Mobile Number Portability

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Abstract

Mobile number portability allows a mobile subscriber to switch operators without changing his/her phone number. This article describes and analyzes mobile number portability routing mechanisms and their implementation costs. We first describe the Signaling Relay Function (SRF)-based solution for call related and non-call related routing. Then we describe the Intelligent Network (IN)-based solution for call related routing. Cost recovery issues for number portability are discussed in this article from a technical perspective. We note that rules for cost recovery also depend on business and regulatory factors that vary from country to country.

Number portability is a network function that allows a subscriber to keep a "unique" telephone number. Imposed by the National Regulatory Authority and agreed upon among different network operators, number portability is one of three important mechanisms[1] to enhance fair competition among telecommunication operators and to improve customer service quality. Three types of number portability have been discussed: location portability, service portability, and operator portability. With *location portability*, a subscriber may move from one location to another without changing his/her telephone number. This type of portability is already implied in mobile phone service. With *service portability*, a subscriber may keep the same telephone number when changing telecommunication services. In the U.S., service portability between fixed telephone service and mobile phone service is implementable because both services follow the "NPA-NXX-XXXX" telephone number format. In Taiwan, the service code "09" for mobile service is distinguished from area codes of fixed telephone service. As a result, service portability cannot be made available in Taiwan unless the numbering plan is modified. With *operator portability*, a subscriber may switch telecommunications operators without changing his/her telephone number.

In most countries, location portability and service portability are not enforced, and only operator portability is implemented. There are two reasons for this. First, operator portability is considered essential for fair competition among operators, while location portability and service portability are typically treated as value-added services. Second, implementation and operation costs can be significantly reduced if service portability and location portability are not considered.

Many countries, including Australia, China, Hong Kong, Japan, Taiwan, the United Kingdom, the U.S., and numerous European countries, have implemented or are in the process of implementing fixed-network number portability. In these countries, the implementation schedule for mobile number portability typically follows that of fixed-network number portability [1, 2]. Survey studies by OFTEL (Office of Telecommunications, United Kingdom) and DGT/Taiwan indicated that most mobile operators are not enthusiastic about implementing number portability. They questioned whether there is a real demand for mobile number portability and whether it would provide significant benefits. However, number portability is considered to be a mechanism that will help a new operator or CLEC (competitive local exchange carrier) compete with the existing operator or ILEC (incumbent local exchange carrier).

Some mobile operators also claimed that the absence of number portability may not deter customers from switching operators. In the U.S., called-party-pays policy is exercised, where mobile subscribers typically pay for the air-time usage and mobility for both incoming and outgoing calls. In order not to receive undesirable calls, customers are unlikely to distribute their numbers widely. From this aspect, number portability may not be an important factor in customers' decision to change mobile operators. Thus, in the U.S., "most mobile operators fought number portability kicking and screaming, and expressed amazement that the FCC would do such an evil thing to them" [3].

On the other hand, in Taiwan or the United Kingdom, *calling-party-pays policy* is exercised, where the mobile subscribers only pay for outgoing calls and the incoming calls are paid by the callers. In this scenario, mobile customers, especially business people who have high mobility (such as salesmen, plumbers, electricians, and builders), are likely to widely distribute their numbers. Furthermore, compared with fixed-network telephone numbers, few mobile numbers are published in telephone directories. Therefore, the benefits of number portability for mobile customers are greater than for the fixed-network customers. According to a U.K. survey, without number portability, only 42 percent of corporate subscribers are willing to change mobile operators. This percentage would increase to 96 percent if number portability were introduced. In-Stat MDR polled 1,050 mobile business users and found that only 6 percent said they were likely to churn in the next 12 months, while 36.6 percent said they might. Significantly, 52 percent said they were more likely to churn if number portability were introduced [4]. Changing telephone numbers becomes a barrier to switching mobile operators, and has turned out to be a major reason why mobile operators are against mobile number portability. As pointed out, the mobile service providers know that with the hold of a unique number, customer loyalty will be even harder to keep [5].

[1] *The other two mechanisms for fair competition are equal access and network unbundling.*

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A recent OFTEL analysis shows that there will be a net gain to the United Kingdom economy of 98 m£ with the introduction of mobile number portability. NERA's analysis indicated that by introducing mobile number portability, the net benefit for Hong Kong's economy will range from HK$1,249 million to HK$1,467 million. Thus it was concluded that to improve a country's economy, the government should enforce mobile number portability.

This article introduces mobile number portability. We discuss number portability mechanisms, the costs incurred by number portability, and the cost recovery issues. We first define basic number portability terms. Originally, a telephone number is assigned to a mobile network. This network is called the *number range holder* (NRH) network. The *subscription network* is the network with which a mobile operator has a contract to implement the services for a specific mobile phone number. Originally, the NRH network is the subscription network of the customer. Suppose that a mobile phone number is ported from mobile operator A to mobile operator B; in that scenario network A is called the *donor network* or *release network*, and network B is called the *recipient network*. Before the porting process, network A is the subscription network. After porting, network B is the subscription network. The "moved" number is referred to as a *ported number*. Note that the ported number indicates the routing information to the NRH network.

Number Portability for Mobile Telecommunications Networks

Although most mobile operators are not enthusiastic about implementing mobile number portability, they cannot avoid the impact of fixed-network number portability. When a *mobile station* (MS) originates a call to a ported number in the fixed network, the originating *mobile switching center* (MSC) needs to route the call to the correct destination by using fixed-network number portability solutions. Alternatively, the MSC may direct the call to a switch in the fixed network, which then routes the call to the recipient switch. In this case, the mobile operator should reimburse the fixed-network operator for extra routing costs.

Before describing mobile number portability, we point out that an MS is associated with two numbers: the *directory* number and the *identification* number. In GSM, the *mobile station ISDN number* (MSISDN) is the directory number, which is dialed to reach the MS. In other words, MSISDN is the telephone number of the MS. The *international mobile subscriber identification* (IMSI) is a confidential number that uniquely identifies an MS in the mobile network. The IMSI is used to authenticate/identify the MS during mobile network access such as location update and call origination, which is hidden from the mobile user. When a mobile user switches operators, a new MSISDN and IMSI pair is assigned to the user. When mobile number portability is introduced, the mobile user would keep the MSISDN (the ported number) while being issued a new IMSI. In other words, IMSI shall not be ported. When the ported number ceases to be an active service number, the number is returned to the NRH network. Note that lawful interception shall be possible on a ported MSISDN.

For mobile systems based on ANSI IS-41 [6, 7], the identification number and the directory number are referred to as the *mobile identification number* (MIN) and the *mobile directory number* (MDN), respectively. Mobile operators typically assume that both MIN and MDN have the same value and are used interchangeably. The MIN/MDN is of the format NPA-NXX-XXXX, where the first six digits NPA-NXX identify the home system of the MS. Without this home network identification, roaming is not possible. The MDN is used as the calling party number parameters in signaling and billing records. If mobile number portability is introduced, the MIN will be different from the MDN. In such a case, using the MIN as the calling party number will result in misrouting in services such as automatic callback and calling number/calling name presentation. Similarly, using MDN for location update will result in errors when performing the registration procedure. Thus, to support portability, separation of MIN and MDN is required for the IS-41-based systems. This means that extra costs will be incurred to modify mobile software in the MSC, the *home location register* (HLR), the *visitor location register* (VLR), the billing system, and so on.

Following the above discussion, the impact of number portability on the mobile network is considered in three aspects.

- **Location Update:** The identification number (IMSI or MIN) is used in the location update procedure. Since the assignment of this number is not affected by the introduction of number portability, location update is not affected by portability except that MIN/MDN separation is required for the IS-41-based systems.
- **Mobile Call Origination:** As mentioned in the beginning of this section, to originate a call to a ported number, the MSC needs to be equipped with a number portability routing mechanism.
- **Mobile Call Termination:** To deliver or terminate a call to a ported mobile number, the standard mobile call termination procedure must be modified to accommodate the portability mechanism.

The U.S. will introduce number portability to mobile operators in two phases. In phase 1, mechanisms for mobile to (ported) fixed-network calls are implemented. In phase 2, the MIN/MDN separation, as well as the mobile call termination mechanism, is implemented.

Number Portability Call Routing Mechanisms

In mobile service, the network tracks the location of every MS. The location information is stored in two mobile databases, the HLR and the VLR. To deliver a call to an MS, the databases are queried for routing information of the MSC where the MS resides. Figure 1 illustrates a simplified GSM call termination procedure where the interaction between the HLR and the VLR are omitted. Refer to [6, 8] for the detailed call termination procedure without number portability. The message flow is described in the following steps.

- **Step GSMCT.1:** When the calling party dials the MSISDN of a mobile station MS2, the call is routed to the *gateway MSC* (GMSC) of MS2 using the *ISDN user part* (ISUP) `initial address message (IAM)`.
- **Step GSMCT.2:** The GMSC queries the HLR to obtain the mobile station roaming number (MSRN), the address of the terminating MSC where MS2 resides.
- **Step GSMCT.3:** Based on the MSRN, the `IAM` message is routed to the destination MSC, and the call is eventually set up.

In Fig. 1, the terminating network (where the MS resides) may be different from its subscription network. Call termination to the MS must be routed to the GMSC at the subscription network due to the following restrictions.

- **Restriction 1:** The GMSC must be in the call path for the provision of special features and services as well as for billing.

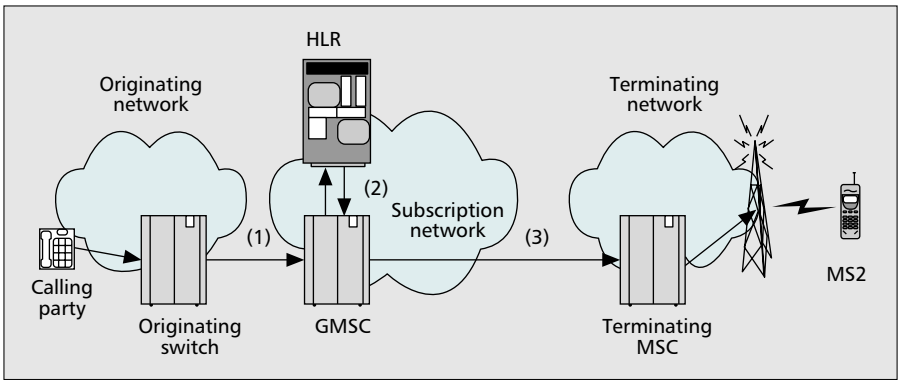

Figure 1. *A simplified GSM call termination procedure without number portability.*

• **Restriction 2:** The originating switch does not have the capability to query the HLR database, which must be done by the GMSC through the *mobile application part* (MAP) C protocol (the protocol between the GMSC and the HLR).

To support mobile number portability, call termination in Fig. 1 should be modified. In 3GPP TS23.066 [9], two approaches are proposed to support number portability call routing: a *Signaling Relay Function* (SRF)-based solution and the *Intelligent Network* (IN)-based solution. Both approaches utilize the *number portability database* (NPDB) that stores the records of the ported numbers. The record information includes the ported MSISDN, the status (active or pending), the time stamps (when the ported number record is created, activated, disconnected, and modified), the NRH mobile operator, the subscription operator, and the routing information. The routing information includes several addresses to support applications such as switch-based services (i.e., CLASS), calling card, and short message service. For non-ported numbers, no records will be maintained in the NPDB. The call routing mechanisms are described in the following subsections.

The SRF-Based Solution for Call Related Signaling

The SRF-based solution utilizes the MAP protocol. The SRF node is typically implemented on the *signal transfer point* (STP) platform [6]. Three call setup scenarios have been proposed for the SRF-based approach: *direct routing*, *indirect*

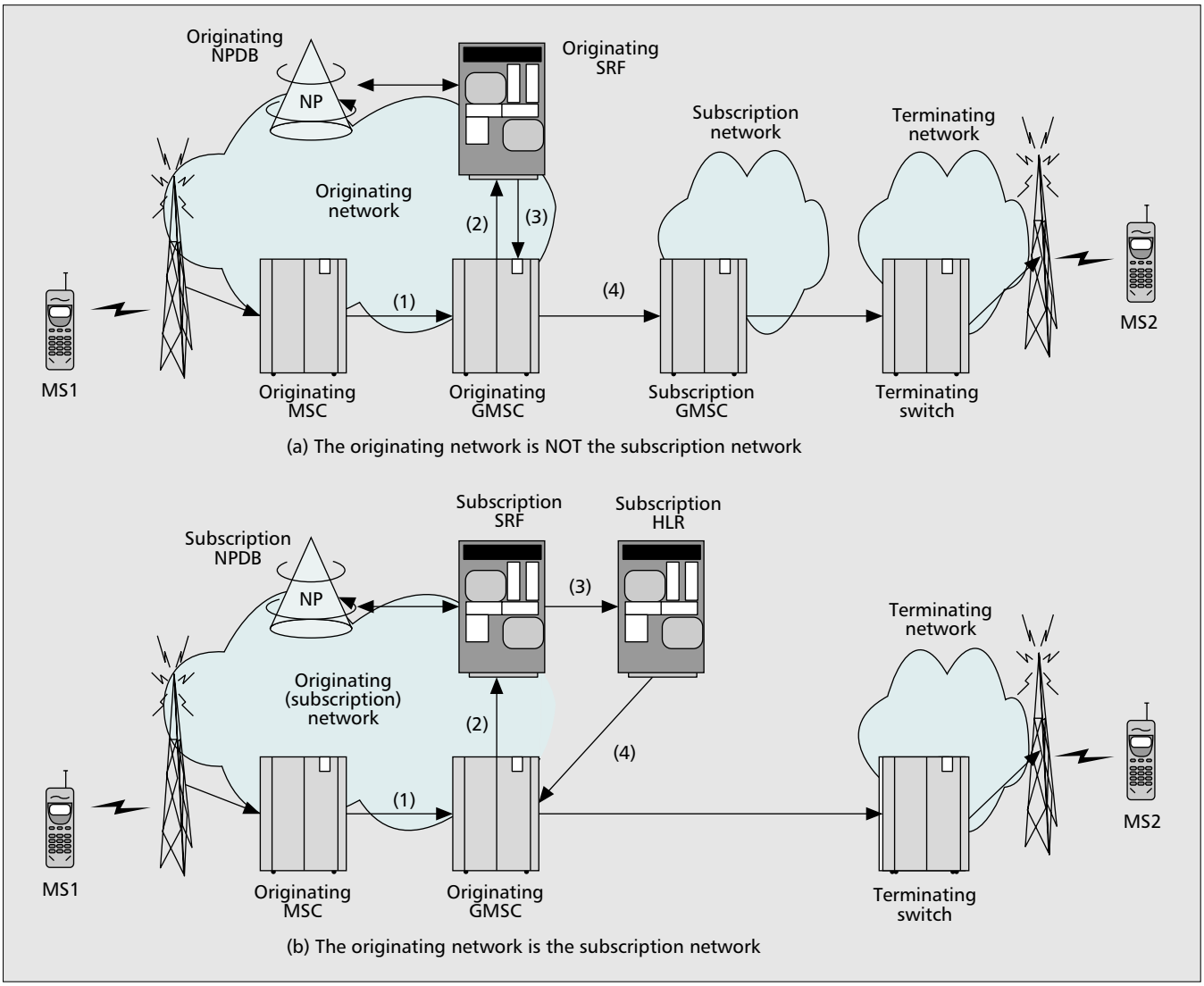

Figure 2. *SRF-based directed routing (DR).*

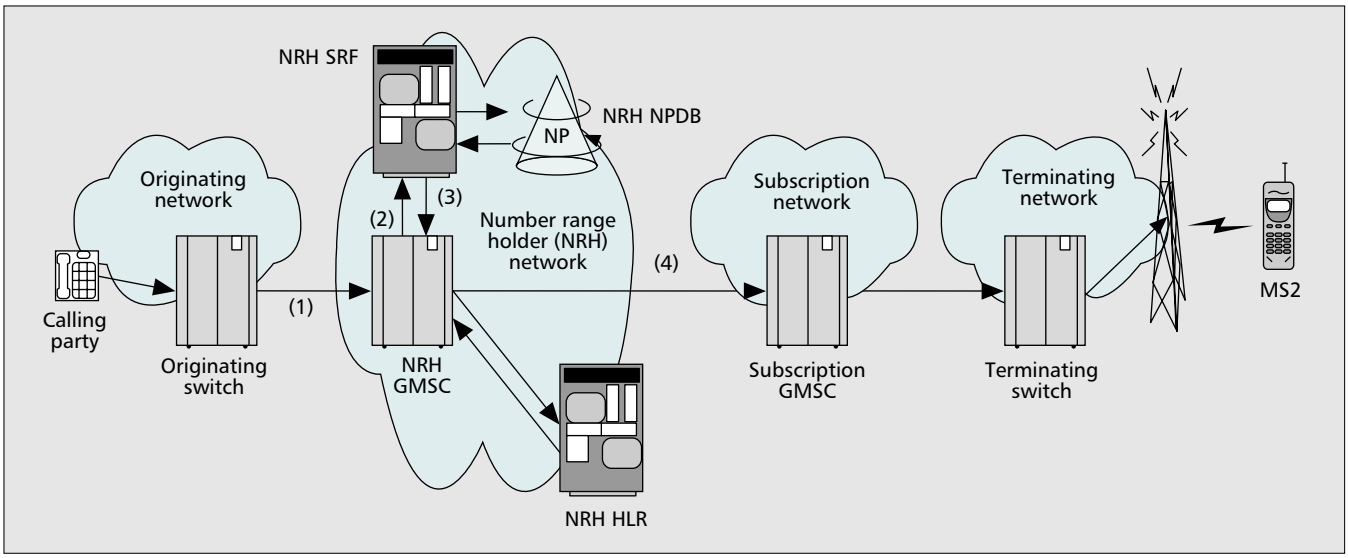

Figure 3.SRF-based indirect routing (IR-I).

routing, and *indirect routing with reference to the subscription network*. These scenarios are elaborated as follows.

Direct Routing Scenario (DR) — The mobile number portability query is performed in the originating network, which is basically the same as the *all-call-query* approach in fixed-network number portability [6]. All call related messages for ported and non-ported subscribers are acknowledged with appropriate routing information in order to route the call to the subscription network. Figure 2a illustrates a DR call from a mobile station MS1 to a ported mobile station MS2 with the following steps:

- **Step DR.1:** MS1 dials the MSISDN of MS2. An ISUP `IAM` message is routed from the originating MSC to the originating GMSC (the GMSC in the originating network). As mentioned in **Restriction 2**, only the GMSC is equipped with the MAP C protocol to communicate with the HLR/SRF.
- **Step DR.2:** The originating GMSC issues the MAP `send routing information` message to the SRF.
- **Step DR.3:** By consulting the NPDB (possibly through the MAP or *intelligent network application part* (INAP)), the SRF obtains the subscription network information of MS2 and forwards the information to the originating GMSC.
- **Step DR.4:** The originating GMSC then routes the `IAM` message to the GMSC of MS2 in the subscription network. After this point, the call is set up following the standard GSM procedure described in Steps GSMCT.2 and 3.

In Step DR.3, the SRF provides the *routing number* (RN) to the originating GMSC. The RN consists of a RN prefix plus the MSISDN of the called party. The RN prefix points to the subscription GMSC, which may also provide the HLR address of the called party. (Note that the subscription networks may have several HLRs, and the HLR address cannot be simply identified by the MSISDN.) If so, the subscription GMSC can access the subscription HLR directly in Step GSMCT.2. If the prefix does not provide the HLR information, then the subscription GMSC must utilize the SRF to route the `send routing information` message to the HLR. Details provided by the RN prefix may be constrained by issues such as security (of the subscription network) and length limit [10]. In Germany, the routing prefix format is `Dxxx` where `D` is a hex digit and `x` is a decimal digit.

If the originating network is the subscription network of MS2, then as illustrated in Fig. 2b, in Steps 3 and 4 the SRF sends the `send routing information` message to the subscription HLR, and the HLR returns the MSRN of MS2 to the originating GMSC (which is also the GMSC of MS2), and the call setup proceeds to Step GSMCT.3.

Indirect Routing Scenario (IR-I) — The mobile number portability query is done in the number range holder (NRH) network, which is similar to *onward routing* (remote call forwarding) in fixed-network number portability [6]. All call related messages for ported subscribers are acknowledged with appropriate routing information in order to route the call to the subscription network. Figure 3 illustrates the IR-I call setup to a ported mobile station MS2 with the following steps.

- **Step IR-I.1:** The calling party dials the MSISDN of MS2, and the `IAM` message is routed to the NRH GMSC of MS2.
- **Step IR-I.2:** The NRH GMSC queries the SRF using the MAP `send routing information` message.
- **Step IR-I.3:** By consulting the NPDB, the SRF obtains the subscription network information of MS2 (the RN prefix points to the subscription GMSC) and forwards the information to the NRH GMSC.
- **Step IR-I.4:** The NRH GMSC then routes the `IAM` message to the GMSC of MS2 in the subscription network. After this point, the call is set up following Steps GSMCT.2 and 3. As mentioned in the DR scenario, if the RN information provided in Step IR-I.3 does not point out the HLR location, then subscription SRF is queried in Step GSMCT.2.

Indirect Routing with Reference to the Subscription Network Scenario (IR-II) — The mobile number portability query is done in the NRH network. All call related signaling messages for ported subscribers are relayed to the subscription network. Figure 4 illustrates the IR-II call setup to a ported mobile station MS2 with the following steps.

- **Step IR-II.1:** The calling party dials the MSISDN of MS2, and the `IAM` message is routed to the NRH GMSC of MS2.
- **Step IR-II.2:** The NRH GMSC queries the SRF using the MAP `send routing information` message.
- **Step IR-II.3:** By consulting the NPDB, the NRH SRF identifies that the called party's MSISDN is ported out. The NPDB provides the RN prefix pointing to the SRF in the subscription network. The NRH SRF relays the `send routing information` request to the subscription SRF.
- **Step IR-II.4:** By consulting the NPDB, the subscription SRF identifies the GMSC of MS2, and returns the routing information to the NRH GMSC.

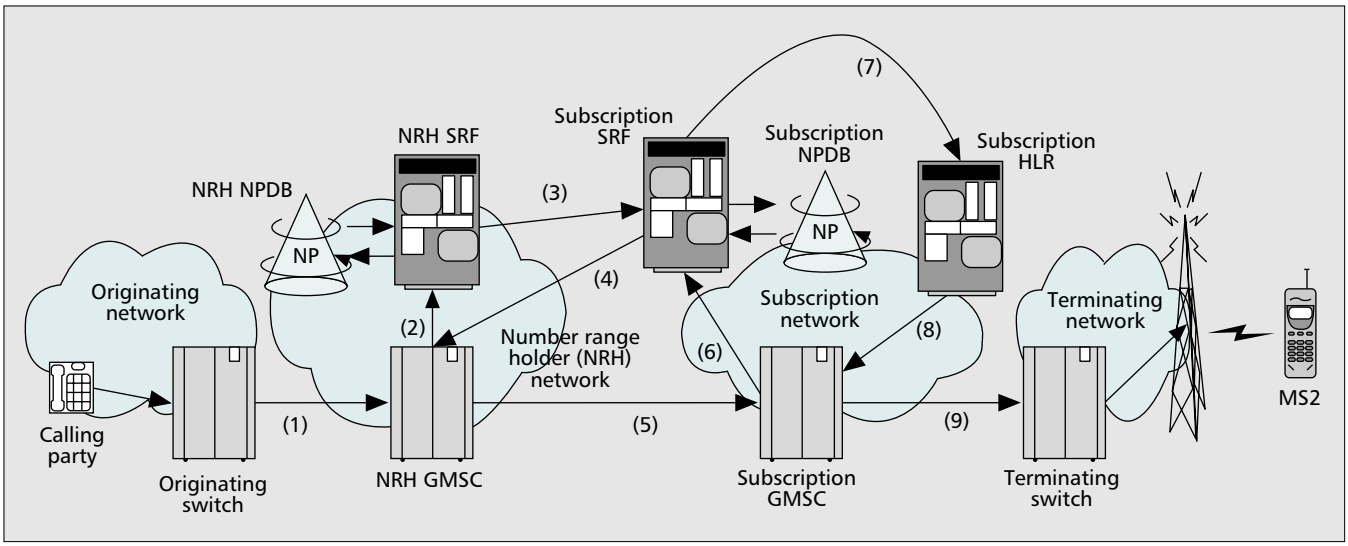

Figure 4. *SRF-based indirect routing with reference to the subscription network (IR-II).*

- **Step IR-II.5:** The NRH GMSC then routes the `IAM` message to the GMSC of MS2 in the subscription network.
- **Steps IR-II.6-8:** These steps are the same as Step GSMCT.2 except that the HLR is queried indirectly through the SRF.
- **Step IR-II.9:** After the NRH GMSC has obtained the MSRN of MS2, Step GSMCT.3 is executed.

The SRF-based DR is utilized when the originating network has the GMSC that can query the SRF, and a routing mechanism exists for the originating switch (that connects to the calling party) to access the GMSC. For a mobile-to-mobile call, this scenario incurs the lowest cost. IR-I is basically the same as onward routing proposed in fixed network number portability [6]. For a fixed-to-mobile call, this scenario is recommended so that the fixed networks do not need to make any modifications due to the introduction of mobile number portability. IR-II is typically used for international call setup where the NRH network and the subscription network are in different countries.[2] To exercise DR, the originating NPDB should contain records for all ported numbers in the portability domain. On the other hand, the NRH NPDB in IR-I and IR-II only needs to contain the numbers ported out of the NRH network, and the subscription NPDB only needs to contain the numbers ported in the subscription network.

The SRF-based Solution for Non-Call Related Signaling

For non-call related signaling such as short message delivery [6, 11] and *Call Completion on Busy Subscriber* (CCBS), no voice trunk setup is involved, and the message flows are different from those described earlier. We describe the *Short Message Service* (SMS) for the SRF-based direct and indirect routing scenarios.

Short Message Service Direct Routing Scenario (SMS-DR) — Figure 5 illustrates a DR short message to a ported mobile station MS2 with the following steps.

- **Step SMS-DR.1:** The SM-SC issues the short message to the SMS GMSC in the same interrogating network using a proprietary interface. In most GSM implementations, the SM-SC is colocated with the SMS GMSC. The term "interrogating network" means that the network will interrogate the HLR for a non-call related signaling message.
- **Step SMS-DR.2:** The SMS GMSC queries the SRF in the interrogating network.
- **Step SMS-DR.3:** By consulting the NPDB, the interrogating SRF identifies that the called party's MSISDN is ported. The interrogating SRF relays the routing query message to the SRF in the subscription network.
- **Step SMS-DR.4:** By consulting the NPDB, the subscription SRF identifies the HLR of MS2, and forwards the routing query message to the HLR.
- **Step SMS-DR.5:** The HLR returns the MSRN of MS2 to the interrogating SMS GMSC.
- **Steps SMS-DR.6:** The interrogating SMS GMSC forwards the short message following the standard SMS delivery procedure [6, 11].

Short Message Service Indirect Routing Scenario (SMS-IR) — Figure 6 illustrates an indirect-routed short message to a ported mobile station MS2 with the following steps.

- **Step SMS-IR.1:** Like Step SMS-DR.1, the SM-SC issues the short message to the SMS GMSC in the same interrogating network.
- **Step SMS-IR.2:** The SMS GMSC queries the NRH SRF.
- **Step SMS-IR.3:** By consulting the NPDB, the NRH SRF identifies that the called party's MSISDN is ported out. The NRH SRF relays the routing query message to the SRF in the subscription network.
- **Steps SMS-IR.4-6:** These steps are similar to Steps SMS-DR.4.-6.

Note that the major difference between SMS-DR and SMS-IR is the execution of Step 2. In direct routing, the interrogating network has its own SRF to forward the routing query message to the subscription HLR.

The-IN based Solution for Call Related Signaling

There are two IN-based solutions for querying the NPDB: ETSI Core INAP and ANSI IN Query [9]. The IN solution is implemented in the service control point (SCP). The major differences between the IN and the SRF solutions are described below.

- Any switch equipped with the IN protocol can query the NPDB. In the SRF solution, only GMSC equipped with the MAP C protocol can query the SRF (see **Restriction 2**).
- The IN approach does not support the non-call related sig-

[2] *IR-II is preferred for international calls because the originating network/country does not have NP information for the subscription network's country.*

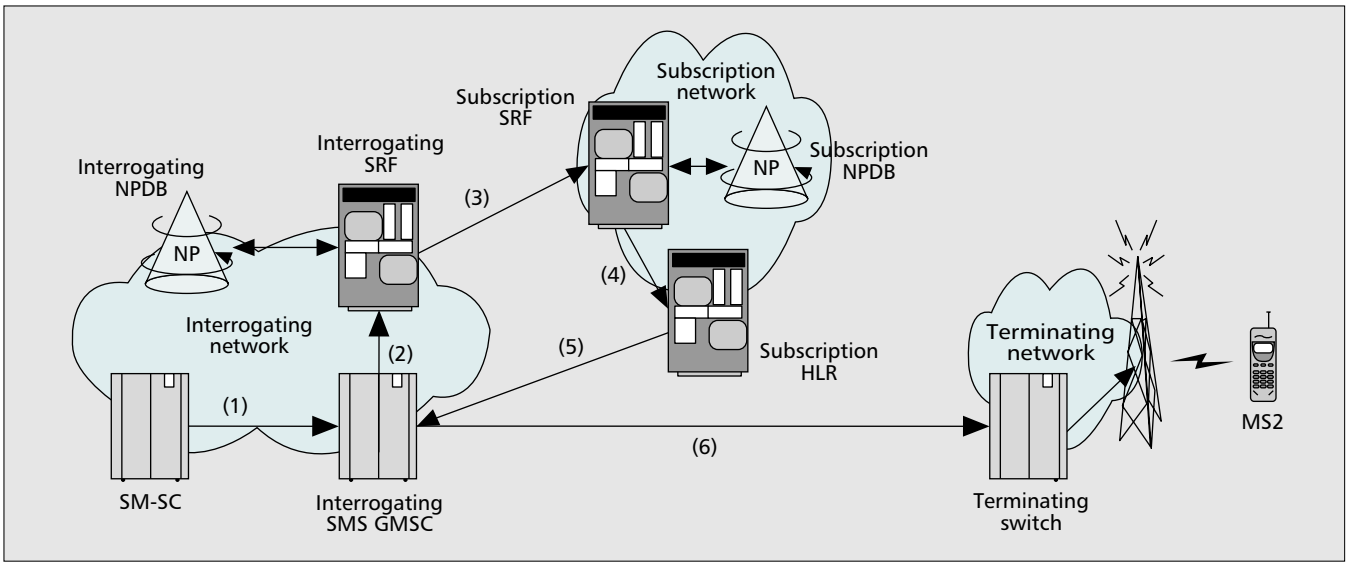

Figure 5. *SRF-based SMS-direct routing (SMS-DR).*

naling messages. Note that the IN approach can support non-call related signaling messages if the message sender first performs an IN query and uses the routing number for routing the signaling message. But this is usually not done in current NP implementations.

To route the calls, three scenarios have been proposed for the IN-based number portability solutions. *Originating call Query on Digit analysis* (OQoD) is similar to direct routing in the SRF-based approach, except that the originating switch can directly query the NPDB using the IN protocol. *Terminating call Query on Digit analysis* (TQoD) is similar to indirect routing (IR-I) in the SRF-based approach. The third scenario of the IN-based approach is called *Query on HLR Release* (QoHR). The message flow of QoHR is illustrated in Fig. 7 and the steps are described as follows.

- **Step QoHR.1:** The calling party dials the MSISDN of MS2. The originating network routes the call to the GMSC of the NRH network.
- **Step QoHR.2:** The NRH GMSC first queries its HLR for the routing information. If MS2 is ported, the NRH HLR replies with the "unknown subscriber" error, which triggers the NRH GMSC to query the NPDB.
- **Step QoHR.3:** Using the INAP `initialDP` message, the NRH GMSC queries the NPDB with the MSISDN of MS2. The NPDB returns the routing number pointing to the subscription network through the INAP connect message.[3]
- **Step QoHR.4.** The NRH GMSC sends the IAM message to the subscription GMSC. Then Steps GSMCT.2 and 3 are executed for call setup. If the RN prefix obtained in Step QoHR.3 does not provide the HLR information, then the subscription GMSC may not be able to identify the HLR from the MSISDN. This issue has not been addressed in

[3] *If no entry is found in the NPDB, the INAP Continue message is returned.*

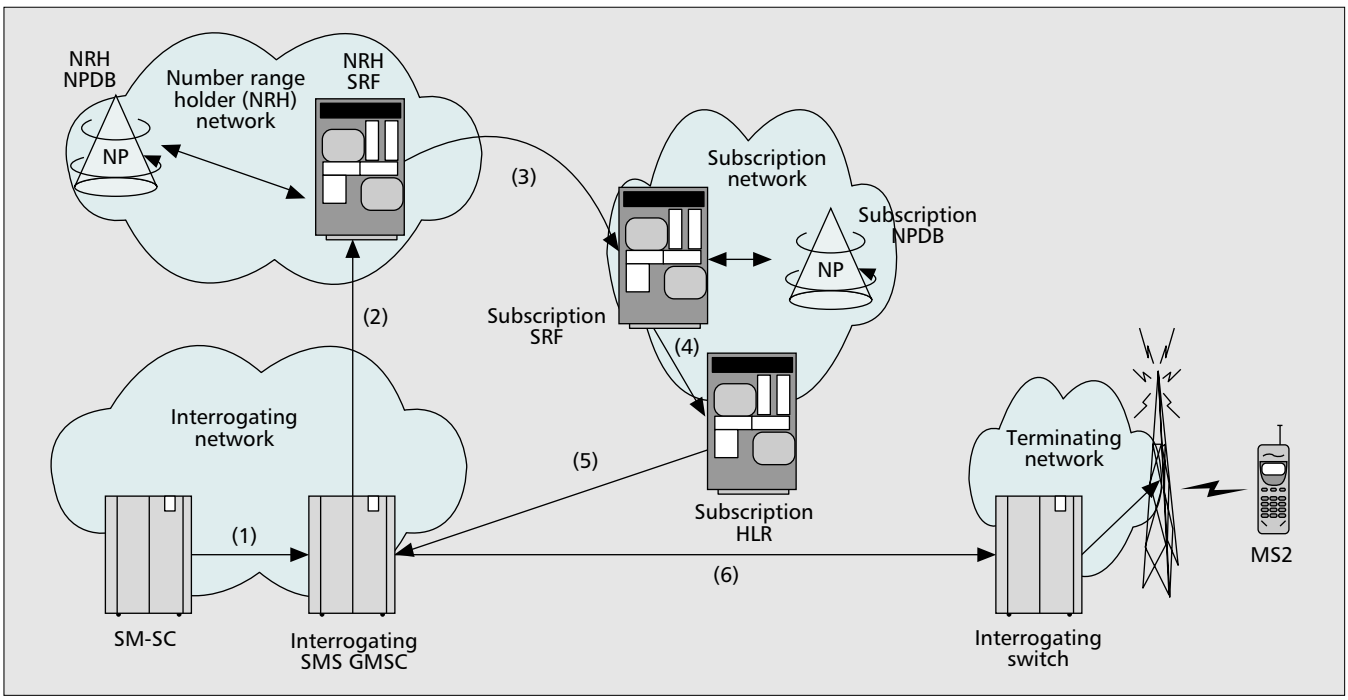

Figure 6. *SRF-based SMS-indirect routing (SMS-IR).*

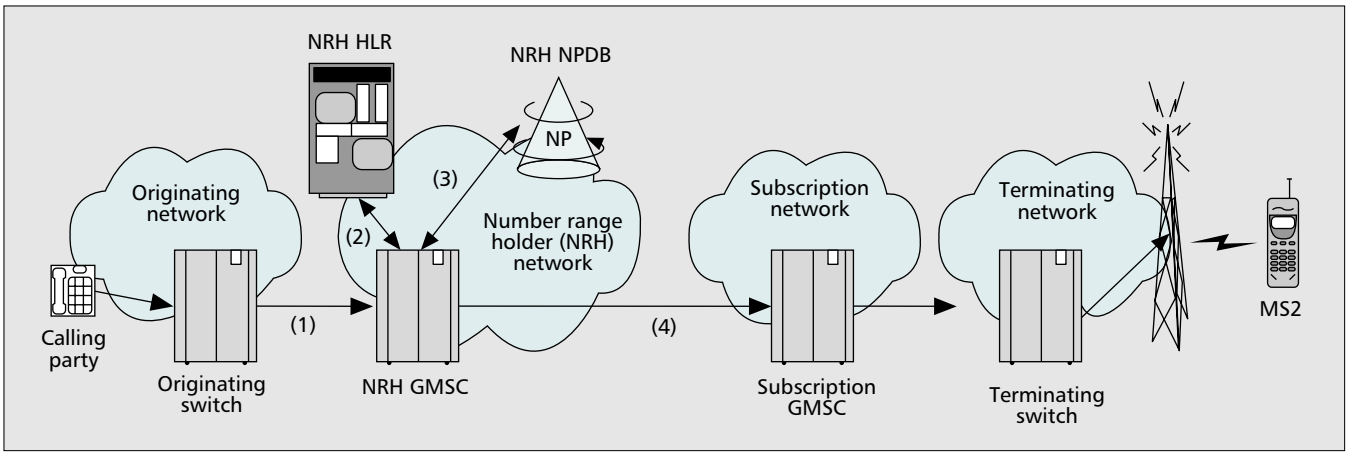

Figure 7. *IN-based query on HLR release (QoHR).*

any specifications [9]. To resolve this problem, a function similar to SRF may need to be implemented in the subscription GMSC to find out the HLR for the ported-in MSISDN.

If the MSISDN of MS2 is not ported, then the NRH network is the same as the subscription network, and Steps QoHR.3 and 4 are not executed. It is clear that the routing cost for OQoD (direct routing) is lower than TQoD (indirect routing). If MS2 is not ported, the routing cost for QoHR is lower than that for OQoD. If MS2 is ported, the result reverses. To exercise OQoD, the originating NPDB should contain records for all ported numbers in the portability domain. On the other hand, the NRH NPDB in QoHR and TQoD only needs to contain the numbers ported out of the NRH network, and the subscription NPDB only needs to contain the numbers ported in the subscription network. Therefore, if the population of ported subscribers is small (for example, less than 30 percent), QoHR is a preferred mobile number portability solution.

Number Porting and Cost Recovery

When a number is ported from the donor operator to the recipient network, the NPDBs of all operators in the portability domain may need to be updated. Number porting is an offline administrative process that can be performed centrally by a neutral third party or distributed among the participating mobile operators. This section describes the number porting mechanisms, then discusses the cost recovery issues.

Number Porting Administration

We use the North America *Number Portability Administration Center* (NPAC) and Hong Kong *Central Ticketing System* (CTS) models to illustrate number porting administration [12]. Mandated by regulators and service providers, North America NPAC is administered by a neutral third party that has a fix-term contract. When the contract expires, the new NPAC is selected through open bidding, and the system ownership is transferred to the new NPAC. The functions of the NPAC include service provider data administration, subscription data administration, audit administration, resource accounting, billing and cost apportionment, and so on. The NPAC is designed to support various types of number portability, and is developed according to standardized functional requirements and interface specifications that are maintained in the public domain. Note that the NPAC supports the master database and is not involved in individual call setups. Figure 8 illustrates the connectivity between the NPAC and a mobile operator. In this figure, the facilities of a mobile operator are *service order administration* (SOA), *local service management system* (LSMS), and the NPDB. The interface among these components is CMISE. The SOA connects to the NPAC SMS for service order processing. An SOA transaction with the NPAC must complete within two seconds or less. The LSMS connects to the NPAC SMS for database updates. The services offered by the NPAC SMS are available 99.9 percent of the time, and the unavailability of scheduled services should not exceed two hours per month. After a record is activated in the NPAC SMS, this change should be broadcast to the LSMSs within 60 seconds. The NPAC should respond to both the SOA and the LSMS within three seconds. Ninety five percent of the NPAC to LSMS transactions must occur at a rate in accordance with the performance improvement plan. Every NPDB connects to the corresponding LSMS for accessing the record of each active ported number. Therefore, switch routing information and network element identification are kept in the NPDB. When a number is ported, the NPAC SMS updates the LSMSs (and therefore the NPDBs and the HLRs) of the participating operators.

In Hong Kong's number porting administration, a Central Ticketing System (CTS) is shared by all operators as illustrated in Fig. 9. The CTS connects to several *administrative databases* (ADs) owned by or leased to the mobile operators. Every AD is connected to the NPDBs of a mobile operator. To port a number, the recipient operator issues a request to the CTS. The CTS approves a limited number of porting requests (5,000–10,000 requests per day) to ensure that the subscribers will not change operators too frequently. The ADs transfer a service order between donor and recipient opera-

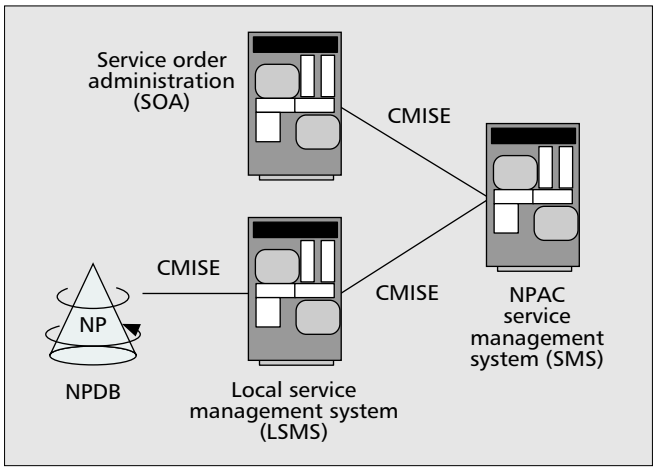

Figure 8. *Connectivity between the NPAC and a mobile operator.*

tors, and notify other network operators when the service order is confirmed. Therefore, the porting process is performed in the distributed manner among the ADs. The ADs also update the NPDBs during the daily cutover window. Table 1 lists all possible scenarios for administrative actions in number porting. For example, in number porting scenario III (where neither the donor network nor the recipient network is the NRH network), the databases of the donor network are modified as follows: the HLR record of the ported number is deleted, and the subscription operator field of the NPDB record is set to the recipient network. Note that the order of the sequence for the administrative actions to be performed both within a network and by different network operators is significant with respect to prevention of disruption in service to the mobile subscriber and prevention of looping calls between networks during the porting process.

Scenario	Donor HLR	Subscription HLR	All NPDB
Donor = NRH*	Delete	Add	Add
Subscription = NRH	Delete	Add	Delete
Neither	Delete	Add	Update
* NRH: the number range holder network			

Table 1. *Administrative actions in number porting.*

Costs of Number Portability

To support number portability, the following costs are incurred: initial system setup costs, customer transfer costs, and call routing costs.

Initial system setup includes the costs for number portability system development, network management, line testing (for fixed networks), operator services, billing information, exchanges overlay, maintenance, and support. Initial system setup costs were estimated to be £ 8.01 millions for BT's mobile number portability [13]. In-Stat/MDR predicted that mobile number portability implementation would cost the U.S. wireless industry up to US$1 billion in setup costs [4].

Customer transfer costs or per-line setup costs are incurred when moving a ported number from the donor operator to the recipient operator. The costs include closing down an old account, opening up a new account, and coordinating physical line switching (for fixed networks). The transfer cost for a mobile ported number is estimated to be £ 19. Some number portability studies considered the customer transfer costs as a part of number portability overhead. It is clear that a major part of the costs exists even if number portability is not implemented. However, extra coordination between the number range holder, the donor, and the recipient operators is required to transfer a ported number. Furthermore, issues such as "what to do when a customer who left bad debt to the donor operator moves to the recipient operator with the ported number" should be carefully resolved. In-Stat/MDR predicted that mobile number portability implementation will cost the U.S. wireless industry up to US$500 million in annual running costs [4].

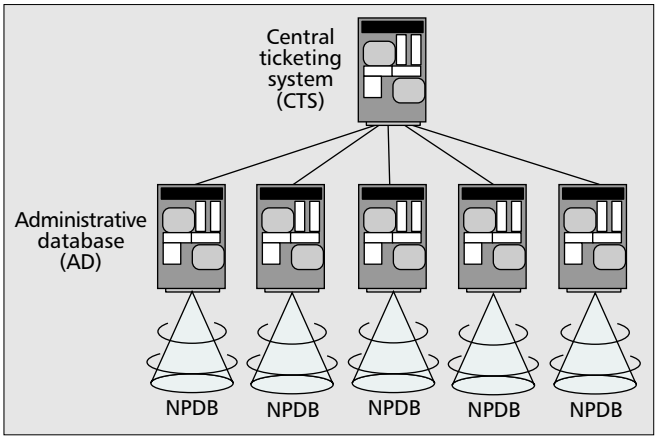

Figure 9. *Connectivity between the CTS and mobile operators.*

There has been a long argument regarding who should cover the costs for number portability. Some argued that the ported customers should cover the costs for number portability. Others concluded that the number portability costs should be borne by all telecommunication users for the following reasons:

- Number portability should be treated as a "default function" instead of an added-value service. Since all users have the opportunity to reach ported numbers, they all benefit from number portability.
- If the cost for a ported number is significantly higher than a non-ported number, then the users will be discouraged from utilizing the number portability feature. If so, the original goal to provide fair competition and service quality improvement will not be achieved. Depending on telecommunication policies, different countries may make different decisions for cost recovery [14].

Most studies suggest that operators should bear their own costs for initial system setup. For customer transfer costs, the donor operator should bear the cost for closing down an account, and the recipient operator should bear the cost for opening up a new account. In indirect routing, the subscription operator needs the NRH operator's assistance to transfer the ported customers. Thus, to require reimbursement from the recipient or originating operators to the donor operator is reasonable. The recipient operator could charge the customers for importing their numbers. For fixed network number portability in the U.S., the FCC's 3rd Report & Order (CC 95-116) pointed out that this cost could be recovered via monthly end-user charges. Monthly charges range from US$.23 (Verizon) to US$.43 (US West) to US$.48 (Sprint Local) per line. It is not anticipated that donor operators will charge customers who move out with ported numbers. In the North America NPAC model, the participating operators should cover the costs of NPAC. For fixed network number portability in the U.S., the FCC's 3rd Report & Order (CC 95-116) identified the cost for NPAC recurring and nonrecurring administration, and it is shared by all fixed network operators based on regional end-user revenue. In Canada, Telecom Order 97-1243 set the ported number transaction charge at C$5.00. Telecom Order 98-761 Stentor proposed a query charge of C$1.05 per 1,000 queries [12].

Conclusions

This article introduced mobile number portability. We described and analyzed number portability routing mechanisms and their implementation costs. We first described the SRF-based solution for call related and non-call related routing, then we described the IN-based solution for call related routing. In these routing mechanisms, if the population of the ported subscribers is small, the NPDB can be integrated with the MSC. Typically a NPDB contains millions of entries. The throughputs of most SRF/NPDB products are up to several thousands of transactions per second. To implement the routing mechanisms, the government needs to specify the routing number (RN) plan. In both the United Kingdom and Spain, the SRF approach is used. In both Hong Kong and Australia,

the operators can choose either the SRF or IN approach. In the above four countries, the network interface is standard ISUP. In the U.S., the Advanced IN approach is used, and the network interface is ANSI ISUP with LRN enhancement. In Portugal, the IN approach is used, and the network interface is standard ISUP with query on release. In most of these countries and Germany as well, the originating networks are responsible for querying NPDB.

Cost recovery issues for number portability were discussed in this article from a technical perspective. We should point out that rules for cost recovery also depend on business and regulatory factors, which vary from country to country. Several surveys for number portability have been conducted by OFTEL [13, 15], NERA [16], DGT/Taiwan [17], and OVUM [18]. An excellent overview for NP can be found in [12]. Service portability between fixed telephone service and mobile phone service is discussed in [19]. MDN/MIN issues for mobile number portability are described in [19].

As a final remark, mobile number portability may affect existing services. For example, it is difficult to provision the prepaid services and friendly tariff (e.g., special tariff D1 to D1) when mobile number portability is exercised. For further reading, refer to the following Web sites for the most up to date information.

- Office of the Telecommunications Authority (Hong Kong): www.ofta.gov.hk/mnp/main.html
- Office of Telecommunications (UK): www.oftel.gov.uk (search with "mobile number portability")
- Number Portability Administration Center: www.npac.com
- Ported Communications: www.ported.com
- FCC: www.fcc.gov/ccb/nanc
- NeuStar: www.neustar.com
- North American Number Plan Administration: www.nanpa.com

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