Evolved Packet Core (EPC) Network Equipment for Long Term Evolution (LTE)

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Long Term Evolution/Evolved Packet Core (LTE/EPC) is a system that will follow on from the 3G mobile system and mobile operators around the world are planning to use it. Indeed, some operators have already started services with this latest technology. Fujitsu has been developing ESPGW, which is a gateway for LTE/EPC, together with Nokia Siemens Networks, and NTT DOCOMO has adopted it. LTE/EPC is standardized by 3GPP, and the maximum theoretical speed for radio is defined as 325.1 Mb/s for downlink and 86.4 Mb/s for uplink. Therefore EPC gateways have come to need a high throughput ability to handle such heavy LTE traffic. Based on Advanced TCA, Fujitsu's ESPGW offers high availability, reliability, scalability, high throughput, a large amount of bearers and many 3GPP-standardized features. In particular, ESPGW has high throughput performance to make good use of the LTE high capacity radio transmission, and thus meets the high performance requirements of large mobile operators.

1. Introduction

As smartphones have become widespread in recent years, the amount of packet traffic generated by mobile phones is dramatically increasing. Unlike the existing feature phones, smartphones allow the use of applications created by users. Many applications make use of networks to provide functions, which further increases the amount of packet traffic in mobile phone networks. Long Term Evolution/Evolved Packet Core (LTE/EPC) is a technology capable of transmitting such packet data more efficiently than the existing 3G systems. In addition, its characteristic low latency in data transmission allows voice calls via conventional circuit switching (CS) to be realized by packet switching (PS). For these reasons, LTE/EPC has become a global standard technology adopted by many mobile operators around the world. LTE is a wireless technology for access networks and EPC refers to a core network architecture that aggregates access networks including LTE and the existing 2G/3G.

Along with the introduction of LTE, EPC has been adopted as a new architecture in place of the packet core network equipment for the existing 2G/3G general packet radio services (GPRSs). In this way, the high efficiency and low latency of LTE can be fully utilized.

Fujitsu has developed ESPGW, which is a gateway for LTE/EPC, in cooperation with Nokia Siemens Networks, one of the global market leaders in this field, and NTT DOCOMO has adopted it. This paper presents an outline of the EPC and the features of Fujitsu's ESPGW.

2. Outline of EPC

The EPC is an IP-based core network system standardized in Release 8 of the 3GPP.[1),2)] The EPC is premised on an always-on connection, or constant network connection. It integrates networks combining synchronous transfer mode/asynchronous transfer mode/ Internet protocol (STM/ATM/IP) in the existing

3G systems. Hence, it can construct all networks by an IP-based structure for simplification. This makes it possible for operators to efficiently offer various services including voice calls (Voice over IP: VoIP) based on the IP multimedia subsystem (IMS) on the core network. In addition, this enables simultaneous connection to more than one packet network, which allows packet communications via an Internet connection while making a voice call based on IMS.

Regarding access networks, handover from the existing 2G/3G access networks and networks other than 3GPP systems such as WiFi and CDMA2000 is also possible. **Figure 1** shows an EPC network architecture with related nodes.

In summary, the characteristics of EPC are as follows:

1) Global standard established by the 3GPP
2) Always-on connection
3) Voice calls provided by packet-based VoIP
4) Linkage with non-3GPP networks

The following describes the nodes that constitute the EPC together with their main functions.

The components of EPC include the Mobility Management Entity (MME), Serving Gateway (S-GW), Packet data network Gateway (P-GW) and Policy and Charging Rules Function (PCRF). The main functions of the respective nodes are explained below.

1) MME

Responsible for the establishment and release of a bearer, which is a connection between a user and packet network, mobility control such as location registration and handover and terminal authentication in cooperation with home subscriber server (HSS).

2) S-GW

Provides an anchor point for wireless base station eNodeBs or 3GPP access networks such as 2G/3G and relays user packet data to/from P-GW. For roaming, the S-GW and P-GW provide boundaries between operators.

3) P-GW

Provides Internet service providers (ISPs) with a connection point to packet networks. It is equipped with functions including IP address assignment to terminals, user authentication in

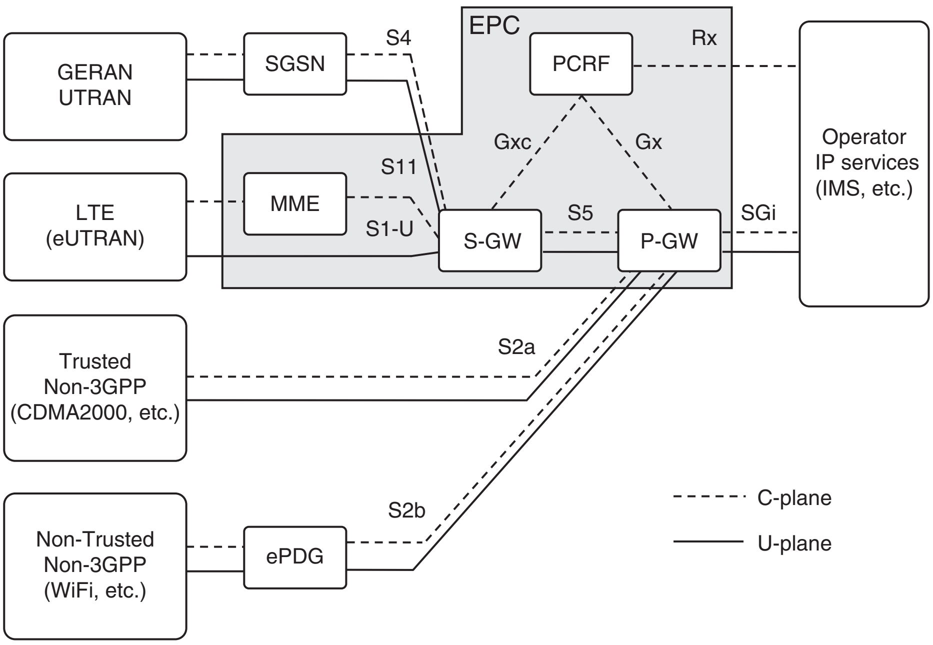

Figure 1
EPC network architecture.

relation to connection to packet networks at the time of bearer establishment, QoS control and charging data creation according to the PCRF instructions, and DHCP server functions. The P-GW is also capable of deep packet inspection (DPI), which involves packet control at the user packet IP address or application level (judgment on whether to pass or drop and charging control). For connection with non-3GPP networks, the P-GW provides a connection point.

4) PCRF

Determines the policies of QoS control and passing or destroying packets and charging method for bearers and gives instructions to the S/P-GW and access networks. For voice calls via IMS, PCRF controls the S/P-GW operation for voice bearer establishment/release in cooperation with IMS.

As the QoS standards, nine QoS class identifiers (QCIs) are defined for the EPC as shown in **Table 1**.[3] Because QoS is standardized, operators around the world can ensure a similar level of quality. Similar services are defined for more than one QCI, which is because the system allows the offering of premiums made available by high communication quality.

Table 1
QCI definitions.

QCI	Type	Priority	Delay (ms)	Loss rate	Assumed service
1	GBR	2	100	10^{-2}	Voice call
2		4	150	10^{-3}	Streaming video
3		3	50	10^{-3}	Real-time game
4		5	300	10^{-6}	Video download
5	Non-GBR	1	100	10^{-6}	IMS call control signal
6		6	300	10^{-6}	Web, e-mail, chat
7		7	100	10^{-3}	Voice, video, game
8		8	300	10^{-6}	Web, e-mail, chat
9		9			

GBR: Guaranteed bit rate

Table 2
Major specifications of ESPGW.

Hardware	Advanced TCA
Maximum number of blades	16 slots
Call processing NW IF	10GbE
Maintenance NW IF	1GbE

3. Features of ESPGW

Fujitsu's ESPGW gateway has functions of the S-GW and P-GW (**Figure 2**). This section presents the features of ESPGW.

1) High availability

As shown in **Table 2**, the hardware consists of a 16-slot blade server in accordance with Advanced TCA and each device has a redundant configuration. ESPGW can continue processing even if the hardware experiences a failure, which shows its high availability that satisfies the stringent operating conditions of large mobile operators.

2) High throughput

The maximum theoretical speed for wireless sections of LTE is defined by the 3GPP as 325.1 Mb/s for downlink and 86.4 Mb/s for uplink. Providing the maximum speed for wireless sections is estimated to take time. However, ESPGW, which processes traffic of a large number of wireless terminals, achieves

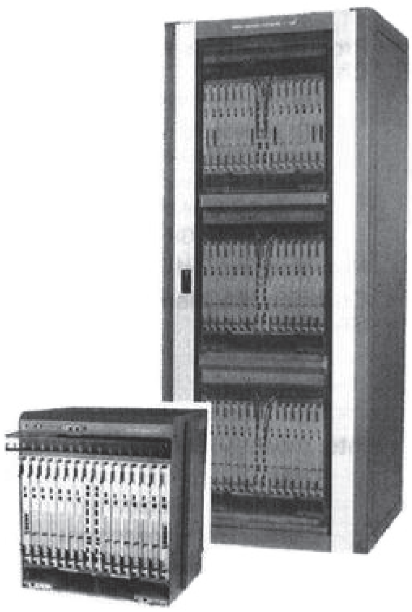

Figure 2
ESPGW (appearance).

extremely high packet transmission capacity with one node and can make the most of LTE's high-speed communications. In addition, it satisfies the high throughput conditions required of large operators and allows aggregated deployment of nodes.

3) Capacity for many bearers

The EPC is premised on an always-on bearer connection. As a usage of the bearers, concurrent constant connection of voice bearers and packet data such as the Internet is assumed and a core network essentially requires capability to accommodate a large number of bearers. ESPGW can accommodate a large amount of bearers based on the assumption of such usage.

4) Scalability

ESPGW consists of a blade server, which means that the number of blades can be flexibly changed according to the volume of traffic. It can respond to operators' facility expansion. For example, after distributed deployment is made with the minimum configuration, blades can be added according to changes in the volume of traffic.

5) Major functions supported

- Dual-stack IPv4/IPv6 EPS bearer
- Inter RAT handover (between LTE and 2G/3G)
- Multiple PDN connection
- Idle state signaling reduction (ISR)
- Direct tunnel
- PMIP-based and GTP-based S5
- Offline/online charging
- Deep packet inspection (DPI)

4. Future challenges

In Japan, commercial LTE/EPC services began with NTT DOCOMO's "Xi" (Crossy)[note)] in December 2010. In addition to the number of users, a dramatic increase is also expected in the volume of data used in the future due to smartphones. Hence, it will be essential to strengthen the traffic processing capacity of core networks. Future challenges include improving the processing capacity of a product itself as well as strengthening the capacity by facility extension. In addition, many operators plan to offer LTE/EPC services in the near future and the inter-operator roaming function will be necessary. Verification of mutual connectivity of the product is another future challenge.

note) "Xi" (Crossy) and its logo are trademarks or registered trademarks of NTT DOCOMO.

5. Conclusion

This paper has outlined the EPC and described the features of Fujitsu's ESPGW. With its high speed and low latency, LTE/EPC has the potential to revolutionize future mobile communications. It is expected not only to allow even more comfortable use of smartphones but also to bring about unprecedented, innovative uses. At present, in addition to communications by people, articles used in daily life such as consumer electronics and automobiles are equipped with mobile communication functions in the 3GPP. Therefore, always-on connectivity to networks via LTE/EPC may realize in the near future a world that was thought to be in the distant future. To bring about such a world, Fujitsu intends to continue making contributions to the development of LTE/EPC.

References

1) 3GPP TS23.401: General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access.
2) 3GPP TS23.402: Architecture enhancements for non-3GPP accesses.
3) 3GPP TS23.203: Policy and charging control architecture.

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