Multi-OLT and Multi-wavelength PON for Improving QoS of Open Access Network

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1. Introduction

With the evolution of information and communication technology, several numbers of service providers such as fiber-to-the-home (FTTH), wireless sensor networks (WSNs), HDTV, and Femto networks have been deployed in the modern cities. A typical scenario in any modern city is that each service provider independently deploys and maintains its own network infrastructures. Main drawbacks for constructing and deploying such network for each individual service provider and accommodating several users using different access terminals are the requirement of an enormous amount of time and expenses. To avoid the enormous expenses and deployment of several backbone networks, a passive optical network (PON) based open access networks (OANs) can be an effective solution. However, comprising several service providers in a time division multiple access (TDMA) PON with single uplink wavelength create high computational complexity of data processing and huge data bottlenecks. To overcome this problem a multi-OLT PON based access network [1] with multiple uplink wavelength can be an effective solution for obtaining optimum quality of services (QoSs) from the networks.

In this paper, we propose a new multi-OLT with multiple uplink wavelengths PON-based OAN (MM-OAN) architecture. In this MM-OAN, multiple uplink wavelengths are used for different service providers in an optical network unit (ONU). We have conducted an extensive theoretical analysis of QoS provisioning in terms of bandwidth utilization, jitter, and throughput and compare those with the single-OLT with single uplink wavelength PON-based OAN (SS-OAN) architecture. All the analyses are conducted for four different service providers with four OLTs and four different uplink wavelengths.

2. Network Architecture and Internal Buffer Structure of an ONU of the Proposed Scheme

Figure 1 shows the proposed MM-OAN concept. Here, only two service providers with two different uplink wavelengths and two different OLTs are shown for simplicity. However, the network can be comprised with \( n \) service providers where \( n \) OLTs and \( n \) upstream wavelengths will be used, but every ONU will be shared by multiple service providers. In the downstream direction of the proposed scheme, each OLT will broadcast data to the network through a passive splitter in TDMA manner.
In this section, we proposed a new MM-OAN architecture and compare its performance with that of the SS-OAN. Simulation results show that the MM-OAN provides better performance than the SS-OAN in terms of bandwidth utilization, jitter, and throughput. The MM-OAN provides 50% less jitter with two times higher throughput at an offered load of 1.0 when compared with the SS-OAN.

3. Simulation Results

In this section, we compare the performance of the proposed MM-OAN to the SS-OAN. All the analyses were done in terms of bandwidth utilization, jitter, and throughput. We considered an OAN architecture with four OLTs and four uplink wavelengths. The number of service providers in a time cycle connected to an ONU was assumed to be random and in the range of 1 to 4. The simulation parameters are summarized in Table 1.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Quantity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N_{\text{ONU}})</td>
<td>Number of ONUs</td>
<td>16 or 32</td>
</tr>
<tr>
<td>(N_{\text{OLT}})</td>
<td>Number of OLTs</td>
<td>4</td>
</tr>
<tr>
<td>(n)</td>
<td>Maximum number of service providers</td>
<td>4</td>
</tr>
<tr>
<td>(R)</td>
<td>Transmission speed</td>
<td>1 Gbps</td>
</tr>
<tr>
<td>(T_g)</td>
<td>Guard time</td>
<td>5 (\mu)s</td>
</tr>
<tr>
<td>(T_p)</td>
<td>Processing time</td>
<td>10 (\mu)s</td>
</tr>
</tbody>
</table>

All the performance parameters were analyzed for self-similar network traffic. Figure 4 shows the bandwidth utilization at a 2-ms cycle time. From the comparison for 16 ONUs, we can see that bandwidth utilization in the MM-OAN exceeds 0.9 at an offered load of 0.2. However, in the SS-OAN, bandwidth utilization never exceeds higher than 0.9. Moreover, the difference of bandwidth utilization becomes very significant if the number of ONUs were increased to 32.

Comparison of jitter performance among the two schemes at a 2-ms cycle time is shown in Fig. 5. The proposed MM-OAN always provides 50% less jitter than the SS-OAN at an offered load of 1.0 for both 16 and 32 ONUs. As shown in Fig. 6, the MM-OAN achieved more than two times higher throughput than the SS-OAN for both 16 and 32 ONUs at an offered load of 1.0.

4. Conclusion

In this paper, we proposed a new MM-OAN architecture and compare its performance with that of the SS-OAN. Simulation results show that the MM-OAN provides better performance than the SS-OAN in terms of bandwidth utilization, jitter, and throughput. The MM-OAN provides 50% less jitter with two times higher throughput at an offered load of 1.0 when compared with the SS-OAN.

References
