      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 interoperation 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

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CS2     Capability Set 2
DN      Directory Number
DNS     Domain Name System
ENUM    Telephone Number Mapping
ETSI    European Tecommunications 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
```

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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.

```
  +-------------+                +-----------+  Number  +-----------+
  | Centralized |                | New Serv. |  ported  | Old Serv. |
  |    NPDB     |   +-------->|  Network  |<------------|  Network  |
  +-------------+   |            +-----------+          +-----------+
     ^   |         |
     |   |         |
    1|   |       3.|
     |   | 2.      |
     |   |         |
     |   v         |
  +----------+     |            +----------+          +----------+
  |  Orig.   |------+            |  Donor   |          | Internal |
  | Network  |                  | Network  |          |   NPDB   |
  +----------+                  +----------+          +----------+
```
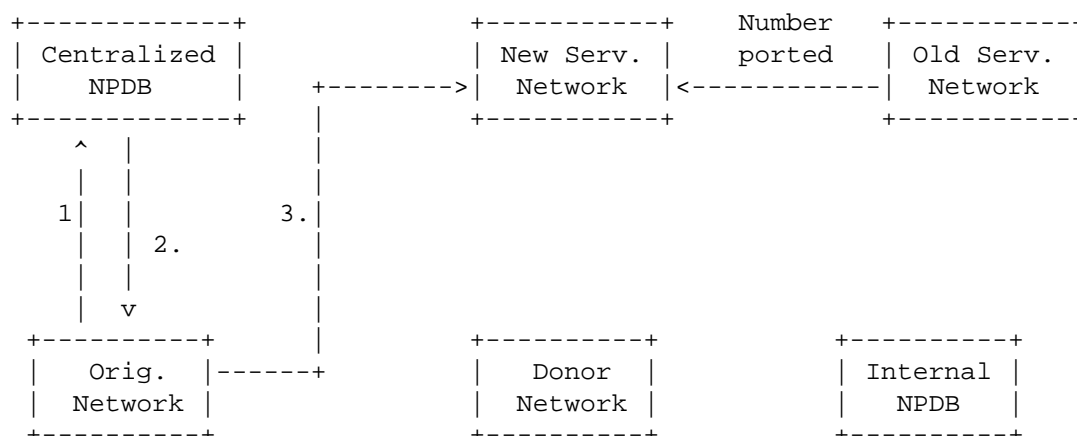
                  Figure 1 - All Call Query (ACQ) Scheme.

4.2 Query on Release (QoR)

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

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

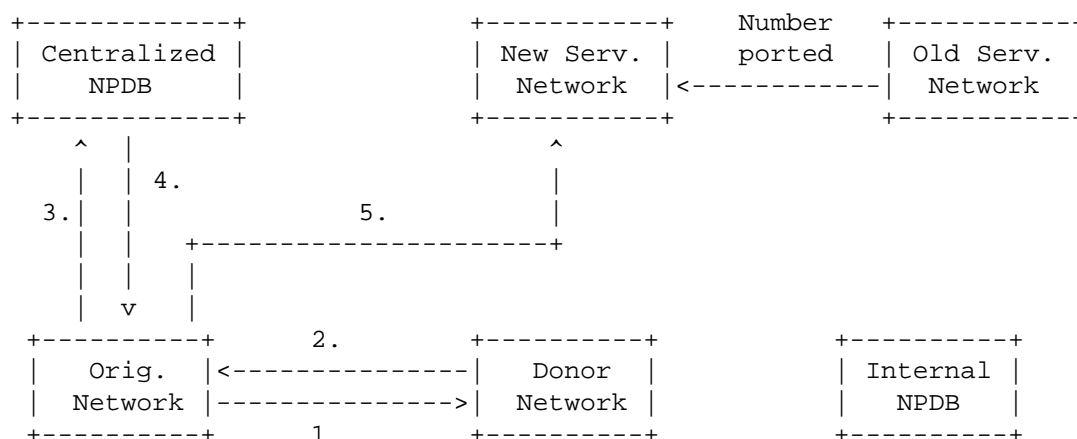   Figure 2 - Query on Release (QoR) Scheme.

   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.

```
   +-------------+              +----------+   Number    +----------+
   | Centralized |              | New Serv.|   porting   | Old Serv.|
   |    NPDB     |              | Network  |<------------| Network  |
   +-------------+              +----------+             +----------+
                                    /\
                                     |
                      5.             |
              +----------------------+
              |
              |
   +---------+          4.        +---------+     3.    +---------+
   |  Orig.  |<---------------|  Donor  |<----------| Internal |
   | Network |--------------->| Network |---------->|   NPDB   |
   +---------+       1.       +---------+     2.    +---------+
```

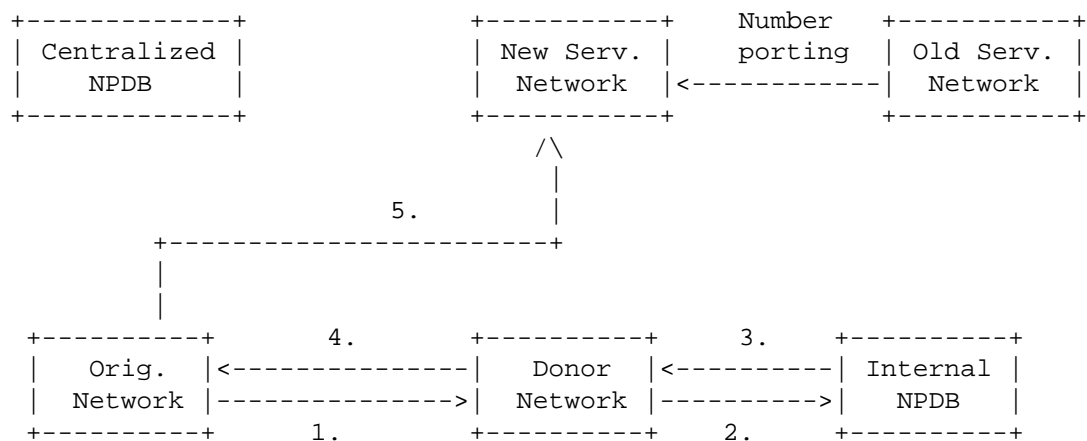   Figure 3 - Dropback Scheme.

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.

```
   +-------------+                  +-----------+   Number   +-----------+
   | Centralized |                  | New Serv. |   porting  | Old Serv. |
   |    NPDB     |                  |  Network  |<-----------|  Network  |
   +-------------+                  +-----------+            +-----------+
                                         /\
                                          |
                                       4.|
                                          |
    +----------+                     +----------+     3.    +----------+
    |   Orig.  |                     |  Donor   |<----------| Internal |
    |  Network |-------------------->|  Network |---------->|   NPDB   |
    +----------+        1.           +----------+     2.    +----------+
```
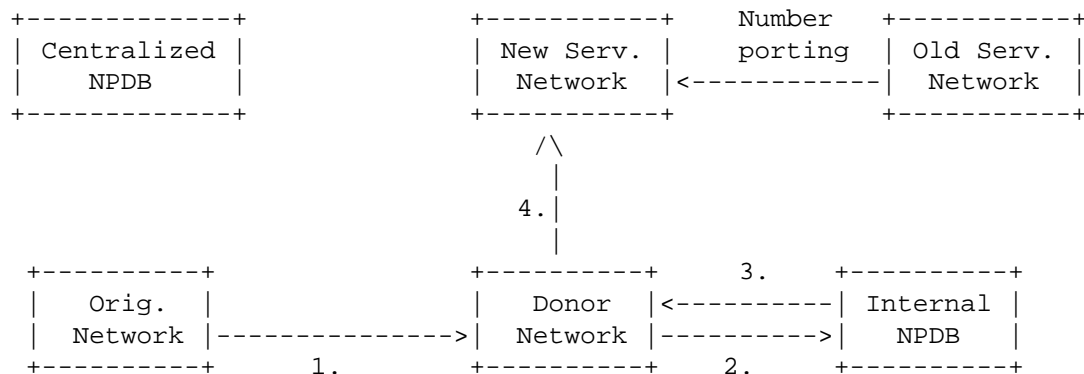
               Figure 4 - Onward Routing (OR) Scheme.

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+NXX) 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+NXX codes are marked as portable NPA+NXX 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+NXX 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 e164.arpa is chosen for "end user" ENUM, a
domain tree different from e164.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

   [ANSI OSS] ANSI Technical Requirements No. 1, "Number Portability -
              Operator Services Switching Systems," April 1999.

   [ANSI SS] ANSI Technical Requirements No. 2, "Number Portability -
              Switching Systems," April 1999.

   [ANSI DB] ANSI Technical Requirements No. 3, "Number Portability
              Database and Global Title Translation," April 1999.

   [CS1]   ITU-T Q-series Recommendations - Supplement 4, "Number
              portability Capability set 1 requirements for service
              provider portability (All call query and onward routing),"
              May 1998.

   [CS2]   ITU-T Q-series Recommendations - Supplement 5, "Number
              portability -Capability set 2 requirements for service
              provider portability (Query on release and Dropback),"
              March 1999.

   [E164]   ITU-T Recommendation E.164, "The International Public
              Telecommunications Numbering Plan," 1997.

   [ENUM]   Falstrom, P., "E.164 number and DNS", RFC 2916, September
              2000.

   [ETSIISUP] ETSI EN 302 097 V.1.2.2, Integrated Services Digital
             Network (ISDN); Signalling System No.7 (SS7); ISDN User
             Part (ISUP); Enhancement for support of Number Portability
             (NP) [ITU-T Recommendation Q.769.1 (2000), modified]

   [GSM]   GSM 09.02: "Digital cellular telecommunications system
             (Phase 2+); Mobile Application Part (MAP) specification".

   [IS41]   TIA/EIA IS-756 Rev. A, "TIA/EIA-41-D Enhancements for
             Wireless Number Portability Phase II (December 1998),
             "Number Portability Network Support," April 1998.

   [ITUISUP] ITU-T Recommendation Q.769.1, "Signaling System No. 7 -
             ISDN User Part Enhancements for the Support of Number
             Portability," December 1999.

   [MNP]   ETSI EN 301 716 (2000-10) European Standard
             (Telecommunications series) Digital cellular
             telecommunications system (Phase 2+); Support of Mobile
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16. Full Copyright Statement

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