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

Future networks

Requirements of soft network architecture for mobile

Recommendation ITU-T Y.3323

ITU-T

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Recommendation ITU-T Y.3323

Requirements of soft network architecture for mobile

Summary

Recommendation ITU-T Y.3323 defines the design principles and requirements of soft network architecture for mobile (SAME), i.e., flexible traffic steering, virtualization of SAME network functions, SAME network slice, and separation of control function and forwarding function. Its scenarios and problem statements are introduced in the appendices.

SAME is a mobile packet core network, which bridges current legacy mobile network towards future networks. Though SAME does not aim to cover key requirements of IMT-2020 core network, these key requirements of SAME may be adopted in IMT-2020.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3323	2016-09-29	13	11.1002/1000/13019

Keywords

Control and forwarding separation, network function virtualization, network slice, soft network architecture for mobile, traffic steering.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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1 Scope

Soft network architecture for mobile (SAME) is a mobile packet core network, which bridges current legacy mobile networks toward future networks. This Recommendation defines design principles of SAME, and its key requirements, i.e., flexible traffic steering, virtualization of SAME network functions, SAME network slice, and separation of control function and forwarding function.

SAME scenarios and problem statements of current mobile packet core network are introduced in the appendices.

2 References

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

[ITU-T Y.2320] Recommendation ITU-T Y.2320 (2015), *Requirements for virtualization of control network entities in next generation network evolutio*n.

[ITU-T Y.3011] Recommendation ITU-T Y.3011 (2012), *Framework of network virtualization for future networks*.

[ITU-T Y.3012] Recommendation ITU-T Y.3012 (2014), *Requirements of network virtualization for future networks*.

[ITU-T Y.3015] Recommendation ITU-T Y.3015 (2016), *Functional architecture of network virtualization for future networks*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 traffic steering: A technology which identifies and steers traffic to go through the related service function entities according to operators' policy.

NOTE 1 – A service function entity is a traffic processing node that caches, transforms, inspects, filters, or otherwise manipulates traffic for purposes other than packet forwarding. Examples of service function entities are URL filter and video optimization.

NOTE 2 – Service function entities are independent from one another, and can be added, removed and bypassed.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

APN Access Point Name

CAPEX Capital Expenditure

GW Gateway

HTTP Hypertext Transfer Protocol

MNO Mobile Network Operator

MVNO Mobile Virtual Network Operator

NFV Network Function Virtualization

OPEX Operating Expenses

QoE Quality of Experience

QoS Quality of Service

RAN Radio Access Network

SAME Soft network Architecture for MobilE

UE User Equipment

URL Uniform Resource Locator

VCN Virtualization of Control Network entities

VM Virtual Machine

5 Conventions

In this Recommendation:

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

The phrase "is recommended" indicates a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be satisfied to claim conformance.

6 Soft network architecture for mobile and its design principle

Facing growing mobile data traffic and the rapid change of new applications, new user requirements, new service requirements and operating policies, operators need to improve the flexibility of their networks, such as using network resources more efficiently and enhancing their network capabilities more quickly.

In current mobile networks, it is often difficult for operators to quickly meet market requirements, because functions are implemented on dedicated equipment and adding new features into the current network usually takes a long time to complete through test, trial and deployment. In addition, new service function entities have to be added statically, which is not flexible. Last but not least, control and forwarding functions are coupled such that they cannot be deployed flexibly and independently.

To achieve the above goals, this Recommendation proposes soft network architecture for mobile (SAME), a mobile core network to be designed as an enhancement of International mobile telecommunications-advanced (IMT-Advanced) mobile packet core network, to realize an even more flexible mobile packet core network that bridges the current legacy mobile network towards future networks. Although SAME does not aim to cover key requirements of IMT-2020 core network, the key requirements of SAME may be adopted in IMT-2020.

Based on the analysis of the scenarios and problems mobile operators face today, which are described in Appendices I and II, SAME focuses on implementing the following design principles:

– Efficient traffic steering: Traffic can be flexibly steered to go through necessary service function entities to support quick addition of new capabilities.
– Efficient resource usage: Infrastructure can be shared among different network functions and slices.
– Flexible deployment of network functions: Control and forwarding functions can be deployed in a centralized or distributed manner with minimum effect to other related functions.
– Flexible network scaling: Network functions can be dynamically adapted to users' demands.
– Easy management of network: Resources and network functions can be managed with logically centralized, intelligent and automatic operations.

NOTE – In this Recommendation, scaling includes scaling in/out, as described in [b-ETSI GS NFV 003]. The virtualization of control network entities (VCN) [ITU-T Y.2320] can be supporting technology of SAME.

7 Requirements of SAME

This clause focuses on the key requirements for SAME.

R1 – Support the capability of flexible traffic steering

SAME aims to support flexible enhancement of new capabilities by adding specific service function entities without affecting existing service function entities. To achieve this, SAME is expected to satisfy the requirements below.

– It is required to support flexibly steering traffic passing through necessary service function entities according to the policies.
– It is required to define and update the traffic steering policies based on the following information:
  • application characteristics of traffic such as application type, and application protocol;
  • access network information of traffic such as IMT-2000 access, IMT-Advanced access;
  • users' subscription information such as users' priorities;
  • service function entities' status such as the failure of service function entities.
– It is required to support layer 3 through layer 7 (L3-L7) traffic classification.

R2 – Support virtualization of SAME network functions

In SAME, virtualization refers to those network entities and/or functions run on virtual computing, storage and networking resources, leveraging the hardware and software decoupling. On virtualization, SAME is expected to satisfy the requirements below.

– It is required to provide a capability for agile and flexible deployment of network functions.
– It is required to provide a capability for scalability of network capacity by auto scaling mechanism.
– It is required to provide a capability for efficient resource usage.
– It is required to provide a capability for isolation of resource usage for different tenants.
– It is required to provide a capability for operation, maintenance management and orchestration of the infrastructure in an automatic and centralized manner.
– It is required to provide a capability to allow the virtualized resource usage to the third party.

NOTE 1 – The third party assumes network customer, e.g., a mobile virtual network operator (MVNO). The third party can raise the requirement to the SAME for using network resources. A tenant or multiple tenants in the SAME are utilized to compose the third party's service.

NOTE 2 – Network function virtualization (NFV) [b-ETSI GS NFV 001] [b-ETSI GS NFV 002] could be a potential technology for SAME to realize the virtualization.

R3 – Support SAME network slice

SAME network slice is a set of SAME network functions and their related physical or virtual resources, forming a complete logical network to provide certain network characteristics. A SAME network slice is isolated from other slices based on common infrastructure. Resources can be computing, storage and networking resource. To this end, SAME is expected to satisfy the requirements below.

– It is required to provide a capability to support the SAME network slices, including the creation/modification/deletion of the SAME network slices.

– It is required to provide a capability to monitor the performance and operating status of the SAME network slices.

– It is required to provide external application programming interfaces (APIs) to create and manage SAME network slices.

NOTE – Logically isolated network partition (LINP) [ITU-T Y.3011], [ITU-T Y.3012] and [ITU-T Y.3015] can be one of realization of SAME network slice.

R4 – Support separation of the control function and forwarding function

To achieve flexibility in deploying network equipment, control function and forwarding function should no longer be in the same equipment, whether the functions are physical or virtual. They should be able to be installed in different places. SAME aims to realize such feature through the requirements below.

– It is recommended to support the capability to realize geographically centralized management of control function entities.

  NOTE – For example, engineers will then not need to go to different data centres or central offices to perform operational work such as deploying and powering on new servers.

– It is required to enable scaling/deployment of control functions and forwarding functions in independent manner.

– It is recommended to support optimization of bandwidth utilization (e.g., traffic localization, traffic scheduling) by centralized control of traffic forwarding and distributed forwarding functions.

– It is required to support optimization of user experience (e.g., latency reduction) by deploying the forwarding functions closer to the subscriber.

Appendix I

Scenarios of SAME

(This appendix does not form an integrated part of this recommendation.)

The clause focuses on the scenarios for SAME.

I.1 Flexible traffic steering

The identification and classification of traffic may be based on the radio access network (RAN) information (e.g., RAN type, and RAN status), application characteristics (e.g., application type, application protocol), user's subscription data, and direction (i.e., upstream or downstream) of the flow.

Scenario 1: traffic steering classified by application type

Descriptions

SAME routes the traffic based on application type.

Preconditions

Three service function entities are deployed by the operator, which are uniform resource locator (URL) filter, protocol optimization and video optimization. Policies are defined such that the flow of a hypertext transport protocol (HTTP) video service should go to the URL filter and video optimization, and the flow of the web browsing service should go to the URL filter and protocol optimization.

Operational flows

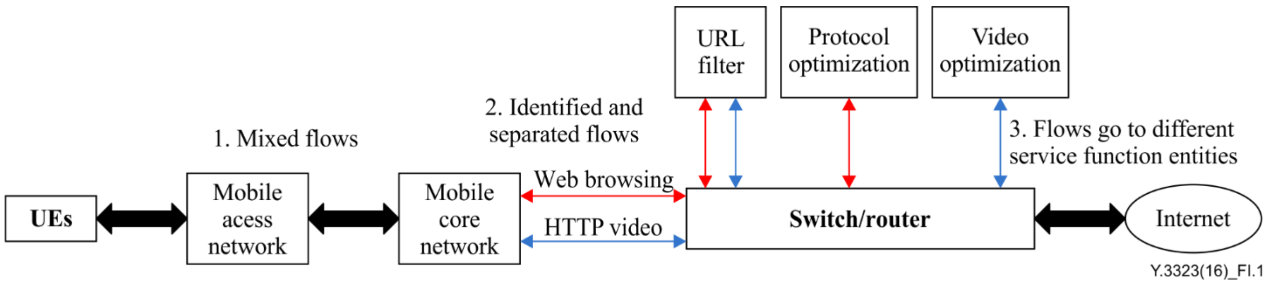

Figure I.1 – Flexible traffic steering scenario

1) There are two groups of flows initiated by users: HTTP video; web browsing.

2) The flows of each group are identified and separated by mobile core network.

3) The HTTP video flow goes through URL filter and video optimization. The web browsing flow goes through URL filter and protocol optimization.

Scenario 2: traffic steering classified by different tenant

Descriptions

The different MVNOs may have individual requirements on the data flows processing at the (S)Gi-LAN position. The SAME network prepares appropriate service function entities and steers traffic based on the identities of the MVNOs.

NOTE 1 – The service function entities could be prepared by mobile network operator (MNO), or by the MVNOs themselves for specific data flows processing.

NOTE 2 – The service function entities prepared by the MVNOs could be an integrated entity of multiple sub-functions. If one of the sub-functions is the same with the MNO's data flows processing function, SAME needs to guarantee not to trigger the data flows going through the MNO's same function again.

Preconditions

There are two MVNOs in an operator's network. MVNO-A focuses more on video services and requires all of its video flows to go through a server for video optimization and transcoding. MVNO-B focuses more on web service and requires these data flows to go through the servers for HTTP acceleration.

Operational flows

1) The data flows are identified and labelled before routing to the packet processing area at the (S)Gi-LAN position based on the MVNO's identification information. The MVNO's identification information should have higher priority than the service information when distinguishing the data flows.

2) The flows from different MVNOs are routed to different service function entities, i.e., the flow of MVNO-A goes through the video optimization and transcoding server, and the flow of MVNO-B goes through the HTTP acceleration server.

I.2 Virtualization of network functions

Scenario 1: fast deployment

Descriptions

Utilizing NFV technology, fast deployment of the mobile network function uses the deployment template which usually contains configuration and instantiation operations and parameters to realise an automatic and dynamical deployment instead of complex manual operations.

Preconditions

The system supporting NFV is ready, and the management system can maintain and access virtual machine (VM) images and deployment templates.

Operational flows

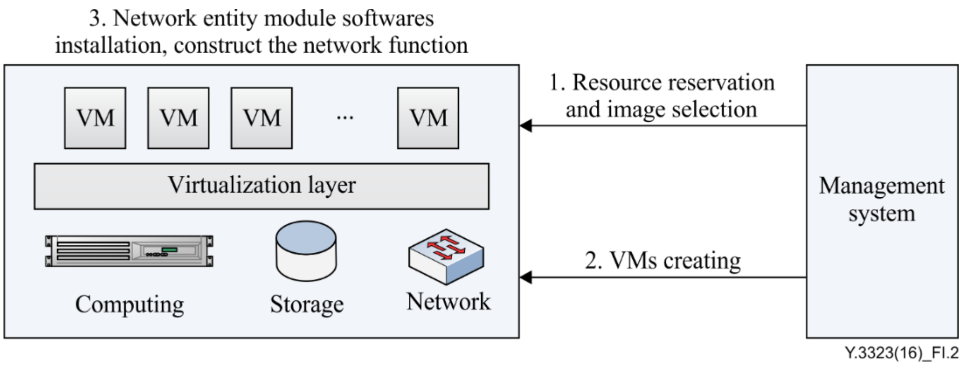

Figure I.2 – Fast deployment

1) Based on the deployment template, the management system reserves necessary resources for creating VMs and selects the desired VM images from the VM image database.

2) The management system creates VMs using the selected VM images, and configures VMs e.g., IP address, the virtual hardware, and the affinity relationships based on the deployment template.

3) The VMs install the software of the network entity modules, and construct the network function.

Scenario 2: on demand resource scheduling

Descriptions

On-demand resource scheduling means dynamically adjusting resources based on traffic volume of network entity; it can be implemented by adding/deleting VMs which is named as scaling out/in, or increasing/decreasing the VM capacity which is named as scaling up/down.

Preconditions

A virtualized network entity is composed of six running VMs.

Operational flows

This operational flow shows scaling out/in.

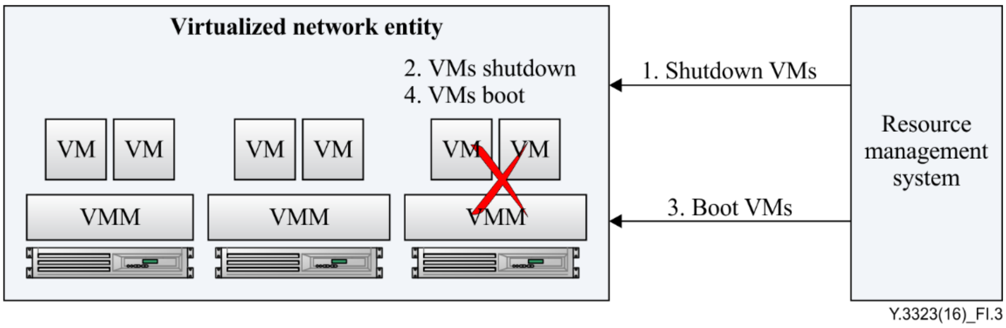

Figure I.3 – Scaling out/in

1) The resource management system detects that the traffic volume is decreasing, and it asks the virtualized network entity to shut down the components of the entity running on two VMs.

2) Two VMs in network entity is shut down, and if there is no VM running on a physical server, the physical server can be shut down.

3) The resource management system detects that the traffic volume is reaching the upper threshold, it asks the virtualized network entity to boot two VMs.

4) Two VMs in network entity boot, and if there is no available resource on running physical servers, a new physical server should be booted firstly.

I.3 SAME network slice for MVNO scenario

Descriptions

An MVNO utilizes part of the operator's current network, such as RAN and IP network, but wants to deploy some other functions independently, such as the gateway (GW), user profile function, IP multimedia subsystem (IMS) and application servers. The MNO provides SAME network slices to the MVNO to deploy the specific function elements in virtual manner.

Preconditions

A MVNO wants to deploy some network functions by itself except the shared infrastructure with the operator. The operator provides a SAME network slice that contains SAME functions, and related resources like computing, storage, networking, to the MVNO. The MVNO deploys its network functions on the hardware resource pool of the operator. The MNO is responsible for the management of the MVNO's network.

Operational flows

1) The MVNO asks the operator to provide the network resource with required network performance, such as bandwidth, session number, quality of service (QoS) level.

2) The operator allocates a SAME network slice to the MVNO that contains SAME functions and related resources. The MVNO can also install individual network functions in a virtualized manner. The MVNO sets up the network and launches the services.

3) The operator adjusts the SAME network slice dynamically following the requirements and the load of the network functions of the MVNO.

4) The operator maintains the MVNO's network built on the hardware resource pool.

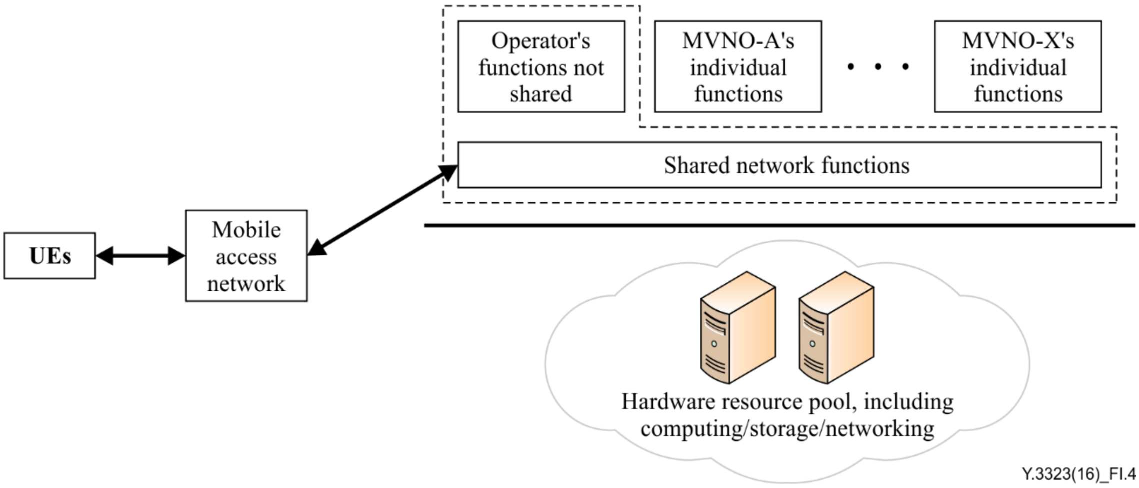

Figure I.4 – SAME network slice for MVNO scenario

I.4 Separation of control function and forwarding function

In these scenarios, the control function and forwarding function of mobile packet core gateway are separated. The GW control function is mainly in charge of mobility management and session management. The GW forwarding function is responsible for packet encapsulation/decapsulation for tunnelling, packet forwarding rules, forwarding performance and QoS level. The tunnel/packet routing/switch information and tunnel parameters are transferred from control function to forwarding function. The charging function could be realized on control function, forwarding function or both, which depends on the implementations. The separation of the GW's control function and forwarding function could improve the deployment flexibility, such as centralized control function and distributed forwarding function deployment, without changing the interfaces to other legacy functions.

Scenario 1: flexible deployment of separated control function and forwarding function

Descriptions

When the GW is separated into control function and forwarding function, the control function is centralized and deployed with other mobile packet core control function such as mobility management function, and policy function.

The centralization of control functions makes the operation and management easier; in addition, NFV technology can be used for the centralized control functions to achieve benefits such as resource sharing, scheduling and faster deployment.

The separation of control function and forwarding function in the same equipment enables the scaling independent of each other.

By separation of control function and the forwarding function, the capacity of forwarding function data handling can naturally be enhanced by increasing the number the forwarding equipment.

When the control function deployed in centralized manner and the forwarding function in distributed manner, the distributed forwarding functions could realize traffic localization, because voice or video service mostly happens between users in the same region. Distributed forwarding function localizes the traffic, which will reduce the transport cost dramatically. Further, when the distributed forwarding function resides closer to the subscriber, the latency could be reduced.

Preconditions

The GW is separated into control function and forwarding function, and the control function and forwarding function can be deployed in a flexible way.

Operational flows

Case 1: centralized control function and forwarding function

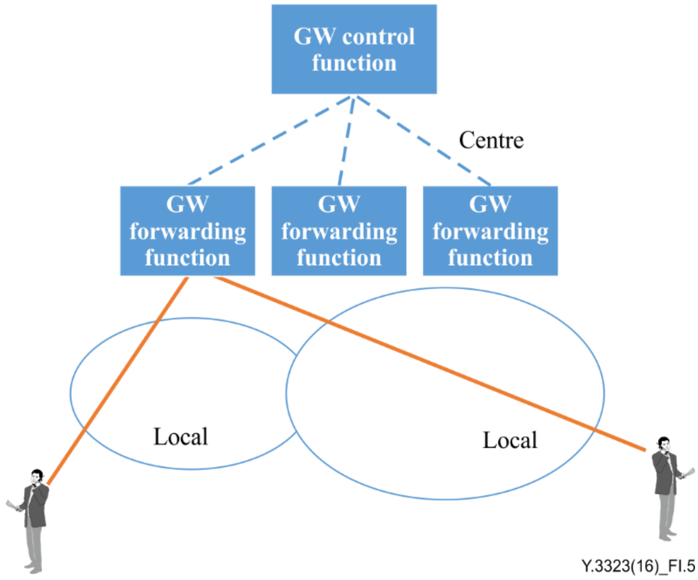

Figure I.5 – Centralized control function and forwarding function

When the control function and the forwarding function are both deployed in a centralized manner, the control function and the forwarding functions are able to dimension and scale independently, and hence, to achieve more optimal processing and efficient resource utilization.

Case 2: centralized control function and distributed forwarding functions: traffic localization and latency reduction

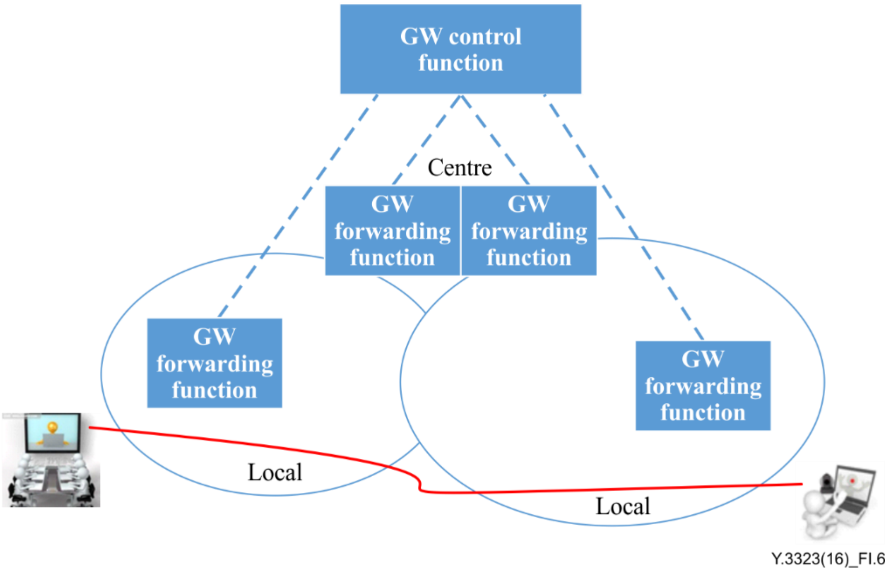

Figure I.6 – Traffic localization and latency reduction

When the forwarding function is deployed closer to the subscriber, the latency could be reduced and traffic is also localized.

1) User equipment (UE) accesses the network and sets up a video conference.
2) The GW control function selects the forwarding function closest to the UE instead of the forwarding function in the centre of the network, in order to localize the traffic and reduce the network latency.
3) The video conference is set up.

Scenario 2: traffic scheduling optimization

Descriptions

The GW is separated into control function and forwarding function, the control function is centralized and the forwarding function is distributed.

The control function can change the GW forwarding function (GW-U) in a flexible manner according to network policies for on-going traffic. This improves the bandwidth utilization and users' experience.

Preconditions

The GW is separated into control function and forwarding function, the control function is deployed in centralized manner and the forwarding function in distributed manner.

Operational flows

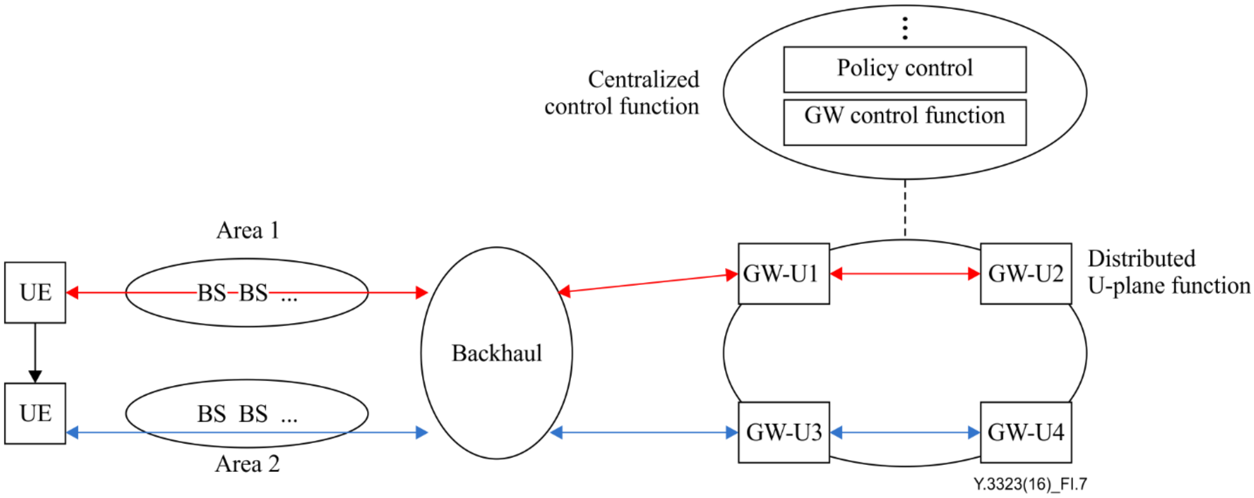

Figure I.7 – Traffic scheduling optimization

1) UE accesses mobile access Area 1, and UE traffic goes through GW-U1 and GW-U2.

2) UE moves from mobile access Area 1 to Area 2.

3) GW control function can change GW-U for UE. As shown in Figure I.7, UE traffic will go through GW-U3 and GW-U4 and the traffic is optimized.

Appendix II

Problem statement of current mobile packet core network

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

This clause focuses on the problem statement of the mobile packet core in the current network based on the analysis of scenarios in Appendix I.

II.1 Problem in traffic steering

Faced with rapid increases of data traffic, MNOs want to and/or have to deploy many service function entities such as URL filter, video optimization, content compression to improve the user's quality of experience (QoE), to reduce the bandwidth pressure and to provide valued added services. Two kinds of service function entity models, i.e., the static serial model and the hairpin model, are deployed [b-3GPP TR 22.808].

Static serial model is one where the service function entities are statically connected with one another, and traffic goes through all the service function entities deployed on the chain. The access point name (APN) is usually used to differentiate each service chain. However, this model has some drawbacks:

– The flows go through the service function entities that are not necessarily needed. As a result, a transfer delay is added.

– All the capabilities on the chain have to be designed to be capable of handling maximum traffic processing capacity, even though the capabilities may only be needed for part of the traffic.

– It is difficult to adjust the service chain if a service function entity is reused in multiple service chains, e.g., a large number of configuration tasks becomes necessary when a shared service function entity is changed.

Hairpin model is one where all service function entities are connected to a centralized traffic routing controller, and the traffic goes back to the controller to decide the next hop after the previous service function entity processing ends. However, this model has some drawbacks:

– All traffic always goes through the centralized controller to determine the next hop, which significantly increases the load on the controller.

– The centralized processing network element becomes a single point of failure.

II.2 Problem caused by proprietary hardware

Network functions usually run on proprietary hardware appliances which require vendor-specific configuration tools. Frequently, the deployment of a new service requires yet another hardware box to be installed and configured. These issues add complexity to the operator's network management and service deployment, and increase operating expenses (OPEX).

In addition, because proprietary hardware usually cannot be shared by different network functions, these specialized hardware appliances suffer from short lifecycles due to the fast innovation in technology and unexpected changes in customers' demands. This worsens the efficiency of capital expenditure (CAPEX) such as hardware investment.

II.3 Problem statement of the mobile packet core gateway

The mobile packet core architecture has decoupled the control function and forwarding function partially by splitting the mobility management function from the hybrid control and forwarding function into mobility management function and gateway function. But the control function and forwarding function of the gateways are still tightly coupled, especially for the tunnel control and forwarding [b-IEEE-Kostas]. The current mobile gateways face some of the following issues:

– The tightly coupled control function and forwarding function of mobile packet core gateway leads to the extension of hardware device as a whole, even when the control function and forwarding function have different extension requirements and capability requirement.

– Selection mechanism of gateway is mainly based on the load information of the GW control function, not the real-time load of the forwarding function. A gateway may be selected even if its forwarding function is experiencing busty traffic overload.

– The gateway's control function and forwarding function are located in the same equipment. However, due to the proliferation of smart phones and tablets, and people's interest in multi-media services, the mobile traffic grows exponentially. Capacity increase of forwarding function is faster than control function. If we keep to couple control function and forwarding function, it becomes difficult for the gateway to improve the data-handling capacity in a flexible manner.

– There is a strong expectation to reduce the network latency when users search the Internet, conduct real-time communication, or others. Simply distributing the gateway closer to the RAN may lead to an increased number of gateways, and also of interfaces to other network entities like mobility management, resulting in a negative impact on configuration and network management.

Appendix III

Mapping between scenarios, problems, design principles and requirements

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

Figure III.1 provides the mapping between scenarios, problems, design principles and requirements. Four high-level requirements have one-to-one mapping to four scenarios.

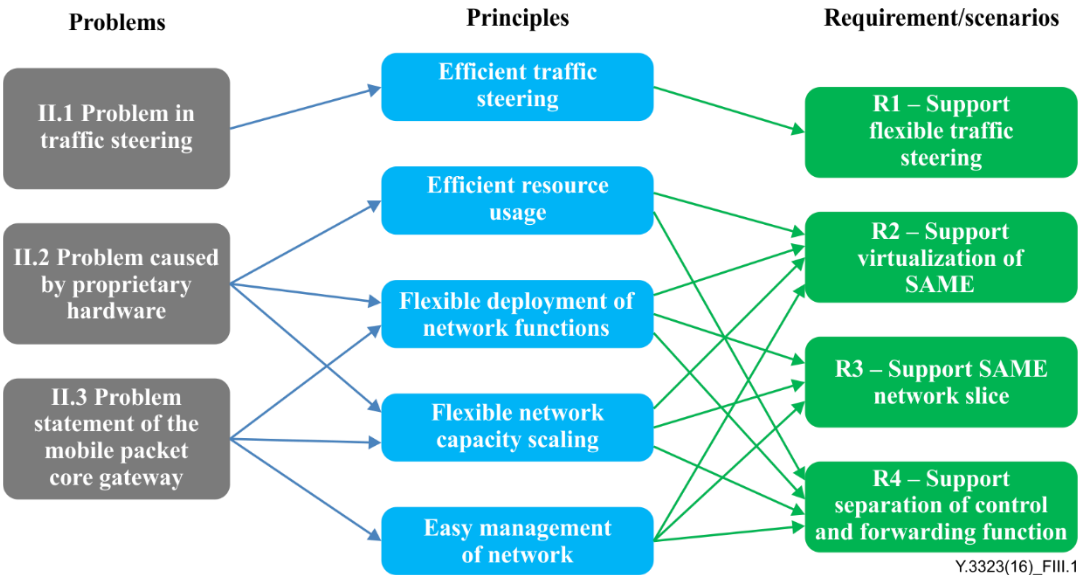

Figure III.1 – Mapping between scenarios, problems, design principles and requirements

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[b-3GPP TR 22.808] 3GPP TR 22.808, *Study on Flexible Mobile Service Steering (FMSS)*.

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