Support for Edge Computing in the 5G Network

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***Abstract* —** Networks beyond 2020 are required to support diverse use cases. Among the emerging services, support of delay critical mobile applications require network enhancements to natively offer low latency and high mobility. In this regard, the 5G network needs to be flexible for new service scenarios, and MEC can be supported to reduce the latency. In this paper, we present the feature of support for MEC in the 5G network and explain working mechanisms for application allocation, user plain selection, traffic local routing and steering.

Keywords—data offloading, MEC suport, 5G network

I. Introduction

The 5G network is expected to support emerging new service scenarios and business models driven by user needs beyond 2020. Some of new applications, such as augmented reality and remote surgery service which are delay sensitive and mission critical, could be the challenge for the mobile networks. In addition to these new use cases, mobile networks need to serve well-known applications such as smart meters, broadband internet, and video streaming services. Figure 1 illustrates some examples of envisioned usage scenarios for IMT for 2020 and beyond [1]. The 5G network should be flexible enough to host all the mentioned applications without compromising performance. In order to provide stable and seamless support for various services, it is necessary to develop a system capable of satisfying the requirements of various services in the 5G mobile communication system.

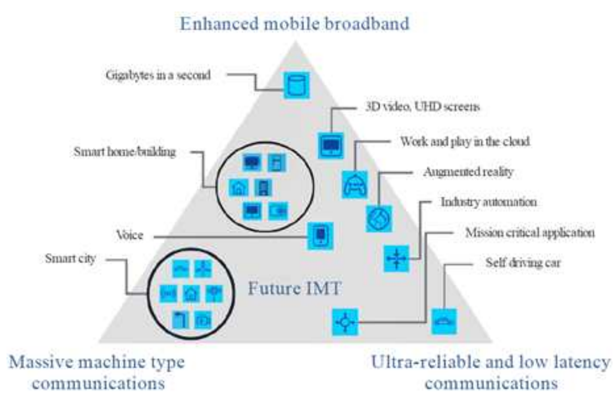

Fig. 1. Usage scenarios of IMT for 2020 and beyond

On the other hand, Multiple-access Edge Computing (MEC), which consists in the IT and Telco domains, and brings their capabilities within the close proximity of mobile subscribers to serve them better, are gaining acceptance in mobile networks [2]. MEC defined in ETSI describes the architecture where computing, storage, and networking resources are available in a cloud fashion on host servers located at the network edge. Based on a virtualized platform, MEC is recognized as one of the key emerging technologies for 5G networks together with NFV and SDN.

To support new challenging use cases, such as AR services which require low latency, by improving resource usage efficiency in the network, the 5G mobile communication system should be designed in consideration of MEC.

In this paper, we present the feature of MEC support in the 5G network which is standardized in the 3GPP, and propose an alternative procedure of session establishment for supporting MEC. After reviewing data offloading related works, we explain the architecture and functions of the 5G network for supporting Edge Computing. Then procedures to control PDU sessions for supporting MEC in the 5G network is followed.

II. Related Works

Gupta et al. [3] explain the Local IP Access (LIPA) and Selected Internet IP Traffic Offload (SIPTO) features for LTE networks introduced in 3GPP Release 10 specifications.

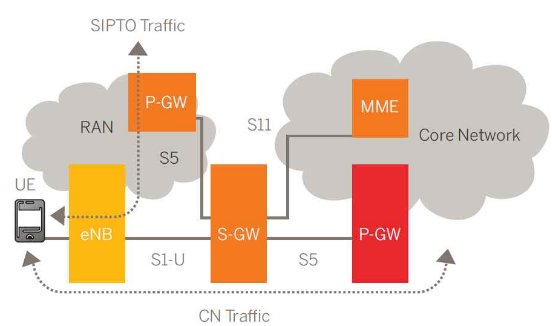

Fig. 2. SIPTO Breakout above RAN - macro network

The LIPA is for residential or enterprise IP networks, and is only valid for indoor femto-cells, while the SIPTO is for Internet access in both femto-cell and macro-cell setups. Although both features aim at offloading some traffic away from the operator's core network, they require separate LGWs. And session control of the network is duplicated.

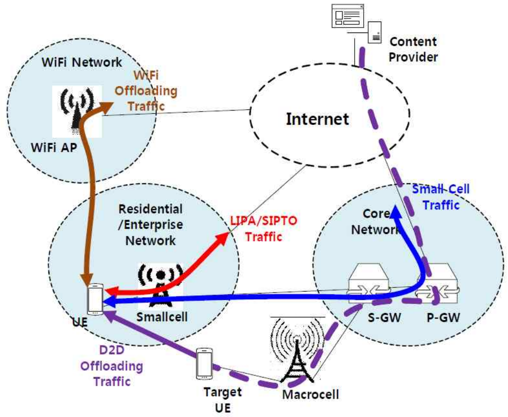

Fig. 3. Mobile data offloading route options

Cheon et al. [4] propose the LIPA and SIPTO offloading algorithm using social context, and define the application selection probability using social context. The optimal offloading weighting factor to maximize the QoS (Quality of Service) of small cell users in term of effective data rate is presented. It provides offloading method based on social context besides QoS in the 4G network.

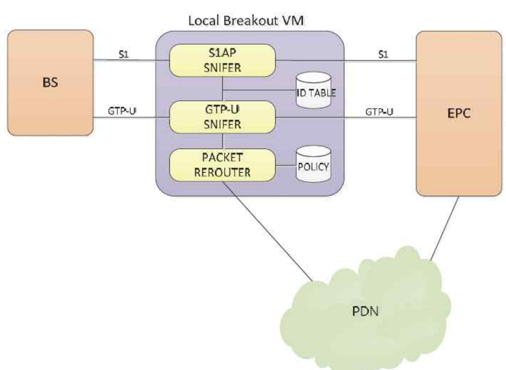

Fig. 4. Local Breakout VM in the MEC Server

Lee et al. [5] present a structure for local breakout function in base station using MEC, and propose service framework and interfaces with MEC server. In base station, the path for all IP packets from user by decapsulation of GTP PDU can be diverted to a local network according to the breakout rule for IP packets which are originally scheduled to forward to the core network. Although 4G Local Gateway is implemented in the MEC, there is no network control procedure for MEC support.

MEC use cases that have gained an attraction to date, such as Intelligent Video Acceleration, Local Content Caching, Augmented Reality, Location Based Services, and Connected Vehicles, are presented in [2]. The importance of the edge location and criteria to take in consideration along with the MEC location tradeoffs is discussed. Although they are considering the tradeoff of MEC location selection, they do not present procedures for accessing MEC in the 5G network.

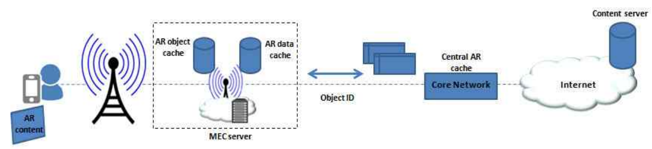

Fig. 5. MEC Applications - Augmented Reality

III. 5G NETWORK ARCHITECTURE

A. Design Principles

The 5G network architecture has been defined in 3GPP to support data connectivity services to use techniques such as e.g. Network Function Virtualization (NFV) and Software Defined Networking (SDN). The 5G network architecture uses service-based interactions between Control Plane Network Functions where identified. Some key principles and concept are as follows [6].

- Separate the User Plane (UP) functions from the Control Plane (CP) functions, allowing independent scalability, evolution and flexible deployments e.g. centralized location or distributed (remote) location.
- Minimize dependencies between the Access Network (AN) and the Core Network (CN).
- Support concurrent access to local and centralized services. User Plane functions can be deployed close to the Access Network to support low latency services and access to local data networks,
- Wherever applicable, define procedures (i.e. the set of interactions between network functions) as services, so that their re-use is possible.

B. Architecture Reference Model

Figure 6 depicts the 5G network architecture in case concurrent access to local and central data networks is provided within a single PDU Session, using the reference point representation [6].

The 5G network architecture consists of the following network functions (NF).

- Authentication Server Function (AUSF)
- Access and Mobility Management Function (AMF): AMF provides functionalities such as Termination of RAN CP/NAS, Registration/Reachability/Mobility management, Access Authentication/Authorization
- Network Slice Selection Function (NSSF)
- Policy Control Function (PCF)
- Session Management Function (SMF): SMF provides functionalities such as session management, UE IP address allocation, control of UPF, termination of SM parts of NAS messages
- Unified Data Management (UDM)

- User Plane Function (UPF): UPF provides functionalities such as Anchor point for mobility, Packet routing & forwarding, QoS handling
- Application Function (AF)
- Data Network (DN): e.g. Internet access, 3rd party services, operator services
- User Equipment (UE)
- Radio Access Network (RAN)

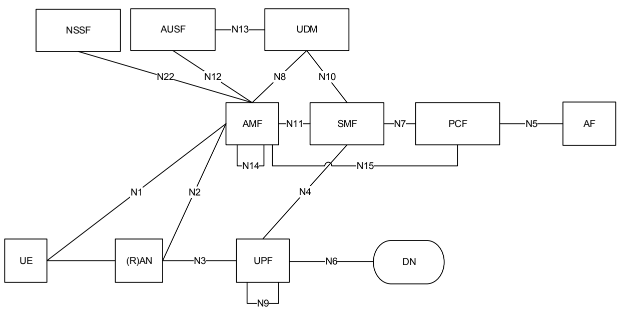

Fig. 6. 5G Network Architecture

The 5G Network (5G) supports a PDU (Protocol Data Unit) Connectivity Service i.e. a service that provides exchange of PDUs between a UE and a data network identified by a DNN (Data Network Name). The PDU Connectivity Service is supported via PDU Sessions that are established upon request from the UE. Subscription Information may include multiple DNNs and may contain a Default DNN.

The UE is assigned to a default DNN if it does not provide a valid DNN in a PDU Session Establishment Request sent to the network. Each PDU Session supports a single PDU Session type. The following PDU Session types are defined: IPv4, IPv6, Ethernet, and Unstructured. PDU Sessions are established (upon UE request), modified (upon UE and 5GC request) and released (upon UE and 5G request) using NAS SM signaling exchanged over N1 between the UE and the SMF [6].

IV. MEC SUPPORT IN THE 5G NETWOK

A. Support for Edge Computing

Edge computing enables operator and 3rd party services to be hosted close to the UE's access point of attachment, so as to achieve an efficient service delivery through the reduced end-to-end latency and load on the transport network.

In the case where UEs frequently request specific application services in a certain area, the service provider installs the service in the MEC server located at the edge of the 5G network serving that specific area. The service provider requests the 5G network to steer the traffic to the MEC when the service is requested. Then, when a UE in that certain area requests the corresponding service, the 5G network offloads the corresponding traffic to the nearby MEC server.

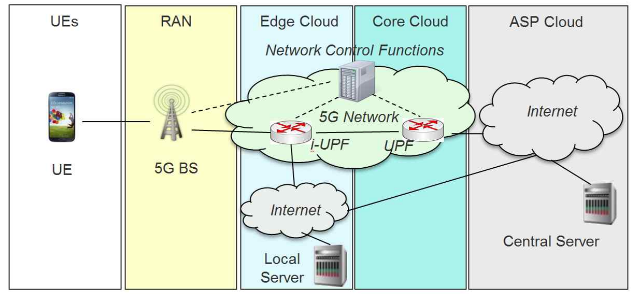

Fig. 7. Support for Edge Computing in the 5G Network

The functionality supporting for edge computing in the 5G network being specified in the 3GPP includes [6]:

- An Application Function may influence UPF selection and traffic routing
- Support for Local Area Data Network (LADN: a DN that is accessible by the UE only in specific locations): 5G Core Network provides support to connect to the LADN in a certain area where the applications are deployed
- User plane selection: the 5G Core Network selects UPF to route the user traffic to the local Data Network
- Local Routing and Traffic Steering: the 5G Core Network selects the traffic to be routed to the applications in the LADN

B. Application Function influence on traffic routing

When service providers need to arrange their services, such as AR that require low latency characteristics for deploying those services, at the network edge, they can request network operators to steer traffics for accessing that service to the LADN at which the MEC server resides.

Figure 8 shows the procedure for processing application request to influence traffic routing.

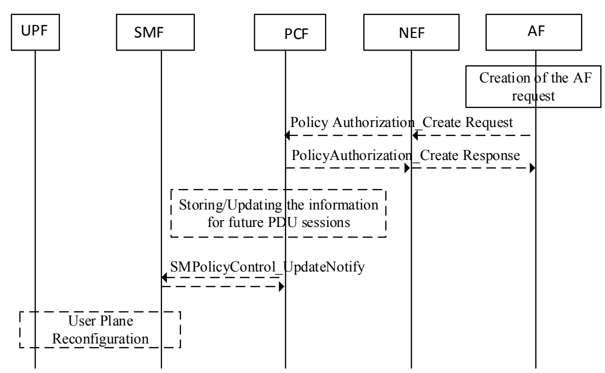

Fig. 8. Processing AF requests to influence traffic routing

The Application Function (AF) is in charge of the relocation of the applications within the local DN. The AF sends requests to the PCF via N5 to influence SMF routing decisions for traffic of PDU Session. The AF requests contain information to identify the traffic, locations of applications towards which the traffic routing should apply, and information on the UE [7].

The traffic can be identified by a DNN and traffic filtering information (e.g. 5 Tuple) which is used by the UPF to detect the traffic of the application. The potential location of application is expressed as a list of DNAI (DN Access Identifier). Information on the UE corresponds to UEs identified using an IP address, or any UEs accessing the combination of DNN and DNAI.

The PCF transforms the AF requests into policies that apply to PDU Sessions and provides the SMF with PCC rules that are generated based on the AF request. The PCC rules contain information to identify the traffic to be routed and information about the DNAI towards which the traffic routing should apply. When a PCC rule is received from the PCF, the SMF update the UPF in the target DNAI with new traffic steering rules to reconfigure the User plane of the PDU Session.

C. Support for Local Area Data Network

Figure 9 shows the 5G network architecture for concurrent access to local and central data networks with a single PDU session [6].

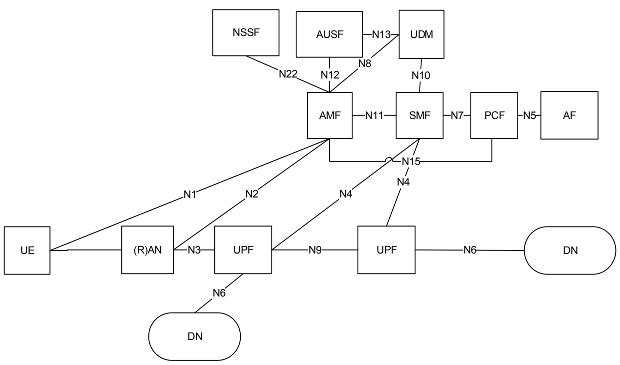

Fig. 9. 5G Network architecture for access to local and central data networks (single PDU session option)

The access to a LADN via a PDU Session is only available in a specific service area. The LADN Information (i.e. LADN service area information and LADN DNN) is configured in the AMF on a per DN basis. For each local DN, the corresponding LADN service area information includes a set of Tracking Areas (TA) that belongs to the current Registration Area of the UE.

In order to support selective traffic routing to the DN, the SMF controls the data path of a PDU Session so that the PDU Session may correspond to multiple N6 interfaces simultaneously. The UPF which terminates these interfaces has to support PDU Session Anchor functionality. Each PDU Session Anchor supporting a PDU Session provides a different access to the same data network.

When the UE performs a successful Reregistration procedure to register a UE with the 5G network, the AMF shall provide to the UE, based on local configuration information about LADN, UE location, UE subscription information about DNNs that is subscribed as LADN, the LADN Information for the LADNs available to the UE in that RA in the Registration Accept message. The AMF tracks UE's location and notifies the SMF about the relationship between UE location and a LADN service area (i.e. IN, OUT, UNKNOWN) [7].

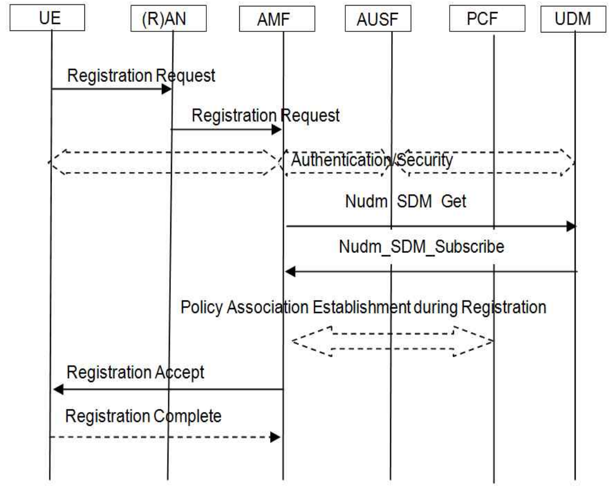

Fig. 10. Reregistration procedure

D. User plane selection

After the Reregistration procedure, the Service Request procedure is used by a UE to request the establishment of a secure connection to an AMF [7].

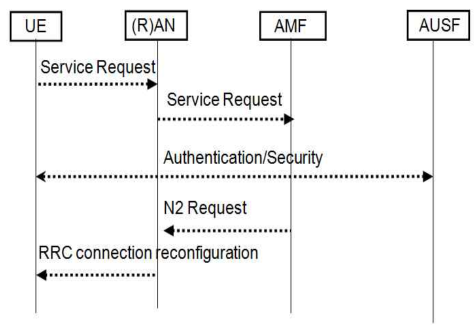

Fig. 11. Service Request procedure

The UE initiates the Service Request procedure in order to send uplink signaling messages. After receiving the Service Request message, the AMF may perform authentication and responds with a Service Accept message to synchronize PDU Session status between UE and network. After the establishment of the signaling connection to an AMF, the UE may send signaling messages, e.g. PDU Session establishment from UE to the SMF, via the AMF. The PDU Session establishment procedure is used to establish a new PDU Session.

We propose an alternative Session establishment procedure compared to 3GPP's for decreasing signaling messages by involving both UPFs in the data path of a PDU Session at the same time. Figure 12 shows the proposed Session establishment procedure.

The 5G Network selects UPF to route the user traffic to the local area Data Network. The selection of the UPF are performed by the SMF by considering UPF deployment scenarios such as centrally located UPF and distributed UPF located close to the Access Network site. SMF checks (If the DNN corresponds to an LADN) whether the UE is located within the LADN service area based on the UE location reporting from the AMF.

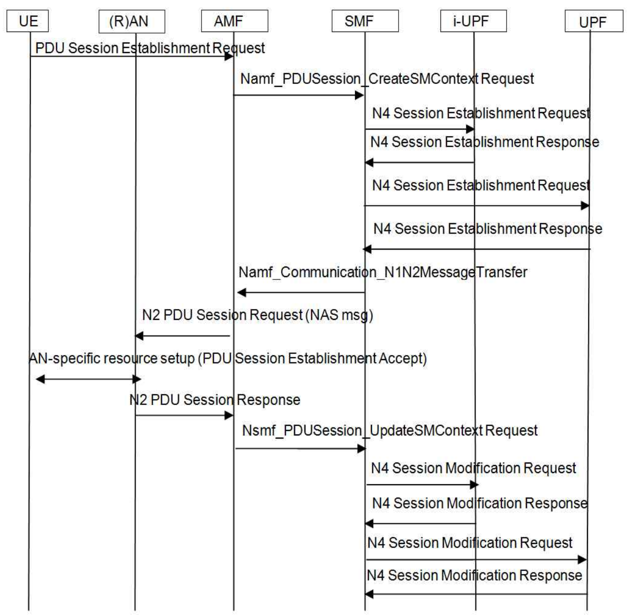

Fig. 12. Session establishment procedure

If the UE is located within the LADN service area, the SMF decides to insert an Uplink classifier (ULCL) in the data path of a PDU Session. The ULCL is a functionality supported by an UPF that reroutes locally some traffic which matches traffic filters provided by the SMF.

The ULCL applies packet filtering rules (e.g. to examine the destination IP address of uplink IP packets sent by the UE) and determines where the packet should be routed. The UE is unaware of the traffic diversion by the UL CL, and does not involve in both the insertion and the removal of UL CL.

In case of PDU Session establishment, the SMF shall provide the allocated Core Network (CN) Tunnel Information to UPF. The SMF shall also provide the CN Tunnel Information to RAN in order to complete the PDU Session establishment. CN Tunnel Information is the Core Network address of the N3/N9 tunnel corresponding to the PDU Session. It comprises the TEID (Tunnel Endpoint ID) and the IP address which is used by the UPF for the PDU Session.

E. Local Routing and Traffic Steering

The 5G Core Network selects a UPF close to the UE and executes the traffic steering from the UPF to the local Data Network via a N6 interface. The SMF is responsible for instructing the UPF about how to detect user data traffic by providing detection information, such as forwarding the traffic according to locally configured policy for traffic steering.

For IP PDU Session type, detection information is a combination of PDU Session, IP Packet Filter Set, and Application Identifier. The Packet Filter Set shall support packet filtering based on at least any combination of Source/destination IP address, Source/destination port number, Protocol ID of the protocol above IP, and Packet filter direction.

V. CONCLUSION

5G networks are required to be able to accommodate services with diverse characteristics. In addition, Edge Computing is being proposed to support low delay services.

In this paper, we explain the feature of MEC support in the 5G network which is standardized in the 3GPP and present an alternative Session establishment procedure.

Support for Edge Computing in the 5G Network makes it possible to select the traffic to be routed to the applications in the local area Data Network. Selective traffic routing supports deployments where some selected traffic is forwarded to the Data Network that is "close" to the Access Network serving the UE. This feature allows operators to reduce inefficient use of network resources, and increases QoE (quality of user experience) because of short traversing path for the service.

The issue of the session continuity due to user or application mobility in the LADN needs to be presented.

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