UPDATED REVISED FINAL REPORT

ON

**A LONG TERM STRATEGIC PLAN
FOR THE NUMBERING AND ADDRESSING OF
TELECOMMUNICATIONS SERVICES IN EUROPE**

6 December 1999

ETO on behalf of ECTRA has prepared this study for the Commission of the European Community.

The report does not necessarily reflect the views of ECTRA or the Commission, nor do ECTRA members or the Commission accept responsibility for the accuracy of the information contained herein.

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EXECUTIVE SUMMARY

The growth of networks and services during the last five years and the likely developments in the communication market over the next five to ten years and beyond indicate that the current numbering arrangements are not sustainable.

In the past, a strategic view on numbering, naming and addressing has been lacking. Technological limitations have set the agenda. Now, with greater technical capabilities in telecommunications networks, any strategy, in particular for numbering and naming, whether national, regional or global, will also be driven by user needs and requirements. Technological reality will set the bounds for and facilitate the strategy and the commercial and political interests of the other players in the industry will provide its shape.

In the short and medium term, ETO envisages the coexistence of different addressing schemes. This will require the deployment in the networks of address translation capabilities to ensure adequate inter-working between the different schemes. From a technical point of view, the deployment of these translation capabilities is not prohibitively difficult or costly.

The expected evolution of naming is different from the scenarios envisaged for addressing. Rather than a situation of coexistence of different naming schemes, ETO foresees a convergence of the existing schemes into one or two naming schemes. We can expect the same evolution for name resolution mechanisms. The different characteristics of Internet-like names and E.164-like names reveal the degree of difficulty that these two forms of naming would have to overcome to converge. In the medium term, we can foresee the need for the coexistence of these two forms of naming, together with the necessary inter-working capabilities.

As far as names are concerned, we make a distinction between name plans used by a network and name plans used by a terminal or other piece of CPE (Customer Premises Equipment). A name plan used by a terminal is only for the user of that particular terminal. It is a customer-tailored name plan providing a user-friendly interface between the user and the network. When the user enters a customer-tailored name, or “nickname”, then the terminal translates the nickname into a name that the network can handle. The nickname would eventually take the form of spoken or written language rather than keyboard characters.

The industry has developed (and will continue to develop) most of the existing and future communications applications to run over the TCP/IP suite of protocols. This will make the availability of IP a kind of pre-condition.

We conclude that with the increasing availability of ATM and IP products in public networks, X.25 (and the PSTN, generally) is likely to lose much of its importance with consequences for the future development and use of X.121. X.121 protocols will play a marginal role in the information infrastructure in future. On the other hand, due to the increasing presence of ATM and IP in public networks, ETO regards IP addresses and AESAs as two of the most promising emerging addressing schemes.

Universal names should be independent of location, terminal, network, service, or service provider. In other words, universal names should be fully personal and fully portable. Users prefer to use names in which all information clearly concerns the person or device to communicate with or to control. There should be no mixing with other information in the names such as indications of the telecommunications service to be used or the tariff to be paid when connecting with that user or device. The industry should find other ways of presenting tariff information, if of interest to users, and other information not related to the user or device identified.

ETO considers the new global structure, with ICANN replacing IANA for management of generic TLDs, to be a good base for industry self-regulation.

The current policy for the management of IP addressing space rests upon three principles: conservation, aggregation, and ability to route. With the growing availability of IPv6, policy for address management will change. The main goals will be aggregation and ability to route with less emphasis on conservation.

The need for dynamism and flexibility in the standardisation process deserves emphasis. Co-operation between bodies that have an interest in standardisation is vital. One essential issue for Europe will be the reform of the ENF that started in 1999. Through this, there should be improved user representation in the Forum.

ETO expects names to gain an increasing commercial relevance as shown by the Internet where names have become a kind of trademark for companies selling products or doing business through the Internet. For the time being, ownership of names is hard to envisage. “Rights of use” of names will continue to provide the juridical status of names and may support the use of “names for life”.

Apart from names of users, names of non-human devices will be increasingly necessary.

Regarding the unified numbering plan for Europe, cost estimates for migrating to a unified numbering plan are highly uncertain because different estimates diverge widely. Moreover, migrating to a unified numbering plan is not a purely market issue; there are political and psychological aspects. Factors other than those of a purely economic nature influence the overall desirability of introducing new number schemes. Whilst recognising this, and the potential benefits set out above, ETO considers that, at least from a merely economic, cost based, analysis, the unified numbering plan for Europe is a prohibitively expensive solution.

We do not foresee an ETNS as an integrated numbering plan for Europe. The ETNS with country code 388 which Europe plans in parallel to existing national numbering plans can capture some of the benefits of an integrated plan without the need for costly changes in the existing plans.

1. PRESENTATION OF THE STUDY

ETO[1] has prepared this study on "A Long Term Strategic Plan for the Numbering and Addressing of Telecommunications Services in Europe" on behalf of ECTRA (European Committee for Telecommunication Regulatory Affairs) for the Commission of the European Communities (CEC).

The work requirement originally addressed to ETO appears in Annex 1

During the course of the study, the Commission requested that the study should focus on the first of the Work Order points and in particular the requirement was:

- to analyse different approaches regarding long term evolution of numbering, naming and addressing, especially the so-called GII (Global Information Infrastructure) and EII (European Information Infrastructure), ATM[2] Forum and Internet, and identify commonalties and differences between these
- to identify issues, which might have an impact on long term numbering, naming and addressing (user needs, network technology, and so on)
- to identify specific European demands regarding long term numbering, naming and addressing
- to develop scenarios for the evolution of numbering, naming and addressing and identify regulatory issues that may emerge

[1] ETO – European Telecommunications Office
[2] ATM – Asynchronous Transfer Mode

Thus, this report is an overview of the potential evolution of numbering, naming and addressing for telecommunication services and analyses the most important numbering naming and addressing schemes pointing out emerging trends, points in common and differences. We pay particular attention to the relationship between the different numbering, naming, and addressing systems. The report also analyses their mutual effects in order to identify potential European demands and specific regulatory issues that may emerge in a five to ten year period. Due to the rapid and sometimes unpredictable way in which things are evolving in the telecommunications arena, extending this overview beyond five to ten years might create problems in terms of reliability of the results.

In chapter 2 of this revised final report, ETO has further developed its views on how the telecommunications industry will develop concerning numbering, naming and addressing in the next five to ten years and beyond.

Chapter 4 presents a summary of some of the existing numbering, naming, and addressing schemes. The chapter includes discussion of the emerging trends of these schemes both from the technical and administration views. To conclude this, chapter 5 analyses the mutual effects of these schemes and their possible evolution.

In chapter 6, we include an analysis of the costs and benefits of an evolution towards a unified numbering plan for Europe.

ETO has carried out this study in close co-operation with the ECTRA Project Team on Numbering (ECTRA PT N) and the parties represented in the European Numbering Forum (ENF).

ETO delivered the final report of the study to the CEC in May 1998. The problem for ETO throughout the study has been that, in this fast moving and complex area, the answers change before we have even asked the questions! This update of the revised final report further explores and develops some issues raised by the CEC.

2. THE STRATEGIC CONTEXT

In the very early days of manual telephony, the operator was able to identify the called party by his name (and other characteristics when more than one subscriber of the same name existed) and to connect the call appropriately. In many cases the operator was also able to identify where the called party could be located if not at home, or could relay a message.

This convenience was replaced by automatic exchanges each of which was numbered and instead of calling the desired party by name, the calling subscriber had to know and dial the telephone number of the called party. This was “progress”. Additional services such as the knowledge of the current location of the called party, messaging and so on were not available until more recently when new technology enabled these functions to be offered to the consumer again.

The growth of networks and services during the last five years and the likely developments in the communication market over the next five to ten years and beyond indicate that the current numbering arrangements are not sustainable. With the convergence of Internet and telecommunications networks and services, the harmonisation of numbering, naming, and addressing requirements between the two environments is imminent.

When evaluating the medium term numbering evolution, we must consider the following issues:

- fixed mobile convergence
- convergence of communications and broadcasting
- evolution of traditional telecommunications
- broadband services, including multimedia services
- evolution of Internet, including IP telephony
- evolution towards user identification rather than identification of geographically located equipment

In the past, a strategic view on numbering, naming and addressing has been lacking. Technological limitations have set the agenda. Now, with greater technical capabilities in telecommunications networks, any strategy, in particular for numbering and naming, whether national, regional or global, will also be driven by user needs and requirements. Technological reality will set the bounds for and facilitate the strategy and the commercial and political interests of the other players in the industry will provide its shape.

Several telecommunication networks are now in concurrent use; fixed, mobile, analogue, digital, line-switched, packet-switched (PSTN[3], ISDN[4], NMT[5], GSM[6], DECT[7] and Internet). New facilities will soon come into general use (UMTS[8], UPT[9], and new Internet protocols). The expectation is that, before 2010, mobile customers will exceed fixed network customers, and, before that, data traffic will exceed telephony traffic on telecommunications networks. Various numbering systems are used in the different networks, the most common being the ITU Recommendation E.164 telephone number, but alphanumeric formats are also used (such as in X.400, Internet electronic mail and World Wide Web URL[10] addresses). The industry is developing new naming and addressing schemes for UMTS (see section 2.4).

2.1 Names and Addresses

The nature of numbers is changing. In the past, a number has both identified and located the termination point for a communication. With the advent of new facilities and technologies such as IP, there is now a growing need to differentiate between the identification of the termination point of a communication and its physical or logical location. This leads us to apply the common concepts of "name" and "address" more rigorously to the numbering environment. A name identifies an entity whereas an address locates it. A number can be either a name or an address. In some circumstances, it can be both, but we should differentiate the logical functionality.

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[3] PSTN – Public Switched Telephone Network
[4] ISDN – Integrated Services Digital Network
[5] NMT – Nordic Mobile Telephone
[6] GSM – Groupe Speciale Mobile
[7] DECT – Digital European Cordless Telephone
[8] UMTS – Universal Mobile Telecommunication System
[9] UPT – Universal Personal Telecommunications
[10] URL – Uniform Resource Locator

To underline the differentiation between a name and an address:

- A name is a string of characters used to identify an entity (such as an interface, a piece of equipment, or an application) in the service segment. The service segment is the part of the network providing a service between two or more termination points. The service segment includes the service request, service provision, billing, and so on.

- An address is a string of characters used to identify and locate an entity (such as an interface, a piece of equipment, or an application) in the transport segment. The transport segment is the part of the network providing a connection between two or more termination points. The transport segment includes transmission and switching.

From the point of view of functions, an address is a locator and an identifier whereas a name is an identifier. Because of this difference in function, a name and an address may have different attributes. For a name, which a customer typically uses to identify the called party, portability and user-friendliness are important. For an address, on the other hand, portability and user-friendliness are irrelevant and in some cases even harmful. Some other attributes are common to names and addresses. For example both a name and an address must be unique and belong to a plan.

We explore this same concept from a technical point of view in section 3.

Having introduced the terms “name” and “address” we can now define a number as a name or an address or both. In particular the concept of E.164 numbers is evolving rapidly. Until recently, networks used an E.164 number simultaneously as a name and as an address. In other words, the same E.164 number both identified a telephone subscriber and provided information to route the call to the final destination. Today, with the introduction of number portability and the growing presence of intelligence in the network, two types of E.164 numbers are typically used:

– one to identify the service or the subscriber (name)

– the other to route the call to the appropriate destination (address)

Relevant in this context is the possible evolution of the addressing and naming schemes in the coming years. In terms of addressing and routing today, we have a certain number of addressing schemes and routing protocols available on different networks. In the short and medium term, ETO envisages the coexistence of different addressing schemes. For routing protocols, the expected trend is toward an initial convergence of different routing protocols. In the long term the trend of convergence between routing protocols will continue, along with incipient convergence between different addressing schemes.

The coexistence of different addressing schemes will require the deployment in the networks of address translation capabilities to ensure adequate inter-working between the different schemes. From a technical point of view, the deployment of these translation capabilities is not prohibitively difficult or costly.

With reference to naming, the current situation is not different from addressing. Today different naming schemes are used and there are different mechanisms for name resolution (name resolution is the mapping of a name into an address). However, the expected evolution of naming is different from the scenarios envisaged for addressing. Rather than a situation of coexistence of different naming schemes, ETO foresees a convergence of the existing schemes into one or two naming schemes. We can expect the same evolution for name resolution mechanisms.

As far as names are concerned, a distinction should be made between name plans used by a network and name plans used by a terminal or other piece of CPE (Customer Premises Equipment). A name plan used by a network is common for all users of the network. Plans of E.164 numbers and of Internet names are examples of this kind of plan. A name plan used by a terminal is only for the user of that particular terminal. It is a customer-tailored name plan providing a user-friendly interface between the user and the network. When the user enters a customer-tailored name, or "nickname", then the terminal translates the nickname into a name that the network can handle. Well known examples of nicknames are short codes for abbreviated dialling of E.164 numbers.

2.2 Terminal Evolution and User Requirements

A number of issues emerge in the consideration of user needs and terminal evolution:

- the concept of nicknames explained above
- the need for universal, personal and multiple identities attached to different functions and with full portability across services
- the availability of “neat” portable terminals in the future where touch screens, nicknames and so on would mean that callers would not have to use or be aware of names in the network
- the removal of implicit or explicit tariff information in names and numbers in future – this could be provided in other ways, such as on the screens of neat terminals
- the requirement for “ownership” of names in the future

We present below a view that integrates these issues.

Of prime importance is what users need. Users want their corespondents to know them by multiple names, both universal ones and specific ones. The universal names should be independent of location, terminal, network, service, or service provider. In other words, universal names should be fully personal and fully portable. In addition, specific names are necessary to be able to communicate with a user at a specific location or in a specific function. More than one name may correspond to a single address and, vice versa, one name may correspond to more than one address.

Users prefer to use names in which all information clearly concerns the person or device to communicate with or to control. There should be no mixing with other information in the names such as indications of the telecommunications service to be used or the tariff to be paid when connecting with that user or device. At present, such mixing of information exists in E.164 numbers. The industry should find other ways of presenting tariff information, if of interest to users, and other information not related to the user or device identified.

Users want control, privacy, and security in their telecommunications.

Apart from names of users, names of non-human devices will be increasingly necessary. These devices comprise computers, databases, terminals, and all other devices that can be communicated with or controlled, such as cars and heating systems. The names for such devices may be specific or universal.

Let us first look at the need for multiple names, both universal and specific.

The most important name plans at present, E.164, and Internet names, are still far from being universal name plans. Internet names do have some advantage in terms of full alphanumeric capabilities which E.164 numbers do not have. Nevertheless, there still is a long way to go before we can completely fulfil the user need for universal names. Historically E.164 telephony "numbers" were geographic, so an E.164 number assigned to a subscriber both identified the subscriber and provided information to route the call. We explore the way in which E.164 will evolve from being simply a global agreement on CCs to a genuine universal naming system in section 4.1.2.

A name of a user would need to contain several elements to make the name globally unique. A universal name would comprise, for example, the personal name of a user and some further elements like birth date and place of birth. A specific name would have some elements added to the personal name, possibly giving indications of location, function, and the like. An example of a specific name would be “topmind.numberingexpert.denmark”, where “topmind” is the personal name, “numberingexpert” is a function, and “denmark” is a location.

Access to certain elements of the names and the related addresses may require authorisation to secure privacy.

When a user starts a communication with another user, he enters the name of the called user in the network. He may first consult a directory, for example an X.500 directory, to get the right name. The network resolves the name by consulting a translation database or a directory. The resulting address enables the network to route the call to the proper destination or to another network where another resolution may be necessary. The network might need to present some elements of the called user's name to the called user's terminal to enable the terminal to alert the right person.

Developments in aspects of terminals and their users may suggest certain directions for the evolution of name and address plan and resolution.

Terminals are developing towards providing more support for the user needs already mentioned. Terminal capabilities will increase. Terminals will generally be more like computers, having processing, storage, and a screen. They will be mobile, multipurpose, and capable of multimedia applications. They will provide improved user-friendliness by offering voice and hand writing recognition in place of the use of keyboards. They also have potential advantages in terms of meeting user needs concerning naming, which we can now consider.

One possible advantage would be to free the caller from the burden of remembering and entering the full name of a called user every time, with all the elements that make the name unique. The intelligence in the terminal enables the user to create his nickname plan instead. The nickname would eventually take the form of spoken or written language rather than keyboard characters. When the user enters a nickname, the terminal must recognise it and translate it into a name that can be resolved by the network. Other user needs related to naming that intelligent terminals can support are automated authorisation and presentation of information such as the tariff for the call.

A last item regarding user needs is name ownership. For the time being, ownership is hard to envisage. At present, names have no universal meaning and therefore users cannot own them. It is better to talk about the right of use of names. Right of use of names will continue to provide the juridical status of names and may support the use of “names for life”.

2.3 Naming and Addressing in the IP World

2.3.1 Constitution of ICANN

ETO considers the new global structure, with ICANN[11] replacing IANA[12] for management of generic Top Level Domains (TLDs), to be a good base for industry self-regulation. ICANN has widespread international support.

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[11] ICANN – Internet Corporation for Assigned Names and Numbers
[12] IANA – Internet

The main executive body of ICANN is the Board of Directors (BoD). This has the support of a secretariat and a number of advisory committees one of which is the Government Advisory Committee (GAC) which has as its members the ITU, WIPO, OECD, SPFS and the EU.

Reporting to the BoD are three Supporting Organisations (SOs):

1. DNSO – the Domain Names Supporting Organisation
2. ASO – the Address Supporting Organisation
3. PSO – Protocol Supporting Organisation

ICANN also recognises a number of "constituencies" which are organisations or groupings already representing the interests of their members regarding Internet numbering and naming. There are currently six constituencies:

1. ccTLD[13] registries
2. commercial and business entities
3. gTLD[14] registries
4. intellectual property
5. ISPs[15] and connectivity providers
6. registrars

The SO of most interest in the context of a strategy for numbering, naming and addressing is the DNSO which consists of an executive body, the Numbering Committee (NC), and a working body (the General Assembly, GA). Each constituency can elect three members to the NC.

One of the essential issues is how far the new structures will respect jurisdictions outside the USA. ICANN still has to confront organisational difficulties and challenges regarding issues such as trademarks and warehousing.

[13] ccTLD – country code TLD
[14] gTLD – geographic TLD
[15] ISPs – Internet Service Providers

An issue for Europe has been the membership of the new Support Organisations. In August 1999, ETSI represented its views to the ICANN BoD regarding the proposals from the Regional Internet Registries (RIRs, see section 4.6.4) for the MoU based ASO. The RIRs had argued for an ASO comprised exclusively of the Registries. They suggested that the RIRs’ open procedures could introduce new expertise and thereby the ASO would deal with policy matters satisfactorily. ETSI felt that this was highly unlikely due to the scarce resources available, and the fact that key people attended ITU, ETSI or participated in the RIRs but did not tend to crossover.

The industry created ICANN to provide "a global private-sector entity to serve as a vehicle for determining consensus across the Internet community". The integration of the telecommunications sector into ICANN activities would help ensure wide acceptance and increased legitimacy for ICANN, which was essential to its future success and to the benefit of the entire Internet community. The objective was to ensure the establishment of an ICANN ASO which was "composed of representatives from regional Internet registries and others with legitimate interests in these issues" consistent with the ICANN Bylaws.

ETO supported ETSI's view, that it was essential that the ASO involved all the appropriate parties, resulting in increased knowledge sharing and ultimately achieving superior results. ETSI proposed that the ICANN BoD should ensure the inclusion of telecommunications industry numbering expertise, either through participation of the companies or the appropriate representative bodies (such as ITU and ETSI itself) in addition to the RIRs. If not, the ASO would be unable to adequately consider policy matters common to Internet and telecommunications.

The outcome of the discussions was that ICANN established a special group to consider the constitution of the ASO. This group has still to announce its conclusions.

2.3.2 Management Principles

The current policy for the management of IP addressing space rests upon three principles: conservation, aggregation, and ability to route. Because of the outstanding success of the Internet, IPv4 addresses are becoming a scarce resource and therefore the conservation of the addressing space is vital. Another aspect related to the growth of the Internet is the need of routers to handle and exchange an ever-bigger quantity of information in order to properly route IP packets. The way in which addresses are assigned can facilitate the aggregation of the routing information and therefore also the ability to route. Networks must assign addresses to reflect as closely as possible the topology of the network.

In section 4.6, we describe the new Internet Protocol, IPv6. The enhancements in IPv6 addressing do not relate only to the increased size of the address (128 bits instead of 32 bits). They also include the capability of IPv6 to reflect the topology of the network and to embed different addressing schemes. The transition and conversion to IPv6 will not be without problems and we explore these in section 4.6. Some commentators consider that introduction of Ipv6 is still "not a foregone conclusion". If the availability of IPv6 does indeed grow, policy for address management will change. The main goals will be aggregation and ability to route with less emphasis on conservation.

The proposal is that, with IPv6, the RIRs will continue to manage Internet addresses with oversight from ICANN and its ASO.

2.3.3 TLD for Europe

In terms of gTLDs, the CEC has expressed its support for the creation of a TLD dedicated to Europe (.eu or .eur). Following the rationale behind the establishment of the ETNS[16] for E.164 numbers today there seems to be a demand from the market place to introduce a TLD with a European connotation. However, some technical and administrative problems still need a solution at the ISO[17] and ICANN level. The CEC has already addressed this with ISO in the context of ISO 3166. Another outstanding issue is whether .eu would be available for the use of the whole of Europe or only the fifteen member countries of the European Union.

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[16] ETNS – European Telephony Numbering Space

[17] ISO – International Standards Organisation

2.4 Third Generation Mobile Systems

Networks based on third generation mobile will be operational at the beginning of the next decade in the major European countries. They will inherit system characteristics both from traditional telecommunications and from computer communications. We must establish a naming and addressing system for third generation mobile that accommodates and coexists with IP and with traditional telephone numbering systems.

We can see convergence between traditional telecommunications and information technology and computer networks in the development of mobile multimedia communication systems. This, in itself, will make new solutions necessary in the area of numbering, naming and addressing.

2.4.1 Numbering

Users of the PSTN or ISDN and second-generation mobile systems will have to address subscribers to third generation mobile using ITU-T Recommendation E.164-numbers. The following options are available:

- global E.164 resources (including resources for geographic areas, global services and networks)
- national E.164 resources in the same ranges as other mobile subscriber numbers
- national E.164 resources as a separately defined category

Some factors that may influence the choice are:

- service differentiation between second and third generation systems
- the demand for number portability
- the demand for European or global harmonisation

The questions that we must discuss are the following:

- Are third generation services so similar to second-generation mobile services that they should share the same numbering space, or should we regard them as two different categories from a numbering point of view?

- Is number portability between GSM, DCS, and third generation a necessity?
- Should there be an obligation for operators to provide number portability?
- What are the factors that we can deal with nationally, and which must we settle at a European or a global level?

2.4.2 Addressing

The Internet addressing system uses servers that translate the name given by the user into a physical address in the network. In this respect, it is similar to addressing in a mobile network, even if the mobile network also updates the physical address in real time as the user moves. Work is going on to allow mobile users also in the Internet.

The questions that we must discuss are the following:

- Will we give each third generation terminal a separate Internet address?
- How are Internet addresses and telephone numbers related?
- Which is the convergence path the third generation addressing system has to follow in order to arrive at a coherent numbering, naming and addressing system?
- What is the time scale for the development and convergence of third generation numbering, naming, and addressing?

2.4.3 UMTS Forum

At the UMTS Forum General Assembly in Bern in September 1999, the chair of the Regulatory Affairs Group (RAG) suggested that:

- UMTS services should share the addressing space of GSM initially, and the fixed network in the long term
- a fuller discussion was needed
- the issue should be discussed by a UMTS Forum Task Group

The Assembly agreed that the UMTS Forum needed a group to lead on this issue and set the framework for the future work of the ICT[18] Group.

2.4.4 Terms of Reference for the UMTS Forum Numbering and Addressing Task Group (TG-NA)

RAG and the ICT Group formulated the following terms of reference for the "TG-NA":

"The TG-NA shall:

- study the characteristics of the numbering and addressing system for third generation mobile multimedia systems, in both short and long term
- study the necessary short-term developments of second generation numbering systems in order to allow for a close inter-working between third generation and second generation systems
- propose necessary regulatory actions to enable this close inter-working from the start of third generation systems
- study possible ways of converging the addressing system of the Internet with the numbering of telecommunication systems
- assess the possible time plan for this process
- propose future actions of the UMTS Forum in the addressing fields"

The TG-NA must focus on the integration and evolution of numbering, naming and addressing schemes in the integration of information technology and telecommunications.

[18] ICT – Information & Communications Technology

2.4.5 Third Generation Mobile and IPv6[19]

IPv6 technology incorporates a range of essential features to permit mobility between services and operators with a range of quality of service options. This “mobile friendly” architecture therefore provides vendors, service providers and network operators with the possibility of defining and developing IP-oriented applications and services for use in third generation networks.

The initiatives for third generation mobile such as IMT-2000 will result in dramatically increased demand for IPv6 addresses. Among the IMT-2000 initiatives, the 3GPPs (third Generation Partnership Projects) have elaborated specifications jointly through ETSI, ARIB/TTC of Japan, TIA/T1 of the USA, TTA of Korea and CTWG of China.

As a result of the developments in third generation mobile, the Internet community, and the RIRs in particular, will have to deal with interoperability between Internet and heterogeneous telecommunications networks, requiring different expertise from their traditional participant base. While the administration of IPv4 addresses is well managed by the RIRs, IPv6 will bring with it new challenges. To satisfy emerging market trends in an enduring fashion, wide awareness and an excellent understanding of important commercial drivers are necessary. The Internet and telecommunications sectors should jointly develop policies to deal with theses new market needs.

At Telecom 99, in October 1999, the UMTS Forum announced a co-operation agreement with the IPv6 Forum, the world-wide consortium of Internet industry players founded to promote IPv6.

Objectives of the co-operation included:

- respective market representation within each others’ organisations
- identifying and building new markets for non-voice services and promotion of IPv6
- preparing for future IP-based value added services

[19] IPv6 - Internet Protocol version 6

2.5 Voice over IP

Voice over IP (VoIP), or IP telephony, is an emerging application that is attracting growing attention from users and operators. IP telephony is the extension of telephony and related services to the Internet and IP-based networks in general. The development of IP telephony may represent a threat for Public Network Operators (PNOs) in terms of loss of national and international telephone traffic and future loss of supplementary and value added services.

The availability of VoIP services makes it necessary to develop inter-working functions between circuit-switched networks (PSTN, ISDN, GSM, and so on) and IP networks to allow the provision of telephony services across the two environments.

E.164 resources, which provide numbers for telephone service in circuit-switched networks, therefore need to map into IP addresses and vice versa. In particular to allow an ISDN, PSTN, or GSM customer to call an IP terminal, an E.164 number must be assigned to the IP terminal. ETSI's project TIPHON is dealing with this issue most actively. At the moment three options are under study: use of local numbers belonging to national numbering plans, use of dedicated National Destination Codes (NDCs) belonging to national numbering plans and use of dedicated global resources. The last option implies the allocation by ITU-T of a Country Code (CC) for the provision of VoIP. At present, ITU-T SG2[20] is evaluating the application for a CC for VoIP and will take a decision at forthcoming meetings.

The three options, which are not mutually exclusive, meet different requirements and imply different solutions for routing and charging calls to IP terminals. ETO considers that the use of a CC for IP telephony allows efficient routing, and support for geographic portability and roaming and supports the approaches to ITU-T in this regard.

2.6 Standardisation

Within the strategic context, the need for dynamism and flexibility in the standardisation process deserves emphasis.

[20] SG2 – Study Group 2

ETO considers that co-operation between bodies that have an interest in standardisation is essential. We consider it impossible to see over the horizon, and consequently there is no "end point" to aim at in the standardisation process. However, the process must not erect any "road blocks" to progress and change in numbering, naming and addressing.

The European Numbering Forum (ENF) exists as a consultative and advisory body involving all sectors of the European telecommunications community with an interest in numbering, naming and addressing issues. It provides advice on European positions on standards (at ETSI and ITU) in these areas. One essential issue for Europe will be the reform of the ENF that started in 1999. Through this, the ENF chair will try to improve user representation in the Forum.

2.6.1 Internet and IP Standardisation

There is a view in the Internet community that the objectives of the telecommunications standards bodies such as the ITU and ETSI do not align with those of the IETF and ICANN. Do they focus on providing prompt and proactive standards solutions for the IP naming and addressing world? An extreme view is that it is in the interests of these traditional standards bodies, dominated as they are by the interests of governments and incumbent operators, to deliberately hamper standardisation activities for the new facilities and technologies.

The ITU has already established a constructive working relationship with the IETF and in January 2000 it will hold a workshop jointly with the IETF on IP and telecommunications inter-working focusing on numbering, naming, addressing and routing issues.

3. THE TECHNOLOGICAL LEGACY AND ITS CONSEQUENCES

As was said at the beginning of section 2, although user requirements will drive a strategy for numbering, naming, and addressing, it must also take account of technical reality. Today customers have access to a large variety of telecommunication services, including voice, data, image, video, and multimedia. Various networks based on different techniques and protocols supply these services. These networks typically use different numbering, naming or addressing schemes to establish communications, route calls and allow the customer to access services.

Considering a period of five to ten years and beyond, this report discusses the possible evolution and mutual interaction of the most important numbering, naming and addressing schemes. It also takes account of the ongoing process of convergence between telecommunications, information technology, and the entertainment industry. ETO expects this process to impact on existing networks and services paving the way for the creation of the EII and GII.

This chapter summarises some of the conclusions that are explored in more detail in chapter 4 which presents a summary of some of the existing schemes and the emerging trends for these schemes both from the technical and administration views. Chapter 5 analyses the mutual effects of these schemes and their possible evolution.

In theoretical terms, we can define the EII and GII as seamless platforms supporting any-to-any connectivity and providing customers with any kind of communication services. More concretely, the EII and GII will be networks of networks communicating with each other. Voice, data, computing, interactive video, broadcasting, multimedia and personal communications will be some of the services offered to the subscribers.

Coming back to the present situation, the numbering, naming and addressing schemes most used today are the following:

- ITU-T Recommendation E.164 numbers

- ITU-T Recommendation E.212 identifiers
- ITU-T Recommendation X.121 numbers
- IP addresses
- AESA (ATM End System Addresses)
- N-SAP (Network Service Access Point) addresses
- Internet names

Callers use E.164 numbers to access a large variety of services and networks including the international telephony service. In the past E.164 numbers were used both to identify the subscriber or service and to route calls to the final destination.

With the introduction of number portability and the assignment of E.164 resources for global services and networks, the E.164 number is losing its routing significance. It is becoming increasingly a kind of high level identifier of the service or called party, which we can then envisage as a name. This separation between the identification function and the routing information requires the deployment of translation capabilities in the network in order to make the right association between the E.164 number and the routing information.

Networks currently use E.212 identifiers to uniquely identify mobile terminals at the international level and then allow them to roam among different networks. The increasing use of personal mobility services and cordless terminals provides an incentive to take into account the definition of personal and terminal identities in the fixed network. In order to meet this emerging requirement, the ITU has just completed some work to extend the scope of E.212 identifiers. The idea is to use E.212 as a unique identifier for both mobile terminals and mobile users in mobile and fixed networks.

Public packet data networks like X.25 (which provides the packet switched backbone for the PSTN) and frame relay networks currently use X.121 numbers. However, with the increasing availability of ATM and IP products in public networks, X.25 (and the PSTN, generally) is likely to lose much of its importance with consequences for the future development and use of X.121. X.121 protocols will play a marginal role in the information infrastructure in future. We deal with this further in section 4.3. On the other hand, due to the increasing presence of ATM and IP in public networks, as mentioned before, ETO regards IP addresses and AESAs as two of the most promising emerging addressing schemes.

In particular, in recent years, IP has gained an increasing popularity. Thanks to its evolution from a simple expedient to an advanced protocol with QoS (Quality of Service) capabilities, the emerging information infrastructure will deploy IP extensively. Moreover, in addition to its intrinsic qualities, another reason which explains the success of IP is that most of the existing and future applications have been and will be developed to run over the TCP/IP[21] protocol suite. This will make the availability of IP a kind of pre-condition.

In terms of addressing, the definition of a new version of IP, called IPv6, has overcome the previous problems of address exhaustion.

Today the main concern related to the administration of IP addresses relates to the aggregation of the routing information. In other words, networks will assign (and possibly withdraw) IP addresses in a way that ensures an adequate level of aggregation of the routing information that routers exchange among each other. In this context, aggregation of the routing information means the ability to indicate in a concise way the addresses reachable by a router by using specific techniques based on the hierarchical structure of the addresses. The possibility of withdrawing IP addresses and renumbering sites in order to aggregate routing information is a new issue that will increasingly gain relevance.

[21] TCP/IP – Transport Control Protocol /IP

ATM networks that support only E.164 (either in the native format or in AESA format) as a valid address at the public user interface are working under a limitation. A solution is to extend the addressing to all three types of public AESAs.

Routing in public ATM networks is currently under study in standardisation bodies. The key issue is to assess whether dynamic routing protocols, such as the PNNI (Private Node-Node Interface) routing protocol as defined in the ATM Forum which has been developed for private networks, are scaleable to the public networks. Alternatively, is the traditional static routing as currently used in E.164 based networks enough? Regardless of the type of routing protocol used, aggregation of the routing information is one of the essential elements in defining the structure of ATM addresses and their administration.

An efficient administration of the ATM addressing space is fundamental to the future development of ATM networks. Unfortunately, the existing mechanisms for the administration do not satisfy the real demands of the market. What is missing today is a centralised body for the management of ATM addressing resources working on a worldwide level.

N-SAP addressing has existed for more than fifteen years, since the development of the OSI (Open System Interconnection) model and principles. In the following years the difficulty and inefficiency of running OSI networks has been demonstrated and we can foresee that the original use of N-SAP will soon disappear.

Looking at the Internet experience, we can foresee in the years to come an increasing use of naming for the identification of terminals. In particular, ETO expects names to gain an increasing commercial relevance as shown by the Internet where names have become a kind of trademark for companies selling products or doing business through the Internet.

The current administration of the Internet TLD (Top Level Domain) has worked in a quite satisfactory way in the last ten years but today we must introduce new rules. These new rules should overcome the present limited availability of naming resources under specific TLD (such as .com) through the creation of new TLDs and will bring to an end the US monopoly of name administration.

Bearing in mind the arguments set out above, ETO expects that, in the medium term, E.164, IP addresses, and AESAs to be the numbering and addressing schemes most used. Attempting to understand how E.164, IP addresses and AESA may evolve we cannot foresee, in the medium term, a convergence of the above mentioned schemes into any specific single one. The deep technical and regulatory differences existing between these schemes and the networks that make use of them hampers the convergence process.

In the medium term, the information infrastructure will be a "network of networks". What is really required is a high level of inter-working between E.164, IP addresses and AESAs to allow, from the addressing and routing point of view, seamless communications between the networks using these different schemes.

At the same time, in telephony networks, there is an increasing separation between the number used to identify the service or the called party and the routing information used to route the call in the networks. This is due to the introduction of number portability and the growing presence of IN[22] services. In this respect, we can regard the E.164 number identifying the service or the called party as a name independent of the routing process.

The different characteristics of Internet-like names and E.164-like names reveal the degree of difficulty that these two forms of naming would have to overcome to converge. In the medium term, we can foresee the need for the coexistence of these two forms of naming, together with the necessary interworking capabilities.

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[22] IN – Intelligent Network

In short, we can draw a parallel between the evolution of addressing and the evolution of naming. This leads to the conclusion that the real problem lies in ensuring the coexistence of different schemes by developing the appropriate inter-working functions rather than attempting to encourage convergence. We explore this in more detail in section 5.1.

ETO expects standardisation bodies such as ETSI and ITU-T and international fora such as the ATM Forum to play an essential role in developing these inter-working functions. This activity must be carried out with close co-operation between the above mentioned bodies. European national regulators will be involved in a marginal way in the technical development of these inter-working capabilities. Their responsibility is to ensure that national regulatory regimes do not hamper the coexistence of these schemes.

4. GENERAL FRAMEWORK

Today customers have access to a large variety of telecommunication services, including voice, data, image, video, and multimedia. Various networks based on different techniques and protocols supply most of these services. These networks typically use different numbering, naming or addressing schemes to establish communications, route calls and allow customers to access services.

We should note that the distinction between a name, an address, and a number is not always clear. Today these three terms have different meanings in different contexts. For example, the concept of number is deeply rooted in telephony but it is missing in the Information Technology (IT) environment where the terms address and name are widely used.

Some activities are under way to clarify the terminology and as an example we report the definitions which ITU-T Study Group 2 (SG2) is working on:

- “Name” is an alphanumeric label used for service reference and may be portable.
- “Number” is a string of digits that uniquely identifies the network termination point.
- “Address” is a string or a combination of decimal digits, symbols and additional information, which identifies the specific termination point of a connection and provides information for routing.
- “Network termination point” is a logical concept, which may refer to a person, a persona (such as work, home, and so on), a piece of equipment (such as telephone), an application or a location.

Figure 1 summarises the most important numbering, naming and addressing schemes used at present in the various networks. In order to avoid confusion and considering that the ITU-T definitions are not yet stable, in the following we use the terms number, name and address with the specific meaning of each context without trying to make these concepts general.

In the following parts of this section, for each of the numbering naming and addressing schemes shown in figure 1, we will provide a brief description. We also attempt to understand how they may evolve in the next five to ten years and beyond.

In discussing the evolution of these schemes, we should bear in mind that a process of convergence between telecommunication, IT, and the entertainment industry is in progress. This will act as a force driving towards the creation of the so-called information society.

Although analysis of the motivations for this convergence process is outside the scope of this report, we can mention some general considerations to improve understanding of the impact on the evolution of numbering, naming and addressing.

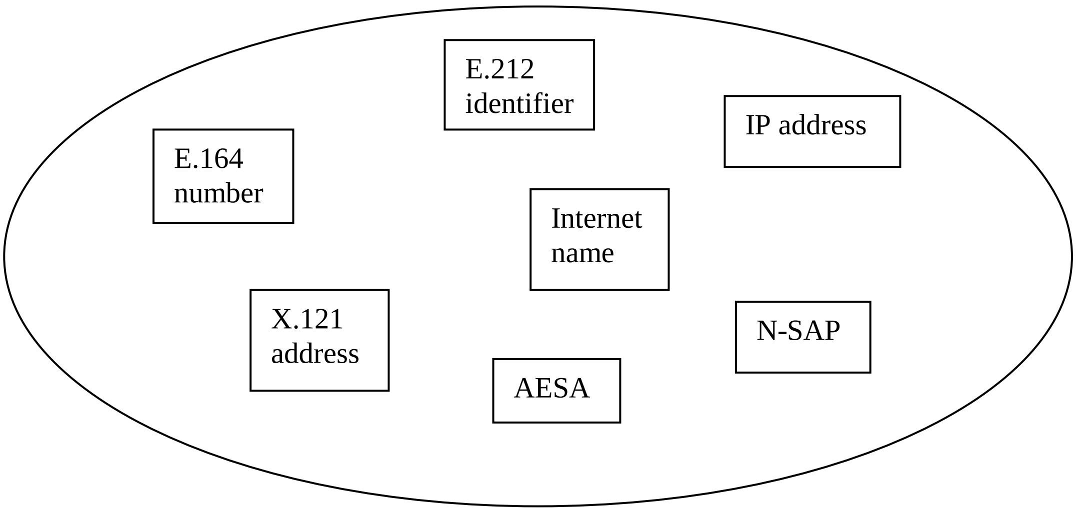

Figure 1: Summary of the Present Schemes

Behind the convergence of telecommunications, IT, and the entertainment industry, there are technical, political and commercial reasons. From a technical point of view the boundaries between the technologies used in telecommunication, information processing and entertainment are disappearing. The digitalisation of all kinds of information, the increasing presence of intelligence in the networks, the growing capacity in terms of transmission and switching, overcome distinctions between technologies and networks for the provision of telecommunication, IT and entertainment services.

The same is happening to services offered to the customer. In the future, it will be increasingly difficult and purposeless to classify a service as telecommunications, IT, or entertainment. Customers are interested in applications such as tele shopping, tele working, and so on, where all the three above-mentioned components are present and in some way integrated.

In summary, we can envisage that the networks and the services, which will emerge from this convergence, are likely to use numbering, naming and addressing schemes coming from all three environments. This coexistence of different schemes requires the development of inter-working capabilities in the networks and in the customer terminals.

4.1 ITU-T Recommendation E.164 Numbers

This section is the first of seven sections presenting the most important numbering, naming and addressing schemes.

4.1.1 Introduction

ITU-T Rec. E.164 numbers are used today to access, in a uniform way, a variety of networks such as the PSTN[23], ISDN[24] and IN and services such as plain telephony, mobile and so on. The particular importance of E.164 numbers relates to their use in the provision of the international telephone service. This makes E.164 the most used number scheme and any change must be carefully weighed in relation to its potential impact on customers and network resources. One can safely deduce that the use E.164 numbers will continue for a long time to come.

The structure and the capabilities of E.164 numbers, as described in ITU-T Rec. E.164, are briefly summarised in Annex 2. Here it is worth mentioning that three structures are considered:

- International public telecommunication numbers for geographic areas
- International public telecommunication numbers for global services
- International public telecommunication numbers for international networks

These three structures allow E.164 numbers to be suitable for the provision of a large set of telecommunication services and for the access to different network platforms.

Callers use E.164 numbers to access many networks and services including the telephone service.

At present, E.164 is the most pervasive numbering scheme in the world.

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[23] PSTN – Public Switched Telephone Network
[24] ISDN – Integrated Service Digital Network

4.1.2 Evolution of E.164 numbers

Until some years ago, the telephony service was the main user of E.164 numbers. Today, E.164 numbers are used to provide a large set of services, and thanks to the introduction of new capabilities in the network, such as number portability and intelligence, the use of E.164 numbers is rapidly changing.

New applications for E.164 numbers

Networks can now use E.164 numbers for access to global services. Such E.164 numbers are no longer geographic numbers; to route the call to the called party necessitates performing some operations to translate the E.164 number into a number used by the network to terminate the call.

In the future, we can foresee an increasing use of E.164 numbers for the provision of emerging global services (such as shared cost and premium rate) and regional services like ETNS (European Telephony Numbering Space) services in Europe.

Recently much attention has been devoted to the possibility of using E.164 numbers to identify international networks. The idea is to have a three-digit Country Code (CC) reserved for this purpose followed by a field of one to four digits, called the Identification Code (IC), for the identification of a specific international network. Although E.164 specifies that ICs are one to four digits long, E.164.1, which takes precedence over E.164, states that the ITU will make future assignment based on two-digit ICs.

As for the global services, an E.164 number used to identify a network is not a geographic number and to route the call some translations must take place.

With the use of E.164 resources for global services and network identification, E.164 numbers will lose their geographic meaning.

Number translations must be performed within networks in order to route calls using E.164 numbers without geographic meaning.

Introduction of Number Portability and Provision of IN Services

Historically E.164 telephony numbers were geographic numbers, so an E.164 number assigned to a subscriber both identified the subscriber and provided information to route the call.

With the progressive introduction of number portability, users can port E.164 telephony numbers between different service providers. With some limitations, they can also port them between different locations (for example, today it is not possible to port a number outside the area identified by a CC). Consequently, additional routing information is required to route a call to a ported E.164 number. Such additional routing information may be either an E.164 number or something else. In the first case the routing number is a number complying with ITU-T Rec. E.164, used not to identify a subscriber or to access a service but only to reach a network termination or more generally a network element. In the second case, the routing number is a number not complying with ITU-T Rec. E.164 that is interpretable by the routing protocols.

The network can obtain the routing information in different ways (for example database dip or donor switch) depending on how the network implements number portability.

Services requiring IN capabilities are becoming increasingly popular. Shared revenue services, personal numbers, Virtual Private Networks (VPN) are just some examples of this category of service. In addition, for these services, the E.164 number associated with the service or the customer can no longer be used to route the call to the final destination and additional routing information is required. The service provider usually provides this additional routing information.

With the increasing presence of number portability and IN services, the E.164 number will lose part of its routing significance and become a kind of name used to select a service or identify a subscriber.

The introduction of number portability and the provision of IN services have an impact on the capabilities of E.164 numbers.

In the future, we will have a clear separation between those E.164 numbers used as names for identifying a service or a subscriber and those used as addresses for routing.

The use of E.164 numbers as names will increase.

E.164 Country Code Exhaustion

The emerging trend to assign CCs to global services, networks, and regions will soon create a problem in terms of CC exhaustion. We need to study some solutions in order to develop a plan to increase the availability of E.164 CCs.

ITU-T SG2 has started discussing and weighing the various solutions. The solutions to which it will be give further consideration must not require any extension of E.164 numbers beyond the present limit of fifteen digits. Solutions that extend the length of the E.164 number beyond fifteen digits are not excluded, but considering the operational problems to which they would give rise, they are given less priority than the other ones.

It is also advisable that the envisaged solutions minimise the impacts on the existing E.164 numbering plans and create sufficient resources to meet future demands.

It is important that European national administrations are involved in the ITU-T studies to increase the supply of E.164 CCs.

4.1.3 Administration of E.164 resources

ITU-T administers E.164 resources at the international level and NRAs (National Regulatory Authorities) administer them at the national level. In some cases, administrations may also manage E.164 resources at a regional level. For example in the case of ETNS, which is a numbering space for the provision of pan-European services, ETO will administer E.164 resources at European level. The North American Numbering Plan is another example of numbering resources administered at a regional level.

In administering E.164 resources NRAs must follow rules which facilitate competition in telecommunications networks and services ensuring an adequate level of number capacity, user friendliness and non discriminatory access. These subjects have been widely addressed in the ETO report "Harmonised national numbering conventions".

With reference to the use of E.164 numbers for global services and networks, it is important to mention that the rules for the assignment of non-geographic E.164 numbers cannot be the same as those defined for geographic E.164 numbers. This has required ITU-T SG2 to work on a set of new rules and the result of this activity is ITU-T Recommendation E.164.1, which describes procedures and criteria for reservation, assignment, and reclamation of the CCs and the associated ICs.

The introduction of number portability may also affect the rules for the assignment and management of E.164 number ranges and may pave the way for new concepts like number pooling.

Rules for the administration of E.164 resources must facilitate competition and ensure an adequate level of number capacity, user friendliness, and non-discriminatory access.

The introduction of number portability may influence the rules for the assignment and management of E.164 resources and may pave the way for new concepts such as number pooling.

4.2 ITU-T Recommendation E.212 Identifiers

4.2.1 Introduction

E.212 defines an international identification plan for mobile stations or terminals, and, in addition, defines a set of rules for the allocation of IMSIs (International Mobile Station Identities) to these stations. Such an identification plan allows mobile terminals to be recognised by a unique international identifier and to roam among different networks.

The increasing use of personal mobility services and PSTN (Public Switched Telephone Network) cordless terminals provides incentive to take into account the definition of personal and terminal identities used in the fixed network.

To meet these requirements ITU-T SG 2 is revising Rec. E.212 to extend the scope of the Recommendation. The idea is to use E.212 as a unique identifier for both mobile terminals and mobile users in mobile and fixed networks (see Annex 3). A mobile user is a user that accesses a mobility service where a mobility service includes mobility for the terminals or individuals.

In the case of mobile users who are UPT (Universal Personal Telecommunication) users, the E.212 identifier is the Personal User Identity (PUI) and uniquely identifies a UPT subscriber.

We note that callers cannot dial IMSIs and PUIs and fixed networks cannot use them for routing purposes.

The concept of E.212 is rapidly evolving to meet the emerging requirements of personal and mobility services offered by the fixed networks.

E.212 is becoming a global and unique identifier for mobile terminals and mobile users within fixed and mobile networks.

4.2.2 Administration of E.212 resources

The ITU-T at the international level and NRAs at the national level administer E.212 resources.

Rules for the administration of E.212 resources must facilitate competition and ensure an adequate level of number capacity and non-discriminatory access. We note that the extension of the scope of E.212 will create an additional demand for E.212 resources that may necessitate a revision of the current national rules for the allocation of E.212 values to avoid exhaustion situations.

To conclude it is worth pointing out that the allocation of IMSI and PUI should be independent of the numbering plans for mobile and personal services. This allows the numbering and the identification plans to function independently of each other and to take into account security issues.

Rules for the administration of E.212 resources must facilitate competition and ensure an adequate level of number capacity and non-discriminatory access.

The proposed use of E.212 for personal and terminal identities in fixed networks will generate an additional demand on E.212 resources that could potentially lead to capacity shortage.

4.3 ITU-T Recommendation X.121 Numbers

4.3.1 Introduction

The ITU-T defines the international numbering plan for public data networks Recommendation X.121.

The Recommendation presents the structure of X.121 numbers and defines the corresponding international number plan to allow the identification of one specific Data Terminal Equipment/Data Circuit-terminating equipment (DTE/DCE) interface in one public data network.

An X.121 number consists of two parts: the DNIC (Data Network Identification Code) and the NTN (Network Terminal Number). A DNIC is a four-digit code used to identify a specific public data network in a country and NTN is the number identifying the DTE/DCE interface within the above mentioned data network. When an integrated numbering scheme exists, X.121 consists of a DCC (Data Country Code) followed by the NN (National Number) of the DTE/DCE interface (for more details on the structure of X.121 see Annex 4).

The data networks using X.121 can be either packet or circuit switched data networks. However, today X.121 is mainly used in packet networks like X.25 and in frame relay networks.

The X.25 protocol is a three level protocol (Physical level, Link level, and Packet level) that allows the transport of packets over circuits that different users share. A packet, the length of which is typically 128 bytes, contains sequences of data and control elements.

When ITU defined the X.25 protocol more than ten years ago, it appeared to be a cost-effective solution for networking systems in wide geographic areas. However, X.25 presents a number of technical disadvantages including:

- unpredictable and limited performance
- repetition of functionality with higher level protocols (like TCP/IP)
- lack of user control over the network
- inefficiency when traffic is very high or very low

These disadvantages have slowed its deployment.

With the ever-increasing presence of ATM and IP in public networks, in the years to come X.25 is likely to lose a significant part of its market. In fact, ATM and IP networks are able to offer better performance in terms of band-width, flexibility, inter-working with other technologies and a larger choice in terms of services provided.

From a numbering point of view we can foresee that X.121 will not develop further and will be regarded as a kind of legacy scheme in the future information infrastructure.

ITU defined X.121 as the international numbering plan for public data networks.

ATM and IP increasingly threaten the further deployment of networks using X.121.

X.121 protocols will play a marginal role in the information infrastructure in future.

4.3.2 Administration of X.121 resources

The ITU-T administers assignment of the DCC (the first three digits of the DNIC), whereas national authorities administer the assignment of the network digit (the last digit of DNIC).

The ITU and national authorities have to carry out allocation of DNICs in a fair, impartial and non-discriminatory way and should prevent the exhaustion of this resource.

Bearing in mind the expected limited growth in the demand for X.121 numbers, the existing rules and procedures for the administration of X.121 resources will remain applicable in the years to come.

ETO expects that, in the years to come, the existing administration of X.121 resources will work in an appropriate way without requiring modification.

The allocation of DNIC resources has to satisfy impartial and non-discriminatory criteria. The exhaustion of DNIC resources will not be an issue.

4.4 Network Service access point Addresses

4.4.1 Introduction

The N-SAP address is the information used by an OSI Network Service Provider to identify a particular N-SAP where N-SAP is the access point between an OSI Network and Transport layers. We describe the architecture and structure of an N-SAP address in Annex 5.

An N-SAP address is an OSI Network address and must not be confused with other types of address like X.121 and E.164. According to OSI terminology, X.121 and E.164 are sub-network addresses (a sub-network is a collection of transmission media and switching nodes providing a data transfer service). Networks use these sub-network addresses to identify the point of attachment of an end system to the sub-network or the point at which the sub-network service is available.

When OSI introduced its model and principles more than fifteen years ago, the telecommunications community regarded them in an extremely positive way but the following years have proved the difficulties and inefficiency of deploying and running OSI networks.

In the coming years we can foresee the complete disappearance of commercial OSI networks. However, as is happening for ATM networks, the structure of N-SAP addresses can be the basis for new addressing architectures and structures.

N-SAP is a Network address identifying an access point between two OSI layers (layer 3 and 4).

The original use of the N-SAP address will disappear soon. The structure of an N-SAP can be the basis for the creation of new addressing schemes.

4.4.2 Administration of N-SAP resources

The basis for the administration of the N-SAP resources is the concept of hierarchical addressing domains where an addressing domain is a set of addresses managed by the same authority. The authority specifies the structure of the N-SAP and reflects this administrative hierarchy in the address itself.

At the international level, ISO administers N-SAP resources. In some cases, it may delegate this responsibility to other bodies. As an example, for the ICD[25] N-SAP, which is a specific type of N-SAP used to identify an organisation identification scheme, ISO has delegated the administration to BSI[26], which manages this scheme for the whole world.

At the national level, rules for the administration of N-SAP are not harmonised. For example, in the case of the DCC[27] N-SAP, which is a specific type of N-SAP carrying geographic information, ISO leaves the administration of the portion of the address behind the DCC to the authorities of the individual nation.

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[25] ICD – International Code Designator
[26] BSI – British Standards Institute
[27] DCC – Data Country Code

In some cases, as in Germany and Norway, the administration of this address is under the direct responsibility of the NRA. In other cases, which are the majority, the administration is under the control of specific and independent institutes. As an example, in the UK the DCC N-SAP is under the control of BSI, and the Federation of Electronic Industry (FEI) acting as registration authority under the supervision of BSI. We can explain the limited involvement of NRAs in the administration of N-SAP by the lack of demand from the market for this kind of resource.

ISO administers N-SAP addresses in a hierarchical way with the involvement of various bodies and institutes.

Today the involvement of NRAs in the administration of N-SAP resources is limited mainly because of the lack of demand from the market for N-SAP addresses.

4.5 ATM END SYSTEM ADDRESSES (AESA)

4.5.1 Introduction

Over the last two years, ATM has matured and ETO expects it to be widely used as the switching technology to build up the future transport platforms.

ATM is a cell relay switching technology able to combine the reliability of circuit switching with the efficiency of packet switching. The cell is a fixed size packet (53 bytes) containing a header and a payload. The fixed size allows networks to perform switching and multiplexing functions in a quick and easy way.

ATM has features of flexibility, scaling ability, quality of service and bandwidth. These make ATM one of the most suitable techniques to create a high-speed transport network able to carry bulk information in different forms (such as voice, data, image, video, and multimedia). In particular, ATM has the ability to transport efficiently any kind of data streams with whatever bit rate and QoS profiles required. This is one of the most important requirements to be met in order to provide the new emerging services and applications (such as Video on Demand, video-conferencing, and so on).

The ATM Forum, in conjunction with the international standardisation bodies (ITU-T, ETSI), carries out process of definition of ATM. Although these groups worked separately in the past, they have now developed close relationships.

Today, both in the private and public network environment, several ATM-based products, according to ATM Forum and ITU-T standards, are available on the market and in a couple of years a significant deployment of ATM products is expected.

ATM (thanks to its characteristics of bandwidth, flexibility and QoS) is one of the essential techniques to build up the transport platform of the years to come.

4.5.2 ATM Addressing and the ATM Forum

In terms of addressing, the ATM Forum has adopted a certain number of addressing schemes based on AESA

The format of an AESA is in accordance with the format of an OSI N-SAP (see section 4.4). We give more details of the AESA format and structure in Annex 6.

AESA identifies the User Network Interface (UNI) to which the called party is connected, and is used by the routing protocols to route the call. UNI is the interface where the user accesses the ATM network. In the case of public ATM networks, the UNI is the public UNI, whereas in the case of private ATM networks the UNI is the private UNI.

The AESA used to identify the public UNI is an address where in the IDI field only three values are allowed: E.164, ISO DCC and ISO ICD. In addition to the three types of AESAs, the ATM Forum also allows plain E.164 numbers to identify the public UNI. In the following, these three kinds of AESAs are called "public AESAs" to distinguish them from AESAs used at the private UNI. In the specific case of private AESAs, an ATM address can use other values in addition to E.164, ICD, and DDC in the IDI field.

It should be noted that the focus of our study is limited to addressing in public ATM networks and in particular to the address schemes to be used to identify the access interfaces (UNI) to these networks.

4.5.3 ATM Addressing and ETSI and ITU-T

SG 2 and NA2 study the addressing aspects of ATM in ITU-T and ETSI respectively. Both groups limit the addresses in use at the public UNI to the E.164 number and E.164 AESA. This limitation is due to the fact that the addressing for ATM networks has mainly been regarded as an evolution of the addressing schemes defined for Narrow-band ISDN (N-ISN).

It was realised in 1997, however, that retaining this limitation would have a heavy impact on the growth of the ATM market for public network operators. Most of the ATM private networks use AESA addressing; ATM private networks wishing to connected to public ATM networks require those public networks to support the same addressing mechanisms to avoid heavy interworking functions between private and public domains.

To bridge the gap both ETSI NA2 and ITU-T SG2 are revising their recommendations to extend addressing to all three public AESAs at the public UNI.

In public ATM networks, addressing capabilities have to include the E.164 number plus the three public AESAs. Limiting addressing to E.164 would imply the loss of important market segments.

4.5.4 Routing in ATM Networks

One of most relevant issues related to the support of public AESAs is the definition of the routing mechanisms in the ATM networks.

The ATM Forum has defined a routing protocol within PNNI (Private Network-Network Interface) which enables network nodes to exchange and aggregate routing information derived from all three AESA formats. The PNNI routing protocol is a dynamic routing protocol working on principles similar to those used by the Internet routing protocols. PNNI sees the ATM network as a network of sub-networks and when a new sub-network connects to the existing topology, this sub-network is automatically recognised by PNNI.

To work in an efficient way the PNNI routing protocol has a hierarchical view of the network based on the concept of peer group. The peer group is a collection of ATM nodes each of which exchanges information (in the following referred to as “reachability information”) with other members of the group. Then the network aggregates the reachability information of a peer group and passes it to the hierarchical level above.

The PNNI routing protocol has proved to work well in the private domain for small-medium ATM networks. Some doubts exist as to the feasibility of implementing the PNNI routing protocol in a public ATM network with many nodes.

An alternative to the support of the PNNI routing protocol in public ATM networks is to continue using existing routing protocols based on E.164 numbers. This also requires the introduction of capabilities to translate public AESAs into E.164 numbers used to route the calls.

For a network implementing dynamic routing protocols like PNNI, one of the issues that requires more attention is the assignment of addresses. It is crucial that networks assign addresses in a way that reflects the topology of the network and allows an easy aggregation of the information of reachability exchanged between switches. Addresses assigned without having aggregation principles in mind will give rise to situations where the network will no longer be able to route the calls.

ATM calls can route using dynamic protocols (such as PNNI) or existing protocols based on E.164 with the required translation mechanisms.

The definition of the structure of the ATM address and the rules for assignment must minimise impacts on routing protocols.

4.5.5 Administration of ATM Addresses

Today the ICD AESA is the address format most used in ATM networks because it is the addressing scheme supported by the major vendors of ATM products.

With reference to ATM addressing, one of the most urgent issues is the administration of the ATM addressing space.

Today there is no central authority responsible for the administration and registration of ATM addresses. Limiting the discussion to the three public AESAs, today we have three different bodies responsible for the administration of these addresses.

We can regard the E.164 AESA as under the administration of ITU-T and the NRAs. In fact, an E.164 number carried in the IDI field is a number in line with the ITU-T Rec. E.164. However for a specific type of ATM address, called Customer owned ATM address, the E.164 number carried in the IDI field is not required to be in line with any of the existing national telephony numbering schemes. In fact, there is no text stating that E.164 AESAs are supposed to comply with the administration rules set up by ITU-T and NRAs.

Hence, in a closed environment, where a private ATM network does not connect to the public network, these rules might not apply. This is because the need for a number with a unique value, which exists at the national level, does not apply in this context. In this case, “private local” E.164 AESAs, which match public E.164, numbers could be used. This situation threatens the future interconnection of the public and private networks.

National representatives of ISO administer DCC AESAs on a national basis. For example, in the United States, the national administrative body is ANSI (American National Standards Institute). However in some countries there is not yet a national body responsible for the assignment of DCC and this lack may seriously jeopardise the use of this kind of AESA. Due to the fact that DCC AESAs are administered at the national level these addresses may differ slightly from country to country, making it impossible to use a standardised address structure all around the world.

The administration of ICD AESA is formally under the responsibility of ISO. In practice, the administration is the responsibility of the BSI operating in the UK and assigning ICDs at a global level. An organisation identification scheme is eligible to have an ICD if it is in common usage in at least one country and has a widespread coverage. An organisation must submit an application for an ICD to BSI through a sponsoring authority, which is usually the applicant's national standards body. Due to the increasing number of requests and the fact that BSI is a national registration authority, BSI has drawn attention to the difficulties of continuing to administer ICDs on a global level.

The availability of ATM addresses and their efficient administration are essential elements for the future development of the ATM networks. Today what is missing is the presence of a single organisation responsible for the administration and management of ATM addresses on a global basis.

Some observers have identified ITU-T as the body that could take the responsibility of acting as a central authority for the assignment and management of ATM addresses in public networks. In this case, we could envisage the definition of a new AESA under the control of ITU-T. ITU-T would be responsible for the administration of the IDI field, which contains a code to identify a specific organisation. The identified organisation would be responsible for the allocation of the values of the remaining part of the address. We show a tentative structure of this new AESA in Annex 6.

The existing mechanisms for the administration of public AESAs do not satisfy the real demands of the market.

It is important to have a centralised authority for the management of ATM addressing which functions on a worldwide level. ITU-T is a valid candidate for the management of AESAs for use in public ATM networks.

Efficient routing must be a priority in defining rules for address assignment.

4.6 Internet Protocol Addresses

4.6.1 Introduction

It is widely recognised that IP will become increasingly widespread in the transport networks. In fact, IP is one of the most suitable and cost effective solutions to satisfy the emerging requirements of the new transport platform.

This platform is expected to be a network of networks based on different technologies such as ATM, ISDN, SDH, Frame Relay, and so on. IP provides the necessary capability to allow inter-working between the different networks and to create in this way a "seamless platform". In fact, the IP protocol is a connection-less network protocol providing a packet delivery service able to accommodate a variety of physical network topologies, links, and network technologies.

In IP based networks the unit transferred is the IP datagram, a variable length packet, which consists of a header and a payload. The header contains the IP addresses. The network can duplicate or lose IP packets without losing the integrity of the communication and routes each one independently. TCP performs flow control and reordering functions. In some cases, another transport layer protocol called UDP (User Datagram Protocol) runs over IP. UDP is a very simple transport protocol, which does not perform flow control and reordering functions.

In addition to its intrinsic qualities, another reason for the success of IP is that most of the existing and future applications have and will run over the TCP/IP protocol suite. This makes the availability of IP a form of pre-condition.

Recently a remarkable effort has been made by IETF (Internet Engineering Task Force) to improve the capabilities and performances offered by the IP. In this context, it is worth mentioning IPv6 and RSVP (Resource Reservation Protocol) whose definitions are almost completed.

IPv6 is a new version of the existing IP (usually called IPv4) with extended addressing capabilities, a simplified structure of protocol, mechanisms for the identification of flows, security and privacy capabilities, an ability to support mobility, and so on. The introduction of IPv6, however, will create some difficulties for migration from IPv4 to IPv6. These difficulties include technical and operational aspects.

RSVP is a protocol that allows the reservation of resources in IP based networks in order to provide services with the requested QoS. With the introduction of RSVP, we can no longer consider IP as only a best effort protocol, since it is now possible to provide IP services with specific QoS. One point that needs more work is the ease of scaling RVSP. In fact today some concerns exist as to well RSVP will work on global networks.

Transport platforms increasingly deploy IP allowing inter-working between networks based on different technologies and the support of many applications.

IP is no longer a simple best effort protocol; it has been enriched with many other capabilities.

4.6.2 IP Addressing

In this section, we provide a short overview of the structures of the addresses used in IPv4 and under definition for IPv6. We include more details about the architecture and formats of IP addresses in Annex 7.

The IPv4 address has a fixed length of four octets (32 bits). The first part of the address is the Network identifier (Netid) followed by the Host identifier (Hostid) as the second part. The Hostid identifies the interface of a host within the IP sub-network identified by Netid. IPv4 addresses are categorised in four classes (class A, B, C, and D) mainly according to the length of Netid and Hostid.

In defining IPv6, the IETF specified a new address architecture able to satisfy future Internet needs in terms of addressing space and routing information. The IPv6 address is 128 bits long and no longer supports the classes defined in IPv4.

The enhancements of IPv6 addressing do not relate only to the greater size of the address. They also include the capability of IPv6 address to have different formats, to reflect the topology of the network and to embed different addressing schemes.

An IPv6 address can be a local address or a global address. Networks use local IP addresses only in local IP networks (IP networks without connection to the public Internet) whereas global addresses have a global validity and networks can use them to reach any point in the Internet.

The type of IPv6 address that is expected to be more widely used is the so-called aggregatable global unicast address (unicast indicates that the packet is delivered to one single interface). In this IPv6 address, we have three levels of hierarchy: public topology, site topology and interface identifier (see Annex 7). The presence of these three hierarchical levels is particularly relevant because it makes it possible to reflect in the IP address the topology of the network, allowing a better aggregation of the reachability information exchanged among the routers.

IP addressing is evolving from IPv4 to IPv6.

IPv6 overcomes many of current limitations of IPv4 address and has remarkable capabilities in terms of address space and flexibility including the ability to embed other types of addresses and carry information about the topology of the network.

With IPv6, ETO does not expect address exhaustion to be an issue.

4.6.3 Routing Protocols

The routing protocols running on the Internet are dynamic, requiring a continuous exchange of routing information (reachability information) between the various routes. To work in an efficient way it is crucial that the routers are able to aggregate the reachability information distributed in the networks. Routers can carry out aggregation if the IP addresses are structured and assigned in a way that reflects the topology of the network.

The IPv6 aggregatable global unicast address with its (public topology, site topology and interface identifier) has been structured in this way to meet the above mentioned requirements of aggregation.

We should note that IPv6 aggregatable global unicast addresses are not portable between ISPs. So each time a subscriber changes his own ISP he may need to renumber his network. Renumbering a site is always a painful and costly exercise and therefore the IETF has developed some mechanisms for a kind of automatic reconfiguration of the subscriber hosts and will improve these in the years to come.

The basis for the structure of the IPv6 address and the rules of assignment is aggregation of the routing information.

Site renumbering will become increasingly required in the near future.

4.6.4 Administration of IP Addresses

In the Internet, the entities responsible for the assignment of IP addresses are Internet Registry Authorities.

The newly created ICANN is the central co-ordinator for the assignment of all unique parameter values in IP including IP addresses.

Under ICANN, there are three RIRs - RIPE, APNIC and ARIN. They manage the assignment and registration of IP addresses. In Europe IP addresses are managed by RIPE NCC[28]. RIPE NCC is responsible for Europe, North and Central Africa and the Middle East. RIPE, and APNIC, operating in the Pacific Rim, are regional Authorities, whereas ARIN covers the areas outside Europe and Asia.

Local Internet Registries operate under the authority of RIR and have the same role and responsibility as Regional Registries within limited geographical areas.

RIPE, because of collaboration between all the European ISPs, ensures the administrative and technical co-ordination needed to run the European IP networks including address assignment to ISPs.

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[28] RIPE NCC – Reseaux IP Europeens Network Co-ordination Centre

The Internet Registries allocate IP addresses to ISPs. ISPs are then responsible for assigning IP addresses to the customers who request them.

The rules that the Internet Registries follow for assignment of IP addresses to an ISP follow two principles: saving addressing resources and favouring aggregation.

Saving addressing resources in particular is extremely important in the case of IPv4, due to the limited address space and the risk of running out of available addresses. On the other hand, in the case of IPv6, due to the extended addressing capacity, the main concern is the ability to aggregate the routing information exchanged by routers. To perform this aggregation it is essential that addresses reflect as closely as possible the topology of the network. When the topology changes, the Registries may request addresses assigned to ISPs back and assign new addresses (renumbering).

Considering the present organisation of ISOC and the procedures for the assignment of IP addresses ETO does not envisage that NRAs can play an active and positive role in the current system.

In the Internet, there are well-established procedures for the assignment of IP addresses.

The rules for the assignment of addresses aim more and more at the optimisation of routing. Renumbering may take place when required.

NRAs cannot play a significantly active role in the current administration of IP addresses.

4.7 Internet Naming

4.7.1 Introduction

IP addresses identify interfaces to which hosts and routers are connected. In addition to the IP address, each host has a name that is a structured string of alphanumeric characters.

Typically names are user-friendlier than IP addresses and human beings feel more comfortable with using names instead of addresses to identify hosts. To establish a communication between two hosts, however, the DNS must translate the name of the called host into the corresponding IP address that routes the call through the IP platform. The DNS is a system of distributed databases connected by using specific protocols.

The name is organised according to a structure that comprises three levels: TLD, domain, sub-domain, and host name (for more details see Annex 8). The TLDs divide into generic TLDs such as .com and .org, and country based TLD with a geographic connotation such as .uk. The presence of this hierarchical structure in the name allows easier identification of the host and translation into the corresponding IP address.

The use, at the application level, of names instead of addresses, and of user-friendly techniques, such as hyper-links, to establish connectivity has contributed in a significant way to the success of the Internet. These facilities have also contributed to its evolution from an academic to a commercial network. In some cases, the Internet name has become a kind of trademark for companies selling products or doing business through the Internet. Today advertisements that put more emphasis on the Internet name of the company than on other information are common. The significance acquired by Internet names in recent years has created commercial and legal battles for the rights to use specific names.

Internet names are structured strings of characters for the identification of hosts.

Internet names translate into IP addresses to establish and route calls.

Internet names are gaining ever-increasing commercial relevance; giving rise to conflicts, for instance on trademark issues and revealing gaps in legal provision.

4.7.2 Administration of Names

As for IP addressing, naming is a resource that needs careful administration. The administration of the TLD has been under the control of InterNIC, which has been directly responsible for the three TLDs: .com, .org, and .net. In addition, InterNIC has had overall authority over the other TLDs. InterNIC has also been in charge of the co-ordination and management of the DNS that is a key element for the appropriate mapping between names and IP addresses.

Since 1993, the registration of TLDs .com, .net, .org, .gov, and .edu was the responsibility of Network Solution Incorporated (NSI) in association with the US National Science Foundation. This arrangement, which expired in September 98, has created a de facto US monopoly in the administration of the generic TLDs and in particular of .com which is today the most used TLD.

The organisation identified by the Second Level Domain (SLD) usually performs the organisation of the domain and the sub-domains behind the TLD. As an example, for the name xxx.yyy.zzz.IBM.com, IBM itself is responsible for the domains and sub-domains (xxx.yyy.zzz) behind TLD .com.

In addition to the generic TLDs, there are other TLDs, which have a geographic connotation (ccTDL). These TLDs use a two-letter code to identify the various countries according to ISO standard 3166. Following the approach defined for the assignment of IP addresses the administration of ccTDL is under the responsibility of regional authorities. RIPE is the local Registry for Europe, APNIC for the Asia-Pacific area and InterNIC for the rest of the world including US. In many cases the above mentioned authorities delegate the administration of ccTLDs to the corresponding national registries. The authority of national registries comes from local consensus and they have autonomy in their relationship with IANA.

Today there are more than 200 ccTDL and the number of hosts registered in ccTDLs is a third of all the hosts connected to the Internet.

The national registries have responsibility for the structure of the country-based sub-domains. In some countries such as France, Japan and UK these sub-domains are organised according to generic categories like the structure of the international TLDs. In other countries, the sub-domains follow political or geographic rules.

We should note that in the case of geographic TLDs no correlation is necessary between the physical location of the host and the country indicated by the TLD code.

The management of ccTLDs at the regional and national levels follows regional and national rules. The national registries are responsible for the structure of geographic SDLs.

Coming back to the generic TLDs, for more than ten years the methods for assignment and management of these TLDs has been satisfactory. However, today the ever-increasing commercialisation of the Internet requires more efficient, flexible and fair mechanisms for name assignment. Companies and organisations that use the Internet for commercial and business activities have realised the importance of the “right” name for marketing their products.

The ongoing discussion on the future governance of the Internet has much to do with new rules for the management of the Internet names.

In order to promote competition in the registration of the SDLs and the management of TLDs, there is a distinction between Registry and Registrar. The Registrar is in charge of registering clients into TLDs and is a kind of interface between the clients and the Registry. The Registry is the entity responsible for maintaining the databases pertaining to a specific TLD. A Registrar can offer his services under more than one Registry, competing with other Registrars.

The newly formed Internet Corporation for Assigned Names and Numbers (ICANN) is in charge of defining the criteria as to how the Registrars can compete between each other without affecting the stability of the Internet. In addition, ICANN should decide whether and to what extent competition should take place between the different Registries. At present, there are different views on the opportunity of introducing competition at the Registry level. Some observers believe that the creation of profit making Registries competing at a worldwide level may seriously damage the stability of the Internet. Registries should be non-profit organisations operating based on cost recovery for the benefit of the whole Internet community. Other observers think the introduction of competition between Registries can improve the quality of the services offered and the range of customer choice.

Another outstanding issue, which the industry needs to discuss at the global level, is the creation of new TLDs. As indicated in the White Paper ICANN has been identified as the right body to define rules for the establishment of TLDs. Such rules have to ensure that new TLDs satisfy the emerging users' demands without putting in danger the stability of the whole Internet. Some observers believe it would be wise to have a slow initial expansion of TLDs introducing a limited and controlled number of new TLDs at a time.

5. COEXISTENCE OF DIFFERENT FORMS OF NUMBERING, NAMING AND ADDRESSING IN THE INFORMATION INFRASTRUCTURE

In the previous chapters, we have presented an overview of the current situation and foreseeable future trends for various numbering, naming, and addressing schemes.

In a migration path from the existing networks towards the future information infrastructure it is important to try to understand how these different schemes relate to each other and may evolve together.

In theoretical terms the information infrastructure can be defined as a seamless platform supporting any-to-any connectivity and providing customers with any kind of telecommunication services. More concretely, the information infrastructure will be a network of networks inter-working with each other. Voice, data, computing, interactive video, multimedia and personal communications will be some of the services offered to the subscribers.

Since each network has its own numbering, naming and addressing schemes the problem that arises is how to guarantee the required level of inter-working between the different schemes. In section 5.1, we discuss the coexistence between E.164 numbers and addressing schemes. In section 5.2, the focus is on the coexistence of Internet names and E.164 numbers used as identifiers of the called party.

5.1 Coexistence of E.164 numbers, IP addresses and AESAs

ETO expects E.164 numbering, IP addresses and AESAs to be the numbering and addressing schemes most used in the years to come.

Making an attempt to understand how E.164, IP addresses and AESA may evolve we cannot foresee in the medium term a convergence of the above mentioned schemes into any specific single one. The deep technical and regulatory differences existing between these schemes and the networks that make use of them hamper the convergence process.

While it would seem to be mistaken to attempt to force a convergence between E.164, IP address, and AESA, what is necessary is the development of inter-working capabilities ensuring interoperability between the different schemes. Such inter-working capabilities allow customers connected to networks using different numbering and addressing mechanisms to communicate without difficulty.

In other words, the goal is not the convergence of E.164, IP addresses, and AESA but a coexistence of these addressing and numbering schemes with inter-working.

The inter-working capabilities required for the coexistence of these different schemes can exist at two levels: inter-working at the numbering and addressing level and inter-working at the routing level.

The first solution implies the deployment of mechanisms that allow the translation from one numbering and addressing scheme to another. Looking at the technology available today, two implementation methods are available. The first, stemming from the telecommunication environment, is based on the use of IN architectures and capabilities. The second, at present mainly used in the IT environment, is based on a DNS approach with the use of dedicated servers.

Figure 3 depicts in a simplified way, without making any assumption as to the technology used, how these translation mechanisms can work. When the Gateway node (GW) receives an incoming call using a number or address not able to be used for routing in network B, it makes a database dip. Through this it can translate the incoming number or address into a new number or address that network B can use to route the call. In the establishment of the call, more than one translation may be necessary depending on the networks crossed to connect the calling party to the called party.

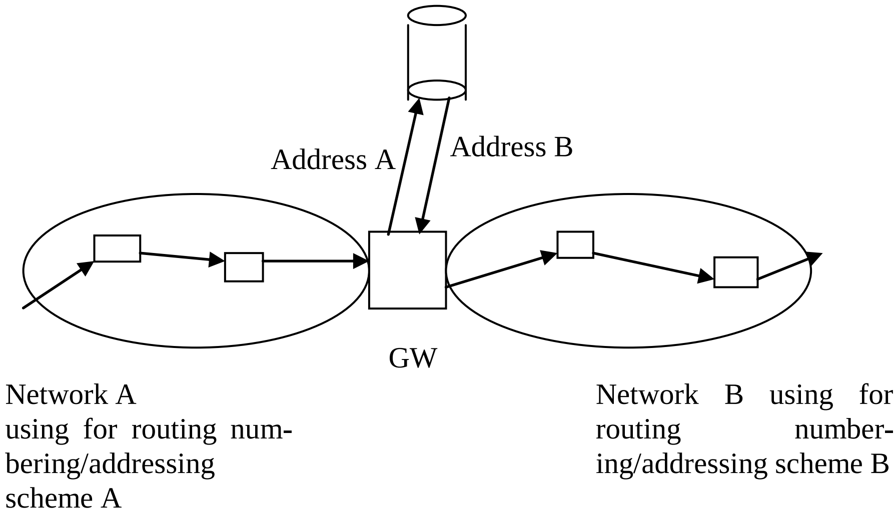


Figure 2:Interworking functions at the numbering and addressing levels

The second solution uses inter-working at the routing level. This means that the routing protocol available in a network must be able to route the calls based on the various numbering/addressing schemes used in the different networks to which it is connected. This solution does not require any query to the database but imposes burdens on the routing protocols.

We should note that the two above-mentioned solutions are not mutually exclusive. In other words, in some cases it may be more advantageous to use inter-working at the numbering/addressing level whereas in other cases it is more convenient to have inter-working functions at the routing level.

To reiterate, focusing our attention on E.164 numbers, IP addresses, and AESAs, it seems highly unlikely that they will converge into one single numbering/addressing scheme. What is really required is a high level of inter-working between E.164, IP address and AESA to allow, from the addressing and routing point of view, seamless communications between the various environments using these different schemes.

Today some solutions for inter-working between IP addresses and AESAs are already under study by the IETF and the ATM forum. These solutions use inter-working both at the routing level and at the addressing level. In the first case a new routing protocol called Augmented PNNI, able to route calls using both IP address and AESA, is under specification. In the second case, the IETF Forum is completing the specification of a new address resolution protocol called NHRP (Next Hop Resolution Protocol) which by using NHRP Servers allows mapping between IP addresses and ATM addresses in an efficient way.

Aspects related to the specification of inter-working mechanisms between E.164 and IP and AESA have received little study so far. As we have illustrated, substantial differences exist between the static routing protocols used in E.164 based networks and the dynamic routing protocols used in ATM and IP based networks. Therefore, it seems more feasible to ensure the required inter-working capabilities by performing mapping between the different number and address schemes rather than operating at the routing level.

The ETSI project Tiphon, with the goal to combining telecommunication and Internet technologies to enable voice-band communications, has started dealing with interoperability between E.164 numbers and IP addresses. More specifically, ETSI has identified four different inter-working scenarios between IP networks and circuit switched networks. It is worth noting that one of the scenarios is based on the idea of allocating E.164 numbers to Internet terminals to allow these terminals to communicate with terminals connected to circuit switch networks for the provision of voice-band services. In this case, E.164 numbers are names that callers can dial from any telephone handset to identify Internet terminals.

The opportunity to reserve E.164 resources for Internet terminals and the structures of these E.164 numbers is now under discussion in ITU-T.

In general terms it should be noted that, irrespective of the solutions envisaged to provide inter-working, a limitation to the availability of any-to-any connectivity among subscribers connected to different platforms is the use of different terminals. Some terminals such as PCs have much more advanced facilities than other terminals such as telephones, creating a kind of asymmetric interworking.

The information infrastructure will be a network of networks using different numbering and addressing schemes (such as E.164, IP address, AESA).

ETO does not envisage that, in the medium term, convergence between E.164 numbers, IP addresses, and AESAs will be technically feasible or required by regulation. What is required is a coexistence of these schemes to allow seamless communication.

Such coexistence will continue to take place through the deployment of inter-working capabilities between the different numbering and addressing schemes.

5.2 Coexistence of Internet Naming and E.164 Numbers

In the information society, telecommunication networks will provide the users with increasingly complex services and applications.

Looking at the Internet experience, we can foresee an increasing use of naming for terminal identification in the information infrastructure. This will lead to pressure towards a clear separation between the identification mechanisms used at the user level (naming) and the mechanism used by the network to route the calls (addressing). The presence of these two mechanisms will require the deployment of efficient mapping capabilities to support the requested translations.

At the same time, in telephony networks, the availability of number portability is increasing and the presence of IN services is growing. This has created a separation between the number used to identify the service or the called party and the routing information used to route the call in the networks.

In this respect, we can regard the E.164 number identifying the service or the called party as a name independent of the routing process. As an example, the well known free phone number "1-800 Hilton" used in the United States by the Hilton Hotel chain looks much more like a name than an number.

In the medium term, we can then foresee the development of two kinds of naming schemes: Internet-like and E.164-like. It should be noted that in this context the word "name" has the broad meaning of an identifier for a service or an end party that is independent from the routing process and is more user-friendly for the subscriber.

The Internet-like naming scheme will use the principles and mechanisms currently used or under development in the Internet. This implies that a name:

- is a string of alphanumeric characters
- is organised according to a specific structure, usually hierarchical, to facilitate translation functions
- belongs to a name plan
- is used in the computer network environment
- mapping between the name and the routing information is performed with DNS solution with the use of dedicated servers

We can regard the E.164-like name as an E.164 number that does not carry any routing information but only service or subscriber identification. This implies that a name:

- is a string of digits
- is organised according to a specific structure that may differ from service to service
- belongs to the E.164 numbering plan
- is used mainly in the telephony environment
- that mapping between the name and the routing information is performed by using IN capabilities

The different characteristics of Internet like names and E.164-like names reveal the degree of difficulty, which these two forms of naming would have to overcome to converge. In the next five to ten years, we can foresee the need for the coexistence and inter-working of these two forms of naming.

We can look on the ETSI Tiphon proposal to assign E.164 number to IP terminals to provide voice over IP services as a first example of coexistence and interoperability between E.164 resources used as names and the Internet.

We can make a parallel between the addressing and naming evolution. This leads to the conclusion that the real problem lies in ensuring the coexistence of different schemes by developing the appropriate inter-working functions rather than attempting to encourage convergence. We explored this issue in more detail in section 5.1.

The information infrastructure will use both Internet and E.164 naming extensively.

In the medium term, because of their different technical and regulatory characteristics, these two schemes cannot be expected to converge but will need to coexist and inter-work.

5.3 Role of Standardisation Bodies and NRAs

The coexistence of different numbering, naming and addressing schemes occurs through the deployment of the correct inter-working capabilities in the networks.

Standardisation bodies such as ETSI and ITU-T and dedicated fora such as ATM Forum and IETF are expected to play an essential role in the definition of these inter-working capabilities. In order to achieve good technical specifications it is vital these bodies work in a close co-operation limiting as much as possible overlaps.

In terms of development of inter-working capabilities, the involvement of NRAs is marginal. The responsibility of NRAs is to ensure the presence of regulatory regimes that do not hamper the coexistence and interoperability between different numbering, addressing and naming schemes. In this sense, the European Commission can also play an important role at the European level.

Standardisation bodies (ITU-T, ETSI) and international fora (such as the ATM Forum and the IETF) have to be heavily involved in the definition of the inter-working capabilities.

NRAs have to remove possible regulatory barriers to the coexistence of the different numbering, naming and addressing schemes.

6. THE COSTS AND BENEFITS OF AN EVOLUTION TOWARDS A UNIFIED NUMBERING PLAN FOR EUROPE

In 1994, the CEC produced a consultation document containing four strategic options for numbering in Europe:

Option 1: Continue with the Present Situation

This was the easiest solution. Europe need not make any decisions here and now. However, even if Europe took this option, in practice it would have to prepare for subsequent changes such as those forced by the market or ITU.

Option 2: Implement a European Numbering Space for Pan-European Services but Make no Changes to CCs

Europe is pursuing this option at present in the form of the ETNS. Although there may be other methods of implementation, this option has resulted in the European countries ask ITU for a CCs for regional use. Administration of the ETNS would be the ETO.

Option 3: As Option 2, but Establish a Consistent Set of Three-Digit CCs (Such as 3XY)

The intention behind this solution was to change the CCs for all European countries to three-digit CCs, all of which have the same first digit. The first digit would also be unique for Europe. This option entails reserving all 100 three-digit CCs for Europe starting with the same digit. As far as administration goes there is a whole range of possibilities from the CCs managed entirely by the ITU to ETO managing them all. Administration of national numbers remains with the national regulatory authorities.

Option 4: Establish a Single-Digit CC for Europe with a European Numbering Space for Pan-European Services

This option is the “unified numbering plan for Europe” resembling the integrated NANP[29] with CC 1. A caller would not have to dial the international prefix and CC (such as 3) when dialling from one European country to another.

[29] NANP – North American Numbering Plan

ETO has derived data on costs and experiences of number changes primarily from countries that have made number changes in the past few years or are planning to do so in the near future. The data received was unofficial in nature and relied on a very rough estimate of the costs involved. Furthermore, the amount of data available was extremely limited. There was no data at all concerning the cost of Country Code changes and costs for residential users.

However, since no other cost estimates exist for this reason, ETO used the data available to draw at least some conclusions regarding the alternatives presented in the consultation document.

ETO drew the following conclusions:

1. It is impossible to gather precise cost figures of number changes. The information will always rely on very rough assessments of costs.

2. Regarding the cost for network operators and users, the trend emerges whereby a change in Subscriber Numbers incurs significantly higher costs than a change in National Destination Code. Correspondingly, the cost of a change of the National Destination Code is significantly higher than the cost of a change in the Country Code.

3. The cost of changes for network operators was estimated as follows:

    - the cost of a SN change is estimated to vary between ECU10 to 50ECU per subscriber

    - the cost of a NDC change is estimated to vary between ECU1 and ECU10 per subscriber

    - the cost of a CC change is estimated to be less than ECU0.5 per subscriber

4. ETO estimates the cost to users to be five to ten times higher than that to network operators.

5. Regarding options 1 and 2 presented in the consultative document of the Strategic Options, no significant direct costs incur to network operators and users.

6. Regarding options 3 and 4 of the Strategic Options, the total costs for the CEPT countries (excluding Russia and Turkey) are estimated as follows:

- ETO estimates the total cost of option 3 to be less than ECU1,000 million.
- ETO estimates the total cost of option 4 to be somewhere between ECU1,000 million and ECU100,000 million.

Estimates for options 3 and 4 above assume a one step change only. However, it seems that more than one step is necessary to implement either of these alternatives. In this case, real costs will then be higher than those indicated.

6.1 Cost Analysis

In order to understand the costs of Europe moving to a unified numbering plan it is necessary to first review the costs incurred in making numbering changes generally. We can then extrapolate these to provide an assessment of the costs of option 4 in particular. The available cost data is included in annex 10.

6.1.1 Background

When considering number changes, cost is a crucial issue. Total cost consists of direct costs related to users, service providers, network operators, and administrations. Indirect costs relate to the cost of lost traffic and lost business opportunities. The direct costs of number changes are difficult to estimate and it is even more difficult to estimate the indirect cost of such changes. Furthermore, in order to assess the cost of proposed alternatives, more information regarding technical solutions and the implementation of time scales for these alternatives is necessary.

The analysis of the direct cost of number changes is based on the practical information and experiences obtained from those countries which have made number changes within the past few years or will make changes in the near future.

6.1.2 What is a Number Change?

Changes of Individual Numbers

Operators may change telephone numbers for different reasons. Subscribers may have to change their number when changing addresses (a change of a single number).

Network operators may have to make changes to numbers when reviewing the present numbering schemes. This may be the case, for example, when the numbering resource is exhausted and an operator creates new capacity by adding one or more digits in front of the old number. These “mass changes” follow decisions made by the network operator or by the National Regulatory Authority.

There is no data on the number of numbers changing each year. However, we can estimate that 10% of the total amount of subscriber numbers change every year without any major reconstruction of numbering schemes. To some extent, number changes are a normal routine for users and network operators.

Changes in national numbering schemes

Many European countries are revising their national numbering schemes for different reasons. These “mass changes” usually have a heavy impact on all users. Mass changes occur only once in a long period, typically some decades. There is no co-ordination between the countries. Changes are taking place at different speed within Europe, according to the time scales of individual countries.

National Regulatory Authorities usually make the decisions on these mass changes.

Changes Based on the Reorganisation of pan-European or Global Schemes

The creation of a pan-European numbering space or the reorganisation of global schemes may have an impact on national numbering schemes.

Within the context of European integration, there is a growing demand for pan-European number space. The ECTRA consultation document on the "Strategic Options for Telephony Numbering Space for Europe" studies a number of alternatives for the creation of this numbering space. Different alternatives have different impacts on national numbering schemes. ECTRA will make decisions regarding these changes.

ITU will make decisions regarding the change of global numbering schemes.

6.1.3 Types of number changes and their impact on different parties

The cost of a number change relates to the type of change involved. That is why the cost estimate has to reflect and justify the type of change and the coverage of the change. The following three types of changes have been identified:

- a change in Country Code (CC)
- a change in National Destination Code (NDC)
- a change in Subscriber Number (SN)

In addition, the change may include a change in number length. Number changes are not necessarily so straightforward in practice. Different types of changes may occur simultaneously.

A Change in Country Code (CC)

A change in country code seems to have an impact on international traffic only. If the Country Code of subscriber X changes, he has to inform callers from other countries about the new CC. Users in other countries have to update X is Country Code.

Network operators in X's country have only to inform different parties about the CC change on a national and international level. No network modifications are necessary on the national level. Network operators outside X's country have to make modifications to their routing tables and must also inform users of the CC change in their own countries.

A simultaneous change in Country Code of more than one country may be easier to communicate to the market than several separate changes.

A Change in National Destination Code (NDC)

A change in National Destination Code has an impact on international and national traffic. If the NDC of subscriber X changes, he has to inform callers from other numbering areas within the country and callers from other countries. Users in other numbering areas of the country and in other countries have to update X's number.

Network operators in X's country have to make modifications to their national network and their internal support systems and must inform different parties about the NDC change on a national and international level. International network operators outside X's country have to pay attention to their routing and call-trapping arrangements.

A Change in Subscriber Number (SN)

A change in Subscriber Number has an impact on international and national traffic. If the SN of subscriber X has been changed, he has to inform callers from his own numbering area, from other numbering areas within his country and callers from other countries. Users in the same numbering area, in other numbering areas of the country and users in other countries have to update X's number.

Network operators in X's country have to make modifications to their national networks even at a local level and in their internal support systems. Subscriber Number change has no major impact on international network operators outside X's country.

6.1.4 Where Does the Cost Occur?

Costs for Residential Users

Regarding the cost for a residential user whose number is changed, costs come for the most part from information used when announcing the user's new number. The user must update his personal registers and pre-programmed numbers in Customer Premises Equipment in the case of changes in the numbers of other users. In most cases, the user himself carries out this work. The “cost” of the change is due to some extra work, which, if the user himself cannot carry it out, the equipment supplier must do. Large national number changes may cause some confusion. However, we can estimate incremental costs as being low.

Costs for Business Users

In the United Kingdom BT has made the following checklist for the UK number change:

Telephone usage:

- changes in auto dialling equipment
- call barring and routing equipment
- changes in equipment using code tables
- telephones and facsimile machines with short-code dialling memories
- switchboard equipment
- call diversion instructions
- pre-set numbers stored in the memory of any telephone or facsimile machine
- facsimile machine identity numbers
- messages on answering machines
- changes in national enquiry and support centre numbers
- help line numbers

Security:

- alarm systems
- emergency instructions and documentation
- hazard control instructions and labels

Printing work:

- stationary - letterheads, invoices, fax header sheets, business cards, address labels
- literature - advertisements, company brochures, product brochures; company art work, packaging, internal directories

Signs**:**

- vehicle delivery
- company signs

Other issues:

- computer and prospect databases
- overseas contacts
- personnel records

The list is not exhaustive. All of the above items involve some direct costs to business users. However, when the change is known well in advance, business users have time to optimise the cost by timing the purchase of new material to coincide with the number change.

Business users avoid extra costs as far as possible. It has been recognised, for example, that numbers shown on vehicles are changed only when the vehicle itself is changed, and not immediately after the implementation of a new number. In this way, the business user can avoid extra cost but at the same time "old numbers" may generate faulty calls and losses to both the business user and network operator. However, when estimating the cost falling to business users, the focus should be on the incremental cost of number changes.

Costs for Network Operators

The cost of number changes to the network operators will arise from changes in software, supplementary systems, databases, directories and in information (panels with text and pictograms) presented on or near the public terminals. Other costs relate to the need to notify other Administrations of the changes and to additional calls to enquiry services from users.

The cost depends on the type of change involved. The more changes that are needed to the network, the more expensive is the change. In this respect, the changing a Country Code is probably cheaper than the changing an NDC. Likewise, it may be cheaper to change NDCs than to change all the subscriber numbers of a country. Information costs related to different types of changes may probably follow the same pattern.

Costs for Administrations

Costs for administrations are information costs only. Nowadays network operators usually finance information costs. However, in some countries national regulatory authority is responsible for financing some portion of the total information cost.

Costs Outside Europe

Costs for those users calling to Europe are related to the cost of updating the subscriber databases, customer registers etc. It is not clear whether there is any significant difference in the cost for users outside Europe, whether the change in Europe is one in CC, NDC or in SN. In each of the above cases, subscriber data has to be changed.

The cost of a number change to network operators outside Europe only results from changes in Country Code and in some cases from changes in the NDC. A change in subscriber number does not necessarily increase the direct cost for network operators outside Europe. In some specific cases the cost for network operators could be higher if the number length, which has to be analysed for routing purposes, has to be increased. Such a number expansion happened during the UK code change by inserting an extra digit to NDC.

Comprehensive changes in numbers, however, may cause confusion and result in faulty calls from outside Europe. This leads to additional calls to directory enquiry services.

Incremental costs

When assessing the cost of number changes, we should keep in mind the incremental costs and the difference between the theoretical cost and the practical cost. The following examples should highlight this issue:

6.1.5 Analysis

Information based on the national number changes in different countries is summarised in the table in Annex 1. The number changes vary significantly according to the type of change (SN, NDC or both), the area covered and the subscriber base. In the column "number of subscribers", only those affected by the number change are considered.

To obtain commensurate estimates, we calculated figures for "ECU per subscriber" in the columns of "the total operator costs", "costs related to communication", and "the total costs of business users". Communication costs means the public promotion of the number change.

When analysing the data, we must consider two issues:

1. the data presented in the table is based on a very rough estimate of costs
2. the amount of data is not sufficient to make accurate conclusions

Cost for network operators

As regards the SN change, the estimates vary from ECU1.6 to ECU26.2 per subscriber.

As regards the cost of an NDC change or a simultaneous NDC and SN change, cost varies from 6 to 12,5 ECU (Poland 0,02).

The total operator cost varies from ECU 1,6 to 26,2 per subscriber, the average being approximately ECU 10 per subscriber.

Regarding communication costs (which are included in the cost of network operators), the presented figures vary from ECU 0,4 to 6,3 per subscriber, the average being approximately ECU 2 per subscriber.

No data exists on the cost of a Country Code change.

Cost for Business Users

Regarding cost estimates for business users; the cost per subscriber varies from ECU7.7 to ECU55.4, an average being approximately ECU25 per subscriber.

Cost for Residential Users

We obtained no information regarding residential users. However, the UK figures to business users also cover some cost of residential users. It seems that incremental costs for residential users are low relative to those for business users.

6.1.6 Conclusion on Cost of Changes in Country Codes, National Destination Codes and Subscriber Numbers

We conclude that a trend emerges whereby a change in the Subscriber Number incurs significantly higher costs than a change to the National Destination Code. In turn, the cost of a change to the National Destination Code is significantly higher than that for a change in the Country Code. We have arrived at these results from informal data that we have received from other Administrations regarding the costs of coping with the UK national code changes. In addition, we have used information received and the assumption that network operators have to make more modifications with SN changes than with NDC and CC changes.

We can also conclude from the data available that the total user costs of any number change are about five to ten times the costs of network operators.

As regards the SN and NDC change, from the table in Annex 9 we can derive a very rough estimate of the relationship of these costs. We present this in the table below.

TYPE OF CHANGE	OPERATOR COSTS (ECU PER SUBSCRIBER)	TOTAL COST FOR ALL USERS
Subscriber Number	10	5 TO 10 TIMES THE OPERATOR COST
National Destination Code	1 - 10	

Country Code	< 0,5	

Table 1. Estimated costs for different type of number changes

As regards the Country Code change, no information was available. For the derivation of cost estimates for CC change, the estimates for SN and NDC changes may not be relevant. However, based on the assumptions that:

1. the network modifications needed are significantly smaller that those needed for NDC/SN change
2. for the CC change the communication needed is also significantly smaller compared to those of NDC and SN change

ETO estimates that for network operators the operational costs, when changing all the CC in Europe to three-digit codes, might be ECU0.1 per subscriber. Publicity and communications costs might be ECU0.2 per subscriber. This represents a total cost of maybe less than ECU0.5 per subscriber.

ETO has not estimated the value of the lost traffic.

The operator costs include the costs of publishing and communicating the change. Current experience is that the operators typically carry these costs rather than the regulators who demand that the change take place.

6.2 Cost of the CEC Strategic Options

We can apply these crude conclusions to the alternatives presented in the consultation document of the Strategic Options.

Option 1

There are no direct costs related to option 1.

Option 2

ETO has identified no direct costs for option 2 for users and network operators.

However, some costs exist. These costs for option 2 relate primarily to the cost of service provision, incurred by operators or other service providers who opt to provide service within the ETNS. Service providers will set these costs against a commercial decision that entry into this market will provide profits.

Option 3

We can relate costs for alternative 3 to those of a Country Code change, but on a European scale. The estimate uses the assumption of the operator cost of less than ECU0.5 per subscriber, totalling less than ECU100 million in the CEPT countries (excluding Russia and Turkey). Based on the assumption that the total cost for users is from five to ten times the operator cost, the total cost for users is < 1000 million ECU, totalling the overall cost of less than 1100 million ECU

Option 4

Option 4 means an integrated numbering scheme in Europe, where a caller does not have to dial the international prefix and country code when dialling from one European country to another. This alternative has impacts on dialling procedures in every European country concerning every European user. Furthermore, it is obvious that the implementation of option 4 results in several consecutive changes in CCs and in NDCs and/or SNs throughout Europe.

Referring to the cost estimates presented, if NDCs change in every CEPT country, the total cost for network operators would be between ECU200 million and ECU2000 million. According to the estimate of cost for users, which is five to ten times the cost of network operators, the total user cost would then be between ECU1,000 million and ECU20,000 million.

If all the Subscriber Numbers (SN) changed, the corresponding figures for network operators would be between ECU2,000 million and ECU10,000 million and for users between ECU10,000 million and ECU100.000 million. The total cost would then be between ECU12,000 and ECU110,000 million.

The figures presented above do not take into account the needed Country Code change. Furthermore, if implementation of options 3 and 4 took more than one step, the cost would be higher.

In all of this, we must be aware that costs will also fall to those outside Europe. World-wide users, operators, service providers, and regulators must take account of changes in Europe and will incur costs. We have not attempted to assess these for the different options.

6.3 Summary of the Total Direct Costs Against the Strategic Options

The cost for network operators and users, as defined in section 4.2 are summarised in the table below. The total cost uses the assumption that there are approximately 200 million subscribers in Europe.

As regards option 4, we present the cost of NDC changes and SN changes separately. That is because we have not identified the type of the change necessary and it may vary country by country. Furthermore, estimates do not take into account the CC change needed.

ALTERNATIVE	Operator cost per subscriber (ECU)	Total operator cost (million ECU)	Total costs for users (million ECU)	Total costs (million ECU)
1	0	0	0	0
2	~ 0	~ 0	~ 0	~ 0
3	< 0,5	< 100	< 1000	< 1100
4	1 -10 (NDC change) 10 - 50 (SN change)	200 - 2.000 2.000 - 10.000	1.000 - 20.000 10.000 - 100.000	1.200 - 22.000 12.000 - 110.000

Table 2: Summary of the Total Direct Costs

6.4 Benefits of a Unified Numbering Scheme for Europe

A unified numbering scheme would potentially provide a harmonised numbering space for existing and future pan-European services. It could create an integrated numbering scheme with united national schemes. The integration might stimulate further harmonisation of national schemes. There would also be increased potential for harmonising carrier selection.

With a unified scheme, there should be enough capacity for pan-European services and flexibility to cater for future services. Europe could have more control over harmonising numbers for all pan-European services and control over all numbers within the unified numbering scheme. There would be more of a European identity in European numbers and potential stimulation of coherence of the European market.

In summary the scheme might result in benefits:

- for network operators due to the increased service traffic
- for service providers due to the increased business opportunities
- benefits for users due to the increased opportunities to use pan-European services and to more competition

6.5 Costs Versus Benefits

Cost estimates for migrating to a unified numbering plan are highly uncertain because different estimates diverge widely. Moreover, migrating to a unified numbering plan is not a purely market issue; there are political and psychological aspects. The overall desirability of introducing new number schemes is influenced by factors other than those of a purely economic nature. Whilst recognising this, and the potential benefits set out above, ETO considers that, from a merely economic, cost based, analysis the unified numbering plan for Europe is a prohibitively expensive solution. There would be:

- High direct costs for network operators to change the CCs of all the European countries and the SNs of huge numbers of European users.
- High direct costs for SPs to change both national and international service numbers.
- High direct costs for users due to the change of huge amounts of European SNs. Costs relate to the information costs and costs due to the change of data in different registers and CPE. Costs concern both business and residential users.
- High costs for administrations to announce the changed CCs and numbering procedures.

In addition, European countries would have their CC replaced by a NDC after the European first digit. At least half the European countries must have their CC changed before integration can be possible. The scheme would reduce the capacity of the national schemes of countries that originally had a two-digit CC. In general, we should handle fundamental changes of numbering plans very cautiously as they may imply high societal costs.

The scheme would take a prohibitively long time to implement.

The ETNS with country code 388 which Europe plans in parallel to existing national numbering plans can capture some of the benefits of an integrated plan without the need for costly changes in the existing plans.

On balance, ETO concludes that the costs involved far outweigh the potential benefits of the unified numbering scheme for Europe.

7. CONCLUSIONS

1. The growth of networks and services during the last five years and the likely developments in the communication market over the next five to ten years and beyond indicate that the current numbering arrangements are not sustainable.

2. Any strategy, in particular for numbering and naming, whether national, regional or global, will be driven primarily by user needs and requirements. Technological reality will set the bounds for and facilitate the strategy and the commercial and political interests of the other players in the industry will provide its shape.

3. In the short and medium term, ETO envisages the coexistence of different addressing schemes. For routing protocols, the expected trend is toward an initial convergence of different routing protocols. The coexistence of different addressing schemes will require the deployment in the networks of address translation capabilities to ensure adequate inter-working between the different schemes. From a technical point of view, the deployment of these translation capabilities is not prohibitively difficult or costly.

4. ETO foresees a convergence of the existing naming schemes into one or two schemes. We can expect the same evolution for name resolution mechanisms.

5. A distinction should be made between name plans used by a network and name plans used by a terminal or other piece of. A name plan used by a terminal is only for the user of that particular terminal. It provides customer-tailored names, “nicknames” and a user-friendly interface between the user and the network. The nickname would eventually take the form of spoken or written language rather than keyboard characters.

6. Universal names should be independent of location, terminal, network, service, or service provider. In other words, universal names should be fully personal and fully portable.

7. Users prefer to use names in which all information clearly concerns the person or device to communicate with or to control. There should be no mixing with other information in the names such as indications of the telecommunications service to be used or the tariff to be paid when connecting with that user or device. The industry should find other ways of presenting tariff information, if of interest to users, and other information not related to the user or device identified.

8. For the time being, ownership of names is hard to envisage. "Rights of use" of names will continue to provide the juridical status of names and may support the use of "names for life".

9. ETO considers the new global structure, with ICANN replacing IANA for management of generic TLDs, to be a good base for industry self-regulation.

10. The current policy for the management of IP addressing space rests upon three principles: conservation, aggregation, and ability to route. With the growing availability of IPv6, policy for address management will change. The main goals will be aggregation and ability to route with less emphasis on conservation.

11. ETO considers that the use of a CC for IP telephony allows efficient routing, and support for geographic portability and roaming and supports the approaches to ITU-T in this regard.

12. One essential issue for Europe will be the reform of the ENF that started in 1999. Through this, there should be improved user representation in the Forum.

13. With the increasing availability of ATM and IP products in public networks, X.25 (and the PSTN, generally) is likely to lose much of its importance with consequences for the future development and use of X.121. X.121 protocols will play a marginal role in the information infrastructure in future. On the other hand, due to the increasing presence of ATM and IP in public networks, ETO regards IP addresses and AESAs as two of the most promising emerging addressing schemes.

14. ETO expects that, in the medium term, E.164, IP addresses, and AESAs will be the numbering and addressing schemes most used.

15. Most of the existing and future communications applications have been and will be developed to run over the TCP/IP protocol suite. This will make the availability of IP a kind of pre-condition.

16. ETO expects names to gain an increasing commercial relevance as shown by the Internet where names have become a kind of trademark for companies selling products or doing business through the Internet.

17. The different characteristics of Internet-like names and E.164-like names reveal the degree of difficulty that these two forms of naming would have to overcome to converge. In the medium term, we can foresee the need for the coexistence of these two forms of naming, together with the necessary inter-working capabilities.

18. Cost estimates for migrating to a unified numbering plan are highly uncertain because different estimates diverge widely. Moreover, migrating to a unified numbering plan is not a purely market issue; there are political and psychological aspects. The overall desirability of introducing new number schemes is influenced by factors other than those of a purely economic nature. Whilst recognising this, and the potential benefits set out above, ETO considers that, from a merely economic, cost based, analysis the unified numbering plan for Europe is a prohibitively expensive solution.

19. Apart from names of users, names of non-human devices will be increasingly necessary.

20. The need for dynamism and flexibility in the standardisation process deserves emphasis. Co-operation between bodies that have an interest in standardisation is essential.

21. We do not foresee an ETNS as an integrated numbering plan for Europe. The ETNS with country code 388 which Europe plans in parallel to existing national numbering plans can capture some of the benefits of an integrated plan without the need for costly changes in the existing plans.

8. ANNEXES

Annex 1 Work order

Work Requirement No. 48 381

ETO reference: 96-12

1. Subject: A Long-term strategic plan for the numbering and addressing of telecommunications services in Europe

2. Purpose

The work requirement covers the work that the European Telecommunications Office (ETO) will conduct on behalf of ECTRA for the European Commission in the area of numbering of telecommunication services. This Annex defines the terms of reference for a study the aim of which is to define a long-term strategic plan for the numbering and addressing of telecommunications services in Europe.

3. Justification

In 1995 ECTRA, in conjunction with the Commission, defined proposals for the "Strategic Options for Numbering of Telecommunications Services in Europe". A Europe wide consultation was carried out on the basis of these proposals. Besides a call for early action to open a European numbering space for pan-European service calls, the consultation led to the conclusion that:

"a study is necessary on the longer term numbering requirements and evolution strategies for numbering in Europe taking account of new technologies such as intelligent networks; including a comprehensive study of the costs and benefits of making over-all changes to European Country Codes and of implementing an integrated numbering plan for Europe."

This conclusion is supported by a study that was carried out in 1995 for the Commission on the long term approach to European numbering.

There is an urgent need to develop a long-term strategic plan for the numbering and addressing of telecommunications services in Europe.

4. Work requirement

(1) To identify potential future requirements for numbering and addressing, stemming from developments in the market and in new technologies;

(2) To identify the cost and benefits of an evolution towards a unified numbering plan for telephony services in Europe, taking into account present integrated numbering schemes in market areas corresponding to the European market area (NANP);

(3) To develop a long term strategy for moving towards a unified numbering plan for Europe - to include a reference scenario with the structure and time schedule for implementation and proposals for cost sharing among players.

5. Execution

The work will be carried out in close co-operation with the CEC, the ECTRA PT on Numbering and the European Numbering Forum.

The final report of the study shall be delivered to the CEC not later than

31 December 1997.

6. Deliverables

Two interim reports and one final report shall be delivered.

The first interim report shall be delivered during the course of the work, containing 1) potential future requirements on numbering and addressing, stemming from developments in the market and in new technologies and 2) the cost and benefits of evolution towards a unified numbering plan for telephony services in Europe.

The first interim report shall be delivered by the end of 1996.

The second interim report shall contain the draft findings and proposals as they will be submitted to CEPT/ECTRA for approval. The second interim report will be delivered by August 1997.

The final report shall contain the findings and proposals, as approved by CEPT/ECTRA and will include any comments individual CEPT/ECTRA members have on implementation in their respective national regimes.

All reports shall be made available in draft form one month before a liaison meeting, at which results will be discussed and approval can be given for their release.

The Commission shall receive three copies of the interim reports, while the approved final report shall be made available in 15 bound copies, one unbound copy and one copy on floppy disk in Word for Windows V2.0 format. *G*raphics shall be made available on separate hard copie*s*.

7. Manpower

It is expected that this task can be accomplished in 15 man-months at expert level, including possible subcontracting.

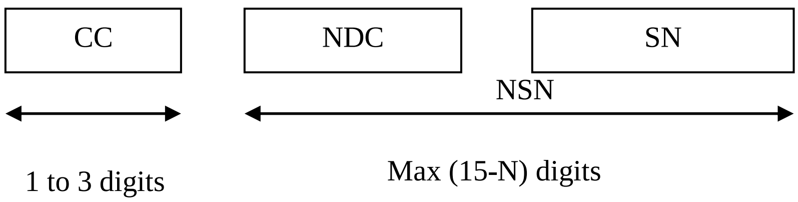
8. Subcontracting

Subcontracts - totalling 5 man-months - may be given to external experts for the execution of parts of this contract.

Annex 2 E.164 Technical Description

ITU-T Recommendation E.164 describes the structure and functionality of E.164 numbers. E.164 numbers identify geographic areas, global services, and networks. They have a length of up to 15 digits (international prefix not included).

Figure 4 describes the international public telecommunication number structure for geographic areas.



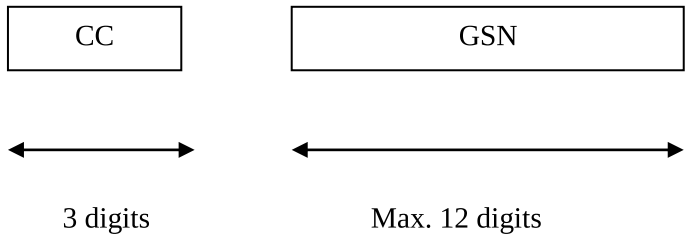
CC Country Code
NDC National Destination Code
SN Subscriber Number
N Number of digits in the Country Code
NSN National Significant Number

Figure 4: International Public Telecommunication Number Structure for Geographic Areas

The Telecommunication Standardization Bureau (TSB) of ITU allocates the Country Code (CC) in consultation with ITU-T Study Group 2. At present, there are one, two and three-digit CC, but the policy of ITU-T is to allocate only three-digit Country Codes in the future. Each geographic area is identified by one CC (a geographic area can be a country, a territory, several countries in an integrated numbering plan and all CEPT countries together in the particular case of CC=388).

The National Significant Number (NSN) usually consists of a National Destination Code (NDC) followed by a Subscriber Number (SN). It is also possible not to allocate a NDC. In that case, the NSN is equivalent to the SN. The NSN has a maximum length of twelve digits after a three-digit CC. This provides ample space for national use.

In figure 2 the structure of an international public number for global services in shown.

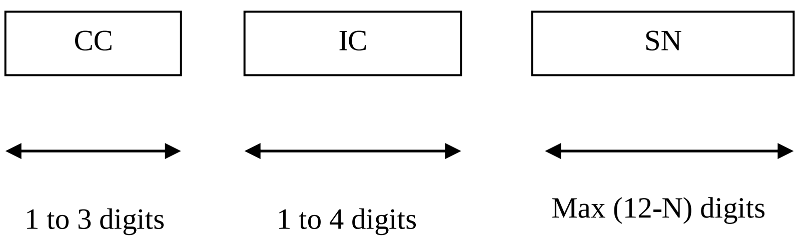


CC   Country Code for global services
GSN   Global Subscriber Number

Figure 2: International Public Telecommunication Number for Global Services

The TSB of ITU allocates the CC in consultation with ITU-T Study Group 2. In this case, the Country Code identifies a specific global service. The digits following the CC are the Global Subscriber Number (GSN) and identify a specific subscriber of the global service. The structure and functionality of GSN is service dependent.

The third structure described in E.164 is the international public telecommunication number for international networks[30] (see figure 3).



CC   Country Code
IC   Identification Code
SN   Subscriber Number
N   number of digits in IC

Figure 3: International Public Telecommunication Number Structure for International Networks

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[30] Although Rec. E.164 specifies that ICs are 1- to 4- digit long, Rec. E.164.1 states that future assignment will be made on the basis of 2-digit IC.

As in the previous case, the TSB allocates the CC in consultation with ITU-T SG2. The CC is a shared combination of three digits and it identifies a set of Networks. The shared country code in combination with IC identifies a specific Network. IC varies between one and four digits.

The SN consists of the remaining digits after CC and IC. The SN identifies a specific subscriber in a network and the network operator determines its structure and functionality.

Annex 3 E.212 Technical Description

ITU-T revised Recommendation E.212 in order to define an international identification plan for mobile terminals and mobile users in fixed, mobile and satellite networks and for personal user identities in global services. We describe the new structures of E.212 identifiers in this annex. ITU approved the Recommendation in November 1998.

The International Mobile Station Identity (IMSI) identifies a unique mobile terminal or mobile user at the international level. As described in figure 7, IMSI consists of three parts: Mobile Country Code (MCC) followed by Mobile Network Code (MNC) and Mobile Subscriber Identification Number (MSIN).

The IMSI identifies mobile terminals and users as roaming terminals or users when they are outside the home networks.

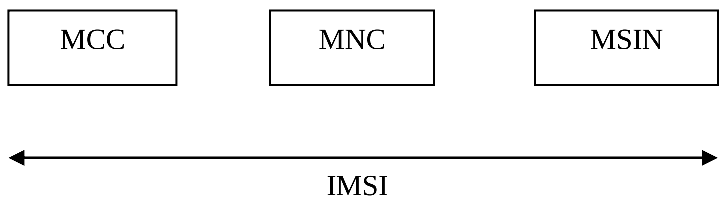


Figure 1: Structure of IMSI

The MCC is a three-digit country code indicating the country or geographical area of the mobile terminal or mobile user. The MCC can also identify a group of international networks.

The MNC is two or three digits in length and in association with MCC uniquely identifies the home network of the mobile terminal or mobile user identified.

The MSIN is up to ten digits in length and identifies a mobile terminal or mobile user within a specific home network.

The Personal User Identity (PUI) identifies, internationally, UPT subscribers (figure 2).

The PUI has a structure similar to IMSI and consists of MMC followed by MNC and UPT User Code (UC).

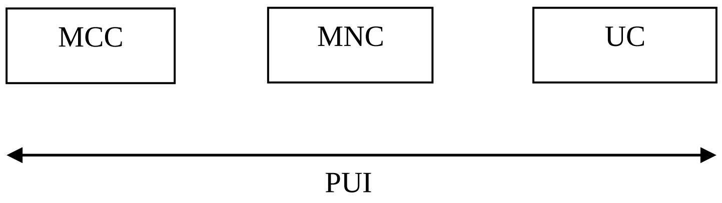


Figure 2: Structure of PUI

The MCC is a three-digit country code that identifies the country where the UPT subscriber resides. The MNC is a sequence of digits identifying the home network of the UPT subscriber. The UC identifies the UPT subscriber.

The total length of the IMSI and IUI must not exceed 15 digits.

The ITU administers the MCC whereas national administrative bodies assign the MNCs.

Annex 4 X.121 Technical Description

ITU-T Rec. X.121 defines the international numbering plan for public data networks.

An international X.121number, whose structure is shown in figure 1, identifies a specific Data Terminal Equipment/ Data Circuit-terminating Equipment (DTE/DCE) interface.

DNIC	NTN

DCC	NN

Figure 1: X.121 Number

Usually X.121 number consists of DNIC (Data Network Identification Code) followed by NTN (Network Terminal Number).

DNIC is a four-digit code used to identify a public data network in a specific country. The first three digits are the Data Country Code (DCC) and the last one is the network digit. The network digit identifies the network to which the called terminal is connected.

The first digit of the DCC cannot be 0, 8 and 9 (8, 9 and 0 are used as escape codes and 1 is reserved for non-zoned system).

It should be noted that in countries where there are more than ten public data networks the first three digits of DNIC identify the group of networks within which the called network is included. The fourth digit of DNIC indicates the called network in the above-mentioned group.

NTN is the full address identifying the called DTE/DCE interface within the data network.

In the case of an integrated numbering scheme X.121 consists of a three-digit DCC followed by NN (National Number). NN is the address used to identify the called DTE/DCE interface within the national integrated numbering scheme.

The total length of an X.121 number must not exceed 14 digits.

For international calls, the originating network is required to analyse the first three digits of the DNIC to determine the country where it must terminate the call. For billing purposes or for more efficient routing the originating network might also be required to analyse the fourth digit of DNIC and the digit immediately after the DNIC.

We should note that some countries use shared DNICs, i.e. the first digit or even the second digit after the DNIC, to identify networks. In these cases, analysis of the first digit or even the second one after the DNIC is desirable.

Annex 5 N-SAP Technical Description

Annex A of ISO Standard 8348 describes the abstract syntax and the semantics of N-SAP.

The N-SAP address as depicted in figure 10 consists of an Initial Domain Part (IDP) followed by a Domain Specific Part (DSP). The length of the N-SAP has a maximum of 20 bytes.

Figure 10: N-SAP address

The IDP is a network addressing domain identifier. The IDP defines a sub-domain of the global network-addressing domain and identifies the network addressing authority responsible for assigning N-SAP addresses in the specified sub-domain. The DSP is the corresponding sub-domain address. The authority identified by the IDP may define a further substructure of the DSP

The IDP consists of Authority and Format Identifier (AFI) followed by Initial Domain Identifier (IDI). The AFI indicates the format of IDI, the network addressing authority responsible for allocating values of the IDI and the abstract syntax of the DSP.

The IDI specifies the network-addressing domain for the DSP values and it identifies the network addressing authority responsible for allocating values of the DSP from that domain. In other words, the IDI is a valid address within the domain indicated by the AFI.

The Domain Specific Part (DSP) represents a sub-domain in the addressing domain identified by the IDI. The network addressing authority identified by the IDI determines the semantics of the DSP. In many cases, however, the DSP is e subdivided into the High Order DSP (HO-DSP) and a Low Order (LO-DSP) part which may consist of the End System Identifier (ESI) and Selector (SEL).

The coding of the HO-DSP is under the responsibility of the authority identified by IDP. This authority specifies the methods for the assignment and interpretation of identifiers within the DSP. The ESI identifies an end system in a specific sub-network. The uniqueness of ESI permits the movement of an end system from a sub-network to another one without any address contention.

The network does not use the SEL for routing and so it is available for use by the end system.

Annex 6 AESA Technical Description

The ATM End System Address (AESA) is the addressing scheme adopted by ATM Forum to identify User Network Interfaces. AESAs are divided into public AESAs which identify UNIs in public ATM networks (public UNIs) and private AESAs which identify UNIs in private ATM networks (private UNIs).

The format of an AESA is in accordance with the format of an OSI Network Service Access Point (N-SAP) (see figure 10). The AESA address is 20 bytes long.

A public AESA is an address that contains an E.164 number or an ICD (International Code Designator) or DCC (Data Country Code) code in the IDI field.

Private AESA is an address which in addition to the above-mentioned E.164, ICD, DCC can contain other values in the IDI field like X.121, F69, and so on.

It is worth noting that AESA has the same format of N-SAP but a completely different semantic. The AESA is used to identify an interface, either public or private, whereas a N-SAP identifies an access point between two layers in a protocol stack (access point between layer 3 and 4 according to the OSI model).

Structure of public AESAs

As mentioned above there are three types of public AESA: E.164 AESA, ICD AESA, and DDC AESA.

In the case of E.164 AESA, the IDI field consists of an E.164 international number that identifies the authority responsible for allocating and assigning values of DSP. Allocation of the E.164 number is according to E.164. The IDI field is eight octets long and the E.164 number is in binary coded decimal syntax. If the E.164 number is shorter than fifteen digits, the system pads the IDI field with leading zeros.

In the case of the ICD AESA, the IDI field consists of a four-digit ICD allocated according to ISO 6523. The ICD identifies a particular organisational coding scheme that is responsible for allocating and assigning values of the DSP. The IDI field is two octets long and the ICD code is in binary coded decimal syntax.

Finally, in the case of DCC AESA the IDI field consists of a three-digit code allocated according to ISO 3166. The DCC specifies the country in which the DSP of the AESA address is registered. The IDI field is two octets long and the DCC code is in binary coded decimal syntax.

Structure of ITU AESA

Some studies are under way to define a new AESA under ITU-T responsibility. In this case, ITU-T should apply for a new AFI used to identify ITU-T ATM addresses. A four-digit IDI, used to identify organisations, follows the AFI field. ITU-T will allocate the IDI values to eligible applicants. The DSP will be under the responsibility of the organisation identified by IDI.

ITU has not yet discussed in detail the issue of which organisations are eligible to acquire an IDI value. However, it seems reasonable that eligible applicants should at least include all Registered Operating Agencies.

Annex 7 IP Address Technical Description

According to the IP addressing model, IP addresses locate interfaces not nodes. A single interface can have more than one IP address.

There are three different types of IP address: unicast, multi-cast, and any cast. The unicast address is the identifier of a single interface. A packet sent to a unicast address will go to the interface identified by the address. The multi-cast address is the identifier for a set of interfaces. A packet sent to a multi-cast address goes to all the interfaces identified by that address. The any-cast address is the identifier for a set of interfaces. A packet sent to an any-cast address arrives at one of the interfaces identified by that address (the nearest according to the routing protocols). IPv6 alone provides any cast, whereas unicast and multicast addresses exist both in IPv4 and IPv6.

An IPv4 address, which has a fixed length of four octets, consists of two parts: Network identifier (Netid) followed by the Host identifier (Hostid) (figure 1).

The Hostid identifies the interface of a host within the IP sub-network identified by Netid.

Netid	Host id

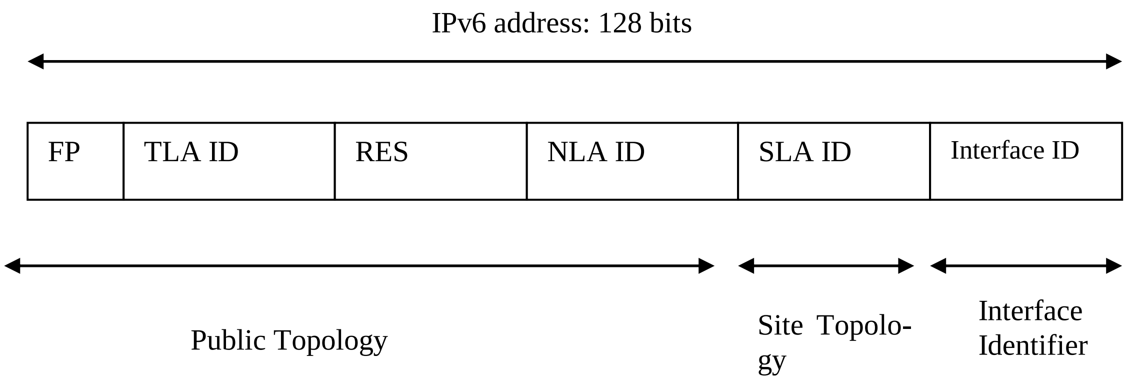
Figure 1: IPv4 address format

IPv4 addresses are categorised in four classes: Class A, Class B, Class C and Class D. In Class A, the highest order bit is 0, the next seven bits are the network identifier and the last 24 bits are the Hostid. In Class B, the two highest order bits are 10, the next fourteen bits are the Netid, and the last sixteen bits identify the host. In Class C, the three higher order bits are 110, the next 21 bits are the Netid, and the last eight bits are the Hostid. Class D is reserved for multi-cast addresses

IPv6 has a fixed length of 128 bits and the first field of the address is a variable length field called Format Prefix (FP). The value of the Format Prefix indicates the various types of IPv6 address (such as unicast, any cast, multi-cast, local, global, and so on).

Today Ipv6 reserves some values of FP to allow the support of the N-SAP and IPX Novell addresses. This means that by using a specific value of the FP the IPv6 address can embed an N-SAP or IPX Novell address.

Among the various types of address, it is important to mention the aggregatable global unicast address that will be widely used in networks running IPv6. In this IPv6 address (see figure 2) we have three levels of hierarchy: public topology, site topology and interface topology.



Where:

FP	Format Prefix (001)
TLA ID	Top-Level Aggregation Identifier
RES	Reserved for future use
NLA ID	Next-Level Aggregation Identifier
SLA ID	Site-Level Aggregation Identifier
INTERFACE ID	Interface Identifier

Figure 2: Aggregatable Global Unicast IP Address

The public topology is the collection of providers and exchanges that provide public Internet transit services. The site topology is local to a specific site or organisation that does not provide public transit service to nodes outside of the site. The Interface identifiers identify interfaces on links.

In order to allow a smooth transition between IPv4 and IPv6 a specific IPv6 address able to embed IPv4 addresses exists. In this case, the IPv4 address occupies the low-order 32 bits of the IPv6 address and this allows routers and hosts to dynamically tunnel IPv6 packets over IPv4 routing platforms.

In addition to the above-mentioned types of IPv6 address there are many others with specific scope (such as addresses valid on a link, on a site) and specific purpose (such as configuration, testing, and so on).

Annex 8 Internet Name Technical Description

An Internet name is a structured alphanumeric string of characters used to identify a host.

In an Internet name we can identify three hierarchical levels: Top-Level Domain (TLD), domain and sub-domain, and host name.

The existing TLDs fall into two categories: geographic TLD and generic TLD. Geographic TLDs are two-letter country codes according to ISO Standard 3166, used to identify single countries and/or territories all around the world. As an example, .uk is the geographic TLD to identify the United Kingdom.

In the case of geographic TLD, the structure of the Internet name after the top-level domain is in the competence of the regional and national authorities. Therefore, the structure of names with geographic TLD may vary from country to country. In some cases, the structure is quite flat, in others it reflects political, geographic or generic categories.

Today there are seven defined generic TLDs: .com, .edu, .net, .org, int, .gov, and .mil

- .com - this domain is intended for commercial companies
- .edu - this domain is intended for educational institutions
- .net - this domain is for networks
- .org - this domain is intended as the miscellaneous TLD
- .int - this domain is intended for organisations established by international treaties
- .gov - this domain is intended for US government offices or agencies
- .mil - this domain is intended for US military use

.com is the TLD domain most used and its management in the last few years has caused some problems. In order to make better management of the existing generic TLDs possible, a proposal to create seven new TLDs exists:

- .firm - this domain is intended for business and firm
- .store - this domain is intended for companies selling goods
- .web - this domain is intended for organisations having activities related to www
- .art - this domain is intended for organisations with cultural activities
- .rec - this domain is intended for organisations with recreation activities
- .info - this domain is intended for organisations providing information services
- .nom - this domain is intended for personal nomenclature

Domain Name System

The names identify hosts in a user-friendly way. However, to establish communication with the called host, the name of the host must translate into the IP address associated with the host. The DNS performs this translation, called name resolution. In the DNS, the names and IP addresses of every system registered in the Internet are stored.

DNS is a hierarchical network of distributed databases called DNS servers. At the top of this hierarchy are the root zone servers that know all the names and IP addresses of the DNS servers for each domain under the TLD. With a recursive process each DNS server knows the names and IP addresses of all the entities in his sub-domain.

When a name needs to translate into an IP address, the local DNS server is the first point of interrogation.

If the local DNS server is not able to perform this translation, it sends the query to the DNS server at the superior hierarchical level. The DNS continues this process until it finds the appropriate DNS server. The DNS then queries the appropriate server and the result of this query is the IP address associated to the name.

We should note that one name can correspond to more than one IP address and vice versa. This implies that there is not one-to-one mapping between names and addresses.

Annex 9 Cost of National Number Changes

Country	Number of subscribers (millions) (7)	Type of change	Additional notes	Operator							Business User		
				Total				out of which Communication					
				National currency (millions)	Exchange rate to ECU	ECU (millions)	ECU/ subscriber	National currency (millions)	ECU (millions)	ECU/ subscriber	National currency (millions)	ECU (millions)	ECU/ subscriber
Germany	35,0	SN		1650,0	1,8	916,7	26,2						
Ireland	0,4	SN	(1)	0,6	0,8	0,8	1,9	0,5	0,6	1,5			
France	28,0	NDC, SN	(5)	1900,0	6,5	292,3	10,4	80	12	0,4	1400	215	7,7
Netherlands	8,0	NDC, SN	(3)	200,0	2,0	100,0	12,5	100	50	6,3			
Norway	2,2	NDC, SN	(3)(6)	165,0	8,2	20,1	9,1				1000	122	55,4
UK	25,0	NDC (SN)	(3)(4)	120,0	0,8	150,0	6,0	16	20	0,8	427	534	21,4
Finland	2,8	NDC	(6)	99,0	5,7	17,0	6,2	35,0	6,2	2,2	150	26	9,4
Poland	0,4	NDC	(2)	0,3	3,0	0,1	0,25						

Explanation for additional notes

(1) Dublin area only, 400.000 subscribers

(2) Warsaw area only 400.000 from 660.000 subscribers

(3) Change of number length

(4) Costs for business users include partly also costs for residential users

(5) Original cost values are from year 1985; to compensate this 35 % has been added to original cost figures
Figures do not include modernisation costs for the telephone network

(6) Information about business users based on one company, only

(7) In this column only those subscribers were considered which are affected by the number change

Annex 10 Available Cost Data

The following countries - listed in alphabetical order - delivered input based on practical information on numbering changes carried out within the last few years: Finland, France, Germany, Ireland, The Netherlands, Norway, Poland and United Kingdom.

As a basis for this analysis, the presented contributions have been summarised and re-structured to identify where data came from, e.g. operators, business customers, and so on. We also discuss and assess the accuracy of each contribution.

Some general remarks apply to all countries:

- there are no cost figures available for residential users
- there are no cost figures available for CC change
- where possible, all cost figures are listed in the national currency and ECU
- all cost figures are based on operator findings if other sources are not mentioned

We used the following exchange rates to ECU to compare the different national cost figures:

Country	1 ECU =
Finland	5,7 FIM
France	6,5 FRF
Germany	1,8 DEM
Ireland	0,8 IEP
The Netherlands	2,0 NLG
Norway	8,2 NOK
Poland	3,0 PLZ
United Kingdom	0,8 GBP

Table 1. Used currency rates

Finland

This cost estimation uses the numbering reform in October 1996. The total costs to operators estimated by one operator were ECU17 million, including ECU6.2 million for market communication. The operator also made an estimation of the costs to business users (about ECU26 million).

As additional information, the estimate for the total cost for network operators in Finland to inform customers who had incorrectly dialled due to the National Code Change in UK was only ECU7900.

Accuracy: The data uses the information gained from the main players and ETO considers it realistic. Some concern exists however, about the estimated cost to business customers.

France

The cost figures from France come from a report dealing with number changes in 1985. We have increased the figures by 35% to approximate to current rates.

The total cost for the whole numbering change programme was 8.8 billion FRF. This was broken down as follows: 6.5 billion FRF for network modifications and 2.3 billion FRF for planning, promotion and so on. The network modification costs were:

- FRF 4.0 billion for first generation crossbar switch replacement
- FRF 2.1 billion for second generation crossbar switch modifications
- FRF 0.4 billion for electronic switch modifications

The cost for promotional campaign of 80 million FRF is included in the total cost.

If the network had been fully electronic in 1985 the estimated cost for network modification would have been just 0.8 billion FRF.

We estimated the costs to users using the cost of changing CPE equipment. We calculated that the costs varied between FRF1 billion and FRF1.4 billion.

The French figures that came from 1985 may not necessarily be valid today. We have included the following cost estimates from the French experience to our study. This may correspond probably better the present digitalisation degree of the network:

Cost for network operators 1.9 billion FRF

(The cost for network modifications 1.4 billion FRF plus planning and promotion 0.5 billion FRF of which the promotion cost is 80 million FRF)

The cost for users 1.4 billion FRF

Accuracy: The report was based on interviews with individuals and is about ten years old. The exchanges at that time were analogue oriented and most of the costs came from changes in switching equipment. The estimates drawn from the French experience are not very accurate when applied to the present day.

Germany

The cost of a mass change of ECU26.2 per number change uses a theoretical study carried out by Deutsche Telekom in 1993 and is the average cost of different approaches, which take into account analogue and digital technical solutions. The second cost figure of about ECU75.5 per single subscriber number change does not seem to be applicable to this study, since the figure is oriented to analogue techniques. The second figure also includes costs that arise when using the directory service and individual announcement capability to inform the caller about the new number.

Accuracy: Since this is merely a theoretical study, we cannot verify the accuracy of the cost figures given.

Ireland

Ireland's contribution uses the change of approximately 400,000 subscriber numbers in Dublin between 1990 and 1994. Ireland presented the cost of number change in respect to manpower used. In order to calculate the cost of the number change the following assumption, regarding the value of manpower, was made: 20IEP per hour, 8 hours per day, 20 days per month and 201 days per year.

This contribution identified three phases of this changeover:

- planning: ECU40,000
- publicity: ECU580,000;
  - inclusion of information in the bill about IEP150 per 1000 subscribers
  - television and newspaper advertisements IEP1 per line
  - one man-month for co-ordination with near neighbours (IEP3,200)
- implementation: ECU48,000;
  - changing routing tables in digital exchanges: 1 man-week per 10,000 lines (IEP32,000)
  - preparation of recorded announcements: 1 man-week per 50,000 lines (IEP6,400)

Accuracy: The figures presented here use actual experience. However, Ireland listed several other cost incurring activities without any cost figures. Therefore, the actual costs seem to be higher than presented.

The Netherlands

The cost figures of the Netherlands use the number change, which took place in October 1995. The total amount of accesses is 8 million (for clarification: one single line equals to 1 access, 30 ISDN channels to one subscriber PABX equals also to 1 access) out of which approximately 75% will have to change their number. This number change includes changes in area codes, subscriber numbers and in number length itself (for some numbers only). The cost of network changes are estimated at about 100 million NLG (50 million ECU). In addition to this the cost of communicating the change is estimated at 100 million NLG (50 million ECU).

Accuracy: The cost estimation is rough and real figure may vary greatly.

Norway

The cost figures given by Norway use an estimation of the cost of the Norwegian number change in 1992/93. This number change took several steps. The costs to network operators were approximately ECU20-21 million. This was nearly ECU10 per subscriber. Norway estimated the costs to Norwegian business users at ECU125 million. This estimate used detailed figures of one company with approximately 2,500 employees. A few other companies were also contacted and they confirmed the cost figures as being in line with their views.

Accuracy: This was a very rough estimation and real figure might vary greatly. Regarding the cost to business users, one company does not necessarily represent the business customers of the whole country.

Poland

Poland's contribution is based on a change in the area code of Warsaw, where 400.000 from 660.000 subscribers had to change their area code from "2" to "22". Poland stated that the operator costs were no more than ECU0.25 per subscriber.

Accuracy: We have no information on how Poland calculated this figure. Therefore, we cannot verify the accuracy of this figure.

United Kingdom

The cost figures from the UK are based on the code change in April 1995 and are a collection of information from all national parties involved in the code change, e.g. BT, Mercury, Users, OFTEL and so on.

Operator costs were estimated at around ECU150 million (including ECU20 million for promotion).

Estimates of costs for other changes were as follows:

- for updating CPE equipment ECU250 million
- for updating of stationary ECU222 million
- ECU61 million for other issues such as incorrect dialling and updating signs

The UK estimated total costs as approximately ECU684 million.

Accuracy: These cost figures use studies and information from market players and ETO considers them realistic.

Annex 11 List of Abbreviations

AESA	ATM End System Address
AFI	Authority and Format Identifier
ANSI	American National Standards Institute
ARIN	American Registry for Internet Numbers
APNIC	Area Pacific Network Information Centre
ATM	Asynchronous Transfer Mode
BSI	British Standards Institute
CC	Country Code
CEPT	European Conference of Postal and Telecommunications Administrations
CEC	Commission of the European Communities
ECMA	Standardising Information and Communication Systems
ECTEL	European Telecommunications and Professional Electronic Industry
ECTRA	European Committee for Telecommunications Regulatory Affairs
EIIA	European Information Industry Association
ENF	European Numbering Forum
ESD	End System Designator
ESI	End System Identifier
ETNO	European Public Telecommunications Network Operators' Association
ETNS	European Telephony Numbering Space
ETO	European Telecommunications Office

ETSI	European Telecommunications Standards Institute
EU	European Union
DCC	Data Country Code
DNIC	Data Network Identification Code
DNS	Domain Naming System
DSP	Domain Specific Part
DTE/DCE	Data Terminal Equipment/ Data Circuit-terminating Equipment
IAB	Internet Architecture Board
IANA	Internet Assigned Network Authority
IC	Identification Code
ICD	International Code Designator
IDI	Initial Domain Identifier
IDP	Initial Domain Part
IETF	Internet Engineering Task Force
IMSI	International Mobile Station Identity
IN	Intelligent Network
InterNIC	Internet Network Information Centre
I-PNNI	Integrated PNNI
IP	Internet Protocol
IR	Internet Registry
ISDN	Integrated Service Digital Network
ISOC	Internet Society Community
ISP	Internet Service Provider

IT	Information Technology
ITU	International Telecommunication Union
ITU-T	Telecommunication Standardisation Sector of ITU
MCC	Mobile Country Code
MNC	Mobile Network Code
MSIN	Mobile Subscriber Identification Number
ETSI NA	ETSI Network Aspects
NHRP	Next Hop Resolution Protocol
N-ISDN	Narrow ISDN
NN	National Number
NRA	National Regulatory Authority
NSI	Network Solution Incorporated
NTN	National Terminal Number
OSI	Open System Interconnection
PNNI	Private Node-Node Interface
PSTN	Public Switched Telephone Network
PUI	Personal User Identity
QoS	Quality of Service
RIR	Regional Internet Registry
RG	Routing Group
RIPE NCC	Reseaux IP Europeens Network Co-ordination Centre
RSVP	Resource Reservation Protocol
SEL	Selector
SLD	Second Level Domain

STP	Site Topology Partition
TLD	Top Level Domain
UNI	User Network Interface
UC	UPT User Code
UDP	User Datagram Protocol

Annex 12 Bibliography

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