VC Layer Network Configuration for SVC Service Provisioning in ATM Networks

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Abstract
SVC (Switched Virtual Circuit) service in ATM networks provides VC level end-to-end connectivity to customers in real-time. To provide SVC service, ATM networks should be configured so that basic VP level networks resources are configured a priori. While various research works can be found on SVC service management at network element level, not much work has been done in network manager side for SVC service management. This paper presents a framework for configuring ATM networks for the provisioning of SVC services. Specifically, the paper presents a framework for configuring VC layer network through interaction between VP and VC layer network management entities. Also, relationships between proposed scheme and TMN logical layer concept are described.

1. Introduction
Telecommunication services are already entering an era of diversity and more services are expected to appear in the future to the extent that has not been foreseen before. At the center of enabling technologies lies Asynchronous Transfer Mode (ATM) technology which has made it possible to support multiple different types of telecommunication services using a single information transfer/switching mechanism. Provisioning of various different types of existing and future telecommunication services requires that underlying basic end-to-end connectivity handling capabilities be both efficient and flexible to meet various different communication requirements[5]. Signaling capabilities in ATM networks have incorporated these requirements and recommendations are being made in several different phases and capabilities.

ATM network itself is composed of two different network layers, i.e., Virtual Path (VP) and Virtual Channel (VC) layers, which share the same information transfer mechanism at different levels. Since signaling service is provided at VC level, provisioning of SVC service in ATM network requires basic VC layer network be configured a priori. This basic VC level network configuration activity requires connectivity-related resource setup in underlying VP layer network. Therefore, configuration management of VC layer network itself becomes basic and important requirement for the provisioning of SVC service in ATM networks.

Also, for efficient utilization of network resources and further adaptation to customer traffic pattern, it should be possible to dynamically reconfigure VC layer network and modify SVC service characteristics without major service interruption.

There have been various research works on SVC service management in ATM networks [4]. However, these works mainly focus on network element views or interactions between manager system and network elements, i.e., manager side functional framework has not been worked on yet extensively. This paper focuses on manager side functions and presents a management framework for configuring VC layer network for providing SVC service in ATM networks. Especially, a framework for provisioning VC layer network resources through interaction with VP layer network management entities is proposed. The framework is based on existing layered network concept[1] and, as such, can be applied not only to VP-VC layer networks but also to other layer network interactions (e.g., ATM networks and SDH networks). The proposed framework is based on TMN logical layered architecture and makes use of existing concepts and research works for connection management [1][2][3].

The paper is organized as follows: Section 2 describes basic management framework for basic VC layer network configuration. Section 3 shows detailed architecture for VC layer network configuration and describes implementation-specific experiences. Section 4 shows relationships between proposed architecture and
TMN logical layered architecture, followed by conclusions.

2. VC LAYER NETWORK CONFIGURATION FOR SVC SERVICE

Layer network concept has been widely accepted as basic framework for hierarchically structuring different types of networks[1]. In this framework, provisioning of a layer network depends on services of lower layer networks. An example is shown in Figure 1, which shows relationship between server and client layer networks where a trail of server layer network serves as a link in client layer network.

![Figure 1. Client-server relationship between two adjacent layer networks](image)

For removing ambiguity in this paper, the following definitions are used.

- **node**: A node in layer network A transfers incoming information from one of its input ports to another port with regard to information specific to layer A. For example, a VP(VC) node handles and switches ATM cells based on the VP(VC) level information in the cells. Ports in a node can be end points of a link in the same layer network.
- **link**: A link in layer network A connects two nodes in layer network A by connecting two ports, one from each node. End points of a link is called link termination points.

The layered network modeling scheme can be applied to model ATM networks in two layer networks. Basically, an ATM network provides VP- and VC-level services which are logically provided by VP and VC layer networks, respectively. In this model, a trail in VP layer network serves as a link in VC layer network and trail termination point in VP layer network corresponds to a link termination point (or port) in VC layer network. Recursively, nodes in VP layer network are interconnected through various different information transport layer networks, e.g., SDH or PDH networks. In any case, a trail in underlying information transport layer network serves as a link in VP layer network.

Unlike the logically separate layer network model described above, typical ATM networks are comprised of both VP and VP/VC switches and crossconnects.

For network nodes handling both VP and VC level cells, VC level functionality can be thought of an equipment or functions external to network from the viewpoint of VP layer network. Therefore, a VP trail can terminate at or passes through a VP/VC switch. In this environment, the logically separated layered network model described above (where end-points of a layer network resides outside the layered network) cannot be directly applied in practical ATM networks. For modeling this situation, the following three different types of trails are defined in this paper:

- **User-to-user trail**: User-to-user trail spans between two end users of ATM network being managed.
- **Network-to-network trail**: Network-to-network trail spans between two internal ports (or link termination points) of a layer network. The trail should be a ordered sequence of one or more link connections and subnetwork connections.
- **User-to-network trail**: User-to-network trail spans between an end-point of the ATM network and one internal port (or link termination point) of a switching equipment in the same layer network. Note that user-to-network trail may not be a single-hop trail, i.e., made up of only one link connection within a link directly connecting a user equipment and a switch. An example can be a user-to-network trail starting from user equipment, passing through a multiplexer and finally reaching a network switch where User-Network Interface (UNI) signal is terminated.

Figure 2 shows a physical ATM network (composed of one VP XC/SW and three VP/VC switching nodes) and corresponding two logical layer networks (VP and VC layer networks). Note that VP layer network in the figure contains two of the above-mentioned three trail types (user-to-user trails in VP layer network is not shown in the figure because it is not relevant to the main focus of this paper). The figure also shows relationships between links in VC layer network and trails in VP layer network.
2.1 Basic Framework

Basic VC layer network configuration activities for SVC service provisioning consist of the followings:

- **VC port setup:** A port in VC layer network is supported by an end-point of a trail in underlying VP layer network. For provisioning of a link in VC layer network, VC ports which correspond to two end points of the VP link should be set up first. Note that provisioning of a port in VC layer network corresponds to creation of trail termination point in VP layer network.
- **VC link setup:** After corresponding VC ports are configured, it is now possible to introduce a link in VC layer network. Provisioning of a link in VC layer network assumes existence of a trail in VP layer network and, as such, corresponding trail in VP layer network should be created a priori.

Since configuration of VC layer network requires connection setup in VP layer network, interaction between configuration management functions in VC layer network and connection management functions in VP layer network is required. Connection management architecture has been well-established in TINA-C[3] and, therefore, this paper makes use of TINA connection management architecture for creating/modifying/deleting trails in VP layer network. Also, interaction between manager and network elements for managing trails and connections are assumed to be based on existing standards.

Figure 3 shows management functional entities and relevant workflow related to VC layer network configuration for providing SVC service in ATM network. In the figure, VC layer network planning data contain information on details of VC links and ports to be created in VC layer network. Typically, this information is obtained from estimated traffic pattern among SVC service subscribers. Based on this information, SVC service configurator requests creation of VC links and ports to VC layer network configuration manager. VC layer network configuration manager validates/translations the request and issues relevant trail setup request to VP layer network connection manager. This trail setup request is handled by VP layer network connection manager through interaction with network element agents for creation of VP level resources such as vpTTPs and crossConnections. Based on results of these operations, corresponding VC ports and links are created in VC layer network.

3. Detailed Architecture for VC Layer Network Configuration

In this section, detailed functional architecture for VC layer network configuration is described. First connection management architecture from TINA is described and integration with configuration management functions is given.

3.1 Connection Management Architecture

As was described above, the framework is based on
TINA connection management architecture. TINA connection management architecture is itself designed to support various different advanced telecommunication services such as VPN, multi-party multimedia conference, etc. Therefore, the connection management architecture includes many advanced concepts which provides technology-independent, flexible connectivity among communicating entities. The scheme in this paper makes use of parts of the results, namely, provisioning of trail by layer network coordinator(LNC).

Figure 4 shows functional view of TINA connection management architecture and its relationship with TMN Logical Layered Architecture(LLA). Communication Session Manager(CSM) provides connectivity resources to the service applications. CSM transforms a request from an application (for a stream, for instance) into a request for a network connection and requests required network connections to Connection Coordinator(CC). CC deals with the network complexity(e.g., with the layer networks) and is not associated with any particular layer network. It will get as input a request to connect two or more network access points, providing a certain bandwidth and a quality of service. Based on this information, CC determines which layer network to use and requests a proper LNC to setup a trail or tandem connection in its layer network. LNC is responsible for providing trails in a layer network and can generate the corresponding requests to the Network Management Layer(NML) Connection Performers(CPs) for interconnecting termination points in a subnetwork (every subnetwork is managed by one CP) and these, in turn, generates requests to the EML CP for required interconnections in the network elements.

Note that, since VC layer network configuration for SVC service deals with VP level trails, only those shaded parts are used in this paper for configuring VC layer network.

3.2 Resource Configuration Management Architecture

Resource configuration management functionality is mainly related to provisioning and maintaining inventory of static resources in a layer network. Figure 5 shows resource configuration management architecture for a layer network.

Network resource installation support(NRIS) receives an installation/removal request and builds resource installation schedule. Based on the schedule, NRIS requests resource setup to network resource inventory manager(NRIV). If the installation of network resources requires external intervention, a corresponding event will be forwarded to network resource event propagator(NREP), which broadcasts or forwards the event in the form of notifications. For the case of auto-configurable resources, creation or modification events of the resources is received by network resource event coordinator(NREC). In this case, the event is forwarded to NRIS which, then, performs configuration of logical resources based on the information.

![Figure 4. TINA connection management architecture](image1)

![Figure 5. Layer network resource configuration management architecture](image2)
requests. An example is to handle a query as to the status of a specific port or a request to activate/deactivate a port. Upon receiving these queries and requests, NRSC generates a resource configuration schedule and performs the query and control based on the schedule generated.

Network resource inventory manager (NRIV) keeps network resource data in terms of topological configuration, resource status, relations among network resources, pointers to network resource objects represented as network resource information model, and other miscellaneous information on network resources.

Network resource event coordinator (NREC) receives notification from external entities, performs filtering, and forwards the event to appropriate modules such as NRIS, NRIV, and network resource event propagator (NREP).

Network resource event propagator collects events from resource configuration domain and forwards the event to external entities, if necessary.

3.3 Integrated Functional Architecture

Figure 6 shows integrated functional architecture for VC layer network configuration.

VC layer network configuration is started upon request from network operator or when layer network configuration plan is available. This information is handled by VC network configuration application which, in turn, requests NRIS for VC layer network port and link setup. NRIS then builds installation schedule and request a trail creation to VP layer network connection management function (LNC, to be specific). When the requested trail is created successfully, NRIS interacts with NRIV for setting up a link and corresponding ports in VC layer network. The result is returned to VC network configuration application, which requests for another link setup to NRIS. When this repetitive procedure is completed, VC network configuration application forms and sends a reply to its client. Detailed interaction diagram for this scenario is given in Figure 7.

3.4 Implementation Experiences

Above VC network configuration scheme has been implemented and verified in ATM network testbed in Korea Telecom (KT). The environment consists of 1) unix-based management system running TMN management platform developed in KT, and 2) ATM VP/VC switching elements providing Q3 interface. Each switching element has internal TMN agent software and supports ATM network element managed object definitions concerning configuration, connection, fault, and performance management. Concerning network manager side, the management system makes use of GDMO-based network level information model. The model has been developed based on existing TINA connection management concept and currently under alignment phase with ATM Forum and ITU-T network level information model and concepts.

Figure 8 shows information model relationship diagram used in the implementation. The diagram shows managed objects related to network-to-network trail. Note that, for user-to-network trail, currently only those managed objects relevant to network side of the trail are instantiated in network level MIB and user side managed objects are only created and handled logically.
The implementation has shown functional verification of the proposed architecture. However, several items have come out as possible problems.

- **Duplicate traffic problem in VC level multicast:** This problem appears when two virtual VP trunks (or trails) originate from the same physical port and destined to different physical ports in other network elements. In this case, when a VC level multicast cell arrives at the originating port, copies of the cell are transmitted over multiple virtual VP trunks, which may cause possible degradation of the performance of the originating physical port. It is expected that this phenomenon may cause serious traffic degradation when VC level multicast traffic is heavily used in the network.

- **Number of UNI virtual VP ports:** In the implementation, each UNI ports in the network have been configured to have a number of VP ports to be used for VC level traffic handling. However, considering that the number of UNI ports in the network will increase rapidly as ATM networks are deployed, it is expected that management of VP ports as a bulk should be sought for to reduce VC and VP level management complexity.

4. Relationship with TMN

TMN has defined logical layered architecture (LLA) for mainly dealing with the complexity for managing a large and diverse networks[2]. The logical layer architecture concept is very generic and can be applied for modeling management architecture for various purposes. In this section, applications of TMN LLA concept to VP and VC layer network management are shown and their relationships are identified.

The proposed architecture assumes two different management system for both VP and VC layer networks. However, a generic functionality can be used for resource configuration and connection management in both layer networks. Figure 9 shows two different management systems for both VP and VC layer networks mapped to TMN logical layers.

The figure shows two management functional areas related to SVC service management, i.e., resource configuration and connection management. Functions of each of these management functional areas are separated into service and management function parts. In this configuration, the service part corresponds to service management layer(SML) and management function part corresponds to NML and EML of TMN logical layers.

Interaction between VP and VC layer network occurs when a link and port resources are needed in VC layer network. In this case, VC layer network configuration management functions perform necessary resource requirements and issue corresponding
connectivity resource creation request to underlying layer network, which, in this case, is VP layer network trail provisioning service. This type of interaction is generic in that VP layer network resource configuration management functions, if needed, can also issue trail setup request to underlying network management system.

5. Conclusions

Basic network management functionality and corresponding architecture to support SVC service in ATM networks have been proposed in this paper. For this purpose, relevant management entities are first defined and, then, functions of and interactions among management entities have been identified. Interactions among management entities can be either within one layer network or between two layer networks. Finally, relationships between TMN logical layering concept and proposed architecture are described.

Signaling can be considered as a basic connectivity service provided by ATM networks and, as such, further works should be done for controlling the behavior of signaling entities in the network. These include signaling channel allocation, route information management, and relevant information setting in signaling entities. Considering that these activities are based on VC layer network configuration, the proposed framework can be used as a basic mechanism for supporting efficient yet flexible operation of SVC service in ATM networks.

[References]