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Number Portability in the Global Switched Telephone Network (GSTN): An Overview

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Abstract

This document provides an overview of E.164 telephone number portability (NP) in the Global Switched Telephone Network (GSTN). NP is a regulatory imperative seeking to liberalize local telephony service competition, by enabling end-users to retain telephone numbers while changing service providers. NP changes the fundamental nature of a dialed E.164 number from a hierarchical physical routing address to a virtual address, thereby requiring the transparent translation of the later to the former. In addition, there are various regulatory constraints that establish relevant parameters for NP implementation, most of which are not network technology specific. Consequently, the implementation of NP behavior consistent with applicable regulatory constraints, as well as the need for interoperation with the existing GSTN NP implementations, are relevant topics for numerous areas of IP telephony works-in-progress with the IETF.

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1. Introduction

This document provides an overview of E.164 telephone number [E164] portability in the Global Switched Telephone Network (GSTN). There are considered to be three types of number portability (NP): service provider number portability (SPNP), location portability (not to be confused with terminal mobility), and service portability.

SPNP, the focus of the present document, is a regulatory imperative in many countries seeking to liberalize telephony service competition, especially local service. Historically, local telephony service (as compared to long distance or international service) has been regulated as a utility-like form of service. While a number of countries had begun liberalization (e.g., privatization, de-regulation, or re-regulation) some years ago, the advent of NP is relatively recent (since ~1995).

E.164 numbers can be non-geographic and geographic numbers. Non-geographic numbers do not reveal the location information of those numbers. Geographic E.164 numbers were intentionally designed as hierarchical routing addresses which could systematically be digit-analyzed to ascertain the country, serving network provider, serving end-office switch, and specific line of the called party. As such, without NP a subscriber wishing to change service providers would incur a number change as a consequence of being served off of a different end-office switch operated by the new service provider. The impact in cost and convenience to the subscriber of changing numbers is seen as a barrier to competition. Hence NP has become associated with GSTN infrastructure enhancements associated with a competitive environment driven by regulatory directives.

Forms of SPNP have been deployed or are being deployed widely in the GSTN in various parts of the world, including the U.S., Canada, Western Europe, Australia, and the Pacific Rim (e.g., Hong Kong). Other regions, such as South America (e.g., Brazil), are actively considering it.

Implementation of NP within a national telephony infrastructure entails potentially significant changes to numbering administration, network element signaling, call routing and processing, billing, service management, and other functions.

NP changes the fundamental nature of a dialed E.164 number from a hierarchical physical routing address to a virtual address. NP implementations attempt to encapsulate the impact to the GSTN and make NP transparent to subscribers by incorporating a translation function to map a dialed, potentially ported E.164 address, into a network routing address (either a number prefix or another E.164 address) which can be hierarchically routed.

This is roughly analogous to the use of network address translation on IP is that enables IP address portability by containing the address change to the edge of the network and retain the use of Classless Inter-Domain Routing (CIDR) blocks in the core which can be route aggregated by the network service provider to the rest of the internet.

NP bifurcates the historical role of a subscriber's E.164 address into two or more data elements (a dialed or virtual address, and a network routing address) that must be made available to network elements through an NP translation database, carried by forward call signaling, and recorded on call detail records. Not only is call processing and routing affected, but also Signaling System Number 7 (SS7)/Common Channel Signaling System Number 7 (C7) messaging. A number of Transaction Capabilities Application Part (TCAP)-based SS7

messaging sets utilize an E.164 address as an application-level network element address in the global title address (GTA) field of the Signaling Connection Control Part (SCCP) message header. Consequently, SS7/C7 signaling transfer points (STPs) and gateways need to be able to perform n-digit global title translation (GTT) to translate a dialed E.164 address into its network address counterpart via the NP database.

In addition, there are various national regulatory constraints that establish relevant parameters for NP implementation, most of which are not network technology specific. Consequently, implementations of NP behavior in IP telephony, consistent with applicable regulatory constraints, as well as the need for interoperability with the existing GSTN NP implementations, are relevant topics for numerous areas of IP telephony works-in-progress with the IETF.

This document describes three types of number portability and the four schemes that have been standardized to support SPNP for geographic E.164 numbers specifically. Following that, specific information regarding the call routing and database query implementations are described for several regions (North American and Europe) and industries (wireless vs. wireline). The Number Portability Database (NPDB) interfaces and the call routing schemes that are used in North America and Europe are described to show the variety of standards that may be implemented worldwide. A glance at the NP implementations worldwide is provided. Number pooling is briefly discussed to show how NP is being enhanced in the U.S. to conserve North American area codes. The conclusion briefly touches the potential impacts of NP on IP and Telecommunications Interoperability.

2. Abbreviations and Acronyms

ACQ	All Call Query
AIN	Advanced Intelligent Network
AMPS	Advanced Mobile Phone System
ANSI	American National Standards Institute
API	Application Programming Interface
C7	Common Channel Signaling System Number 7
CDMA	Code Division Multiple Access
CdPA	Called Party Address
CdPN	Called Party Number
CH	Code Holder
CIC	Carrier Identification Code
CIDR	Classless Inter-Domain Routing
CMIP	Common Management Information Protocol
CO	Central Office
CS1	Capability Set 1

CS2	Capability Set 2
DN	Directory Number
DNS	Domain Name System
ENUM	Telephone Number Mapping
ETSI	European Telecommunications Standards Institute
FCI	Forward Call Indicator
GAP	Generic Address Parameter
GMSC	Gateway Mobile Services Switching Center or Gateway Mobile Switching Center
GNP	Geographic Number Portability
GSM	Global System for Mobile Communications
GSTN	Global Switched Telephone Network
GTT	Global Title Translation
GW	Gateways
HLR	Home Location Register
IAM	Initial Address Message
IETF	Internet Engineering Task Force
ILNP	Interim LNP
IN	Intelligent Network
INAP	Intelligent Network Application Part
INP	Interim NP
IP	Internet Protocol
IS-41	Interim Standards Number 41
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part
ITN	Individual Telephony Number
ITU	International Telecommunication Union
ITU-TS	ITU-Telecommunication Sector
LDAP	Lightweight Directory Access Protocol
LEC	Local Exchange Carrier
LERG	Local Exchange Routing Guide
LNP	Local Number Portability
LRN	Location Routing Number
MAP	Mobile Application Part
MNP	Mobile Number Portability
MSRN	Mobile Station Roaming Number
MTP	Message Transfer Part
NANP	North American Numbering Plan
NGNP	Non-Geographic Number Portability
NOA	Nature of Address
NP	Number Portability
NPA	Numbering Plan Area
NPDB	Number Portability Database
NRN	Network Routing Number
OR	Onward Routing
OSS	Operation Support System
PCS	Personal Communication Services
PNTI	Ported Number Translation Indicator

PODP	Public Office Dialing Plan
PUC	Public Utility Commission
QoR	Query on Release
RN	Routing Number
RTP	Return to Pivot
SCCP	Signaling Connection Control Part
SCP	Service Control Point
SIP	Session Initiation Protocol
SMR	Special Mobile Radio
SPNP	Service Provider Number Portability
SRF	Signaling Relaying Function
SRI	Send Routing Information
SS7	Signaling System Number 7
STP	Signaling Transfer Point
TCAP	Transaction Capabilities Application Part
TDMA	Time Division Multiple Access
TN	Telephone Number
TRIP	Telephony Routing Information Protocol
URL	Universal Resource Locator
U.S.	United States

3. Types of Number Portability

As there are several types of E.164 numbers (telephone numbers, or just TN) in the GSTN, there are correspondingly several types of E.164 NP in the GSTN. First there are so-called non-geographic E.164 numbers, commonly used for service-specific applications such as freephone (800 or 0800). Portability of these numbers is called non-geographic number portability (NGNP). NGNP, for example, was deployed in the U.S. in 1986-92.

Geographic number portability (GNP), which includes traditional fixed or wireline numbers, as well as mobile numbers which are allocated out of geographic number range prefixes, is called NP or GNP, or in the U.S. local number portability (LNP).

Number portability allows the telephony subscribers in the GSTN to keep their phone numbers when they change their service providers or subscribed services, or when they move to a new location.

The ability to change the service provider while keeping the same phone number is called service provider portability (SPNP), also known as "operator portability."

The ability to change the subscriber's fixed service location while keeping the same phone number is called location portability.

The ability to change the subscribed services (e.g., from the plain

old telephone service to Integrated Services Digital Network (ISDN) services) while keeping the same phone number is called service portability. Another aspect of service portability is to allow the subscribers to enjoy the subscribed services in the same way when they roam outside their home networks, as is supported by the cellular/wireless networks.

In addition, mobile number portability (MNP) refers to specific NP implementation in mobile networks, either as part of a broader NP implementation in the GSTN or on a stand-alone basis. Where interoperation of LNP and MNP is supported, service portability between fixed and mobile service types is possible.

At present, SPNP has been the primary form of NP deployed due to its relevance in enabling local service competition.

Also in use in the GSTN are the terms interim NP (INP) or Interim LNP (ILNP) and true NP. Interim NP usually refers to the use of remote call forwarding-like measures to forward calls to ported numbers through the donor network to the new service network. These are considered interim relative to true NP, which seeks to remove the donor network or old service provider from the call or signaling path altogether. Often the distinction between interim and true NP is a national regulatory matter relative to the technical/operational requirements imposed on NP in that country.

Implementations of true NP in certain countries (e.g., U.S., Canada, Spain, Belgium, Denmark) may pose specific requirements for IP telephony implementations as a result of regulatory and industry requirements for providing call routing and signaling independent of the donor network or last previous serving network.

4. Service Provider Number Portability Schemes

Four schemes can be used to support service provider portability and are briefly described below. But first, some further terms are introduced.

The donor network is the network that first assigned a telephone number (e.g., TN +1-202-533-1234) to a subscriber, out of a number range administratively (e.g., +1 202-533) assigned to it. The current service provider (new SP), or new serving network, is the network that currently serves the ported number. The old serving network (or old SP) is the network that previously served the ported number before the number was ported to the new serving network. Since a TN can port a number of times, the old SP is not necessarily the same as the donor network, except for the first time the TN ports away, or when the TN ports back into the donor network and away

again. While the new SP and old SP roles are transitory as a TN ports around, the donor network is always the same for any particular TN based on the service provider to whom the subtending number range was administratively assigned. See the discussion below on number pooling, as this enhancement of NP further bifurcates the role of the donor network into two (the number range or code holder network, and the block holder network).

To simplify the illustration, all the transit networks are ignored. The originating or donor network is the one that performs the database queries or call redirection, and the dialed directory number (TN) has previously been ported out of the donor network.

It is assumed that the old serving network, the new serving network, and the donor network are different networks so as to show which networks are involved in call handling and routing and database queries in each of the four schemes. Please note that the port of the number (process of moving it from one network to another) happened prior to the call setup and is not included in the call steps. Information carried in the signaling messages to support each of the four schemes is not discussed to simplify the explanation.

4.1 All Call Query (ACQ)

Figure 1 shows the call steps for the ACQ scheme. Those call steps are as follows:

- 1) The Originating Network receives a call from the caller and sends a query to a centrally administered Number Portability Database (NPDB), a copy of which is usually resident on a network element within its network or through a third party provider.
- 2) The NPDB returns the routing number associated with the dialed directory number. The routing number is discussed later in Section 6.
- 3) The Originating Network uses the routing number to route the call to the new serving network.

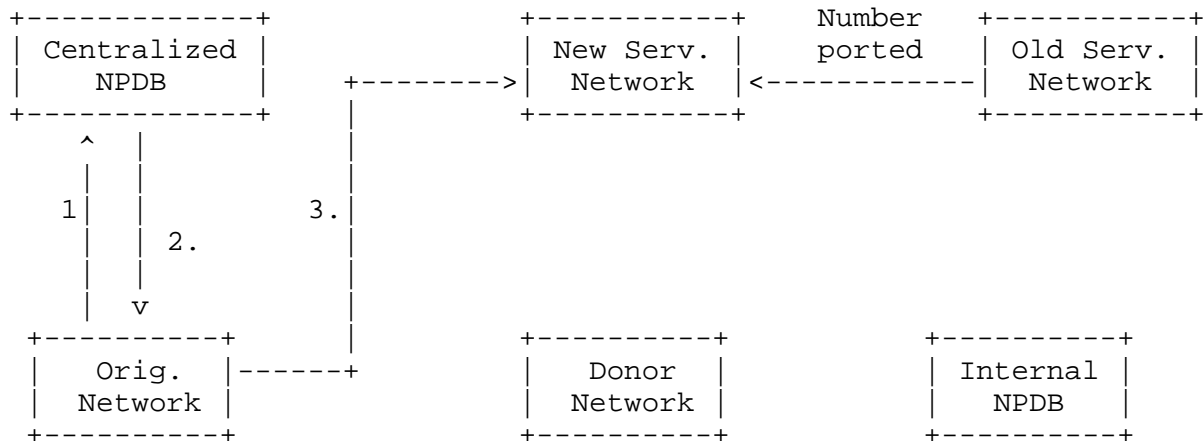


Figure 1 - All Call Query (ACQ) Scheme.

4.2 Query on Release (QoR)

Figure 2 shows the call steps for the QoR scheme. Those call steps are as follows:

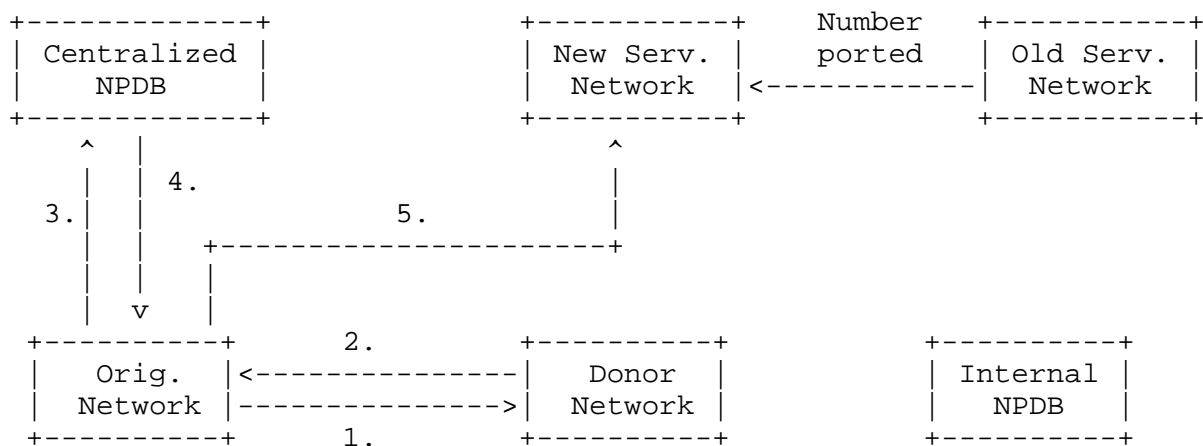


Figure 2 - Query on Release (QoR) Scheme.

- 1) The Originating Network receives a call from the caller and routes the call to the donor network.
- 2) The donor network releases the call and indicates that the dialed directory number has been ported out of that switch.
- 3) The Originating Network sends a query to its copy of the centrally administered NPDB.

- 4) The NPDB returns the routing number associated with the dialed directory number.
- 5) The Originating Network uses the routing number to route the call to the new serving network.

4.3 Call Dropback

Figure 3 shows the call steps for the Dropback scheme. This scheme is also known as "Return to Pivot (RTP)." Those call steps are as follows:

- 1) The Originating Network receives a call from the caller and routes the call to the donor network.
- 2) The donor network detects that the dialed directory number has been ported out of the donor switch and checks with an internal network-specific NPDB.
- 3) The internal NPDB returns the routing number associated with the dialed directory number.
- 4) The donor network releases the call by providing the routing number.
- 5) The Originating Network uses the routing number to route the call to the new serving network.

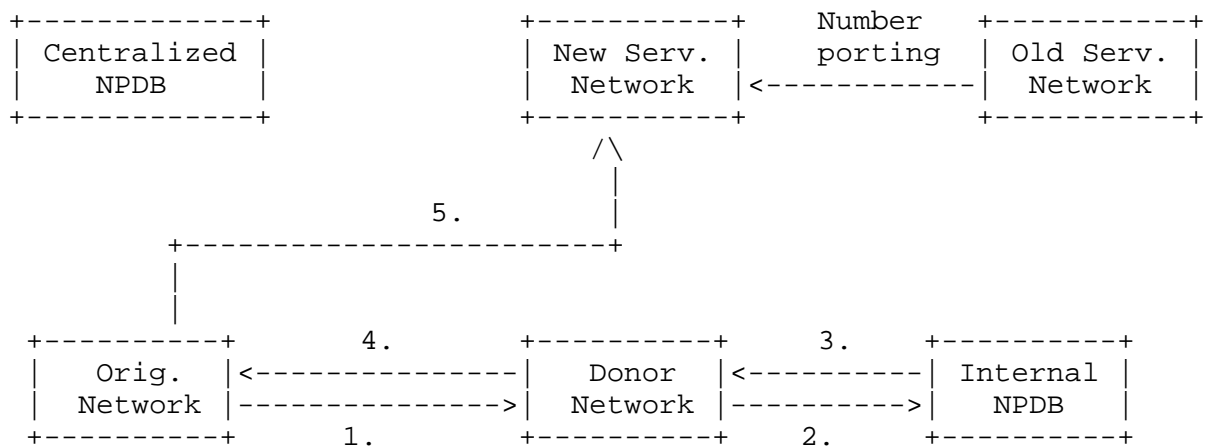


Figure 3 - Dropback Scheme.

4.4 Onward Routing (OR)

Figure 4 shows the call steps for the OR scheme. Those call steps are as follows:

- 1) The Originating Network receives a call from the caller and routes the call to the donor network.
- 2) The donor network detects that the dialed directory number has been ported out of the donor switch and checks with an internal network-specific NPDB.
- 3) The internal NPDB returns the routing number associated with the dialed directory number.
- 4) The donor network uses the routing number to route the call to the new serving network.

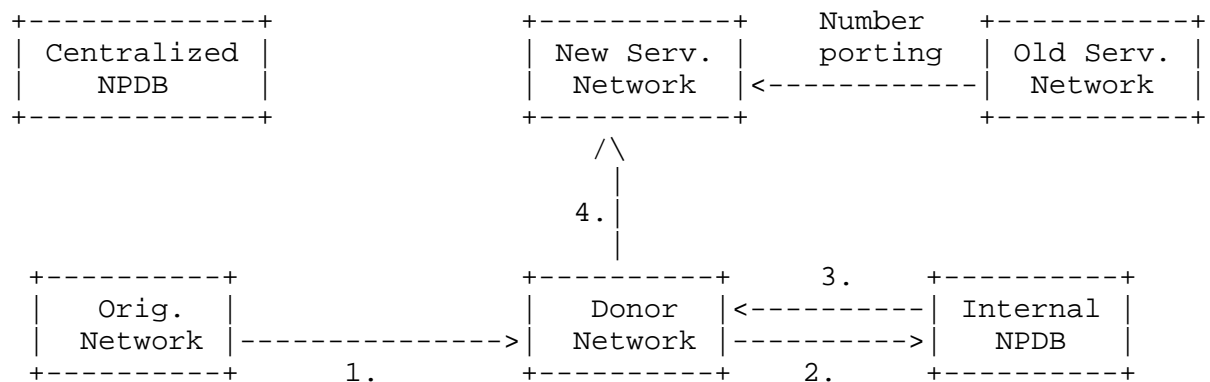


Figure 4 - Onward Routing (OR) Scheme.

4.5 Comparisons of the Four Schemes

Only the ACQ scheme does not involve the donor network when routing the call to the new serving network of the dialed ported number. The other three schemes involve call setup to or signaling with the donor network.

Only the OR scheme requires the setup of two physical call segments, one from the Originating Network to the donor network and the other from the donor network to the new serving network. The OR scheme is the least efficient in terms of using the network transmission facilities. The QoR and Dropback schemes set up calls to the donor network first but release the call back to the Originating Network that then initiates a new call to the Current Serving Network. For the QoR and Dropback schemes, circuits are still reserved one by one

between the Originating Network and the donor network when the Originating Network sets up the call towards the donor network. Those circuits are released one by one when the call is released from the donor network back to the Originating Network. The ACQ scheme is the most efficient in terms of using the switching and transmission facilities for the call.

Both the ACQ and QoR schemes involve Centralized NPDBs for the Originating Network to retrieve the routing information. Centralized NPDB means that the NPDB contains ported number information from multiple networks. This is in contrast to the internal network-specific NPDB that is used for the Dropback and OR schemes. The internal NPDB only contains information about the numbers that were ported out of the donor network. The internal NPDB can be a stand-alone database that contains information about all or some ported-out numbers from the donor network. It can also reside on the donor switch and only contain information about those numbers ported out of the donor switch. In that case, no query to a stand-alone internal NPDB is required. The donor switch for a particular phone number is the switch to which the number range is assigned from which that phone number was originally assigned.

For example, number ranges in the North American Numbering Plan (NANP) are usually assigned in the form of central office codes (CO codes) comprising a six-digit prefix formatted as a NPA+NXX. Thus a switch serving +1-202-533 would typically serve +1-202-533-0000 through +1-202-533-9999. In major cities, switches usually host several CO codes. NPA stands for Numbering Plan Area, which is also known as the area code. It is three-digits long and has the format of NXX where N is any digit from 2 to 9 and X is any digit from 0 to 9. NXX, in the NPA+NXX format, is known as the office code that has the same format as the NPA. When a NPA+NXX code is set as "portable" in the Local Exchange Routing Guide (LERG), it becomes a "portable NPA+NXX" code.

Similarly, in other national E.164 numbering plans, number ranges cover a contiguous range of numbers within that range. Once a number within that range has ported away from the donor network, all numbers in that range are considered potentially ported and should be queried in the NPDB.

The ACQ scheme has two versions. One version is for the Originating Network to always query the NPDB when a call is received from the caller regardless of whether the dialed directory number belongs to any number range that is portable or has at least one number ported out. The other version is to check whether the dialed directory number belongs to any number range that is portable or has at least one number ported out. If yes, an NPDB query is sent. If not, no

NPDB query is sent. The former performs better when there are many portable number ranges. The latter performs better when there are not too many portable number ranges at the expense of checking every call to see whether NPDB query is needed. The latter ACQ scheme is similar to the QoR scheme, except that the QoR scheme uses call setup and relies on the donor network to indicate "number ported out" before launching the NPDB query.

5. Database Queries in the NP Environment

As indicated earlier, the ACQ and QoR schemes require that a switch query the NPDB for routing information. Various standards have been defined for the switch-to-NPDB interface. Those interfaces with their protocol stacks are briefly described below. The term "NPDB" is used for a stand-alone database that may support just one or some or all of the interfaces mentioned below. The NPDB query contains the dialed directory number and the NPDB response contains the routing number. There is certainly other information that is sent in the query and response. The primary interest is to get the routing number from the NPDB to the switch for call routing.

5.1 U.S. and Canada

One of the following five NPDB interfaces can be used to query an NPDB:

- a) Advanced Intelligent Network (AIN) using the American National Standards Institute (ANSI) version of the Intelligent Network Application Part (INAP) [ANSI SS] [ANSI DB]. The INAP is carried on top of the protocol stack that includes the (ANSI) Message Transfer Part (MTP) Levels 1 through 3, ANSI SCCP and ANSI TCAP. This interface can be used by the wireline or wireless switches, is specific to the NP implementation in North America, and is modeled on the Public Office Dialing Plan (PODP) trigger defined in the Advanced Intelligent Network (AIN) 0.1 call model.
- b) Intelligent Network (IN), which is similar to the one used for querying the 800 databases. The IN protocol is carried on top of the protocol stack that includes the ANSI MTP Levels 1 through 3, ANSI SCCP, and ANSI TCAP. This interface can be used by the wireline or wireless switches.
- c) ANSI IS-41 [IS41] [ISNP], which is carried on top of the protocol stack that includes the ANSI MTP Levels 1 through 3, ANSI SCCP, and ANSI TCAP. This interface can be used by the IS-41 based cellular/Personal Communication Services (PCS) wireless switches (e.g., AMPS, TDMA and CDMA). Cellular systems use spectrum at 800 MHz range and PCS systems use spectrum at 1900 MHz range.

- d) Global System for Mobile Communication Mobile Application Part (GSM MAP) [GSM], which is carried on top of the protocol stack that includes the ANSI MTP Levels 1 through 3, ANSI SCCP, and International Telecommunication Union - Telecommunication Sector (ITU-TS) TCAP. It can be used by the PCS1900 wireless switches that are based on the GSM technologies. GSM is a series of wireless standards defined by the European Telecommunications Standards Institute (ETSI).
- e) ISUP triggerless translation. NP translations are performed transparently to the switching network by the signaling network (e.g., Signaling Transfer Points (STPs) or signaling gateways). ISUP IAM messages are examined to determine if the CdPN field has already been translated, and if not, an NPDB query is performed, and the appropriate parameters in the IAM message modified to reflect the results of the translation. The modified IAM message is forwarded by the signaling node on to the designated DPC in a transparent manner to continue call setup. The NPDB can be integrated with the signaling node or, accessed via an Application Programming Interface (API) locally, or by a query to a remote NPDB using a proprietary protocol or the schemes described above.

Wireline switches have the choice of using either (a), (b), or (e). IS-41 based wireless switches have the choice of using (a), (b), (c), or (e). PCS1900 wireless switches have the choice of using (a), (b), (d), or (e). In the United States, service provider portability will be supported by both the wireline and wireless systems, not only within the wireline or wireless domain but also across the wireline/wireless boundary. However, this is not true in Europe where service provider portability is usually supported only within the wireline or wireless domain, not across the wireline/wireless boundary due to explicit use of service-specific number range prefixes. The reason is to avoid caller confusion about the call charge. GSM systems in Europe are assigned distinctive destination network codes, and the caller pays a higher charge when calling a GSM directory number.

5.2 Europe

One of the following two interfaces can be used to query an NPDB:

- a) Capability Set 1 (CS1) of the ITU-TS INAP [CS1], which is carried on top of the protocol stack that includes the ITU-TS MTP Levels 1 through 3, ITU-TS SCCP, and ITU-TS TCAP.
- b) Capability Set 2 (CS2) of the ITU-TS INAP [CS2], which is carried on top of the protocol stack that includes the ITU-TS MTP Levels 1 through 3, ITU-TS SCCP, and ITU-TS TCAP.

Wireline switches have the choice of using either (a) or (b); however, all the implementations in Europe so far are based on CS1. As indicated earlier that number portability in Europe does not go across the wireline/wireless boundary. The wireless switches can also use (a) or (b) to query the NPDBs if those NPDBs contains ported wireless directory numbers. The term "Mobile Number Portability (MNP)" is used for the support of service provider portability by the GSM networks in Europe.

In most, if not all, cases in Europe, the calls to the wireless directory numbers are routed to the wireless donor network first. Over there, an internal NPDB is queried to determine whether the dialed wireless directory number has been ported out or not. In this case, the interface to the internal NPDB is not subject to standardization.

MNP in Europe can also be supported via the MNP Signaling Relay Function (MNP-SRF). Again, an internal NPDB or a database integrated at the MNP-SRF is used to modify the SCCP Called Party Address parameter in the GSM MAP messages so that they can be re-directed to the wireless serving network. Call routing involving MNP will be explained in Section 6.2.

6. Call Routing in the NP Environment

This section discusses the call routing after the routing information has been retrieved either through an NPDB query or an internal database lookup at the donor switch, or from the Integrated Services Digital Network User Part (ISUP) signaling message (e.g., for the Dropback scheme). For the ACQ, QoR and Dropback schemes, it is the Originating Network that has the routing information and is ready to route the call. For the OR scheme, it is the donor network that has the routing information and is ready to route the call.

A number of triggering schemes may be employed that determine where in the call path the NPDB query is performed. In the U.S. a "N-1" policy is used, which essentially says that for local calls, the originating local carriers performs the query. Otherwise, the long distance carrier is expected to follow through with the query. To ensure independence of the actual trigger policy employed in any one carrier, forward call signaling is used to flag that an NPDB query has already been performed and to therefore suppress any subsequent NP triggers that may be encountered in downstream switches, in downstream networks. This allows the earliest able network in the call path to perform the query without introducing additional costs and call setup delays when redundant queries are performed downstream.

6.1 U.S. and Canada

In the U.S. and Canada, a ten-digit North American Numbering Plan (NANP) number called Location Routing Number (LRN) is assigned to every switch involved in NP. In the NANP, a switch is not reachable unless it has a unique number range (CO code) assigned to it. Consequently, the LRN for a switch is always assigned out of a CO code that is assigned to that switch.

The LRN assigned to a switch currently serving a particular ported telephone number is returned as the network routing address in the NPDB response. The service portability scheme that was adopted in the North America is very often referred to as the LRN scheme or method.

LRN serves as a network address for terminating calls served off that switch using ported numbers. The LRN is assigned by the switch operator using any of the unique CO codes (NPA+XXX) assigned to that switch. The LRN is considered a non-dialable address, as the same 10-digit number value may be assigned to a line on that switch. A switch may have more than one LRN.

During call routing/processing, a switch performs an NPDB query to obtain the LRN associated with the dialed directory number. NPDB queries are performed for all the dialed directory numbers whose NPA+XXX codes are marked as portable NPA+XXX at that switch. When formulating the ISUP Initial Address Message (IAM) to be sent to the next switch, the switch puts the ten-digit LRN in the ISUP Called Party Number (CdPN) parameter and the originally dialed directory number in the ISUP Generic Address parameter (GAP). A new code in the GAP was defined to indicate that the address information in the GAP is the dialed directory number. A new bit in the ISUP Forward Call Indicator (FCI) parameter, the Ported Number Translation Indicator (PNTI) bit, is set to imply that NPDB query has already been performed. All the switches in the downstream will not perform the NPDB query if the PNTI bit is set.

When the terminating switch receives the IAM and sees the PNTI bit in the FCI parameter set and its own LRN in the CdPN parameter, it retrieves the originally dialed directory number from the GAP and uses the dialed directory number to terminate the call.

A dialed directory number with a portable NPA+XXX does not imply that a directory number has been ported. The NPDBs currently do not store records for non-ported directory numbers. In that case, the NPDB will return the same dialed directory number instead of the LRN. The switch will then set the PNTI bit, but keep the dialed directory number in the CdPN parameter.

In the real world environment, the Originating Network is not always the one that performs the NPDB query. For example, it is usually the long distance carriers that query the NPDBs for long distance calls. In that case, the Originating Network operated by the local exchange carrier (LEC) simply routes the call to the long distance carrier that is to handle that call. A wireless network acting as the Originating Network can also route the call to the interconnected local exchange carrier network if it does not want to support the NPDB interface at its mobile switches.

6.2 Europe

In some European countries, a routing number is prefixed to the dialed directory number. The ISUP CdPN parameter in the IAM will contain the routing prefix and the dialed directory number. For example, United Kingdom uses routing prefixes with the format of 5XXXXX and Italy uses C600XXXXX as the routing prefix. The networks use the information in the ISUP CdPN parameter to route the call to the New/Current Serving Network.

The routing prefix can identify the Current Serving Network or the Current Serving Switch of a ported number. For the former case, another query to the "internal" NPDB at the Current Serving Network is required to identify the Current Serving Switch before routing the call to that switch. This shields the Current Serving Switch information for a ported number from the other networks at the expense of an additional NPDB query. Another routing number, that be meaningful within the Current Serving Network, will replace the previously prefixed routing number in the ISUP CdPN parameter. For the latter case, the call is routed to the Current Serving Switch without an additional NPDB query.

When the terminating switch receives the IAM and sees its own routing prefix in the CdPN parameter, it retrieves the originally dialed directory number after the routing prefix, and uses the dialed directory number to terminate the call.

The call routing example described above shows one of the three methods that can be used to transport the Directory Number (DN) and the Routing Number (RN) in the ISUP IAM message. In addition, some other information may be added/modified as is listed in the ETSI 302 097 document [ETSIISUP], which is based on the ITU-T Recommendation Q.769.1 [ITUISUP]. The three methods and the enhancements in ISUP to support number portability are briefly described below:

- a) Two separate parameters with the CdPN parameter containing the RN and a new Called Directory Number (CdDN) parameter containing the DN. A new value for the Nature of Address (NOA) indicator in the

CdPN parameter is defined to indicate that the RN is in the CdPN parameter. The switches use the CdPN parameter to route the call as is done today.

- b) Two separate parameters with the CdPN parameter containing the DN and a new Network Routing Number (NRN) parameter containing the RN. This method requires that the switches use the NRN parameter to route the call.
- c) Concatenated parameter with the CdPN parameter containing the RN plus the DN. A new Nature of Address (NOA) indicator in the CdPN parameter is defined to indicate that the RN is concatenated with the DN in the CdPN parameter. Some countries may not use new NOA value because the routing prefix does not overlap with the dialed directory numbers. But if the routing prefix overlaps with the dialed directory numbers, a new NOA value must be assigned. For example, Spain uses "XXXXXX" as the routing prefix to identify the new serving network and uses a new NOA value of 126.

There is also a network option to add a new ISUP parameter called Number Portability Forwarding Information parameter. This parameter has a four-bit Number Portability Status Indicator field that can provide an indication whether number portability query is done for the called directory number and whether the called directory number is ported or not if the number portability query is done.

Please note that all of the NP enhancements for a ported number can only be used in the country that defined them. This is because number portability is supported within a nation. Within each nation, the telecommunications industry or the regulatory bodies can decide which method or methods to use. Number portability related parameters and coding are usually not passed across the national boundaries unless the interconnection agreements allow it. For example, a UK routing prefix can only be used in the UK, and would cause a routing problem if it appears outside the UK.

As indicated earlier, an originating wireless network can query the NPDB and concatenate the RN with DN in the CdPN parameter and route the call directly to the Current Serving Network.

If NPDBs do not contain information about the wireless directory numbers, the call, originated from either a wireline or a wireless network, will be routed to the Wireless donor network. Over there, an internal NPDB is queried to retrieve the RN that then is concatenated with the DN in the CdPN parameter.

There are several ways of realizing MNP. If MNP-SRF is supported, the Gateway Mobile Services Switching Center (GMSC) at the wireless

donor network can send the GSM MAP Send Routing Information (SRI) message to the MNP-SRF when receiving a call from the wireline network. The MNP-SRF interrogates an internal or integrated NPDB for the RN of the MNP-SRF of the wireless Current Serving Network and prefixes the RN to the dialed wireless directory number in the global title address information in the SCCP Called Party Address (CdPA) parameter. This SRI message will be routed to the MNP-SRF of the wireless Current Serving Network, which then responds with an acknowledgement by providing the RN plus the dialed wireless directory number as the Mobile Station Roaming Number (MSRN). The GMSC of the wireless donor network formulates the ISUP IAM with the RN plus the dialed wireless directory number in the CdPN parameter and routes the call to the wireless Current Serving Network. A GMSC of the wireless Current Serving Network receives the call and sends an SRI message to the associated MNP-SRF where the global title address information of the SCCP CdPA parameter contains only the dialed wireless directory number. The MNP-SRF then replaces the global title address information in the SCCP CdPA parameter with the address information associated with a Home Location Register (HLR) that hosts the dialed wireless directory number and forwards the message to that HLR after verifying that the dialed wireless directory number is a ported-in number. The HLR then returns an acknowledgement by providing an MSRN for the GMSC to route the call to the MSC that currently serves the mobile station that is associated with the dialed wireless directory number. Please see [MNP] for details and additional scenarios.

7. NP Implementations for Geographic E.164 Numbers

This section shows the known SPNP implementations worldwide.

Country	SPNP Implementation
Argentina	Analyzing operative viability now. Will determine whether portability should be made obligatory after a technical solution has been determined.
Australia	NP supported by wireline operators since 11/30/99. NP among wireless operators in March/April 2000, but may be delayed to 1Q01. The access provider or long distance provider has the obligation to route the call to the correct destination. The donor network is obligated to maintain and make available a register of numbers ported away from its network. Telstra uses onward routing via an on-switch solution.

Country	SPNP Implementation
Austria	Uses onward routing at the donor network. Routing prefix is "86xx" where "xx" identifies the recipient network.
Belgium	ACQ selected by the industry. Routing prefix is "Cxxxx" where "xxxx" identifies the recipient switch. Another routing prefix is "C00xx" with "xx" identifying the recipient network. Plan to use NOA to identify concatenated numbers and abandon the hexadecimal routing prefix.
Brazil	Considering NP for wireless users.
Chile	There has been discussions lately on NP.
Colombia	There was an Article 3.1 on NP to support NP prior to December 31, 1999 when NP became technically possible. Regulator has not yet issued regulations concerning this matter.
Denmark	Uses ACQ. Routing number not passed between operators; however, NOA is set to "112" to indicate "ported number." QoR can be used based on bilateral agreements.
Finland	Uses ACQ. Routing prefix is "1Dxxy" where "xxy" identifies the recipient network and service type.
France	Uses onward routing. Routing prefix is "Z0xxx" where "xxx" identifies the recipient switch.
Germany	The originating network needs to do necessary rerouting. Operators decide their own solution(s). Deutsche Telekom uses ACQ. Routing prefix is "Dxxx" where "xxx" identifies the recipient network.
Hong Kong	Recipient network informs other networks about ported-in numbers. Routing prefix is "14x" where "14x" identifies the recipient network, or a routing number of "4x" plus 7 or 8 digits is used where "4x" identifies the recipient network and the rest of digits identify the called party.

Country	SPNP Implementation
Ireland	Operators choose their own solution but use onward routing now. Routing prefix is "1750" as the intra-network routing code (network-specific) and "1752xxx" to "1759xxx" for GNP where "xxx" identifies the recipient switch.
Italy	Uses onward routing. Routing prefix is "C600xxxxx" where "xxxxx" identifies the recipient switch. Telecom Italia uses IN solution and other operators use on-switch solution.
Japan	Uses onward routing. Donor switch uses IN to get routing number.
Mexico	NP is considered in the Telecom law; however, the regulator (Cofetel) or the new local entrants have started no initiatives on this process.
Netherlands	Operators decide NP scheme to use. Operators have chosen ACQ or QoR. KPN implemented IN solution similar to U.S. solution. Routing prefix is not passed between operators.
Norway	OR for short-term and ACQ for long-term. QoR is optional. Routing prefix can be "xxx" with NOA=8, or "142xx" with NOA=3 where "xxx" or "xx" identifies the recipient network.
Peru	Wireline NP may be supported in 2001.
Portugal	No NP today.
Spain	Uses ACQ. Telefonica uses QoR within its network. Routing prefix is "xxyyzz" where "xxyyzz" identifies the recipient network. NOA is set to 126.
Sweden	Standardized the ACQ but OR for operators without IN. Routing prefix is "xxx" with NOA=8 or "394xxx" with NOA=3 where "xxx" identifies the recipient network. But operators decide NP scheme to use. Telia uses onward routing between operators.

Country	SPNP Implementation
Switzerland	Uses OR now and QoR in 2001. Routing prefix is "980xxx" where "xxx" identifies the recipient network.
UK	Uses onward routing. Routing prefix is "5xxxxx" where "xxxxx" identifies the recipient switch. NOA is 126. BT uses the dropback scheme in some parts of its network.
US	Uses ACQ. "Location Routing Number (LRN)" is used in the Called Party Number parameter. Called party number is carried in the Generic Address Parameter. Use a PNTI indicator in the Forward Call Indicator parameter to indicate that NPDB dip has been performed.

8. Number Conservation Methods Enabled by NP

In addition to porting numbers NP provides the ability for number administrators to assign numbering resources to operators in smaller increments. Today it is common for numbering resources to be assigned to telephone operators in a large block of consecutive telephone numbers (TNs). For example, in North America each of these blocks contains 10,000 TNs and is of the format NXX+0000 to NXX+9999. Operators are assigned a specific NXX, or block. That operator is referred to as the block holder. In that block there are 10,000 TNs with line numbers ranging from 0000 to 9999.

Instead of assigning an entire block to the operator, NP allows the administrator to assign a sub-block or even an individual telephone number. This is referred to as block pooling and individual telephone number (ITN) pooling, respectively.

8.1 Block Pooling

Block Pooling refers to the process whereby the number administrator assigns a range of numbers defined by a logical sub-block of the existing block. Using North America as an example, block pooling would allow the administrator to assign sub-blocks of 1,000 TNs to multiple operators. That is, NXX+0000 to NXX+0999 can be assigned to operator A, NXX+1000 to NXX+1999 can be assigned to operator B, NXX+2000 to 2999 can be assigned to operator C, etc. In this example, block pooling divides one block of 10,000 TNs into ten blocks of 1,000 TNs.

Porting the sub-blocks from the block holder enables block pooling. Using the example above, operator A is the block holder, as well as the holder of the first sub-block, NXX+0000 to NXX+0999. The second sub-block, NXX+1000 to NXX+1999, is ported from operator A to operator B. The third sub-block, NXX+2000 to NXX+2999, is ported from operator A to operator C, and so on. NP administrative processes and call processing will enable proper and efficient routing.

From a number administration and NP administration perspective, block pooling introduces a new concept, that of the sub-block holder. Block pooling requires coordination between the number administrator, the NP administrator, the block holder, and the sub-block holder. Block pooling must be implemented in a manner that allows for NP within the sub-blocks. Each TN can have a different serving operator, sub-block holder, and block holder.

8.2 ITN Pooling

ITN pooling refers to the process whereby the number administrator assigns individual telephone numbers to operators. Using the North American example, one block of 10,000 TNs can be divided into 10,000 ITNs. ITN is more commonly deployed in freephone services.

In ITN the block is not assigned to an operator but to a central administrator. The administrator then assigns ITNs to operators. NP administrative processes and call processing will enable proper and efficient routing.

9. Potential Implications

There are three general areas of impact to IP telephony works-in-progress with the IETF:

- Interoperation between NP in GSTN and IP telephony
- NP implementation or emulation in IP telephony
- Interconnection to NP administrative environment

A good understanding of how number portability is supported in the GSTN is important when addressing the interworking issues between IP-based networks and the GSTN. This is especially important when the IP-based network needs to route the calls to the GSTN. As shown in Section 5, there are a variety of standards with various protocol stacks for the switch-to-NPDB interface. Furthermore, the national variations of the protocol standards make it very complicated to deal with in a global environment. If an entity in the IP-based network needs to query those existing NPDBs for routing number information to terminate the calls to the destination GSTN, it would be an

impractical, if not impossible, job for that entity to support all those interface standards to access the NPDBs in many countries.

Several alternatives may address this particular problem. One alternative is to use certain entities in the IP-based networks for dealing with NP query, similar to the International Switches that are used in the GSTN to interwork different national ISUP variations. This will force signaling information associated with the calls to certain NP-capable networks in the terminating GSTN to be routed to those IP entities that support the NP functions. Those IP entities then query the NPDBs in the terminating country. This will limit the number of NPDB interfaces that certain IP entities need to support. Another alternative can be to define a "common" interface to be supported by all the NPDBs so that all the IP entities use that standardized protocol to query them. The existing NPDBs can support this additional interface, or new NPDBs that contain the same information but support the common IP interface can be deployed. The candidates for such a common interface include ENUM (telephone number mapping) [ENUM], Lightweight Directory Access Protocol (LDAP) and SIP [SIP] (e.g., using the SIP redirection capability). Certainly another possibility is to use an interworking function to convert from one protocol to another.

IP-based networks can handle the domestic calls between two GSTNs. If the originating GSTN has performed NPDB query, SIP will need to transport and make use of some of the ISUP signaling information even if ISUP signaling may be encapsulated in SIP. Also, IP-based networks may perform the NPDB queries, as the N-1 carrier. In that case, SIP also needs to transport the NP related information while the call is being routed to the destination GSTN. There are three pieces of NP related information that SIP needs to transport. They are 1) the called directory number, 2) a routing number, and 3) a NPDB dip indicator. The NPDB dip indicator is needed so that the terminating GSTN will not perform another NPDB dip. The routing number is needed so that it is used to route the call to the destination network or switch in the destination GSTN. The called directory number is needed so that the terminating GSTN switch can terminate the call. When the routing number is present, the NPDB dip indicator may not be present because there are cases where the routing number is added for routing the call even if NP is not involved. One issue is how to transport the NP related information via SIP. The SIP Universal Resource Locator (URL) is one mechanism. Another better choice may be to add an extension to the "tel" URL [TEL] that is also supported by SIP. Please see [TELNP] for the proposed extensions to the "tel" URL to support NP and freephone service. Those extensions to the "tel" URL will be automatically supported by SIP because they can be carried as the optional parameters in the user portion of the "sip" URL.

For a called directory number that belongs to a country that supports NP, and if the IP-based network is expected to perform the NPDB query, the logical step is to perform the NPDB dip first to retrieve the routing number and use that routing number to select the correct IP telephony gateways that can reach the serving switch that serves the called directory number. Therefore, if the "rn" parameter is present in the "tel" URL or sip URL in the SIP INVITE message, it, instead of the called directory number, should be used for making routing decisions assuming that no other higher priority routing-related parameters such as the "cic" (Carrier Identification Code) are present. If "rn" (Routing Number) is not present, then the dialed directory number can be used as the routing number for making routing decisions.

Telephony Routing Information Protocol (TRIP) [TRIP] is a policy driven inter-administrative domain protocol for advertising the reachability of telephony destinations between location servers, and for advertising attributes of the routes to those destinations. With the NP in mind, it is very important to know, that if present, it is the routing number, not the called directory number, that should be used to check against the TRIP tables for making the routing decisions.

Overlap signaling exists in the GSTN today. For a call routing from the originating GSTN to the IP-based network that involves overlap signaling, NP will impact the call processing within the IP-based networks if they must deal with the overlap signaling. The entities in the IP-based networks that are to retrieve the NP information (e.g., the routing number) must collect a complete called directory number information before retrieving the NP information for a ported number. Otherwise, the information retrieval won't be successful. This is an issue for the IP-based networks if the originating GSTN does not handle the overlap signaling by collecting the complete called directory number.

The IETF enum working group is defining the use of the Domain Name System (DNS) for identifying available services and/or Internet resources associated with a particular E.164 number. [ENUMPO] outlines the principles for the operation of a telephone number service that resolves telephone numbers into Internet domain name addresses and service-specific directory discovery. [ENUMPO] implements a three-level approach where the first level is the mapping of the telephone number delegation tree to the authority to which the number has been delegated, the second level is the provision of the requested DNS resource records from a service registrar, and the third level is the provision of service specific data from the service provider itself. NP certainly must be considered at the first level because the telephony service providers

do not "own" or control the telephone numbers under the NP environment; therefore, they may not be the proper entities to have the authority for a given E.164 number. Not only that, there is a regulatory requirement on NP in some countries that the donor network should not be relied on to reach the delegated authority during the DNS process. The delegated authority for a given E.164 number is likely to be an entity designated by the end user that owns/controls a specific telephone number, or one that is designated by the service registrar.

Since the telephony service providers may have the need to use ENUM for their network-related services (e.g., map an E.164 number to a HLR Identifier in the wireless networks), their ENUM records must be collocated with those of the telephony subscribers. If that is the case, NP will impact ENUM when a telephony subscriber who has ENUM service changes the telephony service provider. This is because that the ENUM records from the new telephony service provider must replace those from the old telephony service provider. To avoid the NP impact on ENUM, it is recommended that the telephony service providers use a different domain tree for their network-related service. For example, if el64.arpa is chosen for "end user" ENUM, a domain tree different from el64.arpa should be used for "carrier" ENUM.

The IP-based networks also may need to support some forms of number portability in the future if E.164 numbers are assigned to the IP-based end users. One method is to assign a GSTN routing number for each IP-based network domain or entity in a NP-capable country. This may increase the number of digits in the routing number to incorporate the IP entities and impact the existing routing in the GSTN. Another method is to associate each IP entity with a particular GSTN gateway. At that particular GSTN gateway, the called directory number is then used to locate the IP-entity that serves that dialed directory number. Yet, another method can be to assign a special routing number so that the call to an end user currently served by an IP entity is routed to the nearest GSTN gateway. The called directory number then is used to locate the IP-entity that serves that dialed directory number. A mechanism can be developed or used for the IP-based network to locate the IP entity that serves a particular dialed directory number. Many other types of networks use E.164 numbers to identify the end users or terminals in those networks. Number portability among GSTN, IP-based network, and those various types of networks may also need to be supported in the future.

10. Security Considerations

In the PSTN, the NPDB queries are generated by the PSTN switches and carried over the SS7 networks to reach the NPDBs and back to the switches. The SS7 networks are operated by telecommunications operators and signaling transport service providers in such a closed environment that make them difficult for the hackers to penetrate. However, when VoIP operators need the NP information and have to launch the NP queries from their softswitches, media gateway controllers or call managers, there would be security concerns if the NP queries and responses are transported over the Internet. If the routing number or routing prefix in the response is altered during the message transport, the call will be routed to the wrong place. It is recommended that the NPDB queries be transported via a secure transport layer or with added security mechanisms to ensure the data integrity.

11. IANA Considerations

This document introduces no new values for IANA registration.

12. Normative References

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