Technology Reports | 5G | Core Network | Network Slicing

Special Articles on 5G Standardization Trends Toward 2020

5G Core Network Standardization Trends

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Aiming for an early deployment of the fifth-generation mobile communications system (5G), component technologies of a core network satisfying 5G requirements are being actively studied in 3GPP SA. A basic study was completed in December 2016 and the normative work based on the results of that study was begun in January 2017 toward actual specifications. This article describes the component technologies of the 5G core network targeted for standardization.

1. Introduction

To meet the service requirements of the fifth-generation mobile communications system (5G), the plan at the 3rd Generation Partnership Project (3GPP) is to formulate specifications for the new core network*1 (hereinafter referred to as "5G core network") as 3GPP Release 15 by June 2018 through studies conducted in 3GPP Service and System Aspects (SA)*2. In this article, we describe the main component technologies of the 5G core network overviewed in the opening article of this issue's Special Articles [1].

2. 5G Core Network Technology Overview

2.1 Division of Functions among Terminal, RAN, and Core Network

In 5G, the system configuration divided into

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*1 Core network: A network consisting of switches and subscriber-information management equipment. Mobile terminals communicate with the core network via the radio access network.

*2 SA: A 3GPP group that formulates specifications in relation to service requirements, architecture, security, coding, and network management.

terminal, Radio Access Network (RAN)*3 and core network and the division of functions among those components are the same as before, but the node configuration within the core network has changed. The core network architecture in 5G is shown in **Figure 1**.

To begin with, the U-plane*4 function, or User Plane Function (UPF), is clearly separated from the C-plane*5 function group. This scheme reflects the concept of C/U separation studied under the item name of Control and User Plane Separation (CUPS) as an enhancement of Evolved Packet Core (EPC)*6.

1) Features of UPF

The UPF in the 5G core network provides functions specific to U-plane processing the same as Serving GateWay (S-GW)-U*7 and Packet data network GateWay (P-GW)-U*8 in CUPS.

2) Features of C-plane Function Group

(1) AMF and SMF separation

The C-plane function group reorganizes the division of functions among the Mobility Management Entity (MME)*9, S-GW-C*10, and P-GW-C*11 in EPC and clearly divides the Access and Mobility management Function (AMF) and Session Management Function (SMF), which, as the names imply, govern mobility management and session*12 management, respectively. In the 5G core network, the idea is to perform terminal-related

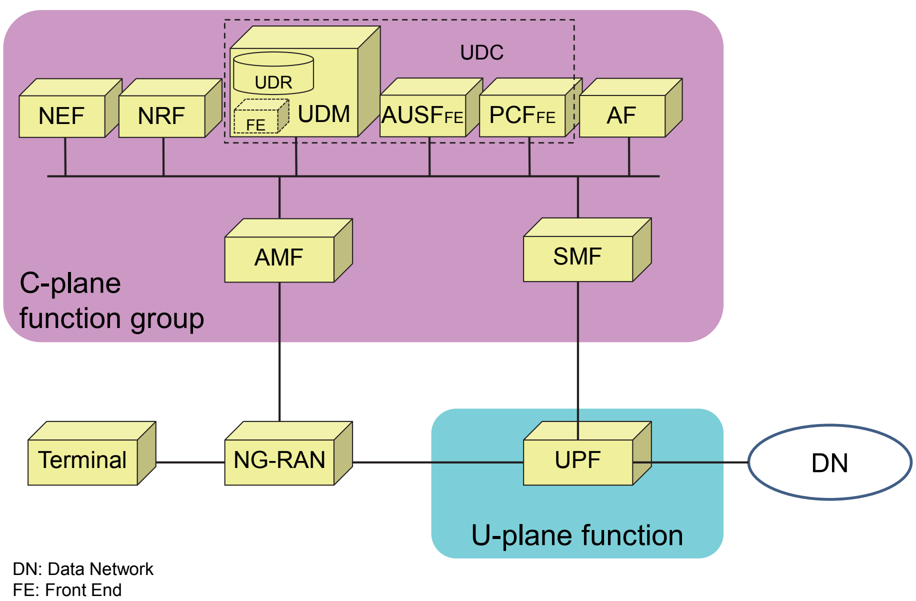

Figure 1 Core network architecture in 5G

*3 RAN: The network consisting of radio base stations and radio-circuit control equipment situated between the core network and mobile terminals.

*4 U-plane: User plane. Refers to transmission and reception of user data.

*5 C-plane: Control plane. Refers to the series of control processes and exchanges involved in establishing communication and other tasks.

*6 EPC: An IP-based core network standardized by 3GPP for LTE and other access technologies.

*7 S-GW-U: An area packet gateway accommodating the 3GPP access system providing functions specific to U-plane processing.

*8 P-GW-U: A gateway acting as a connection point to a PDN (see *25); it allocates IP addresses and transports packets to the S-GW providing functions specific to U-plane processing.

*9 MME: A logical node accommodating a base station (eNodeB) and providing mobility management and other functions.

management at one location and to handle traffic on multiple network slices*13. As a consequence, having a node that performs some session management in addition to mobility management as in MME in conventional EPC is inconvenient. These functions have therefore been reallocated in AMF and SMF so that mobility management can be performed in a centralized manner and session management can be located in each network slice.

(2) Specification of new nodes

Unified Data Management (UDM), which is analogous to the Home Subscriber Server (HSS)*14 in EPC architecture, introduces the concept of User Data Convergence (UDC) that separates the User Data Repository (UDR) storing and managing subscriber information from the front end processing subscriber information. The front-end section also includes new specifications for an Authentication Server Function (AUSF) dedicated to authentication processing and a Policy Control Function (PCF) corresponding to the Policy and Charging Rule control Function (PCRF)*15 in EPC. A Network Exposure Function (NEF) having a function similar to the Service Capability Exposure Function (SCEF)*16 in EPC and an Application Function (AF) fulfilling the role of an application server have also been specified.

Furthermore, while not shown in the above figure, consideration is being given to providing connection to an Access Network (AN) other than Next Generation (NG)-RAN*17 with the aim of accommodating diverse forms of access.

2.2 Service-based Architecture

In 5G core network architecture, service-based architecture is adopted as a method for achieving 5G when the focus is on inter-node linking (**Figure 2**). This architecture defines Network Functions (NFs) as functions required by the network in the manner of AMF and SMF described above. Connections among these NFs are made via a uniform interface called a service-based interface. In addition, an individual NF consists of smaller unit functions called NF services, and an NF service in a certain NF can directly access an NF service in another NF without having to pass through another node. A Network Repository Function (NRF) providing a discovery function for NF services is also specified in service-based architecture.

Specific protocols for the service-based interface are now under study, but discussions are being held on using HyperText Transfer Protocol (HTTP)*18–based RESTful*19 and JavaScript Object Notation (JSON)*20 above that. The plan is to unify the linking of network functions through a common protocol. It also appears that the General Packet Radio Service Tunneling Protocol (GTP)-C*21 used as the C-plane protocol in EPC will not be adopted.

2.3 Enhanced Support for Virtualization

The 5G core network assumes the use of virtualization, the purpose of which is to separate hard-

*10 S-GW-C: An area packet gateway accommodating the 3GPP access system providing functions specific to C-plane processing.

*11 P-GW-C: A gateway acting as a connection point to a PDN; it allocates IP addresses and transports packets to the S-GW providing functions specific to C-plane processing.

*12 Session: A virtual communication path for transmitting data or the transmission of data itself.

*13 Network slice: One format for achieving next-generation networks in the 5G era. Architecture that optimally divides the core network in units of services corresponding to use cases, business models, etc.

*14 HSS: The subscription information database in 3GPP mobile communication networks. Manages authentication and location information.

*15 PCRF: A logical node for controlling user data QoS and charging.

*16 SCEF: A logical node installed in a 3GPP mobile network having a standard interface for providing a number of 3GPP services to third-party application providers.

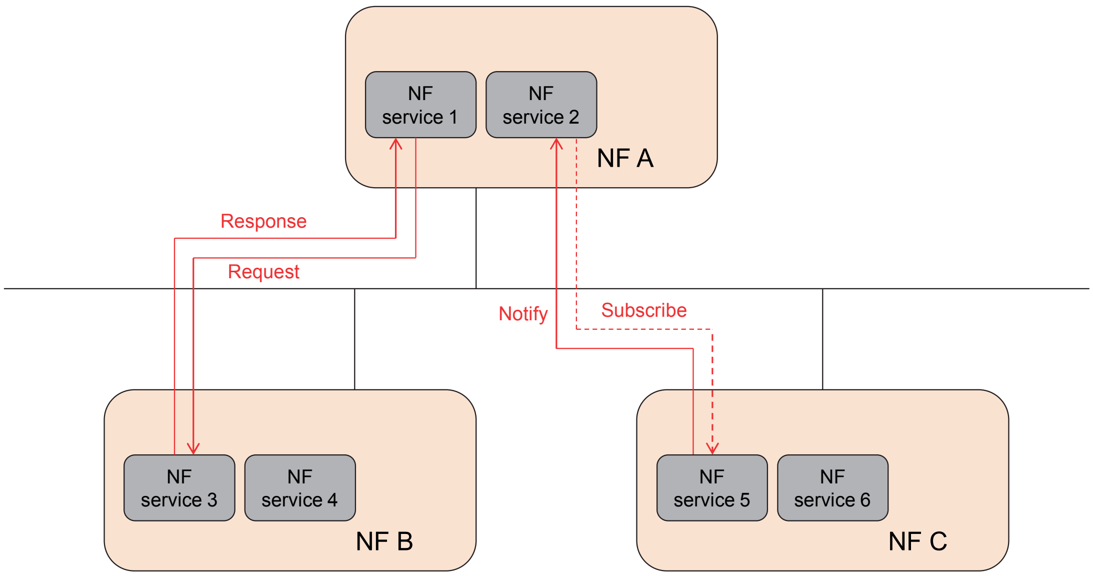

Figure 2 Service-based architecture

ware and software. The various types of identifiers used in 5G architecture take on a configuration that presumes virtualization. In addition, each function such as AMF can separate terminal context information and call processing.

2.4 Network Slices and Simultaneous Connection to Session-related Nodes

In EPC, a single terminal connects to only one S-GW, but in 5G, a single terminal can simultaneously connect to multiple sets of SMF/UPF. In more detail, UPFs are divided among different types of services to efficiently accommodate traffic having different performance requirements. **Figure 3** shows the case of a terminal simultaneously connecting to a network slice accommodating ordinary voice and packet services and a network slice accommodating low-latency services. In this configuration, multiple sets of SMF/UPF each belong to a different network slice while NG-RAN and functions like AMF are shared in common. The network slice for low-latency services places the UPF at a location geographically near radio access. In this case, multiple SMFs are not necessarily needed, but taking as an example the case of providing a low-latency service to a specific enterprise, it

*17 NG-RAN: A RAN connecting to the 5G core network using NR or E-UTRA as radio access technology.

*18 HTTP: A communications protocol used between Web browsers and Web servers to send and receive HyperText Markup Language (HTML) and other content.

*19 RESTful: The idea of obtaining/providing information by directly pointing to the information to be provided in a stateless manner.

*20 JSON: A data description language based on object notation in JavaScript®. Oracle and Java are registered trademarks of Oracle Corporation and its subsidiaries and affiliates in the United States and other countries.

*21 GTP-C: A communication protocol that establishes communication paths within the core network for transferring user data.

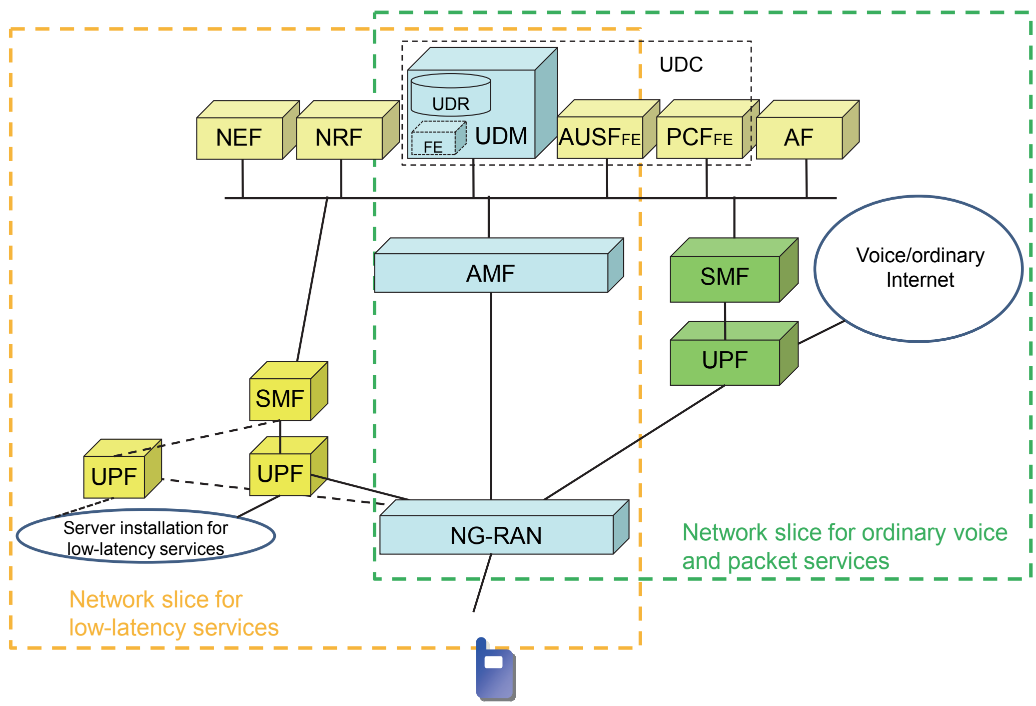

Figure 3 Simultaneous connection to session-related nodes

would be desirable to use a separate SMF to avoid outside effects such as congestion in other services. It may also be desirable to separate SMFs for geographical reasons associated with the distributed arrangement of UPFs.

2.5 Mobile Management and Session Control Procedures

A variety of processing procedures have been reassessed for the 5G core network. The following describes some of these procedures focusing on mobility management and session management.

(1) The attach*22 procedure without session management adopted in Cellular IoT (CIoT) technology in EPC has also been adopted in the 5G core network. Labeled as a registration management procedure, it is also used for periodic location registration and location registration due to movement.

(2) With the aim of accommodating diverse forms of access, session management excludes the concept of a bearer*23 unique to the mobile

*22 Attach: The process of registering a mobile terminal to a network when the terminal's power is turned on, etc.

*23 Bearer: A logical user-data packet transmission path established among P-GW, S-GW, eNodeB, and UE.

communications network in the interface between RAN and the core network and within the core network. The SMF, together with the terminal and NG-RAN, controls the setting/releasing of a Protocol Data Unit (PDU)*24 session corresponding to a Packet Data Network (PDN)*25 connection in EPC.

(3) The AMF and SMF functions operate in a coordinated manner with respect to the handover*26 procedure. For example, switching of the tunnel termination point between NG-RAN and UPF is performed between the NG-RAN and SMF while the provision of handover restrictions to NG-RAN for each RAT is performed by the AMF. At the time of a handover, NG-RAN sends a signal to AMF to switch the communications route.

(4) In EPC, MME obtains all subscriber information from HSS, but in the 5G core, AMF or SMF obtains subscriber information from UDM depending on the type of information needed. Specifically, AMF and SMF obtain information related to mobility management and session management, respectively, from UDM.

(5) As described above, a single terminal can simultaneously connect to multiple sets of SMF/UPF. In this regard, the procedure for returning the connection between the NG-RAN and UPF from a preservation*27 state can do so only for a PDU session that desires that return. Handover can also be performed for each PDU session.

(6) Taking into account the deployment of UPFs corresponding to P-GW-Us in EPC at the network edge, a procedure for switching connections between UPFs by the make before break*28 technique has been provided.

3. Conclusion

This article described the main component technologies of the 5G core network. With the aim of standardizing these component technologies in Release 15 specifications, 3GPP SA and 3GPP Core network and Terminals (CT)*29, which performs detailed protocol studies, are preparing the Technical Reports (TRs) and Technical Specifications (TSs) listed in **Table 1**. As an active promoter of 5G core network standardization at 3GPP, NTT DOCOMO

Table 1 List of architecture/protocol-related documents

	Document name	Completion period
Architecture technical report	TR 23.799	Completed December 2016
Architecture specifications	TS 23.501	September 2017
	TS 23.502	December 2017
Protocol technical report	TR 24.890, TR 29.890, TR 29.891, TR 31.890	December 2017
Protocol specifications	(To be prepared later)	June 2018 target

*24 PDU: A unit of data processed by a protocol layer/sublayer.

*25 PDN: An external network to which the EPC is connected.

*26 Handover: A technology for switching base stations without interrupting a call in progress when a terminal straddles two base stations while moving.

*27 Preservation: The state in which the bearer is preserved between the P-GW and S-GW but released between the S-GW and eNodeB.

*28 Make before break: A method of switching paths by establishing a new path before deleting the old path.

*29 CT: A 3GPP group that specifies protocols for use within the core network or between mobile terminals and the core network.

plans to contribute to the further development of the 5G core network going forward.

REFERENCE

[1] A. Minokuchi et al.: "5G Standardization Trends at 3GPP," NTT DOCOMO Technical Journal, Vol.19, No.3, pp.5–12, Jan. 2018.