mobile numbers and "Destination" does not always refer to a geographic area and so it can also be used where the geographic numbers have become non-geographic.

The international maximum length of a telephone number is 15 digits (see chapter 4.1) as defined in ITU-T recommendation E.164. Before digitalization of the telephone network, the analogue switches typically had limitations in handling long numbers and the maximum length was shorter. Today national networks are normally capable of handling longer strings of numbers than 15 digits and this capability for example enables prefixes for carrier selection or routing numbers for number portability to be added to numbers for use within a country.

Some countries have chosen to have a fixed number length of telephone numbers, while others have a variable number length. The fixed number length determines the capacity of numbering resources. For example, with 8 digits number length, in theory, 10^8 numbers (100 million) can be used.

Variable number length gives more flexibility in capacity, but may require more intelligence in the number analysis that is performed by switches.

4.3.3 Distinction between numbering plan and dialling plan

A numbering plan specifies how the national numbering space is subdivided into different ranges of numbers for different services such as:

- Geographic
- Mobile
- Freephone
- Premium rate
- Others.

For geographic numbers the plan subdivides the geographic numbering range into areas associated with a specific value of the most significant digits, which are called the "area code". The plan specifies the length of each number range and defines the classes of service that may use each numbering range. Because of the importance of tariff transparency, the numbering ranges may each be associated with a permissible range of call termination rates, which have a major influence on the retail rates of calls. Prefixes, suffixes and/or additional information required to complete the call are not part of the numbering plan.

The dialling plan is in principle distinct from but related to the numbering plan and "defines the method by which the numbering plan is used". A dialling plan includes the use of prefixes, suffixes, and/or additional information required to complete the call. Essentially the dialling plan specifies primarily:

- When the whole number has to be dialled and when the most significant digits may be omitted (e.g. reduced length dialling)
- What the national prefix (typically 0) is and when it must be added
- What the international prefix (typically 00) is and when it must be added
- What carrier selection codes may be used and how they must be used.

The method may be different depending on whether the caller is using a fixed phone or a mobile phone.

A dialling plan that always requires a full length number (N(S)N) to be dialled is called a “closed” dialling plan, whereas a dialling plan that allows for dialling of a reduced length number (subscriber number without NDC) in certain circumstances (e.g. only SN within the same area code) is called an “open” dialling plan. Note that the terms “open” and “closed” refer to the dialling plan only and not the numbering plan. In an open dialling plan, a “national prefix”, typically 0, is commonly added before the national (significant) numbers (N(S)N), but this is not the case in all countries (e.g. not in North America). A number of countries have changed from an open to a closed dialling plan since this can help to alleviate shortages in geographic numbers, although major changes can also be made to the numbering plan whilst retaining an open dialling plan. The closure of the dialling plan makes it possible for an average of 20% increase of usable numbering capacity for allocation[2] of geographic numbers since subscriber numbers starting with 0 and possibly also with 1 can be introduced in the numbering plan if they were not used before because of possible conflict with full length numbers and short codes. Full length national dialling has proved to be fairly easy for users to accept since they had become familiar with always dialling a full length number to call a mobile number. No countries are known to have moved from a closed dialling plan to an open one. The implications of closing the dialling plan are out of scope and will therefore not be discussed further in this Report.

4.4 Geographic numbers and tariff transparency

Tariff transparency, or the ability to predict the tariff at least approximately through a simple examination of the called number, is extremely important for users within distance dependent tariff schemes.

Today, in many countries with an open dialling plan calls in the same numbering area are covered by a local (in most cases cheap) tariff scheme while calls between numbering areas, in most cases, are considered as long distance calls which are more expensive. In case, where a geographic area is covered by more than one numbering areas, e.g. because of addition of a new area code to avoid number exhaustion, a call between these numbering areas may not be considered as long distance calls. In countries with a closed dialling plan with distance based tariffs it will only be possible for end-users to estimate the cost of a call if the geographic significance of numbers is retained e.g. by prohibited location portability. Thus if the geographic information is removed it will only be possible to have a single tariff independent of distance if tariff transparency is to be maintained. Conversely retail local and long distance tariffs must converge to a single tariff before geographic information can be removed without destroying tariff transparency.

The arrangements for local tariffs today differ widely in different countries but are normally based on applying charging algorithms to the calling and called numbers. At least the following three possibilities exist:

- Calls between numbers under the same area code are always charged at the local rate but calls between different area codes are always charged at the long distance rate. (e.g. this means that calls between subscribers located either side of the boundary of a area code where the distance between the subscribers is quite short are always charged at the long distance rate).
- Calls between numbers under the same area code are always charged at the local rate and short distance (compare example from the previous bullet point) calls between different area codes are also charged at the local rate but others are charged at the long distance rate. In this case the charging is based not on the area code only but on the area code plus additional digits, i.e. on charging areas that are smaller than the area delineated by the area code.
- There is no simple relationship between the area code and the tariff so that both calls under the same area code and calls under different area codes may be charged at the local rate or at the long distance rate. In this case the charging is based not on the area code but on the area code plus additional digits, ie on charging areas that are smaller than the area delineated by the area code. For the end-user, this therefore provides very limited, if any, tariff transparency.

In all three cases, the calls between numbers under the same area code can use local dialling under an open dialling plan.

[2] The actual increase depends on the existing numbering plan.

5 REMOVAL OF THE GEOGRAPHIC SIGNIFICANCE IN THE NUMBERING PLAN

5.1 The underlying changes

5.1.1 Technological changes

The concept of geographic numbers is changing. For instance in more and more countries the rule of strict coupling between the physical location of a connection point and the geographic information in the geographic number is given a more flexible interpretation (e.g. in nomadic VoIP services). To retain tariff transparency the removal of geographic information must be preceded by the retail end-user tariff schemes becoming correspondingly distance independent, e.g. the same tariff within a numbering area. This is made possible by the technological evolution as a result of which the network costs for the provision of telecommunications services have decreased and have become (almost) independent of the distance. How distance dependent charging works is not central to this report but Annex 1 provides a brief explanation.

The removal of geographic information in the numbering plan is independent of the closure of the dialling plan since geographic information is a numbering plan issue and not a dialling plan issue. Nevertheless where there is an open dialling plan subscribers may have a greater awareness of the geographic meaning of numbers and so they may have a stronger perception of the change than subscribers in a country with a closed dialling plan. This aspect may cause that the social and economic impact of the removal of geographic information may be stronger in the situation that a dialling plan is not closed.

In practice, where tariffs for calls are distance dependent there are normally only two tariff levels, local and nationwide. In some countries there may be three levels, local, regional and nationwide. This section is written on the assumption that there are only two levels but the extrapolation to the situation with three levels should be relatively straightforward.

In any network with more than one switch for geographic services, the network unavoidably has a geographic structure.

This situation does not change. What does change is:

- The rules about geographic structure given in the numbering plan
- The extent to which the geographic structure of the physical network is hidden from or exposed to the users.

Geographic numbers are normally structured as an area code followed by a subscriber number. The geographic information is the linkage between the area code (the most significant digits of a number) and a geographic area with defined boundaries.

Originally there was normally one area code per area but in some countries there may be more than one area code because additional area codes were allocated to an area to handle growth in demand for numbers.

Each operator is normally assigned a number block (typically 1.000 or 10.000 numbers) that is a subset of the subscriber numbers under the area code.

An area code area normally equates to the area covered by a local switch in the incumbent's network but:

- In geographicly large countries with low population densities one switch may serve more than one area code
- In densely populated areas more than one switch may serve the same area code.

Annex 2 gives more information on the relationship between numbering, local switches and concentrators.

5.1.2 The influence of efficient use of numbers

The introduction of an open market for geographic telecommunications has created a very large increase in demand for geographic numbers from new service providers. As new service providers/operators enter the market they require geographic numbers in each numbering area. If the numbering plan is divided into many comparatively small areas then the service providers will need a block in each area even if they have only one of a few subscribers in each area. In addition, the population density and economic activity in a country is usually highly concentrated in certain geographic areas, for example big cities, that consequently need a lot of numbers while in other areas of more of less the same size, this is not the case. This fragmentises the numbering plan and causes numbers not to be used efficiently, dependent on the country-specific situation.

As there may be alternatives for a country to increase the efficiency of the use of numbers, such as reducing the size of the number block allocations, the possible driving force for removing geographic information has a wider scope than purely the efficient use of numbers.

5.2 Location portability

Location portability refers to a subscriber's ability to move geographically while retaining his number and service provider. Few, if any, regulators require location portability thus whether or not it is offered and how expensively it is offered is a commercial matter for operators.

Annex 2 explains the relationship between number blocks, local switches and concentrators within a network. Location portability is possible within the area covered either by a concentrator or by a local switch or by the area code depending on the policy of the operator with respect to concentrators.

Networks with more than one switch need location information to route the call. If this information is removed from the number then it is not deleted altogether but transferred from the number to routing numbers that are put in front of the number.

There are at least two technologies that can be used for wider area location portability within a network:

- Onward routing from the local switch identified by the number block. Calls are routed to the local switch then a routing number is added to indicate the new network location of the number and the call is routed to that location. This onward routing is the same as is used for service provider portability and so is likely to be available in most network within the EU already. (NB: Even where the number portability solution uses All Call Query, onward routing is normally also available for calls from foreign networks.)
- ACQ from the originating switch or interconnection point where the call enters the network. This would add a routing number for the network location and route the call direct to that location.

These alternatives are shown in figure 3, whereby switch B was the former termination point of the called number.

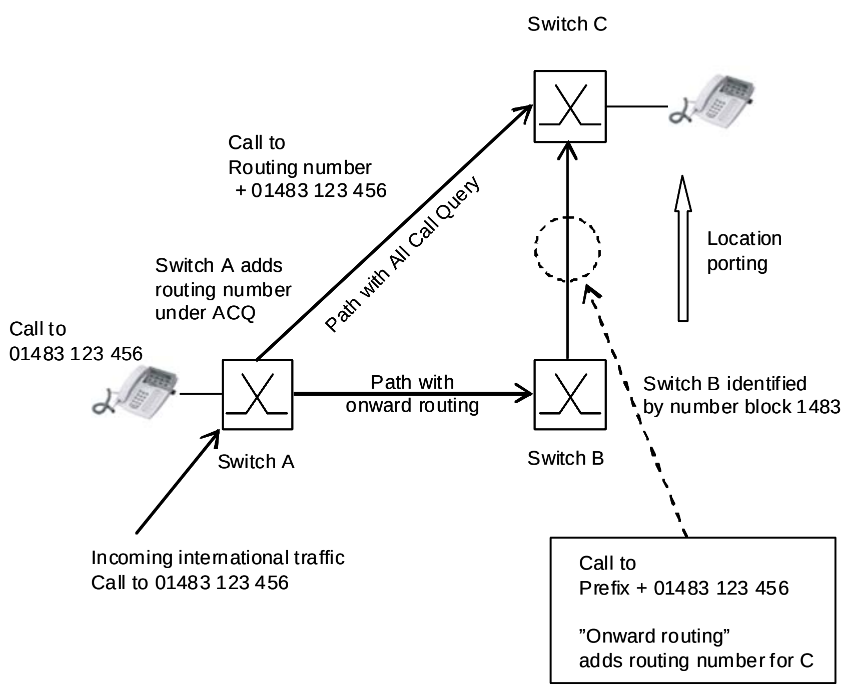


Figure 3: Alternative methods of providing location portability within a network

Location portability is typically implemented only in the network that serves the called number, and there is no mechanism to inform other networks when a number changes location within a network. Thus at present it is not possible for other networks to use "All call query" (ACQ) to route directly to the correct location.

5.3 Location portability and the effect on interconnection

Although in many countries retail tariffs are no longer distance dependent, wholesale tariffs for interconnection are still distance dependent. At the wholesale level distinctions between local, single transit and double transit remain and provide an incentive for an operator to carry a call to a geographic number as far as possible within its own network. This is called "far end handover". The opposite is "near end handover" where the calling network does not know the destination in the called network and so hands the call over as soon as it can. "Near end handover" is used for calls to mobile networks.

Figure 4 shows the difference between near and far end handover.

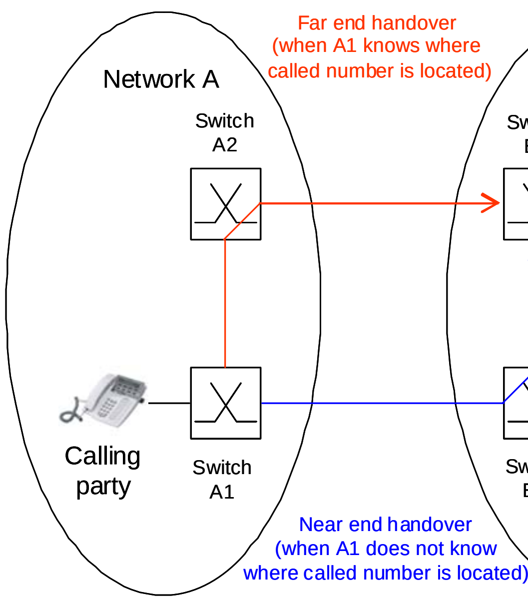


Figure 4: Near and far end handover

The wholesale charging algorithms are based on the number block of the called number (for termination, the calling number for origination in carrier selection) and the network location of the interconnection point.

If location portability is introduced within networks then interconnection rates will cease to be accurate for numbers that have changed location since the destination switch indicated by the numbering block will no longer be accurate. Operators may choose to accept this situation as long as the proportion of numbers that have changed location is small.

The removal of location information from the numbering plan will not affect this wholesale charging immediately because numbers will and network architectures will not move/change immediately. Existing operators may not change their practices other than introducing wide area location portability, however new entrants will probably start to use their number allocations over the whole country creating a situation where:

- There is no regulation over where a number may be used;
- Existing ("old") operators still follow the old geographic numbering plan although increasingly less accurately, so far end handover for calls to existing networks is still possible;
- New operators use numbers anywhere in the country so networks calling them use near end handover.

This situation may lead to a review of interconnection with two quite different possible outcomes:

- The distance element is removed from interconnection rates, in which case all operators adopt near end handover and location portability can remain within a network; or
- The distance element is retained in interconnection rates but operators have to exchange information on location so that far end handover can still be used. Since the called number no longer contains any location information, the location information would have to be specific to each number, e.g. by using a specific routing number.

Where operators have to exchange information that is specific to each number, this could be done using a reference database (central or distributed) similar to that used for service provider portability but containing all numbers not just numbers ported between operators. In effect every number would be treated as if it were location ported. Thus operators would have to add a routing number to each number in the reference database. This means that operators would have to disclose to each other the location structure of their network at least in terms of the interconnection points or switches closest to each number. The same reference database could be used for both service provider portability and location information.

Figure 5 shows a call from Switch A1, which looks up its copy of the reference database (as in All Call Query) to find the location of the called party in the form of a routing number that is added to the called party number. The location is given using a routing number that identifies switch B2. Switch A1 routes the call via Switch A2 to the closest interconnection point to the called number. Figure 5 is an example of far end handover.

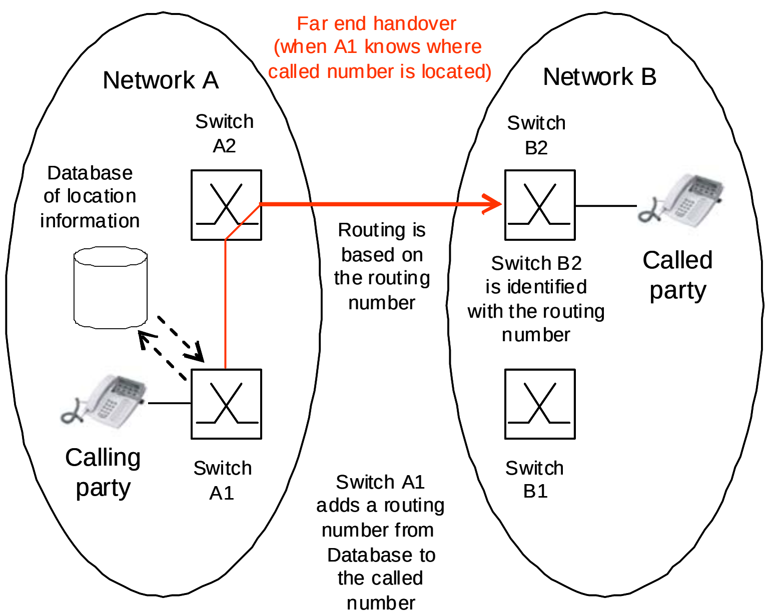


Figure 5: Routing between networks when location information is shared

The relationship between location number portability and service provider portability is explained in annex 3. Furthermore a brief explanation of the effect of migration to NGN is given in annex 4.

6 SUBSCRIBER VIEWS OF GEOGRAPHIC INFORMATION IN GEOGRAPHIC NUMBERING

Geographic numbers enjoy a very positive image unlike, for example, premium rate numbers. This mainly stems from the relative low end-user tariffs for calls to these numbers, the universal smooth interoperability and the lack of fraud options and attempts. Generally all stakeholders, including service providers and end-users, would like to retain this positive image.

Many callers like to be able to see geographic information in a geographic number especially when browsing potential services (e.g. plumbers) as it gives them an idea where the service is be based. This may affect their perception of the likely cost of the service (does it come from an expensive area or a less expensive one? How much is the call out charge likely to be?). Although in some circumstances more accurate location information is provided via other means than the telephone number (e.g. in Directory Enquiry Services), the number area code remains a quick reference point for this information.

Conversely local businesses, e.g. car repair garages, are likely to prefer a number that looks like the numbers of the people close to them, e.g. same area code, as many potential customers are looking for a local service. Thus, although the importance of an area code for users outside that area may be limited as the average user only knows the area codes of his own and adjacent numbering areas as well as some larger urban numbering areas, the importance may be still significant for local users.

Some nationwide businesses, however, would prefer to have non-geographic numbers so that they have flexibility to move their offices anywhere in the country without changing numbers provided that their operators offer this location portability. This is also the case when the business offices are spread over the country and wants to have the same number to all offices. Thus there appears to be both demand for geographic numbers and demand for non-geographic numbers but with similar “safe” and attractive tariffs.

The user-friendliness of numbers may become of less importance due to developments in technology and the simplification of the user interface of electronic communication networks in the long term future. Nevertheless, a practical issue which will at least in the near future remain relevant is that most numbers that are relevant for a certain user are easier to memorize when keeping the geographic information, because a single user is familiar with the area codes of the numbering areas that are most relevant to him. This advantage must be set off in those circumstances against the benefit of location portability when people move between geographic areas.

It is difficult to predict to which extent consumers will make use of location portability which would have an effect on the reliability of the geographic information in the number as mentioned above. This depends in the first place on the number of times that consumers move from an address in one geographic area to another area. As an example, the Dutch situation can be given where about 2,5% of the population changes address in a year (400.000 movements in a year). For movements inside geographic areas, which takes less than half of that number, geographic numbers are ported on a large scale. From this viewpoint it may in principle be assumed that - when national location portability is offered without costs for the consumer - a significant amount of numbers will be ported between different geographic areas. However, the validity of that assumption is doubtful since for moving between different numbering areas other factors related to the use of a geographic number become important, as explained below. Moreover, experiences in other countries tend to show that the average consumer does not consider it important to be able to port a number between regions, as consumers are generally not prepared to pay for such portability, where this is offered.

7 IMPACT OF REMOVING GEOGRAPHIC INFORMATION FROM THE NUMBERING PLAN

The following assumes that geographic information is removed only after retail tariffs have become distance independent. If it is removed before, then tariff transparency is lost and this is a major issue for callers, but most regulators would require adequate tariff transparency so this situation is unlikely to occur. Furthermore, the situation in which the dialling plan is open versus the situation in which it is closed may influence some of the impacts of removing geographic information. Where relevant, this influence is described. Nevertheless, as mentioned earlier changing between an open and a closed dialling plan is a separate issue than the process of removing geographic information in the numbering plan.

7.1 General impact

7.1.1 Increased Efficiency in Using Numbers

As explained earlier, the introduction of an open market for geographic telecommunications has created a very large increase in demand for geographic numbers from new service providers. Where there are distinctions between service providers and network operators numbers, some NRAs assign numbers to service providers rather than network operators and this further increases potential demand. As new service providers/operators enter the market they require geographic numbers in each numbering area. If the numbering plan is divided into many comparatively small areas then the service providers will need a block in each area even if they have only one of a few subscribers in each area. Thus the growth in the number of service providers/operators leads to a rapid growth in demand for geographic numbers. Removal of geographic information would therefore decrease the fragmentation of a numbering plan.

In addition, the population density and economic activity in a country is usually highly concentrated in certain geographic areas, for example in big cities, that consequently need a lot of numbers while in other areas of more of less the same size, this is not the case. The complete removal of geographic significance may thus lead to additional numbering capacity because cutting losses of ranges applied to certain geographic areas disappear. It is strongly dependent on a country's situation how big this benefit could be.

In practice new operators will typically serve a large area encompassing many area codes from the same switch. Thus they would need only one number block for the switch for a large area if the geographic rules did not apply. However, under the geographic rules they require many blocks which will be relatively underused. Therefore, removing the geographic rules for geographic numbers would reduce the demand for new number blocks and increase the effective number capacity utilisation, i.e. increase the efficiency of use of numbers.

Other approaches to address the problem of inefficient number use without removing the geographic structure are to reduce the size of the number block allocations or to close the dialling plan. The first of these has the effect of increasing the loading on the processors in switches because it increases the size of routing tables. The second of these makes more numbers usable for allocation in the existing numbering plan. These could be alternatives to a major change in the numbering plan.

7.1.2 Effects on competition

The effects of the removal of geographic information on market competition are twofold. They consist of *market restructuring effects* on existing operators, and of *lowering barriers for market entry* for parties potentially looking to enter the telephony market.

Market restructuring effects might occur since the implementation of location portability, requires new investments in routing mechanisms. When distance related interconnection tariffs remain, this may have impact on the relative market position of originating and terminating operators. There are two possible situations:

- The originating operators invest in a new system (e.g. based on ACQ) for supporting location portability. If only the large operators can afford to use such systems, which is normally the case, these operators can strengthen their market position as they are able to interconnect with terminating networks for low interconnection rates (because they deliver traffic needing the shortest route in the terminating network, i.e. far end handover).
- If the originating operators do not invest in a new system, the implementation of location portability is solely in the hands of the terminating operator, i.e. near end handover. Not always will this operator be able to route the traffic via the shortest path in his network, so more costs are involved which can only be recovered by charging location portability to the end-user.

It should be noted that when service providers are obliged to offer location portability, these effects can be stronger.

With regards to barriers to market entry, it is important to consider that in the situation that the geographic information is maintained, this constrains opportunities to parties that do not use the traditional telephone network to enter the market. This mainly concerns operators that do not have any control of the physical connection to end-users (including the local loop), such as VoIP operators, in contrast to new operators like VoDSL and cable telephony operators. On the other hand, removing the geographic structure will give operators that already have invested in network infrastructure supporting the geographic structure (both traditional and operators that recently entered the market), a disadvantage.

In summary:

- Market restructuring effects could result in strengthening of the position of large operators and this would be a negative consequence of removing geographic information
- The lowering of barriers of entry would be a positive effect of the removal of geographic information
- If removal of geographic information results in the uniform use of near-end handover (with uniform termination rates), this aspect would affect competition neither positive nor negative. The only consequence would be that location portability would be a service for which an end-user would likely have to pay.

It is difficult to assess whether there is a net benefit on competition.

7.1.3 Effects on services

New types of services based on innovative use of geographic numbers will be possible but this process will merely consist of a transition from existing services to new ones rather than a larger size of the market in total.

7.1.4 Economic effects on the end-user side

Companies wishing to have a local image but utilizing a central call centre outside of the concerned numbering area will be facilitated in the routing of their traffic if geographic information is removed. There would be no need anymore to route such traffic via the subsidiaries of these companies in certain numbering areas, resulting in shorter and less costly route paths.

Furthermore, with the removal of geographic information a high demand could arise for numbers in number areas with "vanity area codes" by companies outside those areas. That development may lead to the erosion of the existing ("good") image of certain areas. As companies tend to base their location behaviour on amongst others, the image of the region, such behaviour may disadvantage the existing "good image" areas.

7.2 Impact per stakeholder

7.2.1 Impact on operators

Removing or reducing geographic requirements from the numbering plan does not immediately affect operators. Such a change would not require the operators to change their use of numbers. Operators would start to be affected only when the use of numbers starts to change in practice. New entrants are likely to introduce changes before incumbents as new entrants often have the latest technology and a smaller number of subscribers spread over a wide area.

The three main impacts of removing or reducing geographic requirements from the numbering plan are:

- The efficiency of use of numbers can increase because new entrants with only a few subscribers will not need so many different number blocks;
- Operators can offer wider area location portability;
- The accuracy of cost based call termination rates will decrease.

The introduction of location portability on a voluntary commercial basis within an operator's own network will not necessarily be difficult or expensive for operators that already implement service provider portability, which is a regulatory obligation in many countries. So long as the volume of numbers ported between locations is small the effects are very limited.

The growth of location portability, or the removal of geographic information from number allocation as well as use, may lead to the need to:

- remove the distance element in interconnection charging so that operators change from far end handover to near end handover for calls between networks; or
- share location information between operators on individual numbers e.g. by implementing a national reference database for the location of numbers, similar to the national reference databases needed to support service provider portability but containing all numbers not just ported ones, i.e. ACQ (Note - such databases can be either centralised or distributed). This may in turn require a review over how number portability routing numbers are used.

Operators should check their support systems to ensure that changes in the relationship between numbers and geography will not cause any problems due for example to number based checks that are embedded in the software to prevent data entry errors.

7.2.2 Impact on end-users

Removing geographic requirements from the numbering plan does not immediately affect end users. Users are affected only when:

- Operators introduce location portability using additional techniques in the PSTN or using the full flexibility of the NGN
- Mainly new entrant operators start to assign numbers from the same numbering block over a much wider area that is used by the incumbent.

- Regulators start to make new numbering assignments to operators where these assignments no longer follow the old numbering plan rules.

The main advantage for end-user will be the possibility to port their old geographic number (that no longer is a geographic number) between different areas. This may reduce administrative burden for businesses, especially in cases of movements within the same urban area, but between different numbering areas where the change of the number would not be “logical”.

When these activities start this will not lead to a direct loss of geographic information but the certainty about geographic information in the number will decrease. A migration process starts, the speed of which depends on the amount of location portability that is applied. For the majority of numbers that have not moved the location, the information remains accurate according to the former geographic structure in the numbering plan, but for the minority of numbers that have moved it becomes inaccurate. Thus, although there will be a slow breakdown rather than a sudden collapse of geographic information, from the start of the process callers can no longer be 100% confident that a given number is located in a certain area.

Apart from the speed of the process in which geographic information is lost, this loss may lead to (slightly) more confusion to consumers in the case of an open dialling plan than in the case of a closed dialling plan. An example is the situation where local level dialling is not possible for calling a person next door because the number of the called person is ported from a different area code, while another person at a further distance in the same geographic area can be reached via local level dialling, and another person far away can be reached via local level dialling because the called person has ported his number from the same area code than the calling person. This will confuse consumers, e.g. regarding the perceived tariffs of the call. It is difficult to say how strong this impact is because user perceptions are involved. Another consequence is that when a certain person moves from area A to B, a person in area A wanting to reach the person in area B can do so using local level dialling, but can only do so if he knows the geographic area where the called person has moved from. This will not work in practice.

It should also be noted that the increased demand for numbers may have already made it necessary for regulators to allocate new unfamiliar area codes to some areas in parallel with existing familiar area codes. This will have already started to reduce the degree of location transparency for many callers.

7.2.3 Impact on service provider portability

Service provider portability should not be affected initially by the removal of geographic information from the numbering plan. As stated earlier, the operation of networks may not change at all. If wide area location portability is introduced then this can be compatible with service provider portability by routing between networks using the existing number analysis and portability arrangements and then handling the location portability within the recipient network (near end handover).

In the longer term it may become necessary to upgrade to a nationally integrated location and service provider portability system with a reference database for both purposes. The use of routing numbers may then need to be reviewed and inter-operator charging may be based on routing numbers (far end handover). This should be considered by national regulators as part of the longer term plans for NGNs.

7.2.4 Impact on Emergency calls

In the geographic telephone network calls to emergency numbers are routed towards different regional PSAPs (Public Service Answering Points) based on the caller’s location. The originating switch adds a specific routing number to an emergency call identifying the specific PSAP to where the call is routed. The algorithm for determining this code is based on analysis of the CLI in many countries, or the switch may always use the same routing number if all its lines are served by the same PSAP. It is likely that removal of geographic information would affect these algorithms and there would be a need to change the approach.

The calling line identification is, however, always transferred to the emergency services to allow a lookup of necessary additional information (e.g. the name and address of the caller). This information could be obtained from a database or by asking the service provider/operator that serves the calling number and may give more accurate information on the location of an incoming call. Thus, for determining the location of the incoming call the geographic information in the number is becoming less important.

In conclusion abandoning the link between a geographic number and a specific numbering area could have an impact on the way emergency services work today. In many cases a new approach would be needed to determine the location of an incoming call. Such a new approach may be superior to deriving the location of the call from the number.

7.2.5 Impact on Lawful Interception

Normally legal intercept equipment is connected to switching nodes. The fact that geographic telephone numbers are being used outside their original numbering area (e.g. a nomadic use) may mean that the law enforcement authorities have to look up a database to find out which local switch serves a given number but major impacts on exiting procedures are not foreseen.

8 SCENARIOS TO SUPPORT REMOVAL OF GEOGRAPHIC INFORMATION FROM THE NUMBERING PLAN

8.1 Introduction

The removal of geographic information in the numbering plans has a number of different effects. End-users (consumers and businesses) and operators will be affected by this removal and it is important to consider the most likely effects when deciding how to deal with the geographic information.

Generally there seem to be three different ways of dealing with this issue;

A. maintaining geographic information;

B. facilitate evolutionary process of diminishing geographic significance of numbers;

C. removal of geographic information.

Countries may choose one of these possible approaches depending on their national situations and depending on the actual and potential effects of removing geographic information.

8.2 Description of scenarios for removal of geographic information from numbering plan

8.2.1 A. Maintaining geographic information

A basic option is not to change any rules on geographic information in the numbering plan. There might be reasons why a country feels it is not beneficial at this time to remove geographic information from the numbering plan. For example, if it is perceived that removal might lead to serious problems for end-users and operators or that removal of geographic information could have negative effects on competition, a country might want to decide not to facilitate changes to the numbering plan that relate to the geographic information until these effects can be made clear.

The benefit of such an approach is that nothing changes for end-users, which might be a very important consideration. On the other hand, the negative aspect of this option is that it does not allow for innovative use of geographic numbers, since it does not

- include the possibility for operators to offer location portability.
- lower barriers to entry into the market for new parties.
- provide opportunities to parties that do not use the traditional telephone network such as VoIP-operators to enter the market.

Furthermore, it does not provide the benefit of more efficient use of numbering resources that removal of geographic information would offer. For the latter however, there are possible alternatives. In the case of an open dialling plan, the need for more efficient use of numbers may already be reduced by closing the dialling plan as described above. Furthermore, assignment of numbers in smaller number blocks may be considered.

8.2.2 B. Facilitate evolutionary process of diminishing geographic significance of numbers

A second approach that a country might choose to deal with the removal of geographic information is an evolutionary one. This would mean that numbering policy would facilitate a more flexible use of geographic numbers on a step-by-step basis, by changing current rules only if requested or if necessary because of number shortages.

This policy option is in line with the basic principle that numbering policy follows of facilitating natural market developments and not itself influencing such market developments.

The removal of geographic information is not necessarily a binary process (all or nothing) but different degrees of removal are possible. They include:

B1. Introduction of a non-geographic numbering range alongside the existing geographic ranges.

B2. Merging smaller areas into larger areas.

B3. Maintaining the geographic structure for the initial assignment of numbers but allowing or obliging location portability to be provided outside the specified area if the subscriber moves and want to keep his number.

B4. Removing the relationship between the area code of the geographic number and the area of termination of calls to the number (nomadic use), but still requiring that the home or business location of the end-user corresponds with the area code.

The benefits of such an approach might be that the development of the numbering plan goes hand-in-hand with the demands from consumers and companies. For example, in option B3 allowing location portability would make it possible for those who want to retain the geographic information in their number to do so, while not restraining others who do not find this useful. Similarly, in option B4 by reducing requirements on the use of geographic number innovative new services could be facilitated. It would, furthermore, mean that if unforeseen market-restructuring effects occur, they could likely be addressed relatively easily and quickly. All these developments would ultimately result in the complete removal of geographic information from the numbering plan because each step would slightly reduce the reliability of the geographic information that a number provides, but it has the benefit that this happens at a slow and orderly pace.

The disadvantage of this approach is that it does not deliver the full benefit of more efficient use of numbering resources; only for option B2 there is a partial benefit. However, as with approach A, the choice remains for possible alternative solutions to the problem of numbering scarcity.

Option B1 is a hybrid solution. Depending on how it is implemented, this option could satisfy demand for geographic numbers and create more options for end-users without disturbing the geographic structure.

Option B2 may only be valid in the case where geographic areas have a hierarchic structure and thus areas with sequent area codes are adjacent to each other. This is only the case in some countries. For example, the French numbering plan specifies 5 regions under the leading digits 1-5 but the 5 regions are divided into a total of 412 numbering areas denoted by the values of the 5 leading digits. Thus a possibility is to remove the distinctions between the numbering areas whilst retaining the distinctions between the regions.

Option B3 provides for a certain degree of location portability (but there is no full location flexibility as a newly used geographic number has to correspond with the home area of the end-user), and has the advantage that the risk on an initial run on popular area codes is limited. However, the geographic structure will erode anyway. The added value of this option may be doubtful as the reliability of the geographic location of number users will diminish from the start of the process depending on the quantity of relocations from end –users from one numbering area to another. In the case of an open dialling plan, due to user perceptions, eventual confusion that could be created with consumers may be slightly larger than in the case of a closed dialling plan.

Option B4 has the advantage that specific services such as VoIP can be facilitated without negative consequences for most actors in the telecom market. A concession is made however regarding the level to which thresholds for new market parties are lowered can enter the market.

8.2.3 C. Removal of geographic information

This approach entails the total removal of all constraints regarding geographic information in the numbering plan, in which case the initial allocations of numbers would no longer be related to any specific area. This is a radical option that has not been implemented to date as far as we are aware. There are two sub variants for this policy option. There can be a regime in which location portability may be offered but it is also possible to oblige the offer of location portability.

This approach would

- allow a more innovative use of geographic numbers.
- decrease the possible barriers of entry for new parties in the geographic telephony market.
- give consumers the option to keep their number when they are moving.
- allow a more efficient use of numbering resources.

The potentially rapid diminishing of the geographic information may lead to more confusion of consumers than in option B3. In the case of an open dialling plan, this negative effect will even be slightly larger than in the case of a closed dialling plan.

On the other hand, a country might not choose this option because local (cheap) tariffs will likely disappear, the market-restructuring effects of the complete removal of geographic information are unclear and the changes that operators would have to make in their systems might be to severe to make in one go. It should be noted that such potentially negative effects are dependent on whether location portability is allowed or whether there is an obligation to offer location portability. In the latter case the negative effects may be higher, while the advantages remain mainly the same.

Furthermore there is a risk that there will be a run on popular NDCs, in contradiction to the desired more efficient use of numbers, which could result in a scarcity of certain popular NDCs. The dimension of this market effect can not be predicted easily.

8.3 Comparison of pros and cons of the policy scenarios

Below are summarized the positive and negative effects of the three policy approaches as described in section 8.2.

Scenarios	PROs	CONs
Maintaining geographic information	– No risk for negative changes for end-users and operators	– No benefits to end-users on location portability – No positive effects for competition – No new opportunities for innovative use – No gains on efficient use of numbering resources
Facilitate evolutionary process	– Market-driven approach; numbering plan in line with its basic goals – Includes possibility for certain degree of location portability – No large negative consequences for end-users – More control on market-restructuring effects – Includes possibility to allow innovative use	– No full gains on efficient use of numbering resources – If a certain degree of location portability is allowed, this could lead to end-user confusion (slightly larger in an open dialling plan)
Removing geographic information	– Full location portability possible – Most efficient use of numbers – Lowers possible barriers of entry – Stimulates innovative use	– Could generate end-user confusion (slightly larger in an open dialling plan) – Might have unforeseen market-restructuring effects – Might require large changes in systems of operators – Might lead to the disappearance of special (local/regional) tariffs

9 CONCLUSIONS

This report has explored ways of reducing or removing requirements for geographic information from the numbering plan and their impacts for the parties involved.

The report shows that:

- The removal or reduction of geographic requirements for the use of numbers makes the use of numbering blocks much more efficient.
- The removal or reduction of geographic requirements for the use of numbers also makes possible wider area location portability, but this is normally an optional commercial decision by operators whether or not to offer such portability within their own networks. The technology needed, though is the same as for service provider portability. In this context it may be appropriate to introduce a common service provider portability and location reference database containing all numbers.
- There are alternatives for removing geographic information from the numbering plan when a solution is needed for a situation of scarcity in numbers, such as reducing the size of the number block allocations or closing the dialling plan.
- There are different ways of reducing or removing requirements for geographic information. Considering that the main target of a numbering plan is to facilitate technological and commercial developments, different steps in time can be taken when appropriate. This would meet new users'/operators' requirements and/or could solve number scarcity, but limit negative effects for end-users and operators.
- The process in which geographic information is (gradually) removed from the numbering plan depends on the country-specific market situation and situation with regard to levels of capacity use within the existing numbering plan.
- The dialling plan is unrelated to removal of geographic significance of numbers, although the impact of the removal of geographic significance of numbers might depend on whether the dialling plan is open or closed.

ANNEX 1: DISTANCE DEPENDENT CHARGING

Distance dependent charging is normally based on the concept of charge areas. The charge areas normally are mapped to number blocks and/or area codes so that the call rating system can determine the tariff to apply by examining the number blocks in the calling and called numbers. The boundaries of the charge areas may correspond to the coverage of the incumbent's switches either in the current digital circuit switched network or in the previous analogue switched network.

Either of two types of charging algorithm may apply:

- Calls wholly within the same charging area are charged at the local rate, calls between different charging areas are charged at the long distance rate. This means that some quite short calls may be charged at the long distance rate if they happen to cross the boundary of the charging area.
- Calls wholly within the same charging area, and all calls between adjacent area, and some other calls are charged at the local rate, other calls are charged at the long distance rate. This means that quite short calls are always charged at the local rate.

Such charging is always based on number block analysis not on calculations of distance. The accuracy with which algorithms based on number block analysis can approximate to distance increases if the charging areas are smaller using the second type of algorithm.

ANNEX 2: RELATIONSHIP BETWEEN NUMBERING, LOCAL SWITCHES AND CONCENTRATORS

The following applies to digital circuit switched networks.

Numbers are normally assigned in blocks by regulators. These blocks may contain 100, 1,000 or 10,000 numbers or even more. The blocks are normally a subset of the area code.

Call routing involves analysing the called number down to the block size.

Each block is associated with a single switch and can only be used for lines served by that switch but a given number from that block can be used for any line serviced by that switch. A numbering block cannot be served by more than one switch unless it is subdivided into separate blocks by the network operator.

A digital local switch normally handles the calls of subscribers served by a number of different concentrators at different locations, each with associated main distribution frame to terminate the copper cables to the subscribers.

Although in practice a switch can serve a block of numbers that is spread over various different concentrators, the network operator may wish to retain the ability to re-organise the structure of the network by transferring a concentrator from one parent local switch to another. If a number block is spread across several concentrators then all those concentrators would have to be transferred together. Thus spreading number blocks across more than one concentrator has the effect of making network re-organisation very difficult. For this reason network operators may wish to restrict a number block to a single concentrator.

Thus overall in a country with a reasonable population density, the network of the incumbent may have a more finely divided geographic structure than that of the numbering plan.

The only way to overcome these restrictions is to use the location portability technologies discussed in the main body of the report.

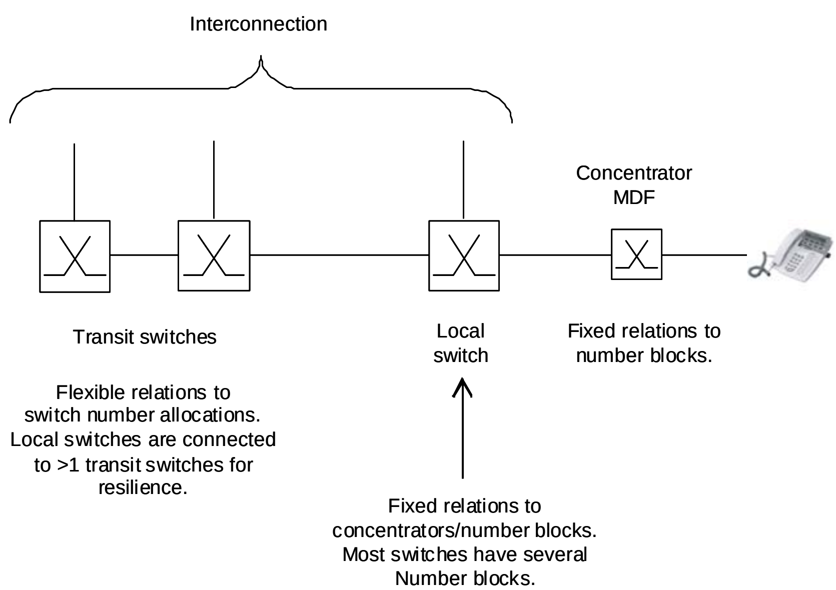


Figure 6: Relationship of numbering blocks to network elements

ANNEX 3: RELATIONSHIP TO SERVICE PROVIDER PORTABILITY

Service provider portability is the possibility for a user to keep their number when changing service provider. This is a regulatory requirement in many countries and throughout the EU.

If location portability is provided only inside one network (from one operator), then its implementation does not affect other interconnected networks and does not need to affect the service provider portability arrangements between networks.

If, however, as discussed earlier, there is a need to exchange location information between operators, then it would be cost effective to have a common system and a common reference database for both portability information and location information. This database would contain all numbers not just ported ones. A design for such a database has been undertaken by operators in UK for example.

There is an issue that may arise where service provider portability is provided between networks with different capabilities for location portability. Some incumbent geographic operators have argued that regulators should require that a number that is ported between operators must remain within the geographic area where it is possible to port the number back to the incumbent. This issue arises because the structure of the incumbent's network is much more finely divided than that of the new entrant, and more finely divided than the geographic information in the numbering plan (e.g. the numbering plans specifies only a few areas with area codes each containing several different towns). Thus a subscriber with an incumbent number in town A can only have location portability within town A. If they want to move to town B (within the same area code as town A) and stay a subscriber of the incumbent then they must have their number changed. If however they port to a new entrant the new entrant can enable them to keep the same number in town B because both are served from the same switch. However once the subscriber has moved to town B they can no longer port back to the incumbent while they remain in town B even if town B is under the same area code as town A as mentioned above.

The incumbents regard this as unfair competition and want the regulator to restrict the location portability to areas where the number can be ported back to its original network. This restriction may be more restrictive than the area code system in the numbering plan if the incumbents network structure is more finely divided than the numbering plan.

The arguments against this are:

- The new entrant should be allowed to take advantage of its more flexible network technology to support market competition and to give the subscriber the advantages of new technologies.
- The subscriber should not be denied the additional benefits that the new operator can offer due to the flexibility to change the operator without the need to change the number with additional costs involved.
- The incumbent could implement better location portability in its existing network, if it wished to, using the technology described elsewhere in this report. This would stimulate technology investments and results in improved networks.

ANNEX 4: EFFECT OF MIGRATION TO NGN

Telcos are gradually changing from digital circuit switched or ISDN based technology to NGN packet based technology. Most are following an overlay process by introducing new NGN technology alongside existing technology, especially in the access network, and so far only few are removing the old technology completely.

As NGN networks have to be built up from scratch, and taking into account the network architecture which is less hierarchical, it is easier to remove geographic significance in geographic number plans.

The design of NGNs implemented today is very much "PSTN on IP based networks" with the features and restrictions of the PSTN being copied. Those NGNs have only a subset of the functions that are described in ITU-T or ETSI NGN Recommendations.

The architecture of the network is however different. Concentrators are replaced by Multi Service Access Nodes and switches by combinations of call servers and media gateways. Call servers or soft-switches serve many more subscribers than digital switches and so the networks are more centralised. Costs are less distance dependent. In the longer term there will be likely fewer points of interconnection.

The NGN technology offers even easier and cheaper implementation of all forms of number portability including location portability, and so the implementation of nationwide location portability will be relatively easy. In NGN it is easy for the softswitch that handles the origination of the call to access a database to determine the location of the called party as in the All Call Query solution for service provider portability.

Even if location information is not completely removed from the numbering plan, when most networks have migrated to NGN, it may be appropriate to upgrade the reference databases for service provider portability to contain all numbers and their network location so that full location portability becomes possible.

In an NGN network, the concentrator is replaced by an MSAN, and a local switch by a call server, which may serve several millions of subscribers. The architecture may vary depending on the equipment suppliers but numbering blocks are likely to be assigned to call servers. MSANs may be assigned to call servers or may be shared by all call servers, ie there is a flexible relationship between call server and MSANs. Whilst signalling is routed between call servers, the media streams within a network would be typically be routed as directly as possible to the relevant IP address, ie IP router. Each router would serve a given range of IP addresses and would handle many MSANs.

NGN networks should therefore have great flexibility over the location of geographic numbers without any major additional arrangements needing to be made.