

technologies, we should develop LTE- infrastructure in two domains i.e., access and core network [2]. In the access section, we have defined a comprehensive heterogeneous access network hAN entity including eNodeB functionalities and new capabilities such as separating the BBU from RRH and establishing small cells for 5G. Therefore, we may provide multi mobile technologies. hAN contains pools of BBUs that facilitate data/control signal flows between RRHs and core network (Fig. 2).

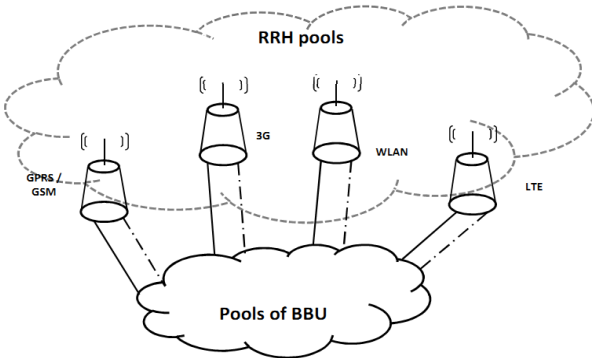


Fig. 2 RRH to hAN connections [2]

To develop LTE functionalities in the core domain, we have created a new entity by the name of TENANT Gateway (TNT Gateway) in the core infrastructure to provide functionalities for vertical market players such as operators, utility companies and other organs such as YouTube, Netflix and OTT applications.

We have provided and summarized entities and functionalities of LTE EPS in Table 1 firstly [14, 15, 16], then to improve the above functionalities, we have added some functions for hAN, and TNT Gateway in Table 1. To improve the QoS parameters in 5G, we should augment flexibility to the network. Thus, we have defined the entity functionalities as distinct f1, f2 etc. functions in Table 1. f1, f2, etc. are EPS functions written in the right side of Table 1. These functions will be dynamically invoked according to the user's requested service.

III. PROPOSED ARCHITECTURE

In 5G, we intend to consolidate different network equipment via making a pool of servers, switches, and storages deployed using SDN. Consequently, we have provided cost saving and flexibility in network operation and better service availability and facilities in this reconfiguration of networks [16]. We can envisage the Evolved Packet Core (EPC) entities e.g., Serving Gateway (SGW) and Packet Data Network Gateway (PGW) as VNFs. To provide the new architecture including the entities and their logical and data connections, we first reviewed the ladder diagrams in [4] and [6] which represent the entities, signalling and data messages following between different network entities in LTE. Table 2 has been derived from those ladder diagrams and reveals control and data entity connections. We put a tick mark in cross section of a row and a column when a control/data message follows between them. In addition, we inserted TGW (TENANT Gateway) entity in Table 2.

To provide the flexibility to 5G infrastructure we use network slicing. This feature allocates the suitable nodes, functions, and topology to a specific service to provide an optimum QoS for it. We may use Tables 1 and 2 to provide functions and logical and data connections.

EPS entity (Virtual Function)	EPC Functions
eNB hosts / hAN	f1: Functions for Radio Resource Management: Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic allocation of resources to UEs in uplink, downlink, and sidelink (scheduling); f2: IP header compression and encryption of user data stream; f3: Selection of an MME at UE attachment when no routing to an MME can be determined from the information provided by the UE; f4: Routing of User Plane data towards Serving Gateway; f5: Scheduling and transmission of paging messages (originated from the MME); f6: Scheduling and transmission of broadcast information (originated from the MME or O&M); f7: Measurement and measurement reporting configuration for mobility and scheduling; f8: Scheduling and transmission of PWS (which includes ETWS and CMAS) messages (originated from the MME); f9: CSG handling; f10: Transport level packet marking in the uplink; f1: S-GW relocation without UE mobility, as defined in [6]; f1: Optionally registering with the X2 GW (if used).
DeNB host	f1: S1/X2 proxy functionality for supporting RNs; f2: S11 termination and S-GW/P-GW functionality for supporting RNs.
MME host	f1: NAS signalling; f2: NAS signalling security; f3: AS Security control; f4: Inter CN node signalling for mobility between 3GPP access networks; f5: Idle mode UE Reachability (including control and execution of paging retransmission); f6: Tracking Area list management (for UE in idle and active mode); f7: PDN GW and Serving GW selection; f8: MME selection for handovers with MME change; f9: SGSN selection for handovers to 2G or 3G 3GPP access networks; f10: Roaming; f11: Authentication; f12: Bearer management functions including dedicated bearer establishment; f13: Support for PWS (which includes ETWS and CMAS) message transmission; f14: Optionally performing paging optimisation; f15: S-GW relocation without UE mobility, as defined in [6]. NOTE 1: The MME should not filter the PAGING message based on the CSG IDs towards macro eNBs.
Serving Gateway (S-GW) host	f1: The local Mobility Anchor point for inter-eNB handover; f2: Mobility anchoring for inter-3GPP mobility; f3: E-UTRAN idle mode downlink packet buffering and initiation of network triggered service request procedure; f4: Lawful Interception; f5: Packet routing and forwarding; f6: Transport level packet marking in the uplink and the downlink; f7: Accounting on user and QCI granularity for inter-operator charging; f8: UL and DL charging per UE, PDN, and QCI.
PDN Gateway (P-GW) host	f1: Per-user based packet filtering (by e.g. deep packet inspection); f2: Lawful Interception; f3: UE IP address allocation; f4: Transport level packet marking in the uplink and the downlink; f5: UL and DL service level charging, gating, and rate enforcement; f6: DL rate enforcement based on APN-AMBR;

PCRF	<p>f1: The PCRF checks that if the policy set-up information received from the AF is consistent with operator policies defined in the PCRF.</p> <p>f2: The PCRF authorizes QoS resources (bandwidth, etc.) for the AF session. The PCRF uses the policy set-up information received from the AF to calculate the proper authorization. The authorization includes the limits on QoS for the set of IP flows and restrictions on individual IP flows (e.g. destination address and port).</p> <p>f3: The PCRF decides if new QoS authorization (bandwidth, etc.) is needed due to a mid-call media or codec change. The PCRF re-authorizes QoS resources when the resources requested by the UE for a flow exceeds previous authorization, or a new flow is added, or when elements of the packet classifier(s) for authorized flows change.</p> <p>f4: The PCRF provides the policy decision information to the GGSN via the Gx interface.</p> <p>f5: The PCRF provides gating control decisions controlling the gate for the authorized media stream. At AF session release, the PCRF revokes the QoS resource authorization for the AF session. The Application Function (AF) is an element offering applications that require the control of IP bearer resources (e.g. UMTS PS domain/GPRS domain resources). One example of an Application Function is the P-CSCF in the IMS architecture.</p>
TNT Gateway (vertical market players)	<p>f1: Per vertical/user-based packet filtering (by e.g. deep packet inspection);</p> <p>f2: Lawful Interception;</p> <p>f3: Verticals IP address allocation;</p>

TABLE II

CONTROL/DATA MESSAGE FLOW BETWEEN LTE ENTITIES

Entities	UE		Serving GW		PDN GW		MME		TGW	
	Da ta	Con trol	Da ta	Con trol	Da ta	Con trol	Da ta	Con trol	Da ta	Con trol
Serv ing GW		✓				✓		✓		
PDN GW			✓	✓					✓	✓
MM E		✓		✓						
HSS								✓		
PCR F					✓					
eNB	✓	✓	✓					✓		

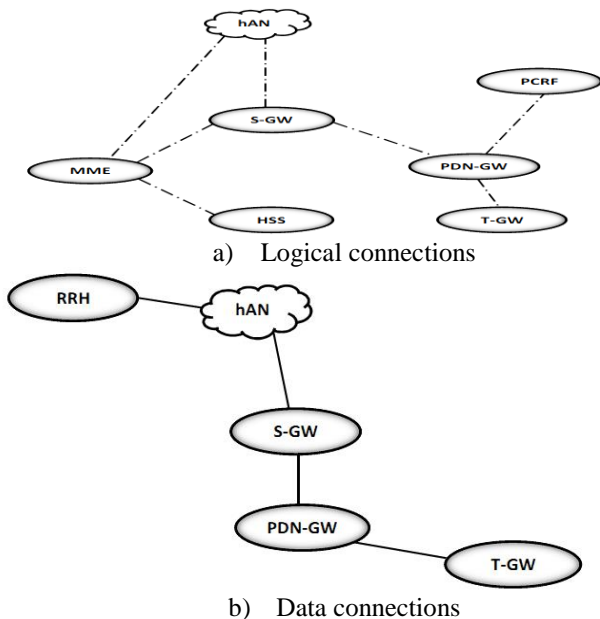


Fig. 3 Logical / Data connections in 5G EPS

Ellipses show Virtual Network Functions (VNF) and the lines between them show logical connections through which control/data messages pass. Then we demonstrate the network configurations in a small and large scale network.

Fig. 4 depicts the proposed view of 5G EPS virtualization in a small scale network which is based on a carrier-grade hypervisor and only one intelligent core server (IC server). Carrier grade hypervisor is a component that is extremely reliable, well tested and proven in its capabilities and the Intelligent Core –Server (IC-Server) is an advanced commercial-off-the-shelf (COTS) hardware platform for software solutions.

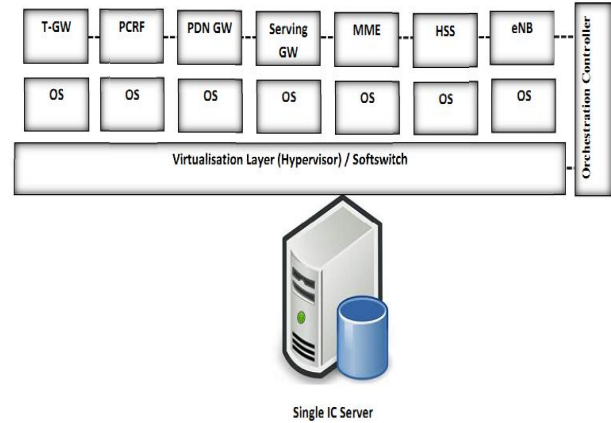


Fig. 4 Virtualization of 5G EPS by a server

To present our architecture we provide to Figs. 5 and 6. Fig. 5 depicts the proposed view of the control plane for 5G EPS virtualization in a large-scale network by a carrier grade hypervisor and a pool of intelligent core servers (IC servers). Fig. 6 depicts the proposed view of a data plane of 5G EPS virtualization in a large-scale network by a carrier grade hypervisor and a pool of servers.

We may use dynamic scheduler module to allocate functions from VNFs in Figs. 5 and 6. Besides, Orchestration controller is responsible for management and maintenance of virtual nodes.

Virtual functions eNB, MME, PCRF, etc. nodes in Figs.5 and 6 are located on top of the hypervisor and provided from Table 1 EPS functions and are made out of IC-server pools.

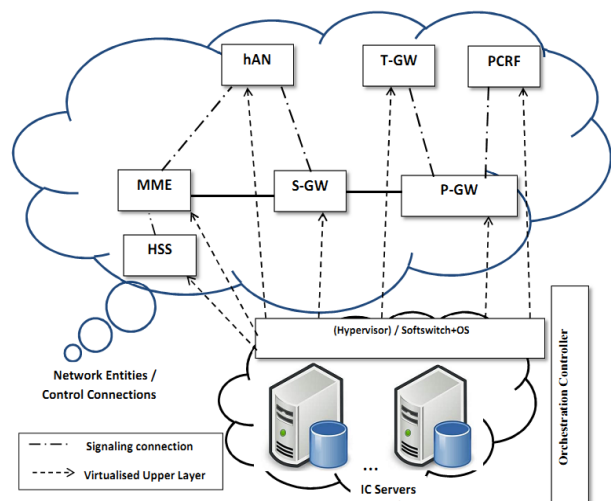


Fig. 5 Control plane virtualization of 5G EPS by a pool of IC servers

The hypervisor has embodied the hardware resources somehow that all of them are recruited optimally which results in cost saving in hardware resources. On the other hand, since all the above nodes are constituted of a unified infrastructure, data exchanges more easily among them. This provides more efficiency in the system throughput. In addition node accessibility is easier in this integrated system which provides service more easily for the users.

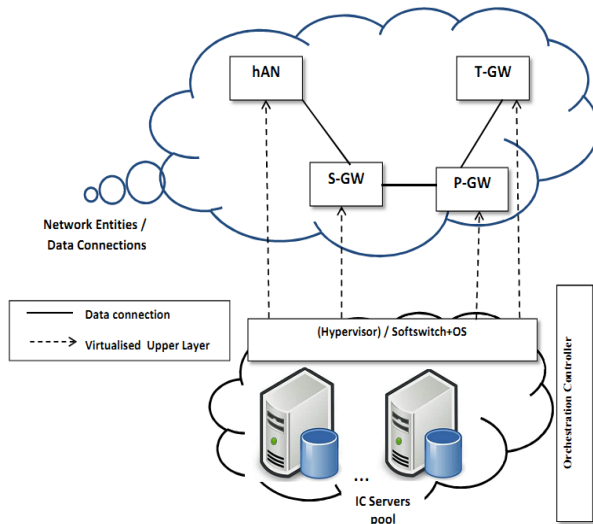


Fig. 6 Data plane virtualization of 5G EPS by a pool of IC servers

IV. CONCLUSION

We defined network entities and functions and new hAN and TGW functionalities in the existing access and core network respectively to upgrade the network to 5G capabilities. We used carrier grade hypervisor and an intelligent core server (IC server) to provide enough processing power and flexibility to the network to improve the QoS network parameters such as delay reduction and increasing the throughput. Besides, each of the functions f1, f2, etc. may be invoked according to the user's service request to provide enough flexibility.

REFERENCES

- [1] DadkhahChimeh, J., "5G Mobile Communications: A mandatory wireless infrastructure for Big data", International Journal of Advancements in Communication Technologies– IJACT, 2015.
- [2] DadkhahChimeh, J., "5G Mobile Communications: A mandatory wireless infrastructure for Big data", International Journal of Advancements in Communication Technologies– IJACT, 2015.
- [3] Korhonen, Juha, "Introduction to 3G Mobile Communications, second Edition," Artech House, 2003.
- [4] 3GPP TS 24.301 Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3.
- [5] Patrick Kwadwo et al., Design Considerations for a 5G Network Architecture, IEEE Communications Magazine, November 2014.
- [6] ETSI TS 123 401 V12.10.0 (2015-10), Radio Access Network (E-UTRAN).
- [7] Gupta, A., Kumar Jha, R., A Survey of 5G Network: Architecture and Emerging Technologies, IEEE Access (Volume 3), July 2015, pp. 1206-1232.
- [8] ETSI GS NFV 002 V1.2.1 (2014-12), Network Functions Virtualisation (NFV); Architectural Framework
- [9] ETSI GS NFV-EVE 005 V1.1.1 (2015-12), Report on SDN Usage in NFV Architectural Framework.

- [10] Guerzoni, R. et al., "SDN-Based Architecture and Procedures for 5G Networks", 2014 1st International Conference on 5G for Ubiquitous Connectivity (5GU), 2014.
- [11] Rost, P. et al., Mobile Network Architecture Evolution toward 5G, IEEE Communications Magazine, Vol. 54, Issue 5, May 2016, pp. 84-91.
- [12] Banch, A. et al., "A Novel Radio Multiservice adaptive network Architecture for 5G networks", 2015 IEEE 81st Vehicular Technology Conference (VTC Spring).
- [13] Monteleone, G. et al., "Session Border Controller virtualization towards service-defined networks based on NFV and SDN, 2013 IEEE SDN for Future Networks and Services", (SDN4FNS), 2013.
- [14] ETSI TS 123 207 V13.0.0 (2016-1), End-to-end Quality of Service (QoS) concept and architecture.
- [15] ETSI TS 123 203, V12.10.0 (2015-10), Policy and charging control architecture.
- [16] ETSI GS NFV 001 V1.1.1 (2013-10), Network Functions Virtualisation (NFV); Use Cases.