MEC and Fixed Access Networks Synergies

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Abstract: Both multi-access edge computing and fixed access networks are experiencing tremendous evolutions. We propose here to discuss their synergies, focusing on the needs for industry. © 2021 The Author(s)

1. Introduction

Multi-access Edge Computing (MEC) has recently drained a lot of interest. Its objective is to provide computational resources closer to the final mobile network user, in order to reduce the distance between the applications running on the devices and the cloud resources. Doing so, edge computing "gets rid of many time-moving unstable network hops originally required to reach the distant cloud datacenter resources" [1]. As a result, edge computing aims to provide improved performances, the first one being the reduced latency which can drastically be reduced depending on the architecture. The available throughput also beneficiates from edge computing as does the reliability, given the proximity between the applications (running on the User Equipment) and the services. It also enables the development of new services such as intelligent video acceleration service scenario, connected vehicles, enterprise deployment of MEC [2,3] etc.

In parallel to the development of mobile networks, fixed networks also encountered a tremendous success through the worldwide deployment of Fiber to the "X" (FTTx). While optical fiber's deployment for access network is still ongoing, the Fixed Access Network (FAN) continues to evolve and to take advantage of the emerging technologies such as Software Defined Networking (SDN), Network Function Virtualization (NFV), or to reach new markets such as Local Area Networks (LANs) for industry [4].

We propose in this paper to discuss the synergy between MEC and FANs from the perspective of Business to Client (B2C) first, and then from a Business to Business (B2B) point of view, for campuses.

2. B2C: MEC field deployment converging with fixed access network

The field deployment of the MEC and the Radio Access Network (RAN) centralization (C-RAN) apply opposite forces on the architecture. While the MEC aims to provide a virtualization platform to run high layer applications, and to take them geographically closer to the User Equipment (UE), the Central Unit (CU) embeds the high layer functions of the RAN to be exposed to high-layer applications and executed closer to the core network. This "tug-of-war" between MEC and C-RAN for the best CU positioning, is studied in the 5G-COMPLETE project [5] in order to understand what could be the best compromise between the advantages of RAN centralization and the services provided by MEC. For now, Orange's French 4G deployments focused by far on Distributed-RAN (D-RAN) deployment based on point-to-point topology, where all RAN functionalities are located at the antenna site.

As 4G deployment is now mature, MEC will be enabled by the ongoing 5G deployment. From an operational point of view, MEC will need in the first place a shelter and a power supply to operate. In parallel to the mobile network, the FAN encountered in the recent years a tremendous success. FAN currently relies on PON technologies designed for short reaches (<20km), and 4000 Central Offices (COs) and Optical Line Terminations (OLTs) are already deployed in France, for example. Many of those OLTs already perform the connection with D-RAN antenna sites, with point-to-point OLT cards deployed in the same OLT shelf than the point-to-multipoint FAN-dedicated cards. The FAN COs is then a natural solution to shelter the MEC, providing a power supply, and a connection to both the backhaul and the antenna site. FAN COs could also ensure a secured location facilitating the 5G services to meet the strong reliability constraints, but also sheltering the RAN CU. As we discussed in [6], several options of fixed and mobile convergence are possible, from full convergence, where the fixed and mobile flows share the optical channel, to opportunistic convergence, where the ducts and supernumerary cables are shared. Fig.1 shows the repartition of today's FAN COs and RAN antenna sites (4G) in the city of Bordeaux, France. In this dense area, each antenna site is located at less than 2km away from the closest CO where the corresponding MEC could be sheltered.

In [7], we proposed to use a generic hardware server as an OLT to demonstrate a fixed-mobile convergence scenario where fixed and mobile share the same generic hardware, while the PON specific features are handled by

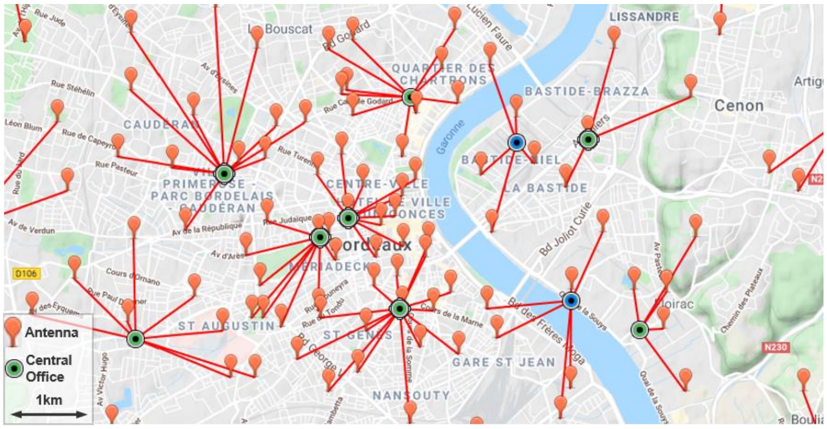

Fig. 1. Antenna and COs repartition in the city of Bordeaux, France.

Use Case	Latency (ms)
Factory Automation	0.25 to 10
Process automation	50 to 100
Smart grids	3 to 20
Intelligent Transport Systems	10 to 100
Professional audio	2

Tab. 1. Latency requirements of latency critical IoT applications [17].

pluggable and remotely manageable Small Form Pluggable (SFP). By doing so, we demonstrated the proper transportation of a midhaul (CU-DU) flow over a generic OLT with MEC capabilities. The work on fixed-mobile convergence continued for example with the standardization of Cooperative Transport Interface (CTI) [8] for fronthaul, which enables cooperation between mobile and PON schedulers in order to decongest the traffic flows. We proposed in [9] to extend the concept of CTI to extended-CTI (eCTI). eCTI focuses on the Optical Line Termination (OLT) machine and not only on its PON port side (as does the CTI), providing a dynamic management of the OLT's aggregation mechanism with a Software Defined Network (SDN) controller, to avoid overprovisioning, overdimensioning, and reduce energy footprint for mobile x-haul trafic.

3. Optical Access technologies in support of Non-Public Network for B2B markets

Besides the B2C approach adopted by legacy mobile networks, Mobile Network Operators (MNOs) aim to use 5G as a key to gain new Business to Business (B2B) markets. The resulting network, alternatively called "5G industry campus network" or "Non-Public Network" (NPNs) [10] directly impacts the overall architecture design, and thus shifts the network paradigm: the services are not anymore classified by types (voice, data,…), but by scenario (smart factory, internet of vehicles, …) [10]. The deployment strategy also diverges, from a population density map for B2C, to small "islands" for B2B, whose coverages radius depends on the targeted business (from major factory to small enterprise). NPNs have specific requirements such as strict data isolation (to avoid mixing the enterprise confidential data with the public data flow), and require an enhanced security. Latency constraints are still of high importance depending on the use case (see Table 1), and the resort to MEC is a necessity for time-critical applications. However, regarding the specificities of NPNs, MEC deployment may be performed in several ways (see Fig. 2):

- Option 1: the MEC can be deployed outside the campus, sharing the resource with B2C markets, and geographically located as previously discussed (see Fig. 1). From the MNO perspective, the MEC resources can be managed to provide better Quality of Service (QoS) to the NPN customer, but the user and control planes are shared with the public network.

- Option 2: the MEC is located inside the campus. The resulting isolation improves the security, since the user plane is not shared with the public network, while the control plane is.

- Option 3: the NPN customer has a dedicated standalone and local 5G core network, enabled thanks to the recent development of virtualization technologies.

FAN technologies could be the keystone of NPNs, as point-to-point FAN is for RAN transport. This is also one of the goals of F5G, an ETSI group whose intention is no less than to "make the paradigm of Fibre to the Home become a *Fiber to Everything*" [11]. In its second white paper, F5G defined fourteen use cases including:

- PON for Industrial Manufacturing, bringing higher connectivity to the uses cases of Industry 4.0, through edge computing capabilities to enable a universal intranet with computation capabilities, but also providing network slicing;

- Or "Passive Optical Local Area Network (POL)" for campuses, which tends to replace the copper switch-

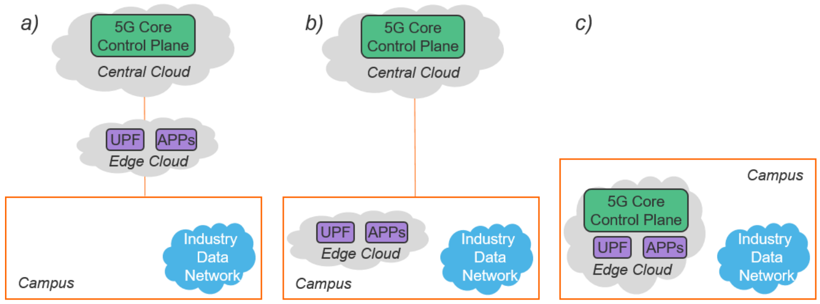

Fig. 2. NPN deployment – core and edge network options according to [10].
a: shared core network with public network ; b: dedicated user plane, shared control-plane with public network ; c: dedicated core network on campus
UPF: User Plane Function ; APP: Industrial application

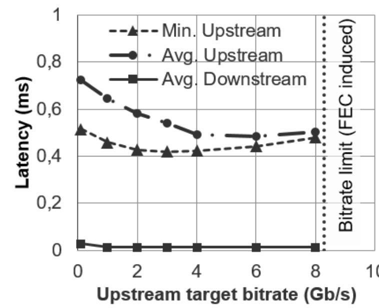

Fig. 3. Latency performances of pluggable XGS-PON SFP+/OLT [16]

based LANs by PON. In this case, the PON terminations can be completed by wireless technologies such as Wi-Fi 6. ETSI delivered the "Access to the 3GPP 5G Core Network (5GCN) via non-3GPP access networks" [12] in order to enable the UE to connect to the 5G network through a mmWave access point, or even a home/corporate Wi-Fi Access Point, using a secured IP tunnel (IPSec) over the "untrusted" wireless hop. Such use case demonstrate the coming synergy between PON, 5G, and Wi-Fi technologies, traditionally partitioned.

In the first NPN-MEC deployment option (see Fig. 2.a), RAN transport is similar to the B2C context, apart from the fact that the QoS for campus will be different than for a regular client. The resort to network slices is then a necessity. FAN recently experienced a tremendous interest for Software Defined Networking, one of the key enablers to network slices, resulting in different Software Defined Access Network (SDAN) achievements [13-15]. SDAN is one of the pieces required to provide a logical dedicated network over a physical architecture made of several segments, including PON.

In [16], we proposed the use of SFP-OLTs enabling custom-made PON deployment on an Optical Distribution Network (ODN) basis using hardware-generic L2 nodes for Small enterprises to major businesses. The associated remote management perfectly fits the NPN-MEC deployment option 2 (see Fig. 2.b), since the PON can be managed remotely, relieving the NPN owner from the network management and providing an added-value to the operator. As we showed in [16], the software management can be also supplied to the NPN owner, and run from a server, potentially embedding the MEC or the near real-time RAN Intelligent Controller (RT-RIC). With a typical upstream latency of 500-750µs (see Fig. 3), such pluggable PON OLT can meet the latency constraints of many IoT applications, summarized in Table 1 [17].

Last but not least, FAN also experienced the worldwide interest for virtualization which submerged all network segments in the past years. Several works demonstrated the possibilities to run the different VNF composing PON technologies over commodity servers [14, 18-20]. While this work is for now mainly a research topic, it goes in the same direction than the recent mobile network progress toward an Open-Cloud, as proposed by the O-RAN Alliance [21]. It paves the way to a next step of fixed-mobile convergence where the FAN, the 5G-core, the RIC and the RAN functions (vCU, vDU and even vRU) are all NFVs deployed on regular hardware. The resulting all-based merged networks would perfectly suit for example the Option-3 NPN (see Fig. 2.c) for custom-made 5G networks.

4. Conclusion

In this invited paper, we presented the synergies between fixed access network and multi-access edge computing for B2B and B2C markets. The ongoing FTTx deployment already enables the MEC to be sheltered with the FTTx devices, while the 5G technologies could benefit from FTTx nodes toward generic hardware. Moreover, the ongoing work on SDN and NFV for Fixed access networks will soon offer new opportunities for mobile network transport, enabling markets with new added-values for operators.

5. Acknowledgements

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