

IEEE Standard for the Functional Architecture of Next Generation Service Overlay Networks

IEEE Communications Society

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IEEE Standard for the Functional Architecture of Next Generation Service Overlay Networks

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Abstract: A framework of Internet Protocol (IP)-based service overlay networks is described and context-aware [e.g., such as required Quality of Service (QoS) level; type of service such as real time versus data; nature of data stream such as I-frame versus B-frame; and type of terminal such as TV monitor versus personal digital assistant], dynamically adaptive (e.g., using locally derived information to discover, organize, and maintain traffic flows in the network within a local area network), and self-organizing networking capabilities (e.g., developing network structures based on the needs of the customers and the capabilities of existing network structures), including advanced routing and forwarding schemes, that are independent of underlying networks, are specified in this Next Generation Service Overlay Network (NGSON) standard.

The NGSON architecture provides advanced service- and transport-related functions to support context-aware, dynamically adaptive, and self-organizing networks. This standard specifies a functional architecture for NGSON. The functional architecture consists of a set of functional entities (FEs), their functions, reference points, and information flows to illustrate service interaction and media delivery among FEs and external components.

NGSON may operate with different underlying networks such as IP Multimedia Subsystem (IMS), next generation network (NGN), peer-to-peer (P2P) overlay, or Web to transmit NGSON signaling messages and/or media among its users and services. Specifications of underlying networks are outside scope of this standard.

Keywords: content delivery, context awareness, dynamic adaptation, IEEE 1903, self-organization, service composition, service discovery and negotiation, service overlay network, service routing

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Introduction

This introduction is not part of IEEE Std 1903-2011, IEEE Standard for the Functional Architecture of Next Generation Service Overlay Networks.

This standard defines a framework of Internet Protocol (IP)-based service overlay networks that support context-aware, dynamically adaptive, and self-organizing networking capabilities, including advanced routing and forwarding schemes, that are independent of underlying networks.

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Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	2
2. Definitions, acronyms, and abbreviations	2
2.1 Definitions	2
2.2 Acronyms and abbreviations	3
3. General	5
4. Architecture	6
4.1 Architecture diagram	7
4.2 Functional entities	8
4.3 Reference points	21
4.4 Service features of NGSON with information flows	23
5. NGSON over underlying networks	90
5.1 NGSON over IMS	90
5.2 NGSON over P2P	96
5.3 NGSON with Web	100
Annex A (informative) Use cases for NGSON services and their information flows	105
Annex B (informative) Other NGSON-related architecture ideas	125
Annex C (informative) Bibliography	133

List of figures

Figure 1—Overview of NGSON functional architecture	6
Figure 2—NGSON reference diagram	7
Figure 3—SC FE block diagram	9
Figure 4—SDN FE diagram	11
Figure 5—SR FE block diagram	12
Figure 6—SReg FE block diagram	13
Figure 7—IDM FE block diagram	15
Figure 8—CIM FE Diagram	16
Figure 9—CD FE block diagram	17
Figure 10—SPD FE block diagram	19
Figure 11—SP FE block diagram	20
Figure 12—OM FE block diagram	20
Figure 13—Flow of basic service routing	24
Figure 14—Flow of service discovery	25
Figure 15—Flow of service subscription/notification	26
Figure 16—Flow of service negotiation	27
Figure 17—Flow of service composition	28
Figure 18—Dynamic service chaining of SC FE	30
Figure 19—Flow of dynamic service instantiation using abstract service logic	30
Figure 20—Flow of service substitution	31
Figure 21—Flow of service composition with CD FE	33
Figure 22—Flow of selection of service composition	34
Figure 23—Flow of termination of service composition	35
Figure 24—Flow of evaluation of service composition	36
Figure 25—The flow of content delivery	37
Figure 26—Flow of content delivery	38
Figure 27—Information flow of content delivery optimization	39
Figure 28—Flow of content delivery to multiple requesters	40
Figure 29—Service QoS concepts	43
Figure 30—Flow of QoS lifecycle	44
Figure 31—Flow of Service-related QoS	46
Figure 32—Flow for charging	48
Figure 33—Flow of composite charging	49
Figure 34—Flow of global ID mapping	51

Figure 35—Flow of authentication authorization and user profile.....	51
Figure 36—Flow of terminal change.....	52
Figure 37—Flow for authentication	53
Figure 38—Flow of user profile access control based on context information	54
Figure 39—Flow of user authentication.....	55
Figure 40—Flow of authentication in service chaining.....	56
Figure 41—Flow of service roaming.....	57
Figure 42—Flow of service roaming—scenario 1	59
Figure 43—Flow of service roaming—scenario 2	60
Figure 44—Flow of service roaming—scenario 3	61
Figure 45—Relationship of context classes	63
Figure 46—Flow for context aware service composition.....	65
Figure 47—Flow of context aware service routing	67
Figure 48—Flow of context information management and usage.....	68
Figure 49—Flows of dynamic adaptive service composition.....	70
Figure 50—Flow of dynamic service rerouting.....	71
Figure 51—Flow of content delivery adaptation	72
Figure 52—Flow of dynamic service routing based on the service context information	73
Figure 53—Flow of dynamic SR FE based on user context information	75
Figure 54—Flow of QoS assured dynamic service composition (for QoS or context changes).....	76
Figure 55—Flows of QoS assured dynamic service composition	78
Figure 56—Different levels of self-organization.....	80
Figure 57—Relation between NGSON nodes and services (FEs residing on NGSON nodes).....	80
Figure 58—Management of NGSON nodes and FE instances by OM FE.....	81
Figure 59—Self-configuration by OM FE	83
Figure 60—Self-optimization by OM FE.....	84
Figure 61—Self-recovery by OM FE	85
Figure 62—Self-organization at node level by OM FE.....	86
Figure 63—Self-organization of service routing	87
Figure 64—Flow of user profile management.....	88
Figure 65—Flow of control of service access via the service portal	89
Figure 66—NGSON architecture with overlay over IMS	90
Figure 67—NGSON service nodes with NGSON over IMS functions.....	91
Figure 68—Reference architecture of NGSON over IMS.....	92
Figure 69—Self-organizing NGSON over IMS	94
Figure 70—Option 1 (without IMS Service Broker).....	95
Figure 71—Option 2 (with IMS Service Broker).....	96

Figure 72—NGSON over P2P	96
Figure 73—NGSON self-organization in P2P	97
Figure 74—P2P as NGSON end users	98
Figure 75—NGSON over P2P	98
Figure 76—Basic flow for P2P content fetch	99
Figure 77—IDM FE for NGSON with Web	101
Figure 78—An example of NGSON with the diversity of web resources.....	103
Figure 79—Flow for service interaction with Web resource.....	103

Annex figures

Figure A.1—Information flow of a writer’s blog, context-aware social network service	106
Figure A.2—Information flow of a reader receiving a blog from a context-aware social network service	108
Figure A.3—Information flow of personalized tour guide services (End-user1)	110
Figure A.4—Content recommendation service using NGSON	112
Figure A.5—Information flow of content recommendation service.....	113
Figure A.6— Information of multimedia session continuity.....	115
Figure A.7—Service QoS-related FEs for RA-NMS	117
Figure A.8—Information flow of service QoS for RA-NMS	118
Figure A.9—Context information management for indoor XPS service.....	120
Figure A.10—Flow of indoor XPS service	120
Figure A.11—Information flow of adaptive video streaming service	123
Figure B.1—Functional components of the NGSON platform	125
Figure B.2—Information flow of interactions for QoS assured dynamic service composition between two NGSONs	126
Figure B.3—Service registration flow.....	127
Figure B.4—Flow of charging with real time tariff information.....	128
Figure B.5—Flow of terminal ID registration	129
Figure B.6—Centralized managed NGSON.....	130
Figure B.7—Distributed managed NGSON	130
Figure B.8—Hybrid managed NGSON.....	131
Figure B.9—End-user function	132

List of tables

Table 1—Classification of context	62
Table 2—Different levels of dynamic adaptation capability	69
Table 3—Different categories of self-organization	79

Annex table

Table B.1—Example of general user data model	131
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IEEE Standard for the Functional Architecture of Next Generation Service Overlay Networks

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1. Overview

1.1 Scope

This Next Generation Service Overlay Network (NGSON) standard describes a framework of Internet Protocol (IP)-based service overlay networks and specifies context-aware [e.g., such as required quality of service (QoS) level; type of service such as real time versus data; nature of data stream such as I-frame versus B-frame; and type of terminal such as TV monitor versus personal digital assistant], dynamically adaptive (e.g., using locally derived information to discover, organize, and maintain traffic flows in the network within a local area network), and self-organizing networking capabilities (e.g., developing network structures based on the needs of the customers and the capabilities of existing network structures), including advanced routing and forwarding schemes, that are independent of underlying networks.

The NGSON architecture provides advanced service and transport-related functions to support context-aware, dynamically adaptive, and self-organizing networks. This standard specifies a functional architecture for NGSON. The functional architecture consists of a set of functional entities (FEs), their functions, reference points, and information flows to illustrate service interaction and media delivery among FEs and external components.

NGSON may operate with different underlying networks such as IP Multimedia Subsystem (IMS), next generation network (NGN), peer-to-peer (P2P) overlay, or Web to transmit NGSON signaling messages and/or media among its users and services. Specifications of underlying networks are outside scope of this standard.

1.2 Purpose

The purpose of this standard is to enable network operators, service/content providers, and end users to provide and consume composite services by the deployment of context-aware, dynamically adaptive, and self-organizing networking capabilities.

2. Definitions, acronyms, and abbreviations

2.1 Definitions

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions* should be consulted for terms not defined in this clause.¹

abstract service request: A message containing generic information about the properties of the destination of service (e.g., keyword, service class) without a concrete service address.

base service: A service that cannot be further decomposed, and it does not contain other services.

composite service: A service that is composed of more than one service that can be a base or composite service. It contains an execution sequence of the composed services.

context: Any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and a service, including the user and services themselves.

context information: Context that is aggregated and processed to be used for context-aware functionalities in Next Generation Service Overlay Network (NGSON).

context source: An entity that provides context to Next Generation Service Overlay Network (NGSON) such as end-user functions, service, underlying network, and NGSON functional entities (FEs).

global ID: An identity (ID) that is provided by Next Generation Service Overlay Network (NGSON) to uniquely represent a user independent of service providers or services.

local ID: An identity (ID) that uniquely represents a user in a specific service or service provider.

NGSON node: The computer resources (e.g., servers) that can host one or more Next Generation Service Overlay Network (NGSON) functional entities (FEs).

peer-to-peer (P2P): A system where entities share their resources to provide a designed service without central co-ordination by any entity of the system.

routing information: A set of information that is used for service routing (e.g., service identity, service address).

service: A set of functions provided by software or a system, usually accessible through an application programming interface (API). The service publishes its description information to a service directory and registers to a service registry before providing the service functionality.

¹ The *IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at <http://shop.ieee.org/>.

service class: A set of services that provide the same or similar functions (e.g., map services involving different map service providers belong to one service class).

service roaming: A service in a location that is different from the home location where the service was published.

service routing: Procedures of sending a service request to services where this request can be satisfied.

2.2 Acronyms and abbreviations

3G	3rd Generation
3GPP™	3rd Generation Partnership Project ²
AP	access point
API	application programming interface
AS	Application Server
BPEL	Business Process Execution Language
BSS	business support system
CA-SNS	context-aware-social network service
CD FE	content delivery functional entity
CIM FE	context information management functional entity
CPU	central processing unit
CRM	customer relationship management
EIA	event integration and adaptation
EUF	end-user function
FE	functional entity
FHTML	Fluid Hyper Text Markup Language
FQL	Facebook Query Language
FTP	File Transfer Protocol
GPS	Global Positioning System
HDTV	high definition television
HSS	Home Subscriber Subsystem
HTML	Hyper Text Markup Language
HTTP	Hyper Text Transfer Protocol
I-CSCF	Interrogating-Call Session Control Function
ID	identity
IDM FE	identity management functional entity
IDP	identity provider

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IM	instant messaging
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IP-CAN	IP Connectivity Access Network
JSON	JavaScript Object Notation
ME	managed element
MMS	Multimedia Messaging Service
NGN	next generation network
NGSON	Next Generation Service Overlay Network
OCS	online charging system
OM FE	operation and management functional entity
OSA	Open Service Architecture
OSS	operation support system
P2P	peer-to-peer
PCC	Policy and Charging Control
PCRF	Policy and Charging Rule Function
P-CSCF	Proxy-Call Session Control Function
PSTN	public switched telephone network
QoS	quality of service
RA-NMS	Remote Autonomous-Network Management Service
REST	Representational State Transfer
RFID	radio frequency identification
RSS	Really Simple Syndication
RSS	received signal strength (related to user device)
RTSP	Real-Time Streaming Protocol
SA	service agents
SC FE	service composition functional entity
SCIM	Service Capability Interaction Manager
S-CSCF	Serving-Call Session Control Function
SDN FE	service discovery and negotiation functional entity
SDO	standards development organization
SDP	service description part
SIM	Subscriber Identity Module
SIP	Session Initiation Protocol
SLA	service level agreement
SLF	Subscriber Location Function
SMS	Short Message Service

SNS	social network service
SOAP	Simple Object Access Protocol
SP FE	service portal functional entity
SPD FE	service policy decision functional entity
SPI	Service Provider Interface
SR FE	service routing functional entity
SReg FE	service register functional entity
SRI	service requesting interface
SSO	single sign on
TR	technical report
TV	television
URL	Uniform Resource Locator
VoD	video on demand
VoIP	Voice over Internet Protocol
WS	Web service
XML	eXtensible Markup Language
XPS	hybrid positioning system
XQuery	XML Query

3. General

This standard specifies a functional architecture for a NGSON that provides advanced service and transport-related functions to support context-aware, dynamically adaptive, and self-organizing networks. NGSON provides a framework and necessary functions to support IP-based service overlay networks, potentially in the evolving work on cloud networks.

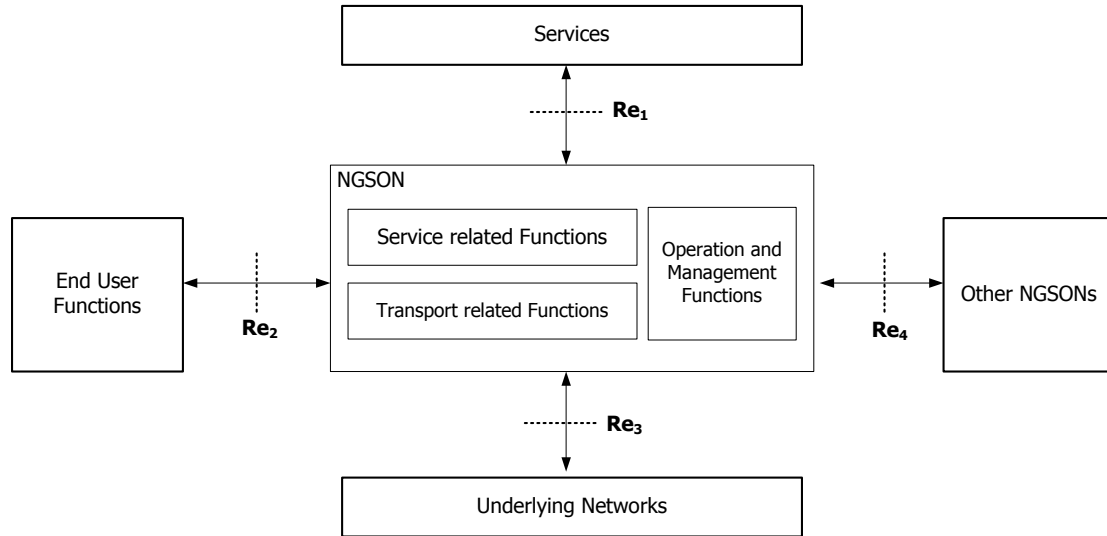
The NGSON includes service-related, transport-related, and operation and management functions. NGSON interacts with external components such as services, end-user functions, underlying networks, and other NGSONs. As shown in Figure 1, NGSON interacts with identified components such as services, end-user functions, underlying networks, and other NGSONs served by different NGSON providers. NGSON may operate with different underlying networks such as IMS, NGN, P2P overlay, or Web to transmit NGSON signaling messages and/or media among its users and services. Specifications of these external components are outside the scope of this standard.

This functional architecture specification is intended to provide the necessary information for the next stage of the standardization process where interfaces and protocols will be specified and standardized. While the functional architecture may allude to these interfaces and protocols, such physical interfaces and protocol specification are outside scope of this standard.

The standard is structured to focus on the functional architecture of NGSON. After introducing a reference diagram, the document provides detailed specifications for FEs, reference points, and information flows. The document also provides a description on the interaction of NGSON with IMS, P2P, and Web.

4. Architecture

Figure 1 illustrates a high-level overview of NGSON's functional architecture and shows various supporting functions and external reference points for interacting with external components.



Re₁ : External Reference point between Services and NGSON
Re₂ : External Reference point between End User Functions and NGSON
Re₃ : External Reference point between Underlying Networks and NGSON
Re₄ : External Reference point between other NGSONs

Figure 1—Overview of NGSON functional architecture

The NGSON functions are divided into *service-related functions*, *transport-related functions*, and *operation and management functions*. The service-related functions correspond to those functions that interact primarily with other service control functions such as service registry, service discovery, service composition (SC), and service routing. The transport-related functions are those functions that support service delivery including network context-aware routing, traffic optimization, resource scheduling, and interworking with underlying networks. The operation and management functions provide management supports such as service management, lifecycle management, and service assurance.

As shown in Figure 1, NGSON provides four external reference points for interactions and exchanges of service signaling and media delivery with identified components such as services, end-user functions, underlying networks, and other NGSONs served by different NGSON providers.

- Re₁—The reference point for applications and services to access NGSON. Using this reference point, third party service providers can publish their own contents or services to NGSON, request authentication and authorization of service and user, and deliver content and service. To perform these functions, the protocols on this reference point may use existing protocols, e.g., Hyper Text Transfer Protocol (HTTP), Session Initiation Protocol (SIP), Simple Object Access Protocol (SOAP).
- Re₂—The reference point for end-user functions to access and utilize NGSON functions. Using this reference point, end-user functions can request content delivery, activate and deactivate content published in NGSON, and register and deregister the global ID of user. This reference point can utilize the existing interfaces and the relevant protocols, e.g., HTTP.

- c) Re_3 —The reference point for NGSON to interact with the underlying networks (e.g., IMS, NGN, legacy IP networks, P2P overlay networks) for data delivery and policy enforcement. This reference point can utilize the existing interfaces and the relevant protocols, such as SIP and Diameter protocols in other standards development organizations (SDOs).
- d) Re_4 —The reference point for NGSON to interwork with other NGSONs served by different NGSON operators. Using this reference point, NGSON operators can exchange data for both policy and charging systems, check authentication and authorization of user and service, and implement federation of basic services between different NGSON operators. The protocols on this reference point are the same as the corresponding protocols on the reference points in the internal NGSON served by one operator and are recommended to be standardized.

4.1 Architecture diagram

The text in this subclause is to be considered normative with the following understanding. The features in this subclause are to be considered *optional*, but if used, the feature *shall* be used as described, i.e., *mandatory*.

Figure 2 provides a *reference diagram* for the NGSON functional architecture. The diagram identifies a set of *functional entities* (FEs) and relationships to show how these FEs are connected to each other. A relationship (also called *reference point* between two FEs) in the reference diagram indicates that two FEs involved can interact and exchange messages.

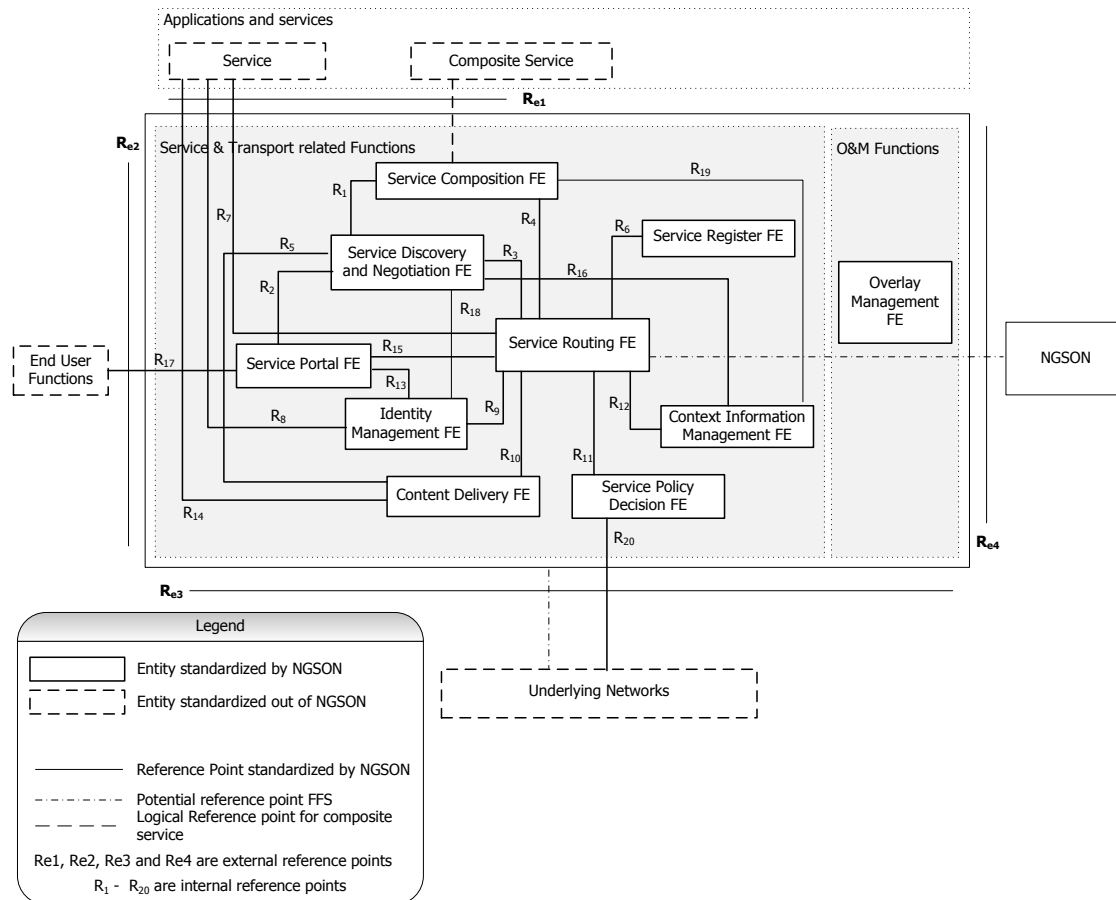


Figure 2—NGSON reference diagram

NOTE 1—In Figure 2, Re_3 represents more reference points described in Clause 5.³

NOTE 2—In Figure 2, R_{14} is media connection.

4.2 Functional entities

The text in this subclause is to be considered normative with the following understanding. The features in this subclause are to be considered *optional*, but if used, the feature *shall* be used as described, i.e., *mandatory*.

4.2.1 Service composition (SC) FE

SC FE is responsible for execution of composite services. The service logic of a composite service is developed for NGSON off-line. The service logic may consist of service execution flow and specific rules for the change of execution flow.

SC FE supports static and/or dynamic service composition. A static SC is accomplished during a service design and pre-provisioned before runtime while a dynamic SC is accomplished during a runtime.

Dynamic SC can mean either (1) dynamic service chaining, or (2) dynamic service instantiation. Dynamic service chaining decides at the runtime how to chain base services in an appropriate order to deliver a desirable composite service. Dynamic service instantiation uses abstract service logic to discover a concrete service at runtime. In this case SC FE obtains the specific services according to abstract service logic and invokes the specific services during the service execution.

If one of the base services of a composite service does not work, SC FE will find another base service to replace the original one by interacting with other FEs.

The SC FE provides the capability for SC (both static and dynamic) as follows:

- Choice of the type of composition
 - Choose between static and dynamic SC (dynamic service chaining and dynamic service instantiation)
- Choice among existing services
 - Allow concrete and abstract services as base services
- Choice of how to manage the process of composition
 - Done via a specification for service chaining and a specification for abstract services
- Optimize the composition sequence
 - Choose among many feasible chaining orders or concrete services for the one with best performance

The main functions of SC FE are described as follows:

- a) Service brokering function

³ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

- Supports static and dynamic SC, which include static service chaining, dynamic service chaining, static service instantiation, and dynamic service instantiation based on semantics and context information.
 - Allows the use of concrete and abstract services as base services.
 - Controls the process of composition via a specification for SC.
 - Supports dynamic service instantiation by using the service negotiation function of service discovery and negotiation (SDN) FE.
 - Processes service chaining based on the stored specification.
- b) Specification interpretation function
- Interprets the specification of SC to perform either static or dynamic composition (dynamic service chaining and dynamic service instantiation) of base services accordingly.
- c) Composite service adaptation function
- Maintains the functionality of the created SC using recomposition, including but not limited to, when any included base service fails or when the interfaces of the base services are modified in SDN FE.
 - Optimizes the composition sequence by choosing the best performance among the feasible chaining orders or feasible concrete services.
 - Supports the mechanism to receive the context information and provides uninterrupted execution of the composite service.
- d) Charging event supporting function
- Supports reporting charging information to the charging system.

NOTE—Charging system is out of scope of NGSON.

Figure 3 depicts the main functions of SC FE.

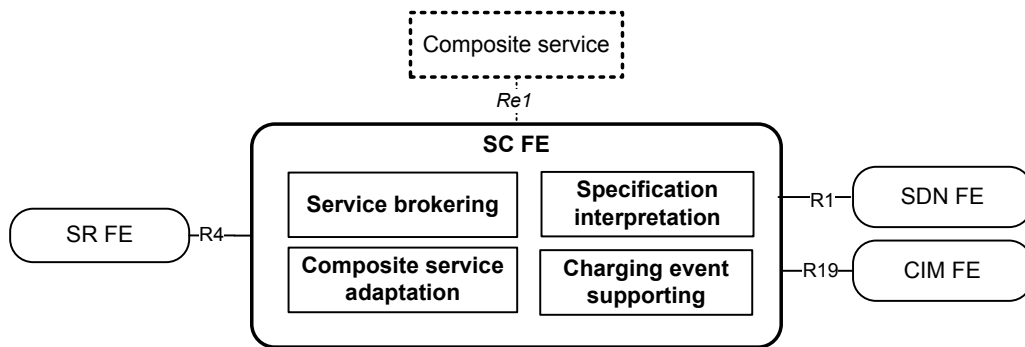


Figure 3—SC FE block diagram

During the SC phase, this FE can send the service discovery request with service information to the SDN FE and receive the service selected by SDN FE.

During the execution of a composite service, SC FE holds the created SC specification. If the composite service cannot continue for some reason such as a failure of one or more of the service components, SC FE performs a recomposition to provide the same service by replacing the failed service component or components.

For media services that continue during a period but fail the QoS specification, SC FE may provide recomposition of composite services by replacing service components causing the QoS failure with new components in order to assure the requested QoS/service level agreement (SLA) is met.

4.2.2 Service discovery and negotiation (SDN) FE

SDN FE supports discovery and negotiation of services using the service information published in NGSON. Accordingly, the end users and NGSON FEs can get appropriate services according to given criteria.

For this purpose, the service information should be published to NGSON, and the publication of service information is out of scope of this standard. SDN FE stores and manages the static information of services during the service lifecycle, for example, interface, provider, service class, service template, service name, SLA, and QoS capabilities.

The main functions of SDN FE are described as follows:

- a) Service discovery function
 - Provides a service matching mechanism to find services according to given service criteria or context information.
 - Provides a service selection mechanism to choose the appropriate services from a number of the discovered services based on the context information or ranking information.
 - Generates a list of similar or relative services and return to the requester based on the service identity and service criteria given by the requester.
 - This function can get the context information from context information management (CIM) FE and ranking information from service register (SReg) FE via service routing (SR) FE.
- b) Service negotiation function
 - Provides a mechanism for service negotiation by sending the service request to multiple destinations, and then selecting the most suitable service based on the responses and the user profile.
- c) Service subscription and notification function
 - Provides a mechanism to support subscription to the service information and corresponding notification.

End users and services subscribe the service information through service portal (SP) FE and SR FE.

The service subscription and notification function receives service subscription requests with the corresponding service identity to allow the end user or other services to be notified about the addition or change of the services.

In addition, SDN FE can generate a list of similar or related services and return it to the requester when the requester subscribes to the service information. Upon receiving the subscription, SDN FE will get the service information and its related service information based on the service identity from the request and generate a recommended service list.

- d) Content location discovery function
 - Retrieves and updates the location of the content for optimizing the content delivery.

Figure 4 depicts the main functions of SDN FE.

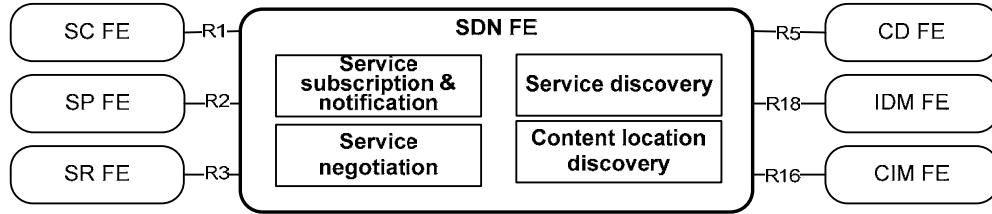


Figure 4—SDN FE diagram

4.2.3 Service routing (SR) FE

SR FE provides the service routing capability in NGSON based on static and dynamic service information. The service routing capability supports end users or services in requesting the interaction with other services. This capability examines the request message and utilizes the information from other FEs to provide service routing.

The main functions of SR FE are described as follows:

a) Service routing function

- Provides routing mechanisms for interaction between services and end users in NGSON. When it receives a service request message, it analyzes the service request by resolving the destination service information (e.g., service address, service class) and forwards the message to its ultimate destination.
- Provides intelligent routing mechanisms based on the context information to process the service requests and route the message to one or multiple destination services and provides the response to the requester.
- Supports message routing mechanisms between the SC FE and the services that constitute the created composite service. During execution of a composite service, each service that constitutes the composite services will inform the SC FE of the status of the service.
- Interacts with other NGSON FEs during service routing including:
 - Querying service static information from SDN FE during intelligent routing.
 - Retrieving service status information from SReg FE to support service routing decision.
 - Providing a mechanism to request identity management (IDM) for retrieving user profile, authentication and authorization requests, and identity mapping requests to enable the security aspects of NGSON.
 - Querying context information from CIM FE. Those contexts can assist the SR FE make routing decisions.
 - Interacting with the content deliver (CD) FE in delivering the content as requested by an end user or service.
 - Interacting with the SC FE in delivering a composite service as requested by an end user or service.

b) Self-organization supporting function

- Supports self-organization along with other NGSON FEs to form and dynamically adapt the overlay network for context changes. It also supports context awareness and dynamic adaptation along with other NGSON FEs.

- c) Service QoS dispatching function
 - Dispatches service QoS requirements to the service policy decision (SPD) FE.
- d) Charging event supporting function
 - Supports charging by reporting usage information to the charging system.

NOTE—Charging system is out of scope of NGSON.

Figure 5 depicts the main functions of SR FE.

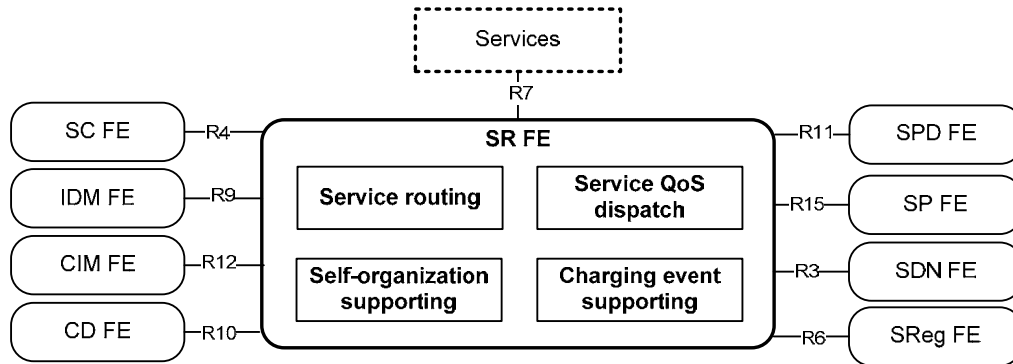


Figure 5—SR FE block diagram

SR FE supports the service routing or content routing according to the requests received. For service routing, SR FE obtains the information from SDN FE and SReg FE, and forwards the service request. For content routing, SR FE forwards the content request to CD FE and then CD FE obtains the information of content from SDN FE.

4.2.4 Service register (SReg) FE

SReg FE provides the dynamic information of services to NGSON FEs by handling registration and maintenance of service dynamic information. SReg FE assists SR FE to discover where and how to route a service request. It maintains current location information of the service, so that SR FE can forward the service request to the service provider when service is roaming.

Examples of the dynamic information about a service are as follows:

- Service address, logical address encoded by NGSON, e.g., service1.example.com
- Service IP address and port number
- Service roaming status, i.e., whether the service is in roaming
- Service rate information that may change dynamically
- Service unavailability information, e.g., in certain region and at certain time
- Service performance information
- Service promotion information, e.g., special discount from a service provider
- Dynamic service policy such as services only available to those who make a reservation ahead of time
- Service ranking information, e.g., statistics of ranking by the user community

- Service priority information, e.g., the service will be treated with high priority under network congestion

The main functions of SReg FE are described as follows:

- a) Retrieval and update function
 - Provides a mechanism to support service registration.
 - Provides a mechanism to retrieve, update, and delete the dynamic information of a service.
- b) Service address mapping function
 - Supports mapping between service address and service IP address and port number.

Figure 6 depicts the main functions of SReg FE.

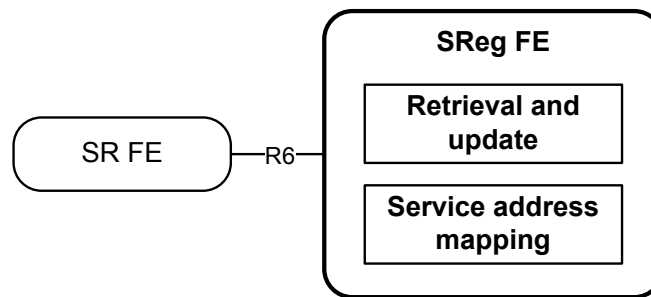


Figure 6—SReg FE block diagram

4.2.5 Identity management (IDM) FE

The IDM FE provides mechanisms to authenticate and authorize the identities of end users and services.

The authentication and authorization in IDM FE is categorized into two levels, i.e., user level and service level. User level identity management deals with determining the identity of the user and the appropriate agreements to use a service. Service level identity management deals with determining the identity of the service and the appropriate agreements to use other services in NGSON.

NGSON uses the global ID for an end user to sign in to multiple services, without needing to create service specific IDs and passwords, i.e., to achieve *single sign on* (SSO) ability. IDM FE provides mechanisms to map the local ID to global ID and local ID to another local ID.

IDM FE manages user profile information of the end user.

The main functions of IDM FE are described as follows.

- a) Authentication and authorization function
 - Provides mechanisms of user level and service level identity control and management, which authenticate and authorize the user identity and service identity.
 - Provides mechanism for user identity control and management based on groups or communities.
 - Supports user authentication and authorization mechanism using global ID.

Authentication means determining the identity of an entity, e.g., by providing an identity credential. The authentication for NGSON means determining the identity of an end user or service before this end user or service can utilize NGSON.

Authorization means approving the end user or service based on a policy or agreement to resolve the rights to the service in NGSON. The rights are governed by the policy or agreement on an identity. Note that it is required to authenticate the identity of end users before an end user is authorized to use the service.

The authentication and authorization function also supports authorization process for an end user based on the user identity and associated group membership. It provides mechanisms to verify if an end user belongs to a group based on the group information (e.g., group members, group description) that is stored in IDM FE or is retrieved from other services according to the user identity.

In order to support SSO, the information of ID provider (IDP) should be included in the IDM FE.

b) ID mapping function

- Provides mechanisms for recognizing different kinds of identities in NGSON, such as global ID, local ID, and temporary ID.
- Provides mechanisms for mapping among global ID, local ID, and temporary ID.

Global ID is the identity used in the whole NGSON. When an end user or service is registered to NGSON, the service authenticates the user using the global ID. Local ID is effective only within the scope of a service provider, and temporary ID is mainly used for the purposes of anonymity/pseudonym.

The ID mapping function provides the mapping from global ID to local ID to the service provider when the end user provides the global ID but the service provider requested the local ID. This function also provides the mapping from temporary ID to local ID to global ID when the user only provides the temporary ID to preserve anonymity and the service provider requested the local ID or global ID to get the user profile. When a service requests another services on behalf of the user, the ID mapping function provides the necessary ID mapping.

c) User profile management function

- Finds the location of the user profile for a specific user.
- Provides mechanisms to retrieve and aggregate the end-user information from the user profile service.

Using the authentication and authorization function, the user profile management function performs the discovery and access control for the user profile. It receives the user profile request and retrieves the user profile information from the intended user profile service. It also allows the owner to manage their user profile, such as creating or updating the user profile, or authorizing the access rights to the user profile.

Figure 7 depicts the main functions of IDM FE.

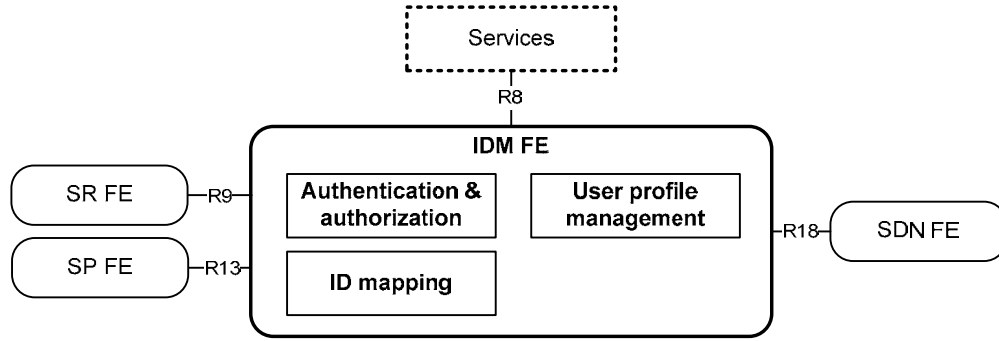


Figure 7—IDM FE block diagram

User data model is a metadata structure for the user profile that can be used to express user-related information for identity management. A user data model describes one aspect or several characteristics of the user by a set of attributes organized in a formal data structure. Different user data models can be defined for different purpose or different types of user though they may have some common attributes, such as name and age. To interwork among different services, user data models are required.

An example of the user data model is described in B.8.

4.2.6 Context Information Management (CIM) FE

CIM FE dispatches context information to services and the other NGSON FEs to support their context-aware operations. This context information is obtained by aggregating the context from various context sources or by further processing the context. CIM FE deals with different types of context including service context, user context, device context, and network context. These contexts are provided by context sources, i.e., end-user function, underlying network, service, and NGSON FEs.

The main functions of CIM FE are described as follows:

- a) Context aggregation function
 - Provides context collection from different context sources.
 - Provides context monitoring that monitors the changes of context and context source state for context-aware operation.
 - Supports publication of context source information to associate context sources to specific context.
- b) Context process function
 - Provides modeling of different types of context to perform the transformation and filtering of context data.
 - Provides mechanism to derive high-level implicit context information from various context data, performs the integration of different types of context information, and generates the interpretation of those integrated context.
 - Provides reasoning of context information through comparing with and estimating not only context information but also stored reference data, which are obtained by managing context information.

c) Context dispatch function

- Provides dispatch mechanism of the context information to the requesting FEs and services. The context information is obtained from the context process function or the context aggregation function.

The context dispatch function supports two possible ways of context delivery from CIM FE to context requesters: request/reply based context delivery and subscription/notification based context delivery. The request/reply base context delivery is a mechanism that delivers the context information when CIM FE is asked by context requesters. The subscription/notification based context delivery is a mechanism that delivers the context information when the context is changed by context sources. The notification is transmitted to context requesters that have subscribed to the context.

Figure 8 depicts the main functions of CIM FE

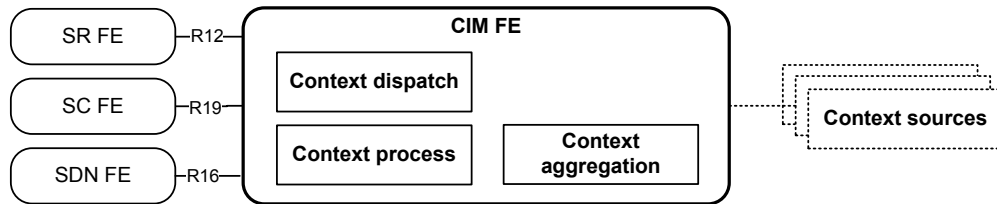


Figure 8—CIM FE Diagram

SR, SDN, and SC FEs utilize context information dispatched from CIM FE. The requesting FEs use predefined context information format when requesting for the context information. The context information format can be simple or complex. The complex format is in the form of multiple contexts connected with logical expressions whereas the simple format contains only one context. For complex format, the context dispatch function provides the context information based on the logical expression in the request.

CIM FE supports safe and efficient context publication or withdrawal. As the use of context is related to privacy policy, context protection mechanisms such as context source security are required.

Context sources can be any kind of relevant software and hardware [such as monitoring software, GPS devices, sensor nodes or sinks, radio frequency identification (RFID) readers, access point] that can provide the context related to the user, the service, the device, and the network.

The interfaces of the aggregating function are highly dependent on the details of the context sources.

4.2.7 Content Delivery (CD) FE

CD FE supports content delivery from a service to another service, from a service to an end user, from an end user to another end user, or from an end user to a service. CD FE performs cache and forward functionalities. This FE also supports requirements for content adaptation when the source content is in a different format than what the requester can accept. CD FE receives content from the content provider, stores, aggregates, and sends it to the service requester over underlying networks.

The main functions of CD FE are described as follows:

a) Content receive function

- Provides mechanism to select a cache or permanent storage and receive content from content sources (i.e., services or end users).
 - Maintains information about cached contents to deliver the same contents as those it has already cached.
 - Updates the location information of the contents to SDN FE at discovery of new location of the contents for optimizing content delivery.
 - Provides distribution policy control mechanism that coordinates the storage and delivery resources, and establishes optimal distribution policy for storage functions. The distribution policy can be different for delivery of files or streams.
- b) Content aggregation function
- Provides cache or storage to store the content from content sources.
 - Provides merging and synchronization mechanism of multiple incoming contents over network.
 - Provides distribution mechanism that transmits content to the content send function.
- c) Content send function
- Provides delivery of contents from the content aggregation function to services or end users by unicast or multicast using the channel managed by SPD FE.

Figure 9 depicts the main functions of CD FE.

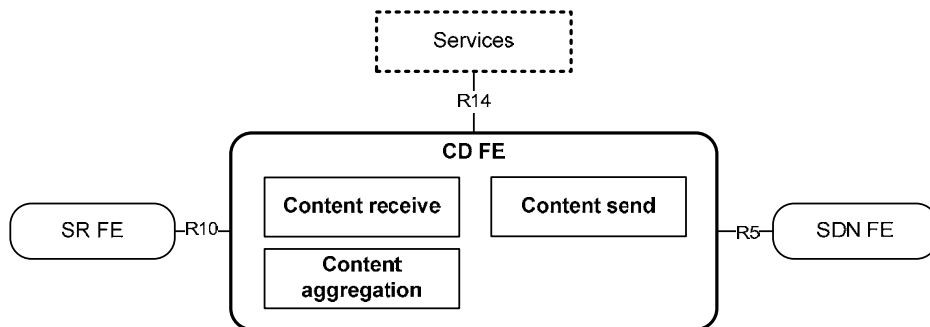


Figure 9—CD FE block diagram

Different types of cache functions with multiple protocols, for example, HTTP, File Transfer Protocol (FTP), P2P (such as BitTorrent), and Real-Time Streaming Protocol (RTSP), can be supported in NGSON.

4.2.8 Service Policy Decision (SPD) FE

SPD FE provides QoS control in the NGSON. It is responsible for QoS negotiation and assurance during service interaction. SPD FE extracts the service QoS requirement from service request and apportions it into service-related QoS and transport-related QoS requirements. SPD FE inspects the resource state of the service providers, monitors the service-related QoS in the service level and sends the transport-related QoS to the underlying networks.

SPD FE is also responsible for determining an efficient service delivery path using the relevant network context information such as routing distance, link state, traffic flow. The service delivery path selected is sent to the underlying networks.

The main functions of SPD FE are described as follows:

a) Service QoS requirement dispatch function

- Provides mechanism to analyze the service QoS requirement from the service request and derive the service-related QoS.

In NGSON, the service request may only imply that it has a QoS requirement without detailed QoS parameters. Hence, the service QoS requirement dispatch function provides mechanism to analyze the service QoS requirement from the service request and derive the service-related QoS.

b) QoS negotiation function

- Determines if the service provider can meet the service-related QoS requirement based on the resource state of the service provider.
- Provides the QoS admission control by accepting or rejecting the service request.
- Selects the service provider that can best meet the service-related QoS requirement based on the resource states of the several service providers corresponding to an anycast service address.

The QoS negotiation function provides a mechanism to determine whether the service provider can meet the service-related QoS requirement based on the resource state of the service provider, including QoS information, such as payload rate, response time, and bandwidth. In addition to utilizing QoS control policy, the QoS negotiation function makes the QoS admission control decision for the service request. If the service-related QoS can be met, then the service request is accepted; otherwise the service request is rejected.

In case that more than one service provider can meet the service-related QoS requirement, this function also provides a mechanism to choose the service provider with minimum payload rate, the service provider with minimum response time, or a random service provider. If several service providers offer the same type of service, the service provider's address can be an anycast service address.

c) Resource state monitoring function

- Provides a mechanism to get the resource state of the service provider(s) by querying underlying networks or the service providers.
- Provides monitoring of service QoS and provides the QoS admission control based on the monitoring result.

The resource state monitoring function either provides a mechanism to get the resource state of the services from the underlying networks or sends request to services through SR FE. Based on the results of this query, the service provider reserves resources.

d) QoS enforcement function

- Provides transport-related QoS enforcement mechanism that requests underlying networks to provide a specific QoS by interacting with the QoS-related entity in underlying networks.

Figure 10 depicts the main functions of SPD FE.

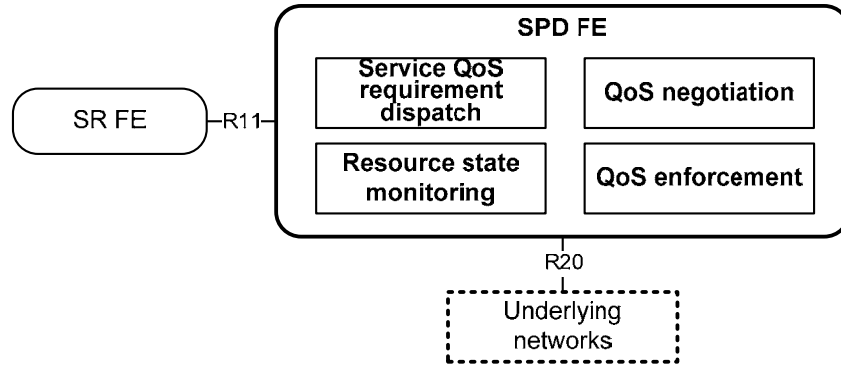


Figure 10—SPD FE block diagram

The QoS enforcement function interacts with QoS-related entity in underlying networks for transport-related QoS enforcement. Because of limited network resources, it is possible that the QoS-related entity in underlying networks rejects the request of service QoS requirement or allocates a new acceptable QoS. If underlying networks cannot meet the QoS requirement, SPD FE makes the QoS admission control for the service request. If the service is QoS-assured, the service request is rejected. If the service is best-effort, the QoS enforcement function makes a decision on acceptance or rejection of the new QoS allocated by the underlying networks or determines a new QoS requirement for the service and resends it to the underlying networks.

4.2.9 Service Portal (SP) FE

The SP FE is an entity that allows users to access NGSON. This FE provides interfaces to register the global ID of users, authenticate the service request, request content delivery, and activate or deactivate service published in NGSON. Note that the end-user function is outside the scope of this document.

The main functions of SP FE are described as follows:

- a) Portal function
 - Provides interfaces to support the end user in subscribing to NGSON services in real time and register the global ID of users.
 - Provides a mechanism to support forwarding requests to SR FE, e.g. content delivery requests and service requests.
 - Provides a mechanism to render the information of services available in SDN FE.
- b) Log-on function
 - Provides the a mechanism to process the user log-on request, maintain the log-on session and provide the background process for user SSO operation.
 - Provides interfaces to support the authentication of service requests.

Figure 11 depicts the main functions of SP FE.

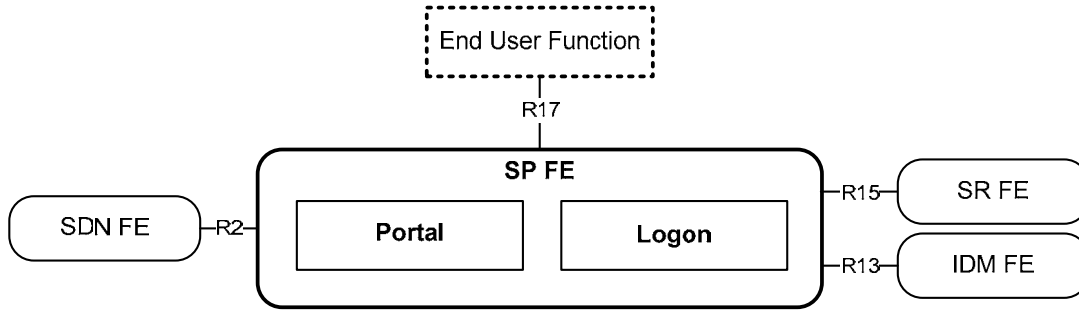


Figure 11—SP FE block diagram

4.2.10 Overlay Management (OM) FE

OM FE provides the management capability for NGSON nodes and FE instances. It manages the static information of an NGSON node such as the node capabilities, capacities, and location. OM FE monitors the dynamic information of an NGSON node such as available resources and node status. It also manages the static information of an FE instance such as location in NGSON nodes and monitors the dynamic information of an FE instance such as FE status, FE performance, and workload. Using this information about NGSON nodes and FE instances, OM FE can assign or modify the role of an NGSON node by activating or deactivating some FE instances on NGSON nodes.

The main functions of OM FE are described as follows:

- a) Overlay management
 - Manages the static information of NGSON nodes and FE instances, and negotiates their capabilities.
- b) Node monitoring
 - Monitors the dynamic information of NGSON nodes (e.g., status and available resources).
- c) FE instance monitoring
 - Monitors the dynamic information of FE instances (e.g., status and performance).
- d) Role assignment and modification
 - Reconfigures NGSON nodes by activating or deactivating FE instances on them.

Figure 12 depicts the main functions of OM FE.

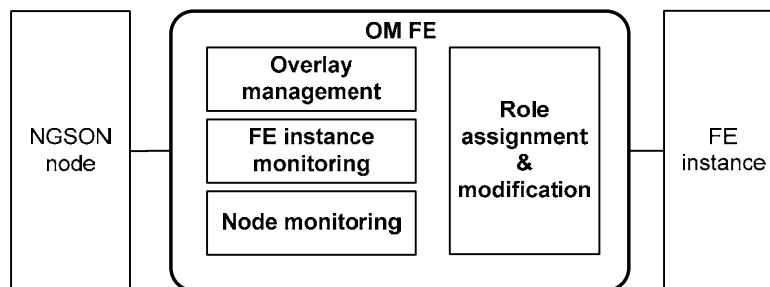


Figure 12—OM FE block diagram

The overlay management function manages the overlay network of NGSON nodes and FE instances. The NGSON operator can deploy more NGSON nodes in the overlay network to increase the availability and performance of the network. If a new NGSON node is installed, it first registers itself to the overlay network by interacting with the overlay management function. Once registered, the static information about an NGSON node (e.g., capability, capacity, and location) is stored and maintained. When a new FE instance is activated on an NGSON node (i.e., a role assignment of an NGSON node), the static information about the FE instance (e.g., location and capacity) is maintained.

The node monitoring function dynamically monitors the dynamic information about each NGSON node (e.g., available resources and status). The monitoring result is utilized to update the NGSON node information or to modify the roles of the node by activating or deactivating the FE instances on the node.

The FE instance monitoring function dynamically monitors the status and QoS of FE instances. The information of FE instances (e.g., status and QoS) is utilized for role modification of an NGSON node.

The role assignment and modification function makes a decision to reconfigure the NGSON nodes by activating or deactivating the FE instances on the NGSON nodes. If an FE instance does not provide adequate QoS, the role assignment and modification function balances its load by redirecting requests to another FE instance or avoids using it by replacing the FE instance with other ones. The role assignment and modification function also activates or deactivates the FE instances dynamically. If an NGSON node comes to be overloaded or experiences a failure, this function balances the load on the node or recovers the failure by replacing some or all of the FE instances on the node with those instances on other nodes.

4.3 Reference points

The text in this subclause is to be considered normative with the following understanding. The features in this subclause are to be considered *optional*, but if used, the feature *shall* be used as described, i.e., *mandatory*.

This subclause provides a list of reference points designating the two-way logical relationship between two or more functions.

R1 (SC FE – SDN FE)

- SC FE requests SDN FE for service static information, service discovery, and service negotiation.

R2 (SP FE – SDN FE)

- SP FE requests SDN FE for service discovery to render services to end user.
- SP FE forwards the service subscription request to SDN FE and returns the notification.

R3 (SDN FE – SR FE)

- SR FE requests the service static information from SDN FE.
- SR FE requests SDN FE for service discovery and negotiation.

R4 (SC FE – SR FE)

- SC FE requests SR FE to invoke base services.
- SR FE requests SC FE for composite service and corresponding service responses.

R5 (CD FE – SDN FE)

- CD FE requests and updates the location of content from (to) SDN FE.

R6 (SR FE – SReg FE)

- SR FE retrieves service status information from SReg FE.
- SR FE forwards the service registration request to SReg FE.
- SR FE forwards the service status request to SReg FE.

R7 (SR FE – Service)

- SR FE routes service request to appropriate services.
- SR FE receives the service responses from services.

R8 (IDM FE – Service)

- Service requests IDM FE for user authentication and authorization.
- Service requests IDM FE for service authentication and authorization.
- Service requests IDM FE for user profiles.

R9 (IDM FE – SR FE)

- SR FE requests IDM FE for retrieving the information of user profile.
- SR FE requests IDM FE for authentication and authorization of end user and service.
- SR FE requests IDM FE for ID mapping.

R10 (CD FE – SR FE)

- SR FE forwards the content delivery request from end users and services to CD FE.
- SR FE forwards the channel request of content delivery from CD FE to SPD FE.

R11 (SPD FE – SR FE)

- SR FE dispatches service QoS requirements to SPD FE.
- SR FE forwards the QoS monitoring request from the other NGSON FEs to SPD FE.

R12 (CIM FE – SR FE)

- SR FE requests the context information from CIM FE.

R13 (IDM FE – SP FE)

- SP FE requests IDM FE for user authentication and authorization.
- SP FE requests IDM FE for the user profile information.
- SP FE requests IDM FE for the registration of global ID of the user.

R14 (CD FE – Service)

- This is media connection used by CD FE to deliver contents from service to other services.
- This is media connection used by CD FE to receive contents from service.

R15 (SP FE – SR FE)

- SP FE forwards the service request from end-user functions to SR FE.

R16 (CIM FE – SDN FE)

- SDN FE requests the context information from CIM FE.

R17 (SP FE – End-user Function)

- End-user Function requests SP FE for service portals.
- End-user Function requests SP FE for log on.

R18 (IDM FE – SDN FE)

- SDN FE requests IDM FE for service authentication and authorization.

R19 (CIM FE – SC FE)

- SC FE requests the context information from CIM FE for composite service adaptation.

R20 (SPD FE – Underlying networks)

- SPD FE sends the transport-related QoS requirement to the QoS-related entities in the underlying networks.
- SPD FE receives the information of transport-related QoS from the underlying networks.

4.4 Service features of NGSON with information flows

This subclause describes different service capabilities of NGSON FEs with information flows. Subclauses 4.4.1 to 4.4.8 illustrate basic functionalities of NGSON such as service routing, service discovery, SC, so on., in order to show how NGSON FEs interact each other to perform their functions. Subclauses 4.4.9 to 4.4.11 illustrate advanced functionalities to show how NGSON FEs interact and cooperate to perform the context-aware, dynamic adaptive, and self-organized capabilities. According to the Figure 2, if there is a reference point between two functional entities, they can interact and exchange messages directly; and if there is no reference point, they should contact via SR FE.

Service Requester in the following flows signifies either end user, service, or any NGSON FE.

4.4.1 Service routing

4.4.1.1 Basic service routing

The information flow in Figure 13 illustrates how a service request is routed to target service provider via SR FE. In this case, the service address of target service is included in service request. The SReg FE maintains the dynamic service information to find out the corresponding service.

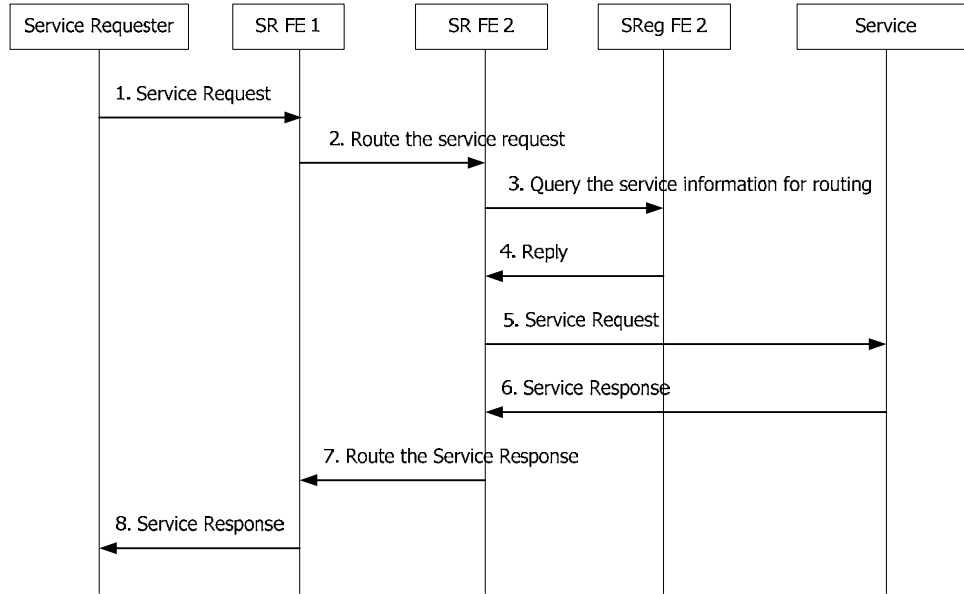


Figure 13—Flow of basic service routing

SR FE 1: SR FE (contacted)

SR FE 2: SR FE (home)

Flow description:

- 1) Service Requester sends the service request to SR FE 1 (contacted) with the service address.
- 2) SR FE 1 routes the service request to SR FE 2 [destination SR FE is SR FE (home)] according to the service address.
- 3) SR FE 2 queries Service Registry entity SReg 2 to get the exact details of the service for the requested routing.
- 4) Service Registry 2 replies to the query.
- 5) SR FE 2 forwards the service request to service provider in which the requested service is deployed.
- 6) Service Provider replies to the service request by sending the service response to SR FE 2.
- 7) SR FE 2 routes the service response to SR FE 1.
- 8) SR FE 1 forwards the service response from service provider to Service Requester.

4.4.2 Service discovery and negotiation

4.4.2.1 Service discovery

Service Requester can discover what services are published in the SDN FE by providing a service-related information request using the following discovery process. See Figure 14.

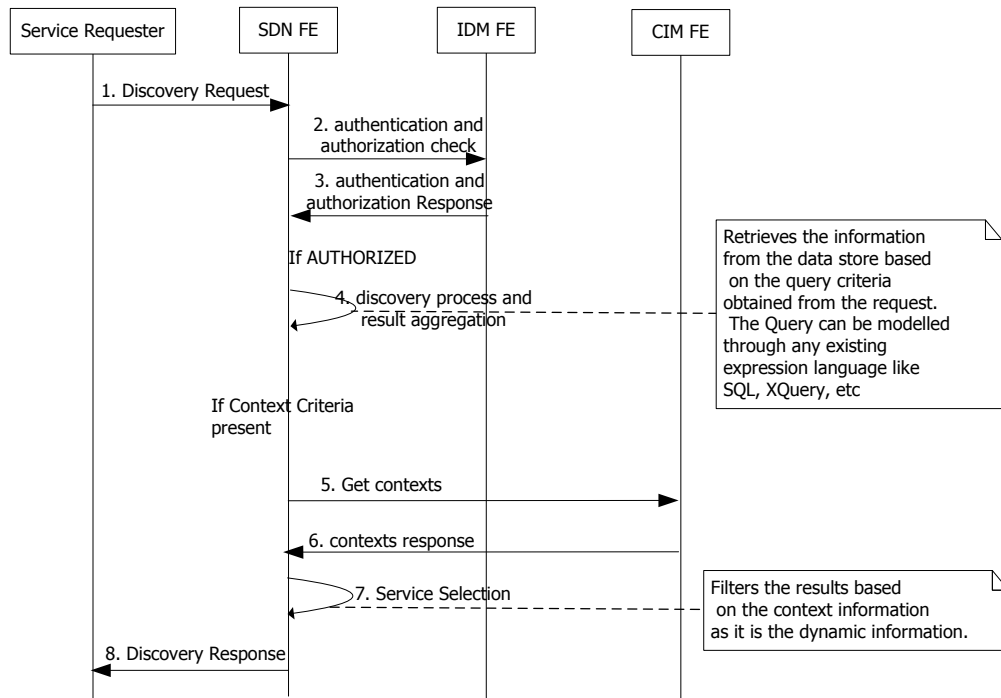


Figure 14—Flow of service discovery

Flow description:

- 1) A service discovery request is issued to SDN FE by a Service Requester of NGSON that includes criteria such as service interface, availability, QoS, SLA, version, network area (IMS/NGN or other network), and regional area.
- 2) The SDN FE authenticates and authorizes the identities of Service Requester via IDM FE.
- 3) The SDN FE receives the response of authentication and authorization from IDM FE and the request is processed upon successful authorization (this can be considered part of the SSO mechanism).
- 4) The SDN FE forms a query based on the criteria obtained from the request. This query is executed in the data store to retrieve the relevant information. The processed result is aggregated based on the query criteria.
- 5) If the discovery request consists of context (dynamic information) criteria, the SDN FE requests CIM FE to obtain the context information for the discovered services.
- 6) The CIM FE responds with the requested context information for the discovered services.
- 7) Based on the obtained context information, the SDN FE selects the appropriate services from the number of the discovered services.
- 8) The selected services are sent to the Service Requester.

4.4.2.2 Service subscription/notification

Service requester can subscribe to service information notifications by providing the service information as noted in request details in the subscription process. See Figure 15.

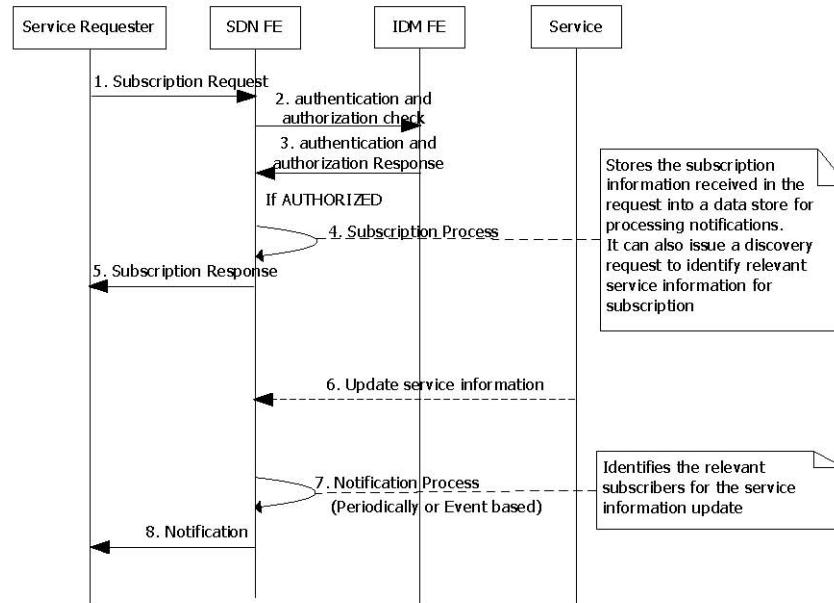


Figure 15—Flow of service subscription/notification

Flow description:

- 1) A Subscription Request is issued to SDN FE by Service Requester in NGSON that includes the relevant service information and relevant network contact address to receive notifications. The service subscription request can also include discovery criteria.
- 2) The SDN FE authenticates and authorizes the identities of Service Requester via IDM FE.
- 3) The SDN FE receives the response of authentication and authorization from IDM FE. Subscription request is processed upon successful authorization. (This can be considered part of the SSO mechanism.)
- 4) The SDN FE processes the subscription request in which it stores the association of service requester and the corresponding subscription information into a data store for processing notifications. It can also issue a discovery request to identify relevant service information for subscription.
- 5) A Subscription response is sent to the service requester.
- 6) Service provides an update to existing service information to SDN FE.
- 7) In SDN FE, the notification process is triggered either periodically or by an event (like the service information being successfully updated). The SDN FE retrieves the relevant subscribers for the updated service information.
- 8) The SDN FE sends the updated service information (asynchronously) using the contact information of the subscribed service requester.

4.4.2.3 Service negotiation

Service negotiation is a mechanism provided by SDN FE. SDN FE supports service negotiation by sending the service request to multiple destinations and then selecting the most suitable service based on the responses and the user profile.

SDN FE can negotiate a suitable service from candidate services based on the user profile stored in it. This information includes functional information of the service, dynamic information of the service, quality of the service, and any other context information that can be used as criteria for negotiating a suitable service. See Figure 16.

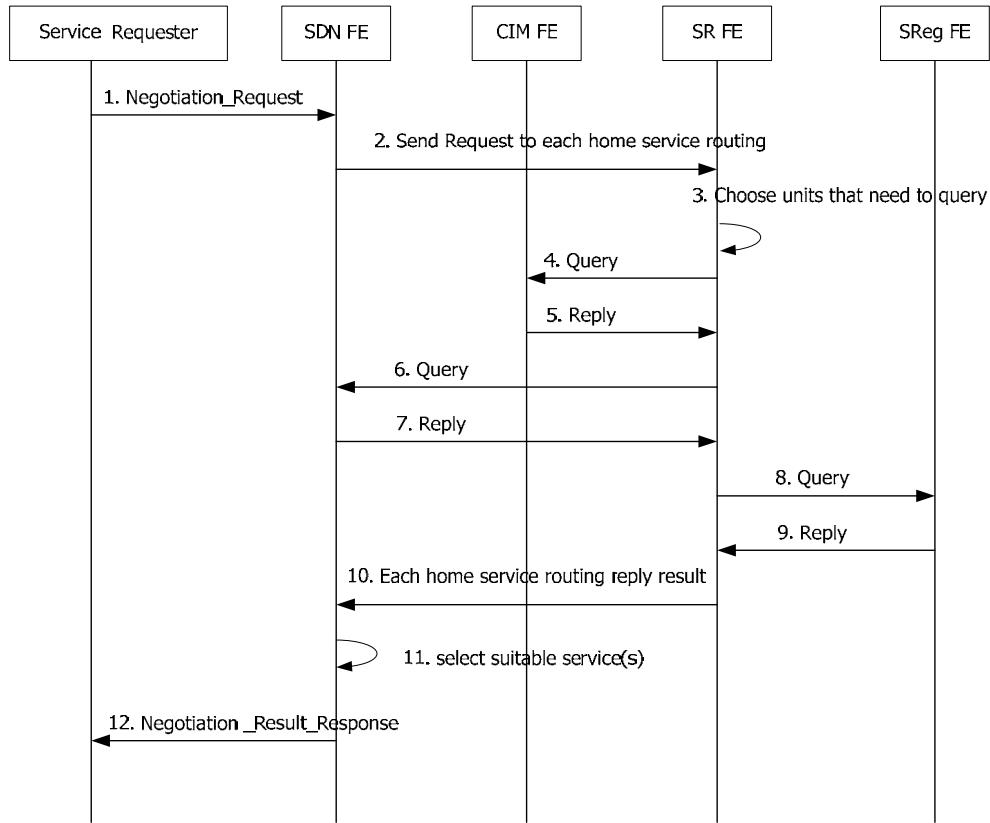


Figure 16—Flow of service negotiation

Flow description:

- 1) A service requester (SC FE/SR FE) sends service negotiation request to SDN FE to start the negotiation process.
- 2) SDN FE obtains the candidate services information from the requester. Based on that information, the SDN FE sends a request to the SR FE for each service to collect detailed service information such as rate, quality, availability, etc.
- 3) SR FE determines which function entities need to be queried based on the service context information and sends the query request to them.
- 4) CIM FE is queried for the required quality of service between SR FE and underlying network (e.g., time delay, stability).
- 5) CIM FE replies with the result to the requesting SR FE.
- 6) SDN FE is queried for the functional information of service (e.g., provider, interface, service class).
- 7) SDN FE replies with the results to the SR FE.
- 8) Service Registry is queried for the information of service (e.g., activity status, available time period).

- 9) The Service Registry replies with the results to SR FE.
- 10) Each home SR FE processes the query results (e.g., checks if all the service context information is processed if necessary) and sends the process results to SDN FE.
- 11) SDN FE processes the resulting message to select the final service that is suitable for the requester.
- 12) SDN FE transmits the negotiation results (e.g., final service information, negotiation logs) to service requester.

4.4.3 Service composition

There are two types of SC flows: *static service composition flows* and *dynamic service composition flows*. Dynamic SC flows can be based on dynamic service chaining or dynamic service instantiation. Furthermore, dynamic service instantiation can be based on abstract service logic and dynamic service logic.

4.4.3.1 Static service composition

The information flow in Figure 17 illustrates static SC. In static SC, the service logic is decided during service design and pre-provisioned before runtime.

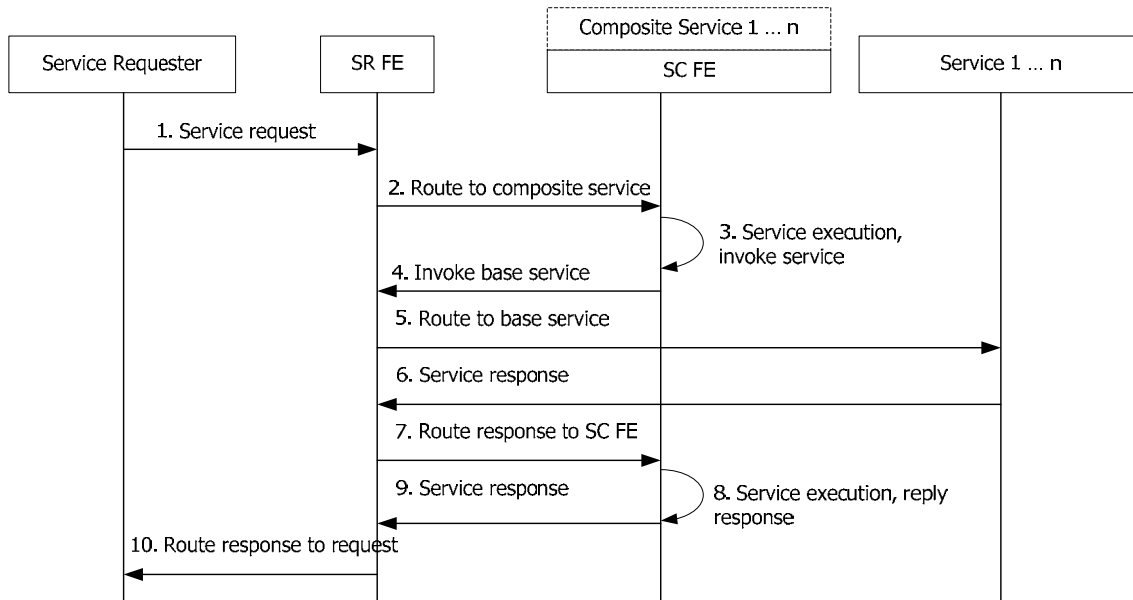


Figure 17—Flow of service composition

Flow description:

- 1) A Service Requester sends a request to invoke a composite service.
- 2) SR FE receives the request and routes the request to the SC FE based on the request address.
- 3) The SC FE decides the order of service chaining based on pre-provisioned data. It also obtains service logic in accordance with the received request from a requester. If the service logic is concrete service logic, SC FE provides a concrete service based on the concrete service logic.
- 4) SC FE requests invocation of a base service.

- 5) SR FE receives the request and routes the request to the base service provider based on the request address.
- 6) The service provider sends the response to the SR FE.
- 7) SR FE receives the response and sends the response to the SC FE.
- 8) SC FE receives the response and continues to execute the service logic based on the order of service chaining (processes the response and invokes other base services) till the end of service chaining.
- 9) SC FE produces the final result of composite service and sends the result to the SR FE.
- 10) SR FE receives the result and sends the result to the service requester.

4.4.3.2 Dynamic service composition

Dynamic SC can be used in two ways, either (1) dynamic service chaining, or (2) dynamic service instantiation.

Dynamic service chaining

In dynamic service chaining, the order of executing base services is decided during runtime based on a rule specification such as the following example. See Figure 18.

In this example, there are four services, A, B, C, and D. Depending on the result of Service A, there are three possibilities in how these four services can be executed.

Service sequence 1: A-C

Service sequence 2: A-D-B, or

Service sequence 3: A-B

This dynamic chaining example thus has a chaining order of A-C-D-B with the following dynamic rules that dependent on what happens with service A at runtime.

Rule 1—If the history contains service A with the result a, execute service C and skip service D and service B.

Rule 2—If the history contains service A with the, result b, skip service C and proceed with services D and B.

Rule 3—If the history contains service A with result c, proceed with B and skip services C and D.

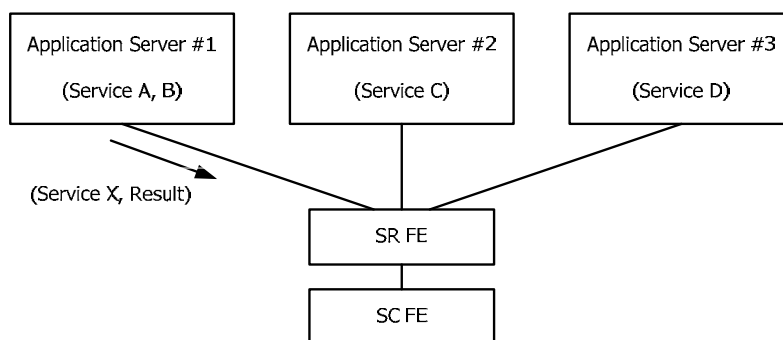


Figure 18—Dynamic service chaining of SC FE

Dynamic service instantiation

In dynamic service instantiation, the SC FE uses abstract service logic that specifies service class (a category of concrete services that exhibits the same service function), rather than the concrete service information. Service class information is published in the SDN FE, and it contains the service class name, service class description, the service function, operation, parameter, etc. The SC FE can find the concrete service based on the relationship between the service class and the concrete service in service discovery.

Following is the call flow for dynamic SC based on the instantiation of abstract service logics. See Figure 19.

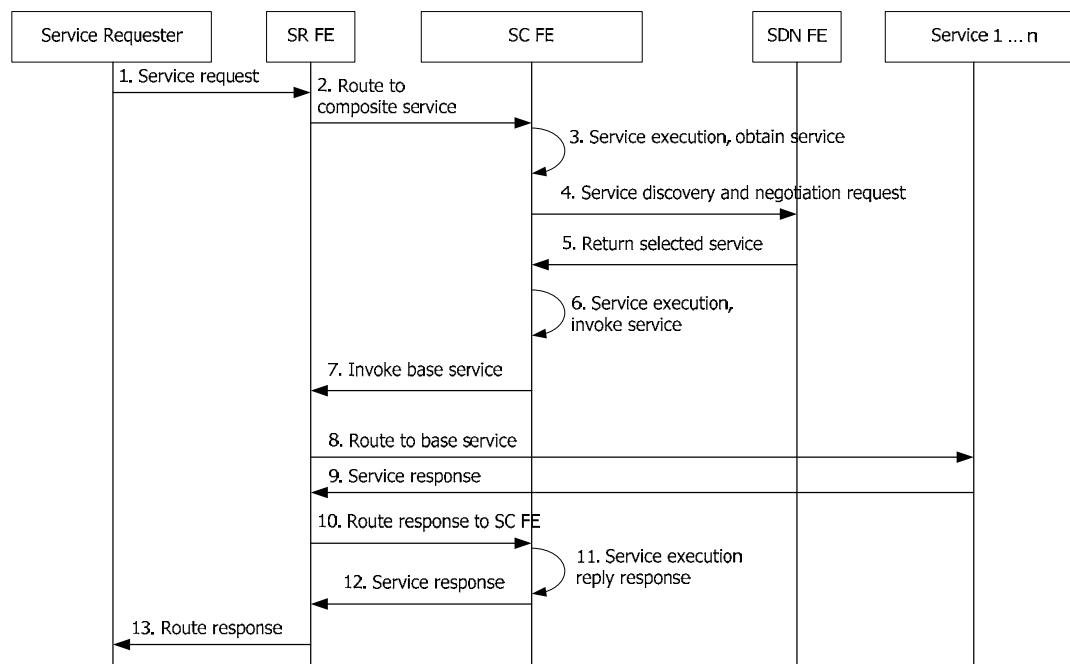


Figure 19—Flow of dynamic service instantiation using abstract service logic

Flow description:

Steps 1) to 2): The same as the steps 1) to 2) of static SC flow in 4.4.3.1.

- 3) The SC FE may decide the order of service chaining dynamically. SC FE then obtains service logic in accordance with the received request from a requestor. If the service logic is not abstract service logic, SC FE processes the concrete services corresponding to steps 4) to 10) in 4.4.3.1.
- 4) The SC FE makes a service discovery and negotiation request to obtain the concrete service if it is abstract service (or service class) description.
- 5) SDN queries to obtain a concrete service according to service class relationship to obtain the corresponding concrete services. If obtained more than one candidate services, SDN triggers service negotiation to filtrate a suitable service. SDN return the selected service.
- 6) The SC FE replaces the abstract service with the concrete service. Then the SC FE generates a service request to the concrete service based on the obtained concrete service.

Steps 7) to 13): The same as the steps 4) to 10) in 4.4.3.1.

4.4.3.3 Service substitution

SC FE provides the service substitution capability to replace the original service with another service when the original service does not work. The new service and the original shall have the same function. Service discovery contains service class information that is a template of service and maps to different concrete services with the same service function. The SC FE can find a similar service based on the mapping relationship between service class and service in the SDN. The SDN can query the mapping relationship to find a new corresponding service to replace original one with an equivalent function. See Figure 20.

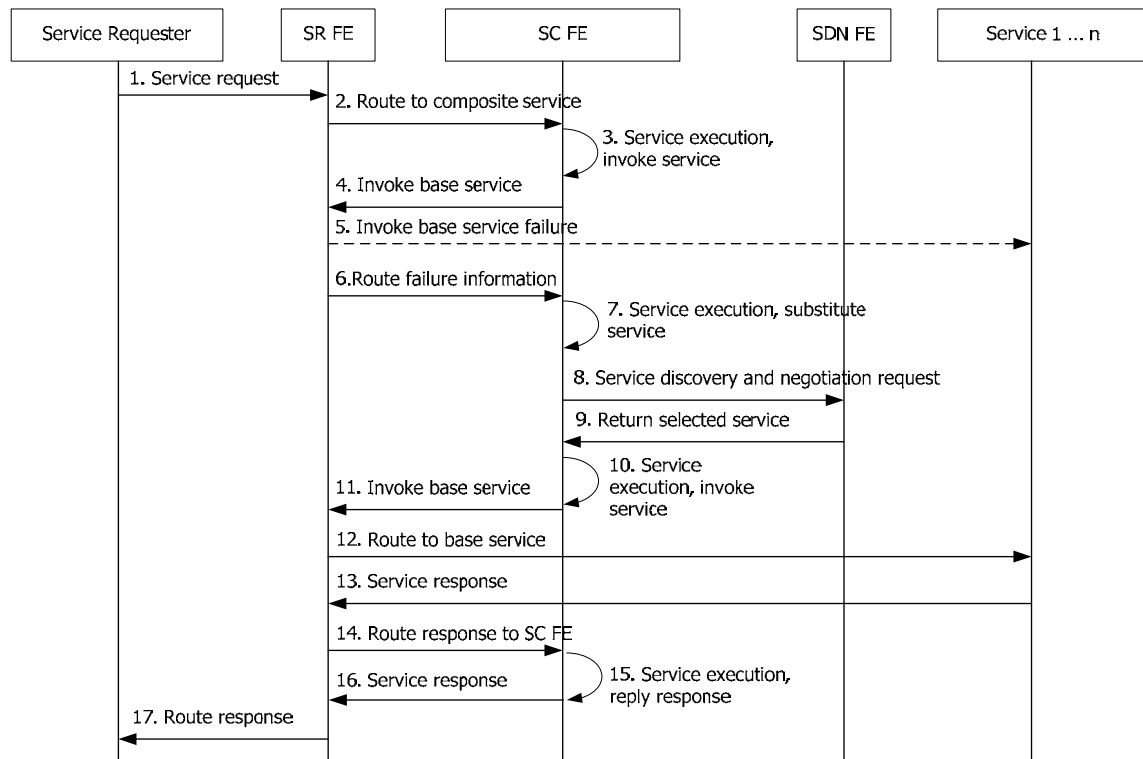


Figure 20—Flow of service substitution