Abstract

The Optical Line Terminal (OLT) and the feeder fiber are the most important components of a PON as the OLT acts as the signal aggregator and disseminator for all Optical network units (ONUs) connected to the PON. OLTs of TWDM PONs are capable of supporting much larger number of ONUs from a single OLT location than the OLTs of TDM PONs or of WDM PONs. This leads to user consolidation i.e. much larger number of ONUs were being served from a single OLT thus reducing the OPEX. However this also made the network more vulnerable as failure of the OLT of a TWDM PON will make a far larger number of ONUs lose connection. This prompted the necessity for conducting studies regarding OLT and feeder fiber protection in TWDM PONs.

In ITU-T recommendation G.983.1, 1:1 protection for OLT and feeder fibers has been proposed. Another protection scheme of 1:N OLT protection has been proposed where N co-located functional OLTs were being protected by a single redundant OLT. Due to co-locating the functional and protection OLTs, the protection switching time in this networks were said to be low. Though more economical than the 1:1 OLT protection architectures, it was nonetheless more vulnerable as co-locating both functional and protection OLTs increased the probability of both functional and protection OLTs failing in case of a local disasters (earthquake, lightening, EMP attack) which may destroy the entire central office. In another OLT protection architecture, where the protection and the functional OLTs are placed is geographically separately located central offices, each central office is said to house one or more protection OLTs and in case of failure of a functional OLT, an OLT from the same central office or a protection OLT from a nearby CO takes over the operation of the ONUs of the failed OLT.

In our research we developed OLT and feeder fiber protection architectures for TWDM PONs such that the functional and protection OLTs in the PON network are not co-located which improves the disaster resilience of the network. The first architecture uses one redundant OLT for every *N* functional OLTs where both the functional and redundant OLTs are connected by a fiber ring that runs through the

primary remote nodes of each PON. In case of failure of one of the functional OLTs in the ring, one of the redundant OLTs connected to the ring can take-over the responsibilities of the ONUs of the failed OLT. An appropriate control mechanism governed by a proposed MAC protocol to reduce the protection switching time has also been developed. We also evaluated the approximate reach of the proposed network.

The second contribution of the thesis aims to provide OLT protection and feeder fiber protection without using any redundant OLT or any redundant feeder fiber. The proposed architecture takes advantage of the under-utilized bandwidth of the functional OLTs to provide support to the ONUs of the failed OLT. This is achieved by interconnecting the remote nodes of TWDM PONs to form a ring-mesh network to enable an OLT to not just service its own primary ONUs but also with ONUs of other TWDM PONs whose RNs are connected via a fiber path to its own RN. The cost and availability analysis with other OLT protection architectures have been done.

The third contribution of the thesis proposes an OLT protection mechanism for TWDM PONs where multiple TWDM OLTs are interconnected via fiber paths through their remote nodes in the form of a ring and in case of failure of any OLTs in the ring, the excess unused bandwidth in all other OLTs in the ring is utilized to provide support to the ONUs of the failed OLT. This using of excess unused bandwidth in the OLTs is a new concept which is termed by us as “load scavenging”. In this architecture all OLTs connected via the ring can interact with one another to frequently update each other of their network load conditions. A suitable load balancing strategy has been implemented in the proposed architecture such that the excess network load of the ONUs of the failed OLT is equitably distributed among the other supporting functional OLTs in the ring. The effect of sudden increase of load on the packet delay characteristics of the supporting OLT has been studied.

In future works a study may be conducted to analyze effect on buffer lengths at ONUs of the failed OLT and of the supporting OLTs during the times of responsibility sharing when an OLT in the network has failed.

Keyboards: Packet Delay, Load balancing Strategy, excess unused bandwidth, co-located OLTs, load scavenging.