

Provision of Global Number Portability Using CORBA

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Abstract

Global Number Portability (GNP) is becoming a key service to increase competition and profit of a service provider for the ever-growing telephone marketplace. In this paper, we propose an architecture for providing GNP by extending the structure of the legacy Local Number Portability (LNP) scheme of Number Portability Administration Center Service Management System (NPAC SMS). The architecture is based on CORBA, so that the proposed system can be well integrated with other management systems. We have defined the interfaces using CORBA IDL to enable NPAC SMS to communicate with each other, and designed the procedures for managing routing numbers in multiple LNP domains. CORBA-based GNP management system can enhance the interoperability required for the integration of different LNP management systems.

Keywords

Global Number Portability, Local Number Portability, Number Portability, NPAC, Intelligent Network, CORBA

1. Introduction

Number portability is the ability to change the location, the service provider, or the service while retaining the same telephone number. It can be classified into three types such as the location portability, the service provider portability and the service portability. With all three types, subscribers are allowed to keep their numbers, move to other locations, access to other service providers, and access to other services [1].

Local Number Portability (LNP) is the ability that supports number portability within a local area domains. The ability that could support number portability through the world is referred to as Global Number Portability (GNP). GNP can provide the number portability service across the multiple LNP domains. In order to avoid the drastic change of the existing numbering infrastructure, it is necessary to provide GNP service while maintaining the structure of LNP. In order to support GNP based on LNP architecture, interfaces across the multiple LNP domains should be defined. The management procedure of LNP should be changed, and the routing number information be redefined. Routing number is the same form as a telephone number (TN) used to identify the TN's serving switch when the TN is a ported number. The support of GNP is the ultimate aim of LNP system.

To provide number portability in any area, LNP uses various routing number methods such as Location Routing Number (LRN), Remote Call Forwarding (RCF) and Carrier Portability Code (CPC) for the LNP domain [3-8]. There exists neither country code nor area code in the routing number scheme of LNP since it provides number portability merely in a local area. The ambiguity of the routing number in the LNP scheme prevents its use in the multiple LNP domains. To solve this problem, the proper conversion of the routing numbers is required between the different LNP domains.

There have been some research works on the provision of GNP using LNP scheme by ITU [3] and others [4,5]. They have focused on the conversion scheme at the level of the network element layer. In these approaches, Number Translation Service (NTS) is used to convert the routing numbers [4,5]. In the United States, LNP is supported by Number Portability Administration Center Service Management System (NPAC SMS) which manages LNP via the interfaces between NPAC SMS and Local Service Order Administration (LSOA) or Local Service Management System (LSMS). To support GNP, the communication interfaces between the different NPAC SMSs should be provided which is, however, not defined yet [7,8].

In this paper, we propose a new number portability architecture for supporting GNP by extending NPAC SMS. The architecture includes the Data Exchanger Module and the RN Generation Module. These modules communicate with other NPAC SMSs and re-generate the routing number, if needed. We define the interface that is needed for NPAC SMS to communicate with another NPAC SMS. We design the procedures for managing GNP and re-generating the routing number. The architecture is based on CORBA, so that the proposed system can be well integrated with other management systems.

The content of the paper is as follows. In Section 2, we describe previous works and current research issues with respected to number portability. In Section 3, we present the basic idea and propose the new architecture for providing GNP. In Sections 4, we show the procedures for supporting GNP with NPAC SMS, and show GNP management in CORBA environments, proposing the interface across multiple LNP domains. Finally, we conclude in Section 5.

2. Previous Works and Research Issues

There are many research activities related to number portability such as ITU [3], Office of Telecommunication (OFTEL) [4,5], Office of the Telecommunications Authority (OFTA) [6] and North America Number Council (NANC) [7,8].

The specification proposed by ITU can support the geographic/non-geographic number portability using the routing number protocols such as Complete Routing Number (CRN) and Partial Routing Number (PRN). For the geographic number portability, CRN contains the recipient exchange data. For the non-geographic number portability, CRN contains the information of the recipient network [3].

In United Kingdom, the Office of Telecommunication (OFTEL) proposes the number portability specification. This method can support number portability between the local areas using the Number Translation Service (NTS) while distinguishing the ported number from non-ported number by attaching the area specific prefix [4,5].

OFTA proposes the distributed method for providing number portability. In addition to the routing number database residing in each service provider, a conceptually centralized but physically duplicated database is found to be essential to facilitate number portability by the database solution [6]. The service provider can backup the accidental loss of the database because each service provider contains the identical database for number portability. However, there is a problem when the service area is expanded because the volume of the database may be drastically increased.

In the specification of NANC, LNP in an area depends on one NPAC SMS. NPAC SMS manages several service providers that include the LSOA and LSMS. It has the interface to communicate with Local Service Order Administration (LSOA) or Local Service Management System (LSMS) [7,8]. The large amount of data for supporting LNP is handled in NPAC SMS. However, there is no way for a NPAC SMS to communicate with another NPAC SMS. It is not feasible to support number portability across the multiple LNP domains.

In a general LNP management using NPAC SMS, NPAC SMS analyzed the subscription information received by two LSOAs in the LNP domain, and checks the correctness. After that, NPAC SMS confirms each LSOA and requests to update the database in LSMSs [7,8]. When NPAC SMS happens to receive the subscription information from only one LSOA, there might be two scenarios. Figure 1 shows the scenarios which are described in detail, below.

When a subscriber in Domain A moves into Domain B, LSOA in Domain B notifies this movement to LSOA in Domain A (1. Notify).

- Domain A
 1. LSOA in Domain A notifies the subscriber movement to NPAC SMS A (2-A. Notify to NPAC SMS A).
 2. According to NANC specification [7,8], NPAC SMS A should discard the received information because NPAC SMS A can not receive

information from the LSOA in Domain B directly (3-A. Discard LSOA's notification).

- NPAC SMS A can not send the movement information to LSMSs, because the information received from LSOA in Domain A can not be validated. Hence, NPAC SMS A can not support number portability in Domain A.

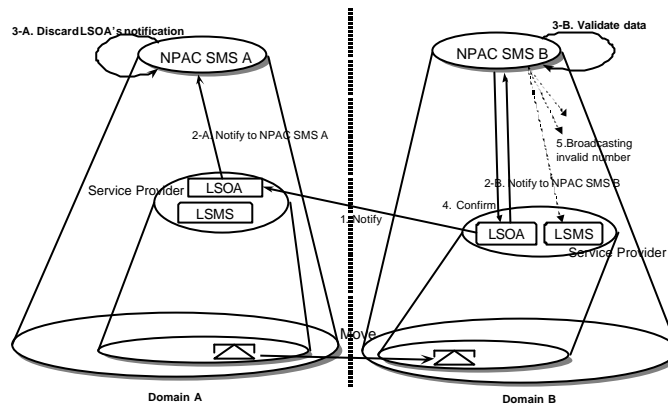


Figure 1: Problem of LNP Extension for Providing GNP

● Domain B

- LSOA in Domain B notifies the subscriber movement to NPAC SMS B (2-B. Notify to NPAC SMS B).
- According to NANC specification [7,8], NPAC SMS B can validate the received information (3-B. Validate data).
- In order to support LNP, each subscriber must own unique telephone number. When a telephone number gets into the Domain B from Domain A, it is possible that the same telephone number, excluding the country code and area code may be used in Domain A may be already in use in Domain B. So, NPAC SMS in Domain B considers the number as invalid one.
- NPAC SMS B broadcasts the invalid information to LSMSs in Domain B. Hence, NPAC SMS B can not support number portability in Domain B.

As a result, number portability service can not be provided between two LNP domains. Hence, when GNP is managed by means of LNP structure proposed by the NANC, it is necessary to convert routing numbers, and to define the interface for exchanging subscriber information across the multiple LNP domains. It is noted that the details of NANC specification [7,8] are out of the scope of this article.

3. An Architecture for Global Number Portability

In this section, we present the architecture for supporting GNP. It can support number portability across the multiple LNP domains.

3.1 Extension of Local Number Portability for Providing Global Number Portability

In the specification of NANC, NPAC SMS controls and monitors the LNP domain. The LNP management may need many kinds of information such as subscription information, network information, and so on. Amount of management information is also tremendous. The interface for communication between NPAC SMSs is required across the multiple LNP domains. In addition, the routing number management should be required for collision proof.

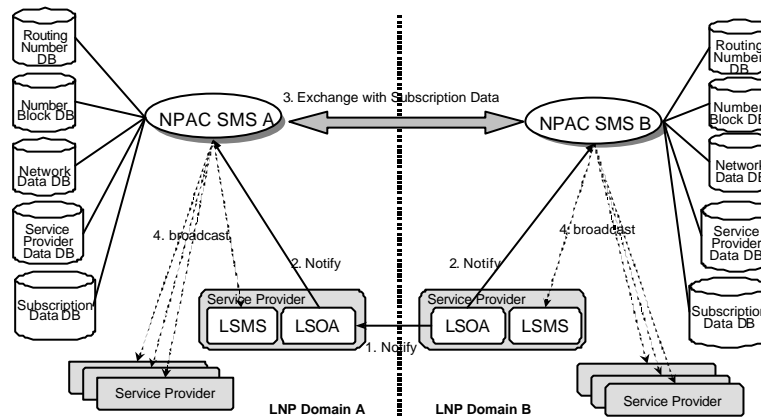


Figure 2: Exchange of Subscription Data between NPAC SMSs

Figure 2 shows the structure for supporting number portability across the multiple LNP domains. Each NPAC SMS retains many kinds of database. The Routing Number DB manages the routing numbers allocated to the subscribers, the Number Block DB manages subscribers' phone number. Other databases such as Network Data DB, Service Provider Data DB, and Subscription Data DB contain network, service provider, and subscriber information, respectively.

As soon as subscriber moves in the LNP domain B, LSOA notifies the moving information to LSOA in LNP domain A (1. Notify). Each NPAC SMS can receive only one information from each LSOA (2. Notify). At the moment, NPAC SMS B may know that it differs from the service providers' identifier or name at its own area and draws a conclusion that it came from other LNP domain. NPAC SMS B requests the related information to NPAC SMS A and exchanges the specified subscriber information with NPAC SMS A (3. Exchange with Subscription Data). NPAC SMS B searches the Routing Number DB and find out whether the routing

number is in use or not. If a subscriber's routing number is already in use there, the routing number would come into collision. It is necessary that NPAC SMS should check the duplication, if any, and be capable of allocating another routing number.

3.2 An Architecture for Global Number Portability

In Figure 3, we propose a new architecture of NPAC SMS. NPAC SMS must include the several modules and databases for managing number portability. The databases are comprised of network database, service provider database, and subscription database. The architecture includes the modules for communicating with the other NPAC SMS and for allocating the routing number, as show in Figure 3.

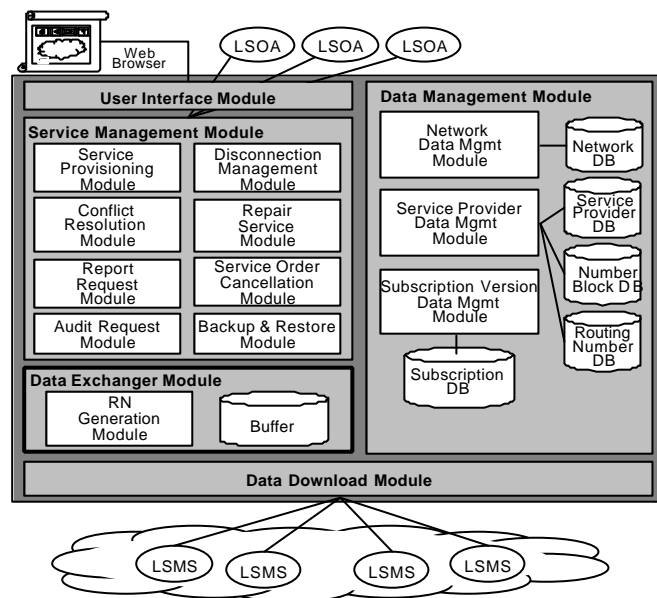


Figure 3: Architecture of NPAC Service Management System.

3.2.1 Service Management Module

Service Management Module consists of Service Provisioning Module, Disconnection Management Module, Conflict Resolution Module, and so on.

- Service Provisioning Module enables a subscriber to port a telephone number to a new service provider.
- Disconnection Management Module associates with the discontinuity of service for a ported number.
- NPAC SMS activates Repair Service Module when a problem is detected

either by the NPAC SMS, the service provider, or by a subscriber. This module analyzes and repairs this problem.

- NPAC SMS operates Conflict Resolution Module when the service providers disagree on who will serve a particular subscriber.
- NPAC SMS activates Service Order Cancellation Module when a service provider cancels a service order.
- Backup and Restore Module performs the backup and the restoration information.
- NPAC SMS activates Audit Request Module when the service providers request the audits of LNP data.
- NPAC SMS operates Report Request Module when the service providers request the report generation and delivery.

3.2.2 Data Exchanger Module

Data Exchanger Module contains RN Generation Module and Buffer. NPAC SMS operates this module when NPAC SMS communicates with the other NPAC SMS. NPAC SMS in the other LNP domain can send the notification to this module. This module has the following features.

- When NPAC SMS receives and analyzes the creation request from the new service provider's LSOA while not receiving the modification request for the old service provider's LSOA, NPAC SMS activates this module. If these requests contain the service provider identifier or name in the other LNP domain, this module would send the notification to the other NPAC SMS and receive information related to the creation request or the modification request.
- When NPAC SMS receives the modification request from the old service provider's LSOA while not receiving the creation request from the new service provider's LSOA, NPAC SMS activates this module. This module stores information that was sent to NPAC SMS Buffer. This module would discard this information, if it did not receive any notification from the other LNP domain. This module sends information to the other NPAC SMS, if it receives the notification from the other NPAC SMS.

RN Generation Module audits the duplication of the routing number in the same LNP domain. This module creates the new subscribers' routing number data that came from the other LNP domain, if needed. The LNP service would not be guaranteed in the LNP domain, if there were the identical routing number data in the same domain. In other words, this module manages the routing number for the duplication proof. This module has the following feature.

- This module compares the ported subscribers' routing number with the Routing Number DB. After comparison, this module would generate the new routing number and allocate the subscribers this routing number if there were the same routing number in the Routing Number DB. The subscriber would use the existing routing number if there were not the same routing number in the Routing Number DB.

The Buffer in the Data Exchanger Module stores the routing number, temporarily. After waiting for timestamp, this buffer discards the routing number data.

3.2.3 Data Management Module

Data Management Module includes Network Data Management Module, Service Provider Data Management Module, and Subscription Version Data Management Module. Each module must contain one or more databases. The coherence of the related data is monitored and maintained using these databases of this module. The Data Download Module can automatically download from NPAC SMS to LSMS or LSOA, when network data are created, modified or deleted on NPAC SMS. Also, User Interface Module provides the convenient interface for the operators.

4. Procedure and Interface for Global Number Portability

4.1 Procedure for Supporting the Global Number Portability

NPAC SMS has to seamlessly communicate with LSMS or LSOA. Figure 4 shows the sequence diagram for number portability across the multiple LNP domains. This procedure shows the subscription information management for providing GNP using the LNP architecture. There are NPAC SMS, LSOA and LSMS in the LNP domains A and B.

- (1) The new service provider LSOA notifies the old service provider LSOA of modifying the subscription version.
- (2) The old service provider LSOA informs NPAC SMS of modifying the subscription version data in the LNP domain B. The new service provider LSOA informs NPAC SMS of creating the subscription version data in the LNP domain A.
- (3) After NPAC SMSs in the LNP domains A and B receive the only one data from the each LSOA, NPAC SMS in the LNP domain B does not ignore the received data from the old service provider LSOA. This NPAC SMS requests the related subscriber version data and the service provider data from the other LNP domain. NPAC SMS in the LNP domain A requests the subscription version data and the service provider data from other NPAC SMS in the LNP domain B.

- (4) NPAC SMSs compare to validate the data received from each LSOA and the other NPAC SMS. If these data are valid, NPAC SMS will create or modify the subscription version data. NPAC SMS checks the routing number database.
- (5) Each NPAC SMS would send the conformation message to each LSOA, if the checked data was valid.
- (6) NPAC SMS downloads the updated attributes that have routing information.

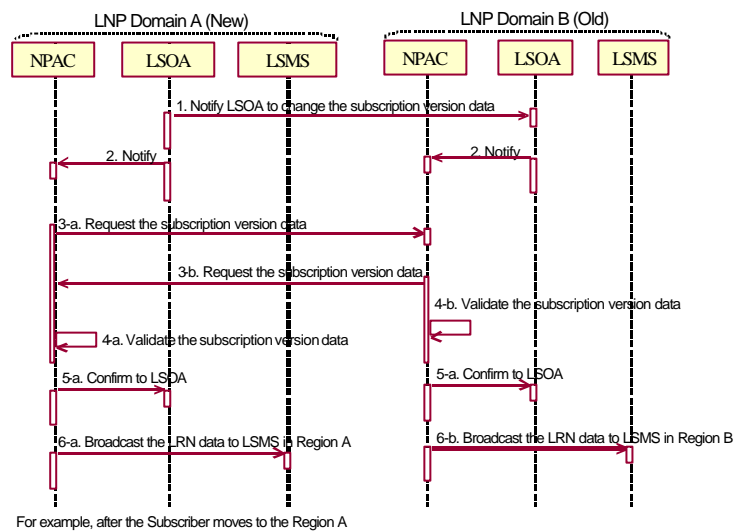


Figure 4: Sequence Diagram for Supporting the GNP

The procedure shows the method for supporting GNP. It uses the existing architecture for LNP management, reduce the cost, and does not need the other services such as NTS for providing GNP. We don't have to need a new system for supporting GNP. We can use legacy LNP system for providing GNP by using CORBA. Consequently, this method can provide the more efficient management method for supporting GNP.

4.2 Procedure for Managing Routing Number

Figure 5 shows the procedure for the routing number management. This procedure describes in more detail the third (3-a and 3-b) and the fourth (4-a and 4-b) procedures in Figure 4. NPAC SMS is comprised of several modules such as SPM (Service Provisioning Module), DEM (Data Exchanger Module), RN GM (Routing Number Generation Module), Buffer, and so on. These modules were presented in Section 3. The procedure of the routing number management is described below.

Each SPM sends the notification to each DEM (1). Each DEM stores the information into the Buffer when it receives information from only LSOA (2). In

LNP domain A, DEM requests the related information from the other DEM in the LNP domain B (3). DEM in LNP domain B restores information from its Buffer and sends this information to DEM in LNP domain A (4,5,6). DEM in LNP domain A compares this information (7,8,9) and requests the new routing number generation to RN GM (10,11), if needed. This new generated routing number is broadcast to all of LSMSs, finally.

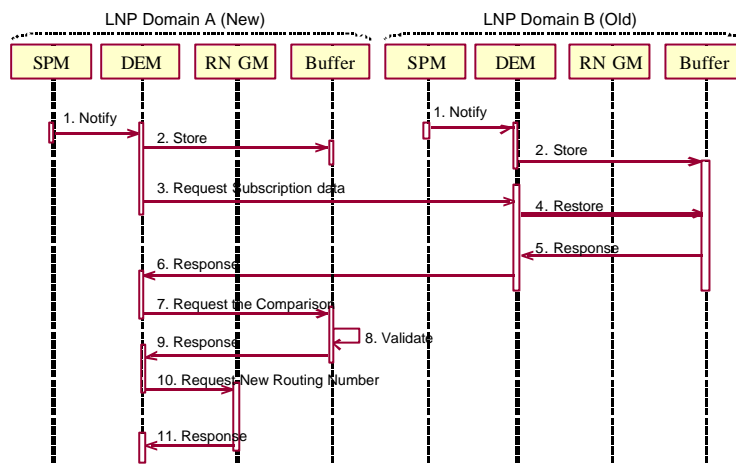


Figure 5: Sequence Diagram for Managing the Routing Number

4.3 CORBA based Global Number Portability Management

4.3.1 CORBA based Global Number Portability Management

CORBA is defined by the OMG to provide a common architecture for designing object-oriented distributed applications [14]. CORBA has been used to develop not only general distributed applications but also network management applications. It is convenient to integrate systems and extend systems by using CORBA IDL interface. CORBA allows LNP systems to be well integrated.

Figure 6 shows the CORBA-based GNP management in which communications between NPAC SMSs and between NPAC SMS and CORBA/CMIP Gateway are done by CORBA ORB. In LNP domain, NPAC SMS communicates with LSMSs and manages them. In general, NPAC SMS manages LSMS using CMIP operations. However, in order to manage them in CORBA environments, we need CORBA/CMIP Gateway between NPAC SMS and LSMSs. CORBA/CMIP Gateway may use CORBA Services such as Naming Service. Because the naming mechanism in CMIP and that in the CORBA Naming Service are different, we need a mapping algorithm for naming. NPAC SMS can communicate with the other NPAC SMS via interface that is defined in Table 1.

The received information from LSOA contains the service provider name. NPAC SMS can find and communicate with the related NPAC SMS using the service provider name and CORBA Naming Service. As a result, GNP management should need CORBA Services in CORBA environments.

This CORBA-based GNP management could support the interoperability between the LNP management systems. It could provide the efficiency and convenience of the management for operators.

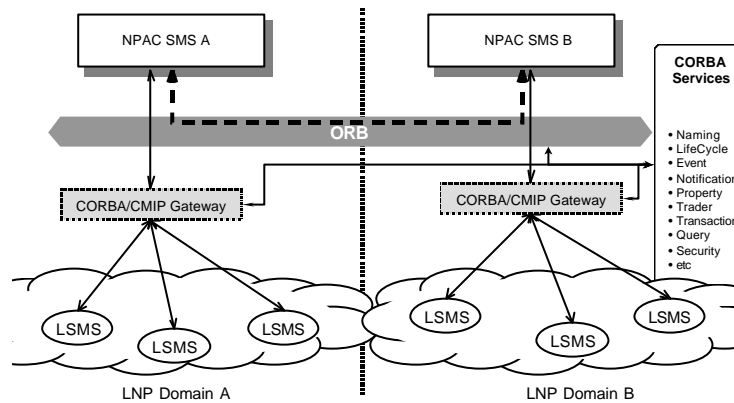


Figure 6: CORBA-based GNP Management

4.3.2 Proposed interface Using CORBA IDL

The communication between the multiple NPAC SMSs needs Data Exchanger Module and RN Generation Module in NPAC SMS. Figure 6 shows the integration with the multiple NPAC SMSs in CORBA environments. We have designed CORBA IDL interface shows in Table 1 which can be necessary for the communication between NPAC SMSs.

The related information can be exchanged via the interface between NPAC SMSs. The data which are exchanged through the interface, may include the subscription version data and the service provider data. The subscription version data may include the version ID, the old and the new service provider identifier and name, the telephone number, type of service, the subscriber status, and so on. The service provider data may include the service provider identifier and name.

Table 1: CORBA IDL for Communication between NPAC SMSs

```
// Prototype IDL module for communication between NPACs
interface subscriptionVersion : X721::top
{
    LNP_ASNI::SubscriptionVersionIdType subscriptionVersionIdGet()
    Raises(ATTRIBUTE_ERRORS);
}
```

```

LNP_ASN1::LRNType subscriptionLRNGet()
    Raises (ATTRIBUTE_ERRORS);
LNP_ASN1::ServiceProvIdType subscriptionNewCurrentSPGet()
    Raises (ATTRIBUTE_ERRORS);
LNP_ASN1::EndUserLocationValueType subscriptionEndUserLocationValueGet()
    Raises (ATTRIBUTE_ERRORS);
LNP_ASN1::EndUserLocationTypeType subscriptionEndUserLocationTypeGet()
    Raises (ATTRIBUTE_ERRORS);
LNP_ASN1::LNPTTypeType subscriptionLNPTTypeGet()
    Raises (ATTRIBUTE_ERRORS);
... ..
};

interface subscriptionVersionNPAC : subscriptionVersion
{
    LNP_ASN1::VersionStatusType subscriptionVersionStatusGet()
        Raises (ATTRIBUTE_ERRORS);
    LNP_ASN1::ServiceProvIdType subscriptionOldSPGet()
        Raises (ATTRIBUTE_ERRORS);
    LNP_ASN1::ServiceProvAuthorizationType subscriptionOldSP_AuthorizationGet()
        Raises (ATTRIBUTE_ERRORS);
    LNP_ASN1::GeneralTimeType subscriptionEffectiveReleaseDateGet()
        Raises (ATTRIBUTE_ERRORS);
    LNP_ASN1::GeneralTimeType subscriptionOldSP_CancellationTimeStampGet()
        Raises (ATTRIBUTE_ERRORS);
    LNP_ASN1::GeneralTimeType subscriptionNewSP_CancellationTimeStampGet()
        Raises (ATTRIBUTE_ERRORS);
    LNP_ASN1::IntegerType subscriptionTimerTypeGet()
        Raises (ATTRIBUTE_ERRORS);
    LNP_ASN1::IntegerType subscriptionBusinessTypeGet()
        Raises (ATTRIBUTE_ERRORS);
    ... ..
};

```

The proposed CORBA IDL module is comprised of two interfaces. We can exchange information for providing GNP via this CORBA IDL. In the subscriptionVersion interface, NPAC SMS can receive the subscriptionVersion data from the other NPAC SMS. For example, NPAC SMS can get the subscriber's identifier in the other LNP domain by using *LNP_ASN1::SubscriptionVersionIdType subscriptionVersionIdGet()* method. In the subscriptionVersionNPAC interface, NPAC SMS can receive the subscriptionVersionNPAC data from the other NPAC SMS. For example, NPAC SMS can get the previous service provider's identifier in the other LNP domain by using *LNP_ASN1::ServiceProvIdType subscriptionOldSPGet()* method.

5. Conclusion

LNP is the key service for increasing competition in the telephone marketplace. However, when we would like to support GNP by extending the LNP structure, problems might be occurred. One thing is that there is no way to exchange information between the different NPAC SMSs, and another is that the subscribers'

routing number may be duplicated in the same LNP domain. To solve these problems, the interface for the exchange of data between NPAC SMSs should be defined, and subscriber's routing number should be managed between domains. In this paper, we have defined the interface between NPAC SMSs and designed the procedures of supporting GNP. We presented how to manage subscribers' routing number. We proposed a new number portability architecture using CORBA for supporting GNP by extending NPAC SMS. The architecture includes the Data Exchanger Module and the RN Generation Module, which communicate with other NPAC SMSs and re-generate the routing number. The proposed solution can use the existing routing number, and reduce the cost of implementing the system for GNP. This CORBA-based GNP management could enhance the interoperability between the LNP management systems, providing the efficiency and convenience of the management for operators.

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