# World numbering developments

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## Contents

## Preface

This review of developments in numbering around the world is intended to help with the design, implementation and management of telephony numbering plans. It covers numbering broadly, from the perspective of regulation, with special emphases on regional harmonisation and initial competition in countries having low teledensities.

The review draws on the work of many people. Thanks are due to Ralph Adam of City University, Riley Allen of Chemonics International and Internews, Roy Blane of Inmarsat, Ron Conners of NANPA, Richard Hill of ITU-T, Vince Humphries of ETO and David Lewin of Ovum and Indepen, who commented on a draft of an earlier version. That earlier version was commissioned by the RAPID project funded by USAID on behalf of the Telecommunications Regulators' Association of Southern Africa (TRASA). Its special emphases matched the needs of the countries of Southern Africa, which are relevant for many other developing countries.

Thanks are also due to representatives of service providers and regulators who have discussed numbering, in Australia, Bangladesh, Botswana, Chile, Colombia, Cyprus, Denmark, East Timor, Finland, the Gambia, Germany, Hong Kong, India, Jordan, the Maldives, Malta, Nepal, the Netherlands, Pakistan, Portugal, Spain, Sri Lanka, Sweden, Switzerland and the UK. Particular thanks are due to the ITU-D, who funded most of the assignments in developing countries. Of course, the responsibility for errors, omissions and expressions of opinion remains with the authors.

The review:

- Identifies the requirements placed on numbering plans that motivate and constrain changes.
- Shows how numbering plans are changing at the global, regional and national levels.
- Discusses network features for numbering that can help with competition or result from convergence between telephony and the internet.
- Provides some guidance to regulators and others who are responsible for developing numbering plans.

Illustrative material from different numbering plans is provided throughout. It is accurate enough for the purposes for which it is used here. However, individual items should be checked before being used for other purposes.

The authors will be pleased to receive comments or suggestions from readers.

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# 1 Requirements of numbering

Numbering is a critical resource for telecommunication regulators. It is used in several ways, but only one of these, E.164 numbering plans for phone numbers, creates major problems. Phone numbers create problems because users dial using them and service providers are allocated them from ranges that may be too small or designed to meet earlier needs of the incumbent telephone company. This chapter scopes the problems of telephony numbering by describing:

- Pressures on numbering from changes in telephony in general, and convergence with the internet and the development of competition in particular (see 1.1).
- Specific requirements from users, service providers and regulators (see 1.2).

## 1.1 Overall pressures

### 1.1.1 Changes in telephony

Though different countries have reached different stages in the development of telecommunications, the whole world is experiencing similar trends. Most national numbering plans were originally devised at least 30 years ago. They are unlikely to be adequate in unforeseen conditions that include:

- High growth in demand for fixed lines and for numbers required per line, because of Direct Dialling In (DDI), Integrated Subscriber Digital Network (ISDN), differentiated ringing and so on.
- Service proliferation, with new mobile and specially tariffed services (such as freephone, shared cost and premium rate services) often having distinctive numbering.
- Market liberalisation, with new entrants entitled to numbering resources on the same terms as incumbent providers.
- Customer expectations, for numbering that is easily used, indicates call costs and stays unchanged.
- Expansions in the roles of numbers, from identifying phone locations and some services to identifying also mobile phones, service providers (through access codes), individual users (with personal telephony) and many services.

### 1.1.2 Convergence with the internet

The internet, and Internetwork Protocol (IP) networks more generally, will not rapidly make phone numbers obsolete. The traditional telephone with its simple user interface will not disappear before cheap IP terminals become widespread. (These terminals need not be computers: some IP phones are deliberately restricted to having numeric key pads, to reduce cost and provide a familiar user experience.)

In the short term the internet raises pressures on numbering plans, by encouraging service proliferation (through specially tariffed dial-up internet access, for example) and expansions in the roles of numbers. In the long term naming schemes like those of the internet may dominate and the pressures may fall. (Yet even then phone numbers may be useful, as personal numbers: a personal number would give access through the internet to all the communication services by which a user could be reached.)

The effects of the internet on numbering are examined in 6.2 and 6.3 along with the associated network features, such as tElephone NUmber Mapping (ENUM).

### 1.1.3 The development of competition

Traditionally, incumbent providers managed national numbering plans. They did so in what they perceived as national interests, which naturally tended to match their own interests. Regulators faced with numbering problems could easily opt to be guided by the industry, and in particular by strong incumbent providers. However, cost-benefit analyses of numbering plan options show that user interests (including those relating to enhanced competition) usually dominate a “national interest” equation. The costs of any change will be larger for an incumbent provider than for any one other party. However, though the costs for individual users are small, when added up they can outweigh the costs for the industry. Similar arguments hold for the benefits (which are even harder to quantify with any degree of accuracy than the costs).

Fortunately there is now new freedom in the design of numbering plans. The design of many earlier numbering plans was largely dictated by the workings of step-by-step exchanges. Redesigned numbering plans can exploit greater technological flexibility to satisfy other requirements. Of course, numbers still have to let calls be routed and charged correctly, but numbering plans are not just the concern of engineering departments of telephone companies. Regulators can now use them to help competition policy and consumer protection policy and can pay extra attention to human factors.

In brief, well-designed numbering plans will accommodate the growth in the market that effective competition brings (and badly-designed ones can restrict growth severely). However, well-designed plans can also encourage competition, particularly when they use the network features of carrier selection and provider number portability discussed in 5.2 and 5.3.

## 1.2 Specific requirements

### 1.2.1 Requirements of users

User opinions about numbering plans have considerable economic importance, but there are few systematic research results about them. However, the results that exist are generally consistent[1]. Users value numbers that help with:

- **Making calls to the right numbers**. Numbers should be short, to make them easy to remember, find, and reproduce accurately. Users also often prefer a single NSN length and uniform number patterns, such as XX XX XX XX in France and XXX XXX XXXX in the North American Numbering Plan (NANP), even if they have to dial extra digits. They are more confident and make fewer mistakes when dialling numbers with familiar patterns.
- **Avoiding making calls to the wrong numbers**. Numbers should not change often or be confusingly similar to numbers that are dialled frequently (such as those of hospitals or large businesses). Users like location number portability, which lets them keep their phone numbers when changing location addresses, at least in the same geographic area[2]. They also like service number portability, which lets them keep their phone numbers when changing service features (or when changing between analogue fixed telephony and ISDN or between analogue mobile telephony and digital mobile telephony).

[1] The findings quoted are based on fieldwork, mainly from the early 1990s and no longer easily accessible, by the consultancy Ovum, the regulator Oftel, and the TUA and TMA user organisations in the UK, by the regulator Austel and the provider Telstra in Australia, and by Ovum in Hong Kong and the EU.

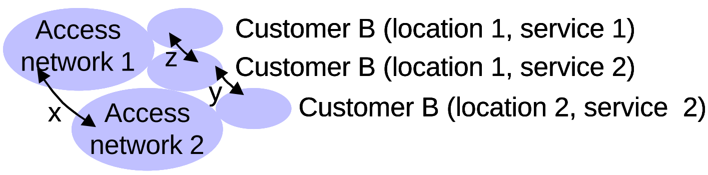
[2] In some documents location number portability is called ‘geographic number portability’, but ‘geographic number portability’ is also used for provider number portability for fixed networks, in which the users keep their locations but change their providers.

- **Deciding to make or to bar calls of particular types**. Numbers should have initial digits that give easily recognisable useful information (for example, about likely call costs or the location of the called party). Users rarely want to have information about the service provider and technology encoded in phone numbers.

Users also have some differences of opinion among themselves. For example:

- They are influenced by their cultures in regarding numbers as “special”. For instance, in Hong Kong, and elsewhere in East Asia, some sets of digits are seen as lucky or unlucky.
- They have different attitudes to international harmonisation, depending on how much they themselves travel or have international outlooks. For instance, travellers may recognise the benefit of having the same short codes in different countries.
- They are not always united on whether to keep local dialling or to have only full national dialling (see 4.3). Keeping local dialling is more important for residential users and in countries where there are long national numbers and many users of fixed networks. Business users, who tend to make more national calls and to have more modern phones, may favour (or at least not dislike) having only full national dialling, which offers a single way of dialling all calls.
- They have varied, and sometimes fast evolving, preferences about provider number portability, which lets them keep their phone numbers when changing service providers (see 5.3)[3]. It is most valuable to small businesses, which could be ruined by number changes. It is less valuable to large businesses, which might keep their old lines (using their old numbers) for incoming calls but add new lines (routed through a new service provider) for outgoing calls. It is least valuable to residential customers, who can cope with number changes by re-establishing their few contacts.

Figure 1 shows various forms of number portability. They all reduce the meanings of phone numbers (see 4.2) and may therefore be unwelcome sometimes. For example, users who change location addresses or service features may wish to keep their numbers, but users who need to call them may be helped by knowing about the changes.




x: Provider number portability lets customer B change
from being connected to access network 1
to being connected to access network 2
without changing phone numbers.
y: Location number portability lets customer B change
from occupying location 1 to occupying location 2
without changing phone numbers.
z: Service number portability lets customer B change
from taking service 1 to taking service 2
without changing phone numbers.

**Figure 1 Forms of number portability**

[3] In some documents provider number portability is called ‘operator number portability’, but ‘operator number portability’ tends to imply that only network operators (or network providers) may control the allocation of numbers to end users, when in fact service providers may also do so.

### 1.2.2 Requirements of service providers

All network providers and service providers have various interests in common[4]. Both alternative providers and incumbent providers want numbering that helps:

- **Traffic growth**. The numbering plan should satisfy customer expectations about the meanings of numbers and offer enough numbers, to stimulate and accommodate growth.
- **Network efficiency.** The numbering plan should not violate network constraints (which might require particular translations to routing) or undergo frequent changes (which disrupt operations).
- **Equipment efficiency**. The numbering plan should try to minimise incorrect dialling (because incorrectly dialled calls use equipment unproductively) and keep numbers short. With step-by-step exchanges, each digit corresponded to a switching stage, so keeping numbers short could reduce costs. With common control exchanges, the linkage to costs is much less significant; however, if fewer digits are enough to determine call routing and charging then less call processing capacity and shorter post-dialling delays are needed.

When a major number change is envisaged, naturally attention focuses on the network costs of change, which can indeed be large, especially for the incumbent provider. However, they should occur only once in a long period and must be kept in perspective. Even very little traffic growth brought about by an improved numbering plan can rapidly pay for the costs of a number change.

The introduction of competition involves the entry into the market of new service providers and often of new network providers. (In developing countries, where there is usually too little network infrastructure, initially all new service providers may well be required to be network providers also.) The alternative providers need numbering plans that let them have:

- **Geographic numbers**, in geographic areas having new fixed access networks. All fixed network providers usually share any geographic significance of numbers.
- **Mobile numbers**, for new mobile access networks[5]. These numbers are usually allocated in ranges that customers recognise as indicating “mobile phones” (and, often, “higher charges”).
- **Specially tariffed numbers**, for specially tariffed services (such as freephone, shared cost and premium rate services)[6]. Again, in accordance with user preferences, all specially tariffed service providers usually share nationally recognised codes for such services.
- **Service access codes**, to let customers reach particular services in ways like those offered by incumbent providers. These codes can be re-used by different networks, so the numbering resources for them are relatively easy to provide.
- **Carrier selection codes**, to let customers route individual calls through particular trunk networks. These codes should be short if they are likely to be used often (because preselection is not available, for example).

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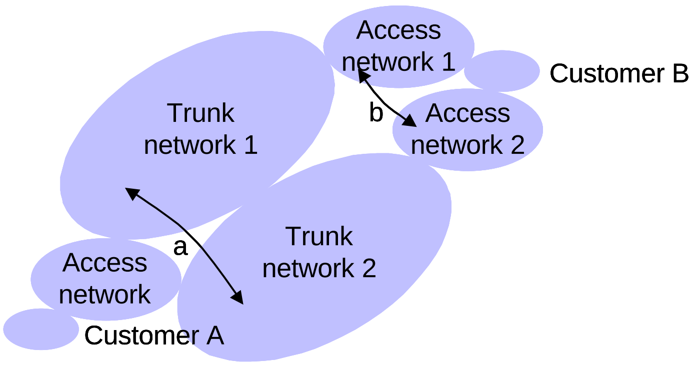
[4] In this report the term ‘service provider’ refers to service providers who may be allocated numbers (and who do not necessarily own network infrastructure), and the term ‘network provider’ may be used where ownership of network facilities is relevant to the discussion.

[5] In some documents mobile and specially tariffed numbers are both called ‘non-geographic numbers’, but ‘non-geographic numbers’ is also used for specially tariffed numbers alone.

[6] In some documents specially tariffed services are called ‘number translation services’, but ‘number translation services’ describes a network implementation, not a user experience.

Carrier selection and provider number portability have different intentions (and implementations) from each other. Figure 2 shows the differences. Carrier selection lets users change the trunk networks over which their calls are carried. Provider number portability lets users change the access networks to which their phones are connected, without changing phone numbers. Some method of carrier selection is crucial if customers are to change trunk networks, but provider number portability is not crucial if customers are to change access networks. In fact even alternative providers do not always want provider number portability, because it has significant costs.




a: Carrier selection lets customer A change
from making calls through trunk network 1
to making calls through trunk network 2
without changing access networks.
b: Provider number portability lets customer B change
from being connected to access network 1
to being connected to access network 2
without changing phone numbers.

**Figure 2 Differences between carrier selection and provider number portability**

### 1.2.3 Requirements of regulators

Regulators, acting in the national interest, aim to support users, especially by encouraging competition and lowering costs. They want numbering that promotes:

- **Effective competition**. The numbering plan should be designed and managed neutrally, treating alternative providers and incumbent providers fairly (in the allocation of "attractive" numbers, for example).
- **Effective consumer protection**. The numbering plan should ensure that widespread customer expectations about the meanings of numbers (in particular, the tariffs associated with particular codes) are valid. Wrong expectations may need to be corrected by publicity.
- **Simple regulation**. The numbering plan should be designed and managed in a way that avoids frequent intervention by the regulator. For instance, eliminating local dialling, by allowing only full national dialling, can increase the plan capacity without increasing the number length, so the regulator can allocate more large number blocks.

The impact of these factors on numbering plan decisions is examined in 4.1, 4.2 and 4.3. Related matters that regulators need to consider are competitor number integration, carrier selection and provider number portability, discussed in 5.1, 5.2 and 5.3. Competitor number integration is particularly affected by convergence between telephony and the internet in the ways described in 6.2 and 6.3.

# 2 Global aspects

Some pressures on numbering plans are felt at the global level, where there are new countries, global services and global networks. Numbering plans rely on a framework imposed by recommendations about number formats and by harmonisation of some code allocations. This chapter outlines this framework by describing:

- The constraints due to the international nature of phone numbers (see 2.1).
- The use of the global numbering space by countries, global services and global networks (see 2.2).
- Code harmonisation though the use of common codes for particular purposes in the global numbering space (see 2.3).

Some new global services and global networks relate to the internet. Convergence between telephony and the internet affects numbering at the national level even more than at the global level, so it is discussed in a separate chapter, 6.

## 2.1 Telephony numbering formalities

### 2.1.1 Number formats

To dial a destination in another country a user normally starts with the international prefix, perhaps accompanied by a carrier selection code, and the Country Code (CC). All the rest of the digits constitute the National Significant Number (NSN)[7].

The NSN is the same as the full number that would be dialled to reach the same destination in the country itself, but without any national prefix (also called a 'trunk prefix') or any carrier selection code. The NSN in turn may be divided into two parts: the National Destination Code (NDC) (also called a 'trunk code' or an 'area code') and the Subscriber Number (SN).

Figure 3 shows the parts of a phone number used by callers into a country from abroad.

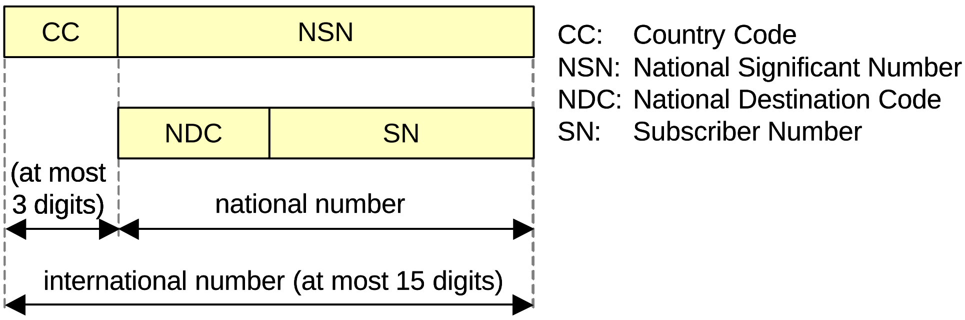



**Figure 3 Telephony numbering structure**

The national numbering plan describes uses of NDCs and the rules for SNs, so it deals with NSNs[8]. It is sometimes distinguished from the dialling plan, which refers to the digits dialled by a caller. The dialling plan therefore specifies also the international prefix (which is usually,

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[7] In some documents NSNs are called 'N(S)Ns', as 'national number' is a more widespread usage than 'national significant number' and as NSNs do not include national prefixes (which are often written in brackets just before the NSNs).

[8] In some documents numbering plans are called 'numbering schemes'; occasionally numbering plans are taken to be specific to particular service providers whilst numbering schemes are larger national designs.

but not always, 00), the national prefix (which, if it exists, is usually 0) and any other numbers that are dialled but that are not NSNs (for example, carrier selection codes)[9].

A full national number from the numbering plan identifies a particular call destination uniquely. The effect of dialling it should be the same from all access networks.

Within a country a user may be able to dial a short code (also called an 'access code') instead of or before the NSN, to use a particular service or tariff. Short codes are part of the dialling plan, but not always strictly part of the numbering plan, because they may not be accessible by international dialling. Indeed inside the country the effects of dialling them may depend on the access network to which the caller is connected[10]. Numbering and dialling plans are also different where there is local dialling; in that case just the SN is dialled for connection to another user in the same NDC area.

### 2.1.2 Number administration

The International Telecommunications Union (ITU) is responsible for allocating country codes. ITU is a specialised agency of the UN.

Besides country codes for countries, and some codes reserved for trials and other purposes, there are codes for global services, global networks and groups of countries[11]. ITU is also responsible for allocating the counterparts of NSNs for global services, of NDCs for global networks and of NDCs for groups of countries.

In each country the regulator or, failing that, an incumbent provider is ultimately responsible for defining the uses of NDCs and some short codes, choosing the international and national prefixes, and allocating number ranges in NSNs. (Other short codes may be specific to a particular access network provider.) Service providers assign SNs from their allocated number ranges to users.

## 2.2 Global number planning

International direct dialling relies on each country having a country code that identifies it from everywhere in the world[12]. Country codes have 1, 2 or 3 digits. Only two 1-digit country codes have ever been issued (1 for the North American Numbering Plan and 7 for the former Soviet Union). There are only 44 2-digit country codes, belonging in general to the more industrialised or more populous countries, including 16 in Europe. The remaining allocated country codes all have 3 digits. There are only about 80 spare 3-digit codes that have not yet been reserved for trials or other purposes; 30 of those (the complete 2-digit codes 28, 83 and 89) have been held back in accordance with E.193 in case longer country codes are needed[13].

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[9] In this report the term 'numbering plan' should be regarded as covering the dialling plan also, except where a distinction must be made.

[10] The prevalent coding of digits for signalling from key pads provides 16 hexadecimal 'digits', comprising 10 'normal' and 6 'overdecadic' ones. The overdecadic digits do not occur in numbering plans, though two of them are represented (by '*' and '#') on many key pads and are sometimes used for proprietary signalling between the telephone and an exchange on the same network.

[11] See *The international public telecommunication numbering plan*, ITU-T Recommendation E.164 (ITU, February 2005) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.164-200502-P. Different types of country code (for countries, global services, global networks and groups of countries) have different names for the parts of the corresponding E.164 numbers.

[12] In this report the term 'country' refers to a territory, without implying independent sovereignty.

[13] See *E.164 Country Code expansion*, ITU-T Recommendation E.193 (ITU, March 2000) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.193-200003-I.

The first significant digit of a country code originally specified the region (2 for Africa, 3 for Europe and so on) but exceptions are now made to make new codes easier to find. In particular, the Faroe Islands and Greenland use +298 and +299 respectively.

Demands for “country codes” have increased greatly, due to:

- **New countries**. Typically new countries do not want to share country codes with others. In particular, most republics of the former Soviet Union do not want +7 as their country code, so, for example, Armenia is using +374.
- **New global services**, for universal international freephone services (allocated +800), universal international shared cost services (allocated +808), universal personal telecommunications (allocated +878), and international premium rate services (allocated +979)[14].
- **New global networks**, for satellite networks (using +881) and other networks (using +882)[15].
- **New groups of countries**. The European Union (EU) has been allocated +3883 to use throughout Europe for special European services[16].

Table 1 summarises the use of geographic country codes by world region in 2005[17]. It shows large discrepancies in numbering space available both per person and per line, most notably between China and India on the one hand, and Russia and Kazakhstan (which are the only countries now using +7) on the other hand.

International service providers that do not have access to country codes sometimes seek spare space behind existing national country codes. For example, a ComoreTel “international” freephone service operates behind the country code +269 shared by Mayotte and Comoros[18]. An ITU circular suggests guidelines to be followed when considering the establishment of such services, which may, in particular, be contrary to E.190[19].

[14] See *Application of Recommendation E.164 numbering plan for universal international numbers for international telecommunications services using country codes for global services*, ITU-T Recommendation E.169 (ITU, May 2002) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.169-200205-I.

[15] In addition Inmarsat has been allocated +870, +871, +872, +873 and +874.

[16] Strictly speaking, the EU has been allocated the identification digit 3 in the group of countries country code +388.

[17] See *List of ITU-T Recommendation E.164 assigned Country Codes (Complement to ITU-T Recommendation E.164 (02/05)) (Position on 1 May 2005)*, ITU Operational Bulletin 835 Annex (ITU, May 2005) at http://www.itu.int/itudoc/itu-t/ob-lists/icc/e164_763.html and *Basic indicators* (ITU, March 2005) at http://www.itu.int/ITU-D/ict/statistics/at_glance/basic03.pdf.

[18] For a description of the service see http://www.global269.com.

[19] See *Use of national numbers for international services*, TSB Circular 66 (ITU, October 2001) at http://www.itu.int/md/meetingdoc.asp?type=sitems&lang=e&parent=T01-TSB-CIR-0066 and *Principles and responsibilities for the management, assignment and reclamation of E-series international numbering resources*, ITU-T Recommendation E.190 (ITU, May 1997) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.190-199705-I.
Clause 6.2.6 states “E-Series numbering resources will only be utilized by the assignee for the specific application for which they have been assigned by the TSB.” and “Numbering resources may not be sold, licensed or traded. Nor may they be transferred, except in the case of a merger, acquisition, or joint venture.”

| Region | Initial significant digits of country codes | Million inhabitants | Million customers [20] | 1-digit country codes used | 2-digit country codes used | 3-digit country codes used | 3-digit country codes spare | Million inhabitants per first three digits | Million customers per first three digits |
|---|---|---|---|---|---|---|---|---|---|
| North America | 1 | 335 | 380 | 1 | 0 | 0 | 0 | 3 | 4 |
| Africa | 2 | 825 | 71 | 0 | 2 | 59 | 12 | 10 | 1 |
| Europe | 3, 4 | 645 | 721 | 0 | 16 | 29 | 10 | 3 | 4 |
| South America | 5 | 518 | 206 | 0 | 8 | 20 | 0 | 5 | 2 |
| Oceania | 6 | 32 | 30 | 0 | 2 | 19 | 8 | 1 | 1 |
| Former Soviet | 7 | 162 | 77 | 1 | 0 | 0 | 0 | 2 | 1 |
| China | 86 | 1257 | 533 | 0 | 1 | 0 | 0 | 126 | 53 |
| India | 91 | 1057 | 75 | 0 | 1 | 0 | 0 | 106 | 8 |
| Rest of Asia | 6, 8, 9 | 1295 | 444 | 0 | 14 | 31 | 21 | 8 | 3 |
| World | | 6130 | 2537 | 2 | 44 | 158 | 51 | 8 | 3 |

**Table 1 Country code resources by region**

## 2.3 Global code harmonisation

ITU-T recommendations (in particular E.164 and E.190) let telephone networks connect and route international calls across the world. Box 1 summarises major provisions of E.164[21].

International recommendations are not binding on countries. However, provisions 1 and 6 in Box 1, which are about international digit analysis, limit what international exchanges need to do. Countries that use more than 15 digits in their international significant numbers, or that need more than 7 digits to be analysed for routing and charging, may lose incoming traffic from some parts of the world. For this reason these two provisions have been very widely, if not universally, implemented.

The other provisions are made only to increase ease of use, so they have less force. However nearly all countries are harmonising their international and national prefixes when they make other changes in the numbering plan[22]. In particular:

- The international dialling prefix 00 is now very widespread. Exceptions include Australia (using 0011), Japan (using 010), the NANP (using 011), a few countries that were formerly in the Soviet Union (using 810), and East Africa (using 000)[23]. In addition some countries have implemented international carrier selection by inserting extra digits between the international prefix and the rest of the number.

[20] The figures for customers sum those for fixed network subscribers and mobile network subscribers.

[21] See *The international public telecommunication numbering plan*, ITU-T Recommendation E.164 (ITU, February 2005) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.164-200502-P. This includes several examples of numbers that violate the rules for the formats of E.164 numbers.

[22] See *Dialling procedures (international prefix, national (trunk) prefix and national (significant) number) (in accordance with ITU-T Recommendation E.164 (05/97)) (Position on 1st January 2005)*, ITU Operational Bulletin 827 Annex (ITU, January 2005) at http://www.itu.int/itudoc/itu-t/ob-lists/op-bull/2005/827.html. Lists like this are re-issued occasionally, with different sequence numbers.

[23] Kenya, Tanzania and Uganda have regional dialling prefixes for each other: 005 for Kenya, 007 for Tanzania and 006 for Uganda. They have country codes +254, +255 and +256 respectively.

- The national dialling prefix 0 is now almost universal, where any national prefix is used. The main exceptions are the NANP, which uses 1, and a few countries that were formerly in the Soviet Union and that still use 8. Again, some countries have implemented national long distance carrier selection by inserting extra digits between the national prefix and the rest of the number.

Provision 3 is present in Box 1 because, when dialling internationally, callers are generally advised to drop any national prefix shown at the start of the numbers. Countries that need a digit looking like a national prefix (in particular, 0) in numbers for calls from abroad therefore risk receiving incorrectly dialled international calls from callers who have dropped it wrongly. Unfortunately, some countries (such as Italy) are using 0 as a first significant digit in some national numbers but not others, to expand the numbering space quickly and inexpensively; they need this digit in numbers for calls from abroad and risk receiving incorrectly dialled international calls from callers who have dropped the 0 wrongly. Other countries (such as Switzerland) also use 0 at the start of all national numbers, even though they have only full national dialling (not local dialling); they can treat the 0 as a national prefix that callers from abroad can drop.

1. Numbers should be no longer than necessary. From 1 January 1997 (time-T), the maximum number of significant digits to be dialled internationally is 15 (including the country code but excluding the international prefix and any carrier selection prefix).
2. If a national prefix is used, it should be 0.
3. The national prefix should not also be used as the first significant digit of national significant numbers.
4. The number to be dialled to reach a given point, from within the same country but outside its local dialling area (if any), should be the same throughout a country: special local or regional dialling codes are to be avoided.
5. Major numbering plan changes should be publicised internationally 2 years in advance.
6. It must not be necessary for a remote exchange to analyse more than the first 7 significant dialled digits to determine how to route and charge for a call. Where the country code has 3 digits, this leaves at most 4 digits for this purpose in the national numbering plan.
7. The international prefix should be 00 (though national arrangements may be made for distinguishing among different international network providers and/or services).

**Box 1 Major provisions of ITU-T recommendation E.164**

# 3 Regional aspects

The geographic part of every national numbering plan is unique. Still, national numbering plans can be harmonised to some extent by:

- Adopting common principles for numbering plan design[24].
- Choosing identical or similar codes for special services and new services.

These are long term undertakings. Changes are rarely thought worthwhile simply to achieve harmonisation. However, if changes are needed anyway to improve capacity or competition, then groups of countries sometimes make changes in a harmonised way.

Any country considering harmonisation will need to assess the following:

- The partners for harmonisation (near neighbours, trading partners, political allies, countries with the same language or culture, or sources of tourists, for example).
- The people benefitting from harmonisation (foreign visitors, those travelling abroad, those calling abroad, or the general public, for example).
- The balance between costs and benefits.

The benefits are more likely to outweigh the costs if harmonisation is prospective (so new codes are being assigned for the first time) than if harmonisation is retrospective (so existing codes are being changed when they may be well-used already)[25].

Emergency codes are especially important. Arguably, a familiar emergency code should never be withdrawn, as it may be the only thing that people remember in a crisis. Of course new, harmonised, codes can be introduced as well. In the UK, for example, there is no intention of withdrawing the well-known 999 emergency code though the EU standard code 112 is also available. (In fact in some countries several specialised emergency codes have been kept; for instance, in Austria there are 8 and in Poland there are 10.)

Recommendations of international harmonisation groups tend to be conservative, as they often require unanimous agreement. However proposals, which are typically put forward by study groups but not yet approved by governing bodies, can also be influential. This chapter considers both recommendations and proposals, as well as what is actually happening, by describing:

- Code harmonisation through the use of common codes for particular purposes in all the countries of a region (see 3.1).
- Numbering plan integration through the use of a single country code and similarly structured numbering plans for all the countries of a region (see 3.2).
- Regional dialling through the use of special codes for dialling between countries to make numbering in one country available in another (see 3.3).

[24] See *Review of national numbering plans on their openness to competition*, ECTRA Report 48378 (ECTRA, October 1997) at http://www.ero.dk/documentation/docs/docfiles.asp?docid=1899. Chapter 6 and Chapter 7 are especially relevant.

[25] For an example of modest proposals for regional harmonisation in Africa see http://www.itu.int/ITU-D/treg/Events/Seminars/2003/Benin/.

## 3.1 Regional code harmonisation

### 3.1.1 Europe

Harmonisation in Europe is handled by the European Conference of Postal and Telecommunications Administrations (CEPT) or, more specifically, the European Committee for Telecommunications Regulatory Affairs (ECTRA) and its successor, the Electronic Communications Committee (ECC). The work is beginning to show results as numbering plans are reviewed in more countries (especially those where competition is later in developing).

Box 2 shows European proposals and recommendations, concentrating on specific choices of national significant numbers[26].

- *Review of national numbering plans on their openness to competition* proposed that:
  - NSNs starting with digits 6 and 7 should preferably be used for the numbering of mobile and personal communications services.
  - NSNs starting with X0 for X=1-9 should preferably be reserved for the numbering of commonly recognised future services.
  - NSN range 800 should preferably be reserved for freephone services. Range 80X should be reserved for future use (for expansion and for service differentiation, for example).
  - NSN range 900 should preferably be reserved for shared revenue services. 90X should be reserved for future use (for example, for expansion and for service and tariff differentiation).
  - In open numbering plans, NDC range 1 should preferably be left free for future expansion of the plan, to allow easy migration from an open numbering plan to a closed numbering plan, for example.
- In 1998, ECTRA recommended that:
  - The number of geographical numbering areas should be reduced to achieve more efficiency in the use of the total available numbering capacity.
  - National dialling sequences beginning with the digit 1 should be used for access to special services (such as emergency services and directory enquiry services), to facilitate easy recognition of these sequences and their possible harmonisation.
  - At least one value of the most significant digit of the NSN should be left spare to allow flexibility for future changes.
  - If the NSNs beginning with 0 become spare because of a fundamental change, they should be left spare, to allow a future harmonised use throughout Europe.

**Box 2 European numbering harmonisation proposals and recommendations for national significant numbers**

Box 3 shows European proposals and recommendations, concentrating on specific choices of short codes[27].

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[26] See *Review of national numbering plans on their openness to competition*, ECTRA Report 48378 (ECTRA, October 1997) at http://www.ero.dk/documentation/docs/docfiles.asp?docid=1899.

[27] See *Harmonisation of short codes in Europe*, ECTRA Report 48380 (ECTRA, September 1998) at http://www.ero.dk/documentation/docs/docfiles.asp?docid=1895.

- *Harmonisation of short codes in Europe* proposed that:
  - The range 11 in particular should be used for information/assistance services.
  - A separate range, preferably either range 10 or range 19 but not excluding range 99, if required, should be used for carrier networks.
  - One or more of the codes 8XY with X ≠ 0, if required, should be used for shared cost services.
- In 1991 the European Council decided that the code 112 should be adopted for emergency calls throughout the European Union. ECTRA then recommended this for all its members, most of which have implemented it.
- In 1997 ECTRA recommended that the code 118 should be used for access to voice directory enquiry services in a fair and non-discriminatory manner.
- In 2004 ECC recommended that the code 116 should be reserved for future harmonised European services.

**Box 3 European numbering harmonisation proposals and recommendations for short codes**

### 3.1.2 South Asia

Harmonisation in South Asia is handled by the South Asian Telecommunications Regulators' Council (SATRC) and, for the broader Asia-Pacific region, the Asia-Pacific Telecommunity (APT). Box 4 shows the current proposals and recommendations[28]. Earlier proposals for paging and personal numbering and for further short codes have not been accepted.

- *Recommendation Document on Numbering* proposed that:
  - The short code 1800 should be preferred for freephone services.
  - The NDC 900 should be preferred for premium rate services.
  - The short codes 100, 101 and 102 or 110, 111 and 112 should be used for emergency calls.
- In 2003 SATRC recommended that the codes 100, 101 and 102 should be adopted for emergency calls (for police, fire and ambulance respectively)

**Box 4 South Asian numbering harmonisation proposals and recommendations**

## 3.2 Regional numbering plan integration

### 3.2.1 North America

A different kind of regional numbering initiative is the integrated numbering plan that covers more than one country behind a single county code. The major successful integrated numbering plan is the NANP: the US, Canada, and 22 small, mainly Caribbean, countries have a uniform integrated numbering plan behind the single-digit country code +1. Membership of the NANP has remained rather stable over a long period. No country has left; Guam, Northern Marianas and American Samoa have joined.

Originally the small countries shared a single NDC, or Numbering Plan Area (NPA) code, 809. They have now been assigned an NPA code each, to make more numbers available but keep 7-digit national dialling. (The NPA code 809 has been kept by the Dominican Republic.) In Puerto Rico, however, two NPA codes are needed to make enough numbers available; the second of these codes is used as an overlay, so 10-digit national dialling is required.

The NANP covers the only major world region that seems unlikely to move towards conformity with ITU-T recommendations. Table 2 compares it with numbering plans that satisfy the recommendations and other widespread conventions.

[28] See *Recommendation Document on Numbering* (by WG3 for SATRC, September 2003) at http://www.aptsec.org/meetings/2003/fifth-satrc/presentations/SATRC5-02%20Additional_Session%206_Draft%20Rapporteur%20on%20Numbering.doc.

| Feature | International numbering[29] | NANP numbering |
|---|---|---|
| National prefix (in countries making distinctions between national and local dialling) | 0 | 1 |
| International prefix | 00 | 011 |
| Short codes | 1XX and so on (100 – 100000 of these) | 211, 311, 411, 511, 611, 711, 811 and 911[30] |
| Emergency calling code | 112 (EU and GSM) | 911 |
| Directory enquiries codes and ranges | 118 (EU) | 555 |
| Live operator codes | 1XX | 0 |
| Carrier selection codes | 1XXX | 10X XXXX |
| Use of 0 | National prefix | Live operator code |
| Use of 10 | Short codes | Carrier selection on 101 XXXX |
| Use of 11 | Harmonised short codes (EU) | Substitute for * on rotary dials |
| Use of 12, 13, 14, 15, 16, 17, 18 and 19 | Short codes | National prefix (along with first national significant digit)[31] |
| Uniformity | Variable but increasing | Complete (1 XXX XXX XXXX) |
| Geographic relief methods | Extra digits and code changes | Area splits and overlays |
| Mobile number ranges | Distinctive | Mainly using geographic codes |
| Specially tariffed number ranges | Distinctive | 456, 500, 555, 800, 866, 877, 888 and 900[32] |
| Distinctions between national and local dialling | Disappearing in smaller countries through extra digits and code changes | Disappearing in Canada and the US through area splits and overlays |

**Table 2 Features of international and NANP numbering**

### 3.2.2 Further examples of integration

There are other examples of potential or actual numbering integration besides the NANP. Among them are the following:

- The first significant digit 7 in the South Korean numbering plan has been reserved for the integration of North Korea.
- The unification of Germany has led to the incorporation of East German numbering into the former West German plan, which had reserved the first significant digit 3 for this.

[29] These characteristics are not all required by international or regional recommendations but are widespread among countries that do not use the NANP.

[30] Because these codes are scarce, they tend to be reserved for important services. Even so, they are not all available wherever the NANP is used. For a description of a service that tells callers about social support organisations, for example, see http://www.211.org/.

[31] The NANP has reserved 29, 39, 49, 59, 69, 79, 89 and 99 for use during the period when the current 10-digit format undergoes expansion. It has also reserved 37 and 96 for as yet unknown purposes that may need 10 contiguous codes each.

[32] The NANP treats all codes having identical second and third significant digits as “easily recognisable” and potentially usable for special purposes (though some are not yet used).

- French overseas territories, such as Guadeloupe and Réunion, have numbering uniform with the numbering of France itself. Calls between France and these territories look like domestic calls within France, though the territories also have their own country codes, which have to be used for calls from the rest of the world.

Early in the 1990s much effort was devoted to exploring the prospects for an integrated European numbering plan on the NANP model. This was finally abandoned because it cost too much. In its place is the +3883 European Telephony Numbering Space (ETNS), which is intended for much more limited uses, such as single customer service numbers that can be advertised all over Europe[33].

The non-political advantages of an integrated numbering plan are:

- Providing the ability to call all countries within the integrated plan without making an international call[34].
- Automatic harmonisation among all member countries of short codes and potentially of special service numbers.

### 3.2.3 Some counterexamples to integration

Examples of movement away from numbering integration are much more numerous than examples of movement towards it. They include the following:

- Notably, the break-up of the former Soviet Union has led to the disintegration of the unified numbering plan behind the country code +7. All the successor states except Kazakhstan and Russia have taken separate new country codes. When these states review their numbering plans, they tend to move from the approach to numbering in the Soviet Union (the national prefix, for example) and towards global or European standards.
- Similarly, the break-up of the former Yugoslavia, the separation of the Czech and Slovak Republics, the separation of Bangladesh from Pakistan, the independence of East Timor, the separation of Namibia from South Africa and the secession of Eritrea from Ethiopia have all been marked by new country codes[35].
- The Palestine Authority has a country code reserved in anticipation of having a country.
- Small countries such as Andorra, Liechtenstein, Monaco and San Marino have adopted their own country codes. The Vatican City has its own country code but uses the country code of Italy. Gibraltar has its own country code but is treated by Spain as needing the country code of Spain.
- Kenya, Tanzania and Uganda have ended close numbering co-operation, though they have kept special arrangements for dialling between themselves. Morocco, Tunisia, Libya and Algeria have also adopted separate country codes, after some years early in the 1990s when they shared a country code[36].

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[33] For descriptions of the intentions, including the number lengths, charges and ranges (for public services, customer services, corporate numbers and personal numbers), see http://www.etns.org/.

[34] To have its full value, national dialling has to imply the use of national tariffs. This does not happen for the NANP: the cost of calls from the US to Caribbean codes is often an unpleasant surprise.

[35] Though such changes may consume code space, they may also produce it. For instance, the break-up of the former Yugoslavia and the separation of the Czech and Slovak Republics each led to the replacement of one 2-digit code by ten 3-digit codes.

[36] As with the break-up of the former Yugoslavia and the separation of the Czech and Slovak Republics, when countries stop sharing a 2-digit country code, if possible they are allocated 3-digit country codes from among those obtained by replacing the 2-digit code by ten 3-digit codes. For instance, Algeria, Morocco and Tunisia now have country codes +213, +212 and +216 respectively.

- Hong Kong and Macau have kept their country codes despite their return to China. The first significant digit 6 in the Chinese numbering plan was reserved for the reintegration of Taiwan but is now beginning to be used for other purposes. However, the first significant digit 0 in the Hong Kong numbering plan remains reserved for possible future “regional dialling”. (This would let calls to China look like national calls rather than international calls, along the lines described in 3.3.) Box 2 includes a recommendation for Europe that if the first significant digit 0 ever becomes free, it should be kept free for future use.

Plainly, country codes are potent political symbols. However, even leaving aside politics, there are the following advantages for independent national numbering plans, especially for smaller countries:

- Numbers can be shorter.
- Codes can be chosen to suit local circumstances.
- Numbering plan changes can be timed to suit local circumstances.
- There is more freedom to choose the routing of inbound international traffic.

Integrated regional numbering plans are very costly to deploy (if separate national numbering plans already exist) and very arduous to maintain (as international consensus is potentially required for every decision). For all these reasons many countries have decided to have separate national numbering plans.

## 3.3 Regional dialling

There are sometimes special codes for some calls from one country to another country. These codes fall into the following classes:

- **National coverage**. The code gives access from one entire country to another entire country. There is often a corresponding code for calls in the opposite direction. Examples include the codes used for calls between Kenya, Tanzania and Uganda, between Lebanon and Syria, between Singapore and Indonesia, and between Singapore and Malaysia. Other such codes are used for calls from Swaziland to Lesotho, Mozambique and South Africa.
- **Local coverage**. The code gives access from a locality in one country to a locality in another country, across the border. There is often not a corresponding code for calls in the opposite direction. Examples include the codes used for calls from Nigeria to the Niger Republic, and from Malaysia to Brunei Darussalam. Such codes were available for calls from Switzerland to parts of adjacent countries, but were withdrawn, as they were thought to be confusing and unnecessary.

Regional codes are often intended to indicate to the users or the exchanges that particular tariffs apply. For example, calls from the Republic of Ireland to Northern Ireland in the UK can be set up using the special code 0 48 (which has the national prefix of the Republic of Ireland, 0, and the particular code for Northern Ireland, 48) and be charged at national or local rates; calls set up using 00 44 28 (which has the international prefix of the Republic of Ireland, 00, the country code for the UK, 44, and the NDC for Northern Ireland, 28) are charged at international rates. There is currently no special code for calls from the UK to the Republic of Ireland, but such calls are already charged at national or local rates[37].

[37] This example also shows how numbering plan integration and regional dialling can conflict: taking the special code to be 0 28 would have given the appearance of integrating Northern Ireland in the dialling plan of the Republic of Ireland but could not be done because the national prefix of the Republic of Ireland is 0 and one NDC in the Republic of Ireland is 28.

# 4 National aspects

Pressures on numbering plans are strongest at the national level. They typically result in changes to accommodate more users and services. As change is costly, it should anticipate long term developments. This chapter is intended to help with this by describing:

- The capacity in numbering plans (see 4.1).
- Numbering for particular types of services (see 4.2).
- Open and closed numbering plans (see 4.3).

Numbering for competition is discussed with the associated network features in a separate chapter, 5.

## 4.1 National number planning

### 4.1.1 Trends in national number planning

Many countries are changing their numbering plans. Each country has a different situation, but some general directions of change are clear. Table 3 summarises national numbering plan changes (in countries where the NSN length is at least 7)[38]. Table 7, Table 9 and Table 10 provide further illustrative material.

The NANP is an interesting case: every year new NPA codes are added and the date when there will be no spare NPA codes is estimated[39]. That date is now 30 years away, at which point two extra digits may be required (along with full national dialling throughout the US).

Deciding the capacity requirements of a numbering plan and then designing it to meet those requirements is an art, not a science. The need to plan for the long term leads to huge uncertainties that often swamp any apparent short term clarity. Nonetheless, some guidance can be given here about:

- Estimating the available numbering capacity.
- Estimating the required numbering capacity.
- Determining number lengths.
- Planning geographic numbers.

The move towards closed numbering plans that is apparent in Table 3 is discussed in 4.3.

[38] For an index of official information on numbering see http://www.itu.int/ITU-T/inr/.

[39] For a recent view see *NANP Exhaust Analysis* (NANPA, October 2004) at http://www.nanpa.com/pdf/NRUF/October2004NANPExhaustAnalysis.pdf.

| Country | Million inhabitants | Review dates | Before change | | After change | |
|---|---|---|---|---|---|---|
| | | | Maximum length of NSN | Closed numbering plan | Maximum length of NSN | Closed numbering plan |
| Argentina | 35 | 1999 | 8 | No | 10 | No |
| Australia | 18 | 1994-1998 | 8 | No | 9 | No |
| Bahrain | 1 | 2003 | 7 | Yes | 8 | Yes |
| Belgium | 10 | 2000 | 8 | No | 9 | Yes |
| China | 1257 | 1998-2002 | 10 | No | 11 | No |
| Colombia | 40 | 2002 | 8 | No | 11 | No |
| Denmark | 5 | 1986-1994 | 7 | No | 8 | Yes |
| Estonia | 2 | 2003-2004 | 9 | No | 9 | Yes |
| Finland | 5 | 1996 | 11 | No | 12 | No |
| France | 58 | 1985-1996 | 9 | No | 9 | Yes |
| Germany | 82 | 1998 | 11 | No | 11 | No |
| Hong Kong | 6 | 1995 | 7 | Yes | 8 | Yes |
| India | 1057 | 1998-2003 | 9 | No | 10 | No |
| Ireland | 4 | 1998 | 8 | No | 9 | No |
| Italy | 57 | 1998 | 9 | No | 10 | Yes |
| Japan | 126 | 2003 | 9 | No | 10 | No |
| Jordan | 6 | 2003 | 8 | No | 9 | No |
| Kenya | 32 | 2003 | 9 | No | 9 | No |
| Malaysia | 24 | 2001-2003 | 9 | No | 10 | No |
| Malta | 1 | 2002 | 9 | No | 8 | Yes |
| Mexico | 93 | 2000 | 8 | No | 10 | No |
| Netherlands | 16 | 1996 | 9 | No | 9 | No |
| New Zealand | 4 | 1991-1993 | 8 | No | 8 | No |
| Norway | 4 | 1993 | 7 | No | 8 | Yes |
| Portugal | 10 | 2001 | 8 | No | 9 | Yes |
| South Africa | 44 | 2001-2002 | 9 | No | 9 | Yes |
| Spain | 39 | 1998 | 8 | No | 9 | Yes |
| Sweden | 9 | 1999 | 9 | No | 9 | No |
| Switzerland | 7 | 2002 | 9 | No | 9 | Yes |
| Turkey | 64 | 1993 | 8 | No | 10 | No |
| UK | 58 | 1995-2000 | 9 | No | 10 | No |

**Table 3 National numbering plan changes**

### 4.1.2 Number supply

In theory, a NSN length of n digits yields $10^n$ numbers; for instance, the widespread NSN length of 8 provides 100 million numbers. However, not all of these numbers can be used, for reasons such as the following:

- **Fragmentation of the numbering space**. Structuring the numbering plan to provide useful information inevitably leads to inefficiency. For example, the former UK 9-digit numbering space, with 650 small geographic areas, was exhausted at only 3% utilisation. Allocating large number blocks to individual service providers (for mobile networks, for example) has a similar effect.
- **Allocation of short numbers**. Some numbers have less than the full NSN length (short codes in the 1XX range, for example).
- **Quarantine of misleading numbers**. Some numbers should not be issued for some time because of the risk of incorrect dialling, especially if they have been used before.

In practice, numbering planners account for such inefficiencies through rough maximum utilisation factors. Typically, 40% utilisation might be thought reasonable for individual geographic areas. A much lower utilisation factor is likely for entire geographic numbering spaces, depending on the number and sizes of the areas. However, in mobile or specially tariffed number blocks 60% or even 80% utilisation might be achieved.

### 4.1.3 Number demand

The utilisation factors used in numbering plan design are approximate. However, estimates of future demand for numbers are even more approximate. Plainly, bigger and wealthier populations are going to need more numbers than smaller and poorer ones. As network planners know well, predicting lines per head is already difficult enough. Predicting numbers per head is worse, because of the pressures on numbering plans outlined in 1.1.

Box 5 reproduces ETO guidelines on numbers per person for planning in Europe[40]. They have not been validated even in Europe. The projected demand could be too low for developed countries, given the rapid take-up of mobile phones and the use of computers as phones. There is no reason to expect the guidelines to be right for low teledensity countries. The sensible approach for numbering planning in such countries is to build on a realistic vision of the state of development and income per head in 20 or 30 years.

- A numbering plan in which the usable geographic space has fallen below one number per person is in danger of exhaustion.
- When carrying out changes to the numbering plan, it is sensible to increase geographic capacity to at least three usable numbers per person.
- Countries in which the numbering space available for specially tariffed services is below two numbers per person should consider a major review.
- A major change should make at least five numbers per person available for specially tariffed services.
- When fundamentally redesigning a numbering plan, it is reasonable to allow one initial digit for short codes, two for geographic numbering and two for specially tariffed numbering, leaving 5 initial digits free for long term flexibility.

**Box 5 ETO proposals for capacity guidelines**

[40] See *Review of national numbering schemes on their openness to competition*, ECTRA Report 48378 (ECTRA, October 1997) at http://www.ero.dk/documentation/docs/docfiles.asp?docid=1899.

### 4.1.4 Number length

The obvious solution to capacity problems is just to add a digit, or even two digits, to the national number length. (An extra digit is usually prefixed as a new first significant digit to the NDC or the SN, but it may appear as a new second significant digit of the NDC, the SN or both.) Adding an extra digit may remove the need for fine matching of number supply and demand, as it increases capacity tenfold. However, it should not be done lightly by countries that would need at least 9 digits to be dialled for each call (as shown by human factors work).

Human factors work has shown that every extra digit dialled increases errors. In a series of experiments, success rates in reproducing digit strings that had been seen or heard were as follows: 4-digit strings 97% correct, 6-digit strings 88% correct, 8-digit strings 47% correct and 10-digit strings 14% correct[41]. Older people make more errors, especially on longer strings[42]. Putting this differently, 7-digit numbers may be acceptable instead of 6-digit numbers, but each additional digit leads to a less tolerable error rate. When 9 digits per call are reached, most people need memory props such as paper records or electronic devices, to which poor people may not have access (especially when they have low educational attainments). Consequently poor countries should be wary of extra digits.

At the time of a major number change such as adding a digit, considerable costs are incurred in changing network and customer equipment, manual and electronic records, and user habits. Sometimes there is a case for adding two digits if one is being added, as the change should last for longer and not cost much more. (Indeed the change may even cost less as it may be simpler and help parallel running of the old and new numbering.) Some countries appear to have been influenced by this logic, and adding two digits is the preferred option for the eventual expansion of the NANP[43].

Table 3 shows that the capacity of 10 digits is seen as adequate for most foreseeable needs of countries outside the two biggest numbering plans (China and the NANP); the main exception is that longer numbers are used for DDI in some countries, such as Germany. There is a rough correlation between population size and numbering plan size. However, there are exceptions in both directions. For example, Finland for historic and cultural reasons has some very long numbers (as well as some very short ones) despite having a small population, and France, having used its former 8 digit plan very efficiently, expects 9 digits to be adequate for the indefinite future.

As mentioned in 1.2, numbers having uniform lengths and patterns are better because of technology and human factors. When numbering plans are changed they are often moved towards greater uniformity. (Complete uniformity may not always be best; for instance, geographic numbers may be shorter than mobile and specially tariffed numbers.)

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[41] See *The expanding telephone number Part 1: Keying briefly presented multiple-digit numbers*, by Knut Nordby and others, **Behaviour and Information Technology** volume 21 part 1 January 2002, pages 27-38, at http://taylorandfrancis.metapress.com/app/home/contribution.asp?wasp=4f41f190a9a44170b5257d42e55d69b9&referrer=parent&backto=issue,3,7;journal,20,55;linkingpublicationresults,1:100652,1.

[42] See *The expanding telephone number Part 2: Age variations in immediate memory for multiple-digit numbers*, by Ruth Raanaas and others, **Behaviour and Information Technology** volume 21 part 1 January 2002, pages 39-45, at http://taylorandfrancis.metapress.com/app/home/contribution.asp?wasp=4f41f190a9a44170b5257d42e55d69b9&referrer=parent&backto=issue,4,7;journal,20,55;linkingpublicationresults,1:100652,1.

[43] For the conventional view see *Industry Numbering Committee (INC) Recommended Plan for Expanding the Capacity of the North American Numbering Plan* (ATIS, December 2001) at http://www.atis.org/inc/docs/finaldocs/020107029.doc. For a different view see *Where have all the numbers gone? Rescuing the North American Numbering Plan from Mismanagement and Premature Exhaust* (by Economics and Technology for the Ad Hoc Telecommunications Users Committee, June 2000) at http://www.econtech.com/library/whatng.pdf.

### 4.1.5 Geographic capacity

Traditional numbering plans were planned around geographic codes that identified different parts of the country[44]. Numbering plan reviews have often tried to simplify such geographic structures, by combining small geographic code areas. Doing this is quite costly but has typically the following advantages:

- It fits underlying network structure, cost and tariff trends (and often also company management structures). Having many geographic code areas, without local call charging between them, can lead to bypass, using voice over the internet, and to the allocation of numbers in multiple areas to a single user[45].
- It compensates for longer local numbers by giving users larger local dialling areas (which users like, especially when there is local call charging).
- It lets numbering resources be used more efficiently, thereby removing an obstacle to introducing local competition.
- It reduces the proportion of the national numbering space occupied by geographic numbers (often from nearly 100% to 30% or less), thereby creating plenty of space for new services and flexibility for future expansion.

The NANP, however, is becoming more complicated geographically. Exhausted areas are either split or overlaid with new codes. The map of area codes is now impossible to read. In some areas, such as Ontario, 10-digit dialling is required for all calls. The preferred expansion plan will not simplify geographic structure.

Even if the geographic NDC structure is not being simplified, future geographic capacity requirements must be reviewed regularly for individual NDCs as well as for the whole plan. Then there should be no surprises and relief plans should be available well before areas become exhausted.

Usually areas at risk of number exhaustion within (say) the next decade can be identified quite easily by regular reviews of the NDCs; they are often the larger cities and towns. For each of these, decisions are needed about:

- Whether change can be avoided for the foreseeable future by introducing number conservation measures. This may be possible with very efficient use of the numbering space, such as location number portability over large geographic areas can provide[46].
- Whether expansion can be achieved within the existing NDCs. This is normally done by adding one or two digits to the start of the subscriber numbers, in which case the initial one or two digits must be reserved for the purpose.
- Whether additional NDCs are needed (for splits or overlays). If this is so the NDCs must be reserved for the purpose.

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[44] Typically geographic codes have some regional structure, so areas having codes with the same first significant digit are near each other. Major exceptions to this are the old UK geographic numbering plan and the NANP. The old UK geographic numbering plan derived many codes from alphabetic abbreviations of the area names; a regional structure (with 20 for London and 28 for Northern Ireland, for example) is now gradually replacing these codes when numbers need to be changed.

[45] In some documents such numbers are described as ‘virtual numbering’, but this usage is not standard or recommended.

[46] Usually location number portability can be supported for fixed access networks at least in the geographic areas of individual local exchanges. Voice over IP networks have no local exchanges and determine call routing in a rather centralised manner, so they can let location number portability extend over large geographic areas.

The capacity of a 7-digit numbering plan may be enough for many small countries but not for some large conurbations. Several cities (such as London, Paris, Tokyo, Beijing, Rio de Janeiro and Mexico City) have moved to 8-digit local numbers. Others that have stayed with 7-digit local numbers (such as all the large cities of North America) have had to introduce extra codes. They must then have either a split or an overlay (of what may be quite a small area) and replace local dialling by full national dialling between the parts. Splits force many locations to change their codes, whilst overlays make near-neighbours have different codes.

### 4.1.6 Mobile capacity

The need for more capacity for mobile numbering is now driving numbering plan reviews in many countries. Underlying take-up is of course growing rapidly. Also, the phenomenon of the "throw-away prepaid mobile phone" and extra services like voice mail are leading to ever greater demand for numbers.

The GSM standard has led to the rising popularity of short text messages and now of multimedia messages (which may include images and sound). Commercial providers of information and entertainment services are offering new services based on such messages (for example, getting updates on football results or voting for winners in television contests). All these services need numbers, and their use "on the move" leads to a preference for those numbers to be short[47]. The codes for such numbers are discussed in 4.2.

## 4.2 Specific service numbering

### 4.2.1 Trends in specific service numbering

Numbering plans that do not conform with ITU-T recommendations are usually moved towards conformity when they are changed. (This is not so for the NANP mainly for historical reasons.) Consequently the international prefix becomes 00, and the national prefix (if there is one) becomes 0. Also, short codes are often moved into the 1XX range.

Numbering plans often provide distinctive codes for use in mobile and specially tariffed numbers, to help customers recognise their characteristics and tariffing. Making distinctive codes available may involve removing geographic numbers from some numbering space. These codes quite often, but not always, use:

- **First significant digit 1 or a high digit**. If a high digit is used, it tends to be 6, 7 or 9 for mobile numbers and 8 or 9 for specially tariffed numbers.
- **Second significant digit 0**. The X0 range (in particular, the X00 range) has often been left vacant from geographic use. The best example is 800, which is extremely common for freephone services; 900 is also common, though less so, for premium rate services.

### 4.2.2 Geographic numbers

As geographic numbers were the first to be provided, at a time when international harmonisation was not a concern, they have traditionally had little consistent pattern between countries[48]. Number changes have lately increased consistency to some extent, mainly by focusing geographic numbering more heavily on low digits[49].

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[47] For the discussion in Australia about providing numbers for such services see http://internet.aca.gov.au/ACAINTER.3997752:STANDARD:1819072826:pp=PC_2465,pc=PC_2471.

[48] Where regional structure exists, regions have often been numbered in order of "importance" starting with the capital as 1 or 2, leaving high digits free or less utilised. This accounts for the concentration of mobile numbering on high digits.

[49] However, there are many exceptions to the use of low digits; for instance, in Spain all geographic numbers have started with 9 since a change when the old national prefix 9 was absorbed into them.

### 4.2.3 Mobile numbers

Table 4 summarises how mobile numbers were distinguished in different countries in 2002, by showing how many countries used each initial digit[50]. In brief:

- In almost all countries mobile numbers are clearly distinguished; in well over half of the countries specific first significant digits are used for this (and in some of the rest specific second significant digits, 0 and 1, are used).
- All digits are in use as the first significant digit to distinguish mobile numbers, but 5, 6, 7, 8 and 9 are more widespread than 0, 1, 2, 3 and 4.
- The first significant digits 6, 7 and 9 are used the most, in respectively 15%, 17% and 26% of the countries.
- There is little regional pattern to the digits used.

Some countries (in particular, Canada, Mexico and the US) use no particular digit to distinguish mobile numbers[51]. Doing this complicates the implementation of tariffs that differentiate between calls to geographic numbers and calls to mobile numbers.

| Region | Initial significant digits of country codes | First significant digit of mobile numbers | | | | | | | | | | Second significant digit of mobile numbers[52] | | No numbers[53] | No network[54] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | | |
| North America | 1 | 0 | 0 | 4 | 2 | 5 | 3 | 1 | 3 | 1 | 2 | 0 | 0 | 2 | 9 |
| Africa | 2 | 4 | 4 | 7 | 1 | 2 | 5 | 9 | 7 | 10 | 15 | 1 | 0 | 0 | 9 |
| Europe | 3, 4 | 1 | 1 | 1 | 1 | 4 | 5 | 8 | 9 | 3 | 11 | 3 | 2 | 0 | 0 |
| South America | 5 | 0 | 3 | 3 | 5 | 5 | 1 | 6 | 6 | 4 | 9 | 1 | 2 | 2 | 2 |
| Oceania | 6 | 0 | 2 | 2 | 1 | 2 | 2 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 7 |
| Former Soviet | 7 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| China | 86 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| India | 91 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Rest of Asia | 6, 8, 9 | 0 | 5 | 1 | 3 | 0 | 7 | 6 | 7 | 2 | 14 | 0 | 1 | 0 | 5 |
| World | | 5 | 16 | 19 | 14 | 18 | 23 | 30 | 35 | 21 | 54 | 5 | 5 | 4 | 32 |

**Table 4 Mobile network numbering by region**

[50] See *Access codes/numbers for mobile networks (According to ITU-T Recommendation E.164 (05/97)) (Position on 1 June 2002)*, ITU Operational Bulletin 765 Annex (ITU, June 2002) at http://www.itu.int/itudoc/itu-t/ob-lists/op-bull/2002/765.html. This Annex collates information supplied by the countries in different ways, but despite its age and possible inaccuracy it is probably still representative overall (except that fewer countries now have no mobile network).

[51] In the US the caller pays the same to call a mobile phone as to call a fixed phone having the same NPA, and the mobile phone user pays the difference in price to receive the call; this "called party pays" or "receiving party pays" arrangement tends to be linked with much lower take-up of mobile phones.

[52] This refers to the use of the second significant digit to identify mobile numbering; for instance, the ranges 20, 30 and 60 are used in Hungary and the ranges 50, 60 and 90 are used in Poland.

[53] This refers to the presence of mobile networks with no readily recognisable identification.

[54] This refers to the absence of mobile networks.

### 4.2.4 Specially tariffed numbers

Number ranges have been allocated in most countries for freephone (toll free) services, in many countries for premium rate (shared revenue) services and in some countries for shared cost (local rate and national rate) services. In brief:

- Freephone services almost always use 800 or 80 (and in the NANP, where such services started, 800 has been supplemented by 888, 877, 866 and so on). This usage has developed through market forces rather than by international agreement. Additional codes or particular parts of the range may be used to identify particular types of service; for instance, in the UK approved social welfare help lines have exclusive use of the range 8088, and in the Netherlands freephone numbers associated with adult entertainment can be barred separately.
- Premium rate services very often, but not always, use 900 or 90; alternatives include 600 and 60. Additional codes or particular parts of the range may be used to identify particular types of service that may be barred separately; these could include television voting, adult entertainment and games.
- Shared cost services often use the 8X range. However, there is considerable variation; for instance, in Australia the 13X range is used, with 6-digit, 8-digit or 10-digit total number lengths in different parts of the range[55]. Usually different parts of the range distinguish calls charged at lower (or local) rates from calls charged at higher (or national) rates.

Distinctive number ranges have also been provided for other service types in some countries. For example:

- Personal numbers may be provided for Universal Personal Telecommunications (UPT). The code 878 (which is equivalent to 'UPT' on an alphanumeric key pad) has been allocated as the country code for UPT at the global level. By analogy with the use of 800 for freephone services at both the global level and the national level, the use of 878 has also been adopted in some countries (such as Switzerland) at the national level. In other countries (such as the UK) personal numbers have been seen as more like mobile numbers and have been allocated ranges to indicate this. For instance, a code having the first significant digit 7, especially 700 or 70, is sometimes used.
- Nomadic numbers may be provided so that the called party need not be in a particular geographic area (by contrast with geographic services) but may not have high speed wide area hand-over available (by contrast with mobile services)[56]. If they are distinguished from personal numbers, they probably signify services having the low tariffs often associated with IP telephony. Countries having them include the UK (using 56).
- Nationwide numbers may be provided so that a user may change location throughout the country, not just in the local area. If they are distinguished from personal and nomadic numbers, they probably require a period of notice before the user changes the phone location. They can usually be implemented much like shared cost numbers. Countries having them include Austria (using 720), Finland (using 71) and Switzerland (using 51).

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[55] Also, in Australia freephone services occupy the 18X range and premium rate services occupy the 19X range.

[56] Nomadic users register with the network to indicate their locations when calls are to be made. If they have wireless connections to the network they may also have low speed local area hand-over during calls, so the signalling and speech paths can be redirected to different base stations while the users walk. Typically high speed wide area hand-over lets the signalling and speech paths be redirected while the users travel in cars or on trains. These distinctions are not absolute; also, fixed-mobile convergence might allow hand-over between local area and wide area wireless technologies, such as DECT (which is usually found in fixed access networks) and GSM (which is usually found in mobile access networks).

- Corporate numbers may be provided so that a corporation can have a single number range; routing inside that number range might be performed by the corporate network, the public network or both. If they are distinguished from personal, nomadic and nationwide numbers, they probably allow number block allocations to corporations. They can usually be implemented much like shared cost numbers. Countries having them include Switzerland (using 58), the Netherlands (using 88) and the UK (using 51). (VPN access from particular VPN locations may also be handled by prefixing suitable private numbers with short codes, such as 869 in Switzerland.)

The internet affects E.164 numbering in various ways. These can be summarised as follows:

- Internet access numbers are given special codes (and sometimes short codes) in many countries. These numbers, and other numbers that are dialled mainly by machines, can be given the longest possible number length to conserve numbering space without affecting users. There is no pattern to the numbers chosen, though they may conform to the widespread national expectations about charges associated with codes for freephone, premium rate and shared cost services.
- IP telephony numbers (see 6.2) are given special codes in some countries. If they are distinguished from nomadic numbers, they probably signify services having features such as video images that are not generally available in traditional telephony networks (except through the use of multiple ISDN channels, for example). Countries having them include Ireland (using 76) and Japan (using 50).
- ENUM subscription numbers (see 6.3) are given special codes in some countries. If they are distinguished from IP telephony numbers, they probably require the use of public ENUM, with the resulting loss of privacy. Countries having them include Austria (using 780).

Beside “two-way communication” services like those above there are “one-way communication” services. These services are sometimes regarded as appendages to mobile services, with corresponding numbering. In particular:

- Paging numbers may be provided until mobile numbers supersedes them, which is likely to happen except where the called party pays for mobile calls.
- Text mail delivery numbers may be provided for services that deliver text messages to fixed phones. (In effect the fixed phones are then treated as mobile phones to avoid modifying the networks to use the geographic numbers of the fixed phones.)
- Voice mail delivery numbers may be provided for services that deliver voice messages to voice mail boxes owned by users without their own access network links[57]. (Voice mail retrieval, by the owners of voice mail boxes instead of callers, is usually handled by prefixing numbers with short codes, such as 860 in Switzerland.)

### 4.2.5 Distinctions between codes used for new services

Distinctions between number ranges could be made in many ways according to what information the calling and called parties expect about the services. The calling party is more likely to benefit from information provided in the number, because the called party chooses to take a service and therefore already knows what the service provides[58].

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[57] In some documents such services are described as ‘virtual telephony’, but this usage is not standard or recommended.

[58] For instance, losing privacy through the use of public ENUM is potentially significant to the called party, not to the calling party, so allocating ENUM subscription numbers from a particular range just to highlight their privacy aspects does not help users much.

The calling party might like the number to provide information of various kinds, but opportunities for this are tending to disappear. For example, callers may like to know about:

- **Call costs**. This is the most important expectation. However, in many countries, differences in charges between local, national long distance and mobile calls are decreasing; also, ways of discovering charges for calls are increasing. Consequently the called party number often has diminishing value as a source of information about call charges, except for specially tariffed calls.
- **Call quality**. The access network of the calling party, and various transit networks, as well as the access network of the called party, affect call quality. Consequently the called party number has limited value as a source of information about call quality.
- **Service features**. Differences in features that lead to differences in communication (such as video images) are significant to the calling party; however, these features depend on the use of IP terminals to an increasing extent, and a calling party using such a terminal may prefer URIs to phone numbers. Consequently the called party number has diminishing value as a source of information about service features.
- **The accessibility of the called party**. The called party is evidently less accessible in voice messages than in phone calls when the phone is answered (so differences in number ranges between "one-way communication" and "two-way communication" might be justified). Unfortunately the phone may not be answered, for many reasons that depend on the personal habits, as well as the access network, of the called party. For instance, some users prefer to keep their mobile phones switched off (and are therefore more accessible through their fixed phones), even where the calling party pays for mobile calls. Consequently the called party number has limited value as a source of information about the accessibility of the called party.
- **The location of the called party**. Even geographic numbers offer limited help in showing where the called party is, especially with the introduction of nomadic services and the merging of geographic areas due to Next Generation Networks (NGNs). Consequently the called party number has diminishing value as a source of information about the location of the called party.

Overall, the information conveyed by number ranges is fairly restricted; making number ranges proliferate will not help. From the point of view of users, services are best allocated to number ranges firstly according to their tariffs, secondly according to their features and thirdly according to their implications for the called party location.

### 4.2.6 Short codes

The 1XX range is widely, but not universally, used for short codes. In many countries, much of this range is still vacant, or used in ways which could be changed with little social impact (for example, as test codes by service providers). Consequently this range has been the focus of many harmonisation efforts (as Box 3 and Box 4 show), especially for essential and common services[59]. These efforts have now delivered some results. In brief:

- The emergency call code is 112 in the EU, in several other countries in Europe and elsewhere, and for many GSM networks.
- The directory enquiry code is 118, or selection codes offering competitive directory enquiry services are in the 118X, 118XX or 118XXX range, in ever more countries in Europe.

[59] For an entire report on this see *Harmonisation of short codes in Europe*, ECTRA Report 48380 (ECTRA, September 1998) at http://www.ero.dk/documentation/docs/docfiles.asp?docid=1895.

- Carrier selection codes are in the 1XX range (in particular, the 10X range) in many countries, as discussed in 5.2.

Often the second digit of a short code (following the initial 1) is used to identify a particular class of short codes. The following are typical classes of short codes:

- Codes for essential services, such as emergency calls, that must be the same on all access networks and must be provided by all access networks.
- Codes for common services, such as fault reports or directory enquiries, that must be the same on all access networks but need not be provided by all access networks. These codes can be further classified as follows:
  - Codes specifying call destinations on the access networks of the callers (for example, for directory enquiries, if the callers are obliged to use the directory enquiry service of the access networks).
  - Codes specifying call destinations on other access networks (for example, for fault reports, if the callers are unable to use the faulty access networks).
  - Codes imposing call routing through specific trunk networks (in particular, for carrier selection) and therefore needing to be followed by phone numbers of call destinations.
- Codes for commercial services, such as football results, that need not be the same on all access networks and need not be provided by all access networks.

When examining the use of short codes regulators usually decide that the supply needs to be managed carefully. They devise strict rules for the uses and lengths of short codes. In particular, they usually let at most two 3-digit or 4-digit codes identify a particular service provider. For instance, in India a service provider may have only two carrier selection codes, which are intended to signify different levels of quality.

Regulators often refuse to allocate short codes for services that could be accommodated in full national numbers, especially if the services are not free to customers. Allocations of numbers for these services are considered below.

### 4.2.7 Parts of the numbering plan used for new services

In different countries different numbering structures are chosen for new services: national NDC space, short code space (1XX and so on) or local SN space are all chosen, at least in open numbering plans. The most common choice is NDC space and the least common choice is SN space.

No choice of numbering structure is correct for all countries. The following general points may be helpful in making a choice:

- SN space might be suitable for services that are conveniently provided at the local level; in particular, it could be suitable for a service such as a voice message service that is tied to particular customers. Specially tariffed services that potentially have national reach usually use NDC space or short code space. However, there are exceptions; for instance, in Bolivia freephone services use local numbers starting with 800.
- Short code space is regarded in some countries as a scarce resource that should be reserved for memorable codes for special services of public interest; typically new services need long numbers and would not qualify. This is the view in the Netherlands. The opposite view is taken in Australia, where most new services are in 1XX space.
- 1XX space is often inaccessible from abroad. This must be so in open numbering plans, which use a national prefix for national dialling, if there is duplication between the allowed parts of the 1XX range and the NDCs having 1 as their first digit.

- 1XX space may be the easiest to use for internationally harmonised applications. SN space will be the hardest to use, as often few local number ranges are clear even throughout a single country, let alone throughout several countries with numbering plans that have evolved independently.
- 1XX space should only be used for services having high charges as well as ones having low charges if users are warned about potentially expensive calls. This may be a reason that premium rate services are usually found in NDC space (for example, 0900) even when freephone services use numbers starting with 1800.
- Short code space may need careful treatment so that special services provided on one network can be accessed from a different network. One example of the need for this is fault reporting: an out-of-order line is obviously not reported from the line in question. If a mobile network with numbers 078 XXX XXX provides the short code 123 for its customers to report faults from their mobile phones, it may also have any or all of the following options for fault reporting from other networks:
  - A standard number of its own, such as 078 456 123 (using nine digits).
  - A short number of its own, which would be 078 123 (blocking 1 000 potential subscriber numbers).
  - A number for a specially tariffed service, such as 0800 078 123.
  - A carrier selection prefix (1078, say) preceding the network-specific fault reporting short code, which would give 1078 123.
  - A shared industry fault reporting short code (124, say) with a network-specific extension, which would result in 124 078.

## 4.3 Numbering plan restructuring

### 4.3.1 Variants of numbering plan restructuring

When an untidy numbering plan is changed efforts are usually made to restructure it, so that it becomes more convenient to use and less disruptive to alter. These efforts complement those to move the plan towards uniformity and conformity with ITU-T recommendations, mentioned in 4.1 and 4.2. The critical decision is whether the numbering plan should be ‘open’ or ‘closed’ in the following sense:

- **Open numbering plan**. This has separate local and national dialling procedures and needs a national prefix to show when national dialling is being used. The lengths of codes and subscriber numbers may vary.
- **Closed numbering plan**. This has a single dialling procedure for an entire country and needs no national prefix to show when national dialling is being used (because national dialling is always used)[60]. There is usually a single uniform number length.

In principle a numbering plan could start as closed and be restructured to be open, but in practice this rarely happens. By contrast the restructuring of an open numbering plan may well result in a closed numbering plan.

Table 5 summarises the main features and some advantages and disadvantages of open and closed numbering plans. The examples given are from an imaginary 8-digit plan; the advantages and disadvantages assume that the plan starts as open and needs to be restructured.

[60] Nonetheless, a national prefix or a carrier selection code may be required for all dialling in the country (but not for dialling from abroad); this is so in France, for example.

An open numbering plan lets numbers be shorter for local calls and has more readily identifiable geographic areas (and associated tariff indications). A closed numbering plan lets numbers be dialled in the same way for all local and national calls. A closed numbering plan also uses the numbering space more efficiently. In particular, closing a numbering plan provides an immediate 25% increase in local number capacity, by using the ranges starting with the former national prefix (such as 0) and short code indicator (such as 1) for local numbers within each former geographic area. (In addition, closing a numbering plan can shorten national numbers by one digit, by eliminating the national prefix; however, because eliminating the national prefix may be confusing for users, many countries do not do this, at least for a transitional period.)

| Feature | Open numbering plan | Closed numbering plan |
|---|---|---|
| Local dialling | Local number<br>(for example, 456789) | National number<br>(for example, 2345 6789) |
| National dialling | National prefix + NDC + local number<br>(for example, 0 23 456789) | National number<br>(for example, 2345 6789) |
| National prefix | Needed in national dialling | Not needed |
| Tariff indicators | Absence of national prefix or content of NDC<br>(for example, 0 23) | Early digits of national number<br>(for example, 23) |
| Number length | Sometimes uniform | Often uniform |
| Number formats | Required to reflect the start of the local number<br>(for example, 0 23 456789 or 0 2345 6789) | Typically fewer<br>(with 2-digit NDC + 6-digit SN and 4-digit NDC + 4-digit SN, say, both written as XXXX XXXX) |
| Location number portability | Conceivable throughout the code area | Conceivable throughout the entire country |
| Geographic relief | Obliged to use geographic area splits or longer numbers | Made straightforward using overlays |
| Short term value | Avoiding large changes to familiar number patterns | Increasing local number capacity immediately |
| Long term value | Keeping development options open | Decreasing inefficiencies in the use of the number space |
| Main advantage | Allowing short local dialling (and local tariff indications) | Allowing uniform local and national dialling |
| Next advantage | Changing only numbers needing changes | Reducing requirements for future number changes |
| Main disadvantage | Having multiple number formats | Making users learn new dialling habits and ways of recognising tariffs |
| Next disadvantage | Doing nothing to make geographic relief less disruptive in the future | Needing longer numbers for all geographic areas |

**Table 5 Features of open and closed numbering plans**

### 4.3.2 Numbering effects of numbering plan restructuring

In many larger countries with longer numbers, open numbering plans remain and may well do so indefinitely. However, as time passes, the balance of advantage shifts towards closing numbering plans, because:

- A higher proportion of calls is dialled with full national numbers (often partly because of a rise in calls to and from mobile phones).
- A larger number of people use dialling aids (for example, memory phones), so the lengths of called party numbers are less troublesome.
- There are smaller differences in charges between local, national long distance and mobile calls, so less effort is spent on finding out exact tariffs.
- There are more ways of indicating charges without interpreting called party numbers, such as announcements of remaining prepaid call credit, announcements of charge rates at the starts of calls, visual displays of call costs, and on-line databases[61].

Countries having open numbering plans usually want to preserve the option of closing their numbering plans in the future. In practice, the option is preserved most easily by avoiding the duplicate use of any first significant digit both for NDCs and for short codes; then dropping the national prefix will not cause a clash between NDCs and short codes. Doing this usually involves avoiding the use of 1 as a first significant digit of NDCs.

Widespread location number portability and service number portability are made easier by having a closed numbering plan and inevitably lead to a loss of meaning in the NDCs. Ultimately there might be a single pool of numbers which can be used for any purpose in a country, with no meaning in the early digits. People would be able to keep their numbers wherever they moved and whatever services they subscribed to. This would have obvious advantages for number “owners” and allow very efficient use of the numbering space.

Denmark is furthest along this route, by providing location number portability and service number portability between geographic and mobile numbers. The only number ranges having special meanings are intended to be international numbers (starting with 00), short codes (starting with 1), freephone numbers (starting with 80) and premium rate numbers (starting with 90). All other numbers are intended to be interchangeable. For this route to be taken, market research should check that geographic and mobile call tariffs are similar enough to make losing tariff information in numbers acceptable to callers[62].

However, the route taken by Denmark may not be followed generally. For instance, in Sweden, which has demographic characteristics similar to those of Denmark, a review in 2002 concluded that an open numbering plan should be kept for some time, because:

- Users liked to dial local numbers that are short.
- Users had little interest in location number portability outside limited geographic areas.
- Fixed-mobile convergence, with hand-over of calls between fixed access networks and mobile access networks, was not seen as being imminent.
- The number length (which is 9 in Sweden, compared with 8 in Denmark) ensured that there were no shortages of local numbers.

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[61] See *Tariff transparency in a multioperator environment* (by Ovum for the European Commission, November 1999) at http://europa.eu.int/ISPO/infosoc/telecompolicy/en/tarifftran.pdf.

[62] In fact the differences between geographic and mobile call tariffs in Denmark appear to be comparable with those in Sweden, Switzerland and the UK. See *Communications Outlook* (OECD, May 2003) at http://www1.oecd.org/publications/e-book/9303021E.pdf.

### 4.3.3 Status of numbering plan restructuring

Table 6 summarises the incidence of open and closed numbering plans in 2002[63]. Traditionally, closed numbering plans prevailed in countries with:

- Relatively small geographic areas (for example, Hong Kong) limiting the geographic structure needed.
- Relatively small populations or number of lines (for example, Norway and Denmark).
- Maximum NSN lengths of 8 or less, which limit the burden of dialling all digits for every call.

However, now many numbering plans (some of them identified in Table 3) have moved from being open to being closed; several of these even have NSN lengths of 9 or 10. In some cases (for example, Switzerland and congested areas of the NANP) closing the numbering plan has created additional usable capacity, as a substitute for, or at the same time as, adding a digit. In other cases (for example, Italy and Spain) closing the numbering plan has seemed the only practicable expansion option.

| **Measure** | **Maximum length of NSN** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **4 - 13** |
| Number of closed numbering plans | 5 | 10 | 30 | 25 | 14 | 10 | 1 | 3 | 1 | 0 | 99 |
| Proportion of closed numbering plans (%) | 100 | 100 | 97 | 61 | 30 | 25 | 6 | 50 | 20 | 0 | 49 |
| Number of open or closed numbering plans | 5 | 10 | 31 | 41 | 46 | 40 | 18 | 6 | 5 | 1 | 203 |

**Table 6 Incidence of open and closed numbering plans**

[63] See *Dialling Procedures (International prefix, national (trunk) prefix and national (significant) number) (In accordance with ITU T Recommendation E.164 (05/97)) (Position on 1 March 2002)*, ITU Operational Bulletin 759 Annex (ITU, March 2002) at http://www.itu.int/itudoc/itu-t/ob-lists/op-bull/2002/759.html. This Annex relies on information supplied by countries that does not always use consistent definitions, so some discrepancies are inevitable.

# 5 Numbering for competition

National numbering plans can help the growth of competition in various ways, each of which has its own costs and benefits. This chapter discusses the arrangements for, and advantages and disadvantages of, features that can help competition to grow, by describing:

- Competitor number integration to give all service providers fair access to numbers (see 5.1).
- Carrier selection to let users choose service providers for the transit networks over which calls from them are carried (see 5.2).
- Provider number portability to make it easier for users to change service providers for the access networks to which their phones are connected (see 5.3).

## 5.1 Competitor number integration

### 5.1.1 Motivation for competitor number integration

Competition usually involves competition in fixed access, at least for business customers. In nearly all countries with competing fixed access (including those in the NANP) all the competitors providing fixed access must share the same set of geographic codes. Otherwise:

- Users may be confused by rival geographic code structures.
- New competitors are at a disadvantage because calls to their customers look like national calls instead of local ones.
- Provider number portability is harder to implement.

Rather similar considerations apply to mobile and specially tariffed services.

### 5.1.2 Numbering effects of competitor number integration

New entrants require distinct number blocks within the geographic codes where they provide fixed access. Ideally these blocks should be identified by the first significant digit (and, if required, the second significant digit) of subscriber numbers, to ensure:

- **Efficient and standard call routing**. As mentioned in 2.3, inbound international traffic, in particular, must be identifiable by the distant gateway in the first 7 international significant digits if it is to be routed differently from other traffic to the same country (for example, to a competing gateway chosen by a new entrant). Typically these 7 digits are a 3-digit country code, a 2-digit NDC and the first two digits of subscriber numbers.
- **Caller recognition of any higher charges**. Higher charges may occur where large geographic code areas are split into multiple charge groups or where interconnection charging is asymmetric[64].

Where different competitors provide similar mobile or specially tariffed services, they are allocated number blocks behind the same meaningful codes. Doing this lets callers recognise that charges and services should be roughly similar.

An alternative approach, in which high level number blocks (corresponding typically with a whole first significant digit) are allocated to new service providers, has been proposed in

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[64] Asymmetric interconnection charging is often recommended for improving rural network revenues. See *Telecommunications Challenges in Developing Countries: Asymmetric Interconnection Charges for Rural Areas*, World Bank Working Paper 27 (by Intelecon for the World Bank, March 2004) at http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2004/04/06/000090341_20040406141239/Rendered/PDF/284020PAPER0WBWP027.pdf.

some small countries. This approach may well be favoured by incumbent providers (as it minimises disturbance to them and makes their numbers appear to be the normal ones). It may also be acceptable to the first new entrants (as it naturally limits later market entry to the number of free high level number blocks). It may work in the long term in rather exceptional circumstances: if the numbering plan is closed, tariffs are flat, geographic distinctions are unimportant, and few competitors are expected. However, it is not generally recommended.

Table 7 summarises features of numbering plans in various liberalised countries, to show the relation between numbering and competition. Outside the NANP, in which geographic and mobile numbers typically use the same NDCs, there are usually recognisable distinctions between geographic and mobile numbers. The distinctions between mobile and specially tariffed numbers can be recognised also but are blurred by services (such as paging and personal numbering) that have characteristics of both mobile and specially tariffed services.

| **Country** | **Review position** | **Maximum length of NSN** | | | **Initial digits of NSN**[65] | | |
|---|---|---|---|---|---|---|---|
| | | **For geographic numbers** | **For mobile numbers** | **For specially tariffed numbers** | **For geographic numbers** | **For mobile numbers** | **For specially tariffed numbers** |
| Australia | Geographic areas reduced from 54 to 4 and extra digit added in 1994-1998 | 9 | 10 | 10 | 2, 3, 7, 8 | 1X, 4 | 16, 5 |
| Finland | Geographic areas reduced from 74 to 13 and national prefix changed in 1996 | 12 | 11 | 10 | 1X, 2X, 3X, 5X, 6X, 8X, 9 | 4, 50 | 10, 20, 29, 30, 60, 7, 80 |
| New Zealand | Geographic areas reduced from 80 to 5 and national prefix changed in 1991-1993 | 8 | 8 | 8 | 3, 4, 6X, 7, 9 | 2X | 24, 26, 60, 8 |
| Sweden | Geographic areas stayed at 264 in 1999 | 9 | 9 | 10 | 1X, 2, 3, 4, 5, 6, 8, 9XX | 10, 7X | 71, 74, 75, 77, 900 |
| UK | Geographic areas stayed at about 650; extra digit added in 1995; plan tidied in 2000 | 10 | 10 | 10 | 1, 2 | 7X | 5, 70, 75, 8, 9 |
| US | Geographic areas stayed at about 230; more codes added after 1995; number length increase possible some time | 10 | 10 | 10 | 2, 3, 4XX, 5XX, 6, 7, 8XX, 9XX | 2, 3, 4XX, 5XX, 6, 7, 8XX, 9XX | 456, 500, 555, 800, 866, 877, 888, 900 |

**Table 7 Numbering plans in some liberalised countries**

## 5.2 Carrier selection

### 5.2.1 Motivation for carrier selection

Competition often begins with the introduction of alternative providers of trunk networks carrying international or national long distance calls. There must then be indirect access to the trunk networks, so that customers using the access network of the incumbent provider can route their calls through them. The regulator aims to treat all the providers fairly by ensuring "equal access", in that customers can use the services of the alternative providers in the same way as they use those of the incumbent provider.

[65] 'X' signifies any digit not explicitly mentioned at the same position in another code for the country.

When alternative providers extend their offerings, indirect access can be extended in scope: it can allow the choice of service providers not just for international calls and national calls, but also for calls to mobile phones and local calls.

If indirect access is not available, service providers route traffic from their access networks through trunk networks that they choose (and that they may own). Doing this may be acceptable if the customers can choose between several access networks of the same type (in particular, several fixed access networks or several mobile access networks). Often a country has only one service provider with a fixed access network having significant market power but has several service providers with mobile access networks; then the regulator may have decided that indirect access is needed for calls from that fixed access network but not for calls from the mobile access networks, where there is already competition[66].

### 5.2.2 Variants of carrier selection

In some respects the simplest method of letting users choose the trunk networks through which their calls are routed is to have "two-stage dialling". In this method the calling party dials a number to gain access to the chosen trunk network, receives dial tone again, and then dials another number, perhaps preceded by an authorisation code, to set up the call to the called party[67]. An authorisation code is not usually needed if the service provider of the access network is responsible for billing the calling party or the Calling Line Identification (CLI) is passed to the trunk network[68].

This method of letting users choose trunk networks is widely available in exchanges, as it is used to gain access to Virtual Private Networks (VPNs), with corporate numbering plans and distinctive call charges. However, on its own it should be only a short term expedient, because it treats alternative providers unfairly. Setting up calls this way becomes cumbersome for users, at least if authorisation codes are needed[69].

There are better methods of providing indirect access than "two-stage dialling"[70]. They are:

- **Call-by-call selection**. The customer dials extra digits for each call to identify the carrier. These extra digits form a Carrier Selection Code (CSC), which usually comprises digits identifying the carrier, often preceded by digits meaning "carrier selection"[71]. Call-by-call selection can be made to treat alternative providers fairly by requiring that calls through incumbent providers, as well as calls through alternative providers, need CSCs. However, most countries do not demand this, as it burdens customers who do not have equipment to dial CSCs automatically, without helping those who do have such equipment.

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[66] However Switzerland, for example, lets callers from mobile phones select international service providers call-by-call.

[67] The first number dialled may not need to be a full national number; for instance, in France some members of the 30XX range of short codes may be used.

[68] Where the first number dialled is a short code and an authorisation code is not needed, the main difference for the user between this method and true call-by-call selection is that this method requires a short pause before the called party number is dialled

[69] However, authorisation codes allow two-stage dialling to be used at any phone locations, whilst call-by-call selection needs CLIs for customer authorisation and is tied to particular locations. Consequently two-stage dialling can still be useful after the introduction of call-by-call selection; in particular, it remains usual for calling cards.

[70] For further details see *Carrier selection*, ECTRA Report 48341 (ECTRA, July 1997) at http://www.ero.dk/documentation/docs/docfiles.asp?docid=1900.

[71] See *Alternatives for carrier selection and network identification*, ITU-T Recommendation E.164 Supplement 1 (ITU, March 1998) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.164-199803-I!Sup1.

- **Preselection**. The customer makes a one-off choice of the preferred carrier. Preselection usually allows “override” (call-by-call selection of a carrier other than the preselected one). Preselection with call-by-call overriding is usually ideal for customers, as it maximises choice while minimising the need to remember and dial extra digits. It is also preferred by most new entrants, as it provides flexibility over the packaging and marketing of services.

Preselection requires more network adaptation than call-by-call selection, and is often implemented later. Though introducing call-by-call selection is often seen as an interim step before introducing preselection, the further step may never be taken. It may not seem worthwhile where competition is limited or call-by-call selection is well established.

Possible dialling procedures for call-by-call selection are:

- **Prefixing**. The customer dials a CSC before any international or national prefix and before the rest of the number. Any free short code range can be used for CSCs; the most common choices are 10XXX and 1XXX. For example, from the UK a customer of Superline could dial 1461 00 27 11 234 5678 to reach a phone in Johannesburg (using 1461 as the CSC).
- **Insertion**. The customer dials a CSC after the international or national prefix and before the rest of the number. For example, from Hong Kong a customer of New World Telecommunications could dial 00 9 27 11 234 5678 to reach a phone in Johannesburg (using 9 as the CSC).
- **Substitution**. The customer dials a CSC instead of the international or national prefix and before the rest of the number. For example, from France a customer of Neuf Telecom could dial 90 27 11 234 5678 to reach a phone in Johannesburg (using 90 as the CSC).

Box 6 provides examples of the codes used with these procedures.

**Prefixing (CSC followed by normal dialling, including any required prefix)**[72]
*10W*
Austria, Denmark, Estonia, Finland, Italy, Liechtenstein, Malta, NANP, Philippines, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Switzerland, Turkey
*1XW (with X ≠ 0)*
Australia (14W), Belgium (15W, 16W), France (16XX), Greece (16W, 17W), Hong Kong (15W, 16W), Hungary (15W), Ireland (13W), Jordan (12XX), Luxembourg (15W), Malaysia (18W), Netherlands (16W), Norway (15W), Philippines (11W, 12W), Taiwan (18W), UK (12W, 13W, 14W, 16W, 18W)
*Other*
Finland (90XXX), Japan (00W), Singapore (15W), Sweden (95XX)

**Insertion (CSC inserted after prefix 0 or 00)**
Bolivia: 1W (national)
Germany: 10W (national)
Hong Kong: 6, 7, 8, 9, 3XX, 5XX, 4XXX (international)
India: 10XX (national, international)
Mongolia: 1, 2 (national)
Singapore: W (international)
South Korea: 8W (national)

**Substitution (CSC substituted for prefix 0 or 00)**
Chile: 1XX (national); 1XX0 (international)
Finland: 99W (international)
France: 2, 4, 5, 6, 7, 8, 9 (national); 20, 40, 50, 60, 70, 80, 90 (international)
Israel: 01W (international)

**Box 6 Examples of carrier selection codes**

[72] ‘X’ signifies 1 digit. ‘W’ signifies several digits (usually between 1 and 3, with 5 in the NANP).

Table 8 compares some features of these procedures, which show that the prefixing procedure has several advantages over the insertion and substitution procedures. In particular, the prefixing procedure is better for upgrading to preselection, as the prefix can then simply be omitted. However, when preselection is not available but alternative providers of trunk networks can be selected call-by-call, the insertion and substitution procedures may result in fewer digits being dialled overall.

The insertion and substitution procedures were adopted by several countries when less competition was expected than is expected now. They may have originally seemed attractive because of particular non-standard features of numbering plans. (For example, in Hong Kong, the international prefix was 001 rather than 00, which invited the use of 00X for alternative international service providers.) Countries such as Hong Kong and France that have adopted these procedures have sometimes also adopted the prefixing procedure, usually to create more CSCs.

In brief, most countries that are now introducing long distance competition should plan for preselection and use the prefixing procedure for call-by-call selection as an interim measure. The insertion and substitution procedures now appear to be good options only if preselection is unlikely to be introduced for several years.

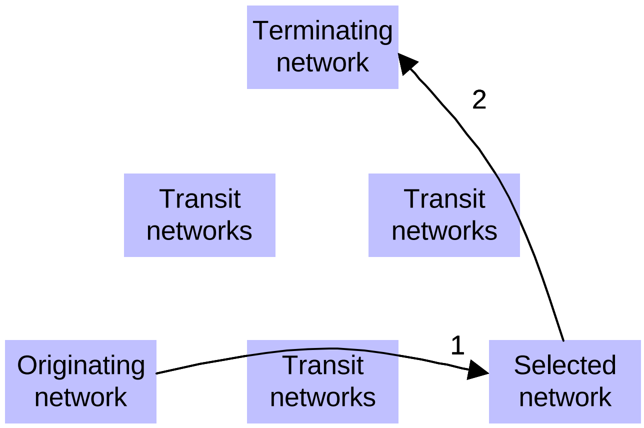
| Feature | Prefixing | Insertion and substitution |
|---|---|---|
| Number of extra digits dialled | Typically 3 or 4 ("carrier selection" as well as the carrier identification code) | Typically 1 or 2 (only the carrier identification code) |
| Way of increasing traffic to new entrants | Making callers dial extra digits or making customer premise equipment automatically insert CSCs | Making callers dial extra digits |
| Exchange implementation | Generally requiring reconfiguration work at local exchanges | Possibly avoiding reconfiguration work at local exchanges |
| Ease of use with international and national carriers | High: the dialling procedures are the same | Low: the dialling procedures are different |
| Compatibility with automatic dialling | High: the caller drops the prefix and dials as previously | Low: the caller learns new dialling pattern |
| Compatibility with preselection | High: the caller uses the prefix to override preselection | Low: the caller relearns old dialling patterns (or continues to dial redundant extra digits) |
| Extensibility to local calls | High: the caller dials the prefix before the local number | Low: the caller dials another prefix before the local number |
| Robustness to incorrect dialling | High: the numbering plan can be devised so that there is normally a sparse allocation of short codes | Low: customer identification codes are likely to match country codes and even NDCs |
| Ease of providing equal access for later entrants | High: the numbering plan can be devised so that there is normally a supply of vacant short codes of the same length | Low: carrier identification codes of the same length are in very short supply |
| Flexibility for different access networks | High: an access network uses no prefixes (if the regulator allows this) | Low: all access networks use the same prefixes or risk customer confusion |

**Table 8 Features of call-by-call selection dialling procedures**

### 5.2.3 Network implementation for carrier selection

Carrier selection represents a choice made by the calling party, so its implementation depends on the network hosting the calling party, which is the 'originating network' for the call. As the originating network already has much of the information about the calling party, the implementation is fairly easy.

Figure 4 shows the networks, with the activities required. The originating network routes the call towards the network selected by the calling party, which is the 'selected network' for the call (by arrow 1). The selected network routes the call towards the network hosting the called party, which is the 'terminating network' (by arrow 2). (Typically the originating network interconnects directly with the selected network, so there are no transit networks between the originating network and the selected network.) In the absence of carrier selection the originating network would route the call towards the terminating network.




1: The originating network routes the call to the selected network.
2: The selected network routes the call to the terminating network.

**Figure 4 Networks for carrier selection**

### 5.2.4 Advantages of carrier selection

The benefits of carrier selection are as follows:

- It is much less cumbersome for indirect access to trunk networks than "two-stage dialling". Without it, alternative providers are unable to offer convenient services to customers who do not want to change the access networks to which their phones are connected.
- It gives customers more choices in tariffs and service quality; the resulting competition then makes the prices fall faster then they otherwise would.

### 5.2.5 Disadvantages of carrier selection

In some countries, preselection has been sold to customers using undesirable sales practices, including excessive pressure, misleading statements and even transfers without telling customers ("slamming"). (The last of these is specific to preselection, which can be implemented without customers doing anything; the others could occur with call-by-call selection bur then might have less serious consequences, because call-by-call selection needs continued customer choices.) Consumer protection measures may therefore need to be reviewed when preselection is introduced.

Implementing carrier selection requires the following activities:

- Making exchanges translate CSCs into routing information (for call-by-call selection) or extract routing information from customer data (for preselection) in the originating network.
- Making exchanges use the routing information.

- Increasing the exchange port capacity to handle the extra traffic between the originating network and the selected network.
- Amending operation support systems to record customer choices (for preselection) and, if required, to let customer billing data be exchanged between service providers.
- Developing administrative arrangements for authenticating and responding to customer requests (for preselection).
- Negotiating the terms and conditions of carrier selection between service providers. The regulator may need to help the service providers to agree.

None of these activities is technically challenging or extremely costly. The costs of introducing preselection are likely to be greater than those of introducing call-by-call selection, as it needs extra customer-specific data in the exchanges and additional authentication procedures. However, in both cases the costs should be modest, at least for modern exchanges.

### 5.2.6 Policy implications of carrier selection

Usually call-by-call selection is technically straightforward as well as beneficial in reducing prices, so it should be adopted when competition is introduced. As both it and preselection serve customer interests well, even if they are not introduced immediately the way should be kept open for them by:

- Ensuring that the numbering plan does not make carrier selection difficult to adopt. In particular, there should be enough short code space for CSCs for call-by-call selection.
- Ensuring that the regulator has the power to impose carrier selection, and to decide who is to bear each component of the cost, when it can be shown to be in the national interest.
- Encouraging or requiring the industry to include carrier selection in exchanges, even if it is not activated, and to allow for carrier selection in future when investing in operations support systems.
- Reviewing regularly the decisions about the nature and scope of carrier selection.

The decisions about the nature and scope of carrier selection include:

- Whether to require carrier selection just for calls originating on fixed access networks. If the incumbent provider has the only major mobile access network, then there is an argument for requiring carrier selection for calls originating from mobile phones; if there are several significant mobile access networks, this argument is less telling, at least if customers can change easily between mobile access networks (and, in particular, if customers can use provider number portability when changing).
- Whether to require carrier selection just for access network providers having significant market power. Other access network providers might not be required to implement carrier selection if the national policy was to bolster them. In particular, there may be a trade-off between local competition and national competition; for instance, new access network providers may argue that their ability to choose routes for national long distance traffic is critical to their viability and that their customers are happy to have a ready-made choice.
- Which methods of carrier selection (call-by-call selection and preselection) to adopt, which procedures for call-by-call selection (prefixing, insertion and substitution) to adopt, and whether to let preselection be overridden call-by-call. If preselection is introduced after call-by-call selection, overriding it call-by-call is usually technically straightforward as well as desirable for customers (at least if the call-by-call selection uses the prefixing procedure).

- Which types of call (international calls, national calls, local calls and calls to mobile phones) to handle, and whether to let customers preselect different carriers for different types[73]. Making exchanges differentiate between types of call for preselection for each customer could be more costly than letting the customer make different selections. A cheaper approach, with similar benefits, may be to let the customer preselect one service provider and override preselection call-by-call.

- How to assign to service providers calls from customers who do not make conscious selections[74]. In some countries (such as Australia) the regulator has asked every customer to choose a national long distance service provider for preselection. Even so, there are customers who do not make choices consciously (for both call-by-call selection and preselection). The treatment of their calls can help either alternative providers or incumbent providers. For instance:

  - In Finland, calls dialled without carrier selection are allocated randomly among carriers in proportion to all selections made deliberately. Typically new entrants benefit from the allocations. However, whether a new entrant immediately welcomes them depends on its market status (for example, whether it is a second entrant or a later entrant) and its readiness to handle and bill bulk traffic.

  - In most countries, calls dialled without carrier selection are allocated to the national long distance service provider chosen by the access network provider. Often both these providers will be the incumbent provider, but sometimes new access network providers may benefit from the allocations, by being able to choose routes for national long distance traffic.

- How to recover costs. Though the costs of call-by-call selection, and even of preselection, should be modest, there are debates about them. Because carrier selection can often be implemented without big changes to the network, the incumbent provider is likely to be suspected of loading its costs for carrier selection with other costs[75].

- How to ensure that service providers respond to customer requests fairly and openly, and how to minimise risks of mis-selling. The agreed administrative arrangements may include checks on the authenticity of the requests (so that users are not moved to other networks without their consent) and be backed up by penalties for delays in fulfilling the requests.

### 5.2.7 Status of carrier selection

Table 9 demonstrates the extent to which carrier selection is becoming common, by indicating its deployment status in 2005 for fixed network providers having significant market power[76].

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[73] For information about the experience of such matters in Australia see *Telecommunications Competition Regulation* (Australian Government Productivity Commission, December 2001) at http://www.pc.gov.au/inquiry/telecommunications/finalreport/.

[74] If all calls of the relevant types had to be dialled with carrier selection then customers would be forced to make selections; however, this is rarely advocated.

[75] See *Developments in carrier selection and pre-selection* (OECD, November 2001) at http://www.oecd.org/dataoecd/10/1/27127466.pdf. For a review of the situation in the UK see *Per-provider and per-customer line costs and charges for Carrier Pre-Selection*, (Ofcom, March 2005) http://www.ofcom.org.uk/consult/condocs/carrier/carrier.pdf.

[76] This is partly based on *Stocktake of progress toward the key elements of a fully liberalised telecommunications sector in the APEC region* (APEC, June 2004) at http://www.apec.org.au/docs/stocktake.pdf and *Communications Outlook* (OECD, May 2003) at http://www1.oecd.org/publications/e-book/9303021E.pdf. Empty table cells indicate where information is missing.

| Country | Carrier selection[77] | | | |
|---|---|---|---|---|
| | For inter-national calls from geographic numbers | For national calls from geographic numbers | For local calls from geographic numbers | For calls to mobile phones from geographic numbers |
| Argentina | | | | |
| Australia | Yes | Yes | | Yes |
| Austria | Yes | Yes | Yes | Yes |
| Bahrain | Yes | Yes | | |
| Belgium | Yes | Yes | Yes | Yes |
| Bolivia | Yes | Yes | Yes | Yes |
| Botswana | No | No | No | No |
| Bulgaria | No | No | No | No |
| Canada | Yes | Yes | | |
| Chile | Yes | Yes | Yes | Yes |
| China | No | No | No | No |
| Colombia | | | | |
| Cyprus | Yes | Yes | Yes | Yes |
| Czech Republic | Yes | Yes | Yes | Yes |
| Denmark | Yes | Yes | Yes | Yes |
| Estonia | Yes | Yes | Yes | Yes |
| Finland | Yes | Yes | Yes | Yes |
| France | Yes | Yes | Yes | Yes |
| Germany | Yes | Yes | Yes | Yes |
| Greece | Yes | Yes | Yes | Yes |
| Hong Kong | Yes | Yes | | |
| Hungary | Yes | Yes | Yes | Yes |
| Iceland | Yes | Yes | Yes | Yes |
| India | Yes | Yes | | |
| Indonesia | No | No | No | No |
| Ireland | Yes | Yes | Yes | Yes |
| Italy | Yes | Yes | Yes | Yes |
| Japan | Yes | Yes | Yes | Yes |
| Jordan | Being planned | | | |
| Kenya | | | | |

[77] In some cases only call-by-call selection is provided but most of the entries describe the position of both call-by-call selection and preselection, and even of preselection with override.

| Country | Carrier selection[77] | | | |
|---|---|---|---|---|
| | For inter-national calls from geographic numbers | For national calls from geographic numbers | For local calls from geographic numbers | For calls to mobile phones from geographic numbers |
| Latvia | Yes | Yes | Yes | Yes |
| Lithuania | Yes | Yes | Yes | Yes |
| Luxembourg | Yes | Yes | Yes | Yes |
| Malaysia | Yes | Yes | | |
| Malta | Yes | Yes | Yes | Yes |
| Mexico | Yes | Yes | | |
| Nepal | No | No | No | No |
| Netherlands | Yes | Yes | Yes | Yes |
| New Zealand | Yes | Yes | Yes | Yes |
| Nigeria | No | No | No | No |
| Norway | Yes | Yes | Yes | Yes |
| Pakistan | Yes | Yes | | |
| Poland | Yes | Yes | | |
| Philippines | No | No | No | No |
| Portugal | Yes | Yes | Yes | Yes |
| Romania | Yes | Yes | | |
| Russia | No | No | No | No |
| Singapore | Yes | Yes | | |
| Slovak Republic | Yes | Yes | Yes | Yes |
| Slovenia | Yes | Yes | Yes | Yes |
| South Africa | Being planned | | | |
| South Korea | | Yes | | |
| Spain | Yes | Yes | Yes | Yes |
| Sri Lanka | Being planned | | | |
| Sweden | Yes | Yes | Yes | Yes |
| Switzerland | Yes | Yes | Yes | Yes |
| Taiwan | Yes | Yes | Yes | Yes |
| Turkey | Being planned | | | |
| UK | Yes | Yes | Yes | Yes |
| US | Yes | Yes | Yes | Yes |

**Table 9 Status of carrier selection**

## 5.3 Provider number portability

### 5.3.1 Motivation for provider number portability

Provider number portability lets customers keep numbers when changing access networks. In high teledensity countries with competition it is seen as encouraging the development of competition because it lets customers change service providers more easily. Cost-benefit studies in high teledensity countries have predicted that it provides net benefits (though the predictions are difficult to validate).

The position in low teledensity countries is less clear, for the following reasons:

- Opportunity costs may be severe because of the limited availability of skills. For example, making the incumbent provider focus on number portability may distract it from improving quality of service.
- As there is a large unserved market, competition is less inhibited by the absence of number portability. In fact number portability might even encourage new entrants to compete for the existing (relatively high value) customers of the incumbent provider, rather than to provide services to unserved customers.
- Substitutes for provider number portability, such as changed number announcements, may prove acceptable and cost-effective, at least for a period[78].

Consequently provider number portability could be counterproductive in low teledensity countries, especially where it would require adaptation of the technology or the customer base was too small to bear its initial cost[79].

### 5.3.2 Variants of provider number portability

Typically incumbent providers dominate fixed networks; provider number portability for fixed networks is seen as one way of limiting this domination[80]. However, provider number portability is also relevant to mobile networks. The following factors point to having it for mobile networks:

- Mobile networks are usually modern, so the additional cost of introducing provider number portability should be correspondingly low.
- Mobile networks are more likely to have overlapping coverage than fixed networks, so customers are more likely to have choices and therefore to use number portability.

However:

- Customers may be more willing to change their mobile numbers than their geographic numbers. In rich countries many people discard their old phones when they can get more up-to-date ones, and they may change their mobile numbers more often than they change their mobile network providers. (Important exceptions are Hong Kong, where provider

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[78] Wholesale line rental might be seen as a substitute for provider number portability where alternative providers do not have their own access networks, but it has yet to prove itself, especially in fixed access networks. (Single mobile access networks often support multiple service providers, in the form of “mobile virtual network operators”, without much difficulty.)

[79] Usually high teledensity countries with competition have implemented or planned to implement provider number portability whilst low teledensity countries have not implemented provider number portability; middle teledensity countries that have joined or applied to join the EU are obliged to plan for provider number portability.

[80] Where there is only one access network, there may still be different service providers (if there is wholesale line rental, for example). Provider number portability is relatively easy to implement between service providers offering service over a single access network.

number portability for mobile networks was introduced at the same time as new mobile network providers entered the market, and Finland; in both cases almost 25% of customers used provider number portability for mobile networks in the year after its introduction.)

- Mobile service providers often have more evenly matched sizes and strengths than fixed network service providers.

In high teledensity countries, provider number portability usually arrives rather later for mobile networks than for fixed networks. For example:

- In Ireland the introduction of provider number portability for mobile networks at the same time as for fixed networks was claimed to be unnecessary, because a customer moving from one mobile service provider to another could already keep the same SN (but not the NDC)[81].
- In the US the introduction of provider number portability for mobile networks was delayed several times (before arriving in a form that sometimes lets numbers be moved from fixed networks to mobile networks that use the same NPA )[82].

In low teledensity countries, provider number portability may be more important for mobile networks than for fixed networks, because customers depend for their livelihoods more on mobile networks than on fixed networks.

Moreover, provider number portability is also relevant to specially tariffed services[83]. The following factors point to having it for specially tariffed services:

- Full number translation is required for every call anyway, so the additional cost of introducing provider number portability should be very low.
- Freephone numbers are often widely advertised, so customers have strong interests in keeping their numbers (and service providers have strong interests in competing for what may be significant revenue streams).

In fact, provider number portability between freephone services in the US was the first working form of provider number portability to be introduced, in 1993.

### 5.3.3 Network implementation for provider number portability

Figure 5 shows the networks that may be involved in implementing provider number portability, together with the activities that may be required in various implementation techniques. Here the ‘donor network’ and the ‘recipient network’ host the called number before porting and after porting, respectively. (The implementation techniques actually let a transit network take the routing and network determination roles played in Figure 5 by the originating network.)

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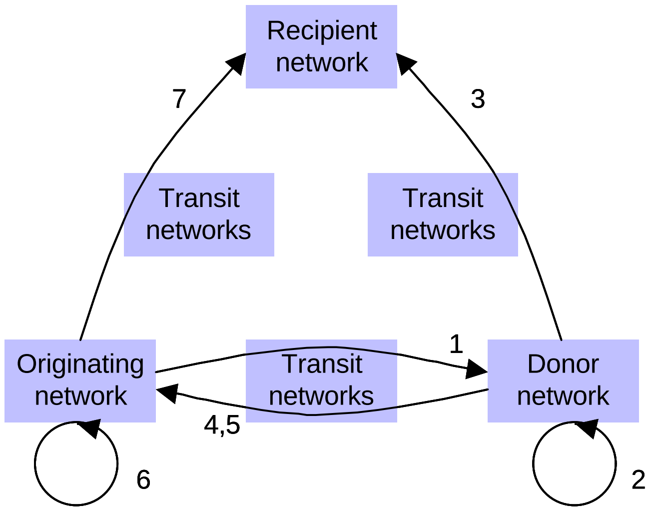
[81] This arrangement is termed ‘subscriber number portability’; for instance, someone with number 078 123 456 might change provider by moving to number 079 123 456. Subscriber number portability does not offer the same benefits as provider number portability or require the same technical arrangements as provider number portability, but it does require similar administrative arrangements.

[82] In the NANP, mobile phones typically draw their numbers from the same NPA as fixed phones. The corresponding forms of provider number portability (for geographic numbers and mobile numbers) are then collectively termed ‘local number portability’.

[83] The requirement is for provider number portability, which allows the provider to be changed while leaving the service unchanged, not service number portability, which allows the service to be changed while leaving the provider unchanged.




1: The originating network routes the call to the donor network.
2: The donor network determines the recipient network.
3: The donor network routes the call to the recipient network.
4: The donor releases the call back to the originating network, with the identification of the recipient network.
5: The donor releases the call back to the originating network, with an indication that the number has been ported.
6: The originating network determines the recipient network.
7: The originating network routes the call to the recipient network.

**Figure 5 Networks for provider number portability**

In increasing order of cost and also in decreasing order of involvement of the donor network, the implementation techniques are:

- **Onward routing** (which is also known as 'facility redirect'). The originating network routes the call to the donor network (by arrow 1). The donor network determines the recipient network (by arrow 2) and routes the call to it (by arrow 3).
- **Call drop back**. The originating network routes the call to the donor network (by arrow 1). The donor network determines the recipient network (by arrow 2) and releases the call back to the originating network, with the identification of the recipient network (by arrow 4). The originating network routes the call to the recipient network (by arrow 7).
- **Query on release**. The originating network routes the call to the donor network (by arrow 1). The donor network releases the call back to the originating network with an indication that the number has been ported (by arrow 5). The originating network determines the recipient network (by arrow 6) and routes the call to it (by arrow 7).
- **All call query** (which is also known as 'query by default'). The originating network determines the recipient network (by arrow 6) and routes the call to it (by arrow 7).

The details of these implementation techniques differ for fixed networks and mobile networks[84].

[84] For descriptions of the signalling see *Number Portability in the Global Switched Telephone Network (GSTN): An Overview*, RFC 3482 (IETF, February 2003) at http://www.ietf.org/rfc/rfc3482.txt and *Number Portability*, ITU-T Recommendation E.164 Supplement 2 (ITU, November 1998) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.164-199811-I!Sup2. Signalling relay in mobile networks is here regarded as a way in which a donor network determines a recipient network, not as a technique in its own right.

None of the implementation techniques is cheap to provide[85]. Onward routing might be used initially, while the amount of porting is low. A technique using a centralised database, such as query on release or all call query, might become desirable when the amount of porting becomes high (as it makes routes more direct). However, service providers are reluctant to incur the costs and inconvenience of changing from an initial technique that operates acceptably[86].

### 5.3.4 Advantages of provider number portability

The advantages of provider number portability are as follows:

- It avoids the need for users who change their numbers to inform contacts and replace stationery, or for their contacts to update number databases or waste time and money finding new numbers or dialling old ones. For residential users these activities ("switching costs") are mainly irritants, but for some business users they represent serious costs. These costs have to be offset against the costs of implementation when deciding whether to implement provider number portability[87].
- It stimulates competition, from which all customers should benefit. However, this stimulus is extremely difficult to quantify. (It may nonetheless be substantial: the weak state of competition in retail banking is widely attributed to the switching costs of changing account details when changing banks.)
- It can help to relieve shortages of numbers by letting allocated number blocks be pooled between different service providers. Of course this number pooling is not a replacement for designing the numbering plan according to predicted demand.

### 5.3.5 Disadvantages of provider number portability

The disadvantages of provider number portability are varied. Some come from the cost of introducing it, which involves:

- Making exchanges extract routing information from customer data in the originating network or the donor network (depending on the technique).
- Making exchanges use the routing information.
- Increasing the exchange port capacity to handle the extra traffic between the originating network or the donor network (depending on the technique) and the recipient network.
- Amending operation support systems to record number porting.
- Developing administrative arrangements for authenticating and responding to customer requests for provider number portability.
- Negotiating the terms and conditions of provider number portability between service providers, which may also involve the regulator.

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[85] For estimates of the costs for fixed networks in Australia, which amount to AU$100M for a smaller provider using all call query and AU$70M for a larger provider using onward routing, see *Telecommunications Competition Regulation* (Australian Government Productivity Commission, December 2001) at http://www.pc.gov.au/inquiry/telecommunications/finalreport/.

[86] For suggestions about the net presents cost over 10 years of changing the implementation technique for fixed networks in the UK, which amount to UK£40M for query on release and UK£200M for all call query, see *An assessment of alternative solutions for UK number portability* (Ofcom, August 2004) at http://www.ofcom.org.uk/consult/condocs/uk_numb_port/uk_numb_port_cons/?a=87101.

[87] There has been market research into the comparative proportions of customers who would change network providers to get a given price reduction, with and without provider number portability; it may overestimate the proportions by not considering the true switching costs.

There are other disadvantages. Provider number portability could distract attention from matters that could be more important for customers, such as quality of service. Deploying provider number portability could encourage alternative providers to compete for existing customers of the incumbent provider, instead of finding new customers.

### 5.3.6 Policy implications of provider number portability

Countries that have low teledensity may not want to require provider number portability when they first introduce competition. However, as it often serves customer interests the way should be kept open for it by:

- Ensuring that the numbering plan does not make provider number portability hard to adopt. This involves having competitor numbering integration (see 5.1).
- Ensuring that the regulator has the power to impose provider number portability, and to decide who is to bear each component of the cost, when it can be shown to be in the national interest. This may call for a suitable provision in the law and in licence conditions. In principle provider number portability could be introduced without a regulatory requirement to do so, particularly by agreement in a country with a mature, well-balanced industry; however, this does not seem to happen. (Provider number portability was introduced into New Zealand when there was no regulator and therefore no regulatory requirement, but there was government pressure.)
- Taking account of the benefits of location number portability and service number portability when considering the introduction of provider number portability. Often location number portability and service number portability can be broadened to cover larger areas and more features by using network features similar to those used by provider number portability.
- Encouraging or requiring the industry to include provider number portability in exchanges, even if it is not activated, and to allow for provider number portability in future when investing in operations support systems.
- Reviewing regularly the decisions about the nature and scope of provider number portability.

The decisions about the nature and scope of provider number portability include:

- Whether to require provider number portability just for calls terminating on fixed networks. In fact provider number portability might not be introduced first for geographic numbers, but instead for specially tariffed numbers or for mobile numbers. In fact, when there is only one network provider with a fixed access network (as opposed to a national long distance network, for example), provider number portability is pointless for fixed networks.
- Whether to require provider number portability just from service providers having significant market power. Customers can usually choose between more mobile network providers than fixed network providers, so considerations of significant market power may not be important for mobile networks.
- How to recover costs. The costs themselves depend on the implementation techniques. For a given choice of implementation technique, the costs can probably be minimised by making each service provider responsible for the costs in its own network. The benefits can probably be maximised by ensuring that users are not directly charged for provider number portability; doing this spreads the costs across all customers, including those who do not change service providers, and may be justified on the grounds that all customers get the benefits ultimately. (Having simple administrative arrangements and widespread publicity can also raise the number of users of provider number portability and, presumably, the overall benefits.)

- How to ensure that service providers respond to customer requests fairly and openly. The agreed administrative arrangements may include checks on the authenticity of the requests (so that users are not moved to other networks without their consent) and be backed up by penalties for delays in fulfilling the requests. If customer requests, and network queries, are directed towards a centralised database that is not controlled by the service providers there is no problem (provided that the owner of the centralised database exercises its monopoly in the public interest).
- Which techniques for provider number portability (onward routing, call drop back, query on release and all call query) to adopt. Different service providers in one country may be able to use different techniques (and to choose the techniques for themselves), if they can agree on the administrative and technical arrangements.

### 5.3.7 Status of provider number portability

Table 10 shows the deployment status of number portability in 2005 in various countries[88].

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[88] This is partly based on *Stocktake of progress toward the key elements of a fully liberalised telecommunications sector in the APEC region* (APEC, June 2004) at http://www.apec.org.au/docs/stocktake.pdf and *Communications Outlook* (OECD, May 2003) at http://www1.oecd.org/publications/e-book/9303021E.pdf. Empty table cells indicate where information is missing.

| Country | Provider number portability[89] | | |
|---|---|---|---|
| | For geographic numbers | For mobile numbers | For specially tariffed numbers |
| Argentina | Being studied | | |
| Australia | Yes | Yes | Yes |
| Austria | Yes | Yes | Yes |
| Bahrain | No | Being planned | |
| Belgium | Yes | Yes | |
| Bolivia | | | |
| Botswana | No | No | No |
| Bulgaria | No | No | No |
| Canada | Yes | Yes | Yes |
| Chile | | Being studied | |
| China | No | No | No |
| Colombia | No | No | No |
| Cyprus | Yes | Yes | Yes |
| Czech Republic | Yes | Yes | |
| Denmark | Yes | Yes | Yes |
| Estonia | Yes | Yes | |
| Finland | Yes | Yes | |
| France | Yes | Yes | Yes |
| Germany | Yes | Yes | Yes |
| Greece | Yes | Yes | Yes |
| Hong Kong | Yes | Yes | Yes |
| Hungary | Yes | Yes | Yes |
| Iceland | Yes | Yes | |
| India | No | No | No |
| Indonesia | No | No | No |
| Ireland | Yes | Yes | Yes |
| Italy | Yes | Yes | Yes |
| Japan | Yes | Being planned | |
| Jordan | | Being planned | |
| Kenya | Being planned | | |
| Latvia | Yes | Yes | Yes |

[89] In some cases provider number portability for specially tariffed numbers is limited to freephone services, for example.

| Country | Provider number portability[89] | | |
|---|---|---|---|
| | For geographic numbers | For mobile numbers | For specially tariffed numbers |
| Lithuania | Yes | Yes | Yes |
| Luxembourg | Yes | Yes | Yes |
| Malaysia | | Being studied | |
| Malta | No | No | No |
| Mexico | Yes | Yes | Yes |
| Nepal | No | No | No |
| Netherlands | Yes | Yes | Yes |
| New Zealand | Yes | Yes | Yes |
| Nigeria | No | No | No |
| Norway | Yes | Yes | Yes |
| Pakistan | | Being studied | |
| Poland | Yes | Yes | |
| Philippines | No | No | No |
| Portugal | Yes | Yes | |
| Romania | No | No | No |
| Russia | No | No | No |
| Singapore | Yes | Yes | |
| Slovak Republic | Yes | Yes | Yes |
| Slovenia | Yes | Yes | Yes |
| South Africa | | Being planned | |
| South Korea | | Yes | |
| Spain | Yes | Yes | Yes |
| Sri Lanka | No | No | No |
| Sweden | Yes | Yes | Yes |
| Switzerland | Yes | Yes | Yes |
| Taiwan | Yes | Yes | Yes |
| Turkey | Being studied | | |
| UK | Yes | Yes | Yes |
| US | Yes | Yes | Yes |

**Table 10 Status of provider number portability**

# 6 Convergence in numbering

The internet and other IP networks are now being used to carry voice and other real-time traffic, because economies of scale and scope are expected from carrying voice over the same network as data. Telephony service providers are changing their networks so that voice is carried over IP, and internet service providers are developing services like telephony. Consequently organisations that once provided very different services, in very different commercial, regulatory and operating environments, are now competing with rather similar services[90]. This is the 'convergence' of telephony and the internet.

Sometimes 'convergence' refers to other pairings, such as fixed access networks and mobile access networks, voice core networks and data core networks, carriage and content, telecommunications and broadcasting, or telecommunications and computing. These are more or less closely related to convergence between telephony and the internet but have different emphases.

For numbering purposes the most significant of these other forms of convergence is 'fixed-mobile convergence'. This term itself has had various meanings, ranging from the use of a single bill for both fixed and mobile services to the provision of a single service over a single network to both fixed and mobile devices. Perhaps the most far-reaching interpretation of fixed-mobile convergence that does not involve the internet is the support of dual mode wireless phones, providing DECT through a fixed access network and GSM through a mobile access network. A similar scheme now involves wireless phones that provide, instead of DECT, voice over IP with various wireless mechanisms (such as Bluetooth, WiFi or WiMax).

There is also now a recognition that the Third Generation Partnership Programme (3GPP) network architecture for successors to GSM is largely independent of mobile access networks and can be extended to provide roaming and advanced services for IP networks in general, including those using other wireless mechanisms or indeed fixed access networks.

Even without fixed-mobile convergence or 3GPP services, networks that carry voice over IP need to interoperate with traditional telephony networks. In particular, they need to let users of IP terminals and traditional phones set up calls to each other. This chapter indicates how this can be done, by describing:

- IP addresses and domain names for the internet having roles analogous to those of phone numbers for telephony (see 6.1).
- Ways of interoperating suited to telephony service providers, typically by associating new phone numbers with end points in IP networks (see 6.2).
- Ways of interoperating suited to internet service providers, typically by associating end points in IP networks with existing phone numbers (see 6.3).

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[90] For illustrative discussions oriented to the EU see *Implications for Numbering, Naming and Addressing of the convergence of the Internet and the Telco Networks*, ECC Report 036 (ECC, October 2003) at http://www.ero.dk/documentation/docs/docfiles.asp?docid=1963 and *Policy Implications of Convergence in the Field of Naming, Numbering and Addressing* (by Political Intelligence for European Commission, September 2003) at http://europa.eu.int/information_society/topics/ecomm/doc/useful_information/library/studies_ext_consult/regulatory_implications_study.pdf.

## 6.1 Internet addressing and naming formalities

### 6.1.1 Address formats

Phone numbers originally determined routing through the network directly; they now do so indirectly. They have in fact shifted from being rather like addresses to being much like names, according to the following definitions:

- **Address**. This identifies an end point to networks.
- **Name**. This identifies an end point to users independently of the networks.

The internet, and IP networks more generally, distinguish between addresses and names[91]. An IP address for IP version 4 (IPv4), such as 213.162.107.109, comprises 4 numbers (each lying between 0 and 255 and expressed in decimal notation) separated by '.'. An IP address for IP version 6 (IPv6), such as 0:0:0:0:0:0:D5A2:6B6D, comprises 8 numbers (each lying between 0 and 65535 and expressed in hexadecimal notation), separated by ':'[92].

Addresses are hierarchical, to some degree, with the most "important" number at the left and the least "important" number at the right. The hierarchy is useful for address allocation and route determination.

IPv6 was devised chiefly to get around the perceived limitations imposed by IPv4 on the size and structure of the addressing space[93]. Lavish allocations of addresses early in the life of the internet and high growth in demand for addresses subsequently have led to localised shortages of IPv4 addresses, which the use of IPv6 could overcome. IPv6 incorporates various other improvements over IPv4 (with support for automatic device configuration, security and mobility, as well as address management), but many of these have also been grafted on to IPv4, though not always very elegantly. Also, address conservation measures, such as Classless Inter-Domain Routing (CIDR) and Network Address and Port Translation (NAPT), are relieving shortages of IPv4 addresses[94].

Changing to the use of IPv6 is costly and complicated. Though transition schemes have been devised, and some networks now use IPv6, many years will pass before the transition from IPv4 to IPv6 is complete for the internet[95]. Parallel running is possible because every IPv4 address can be embedded in an IPv6 address[96].

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[91] IP networks other than the public internet generally use private IP addresses, with translation to public IP addresses at the points where they connect with the public internet. Such private IP networks may be used instead of the public internet even for public IP telephony.

[92] For other representations of IPv6 addresses see *Internet Protocol Version 6 (IPv6) Addressing Architecture*, RFC 3513 (IETF, April 2003) at http://www.ietf.org/rfc/rfc3513.txt.

[93] In principle there are 340,282,366,920,938,463,463,374,607,431,768,211,456 IPv6 addresses and 4,294,967,296 IPv4 addresses. Fewer addresses are available for global routing because of the reservation of some blocks for private addresses and the underuse inherent in address block allocation. (However blocks may be allocated with $2^n$ addresses for any n, not just with 1000 or 10000 numbers, so underuse can be moderated.)

[94] In fact there is no immediate danger of exhausting the IPv4 addressing space: in 2004 29% remained unallocated, 32% remained unused and 2.5% had been newly allocated. For further statistics related to these see *Internet Number Resource Report* (NRO, April 2005) at http://www.nro.net/documents/presentations/nro-jointstats-mar-05-draft.ppt.

[95] For some of the transition schemes that have been discussed see *Transition Mechanisms for IPv6 Hosts and Routers*, RFC 2893 (IETF, August 2000) at http://www.ietf.org/rfc/rfc2893.txt.

[96] There are actually two ways of embedding an IPv4 address in an IPv6 address; one requires that the IPv4 end point can use IPv6 and the other does not do so.

### 6.1.2 Name formats

Addressing space shortages for the internet are analogous in some ways to numbering space shortages for telephony. However, the internet concept of a domain name, not the internet concept of an IP address, is actually more relevant to the telephony concept of a phone number. A domain name, such as one-isp.co.uk, comprises sequences of domain labels (which themselves are sequences of 63 characters) separated by '.' and totalling at most 255 characters. Domain names are independent of addresses: they are the same for IPv6 as for IPv4.

Domain names are hierarchical, with the most "important" domain label at the right and the least "important" domain label at the left (by contrast with IP addresses and phone numbers). The hierarchy is used for name allocation and mapping domain names to IP addresses.

There are generic top level domain labels (such as 'int' and 'com') and country top level domain labels (such as 'in' and 'uk')[97]. Different top level domain labels have potentially different organisations responsible for allocating second level domain labels (such as 'ac' and 'itu'); similarly different second level domain labels have potentially different organisations responsible for allocating third level domain labels, and so on.

Rules govern which users may have which domain names; for instance, 'ac.in' is intended for academic institutions in India and 'itu.int' is intended for one international treaty organisation. However, with domain labels like 'com' users can have their own personal or corporate domain names (not just the names of internet service providers, such as 'one-isp.co.uk').

Some countries benefit commercially by having top level domain labels to which people want to attach second level domain labels[98]. Meaningful domain names produce not just such opportunities for commerce but also problems of rights of use. These may increase as scripts other than Roman become more widespread in domain names[99].

Identifications often need to be more specific than IP addresses or domain names, so Uniform Resource Identifiers (URIs) are used[100]. These often have domain names (or even IP addresses) embedded in them; for instance, htpp://www.one-isp.co.uk, mailto:person@one-isp.co.uk and sip:+44-20-7946-0235@one-isp.co.uk are all URIs[101]. However, URIs can take other forms, such as tel:+ 44-20-7946-0235[102].

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[97] In this report the term 'domain' refers to a domain label in appropriate contexts. The term 'label' is rare outside descriptions of domain name syntax, where it is not usually accompanied by 'domain'.

[98] For example, up to US$50M is being paid over 12 years to Tuvalu by an organisation that has leased the right to provide registrations of second level domain labels attached to the 'tv' top level domain label. Such rights can be revoked if the registry is found (by ICANN) not to be acting sufficiently in the interests of the country, as happened for the 'pn' top level domain label for Pitcairn Island in 2000, when almost all the 50 inhabitants requested revocation.

[99] See *Internationalizing Domain Names in Applications (IDNA)*, RFC 3490 (IETF, March 2003) at http://www.ietf.org/rfc/rfc3490.txt.

[100] See *Uniform Resource Identifier (URI): Generic Syntax*, RFC 3986 (IETF, January 2005) at http://www.ietf.org/rfc/rfc3986.txt.

[101] Here 'mailto' signifies an email communication service, 'sip' signifies a telephony communication service (or even a multimedia communication service) using the Session Initiation Protocol (SIP), and +44-20-7946-0235 is an E.164 number. Another user name, such as 'person' (with the URI sip:person@one-isp.co.uk), could be used instead of +44-20-7946-0235 (with the URI sip:+44-20-7946-0235@one-isp.co.uk). See *SIP: Session Initiation Protocol*, RFC 3261 (IETF, June 2002) at http://www.ietf.org/rfc/rfc3261.txt.

[102] Here 'tel' signifies a telephony communication service without making a commitment to any specific protocol, such as SIP. See *The tel URI for Telephone Numbers*, RFC 3966 (IETF, December 2004) at http://www.ietf.org/rfc/rfc3966.txt.

The syntax of URIs is general enough to let very many standard schemes for identifiers be used in types of URI; all that is required is the registration of the scheme name (such as ‘tel’ for phone numbers) and the definition of any parts of the URIs that are additional to the identifiers. URIs can be generalised to Internationalised Resource Identifiers (IRIs) that are presented in scripts other than Roman[103].

### 6.1.3 Address administration

The Internet Corporation for Assigned Names and Numbers (ICANN) is a private not-for-profit organisation advised on public policy by a committee that in principle is open to all governments. Through the Internet Assigned Numbers Authority (IANA), it delegates the management of IP addresses to registries covering different regions of the world. These regional internet registries allocate IP addresses to national and local internet registries such as internet service providers. These in turn assign IP addresses either statically (for an indefinite time) or dynamically (for the duration of a “connection”) to internet service providers and users; these may themselves assign IP addresses to further internet service providers and users, and so on.

The regional internet registries co-ordinate their activities through the Number Resource Organisation (NRO).

### 6.1.4 Name administration

ICANN creates top level domains for different purposes (such as identifying particular countries and particular information or organisation types) and delegates the administration of these domains to specific organisations (“registries”). These organisations create, and delegate the management of, second level domains; the organisations responsible for the second level domains create, and delegate the management of, third level domains, and so on.

A global hierarchy of server computers, accommodating the hierarchy of domains, maintains the Domain Name System (DNS) that maps between domain names and IP addresses. (When an application needs to send a message from one domain to another, DNS translates the domain names into the IP addresses used for routing the message.) The servers are controlled by the registries under the guidance of ICANN. The administrative details of this are handled by registrars on behalf of users: when users are granted domain names by registrars, the registrars pass information about the domain names and IP addresses to the registries for storage in the servers.

## 6.2 IP telephony numbering

### 6.2.1 Motivation for IP telephony numbering

Telephony service providers want to let calls be set up between IP terminals and traditional phones, so that networks can support IP terminals. The numbering aspect of this is easy to support: the E.164 numbering plan can be extended with phone numbers for IP terminals, so calls to IP terminals can use ordinary dialling procedures and calls from IP terminals can present ordinary CLIs.

The phone numbers are regarded as names rather than addresses: they are associated with IP addresses that are then used in IP traffic routing. The hierarchical structure of phone numbers may say nothing about the hierarchical structure of the IP network, though it will influence the choice of gateway between the telephony network and the IP network.

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[103] Particular challenges arise with IRIs in which some components are to be read from left to right and other components are to be read from right to left. See *Internationalized Resource Identifiers (IRIs)*, RFC 3987 (IETF, January 2005) at http://www.ietf.org/rfc/rfc3987.txt.

### 6.2.2 Numbering effects of IP telephony numbering

IP telephony might draw numbers from either new NDCs or existing NDCs[104]. Particular number blocks in existing NDCs could be used for administrative convenience, without requiring users to know that these number blocks contained IP telephony numbers.

Also, different types of NDCs might be used by different networks; for instance, in France Neuf Telecom uses geographic numbers and Free uses shared cost numbers.

As discussed below, there are both advantages and disadvantages to using distinctive numbering for IP telephony through the introduction of new NDCs.

### 6.2.3 Network implementation for IP telephony numbering

In a single IP network the association between phone numbers and IP addresses can be implemented in various ways, which do not need standardisation. For instance, it can use information distributed between several call servers or centralised in one database. There are complications when IP addresses of terminals change (typically because terminals are relocated physically or addresses are assigned dynamically) but these can be handled by usual internet protocols.

If, however, one IP network is to set up a call to another IP network, the calling party network must use the called party number to find routes towards the called party network. Doing this requires agreement on protocols, as discussed in 6.3.

### 6.2.4 Advantages of IP telephony numbering

The arguments for using distinctive numbering for IP telephony concern both service features and operational efficiency; they include the following:

- IP terminals can typically be moved, registered on the IP network again and use the same phone numbers as before. This nomadic behaviour is different from the roaming and hand-over supported by mobile networks, as roaming lets the user visit a location attached to another network and hand-over lets the user change location during calls.
- An internet service provider with international reach could provide IP telephony to its users internationally, at the same (usually low) tariffs as it would use nationally. This again contrasts with what happens on mobile networks.
- IP telephony resembles Universal Personal Telecommunications (UPT) by having nomadic uses; indeed VISIONng has been allocated +87810 from the UPT country code +878 to support IP telephony service providers with international reach, and Sentiro is offering a service drawn from a number range included in +87810. However, some forms of UPT might be used for incoming calls only, because of their billing arrangements, whilst IP telephony would be used for outgoing calls also.
- IP terminals do not typically support emergency calls with the same reliability as fixed phones: they are not usually powered from the lines (though power over Ethernet can sometimes be used), do not identify their locations readily (though there are techniques that help with this) and may not offer high quality voice (at least if they use low bandwidth internet access) [105].

[104] See *Implications for Numbering for VoIP Services*, ECC Report 059 (ECC, December 2004) at http://www.ero.dk/documentation/docs/docfiles.asp?docid=2047.

[105] The emergency call features of IP terminals may seem irrelevant to numbering, if phone numbers are intended to provide information to callers to the numbers, not to callers from the numbers. However, emergency call recipients extract information from the CLIs, make return calls using the CLIs, and might infer something about the terminal features from the CLIs, especially if they had no automated way of locating the emergency callers.

- IP terminals may support services (such as video and text) that fixed phones do not usually support.
- If IP telephony uses geographic numbers, it can lead to shortages of numbers, because:
  - IP telephony service providers can serve customers in many geographic areas without needing local exchanges. They may ask for number blocks wherever they have customers, no matter how few customers they may have. (They will not generally be satisfied with being granted instead number blocks just in the geographic areas of their gateways to traditional telephony networks, as these numbers will then lose their geographic significance.) By contrast traditional service providers ask for number blocks only in the geographic areas where they have local exchanges.
  - If tariffs depend heavily on the NDCs of the calling and called parties, some IP telephony users will want multiple numbers, in different geographic areas and even in different countries (as offered by some IP telephony service providers).

### 6.2.5 Disadvantages of IP telephony numbering

The arguments against using distinctive numbering for IP telephony include the following:

- Some of the characteristics of IP terminals are relevant mainly to called parties. Numbers are most useful in distinguishing between different services for calling parties, because the called party usually knows what services are available. In the fixed and mobile networks services are not generally given different number ranges just because of characteristics (such as caller display) relevant mainly to called parties.
- If IP telephony numbers are not drawn from existing number ranges, then users must change their numbers when moving to IP telephony. This impedes competition between IP telephony and other services that for many users do not seem very different.
- IP terminals have different features from each other, so IP telephony is not a well-defined service. Any attempt to distinguish different services for IP telephony and allocate separate number ranges to them would risk stifling innovation and fragmenting the numbering plan.

### 6.2.6 Policy implications of IP telephony numbering

The decisions to be made about IP telephony using E.164 numbering include:

- Whether to use new NDCs, existing NDCs or both for IP telephony numbers. In several countries (such as Ireland) both can be used; typically new NDCs are intended for nomadic behaviour and existing NDCs are intended for voice over IP networks that meet essentially the same obligations as fixed networks.
- Whether to ensure that access networks for IP telephony offer carrier selection. The simple billing arrangements between many IP networks may make this both difficult and counterproductive to do; it may also be pointless, if the service providers do not have significant market power.
- Whether to ensure that access networks for IP telephony offer provider number portability. The service providers might not welcome this, because they are used to communication services such as email in which their domain names appear in the URIs and thereby help them to keep their customers.
- Which further rights and obligations to introduce for IP telephony. These deal with such matters as directories, CLIs, malicious calls, lawful interception, emergency calls, universal service, consumer information, reliability, security and interconnection. (For instance, the right to provider number portability might be granted in return for the obligation to support emergency calls adequately.)

## 6.3 ENUM and similar systems

### 6.3.1 Motivation for ENUM and similar systems

Extending the E.164 numbering plan to IP telephony, as described in 6.2, lets calls be set up between IP terminals and traditional phones. However, it is unsatisfactory on its own, if calls using phone numbers are to be set up from one IP network to another IP network. It can lead to indirect routes, with calls leaving the calling party network through gateways into an intermediate traditional telephony network, traversing that network, and entering the called party network through other gateways. The intermediate traditional telephony network would offer more routing information; however, it would also convert between voice over IP and its own representation, thereby increasing call costs and decreasing call quality. (Calls using domain names, instead of phone numbers, do not take similar indirect routes, because DNS can translate the domain names into the IP addresses used for routing.)

To make routes direct for calls using phone numbers, an IP network needs to find routes towards other IP networks by inspecting the phone numbers. In fact a network may find several IP communication services (such as email, fax and voice mail), with different routes, for each phone number. Some routes may use direct IP connections and other routes may pass through gateways into traditional telephony networks.

### 6.3.2 Variants of ENUM and similar systems

There are various ‘enum’ systems, with various implementation techniques, for finding IP communication services from phone numbers[106]. The best known is tElephone NUmber Mapping (ENUM), which defines a mapping of phone numbers into domain names that can then be looked up using DNS; for instance, the phone number +44 20 7946 0235 is mapped to 3.5.2.0.6.4.9.7.0.2.4.4.e164.arpa[107]. However, there are already systems that use DNS in the same way as ENUM but do not use the e164.arpa domain[108]. There are also systems that do not use DNS but instead have entirely different implementation techniques[109].

When an IP network finds other communication services from phone numbers, the phone numbers are just treated as familiar unambiguous names; other naming systems could be devised and used instead. IP telephony providers could choose to by-pass the national number allocation arrangements by adopting their own numbers looking like phone numbers. These numbers would provide IP telephony but would not give access to traditional telephony networks; they could even cause number changes when they are finally found to conflict with the national numbering plan[110]. To ensure that only valid E.164 numbers are

[106] In this report the term ‘enum’ refers to any system that is similar to ENUM just by being intended for finding IP communication services from phone numbers; this usage is not standard. The term ‘ENUM’ should really be used only for such a system that has a centralised implementation using a particular mapping of phone numbers to domain names in the e164.arpa domain.

[107] See *The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application (ENUM)*, RFC 3761 (IETF, April 2004) at http://www.ietf.org/rfc/rfc3761.txt. Strictly speaking, variants of this mapping of phone numbers to domain names that use domains other than e164.arpa, such as ones for private networks and others for public networks, are not ENUM.

[108] For a current implementation using the e164.info domain see http://www.e164.info/. ICANN, after receiving advice from ITU-T, has rejected proposals for new top level domains such as ‘tel’ for systems for finding IP communication services from phone numbers (or even from alphanumeric strings). Nonetheless, the use of e164.arpa is not yet settled, because of concerns about whether the management of arpa through ICANN is international enough.

[109] For a prominent possibility, Distributed Universal Number DIscovery (DUNDI), see http://www.dundi.com/. In this case the implementation is distributed, not centralised.

[110] Some voice over IP service providers in the US may be risking doing this, by giving users numbers that are too long to conform with E.164 but that start with NPA codes not allocated in the NANP.

used, there need to be agreements between the service providers and any central authority. For ENUM this central authority is provided at the global level by ITU-T and at the national level by a neutral organisation working with the regulator and the registries controlling the DNS servers[111].

There can be different sources for the mapping of phone numbers to IP communication services. To minimise confusion, and ensure that only one of these sources needs to be consulted, there should be one authoritative primary source of the complete information that service providers or users need; secondary sources may then extract this information and be consulted by service providers or users[112]. In a country that adopted ENUM these systems might be expected to be secondary sources taking their information from the ENUM system.

The most important distinction between enum systems concerns whether service providers or users can supply information to, and get information from, these sources. The corresponding enum systems are:

- **Carrier enum** (which for ENUM is also known as 'infrastructure ENUM'). Service providers supply information about the phone numbers and preferred communication services of their customers, and other service providers can get that information. The preferences in this case are likely to be those of the service providers; in fact service providers may not have, or may not wish to supply, information about all the communication services preferred by their users[113].
- **User enum** (which for ENUM is also known as 'public ENUM'). Users supply information about their phone numbers and preferred communication services, and other users can get that information. The preferences in this case are those of the users and can include all of the communication services that the users take.

As discussed below, there are both advantages and disadvantages to carrier and user enum. Because carrier enum has fewer disadvantages, it is favoured more often than user enum[114].

### 6.3.3 Network implementation of ENUM and similar systems

For a call to set be up from one IP network to another IP network without using an intermediate traditional telephony network, the originating network must find routes towards the terminating network (or, more generally, find the IP communication services of the user of the terminating network). Finding these routes involves finding a domain name associated with the user of the terminating network, so if a phone number identifies the call destination the originating network must use the phone number to find that domain name.

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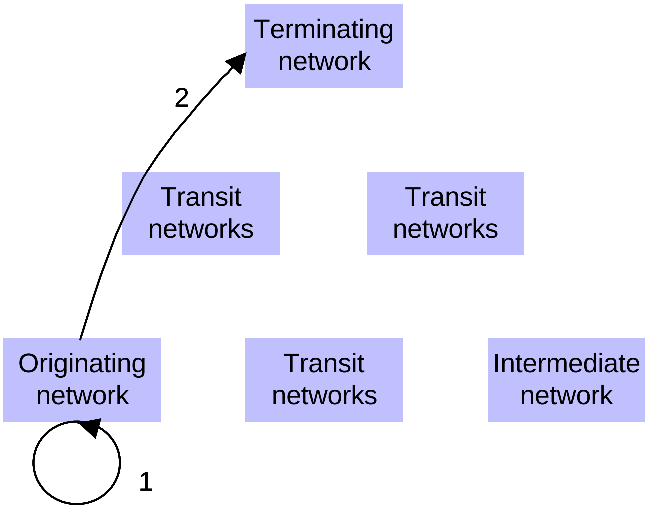
[111] See *Operational and administrative issues associated with national implementations of the ENUM functions*, ITU-T Recommendation E.164 Supplement 3 (ITU, May 2004) at http://www.itu.int/rec/recommendation.asp?type=items&lang=E&parent=T-REC-E.164-200405-I!Sup3 and *Operational and administrative issues associated with the implementation of ENUM for non-geographic country codes*, ITU-T Recommendation E.164 Supplement 4 (ITU, May 2004) at http://www.itu.int/rec/recommendation.asp?type=items&lang=E&parent=T-REC-E.164-200405-I!Sup4.

[112] A primary source of information is needed also for directory enquiries (when there are several providers of directory enquiry services) and provider number portability. The primary information source need not be a centralised database; for instance, in implementations of provider number portability using onward routing or call drop back the primary source of information about the recipient network is the donor network, though in implementations using query on release or all call query it might well be the centralised database of an intelligent network system.

[113] For example, if a user has a phone number and a 'sip' URI sip:person@one-isp.co.uk provided by one service provider, that service provider may be unwilling to update the information when the user replaces the 'sip' URI with, say, sip:person@another-isp.co.uk from a different service provider.

[114] In particular, DUNDI and the implementation using the e164.info domain have been deployed for carrier enum, not user enum.

Figure 6 shows the networks, with the activities required. The originating network determines the terminating network (by arrow 1) and routes the call to it (by arrow 2). Determining the terminating network involves finding the domain name from the phone number, and routing the call involves standard IP routing.




1: The originating network determines the terminating network.
2: The originating network routes the call to the terminating network.

**Figure 6 Networks for ENUM and similar systems**

There are various techniques by which the originating network could use the phone number to find a domain name. Essentially they use information distributed between networks by an agreed protocol or centralised in one database available to all subscribing networks. (This "centralised" database is not necessarily centralised physically, but the information in it is available to all the networks.) Distributed techniques use new protocols between networks. Centralised techniques define a mapping of phone numbers into domain names that DNS can associate with IP communication services. The scaling ability of the distributed techniques is not yet demonstrated, whilst that of these centralised techniques is established by general experience with DNS.

The choice between distributed and centralised techniques is less important to regulators than the choice between carrier enum and user enum.

### 6.3.4 Advantages of ENUM and similar systems

The arguments for having an enum system include the following:

- It lets participating service providers have direct routes for IP telephony calls using phone numbers. It therefore helps with the growth of competition between IP telephony and traditional telephony.
- It can be used by communication services other than IP telephony. For instance, multimedia messages between mobile phones and computers have been specified to use ENUM[115]. Global Networks, using +88234 in Antarctica, has an ENUM delegation for this purpose.

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[115] However, multimedia messages are generally implemented without the use of ENUM, because of potential regulatory problems when ENUM information is shared internationally between service providers; in particular, provider number portability for multimedia messages is implemented using a distributed technique, not a centralised one, with queries from the originating network to the donor network.

- It can even be used in implementations of traditional telephony network features like provider number portability and specially tariffed numbering.
- In the form of user enum, it could provide something like number portability of domain names (for email addresses, for example) for users who do not have their own domain names; these users would tell people their phone numbers, not the URIs of their communication services[116].
- In the form of user enum, it could let users make personal information available globally for new internet applications just by using phone numbers as a naming system.

### 6.3.5 Disadvantages of ENUM and similar systems

Several trials have shown that public ENUM presents various problems. Many of these would exist for user enum in general, but not for carrier enum. The main problems are as follows:

- User enum lets people read user information about others. It thereby makes "spamming" (communicating with someone else without any implied consent, particularly through email) and "spoofing" (pretending to be someone else) easier. This sort of abuse could be limited by restricting user enum to users who opt in; there could even be a special number range, from which users would be get numbers only if they opted in to user enum[117]. However, restricting user enum to users who opt in merely limits this sort of abuse, without eliminating it, and reduces the potential market for user enum[118].
- User enum lets people try to change user information about others. The changes could be intended for "slamming" (transferring the service for a user to another service provider without consent) or for redirection, perhaps to steal traffic containing business information. Consequently users need to be authenticated before they change their information. Often the service provider to whom a number has been allocated and with whom the user has a billing relationship could do this authentication readily. However, the service provider might not help, believing that user enum wastes effort or even reduces revenue (by replacing phone calls by email, for example). Extra ways of authenticating users are needed, just as they are for requests about carrier selection and provider number portability.
- Users who opt in to user enum have incentives to keep their user information correct, while they are using the phone numbers concerned. However, they may have no incentives for keeping it correct when they stop using the numbers. Moreover, in a centralised implementation service providers may have no incentives for ensuring that the information is correct, especially when it applies to their former customers. If the system includes incorrect information then new "owners" of these numbers may be denied access or may have communications misdirected. Users could be given incentives to keep their user information correct by being charged for records in the user enum system, but doing this again reduces the potential market for user enum.
- Though user enum gives a new role to phone numbers (and to DNS, in a centralised implementation), the value of this is debatable, for the following reasons:

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[116] For example, a user having phone number +44 20 7946 0235 might switch from using sip:person@one-isp.co.uk to using sip:person@another-isp.co.uk without telling other users: 3.5.2.0.6.4.9.7.0.2.4.4.e164.arpa would act as a domain name for the user.

[117] There are also systems for finding the identities, and even the location addresses, of owners of domain names. These systems might need to be changed for public ENUM, so that they did not find the identities of users from domain names to which phone numbers were mapped.

[118] Users could also reduce the loss of privacy by imposing SIP called party control and providing only 'sip' URIs containing SIP aliases, not their usual names, to DNS.

- To use user enum, callers need to know phone numbers first. Directories indexed by the names of contacts are more generally useful, especially as they identify the communication services for an individual contact, not for all the people with which that contact shares the phone number.
- By using user enum, callers may be able to find email URIs (for example) from phone numbers but they will not be able to find phone numbers from email URIs. Other services would be needed to supply such information.
- Though user enum resembles a “find me / follow me” service (which lets calls track the locations and availability of users), at least in a centralised implementation it is not one, because by design DNS does not support features essential to such a service. Consequently any users wanting such a service would need to get it separately and might not then bother to maintain their records in the user enum system.

### 6.3.6 Policy implications of ENUM and similar systems

Carrier enum helps with IP telephony interconnection and therefore with the growth of competition. User enum, however, is much more questionable, for several reasons; generally regulators are therefore unwilling to impose it or even to propose it. The policy considerations for enum include:

- Whether to deploy carrier enum, user enum or both. The use of carrier enum in a closed group of service providers may be a matter for that group alone, provided that:
  - User information is not accessible from the public internet.
  - Only numbers allocated in the national numbering plan are handled.
  - Service providers are not excluded from the group in an anti-competitive way.
  - Service providers in the group supply correct and complete user information, no matter which service providers are mentioned in the information.
- How to maintain the privacy of the users and the correctness of the information if user enum is deployed.
- Whether to use new NDCs, existing NDCs or both for IP telephony numbers if user enum is deployed. In some countries (such as Austria) both are expected to be used, but in many countries user enum has not yet been deployed outside limited trials.
- Which roles to give to the enum registries (which maintain the databases) and registrars (which authenticate and validate information from the users for the databases) in a centralised implementation. The registrars are to be distinguished from the service providers, especially if there is provider number portability.
- How to recover costs. The costs themselves depend on the implementation techniques. The deployment of user enum alongside carrier enum would benefit from economies of scale and scope, but in a centralised implementation the databases would need to be kept largely separate, to preserve their integrity.
- How to ensure that service providers respond to customer requests fairly and openly. The considerations here are very similar to those for provider number portability (see 5.3).

# 7 Regulation for numbering

There is understandable reluctance from some incumbent providers to relinquish control of the numbering plan. There is also often a matching hesitation from regulators to take on this role, for which they may feel unready. However, there is widespread agreement with the following principles implicit in statements by the World Trade Organisation (WTO)[119]:

- The national numbering plan is a national resource.
- Number management, along with spectrum management and rights of way management, should be performed in the overall national interest.
- In a competitive environment, the regulator needs to ensure that number management is performed in the national interest.
- The regulator should be independent of telecommunication companies (and of the government, if that has financial interests in telecommunication companies).

This chapter covers practical implications of these principles by describing:

- General duties of the regulator (see 7.1).
- Particular responsibilities of the regulator (see 7.2).
- Some legal and commercial problems for a new regulatory system (see 7.3).
- The content of numbering reviews (see 7.4).
- The implementation of number changes (see 7.5).

## 7.1 General duties of the regulator

### 7.1.1 Numbering plans based on E.164

The regulator may be able to delegate day-to-day aspects of numbering plan administration, perhaps to a suitably monitored industry organisation. However there are some tasks that remain with the regulator. Among them are:

- **Maintaining a long term vision for the numbering plan**. The regulator must resist short term pressures (from either the industry or the government) that may lead to dead ends. The regulator must foresee potential shortages of numbers, start reviews when necessary, and take overall responsibility for the plan architecture in the national interest.
- **Deciding the basic rules governing the use of the numbering plan**. These cover number structures and lengths (see 4.1) and number ranges to be reserved or used for particular purposes (see 4.2).
- **Consulting all interested parties regularly**. In particular, the regulator must act as guardian of the user interest (see 7.2).
- **Setting rules for the allocation, use and sale of numbers** (see 7.3).
- **Ensuring that allocations observe principles of good husbandry** (see 7.4).

[119] See *Negotiating Group on Basic Telecommunications (NGBT) Reference Paper* (WTO, April 1996) at http://www.wto.org/english/news_e/pres97_e/refpap-e.htm. Clause 5 states “The decisions of and the procedures used by regulators shall be impartial with respect to all market participants.” Clause 6 states “Any procedures for the allocation and use of scarce resources, including frequencies, numbers and rights of way, will be carried out in an objective, timely, transparent and non-discriminatory manner.”

- **Facilitating the implementation of number changes** (see 7.5).
- **Administering the numbering plan in a competitively neutral way**. If aspects of administration are delegated to an industry organisation, the regulator must ensure that existing service providers do not shut new ones out.
- **Supervising number use, particularly for premium rate content**. If details of supervision are delegated to an industry organisation, the regulator must ensure that this organisation is not "captured" by vested interests.
- **Setting rules for other competition matters with numbering implications**. Among these are carrier selection (see 5.2), provider number portability (see 5.3), ENUM and similar systems (see 6.3), the production of telephone directories, and the management of number databases (which is sometimes shared across the industry).
- **Resolving disputes**. Typically incumbent providers have an advantage over alternative providers through possessing economic and technical facts and performing administrative and technical procedures. The regulator may need to intervene speedily or even to appoint arbiters, so that this advantage is not exploited and procedural details are settled.

In all this there can be conflicts of interest like the following:

- Incumbent service providers may not be willing to share numbering resources fairly with new entrants or even to reveal their existing usage of number blocks.
- Service providers may wish to use numbers for "branding" their services, whilst users want simplicity and uniformity, with numbers having meanings that are useful to them.
- Business users may prefer to have only full national dialling whilst residential users want to keep local dialling.

### 7.1.2 Addressing and naming systems not based on E.164

Many telecommunications regulators manage telephony addressing and naming systems other than phone numbers on behalf of their countries. Among these are national and international Signalling Point Codes (SPCs) and International Mobile Station Identities (IMSIs), which have roles and functions defined by international recommendations[120]. Other telephony addressing and naming systems usually just identify service providers for interconnect schemes (in carrier selection and provider number portability, in particular) or for administrative arrangements that involve more than one service provider.

Telecommunications regulators may also be concerned with data network addressing and naming systems. However, apart from those for the internet described in 6.1, in general they have decreasing importance, especially in public networks.

Phone numbers are difficult to manage by comparison with all of these, because of:

- The use of phone numbers in a user interface.
- The potentially short supply of phone numbers.
- Access to phone numbers by incumbent providers who might (for example) allocate few numbers from many number blocks and thereby exclude alternative providers from the blocks.

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[120] See *Signalling network functions and messages*, ITU-T Recommendation Q.704 (ITU, July 1996) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-Q.704-199607-I and *The international identification plan for mobile terminals and mobile users*, ITU-T Recommendation E.212 (ITU, May 2004) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.212-200405-I. The IMSI is coded in the Subscriber Identity Module (SIM) card to provide all the information necessary to find the record for the mobile phone within a specific mobile network.

IP addresses for IPv4 are in rather short supply and domain names are used in a user interface. Perhaps because of this, there is a continuing debate about whether telecommunications regulators should manage IP addresses and internet domain names. This debate occurs at both the global level and the national level. At the global level it originated in discussions about the relative roles of ITU and ICANN; it is now sometimes part of a broader debate that also covers multilingual domain names, intellectual property rights, acceptable use policies, spectrum management, security and several other topics[121]. At the national level a widespread view is that the internet should be largely outside the scope of telecommunications regulators (or at least largely beyond the reach of government ministers), to avoid unnecessary restrictions on civil liberties and private enterprise. There are differences in emphasis, however. For example:

- A study for the Netherlands of several addressing and naming systems recommended that the government should focus its attention on phone numbers, IMSIs, IP addresses and internet domain names but should manage only phone numbers directly[122].
- A report in Norway on managing the ‘no’ top level domain concluded that responsibility for the domain should rest with the government (and be exercised by the telecommunications regulator), even if operations were delegated to another organisation[123].

Some telecommunications regulators manage internet domain names, but a more usual arrangement, which reflects the growth of the internet as an entity outside formal government structures, is to have an autonomous academic or industry organisation for this purpose. Though there may be no need to change this arrangement, the growing convergence between telephony and the internet necessitates at least sharing of expertise and consistency of approach between telecommunications regulators, internet domain name managers and other organisations concerned with internet access and content. Examples where this is likely to be so include:

- Procedures for resolving disputes about rights to use phone numbers and domain names that are closely related to each other[124].
- Rules governing the use of ENUM, especially together with provider number portability.
- Rules governing premium rate content for IP telephony and the internet (with, for example, different payment methods used for the same content).
- Measures to eliminate rogue internet dial-up programs that replace cheap internet dial-up sessions by expensive ones.

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[121] For background papers see http://www.unicttaskforce.org/sixthmeeting/background.html, http://www.oecd.org/site/0,2865,en_21571361_34590630_1_1_1_1_1,00.html and http://www.wgig.org/.

[122] See *A strategic numbering review* (by Ovum for DGTP, February 2000) at http://www.antelope.org.uk/numbering/DGTP_report.pdf.

[123] See *Model for the management of the Norwegian Domain Name Administration and the resolution of disputes, Report by the Working Group on Domain Names* (NPT, March 2002) at http://www.npt.no/pt_internet/eng/publications/other_reports/Dot_no_report_summary.htm.

[124] Phone numbers and domain names are most closely related when the phone numbers are given alphanumeric forms or the domain names are allowed to be purely numeric (as they are by some domain name managers, though they cause various problems besides potential confusion with phone numbers and indeed IP addresses). For example, 112 has occasionally been allocated to private organisations though it might reasonably be expected to be dedicated to emergency services. See *“112” Domain Names*, Communications Committee Working Document COCOM04-39 (European Commission, May 2004) at http://forum.europa.eu.int/irc/DownLoad/kkeeAAJJmmGGcgO1-4T5Uca3pLk2pUmA3K-WLRYYU-11STapeSGGkeZOpHxZgCcGZrje/COCOM04-39%20112%20Domain%20names.pdf.

## 7.2 Particular responsibilities of the regulator

The national numbering plan is common property. The plan itself, any rules relating to it and the numbers allocated from it should be clearly documented and a matter of public record. (There may be very limited exceptions due to commercial confidentiality; these are likely to apply only to number blocks reserved but not allocated for new services that have not yet been announced.) Many regulators take advantage of the internet, which is an excellent vehicle for making such materials widely available[125].

A fully documented numbering plan can be hundreds of pages long. However, exactly what rules are needed for successful numbering management and administration depends on the national legal and regulatory framework and the national competitive and social conditions[126]. Many countries will find a short and simple collection of rules enough[127].

Box 7 outlines recommended responsibilities for numbering administration and management; along with Box 8 and Box 9 it maybe useful in checklists of topics to be covered by the rules[128].

- The national numbering plan and the associated designated number ranges should be controlled by an NRA.
- The administration of the national numbering plan should be performed by an NRA or another national organisation independent of telecommunications organisations.
- The national numbering plan and the associated designated number ranges should:
  - Provide sufficient capacity in both the short term and the long term.
  - Enable fair and open competition.
  - Be in line with the relevant ITU-T Recommendations.
- The management of the national numbering plan, consisting of the assignment of numbers to market parties, surveillance of usage and withdrawal of assigned numbers, should be controlled by an NRA.
- The primary management of the national numbering plan should be performed by an NRA or another national organisation independent of telecommunications organisations.
- The management should be carried out in an objective, non-discriminatory, equitable, proportionate, timely and transparent manner.

**Box 7 ETO proposals for responsibilities of regulators for numbering administration and management**

Box 8 outlines recommended responsibilities for numbering assignment, including potential delegations of authority from regulators to service providers.

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[125] For an example from Switzerland (partly in English and Italian, as well as French and German) see http://www.bakom.ch/en/telekommunikation/numad/. The websites for Australia, Hong Kong, the UK and the NANP are also excellent sources of relevant material.

[126] In some documents such rules are called 'numbering conventions'.

[127] For an example from Tanzania see http://www.tcra.go.tz/Regulation/Regulations-Numbering.htm and http://www.tcra.go.tz/Publications/numbering%20plan.doc.

[128] For further details see *Harmonised national numbering conventions*, ECTRA Report 48465 (ECTRA, October 1997) at http://www.ero.dk/documentation/docs/docfiles.asp?docid=1898.

- Applications for primary assignment
  - Eligible applicants should be defined.
  - The information required for the numbering plan manager to decide on an application should be defined.
- Primary assignment and the choice of numbers
  - The principle of 'first come, first served' should be applied, except when starting assignment from newly designated number ranges.
  - Applicants should have the right to indicate their preference for specific telephone numbers.
  - Users should have the right to use telephone numbers that are not often incorrectly dialled.
- Timescales for decision on applications for primary assignment
  - The time limit between receipt of an application and notification of the decision on the application should be laid down.
  - The applicant should be informed by the numbering plan manager as soon as possible on receipt of the application.
- Refusal of primary assignment
  - The applicant should immediately be informed about a refusal, its reasons and the procedure for appeal against the refusal.
  - Refusal should only be allowed for a limited set of reasons, which should be laid down.
- Usage conditions after primary assignment
  - Assignment should only imply the granting of rights of use.
  - The legitimate purpose of usage of assigned numbers should be laid down.
  - The time limit for activation should be laid down.
  - The assignee should provide information on usage to the numbering plan manager.
  - Fees should seek to cover the administration and management costs.
  - Transfer of assigned numbers should be prohibited so long as no appropriate regulatory framework for number trading has been put in place.
  - The assignee should not use network-specific telephone numbers that may cause interference with the national telephone numbering plan
- Withdrawal of numbers from assignees of primary assignments
  - Withdrawal should only be allowed for a limited set of reasons, which should be laid down.
  - The overall societal costs of a withdrawal should be carefully considered.
  - The procedure for a withdrawal should allow an assignee to clarify its position before a decision is taken.
  - When a change of active telephone numbers is imposed, the users of these active numbers should have the right to have disruption minimised.
- Conditions for secondary and tertiary assignment
  - Secondary and tertiary assignment should comply with the national numbering plans.
  - The usage conditions for primary assignment should also apply regarding the granting and transfer of rights of use and the right of users to have disruption minimised because of a number change.

**Box 8 ETO proposals for responsibilities of regulators for numbering assignment**

Box 9 outlines recommended responsibilities for numbering consultation, publicity and appeal. In many countries numbering advisory committees help. These comprise industry experts and sometimes also user representatives and independent experts such as academics. Not only are these bodies a source of numbering expertise, but they may also be helpful in making unwelcome changes politically acceptable. Meetings open to the public can also be used. In any event, regulators must ensure that user views are found out and given due weight (especially during reviews) and provide the right notice periods and publicity for any changes[129].

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[129] For information about numbering advisory committees in Australia and Hong Kong see http://internet.aca.gov.au/ACAINTER.3997752:STANDARD:1819072826:pp=PC_2465,pc=PC_2472 and http://www.ofta.gov.hk/ad-comm/nac/nacpaper.html. For information about open meetings in the UK see http://www.ofcom.org.uk/licensing_numbering/numbers/num_w_groups/num_forum/?a=87101.

- The NRA should consult all interested market parties or their representatives (for example, through a consultation forum) on important issues concerning numbering conventions and on large-scale withdrawals of assigned numbers.
- Up-to-date information should be published appropriately about the national numbering plan (with the rules for its administration and management), the designated number ranges, the assigned numbers (with any usage conditions that are not commercially sensitive or do not violate user privacy) and the status of each number (typically free, reserved, allocated, permanently unavailable or temporarily unavailable).
- Appropriate procedures should be laid down for independent appeal against numbering plan management decisions.
- The publicity of a change in a substantial part of the active national telephone numbers should be well co-ordinated and started well in advance.

**Box 9 ETO proposals for responsibilities of regulators for numbering consultation, publicity and appeal**

## 7.3 Legal and commercial aspects of numbering

### 7.3.1 Overall framework

The legal status of numbers is often unclear. If possible, telecommunications legislation or regulations should establish a system of rights and obligations that addresses the following:

- National ownership of numbers. This should let the regulator control the use of the numbering plan in the national interest, subject to the usual requirements on consultation and transparency, while delegating day-to-day administration.
- Intellectual property in numbers and the numbering plan. This should prevent the misappropriation of some aspects of the plan by service providers or powerful corporations.
- Any necessary distinctions between number holders such as end users, content providers, service providers and network providers. These distinctions are being eroded and as far as possible should be ignored in the overall framework; for instance, service providers leasing network infrastructure might treat leases as capital assets and thereby resemble network providers.
- Delegations of authority by the regulator. These delegations include those for administering the numbering plan and supervising number use.
- Rights of use by number holders. These rights do not usually amount to “ownership”: they let the regulator keep any desired control of number trading, number withdrawal and number changes in the national interest[130].
- Trading in numbers by number holders.
- Charging for numbers by the regulator.

### 7.3.2 Rights of use

There is an increasing need for rights of use to be made explicit when end users and service providers are allocated numbers. In particular, there is an increasing need for customers to understand the circumstances in which numbers might be changed or withdrawn. This need arises for reasons such as the following:

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[130] For a relatively straightforward draft collection of rules about rights of use for the UK see http://www.ofcom.org.uk/static/archive/oftel/ind_groups/numbering/wg1/rgu0100.htm#Rules.

- Phone numbers have growing importance to customers, especially those who want to make their business numbers recognisable by or memorable to the public.
- There is a trend towards charging for numbers, either on first allocation or on subsequent transfer ("secondary trading").

In specifying rights of use the regulator needs to take account of:

- The rights of the regulator to change numbers after consultation if changes are needed.
- The rights of the regulator to withdraw number blocks, or to reject applications for further number blocks, if existing allocated number blocks are unused, underused or misused.
- The transfer or retention of rights when numbers are ported.
- The procedures for ensuring that anyone who transfers or allocates a number is the number holder.
- The rights of the regulator or a number holder to charge when transferring or allocating numbers.
- Any conflict of interest between potential number holders over rights of use.
- Any conditions on the tariffs or content associated with numbers that, when violated, could lead to withdrawal of the numbers[131].
- Closely related domain names, especially where there are registered trade marks and other familiar names.
- Possibly valuable numbers. These might be "golden" numbers (which have attractive or memorable digit patterns, like 800 800 800) or numbers having meaningful alphanumeric forms (such as 800 FLOWERS).

Figure 7 shows how alphanumeric forms arise by mapping alphabetic characters to digits on a key pad[132].

| | | |
|---|---|---|
| 1 | 2 ABC | 3 DEF |
| 4 GHI | 5 JKL | 6 MNO |
| 7 PQRS | 8 TUV | 9 WXYZ |
| | 0 | |

**Figure 7 Mapping from digits to alphabetic characters**

[131] The conditions can be particularly difficult to police when there are the chains of content providers, service providers and network providers that are typical of some specially tariffed services.

[132] See *Arrangement of digits, letters and symbols on telephones and other devices that can be used for gaining access to a telephone network*, ITU-T Recommendation E.161 (ITU, February 2001) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.161-200102-I. A further mapping interprets multiple or long key presses as characters and thereby allows general text entry (for text messages and phone directories, for example). For a version of it supporting at least 28 scripts (including Greek and Cyrillic characters as well as Roman characters with diacritical marks) see *Human Factors (HF): User Interfaces; Repertoires, ordering rules and assignment of characters to the 12-key telephone keypad (European languages)*, ETSI Standard ES 202 130 (ETSI, October 2003) at http://portal.etsi.org/docbox/EC_Files/EC_Files/es_202130v010101p.pdf. For initial work on harmonising the interpretations of other key actions (such as pressing the + key to get the international prefix for the country where it is pressed) see *Human Factors (HF); Potential harmonized UI elements for mobile terminals and services*, ETSI Technical Report TR 102 125 (ETSI, October 2002) at http://portal.etsi.org/stfs/documents/stf231/etr102125.doc.

### 7.3.3 Trading in numbers

Lotteries and auctions for valuable numbers are used in some countries, so that numbers go to whoever values them most highly. For example:

- In Australia there are web auctions for the rights of use to specially tariffed short codes, with reserve prices and preferential treatment for charities.
- In the Netherlands corporate numbers for which there are competing applications may be auctioned initially, while they may be exceptionally valuable, and later allocated by lottery.

It is economically efficient for valuable numbers to be allocated to the users who can generate most calls from them. Efficient allocation of this kind can be encouraged through secondary trading. It may also be encouraged by “beauty contests” (where the regulator might need to judge the usefulness of numbers to applicants before making allocations); however, these are less transparent and more prone to errors of judgement by the regulator.

Individual allocation of valuable numbers, whether to service providers (as in the US) or to end users (as in several European countries), remains a subject of debate. It involves routing calls in ways that are not identified immediately by the numbers, so it needs implementation techniques like those for provider number portability; consequently there are concerns about costs and benefits similar to those discussed in 5.3.

Box 10 lists some useful principles for number trading put forward in Hong Kong, taking account of developments in other countries[133].

- Employ a fair and transparent procedure.
- Promote efficient use of numbers and codes.
- Obtain market value for attractive numbers and codes.
- Allow for and encourage the recovery and reallocation of unused, or no longer required, numbers and codes.
- Allow for the allocation of numbers and codes only where there is a legitimate need or intent to use the numbers and codes for the purpose of telecommunications services.
- On the one hand seek to minimise windfall gains through numbers and codes and prevent the inflation of the price of numbers and codes due to artificial scarcity, and on the other hand ensure that each number or code can be allocated to the user who places the highest value on it.
- Not unduly add complexity to the allocation system.
- Not encourage number or code hoarding.
- Not give unfair competitive advantage to any provider or customer.

**Box 10 OFTA proposals for principles for special number arrangements**

### 7.3.4 Charging for numbers

Charging for number allocations by the number administrator can sometimes be justified by economic arguments[134]. They may include the following:

- Encouraging care in the use of numbering resources. Charging can be a valuable tool where number conservation measures are adopted to postpone number exhaustion and the need for relief.

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[133] See *Special number arrangements* (OFTA, June 2002) at http://www.ofta.gov.hk/report-paper-guide/paper/consultation/cp20020614.pdf.

[134] See *The economic and regulatory aspects of telecoms numbering* (OECD, January 1995) at http://www.oecd.org/dataoecd/11/30/2091274.pdf. For the debate in the UK occurring in 1998-1999 see http://www.ofcom.org.uk/static/archive/oftel/publications/1995_98/numbering/dna798.htm and http://www.ofcom.org.uk/static/archive/oftel/publications/1999/consumer/frdna599.htm.

- Reflecting the inherent value of the numbers in allocated blocks. This is especially relevant for specially tariffed numbers, as service providers can sometimes make windfall gains by charging customers for golden numbers that they got without payment[135].
- Covering the operational costs of managing numbering resources that are not already funded in another way[136].

Arguments against charging for number allocations are as follows:

- Charges may be perceived as a "tax" that increases overall burdens on the industry and ultimately on end users.
- As the operational costs per number should be low, the effort involved in calculating charges, and in billing and collecting payments, may outweigh the available benefits, especially where there is no shortage of numbers and golden numbers are not significant.
- Payments for numbers may lead to a presumption of ownership of the numbers, when in reality they remain public property. This concern has been voiced in the US and deployed against legalising trading in individual numbers, but it has not prevented charging to cover operational costs.

Overall, countries should consider their position in relation to charging for numbers, allow for it in their legislation, and be ready to introduce charging in those number ranges where it appears to be in the public interest[137]. When charges are introduced, other payments (such as licence fees) may need to be adjusted in compensation.

Charges may depend on the amount of numbering space allocated and on the services available with the numbers[138]. For instance, the charge for a 4-digit short code may be higher than that for a 5-digit short code. There can even be a linear relation between the charges for numbers of different lengths, so that as a 5-digit carrier selection code fills 10000 times as much numbering space as a 9-digit telephone number (say) it costs 10000 times as much[139].

Table 11 provides as an illustration the initial and annual charges in European countries in 2002 for ordinary telephone numbers and for carrier selection codes[140]. The regulations of

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[135] For information about golden numbers in Singapore see *National Numbering Plan* (IDA, November 2004) at http://www.ida.gov.sg/idaweb/doc/download/I476/National_Numbering_Plan1.pdf. The one-off charge for a golden number is S$50 for a geographic or mobile number and S$30 for a paging number, and there are 486 golden numbers in each 10000 number block, so a service provider would pay S$24300 for a complete geographic or mobile number block and S$14580 for a complete paging number block.

[136] In Tanzania, for example, all the costs of number administration are covered by initial and annual charges. See *Application Guidelines And Fees For Numbering Resources* (TRA, December 2004) at http://www.tcra.go.tz/Licensing/REVISED%20NUMBERING%20GUIDELINES%20AND%20FEES.pdf.

[137] For a survey of practices on charging for numbers see *Numbering Survey* (ITU, January 2005) at http://www.itu.int/ITU-T/inr/misc/files/bdt_numbsurvey-en.doc. In the survey 39 countries (including 19 in Europe) have charges and 48 do not.

[138] A possible way of assessing what the charge should be is to make it reflect the long term incremental cost of enlarging the numbering plan, so if it cost €10 M (say) to expand from 10 million to 100 million numbers then the charge should be at least €10/(100-10).

[139] This relation between charges is used in Denmark and Australia. For the case of Australia see http://internet.aca.gov.au/ACAINTER.3997752:STANDARD:1819072826:pp=PC_2465,pc=PC_2467.

[140] The figures make some simplifying assumptions. See *Eighth Report from the Commission on the Implementation of the Telecommunications Regulatory Package Annex 1 Table 3* (December 2002) at http://europa.eu.int/information_society/topics/telecoms/implementation/annual_report/8threport/index_en.htm and *Second Report on Monitoring of EU Candidate Countries (Telecommunication Services Sector*) Annex 1 Table C (December 2002) at http://europa.eu.int/information_society/topics/telecoms/international/accession/index_en.htm.

the EU, which apply to all of these countries, allow but do not require cost-based charging. (No other countries in the EU imposed charges.) The charges in Table 11 vary greatly but even the highest are low compared with the relevant revenues.

| Country | Charge for 10000 ordinary phone numbers (€) | | Charge for one 4-digit carrier selection code (€)[141] | |
|---|---|---|---|---|
| | Initial | Annual | Initial | Annual |
| Belgium | 400 | 134 | 1333 | 13327 |
| Czech Republic | 171 | 300 | 171 | 684 |
| Denmark | 0 | 2571 | 0 | 2571 |
| Estonia | 0 | 15300 | 0 | 3835 |
| Finland | 0 | 3400 | 0 | 9000 |
| France | 0 | 200 | 0 | 40000 |
| Germany | 500 | 0 | 500 | 0 |
| Greece | 300 | 2500 | 15000 | 15000 |
| Hungary | 900 | 2700 | 0 | 5395 |
| Italy | 0 | 1100 | 0 | 109198 |
| Lithuania | 111 | 500 | 79 | 1227 |
| Luxembourg | 1200 | 1200 | 1239 | 1239 |
| Netherlands | 136 | 97.5 | 450 | 225 |
| Poland | 0 | 700 | 0 | 1300 |
| Slovak Republic | 34 | 500 | 34 | 451 |
| Slovenia | 0 | 1100 | 0 | 440 |

**Table 11 Examples of number allocation fees in European countries**

## 7.4 Numbering reviews

### 7.4.1 Options

A systematic approach to a numbering review will involve:

- Defining options to be considered, covering all sensible possibilities.
- Deriving criteria for evaluating the options from the requirements outlined in 1.2.
- Evaluating the options against the criteria, to result in perhaps one apparent “winner” and two plausible “runners-up”. The evaluation is necessarily imprecise, so distinguishing between “good”, “acceptable” and “poor” options is usually adequate.
- Subjecting the results of the evaluation to criticism, typically by circulating the options and reasons widely in a public consultation.
- Revising the results to take account of the criticism.

[141] In some cases the charges shown are valid also for codes of other lengths; in other cases the charges shown are multiplied by suitable factors before being applied to codes of other lengths.

Requirements on all numbering options include:

- Providing enough usable numbering for all foreseeable needs in the planning period.
- Being evolutionary (moving step-by-step from the starting position), not revolutionary.
- Allowing the new numbers while first retaining the old numbers and then replacing the old numbers by changed number announcements. This “parallel running” needs clearly different number ranges for the old and new numbers. Ideally the first significant digit can distinguish between the ranges; for instance, if the old numbers never have first significant digit 2 and the new numbers are formed by putting 2 in front of the old numbers, exchanges can tell immediately whether an old number or a new number is being dialled.
- Providing long term flexibility for handling unforeseen needs (including trying to make parallel running feasible if a further numbering plan change is ever needed).

A proper balance between long term and short term considerations must be maintained when an option is chosen. Some countries have let the migration arrangements themselves dictate the shape of the new plan. An easy migration is very desirable, but it only happens once. The plan should apply for many years. A more costly transition may be justified by providing a longer lasting or better plan, with benefits for users and the industry.

### 7.4.2 Good husbandry

Some basic principles of numbering planning are obvious but may be worth restating:

- Think long term so as to minimise expensive changes.
- Keep options open for as long as possible, until one of them is clearly right.
- Bear in mind that the costs of changes occur once but the benefits recur.

Some guidelines for numbering good husbandry follow immediately:

- Keep incumbent providers to number blocks that are already used and make incumbent providers, as well as alternative providers, justify their requests for more number blocks.
- Allocate numbers in blocks of modest size (for example, 1000 or 10000 numbers) and reserve capacity for foreseeable growth in neighbouring blocks.
- Keep the ability to reclaim under-used numbering space.

## 7.5 Number changes

### 7.5.1 The timing of changes

The timing of number changes is itself a big decision. In high teledensity countries there is usually a desire to delay changes for as long as possible. This can often be justified by cost savings. Technical developments may reduce the costs of numbering plan changes in future; even if they do not do so, the time value of money points to postponing changes[142]. The NANP is a good example: though expansion plans exist, their expected implementation date keeps retreating (and is now 30 years away) and some people believe they will never be needed. Meanwhile numbers are conserved by measures such as rate centre consolidation (the simplification of charging areas) and number pooling (the allocation of numbers in 1000 number blocks instead of 10000 number blocks)[143].

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[142] Similar remarks apply to IP addresses: IPv6 will eliminate shortages of IP addresses, but conservation measures are extending the life of IPv4 and thereby postponing the change to IPv6.

[143] For a treatment of these, and several other, topics see *An introduction to numbering* (NANPA, September 1999) at http://www.nanpa.com/pdf/intro_numbering.pdf.

However, low teledensity countries, especially if they are small, may be better served by changing their numbering plans sooner rather than later, if changes are clearly needed. Most change costs usually fall on customers rather than on the industry. Where the customer base is growing rapidly, numbering plan changes may be cheaper overall if done sooner.

### 7.5.2 Implementing major number changes

Major number changes make major management challenges. After the numbering plan has been reviewed and the change has been agreed, there may still need to be decisions about practical details such as whether the change should be made all at once ("big bang") or in stages. A "big bang" may be simpler to publicise and understand. However, staged changes have flatter resource profiles and imply less commitment to precise dates; they may also be easier for the public to assimilate when the changes are complex.

The role of the regulator in implementation would normally be confined to top-level oversight to ensure that everything is going to plan, and where appropriate helping with public relations to justify and explain the change. (For this purpose the regulator could devise a checklist of implementation requirements, including the items mentioned below.) It would not include meeting any substantial costs of change, which would be met where they fell, unless the industry agreed otherwise (for example, by carrying out jointly-funded publicity campaigns).

Service providers should be sure to:

- Implement the right modifications in exchanges of different types. This must be done gradually, to avoid unacceptable risk of network failure. The modifications include ones to CLI functions as well as to number recognition, charging and routing functions[144].
- Implement recorded announcements for incorrectly dialled calls.
- Make modifications to operational support systems (directories and any computer systems holding telephone numbers, for example).
- Ensure modifications match at international exchanges of service providers abroad[145].

Collectively the regulator and the service providers should be sure to:

- Get political acceptance of the change.
- Provide advance publicity of the change both to people with phone numbers (who may need to change stationery, signs, vehicles and so on) and those who call them (who may need to change records in databases as well as personal habits). Publicity must be far enough but not too far ahead; diary publishers usually need information two years ahead.
- Plan a period of parallel running, to let business systems be reprogrammed gradually.
- Support changes to customer premise equipment like payphones and automatic alarms.

The regulator and the service providers must work together on the administrative and technical arrangements for changes to the numbering plan. Small changes, such as letting some further numbers be allocated when the plan is already established, should be easy. Large changes, however, can be difficult, especially where they involve changing the rules for competition through the introduction of carrier selection or provider number portability.

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[144] For an overview of the BT handling of changes in the UK see *National Code and Number change – Technical Solutions for BT's Network*, by Beatrice Osborn and others, **The Journal of the Communications Network** volume 1 part 1 April 2002, pages 107-113, at http://www.ibte.org/recent/tcn011bo.pdf.

[145] For ways of communicating numbering plan changes around the world see *Presentation of national numbering plans*, ITU-T Recommendation E.129 (ITU, September 2002) at http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-E.129-200209-I.

## References

The footnotes to this paper already provide many references to relevant published sources. The references here provide extra general information. In addition, the websites of most regulators and many service providers include useful material on numbering.


http://www.getit-multimedia.com/itu_aca/ (provided by the ITU Asia-Pacific Office and ACA) contains an on-line numbering course.

http://www.nanpa.com/pdf/intro_numbering.pdf (provided by NANPA) contains an introduction to numbering.

http://www.ero.dk/documentation/ (provided by ECTRA) contains reports on regional numbering and other topics.

http://www.itu.int/ITU-D/treg/related-links/links-docs/numbering.html (provided by ITU-D) contains reports on global numbering.

http://www.itu.int/ITU-T/inr/nnp/ (provided by ITU-T) contains information on national numbering plans.

http://www.itu.int/ITU-T/studygroups/com02/ (provided by ITU-T) contains documents about ITU-T Study Group 2.

http://www.numberingplans.com/ (provided privately) contains information on national numbering plans.

http://www.wtng.info/ (provided privately) contains information on national numbering plans.

## Abbreviations

| | |
|---|---|
| 3GPP | Third Generation Partnership Programme |
| ACA | Australian Communications Authority |
| APT | Asia-Pacific Telecommunity |
| CC | Country Code |
| CEPT | European Conference of Postal and Telecommunications Administrations |
| CIDR | Classless Inter-Domain Routing |
| CLI | Calling Line Identification |
| CSC | Carrier Selection Code |
| DDI | Direct Dialling In |
| DECT | Digital Enhanced Cordless Telecommunications |
| DNS | Domain Name System |
| DUNDI | Distributed Universal Number DIscovery |
| ECC | Electronic Communications Committee (the current telecommunications organisation for CEPT) |
| ECTRA | European Committee for Telecommunications Regulatory Affairs (the former telecommunications organisation for CEPT) |
| ERO | European Radiocommunications Office (the current telecommunications office for CEPT) |
| ENUM | tElephone NUmber Mapping |
| ETNS | European Telephony Numbering space |
| ETO | European Telecommunications Office (the former telecommunications office for CEPT) |
| ETSI | European Telecommunications Standards Institute |
| EU | European Union |
| GSM | Global System for Mobile communications |
| GSN | Global Significant Number |
| IANA | Internet Assigned Numbers Authority |
| ICANN | Internet Corporation for Assigned Names and Numbers |
| IETF | Internet Engineering Task Force |
| IMSI | International Mobile Station Identity |
| IP | Internetwork Protocol |
| IPv4 | IP version 4 |
| IPv6 | IP version 6 |
| IRI | Internationalised Resource Identifier |
| ISDN | Integrated Subscriber Digital Network |
| ITU | International Telecommunication Union |

| | |
|---|---|
| ITU-D | ITU – Telecommunication Development Sector |
| ITU-T | ITU – Telecommunication Standardisation Sector |
| NANP | North American Numbering Plan |
| NANPA | NANP Administration |
| NAPT | Network Address and Port Translation |
| NDC | National Destination Code |
| NGN | Next Generation Network |
| NPA | Numbering Plan Area |
| NRA | National Regulatory Authority |
| NRO | Number Resource Organisation |
| NSN | National Significant Number |
| OECD | Organisation for Economic Co-operation and Development |
| OFTA | Office of the Telecommunications Authority (the Hong Kong NRA) |
| Ofcom | Office of Communications (the current UK NRA) |
| Oftel | Office of Telecommunications (the former UK NRA) |
| SATRC | South Asian Telecommunications Regulators' Council |
| SIM | Subscriber Identity Module |
| SIP | Session Initiation Protocol |
| SN | Subscriber Number |
| SPC | Signalling Point Code |
| UK | United Kingdom |
| UN | United Nations |
| UPT | Universal Personal Telecommunications |
| URI | Uniform Resource Identifier |
| US | United States |
| VPN | Virtual Private Network |
| WTO | World Trade Organisation |