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Number Portability in the GSTN: An Overview

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1. Abstract

This document provides an overview of E.164 telephone number portability (NP) in the Global Switched Telephone Network (GSTN). There are three types of number portability: service provider portability (SPNP), location portability, and service portability. Service provider portability, the focus of the present draft, is a regulatory imperative in many countries seeking to liberalize local telephony service competition, by enabling end-users to retain pre-existing telephone numbers while changing service providers. Implementation of NP within national GSTN 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, thereby requiring the transparent translation of the later to the former. In addition, there are various regulatory

constraints which 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 work-in-progress at IETF.

2. Introduction

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

Service number provider portability (SPNP), the focus of the present draft, 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) 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 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 cost and convenience impact to the subscriber of changing numbers is seen as 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 US, 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 impacts 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 addresses to enable IP address portability by containing the impact of the address change to the edge of the network and retain the use of 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 subscriberÆs 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 translations database, carried by forward call signaling, and recorded on call detail records. Not only is call processing and routing affected, but so is SS7/C7 messaging. A number of TCAP-based SS7 messaging sets utilize an E.164 address as an application-level network element address in the global title address field (GTA) field of the 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 which 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 interoperation with the existing GSTN NP implementations, are relevant topics for numerous areas of IP telephony work-in-progress at IETF.

This document describes three types of number portability and the four schemes that have been standardized to support SPNP 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 the North America and Europe are described to show the variety of standards that may be implemented worldwide. Number pooling is briefly discussed to show how NP is being enhanced in the US to conserve North American area codes. The conclusion briefly touches the potential impacts of NP on IP & Telecommunications Interoperability. Appendix A provides some specific technical and regulatory information on NP in North America. Appendix B describes the number portability administration process that manages the number portability database in North America.

3. Abbreviations and Acronyms

ACQ	All Call Query

AMPS	Advanced Mobile Phone System
ANSI	American National Standards Institute
CDMA	Code Division Multiple Access
CdPA	Called Party Address
CdPN	Called Party Number
CH	Code Holder
CMIP	Common Management Information Protocol
CRTC	Canadian Radio and Television Commission
CS1	Capability Set 1
CS2	Capability Set 2
DN	Directory Number
ETSI	European Technical Standards Institute
FCC	Federal Communications Commission
FCI	Forward Call Indicator
GAP	Generic Address Parameter
GMSC	Gateway Mobile Services Switching Center
GSM	Global System for Mobile Communications
GSTN	Global Switched Telephone Network
GW	Gateways
HLR	Home Location Register
IAM	Initial Address Message
ICC	Illinois Commerce Commission
IN	Intelligent Network
INAP	Intelligent Network Application Part
IP	Internet Protocol
IS-41	Interim Standards Number 41
ITN	Individual Telephony Number
ITU	International Telecommunication Union
ITU-TS	ITU-Telecommunication Sector
ISUP	ISDN User Part
ISDN	Integrated Services Digital Network
LEC	Local Exchange Carrier
LLC	Limited Liability Corporation
LNP	Local Number Portability

LRN	Location Routing Number
LSMS	Local Service Management System
MAP	Mobile Application Part
MNP	Mobile Number Portability
MSRN	Mobile Station Roaming Number
MTP	Message Transfer Part
NANC	North American Numbering Council
NANP	North American Numbering Plan
NP	Number Portability
NPAC	Number Portability Administration Center
NPDB	Number Portability Database
NPRM	Notice of Proposed Rulemaking
NRN	Network Routing Number
OR	Onward Routing
PCS	Personal Communication Services
PUC	Public Utility Commission
QoR	Query on Release
RBOC	Regional Bell Operating Company
RN	Routing Number

RTP	Return to Pivot
SCCP	Signaling Connection Control Part
SMS	Service Management System
SOA	Service Order Administration
SRF	Signaling Relaying Function
SRI	Send Routing Information
SS7	Signaling System Number 7
TCAP	Transaction Capabilities Application Part
TCNI	Translated Called Number Indicator
TDMA	Time Division Multiple Access
TN	Telephone Number

4. 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-call non-geographic E.164 numbers, commonly used for service specific applications such as freephone (800 or 0800). Portability of these are call non-geographic number portability (NGNP). NGNP, for example, was deployed in the US in 1986-92.

Geographic number portability, 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 in the US local number portability (LNP).

Number portability allows the telephony subscribers in the Global Switched Telephone Network (GSTN) to keep their phone numbers when they change their service providers or subscribed services, or when they move to new 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 subscriberÆs 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, also known as single number services.

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 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. US, 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.

5. 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 old serving network (or old SP) is the network that previously served the ported number before the number ported to another network, called the new serving network or current service provider (SP). The new service provider (new SP) or current serving network is the network that currently serves the ported number.

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 if 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 to NP further bifurcates the role of 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 been ported out of the donor network before.

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 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.

5.1 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 7.
(3) The Originating Network uses the routing number to route the
    call to the new serving network.

```
   +-------------+              +-----------+    Number   +-----------+
   | Centralized |              | New Serv. |    ported   | Old Serv. |
   |    NPDB     |    +-------->|  Network  |<------------|  Network  |
   +-------------+    |         +-----------+             +-----------+
       ^  |           |
       |  |           |
      1|  |         3.|
       |  | 2.        |
       |  |           |
       |  v          |
    +----------+      |         +----------+          +----------+
    |   Orig.  |------+         |   Donor  |          | Internal |
    |  Network |                |  Network |          |   NPDB   |
    +----------+                +----------+          +----------+
```

Figure 1 - All Call Query (ACQ) Scheme.

5.2 Query on Release (QoR)

Figure 2 shows the call steps for the QoR 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 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 new serving network.

```
   +-------------+              +-----------+    Number   +-----------+
   | Centralized |              | New Serv. |    ported   | Old Serv. |
   |    NPDB     |              |  Network  |<------------|  Network  |
   +-------------+              +-----------+             +-----------+
       ^  |                          ^
       |  | 4.                       |
     3.|  |              5.          |
       |  |   +----------------------+
       |  |   |
       |  v   |
    +----------+      2.        +----------+           +----------+
    |   Orig.  |<---------------|   Donor  |           | Internal |
    |  Network |--------------->|  Network |           |   NPDB   |
    +----------+      1.        +----------+           +----------+
```

Figure 2 - Query on Release (QoS) Scheme.

5.3 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.

```
   +-------------+              +-----------+    Number   +-----------+
   | Centralized |              | New Serv. |    porting  | Old Serv. |
   |    NPDB     |              |  Network  |<------------|  Network  |
```



```
   +-------------+              +-----------+             +-----------+
                                    /\
                                     |
                           5.        |
```

```
        +-------------------------+
        |
        |
+----------+       4.       +----------+     3.    +----------+
|   Orig.  |<---------------|   Donor  |<----------| Internal |
|  Network |--------------->|  Network |---------->|   NPDB   |
+----------+      1.        +----------+    2.     +----------+
```

Figure 3 - Dropback Scheme.

5.4 Onward Routing (OR)

Figure 4 shows the call steps for the Dropback scheme. This scheme is also called Remote Call Forwarding. 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.

```
+-------------+             +-----------+    Number   +-----------+
| Centralized |             | New Serv. |    porting  | Old Serv. |
|    NPDB     |             |  Network  |<------------|  Network  |
+-------------+             +-----------+             +-----------+
                                /\
                                 |
                               4.|
                                 |
                                 |
                                 |
+----------+                +----------+     3.    +----------+
|   Orig.  |                |   Donor  |<----------| Internal |
|  Network |--------------->|  Network |---------->|   NPDB   |
+----------+      1.        +----------+    2.     +----------+
```

Figure 4 - Onward Routing (OR) Scheme.

5.5 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 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 resources. 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 contains 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 +1 202-533-2000 thru +1 202-533-9999. In major cities, switches usually host several CO codes. NPA stands for Numbering Plan Area that is also known as the area code. It is three-digit 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 the first number out of an NPA+NXX code is ported out to another switch, that NPA+NXX is called portable NPA+NXX.

Similarly, in other national E.164 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 whether the dialed directory number is ported or not. The other version is to check whether the dialed directory number belongs to any portable number range. 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.

6. 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 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 are certainly other information that is sent in the query and response. The primary concern is to get the routing number from the NPDB to the switch for call routing.

6.1 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 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 American National Standards Institute (ANSI) Message Transfer Part (MTP) Levels 1 through 3, ANSI Signaling Connection Control Part (SCCP), and ANSI Transaction Capabilities Application Part (TCAP). This interface can be used by the wireline or wireless switches, is specific to the LRN implementation of LNP in North America, and is modeled on the PODP trigger defined in the 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 switch network by the signaling network (e.g. 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.

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 North America, 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.

6.2 Europe

One of the following three 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 ITU-TS MTP Levels 1 through 3, ITU-TS SCCP, and ITU-TS TCAP.

(c) ISUP triggerless translation. NP translations are performed transparently to the switch network by the signaling network (e.g. 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.

Wireline switches have the choice of using either (a), (b), or (c); 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 MNP Signaling Relay Function (MNF-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 donor network.   Call routing involving MNP will be explained in Section 7.2.

7. 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 NPDP query is performed. In the US an ôN-1ö policy is used, which essentially says that for local calls, the orinigating local carriers performs the query, otherwise, the long

distance carrier is expected to. To ensure independence of the actual trigger poligy 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 were redundant queries performed downstream.

7.1 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 by 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+NXX) assigned to that switch. The LRN is consider 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 dial directory number. 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 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. NPDB queries are performed for all the dialed directory numbers whose NPA+NXX codes are marked as portable NPA+NXX at that switch. A new bit in the ISUP Forward Call Indicator (FCI) parameter, the Translated Called Number Indicator (TCNI) 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 TCNI bit is set.

When the terminating switch receives the IAM and sees the TCNI 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 with a portable NPA+NXX does not imply that 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 TCNI 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.

7.2 Europe

In Europe, 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

CXXXXXXXX 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, may 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.

In addition to the addition of the routing prefix to the CdPN parameter, some other information may be added/modified as is listed in the draft ITU-T Recommendation Q.769.1 [ISUP].   Those enhancements in the ISUP to support number portability are briefly described below.

Three methods can be used to transport the Directory Number (DN) and the Routing Number (RN):

(a) Two separate parameters with the CdPN parameter containing the RN and a new Called Directory Number (CdDN) parameter containing the DN. A new 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.

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 those enhancements are for national use. 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 never passed across the national boundaries.

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.

If MNP-SRF is supported, the Gateway Mobile Services Switching Center (GMSC) at the wireless donor network, when receiving a call from the wireline network or originated from within its network, can send the GSM MAP Send Routing Information (SRI) message to the MNP-SRF. 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 host 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.

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 (TN). For example, in North America these blocks contain 10,000 TNs and are 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 second 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.

10. Conclusion

There are three general areas of impact to IP telephony work-in-progress at IETF:

1. NP implementation or emulation in IP telephony
2. Interoperation between NP in GSTN and IP telephony
3. 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 6, there are a variety of standards with various protocol stacks for the switch-to-NPDB interface. If an entity in the Internet needs to query those existing NPDBs for routing number information to terminate the calls to the destination GSTN, it would be impractical, if not an impossible, job for that entity to support all those interface standards.

If not all of the IP telephony gateways (GWs) can reach the Current Serving Switch of a ported number, then the IP based network may need to obtain the RN of the Current Serving Network or Switch before selecting the terminating GW to terminate a call to the GSTN. The RN should be passed to the terminating GW so that another NPDB query at the terminating GW or the terminating GSTN is avoided. As indicated earlier, the ISUP support of the number portability is confined within the national boundary (e.g., the RN contains a national number instead of an international number). When routing a call to the terminating GSTN from the IP based network, the signaling messages, be it ISUP, Session Initiation Protocol (SIP), or others, will need to be enhanced to carry the number portability related information so that the terminating GW or GSTN can make use of the information without an additional NPDB lookup.

Overlap signaling exists in the GSTN. For a call routing from the originating GSTN to the terminating GSTN via the IP based network that involves overlap signaling, NP will impact the call processing within the IP based network 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 party number information before retrieving the NP information for a ported number. Otherwise, the information retrieval won't be successful.

The IP based networks also may need to support some forms of number portability in the future if E.164 numbers [E164] are assigned to the IP based end users. Many different types of networks use E.164 numbers to identify the end users or terminals in those networks. Number portability among those various types of networks may also need to be supported in the future.

11. References

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APPENDICES

APPENDIX A. NP Requirements in the North America

A.1 Background

The North American telecommunications industry began to seriously investigate methods of providing local number portability (LNP) in late 1994. On July 13, 1995, the Federal Communications Commission (FCC) in the U.S. issued a Notice of Proposed Rulemaking (NPRM) FCC Docket Number 95-116 that opened discussion on NP and sought comments on a wide variety of policy and technical issues related to NP.

In 1995 and 1996 several state regulatory bodies, notably the Illinois Commerce Commission (ICC), began the process of officially selecting the architecture to be used for NP in their respective states. After considerable discussion and deliberation, the "Location Routing Number (LRN)" scheme was selected by Illinois, and other states. The switching and signaling requirements for number portability developed in the Illinois LNP workshop under the auspices of the ICC became the basis of the de facto North American industry standards [ICC]. The activities on number portability in the North America also interacted with activities in many other parts of world.

A.2 Performance/Legal/Regulatory Requirements

After substantial industry discussion and debate, and extensive comments filed with the FCC, the FCC and the US telecommunications industry set the following minimum performance criteria for LNP:

1. Support existing network services, features and capabilities.
2. Efficiently use numbering resources.
3. Not require end users to change their telecommunication numbers.
4. Not require telecommunications carrier to rely on databases, other network facilities, or services provided by other

telecommunications carriers in order to route calls to proper termination point.
5. Not result in unreasonable degradation in service quality or network reliability when implemented.
6. Not result in unreasonable degradation of service quality or network reliability when customers switch carriers.
7. Not result in a carrier having a proprietary interest.
8. Be able to accommodate location and service portability in the future.
9. Have no significant adverse impact outside areas where number portability is deployed.

In July 1996, the FCC issued the First Report and Order on LNP under 95-116, calling for the deployment of LNP across the US starting in 1997. The FCC did not mandate any specific implementation of LNP in the US, but it did call upon the industry to develop and endorse a

national standard that would ensure interoperability with all industry segments, including wireless. While providing overall guidelines and requirements for LNP, it did explicitly state that the LRN method met these requirements, whereas alternate proposals (such as QoR) did not.

A core requirement was that a carrier who is serving ported numbers need not be reliant on any other carrier (especially the donor network) for completing calls, whether for call transport/routing or for signaling. That's not to say that a carrier couldn't voluntarily opt to use another carrier or the donor network for queries or call routing. But the key is voluntarily. This requirement was imposed on all NP implementations in the U.S. for common carrier telephony services regardless of the network technology employed.

Similar requirements were adopted by the Canadian Radio and Television Commission (CRTC), the equivalent of the FCC in Canada, and in a number of regulatory and industry bodies in other countries (e.g., Belgium, Denmark, Spain, Switzerland) which resulted in the use of centralized NPDBs to support number portability.

In the U.S. and Canada, the ACQ scheme was adopted because it does not rely on the donor network for call routing (see requirements numbers 4 and 7) and it can accommodate location and service portability in the future.

In the U.S. and Canada, there is also the "N-1" guideline that recommends that the network next to the destination network perform the NPDB query if the NPDB query has not been done or the routing information is not available (e.g., due to signaling interworking).

This is to prevent the call from being re-routed at the donor network. In the U.S., the wireline carriers are required to support NP in certain service areas in phases. The wireless carriers' support of NP has been postponed until November 2002.

APPENDIX B. NP Administration Process in the North America

B.1 Business Model

Figure B.1 shows the NP business model that was adopted in the U.S. and Canada. The U.S. is divided into seven regions coinciding with the boundaries of the original seven Regional Bell Operating Company (RBOC) regions. This was done to facilitate the formation of separate contracting and administrative areas (formed as limited liability companies) for LNP in the US intentionally coinciding with the original RBOC boundaries, thus enabling each RBOC to participate singly in each of these areas.

NeuStar, Inc., formerly the Communication Industry Services business unit with Lockheed Martin IMS, was selected in open competitive procurements conducted by the industry to be the Number Portability Administration Center (NPAC) provider for all the seven NPAC regions (Midwest, Northeast, Mid-Atlantic, Southwest, Southeast, Western, and West Coast) in the U.S. Lockheed Martin was subsequently named as the NPAC provider in Canada as well. Each Limited Liability Corp. (LLC) in the seven U.S. regions and Canadian Consortium maintain largely identical contracts with with NeuStar covering each region.

The FCC and North American Numbering Council (NANC) oversee the technical and operational standards, originally developed by

Lockheed Martin and offered as open industry standards, and cost recovery rulemakings.

Each LLC signed a master contract with NeuStar that set the prices and terms and provided the form of User Agreement for NeuStar to sign with each individual NPAC user. NPAC users are any bona fide entity which either ports numbers or subscribes to updates to the NPDB provided by the NPAC.

```
     +--------+             +----------+
     |  FCC   |------------>|   State  |
     |  NANC  |<---+   +--->|   PUCs   |
     +--------+    |   |    +----------+
                   |   |
                   v   v      (Master
            +--------------+  Agreement) +----------+
            | Regional LLC |<------------>|   NPAC   |
            |   Contract   |             | (NeuStar)|
            | Administrator|             +----------+
            +--------------+                  ^
                     ^                        |
                     |                        |
                     v                        |
               +----------+                   |
               |   NPAC   |<------------------+
               |   Users  |  (One User Agreement per User)
```



```
               +----------+
```

Figure B.1 - NP Administration Business Model in US.

B.2 NPAC Architecture

Figure B.2 shows the architecture for number portability administration in the U.S. and Canada. NeuStar is the NPAC Service Management System (SMS) service provider in the architecture diagram.

```
  (Carrier Facilities)                    :    (NPAC Facilities)
                      +---------+         :
                      |   SOA   |         :
                      |         |-------------------+
                      +---------+         :          |
                                          :          |
                                          :     +----------+
                                          :     | NPAC/SMS |
```

```
                                            :     | (NeuStar)|
                                            :     +----------+
                                            :          |
     +---------+         +---------+        :          |
     |  NPDB   |---------|  LSMS   |-------------------+
     |(e.g.SCP)|         |         |        :
     +---------+         +---------+        :
                                            :
```

Figure B.2 - NPAC Architecture.

The interface between the Service Order Administration (SOA) and the NPAC/SMS is for provisioning ported end-user data including the support of the creation, cancellation, retrieval and update of subscription, service provider, and network information. The SOAs are operated by the local exchange carriers.

The interface between the Local Service Management System (LSMS) and the NPAC/SMS is mainly used for downloading ported number information from the NPAC/SMS to the LSMS. The LSMS then updates the NPDB. A local exchange carrier may operate the LSMS if it decides to deploy an NPDB itself. A service bureau can also operate the LSMS to provision several LECs' NPDBs or operate the LSMS and the NPDB for the operators (e.g., LECs or long distance carriers) to query. The interface between the LSMS and the NPDB is up to the entities that operate them.

The functional requirement specification developed under the auspices of the North American Numbering Council (NANC) defines the external functionality of the NPAC SMS [FRS]. The interfaces between the NPAC/SMS and the SOA or LSMS use standards-based communications and security technologies and are made public [IIS].

Please note that only the information about the ported numbers is stored at the NPAC databases and the NPDBs at present.

B.3 NPAC SMS Functions

This section provides a list of the NPAC SMS functions. Please see [FRS] for details.

- Provisioning Service: For the new service provider to notify the NPAC SMS of a provision request for a ported number and to send an activation notice to activate the update from the NPAC SMS to the LSMS.

- Disconnect Service: For handling disconnection of the telephony service for a ported number.

- Repair Service: For resolving problems detected either by a Service Provider or by a customer contacting a Service Provider.

- Conflict Resolution: For resolving a conflict when there is disagreement between the old and new Service Providers as to who will be providing service for the telephone number (TN). Please note that the processes for obtaining authorization from the customer to port a number are defined by the Service Providers. The NPAC is not involved in obtaining or verifying customer approval to port a telephone number.

- Disaster Recovery and Backup: For having a backup facility and the disaster recovery procedures in place for planned and unplanned downtime at the primary facility.

- Order Cancellation: For the new Service Provider to cancel a previously submitted but not activated provision request.

- Audit Request: For troubleshooting customer problems and also as a maintenance process to ensure data integrity across the entire NP network.

- Report Request: For supporting report generation for pre-defined and ad-hoc reports.

- Data Management: For managing network, Service Provider, and customer subscription data. The network data defines the configuration of the NP service and network and includes such data as: participating Service Providers, NPA-NXXs that are portable, and LRNs associated with each Service Provider. The Service Provider data indicates who the NP Service Providers are and includes location, contact name, security, routing, and network interface information. The subscription data indicates how local number portability should operate to meet subscribers' needs.

- NPA-NXX Split Processing: For the administration of the information for NPA split (the current NPA, the new NPA, and the affected NXXs) plus the beginning and end date of the permissive dialing period.

- Business Support: For supporting service providers that have different needs for business hours and days available for porting.

- Notification Recovery: For allowing a Service Provider to capture, via a recovery process, all notifications that were missed during a downtime period for the Service Provider.

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