Abstract

Recent surge in the data rate requirements due to the bandwidth demanding applications has triggered the quest for developing high capacity Access Networks. The only data transfer technology that has the potential to provide such high data rates is the optical fiber. A fiber can transmit data in the order of tens of gigabits per second. Unfortunately, fiber does not allow mobile users. Since, mobility is a highly sought after facility that the users want to avail, the service providers have to consider wireless transmission solutions for their last mile connectivity. However, the wireless channel is time variant. This makes the wireless transmission technologies very unreliable and the data rate that a wireless technology provides over long distances is limited in the order of tens of megabits per second. Therefore, wireless transmissions schemes alone cannot provide a broadband connectivity that can support a very high data rate demanding service. Further, it is well known that if the distance of separation between the wireless transmitter and the wireless receiver is reduced, the data rate can be increased.

Hence, a solution can be thought of where an antenna provides coverage to a very small area and the antenna is being fed by an optical fiber. This kind of approach paves way for the wireless optical integrated networks (WOINs). WOINs have emerged as a potent solution for providing mobile broadband connections to the users. However, the independence of the wireless and optical network components makes it quite difficult for the operations to provide good Quality of Service (QoS) after integrating the two network components. The hybrid network can be formed by interfacing Ethernet Passive Optical Networks (EPONs) or Resilient Packet Rings (RPRs) with Wireless Local Area Networks (WLANs), Long Term Evolution (LTE) or Worldwide Interoperability for Microwave Access (WiMAX).

If LTE is being backhauled, transmission of both control and data messages from the LTE network must be facilitated by the backhaul. Firstly, in LTE, the base stations (eNodeBs) are logically connected to each other through the X2 interface. The eNodeBs can communicate with each other through the X2 interface without the involvement of the LTE core network. A backhaul must provide provision for the eNodeBs to directly communicate with each other without the intervention of the LTE core. Hence, there is a need for developing proper backhauling architecture and associated protocols. Secondly, the medium access control (MAC) protocols of EPON and LTE are different. Therefore, if the MAC layers of the two network segments are allowed to work independently, then the end-to-end QoS will degrade. Consequently, the network designer must design a proper interfacing protocol to ensure end-to-end QoS. Hence, the thesis introduces new optical backhauling architectures and associated protocols. Thereafter, the thesis proposes medium access control (MAC) protocols for interfacing the LTE and EPON networks.

Initially, a ring-based integrated wireless optical network architecture and an associated protocol that involves EPON is proposed in the chapter 3 of the thesis. In chapter 4, a RPR based backhauling architecture is introduced. Both the architectures seamlessly implement the X2 interface of LTE. The architectures are further extended to support an open access network where a single network can be used by multiple mobile service providers without compromising information security.

In the chapter 5 of the thesis, the inefficient channel aware scheduling with an infinitely backlogged buffer model is replaced by an optimal channel and buffer aware LTE uplink packet scheduling procedure with a realistic traffic source. The proposal is then extended to operate with multiple traffic classes. An Integer Linear Program (ILP) is formulated to address the scheduling problem. Since ILPs are generally np-hard, a polynomial time algorithm is proposed to solve the ILP. The proposal ensures QoS maintenance and provides user fairness.

In chapter 6, the focus is on Service Level Agreement (SLA) based end-to-end QoS maintenance across a WOIN. The wireless network used is LTE and the optical network is comprised of an EPON. The proposal targets opportunistic allocation of any bandwidth that is available after meeting the SLA requirements. The opportunistic scheduling is facilitated using distributed Learning Automata.

Keywords: Wireless optical Integrated Networks, WOBAN, FiWi, EPON, RPR, LTE, Handover, Mobile backhauling, MAC Protocols, Open Access, Uplink, X2, Destination Stripping, ILP, Hungarian Algorithm, Assignment, Knapsack, Priority flipping, VCG Auction, Learning Automata.