

Abstract

The emergence of new bandwidth-intensive applications articulated by distance learning, online gaming, Web 2.0 and movie delivery by means of high-definition video, has ultimately justified the necessity of upgrading the access network infrastructure to provide fat-bandwidth pipelines at subscriber close proximity. Passive optical networks (PONs) are an emerging technology to deliver these services. This thesis presents innovative work performed towards the application of coarse wavelength division multiplexing (CWDM) to route communications to and from reflective optical network units (ONUs) incorporated in time and wavelength division multiplexed PONs. The concept of coarse and dense WDM grid integration and its adaptation in access networks to map, for the first time, selective closely-spaced wavelengths into coarse passband windows of Gaussian and flat-top arrayed waveguide gratings (AWGs), exhibiting coarse-fine grooming, is initially developed. This is followed by the identification of a new network architecture combining multiple PONs, using a coarse AWG to form a next-generation access network. A significant feature of this approach allows for time division multiplexing (TDM) and WDM PON technologies to be integrated through the 7 nm coarse passband windows of a single AWG, providing for interoperability and high scalability. The network performance through simulation, in the presence of polarisation-dependent wavelength shift and associated polarisation-dependent loss, shows the capability of a single optical line terminal (OLT) to access various physical PONs in 25 km proximity with multiple wavelengths through a single AWG router. This approach enables centralised bandwidth allocation and a smooth migration path between time-shared and densely-penetrated access networks. Furthermore, to demonstrate full-duplex operation, allowing for increased bandwidth utilisation of the reflective access network architecture, full-duplex functionality is achieved by using polarisation division multiplexing. This is implemented in the OLT by assigning each ONU downstream data and continues waves on orthogonal states of polarisation. Hence, by assuming the use of symmetrical broadband services, the novel multi-PON access network verifies its potential to double the bandwidth utilisation for each subscriber, allowing for increased bidirectional network throughput. In addition, an experimental test-bed is performed which demonstrates the core operation of the network being, by means of a readily-available 2.7 nm-wide AWG router. Hence, the practical feasibility of the new access network concept is demonstrated.