International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.2027

(07/2012)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Frameworks and functional architecture models

Functional architecture of multi-connection

Recommendation ITU-T Y.2027

ITU-T

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	**Y.2000–Y.2099**
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Numbering, naming and addressing	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	Y.3000–Y.3499
CLOUD COMPUTING	Y.3500–Y.3999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.2027

Functional architecture of multi-connection

Summary

Recommendation ITU-T Y.2027 describes the functional architecture of multi-connection taking into account the requirements provided in Recommendation ITU-T Y.2251 and the next generation network (NGN) functional architecture as provided in Recommendation ITU-T Y.2012.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T Y.2027	2012-07-29	13

Keywords

Access control layer, access layer, application layer, coordination, functional architecture, heterogeneous access, multi-connection, multi-connection architecture, NGN heterogeneous access, NGN, session control layer.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.2027

Functional architecture of multi-connection

1 Scope

As defined in [ITU-T Y.2251], multi-connection functionality provides capabilities to the user equipment and network to support simultaneous attachment to multiple access technologies. Furthermore, it controls and coordinates media sessions and components through multiple access technologies.

The user experience depends on the access technologies provided: high throughput, low delay, high security, etc. Multi-connection enables users to utilize either one of the available access technologies, or to utilize several at the same time. It is recognized that both operators and users will benefit from the harmonization of multiple connections, such as efficient utilization of network bandwidth, load balancing, high reliability of connection and continuity of services.

This Recommendation describes the functional architecture of multi-connection in terms of the overall functional requirements and the high-level overview of the multi-connection framework itself. The objective of this Recommendation is to develop the functional architecture, definitions and capabilities of the relative functional entities, and to describe the relationship between the multi-connection functional architecture and the NGN functional architecture [ITU-T Y.2012].

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.2012] Recommendation ITU-T Y.2012 (2010), *Functional requirements and architecture of next generation networks.*

[ITU-T Y.2251] Recommendation ITU-T Y.2251 (2011), *Multi-connection requirements*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 functional entity [ITU-T Y.2012]: An entity that comprises an indivisible set of specific functions. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.1.2 mediated services [ITU-T Y.2012]: Services that are based on intermediate service stratum facilities provided by one or more service providers.

3.1.3 multi-connection [ITU-T Y.2251]: The functionality which provides capability to the user equipment (UE) and network to maintain more than one access network connection simultaneously.

NOTE 1 – All connections are coordinated to provide service to higher layer entities.

NOTE 2 – In a multi-connection communications at least one UE is required to be a multi-connection UE.

3.1.4 non-mediated services [ITU-T Y.2012]: Services that are not based on intermediate service stratum facilities provided by any service provider.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 multi-connection user equipment (MUE): A user equipment which can support two or more network connections simultaneously under the control of a network enhanced for multi-connection capability.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

2G	Second Generation
3G	Third Generation
AAA	Authentication Authorization Accounting
AC-FE	Access Control FE
ADSL	Asymmetrical Digital Subscriber Line
AN	Access Network
AP	Access Point
API	Application Program Interface
BSS	Base Station Subsystem
CS	Circuit Switched
EPC	Evolved Packet Core
FE	Functional Entity
FTP	File Transfer Protocol
HO	Handover
IF	Interface
IMS	IP Multimedia Subsystem
IP	Internet Protocol
ISP	Internet Service Provider
LTE	Long Term Evolution
MAS-F	Multi-connection Application Support Function
MC-ARCH	Multi-connection Architecture
MC-FE	Multi-connection Coordination FE
MMF	Multi-connection Media Function
MPC-FE	Multi-connection Policy Control FE
MR-FE	Multi-connection Registration FE
MSISDN	Mobile Subscriber International ISDN / PSTN Number
MTC-FE	Multi-connection Terminal Control FE
MUE	Multi-connection UE

MUP-FE	Multi-connection User Profile FE
NGH	Next Generation Hotspot
NGN	Next Generation Network
OSI	Open System Interconnect reference model
P2P	Peer to Peer
PC	Personal Computer
PS	Packet Switched
QoE	Quality of Experience
QoS	Quality of Service
SCF	Service Control Functions
SDP	Session Description Protocol
SIP	Session Initial Protocol
SUE	Single connection UE
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
VoIP	Voice over IP
VPN	Virtual Private Network
WBA	Wireless Broadband Alliance
WFA	Wi-Fi Alliance
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network

5 Conventions

None.

6 Overview of the multi-connection architecture

6.1 General architecture

The multi-connection architecture (MC-ARCH) enhances the NGN to support the ability of multiple concurrent sessions from a single UE in a coordinated manner. In order to achieve this, NGNs and UEs require the addition of new functions.

The general architecture for multi-connection includes the following major functions, as shown in Figure 6-1:

1) Deployment of the multi-connection access technology policy and maintain information (such as traffic, usage duration, bandwidth, connection status, etc.) of the available connections for MUEs;
2) Manage connections to initiation, transfer, release and update;
3) Provide mobility related services;
4) Provide flow-based management related services;

5) Provide session continuity for applications/services;
6) Provide QoS and relevant policy control;
7) Manage multi-connection applications with proper access information statically or dynamically;
8) Support authentication, authorization and accounting (AAA) functions for multi-connection services and assist AAA related events in each access technology;
9) Support mechanisms for service composition and decomposition which allow separation of one session of the relevant service (e.g., audio/video service) into several flows and vice versa;
10) Improve application performance by utilising available access technologies.

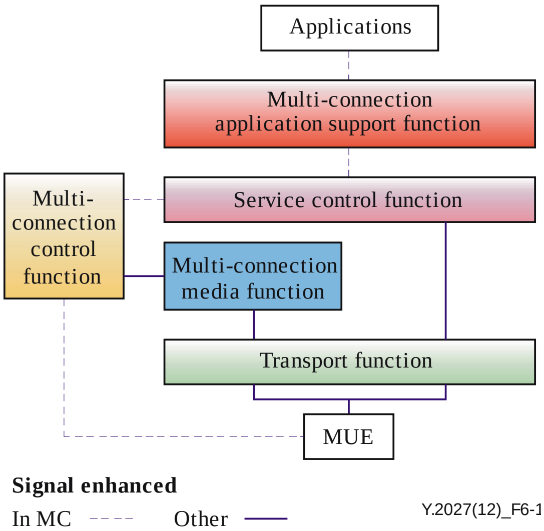

Figure 6-1 – Overview of multi-connection architecture

Figure 6-2 shows how an MUE and MC-ARCH enhanced network can align with the OSI layering. It also highlights that MC-ARCH introduces new functions in user equipment and network nodes supporting multi-connection.

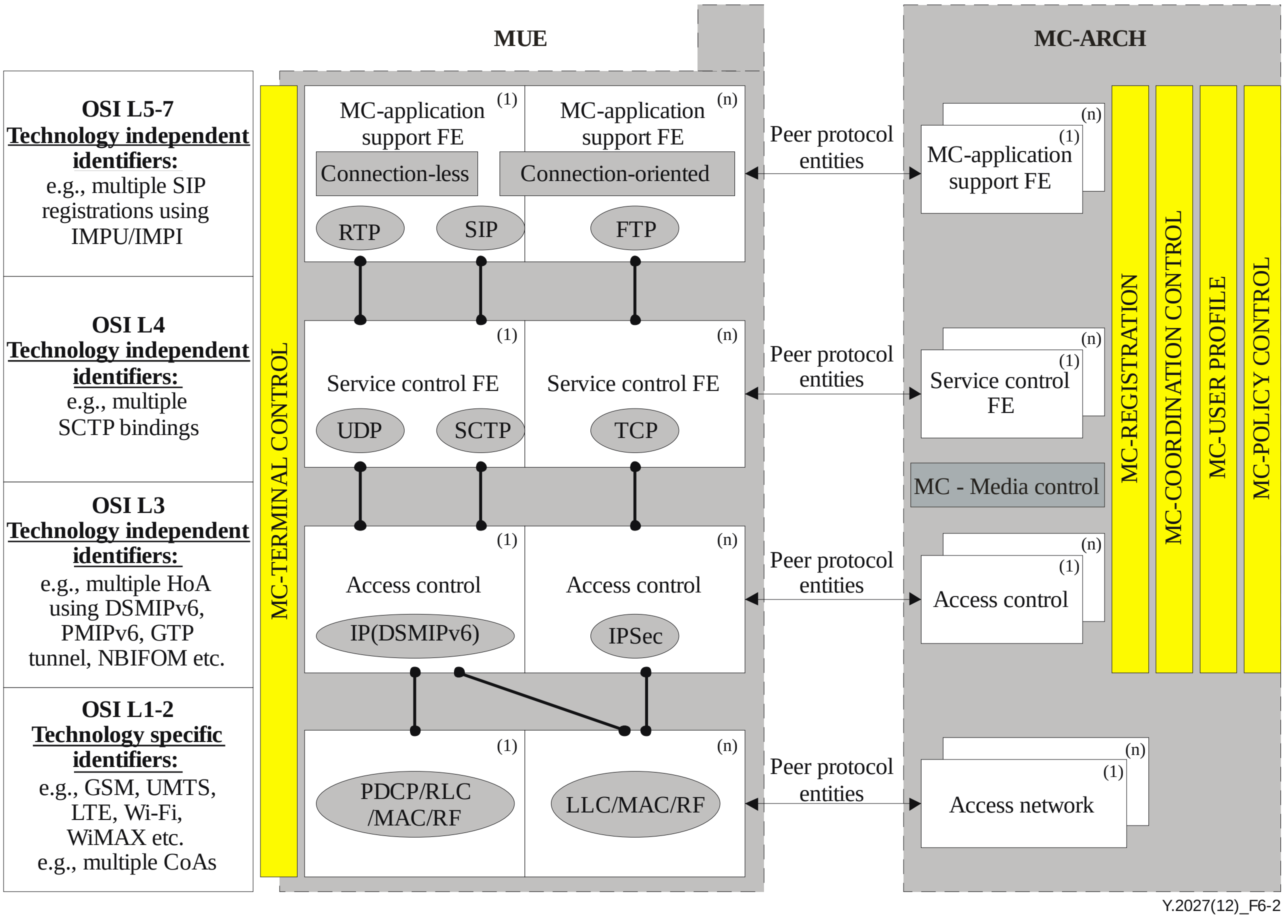

Figure 6-2 – Functional entities supporting multi-connection architecture

Figure 6-2 assumes, as an example, that the MUE has two concurrent ongoing sessions:

– The first session is a SIP based communication. In this instance, the SIP based application is enhanced for multi-connection since the service flow is decomposed between UMTS and Wi-Fi. In particular, the flow related to SIP signalling is carried over UMTS while the user plane is transported over Wi-Fi using UDP/RTP.

– The second session is a FTP session over Wi-Fi. In this case, the FTP application is not enhanced for multi-connection.

The functional entities shown in yellow, support multi-connection, both in the UE and network nodes.

Clause 6.2 provides a description of the functional groups shown in Figure 6-1 while clause 6.3 describes the functional entities used of the multi-connection architecture.

6.2 High level function descriptions

6.2.1 Transport function (TF)

The transport function provides the connectivity for all components and independent functions within NGN. The function provides support for unicast and/or multicast transfer of media, as well as the transfer of control and management signalling.

6.2.2 Multi-connection media function (MMF)

The multi-connection media function is responsible for enforcing multiple access policies including load assignment and/or QoS to meet the requirement of multi-connection service experience.

The MMF performs the following functions:

1) Identify flows and handle the mapping between a certain multi-connection service to one or more connections across heterogeneous access technologies;
2) Enforce the specific policy in each access technology according to dynamic information in such as the handover activity, network utilization, and access aggregation for multi-connection service;
3) Report dynamic traffic load information to MC-FE;
4) Maintain the mapping of resource identifiers among flow ID, access network ID, interface ID.

6.2.3 Service control function (SCF)

The service control function includes the resource control, registration, and authentication and authorization functions at the service level for both mediated and non-mediated services. It supports service initiation, release, authentication, authorization, routing of service messages, etc.

The functions of SCF are:

1) Send service control messages to appropriate MAS-F to support services and third-party applications;
2) Receive and process service control messages;
3) Provide authentication and authorization to the requested service.

6.2.4 Multi-connection application support function (MAS-F)

The multi-connection application support function provides control capability for services accessed by interacting with MUP-FE. It includes functions at the application level such as the service gateway (including open API), registration and AAA for applications.

MAS-F exists between applications and SCF. By using MAS-F, applications can utilize the capability of multi-connection (e.g., bandwidth converge, low time delay, high security, efficient utilization of network resources, load balancing, reliability of connection and continuity of services, etc.).

The functions of MAS-F are as follows:

1) Provide multi-connection application support functionalities, such as executing service procedures of service composition and service decomposition based on subscriber's profile and/or on available network capabilities, etc.;
2) Support legacy application (i.e., single-connection application) by hiding the existence of multi-connection to applications;
3) Support the interaction between multi-connection applications and legacy applications;
4) Provide open interfaces for applications to use the capabilities and resources of multi-connection.

6.2.5 Multi-connection control function

The multi-connection control function coordinates the control of multi-connection communication across heterogeneous access technologies such as UMTS, LTE and WiFi.

As the key function in multi-connection architecture, it contains the following FEs, as shown in Figure 6-3:

1) Multi-connection user profile functional entity (MUP-FE);
2) Multi-connection policy control functional entity (MPC-FE);
3) Multi-connection coordination functional entity (MC-FE);
4) Multi-connection registration functional entity (MR-FE).

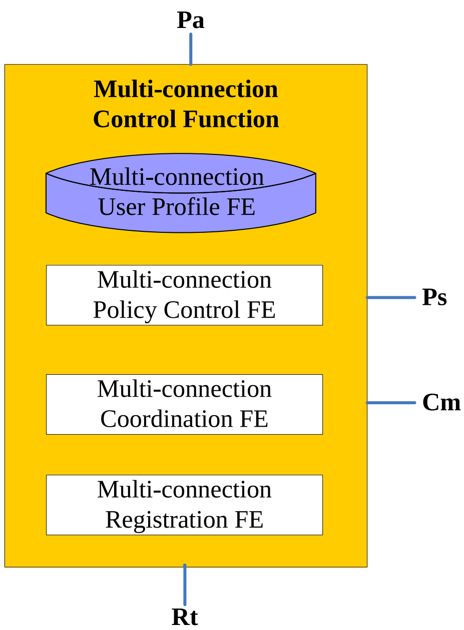

Figure 6-3 – Multi-connection control function

6.2.6 Multi-connection UE characteristics

Multi-connection requires new functions in both the UE and network. To clarify the definition of a multi-connection UE, the distinction between single connection UE (SUE) and multi-connection UE (MUE) is shown in Figure 6-4.

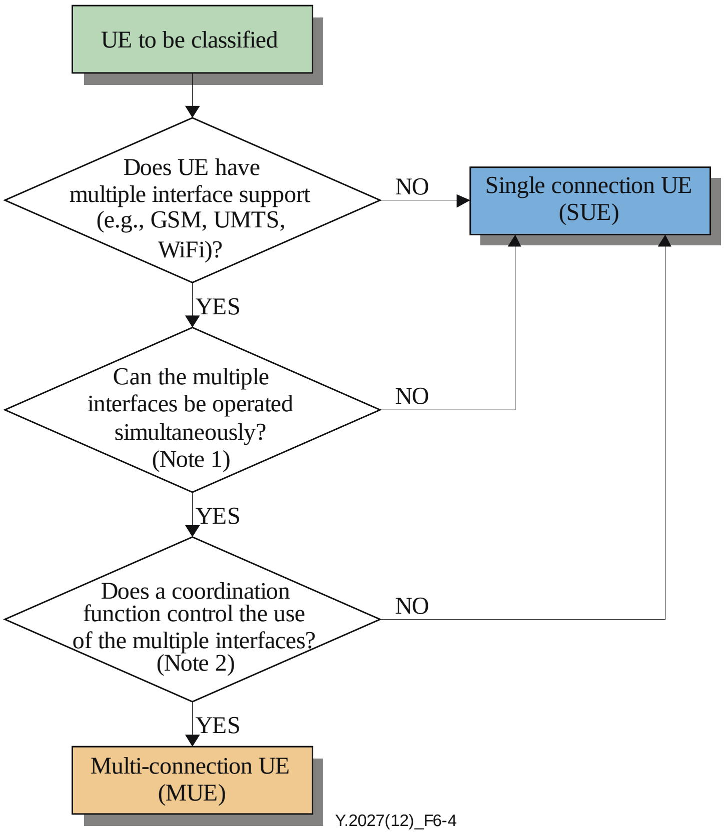

Figure 6-4 – Distinction between SUE and MUE

MUE is required to coordinate multiple interfaces supported by the UE, as shown in Figure 6-5.

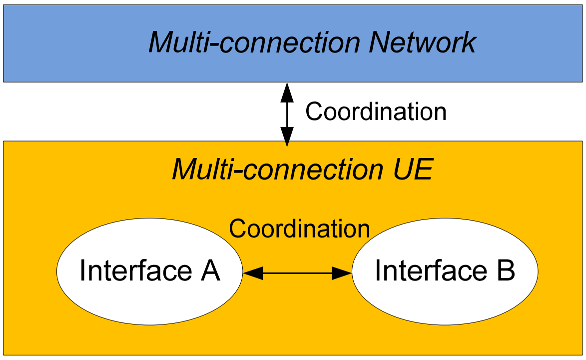

Figure 6-5 – Characteristic of MUE

6.3 Functional entities

Figure 6-6 shows the functional entities of the multi-connection architecture.

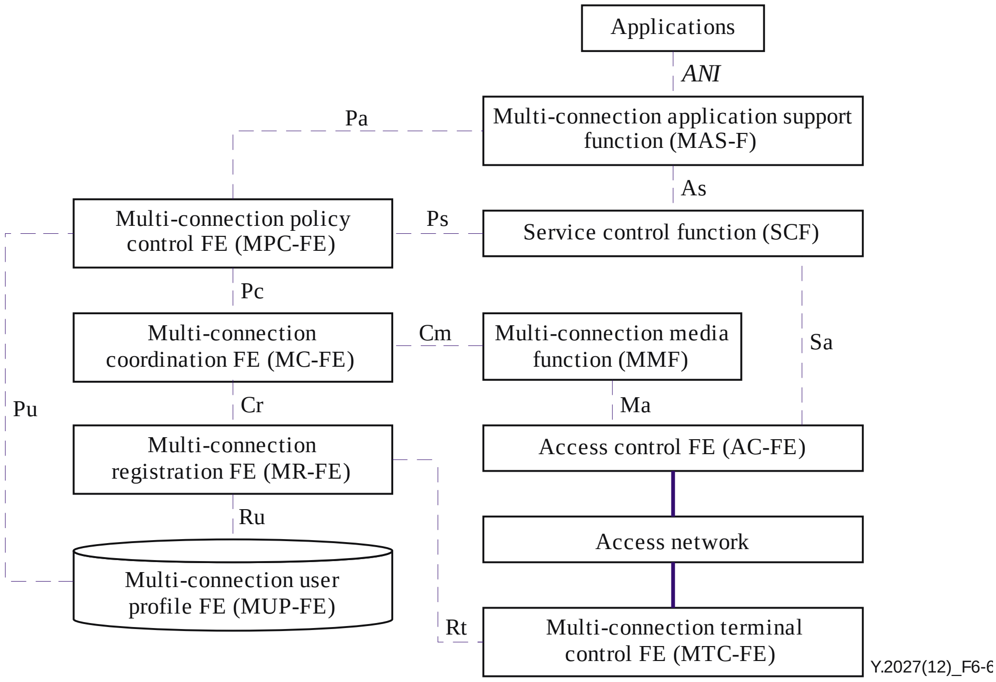

Figure 6-6 – Functional entities in multi-connection architecture

6.3.1 Multi-connection terminal control functional entity (MTC-FE)

The multi-connection terminal control functional entity is an enhanced function in MUE, which supports the MUE in exchanging multi-connection related information with the network by reference point Rt (see clause 6.4). It interacts with MR-FE to support multi-connection, such as multiple interface registration and management, the discovery and selection of reachable access networks, etc.

The functions of the MTC- FE are as follows:

1) Identify and maintain available access information in MUE;
2) Remove invalid access network information of MUE;
3) Receive and enforce access network selection recommendation/policy in MUE by the reference point Rt. It is recommended to provide access reference information to the MUE such as supported authentication type, home/roaming operator lists, location and other access specific information before initiating the connection;
4) Optionally, maintain authentication and authorization information in MUE.

6.3.2 Access control functional entity (AC-FE)

The access control functional entity is responsible for coordinating the control and user plane tunnels established by MUEs. The AC-FE interacts with the MC-FE, MR-FE and MPC-FE in the initiation, addition, removal, composition and decomposition of connections in each access network.

The functions of the AC-FE are as follows:

1) Interact with the MR-FE for authorization of connection establishment;
2) Interact with the MC-FE to report the access network resource availability;
3) Lawful interception;
4) IP address allocation (v4 or v6);
5) QoS enforcement (gating and bandwidth control in accordance with a QoS policy);
6) Charging rules enforcement (both online and offline);

7) DHCPv4 or v6 services;

8) Mobility anchoring within a single access;

9) Optionally, support deep packet inspection function.

6.3.3 Multi-connection registration functional entity (MR-FE)

The multi-connection registration functional entity manages the status of the access technologies available to the MUE. It accepts the registration requests from every MUE for all of its valid access technologies. It is responsible for binding each MUE with its all available access IDs (such as IP address, MSISDN, etc.). It shares the latest access information to MUEs and is recommended to provide information which would optimize the multi-connection pre-configuration in MUEs. It also exchanges multi-connection signalling with MUEs by reference point Rt.

The functions of the MR-FE are as follows:

1) Identify and maintain the binding between different access technologies from each MUE;

2) Remove invalid access network information of MUEs;

3) Push access network policy information to MUEs;

4) Update the available access network information to MUEs;

5) Provide available multi-connection information of MUEs to the MC-FE for making multi-connection policy decisions;

6) Provide multi-connection authentication and authorization;

7) Allocate and maintain MUE identifiers.

6.3.4 Multi-connection coordination functional entity (MC-FE)

The multi-connection coordination functional entity supports IP-based mobility management depending on available access technologies The MC-FE is a component of the multi-connection control function.

The functions of MC-FE are as follows:

1) Monitor and update the specific load and/or QoS policy for each access network and assign to MMF;

2) Dynamically collect and maintain traffic load information across the available access technologies;

3) Report abnormal status of the access network;

4) Get user preference about the network selection.

6.3.5 Multi-connection policy control functional entity (MPC-FE)

The multi-connection policy control functional entity assigns policies for each session and guarantees the QoS of the session by sending the policies to the MC-FE and/or AC-FE. The MC-FE and/or AC-FE would assign specific policies for each access based on the policies from MPC-FE, such as control routing paths or rate of IP flows.

The functions of MPC-FE are as follows:

1) Acquire service information from the SCF;

2) Receive and authorize the QoS resource request from the SCF;

3) Store and maintain the rules to make policies defined by the network operator;

4) Obtain subscription profile from the MUP-FE;

5) Make policy decisions based on the above information and provide the decisions to the MC-FE;

6) Support and provide policy mapping between different networks for AC-FEs.

6.3.6 Multi-connection user profile functional entity (MUP-FE)

The multi-connection user profile functional entity contains and maintains all subscription related information of MUEs and provides information for MPC-FE to make policy decisions and for MR-FE to make registration management decisions. MUP-FE responds to queries for user profiles which can be stored in one database or separated into several databases.

The following is a list of the type of information contained in the MUP-FE:

1) User information;
2) Allowed services;
3) Allowed QoS, such as bandwidth, priority, etc.;
4) Subscription and charging information;
5) Authentication and authorization information;
6) Location information;
7) Presence (e.g., online and/or offline status);
8) IP address information.

6.4 Reference points

This clause describes the reference points shown in Figure 6-6.

Reference point ANI

It exists between Applications and MAS-F. Applications and MAS-F exchange signalling messages for application support, such as SIP messages, through this point.

Reference point As

It exists between MAS-F and SCF. SCF and MAS-F exchange signalling messages for service control, such as SIP messages, through this point.

Reference point Pa

It exists between MAS-F and MPC-FE. MPC-FE sends the policies to MAS-F through this point. The reference point is provided only to the trusted MAS-F.

Reference point Ps

It exists between SCF and MPC-FE. It allows QoS resource request information needed for QoS resource authorization and reservation to be exchanged between the SCF and MPC-FE.

Reference point Ru

It exists between MR-FE and MUP-FE. MR-FE and MUP-FE exchange registration messages, such as user profile, authentication and authorization information, presence (e.g., online and/or offline status) through this point.

Reference point Pu

It exists between MPC-FE and MUP-FE. It allows MPC-FE to interact with MUP-FE to obtain MUE subscription information.

Reference point Pc

It exists between MPC-FE and MC-FE. It allows MPC-FE to interact with the MC-FE to coordinate the traffic over multiple access technologies. MC-FE reports the status of access network resources to MPC-FE, and MC-FE could obtain service information from MPC-FE through this point.

Reference point Cr

It exists between MC-FE and MR-FE. It allows MC-FE to interact with the MR-FE for checking on MUE available connections information. MC-FE would report abnormal status of access network to MR-FE to update available access network information and MR-FE would updates connection information of MUE to MC-FE through this point.

Reference point Cm

It exists between MC-FE and MMF. It allows MC-FE to push the policy decisions to the MMF for enforcement. MC-FE sends specific load and/or QoS policy to MMF through this point, MMF is recommended to update real-time connection information to MC-FE to reauthorize multi-connection policy.

Reference point Ma

It exists between MMF and AC-FE. It allows MMF to assist AC-FE to enforce specific policy decisions and to assign traffic among access networks.

Reference point Rt

It exists between MR-FE and MUE. MUE would report MUE available access information or location information to MR-FE by Rt. MR-FE might also record user's preference or ISP's network selection recommendations and push them to MUEs through this point.

7 Multi-connection architecture in relation to the NGN architecture

The relation between multi-connection architecture and the NGN architecture is shown in Figure 7-1. Multi-connection FEs are added to NGN architecture.

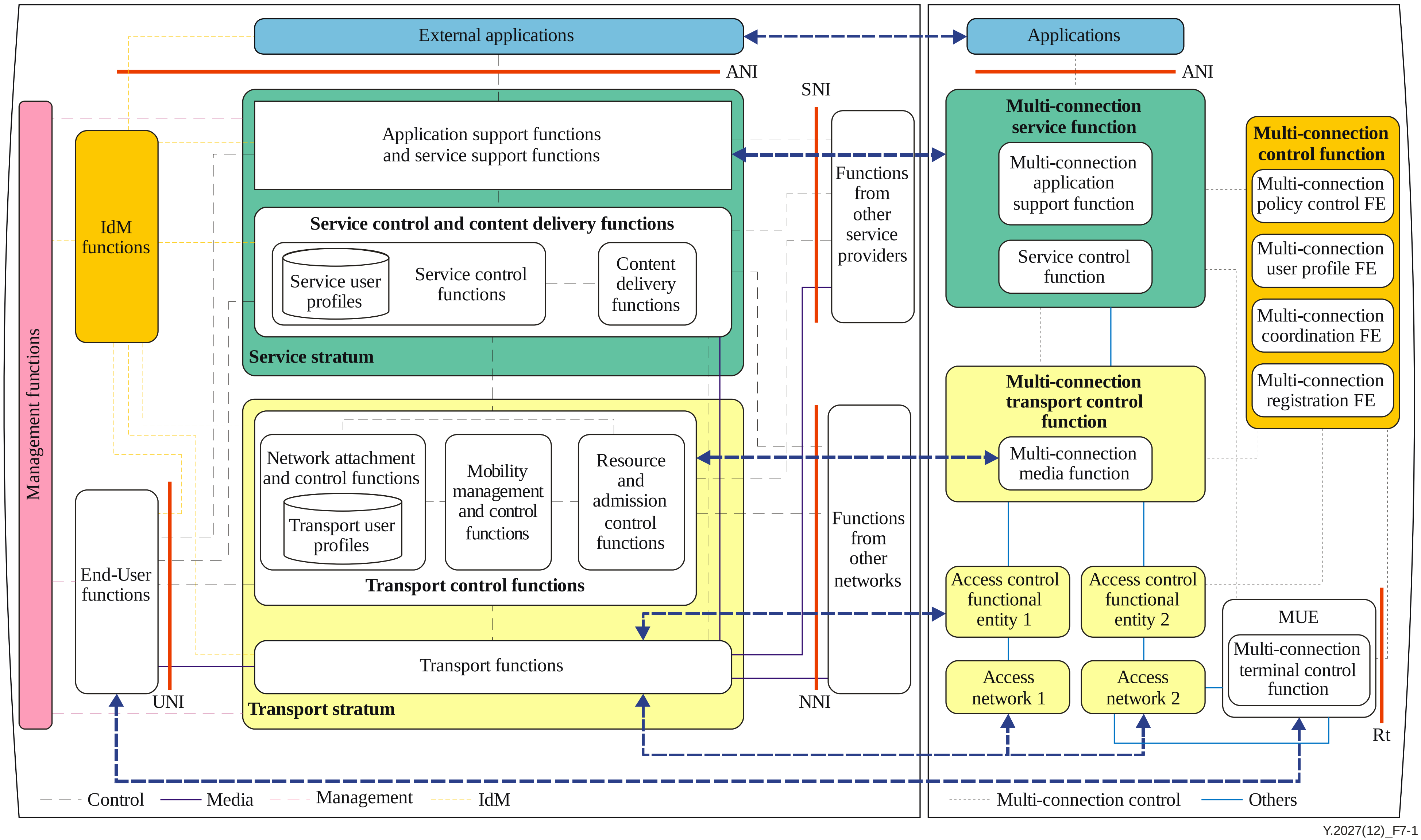

Figure 7-1 – Relationship between multi-connection architecture and NGN architecture

The dotted black arrows show peer-to-peer relationship between NGN and multi-connection architecture.

The various access points in multi-connection architecture correspond to components of the transport functions in NGN.

The access control functional entity and access network correspond to components of transport functions in NGN.

Multi-connection media function corresponds to components of transport control functions in NGN.

The multi-connection service function corresponds to components of service stratum in NGN.

The multi-connection control function coordinates all of multi-connection related functions to cater for all the active access networks.

8 Security considerations

Different access networks, such as trusted access and untrusted access, impose different security policies controlled by different access network operators. For example, the airports tend to prepare a free Wi-Fi which is open to the public, while the operators provide chargeable GSM and/or UMTS and/or LTE for their service subscribers. Based on various security requirements for the distinct networks, there are two main aspects for multi-connection architecture security consideration:

The multi-connection architecture will bring new security requirements across the functional entities supporting multi-connection. For example, when data is transferred across multiple access technologies in a coordinated manner, and these access technologies have different authentication schemes, the MC-control function will need to ensure that the overall security requirements for the service is supported.

Appendix I

The evolvement of multi-connection architecture

(This appendix does not form an integral part of this Recommendation.)

The multi-connection architecture facilitates advanced networking with pervasive accessibility and high reliability, accumulative access bandwidth and economical operating expenditure (OPEX) and capital expenditure (CAPEX). It is assumed that there are four stages for introducing multi-connection architecture into current networks:

Stage 1: UE enhanced for multi-connection

Current multi-mode terminals support employing more than one access technology simultaneously (e.g., smartphones). Actually, it is common all over the world that an ordinary smartphone can support multiple access modes such as GPRS and Wi-Fi at the same time. Apparently, the key problem for UEs in this period is not to find and attach to an available access any longer, but to avoid two events: The first is that users have to manually choose expected networks in complicated, even unpredicted, access environments; the second is that services would be frequently interrupted by accidental changes of access. For these reasons, it is required to improve QoE in access selection and service continuity, such as keeping online gaming alive while answering a call, shifting traffic among GPRS/UMTS/WLAN, etc. It is possible to solve those problems simply by an enhanced device such as an MUE.

In this stage, a certain function, such as a connection manager (as an implementation of MTC-FE), is recommended to be supported in various terminals. The improvement is that users' preference for network accessing methods can be recorded and automatically enforced in MUEs. The MUE is recommended to support the transfer multi-connection messages with any other devices.

Stage 2: Multi-connection signalling introduced between terminals and networks

The introduction of multi-connection signalling allows MUEs to exchange access policies and status with heterogeneous networks. The distinguished networks are recommended to do AAA independently, traffic control, QoS, charging, etc. It is too complicated to enhance MUE to support both gathering all the possible connection information and making the perfect decision with little knowledge of the status of each access. It is reasonable for the network to provide a common access policy to guide MUEs to multi-connection service.

In this stage, functions similar to MR-FE and/or MPC-FE would be set into the network to assign pre-configured multi-connection policy to MUEs. Users would mainly benefit from statistical optimization by the network without detecting access statuses.

Stage 3: Various multi-connection solutions accepted by the public

In stage 3, some enterprises/operators/ISPs would tend to introduce required functions for their own purpose to profit from load-balancing, high reliability, accumulative bandwidth, etc. For example, MC-FE and MMF are recommended to be deposed to offload traffic in some specific networks to encourage operators to fulfil individual preferences as well as to limit the investment in legacy network elements. Or it is recommended to use MAS-F and SCF functions to provide multi-connection based services to users.

Stage 4: Multi-connection architecture evolvement implemented

In the final stage, the whole multi-connection architecture would be implemented across heterogeneous networks. The existing networks can be reused without further modification. Users and network operators would gain a win-win relationship by enjoying the harmony of ambulant network resources.

The evolvement of multi-connection architecture would achieve two targets: The first is that the services would intelligently select and utilize heterogeneous network resources without user intervention; the second is the flexibility obtained by having multiple networks exchange either a single flow or a group of traffic flows.

Appendix II

Mapping of baseline to 3GPP EPC/IMS

(This appendix does not form an integral part of this Recommendation.)

Figure II.1 provides a reference architecture based on 3GPP EPC and IMS and shows how some of the MC-ARCH FEs would map to potential technical solutions.

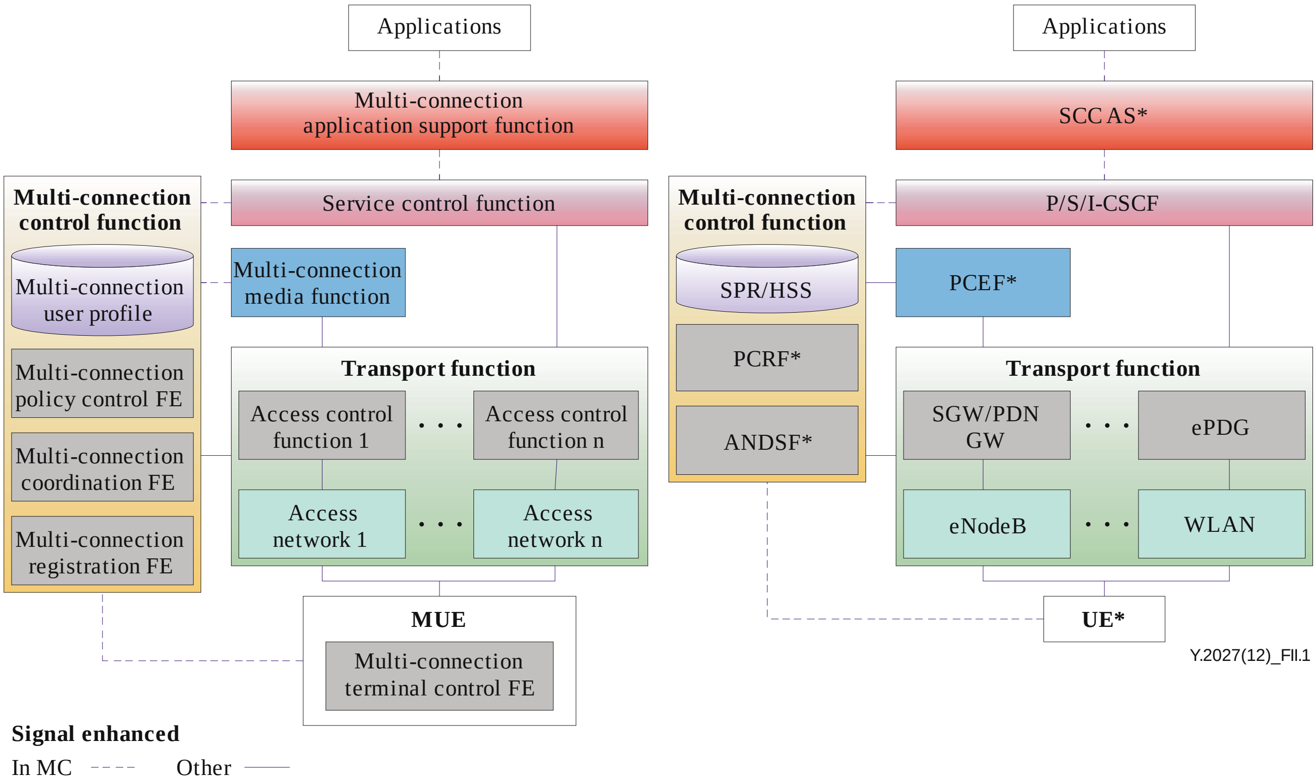

Figure II.1 – Mapping of baseline to 3GPP EPC/IMS

The figure on the left is the multi-connection general architecture and the other one is evolved 3GPP EPC and IMS architecture. The functions marked with a star "*" refer to enhancement requirements in specific network elements, for instance, UE* would be upgraded into MUE.

Appendix III

Mapping of baseline to next generation hotspot (NGH)/IMS

(This appendix does not form an integral part of this Recommendation.)

Figure III.1 provides reference architecture based on WFA/WBA Hotspot2.0 and IMS and shows how some of the MC-ARCH FEs would map to potential technical solutions.

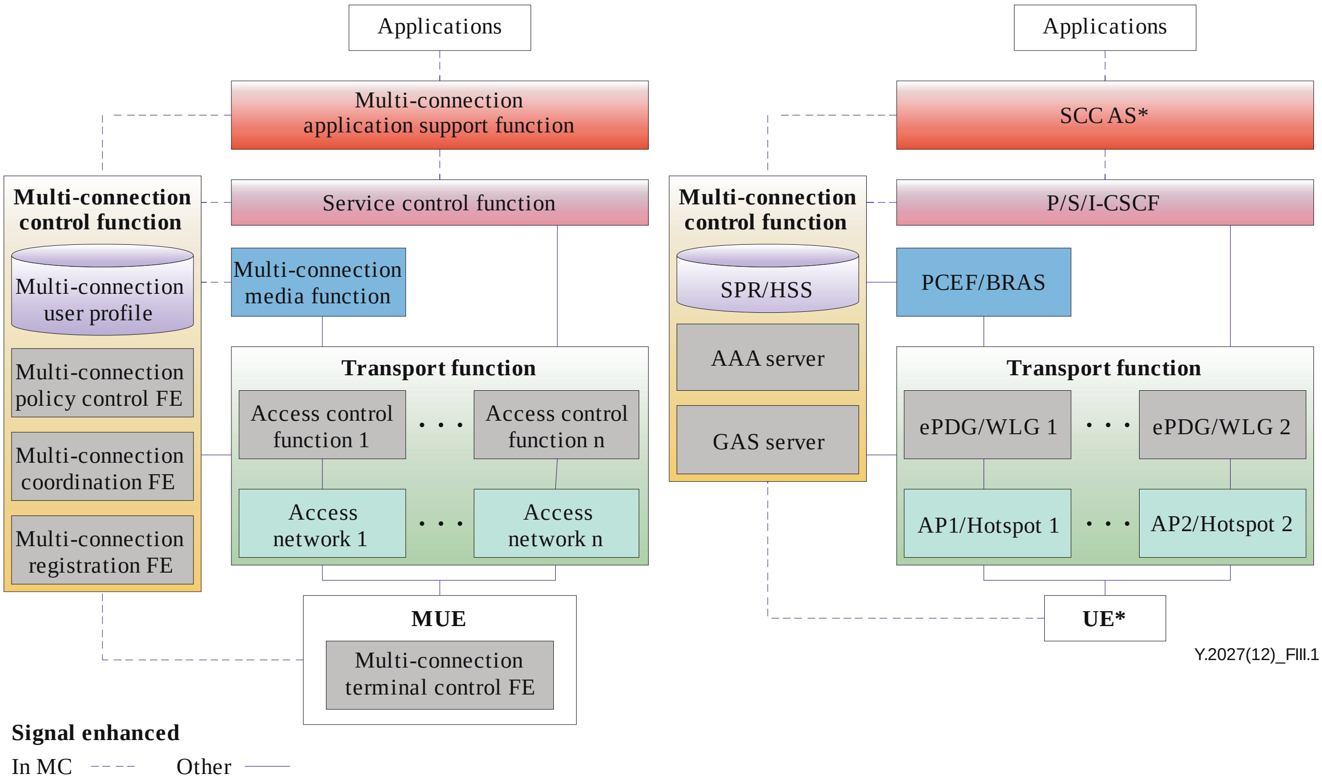

Figure III.1 – Mapping of baseline to NGH/IMS

The functions marked with a star "*" refer to enhancement requirements in specific network elements, for instance, UE* would be upgraded into MUE.

Appendix IV

Information procedures of multi-connection

(This appendix does not form an integral part of this Recommendation.)

This appendix provides information procedures related to multi-connection.

IV.1 Initiating/adding a new connection

If an MUE is using multiple connections to receive and send flows, it is recommended that changes of the connections, such as adding a new connection, change the IP flow routing path. This appendix describes the high-level information flows triggered by the changes of multiple available connections in the MUE.

When an MUE moves into the coverage of a new access network and successfully completes authentication, the MUE can use the access network to send and receive packets. Before the MUE uses the new connection, it is required to register the new connection to MR-FE. Figure IV.1 shows an abstract flow when a new connection is added.

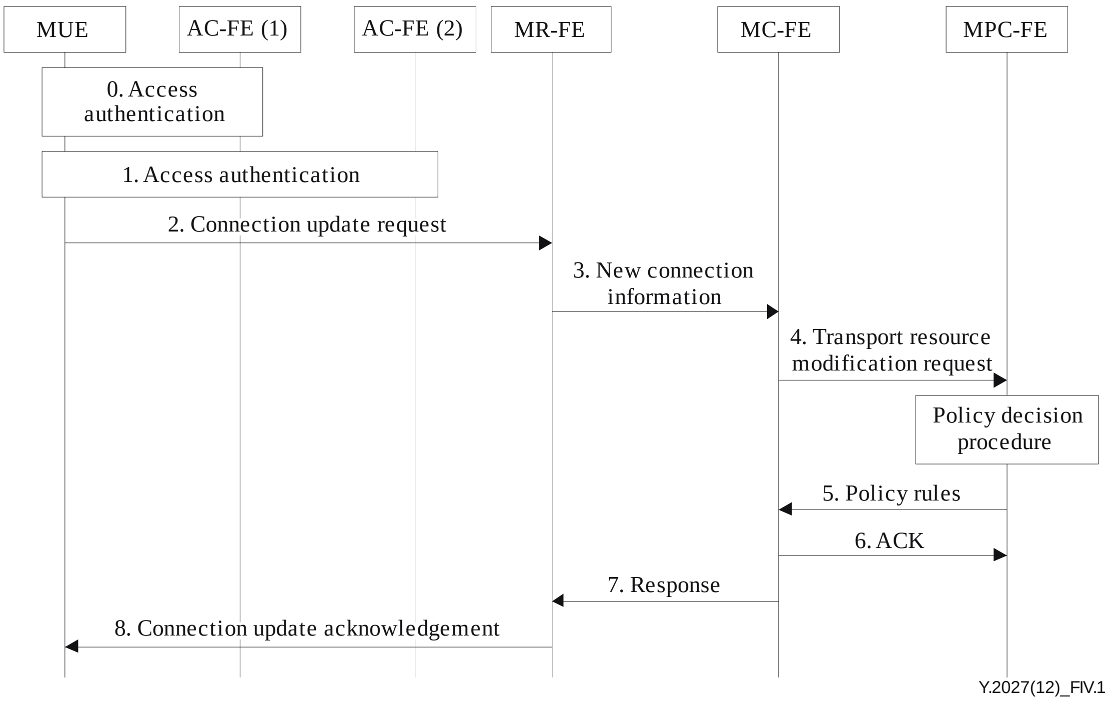

Figure IV.1 – Adding a new connection

0) An MUE accesses an access network via AC-FE (1) through the access authentication process. After the successful access authentication, the MUE will get an IP address for the interface connecting the access network;

1) After detecting a new available access network, the MUE starts the authentication process via AC-FE (2) and get a new IP for it;

2) The MUE sends a Connection Update Request message with the new IP address to MR-FE to register a new connection;

3) MR-FE updates the available connections of the MUE and sends a New Connection Information message which contains the available connections of the MUE to MC-FE;

4) MC-FE sends a Transport Resource Modification Request message to MPC-FE;

5) MPC-FE selects a set of QoS rules for the new connection based on the operator policy and the information of the new connection. And then MPC-FE makes out the policy for the MUE ongoing IP flows based on the policies and sends to MC-FE;

6) MC-FE sends an ACK message to MPC-FE after receiving the policy rules;

7) MC-FE sends a Response message to MR-FE;

8) MR-FE binds between the MUE and new connections and sends a Connection Update Acknowledgement message to the MUE.

IV.2 Removing a connection

When an MUE moves out of the coverage of an access network, it is required to remove all IP flows associated with that access network and detaches from that access network. Figure IV.2 shows an abstract flow for deleting or updating a connection.

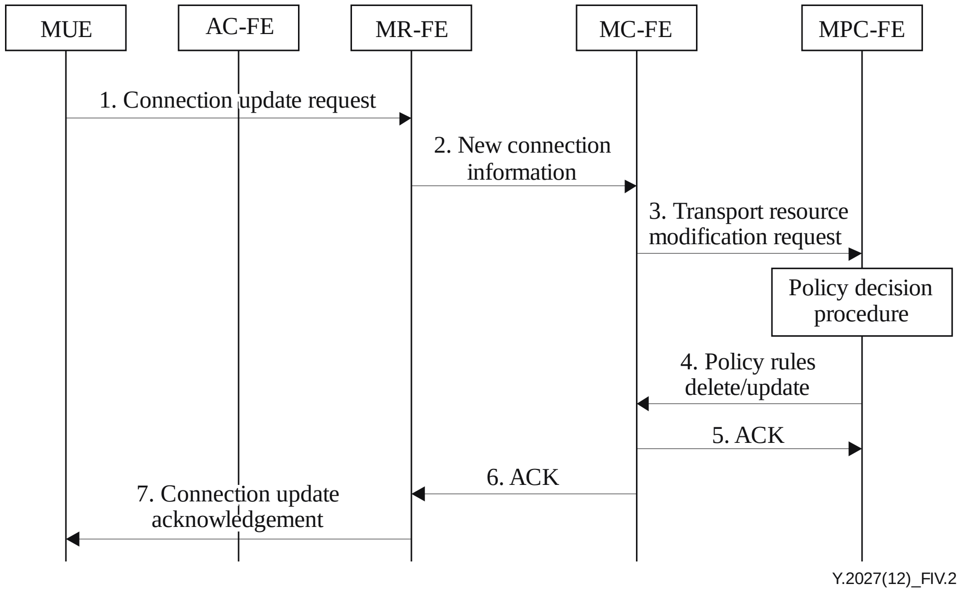

Figure IV.2 – Deleting or updating a connection

1) The MUE sends a Connection Update Request message to MR-FE. The message contains the identifier of the connection to be deleted;

2) MR-FE deletes the associated connection information based on the Connection Update Request message. And then MR-FE sends a New Connection Information message which contains the available connections of the MUE to MC-FE;

3) MC-FE sends a Transport Resource Modification Request message to MPC-FE;

4) MPC-FE controls transport resource based on the Transport Resource Modification Request, and then sends a QoS Policy Rules Delete/Update message to MC-FE;

5) MC-FE receives the QoS Policy Rules Delete/Update message and then returns an ACK message to MPC-FE;

6) MC-FE returns an ACK message to MR-FE;

7) MR-FE binds between the MUE and new connections and returns a Connection Update Acknowledgement message to the MUE.

IV.3 IP flow mobility

a) MUE initiated IP flow mobility

When an MUE is connected simultaneously to multiple access networks, the MUE can use multiple connections to send and receive IP flows. Because of the changes in the access network, sometimes MUE needs to transfer one IP flow from one access network to another. In that case, MUE is required to modify the parameters of the available connections, shown as Figure IV.3.

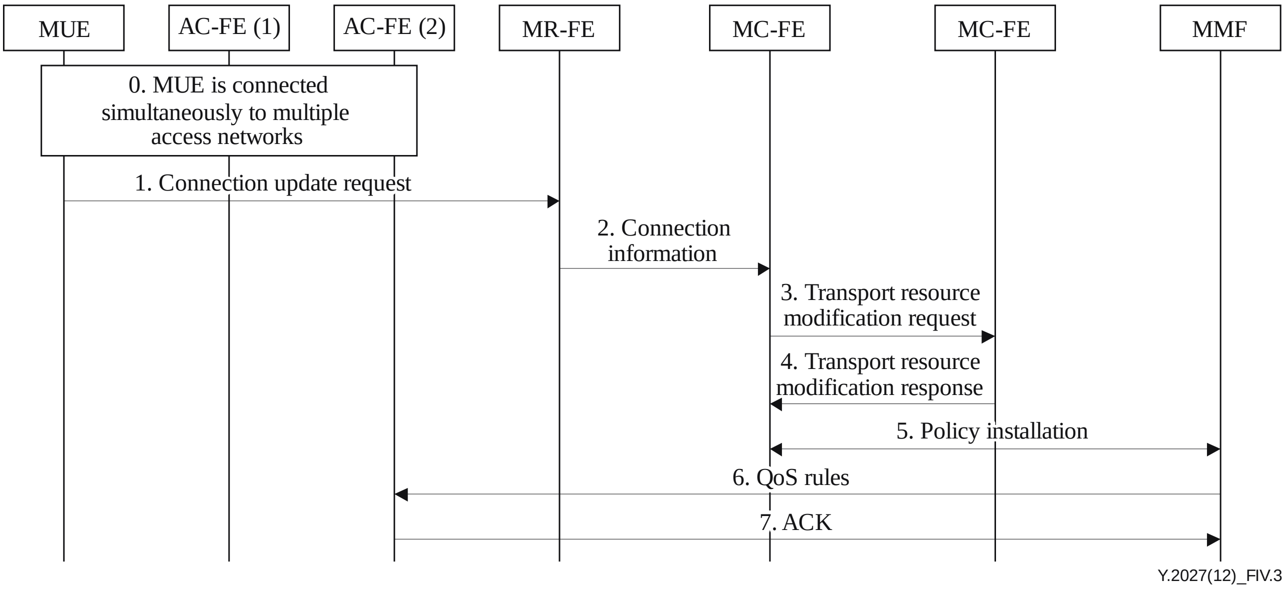

Figure IV.3 – MUE initialled IP flow mobility

0) The MUE has been connected simultaneously to multiple access networks and the MUE is using multiple connections to send and receive IP flows;

1) MUE sends a Connection Update Request message to MR-FE. The message contains the identifier and new information of the connection that the network wants to modify;

2) MR-FE updates the information of the connection based on the Connection Update Request message. Then MR-FE sends a Connection Information message to MC-FE;

3) MC-FE sends a Transport Resource Modification Request message which contains the updated information of the connections to MPC-FE;

4) MPC-FE selects new QoS policy rules for the connection based on the operator policy and the updated connection information. Then it returns a Transport Resource Modification Response message to MC-FE.

5) MC-FE makes and assigns related rules for access network to MMF, MMF installs the rules.

6) MMF sends the new QoS rules to AC-FE (2);

7) AC-FE (2) updates the QoS policy rules of the connection. Then it returns an ACK message to MMF.

b) Network initiated IP flow mobility

Based on current status of an access network, one of the existing IP flows is moved from one access network to another automatically. In this case, the network is required to initiate the IP flow mobility and interact with related functional entities directly. Figure IV.4 shows an abstract flow of network initiated IP flow mobility.

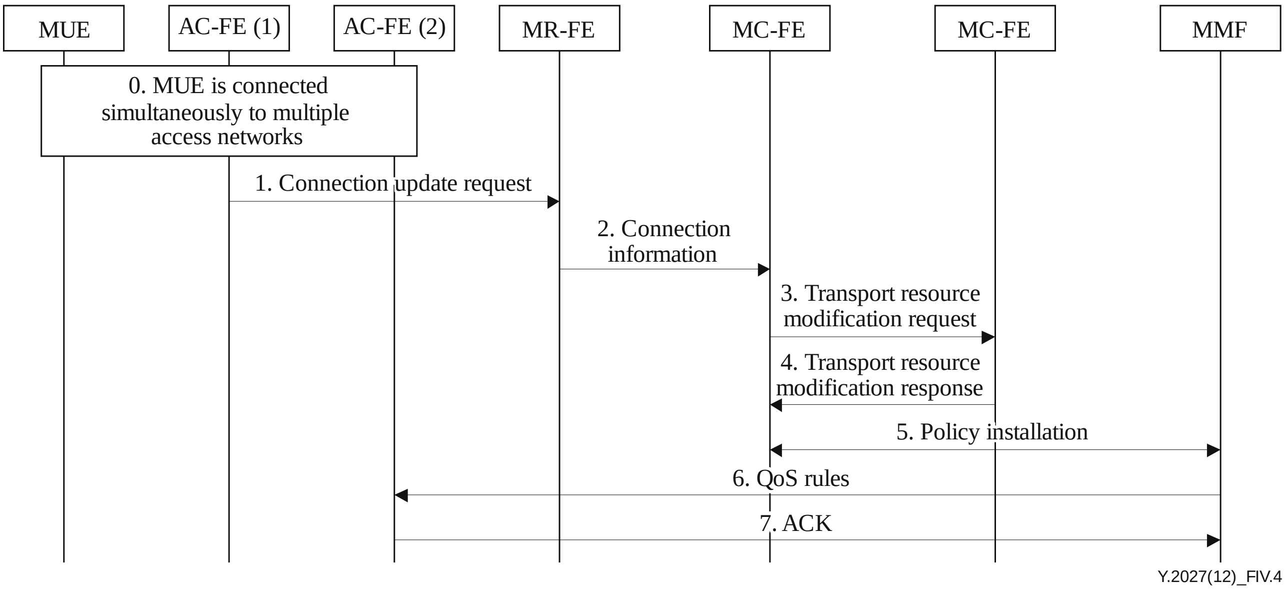

Figure IV.4 – Network initialled IP flow mobility

0) The MUE is connected to multiple access networks simultaneously and uses multiple connections to send and receive IP flows;

1) AC-FE (1) sends a Connection Update Request message to MR-FE. The message contains the identifier and new information of the connection that the network wants to modify;

2) MR-FE updates the information of the connection based on the Connection Update Request message. Then MR-FE sends a Connection Information message to MC-FE;

3) MC-FE sends a Transport Resource Modification Request message which contains the updated information of the connections to MPC-FE;

4) MPC-FE selects new QoS policy rules for the connection based on the operator policy and the updated connection information. Then it returns a Transport Resource Modification Response message to MC-FE.

5) MC-FE makes and assigns related rules for access network to MMF, MMF installs the rules.

6) MMF sends the new QoS rules to AC-FE (2);

7) AC-FE (2) updates the QoS policy rules of the connection. Then it returns an ACK message to MMF.

IV.4 Service composition during call establishment

When an MUE creates several service components through multiple network interfaces, the service components can be composed into one to serve application and the remote UE. The procedure in the figure below takes place during call establishment. This procedure supports several of the use cases described in [b-ITU-T Y-Sup.9].

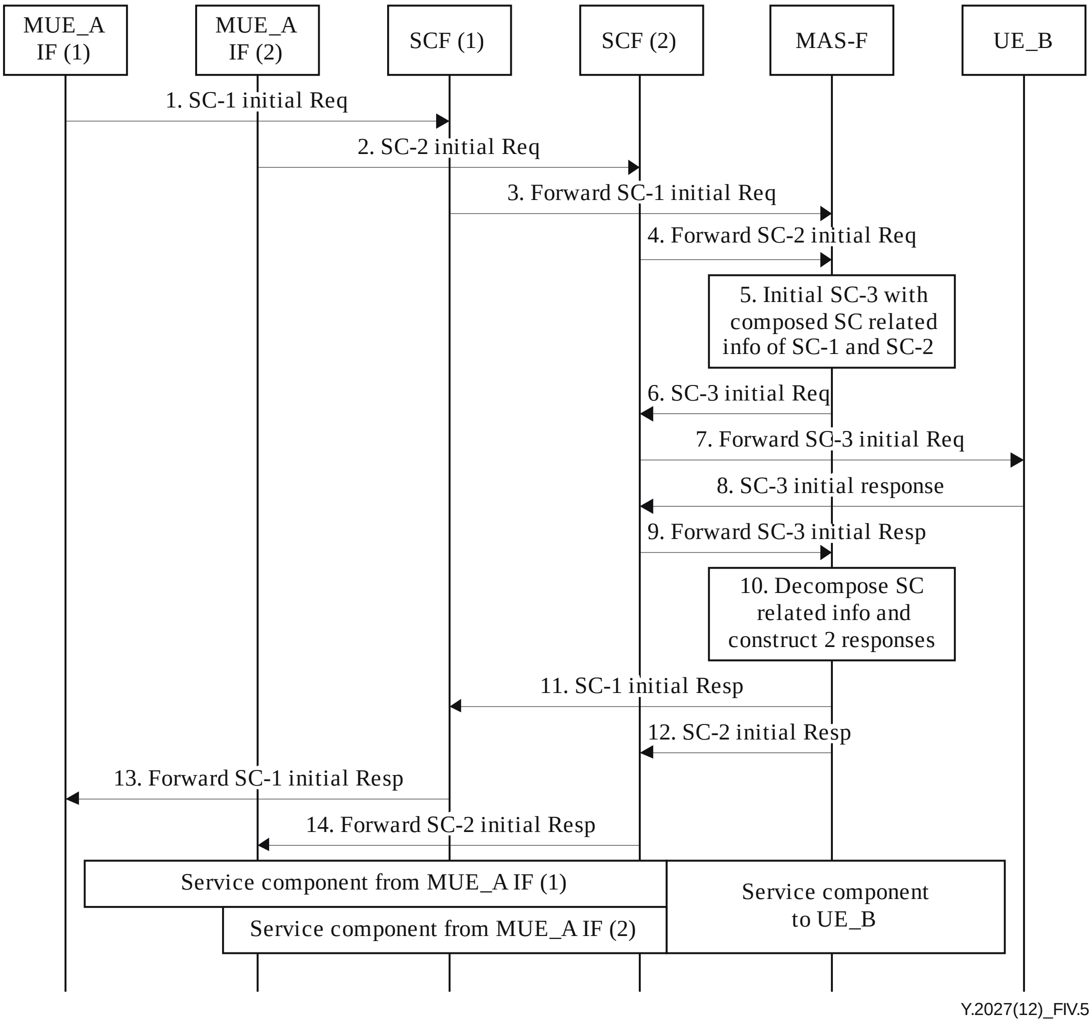

Figure IV.5 – Service composition during call establishment

1)-4) MUE_A initiates two service components (SC-1 and SC-2) from two interfaces, i.e., MUE_A IF(1) and MUE_A IF(2). The initial requests are sent to the corresponding SCEs through different networks, and are forwarded to MAS-F respectively.

5) MAS-F identifies that the requests belong to a same call and can be composed. Hence, it composes the information of SC-1 and SC-2, and initiates a new service component (SC-3) to UE_B, which can be a multi-connection UE or even an ordinary UE.

6)-7) The initial request of SC-3 is routed to a SCF, which is SCF (2) in the figure but could be any appropriate one, and is forwarded to UE_B. UE_B can be a multi-connection UE or an ordinary UE.

8)-9) UE_B negotiates media parameters to establish SC-3. Then, UE_B constructs a response for SC-3, and returns it along the transmission path. The response is then forwarded to MAS-F.

10) MAS-F decomposes service components related information from the response, and constructs two responses for SC-1 and SC-2.

11)-14) MAS-F constructs two responses for SC-1 and SC-2. The responses are routed to MUE_A along the original paths.

After the steps above, MUE_A and UE_B have established a call. It contains two service components for MUE_A, which are through different interfaces and different networks, and only one service component for UE_B.

IV.5 Service decomposition during call establishment

A service that supports multi-connection capability can be decomposed into several service components. The procedure in the figure below takes place during call establishment. This procedure supports several of the use cases described in [b-ITU-T Y-Sup.9].

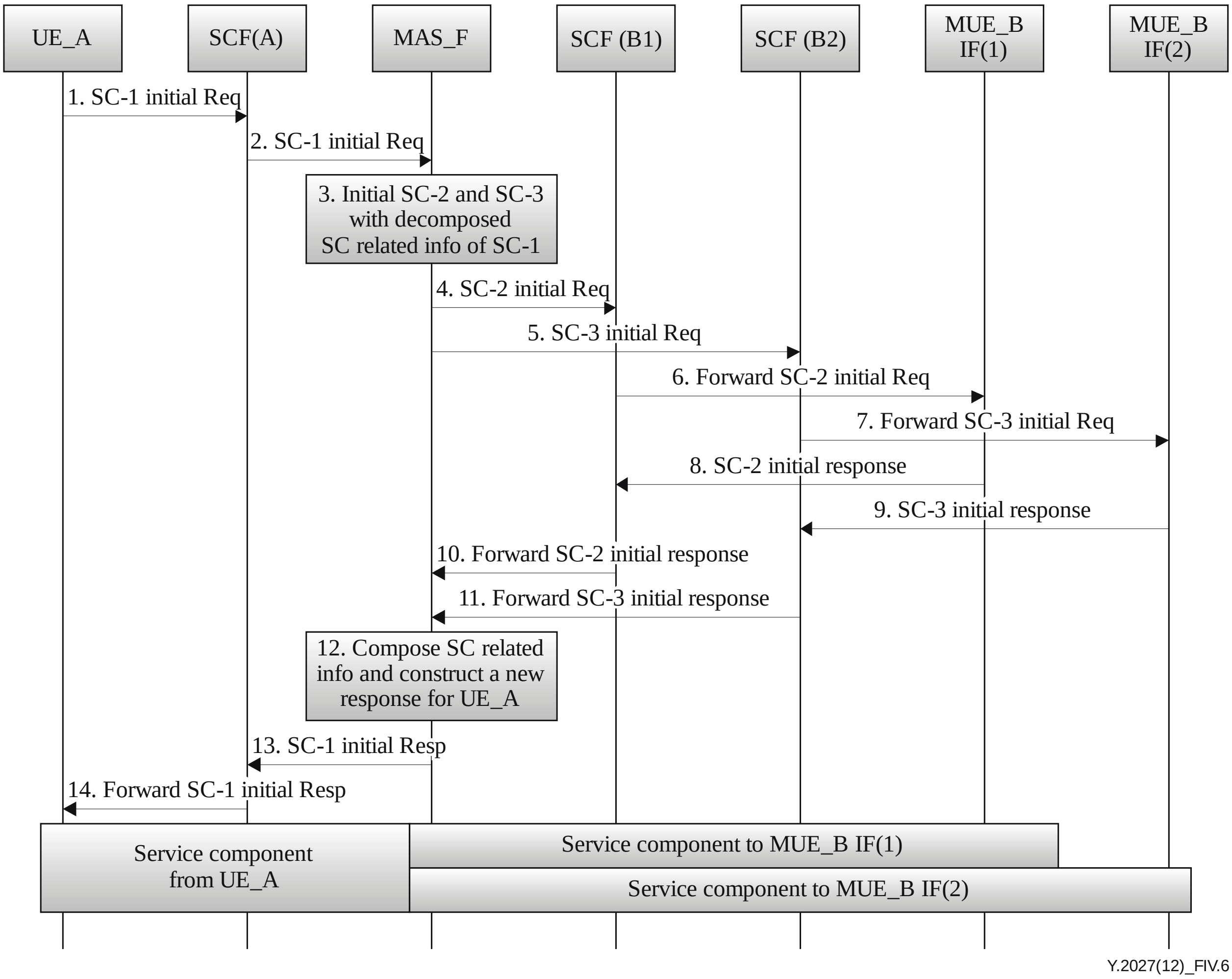

Figure IV.6 – Service decomposition during call establishment

1)-2) UE_A, which can be an MUE or even an ordinary UE, initiates a service (SC-1) to MUE_B, which is an MUE. The initial request is routed to SCF(A), and SCF(A) forwards it to MAS-F.

3) MAS-F identifies that SC-1 can be decomposed for MUE_B, since MUE_B is an MUE. So MAS-F splits the SDP descriptions extracted from the initial request of SC-1, and initiates two new service components (SC-2 and SC-3) to two interfaces of MUE_B, i.e., MUE_B IF(1) and MUE_B IF(2).

4)-7) MAS-F sends the new initial requests the MUE_B. The requests are routed through SCF(B1) and SCF(B2) which correspond to the different interfaces of MUE_B.

8)-11) The responses are routed to MAS-F via the SCFs.

12) MAS-F composes service component related information from the two responses, and constructs a new response.

13)-14) The responses are routed to UE_A through SCF(A).

After the steps above, UE_A and MUE_B have established a call. Within it, there are two service components for MUE_B, which are through different interfaces and different networks, and only one service component for UE_A.

IV.6 Service decomposition with QoS policy control

This procedure shows the service decomposition with QoS policy control when a call is established.

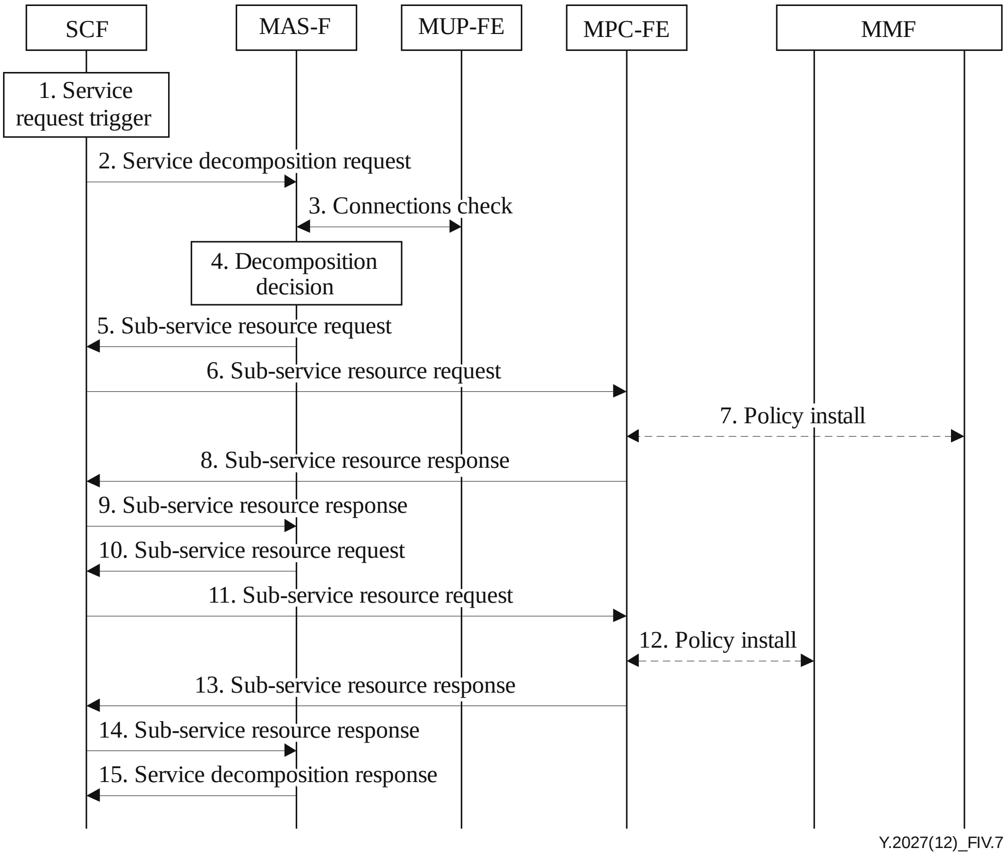

Figure IV.7 – Service decomposition

1) SCF receives a service request from remote MUE, which triggers SCF to initiate a service request.

2) SCF further sends a service decomposition request to MAS-F, to request MAS-F to decide if the MUE is under multi-connections, and if the MUE needs service decomposition.

3) MAS-F sends connection check request to MUP-FE to obtain the available connections of the MUE.

4) MAS-F makes decomposition decision based on the service decomposition request and the available connections of the MUE.

5) MAS-F sends sub-service resource request to SCF with service resource requirements which would be divided to the connection one.

6) SCF further sends the sub-service resource request to MPC-FE.

7) MPC-FE makes policy rules based on QoS resource requirements, etc., and then sends a request to install the rules in MMF under connection one.

8) MPC-FE sends sub-service resource response to SCF.

9) SCF sends sub-service resource response to MAS-F.

10) MAS-F sends sub-service resource request to SCF with service resource requirements which would be divided to the connection two.

11) SCF further sends the sub-service resource request to MPC-FE.

12) MPC-FE makes policy rules based on QoS resource requirements, etc., and then sends a request to install the rules in MMF.

13) MPC-FE sends sub-service resource response to SCF.

14) SCF sends sub-service resource response to MAS-F.

15) MAS-F sends sub-service resource response to SCF.

IV.7 Subscriber attaches to the access network

This clause provides high level information flow that defines the network attachment and connection registration process.

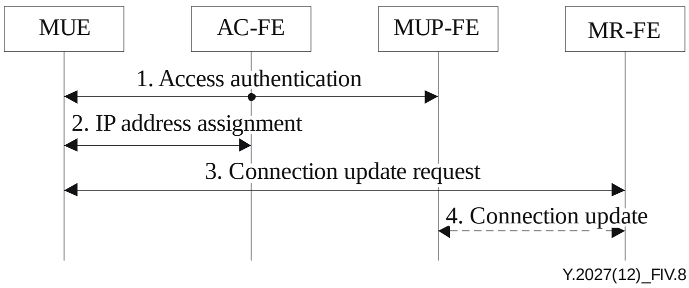

Figure IV.8 – Subscriber attaches to the access network

1) The MUE attaches to an access network through the access authentication process.

2) After successful access authentication, the MUE will get an IP address for the new interface.

3) The MUE sends a Connection Update Request message with the new IP address to the MR-FE to register a new connection.

4) The MR-FE updates the available connections of the MUE. If needed, the MR-FE further sends a Connection Update message which contains the available connections of the MUE to the MUP-FE.

IV.8 Policy control procedure

The multi-connection policy control procedure is illustrated in Figure IV.9. When the MUE initiates a multi-connection service, a multi-connection control request is triggered in the SCF.

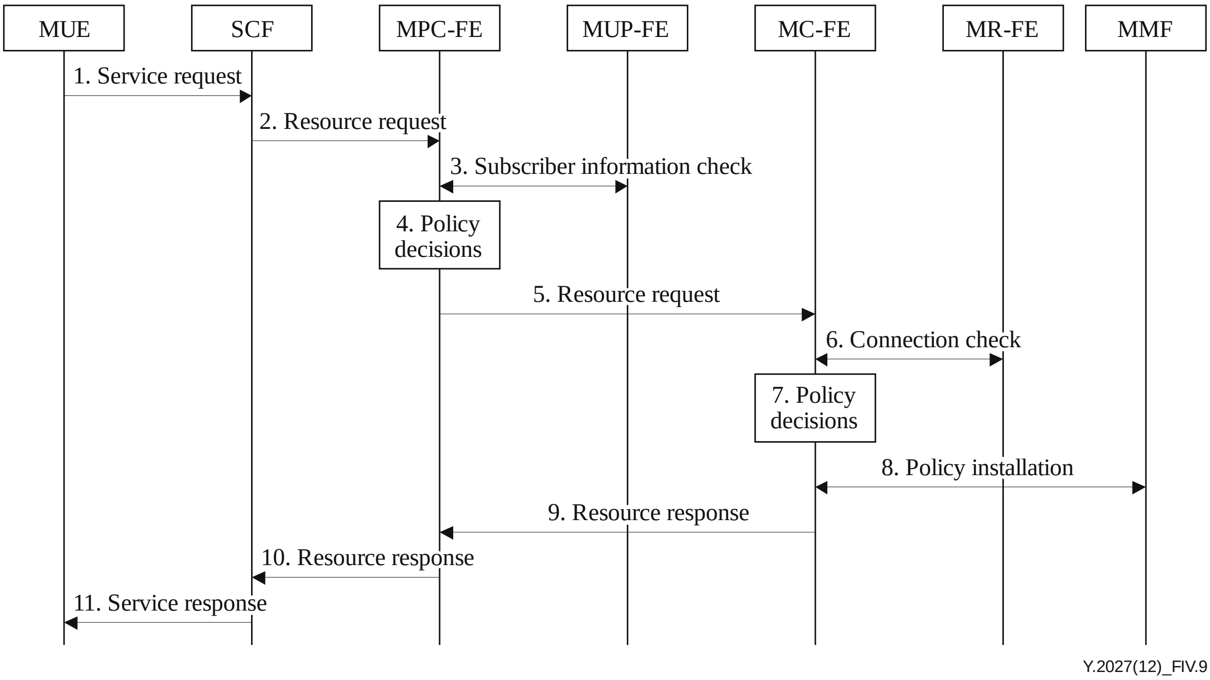

Figure IV.9 – Policy control procedure

1) The MUE requests a multi-connection service by sending a service request to the SCF.
2) The SCF extracts or derives the resource requirements for the requested service, and sends a resource request to the MPC-FE for resource authorization and reservation.
3) The MPC-FE sends a subscriber information check to the MUP-FE to check the subscription related information of the MUE.
4) The MPC-FE makes the policy decisions based on the above information.
5) The MPC-FE sends a resource request to the MC-FE to support the traffic over multiple accesses.
6) The MC-FE sends a connection check to the MR-FE to check the current available connections of the MUE.
7) The MC-FE makes the policy decisions based on the above information.
8) The MC-FE sends the policies to MMF for installation.
9) The MC-FE sends a resource response to the MPC-FE.
10) The MPC-FE sends a resource response to the SCF.
11) The SCF sends a service response to the MUE.

Bibliography

[b-ITU-T Y.2001] Recommendation ITU-T Y.2001 (2004), *General overview of NGN*.

[b-ITU-T Y.2014] Recommendation ITU-T Y.2014 (2008), *Network attachment control functions in next generation networks*.

[b-ITU-T Y.2091] Recommendation ITU-T Y.2091 (2011), *Terms and definitions for next generation networks*.

[b-ITU-T Y.2111] Recommendation ITU-T Y.2111 (2011), *Resource and admission control functions in next generation networks*.

[b-ITU-T Y.2201] Recommendation ITU-T Y.2201 (2009), *Requirements and capabilities for ITU-T NGN*.

[b-ITU-T Y-Sup.9] ITU-T Y-Series Recommendations – Supplement 9 (2010), *ITU-T Y.2000-series – Supplement on multi-connection scenarios*.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Terminals and subjective and objective assessment methods
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects and next-generation networks**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2013