An Integrated Network Managment Framework for ATM over ADSL Service

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ABSTRACT

In this paper, we describe an integrated network management system for ATM over ADSL service provisioning. There are two distinct networks of ATM and Internet. Most of routers in Internet connected with WDM. The Network Access Server (NAS) in the Internet provides the Internet access service for the ATM over ADSL subscriber. The ATM network takes the roles of backbone network for the pure ATM PVC and SVC services and the access network for the ATM over ADSL service. In order to define the generic network model that can be commonly applicable for the backbone network for pure ATM service and the access network for ATM over ADSL service taking into account the scalability, we suggest two fragments of the topological fragment and connectivity fragment to maximize the scalability in accordance with the ITU-T G.805 layering and partitioning concepts and the RM-ODP information viewpoint. In addition, we propose the distributed computational model of the ATM over ADSL network management system using the RM-ODP computational viewpoint and TMN functional decomposition of FCAPS taking into account the functional distribution and the modularity. Lastly, we describe the scenario for providing the integrated ADSL service.

Keywords: ATM, ADSL, Network Management, TMN, CORBA

1. INTRODUCTION

As a widely accepted telecommunications system, the B-ISDN and its packet-oriented transmission technology in ATM have many promising new telecommunications services, such as multimedia and high-speed QoS guaranteed data transfer. Those services demand higher bandwidth connectivity that can be transferred through optic or coaxial cables.[1] Plan Old Telephone System (POTS) copper cables offer a low cost access media both in telecommunications and data communications areas, but the existing modems cannot accommodate the high-speed broadband services. Asymmetric digital subscriber loop (ADSL) technology is a new platform for delivering broadband service to homes and small businesses, thus bringing the information highway to the mass market. ADSL can be implemented on most of the existing copper infrastructure, enabling the rapid and near ubiquitous offering of new high-speed data access services with minimal expense. ADSL supports a wide variety of high-bandwidth applications, such as high-speed Internet access, telecommuting, virtual private networking, and streaming multimedia content.[2]

Because the real-time audio and video applications over the Internet have become increasingly popular, these applications require quality of service (QoS) support to ensure their performance. And most of network service providers (NSPs) have the responsibility of provisioning of high-speed QoS guaranteed transport capacities to network access providers (NAPs). Therefore, most of NAPs prefer to use ATM rather than frame-based technology in their access network. On the other hand, ATM network takes the two perspectives of roles: one is for backbone network to provide the intrinsic ATM PVCs or SVCs services and the other is for access network to provide the logical access links between customer and Internet.

In Korea, the ADSL subscribers of Korea Telecom are explosively increased as many as fifteen thousand per day and has already two million ADSL subscribes. Under such a large number of customers, customer satisfaction is the key to success in today's hyper-competitive environment. The network provider's success depends on bringing collocation facilities on line easily, transmitting data flawlessly, and pinpointing problems instantly to avoid service disruptions. To meet these requirements from the perspective of NSP sand NAPs, we propose an integrated network management system for managing the pure ATM network service and the ATM over ADSL service with the unified

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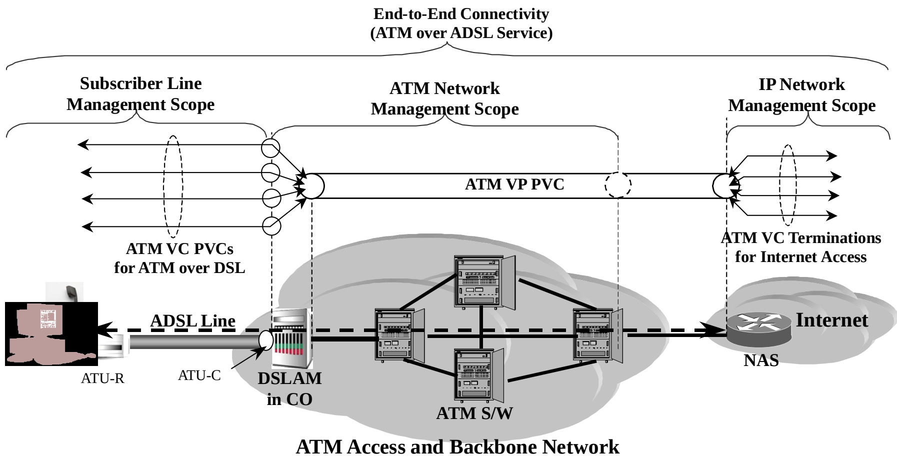

Figure 1. ATM over ADSL Environment

viewpoint. Firstly, we define a unified network model that can guarantee the scalability in terms of large-scale network management. It is designed with the ITU-T G.805 layering and partitioning concepts[3] and the RM-ODP information viewpoint.[4] Secondly, this paper proposes the distributed network management system. It is designed with RM-ODP computational viewpoint[4] and TMN functional decomposition of FCAPS.[5,6] In addition, we implement the network management system with distributed processing technology of CORBA.[7] Thirdly, we describe the scenario for provisioning of ATM over ADSL service with the proposed integrated network management system.

The rest of this paper organized as follows: in the next section, we present the unified network model that can be applicable for ATM services and ATM over ADSL services. Section 3 illustrates the integrated network management system architecture that is designed with the TMN FCAPS and implemented by distributed processing technology of COBRA. Section 4 describes the scenario for provisioning of ATM over ADSL service with the proposed integrated network management system. Section 5 discusses the issues of the integrated network management followed by the concluding remarks.

2. A UNIFIED NETWORK CONFIGURATION

In traditional network topology for providing ATM over ADSL service, the ATM network takes the role of access network to provide the connectivity between DSL access multiplexer (DSLAM) located in central office (CO) and network access server (NAS) located in Internet. However, ATM network takes the additional role of backbone network for providing the pure ATM PVCs or SVCs services to ATM subscribers. There are many network management systems for managing the ATM backbone network itself. However, there was no any network management system that manages the end-to-end network connectivity traversing DSLAM, ATM network and Internet for providing DSL services. That is to say, the DSLAMs are located in CO and are managed by network operators in CO with their proprietary management interfaces. Here, we make a paradigm change on DSLAM. In traditional DSL network configuration, the DSLAM is a multiplexer. If we emulate the DSALM as an ATM switch, the DSLAM can be the managed object of ATM network as shown in Figure 1. For maximization of integrated management of DSLAMs and ATM switches, a unified scalable network model is needed. Fortunately, ITU-T G.805 gives useful concepts of layering and partitioning.[3] According to its layering concept, there are three layer networks such as ATM VC layer network, ATM VP layer network and SDH transmission layer network. In accordance with the layering concept, we logically separate the ATM network into VP and VC layer networks. On the other hand, it is very difficult to manage hundreds of network elements without management hierarchy. ITU-T G.805 partitioning concept is to define the management hierarchy to maximize the manageability and scalability.[8] A layer network can be partitioned into a number of management domains, sub-networks (SNWs) connected by topological links (TLs). Each SNW can be successively decomposed into smaller SNW that is equivalent to an ATM switch or a DSLAM.

In most cases, today's ATU-Rs do not yet have the switched virtual circuit (SVC) capability that would allow flexible operation as in a conventional telephone network. Instead, the ATM network use permanent virtual cir-

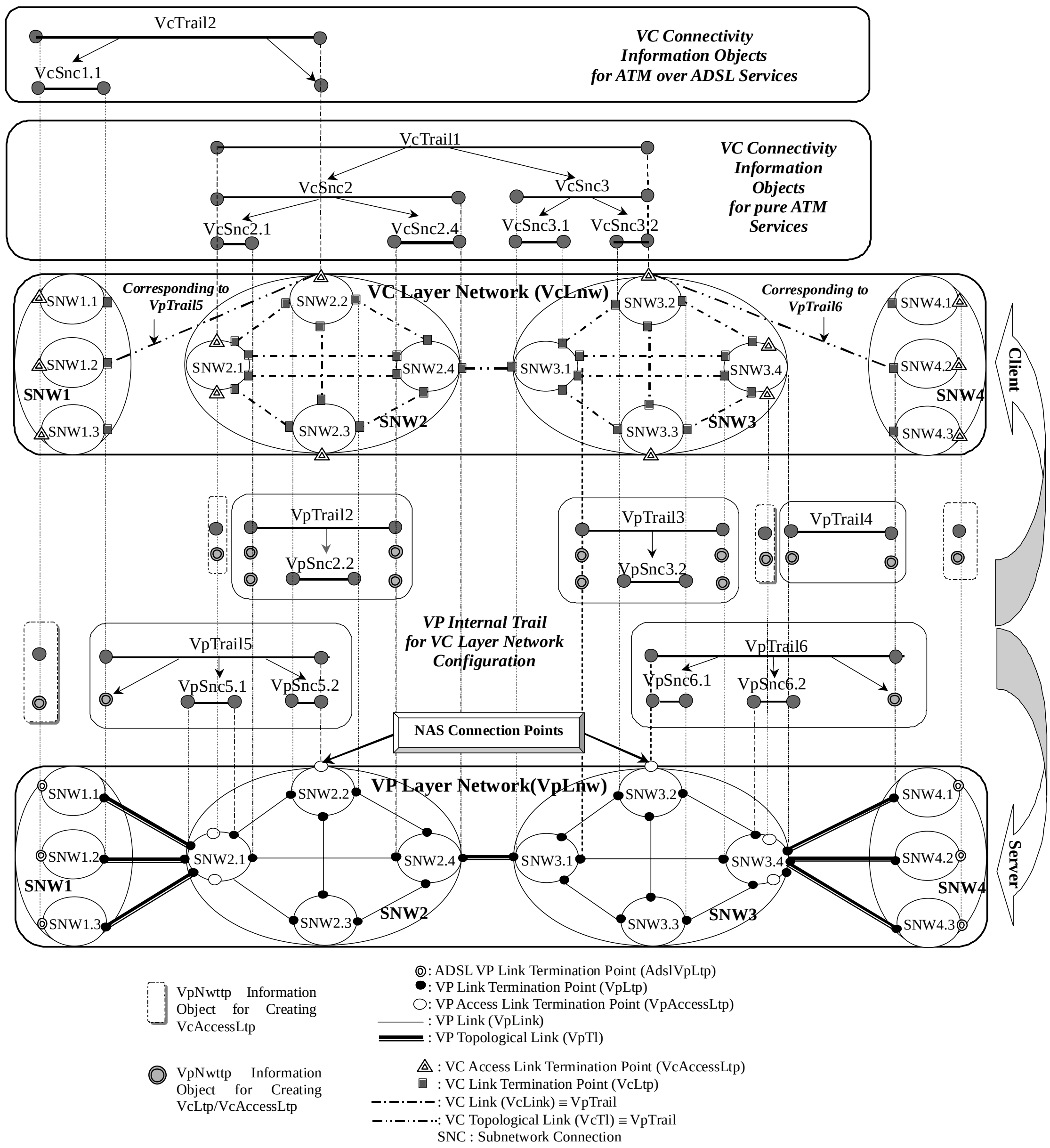

Figure 2. Information Object Model for the Unified Network Configuration

cuits (PVCs) that acts as static pipes,[2] as shown in Figure 1. We define two network fragments that represent the integrated network model for supporting ATM over ADSL service from the perspective of RM-ODP information viewpoint[4]: one is topological fragment and the other is connectivity fragment as shown in Figure 2. Topological fragment represents the network topology that is mostly based on the ITU-T G.805 layering and partitioning concepts.[3] We define five topological information objects as follows:

- *Layer network (LNW)* - A layer network (LNW) represents the network boundary that transfers any specific characteristic information without adaptation.

- Sub-network (SNW) - A Sub-network represents the management domain or administrative domain. We partitioned the layer network according to the management domain and equipment properties. A group of ATM switches is defined as an SNW and a group of DSLAMs is also defined as an SNW in terms of equipment properties. In addition, we defines two kinds of SNWs in accordance with the TMN functional layering concept[5,6]: one is NML sub-network (nmlSNW) that takes the roles of NML functions and the other is EML sub-network (emlSNW) that takes the roles of EML function. For example, the SNW1, SNW2, SNW3 and SNW4 in VP and VC layer networks are nmlSNWs and the SNW1.x, SNW2.x, SNW3.x and SNW4.x are emlSNWs in Figure 2. Each emlSNW corresponds to network element such as ATM switch or DSLAM.

- *Link termination point (LTP)* - Link termination point represents the physical or logical port quipped with network elements. There are two kinds of LTPs: one is access LTP that represents the port connected with subscribers and the other is transit LTP that terminates the transit link connecting between network elements. The access LTP can be categorized as VP access LTP (VpAccessLtp), VC access LTP (VcAccessLtp) and ADSL access LTP (AdslAccessLtp). VpAccessLtp represents the physical access port in ATM switch and AdslAccessLtp represents the ATU-C port in DSLAM. However, VcAccessLtp indicates the VPI terminated at the VpAccessLtp or AdslAccessLtp, which is logical access point defined in VC layer network and maintains the properties of ADSL line and alarm profiles.[4,7,9–11]

- *Topological link (TL)* - A TL represents the connection link between SNW. Each TL has the near and far link termination point (LTP). A TL in client layer network can be a trail in server layer network. The VpTrail5 in VP layer network corresponds to the VcTl connecting between SNW1 and SNW2 in Figure 2. Thus, there is client/server relationship between TL in client layer and Trail in server layer.

- *Link* - A link represents the connection link between network elements corresponding to emlSNWs contained within an nmlSNW. Link has the same properties as TL except that the management scope is restricted to a Sub-network.

On the other hand, the connectivity fragment represents the connections necessary for ATM over ADSL service through ATM network. It is designed in accordance with the topological fragment. We define ten connectivity information objects as follows:

- *Trail* - A Trail represents the end-to-end connection within a specific layer network. There are two kinds of Trails: one is VP Trail (VpTrail) indicating the end-to-end VP PVC and the other is VC Trail (VcTrail) representing the end-to-end VC PVC. In the case of VP Trail, it can be subdivided into one for provisioning VP PVC services to subscriber and the other for provisioning VP tunnels to deploy the VC layer network. All of these VpTrails are depicted in Figure 2 are to deploy the VC layer network. These VpTrails correspond to the topological links or links in VC layer network. Therefore these types of VpTrails take the adaptation role between client and server layer networks. For example, The VpTrail5 in Figure 2 is VP PVC for VC layer network construction, which takes the role of the VP tunnel for the provisioning of ATM over ADSL service in the VC layer network. It represents the VP PVC between the port of DSLAM (SNW1.2) connected with the ATM switch (SNW2.1) and the port of ATM switch (SNW2.2) connected with the NAS in IP network domain.

- *Sub-network connection (SNC)* - An SNC describes the connectivity within a sub-network. A sub-network connection can be categorized as NML SNC (nmlSNC) and EML SNC (emlSNC) according to the SNW types of nmlSNW and emlSNW.

- *Network termination point (Nwtp)* - An Nwtp represents the connection ending point that terminate at the LTP such as VpAccessLtp, VcAccessLtp, and AdslAccessLtp. We classify it into network trail termination point (Nwttp) and sub-network connection termination point (Nwctp). That indicates the near or far termination point of Trail and this indicates the near or far termination point of sub-network connection. One of the prominent difference between Nwttp and Nwctp is that we can only enable the segment loop-back at the Nwctp and enable the end-to-end loop-back at the Nwttp for PM OAM.

These information objects are managed by the network management system to provide the ATM over ADSL service and the pure ATM service with the unified viewpoint. In order to manage the unified network information model, the naming tree representing the inter-relationship and the containment hierarchy among the information objects is need as shown in Figure 3. Figure 3 shows the inter-relationship and the containment relationship among the proposed information objects for managing the end-to-end ATM over ADSL service.

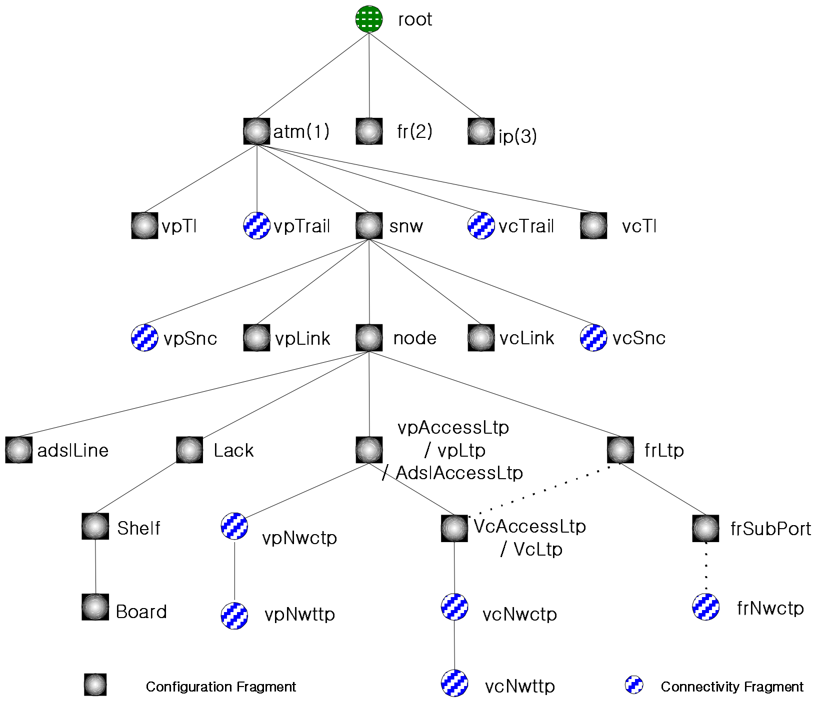

Figure 3. Information Object Hierarchy

3. THE COMPUTATIONAL MODEL OF THE INTEGRATED NETWORK MANAGEMENT SYSTEM

From the perspective of RM-ODP computational viewpoint, the system can be decomposed into various distributed functional modules. This functional decomposition can be done with various kinds of criteria for example maximization of system performance and system modularity, minimization of processing and communication overhead, scalability and manageability in terms of deployment of integrated network management system. We decomposed the integrated network management system into two parts: one is for provisioning ATM over ADSL service and the other is for providing the pure ATM service with the TMN functional layering concepts of SML, NML, EML, and EL and functional decomposition of FCAPS[5] as shown in Figure 4.

3.1. Overall System Architecture

Figure 4 shows the overall system architecture from the perspective of TMN Functional layering concept.[5] The network elements of DSLAMs, ATM switches and NASs provides the SNMP and CMIP interfaces to each management systems such as DSLAM EMS, SubNMS and NAS EMS. These management systems provide the unified element view or network view[12–15] with CORBA interfaces to IAANMS or IP NMS. Therefore, the management system located at the EML takes the role of CORBA/CMIP and CORBA/SNMP gateway functions.[16,9] DSLAM EMS and SubNMS provide the identical CORBA interfaces to IAAMS in order to increase the manageability and scalability. However, DSLAM EMS provides additional CORBA interfaces related with the management functions of ATU-C ports such as ADSL line and alarm profile.[17–22] The integrated ATM over ADSL network management system (IAANMS) takes the role of network management functions such as configuration, connection, performance and fault managements. The difference between element view and network view is that the element view[13] does not provide the routing function and the network view[12] provides routing function. Because DSLAMs are connected with ATM switches with star topology, DSLAM EMS need not do routing and provides the element view to IAANMS. As SubNMS manages various ATM switches, it needs routing function and provides the network view to IAANMS.

Each system has its own role in accordance with the TMN functional layering as follows:

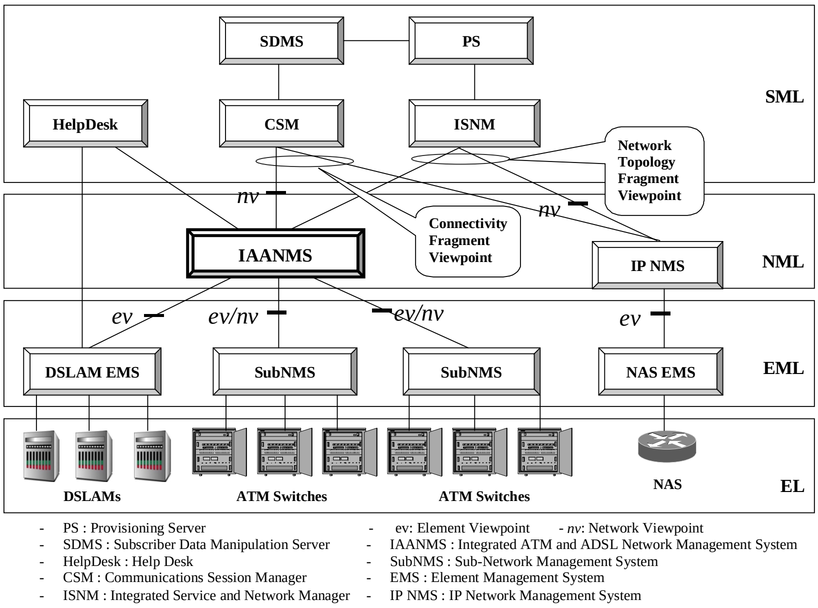

Figure 4. Overall System Architecture

- *Provisioning server (PS)* - PS collects all facility information such as node, board and port from the network elements of DSLAMs, ATM switches and NASs. It also provides the most reasonable ADSL access port (AdslAccessLtp) when a subscriber requests the ATM over ADSL service and ATM access port (VpAccessLtp) when a subscriber requests the pure ATM service. It provisions the IP address for the ATM over ADSL service subscriber.

- *Subscriber data manipulation server (SDMS)* - SDMS deal with subscription of ATM over ADSL and pure ATM service. It maintains the subscription information such as subscriber location, subscription information, information for billing, and so on.

- *Integrated service and network manager (ISNM)* - ISNM provisions the ATM VP layer network and ATM VC layer network. For provisioning VP layer network, ISNM refers to the facility information maintained by provisioning server. In addition, it dimensions the VC layer network topology according to the subscriber distribution and network traffic load.

- *Communications session manager (CSM)* - Locating at SML, CSM manages the communications session traversing multi-domain layer networks such as ATM and IP network. Because it takes the role of end-to-end connectivity management for ATM over ADSL service, it mediates number of NMSs to provision the end-to-end connectivity as shown in Figure 1.

- *Help desk (HelpDesk)* - HelpDesk system takes the role of trouble shutting. It receives the subscriber's complaints and tests the integrity of the subscriber's connectivity from ATU-R to NAS using the loop-back and continuity check provided by IAANMS.

- *Integrated ATM over ADSL network management system (IAANMS)* - IAANMS takes the roles of provisioning of the pure ATM VP/VC PVC service in terms of ATM backbone network management and the ATM over ADSL service in terms of ATM access network management.

- *Sub-network management system (SubNMS)* - SubNMS manages the connectivity within a sub-network domain. It has the gateway functions such as CORBA/CMIP and CORBA/SNMP in accordance with JIDM approach.[9,16] It provides the CORBA interfaces to IAANMS and controls network elements using CIMIP or SNMP.

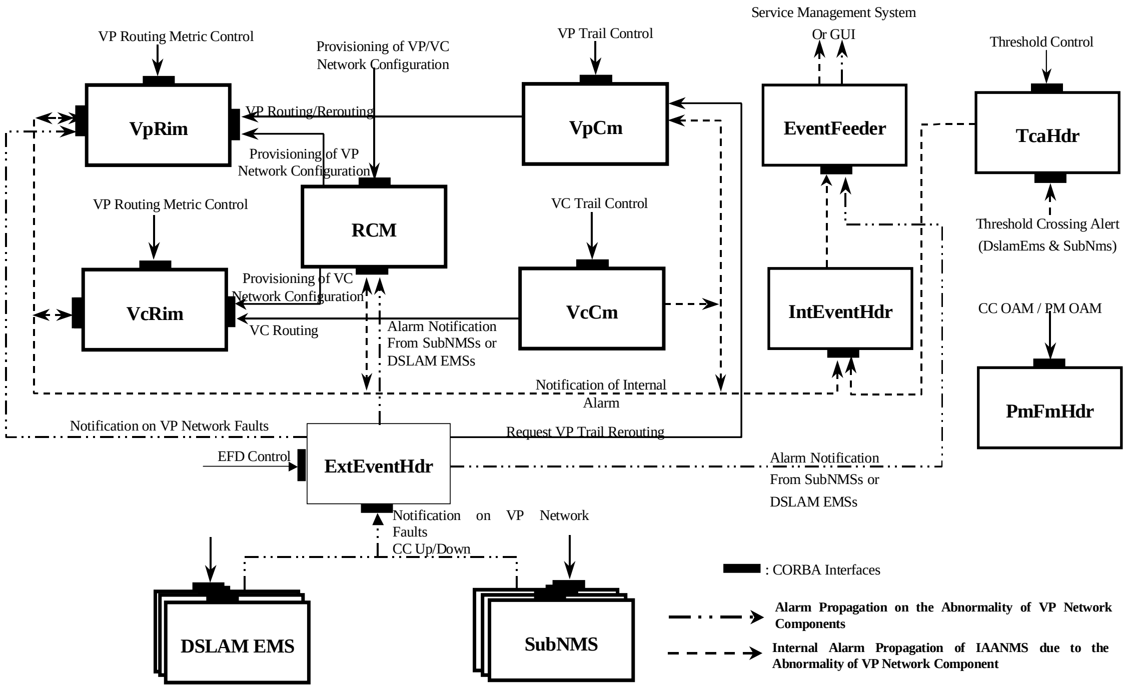

Figure 5. IAANMS Computational Model

- *DSLAM element management system (DSLAM EMS)* - DSLAM EMS manages a number of DSLAMs and takes the role of CORBA/SNMP gateway. DSLAM EMS is allocated to a sub-network that contains a number of same vendor's DSLAMs. DSLAM EMS also provides the CORBA interfaces to IAANMS.
- *IP network management system (IP NMS)* - IP NMS manages all of the Routers in IP network including network access server (NAS). This paper focuses on only the management of NAS to support ATM over ADSL service.

3.2. IAANMS Computational Architecture

As described in the previous section, IAANMS takes the role of management of ATM switches and DSLAMs to provide the ATM over ADSL service. IAANMS has four functional areas of configuration, connection, performance and fault managements in accordance with TMN FCAPS. This paper describes the IAANMS using the RM-ODP computational viewpoint[4] that can be used to specify the functionality of a distributed management system in a distribution transparent manner. The computational specification defines the objects within a management system, the activities within these objects, and the interactions that occur among these objects. The objects identified in the process of the computational specification are running over the distributed processing environment such as CORBA, JAVA, DCOM, etc.

In this section, we describe the IAANMS computational architecture in terms of TMN functional decomposition and RM-ODP computational viewpoint as shown in Figure 4. There are four management functional areas:

3.2.1. Configuration Management

Configuration management aims to support the provisioning and state control of topological information objects defined in the unified network model. There is a computational object for configuration management in IAANMS as shown in Figure5. The computational object of resource configuration manager (*RCM*) provisions the topological information objects into the IAANMS. Provisioning of topological information objects consist of procedures that are necessary to bring a network resource into network management service. In addition, it controls and monitors the state of provisioned topological information objects in real-time. The states to be managed by *RCM* are administrative sate, operational state and available state.[5,6] The RCM provides a number of IDL interfaces for provisioning and state management to integrated service and network manager (ISNM). One *RCM* computational object manages overall network topology information of ATM VP and VC layer networks including sub-networks and their internal topological structure in terms of provisioning and state management. *RCM* gives the network topology information of each layer network to the routing information manager (*VpRim/VcRim*) to construct routing table each layer routing table including the case of changing network topology.

3.2.2. Connection Management

The mission of connection management functions in IAANMS is to support ATM over ADSL services and pure ATM PVC services in their need for connections. It creates, releases and modifies the connectivity information objects described in the unified network model. There are two four computational objects related with connection management: VP connection manager (*VpCm*), VC connection manager (*VcCm*), VP routing information manager (*VpRim*), and VC routing information manager (*VcRim*).

The connection managers of *VpCm* and *VcCm* establish, release and modify the ATM VP PVCs and VC PVCs traversing DSLAMs and ATM switches. The routing information managers of VpRim and VcRim create their routing table according to the network configuration of VP and VC layer networks respectively. In addition, the routing information managers rebuild the routing table reflecting the four kinds of routing metrics: the available bandwidth of topological links (TLs) between sub-networks and links between nodes, administrative states of lock, unlock or shut down, the operational states of enable and disable representing the operability of network resources, and the availability states of degraded and normal reflecting performance status. They provide the optimal route to establish end-to-end ATM VP and VC PVCs and provide alternative route in the case of rerouting.

3.2.3. Fault Management

Fault management is concerned with detection, localization and detection of abnormal behaviour of the telecommunication network ad its environment. There are four computational objects related with fault management: external event handler (*ExtEventHdr*), internal event handler (*IntEventHdr*), event feeder (*EF*) and PM and FM handler (*PmFmHdr*). As shown in Figure 2, there is client/server relationship between VC layer network and VP layer. The VP trail takes the role of adaptation making this relationship. A VP trail traverses a number of network elements from the perspective of VP layer network. In addition, a topological link (TL) between sub-networks and link between nodes in VP layer network have a number of VP trails. Each VP trail can be the topological link (TL) or link in VC layer network. Also VC trail traverses a number of DSAMs and ATM switches in VC layer network.

The external and internal event handlers are distinct fault management functions in accordance with the client/server relationship between VP and VC layer networks. The external event handler receives the various kinds alarms especially the alarms related with the network topology information objects of VP layer network from DSLAM EMS and SubNMS and finds the root cause of alarms analysing them. On the other hand, the internal event handler propagates the alarms caused by the root event cause that is decided by the analysing the alarms from DSLAM EMSs and SubNMSs, which is based on the information object hierarchy shown in Figure 3. Of cause, the DSLAM EMSs and SubNMSs can propagate the alarms related with VP connectivity, VC layer network and VC connectivity information objects. If IAANMS receives such kinds of all alarm from DSLAM EMSs and SubNMSs, its processing overhead should be high. In order to minimize the processing overhead, the external event handler only deal with the alarms of VP network topology related information objects. The event feeder takes the role of alarm notification to the service management system and IAANMS GUI.

When the external and internal event handlers detect the network topology related alarms, they notify the alarms to *RCM* for reflecting the status of network resources and to *VpRim* and *VcRim* for modifying their routing tables. The *PmFmHdr* takes the two folds of network management functions of performance and fault managements. From the perspective of fault management, it tests and diagnosis the network abnormality using the Continuity Check. As a result of continuity check, if it detects any abnormality, the alarm also should send to *RCM*, *VpRim* and *VcRim*.

3.2.4. Performance Management

Performance Management is intended to capture intermittent error conditions and troubles resulting from the gradual deterioration of physical and logical network elements. There are two computational objects for performance management: PM and FM handler (*PmFmHdr*) and threshold crossing alert handler (*TcaHdr*).

The threshold crossing alert handler provides the pro-active maintenance functions such as performance monitoring enable the network elements to do early detection of troubles before they escalate in severity such as sever,

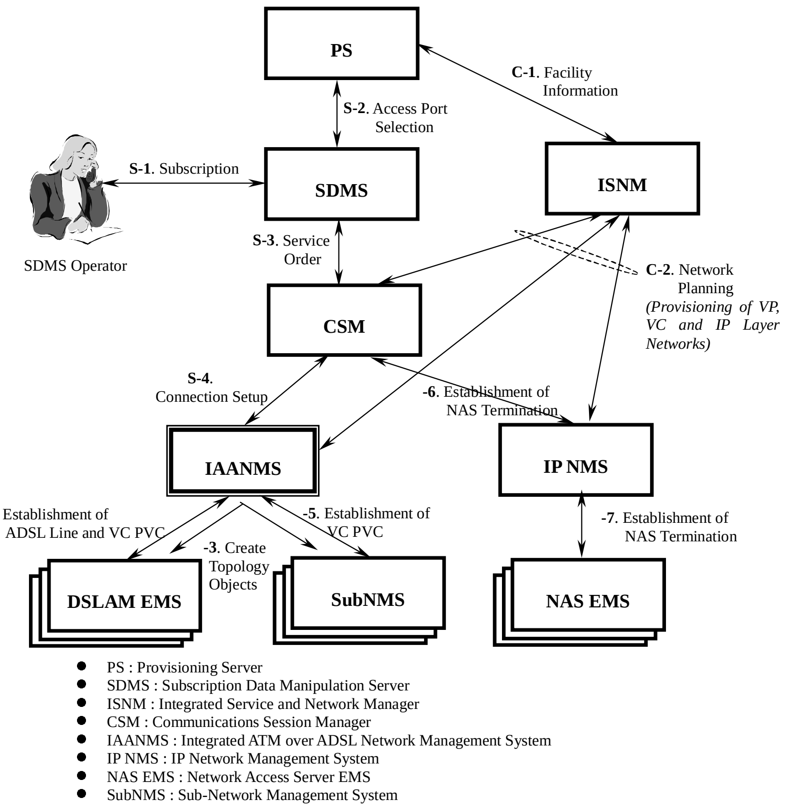

Figure 6. Scenario for Provisioning ATM over ADSL Service

major, minor, normal, and cleared. On the other hand, the *PmFmHdr* provides such functions as monitoring of physical network elements, protocol monitoring at ATM layer and the AAL and monitoring of VP/VC PVCs from the perspective of performance management. Especially, it provides the end-to-end and segment look back function.

4. SCENARIO FOR ATM OVER ADSL SERVICE PROVISIONING

Many systems are involved in provisioning the ATM over ADSL service as shown in Figure 6. We implement the defined information objects for the definition of the unified network mode using C++ object class. We adopt the Oracle database for the persistency of information objects. In addition, we implement the computational objects for the definition of the integrated network management functions using the IOAN Orbix.[10] All of the computational object in the integrated ATM over ADSL network management system (IAANMS) are running on the SUN E6500 equipped with 2 CPUs and 2G main memory. The SubNMS, DSLAM EMS and NAS EMS provide the CORBA interfaces to each network management system and take the role of CORBA/SNMP adaptations[9,16] to control ATM switches, DSLAMs and NASs. In this section, we describe the two scenarios: one is to configure the unified network model and the other is to provide the ATM over ADSL service based on the unified network model. At first, the scenario for configuring the unified network model is as follows:

C-1 The provisioning server (PS) directly collects the facility information from ATM switches, DSLAM using SNMP. The integrated service and network manager (ISNM) get the facility information from PS and designs the ATM VP and VC layer networks from the perspective of network planning.

C-2 The integrated service and network manager (ISNM) provisions the VP and VC layer networks such as layer network, sub-network, node, Ltp, link and Tl. In the case of the provisioning of VC layer network, the ISNM requests the establishment of the ATM VP connections to CSM. These connections are corresponding to the Links or Topological Links in the VC layer network in terms of the client/server association between VP and VC layer networks.

C-3 On receiving the request of the layer network topology provisioning from ISNM, the integrated ATM over ADSL network management system (IAANMS) creates the necessary topological objects. If the created objects are need to be managed by the sub-network management system (SubNMS) or DSLAM EMS, the IAANMS requests the topological object creation to the proper SubNMSs or DSLAM EMSs.

The scenario to provide the ATM over ADSL service based on the pre-provisioned unified network model is as follows:

S-1 An end user subscribes the ATM over ADSL service using fax, phone, and web. The operator of the subscription data manipulation server (SDMS) receives the end user's subscription information and issues a work order to SDMS.

S-2 The subscription data manipulation server (SDMS) queries the most reasonable ADSL and NAS ports and the IP address to the provisioning server (PS) with the subscriber's postal address. Thus, the PS maintains the facility information and IP address pool to allocate the most nearest ADSL port and the available NAS port and IP address to SDMS.

S-3 The subscription data manipulation server (SDMS) requests the establishment of the end-to-end communications session between the selected ADSL and NAS ports to the communications session manager (CSM).

S-4 On receiving the establishment of the end-to-end communications session, the CSM identifies the ATM port connected with the NAS port and issues the establishment of the ATM VC connection between ADSL port and the ATM port to the integrated ATM over ADSL network management system (IAANMS).

S-5 The integrated ATM over ADSL network management system (IAANMS) establishes the ATM VC connection (vcTrail) between the ADSL port and the ATM port connected with the NAS port. In addition, it set the ADSL line and alarm properties to AdslAccessLtp. Lastly, the IAANMS returns the VCI value terminated at the ATM port connected with the NAS port to the communications session manager (CSM).

S-6 On receiving the VCI value terminated at the ATM port connected with the NAS port, the communications session manager (CSM) issues the VC termination request at the NAS port to IP-NMS with the subscriber's IP address.

S-7 The IP-NMS terminates the VCI value at the NAS port and set the subscriber's IP address to the NAS port for authentication.

Thus, there are three steps to provide the unified network model that can be applicable for the pure ATM PVC service and the ATM over ADSL service provisioning. In addition, there are the five steps to provide the integrated ATM over ADSL service in the proposed network management system.

5. CONCLUDING REMARKS

In Korea, the ADSL subscribers of Korea Telecom are explosively increased as many as fifteen thousand per day and has already two million ADSL subscribes. It is very difficult to accommodate such a large number of customers as fifteen thousand a day by the operator's manual operations. In order to accommodate such a large number of ADSL subscribers and to provide the systematic network management, this paper proposed the integrated ATM over ADSL network management system (IAANMS). We described the unified network model that can be applicable to the pure ATM PVC service and the ATM over ADSL service provisioning. It is designed by the ITU-T G.805 layering and partitioning concepts to maximize the manageability and the scalability and is described in terms of RM-ODP information viewpoint. According to the ITU-T G.805 layering and partitioning concepts, we defined two fragments such as the topological fragment and the connectivity fragment.

In addition, this paper described the computational mode that is designed with the RM-ODP computational viewpoint taking into account the functional decomposition and distribution and with the TMN functional layering and FCAPS. In addition, each functional module is specified by the CORBA and is implemented by the IONA Orbix [27] to provide its distribution and location transparency. Lastly, we described the scenarios for the configuration of the unified network model and the provisioning of the ATM over ADSL service.

With the proposed integrated ATM over ADSL network management system (IAANMS), Korea Telecom can provide over fifteen thousand ADSL subscribers per day and can systematically manage the ATM access network in terms of configuration, connection, fault and performance. In addition, because the unified network model is designed to provide the scalability, we can cope with the situation of the explosive increase of the ADSL subscribers. On the other hand, because the functional model are designed with the CORBA object taking into account the functional decomposition and distribution and the modularity, we can easily add the new management functions to the existing network management system and easily revise the existing network management functions.

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