# SDN-based architecture for end-to-end path provisioning in the mixed circuit and packet network environment

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***Abstract*—Recently there have been a lot of discussions about the benefits and usages of SDN technologies, but not many practical proposals for how to interconnect the various heterogeneous and disparate networks maintained by the telecommunication companies. Current level of SDN technologies does not show any sign of transforming the whole legacy network into the SDN oriented one all at once, but instead, SDN concept may need to be deployed into the small parts of the current heterogeneous mixed network first and then it would be able to expand its area gradually [1].**

**Being started to consider the new aspects of network services, such as off-loading the mobile data, transferring smart contents, adjusting and adapting the network resources and traffic amount, the telecommunication companies need to establish a strategy for virtualization of the networks, including metro Ethernet and optical transport networks, for systematic unification of the control mechanisms, and eventually for the SDN based network management and control system operated in real-time.**

**Since the research and development of SDN technology to be adapted onto the large scaled telecommunication network is in the beginning stage, we focus on the activities for the interconnection methods for the disparate heterogeneous networks. This paper especially suggests SDN-based end-to-end path provisioning architecture for mixed circuit and packet networks.**

***Keywords—component; Transport SDN, End-to-end Path Provisioning***

## I. INTRODUCTION

Looking at the network architecture from the point of traditional view, each network node has been considered as an independent entity equipped with both the data plane receiving and forwarding the data and the control plane controlling the data flows.

Introducing SDN concepts into the network architecture brought the physical separation of these two planes, pushing up the control planes to the centralized controller of the architecture and putting the data planes remained on the network elements [2].

The stakeholders for developing and deploying SDN technology can be roughly classified into standardization bodies, vendors, network service providers, etc. Various projects are being conducted by the participation of these stakeholders with clear understanding for their benefits.

SDN provides obvious opportunities to the network service providers due to the following reasons. Firstly, as the functions belonged to the control plane subtracted from the original network elements and gathered to the centralized controller, the price of the equipment itself can be lowered. Secondly, as the vendors should make their products' control plane standardized to be attached to the service provider's controller, the vendor-independency can be improved. And lastly, as the management and control point will be centralized and focused, the OPEX may be reduced.

Up to this point, most of the successful deployments of SDN technology have been reported in the area of IP networks [3]. But the network service providers' networks consist of totally different types of networks. The two major network types discussed in this paper are the circuit and the packet networks. The packet network consists of IP based routers and switches to convey the datagram type of data. The circuit network consists of transport equipment transferring the circuit data between two nodes on the connections established and maintained by them.

Typically, these two different types of networks have been separated in two independent layers, but SDN concept and other new ideas are suggesting various unifying methods for them.

Currently one of the most possible unification methods may be the one that implements the packet and the circuit transport functions into single equipment. The other option is to construct a unified network using the centralized controller which manages and controls both the packet and the circuit networks without changing the original network configuration.

SDN should conduct an important role to converge the packet and the circuit networks providing practical values to

the network service providers maintaining especially circuit-based transport network intensively [4].

In this paper we propose an end-to-end path provisioning architecture controlled by the hybrid type of SDN controller in the mixed network environment consisted of circuit and packet networks.

## II. SDN-BASED SERVICE SCENARIO ON THE MIXED CIRCUIT AND PACKET NETWORK

The principles of circuit communication technology should provide the circuit network with a bandwidth guaranteed communication paths between two nodes. For example, an IP based connection link between two routers sets up its physical connection on the transport layer by acquiring the proper slot allocated in the TDMA and WDMA architecture.

It is not easy to interconnect the various transport equipment produced by the different vendors, for each of them has established a proprietary way of control and management technology for their equipment. When a telecommunication company wants to interconnect different vendor's networks, it first constructs the logical or regional networks, each of the networks consisted of a single vendor's product, and then the central O&M system handles the interconnection works. So the circuit-based transport networks tend to take centralized control architecture.

On the other hand, the service network established on top of the transport network puts the basis on the packet transmitting technology and has a standardized interconnection method among the vendors. Basically each network element can control itself independently, but the whole network is maintained robustly thanks to the delicately implemented operation mechanism. So the service network mainly consisted of packet network take a distributed type of control architecture.

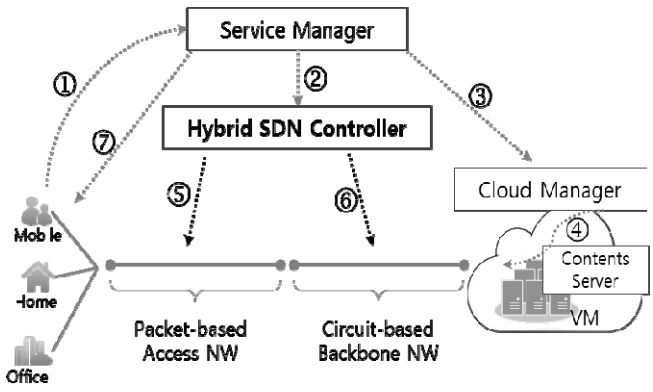


Figure 1. SDN-based service configuration in the mixed circuit and packet network

Figure 1 depicts a configuration for any service provider or user who wants to provide or use a certain application service in the mixed packet and circuit network controlled by the hybrid SDN controller.

The service manager on the top of the figure takes a role of broker providing the application service information to the users.

Cloud manager searches for the resources in the cloud center, creates the virtual machines to support the specified application services and sets up the path from the virtual machines to the exterior node.

Hybrid SDN controller creates and connects the circuit domain path and the packet domain path to establish the total end-to-end path. It will be interconnected with the one provided by the cloud manager to deliver the application service to the users.

Users access the services running on the cloud center by the following steps (the step numbers are correspond with the circled numbers on the figure 3).

Step 1) Users search through the types of services and select the one of them to use. This activity initiates the path setup request.

Step 2) Service manager determines the topological position of the user requesting the path setup as well as the characteristics of the path, and sends a path setup request to the hybrid SDN controller for the mixed circuit and packet domain.

Step 3) Service manager sends an order to the cloud manager for the preparation of the service virtual machine and the path between the virtual machine and the border node.

Step 4) Receiving the request from the service manager, cloud manager prepares the service virtual machines and the path for the border node.

Step 5, 6) Hybrid SDN controller creates the circuit domain path and the packet domain path, and interconnect them to create the mapping information and to complete the end-to-end path in the mixed circuit and packet network.

Step 7) Service manager puts together the path produced by the hybrid SDN controller for the mixed circuit and packet domain, and the path for the service virtual machine prepared by the cloud manager, to provide the final service communication path to the users.

After the above process is completed, the users can use the requesting services on the end-to-end service path.

## III. THE STRUCTURE OF THE HYBRID SDN CONTROLLER

In general SDN environment where the control and the data planes are separated, in order to acquire the service delivery path, a centralized SDN controller needs to be implemented to control and manage the network elements lacking in control functions

When a controller is implemented, the core functions should not be changed greatly for the different domain.

Considering this constraint, this research pursuit the hybrid type of SDN architecture which is operable regardless in packet or circuit domains, while not to affect the core logic. This makes it possible to provide and manage the efficient and stable end-to-end paths among the mixed circuit and packet network environment.

On receiving the user's path creation request from the service manager, the hybrid SDN controller sets up and manages the end-to-end path by interconnecting the packet-based access path and the circuit-based backbone path. Figure 2 shows the detailed architecture of the hybrid SDN controller.

Packet switching API is a communication interface to send down the command for the path set up and management for the packet devices, and to gather the information from them.

Packet topology module maintains and manages the connectivity configuration for the network elements in the packet domain. The connectivity configuration information mostly comes from the update information of the packet link discovery module.

Packet link discovery module automatically finds the new links, fault links, or recovered links to update the topology information.

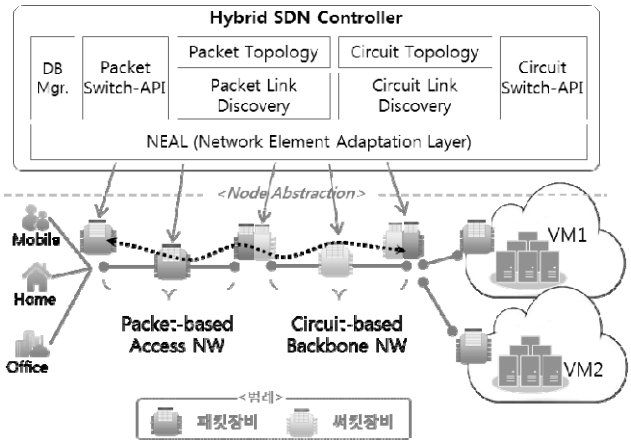


Figure 2. Configuration for hybrid SDN controller

Circuit switching API sends out the commands to set up and to manage the paths to the circuit devices and gathers the information from them.

Circuit topology module maintains and manages the connectivity configuration for the network elements in the circuit domain in real-time. Connectivity configuration is mainly updated by the information from the circuit link discovery. The circuit connectivity information will be aggregated with the packet connectivity information to provide the final topology information for the whole network.

Circuit link discovery module automatically detects the new, faulty, recovering links, and updates the topology information.

NEAL(Network Element Adaptation Layer) is an adaptation layer which adapts the commands from the hybrid SDN controller into the network elements, and converts the information from the network elements into the understandable format for the internal logics of the hybrid SDN controller.

DB manager stores and manages the information created and maintained by the packet and circuit management modules as the database information.

## IV. PATH SETUP IN THE MIXED CIRCUIT AND PACKET DOMAIN

The hybrid SDN Controller described in the previous section, receives the path creation request from the service manager depicted in the Figure 1. It then sets up the packet and the circuit paths respectably to complete the end-to-end path based on the mapping table information.

First of all, for the circuit path setup, the circuit topology module in Figure 2 computes the connectivity configuration between the source and destination nodes based on the connectivity information following the circuit path setup method in Figure 3.

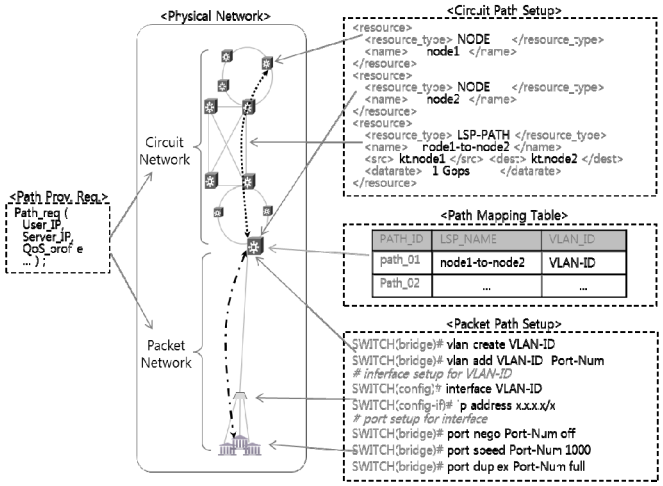


Figure 3. Structure for the mixed circuit and packet path setup

Circuit path setup module traverses all the links existing on the road to the corresponding nodes in a row to complete the circuit path. The command set implementing the completed path will be transmitted to the physical circuit devices by way of NEAL layer observing the regulation of the circuit switch API protocol.

Likewise, as for the packet domain, the virtual network names will be assigned to all the network nodes on the road to set up the packet path.

The packet topology module in Figure 2 searches for the current connectivity configuration information to find out the

available paths. When the one of the available paths is selected, the command set implementing the physical path will be sent to packet devices by way of NEAL layer observing the regulations of the packet switch API protocol.

Once the circuit and packet paths are established, path mapping table will create the mapping information for the two paths to complete the end-to-end path and manages the information in the database tables.

## V. CONCLUSION

This paper shows a path provision architecture providing end-to-end paths in the mixed circuit and packet network environment. It does not require the original network configuration, because the hybrid SDN controller can manage and control the packet and the circuit network in a unifying fashion.

As the hybrid SDN controller can handle the both circuit and the packet domain flows, all the end-to-end flows can be monitored and managed by this architecture.

This work is expected to give a small contribution to the SDN infrastructure technology opening up the new opportunity for the SDN-based business market

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