An Efficient Provisioning Mechanism for In-Service Migration in Access Network

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***Abstract*- The tremendous bandwidth demand for content-rich services on service providers initiates new access networks deployment and leads the networks increasingly complex and functional. In general, the commercial access networks are composed of a large number heterogeneous, multi-domain, multi-technology and multi-vendor network devices. In such a network environment, the network migration is a challenging task for any service providers. The process of network migration traditionally involved a series of manual and repetitive steps. The manual process of network migration requires highly skilled staffs and is prone to human error. In this paper, we present the integrated and automated provisioning operational supporting systems (OSSs) for in-service network migration. The developed OSSs provide two kinds of in-service network migration mechanisms and support a diversity of network migration scenarios in heterogeneous networks. Finally, the results show that the proposed efficient provisioning mechanism significantly speeds up the network migration and reduces service providers' operational expenditures (OPEX).**

Keywords- Broadband Access Network, GPON, VDSL2 Bonding, In-Service Migration, Automatic Provision

I. INTRODUCTION

The tremendous bandwidth demand for content-rich services including high-definition multicast and unicast video on service providers initiates new networks deployment. To support multi-play services, access networks have become increasingly complex and functional. In general, the commercial access networks are composed of a large number heterogeneous, multi-domain, multi-technology and multi-vendor network devices.

Today, copper-based access technologies terminate more than two thirds of the 466 million broadband users [1]. The most notable for residential use are Extended bandwidth Asymmetric Digital Subscriber Line (ADSL2+) and Very-high-bit-rate Digital Subscriber Line 2 (VDSL2) which offers a downstream capacity of up to 100 Mb/s [2]. In copper-based access networks, the new breakthrough technologies include DSL channel bonding, Vectored DSL, and G.fast [6[. DSL channel bonding (ITU-T standards G.998.1 and G.998.2 [4], [5]) allows the service providers using two or more copper loops per subscriber instead of one to improve the performance of the DSL technologies for a given loop length. Vectored DSL mitigates crosstalk from neighboring lines at the signal level to increase data rates, thus it is a promising feature to further enhance competitiveness with other access technologies [5]. In addition, continuous improvements in optical-based access networks have enabled hybrid fiber/copper access networks that provide ever increasing broadband data rates. Passive optical network (PON) is one of the most successful optical-based access architectures being deployed worldwide. Key models being used today and in the foreseeable future include fiber to the node (FTTN), fiber to the distribution point (FTTdp), fiber to the building (FTTB), and fiber to the home (FTTH).

In such a multi-domain environment with diverse technology deployments, the network migration is a challenging task for any service providers. A migration to the new deployed network should not affect already existing networks and services. Service providers need to make careful analysis of deployed networks, service demands, link technologies, and capability to support present and future traffic. Moreover, the process of upgrading an existing network device (or port) to a new deployed network device (or port) commonly involved a manual and repetitive series of steps. Such a network migration process requires highly skilled staff, although it only works fine for a very limited number of services. It is also prone to human error.

In this paper, we present the integrated and automated provisioning operational supporting systems (OSSs) for in-service network migration in the largest commercial broadband network in Taiwan. The developed OSSs provide two kind of automatic in-service network migration mechanisms and support a diversity of network migration scenarios in heterogeneous networks. As noted above, the process of network migration involves manual intervention interfaces, and lasts days or even weeks, while the proposed architecture reduces the service provisioning time frame to minutes.

The remainder of this paper is structured as follows. In Section 2, we investigate some selected network migration features for the commercial broadband networks. In Section 3, we describe the design of the integrated and automated network migration provisioning systems in detail. We then present the results and related works. Finally, concluding remarks are given in Section 4.

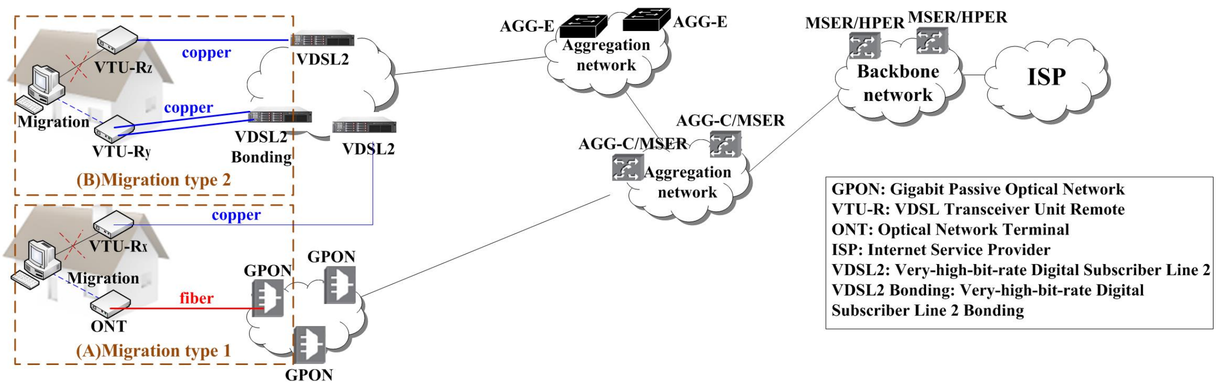


Figure 1. Two types of access network migration.

II. Introduction of Access Network Migration

In this section, we investigate two types of broadband access network migration in detail: the network migration from VDSL2 device to GPON device and the network migration from VDSL2 device to VDSL2 Channel bonding device.

1) The access network migration from VDSL2 device to GPON device

For those subscribers currently using VDSL2 device with higher bandwidth demand, CHT will make composite evaluation including transmission distance of VDSL2 bonding devices and fiber environment around those subscribers. If there is no available VDSL2 bonding device and the fiber environment permitted, CHT will start-up the migration plan from VDSL2 device to GPON device.

The Figure 1 shows the architecture of the access network migration from VDSL2 device to GPON device. The customer premises equipment (CPE) used in GPON device is different from CPE used in VDSL2 device. When executing this kind of network migration, operators are required to go to subscribers' home and change their CPE device from VDSL Transceiver Unit Remote (VTU-R) to ONT. Generally, there are three steps to execute in-service migration from VDSL2 device to GPON device. First of all, the network designer should designate a VLAN service routing plan, find and select an available GPON device, and assign a VLAN setting of new VLAN service routing. Secondly, the network maintenance staff will finish all VLAN service routing devices instruction sets based on service type and rate. After finishing new path setting, the constructor will go to customer's home and change the VTU-R to ONT.

In order to reduce the influence on service, two VLAN services will work simultaneously during migration. After confirmed the new VLAN service operates normally, the staff will remove devices setting on the old VLAN service routing and finish the migration process.

2) The access network migration from VDSL2 device to VDSL2 Channel bonding device

Until now, VDSL2 equipment still plays a major role in CHT's access network architecture. The construction of FTTH network needs the government approval to lay underground pipelines. Deploying fiber into the building is very difficult without comprehensive laws. Based on above reasons, laying underground pipelines and deploying fiber into the building will cause high CAPEX. For those customers who cannot adopt FTTH with high bandwidth requirements, we can use the hybrid architecture. The hybrid architecture not only can reduce the CAPEX, but also extend the provision distance and enhance network coverage of high-bandwidth networks.

VDSL2 Bonding technology is used to combine multiple wire pairs to increase available capacity, or extend the copper network's reach. The migration designer needs to choose an available VDSL2 Bonding device with two available ports. The staff needs to setup the parameters on the Bonding Group which consists of two ports. Compared with general VDSL2 devices, the VDSL2 Bonding devices enable CHT to position themselves with data rates of up to 100 Mbps symmetrical. The VTU-R for VDSL2 Bonding device, with two VDSL2 physical ports, is different from VTU-R for VDSL device. When executing this kind of network migration, operators are required to go to subscribers' home and replace their CPE device.

Similarly, in order to reduce the influence on service, two VLAN services will work simultaneously during migration. After confirmed the new VLAN service may operate normally, the staff will remove devices setting on the old service routing and finish the migration process.

III. An Efficient Provisioning Mechanism for In-Service Migration

We present the integrated and automated provisioning operational supporting systems (OSSs) for in-service network migration in the largest commercial broadband network in Taiwan. The simplified provisioning OSSs include Network Rearrangement Management (NRM), the Inventory Management (IM), the Service Configuration & Activation (SC&A), the Analysis System, and a set of Rinpoche Integrated Operations System (RINOS) resource provisioning and monitor systems, as depicted in Figure 2.

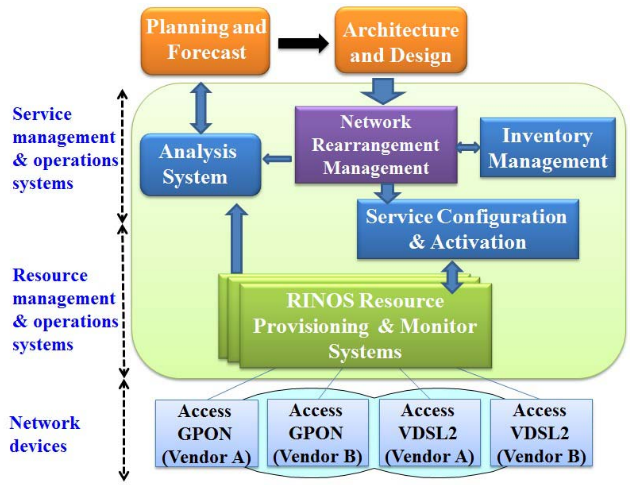


Figure 2. The flow chart of broadband network migration.

The NRM system supports three kinds of network migration choices: device migration, aggregated GE interface migration, and service migration. When central network maintenance staffs start the migration procedure, they need to enter the NRM system, fill out a migration application form and post a migration announcement. Meanwhile, when Analysis System detects traffic congestion, the system will trigger NRM to start the migration procedure. When the procedure starts, the NRM will trigger IM system to designate a new path routing. Then, the NRM system will generate migration profiles of old/new paths. The staff or system needs to generate corresponding device instruction sets according the migration profiles and start the migration setting. The migration setting result will be responded to NRM system after the procedure finished.

A. *Provisioning Mechanism for In-Service Migration*

In this section, we will introduce three kinds of broadband network provision mechanism for in-service migration: manual migration mechanism, integrated automatic network migration mechanism, and efficient integrated automatic network migration mechanism.

1) Traditional Manual Migration

In traditional manual migration mechanism, the network maintenance staffs need to analyze the device type to generate corresponding device instruction sets individually based on migration profiles of old/new paths that NRM generated. Therefore, network maintenance staffs need to take care of not only heterogeneous network technologies, but also devices developed by different vendors. If the path has multiple devices need to be set, he/she must repeat the above process several times. This traditional manual provision mechanism is quite complex and is easy to cause manual setting errors.

2) Integrated Automatic Network Migration Mechanism

Facing rapid evolution of high-speed Internet technology, the service types on the market are highly diverse, and the maintenance cost and risk are greatly increasing. The RINOS system we proposed provides a unique provision interface to manage different provision setting modules according to service types. Network maintenance staffs login into NRM to raise a new migration procedure and post a migration announcement. The IM system will generate migration profiles of old/new VLAN services. Next, SC&A system will create provision parameters of new VLAN service and eliminated parameters of old VLAN service based on information assigned by IM system. SC&A will send provision parameters to RINOS. RINOS will generate corresponding device instruction sets according the provision parameters and start the devices setting with multi-thread method. When the setting request is finished, RINOS reports the setting result to SC&A automatically. After creating new VLAN service, SC&A send the requests to RINOS to remove the setting of old path. If any setting error occurs, SC&A changes the migration procedure back to original manual migration.

The automatic migration mechanism can determine the type of device, set the device and report the migration result automatically though the integrated OSS.

3) Efficient Integrated Automatic Network Migration Mechanism

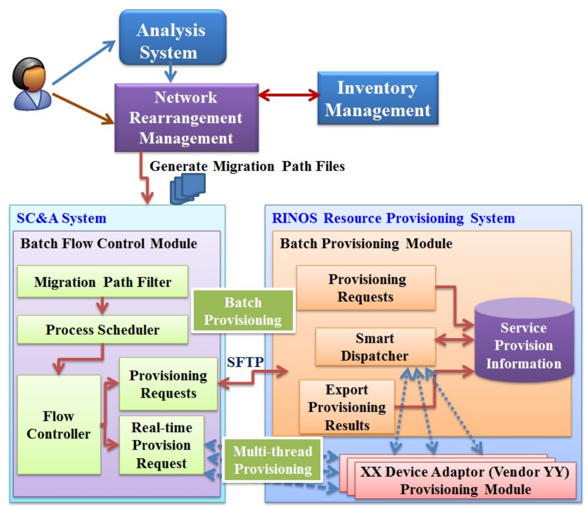


Figure 3. An Efficient Integrated Automatic Network Migration Mechanism for in-service migration

In order to complete the large-scale network migration more quickly and speed up the development of digital convergence, we further develop efficient integrated automatic network migration mechanism to enhance the efficiency of provision.

The high-efficient migration mechanism for in-service migration in broadband network is shown in Figure 3. IM system will designate a new VLAN service routing based on service type. Then, the NRM system will generate migration path files. SC&A and RINOS systems replace original single-provision-request method with batch file exchanging method. We briefly describe the design concepts of SC&A:

i. Migration Path Filter: This sub-module is responsible for choosing those network devices and elements which are required to add/delete.
ii. Process Scheduler: This sub-module is responsible for the provision job arrangement of those network devices and elements.

iii. Flow Controller: This sub-module is responsible for dispatching the provision job to device-based or batch file method.

iv. Batch File Generator: This sub-module is responsible for producing files of all provisioning parameters and putting files to SFTP server.

We then describe the design concepts of RINOS batch automatic provisioning module.

i. Batch Files Fetcher: This sub-module is responsible for fetching provision batch files from SFTP server of SC&A, parsing provision parameters of the request from SC&A, such as VLANID, bandwidth, priority…etc.

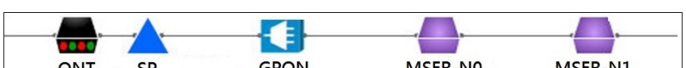
ii. Smart Dispatcher: In large-scale network migration, we execute numerous provision jobs with multi-thread method in a short time. Due to the limitation of telnet sessions, it is hard to set multiple VLAN services on the same device at the same time. Using multi-thread method is easy to cause telnet session collision of network device. In order to solve this problem, we intelligently gather the same device provision jobs in one thread and execute different device provision jobs simultaneously. This sub-module can reduce the probability of telnet session collision and improve the provision efficiency. It also provides the retry function to enhance the success rate of provision.

iii. Provision Result Generator: This sub-module is responsible for gathering all finished provision result and uploading the result to SC&A system via SFTP.

IV. RESULT AND ANALYSIS

In the section, we compare the migration execute time and analyze the execution benefit between the manual and two kinds of automatic provision mechanisms.

There are two steps in the process of in-service migration: One is provision of new service path, the other is elimination of old service path. Taking whole routing migration as an example, the access network device is GPON and the aggregated network devices are MSER-N0 and MSER-N1, as shown in Figure 4. The total number of instruction sets of these three devices is 220. In manual provision mechanism, the network maintenance staffs need to generate corresponding device instruction sets individually based on migration profiles of old/new service paths. If the service path has multiple devices need to be set, He/she must repeat the above process several times. It is quite complex and is easy to cause manual setting errors. As Figure 4 shows, setting up each equipment need from 0.5 to 1 hour, so the total time for manual setting is 2 hours. On the other hand, the proposed automatic provisioning mechanisms can execute different device provision jobs simultaneously. The execution time of whole routing migration is around 42s. It significantly reduces OPEX of manual setting errors without human intervention.



	GPON	MSER-N0	MSER-N1	Whole routing migration
Number of instruction sets	30	95	95	220
Execution time of traditional manual migration (Second)	42s	10s	10s	42s (Simultaneously)
Execution time of integrated automatic network migration mechanism (Hour)	1Hr	0.5Hr	0.5Hr	2Hr

Figure 4. The comparison of manual and automatic migration

Efficient automatic provisioning mechanism we proposed can support multiple routing migration paths with batch provisioning method. It can effectively reduce the transmission time between SC&A system and RINOS system. In addition, it can also reduce provision time of each device and enhance success rate of provision. In CHT 2013 annual bandwidth rate-up project, the total number of subscribers is 3.2 million. The provision number of automatic provisioning mechanism is 45,000 service paths per day and the number of efficient automatic provisioning mechanism is 150,000 service paths per day. We prove the efficient batch provisioning mechanism can increase migration efficiency up to 3 times and the success rate of provision is around 99.3%.

V. CONCLUSION

Facing rapid evolution of high-speed internet technology and high diverse service types, CHT positively carries on with the network construction and optimization. We discuss optimal migration mechanism about broadband access network for various services. We propose three kinds of broadband network provision mechanism for in-service migration: manual migration mechanism, automatic provision mechanism, and enhanced automatic provisioning mechanism. The automatic provisioning mechanism can determine the type of device, set the device and report the migration result automatically though the integrated OSSs.

Finally, we analyze the result and benefit of integrated automatic network migration mechanism. Compared with traditional manual migration and integrated automatic network migration mechanism, the migration time can be shortened from 2 hours to 42 seconds. Moreover, the efficient provision mechanism can increase migration efficiency up to 3 times and the success rate of provision is around 99.3%. The automatic network migration mechanism can reduce the time for overall migration and reduces OPEX of manual setting errors without human intervention significantly to speed up network construction and optimization.

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