CHAPTER

4

PASSIVE OPTICAL NETWORK-5G FRONTHAUL: OPTICAL DEVICE AND FUNCTIONAL SPLITS

Chuah Shi Yi, Arnidza Ramli, Nadiatulhuda Zulkifli, and Nik Noordini Nik Abdul Malik

4.1 INTRODUCTION

In the ever-evolving landscape of telecommunications, the demand for faster, more reliable, and lower-latency networks has grown exponentially. With the advent of the Fifth Generation (5G) wireless technologies, the world has witnessed a remarkable transformation in the way we connect, communicate, and consume data. Central to this technological revolution is the crucial role played by fronthaul networks.

Fronthaul serves as the vital link connecting the Baseband Units (BBUs) and Remote Radio Heads (RRHs) in the Radio Access Network (RAN). It is the backbone in serving as a conduit for the seamless transmission of data, voice, and multimedia content. Understanding and optimizing fronthaul networks are paramount for meeting the ever-increasing demands of modern wireless communication.

4.2 4G C-RAN AND 5G FRONTHAUL NETWORK

To fulfil the requirement of IMT-2000, which is providing standard Quality of Service (QoS) to all of the mobile services (Johnson, 2012), the network system has to update from 4G to 5G. 5G network architecture adopts from 4G Centralized-Radio Access Network (C-RAN) architecture. Fronthaul network of 4G-RAN locates in between RRH and BBU while 5G fronthaul network locates in between RU and DU (Lavallée, 2020).

Differences of the two networks can be seen in Figure 4.1. With the update from 4G C-RAN to 5G, a mobile network operator does not require to afford limited and high-priced RRHs and BBUs from the same vendors because this architecture will allow Open-RAN (ORAN) specifications. Compared to C-RAN, O-RAN has a similar architecture, but it can define a fully open interface that supports cloud computing (Semov et al., 2020). This allows smoother, faster, and more effective network communication.

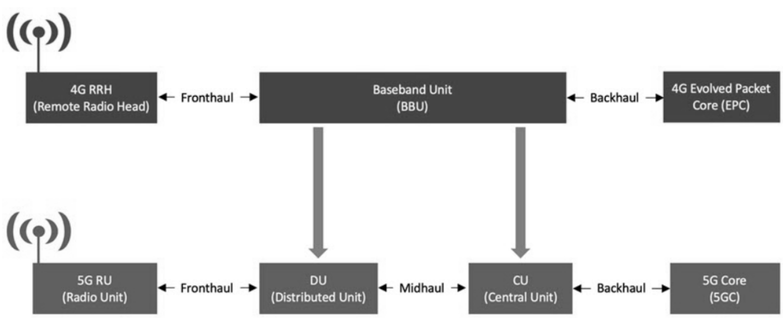

Figure 4.1 Architecture of 4G C-RAN and 5G Network (Semov et al., 2020)

4.2.1 5G Fronthaul Network Requirement

Radio access networks will evolve towards denser deployments to meet with the high-capacity requirements of the next generation mobile services (Liem et al., 2018). The traffic and demand generated by the audience, the production of the event itself as well as potential media coverage will require ultra-high capacity, low latency, and highly reliable communications to both fixed locations and mobile recording, video, and production equipment.

Currently, Ethernet has become the main choice of data transport protocol regardless of the choice of the particular functional splits due to its maturity, low cost, and ubiquitous use (Zou et al., 2020). As defined in the enhanced CPRI (eCPRI) transport requirement specification (CPRI, 2018), a packet transport network based on Ethernet is adopted to carry the LLS data. Due to the existence of variable bit rate traffic, the employment of packet-based transport solution that enables statistical multiplexing is possible. It is foreseen that 10 Gbps to 25 Gbps optical interfaces will be adequate for 5G fronthaul (Sehier et al., 2019). According to Zou et al. (2020), it is beneficial and feasible to aggregate fronthaul traffic to 100 Gbps between cell site gateways and Distribution Unit (DU) sites at large cell sites with multiple Radio Units (RUs).

While talking about 5G network, low latency is the critical requirement as it determines the end-user experience. Strict latency requirement of 250 μs Round-Trip Time (RTT) between RU and DU (Nakayama & Hisano, 2019; Zou et al., 2020) have been specified for 5G traffic. However, by considering the light propagation delay in fibre, additional 5 μs/km delay is introduced which dominates the end-to-end latency. In comparison, optical components (e.g. transceivers, splitters, filters) contribute only a negligible latency in the range of nanoseconds (Zou et al., 2020).

Passive Optical Network (PON)-based mobile fronthaul has been proposed to improve the utilization of optical links and to deploy inexpensive fronthaul. In PON system, Wavelength Division Multiplexing (WDM) and Time Division Multiplexing (TDM) techniques are normally employed to further enhance the capacity and fibre efficiency. However, in TDM-PON, communication speed is limited by physical data rates. With mobile network traffic still increasing markedly, the current TDM-PON bandwidths will become deficient in the near future. In other hand, wavelength assignment of the Arrayed