Unified Control Architecture for 5G Convergence Network

Jeounglak Ha, Noik Park
Network Research Division
Electronics and Telecommunications Research Institute
Daejeon, Republic of Korea
e-mail: jlha@etri.re.kr

***Abstract*—Future data traffic is expected to be tremendously increased. The huge traffic is necessary to be supported by various types of access networks rather than a single type of access network. The 5G network assumes fixed wireline and WiFi as access technologies as well as a new 5G Radio Access Technology (RAT). In this paper, we discuss a unified control architecture to provide access control and session control using a common signaling scheme in 5G. The proposed unified control minimizes access network dependency. The discussion of access control and session control reveals our study on their functionalities. Although the proposed architecture is not fully comply with 3GPP developing standard, our study on access control and session control reveals their functionalities.**

Keywords-5G mobile network; convergence; core network; access control; session control

I. INTRODUCTION

ITU-R estimates global IMT traffic will grow in the range of 10-100 times from 2020 to 2030. It also expects IMT-2020, which is ITU term for 5G, is to support three different sort of services: enhanced mobile broadband, ultra-reliable and low latency communications, and massive machine type communications. [1] The three types of services may not be supported by a single access network. 5G network will support various access networks including 5G new RAT, fixed wireline and WiFi. [2], [3]

We studied a unified control architecture to support various access networks in order to provide consistent control signaling in 5G convergence network. Regardless the access network the user is using, 5G convergence network provides consistent access control and session control signaling and further almost same experience to the user.

We designed a common signaling architecture and separated session control from access control to minimize access network dependency in 5G convergence network. Common signaling framework is implemented in control plane (CP) which is separated from user plane (UP) and a single authentication framework and network resource is reused among access through different access network from a single user. Separation of session control from access control will lead to flexible composition of various future services. Differing from the network connection service of today, some of future service will not establish an explicit session but send its data in a signaling message.

This paper is organized as follows. The next section discusses converged network architecture. Section III and IV discusses access control and session control respectively. Finally, conclusion is given in the last section.

II. CONVERGED 5G CORE NETWORK

A. CP/UP Separation

Fig. 1 shows CP and UP interfaces in 4G LTE in which S-GW and P-GW has both control function and traffic function. It leads to inefficient management of S-GW and P-GW due to aggregated functionalities of CP/UP. In order to resolve such problem [4], [5] are trying to separate CP function (CPF) and UP function in S-GW and P-GW.

5G advocates clear separation of CP/UP than 4G. Fig. 2 shows disaggregation of CPF and UPF. We separated access control and session control to control user access and session control in a common way regardless of wired and wireless access technology. Separated CPF and UPF can be placed and managed flexibly. We, for example, can put UPF at the edge of 5G network and CPF at the central cloud.

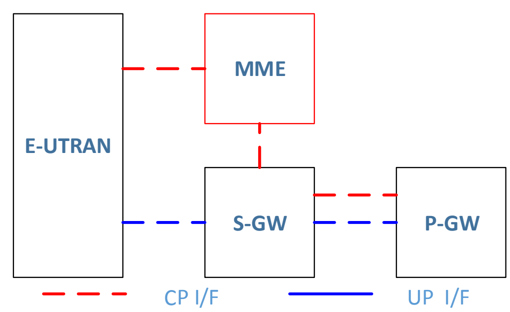

Figure 1. CP and UP interfaces in 4G LTE.

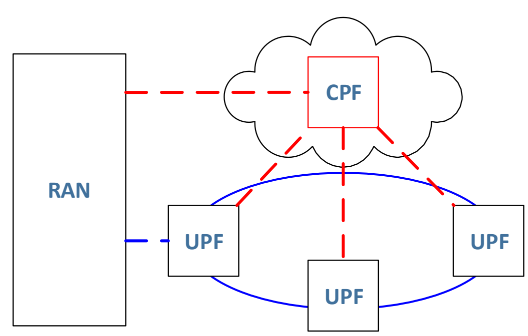

Figure 2. CP/UP separation in 5G.

B. *5G Convergence Network*

3GPP SA2 working group is drafting 5G network architecture. Fig. 3 is a very simplified reference architecture from 3GPP TS23.501. [6] Access and mobility management function (AMF) and session management function (SMF) are key functions of CP. AMF controls access and mobility and SMF controls user data session.

Fig. 4 shows an exemplary 5G convergence network architecture with which we are prototyping 5G network service. [7] With 4G network architecture all user traffic is passed PGW and it leads to inefficient use of network resources. 5G network, however can be deployed in distributed architecture. Converged gateways (CGWs) are UPFs that can be located at the edge of networks. CPFs are mapped into unified control entity (UCE). AMF and SMF are prototyped by UCE. The UCE located at the edge of network is named as eUCE and UCE is located at the center of network.

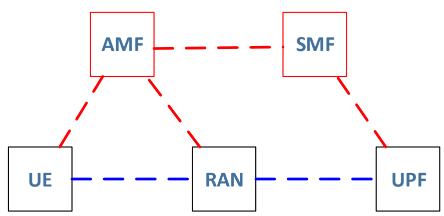

Figure 3. Simplified 5G reference architecture.

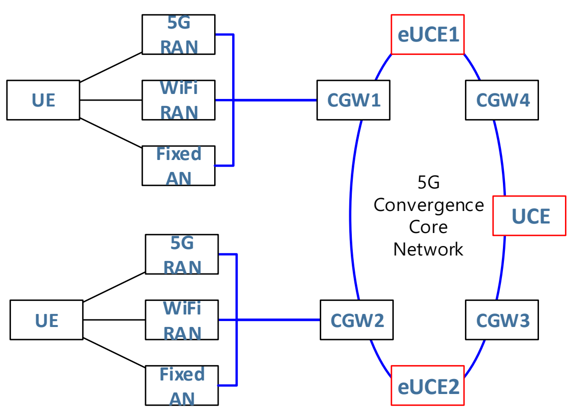

Figure 4. 5G convergence network architecture.

In order to minimize delay and manage hierarchical mobility efficiently, eUCE (edge UCE) distributes major control functions on the network edge, and UCE handles coordination and integration of control functions between eUCEs. UCE performs, through signal interworking with eUCEs, inter-CGW mobility management function and Inter-CGW path optimization control function while eUCE performs CGW selection function and Intra-CGW mobility management function. The CGW is placed on the edge to distribute large-scale traffic of 5G in the network effectively, and to accommodate various access networks. The wired / wireless access network (5G-RAN, WiFi-RAN, Fixed-AN) has a connection interface to the terminal and has a control interface with the eUCE and a traffic transmission interface with the CGW. The terminal may have various wired / wireless connection interfaces together with 5G wireless connection interface.

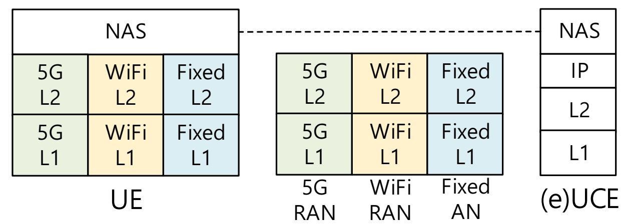

Figure 5. NAS protocol stack in 5G convergence network.

Fig. 5 shows protocol stack for 5G Non access stratum (NAS). In contrast with our previous study in [8], NAS signal can be transported through each access network. NAS conveys control signal between user equipment (UE) and AMF and SMF. NAS protocol of an access technology controls access and session on the access technology.

III. Access Control

This function is designed to allow connection control through a consistent signaling method for connection through different access networks. Even though the access networks are different, they have the same signaling procedure, so that the access services via various access networks can be served by the same framework. In addition, by separating access control and session control, we are able to adapt flexibly to various types of new services that will appear in the future. The development scope of access control function provides the following functions for service requests through multiple access technologies UE.

- User context management
- IP address allocation
- Authentication and security management
- attach procedure management
- detach procedure management

Fig. 6 shows diagram of access control. Access manager (AM) receives request from UE through AN and processes the access control function. AM retrieves user profile from home subscriber server (HSS) and updates UE's location on HSS. AM routes session related request from UE to SM.

A. *User Context Management*

AM has various context information related to the user in the eUCE to manage the information of the connected user. In response to the user's access request, AM retrieves information related to the user from the HSS and creates and manages the context information based on the information. First, we defined a data schema for User context. It can store 5G/WiFi/Fixed RAT-specific authentication vector information, 5G/WiFi/Fixed connection status information for each RAT, 5G/WiFi/Fixed connected base station information and CGW information. In particular, a GUTI

(Global Unique Temporary Identification) and an IP address are dynamically assigned to a user and they are used by the UE regardless of access technology.

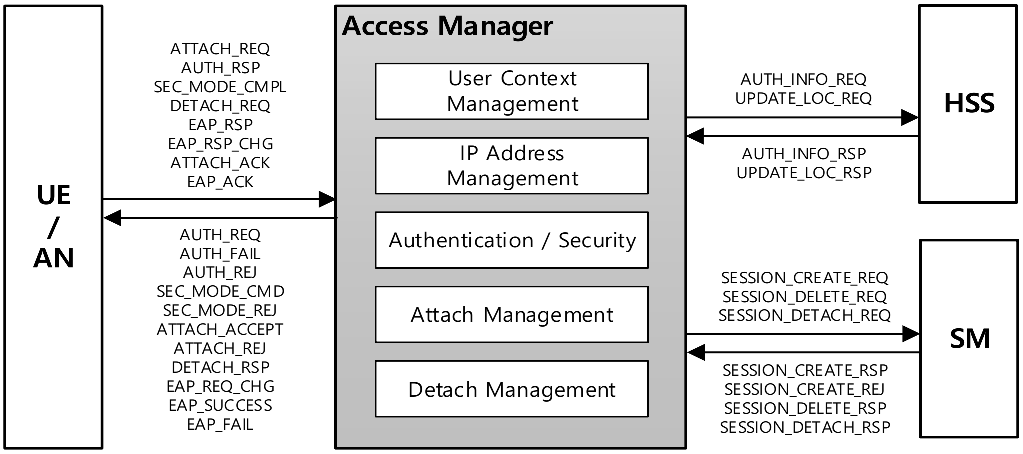

Figure 6. Access control.

B. *IP Address Management*

AM assigns a new IP address to be used by the UE to the user for which the user authentication has been successfully performed. The IP address is allocated from the IP address pool of the CGW accessed by the user. The IP address pool of CGW can assign classless IP by using Network ID and NetMask. In order to support connection through WiFi and Fixed access network, IP address assigned to WiFi and Fixed access point is connected to CGW IP address pool. When the user's connection is terminated, the user's IP address is returned.

C. *Authentication Management*

AM verifies the qualification and authority of the user's access. It is designed the signaling and system structure can accommodate the necessary algorithms and parameters. We design a function to assign GUTI to a successfully authenticated user and a EAP authentication function for WiFi and Fixed connection associated with 5G connection. Access control at the data link layer, which is directly affected by access technology, uses Extensible Authentication Protocol (EAP) technology for WiFi and Fixed access. Access control of the NAS layer independent of access technology applies a common signaling.

D. *Attach Management*

The attach management allows the user to perform connection setup procedure. It includes encoding / decoding function of messages for connection request, HSS connection function, and EAP message encoding / decoding function for WiFi/Fixed connection. The messages for the connection request are designed with reference to the signals in 4G LTE and are used to complete the attach procedure. The HSS connection was designed to complete the user profile and authentication vector acquisition and user location update procedures needed to complete the Attach procedure.

E. *Detach Management*

The detach management allows the user to perform all connection release procedure. It includes a message encoding / decoding function for detaching accesses, a session detach request function according to detachment. The messages for 5G connection detach was designed with reference to 4G LTE signals.

F. *Transaction Management*

The transaction management function is for processing the NAS messages. It includes management of transactions between AM and SM or HSS, and deletion of transactions when a response is not received within a specified time. The transaction queue and the timer queue are managed by cross-referencing at each other.

IV. Session Control

This function is designed to enable session control through a consistent signaling method for session requests over different access networks. The same session setup and release procedure is applied regardless of access technology. It is possible to control GBR (Guaranteed Bit Rate) and non-GBR by the same signaling procedure. The development scope of this function provides the following functions for session requests through multiple access technologies UE.

- Session information management
- Session creation
- Session release
- Session detach

Fig. 7 shows diagram of session control. Session manager (SM) receives and processes requests from AM, which routes session related messages from UE. SM manages session information and sends commands to UPF so that UPF may handle user data packets properly.

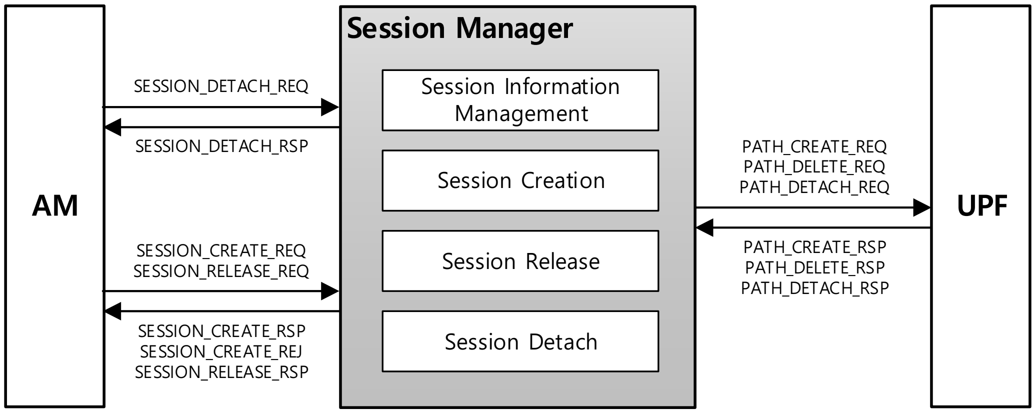

Figure 7. Session mangement.

A. Session Information Management

We defined a data schema that represents a user session information needed to manage the user's session. The session data first includes the session ID. Session IDs are defined to be unique for a user to be able to move between different access networks within a single CGW. In other words, the session ID is unique to the user, so pairing with the user information is still unique throughout the network. It is designed to have a maximum of three flows, for experimental purpose example, in one session. Each flow defines a property with a 5-tuple, and 5-tuple contains source IP address, source port, destination IP address, destination port and protocol type and each field can contain a wildcard. The flow ID is assigned to each CGW and it is unique and managed in CGW basis.

B. Session Creation

The session creation function verifies that the user has the right to use the requested session. The user profile information downloaded by the AM from the HSS includes the user's authority information. Information about how much bandwidth is available in an access network and the bandwidth available in the entire network is defined. The user can use non-GBR data within the allowed bandwidth, and the GBR bandwidth can be set for each session and each flow. In addition, the maximum number of sessions is defined for each access network that can be used for each user. The generated per-user session or per-session flow information is managed in database.

C. Session Release

The session release function deletes a session set by a user, and normally deletes a GBR session first and then deletes a non-GBR session lastly. When deleting a non-GBR session, the traffic tunnel for the user is deleted. When the session is deleted, the flows that were being served by the session are also deleted. All IDs of deleted sessions or flows are returned. Since the session ID is allocated in CGW basis, it is continuously increased, but the flow ID is allocated from 0 for each user.

D. Session Detach

The session detach function is a function that deletes all sessions in service when the user requests detach. User sessions are also managed for each access network. When the user terminates the service of a RAT, all sessions on the access network are terminated. When the session ends, the ID of the session and the flows that were being used in the session are also deleted together, and all of the assigned session ID and flow ID are also returned.

V. Conclusion

As 5G network addresses combination and integration of various access network, this paper considers a unified control architecture to control 5G, WiFi and fixed wireline access networks. In order to have access control and session control functions in a unified control framework we proposed a 5G convergence network architecture. The proposed architecture is distributed one and it separated access control from session control. This direction of research is generally the same as 3GPP SA2 standardization, but some details are not fully congruent with the standardization. A typical point is IP address allocation. This work allocates one IP address to a UE, while 3GPP allocates one per PDU session. We plan to link with standardization through continuous research.

Acknowledgment

This work was supported by Institute for Information & communications Technology Promotion (IITP) grant funded by the Korea government (MSIT) (No. B0132-17-1005, Development of Wired-Wireless Converged 5G Core Technologies).

References

[1] ITU-R, *Recommendation M.2083-0 IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond*, September 2015.

[2] 5G PPP Architecture Working Group, *View on 5G Architecture V1.0*, Jul., 2016.

[3] NGMN Alliance, *NGMN 5G White Paper*, Mar. 2015.

[4] H.-J. Einsiedler, A. Gavras, P. Sellstedt, R. Aguiar, R. Trivisonno, and D. Lavaux, “System design for 5G converged networks,” in Networks and Communications (EuCNC), 2015 European Conference on, pp. 391– 396, June 2015.

[5] 3GPP TS23.214, “Architecture enhancements for control and user plane separation of EPC nodes”, Mar. 2017.

[6] 3GPP TS23.501, “System Architecture for the 5G system”, Mar. 2017.

[7] J. Ha and N. Park, “Connection Management and Session Management in 5G Convergence Network,” The 27th Joint Conference on Communications and Information, Apr. 2017.

[8] J. Ha and N. Park, “5G Convergence Network Access Signaling with DHCP,” The 26th Joint Conference on Communications and Information, Apr. 2016.