Analysis and Optimization of Fiber-to-the-Room MAC protocols

The widespread deployment of Fiber-to-the-Home (FttH) in various markets has given consumers access to high-speed data connections over the extensive optical fiber-based core networks. End users usually access these networks with wireless devices using the 802.11 standard. However, as the next generation of IoT devices with VR and AI applications enter the market, the demand for improved bandwidth and latency has increased drastically. This has led to the development of Fiber-to-the-Room (FttR) networks, which seek to extend the fiber connections closer to the terminal devices by eliminating the bottleneck caused by traditional ethernet and wireless access. Current implementations utilize a cascaded XGPON optical distribution network (ODN) in convergence with WiFi 6. The ONU at the user’s premises is replaced with a Main FttR Unit (MFU), which acts as the OLT for the Sub FttR Units (SFU) in each room using point-to-multipoint architecture. The SFUs convert the optical signals to baseband and retransmit the data as WiFi frames.

These solutions keep both MAC and PHY layers between the optical transport and WiFi completely separated without using any synergies. This introduces various limitations to the FttR setup, such as degraded data rates, jitter / latency, and high power consumption. To solve these problems, a centralized wireless - optical access network (C-WAN) has been conceptualized, where the MFU becomes a central controller to enable seamless roaming, with deterministic low latency transmission and gigabit coverage for the entire room. Within the scope of this solution, a cross-domain MAC layer between optical and WiFi has been proposed to implement dynamic resource management and scheduling. Such a centralized and converged MAC protocol must reduce overhead and optimize the framing of both physical layers to minimize the processing delay at the SFUs. This thesis aims to design and evaluate such a minimal optical access protocol with a centralized controller and test its performance in an FttR setup. The ns-3 network simulator is used within the context of this thesis to implement, simulate, and analyze the designed protocol with C++. Extensive modules that simulate both XGPON and WiFi 6 are already implemented in ns-3 and can be modified as required.

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