

TMN-based Intelligent Network Number Portability Service Management System Using CORBA

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Abstract

Local Number Portability (LNP) is an Intelligent Network (IN) service, which provides end users the ability to change local telephone service providers without changing their telephone numbers. LNP is a key service for increasing competition in the local telephone marketplace. To implement LNP, Number Portability Administration Center (NPAC) is needed to manage the LNP databases. Service providers also must implement the carrier-level system and update their existing IN components to provide LNP. In this paper, we present our work on applying the TMN and CORBA technology to the service management of Intelligent Network, particularly the LNP. We propose a TMN-based LNP system architecture and present a design and implementation of NPAC service management system using CORBA.

Keywords

Intelligent Network Management, TMN, Local Number Portability, CORBA, Number Portability Administration Center, Service Management

1. INTRODUCTION

Local Number Portability (LNP) [1] provides the ability to retain existing telephone numbers when switching from one telecommunications carrier to another, from one region to another, or from one service to another. LNP is a key service for increasing competition in the local telephone marketplace. Many countries are now establishing detailed rules for ensuring competition between telecom operators.

While there are several ways to implement LNP, many operators suggest that the best way is to establish databases which contain the customer-routing information necessary to route telephone calls to the appropriate terminating switches. The LNP databases use Intelligent Network (IN) [8] capabilities. These capabilities separate the customer-identification information from the call-routing information. In other words, IN technology separates service control functions from service switching functions.

This separation of functions allows creating flexible and rapid service, implementation and delivery, using standard IN functions and standardized network communication protocols. The Telecommunication Management Network (TMN) [2] provides a generally accepted framework for unified management of telecommunication services and their underlying networks, by means of generic management services and related management interfaces. Hence, IN represents only one part of the whole telecommunications system, which will be managed by TMN-based systems. Consequently, TMN concepts may be applied for managing IN and their services. Several standard organizations, such as TINA [3] or OMG [5], are working towards the integration of IN and TMN, TMN and CORBA [4], and IN and CORBA.

Because many major carriers will deploy their own LNP databases, a single access point must be provided to effectively manage and distribute updates to the common regional LNP database. This is called Number Portability Administration Center (NPAC), whose specification has been defined by North America Numbering Council (NANC) [9, 10]. To implement LNP, each telecom service provider must implement carrier-level systems, called Local Service Ordering Administration (LSOA) and Local Service Management Systems (LSMS). Service providers also must update existing Service Control Points (SCP) and Signaling Transfer Points (STP) to provide number portability.

In this paper, we present our work on applying the TMN and CORBA technology to the service management of local number portability of Intelligent Network. We first propose a TMN-based LNP system architecture. We then present a design and implementation of NPAC service management system using CORBA. We believe our work can contribute towards the integration of IN, TMN and CORBA.

The organization of the paper is as follows. In Section 2, we survey related work which include IN, TMN, CORBA, and their integration. In Section 3, we present an overview of LNP and describe an LNP architecture within the TMN architecture. In Sections 4, 5, and 6, we present the requirements, design, and implementation of the proposed LNP architecture, respectively. In Section 7, we summarize our work and discuss possible future work.

2. RELATED WORK

In this section, we present a brief overview of relevant topics such as IN, TMN, CORBA, IN/TMN integration and IN/CORBA interworking.

2.1. Intelligent Network

The Intelligent Network (IN) [8] is a service-independent telecommunications network. Intelligence is taken out of the traditional telephone switch and placed in computer nodes that are distributed throughout the network. This provides the network operator with the means to develop and control services more efficiently. New capabilities can be rapidly introduced into the network. Once introduced, services are easily customized to meet individual customer's needs. The IN functional model consists of three levels.

- The management and service creation level provides the means for creation, deployment, and maintenance of the functions provided in the lower levels.
- The service control level stores the service logic and data.
- The service switching level encompasses the detection of IN calls.

2.2. Telecommunication Management Network

TMN [2] provides a managing network framework, which is flexible, scalable, reliable, and easy to enhance. TMN provides capable and efficient networks by defining standard ways of doing network management tasks and communicating across networks. TMN allows processing to be distributed to appropriate levels for scalability, optimum performance, and communication efficiency.

TMN principles are incorporated into a telecommunications network to send and receive information, and to manage its resources. A telecommunications network is comprised of switching systems, circuits, terminals, etc. In TMN terminology, these resources are referred to as network elements (NEs). TMN enables communication between Operations Support Systems (OSS) and NEs.

2.3. CORBA

CORBA [4] is defined by the OMG [5] to provide a common architecture framework for object-oriented applications. With CORBA, users gain access to information transparently, without them having to know what software or hardware platform it resides on or where it is located on a network.

2.4. IN and TMN Integration in TINA

Telecommunication Information Networking Architecture (TINA) [3] represents an architecture for future telecommunications and operations services driven by IN, TMN and CORBA. TINA is being developed by an international consortium of network operators and equipment manufacturers, exploring the future evolution of telecommunication environments.

Integration of IN, TMN and CORBA in TINA is believed to start with the substitution of a few IN components to save the network operator's investments. This means that the Service Switching Points (SSP) already deployed on a global basis in the exchanges, representing the biggest amount of IN-related investment,

would most likely be the last elements to be replaced (or TINARised). Figure 1 illustrates the proposed migration steps in TINA. The first migration step could be in the Service Management System (SMS). Between the IN and TINA parts of the network, Adaptation Units must be replaced. These units should support the communication between the existing IN and TINA.

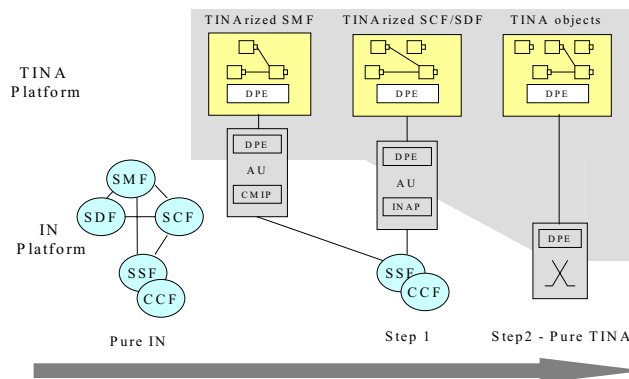


Figure 1: Step by step IN TINARisation

2.5. OMG's IN/CORBA Interworking

OMG addresses the interworking between CORBA based IN applications and the same applications implemented using the existing IN infrastructure. So, they define two scenarios for the use of CORBA in IN signaling.

- The interworking of CORBA-based IN application entities (e.g., Service Control Points) with legacy IN application entities (e.g., Service Switching Points) through a gateway mechanism which provides a CORBA view of a legacy target and a legacy view of a CORBA target.
- The interworking of CORBA-based IN application entities while using the existing Signaling System No. 7 (SS7) infrastructure as a transport network for GIOP messages.

For the first case, OMG defines functions and specifications of a gateway based on the JIDM work [12]. For the second case, OMG defines a GIOP mapping onto the connectionless Signaling Connection Control Part (SCCP) protocol of the SS7 protocol suite.

3. LOCAL NUMBER PORTABILITY

Local Number Portability (LNP) provides the ability to retain existing telecommunications numbers without impairment of quality, reliability, or convenience, when switching from one telecommunications carrier to another, from one region to another, or from one service to another.

The three currently recognized types of LNP are service provider, location, and service portability. With all three types, subscribers are allowed to keep their numbers, access to cross-carrier services (e.g., calling name delivery and automatic callback), and access to other services using cross-carrier information.

The United States Congress and State Public Service Commission have been steadily leading the United States down the road toward service provider LNP [16]. In February, 1998, the U.S. Congress passed the Telecommunications Act of 1996 [17] aimed mainly at increasing competition in the local telephone marketplace, and required service providers to implement LNP as soon as technically feasible. The U.S. Federal Communications Commission (FCC) already had proceedings underway (FCC Docket 95-116) and issued their first order in July 1996. In this order, the FCC ordered the implementation of LNP in the largest 100 metropolitan areas in the U.S. over a 15-month period, beginning with the largest cities in October 1997. In a second order, issued in August 1997, the FCC delayed implementation until 1998. Cost recovery for number portability will be defined in a third order. Many states in the U.S. have also mandated the implementation of a number portability service.

3.1. Addressing Schema of LNP

In the U.S, most states have selected the location routing number (LRN) model, which calls for every switch to be identified to the network by a unique-10-digit number. Unlike today's routing scheme, in which the dialed-party number identifies the terminating switch and subscriber, the LRN model uses the location routing number returned from the LNP database to route the call. As the call traverses the network, all switches will use the LRN to route the call.

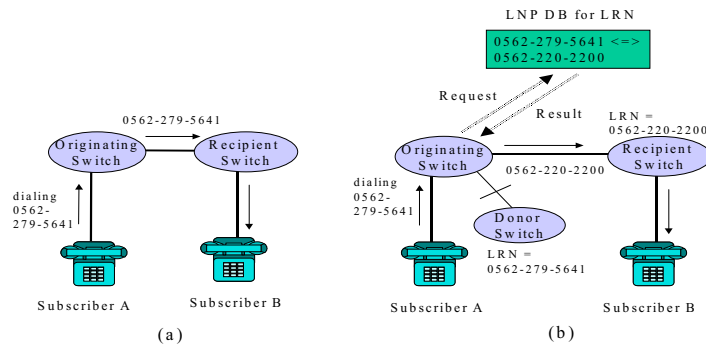


Figure 2: Example of Changing Service Providers using the LRN Model

Figure 2 illustrates how the LRN model implements LNP. In Figure 2 (a), a phone call to 0562-279-5641, is routed and connected to Subscriber B. In Figure 2 (b), when the service provider is changed, the originating switch sends an LNP database query and gets the LRN of the new local service provider's switch, in this case, 0562-220-2200. For routing the call, all switches use this LRN. The donor

switch, which is the old service provider's, does not have the LRN and thus the call is not routed to the donor switch. The new recipient switch determines whether the LRN is its own LRN and completes the call to Subscriber B if the LRN matches.

3.2. Number Portability Administration Center

To implement LNP, we need to establish databases that contain the customer-routing information necessary to route telephone calls to the appropriate terminating switches. Because many of the major carriers will deploy their own SCPs on which the LNP databases run, a single access point must be provided to effectively manage and distribute updates to the common regional LNP database. These updates will provide all carriers with the changes made when end users change from one local service provider to another. In the U.S., most states have decided that Number Portability Administration Center (NPAC) [9, 10] will be used for this. Management of the LNP database by a third party will ensure the security of all carriers' customer bases.

Figure 3 illustrates an overall LNP system architecture using NPAC. LNP is supported, validated, enabled, and managed by NPAC. Each telecommunications service provider must implement the carrier-level systems, called Local Service Order Administration (LSOA) and Local Service Management Systems (LSMS) to communicate effectively with NPAC. LSOA handles order mediation functions, including the collection of number portability order data and the coordination of subscription negotiation and activation with the NPAC. LSMS communicates information to the various network elements that make number portability a practical reality. The LSMS receives downloads from NPAC and passes the updated database to the SCP or SSP.

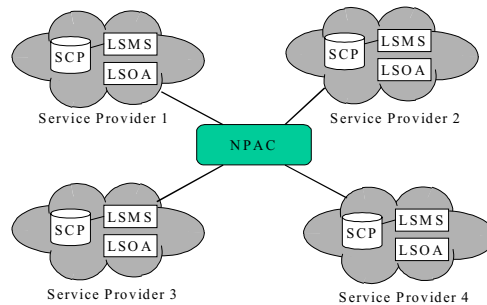


Figure 3: LNP System Architecture Based on NPAC

3.3. LNP and TMN

The LNP network architecture within the TMN framework is depicted in the Figure 4. In the Service Management Layer (SML), LSOA handles order mediation functions, including the collection of number portability order data and the coordination of subscription negotiation and activation with the NPAC. In the

Network Management Layer (NML), NPAC is responsible for the service mediation functions, including the collection of number portability subscription changes and the distribution of these updates to the appropriate Element Management Layer (EML) element. In the EML, LSMS is responsible for sending number portability subscription updates to the appropriate Network Element layer (NEL) elements, SCP and SSP.

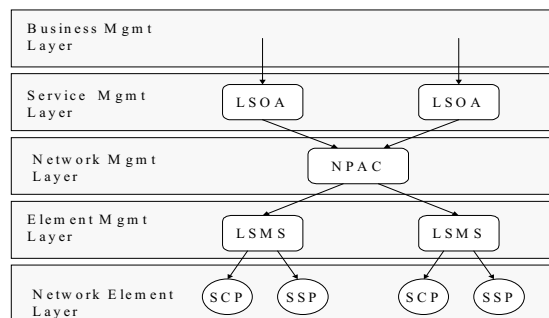


Figure 4: LNP within the TMN Architecture

4. REQUIREMENTS

In this section, we describe the system requirements of NPAC specified by NANC documents.

4.1. Functional Requirements of NPAC

The following are some of the functional requirements of NPAC.

- **Service Provision:** allows a customer to port a telephone number to a new service provider.
- **Disconnect Service:** assist the activities for discontinuance of service for a ported number.
- **Repair Service:** defines the activities performed when a problem is detected either by NPAC, a service provider, or by a customer who contacts a service provider.
- **Conflict Resolution:** resolves the activities when service providers disagree on who will serve a particular customer.
- **Disaster Recovery and Backup:** defines backup and restore activities performed by NPAC and service providers.
- **Order Cancellation:** activates processes necessary when a service provider cancels a service order.
- **Audit Request:** defines the activities performed by NPAC when service providers request audits of LNP data.
- **Report Request:** defines the activities performed by NPAC when service

- providers request report generation and delivery.
- **Data Management:** defines the activities performed by NPAC when service providers make a manual request for data administration.

4.2. NPAC Interfaces

NPAC has the interfaces with LSOA and LSMS. The relationship between an LSOA and an NPAC is a manager-agent relationship. The relationship between the LSMS and the NPAC can be a manager-agent or a agent-manager relationship, depending on the function being performed.

4.2.1. LSOA to NPAC Interface

The LSOA to NPAC interface, which allows communications between a service provider's LSOA and NPAC, supports the retrieval and update of subscription, service provider, and network information. The following transactions occur to support local number portability functionality:

- LSOA requests for subscription administration to the NPAC and responses from the NPAC to the LSOA.
- Audits requests from the LSOA to the NPAC and responses from the NPAC to the LSOA.
- Notifications from the NPAC to the LSOA of subscription version data changes, need for concurrence or authorization for number porting, conflict-resolution, cancellation, outage in information, or customer disconnect dates.
- Service provider data administration from the LSOA to the NPAC.

4.2.2. NPAC to LSMS Interface

The NPAC to LSMS interface, which allows communications between a service provider's LSMS and NPAC, supports LNP network element provisioning. The following transactions occur to support LNP:

- Subscription version and network data are downloaded from the NPAC to the LSMS.
- Service provider data administration from the LSMS to the NPAC.
- Notifications from NPAC to the LSMS of planned NPAC outages.

5. DESIGN

In this section, we present the design of a TMN-based Intelligent Network management system that provides Local Number Portability using CORBA.

5.1. IDL for NPAC

To implement NPAC using CORBA, we need the CORBA IDL definitions for NPAC. Since GDMO definition for NPAC is defined in [10], we used the GDMO to CORBA IDL translation specification [11] to generate IDL definitions for NPAC.

Figure 5 shows a sample GDMO to IDL translation.

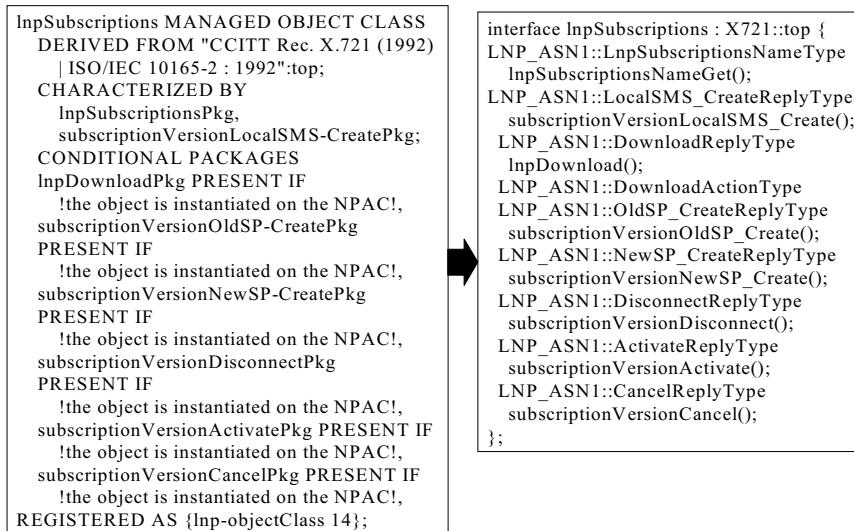


Figure 6: GDMO to CORBA IDL Mapping

A managed object class in GDMO definition is translated into an IDL interface. Every managed object inheritance hierarchy is retained and the resulting hierarchical structure is the same as the class inheritance structure of managed objects. In Figure 6, every interface of managed object is derived from the `top` class. The attributes are translated into attribute get or set operations. The GET attribute has only a get operation, and the GET-REPLACE attribute has get and set operations.

5.2. CMIP/CORBA IDL Operation Mapping

CMIP operations are defined by M-CREATE, M-DELETE, M-SET, M-GET, M-EVENT-REPORT, M-ACTION primitives. We have implemented these operations using CORBA. We have mapped one CMIP primitive to one CORBA IDL method, or several primitives to one CORBA IDL method. We have also used threads for creating event after server return. Figure 7 shows an example of the operation mapping.

5.3. CMIP/CORBA Naming Mapping

In CMIP, to define a manager/agent interface to Managed Information Tree (MIT), we have to define a managed object and then create its name binding. Each node in MIT represents a managed object and has own name. To support MIT in CORBA, we first map GDMO to CORBA IDL, and then name CORBA objects using CORBA Naming Service [18]. However, the naming mechanism in CMIP and that

in the CORBA Naming Service are not same. For example, in CMIP MIT, every node can have its own managed object, but in CORBA, only leaf nodes can. Thus, we need a mapping algorithm for naming.

In CORBA, an object is named by a list of id and kind string pair. We use the kind for attribute type and the id for its value. To map non-node to managed object, we create new node named "object". Figure 8 illustrates the name mapping of CMIP to CORBA.

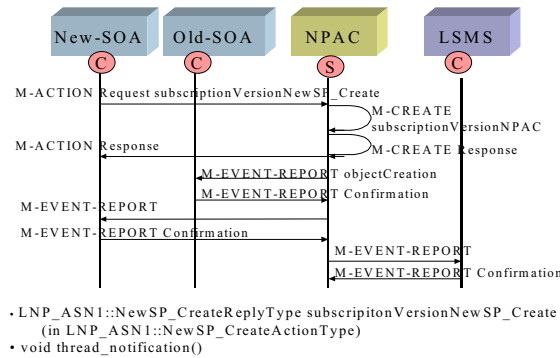


Figure 7: CMIP to CORBA IDL Operation Mapping

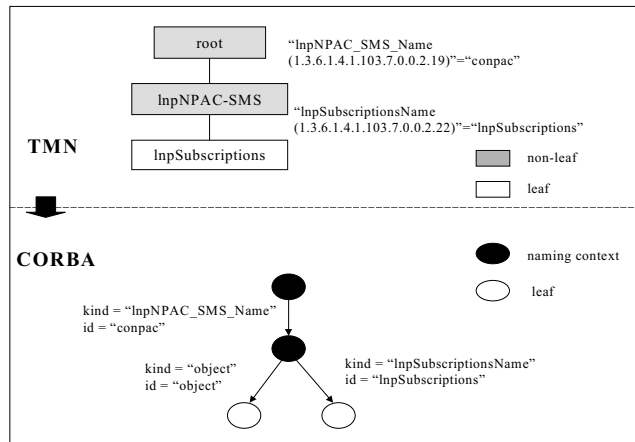


Figure 8: CMIP Naming Hierarchy to CORBA Naming Graph Mapping

6. IMPLEMENTATION

The introduction of distributed processing in the service management area is promising because it offers the ability to integrate service management and control aspects by means of common objects and protocols. Thus, we have implemented

NPAC, LSMS, and LSOA using CORBA. We call this system CONPAC, which stands for CORba-based NPAC. CONPAC conforms to the NANC specifications [9, 10], which specify the NPAC interoperable interface and functional requirements. To demonstrate how CONPAC works, we selected one NPAC functionality, namely service provisioning.

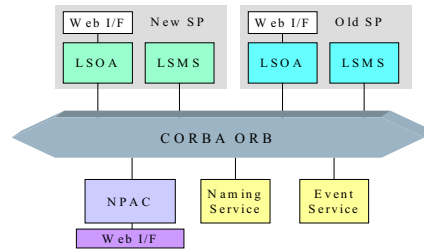


Figure 9: CONPAC System Architecture

We have implemented NPAC, New SOA, Old SOA and LSMS using CORBA. These are implemented as CORBA objects, which communicate with each other through an Object Request Broker (ORB) [4]. NPAC and LSMS have databases for LNP information. Between NPAC and LSOA, NPAC acts as a CORBA server and LSOA as a CORBA client. Between NPAC and LSMS, NPAC and LSMS can act as either server or client. Figure 9 illustrates the architecture of CONPAC.

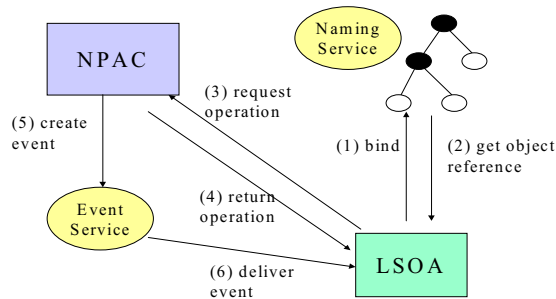


Figure 10: Service Provisioning in CONPAC

Figure 10 illustrates how service provisioning is carried out in CONPAC. First, NPAC registers the managed objects to the Naming Service during initial processing. Then, the following actions take place.

- (1) LSOA connects to the Naming Service to get the reference of the managed object using the name of managed object.
- (2) The Naming Service returns the object reference, if found.
- (3) Using the object reference, LSOA sends a request to NPAC for the operation

- to be performed on the managed object.
- (4) NPAC returns the result of the operation.
 - (5) If it is needed, NPAC creates an event using the CORBA Event Service [18].
 - (6) LSOA or LSMS receives and processes the event.

7. CONCLUDING REMARKS

LNP is the key service for increasing competition in the telephone marketplace. Many countries are now establishing detailed rules for LNP to ensure competition between network operators. Since LNP is one of the IN services, it is essential to be provided by telephone service operating companies.

In North America, Location Routing Number (LRN) has been adopted for addressing schema and NPAC for LNP databases. Based on this approach, we have proposed a TMN-based LNP system architecture. We have implemented CONPAC, which consists of NPAC, LSOA, and LSMS. All of these have been implemented as CORBA objects and communicate with each other through ORB. We have implemented CONPAC for validating our integrated architecture. We have demonstrated the use of CONPAC by implementing one of the NPAC functions, namely the service provision.

We believe that CONPAC is the first step towards the integration of IN, TMN and CORBA. We are currently implementing the remaining NPAC functions. When completed, we hope to evaluate its performance and to assess the implementation of Local Number Portability using CORBA.

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List of Acronyms

AIN	Advanced Intelligent Network
CMIP	Common Management Information Protocol
CONPAC	CORBA-based NPAC
CORBA	Common Object Request Broker Architecture
EML	Element Management Layer
FCC	Federal Communications Commission
GDMO	Guidelines for Definition of Managed Objects
IDL	Interface Definition Language
IN	Intelligent Network
LNP	Local Number Portability
LRN	Location Routing Number
LSMS	Local Service Management System
LSOA	Local Service Ordering Administration
MIT	Management Information Tree
NANC	North American Numbering Council
NE	Network Element
NEL	Network Element Layer
NML	Network Management Layer
NPAC	Number Portability Administration Center
ORB	Object Request Broker
OSS	Operations Support System
SCCP	Signaling Connection Control Part
SCP	Service Control Point
SML	Service Management Layer
SMS	Service Management System
SSP	Service Switching Point
SS7	Signaling System No. 7
STP	Signaling Transfer Point
TINA	Telecommunication Information Networking Architecture
TMN	Telecommunication Management Network