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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Future networks

Fixed mobile convergence enhancements to support IMT-2020 based software-defined wide-area networking service

Recommendation ITU-T Y.3139

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Recommendation ITU-T Y.3139

Fixed mobile convergence enhancements to support IMT-2020 based software-defined wide-area networking service

Summary

IMT-2020 based fixed mobile convergence (FMC) is one of the main trends in the future development of telecommunications. The main purpose of FMC is to combine all access technologies, including fixed and mobile access method, to access the network without network constraints. When adopting IMT-2020 technologies, software-defined wide- area networking (SD-WAN) service is required to support IMT-2020 access as one of the multiple connection types. With the enhancements of FMC, an IMT-2020 based SD-WAN service could gain features such as end-to-end isolated connections and duel link transmission. Recommendation ITU-T Y.3139 provides specifications for FMC enhancements to support an IMT-2020 based SD-WAN service.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3139	2022-09-29	13	11.1002/1000/15056

Keywords

FMC, IMT-2020, SDN.

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Fixed mobile convergence enhancements to support IMT-2020 based software-defined wide-area networking service

1 Scope

This Recommendation specifies fixed mobile convergence (FMC) enhancements to support IMT-2020 based software-defined wide-area networking service, considering the following issues:

– Scenarios of an IMT-2020 based SD-WAN service;

– The requirements of enhanced FMC to support an IMT-2020 based SD-WAN service;

– The architecture of enhanced FMC to support an IMT-2020 based SD-WAN service.

The functional architecture of enhanced FMC of this Recommendation is based on [ITU-T Y.3131].

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 Q.3741] Recommendation ITU-T Q.3741 (2019), *Signalling requirements for SD-WAN ervice*.

[ITU-T Y.3130] Recommendation ITU-T Y.3130 (2018), *Requirements of IMT-2020 fixed mobile convergence*.

[ITU-T Y.3131] Recommendation ITU-T Y.3131 (2019), *Functional architecture for supporting fixed mobile convergence in IMT-2020 networks*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 fixed mobile convergence [b-ITU-T Y.3100]: In the context of IMT-2020, the capabilities that provide services and applications to end users regardless of the fixed or mobile access technologies being used and independently of the users' location.

3.1.2 fixed network [b-ITU-T Q.1762]: A network that provides wire-based (e.g., copper, fibre) or wireless access to its services. The fixed network may support nomadism, but does not support mobility.

3.1.3 IMT-2020 [b-ITU-T Y.3100]: Systems, system components, and related technologies that provide far more enhanced capabilities than those described in [ITU-R M.1645].

3.1.4 mobile network [b-ITU-T Q.1762]: A network that provides wireless access to its services and supports mobility.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

APN	Access Point Name
Diff-Serv	Differentiated Services
DNN	Data Network Name
DPI	Deep Packet Inspection
FMC	Fixed Mobile Convergence
GRE	Generic Routeing Encapsulation
ID	Identifier
L2TP	Layer2 Tunnelling Protocol
MIMO	Multi Input Multi Output
mMTC	massive Machine Type Communication
MPLS	MultiProtocol Label Switching
PDU	Protocol Data Unit
SDN	Software-Defined Network
SD-WAN	Software-Defined Wide-Area Networking
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
VPN	Virtual Private Network
VxLAN	Virtual extensible Local Area Network
WAN	Wide-Area Networking

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The keywords "is recommended" indicate a specification which is recommended but which is not absolutely required. Thus, this specification need not be present to claim conformance.

6 Overview of FMC enhancements to support a software-defined wide-area networking (SD-WAN) service

An SD-WAN service enables service providers to launch such a service for enterprises. It provides high-quality wide area networking (WAN) performance, reliability and security in various ways. [ITU-T Q.3741] specifies the signalling issues of a general SD-WAN service; it uniformly manages the whole network by introducing a centralized controller to implement features such as quick deployment and flexible configuration. By adopting IMT-2020 technologies, an SD-WAN service supports IMT-2020 access as one of multiple connection types. Additionally, it can apply dynamic path selection by allowing for load sharing across WAN connections and provide a simple interface for managing WAN with both fixed and IMT-2020 access. Figure 6-1 shows the basic idea of an IMT-2020 based SD-WAN service with FMC enhancements.

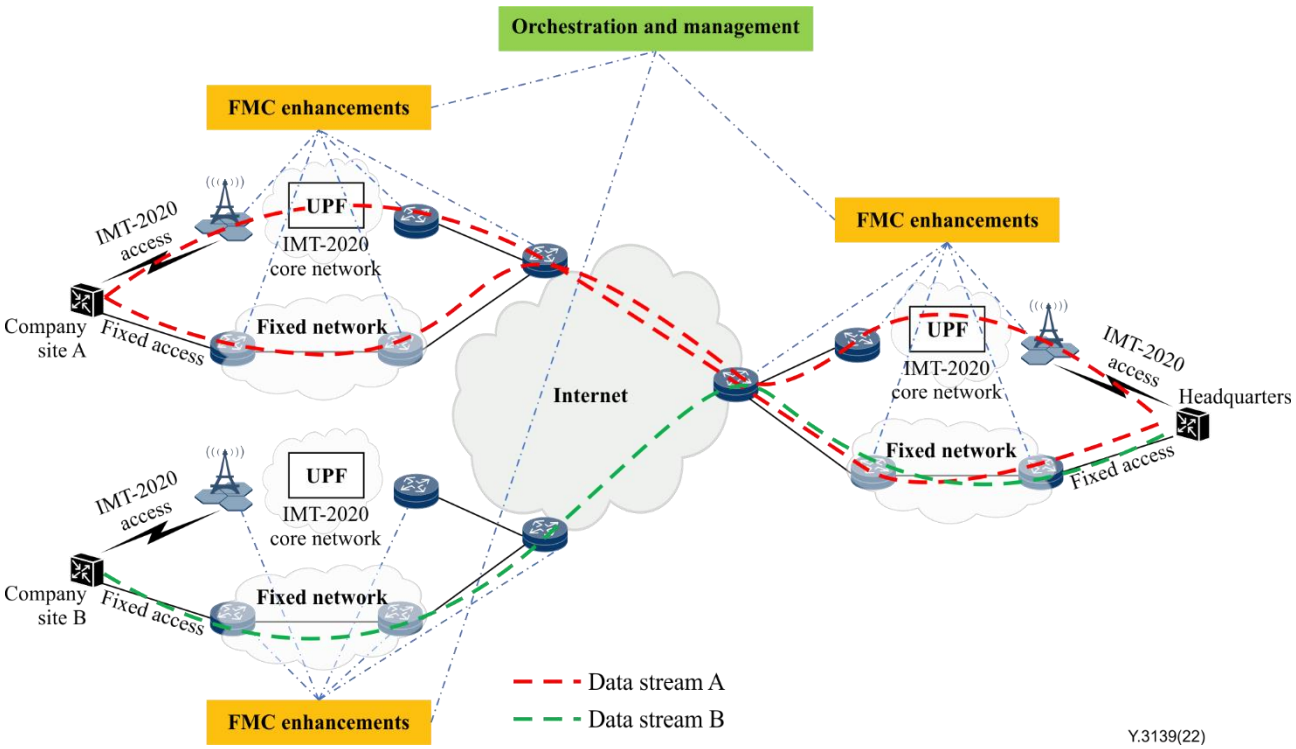

Figure 6-1 – IMT-2020 based SD-WAN service with FMC enhancements

An IMT-2020 based SD-WAN service will utilize IMT-2020 access technology on the basis of IMT-2020 bearer and combine it flexibly with multiple connection types. With the enhancements of FMC,an IMT-2020 based SD-WAN service could have the following advantages:

– FMC enhancements enable an SD-WAN service to establish an end-to-end isolated connection of the customer equipment from one end user of company node A to other end users of headquarter and company node B by introducing the end-to-end connectivity management functionality in FMC enhancement and by having the global view of the orchestration. Different enhanced FMC functions or platforms could cooperate together to guarantee end-to-end security and isolation. However, traditional SD-WAN service providers could only provide similar features in the Internet domain rather than end-to-end, which may not satisfy the requirements of the enterprises.

– FMC enhancements enable each company node to have the ability to transmit data traffic on dual links (IMT-2020 and fixed access network) simultaneously to ensure ultra-broad bandwidth to some critical services. However, traditional SD-WAN service could only utilize one of the two links for each session of transmissions.

To provide these advantages to an IMT-2020 based SD-WAN service, the FMC is required to be enhanced in IMT-2020 based FMC scenarios.

7 Scenarios of an IMT-2020 based SD-WAN service

7.1 The dual-link transmission scenario of IMT-2020 based SD-WAN service

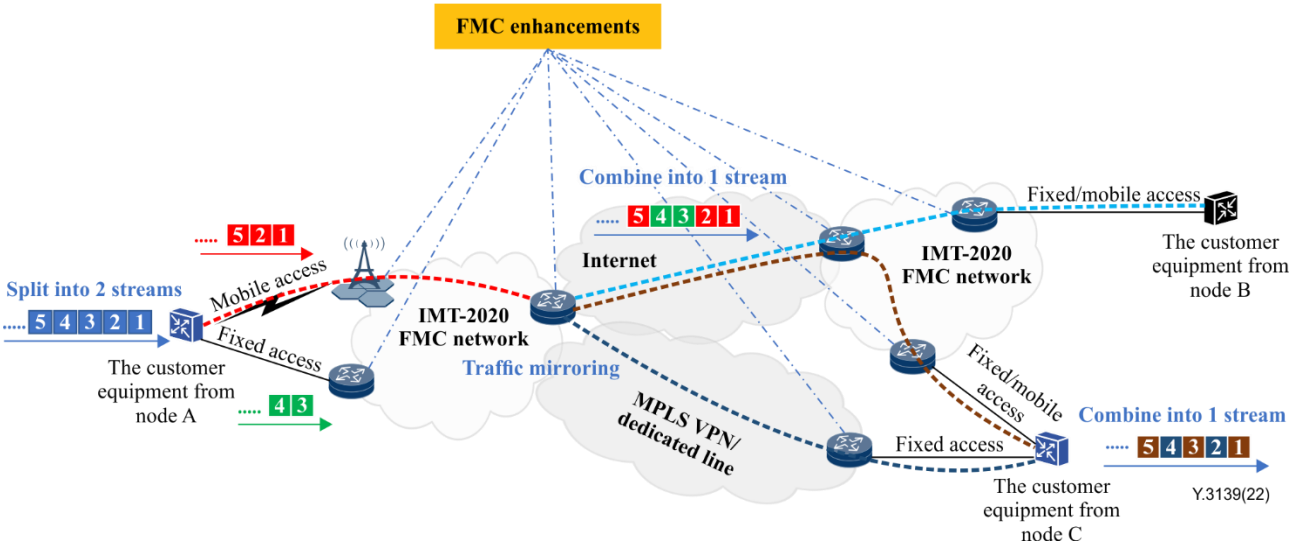

Figure 7-1 – FMC enhancements to support a dual-link transmission scenario

With the enhancements of FMC, the dual-link transmission scenario of an IMT-2020 based SD-WAN service could be achieved, as shown in Figure 7-1.

The dual-link transmission scenario of an IMT-2020 based SD-WAN service requires at least one IMT-2020 access and one fixed access to the network. Data traffic is transmitted by both links simultaneously to provide ultra-broad bandwidth to some important services. As shown in Figure 7-1, if the customer from node A wants to upload large files to node B by an IMT-2020 based SD-WAN connection, the data traffic can be split into two streams and transmitted by an IMT-2020 access link and a fixed access link separately. In this case, the access bandwidth of node A will be increased by utilizing the two links simultaneously.

Several SD-WAN nodes of IMT-2020 based SD-WAN service which can be managed and controlled by the FMC enhancement system exist. When the SD-WAN node receives the data stream, it can perform operations such as traffic mirroring, stream combination and/or re-splitting according to different customer service requirements. As shown in Figure 7-1, the SD-WAN node combines the two streams transmitted by two access links from node A into one stream, and sends it to node B by one link. Meanwhile, the SD-WAN node mirrors the combined stream, re-splits it into two streams and sends them separately to node C through two different underlay links. In this case, the end-to-end connections can be carried by more than one underlay interdomain backbone network (e.g., public Internet, multiprotocol label switching virtual private network (MPLS VPN), dedicated line) simultaneously to enhance service quality.

Additionally, some critical technologies and mechanisms need to be adopted in this scenario to guarantee service quality, such as multilink bundling technology, load balancing technology, link backup mechanism, data retransmission and verification mechanism.

7.2 The end-to-end orchestration scenario of IMT-2020 based SD-WAN service

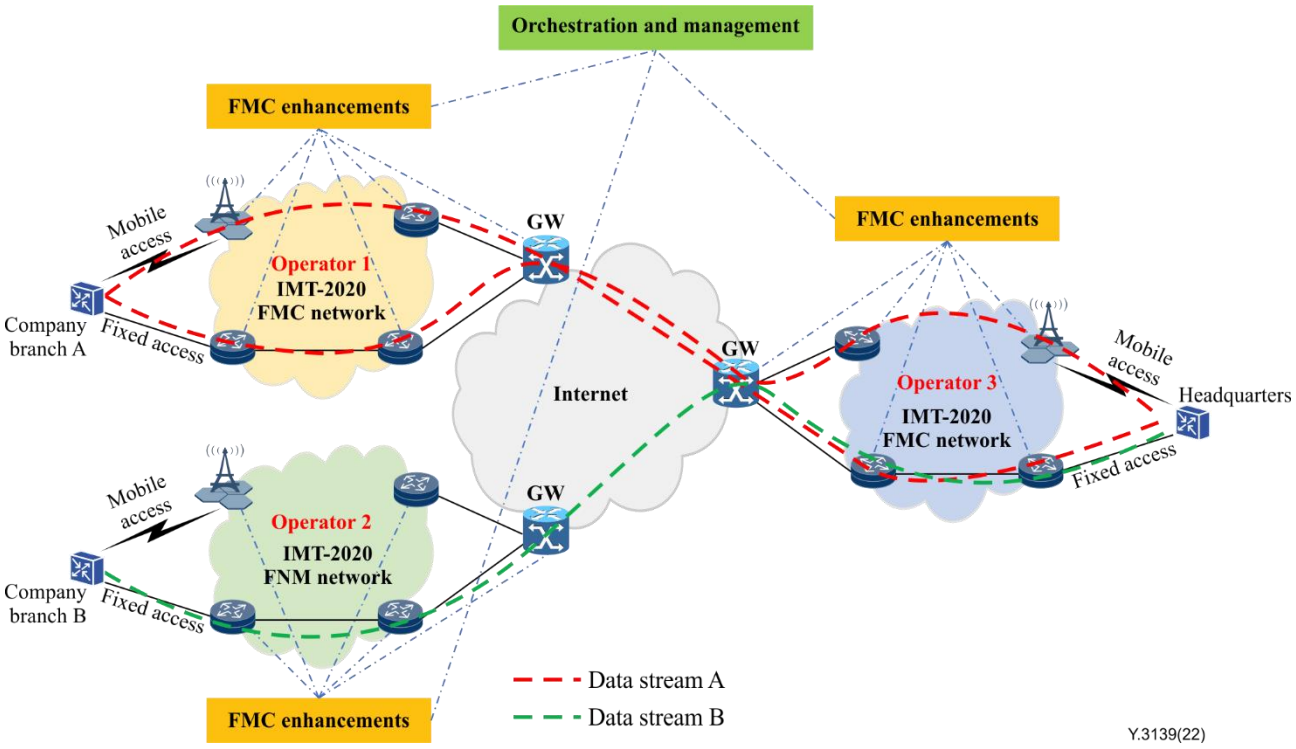

Figure 7-2 – FMC enhancements to support end-to-end SD-WAN service

With the enhancements of FMC, the end-to-end orchestration scenario of the IMT-2020 based SD-WAN service, which mainly takes place under interoperator conditions, could be achieved. By introducing a unified global orchestration and management platform, the IMT-2020 based SD-WAN service can manage and control multiple FMC enhancement systems from different operators to interwork with each other. Orchestration and management of FMC enhancements in IMT-2020 can coordinate multidomain network resources (e.g., links, connections, bandwidth) to perform operations such as creation, retrieval, updating or deletion of end-to-end connections in different networks in order to provide an interoperator end-to-end IMT-2020 based SD-WAN service to customers.

In the example shown in Figure 7-2, a company has one headquarters located in operator three's dominant area while its two branches – branch A and branch B – are located in operator one's and operator two's dominant area, respectively. Each site of this company can access the network by dual-link access (an IMT-2020 access and a fixed access), with the control of a local FMC enhancement system of its operator. Meanwhile, end-to-end connections can be established between any two sites by the adoption of the unified global orchestration and management platform.

In addition, enhanced FMC could provide a slice identification management method applied to the core network side. When receiving the session connection request sent by the SD-WAN terminal and the session connection request includes its application ID, enhanced FMC finds the target slice ID matching the application ID according to the pre-set application slice identification table. Then the destination slice ID is determined according to the relationship between the target slice ID and the default slice ID signed by the terminal, so the service is carried in the transmission channel of the destination slice ID in order to achieve differentiated Quality of Service (QoS) control.

When the target slice ID is different from the default slice ID, the target slice ID is assigned to the terminal to enable the terminal to re-initiate the session connection request carrying the target slice ID.

When the target slice ID is the same as the default slice ID, the terminal IP is sent to the SD-WAN terminal, and a transmission channel is established between the base station and the user plane function UPF of the core network, so that the user data can be transmitted through this transmission channel.

8 Requirements of enhanced FMC to support an IMT-2020 based SD-WAN service

8.1 Service requirements of enhanced FMC

8.1.1 Requirements to support flexible networking

FMC enhancements enable an SD-WAN to achieve flexible end-to-end networking. The service requirements to support flexible end-to-end networking of an IMT-2020 based SD-WAN service are as follows:

– Enable IMT-2020 access as one of the multiple access types to enrich the access capability of SD-WAN.

– Enable flexible end-to-end traffic path selection based on network policies according to customer requirements.

– Enable a link backup mechanism to guarantee end-to-end connection reliability. That is, when one of the connection links deteriorates, the system is required to immediately detect the deterioration and switch the traffic to one or more other selected links.

– Enable application identification and intelligent traffic scheduling to improve service performance or attain application acceleration. That is, the forwarding nodes of the system are required to identify different application traffic and schedule the packets according to the specific service requirements.

8.1.2 Requirements to enhance network security

FMC enhancements enable an SD-WAN to achieve end-to-end network security, providing higher network isolation security and data reliability for customers. The service requirements to enhance the network security of an IMT-2020 based SD-WAN service are as follows:

– Support a multiple isolated network connection scheme to guarantee network security, which may be composed of one or more isolation technologies such as IMT-2020 based network slicing, APN/DNN isolation and various virtual tunnel technologies.

– Support multiple encryption technology to enhance data reliability and security.

– Provide a unified authentication platform and support multiple authentication, authorization and access control technologies to guarantee access security.

8.1.3 Requirements to provide enhanced quality of service (QoS)

FMC enhancements enable SD-WAN to achieve end-to-end QoS management, providing a comprehensive and high-quality communication service experience. The service requirements to provide enhanced QoS of an IMT-2020 based SD-WAN service are as follows:

– Provide refined differentiated services based on a comprehensive end-to-end QoS solution including but not limited to refined QoS level design, differentiated services (diff-serv) based QoS scheduling, end-to-end congestion control and traffic shaping, unified QoS interpretation and control architecture.

– Provide multiple QoS mapping schemes that customers could choose according to their service requirements by maintaining an application slice identification table in end-to-end connectivity management functions, which stores the mapping relationship between the application ID and slice ID of the SD-WAN terminal service.

– Provide service continuity to improve the experience of the customers.

8.1.4 Requirements to enhance mobile connectivity

FMC enhancements enable SD-WAN to achieve advanced mobile access performance. The service requirements to enhance mobile connectivity of IMT-2020 based SD-WAN service are as follows:

– Support high mobile access bandwidth and achieve low mobile access delay by adoption of IMT-2020 technologies such as massive multi-input multi-output (MIMO), super uplink and network slicing.

– Provide ubiquitous access coverage and support massive connections by utilizing IMT-2020 technologies which are implemented to support mMTC.

– Allow high mobility of the terminal device while providing excellent communication quality by utilizing IMT-2020's mobility enhancement.

8.1.5 Requirements to improve customer self-service management

FMC enhancements enable SD-WAN to provide flexible customer self-service. The service requirements to improve customer self-service management of an IMT-2020 based SD-WAN service are as follows:

– Provide graphical management and network status monitoring for customer self-service.

– Provide end-to-end traffic path selection for customer self-service.

– Provide flexible VPN topology management for customer self-service.

– Provide flexible bandwidth adjustment function for customer self-service, by which the link bandwidth between customer sites can be adjusted in real-time based on customer needs.

– Provide value-added service function configuration for customer self-service, such as virtual firewall, traffic cleaning, traffic analysis and load balance.

8.2 Capability requirements of enhanced FMC

The general requirements of enhanced FMC capabilities are based on the capability requirements of IMT-2020 FMC described in [ITU-T Y.3131] and with some additional aspects to fulfil the service requirements of enhanced FMC to support an IMT-2020 based SD-WAN service.

8.2.1 Global orchestration and management

Enhanced FMC is required to provide a global orchestration and management platform to support the following requirements:

– Enhanced FMC is required to provide management functionality and global view concerning an end-to-end SD-WAN service by coordinating multidomain network resources, establishing end-to-end connection of the connected nodes in different networks and selecting the most appropriate access link for the SD-WAN service based on link capability, link status, user attributes and service requirements.

– Enhanced FMC is required to perform operations such as creation, retrieval, updating or deletion of end-to-end connections in different networks.

– Enhanced FMC is required to enable administrator and customers to manage the SD-WAN service by configurating the enhanced FMC network in real-time based on service requirements, such as adjusting bandwidth, changing traffic flow direction and analysing traffic information.

8.2.2 Bandwidth control

The requirements of bandwidth control of enhanced FMC to support an IMT-2020 based SD-WAN service include the following:

– Enhanced FMC is required to ensure ultrabroad bandwidth utilization for services which require high data rate for simultaneous traffic streams on dual-links.

– Enhanced FMC is required to enable the SD-WAN node to identify and process the received data flows, including performing operations such as traffic mirroring, traffic combination and/or redivision, and scheduling packets based on service requirements to improve performance.
– Enhanced FMC is required to support high mobile access bandwidth and achieve low mobile access delay by adoption of various advanced IMT-2020 technologies.
– Enhanced FMC is required to provide wide-area coverage capability supporting mobile large-scale connection.

8.2.3 QoS control

QoS control for enhanced FMC is aligned with the requirements of QoS control identified in [ITU-T Y.3131], in particular with the following additional requirements:

– Enhanced FMC is required to support multiple QoS control mechanism including refined QoS level design, diff-serv based QoS scheduling, end-to-end congestion control and traffic shaping, unified QoS interpretation and control architecture, to fulfil different requests of customer services based on the characteristic of these services.
– Enhanced FMC is required to support application identification and intelligent traffic scheduling to improve service performance or attain application acceleration.
– Enhanced FMC is required to enable end-to-end network coordination and improve service communication experience in terms of delay, packet loss rate and jitter by end-to-end network QoS mapping.
– Enhanced FMC is required to map differentiated service scheduling requirements to network performance requirements and implement end-to-end traffic scheduling.
– Enhanced FMC is required to ensure an agile fixed link and mobile link backup mechanism to guarantee the end-to-end connection reliability.
– Enhanced FMC is required to provide a slice identification management method applied to the core network side. When receiving the session connection request sent by the SD-WAN terminal and the session connection request includes its application ID, enhanced FMC is required to find the target slice ID matching the application ID according to the pre-set application slice identification table. Then the destination slice ID is determined according to the relationship between the target slice ID and the default slice ID signed by the terminal, so that the service is carried in the transmission channel of the destination slice ID in order to achieve differentiated QoS control.

8.2.4 Security enhancements

To enhance end-to-end security for enhanced FMC to support an IMT-2020 based SD-WAN service, requirements for security enhancements include the following:

– Enhanced FMC is required to support end-to-end service logic isolation and different isolation technologies, including network slicing, APN/DNN isolation and various virtual tunnel technologies.
– Enhanced FMC is required to ensure service access security by using various network security policies to protect user service data streams from malicious attacks.

9 Architecture of enhanced FMC to support an IMT-2020 based SD-WAN service

9.1 Functional architecture of enhanced FMC

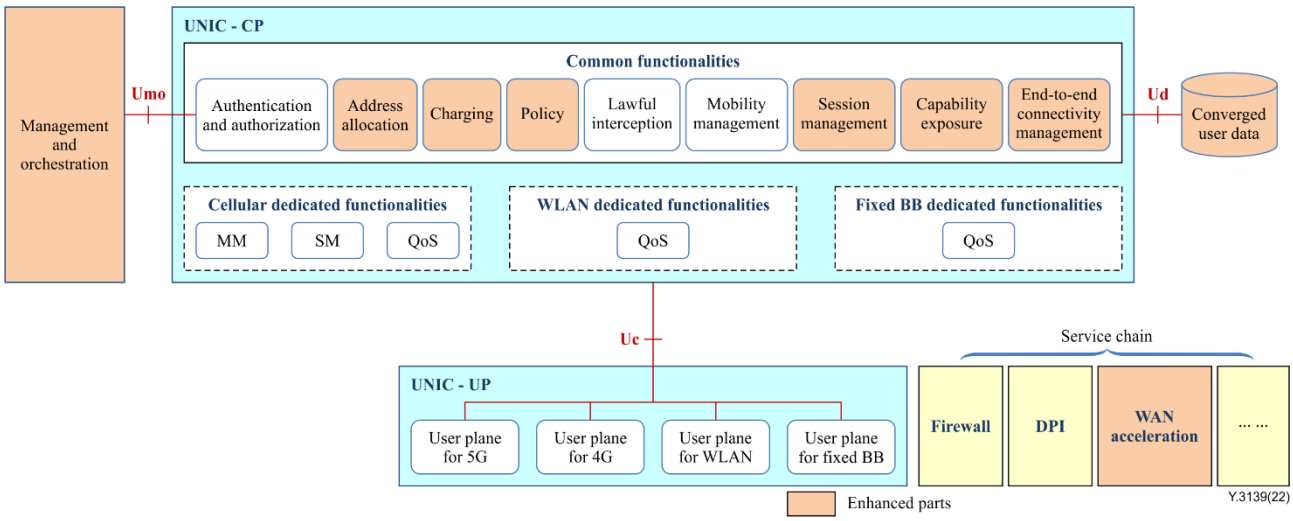

Figure 9-1 – Enhanced fixed mobile convergence (FMC) architecture to support an SD-WAN service

To support an IMT-2020 based SD-WAN service, some functions are added or enhanced to enhanced FMC compared with the common functionalities of FMC. The enhanced functions are described as follows.

1) UNIC-CP

In order to support an SD-WAN service, the following functionalities are required to be extended in UNIC-CP component:

The end-to-end connectivity management functionality is required to be supported in the architecture of enhanced FMC. The end-to-end connection needs to be managed by this functionality, and could involve SD-WAN topology management, SD-WAN connection management, SD-WAN service performance management, SD-WAN service traffic monitoring or alarm monitoring. The end-to-end connectivity management functionality also supports slice ID management which is used to store the mapping relationship between the application ID and slice ID of the SD-WAN terminal service. The functionality of slice ID management supports receiving the session connection request sent by the SD-WAN terminal, while the session connection request includes the application ID of the terminal service. It also includes a matching module for finding the target slice ID matching the application ID according to the pre-set application slice identification table, and a determination module for determining the destination slice ID according to the relationship between the target slice ID and the default slice ID signed by the terminal, so that the terminal service is carried in the transmission channel corresponding to the destination slice ID.

The session management functionality is required to be enhanced to support an SD-WAN service. For example, PDU session management needs to support SD-WAN tunnel (such as generic routeing encapsulation (GRE), Layer2 tunnelling protocol (L2TP), Virtual extensible local area network (VxLAN)) detection, selection and configuration of traffic steering as user plane function also needs to support an SD-WAN tunnel.

Policy functionality is required to support the SD-WAN service, such as a different network selection policy, and an SD-WAN service steering policy and splitting policy, to provide a unified policy for end users.

A charging functionality is required to support an SD-WAN service based on different SD-WAN service policy and real-time cost.

Address allocation functionality needs to provide unified address allocation for end users irrespective of whether a fixed network, mobile network or even a network from different operators is involved; this is possible with an SD-WAN service.

A capability exposure functionality needs to include an SD-WAN service in network capability exposure, such as QoS control, network slice control and network status of SD-WAN service.

2) UNIC-UP

As an SD-WAN service is based on network tunnel technologies, the user plane for fixed broadband is taken to be the responsibility of an SD-WAN service as part of its user plane and the UNIC-UP is required to support tunnel technologies used in an SD-WAN service.

3) Converged user data function

Data from different enterprises need to be well saved and managed, to ensure the reliability, security and efficiency of the data.

4) Management and orchestration function

As the network resources an SD-WAN service uses have some special features, such as network performance not being stable, costs are comparatively low, and the real-time network performance should be taken into consideration during network management, service management, user management and resource orchestration.

5) Service chain

As an SD-WAN service is based on Internet access to an enterprise's internal network, network delay, jitter or packet loss may cause service to be affected or interrupted, so a WAN acceleration function is suggested to be introduced in the service chain part for a better service experience. The following functionalities are recommended to be introduced:

– A DPI functionality, which is used to detect the packet feature, not only on the IP layer, but also on the transmission control protocol (TCP) / user datagram protocol (UDP) layer, even on the application layer, to be aware of the service types.
– An intelligent service analysis functionality, which is used to analyse the service types, features and network requirements for further processing.
– A TCP acceleration functionality, which is used to control TCP performance through network congestion status detection and optimize the algorithm or parameters on the TCP layer.
– A UDP acceleration functionality, which is used to control UDP performance through network congestion status detection and optimize the algorithm or parameters on the UDP layer.
– An application layer acceleration functionality, which is used to decrease the service affection due to network layer problems, by adoption of application layer packet loss compensation technology.

9.2 Reference points of enhanced FMC

This clause describes enhanced FMC related reference points.

1) Enhanced reference point Uc

As an SD-WAN service is possibly based on an unpredictable network, end-to-end connectivity management and real-time network performance monitoring are required to be enhanced via reference point Uc.

2) Enhanced reference point Ud

Enhanced reference point Ud exists between UNIC-CP and converged user data. The enhanced functionalities such as the end-to-end connectivity management function can use this enhanced reference point to accomplish user authentication and authorization, user data downloading and updating, user information query, user data restoration, desensitized user data exposure, etc.

3) Enhanced reference point Umo

SD-WAN service resources, SD-WAN service connectivity status and SD-WAN service performance are required to be exchanged in the process of network management, service management, user management and resource orchestration via reference point Umo.

10 Security considerations

Enhanced FMC to support IMT-2020 SD-WAN service should take into account the issues of security and privacy, and the security and privacy concerns in this Recommendation should be aligned with the requirements specified in [ITU-T Y.3130] and [ITU-T Y.3131].

Bibliography

[b-ITU-T Q.1762] Recommendation ITU-T Q.1762/Y.2802 (2007), *Fixed-mobile convergence general requirements*.

[b-ITU-T Y.3100] Recommendation ITU-T Y.3100 (2017), *Terms and definitions for IMT-2020 network*.

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