MEC service placement over the Fronthaul of 5G Cloud-RANs

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***Abstract*—Radio Access Network (RAN) disaggregation is transforming mobile networks, as it allows the single click instantiation of base stations in the Cloud, and can potentially ease the integration of heterogeneous technologies for wireless access. At the same time, Multi-access Edge Computing is proven to minimize the latency for accessing services located at the network edge. In this demo, we showcase a disaggregated heterogeneous Cloud-RAN, consisting of cellular and WiFi infrastructure, providing access to edge resources placed on the fronthaul of the network to multi-homed UEs. We experiment with different wireless technologies and placements for the MEC service, and illustrate our experimental results.**

I. INTRODUCTION

5G Mobile Networks are expected to bring several advancements for providing higher speeds with lower latency over the network. The requirements for low-latency are expected to be met through the wide proliferation of Multi-access Edge Computing (MEC); services being deployed closer to the network edge, will serve users with lower response times and with content that is appropriately replicated at the edge datacenters. User access will rely on different technologies for wireless, such as the forthcoming 5G New Radio (5G-NR) or the legacy LTE and WiFi technologies. At the same time, 5G brings new architectures for base stations, adding up to their flexibility and management through the Cloud-RAN concept. In this paper we deal with the disaggregation of base station units based at the PDCP layer, according to the 3GPP Option-2 split for base stations [1], with multiple heterogeneous technologies integrated in the network cell [2]. The base station is split at two components, the Central Unit (CU) placed at the edge datacenter, and the Distributed Units (DUs) offering wireless connectivity to the UEs of the network. The DUs can be heterogeneous, allowing the operator to introduce intelligent solutions for the wireless technology selection for serving each multi-homed UE.

The base station disaggregation allows the re-conception of technologies such as MEC, towards placing the provided services deeper in the network. Although MEC is considered as a low-latency solution for 5G, its integration is foreseen at the best case as co-locating the edge services with the CU. In this work, we demonstrate a prototype extending our work in [2] and [3] for the placement of services on the fronthaul of the network, between the CU and DUs of the network. We compare our approach to existing placements over the Core Network, and illustrate the benefits of our solution.

II. EXPERIMENT SETUP

The system architecture that allows us to place the services on the fronthaul interface is summarized in Figure 1. It consists of different elements for orchestrating the CU - DU intercommunication and a MEC Agent handling the delivery of user data to services running on the edge and communicating with the DUs. In the sections below we detail each element.

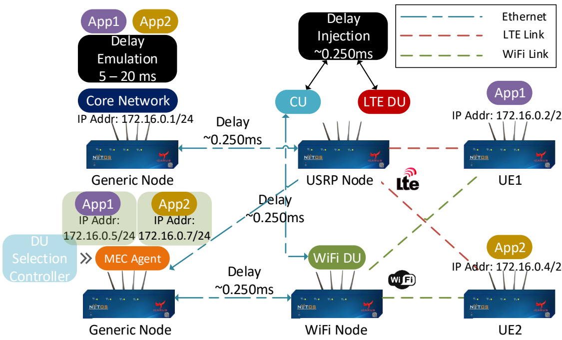

Fig. 1: Architecture and Experiment setup over the testbed

A. Radio Access Network (RAN)

For the wireless part of the network, we employ the OpenAirInterface platform [4] appropriately extended in order to integrate WiFi access in the RAN. For this purpose we use three testbed nodes: one configured as the Evolved Packet Core (EPC), one using a USRP device for running the LTE part of the network and one for running the WiFi DU software. The functionality is based on the disaggregation of the traditional base station architecture to two different parts, the CU and the DU, and the introduction of signalling between these two entities. In [2] we present the signalling format, and the manner in which new DUs can be supported by the platform. Through a software layer running on top of WiFi Access Points, we control the traffic that goes through the wireless network from the CU point of view (PDCP layer and onwards). The behaviour of the scheme resembles the operation of the LTE WLAN Aggregation scheme, introduced in 3GPP Release 14. The configuration of the LTE network is a 10MHz LTE cell operating at FDD band 7, and as a UE we use an off-the-shelf dongle with our own SIM cards. For the WiFi network we use a 40MHz IEEE802.11n configuration, operating in an entirely free from external interference environment.

B. MEC Agent and MEC services

For placing user accessible services on the fronthaul interface, we develop the respective functionality between the DUs and the MEC server hosting the provided services. For this purpose, we developed a protocol for the DU to MEC communication, by introducing a *MEC Agent* component. The agent can generate and exchange the appropriate messages with the DUs, or receive and deliver the respective data packets to the hosted MEC services. Moreover, as the different DUs in the network may receive information using different addressing schemes from the wireless clients (MAC addresses for the WiFi network, RNTIs for the cellular), the agent holds

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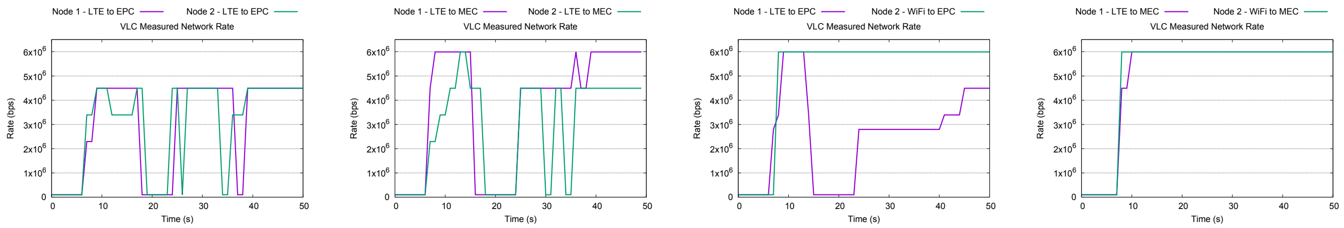

(a) VLC Rate - 2 LTE UEs requesting at the EPC

(b) VLC Rate - 2 LTE UEs requesting at the MEC

(c) VLC Rate - 1 LTE and 1 WiFi UEs requesting at the EPC

(d) VLC Rate - 1 LTE and 1 WiFi UEs requesting at the MEC

Fig. 2: VLC rates for different access technologies

TABLE I: RTT Results (msec) for LTE and WiFi access to the service (Fronthaul or EPC)

	LTE to FH	**WiFi to FH**	**LTE to EPC**	**WiFi to EPC**
Avg. RTT	19.7	4.78	32.32	5.26
Min. RTT	15.1	4.39	26	4.59
Max. RTT	24.7	5.12	43.4	6.64

a book-keeping process for mapping each RNTI value of each UE. The RNTI information is being used in the packets sent to/from the DUs and the MEC agent. Through this process, we are able to expose an interface on the MEC agent for selecting the DU through which traffic will be transmitted to each UE of the network in a per-packet basis. Therefore, different policies can be applied on the selection of the DU from the MEC agent side. Complete details on this process are provided in [5].

Moreover, each service running on top of the MEC agent is running in an LXC container. Whenever the agent receives traffic intended for the hosted services, it handles it and injects the user payload to the MEC service. We decide to host the services containerized through Linux Containers (LXC), as they can be instantiated on the fly, whenever an end-user requests different services from the MEC platform. Adopting LXC containers is very beneficial as it allows each new service to be addressed with a new container, with a new network IP address and can be easily migrated if needed to another edge host. For our experiments, the same container is instantiated on either the fronthaul (between the CU and DU) or the EPC.

III. EXPERIMENTAL RESULTS

For the evaluation of the platform, we measure two different network performance indicators: 1) the latency for accessing the MEC services and 2) the time to converge for streaming high quality video from the service. For both setups, we use two multihomed UEs connected to two DUs (LTE and WiFi).

We compare the latency time for both access technologies between the UE and the service using two different placements: one being on the fronthaul, with approx 0.250ms delay between the DU and the MEC agent, and one being on the core network (EPC). Table I shows averaged RTT times. Assuming that latency is almost half of the RTT time, we see that for the cases of MEC access over LTE or WiFi, the latency is consistently less than 10ms, thus allowing several 5G applications to run, according to [6]. As the experiments are conducted in an entirely interference-free environment, we observe that WiFi outperforms LTE latency times.

For the second part of the evaluation, we test the network with two UEs, connected through either LTE or WiFi and request the video from a server located at the EPC or the MEC agent. We plot the requested video rate of the application based on its assumption of the underlying wireless channel, using the Dynamic adaptive Streaming over HTTP (DASH) capabilities of VLC player. When requesting the video from the MEC server over LTE (Figure 2b), one of the two UEs manages to get video rate coded at 6Mbps, whereas the second is limited at maximum 4.5Mbps, as for the EPC case. When we use different technologies (one user to LTE, one to WiFi) to request data from the EPC server (Figure 2c), both clients get video coded at 6Mbps, until the LTE UE's buffer is emptied. Then it gradually starts getting better video segments up to 4.5 Mbps. From the other side, the WiFi client quickly converges to getting the best video quality available. For the case of using the same setup to get video from the MEC service, we see that both clients quickly converge to receiving the best available video quality (Figure 2d). From these results we conclude that the technology used to request the video plays a key role in the overall experience of the user. Moreover, the services that are placed on the MEC agent and therefore are closer to the UE outperform the cases of remote testbed placement.

IV. CONCLUSION

In this paper, we demonstrated the deployment of an Edge Computing service over a disaggregated base station network, consisting of multiple DUs at the RAN. The novelty relies on the deployment of services over the fronthaul interfaces, contrary to existing suggestions for MEC. Through the selection of the wireless technology at the MEC side, we can use the link that offers the minimum possible latency per each UE.

ACKNOWLEDGMENT

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