Demo: LL-MEC A SDN-based MEC Platform

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ABSTRACT

Software-defined Networking (SDN) is seen as a promising solution that allows for a more distributed, flexible, and scalable network. Multi-access Edge Computing (MEC), initiated as an Industry Specification Group (ISG) within ETSI, is also emerging as a low-latency and high-throughput cloud environment at the edge of network. The noticeable success that aforementioned technologies made attracts massive research interests and the interplay between them on programmable network requires an open source platform to evaluate. In this work, we present a low-latency MEC platform (LL-MEC) providing the required flexibility and programmability to meet the expected performance gain following SDN and MEC principles. We also demonstrate an use case of real-time content caching application using LL-MEC platform and OpenAirInterface LTE implementation on commodity hardware.

KEYWORDS

MEC, OpenAirInterface, SDN, LTE, OpenFlow, Programmability.

1 INTRODUCTION

Recently, Multi-access Edge Computing (MEC), introduced and specified by European Telecommunications Standards Institute (ETSI)[5], has attracted huge interests among research communities due to the promising benefits at the network edge. MEC is a platform enabling applications with the function of clouds[1, 2] at the network edge and in close proximity to end-users. Besides, MEC is not only characterized by its proximity to Radio Access Network (RAN) but also by providing a real-time access to radio network information that can be exposed to applications; therefore *low latency* comes as one of the key features of MEC. The ETSI specifications also have rich set of functionalities to ensure that the MEC concept can be the solutions to the problems surfacing. Not only does MEC provide technical benefits, but it also creates a new market and value chain not seen before in mobile networks by opening the network to authorized third-parties, who can develop and rapidly install innovative applications, benefiting both the third-parties and the network owners. Having smart and diversified applications toward 5G mobile network requires pushing the boundaries of existing network and service infrastructure. Services desiring lower-latency are emerging and pushing network services to the edge has the potential to enhance user latency and experience, as well as to offload Internet traffic.

The noticeable success in non-mobile networks made by SDN gives the initiatives to apply it onto the core network (CN) of LTE [6]. With the separation of control and data plane, SDN provides the possibilities to program and virtualize the mobile network components, such as Mobility Management Entity (MME), control plane of Serving-Gateway (SGW-C), and control plane of Packet-Gateway (PGW-C) as potential MEC applications. The programmability of the CN provided by SDN is exactly where MEC can facilitate its programmability in RAN and further delegate control decisions. SDN and MEC are complementary concepts and SDN has the same objectives as MEC in the way of applying specific rules to data plane. Not surprisingly, there have been considerable research interests on SDN and MEC with most of them focusing on conceptual frameworks but no open source platform for researchers as a reference to evaluate the benefits of MEC and SDN enabled services. This gives the initiatives of LL-MEC to exploit SDN in providing an end-to-end network programmability through an ecosystem of network services and applications. Given the open specifications of MEC for vendor implementation, the SDN concept is applied in LL-MEC with OpenFlow and FlexRAN [3].

In this work, we present the first open source low latency multi-access edge computing platform (LL-MEC) with 3GPP and ETSI compliance, as a complete implementation of previous work[4] to fill the aforementioned void. LL-MEC incorporates data plane APIs to provide an end-to-end separation between control-plane and data-plane following the SDN principles. It features real-time application task manager and low-level application APIs to support low latency. Furthermore, practical use cases are provided to be deployed on the top of LL-MEC. LL-MEC is built and evaluated upon a real-time LTE platform, OpenAirInterface [7] and LL-MEC along with its toolbox adopted in this work will soon be made available to the wide research community.

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2 LL-MEC OVERVIEW

This section gives an overview of LL-MEC platform and describes how LL-MEC can operate over software-defined mobile network at the edge. We present a high-level schematic of LL-MEC in Figure 1, mainly composed of a three-layer design: *MEC Application*, *MEC Platform*, and *Abstraction*. This platform functions upon software-defined mobile network consisting of multiple LTE eNodeBs and OpenFlow-enabled switches, whether it is physical or software, and fully separates the data plane from control functions. Furthermore, the agent (refer to Figure 1) acts as a local controller on behalf of RAN or OpenFlow-enabled switches. The entities and interfaces we implement in this platform follow the ETSI MEC specifications[5] to support the full functionalities provided by the Mp1 and Mp2 interfaces while retaining the 3GPP compatibility.

2.1 Abstraction

The abstraction layer models and exposes the required operations for the underlying network through a unified interface. In LL-MEC, the *C-plane API* and *D-plane API* naturally comprise the abstraction layer for control plane and data plane of mobile network respectively by providing only the necessary information for the development of *MEC Applications* and *MEC Platform*. In addition to monitoring, they allow flexible and programmable control of the RAN infrastructure.

2.2 MEC Platform

MEC Platform resides in LL-MEC as a core entity between the MEC applications and the real network elements. It constitutes the brain of LL-MEC that controls the fundamental services such as events trigger and register, and provides low latency support, and library integration. Besides, MEC Platform also implements the necessary building blocks to create MEC applications by simplifying the reuse of core components and services. This gives the possibilities for application developers to focus on their specific MEC applications rather on the detailed functionalities of underlying network. It's also worth mentioning that the current implementation of LL-MEC does not support the Mp3 reference point used for the communication with the other MEC platforms.

2.3 MEC Application

MEC applications have limitless possibilities to be developed for any specific purpose without knowing the detailed knowledge of the underlying network. The Mp1 reference point enables the MEC applications to access the network information or delegate the control decision towards network. Multiple choices are provided as the Mp1 including REST API, message bus, and local APIs. Another pivotal feature LL-MEC has is that the application can be deployed in different scheduling recipes such as round robin, first-in-first-out, or deadline scheduler for having different time-scales and priority when executing the task behind the scene. Especially, the RAN-related applications can benefit from this feature to avoid further delay when interacting with radio network.

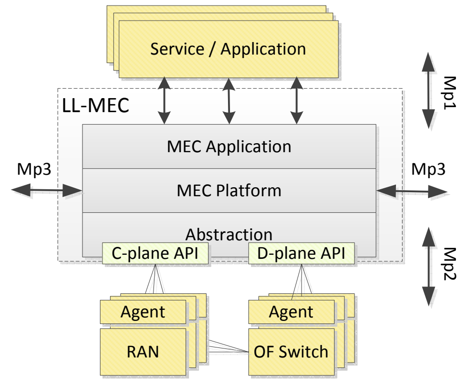

Figure 1: High-level schematic of LL-MEC

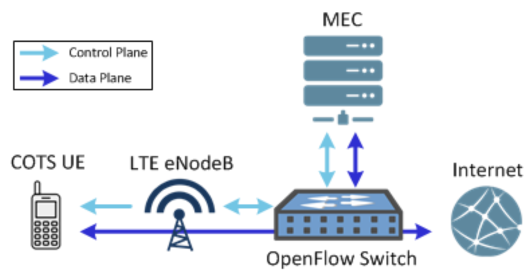

Figure 2: The deployment of LL-MEC demonstration

3 DEMO DESCRIPTION

The considered demonstration scenario is illustrated in Figure 2 and consists of 2 commercial LTE-enabled smart phones (Huawei Nexus 6p), National Instrument/Ettus USRP B210 as RF front-end, and 4 Linux-based PC running OAI eNodeB, OAI core network, Open vSwitch v2.7, and LL-MEC. The demonstration will be deployed in FDD SISO mode with 5MHz channel bandwidth. The target frequencies will be band 7 (Europe) radio environment. In the proposed demonstration, we will assess the following objectives.

- feasibility of low latency MEC framework based on SDN concept;
- ease of MEC application deployment at the network edge;
- gain in latency for content optimization use case.

3.1 Workflow to setup default bearers

Figure 3 shows the workflow of how an SDN-based mobile network operates and interacts with LL-MEC to handle UE initial attach procedures for bearers establishment. The main point of the sequence diagram starts from the message

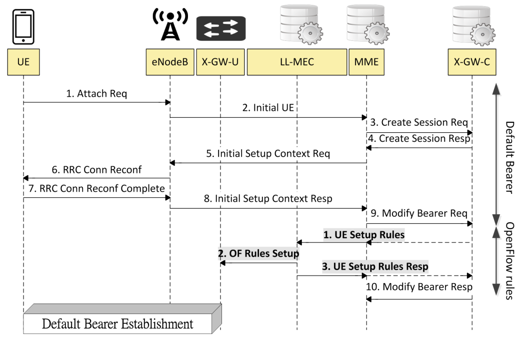

Figure 3: Sequence diagram of default bearers setup

calls initiated all the way from X-GW-C through LL-MEC to X-GW-U. As soon as the UE is properly attached to the network with MME and X-GW-C knowing the GTP information, X-GW-C will initiate the procedure to transmit the UE information (*UE Setup Rules*) to LL-MEC and then based on the rules, LL-MEC is able to setup the OpenFlow rules (*OF Rules Setup*) in the corresponding switches. By introducing the concept of SDN into mobile network, the default bearer can be setup by configuring the OpenFlow rules when UE completes the initial attach procedure.

3.2 RAN-aware Content Optimization

As a showcase of mobile network slicing, RAN-aware content optimization is chosen as the representative use case to study the benefit of RAN information reported by the eNodeB on improving user quality of experience (QoE). For example, the application can monitor the cell load status and radio link quality in order to enforce a new resource allocation policy or change the content quality. In this work, we implement a video streaming over HTTP as one LL-MEC application and choose channel quality indicator (CQI) as a flag to reflect radio status of each UE. Besides, an Android video application developed in the context of one of the ETSI proof-of-concept[8] is utilized in this work in order to measure the uplink and downlink performance as well as the mean opinion score (MOS). When two UEs start the video streaming, LL-MEC has the ability to program the routing path so that the video application can be redirected to a relay server instead of the real server in Internet and further adapt the streaming rate according to the RAN status. In Table 1, we show the measurements of the maximum sustainable TCP bitrate of a video stream through the mapping between CQI index and bi-directional TCP throughput identified during experiments. Surely, CQI index is one of the meaningful parameters and any potential parameter can be involved easily to optimize video streaming and QoE.

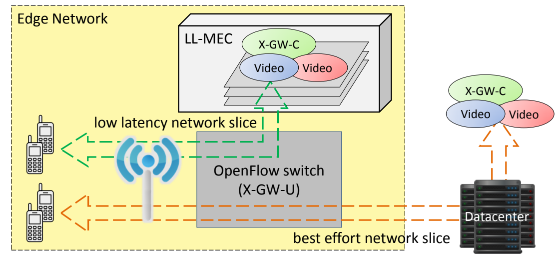

Figure 4: Video optimization setup schematic

Table 1: CQI index mapped as max TCP throughput

CQI	Downlink (Mb/s)	Uplink (Mb/s)
15	15.224	8.08
11	11.469	6.04
9	9.88	4.47
7	5.591	2.49
4	1.08	0.69

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