Performance measuring of Shared Channel Thresholds in Overlay WDM-PON

Bokrae Jung, Minho Kang, TacYeon Kim*, Jungju Yoo*, ByoungWhi Kim*
Optical Internetworking Lab, Information and Communications University,
119 Munjiro, Yuseong-gu, Daejeon, 305-714
e-mail : {gaole3, mhkang}@icu.ac.kr
* W-PON Team, ETRI, 161 Kajong-dong Yuseong-gu Daejeon, 305-350
e-mail : {tykim, jjyoo, kbw}@etri.re.kr

Abstract — Among several kinds of high-speed access network technologies, wavelength-division-multiplexing passive optical network (WDM-PON) is the most suitable for the increasing bandwidth requirements in the future. In this paper, we propose Overlay WDM-PON which uses multicast and virtual local area network (VLAN) technologies for the integration of services such as internet surfing, voice-over Internet protocol (VoIP) and video on demand (VoD). In addition, Shared channel based performance evaluations demonstrate operations and advantages of Overlay WDM-PON using OPNET.

Keywords — **Overlay WDM-PON, multicast, VLAN, IGMP.**

1. Introduction

A demand for the multimedia service has been growing everyday in accordance with advances in internet and hyper-media in contrast to text based PC communications in the past. In addition, many of the network providers are in trouble with shortage of the bandwidth to support increasing request. Due to WDM technologies, the capacity of backbone network can be expanded relatively easily. However, the improvement of access network faces much more complicated problems [2].

Several PONs have been a promising solution of unbalanced traffic condensation between backbone and access network. Among them, WDM-PON is considered an optimal solution to extend the capacity of optical networks with currently deployed fiber infrastructure. WDM-PON is fundamentally a point to multipoint optical network architecture employing passive optical components where ONUs share an Optical Line Terminal (OLT) located at the central office throughout a or coupler. Proposed Overlay WDM-PON consists of optical power splitter for shared channels and arrayed wavelength grating (AWG) allowing ONTs to be allocated with individually dedicated channels [4]. WDM-PON using AWG provides a virtual point to point connection to each end-user, which is totally independent of line rate and frame format.

To support efficient broadcast or video services, the multicast group management mechanisms using the IGMP snooping supervises ONT's behaviours such as join or leave of the service group membership, and provides broadcast and data services only to the designated ONT for the required service [1],[3]. By using IGMP and multicast group management table (MGMT), bandwidth ratio between shared and dedicated channels can be adjustable with Shared Channel Thresholds (SCT). As doing so, both λ_b and λ_n of shared and dedicated channels are available to use more flexibly according to required bandwidth for the end-user. Moreover, ONTs which want to join specific service group can be simply managed via the VLAN group field of MGMT [6].

In this paper, we concentrate on performance measuring of Overlay WDM-PON with a view of OLT – ONT average throughput as several SCT values in order to observe actual operations, and measure traffic fluctuations. The general architecture of Overlay WDM-PON will be shown in section 2. Section 3 presents the operation principle of Overlay WDM-PON that employs IGMP MGT mechanism. The simulation conditions and results using OPNET as variations of SCT values will be demonstrated in section 4. In section 5, the discussion comes to conclusion in the end.

2. Overlay WDM-PON Architecture

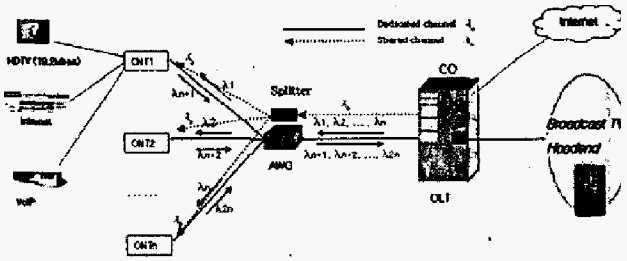


Figure 1. Architecture of Overlay WDM-PON

Figure 1 shows a general architecture of Overlay WDM-PON network. In this picture, it consists of optical power splitter for shared lambda λ_b and AWG allowing ONTs to be allocated with individually dedicated lambda between OLT and optical network units (ONU). Each ONT is given common lambda λ_n for one side direction from OLT to ONT as well as AWG provides each ONT with exclusive lambda for bi-directional transmission between OLT and ONT [5]. Since

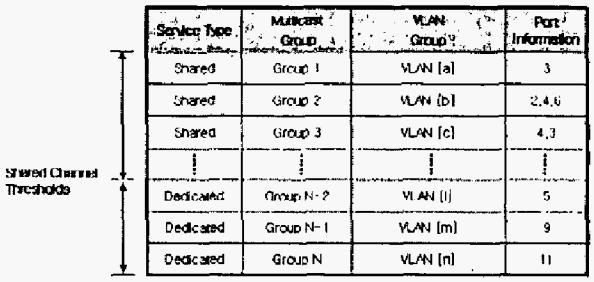
basic PON architecture using optical power splitter is suitable for broadcast service, it is reasonable for video streams such as broadcast or VoD services to be allocated shared channels. Both λ_b and λ_n follow up to 1Mbps bandwidth individually based on suggested network architecture. In dedicated lambda, the downstream and upstream transmissions occur with the exclusive wavelengths separated by an AWG. In order to resolve insufficient bandwidth of λ_b that is mainly used in transmitting broadcast traffic, the other λ_n makes up for shared lambda to support wideband requirements of end-user which can be placed with not only broadcast services but also bi-directional data services such as web surfing. A large amount of bandwidth in Overlay WDM-PON make it more optimal scheme to accommodate broadcast and data transmission with the maximum 1Gbps capacity compared with the cable modem having relatively small bandwidth.

3. The operation principle of Overlay WDM-PON

For efficient bandwidth management of the shared and dedicated channels, OLT takes advantage of the IGMP multicast group management and VLAN technologies. By adjusting SCT values, we can observe how the traffics of shared channel pass over dedicated channels. For instance, if most customers require for same broadcast services, it is more profitable to increase SCT values. In other hand, when it is hard to find requiring common channel services, reducing SCT values will be more reasonable.

The operation of the IGMP group management follows next descriptions. The broadcast services are basically downstream transmission and are intended for many customers who want to catch all of the services from one broadcast source even though they actually fix only one channel at the moment. For the broadcast service, the OLT manages membership join and leave to same service ONT groups using IGMP snooping that performs IGMP group management functions as a proxy on behalf of multicast router and then makes specific VLAN groups in order to manage ONT port groups when some ONTs want to be served. IGMP report message from ONT received with an IGMP query message is send to the ONT and then search a table whether a multicast group exists or not. If it exists in the table, add port itself to the VLAN groups mapped with. Group leave messages delete the port from the multicast groups it belongs to after group searching in the MGMT. If there is no port included in the VLAN group, remove the group it belongs to. For data service, the traffics come from general routers go through OLT without multicast group management and then arrive target destination based on destination IP address.

Following figure 2 shows the multicast MGMT. In this table, the service type divide into two parts, which called shared or dedicated. Shared means that required services included same multicast group utilize λ_b common link, and dedicated uses λ_n logically dedicated link. VLAN group, third column of table, manages the ports of ONT that hope to join or leave specific multicast group.



Service Type	Multicast Group	VLAN Group	Port Information
Shared	Group 1	VLAN [a]	3
Shared	Group 2	VLAN [b]	2,4,6
Shared	Group 3	VLAN [c]	4,8
⋮	⋮	⋮	⋮
Dedicated	Group N-2	VLAN [l]	5
Dedicated	Group N-1	VLAN [m]	9
Dedicated	Group N	VLAN [n]	11

Figure 2. Multicast Group Management Table

Shared channel threshold (SCT) can be controllable to maximize total bandwidth utilization of the shared and dedicated channels. We can observe how the traffics of shared channel pass over dedicated channels using OPNET simulator next section.

4. Simulation Results

The proposed Overlay WDM-PON network is modelled by OPNET simulator for the validation of various SCT values. We assume 16 ONTs connected optical power splitter for shared lambda and AWG for dedicated lambda separately. Multicast traffic such as broadcast and VoD services comes from multicast router (MR) and trivial data traffic from general router, for example web browsing and file transfer, can be reach end-user. In this simulation, IGMP control packets come and go between MR and each ONT throughout optical power splitter and AWG. IGMP query messages that ask each ONT if the services continue or not are generated every 1 second from MR and randomly made leave messages make the ONT terminated from the services. Also IGMP report messages promptly respond for each query message. Since it is hard to generate 20Mbps traffic having a 1500 byte Ethernet frame for a long time in the OPNET, generating rates of traffic source can scale down to a few Mbps for the convenience. The period of measurement reaches up to 300 seconds and OLT-ONT average throughput is measured in accordance with increment of SCT values with 10, 30, 50 and 80.

Figure 3 shows OLT-ONT average throughput of shared channel. In this picture, as the SCT values increase, average throughput keeps track of increasing trend of SCT values. We can intuitively predict this result because if SCT values decrease, most of the video traffics readily pass over dedicated channels. Hence the average throughput of threshold 10 is placed with the lowest levels in the four plots. Contrary to figure 3, average throughput of dedicated channels decrease as the rise of SCT values in figure 4.We can interpret that almost all of the video traffics compact into dedicated channels while small SCT values. Therefore if most customers require for same broadcast services, it is more profitable to increase SCT values. In other hand, when it is hard to find requiring

common channel services, reducing SCT values will be more reasonable.

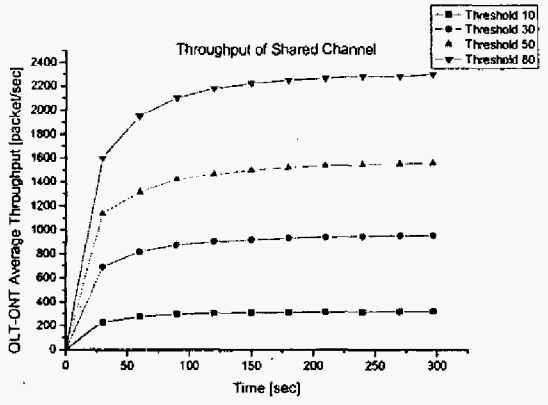


Figure 3. OLT-ONT Average Throughput of Shared Channel

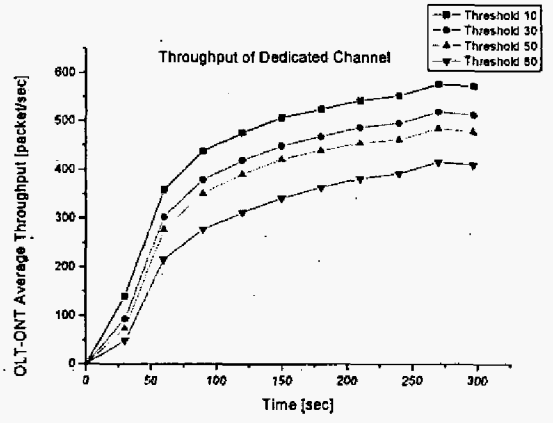


Figure 4. OLT-ONT Average Throughput of Dedicated Channel

5. Conclusion

In this paper, we propose Overlay WDM-PON network architecture, and present the operation principle of Overlay WDM-PON that employs IGMP MGMT mechanism. By using IGMP and MGMT, bandwidth ratio between shared and dedicated channels can be adjustable with SCT. As doing so, both λ_b and λ_a of shared and dedicated channels are available to use more flexibly according to required bandwidth for the end-user. After simulation using OPNET, we can recognize relationship between increment of SCT values and OLT-ONT average throughput in both shared and dedicated channels.

Acknowledgement

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