First Field Trial of FTTR Based on Native Management and Control Architecture for 5G Small Cell Backhaul

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Abstract: We firstly propose a native management and control architecture of FTTR, based on which a field trial for 5G small cell backhaul is demonstrated. The download speed of each user equipment reaches nearly 800 Mbps. © 2023 The Author(s)

1. Introduction

Passive optical network (PON) is rapidly evolving to satisfy the ever-increasing bandwidth demand of optical access networks, which has been proved to be the most promising broadband access technology [1]. Traditionally, the evolution direction of PON is to supported higher line rate and longer reach. The ITU-T standards development organization has initiated single-wavelength 50-Gb/s [2] as the next generation PON technology after XG(s)-PON. However, with the further evolution of home networks, such as the could VR, home network attached storage and live streaming, the demand for home networking is increasing dramatically. Recently, the fiber-to-the-room (FTTR) is proposed [3] and becomes a mainstream networking technology for home and business scenarios. The ITU-T Q3/SG15 has been starting the standardization of FTTR, which is G.FIN [4-5].

With the landing of millions of 5G macro stations, indoor and deep coverage becomes the new key point of 5G construction. So the number of 5G small cell will be dramatically increased and will go into home and commercial buildings in the near future. It means that the 5G and fixed-access businesses will simultaneously exist in home and business scenarios. FTTR as a promising local area networking technology, is very suitable for the small cell backhaul, because of its gigabit access capacity, high reliability, low operational cost and capable of reusing optical distribution network of PON. However, unlike PON, current FTTR network cannot support 5G business. So the capability of 5G carrying should be firstly extended to FTTR. Besides, the bandwidth, latency and maintenance requirements of small cells need the collaboration of FTTR and PON, which means the FTTR must support unified control and end-to-end slicing with PON. Until now, this issue has not been addressed.

In this paper, we propose, for the first time, a native management and control architecture of FTTR, which can realize the delicacy management and control of FTTR and end-to-end slicing of PON and FTTR, based on the optical-layer OAM of PON that extended to FTTR. Based on this architecture, a field trial of FTTR as 5G small cell backhaul is demonstrated. The native management and control capabilities, together with key wireless communication parameters including download speed and latency are characterized.

2. The Principle of Native Management and Control Architecture for FTTR

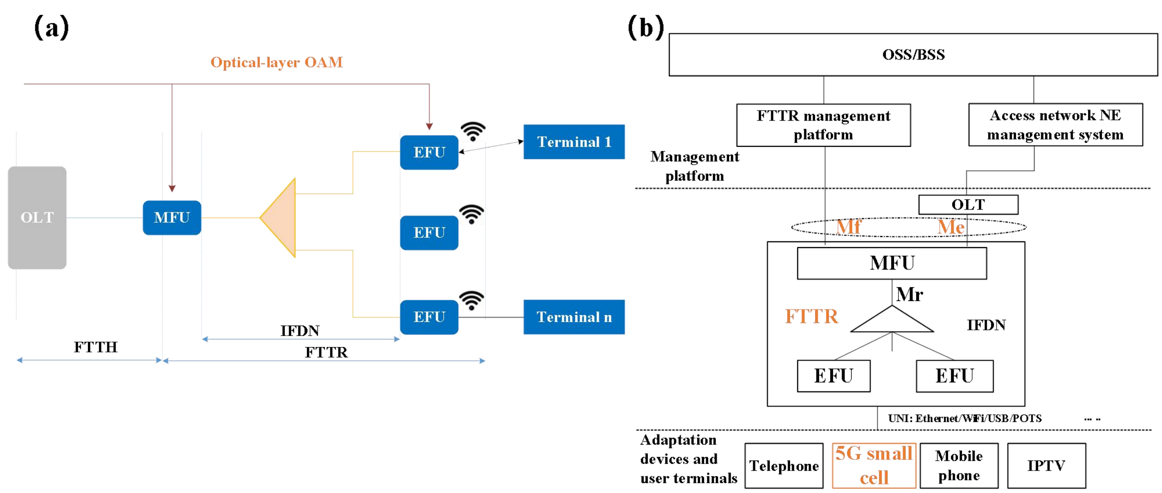

Fig.1 (a) Network location of FTTR system; (b) The proposed native management architecture of FTTR system

The FTTR network includes a main FTTR unit (MFU), indoor fiber distributed network (IFDN), and edge FTTR units (EFUs), as shown in Fig. 1(a). The FTTR MFU is connected to the OLT through the xGPON interface, and the FTTR MFU and EFU are connected to each other through the FTTR interface. The FTTR network could be regarded as the further extension of FTTH network in a way, and it is desirable to support fundamentally remote management ability for FTTR.

Figure 1(b) shows the proposed the native management and control architecture of FTTR system, which can be compatible with the commercial PON chassis. In this architecture, the optical-link OAM extension to FTTR is proposed. The realization scheme can be seen in Fig. 2. The OLT have established two management channels through Me interface. One is for MFU, which is the same with PON. The other is for EFU, which is newly established. The OLT can logically directly manage the EFU. In this case, two-stage of P2MP network can be treated as one-stage P2MP network. Thus we can easily realize the end-to-end slicing of PON and FTTR network and clock synchronization of MFU and EFU through the OLT as a master clock node to support 5G small cell backhaul. The function can be summarized as following:

1) The Me interface provides the optical-link OAM for FTTR, such as the running once optical link up, helping to establish higher layer management links, independent management channel isolated from data channel between MFU and EFU, OLT and MFU, and basic remote management function, such as test and diagnostics ability even if higher layer management link down. Its realization can refer to management and control interface (OMCI) protocol for PON system.

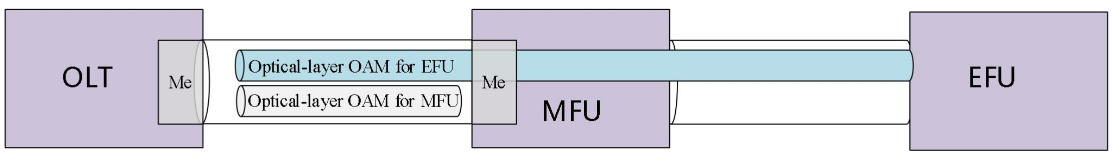

Fig.2 The scheme of optical-layer OAM extension for FTTR

Besides, a FTTR management platform is newly increased, which manages the FTTR network by Mf interface, especially Wi-Fi networking management, and the function can be summarized as follow:

2) The Mf interface manages FTTR networks in a unified manner, including visualized managements, configurations, faults and alarm monitoring, and network analysis and maintenance. The FTTR management platform also performs optimization of Wi-Fi performance and user experience in the system. Its realization bases on MQTT protocol. In reference [1], we have demonstrated the possibility for Wi-Fi performance optimizing.

Thus, with the Me and Mf interfaces, the native management and control architecture of FTTR network is established, which makes the FTTR network efficiently carry 5G and fixed-access businesses simultaneously.

3. Experimentally setup and results

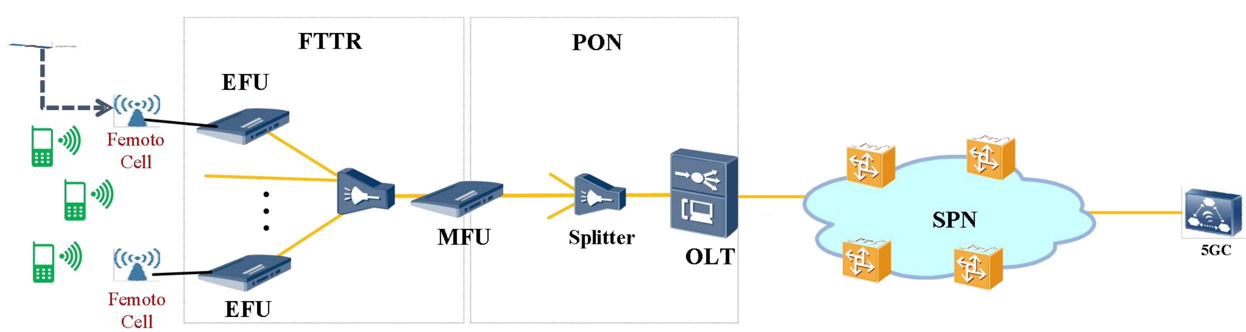

Fig.3 Schematic setup of the field trial of FTTR based 5G small cell backhaul

We carried out a field trial of 5G small cell backhaul using the proposed FTTR system in Guangdong province of China. Because the 50G PON has not been commercially deployed yet, here we used a 10G GPON OLT. The uplink interfaces of the OLT are connected to 5G slicing packet network (SPN) switching node. It is further connected to the 5G core networks of China Mobile. All the SPN protocols are supported by the 10G GPON equipment. The downlink interfaces of the OLT are connected with the FTTR segment through 20 km feeder fiber and a splitter.

Each of the two EFUs was connected with a 5G femto cell, which has internally integrated a distribution unit (DU) and a remote radio unit (RRU) antenna, capable of carrying all types of 5G services. Here, the femto cells used in our experiment have 2 transmitters and 2 receivers, the maximum download rate of which is about 850Mbit/s. We turn on 2 user equipment (UEs) that are 5G cellphones, and connect them to the two femto cells. Each cellphone is registered to an individual femto cell. The Speed Test Application of the two cellphones are run simultaneously to measure the downstream speed and latency.

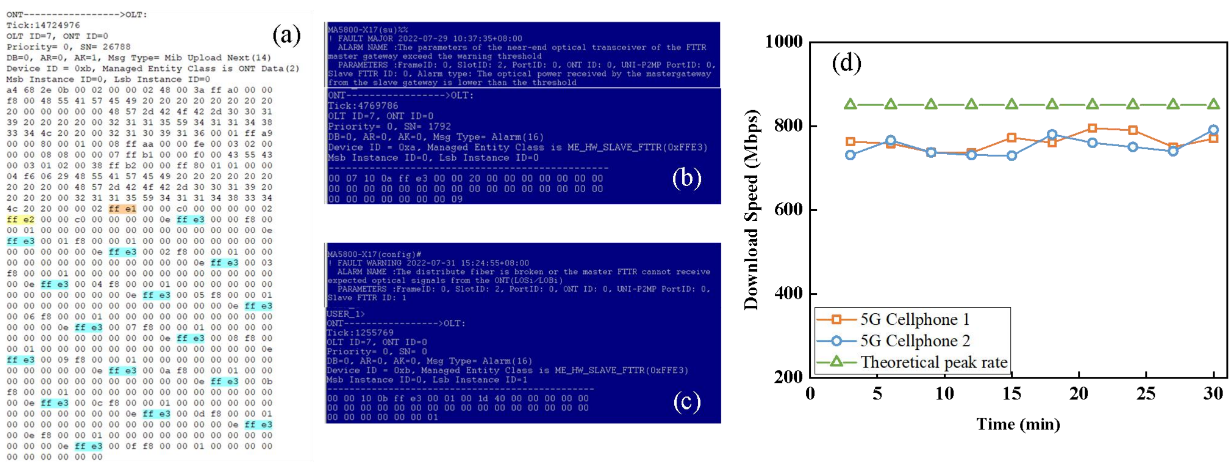

Fig.4 the measured download speed of each UEs

Firstly, we tested the native management and control function of FTTR. Fig. 5(a) shows the control plane of the OLT. We can see that the OLT has successfully established 16 EFU management channels through Me interface extension (blue shading), based on which the optical-layer OAM is directly extended to EFUs. Here, the Me interface realization is based on OMCI protocol extension, and the MFU only transfers the OMCI message of EFU coming from OLT. So, the 5G business opening and the end-to-end slicing creating of PON and FTTR are available. Fig. 5(b) and 5(c) show OLT receives the alarm messages of receiver power of MFU downstream optical module and optical fiber disconnect between MFU and EFU, respectively. Therefore, the network malfunction can be immediately found for 5G small cell backhaul.

Secondly, the maximum download speed of two UEs was measured over half an hour, and the results are shown in Fig. 5(d). Cellphone 1 was registered to BBU 1, and the other one was registered to BBU 2. We can see that the download speeds of two UEs are near 800 Mbps for most of the time. We also characterize the latency properties of our system. The measured average latency of PON+FTTR downstream and upstream are only 158.5 us and 335.9 us, thanks to the dedicated activation wavelength technology. Including the latency of BS itself, it is still less than 1 ms, which fulfills the requirement of 5G small cell backhaul. Besides, we also measure the coexistence of 5G and fixed-access businesses. By using the end-to-end slicing for 5G business, the 5G business always has high priority to fixed-access business. Each cellphone maintains about 700Mbps download rate and no packet loss observed even the network congestion happened.

4. Conclusions

We have firstly proposed a native management and control architecture of FTTR, based on which a field trial of 5G small cell backhaul is successfully carried out. The measured download speed of each cellphone is around 800 Mbps. By using the end-to-end slicing technique of PON and FTTR, the measured average latency of PON+FTTR downstream and upstream are only 158.5 us and 335.9 us, respectively.

5. References

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