ETSI GS F5G 006 V1.1.1 (2022-09)

Fifth Generation Fixed Network (F5G); End-to-End Management and Control; Release #1

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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Fifth Generation Fixed Network (F5G).

Modal verbs terminology

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1 Scope

The present document focuses on the management and control aspects of the F5G End-to-End network architecture ETSI GS F5G 004 [1]. The present document specifies the End-to-End management and control architecture and its related interfaces, including:

- The technical requirements and functional blocks of the domain controllers and the E2E orchestrator in the F5G networks (Customer Premises Network (CPN), Access Network and Aggregation Network);
- The technical requirements and interface parameters of the northbound interfaces of the domain controllers of the Customer Premises Network (CPN), the Access Network, the Aggregation Network, the Core Network, and the E2E orchestrator.

NOTE: The technical requirements and functional blocks of the Core Network Controller is out of scope of the present document. However, it is part of the management architecture and interface.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

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The following referenced documents are necessary for the application of the present document.

[1] ETSI GS F5G 004 (V1.1.1): "Fifth Generation Fixed Network (F5G); F5G Network Architecture".

[2] IETF RFC 8795: "YANG Data Model for Traffic Engineering (TE) Topologies".

[3] ETSI GS ZSM 002 (V1.1.1): "Zero-touch network and Service Management (ZSM); Reference Architecture".

[4] IETF RFC 8453: "Framework for Abstraction and Control of TE Networks (ACTN)".

[5] IETF RFC 8346: "A YANG Data Model for Layer 3 Topologies".

[6] IETF RFC 8944: "A YANG Data Model for Layer 2 Network Topologies".

[7] IETF RFC 8299: "YANG Data Model for L3VPN Service Delivery".

[8] IETF RFC 8466: "A YANG Data Model for Layer 2 Virtual Private Network (L2VPN) Service Delivery".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] TM Forum IG1230 (V1.1.0): "Autonomous Networks Technical Architecture".

[i.2] TM Forum IG1218 (V2.1.0): "Autonomous Networks - Business requirements & architecture".

[i.3] TM Forum IG1251 (V1.0.0): "Autonomous Networks - Reference Architecture".

[i.4] ETSI GR F5G 008 (V1.1.1): "Fifth Generation Fixed Network (F5G); F5G Use Cases Release #2".

[i.5] IETF RFC 7926: "Problem Statement and Architecture for Information Exchange between Interconnected Traffic-Engineered Networks".

[i.6] ETSI GR F5G 010 (V1.1.1): "Fifth Generation Fixed Network (F5G); Security; Threat Vulnerability Risk Analysis and countermeasure recommendations for F5G".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI GS F5G 004 [1] and the following apply:

alarm propagation relationship: logical association of a set of correlated alarms

NOTE: The logical association of a set of correlated alarms includes but not limit to derivative association, causal association and time association.

autonomous domains: basic logical business entities to expose network resources/functionalities as services/capabilities in support E2E lifecycle of automated intelligent network/ICT services

NOTE: The definition of this term comes from TM Forum IG1218 [i.2].

autonomous network: system of networks and software platforms that are capable of sensing its environment and adapting its behaviour accordingly with little or no human input

NOTE: The definition of this term comes from TM Forum IG1230 [i.1].

domain: logical collection of network nodes and interconnecting links, including their management and control system. A domain may be further divided into multiple sub-domains

NOTE: In F5G, a domain is a network segment with its domain controller.

event source: the network components where the root alarm event is generated

NOTE: The network components could be a network element or a port.

incident: set of correlated events

intent: formal specification of the expectations, including requirements, goals, and constraints, given to a technical system

NOTE: The definition of this term comes from TM Forum IG1230 [i.1].

network segment: logical collection of network nodes and interconnecting links, grouped based on network technologies or for administration purposes

NOTE: In F5G networks, there are four types of network segments: the Customer Premises Network (CPN), Access Network (AN), Aggregation Network (AggN) and the Core Network (CN).

root alarm event: primary event of the original alarm event(s) that is triggered by the root cause of an incident

root cause: original cause or the critical factor(s) which leads to an incident

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

10G-EPON	10 Gbit/s Ethernet Passive Optical Network
ACTN	Abstraction and Control of TE Networks
AggN	Aggregation Network
AI	Artificial Intelligence
AN	Access Network
API	Application Programming Interface
BOM	Bill Of Materials
CMI	CNC-MDSC Interface
CN	Core Network
CPE	Customer Premise Equipment
CPN	Customer Premises Network
CSN	Commit Sequence Number
DC	Data Centre
E2E	End-to-End
E-O-CPE	Enterprise-OTN-Customer Premise Equipment
EPON	Ethernet Passive Optical Network
FTTR	Fibre To The Room
GEM	GPON encapsulation mode
GOSNR	Generalized Optical Signal-to-Noise Ratio
GPON	Gigabit Passive Optical Network
GRE	Guaranteed Reliable Experience
HGU	Home Gateway Unit
HSI	High Speed Internet
ID	Identifier
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPTV	Internet Protocol Television
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ISG	Industry Specification Group
LTP	Link Termination Point

NOTE: See section 3.5 of IETF RFC 8795 [2] for the definition of LTP.

MAC	Media Access Control
MCA	Management, Control & Analytics
MDSC	Multi-Domain Service Coordinator
MDU	Multi-Dwelling Unit
MP2MP	Multi-Point to Multi-Point
MPI	MDSC-PNC Interface
MTU	Maximum Transmission Unit
NBI	Northbound Interface
ODN	Optical Distribution Network
ODU	Optical Data Unit
OLT	Optical Line Terminal
OMCI	ONU Management and Control Interface
ONU	Optical Network Unit
OSNR	Optical Signal-to-Noise Ratio
OTN	Optical Transport Network
OTU	Optical Transport Unit
PNC	Provisioning Network Controller
POL	Passive Optical LAN
PON	Passive Optical Network

QoS	Quality of Service
RFC	Requests for Comments
SAP	Service Access Point
SFU	Single Family Unit
SLA	Service Level Agreement
SME	Small and Medium Enterprises
SMP	Service Mapping Point
SPP	Service Processing Point
TE	Traffic Engineering
TM	Telecommunication Management Forum
TPN	Tributary Port Number
TTP	Tunnel Termination Point

NOTE: See section 3.6 of IETF RFC 8795 [2] for the definition of TTP.

UUID	Universally Unique Identifier
VLAN	Virtual Local Area Network
VOD	Video On Demand
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
VR	Virtual Reality
VxLAN	Virtual extensible Local Area Network
WTR	Wait-To-Restore
XC	Cross-Connect
XG-PON	10-Gigabit-capable Passive Optical Network
XGS-PON	10-Gigabit-capable Symmetric Passive Optical Network
YANG	Yet Another Next Generation data modelling language
ZSM	Zero-touch network and Service Management

4 Requirements for E2E management and control of F5G networks

4.1 Motivation

Guaranteed Reliable Experience (GRE) is one of the key dimensions of a F5G network, which enables the business demand of highly sensitive services, high reliability and high availability communication, and high operational efficiency.

To meet the requirements of GRE, the Management, Control & Analytics (MCA) Plane is introduced in the F5G architecture, which is responsible for the management, control and analytics of the E2E F5G networks covering the CPN, AN, AggN and CN.

The present document defines the F5G E2E management and control architecture as a subset of the overall F5G MCA Plane as defined in ETSI GS F5G 004 [1].

4.2 General requirements and management aspects

In the following a general set of management aspects of the F5G E2E management and control system are described.

- E2E service provisioning:

  The F5G network supports a rich set of applications and services traversing multiple network segments. The F5G E2E management and control system shall support the instantiation, configuration and maintenance of these F5G E2E services, including their creation, modification and termination, and supporting the automation of the corresponding workflows.

- Efficient network operation:

  The F5G network improves the efficiency of the network operation by an intelligent E2E management and control system. The key requirements of this intelligent E2E management and control system include:

  - Network resource visibility: The F5G E2E management and control system shall support the necessary functionality to provide the F5G network resource information to the network administrators. This improves the efficiency for the network operators to operate and manage their networks. Additionally, the system should support the visualization of the information at a high-level of abstraction for administrators to see important system aspects.

  - Intelligent fault management: The F5G E2E management and control system shall support intelligent root cause analysis and alarm correlation analysis, which provides effective guidance to the network operators for accurate troubleshooting. The management and control E2E management and control system shall also support proactive fault management to identify and eliminate potential risks in advance.

- Interoperability:

  In the F5G network, different network segments may be from different vendors. The F5G E2E management and control system shall support the collaboration and orchestration of the domain controllers for different network segments. This is achieved through open interfaces between the E2E orchestrator and each domain controller.

5 Architecture of E2E management and control of F5G network

5.1 Design principles

TM Forum IG1251 [i.3] defines the methodology, general principles, and the high-level business and technical architecture of Autonomous Networks. The present document specifies he E2E management and control architecture as an "Autonomous F5G Network", which enables the self-configuration, self-healing, self-optimizing and self-evolving of F5G resources and services with less human intervention.

The design principles for this management and control architecture include:

- Autonomous domain:

  Each of the F5G domains, the CPN, the AN and the AggN (together with the management and control system of that domain) are considered an autonomous domain. This enables the support of F5G E2E services.

- Intent-driven:

  Intent defines what is expected to be achieved but leaves the details of how the network is deployed and operated to the autonomous domain. In the F5G E2E management and control system, the interfaces exposing to the E2E Orchestrator the resources/functionalities of each autonomous domain shall be designed in an "intent" style. In this way, each F5G autonomous domain could be treated as a whole, and the E2E management and control system does not need to be aware of the detailed information of each domain.

  The F5G E2E management and control system shall focus on the interaction and orchestration of different autonomous domains through their intent-driven interfaces.

- Closed-loop control:

  Based on the autonomous domain and intent-driven interfaces, it is possible to design the resource and service control closed-loops in the F5G E2E management and control system. The service control closed-loop enables the full lifecycle service operation, while the resource control closed-loop enables the full lifecycle cross-domain and cross-layer resource orchestration.

- Simplicity:

  The concept of "simplicity" is a fundamental principle of network design. For management and control aspects, it means fewer layers, interfaces, and protocols. Intelligent and automatic mechanisms enable simplicity. In the F5G network, the E2E management and control system shall be designed hierarchically and includes intelligent components to simplify the architecture.

5.2 Hierarchy architecture overview

5.2.1 F5G E2E management and control architecture

ETSI GS ZSM 002 [3] defines the End-to-End network and service management framework for multi-domain, multi-technology and multi-layer networks with hierarchical service management domains. The management and control of F5G networks is an instance of the ZSM architecture applied to optical communication networks.

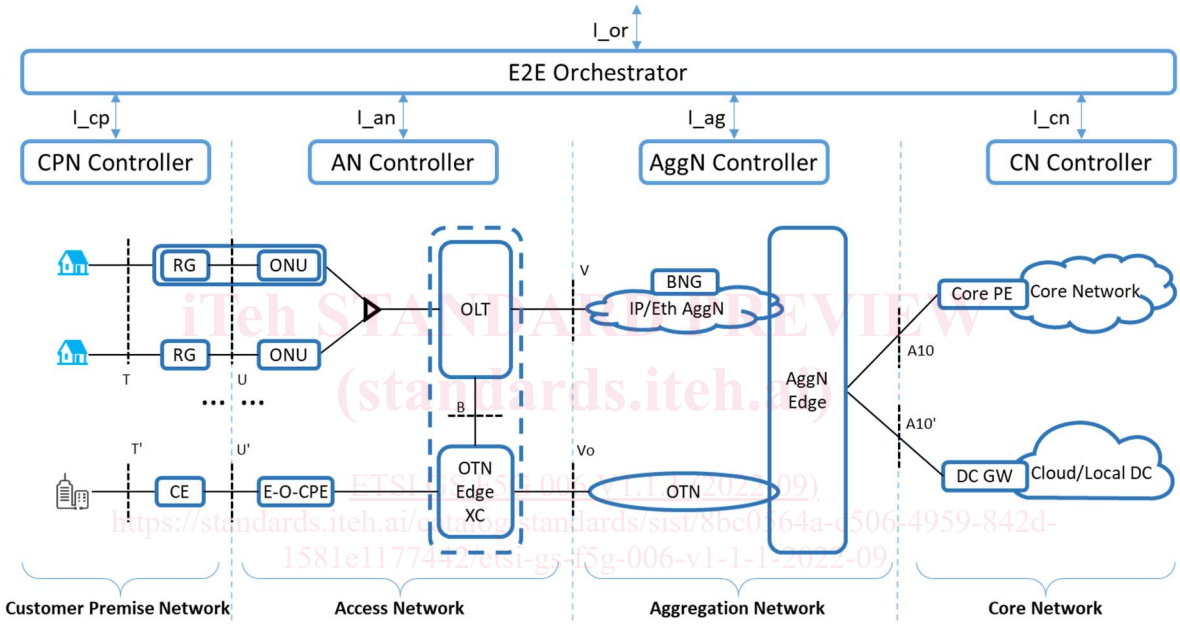

Figure 1: F5G E2E management and control architecture

Figure 1 shows the F5G E2E management and control system architecture, which adds hierarchical controllers and an orchestrator to the F5G network topology defined in ETSI GS F5G 004 [1]. Note that all the controllers and the orchestrator in this architecture are logical functional blocks, which are not necessarily physical controllers in the network.

A domain controller is introduced for each F5G network segment:

- Customer Premises Network Controller (CPN Controller): Used to manage and control the CPN. The CPN Controller could be deployed within the CPN or in a remote location. In the remote deployment case, the management and control of the CPN is the responsibility of the network operator.

- Access Network Controller (AN Controller): Used to manage and control the Access Network, including OLTs, ODNs and associated ONUs. The AN Controller function includes management and control of the Underlay Plane (PON network) and the SAP, SPP and SMP in the Service Plane of the Access Network.

- Aggregation Network Controller (AggN Controller): In F5G, both IP/Ethernet network and OTN are possible options for the Aggregation Network, and both types of Aggregation Networks can co-exist. The AggN Controller is used to control different types of Aggregation Networks, and provides the resource and services orchestration function for both IP/Ethernet and OTN.

- Core Network Controller (CN Controller): The CN Controller controls the Core Network and may or may not control the Cloud/Local Data Centre. The CN Controller is outside the scope of the present document, but the interface I_cn on the northbound interface of the CN Controller is still in the scope, which is needed for E2E service provisioning.

The E2E Orchestrator interacts with each domain controller through the I_cp, I_an, I_ag and I_cn interfaces and performs the resource and service orchestration functions as follows:

- E2E resource orchestration function: this function mainly focuses on the orchestration of the F5G Underlay Plane. This function includes collecting the (abstracted) topology, resource and status information, triggering the creation of tunnels in each network segment, resource optimization across multiple network domains, identification and location of network failures, analysis of status change and prediction of failures.

- E2E service provisioning function: mainly focusing on the management and control of the F5G Service Plane. The E2E Orchestrator configures the SAP, SPP, and SMP for service access, service processing, and service mapping into respective tunnels to automatically enable the creation, activation, modification, and deletion of services. The E2E Orchestrator monitors the performance of the services, and takes necessary actions when service degradation occurs, according to the SLAs of the services.

5.2.2 Relationship with ZSM architecture

Figure 2 illustrates the mapping relationship between the F5G management and control architecture and the ZSM architecture defined in ETSI GS ZSM 002 [3].

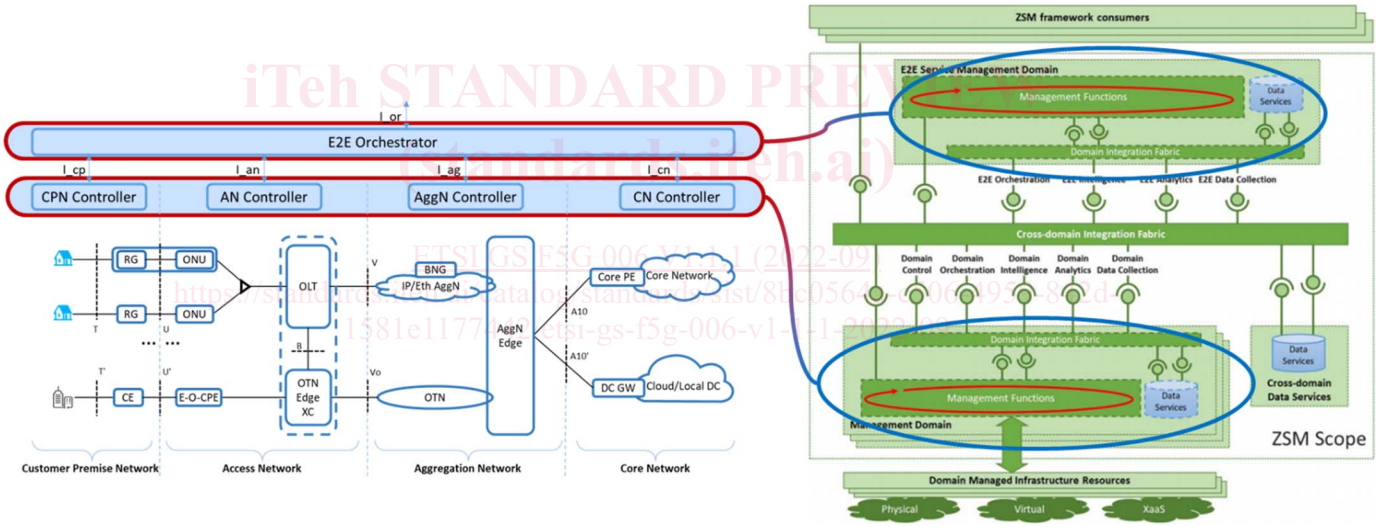

Figure 2: Relationship between the F5G E2E management and control architecture and the ZSM architecture

In ZSM architecture (ETSI GS ZSM 002 [3]), each management domain manages one or more entities, such as infrastructure resources and/or resource-facing services associated with the management domain. The F5G domain controllers, the CPN Controller, the AN Controller, the AggN Controller and the CN Controller, are equivalent to the entities of the ZSM Management Domains.

The E2E service management domain is a special management domain that provides End-to-End management of customer-facing services, composed from the customer-facing or resource-facing services provided by one or more management domains. The F5G E2E Orchestrator is an equivalent to an instance of the ZSM E2E Service Management Domain, which manages the F5G E2E services across multiple domains.

The management functions of the F5G E2E Orchestrator and the domain controllers are described in clause 6 of the present document.

5.3 Service Management Processes

5.3.1 Overview

The ETSI ISG ZSM architecture defines the general processes of cross-domain E2E service lifecycle management (covering the fulfilment and assurance processes) and describes the interactions between the E2E service management domain and the underlying management domains during these processes. This clause specifies the processes of service fulfilment and service assurance in the context of F5G.

Note that the error conditions of the service provisioning processes are not included below and are for further study.

5.3.2 F5G service fulfilment

5.3.2.1 Overview

The fulfilment of F5G services includes the processes of service instantiation, service activation, service modification, service deactivation and service decommissioning.

5.3.2.2 Service instantiation:

a) The E2E Orchestrator receives the E2E service instantiation request from the customer management system.

b) The E2E Orchestrator determines the performance requirements of the service and the policies to instantiate the service.

c) The E2E Orchestrator communicates with each domain controller associated with the service instantiation to perform a feasibility check. The feasibility check evaluates whether the service performance can be satisfied based on the current state of its domain network.

d) The E2E Orchestrator communicates with each domain controller associated with the service to instantiate the service instances in their respective domain networks. Depending on the service instantiation policies and the current network state, one of the following steps may be executed for each domain:

- To create a new service instance in a domain. That domain controller allocates the resource for the service instance in its domain. The path segment for the service instance of that domain in the Underlay Plane may be created at this stage or later when activating the service instance.

- To re-use an existing path segment instance in the domain shared by multiple E2E service instances. An existing path segment instance may be re-configured to increase its capacity for the new service request. For example, in the OTN AggN domain, an OTN container carries multiple E2E service instances from different CPNs. In the case of a new service request, an existing OTN container needs to be reconfigured.

e) Each domain controller communicates its updated topology/inventory information to the E2E Orchestrator.

f) The E2E Orchestrator creates a service instance in its database.

NOTE: The action f) may occur in at any stage in the aforementioned sequence.

5.3.2.3 Service activation

a) The E2E Orchestrator receives the service activation request from the customer management system.

b) The E2E Orchestrator communicates with each domain controller associated with the service to activate the service instance within its domain. The domain controller may activate the path of the service instance within its domain in the Underlay Plane, if it has not already been activated. The domain controllers at both ends of the path for this service instance may also configure the admission control in the Service Plane, to allow the customer's traffic to be adapted and carried by the service instance.

c) Each domain controller communicates its updated topology/inventory information to the E2E Orchestrator.