CORBA-based Integrated Control and Management for IMT-2000 Global Roaming Service

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Abstract

Service control and management of IMT-2000 should be flexible and scalable to make an easy introduction of multimedia services from various service providers. It requires the extension of IN control capabilities for multimedia service provisioning and integration of TMN service management functions and IN functional entities. In this paper, we propose the architecture for the integration of TMN and IN functions using CORBA technology especially focusing on control and management of IMT-2000 global roaming service. IN service data function is integrated into TMN management information bases (MIBs) for the centralization of customer profile management. Network to network interface (NNI) signaling information flows of service management are integrated with intersystem management information flows across TMN X interface for the integrated control and management. Management operation flows and the interface for automatic establishment of global roaming agreement have been designed using CORBA IDL. Service management applications, CORBA/IN interworking function and CORBA/TMN gateway to support backward compatibility with legacy TMN and IN functional entities have also been designed.

Keywords

IMT-2000, Service Management, Global Roaming, IN, TMN, CORBA

1. Introduction

IMT-2000 is the next generation mobile telecommunication system, which is being standardized by ITU [1, 2]. IMT-2000 provides high bandwidth of wireless transmission, mobile multimedia communication service, global roaming service, and IN based services such as virtual private network, prepaid calling and wireless

number portability. An essential service of IMT-2000 is global roaming service that allows IMT-2000 users to use their equipment and subscriptions in different family member networks, and to establish calls and connections between networks of different operators. To support this, interworking between different IMT-2000 family member networks is required in service control and management.

IMT-2000 functional model consists of IN functional entities and IMT-2000 specific ones. IN is a framework that provides service creation and provisioning as well as service control capabilities. Although IMT-2000 service controls such as call routing, mobility management are similar to those of IN, service control logic of IN should be extended to support global roaming service of IMT-2000. There have been active researches on the development of signaling and control architectures to support a global roaming service. For instance, customized applications for mobile network enhanced logic (CAMEL) in Europe and wireless intelligent network (WIN) in North America are two outstanding works for IMT-2000 control framework. However, IN has some limitations for full service control of IMT-2000. IN is difficult to support services like multimedia conferences and connectionless services in IMT-2000 because IN adapted to point-to-point connection-oriented services for telephony service. IN is very weak to support customized or customer-specific services. Additionally, Management part of IN is not well defined, and this had led all vendors to implement their own management systems[3]. Therefore, There is a strong need to enhance the capability of IMT-2000 service control, which should be flexible and scalable to support global roaming service.

IMT-2000 management is based on Telecommunication Management Network (TMN), which provides management framework by using management layer concept, standardized management information and standardized management interfaces. IMT-2000 management may be performed in TMN layered management architecture. TMN is efficient to manage network and network elements of IMT-2000. However, IMT-2000 service management requires more flexible management functions and interfaces able to process and exchange management information related to various services. Especially, Common management information protocol (CMIP) of TMN has limitation to support service management. The diverse and negotiable service management functions for IMT-2000 service management should be provided in flexible interface, which makes it easy to manage new services from diverse service providers and support inter-domain service management.

Efficient provisioning of global roaming service requires the inter-domain management and control of services provided by diverse telecom operators. X interface, which provides management information exchange between management systems in different management domain, and IMT-2000 network to network interface (NNI) should be taken into account for service management. X interface for intersystem management and NNI for signaling should be well defined to efficiently enhance the inter-domain service control and management. Especially, provisioning of global roaming service in virtual home environment requires

management functions of both TMN and IN, so that there is a strong need for the integration of IN and TMN functions [4, 5, 6].

CORBA is the architecture to build object-oriented distributed applications in multi-vendor environment with well-defined standardized and simple application interfaces. The scalability and flexibility for control and management of IMT-2000 global roaming service can be effectively satisfied by CORBA because CORBA adopted object-oriented concept and is transparent to underlying network technologies. Furthermore, CORBA can also be used as a possible technology for the integration of IN and TMN for IMT-2000 control and management.

The rest of this paper is organized as follows. In section 2, we analyze service control and management of IMT-2000 and needs for integration of these specially focusing on IMT-2000 global roaming service. The solution for the integration of service control and management for IMT-2000 services is presented in section 3. In section 4, we illustrate the platform architecture for the CORBA-based integrated service control and management for IMT-2000. In Section 5, we define information flow and the interface using CORBA IDL for automatic establishment of global roaming agreement. Concluding remarks are discussed in Section 6.

2. Control and Management of IMT-2000 Global Roaming Service

In this section, we describe the functions and architecture of the control and management for IMT-2000 global roaming service. IMT-2000 capabilities for global roaming service are specified in ITU-T Recommendation Q.1701 [1]. Figure 1 shows IMT-2000 functional model including functional entities and interfaces for management operation and control signaling.

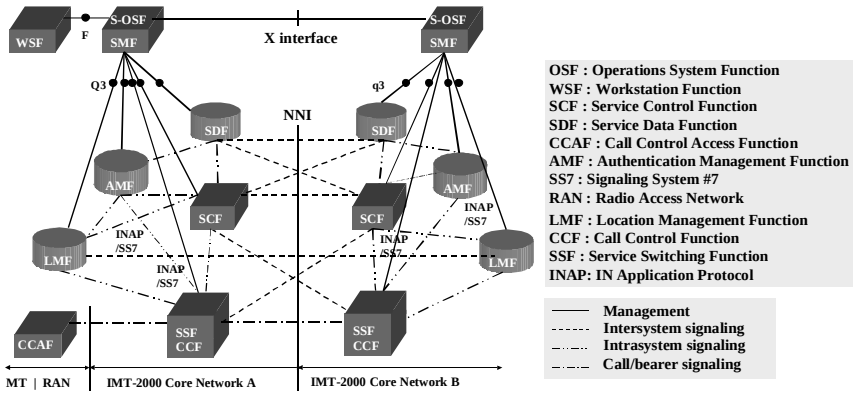


Figure 1: IMT-2000 functional model

The IMT-2000 family concept is used to realize global roaming service offering among IMT-2000 systems. The IMT-2000 family is a federation of IMT-2000 systems providing IMT-2000 capabilities to its users.

Service control functions for global roaming service include the establishment of calls and connections between different IMT-2000 family member network, and it also includes transfer/retrieval of customer profile and location information of roaming user for call setup, location management and mobility management across NNI. These are performed by IMT-2000 functional entities such as service control function, service data function, location management function and authentication management function as shown in Figure 1. IMT-2000 functional entities are based on IN framework. However, IN is neither flexible nor scalable to make rapid provisioning of new services from various service providers. Especially, IMT-2000 system is planned to provide various multimedia mobile communication services in competitive market place, so that IN control capabilities for IMT-2000 services need to be enhanced.

The framework for IMT-2000 management is specified in ITU-R Recommendation M.1168 [7]. Management services, goals, and context for the IMT-2000 management are being specified in ITU-T Recommendation M.3210 for TMN management service recommendation. Management of IMT-2000 global roaming service may include management of service data, customer profile, QoS, security, fault and performance across Q3 interface, and it also includes transfer of call detail records, automatic establishment of roaming agreement and billing across X interface. These are performed by TMN service operation system function (S-OSF) and IN service management function (SMF). In Figure 1, TMN S-OSF and IN SMF are represented as the same functional block because IN SMF is similar to TMN S-OSF. Service management functions of TMN and IN are integrated by implementing IN SMF using TMN technology.

Table 1: Service control and management function for global roaming service

	Functions	Associated Functional Entities
Service Control	● Transfer and retrieval of user and location data ● Retrieval of user data for routing of calls ● Support Virtual Home Environment ● Obtaining and transferring fraud/abuse control related data ● Network interconnection for Packet Data Services	SCF SDF LMF SSF
Service Manage-ment	● Service data management ● Establishment of roaming agreement ● Transfer of call detail records ● Customer profile management ● Billing ● Authentication	SMF SCF SDF AMF

Table 1 shows service control and management fuctions required to support global roaming service. As shown in Table 1, some of functions for IMT-2000 global roaming service management are associated with SCF, SDF, and AMF. These functional entities provide service management using control signaling. Service management is not performed centrally. Therefore, service management functions such as authentication, service data management and customer profile management performed by SCF, AMF and SDF should be integrated with those of IN SMF for central service management. Furthermore, service control and management should be integrated.

Management operation for authentication, service/user profile management, mobility management, security management and quality of service management must be provided across X interface for intersystem management and NNI for the exchange of signaling. In order to provide global roaming service, many interactions occur between service providers across NNI. NNI is to be treated as a valuable and scarce resource. Therefore, management information flows that do not have stringent real-time requirements should be carried across X interface rather than NNI. The signaling load across NNI must be limited as much as possible to ensure that network will not overload its signaling capacity. This feature of NNI should be taken into account to integrated control and management of IMT-2000 services. Functional entity which has realtime interaction across NNI should be excluded a set of functions to be integrated for the performance maintenance of service.

Accordingly, the integration of service control and management for IMT-2000 is required to enhance IN SMF, to control and manage IMT-2000 global roaming service efficiently, and to reduce signaling load across NNI interface. In following section, we describe the detailed integration methodology of service control and management for IMT-2000.

3. Integration of Service Control and Management for IMT-2000

In order to realize the integration of service control and management for IMT-2000, the following requirements need to be satisfied.

- Integration of functions for service control and management in common management platform
- Coordination of management functions provided across NNI and X interface
- Centralization of customer profile management

In this section, we describe the model, functions and interfaces for the integrated control and management for IMT-2000 services in detail.

3.1 Integration of Functions for Service Control and Management

Figure 2 shows the model for the integrated control and management of IMT-2000 services, interfaces for signaling, and exchange of management information. In this model, SMF, SCF, SDF and AMF are integrated and customer profile management

is centralized as shown in Figure 2. TMN service management operation system (S-OSF) and IN SMF are integrated. IN SCF is implemented in the form of TMN control operation system function (C-OSF), which is in charge of service control. SDF is implemented in form of TMN management information bases (MIBs), which contains customer profile data, service data, operation data and authentication data. AMF is embedded in S-OSF as a management function. Location management function (LMF) contains location information of roaming users, which is changed in realtime. There are many LMFs located geographically in IMT-2000 system, so that LMF is implemented as an independent functional entity.

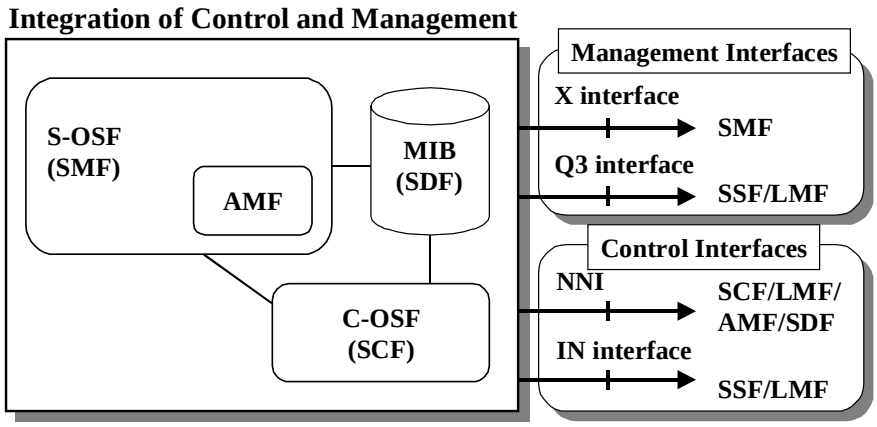


Figure 2: Integration model of service control and management functions

Integration of functional entities changes interaction using signaling or management operation into inner interactions in the integrated model. As a result, signaling traffic can be reduced. Customer profile management, authentication and service control can be performed centrally.

3.2 Interfaces for the Integrated Model

Interfaces for the integrated model are illustrated in Figure 2. These interfaces can be classified into two categories. One is control interface, which provides signaling for IN transaction. The other is management interface, which provides management information exchange. Table 2 shows interfaces in the integrated model and operations provided across them

In order to support IMT-2000 global roaming service, X interface and NNI are very important. In the integrated model, we coodinate operations provided across X interface and NNI. Realtime information exchanges such as location information requst and call sutup are provided across NNI, non-realtime ones are provided across X interface. As a result, signaling traffic across NNI can be reduced.

3.3 Centralization of Customer Profile Management

Customer profile consists of customer identification, customer subscription, terminal subscription, service usage, location information, authentication data, personalized service specification, and so forth. These informations over the overall IMT-2000 system should be not duplicated and easy to be managed. Therefore, customer profile data is located in form of TMN MIB as shown in Figure 2. It makes the centralized customer profile management possible.

Table 2: Interfaces of the integrated model

Classification	Interfaces	Operation
Service Control Interface	Inferface with LMF	AMF to LMF, SCF to LMF and SDF to LMF interfaces in standard functional model are integrated into this interface. It performs IN transaction related to mobility management and authentication
	Interface with SSF	SSF requests service control to service control function in ISMS through this interface. ISMS can manage SSF through it. Therefore, Service control and management can be provided across this interface.
	Network to Network Interface	Intersystem signaling for service control is performed across it. ISMS must support NNI because integrated model contains SCF and SDF. However, capabilities of it are coordinated for realtime interoperation across NNI. NNI interface supports realtime exchange of roaming related information such as location, user ID, Home network ID, and so forth
Service Management Interface	Q3 interface	Integrated model exchanges management information with network management system of SS7 and IMT-2000 across TMN Q3 interface for network configuration, performance and fault management
	X interface	Inter-system service management across X interface include global roaming management, security and account management. Capabilities of X interface are extended to support non-realtime control signaling of NNI.

4. Platform Architecture for the CORBA-based Integrated Control and Management System.

The service management system in integrated model interacts with other service providers across the interfaces coordinated according to the integration of service control and management. The service management system requires a common platform to support the interfaces including TMN management interfaces, interfaces between IN-based IMT-2000 functional entities, and the NNI.

CORBA is an architecture for building a object-oriented distributed applications in multi-vendor environment with well-defined standardized and simple application interfaces. The scalability and flexibility for control and management of IMT-2000 global roaming service can be effectively satisfied by CORBA. Furthermore, CORBA can also be used as an enabling technology for the integration of IN and TMN for IMT-2000 control and management. Therefore, using CORBA to implement platform of serive contol and management will become a feasible technical choice.

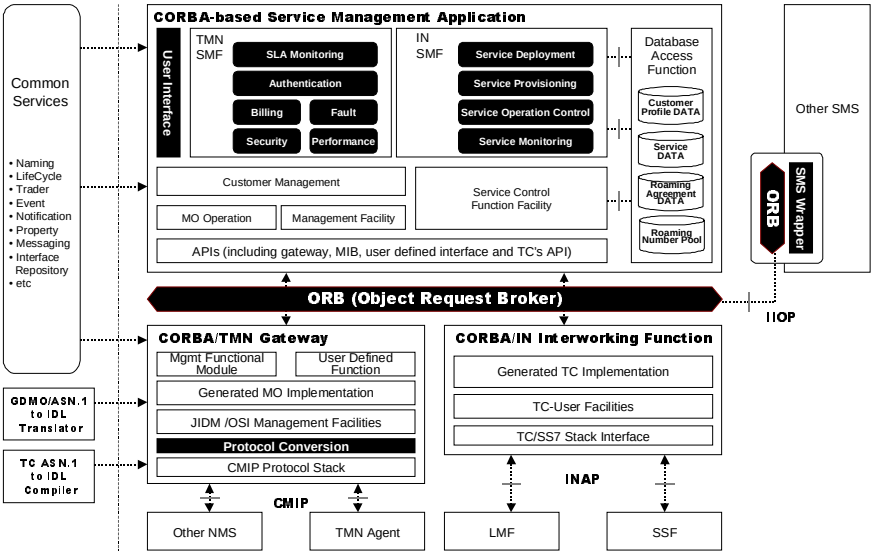


Figure 3: Platform architecture for the CORBA-based integrated control and service management system

In this section, we design the integrated control and service management system for IMT-2000. Figure 3 shows the platform architecture for the construction of CORBA-based integrated model, which consists of integrated service management application, CORBA/TMN gateway, CORBA/IN interworking function, GDMO/ASN.1 to IDL translator and TC ASN.1 to IDL compiler. These are constructed by using various common services and facilities of CORBA as followed: Naming, LifeCycle, Trader, Event, Notification, Property, Messaging, Interface Repository, and so on.

4.1 Service Management Application

CORBA-based service management application in Figure 3 consists of various APIs, several management facilities, service control function facility, TMN/IN service management functions, database access function, and so on. Service

management application consists of various management functions as follows.

- Service management functions consist of the service deployment, provisioning and deletion, service monitoring, customer profile management, performance and location, intersystem management on billing, service level agreement monitoring, and supporting roaming in VHE.
- Service control function facility provides service control with respect to bearer service, call setup, and supplimentary service.
- Data Access function provides storage, access and retrieval of management information. It includes customer profile data, service data, roaming agreement data and roaming number pool in order to support the interworking with other service management system
- Cutomer management supports modification of customer profile across F interface or S-OSF to user identification module function (UIMF) interface.
- Service management system (SMS) wrapper encapsulates the legacy service management system's functions.

4.2 GDMO/ASN.1 to IDL translator

GDMO/ASN.1 to IDL translator translates GDMO and ASN.1, which are the management information modeling language of TMN CMIP into OMG CORBA IDL [8]. Transaction capabilities (TC) ASN.1 to IDL compiler translates TC ASN.1 of SS7 for INAP into IDL. The generated IDL interfaces are implemented in CORBA/TMN gateway and CORBA/IN IWF respectively.

4.3 CORBA/TMN Gateway

CORBA/TMN gateway plays the role of protocol conversion to interact between CORBA-based management application and either existing CMIP-based network management system or TMN agents [9,10]. The building of CORBA/TMN gateway requires JIDM's OSI management facilities, MO interface IDL produced by GDMO/ASN.1 to IDL translator and management functional module, which supports management operations of management application. JIDM Facilities provide generic modules for accessing a managed domain, regardless of the management reference model being used.

On the other hand, OSI management facilities extends the generic JIDM Facilities to support all CMIS interactions in CORBA and OSI specific concepts such as scoping, filtering and multiple replies both in pure CORBA environments and in interworking environments through gateways.

4.4 CORBA/IN Interworking Function

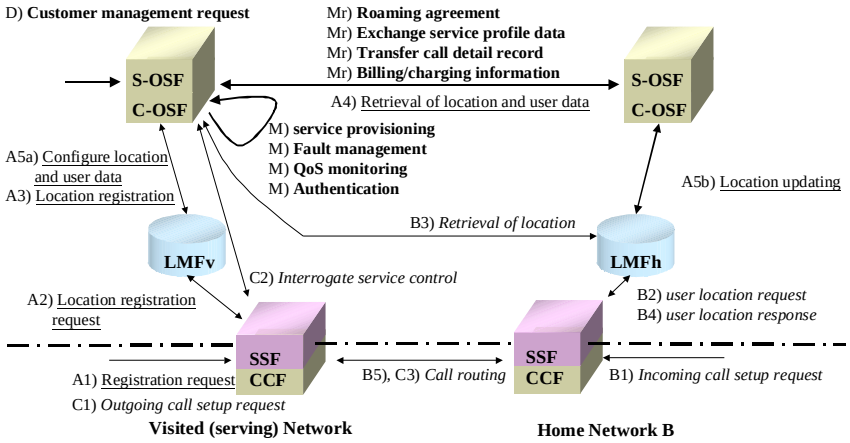
CORBA/IN interworking function supports the interworking of service control function facilities in the integrated model with SSF and LMF [11, 12, 13, 14]. CORBA/IN interworking function is based on interaction translation specification of OMG telecom about the interworking CORBA and TC systems. The building of CORBA/IN interworking function requires TC/SS7 interface, TC-User Facilities

and generated TC interface produced by TC ASN.1 to IDL translator.

CORBA/IN interworking function supports four major interaction features as follows: application location (finding), dialog initiation, dialog maintenance and operation invocation. In general, application location and dialog initiation are provided by the CORBA naming service and the life cycle service. Dialog maintenance is provided by the base interfaces of all TC-user CORBA server objects and operation invocation is provided by generated TC interface, the ORB, the messaging service and optionally the interface repository and TC repository.

5. Design of Information Flow and Interface for Integrated Control and Management of IMT-2000 Global Roaming Service

In this section, we design the information flows and IDL interface for global roaming service.



Procedures	Operation	Procedures	Operation
A	Global roaming registration Location updating & cancellation	D	Customer management its own service and customer profile data
B	Incoming call setup to roaming user	M	Common service management
C	Outgoing call setup of roaming user	Mr	Roaming-related service management

Figure 4: Information flows for global roaming service in integration model

Figure 4 shows the information flows for the integrated control and management of global roaming service, which includes management of roaming agreement, customer profile management, QoS management, security management, authentication and call setup for roaming user.

Monitoring of security and service level agreement should be performed when

information is accessed by other system or a specific service is requested for global roaming. In existing IMT-2000 system, this monitoring is very difficult and complicated because the location update and registration for global roaming user need transmission of customer profile between LMFs of both service providers by signaling across NNI. In the integrated model, customer profile is centrally managed by S-OSF and transferred from S-OSF of the home service provider to S-OSF of the visited service provider by management operation across X interface. The S-OSF of the visited service provider registers customer profile of roaming user to its MIB and configures network resources according to customer profile. Therefore, NNI signaling load is transit to X interface. Authentication of roaming user is managed by S-OSF using authentication data in MIB. Signaling procedure for call setup is performed by existing SSF and LMF to support real-time operation.

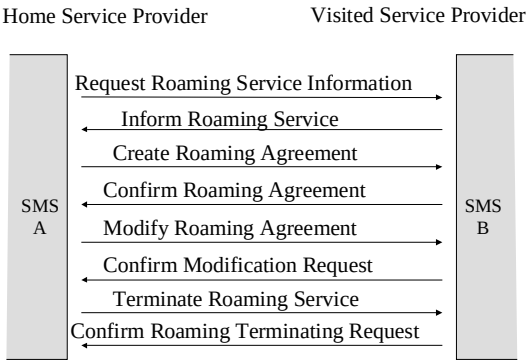


Figure 5: Management operation procedure for automatic establishment of global roaming agreement

Figure 5 shows the operation procedure for global roaming agreement. Roaming agreement is automatically negotiated between the home service provider and the visited service provider across X interface. The home service provider always initiates the roaming agreement scenario to request for information to a specific visited service provider by using “Request Roaming Service Information” management operation. The visited service provider responds with the capabilities for roaming including service and QoS parameters by using “ Inform Roaming Service” management operation. The home service provider then creates the roaming agreement and responds by using “Create Roaming Agreement” management operation.

We design the interface using CORBA IDL for management of global roaming agreement across X interface. Figure 6 shows the CORBA IDL description of the interface for management of global roaming agreement across X interface. Management information functions are defined as methods such as requestRS,

createRS, modifyRS and terminateRS. Each IDL operations have mandatory and optional parameters. These parameters are defined by IDL struct type. For example, requestRS operation sends RSRequestParameters for request of roaming service to the home service provider, and it receives roaming information of home service provider through RSInformParameters.

Other interactions across X interface such as customer profiling, billing and audit can be also defined by using CORBA IDL.

```
#ifndef _ROAMING_Service_IDL_
#define _ROAMING_Service_IDL_
module RoamingService {
   struct QOSParametersType {
                Class1QOSParametersType    c1qosp,
                Class2QOSParametersType    c1qosp,
                Class3QOSParametersType    c1qosp,
   };
   union QOSParametersTypeOpt switch (boolean)    {
         case TRUE : QOSParametersType value;
   };
   ...
   struct RSRequestParameters {
                MobileCountryCodeType    mcc,
                MobileNetworkCodeType    mnc,
                LocationType    loc,
                IMT2000FamilyMemberNetworkProtocolType    fmnp,
                RadioTechnologyType    rt,
                FrequencySpectrumType    fs,
                ClassOfServicesType    cos,
                QOSParametersTypeOpt    qosp,
                BillingCycleReconciliationPeriodType    bcrp,
                BillingFormatUsedTypeOpt    bfu,
                PreferredBillingCycleDateTypeOpt    pbcd,
                RoamingServiceInitiationDateType    rsid,
                RoamingServiceTerminationDateType    rstd,
                RespondDateType    rd
   };
   struct RSInformParameters    { ... };
   struct RSCreateParameters    { ... };
   struct RSConfirmParameters    { ... };
   struct RSModifyParameters    { ... };
   struct RSModifyConfirmParameters    { ... };
   struct RSTerminateParameters    { ... };
   struct RSTerminateConfirmParameters    { ... };
    RSInformParameters requestRS(in RSRequestParameters rsrp)
                                raises(DENY_RS_REQUEST);
   RSConfirmParameters createRS(in RSCreateParameters rscp)
                                raises(CANCEL_RS_CREATE);
   RSModifyConfirmParameters modifyRS(in RSModifyParameters rscp)
                                raises(DENY_RS_MODIFY);
  RSTerminateConfirmParameters terminateRS(in RSTerminateParamters rstp);
};
#endif     /* _ROAMING_SERVICE_IDL_ */
```

Figure 6: Management interface definition using CORBA IDL for automatic establishment of global roaming agreement

6. Conclusion and Future Work

In this paper, we propose the architecture for the integrated control and management of IMT-2000 global roaming service. IN service control function is implemented as a C-OSF. Service data function is integrated into TMN management information base (MIB) for the centralization of customer profile management. AMF is also integrated S-OSF. NNI signaling information flows of service management are integrated with intersystem management information flows across TMN X interface for the integrated control and management. Management operation procedure and the interface for automatic establishment of global roaming agreement have been designed using CORBA IDL. Service management applications, CORBA/IN interworking function and CORBA/TMN gateway to support backward compatibility with legacy TMN and IN functional entities have also been designed.

The integration of service control and management can provide more enhanced performance and extended operations and makes the integrated service control and management system interoperable with legacy systems. In the integrated architecture, information flows is simplified and signaling load across NNI of IMT-2000 can be diminished. Furthermore, policy-based service management, which will be general management paradigm in the near future, can be easily introduced.

For further study, efficiency and performance of our CORBA-based integrated service control and management will be evaluated through simulation.

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