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TECHNICAL SPECIFICATION

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Access Traffic Steering, Switching and Splitting (ATSSS);
Stage 3
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In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Contents

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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where:

x   the first digit:

1   presented to TSG for information;

2   presented to TSG for approval;

3   or greater indicates TSG approved document under change control.

y   the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z   the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, certain modal verbs have the following meanings:

shall   indicates a mandatory requirement to do something

shall not   indicates an interdiction (prohibition) to do something

NOTE 1: The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

NOTE 2: The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

should   indicates a recommendation to do something

should not   indicates a recommendation not to do something

may   indicates permission to do something

need not   indicates permission not to do something

NOTE 3: The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

can   indicates that something is possible

cannot   indicates that something is impossible

NOTE 4: The constructions "can" and "cannot" shall not to be used as substitutes for "may" and "need not".

will   indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

will not   indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

might   indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not   indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is   (or any other verb in the indicative mood) indicates a statement of fact

is not   (or any other negative verb in the indicative mood) indicates a statement of fact

NOTE 5: The constructions "is" and "is not" do not indicate requirements.

1 Scope

The present document specifies the procedures for access traffic steering, switching and splitting (ATSSS) between the UE and the network across one 3GPP access network and one non-3GPP access network as specified in 3GPP TS 23.501 [2], 3GPP 23.502 [3], and 3GPP TS 23.316 [4].

The ATSSS can be supported over the access network where an MA PDU session can be established. The type of access network includes NG-RAN and untrusted non-3GPP access network as specified in 3GPP TS 23.501 [2], trusted non-3GPP access network, wireline access network and as specified in 3GPP TS 23.316 [4]. An MA PDU session established by the UE can also simultaneously use one 3GPP access network connected to EPC and one non-3GPP access network connected to 5GCN as specified in 3GPP TS 23.502 [3].

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1]   3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2]   3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[3]   3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[4]   3GPP TS 23.316: "Wireless and wireline convergence access support for the 5G System (5GS)".

[5]   3GPP TS 24.526: "UE policies for 5G System (5GS); Stage 3".

[6]   3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

[7]   3GPP TS 24.502: "Access to the 3GPP 5G System (5GS) via non-3GPP access networks; Stage 3".

[8]   IETF RFC 8684: "TCP Extensions for Multipath Operation with Multiple Addresses".

[9]   IETF RFC 8803: "0-RTT TCP Convert Protocol".

[10]   3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3".

[11]   IEEE Std 802-2014: "IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture".

[12]   IEEE 802.3-2018: "IEEE Standard for Ethernet".

[13]   3GPP TS 24.007: "Mobile radio interface signalling layer 3; General aspects".

[14]   3GPP TS 33.501: "Security architecture and procedures for 5G system".

[15]   3GPP TS 37.324: "E-UTRA and NR; Service Data Adaptation Protocol (SDAP) specification".

[16]   3GPP TS 29.244: "Interface between the Control Plane and the User Plane Nodes; Stage 3".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.501 [2] apply:

MA PDU session
Measurement assistance information

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

5G-RG	5G Residential Gateway
ATSSS	Access Traffic Steering, Switching, Splitting
ATSSS-LL	ATSSS Low-Layer
LADN	Local Area Data Network
MA PDU	Multi-Access PDU
MAI	Measurement Assistance Information
MPTCP	Multi-Path TCP Protocol
PDU	Protocol Data Unit
PLR	Packet Loss Rate
PMF	Performance Measurement Function
QFI	QoS Flow Identifier
RTT	Round Trip Time
SA PDU	Single-Access PDU
SDF	Service Data Flow
UAD	UE Assistance Data
UAT	UE Assistance data Termination
UPF	User Plane Function
URSP	UE Route Selection Policy

4 General description

4.1 Introduction

ATSSS is an optional feature that can be supported by the UE and the 5GC network to route data traffic across 3GPP access and non-3GPP access networks. An ATSSS capable UE establishes an MA PDU session supporting multi-access connectivity over 3GPP access and non-3GPP access networks as described in clause 4.2. The ATSSS capable UE can support ATSSS-LL and/or MPTCP steering functionality as described in clause 4.3, with associated steering modes, i.e. active-standby, smallest delay, load balancing, priority based. The ATSSS capable UE indicates the steering functionality and associated steering modes to the 5GC network.

When the ATSSS capable UE registers to a registration area, it receives an indication from the AMF if the network supports the ATSSS. The procedure for how the AMF indicates the UE about its ATSSS support is specified in 3GPP TS 24.501 [6]. The UE capable ATSSS and the network supporting ATSSS exchange access performance measurements as described in clause 4.4. Clause 4.5 describes the traffic distribution over 3GPP access and non-3GPP access networks. Clause 4.6 provides a description for interworking with EPS network. Clause 4.7 describes ATSSS when the ATSSS capable UE is interconnected with EPS.

The architecture reference model for ATSSS support is described in clause 4.2.10 of 3GPP TS 23.501 [2].

4.2   Multi-access PDU session

A PDU session supporting a multi-access PDU connectivity service is referred to as multi-access PDU (MA PDU) session. An MA PDU session is a PDU session which can use one 3GPP access network or one non-3GPP access network at a time, or simultaneously one 3GPP access network and one non-3GPP access network as defined in 3GPP TS 23.501 [2].

An MA PDU session can be established when the UE is registered to the same PLMN over 3GPP access network and non-3GPP access network or registered to different PLMNs over 3GPP access network and non-3GPP access network respectively. A UE can initiate MA PDU session establishment when the UE is registered to a PLMN over both 3GPP access network and non-3GPP access network, or only registered to one access network. Therefore, at any given time, the MA PDU session can have user-plane resources established on both 3GPP access and non-3GPP access, or on one access only (either 3GPP access or non-3GPP access), or can have no user-plane resources established on any access.

An ATSSS capable UE can establish an MA PDU session based on the URSP rules as defined in 3GPP TS 24.526 [5].

The following PDU session types are defined for an MA PDU session: IPv4, IPv6, IPv4v6 and Ethernet.

NOTE 1: The unstructured PDU session type is not supported in this release of the specification.

NOTE 2: An MA PDU session using IPv6 multi-homing or uplink classifier is not specified in this release of the specification.

MA PDU sessions for LADN are not supported.

4.3   Steering functionalities

An ATSSS capable UE can use a steering functionality to steer, switch and split the UL traffic across the 3GPP access network and the non-3GPP access network as defined in clause 5.32.6 of 3GPP TS 23.501 [2]. An ATSSS capable network can use the corresponding steering functionality for the DL traffic.

The UE and the network can support one or more of the following steering functionalities:

a) the MPTCP steering functionality operates above the IP layer. The UE and an associated MPTCP proxy functionality in the UPF can communicate by using the MPTCP protocol; and

b) the ATSSS-LL steering functionality operates below the IP layer as a data switching function.

4.4   Support of access performance measurements

The ATSSS capable UE can perform access performance measurements to decide how to distribute traffic over 3GPP access and non-3GPP access. The access performance measurements can be performed by using the QoS flow(s) of default QoS rule. Based on the UE capability that the UE has indicated to the network, the access performance measurements can also be performed by using the QoS flows of non-default QoS rules.

An ATSSS capable UE receives MAI from the SMF during the PDU session establishment procedure for an MA PDU session as described in clause 5.32.5 of 3GPP TS 23.501 [2], during a network-requested PDU session modification procedure as specified in clause 6.3.2 of 3GPP TS 24.501 [6], during UE requested PDN connectivity procedure according to clause 6.5.1 of 3GPP TS 24.301 [10] or during EPS bearer context modification procedure according to clause 6.4.3 of 3GPP TS 24.301 [10]. The MAI can contain the addressing information of the PMF in the UPF, as well as an indicator on whether access availability/unavailability reports need to be sent to the network. If the UE indicates to the network the capability to perform the access performance measurements by using the QoS flows of non-default QoS rules, the MAI can also indicate to the UE that the performance measurement is for the QoS flows of non-default QoS rules and therefore include a QoS flow list for which, the measurements are to be performed. The encoding of the MAI is specified in clause 6.1.5.

An ATSSS capable UE that supports the MPTCP steering functionality can use the measurements available at the MPTCP layer.

The following PMF protocol messages can be exchanged between the PMF in the UE and the PMF in the UPF:

a) messages for RTT measurements, only applicable for the ATSSS-LL steering functionality;

b) messages for reporting access availability/unavailability by the UE to the UPF;

c) messages for PLR measurements, only applicable for the ATSSS-LL steering functionality; or

d) messages for UAD provisioning ; or

e) messages for UAT.

An ATSSS capable UE does not apply the ATSSS rules to the PMF protocol messages.

The performance measurement function protocol procedures are specified with following procedures:

a) UE-initiated RTT measurement (see clause 5.4.3);

b) Network-initiated RTT measurement (see clause 5.4.4);

c) UE-initiated PLR measurement (see clause 5.4.6);

d) Network-initiated PLR measurement (see clause 5.4.7);

e) UE assistance data provisioning procedure (see clause 5.4.8);

f) The access availability/unavailability procedures (see clause 5.4.5); and

g) UE assistance data termination procedure (see clause 5.4.9).

4.5 Distribution of traffic across 3GPP access and non-3GPP access networks

The UE can receive ATSSS rules during the PDU session establishment procedure for an MA PDU session or network-requested PDU session modification procedure. The ATSSS rule ID and ATSSS rule operation for each rule is used to add a new ATSSS rule, or to delete or update an existing ATSSS rule. The UE can distribute the UL traffic except for the PMF protocol messages across the 3GPP access network and the non-3GPP access network according to the ATSSS rules and other local conditions (such as network interface availability, signal loss conditions, user preferences, etc.).

NOTE: On the network side, the SMF configures relevant N4 rules according to the ATSSS control information provided by the PCF for the UPF to distribute DL traffic across two access networks.

4.6 EPS interworking

In the network supporting N26 interface:

a) if the UE established an MA PDU session over non-3GPP access only, no EPS bearer identity can be assigned to any QoS flow of the MA PDU session as specified in 3GPP TS 23.502 [3];

b) if the UE established an MA PDU session over 3GPP access and non-3GPP access and the user plane of the MA PDU session over 3GPP access is released, the EPS bearer identity assigned for the MA PDU session can be revoked as specified in 3GPP TS 23.502 [3];

c) for an inter-system change from N1 mode to S1 mode:

1) if the UE established an MA PDU session over 3GPP access only, the UE follows the procedure as specified in clause 6.1.4.1 of 3GPP TS 24.501 [6]; or

2) if the UE established an MA PDU session over 3GPP access and non-3GPP access, the UE follows the procedure as specified in clause 6.1.4.1 of 3GPP TS 24.501 [6], and

A) if the MA PDU session is transferred to EPS as a PDN connection and the UE did not indicate its support of establishing a PDN connection as the user plane resource of an MA PDU session during the MA PDU session establishment procedure as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6], the SMF can initiate the network-requested PDU session release procedure over non-3GPP access as specified in clause 6.3.3.2 of 3GPP TS 24.501 [6] or perform a local release of the MA PDU session. The UE performs a local release of the MA PDU session over 3GPP access and non-3GPP access;

NOTE 1: If the UE receives from the network a PDU SESSION RELEASE COMMAND message which indicates to release the MA PDU session over non-3GPP access and the UE has already performed or is performing a local release of the MA PDU session, the error handling as specified in clause 6.3.3.6 of 3GPP TS 24.501 [6] is applied.

NOTE 2: The QoS flow(s) with EBI assigned over non-3GPP access is also transferred to the corresponding PDN connection.

B) if the MA PDU session is transferred to EPS as a PDN connection and the UE indicated its support of establishing a PDN connection as the user plane resource of an MA PDU session during the MA PDU session establishment procedure as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6], the SMF can keep the MA PDU session over non-3GPP access; or

C) if the MA PDU session is not transferred to EPS as a PDN connection and the SMF decides to move the traffic of the MA PDU session from 3GPP access to non-3GPP access, the SMF can initiate the network-requested PDU session modification procedure as specified in clause 6.3.2.2 of 3GPP TS 24.501 [6]; and

d) for an inter-system change from S1 mode to N1 mode, if the UE requests an MA PDU session or the related URSP or UE local configuration does not mandate that the PDU session is established over a single access when transferring the PDN connection to 3GPP access, the PDN connection can be converted by the network to an MA PDU session via the UE-requested PDU session modification procedure (see clause 5.2.5).

In the network not supporting N26 interface:

a) for an inter-system change from N1 mode to S1 mode, if the UE intends to transfer the MA PDU session to EPS and the UE did not indicate its support of establishing a PDN connection as the user plane resource of an MA PDU session during the MA PDU session establishment procedure as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6], the UE follows the procedure as specified in clause 6.1.4.2 of 3GPP TS 24.501 [6] and performs a local release of the MA PDU session over 3GPP access and non-3GPP access. The SMF can initiate the network-requested PDU session release procedure over non-3GPP access as specified in clause 6.3.3.2 of 3GPP TS 24.501 [6] or perform a local release of the MA PDU session;

NOTE 3: If the UE receives from the network a PDU SESSION RELEASE COMMAND message which indicates to release the MA PDU session over non-3GPP access and the UE has already performed or is performing a local release of the MA PDU session, the error handling as specified in clause 6.3.3.6 of 3GPP TS 24.501 [6] is applied.

b) for an inter-system change from N1 mode to S1 mode, if the UE intends to transfer the MA PDU session to EPS and the UE indicated its support of establishing a PDN connection as the user plane resource of an MA PDU session during the MA PDU session establishment procedure as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6], the UE follows the procedure as specified in clause 6.1.4.2 of 3GPP TS 24.501 [6] and performs a local release of the MA PDU session over 3GPP access. The SMF can keep the MA PDU session over non-3GPP access; and

c) for an inter-system change from S1 mode to N1 mode, if the related URSP or UE local configuration does not mandate that the PDU session is established over a single access, the UE can initiate the UE-requested PDU session establishment procedure to request an MA PDU session (see clause 5.2.1) or to allow the PDU session to be upgraded to an MA PDU session (see clause 5.2.6) when transferring the PDN connection to 5GS.

4.7 MA PDU session establishment with 3GPP access connected to EPC and non-3GPP access connected to 5GCN

A UE can establish an MA PDU session via non-3GPP access connected to 5GCN and E-UTRAN EPC as specified in clause 4.22.2.3 of 3GPP TS 23.502 [3].

When establishing a PDN connection via 3GPP access connected to EPS, the UE can indicate that the PDN connection is to be used as a user-plane resource associated with:

a) a new MA PDU session; or

b) an existing MA PDU session established in non-3GPP access connected to 5GCN.

NOTE: "Non-3GPP access" is replaced with "wireline access network" connected to 5GCN if the UE is the 5G-RG.

If the UE does not support Ethernet PDN type or the Ethernet PDN type is not supported in EPC, there are following requirements:

a) the UE cannot establish a PDN connection as the user plane resource associated with a new MA PDU session of Ethernet PDU session type; and

b) the UE can establish a PDN connection of non-IP PDN type as the user plane resource associated with an existing MA PDU session of Ethernet PDU session type.

Clause 5.3 specifies the procedure of MA PDU session establishment with 3GPP access connected to EPC and non-3GPP access connected to 5GCN.

5 ATSSS control procedures

5.1 Introduction

The ATSSS control procedures include:

a) multi-access PDU connectivity service procedures (see clause 5.2);

b) multi-access PDU connectivity over E-UTRAN and non-3GPP access network (see clause 5.3); and

c) performance measurement function protocol procedures (see clause 5.4).

In clause 5.2, multi-access PDU connectivity service procedures include following management procedures:

a) activation of multi-access PDU connectivity service;

b) re-activation of user-plane resources;

c) release of user-plane resources;

d) updating ATSSS parameters;

e) converting PDU session transferred from EPS to MA PDU session; and

f) PDU session establishment with network modification to MA PDU session.

In clause 5.3, the multi-access PDU connectivity procedures over E-UTRAN and non-3GPP access network are specified.

In clause 5.4, performance measurement function protocol procedures are performed by exchanges of PMF protocol messages between the PMF in a UE and the PMF in the UPF over the user plane. For MA PDU sessions of IPv4, IPv6, or IPv4v6 PDU session type, the PMF protocol messages are transported using UDP. For MA PDU sessions of Ethernet PDU session type, the PMF protocol messages are transported using Ethernet frames. The protocol stacks of the PMF protocol are specified in clause 5.32.5.4 of 3GPP TS 23.501 [2].

5.2 Multi-access PDU connectivity service

5.2.1 Activation of multi-access PDU connectivity service

Activating multi-access PDU connectivity service refers to the establishment of user-plane resources on both 3GPP access and non-3GPP access:

a) if the UE is registered over both 3GPP access and non-3GPP access in the same PLMN, the UE shall initiate the UE-requested PDU session establishment procedure as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6] over a selected access, either 3GPP access or non-3GPP access. Over which access to initiate this UE-requested PDU session establishment procedure is UE implementation specific. When the UE receives the PDU SESSION

ESTABLISHMENT ACCEPT message including the ATSSS container IE as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6], the UE shall consider that the MA PDU session has been established and the user plane resources are successfully established on the selected access. When the user plane resources are established on the access other than the selected access (e.g. received lower layer indication in 3GPP access or established user plane IPsec SA in untrusted non-3GPP access), the UE shall consider the user plane resources are established on both;

NOTE: If the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message including the ATSSS container IE and fails to receive user plane resources established on the access other than the selected access, upon an implementation specific timer expiry the UE re-initiates the UE-requested PDU session establishment procedure over the access other than the selected access, in order to establish user plane resources on the access other than the selected access.

b) if the UE is registered over both 3GPP access and non-3GPP access in different PLMNs, the UE shall initiate the UE-requested PDU session establishment procedure as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6] over 3GPP access and non-3GPP access sequentially. Over which access to first initiate the UE-requested PDU session establishment procedure is UE implementation specific. When the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message including the ATSSS container IE as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6] over the selected access, the UE shall consider that the MA PDU session has been established and the user plane resources of the MA PDU session on this access are successfully established. The UE shall then initiate the UE-requested PDU session establishment procedure with the same PDU session ID, as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6] over the other access, in order to establish user plane resources on the other access for the MA PDU session. If the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6] over the other access, the UE shall consider that the user plane resources of the MA PDU session have been established on both 3GPP access and non-3GPP access; or

c) if the UE is registered to a PLMN over only one access, either 3GPP access or non-3GPP access, the UE shall initiate the UE-requested PDU session establishment procedure as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6] over this access. When the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message including the ATSSS container IE as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6] over the access, the UE shall consider that the MA PDU session has been established and the user plane resources of the MA PDU session on this access are successfully established. When the UE at a later point in time registers over the other access, either in the same PLMN or in a different PLMN, the UE shall initiate the UE-requested PDU session establishment procedure with the same PDU session ID as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6] over the other access in order to establish user plane resources on the other access for the MA PDU session. If the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6] over the other access, the UE shall consider that the user plane resources of the MA PDU session have been established over both 3GPP access and non-3GPP access.

If the UE is in the non-allowed area, the UE shall not initiate a PDU session establishment procedure for an MA PDU session over the 3GPP access. It may still initiate a PDU session establishment procedure for an MA PDU session over the non-3GPP access other than wireline access network, however the network shall not establish user plane resources for the 3GPP access if the UE is in the non-allowed area. The handling of non-allowed area when using wireline access is described in 3GPP TS 23.316 [4].

5.2.2   Re-activation of user-plane resources

In order to re-establish the user-plane resources of an MA PDU session:

a) if the UE requests re-establishment of the user-plane resources of the MA PDU session over 3GPP access which were released, the UE shall include the Uplink data status IE indicating the related MA PDU session,

1) in the REGISTRATION REQUEST message when the registration procedure for mobility and periodic registration update is initiated by the UE over 3GPP access as specified in clause 5.5.1.3.2 of 3GPP TS 24.501 [6]; or

2) in the SERVICE REQUEST message when the service request procedure initiated by the UE over 3GPP access as specified in clause 5.6.1.2 of 3GPP TS 24.501 [6];

b) if the UE requests re-establishment of the user-plane resources of the MA PDU session over non-3GPP access which were released and the UE is in 5GMM-CONNECTED mode over non-3GPP access, the UE shall include the Uplink data status IE indicating the related MA PDU session,

1) in the REGISTRATION REQUEST message when the registration procedure for mobility registration update is initiated by the UE over non-3GPP access as specified in clause 5.5.1.3.2 of 3GPP TS 24.501 [6]; or

2) in the SERVICE REQUEST message when the service request procedure initiated by the UE over non-3GPP access as specified in clause 5.6.1.2 of 3GPP TS 24.501 [6];

c) if the UE requests re-establishment of the user-plane resources of the MA PDU session over non-3GPP access which were released and the UE is in 5GMM-IDLE mode over non-3GPP access,

1) for untrusted non-3GPP access, the UE shall perform the procedure as specified in clause 7.3 of 3GPP TS 24.502 [7] and include the Uplink data status IE indicating the related MA PDU session in the SERVICE REQUEST message when the service request procedure initiated by the UE over non-3GPP access as specified in clause 5.6.1.2 of 3GPP TS 24.501 [6]; or

2) for trusted non-3GPP access, the UE shall perform the procedures as specified in clause 7.3A of 3GPP TS 24.502 [7] and include the Uplink data status IE indicating the related MA PDU session in the SERVICE REQUEST message when the service request procedure initiated by the UE over non-3GPP access as specified in clause 5.6.1.2 of 3GPP TS 24.501 [6]; and

d) if the network requests re-establishment of the user-plane resources of the MA PDU session, the UE shall initiate the service request procedure by sending a SERVICE REQUEST message to the AMF upon receipt of the paging request as specified in clause 5.6.1.2 of 3GPP TS 24.501 [6] or shall follow the procedure specified in clause 5.6.3 of 3GPP TS 24.501 [6] upon receipt of a NOTIFICATION message.

If the UE is in the non-allowed area, the UE shall not request re-establishment of the user plane resources of the MA PDU session for the 3GPP access. It may still request re-establishment of the user plane resources of the MA PDU session for the non-3GPP access.

5.2.3 Release of user-plane resources

In order to release the MA PDU session:

a) the SMF shall initiate the network-requested PDU session release procedure as specified in clause 6.3.3.2 of 3GPP TS 24.501 [6] over 3GPP access or non-3GPP access, by sending the PDU SESSION RELEASE COMMAND message to the UE. Over which access to initiate this network-requested PDU session release procedure is SMF implementation specific; or

b) the UE shall initiate the UE-requested PDU session release procedure as specified in clause 6.4.3.2 of 3GPP TS 24.501 [6] over 3GPP access or non-3GPP access by sending the PDU SESSION RELEASE REQUEST message to the network. Over which access to initiate this UE-requested PDU session release procedure is UE implementation specific.

When the UE receives the PDU SESSION RELEASE COMMAND message, the UE shall behave as specified in 3GPP TS 24.501 [6] clause 6.3.3.3.

In order to release the MA PDU session's user-plane resources on either 3GPP access or non-3GPP access, the SMF shall initiate the network-requested PDU session release procedure as specified in clause 6.3.3.2 of 3GPP TS 24.501 [6] over 3GPP access or non-3GPP access, by sending the PDU SESSION RELEASE COMMAND message with the Access type IE indicating of which access the user-plane resources are released to the UE, e.g. when the AMF indicates to the SMF that the UE is deregistered over an access or when S-NSSAI of the MA PDU session is not in the Allowed NSSAI over an access. Over which access to initiate this network-requested PDU session release procedure is SMF implementation specific. When the UE receives the PDU SESSION RELEASE COMMAND message, the UE shall behave as specified in 3GPP TS 24.501 [6] clause 6.3.3.3, and consider that the user plane resources of the MA PDU session have been released on the access indicated in the Access type IE.

5.2.4 Updating ATSSS parameters

An SMF may update ATSSS parameters, i.e. the ATSSS rules, and the MAI, according to the procedure for the network-requested PDU session modification as specified in clause 6.3.2 of 3GPP TS 24.501 [6] over 3GPP access network or non-3GPP access network. The ATSSS rules may be individually added, deleted or updated using the ATSSS rule ID and ATSSS rule operation. The SMF may change the access network over which the traffic of the GBR

QoS flow is transmitted by updating the UE's ATSSS rules. The SMF may change the QoS flows over which access performance measurements may be performed by updating the MAI.

5.2.5 Converting PDU session transferred from EPS to MA PDU session

When an ATSSS capable UE has transferred a PDN connection from S1 mode to N1 mode in the network supporting N26 interface and the related URSP or UE local configuration does not mandate the PDU session shall be established over a single access:

  a) if the UE is registered over both 3GPP access and non-3GPP access in the same PLMN, and the S-NSSAI associated with the PDU session over 3GPP access is included in the allowed NSSAI of non-3GPP access, the UE may initiate the UE-requested PDU session modification procedure by sending the PDU SESSION MODIFICATION REQUEST message including 5GSM capability IE over 3GPP access as specified in clause 6.4.2.2 of 3GPP TS 24.501 [6]. The UE may set the Request type IE to either:

   1) "modification request" and include the MA PDU session information IE set to "MA PDU session network upgrade is allowed" as defined in clause 9.11.3.31A of 3GPP TS 24.501 [6]; or

   2) "MA PDU request"

   in the UL NAS TRANSPORT message as specified in clause 8.2.10 of 3GPP TS 24.501 [6]. When the UE receives the PDU SESSION MODIFICATION COMMAND message including the ATSSS container IE as specified in clause 6.4.2.3 of 3GPP TS 24.501 [6], the UE shall consider that the requested PDU session was converted by the network to an MA PDU session and the user plane resources are successfully established on 3GPP access. When the user plane resources are established on the non-3GPP access (e.g., received established user plane IPsec SA in untrusted non-3GPP access), the UE shall consider the user plane resources are established on both accesses;

  NOTE: If the UE receives the PDU SESSION MODIFICATION COMMAND message including the ATSSS container IE and fails to receive user plane resources established on the non-3GPP access, upon an implementation specific timer expiry the UE initiates the UE-requested PDU session establishment procedure over the non-3GPP access, in order to establish user plane resources on the non-3GPP access.

  b) if the UE is registered over both 3GPP access and non-3GPP access in different PLMNs, the UE may initiate the UE-requested PDU session modification procedure by sending the PDU SESSION MODIFICATION REQUEST message including 5GSM capability IE over 3GPP access as specified in clause 6.4.2.2 of 3GPP TS 24.501 [6]. The UE may set the Request type IE to either:

   1) "modification request" and include the MA PDU session information IE set to "MA PDU session network upgrade is allowed" as defined in clause 9.11.3.31A of 3GPP TS 24.501 [6]; or

   2) "MA PDU request"

   in the UL NAS TRANSPORT message as specified in clause 8.2.10 of 3GPP TS 24.501 [6]. When the UE receives the PDU SESSION MODIFICATION COMMAND message including the ATSSS container IE as specified in clause 6.4.2.3 of 3GPP TS 24.501 [6], the UE shall consider that the requested PDU session was converted by the network to an MA PDU session and the user plane resources are successfully established on 3GPP access. The UE shall then initiate the UE-requested PDU session establishment procedure with the same PDU session ID, as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6] over non-3GPP access, in order to establish user plane resources on the other access for the MA PDU session; or

  c) if the UE is registered over 3GPP access only, the UE may initiate the UE-requested PDU session modification procedure by sending the PDU SESSION MODIFICATION REQUEST message including 5GSM capability IE over 3GPP access as specified in clause 6.4.2.2 of 3GPP TS 24.501 [6], The UE may set the Request type IE to either:

   1) "modification request" and include the MA PDU session information IE set to "MA PDU session network upgrade is allowed" as defined in clause 9.11.3.31A of 3GPP TS 24.501 [6]; or

   2) "MA PDU request"

   in the UL NAS TRANSPORT message as specified in clause 8.2.10 of 3GPP TS 24.501 [6]. When the UE receives the PDU SESSION MODIFICATION COMMAND message including the ATSSS container IE as specified in clause 6.4.2.3 of 3GPP TS 24.501 [6], the UE shall consider that the requested PDU session was

converted by the network to an MA PDU session and the user plane resources are successfully established on 3GPP access. When the UE at a later point in time registers over the non-3GPP access, either in the same PLMN or in a different PLMN, the UE shall initiate the UE-requested PDU session establishment procedure with the same PDU session ID as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6] over non-3GPP access in order to establish user plane resources on non-3GPP access for the MA PDU session.

5.2.6 PDU session establishment with network modification to MA PDU session

When an ATSSS capable UE establishes a new PDU session and the related URSP or UE local configuration does not mandate the PDU session shall be established over a single access:

a) if the UE is registered over both 3GPP access and non-3GPP access in the same PLMN and the UE initiates the UE-requested PDU session establishment procedure over a selected access, either 3GPP access or non-3GPP access, the UE may include the MA PDU session information IE in the UL NAS TRANSPORT message and set the IE to "MA PDU session network upgrade is allowed" as defined in clause 9.11.3.31A of 3GPP TS 24.501 [6]. When the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message including the ATSSS container IE as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6], the UE shall consider that the requested PDU session is established as an MA PDU session and the user plane resources are successfully established on the selected access. When the user plane resources are established on the access other than the selected access (e.g. received lower layer indication in 3GPP access or established user plane IPsec SA in untrusted non-3GPP access), the UE shall consider the user plane resources are successfully established on both accesses;

NOTE: If the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message including the ATSSS container IE and fails to receive user plane resources established on the access other than the selected access, upon an implementation specific timer expiry the UE re-initiates the UE-requested PDU session establishment procedure over the access other than the selected access, in order to establish user plane resources on the access other than the selected access.

b) if the UE is registered over both 3GPP access and non-3GPP access in different PLMNs and the UE initiates the UE-requested PDU session establishment procedure over 3GPP access or non-3GPP access, the UE may include the MA PDU session information IE in the UL NAS TRANSPORT message and shall set the IE to "MA PDU session network upgrade is allowed" as defined in clause 9.11.3.31A of 3GPP TS 24.501 [6]. When the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message including the ATSSS container IE as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6] over the access, the UE shall consider that the requested PDU session is established as an MA PDU session and the user plane resources are established on this access. The UE shall then initiate the UE-requested PDU session establishment procedure with the same PDU session ID, as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6] over the other access, in order to establish user plane resources on the other access for the MA PDU session. If the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message including the ATSSS container IE as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6] over the other access, the UE shall consider that the user plane resources of the MA PDU session have been established on both 3GPP access and non-3GPP access; or

c) if the UE is registered to a PLMN over only one access, either 3GPP access or non-3GPP access, and the UE requests to establish a PDU session over this access, the UE may include the MA PDU session information IE in the UL NAS TRANSPORT message and shall set the IE to "MA PDU session network upgrade is allowed" as defined in clause 9.11.3.31A of 3GPP TS 24.501 [6]. When the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message including the ATSSS container IE as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6] over the access, the UE shall consider that the requested PDU session is established as an MA PDU session and the user plane resources are established on this access. When the UE at a later point in time registers over the other access, either in the same PLMN or in a different PLMN, the UE shall initiate the UE-requested PDU session establishment procedure with the same PDU session ID as specified in clause 6.4.1.2 of 3GPP TS 24.501 [6] over the other access in order to establish user plane resources on the other access for the MA PDU session. If the UE receives the PDU SESSION ESTABLISHMENT ACCEPT message including the ATSSS container IE as specified in clause 6.4.1.3 of 3GPP TS 24.501 [6] over the other access, the UE shall consider that the user plane resources of the MA PDU session have been established on both 3GPP access and non-3GPP access.

5.3 Multi-access PDU connectivity over E-UTRAN and non-3GPP access network

5.3.0 General

If the UE supports MA PDU session and procedures for PDN connection establishment as specified in 3GPP TS 24.301 [10], then the UE shall also support handling as described in clauses 5.3.1 and 5.3.2.

> NOTE: The PDN connection established as a user plane resource of an MA PDU session is not applicable for CIoT EPS optimizations in this release of specification.

5.3.1 UE establishing a PDN connection as a user-plane resource of an MA PDU session to be established

In order to establish a PDN connection as a user-plane resource of an MA PDU session to be established, the UE shall initiate the UE requested PDN connectivity procedure according to 3GPP TS 24.301 [10].

In the PDN CONNECTIVITY REQUEST message or, when applicable, in the ESM INFORMATION RESPONSE message, of the UE requested PDN connectivity procedure:

a) the UE shall set the request type to "initial request" as specified in 3GPP TS 24.301 [10];

> NOTE: According to 3GPP TS 24.301 [10], a newly generated PDU session ID is included in the protocol configuration options IE or the extended protocol configuration options IE of the PDN CONNECTIVITY REQUEST message with the request type "initial request".

b) the UE shall set the PDN Type IE to "IPv4", "IPv6", "IPv4v6" or "Ethernet"; and

c) in the protocol configuration options or extended protocol configuration options IE of the PDN CONNECTIVITY REQUEST message, the UE shall include the ATSSS request PCO parameter. In the ATSSS request PCO parameter:

   1) if the UE supports ATSSS Low-Layer functionality with any steering mode as specified in clause 5.32.6 of 3GPP TS 23.501 [2], the UE shall set the ATSSS-ST field to "ATSSS Low-Layer functionality with any steering mode supported";

   2) if the UE supports MPTCP functionality with any steering mode and ATSSS-LL functionality with only active-standby steering mode as specified in clause 5.32.6 of 3GPP TS 23.501 [2], the UE shall set the ATSSS-ST field to "MPTCP functionality with any steering mode and ATSSS-LL functionality with only active-standby steering mode supported"; or

   3) if the UE supports MPTCP functionality with any steering mode and ATSSS-LL functionality with any steering mode as specified in clause 5.32.6 of 3GPP TS 23.501 [2], the UE shall set the ATSSS-ST field to "MPTCP functionality with any steering mode and ATSSS-LL functionality with any steering mode supported".

Upon receipt of an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message of a default EPS bearer context activation procedure as a response to the PDN CONNECTIVITY REQUEST message as specified in 3GPP TS 24.301 [10], the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message containing the extended protocol configuration options IE with the ATSSS response with the length of two octets PCO parameter:

a) the UE shall consider that the MA PDU session is established based on parameters from the default EPS bearer context of the PDN connection, as follows:

   1) the PDN type of the default EPS bearer context shall be mapped to the PDU session type of the MA PDU session as follows:

      i) if the PDN type is "IPv4", the PDU session type is set to "IPv4";

      ii) if the PDN type is "IPv6", the PDU session type is set to "IPv6";

      iii) if the PDN type is "IPv4v6", the PDU session type is set to "IPv4v6"; or

iv) if the PDN type is "Ethernet", the PDU session type is set to "Ethernet";

2) the PDN address of the default EPS bearer context shall be mapped to PDU address of the MA PDU session;

3) the APN of the default EPS bearer context shall be mapped to the DNN of the MA PDU session;

4) the PDU session identity of the MA PDU session shall be set to the PDU session identity included by the UE in the Protocol configuration options IE or Extended protocol configuration options IE in the PDN CONNECTIVITY REQUEST message;

5) the S-NSSAI of the MA PDU session shall be set to the S-NSSAI included by the network in the Protocol configuration options IE or Extended protocol configuration options IE in the ACTIVATE DEFAULT EPS BEARER REQUEST message, if the PDN connection is a non-emergency PDN connection;

6) the SSC mode of the MA PDU session shall be set to "SSC mode 1";

7) state of the PDU session shall be set to PDU SESSION ACTIVE; and

8) the ESM cause of the default EPS bearer context, if any, shall be mapped to the 5GSM cause of the MA PDU session as follows:

i) if the ESM cause is #50 "PDN type IPv4 only allowed", the 5GSM cause of the MA PDU session is set to #50 "PDU session type IPv4 only allowed"; or

ii) if the ESM cause is #51 "PDN type IPv6 only allowed", the 5GSM cause of the MA PDU session is set to #51 "PDU session type IPv6 only allowed";

and that the PDN connection is established as a user-plane resource of the MA PDU session;

b) if the network steering functionalities information is included in the ATSSS response with the length of two octets PCO parameter, the UE shall use the network steering functionalities information; and

c) if the measurement assistance information is included in the ATSSS response with the length of two octets PCO parameter, the UE shall use the measurement assistance information.

Upon receipt of:

a) a PDN CONNECTIVITY REJECT message as a response to the PDN CONNECTIVITY REQUEST message as specified in 3GPP TS 24.301 [10]; or

b) an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message of a default EPS bearer context activation procedure as a response to the PDN CONNECTIVITY REQUEST message as specified in 3GPP TS 24.301 [10] without the extended protocol configuration options IE containing the ATSSS response with the length of two octets PCO parameter;

the UE shall consider that the MA PDU session is not established and the PDN connection is not established as a user-plane resource of the MA PDU session.

5.3.2   UE establishing a PDN connection as a user-plane resource of an already established MA PDU session

In order to establish a PDN connection as a user-plane resource of an already established MA PDU session, the UE shall initiate the UE requested PDN connectivity procedure according to 3GPP TS 24.301 [10].

In the PDN CONNECTIVITY REQUEST message or, when applicable, in the ESM INFORMATION RESPONSE message, of the UE requested PDN connectivity procedure:

a) the UE shall set the request type to "handover" as specified in 3GPP TS 24.301 [10];

NOTE 1: According to 3GPP TS 24.301 [10], the PDU session ID of the already established MA PDU session is included in the protocol configuration options IE or the extended protocol configuration options IE of the PDN CONNECTIVITY REQUEST message with the request type "handover".

b) the UE shall set the PDN Type IE to "IPv4", "IPv6", "IPv4v6", "Ethernet" or "non-IP"; and

NOTE 2: If the UE does not support Ethernet PDN type or the Ethernet PDN type is not supported in EPC, the UE sets "non-IP" PDN type when the established MA PDU session is Ethernet PDU session type.

c) in the protocol configuration options or extended protocol configuration options IE, the UE shall include the ATSSS request PCO parameter.

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message of a default EPS bearer context activation procedure as a response to the PDN CONNECTIVITY REQUEST message as specified in 3GPP TS 24.301 [10], the UE shall consider that the PDN connection is established as a user-plane resource of the MA PDU session.

Upon receipt of a PDN CONNECTIVITY REJECT message as specified in 3GPP TS 24.301 [10], the UE shall consider that the PDN connection is not established as a user-plane resource of the MA PDU session.

5.3.3   Re-activation of user-plane resources

For an MA PDU session with a PDN connection established as a user-plane resource:

a) if the UE in EMM-IDLE mode has pending user data to be sent over the PDN connection, the UE shall:

1) set the "active" flag in the EPS update type IE in the TRACKING AREA UPDATE REQUEST message when the normal and periodic tracking area updating procedure is initiated by the UE as specified in clause 5.5.3.2.2 of 3GPP TS 24.301 [10]; or

2) initiate service request procedure as specified in clause 5.6.1.2.1 of 3GPP TS 24.301 [10];

b) if the UE requests re-establishment of the user-plane resources of the MA PDU session over non-3GPP access which were established but released, the UE shall initiate registration procedure for mobility registration update or service request procedure as specified in clause 5.2.2 bullets b) and c); or

c) if the UE is in EMM-IDLE mode and the network has pending user data to be sent over the PDN connection, the UE shall initiate the service request procedure by sending a SERVICE REQUEST message to the MME upon receipt of the paging request as specified in clause 5.6.1.2.1 of 3GPP TS 24.301 [10].

5.3.4   Release of user-plane resource(s)

In order to release an MA PDU session which has a PDN connection established as a user-plane resource:

a) to release the PDN connection established as a user-plane resource of the MA PDU session:

1) the network shall:

i)   initiate the network initiated detach procedure as specified in clause 5.5.2.3 of 3GPP TS 24.301 [10] by sending the DETACH REQUEST message to the UE if EMM-REGISTERED without PDN connection is not supported by the UE and the MME and the PDN connection is the last PDN connection; or

ii) initiate the EPS bearer context deactivation procedure as specified in clause 6.4.4 of 3GPP TS 24.301 [10] by sending the DEACTIVATE EPS BEARER CONTEXT REQUEST message to the UE if EMM-REGISTERED without PDN connection is supported by the UE and the MME or the PDN connection is not the last PDN connection; or

2) the UE shall:

i)   initiate the UE initiated detach procedure as specified in clause 5.5.2.2 of 3GPP TS 24.301 [10] by sending the DETACH REQUEST message to the network if EMM-REGISTERED without PDN connection is not supported by the UE and the MME and the PDN connection is the last PDN connection; or

ii) initiate the UE requested PDN disconnect procedure as specified in clause 6.5.2 of 3GPP TS 24.301 [10] by sending the PDN DISCONNECT REQUEST message to the network if EMM-REGISTERED without PDN connection is supported by the UE and the MME or the PDN connection is not the last PDN connection; and

b) to release the user-plane resources, if any, established on non-3GPP access of the MA PDU session:

1) the network shall initiate the network-requested PDU session release procedure as specified in clause 6.3.3.2 of 3GPP TS 24.501 [6] by sending the PDU SESSION RELEASE COMMAND message with the Access type IE indicating "Non-3GPP access" or without including the Access type IE to the UE; or

2) the UE shall initiate the UE-requested PDU session release procedure as specified in clause 6.4.3.2 of 3GPP TS 24.501 [6] by sending the PDU SESSION RELEASE REQUEST message to the network.

5.3.5   Updating ATSSS parameters

A PGW-C+SMF may update ATSSS parameters as specified in clause 5.2.4 and include the updated MAI in the extended protocol configuration options IE with the ATSSS response with the length of two octets PCO parameter. The updated MAI in the extended protocol configuration options IE with the ATSSS response with the length of two octets PCO parameter is sent to the UE during the EPS bearer context modification according to clause 6.4.3 of 3GPP TS 24.301 [10].

5.3.6   A/Gb mode or Iu mode Interworking

Upon inter-system change from S1 mode to A/Gb mode or Iu mode, for a PDN connection which was established as a user-plane resource of an MA PDU session:

a) if the SM activates a PDP context using parameters from the default EPS bearer context of the PDN connection as specified clause 6.1.4 of 3GPP TS 24.301 [10]:

1) the SMF can initiate the network-requested PDU session release procedure over non-3GPP access as specified in clause 6.3.3.2 of 3GPP TS 24.501 [6] if the user plane resources are established on non-3GPP access for this MA PDU session, or perform a local release of the MA PDU session; and

2) the UE performs a local release of the MA PDU session.

NOTE 1: If the UE receives from the network a PDU SESSION RELEASE COMMAND message which indicates to release the MA PDU session over non-3GPP access and the UE has already performed or is performing a local release of the MA PDU session, the error handling as specified in clause 6.3.3.6 of 3GPP TS 24.501 [6] is applied.

NOTE 2: If the SM does not activate a PDP context using parameters from the default EPS bearer context of the PDN connection and the user plane resources are established on non-3GPP access for this MA PDU session, the SMF initiates the network-requested PDU session modification procedure as specified in clause 6.3.2.2 of 3GPP TS 24.501 [6] over non-3GPP access if the SMF decides to move the traffic of the MA PDU session to non-3GPP access, or the SMF initiates the network-requested PDU session release procedure as specified in clause 6.3.3.2 of 3GPP TS 24.501 [6] over non-3GPP access without including the Access type IE or with the Access type IE indicating "Non-3GPP access".

5.3.7   Abnormal cases in the UE

The following abnormal cases can be identified:

a) For an MA PDU session already established over non-3GPP access, upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, if any of the following conditions is not fulfilled:

1) the "PDN type value" of the PDN address IE is set to

i) "IPv4" and the stored PDU session type of the MA PDU session is set to "IPv4";

ii) "IPv6" and the stored PDU session type of the MA PDU session is set to "IPv6";

iii) "IPv4v6" and the stored PDU session type of the MA PDU session is set to "IPv4v6"; or

iv) "Ethernet" and the stored PDU session type of the MA PDU session is set to "Ethernet";

2) the PDN address in "PDN address information" of the PDN address IE is the same as the stored PDU address of the MA PDU session;

3) the stored selected SSC mode of the MA PDU session is set to "SSC mode 1";

    4) the ESM cause IE is:

        i) not included and there is no stored 5GSM cause of the MA PDU session;

        ii) set to #50 "PDN type IPv4 only allowed" and the stored 5GSM cause of the MA PDU session is set to #50 "PDU session type IPv4 only allowed";

        iii) set to #51 "PDN type IPv6 only allowed" and the stored 5GSM cause of the MA PDU session is set to #51 "PDU session type IPv6 only allowed"; or

        iv) set to #52 "single address bearers only allowed" and there is no stored 5GSM cause of the MA PDU session;

    5) the S-NSSAI is included by the network in the Protocol configuration options IE or Extended protocol configuration options IE and is the same as the stored S-NSSAI value of the MA PDU session; and

    6) the APN maps to the same DNN as the stored DNN of the MA PDU session;

the UE shall send ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message to the network as specified in clause 6.4.1.4 of 3GPP TS 24.301 [10], may perform a local release of the MA PDU session and the registration procedure for mobility and periodic registration update with a REGISTRATION REQUEST message including the PDU session status IE over non-3GPP access.

5.4 Performance measurement function (PMF) protocol (PMFP) procedures

5.4.1 General

Performance measurement function protocol (PMFP) procedures are performed between a performance measurement function (PMF) in a UE and a PMF in the UPF.

The following UE-initiated PMFP procedures are specified:

    a) UE-initiated RTT measurement procedure; and

    b) access availability or unavailability report procedure;

    c) UE-initiated PLR measurement procedure;

    d) UE assistance data provisioning procedure; and

    e) UE assistance data termination procedure.

The following UPF-initiated PMFP procedures are specified:

    a) UPF-initiated RTT measurement procedure; and

    b) UPF-initiated PLR measurement procedure.

The UE-initiated PMFP procedures and the UPF-initiated PMFP procedures can be performed:

    a) on the user plane of an MA PDU session via either 3GPP access or non-3GPP access in 5GS if the MAI is provided to the UE during establishment of the MA PDU session; or

    b) on the user plane of the PDN connection established as the user plane resource of an MA PDU session via 3GPP access in EPS or the user plane of the MA PDU session via non-3GPP access in 5GS as specified in clause 5.3.

PMFP messages are transported in an IP packet or an Ethernet frame according to clause 5.3.2.

If the UE supports performance measurement function protocol procedures for the QoS flow of a non-default QoS rule, the UE indicates its "access performance measurements per QoS flow" capability as defined in clause 9.11.4.1 of 3GPP TS 24.501 [6] to the SMF. If the SMF determines that PMFP using the QoS flow of the non-default QoS rule is applied to the MA PDU session for the UE, the SMF provides the UE with the MAI including a list of QoS flows over

which access performance measurements may be performed. The UE performs the RTT measurement procedure or the PLR measurement procedure over the QoS flow(s) as indicated in the received MAI.

NOTE 1: In this release of the specification, for the PDN connection established as a user-plane resource of an MA PDU session, the PMFP procedures are only performed over the default EPS bearer of the PDN connection.

If the UPF receives the indication from the SMF that the performance measurement is for QoS flow(s) of the non-default QoS rule, the UPF performs the RTT measurement procedure or the PLR measurement procedure over the QoS flow(s) of non-default QoS rule as indicated by the SMF. Otherwise, the UPF performs the RTT measurement procedure or the PLR measurement procedure over the QoS flow of the default QoS rule

PMFP messages, transported between the UE and the UPF over one (or more) QoS flows of a non-default QoS rule, are specified in clause 5.4.2.1.3.

PMFP messages transported between the UE and the UPF (and vice versa) are protected using the security mechanisms protecting the user data packets transported over NG-RAN or non-3GPP access connected to the 5GCN and over the N3 and N9 reference points, are specified in 3GPP TS 33.501 [14]. A PMFP-specific security mechanism is not specified.

NOTE 2: Even though transport of PMFP messages between the UE and the UPF is protected, a compromised UE can send false or incorrect PMFP messages.

PMFP is a standard L3 protocol according to 3GPP TS 24.007 [13], PMFP messages are standard L3 messages according to 3GPP TS 24.007 [13] and error behaviour specified for L3 protocol in according to 3GPP TS 24.007 [13] applies for PMFP.

The access availability or unavailability report procedure is only performed over the QoS flow of the default QoS rule, or over the default EPS bearer of the PDN connection established as a user-plane resource.

5.4.2 Elementary procedures for PMFP

5.4.2.1 PMFP message transport

5.4.2.1.1 PMFP message transport in IPv4, IPv6 or IPv4v6 PDU session

In order to send a PMFP message over an access of an MA PDU session of IPv4, IPv6 or IPv4v6 PDU session type:

    a) if the UE obtained IPv4 address for the PDU session and the received measurement assistance information contains an IPv4 address of the PMF in the UPF, the UE shall create a UDP/IPv4 packet. In the UDP/IPv4 packet, the UE:

        1) shall set the data octets field to the PMFP message;

        2) shall set the source port field to the UDP port of the PMF in the UE;

        3) shall set the destination port field to the UDP port of the PMF in the UPF associated with the access of the MA PDU session indicated in the received measurement assistance information according to the target QoS flow which is used to transport the PMFP message:

            A) if the target QoS flow is the QoS flow of the default QoS rule, the destination UDP port field is set to the value of:

              - the "PMF 3GPP port" as specified in figure 6.1.5.2-1 for the PMFP message to be transported over 3GPP access; or

              - the "PMF non-3GPP port" as specified in figure 6.1.5.2-1 for the PMFP message to be transported over non-3GPP access; and

            B) if the target QoS flow is a QoS flow of the non-default QoS rule, the destination UDP port field is set to the value of:

              - the "PMF 3GPP port" of the corresponding QoS flow as specified in figure 6.1.5.2-4 for the PMFP message to be transported over 3GPP access; or

- the "PMF non-3GPP port" of the corresponding QoS flow as specified in figure 6.1.5.2-4 for the PMFP message to be transported over non-3GPP access;

    4) shall set the source address field to the IPv4 address of the UE; and

    5) shall set the destination address field to the IPv4 address of the PMF in the UPF as specified in figure 6.1.5.2-1, included in the received measurement assistance information; or

  b) if the UE obtained IPv6 prefix for the PDU session, generated an IPv6 address for the PMF in the UE and the received measurement assistance information contains an IPv6 address of the PMF in the UPF, the UE shall create a UDP/IPv6 packet. In the UDP/IPv6 packet, the UE:

    1) shall set the data octets field to the PMFP message;

    2) shall set the source port field to the UDP port of the PMF in the UE;

    3) shall set the destination port field to the UDP port of the PMF in the UPF associated with the access of the MA PDU session indicated in the received measurement assistance information according to the target QoS flow which is used to transport the PMFP message:

      A) if the target QoS flow is the QoS flow of the default QoS rule, the destination UDP port field is set to the value of:

        - the "PMF 3GPP port" as specified in figure 6.1.5.2-1 for the PMFP message to be transported over 3GPP access;

        - the "PMF non-3GPP port" as specified in figure 6.1.5.2-1 for the PMFP message to be transported over non-3GPP access; and

      B) if the target QoS flow is a QoS flow of the non-default QoS rule, the destination UDP port field is set to the value of:

        - the "PMF 3GPP port" of the corresponding QoS flow as specified in figure 6.1.5.2-4 for the PMFP message to be transported over 3GPP access; or

        - the "PMF non-3GPP port" of the corresponding QoS flow as specified in figure 6.1.5.2-4 for the PMFP message to be transported over non-3GPP access;

    4) shall set the source address field to the IPv6 address of the PMF in the UE; and

    5) shall set the destination address field to the IPv6 address of the PMF in the UPF as specified in figure 6.1.5.2-1, included in the received measurement assistance information.

The UE shall send the UDP/IPv4 packet or UDP/IPv6 packet over the access of the MA PDU session.

In order to send a PMFP message over an access of an MA PDU session of IPv4, IPv6 or IPv4v6 PDU session type:

  a) if the UPF is aware of the UDP port of the PMF in the UE used with IPv4, the UPF shall create a UDP/IPv4 packet. In the UDP/IPv4 packet, the UPF:

    1) shall set the data octets field to the PMFP message;

    2) shall set the source port field to the UDP port of the PMF in the UPF associated with the access of the MA PDU session indicated in the measurement assistance information provided to the UE according to the target QoS flow which is used to transport the PMFP message:

      A) if the target QoS flow is the QoS flow of the default QoS rule, the source UDP port field is set to the value of:

        - the "PMF 3GPP port" as specified in figure 6.1.5.2-1 for the PMFP message to be transported over 3GPP access;

        - the "PMF non-3GPP port" as specified in figure 6.1.5.2-1 for the PMFP message to be transported over non-3GPP access; and

      B) if the target QoS flow is a QoS flow of the non-default QoS rule, the source UDP port field is set to the value of:

- the "PMF 3GPP port" of the corresponding QoS flow as specified in figure 6.1.5.2-4 for the PMFP message to be transported over 3GPP access; or

- the "PMF non-3GPP port" of the corresponding QoS flow as specified in figure 6.1.5.2-4 for the PMFP message to be transported over non-3GPP access;

3) shall set the destination port field to the UDP port of the PMF in the UE used with IPv4;

4) shall set the source address field to the IPv4 address of the PMF in the UPF as specified in figure 6.1.5.2-1, included in the measurement assistance information provided to the UE; and

5) shall set the destination address field to the IPv4 address of the UE; or

b) if the UPF is aware of the UDP port and the IPv6 address of the PMF in the UE, the UPF shall create a UDP/IPv6 packet. In the UDP/IPv6 packet, the UPF:

1) shall set the data octets field to the PMFP message;

2) shall set the source port field to the UDP port of the PMF in the UPF associated with the access of the MA PDU session indicated in the measurement assistance information provided to the UE according to the target QoS flow which is used to transport the PMFP message:

A) if the target QoS flow is the QoS flow of the default QoS rule, the source UDP port field is set to the value of:

- the "PMF 3GPP port" as specified in figure 6.1.5.2-1 for the PMFP message to be transported over 3GPP access;

- the "PMF non-3GPP port" as specified in figure 6.1.5.2-1 for the PMFP message to be transported over non-3GPP access; and

B) if the target QoS flow is a QoS flow of the non-default QoS rule, the source UDP port field is set to the value of:

- the "PMF 3GPP port" of the corresponding QoS flow as specified in figure 6.1.5.2-4 for the PMFP message to be transported over 3GPP access; or

- the "PMF non-3GPP port" of the corresponding QoS flow as specified in figure 6.1.5.2-4 for the PMFP message to be transported over non-3GPP access;

3) shall set the destination port field to the UDP port of the PMF in the UE;

4) shall set the source address field to the IPv6 address of the PMF in the UPF as specified in figure 6.1.5.2-1, included in the measurement assistance information provided to the UE; and

5) shall set the destination address field to the IPv6 address of the PMF in the UE.

The UPF shall send the UDP/IPv4 packet or UDP/IPv6 packet over the access of the MA PDU session.

The UE shall select the UDP port of the PMF in the UE upon establishment of an MA PDU session of IPv4, IPv6 or IPv4v6 PDU session type. The UE shall use the same UDP port of the PMF in the UE till release of the MA PDU session. The UE shall select the IPv6 address of the PMF in the UE upon establishment of an MA PDU session of IPv6 or IPv4v6 PDU session type. The UE shall use the same IPv6 address of the PMF in the UE till release of the MA PDU session.

NOTE: Regardless of whether the target QoS flow is associated with default QoS rule or not, the UE only allocates a single UDP port for PMFP messages.

The UPF shall discover the UDP port of the PMF in the UE used with IPv4 of an MA PDU session of IPv4 or IPv4v6 PDU session type, in the source port field of an UDP/IPv4 packet:

a) received via the MA PDU session;

b) with the destination port field set to the UDP port of the PMF in the UPF associated with an access, included in the measurement assistance information provided to the UE; and

c) with the destination address field set to the IPv4 address of the PMF in the UPF, included the measurement assistance information provided to the UE.

The UPF shall discover the UDP port and the IPv6 address of the PMF in the UE of an MA PDU session of IPv6 or IPv4v6 PDU session type, in the source port field and the source address field of an UDP/IPv6 packet:

a) received via the MA PDU session;

b) with the destination port field set to the UDP port of the PMF in the UPF associated with an access, included in the measurement assistance information provided to the UE; and

c) with the destination address field set to the IPv6 address of the PMF in the UPF, included the measurement assistance information provided to the UE.

In order to enable the UPF to discover:

a) the UDP port of the PMF in the UE in case of an MA PDU session of IPv4 or IPv4v6 PDU session type, or

b) the UDP port and the IPv6 address of the PMF in the UE in case of an MA PDU session of IPv6 or IPv4v6 PDU session type;

the UE shall perform a access availability or unavailability report procedure over an access immediately after the MA PDU session is established. If the MA PDU session is established over both 3GPP access and non-3GPP access, the UE may use either of the accesses for the access availability or unavailability report procedure. If the access availability or unavailability report procedure is aborted, the UE shall repeat the access availability or unavailability report procedure over the same access or, if the MA PDU session is established over both 3GPP access and non-3GPP access, over the other access.

5.4.2.1.2 PMFP message transport in Ethernet PDU session

In order to send a PMFP message over an access of an MA PDU session of Ethernet PDU session type, the UE shall create an Ethernet frame as specified in IEEE 802.3 [12]. In the Ethernet frame, the UE:

a) shall set the length/type field of the Ethernet frame to the ethertype value included in the received measurement assistance information;

b) shall set the destination address field of the Ethernet frame to the MAC address of the PMF in the UPF associated with the access of the MA PDU session indicated in the received measurement assistance information according to the target QoS flow which is used to transport the PMFP message:

1) if the target QoS flow is the QoS flow of the default QoS rule, the destination address field of the Ethernet frame is set to the value of:

A) the "PMF 3GPP MAC address" as specified in figure 6.1.5.2-2 for the PMFP message to be transported over 3GPP access; or

B) the "PMF non-3GPP MAC address" as specified in figure 6.1.5.2-2 for the PMFP message to be transported over non-3GPP access; and

2) if the target QoS flow is a QoS flow of the non-default QoS rule, the destination address field of the Ethernet frame is set to the value of:

A) the "PMF 3GPP MAC address" of the corresponding QoS flow as specified in figure 6.1.5.2-5 for the PMFP message to be transported over 3GPP access; or

B) the "PMF non-3GPP MAC address" of the corresponding QoS flow as specified in figure 6.1.5.2-5 for the PMFP message to be transported over non-3GPP access;

c) shall set the source address field of the Ethernet frame to the MAC address of the PMF in the UE;

d) shall set the MAC client data field of the Ethernet frame to the 3GPP IEEE MAC based protocol family envelope;

e) shall set the protocol subtype field of the 3GPP IEEE MAC based protocol family envelope to "Performance measurement function protocol (PMFP)"; and

    f)   shall set the PMFP message field of the protocol data field of the 3GPP IEEE MAC based protocol family envelope to the PMFP message.

The UE shall send the Ethernet frame over the access of the MA PDU session.

In order to send a PMFP message over an access of an MA PDU session, the UPF shall create an Ethernet frame as specified in IEEE 802.3 [12]. In the Ethernet frame, the UPF:

    a)   shall set the length/type field of the Ethernet frame to the ethertype value included in the measurement assistance information provided to the UE;

    b)   shall set the source address field of the Ethernet frame to the MAC address of the PMF in the UPF associated with the access of the MA PDU session indicated in the measurement assistance information provided to the UE according to the target QoS flow which is used to transport the PMFP message:

        1)   if the target QoS flow is the QoS flow of the default QoS rule, the source address field of the Ethernet frame is set to the value of:

            A)   the "PMF 3GPP MAC address" as specified in figure 6.1.5.2-2 for the PMFP message to be transported over 3GPP access; or

            B)   the "PMF non-3GPP MAC address" as specified in figure 6.1.5.2-2 for the PMFP message to be transported over non-3GPP access; and

        2)   if the target QoS flow is a QoS flow of the non-default QoS rule, the source address field of the Ethernet frame is set to the value of:

            A)   the "PMF 3GPP MAC address" of the corresponding QoS flow as specified in figure 6.1.5.2-5 for the PMFP message to be transported over 3GPP access; or

            B)   the "PMF non-3GPP MAC address" of the corresponding QoS flow as specified in figure 6.1.5.2-5 for the PMFP message to be transported over non-3GPP access;

    c)   shall set the destination address field of the Ethernet frame to the MAC address of the PMF in the UE;

    d)   shall set the MAC client data field of the Ethernet frame to the 3GPP IEEE MAC based protocol family envelope;

    e)   shall set the protocol subtype field of the 3GPP IEEE MAC based protocol family envelope to "Performance measurement function protocol (PMFP)"; and

    f)   shall set the PMFP message field of the protocol data field of the 3GPP IEEE MAC based protocol family envelope to the PMFP message.

The UPF shall send the Ethernet frame so that the UE receives it over the access of the MA PDU session.

The UE shall select the MAC address of the PMF in the UE upon establishment of an MA PDU session of Ethernet PDU session type. The UE shall use the same MAC address of the PMF in the UE till release of the MA PDU session.

    NOTE: Regardless of whether the target QoS flow is associated with default QoS rule or not, the UE only allocates a single MAC address for PMFP messages.

The UPF shall discover the MAC address of the PMF in the UE of an MA PDU session of Ethernet PDU session type, in the source address field of an Ethernet frame:

    a)   received via the MA PDU session;

    b)   with the length/type field of the Ethernet frame set to the ethertype value included in the measurement assistance information provided to the UE; and

    c)   with the destination address field of the Ethernet frame set to the MAC address of the PMF in the UPF associated with an access, included in the measurement assistance information provided to the UE.

In order to enable the UPF to discover the MAC address of the PMF in the UE of an MA PDU session of Ethernet PDU session type, the UE shall perform an access availability or unavailability report procedure over an access immediately after the MA PDU session is established. If the MA PDU session is established over both 3GPP access and non-3GPP

access, the UE may use either of the accesses for the access availability or unavailability report procedure. If the access availability or unavailability report procedure is aborted, the UE shall repeat the access availability or unavailability report procedure over the same access or, if the MA PDU session is established over both 3GPP access and non-3GPP access, over the other access.

5.4.2.1.3 PMFP message transport associated with QoS flow

In this release of specification, RTT measurement procedure and PLR measurement procedure can be performed per QoS flow.

In order to transport PMFP ECHO REQUEST message, PMFP ECHO RESPONSE message, PMFP PLR COUNT REQUEST message, PMFP PLR COUNT RESPONSE message, PMFP PLR REPORT REQUEST message and PMFP PLR REPORT RESPONSE message over the specific QoS flows, SMF shall provide the UE with the QoS rules including the packet filters containing the UDP port or the MAC address associated with the QoS flow in the MAI.

> NOTE: The SMF providing the UPF with the UL PDR including the UDP port or the MAC address associated with a QoS flow is specified in 3GPP TS 29.244 [16].

5.4.2.2 Extended procedure transaction identity (EPTI)

The UE shall maintain the current available UE EPTI value. When the MA PDU session is established, the UE shall set the current available UE EPTI value to 0000H. When a UE-initiated PMFP procedure is initiated, the UE shall allocate the current available UE EPTI value to the UE-initiated PMFP procedure and:

- if the current available UE EPTI value is 7FFFH, shall set the current available UE EPTI value to 0000H; or

- otherwise, shall increase the current available UE EPTI value by one.

The UE shall release the EPTI value allocated to the UE-initiated PMFP procedure when the UE-initiated PMFP procedure completes or is aborted.

The UPF shall maintain the current available UPF EPTI value. When the MA PDU session is established, the UPF shall set the current available UPF EPTI value to 8000H. When a UPF-initiated PMFP procedure is initiated, the UPF shall allocate the current available UPF EPTI value to the UPF-initiated PMFP procedure and:

- if the current available UPF EPTI value is FFFFH, shall set the current available UPF EPTI value to 8000H; or

- otherwise, shall increase the current available UPF EPTI value by one.

The UPF shall release the EPTI value allocated to the UPF-initiated PMFP procedure when the UPF-initiated PMFP procedure completes or is aborted.

5.4.3 UE-initiated RTT measurement procedure

5.4.3.1 General

The purpose of the UE-initiated RTT measurement procedure is to enable the UE to measure the RTT of an exchange of user data packets between the UE and the UPF over an access of an MA PDU session.

The UE-initiated RTT measurement procedure can be performed over an access of an MA PDU session only when the UE has user-plane resources on the access of the MA PDU session.

5.4.3.2 UE-initiated RTT measurement procedure initiation

In order to initiate a UE-initiated RTT measurement procedure over an access of an MA PDU session, the UE shall allocate an EPTI value as specified in clause 5.4.2.2 and shall create one or more PMFP ECHO REQUEST messages. The number of created PMFP ECHO REQUEST messages is UE implementation specific. In each PMFP ECHO REQUEST message, the UE:

a) shall set the EPTI IE to the allocated EPTI value;

b) shall set the RI IE to a unique value identifying the particular PMFP ECHO REQUEST message within the transaction; and.

c) if the upper layers request a particular length of PMFP messages, shall include the Padding IE such that length of the PMFP message becomes equal to the requested length.

The UE shall start a timer T101 and shall send the one or more PMFP ECHO REQUEST messages over the access of the MA PDU session.

An example of the UE-initiated RTT measurement procedure is shown in figure 5.3.3.2-1.

UE   network

Start T101 ─────────── PMFP ECHO REQUEST ───────────▶

             ─────────── PMFP ECHO REQUEST ───────────▶

                   ─────────── PMFP ECHO REQUEST ───────────▶

             ◀─────────── PMFP ECHO RESPONSE ───────────

                   ◀─────────── PMFP ECHO RESPONSE ───────────

Stop T101   ◀─────────── PMFP ECHO RESPONSE ───────────
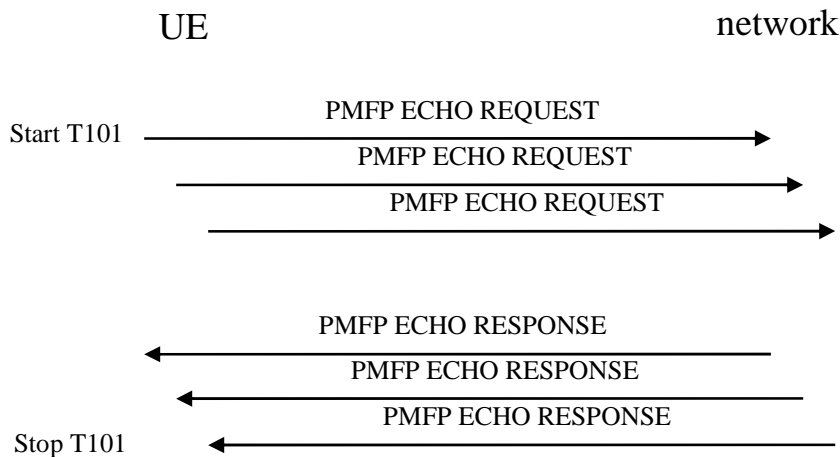
Figure 5.4.3.2-1: UE-initiated RTT measurement procedure

5.4.3.3   UE-initiated RTT measurement procedure completion

Upon reception of the PMFP ECHO REQUEST message, the UPF shall create a PMFP ECHO RESPONSE message. In the PMFP ECHO RESPONSE message, the UPF shall set the EPTI IE to the EPTI value in the PMFP ECHO REQUEST message and shall set the RI IE to the RI value in the PMFP ECHO REQUEST message. If the PMFP ECHO REQUEST message contains the Padding IE, the UPF shall include the Padding IE such that length of the PMFP message becomes equal to length of the received PMFP message. The UPF shall send the PMFP ECHO RESPONSE message over the access of the MA PDU session via which the PMFP ECHO REQUEST message was received.

Upon reception of a PMFP ECHO RESPONSE message with the same EPTI as the allocated EPTI value and with the RI value of a sent PMFP ECHO REQUEST message, the UE shall determine the RTT value for the request identified by the RI value by subtracting the current value of the timer T101 from the value of the timer T101 valid when the PMFP ECHO REQUEST with the RI value was sent.

When a PMFP ECHO RESPONSE message with the same EPTI as the allocated EPTI value has been received for each sent PMFP ECHO REQUEST message, the UE shall calculate an average of the RTT values for the requests, shall stop the timer T101.

5.4.3.4   Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiration of the timer T101

Upon expiration of the timer T101, the UE shall abort the procedure, shall calculate an average of the RTT values for the requests for which a response was received and shall count the number of requests for which no response was received.

5.4.4 Network-initiated RTT measurement procedure

5.4.4.1 General

The purpose of the UPF-initiated RTT measurement procedure is to enable the UPF to measure the RTT of an exchange of user data packets between the UPF and the UE over an access of an MA PDU session.

The UPF-initiated RTT measurement procedure can be performed over an access of an MA PDU session only when the UE has user-plane resources on the access of the MA PDU session.

5.4.4.2 UPF-initiated RTT measurement procedure initiation

In order to initiate a UPF-initiated RTT measurement procedure over an access of an MA PDU session, the UPF shall allocate a EPTI value as specified in clause 5.4.2.2 and shall create one or more PMFP ECHO REQUEST messages. The number of created PMFP ECHO REQUEST messages is UPF implementation specific. In each PMFP ECHO REQUEST message, the UPF:

a) shall set the EPTI IE to the allocated EPTI value;

b) shall set the RI IE to a unique value identifying the particular PMFP ECHO REQUEST message within the transaction; and

c) if the upper layers request a particular length of PMFP messages, shall include the Padding IE such that length of the PMFP message becomes equal to the requested length.

The UPF shall start a timer T201 and shall send the one or more PMFP ECHO REQUEST messages over the access of the MA PDU session.

An example of the UPF-initiated RTT measurement procedure is shown in figure 5.4.4.2-1.

UE   network

PMFP ECHO REQUEST
←───────────────────────────────────   Start T201
PMFP ECHO REQUEST
←───────────────────────────────────
PMFP ECHO REQUEST
←───────────────────────────────────

PMFP ECHO RESPONSE
───────────────────────────────────→
PMFP ECHO RESPONSE
───────────────────────────────────→
PMFP ECHO RESPONSE
───────────────────────────────────→   Stop T201
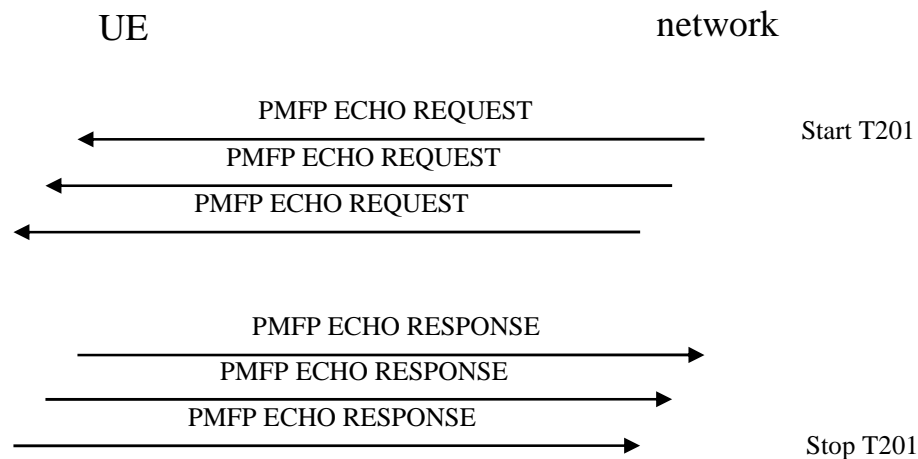
Figure 5.4.4.2-1: UPF-initiated RTT measurement procedure

5.4.4.3 UPF-initiated RTT measurement procedure completion

Upon reception of the PMFP ECHO REQUEST message, the UE shall create a PMFP ECHO RESPONSE message. In the PMFP ECHO RESPONSE message, the UE shall set the EPTI IE to the EPTI value in the PMFP ECHO REQUEST message and shall set the RI IE to the RI value in the PMFP ECHO REQUEST message. If the PMFP ECHO REQUEST message contains the Padding IE, the UE shall include the Padding IE such that length of the PMFP message becomes equal to length of the received PMFP message. The UE shall send the PMFP ECHO RESPONSE message over the access of the MA PDU session via which the PMFP ECHO REQUEST message was received.

Upon reception of a PMFP ECHO RESPONSE message with the same EPTI as the allocated EPTI value and with the RI value of a sent PMFP ECHO REQUEST message, the UPF shall determine the RTT value for the request identified

by the RI value by subtracting the current value of the timer T201 from the starting value of the timer T201 valid when the PMFP ECHO REQUEST with the RI value was sent.

When a PMFP ECHO RESPONSE message with the same EPTI as the allocated EPTI value has been received for each sent PMFP ECHO REQUEST message, the UPF shall calculate an average of the RTT values for the requests, shall stop the timer T201.

5.4.4.4 Abnormal cases in the network

The following abnormal cases can be identified:

a) Expiration of the timer T201

   Upon expiration of the timer T201, the UPF shall abort the procedure, shall calculate an average of the RTT values for the requests for which a response was received and shall count the number of requests for which no response was received.

5.4.5 Access availability or unavailability report procedure

5.4.5.1 General

The purpose of the access availability or unavailability report procedure is to enable the UE to inform the UPF about availability or unavailability of an access of an MA PDU session.

5.4.5.2 Access availability or unavailability report procedure initiation

In order to initiate an access availability or unavailability report procedure over an access of an MA PDU session, the UE shall allocate a EPTI value as specified in clause 5.4.2.2 and shall create a PMFP ACCESS REPORT message. In the PMFP ACCESS REPORT message, the UE shall set the EPTI IE to the allocated EPTI value. The UE shall send the PMFP ACCESS REPORT message over the access of the MA PDU session and shall start a timer T102.

An example of the access availability or unavailability report procedure is shown in figure 5.4.5.2-1.
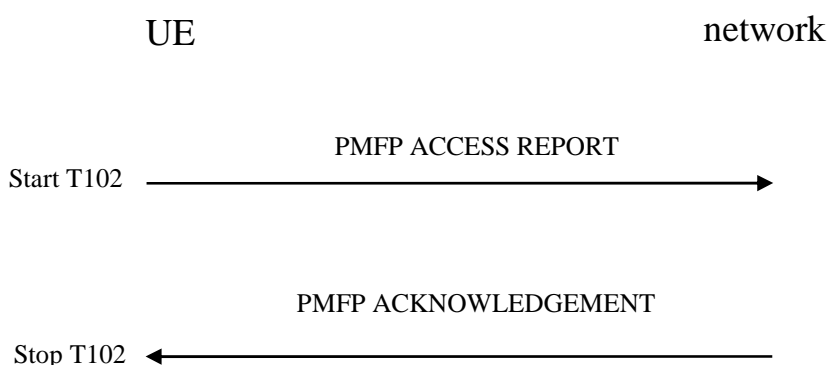
Figure 5.4.5.2-1: Access availability or unavailability report procedure

5.4.5.3 Access availability or unavailability report procedure completion

Upon reception of the PMFP ACCESS REPORT message, the UPF shall create a PMFP ACKNOWLEDGEMENT message. In the PMFP ACKNOWLEDGEMENT message, the UPF shall set the EPTI IE to the EPTI value in the PMFP ACCESS REPORT message. The UPF shall send the PMFP ACKNOWLEDGEMENT message over the access of the MA PDU session via which the PMFP ACCESS REPORT message was received.

Upon reception of a PMFP ACKNOWLEDGEMENT message with the same EPTI as the allocated EPTI value, the UE shall stop the timer T102.

5.4.5.4 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiry of the timer T102

   The UE shall, on the first expiry of the timer T102, retransmit the PMFP ACCESS REPORT message and shall reset and start timer T102. This retransmission is repeated up to four times, i.e. on the fifth expiry of timer T102, the UE shall abort the procedure.

5.4.6 UE-initiated PLR measurement procedure

5.4.6.1 General

The purpose of the UE-initiated PLR measurement procedure is to enable the UE to measure the PLR of UL traffic to the UPF over an access of an MA PDU session.

The UE-initiated PLR measurement procedure can be performed over an access of an MA PDU session only when the UE has user-plane resources on the access of the MA PDU session. The UE-initiated PLR measurement procedure can be performed for the QoS flow of the default QoS rule or the QoS flow of the non-default QoS rule.

The UE-initiated PLR measurement procedure consists of following:

a) one UE-initiated PLR count procedure (see clause 5.4.6.2); and

b) one or more UE-initiated PLR report procedure (see clause 5.4.6.3).

If an indication to request restart of counting procedure is sent by the UE and accepted by the UPF, the UE-initiated PLR measurement procedure consists of more than one UE-initiated PLR report procedure. Otherwise, the UE-initiated PLR measurement procedure consists of one UE-initiated PLR report procedure.

The UE shall not initiate another PLR measurement procedure over the same QoS flow on the same access until current UE-initiated PLR measurement procedure is completed.

An example of UE-initiated PLR measurement procedure which consists of the two procedures is shown in figure 5.4.6.1-1.
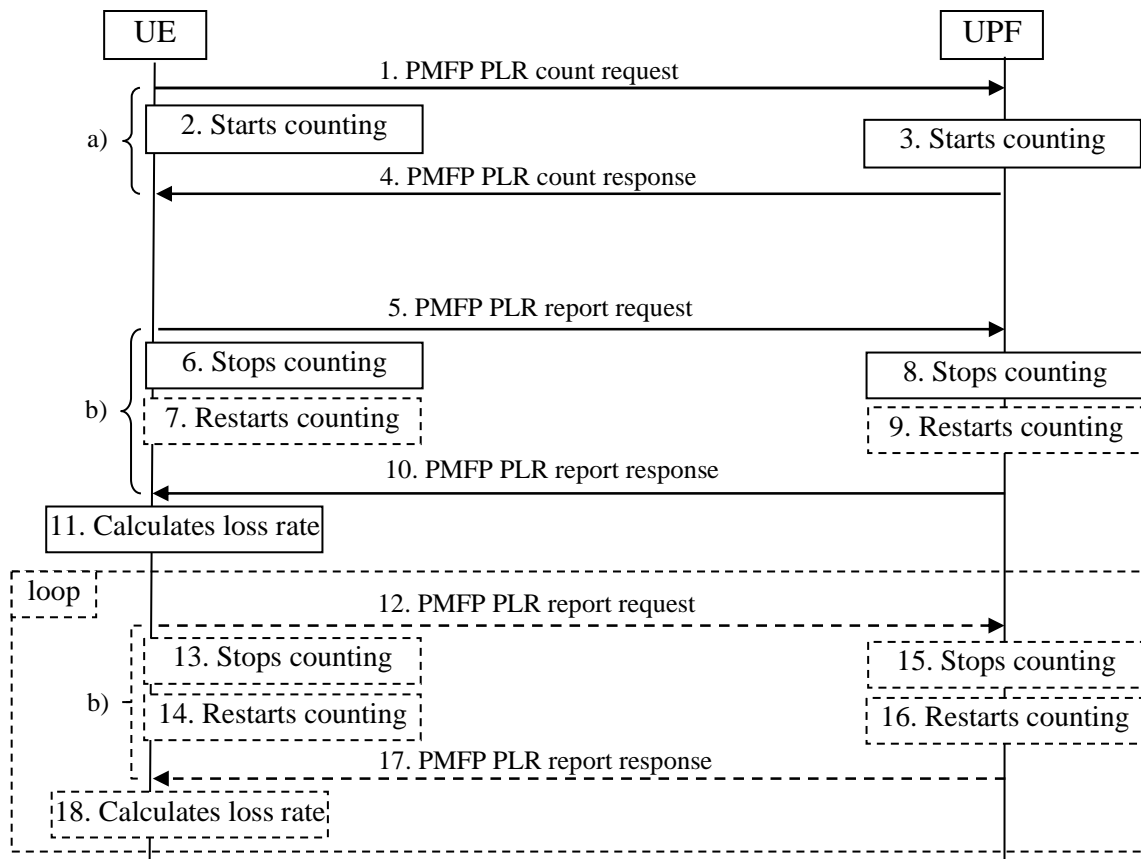
Figure 5.4.6.1-1: UE-initiated PLR measurement procedure

1. The UE sends a PMFP PLR count request message to the UPF. If the UE-initiated PLR measurement is to meaure the PLR of the SDF over a QoS flow of the non-default QoS rule, the PMFP PLR count request message is transported over the QoS flow of the non-default QoS rule. Otherwise, the PMFP PLR count request message is transported over the QoS flow of the default QoS rule.

NOTE 1: In the UE-initiated PLR measurement procedure, all the PMFP messages are transported over the same QoS flow on the same access.

2. Upon sending the PMFP PLR count request message, the UE starts counting the transmitted UL packets over the QoS flow.

3-4. Upon receiving the PMFP PLR count request message, the UPF starts counting the received UL packets over the QoS flow which the PMFP PLR count request message is received from and sends the PMFP PLR count response message to the UE.

5-7. The UE sends a PMFP PLR report request message to request the UPF to report the number of the counted UL packets and stops counting the transmitted UL packets over the QoS flow. If the UE intends to request the UPF to restart counting the UL packets, the UE can include an indication in the PMFP PLR report request message and restart counting the transmitted UL packets over the QoS flow.

8-10. Upon receiving the PMFP PLR report request message, the UPF stops counting the UL packets and sends PMFP PLR report response message which includes the number of the UL packets counted since the reception of the last PMFP PLR count request message. If an indication to request restart of counting procedure is received in the PMFP PLR report request message and accepted by the UPF, the UPF restarts counting the received UL packets.

11. The UE calculates the UL packet loss rate based on the local counting result of the number of transmitted UL packets and the reported number of received UL packets included in the PMFP PLR report response message. If the UE includes an indication to request restart of counting in the PMFP PLR report request message in step 5 and the UE receives PMFP PLR report response message with an indication of restart counting is not accepted or without an indication of restart counting, the UE shall abort the restart of PMFP PLR measurement procedure.

12. Same as step 5, if the UE restarts counting the transmitted UL packets as specified in step 7.

13. Same as step 6, if the UE restarts counting the transmitted UL packets as specified in step 7.

14. Same as step 7.

15. Same as step 8, if the UPF restarts counting the received UL packets as specified in step 9.

16. Same as step 9.

17 Same as step 10, if the UPF restarts counting the transmitted UL packets as specified in step 9.

18 Same as step 11, if the UE restarts counting the transmitted UL packets as specified in step 7.

NOTE 2: When the UE requests and the UPF accepts the restart of counting, there can be multiple occurrences of step 7, 9, and 12-18.

5.4.6.2 UE-initiated PLR count procedure

5.4.6.2.1 UE-initiated PLR count procedure initiation

In order to initiate a UE-initiated PLR count procedure over an access of an MA PDU session, the UE shall:

- allocate an EPTI value as specified in clause 5.4.2.2;

- create a PMFP PLR COUNT REQUEST message;

- set the EPTI IE of the PMFP PLR COUNT REQUEST message to the allocated EPTI value;

- send the PMFP PLR COUNT REQUEST message using the QoS flow indicated in the MAI over the access of the MA PDU session;

- start a timer T103 upon sending the PMFP PLR COUNT REQUEST message; and

- start counting the transmitted UL packets over the QoS flow.

An example of the UE-initiated PLR count procedure is shown in figure 5.4.6.2.1-1.

UE   network

                         PMFP PLR COUNT REQUEST
Start T103 ──▶

                         PMFP PLR COUNT RESPONSE
Stop T103 ◀──
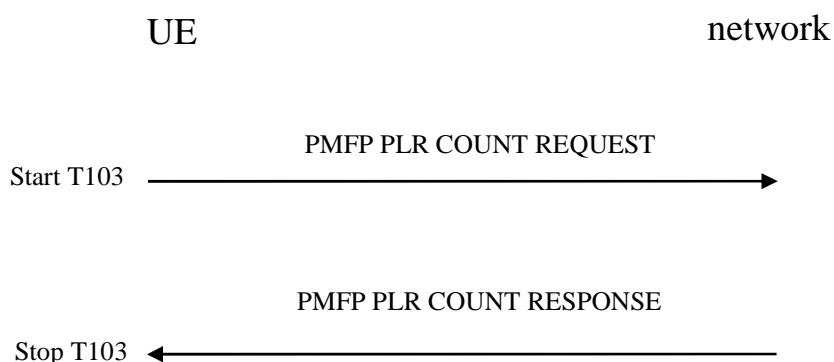
Figure 5.4.6.2.1-1: UE-initiated PLR count procedure

5.4.6.2.2 UE-initiated PLR count procedure completion

Upon receiving the PMFP PLR COUNT REQUEST message, the UPF shall:

- create a PMFP PLR COUNT RESPONSE message;

- set the EPTI IE of the PMFP PLR COUNT RESPONSE message to the EPTI value of the received PMFP PLR COUNT REQUEST message;

- send the PMFP PLR COUNT RESPONSE message over the access of the MA PDU session via which the PMFP PLR COUNT REQUEST message was received; and

- set the counted received UL packets, if any, to zero, and start counting the received UL packets over the QoS flow on the same access which the PMFP PLR COUNT REQUEST message is received.

Upon receiving PMFP PLR COUNT RESPONSE message with the same EPTI as the allocated EPTI value of the sent PMFP PLR COUNT REQUEST message, the UE shall stop the timer T103 and consider that the counting has started.

5.4.6.2.3 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiration of the timer T103

   Upon expiration of the timer T103, the UE shall abort the procedure.

5.4.6.3 UE-initiated PLR report procedure

5.4.6.3.1 UE-initiated PLR report procedure initiation

In order to initiate a UE-initiated PLR report procedure over an access of an MA PDU session, the UE shall

- allocate an EPTI value as specified in clause 5.4.2.2;

- create a PMFP PLR REPORT REQUEST message;

- set the EPTI IE of the PMFP PLR REPORT REQUEST message to the allocated EPTI value; and

- include the Additional measurement indication IE with "RC" bit set if the UE intends to request the UPF to restart counting the UL packets.

Upon sending the PMFP PLR REPORT REQUEST message the UE shall:

- start a timer T104;

- stop counting the UL packets; and

- restart counting the transmitted UL packets if the Additional measurement indication IE with "RC" bit set is included in the PMFP PLR REPORT REQUEST message.

An example of the UE-initiated PLR report procedure is shown in figure 5.4.6.3.1-1.

UE   network

PMFP PLR REPORT REQUEST

Start T104 ————————————————————————————————▶

PMFP PLR REPORT RESPONSE

Stop T104 ◀————————————————————————————————
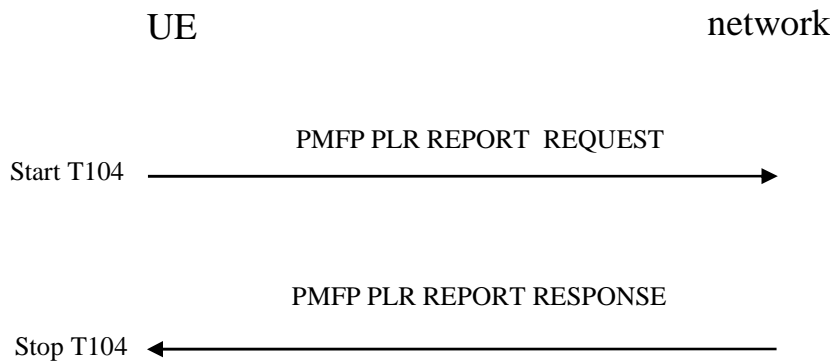
Figure 5.4.6.3.1-1: UE-initiated PLR report procedure

5.4.6.3.2 UE-initiated PLR report procedure completion

Upon receiving the PMFP PLR REPORT REQUEST message, the UPF shall:

- create a PMFP PLR REPORT RESPONSE message;

- set the EPTI IE of the PMFP PLR REPORT RESPONSE message to the EPTI value of the received PMFP PLR REPORT REQUEST message;

- stop counting the received UL packets and set the Counting result IE to the number of counted received UL packets since the reception of the last PMFP PLR COUNT REQUEST message over the QoS flow; and

- include the Additional measurement indication IE with "RC" bit set if accepting the request from the UE to restart counting the UL packets.

The UPF shall send the PMFP PLR REPORT RESPONSE message over the QoS flow on the same access which the PMFP PLR REPORT REQUEST message was received. Upon sending the PMFP PLR REPORT RESPONSE message, the UPF restarts counting the received UL packets over the QoS flow on the same access which the PMFP PLR REPORT REQUEST message is received if accepting the request from the UE to restart counting the UL packets.

Upon receiving the PMFP PLR REPORT RESPONSE message with the same EPTI as the allocated EPTI value of the sent PMFP PLR REPORT REQUEST message, the UE shall:

- stop the timer T104; and

- calculate the UL PLR over the QoS flow based on the number of the UL packets counted locally and the number indicated in Counting result IE in the received PMFP PLR REPORT RESPONSE message.

5.4.6.3.3 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiration of the timer T104

   Upon expiration of the timer T104, the UE shall abort the UE-initiated PLR measurement procedure.

5.4.7 Network-initiated PLR measurement procedure

5.4.7.1 General

The purpose of the network-initiated PLR measurement procedure is to enable the UPF to measure the PLR of DL traffic to the UE over an access of an MA PDU session.

The network-initiated PLR measurement procedure can be performed over an access of an MA PDU session only when there is user-plane resources on the access of the MA PDU session. The network-initiated PLR measurement procedure can be performed for the QoS flow of the default QoS rule or the QoS flow of the non-default QoS rule. In the latter case, the SMF shall provide the UE with the QoS rules including downlink only or bidirectional packet filter matching the SDF to be measured, unless reflective QoS is used for the SDF during the PDU session establishment procedure or PDU session modification procedure as specified in 3GPP TS 24.501 [6].

The network-initiated PLR measurement procedure consists of following:

a) one network-initiated PLR count procedure (see clause 5.4.7.2); and

b) one or more network-initiated PLR report procedure (see clause 5.4.7.3).

If an indication to request restart of counting procedure is sent by the UPF and accepted by the UE, the network-initiated PLR measurement procedure consists of more than one network-initiated PLR report procedure. Otherwise, the network-initiated PLR measurement procedure consists of one network-initiated PLR report procedure.

The network shall not initiate another PLR measurement procedure over the same QoS flow until current network-initiated PLR measurement procedure is completed.

An example of network-initiated PLR measurement procedure which consists of the two procedures is shown in figure 5.4.7.1-1.
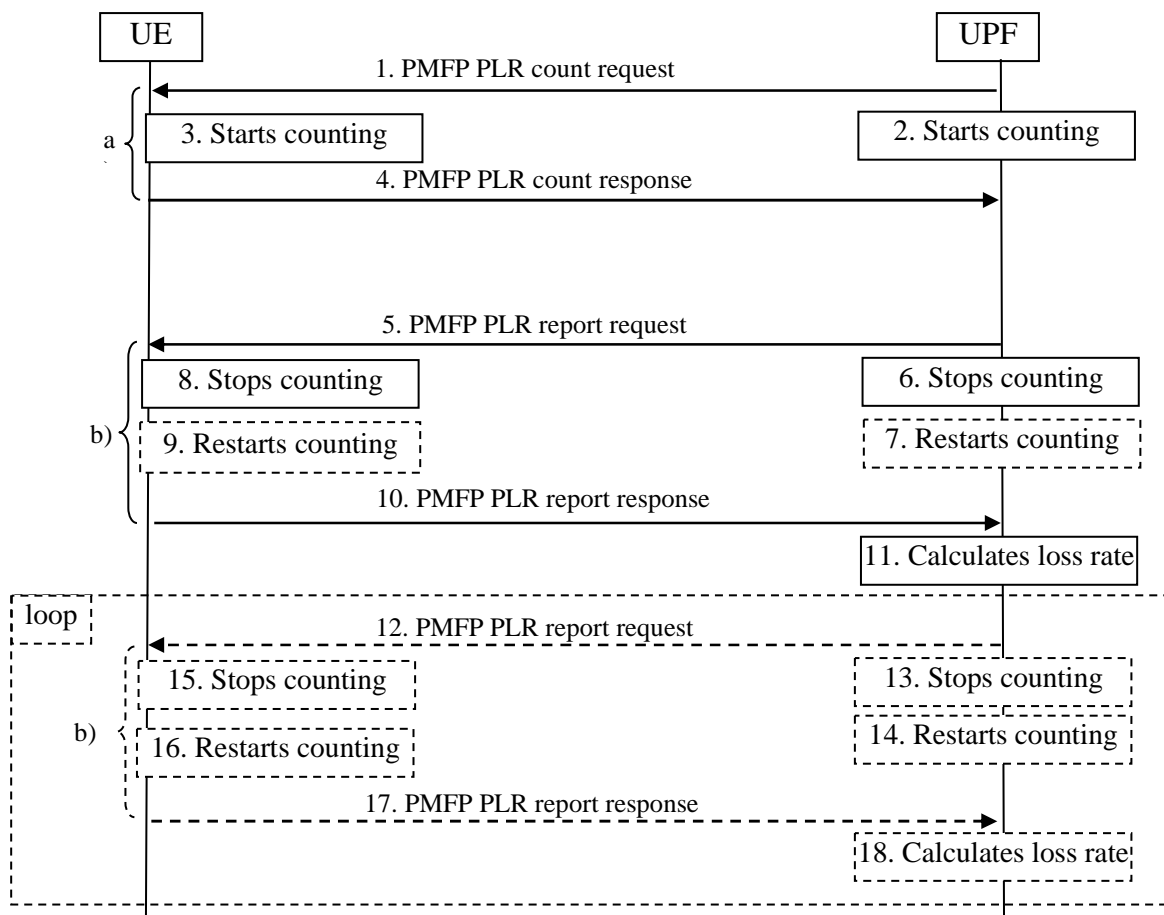
Figure 5.4.7.1-1: Network-initiated PLR measurement procedure

1. The UPF sends a PMFP PLR count request message to the UE. If the network-initiated PLR measurement is to measure the PLR of the SDF over a QoS flow of the non-default QoS rule, the PMFP PLR count request message is transported over the QoS flow of the non-default QoS rule. Otherwise, the PMFP PLR count request message is transported over the QoS flow of the default QoS rule.

NOTE 1: In the network-initiated PLR measurement procedure, all the PMFP messages are transported over the same QoS flow on the same access of the MA PDU session.

2. Upon sending the PMFP PLR count request message, the UPF starts counting the transmitted DL packets over the QoS flow.

3-4. Upon receiving the PMFP PLR count request message, the UE starts counting the received DL packets over the QoS flow which the PMFP PLR count request message is received from and sends the PMFP PLR count response message to the UPF. In order to determine the QFI the counted DL packet is associated with, the UE:

- learns the QFI from the header of the received DL packet (e.g. in the SDAP header as specified in 3GPP TS 37.324 [15]); or

- maps the DL packet to the QFI by evaluating the QoS rules for downlink only or bidirectional packet filter(s) if no QFI is included in the header of the received DL packet.

5-7. The UPF sends a PMFP PLR report request message to request the UE to report the number of the counted DL packets. If the UPF intends to request the UE to restart counting the DL packets, the UPF can include an indication in the PMFP PLR report request message and restart counting the transmitted DL packets over the QoS flow.

8-10. Upon receiving the PMFP PLR report request message, the UE stops counting the DL packets and sends PMFP PLR report response message which includes the number of the DL packets counted since the reception of the last PMFP PLR count request message. If an indication to request restart of counting procedure is received in the PMFP PLR report request message and accepted by the UE, the UE restarts counting the received DL packets.

11. The UPF calculates the DL packet loss rate based on the local counting result of the number of transmitted DL packets and the reported number of received DL packets included in the PMFP PLR report response message. If the UPF includes an indication to request restart of counting in the PMFP PLR report request message in step 5 and the UPF receives PMFP PLR report response message with an indication of restart counting is not accepted or without an indication of restart counting, the UPF shall abort the restart of PMFP PLR measurement procedure.

12. Same as step 5, if the UPF restarts counting the transmitted DL packets as specified in step 7.

13. Same as step 6, if the UPF restarts counting the transmitted DL packets as specified in step 7.

14. Same as step 7.

15. Same as step 8, if the UE restarts counting the received DL packets as specified in step 9.

16. Same as step 9.

17. Same as step 10, if the UE restarts counting the received DL packets as specified in step 9.

18. Same as step 11, if the UPF restarts counting the transmitted DL packets as specified in step 7.

NOTE 2: When the UPF requests and the UE accepts the restart of counting, there can be multiple occurrences of step 7, 9, and 12-18.

5.4.7.2 Network-initiated PLR count procedure

5.4.7.2.1 Network-initiated PLR count procedure initiation

In order to initiate a network-initiated PLR count procedure over an access of an MA PDU session, the UPF shall:

- allocate an EPTI value as specified in clause 5.4.2.2;

- create a PMFP PLR COUNT REQUEST message;

- set the EPTI IE of the PMFP PLR COUNT REQUEST message to the allocated EPTI value;

- send the PMFP PLR COUNT REQUEST message using the QoS flow indicated in the MAI over the access of the MA PDU session;

- start a timer T203 upon sending the PMFP PLR COUNT REQUEST message; and

- start counting the transmitted DL packets over the QoS flow.

An example of the network-initiated PLR count procedure is shown in figure 5.4.7.2.1-1.
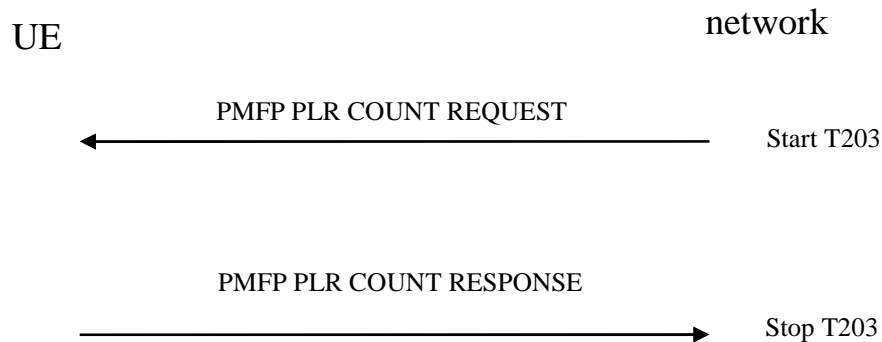
Figure 5.4.7.2.1-1: Network-initiated PLR count procedure

5.4.7.2.2 Network-initiated PLR count procedure completion

Upon receiving the PMFP PLR COUNT REQUEST message, the UE shall:

- create a PMFP PLR COUNT RESPONSE message;

- set the EPTI IE of the PMFP PLR COUNT RESPONSE message to the EPTI value of the received PMFP PLR COUNT REQUEST message;

- send the PMFP PLR COUNT RESPONSE message over the access of the MA PDU session via which the PMFP PLR COUNT REQUEST message was received; and

- set the counted received DL packets, if any, to zero, and start counting the received DL packets over the QoS flow on the same access which the PMFP PLR COUNT REQUEST message is received.

Upon receiving PMFP PLR COUNT RESPONSE message with the same EPTI as the allocated EPTI value of the sent PMFP PLR COUNT REQUEST message, the UPF shall stop the timer T203 and consider that the counting has started.

5.4.7.2.3 Abnormal cases in the UPF

The following abnormal cases can be identified:

a) Expiration of the timer T203

   Upon expiration of the timer T203, the UPF shall abort the procedure.

5.4.7.3 Network-initiated PLR report procedure

5.4.7.3.1 Network-initiated PLR report procedure initiation

In order to initiate a network-initiated PLR report procedure over an access of an MA PDU session, the UPF shall

- allocate an EPTI value as specified in clause 5.4.2.2;

- create a PMFP PLR REPORT REQUEST message;

- set the EPTI IE of the PMFP PLR REPORT REQUEST message to the allocated EPTI value; and

-   include the Additional measurement indication IE with "RC" bit set if the UPF intends to request the UE to restart counting the DL packets.

Upon sending the PMFP PLR REPORT REQUEST message the UPF shall:

-   start a timer T204;

-   stop counting the DL packets; and

-   restart counting the transmitted DL packets if the Additional measurement indication IE with "RC" bit set is included in the PMFP PLR REPORT REQUEST message.

An example of the network-initiated PLR report procedure is shown in figure 5.4.7.3.1-1.

UE   network

PMFP PLR REPORT REQUEST
←————————————————————————————————   Start T204

PMFP PLR REPORT RESPONSE
————————————————————————————————→   Stop T204
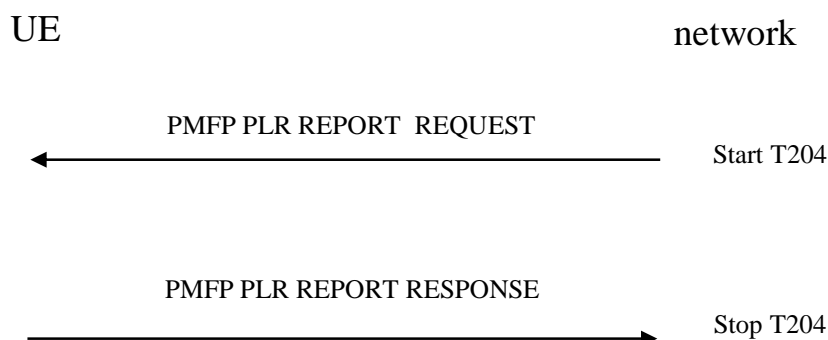
Figure 5.4.7.3.1-1: Network-initiated PLR report procedure

5.4.7.3.2   Network-initiated PLR report procedure completion

Upon receiving the PMFP PLR REPORT REQUEST message, the UE shall:

-   create a PMFP PLR REPORT RESPONSE message;

-   set the EPTI IE of the PMFP PLR REPORT RESPONSE message to the EPTI value of the received PMFP PLR REPORT REQUEST message;

-   stop counting the received DL packets and set the Counting result IE to the number of counted received DL packets since the reception of the last PMFP PLR COUNT REQUEST message over the QoS flow; and

-   include the Additional measurement indication IE with "RC" bit set if accepting the request from the UPF to restart counting the DL packets.

The UE shall send the PMFP PLR REPORT RESPONSE message over the QoS flow on the same access which the PMFP PLR REPORT REQUEST message was received. Upon sending the PMFP PLR REPORT RESPONSE message, the UE restarts counting the received DL packets over the QoS flow on the same access which the PMFP PLR REPORT REQUEST message is received if accepting the request from the UPF to restart counting the DL packets.

Upon receiving the PMFP PLR REPORT RESPONSE message with the same EPTI as the allocated EPTI value of the sent PMFP PLR REPORT REQUEST message, the UPF shall:

-   stop the timer T204; and

-   calculate the DL PLR over the QoS flow based on the number of the DL packets counted locally and the number indicated in Counting result IE in the received PMFP PLR REPORT RESPONSE message.

5.4.7.3.3 Abnormal cases in the UPF

The following abnormal cases can be identified:

a) Expiration of the timer T204

    Upon expiration of the timer T204, the UE shall abort the network-initiated PLR measurement procedure.

5.4.8 UE assistance data provisioning procedure

5.4.8.1 General

The purpose of the UE assistance data provisioning procedure is to enable the UE to provide to the UPF a DL traffic distribution that can be applied by the UPF for all DL traffic that applies to the UE assistance operation.

If the UE has received the UE assistance indicator in an ATSSS rule and decides to apply for an SDF a UL traffic distribution different from the default UL traffic distribution indicated in the load balancing steering mode of the ATSSS rule, the UE sends a PMFP UAD provisioning message to the UPF.

NOTE 1: It is based on UE implementation that how the UE decides to apply a different UL traffic distribution for an SDF and how the corresponding DL traffic distribution is decided.

NOTE 2: Once the UE assistance data provisioning procedure is successfully completed, if the UE receives updated ATSSS rules in which the value of the load balancing percentages adjustment operation filed is changed from "UE assistance operation is allowed" to other values, the UE needs to turn to apply immediately the UL traffic distribution for the SDF indicated in the updated ATSSS rules.

5.4.8.2 UE assistance data provisioning procedure initiation

In order to initiate a UE assistance data provisioning procedure over an access of an MA PDU session, the UE shall:

a) allocate an EPTI value as specified in clause 5.4.2.2;

b) create a PMF UAD PROVISIONING message;

c) set the EPTI IE of the PMFP UAD PROVISIONING message to the allocated EPTI value; and

d) include the DL distribution information IE with a DL traffic distribution that can be applied by the UPF for all DL traffic that applies to the UE-assistance operation.

Upon sending the PMFP UAD PROVISIONING message the UE shall start a timer T106.

The UE in the PMFP UAD provisioning message includes DL distribution information.

UE   network

                     PMFP UAD PROVISIONING

Start T10x   ————————————————————————→

          PMFP UAD PROVISIONING COMPLETE

Stop T10x   ←————————————————————————
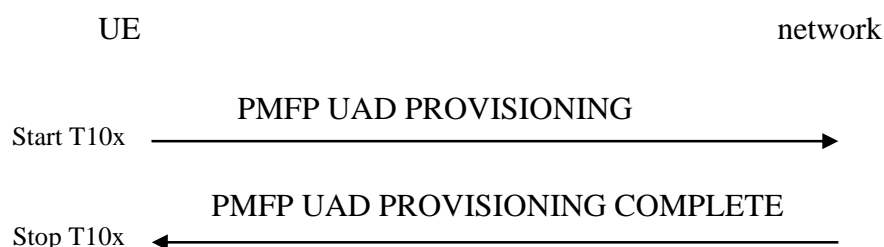
Figure 5.4.8.2-1: UE assistance data provisioning procedure

5.4.8.3 UE assistance data received by the network

On receipt of a PMFP UAD PROVISIONING message, the UPF may use the information in the received PMFP UAD PROVISIONING message to align the DL traffic distribution for all DL traffic that applies to the UE-assistance operation. Furthermore, the UPF shall create a PMFP UAD PROVISIONING COMPLETE message. In the PMFP

UAD PROVISIONING COMPLETE message, the UPF shall set the EPTI IE to the EPTI value in the PMFP UAD PROVISIONING message. The UPF shall send the PMFP UAD PROVISIONING COMPLETE message over the access of the MA PDU session via which the PMFP UAD PROVISIONING message was received.

5.4.8.4 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiry of the timer T106

The UE shall, on the first expiry of the timer T106, retransmit the PMFP UAD PROVISIONING message and shall reset and start timer T106. This retransmission is repeated up to four times, i.e. on the fifth expiry of timer T106, the UE shall abort the procedure.

5.4.9 UE assistance data termination procedure

5.4.9.1 General

The purpose of the UE assistance data termination procedure is to enable the UE to inform the UPF that the UE assistance data operation is terminated and the UE performs UL traffic distribution according to load balancing percentages of the ATSSS rule received from the network.

If the UE decides to terminate the UE assistance data operation and instead use the split percentages for respective SDF traffic transmitted over 3GPP access and non-3GPP access as indicated in the load balancing steering mode of the ATSSS rules, the UE sends a PMFP UAT command message to the UPF.

NOTE: It is based on UE implementation how the UE decides to terminate applying UL traffic distribution different from the percentages indicated in the load balancing steering mode of the ATSSS rules.

5.4.9.2 UE assistance data termination procedure initiation

In order to initiate a UE assistance data termination procedure over an access of an MA PDU session, the UE shall:

a) allocate an EPTI value as specified in clause 5.4.2.2;

b) create a PMF UAT COMMAND message; and

c) set the EPTI IE of the PMFP UAT COMMAND message to the allocated EPTI value.

Upon sending the PMFP UAT COMMAND message the UE shall start a timer T105.
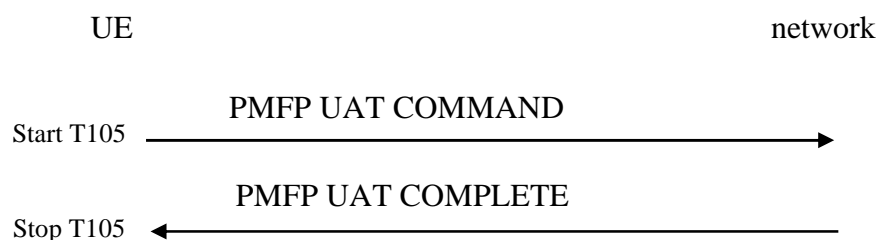
Figure 5.4.9.1-1: UE assistance data termination procedure

5.4.9.3 UE assistance data termination received by the network

On receipt of a PMFP UAT command message, the UPF shall remove the DL steering information, if created for a previous UE assistance data operation, and shall perform DL traffic distribution according to the load balancing percentages without UE assistance operation. Furthermore, the UPF shall create a PMFP UAT COMPLETE message . In the PMFP UAT COMPLETE message, the UPF shall set the EPTI IE to the EPTI value in the PMFP UAT COMMAND message. The UPF shall send the PMFP UAT COMPLETE message over the access of the MA PDU session via which the PMFP UAT COMMAND message was received.

Upon reception of a PMFP UAT COMPLETE message with the same EPTI as the allocated EPTI value, the UE shall stop the timer T105.

5.4.9.4 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiry of the timer T105

The UE shall, on the first expiry of the timer T105, retransmit the PMFP UAT COMMAND message and shall reset and start timer T105. This retransmission is repeated up to four times, i.e. on the fifth expiry of timer T105, the UE shall abort the procedure.

6 PDUs and parameters specific to the present document

6.1 ATSSS parameters

6.1.1 General

The ATSSS parameters are the contents of the ATSSS container as defined in clause 9.11.4.22 of 3GPP TS 24.501 [6].

The purpose of the ATSSS parameters is to indicate the parameters associated with ATSSS (e.g. ATSSS rules).

6.1.2 Encoding of ATSSS parameters

The ATSSS container contents include one or more ATSSS parameters and they are coded as shown in figure 6.1.2-1, figure 6.1.2-2 and table 6.1.2-1.
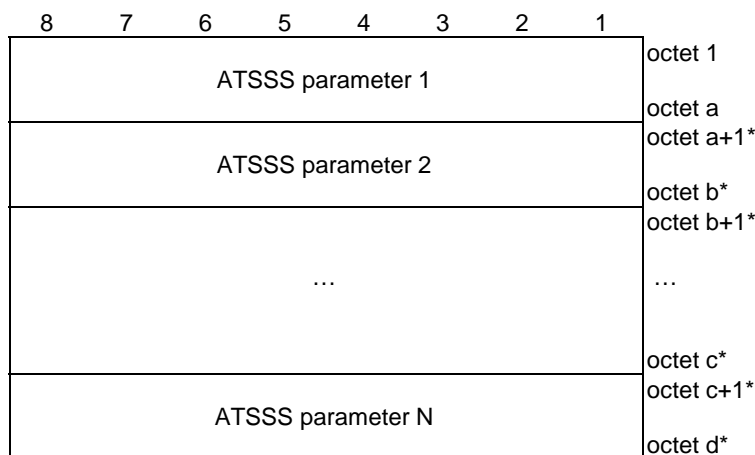
Figure 6.1.2-1: ATSSS container contents
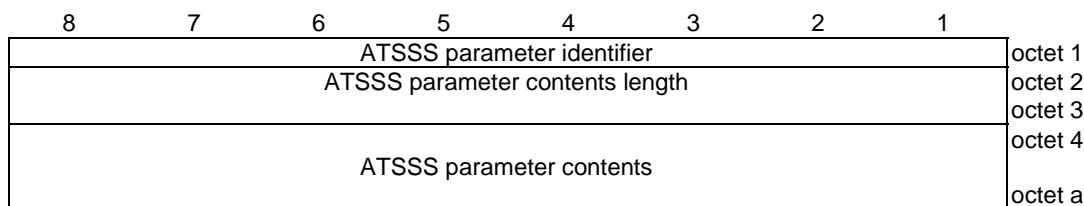
Figure 6.1.2-2: ATSSS parameter

Table 6.1.2-1: ATSSS parameter

The ATSSS parameter identifier is encoded as follows:
Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 1   ATSSS rules
0 0 0 0 0 0 1 0   Network steering functionalities information
0 0 0 0 0 0 1 1   Measurement assistance information
All other values are spare.
The ATSSS parameter contents for the ATSSS rules are specified according to clause 6.1.3.
The ATSSS parameter contents for the network steering functionalities information are specified according to clause 6.1.4.
The ATSSS parameter contents for the measurement assistance information are specified according to clause 6.1.5.

6.1.3 ATSSS rules

6.1.3.1 Definition of ATSSS rules

The ATSSS rules are defined in 3GPP TS 23.501 [2] and is set of one or more ATSSS rules, where a rule is composed of:

    a) an ATSSS rule ID identifying the individual ATSSS rule;

    b) an ATSSS rule operation identifying whether the ATSSS rule is added to or deleted from the set of ATSSS rules;

    c) a precedence value of the ATSSS rule identifying the precedence of the ATSSS rule;

    d) a traffic descriptor matching a service data flow (SDF); and

    e) an access selection descriptor including:

        1) a steering functionality set to:

            A) MPTCP functionality, the UE steers the SDF by using the MPTCP functionality; or

            B) ATSSS-LL functionality, the UE steers the SDF by using the ATSSS-LL functionality;

            C) UE's supported steering functionality;

NOTE 0: The steering functionality can only be set to "UE's supported steering functionality" if the UE indicated that the UE supports only "ATSSS Low-Layer functionality with any steering mode".

NOTE 1: If the included steering functionality is not supported by the UE, the UE ignores this ATSSS rule, and proceeds with the evaluation of the ATSSS rule with the next smallest precedence, if available.

        2) a steering mode:

            A) active-standby, the UE steers the SDF by using the active access if the active access is available. If the active access is not available and the standby access is available, the UE steers the SDF by using the standby access;

            B) smallest delay, the UE steers the SDF by using the access network with the smallest RTT. If there is only one access available, the UE steers the SDF by using the available access. This steering mode is only applicable to non-GBR SDF;

            C) load balancing, the UE steers the SDF across both the 3GPP access and the non-3GPP access with a given precentage if both accesses are available. If there is only one access available, the UE steers the SDF by using the available access. This steering mode is only applicable to non-GBR SDF; or

D) priority based, the UE steers the SDF over the access with high priority unless the access with high priority is congested or unavailable, when the UE steers the SDF over both the access with high priority and the access with low priority. This steering mode is only applicable to non-GBR SDF;

3) optionally, a steering mode additional indicator:

A) load balancing percentages adjustment operation (LBPAO):

- autonomous load-balance operation, this operation is only applicable to load balancing steering mode. With this operation, the UE may ignore the information provided in the steering mode information (i.e. percentages of the SDF traffic transmitted over 3GPP access and non-3GPP access), and that the UE may autonomously determine its own percentages for traffic splitting, in a way that maximizes the aggregated bandwidth in the uplink direction. The UPF may apply a similar behaviour in the downlink direction; or

- UE assistance operation, this operation is only applicable to load balancing steering mode. With this operation, the UE may decide how to distribute the UL traffic of the matching SDF based on the UE's internal state (e.g. when the UE is in the special internal state such as lower battery level) and inform the UPF how it decided to distribute the UL traffic of the matching SDF by performing UE assistance data provisioning procedure as specified in clause 5.4.8.

NOTE 2: The UE is expected to determine its own percentages for traffic splitting by performing measurements across both the 3GPP access and the non-3GPP access.

4) threshold values include one maximum RTT value or one maximum packet loss rate value or both. The threshold values are only used when the steering mode is indicated as load balancing or priority based.

NOTE 3: The threshold values and the LBPAO set with either "autonomous load-balancing operation is allowed" or "UE assistance operation is allowed" in the steering mode additional indicator cannot exist at the same time in an ATSSS rule.

The UE and the UPF use the provided threshold values on both 3GPP access and non-3GPP access as follows:

A) for the load balancing steering mode,

i) if the maximum RTT value or the maximum packet loss rate value of the MA PDU session in an access exceeds the indicated value, the UE and the UPF reduce the amount of traffic sent over that access and they send traffic over the other access; and

ii) if both the maximum RTT value and the maximum packet loss rate value of the MA PDU session for both accesses do not exceed the provided threshold values, the UE and the UPF steer the SDF traffic across both the 3GPP access and non-3GPP access as indicated by the steering information of the ATSSS rule; and

B) for the priority based steering mode, the UE and the UPF use the maximum RTT value or the maximum packet loss rate value or both to detect when an access of an MA PDU session is congested. If the maximum RTT value or the maximum packet loss rate value in an access of the MA PDU session exceeds the indicated value, the UE and the UPF may send some traffic over the other access, i.e. the UE splits the SDF traffic over both the access with high priority and the access with low priority.

6.1.3.2   Encoding of ATSSS rules

The ATSSS rules are encoded as shown in figure 6.1.3.2-1, figure 6.1.3.2-2 and figure 6.1.3.2-3 and table 6.1.3.2-1.

8	7	6	5	4	3	2	1	
			ATSSS rule 1					octet 4 octet s
			ATSSS rule 2					octet s+1 octet t
			…					octet t+1 octet u
			ATSSS rule n					octet u+1 octet a
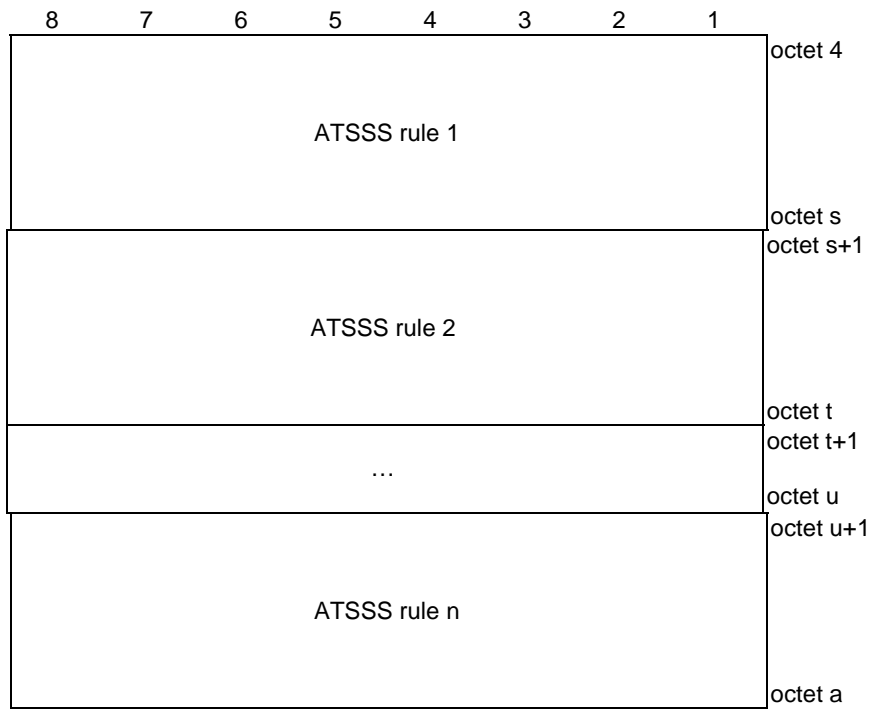
Figure 6.1.3.2-1: ATSSS parameter contents including one or more ATSSS rules

8	7	6	5	4	3	2	1	
Length of ATSSS rule								octet 4
								octet 5
ATSSS rule ID								octet 6
ATSSS rule operation								octet 7
Precedence value of ATSSS rule								octet 8
Length of traffic descriptor								octet 9
								octet 10
								octet 11
Traffic descriptor								
								octet f
								octet f+1
Access selection descriptor								
								octet s*

Figure 6.1.3.2-2: ATSSS rule

Length of access selection descriptor	octet f+1
Steering functionality	octet f+2
Steering mode	octet f+3
Steering mode information	octet f+4*
Steering mode additional indicator	octet z* (NOTE)
Threshold values	octet z+1*
	octet s*
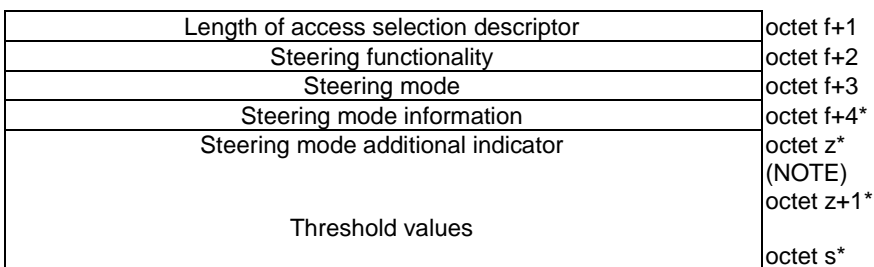
NOTE: If the steering mode is defined as smallest delay, then "Steering mode information" is not present and z=f+4; otherwise, z=f+5.

Figure 6.1.3.2-3: Access selection descriptor

0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	LBPAO		octet z*
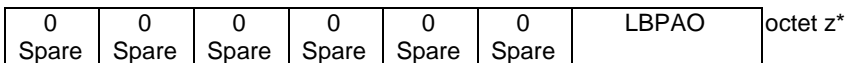
Figure 6.1.3.2-4: Steering mode additional indicator

Length of threshold values	octet z+1*
Maximum RTT value	octet z+2*
	octet z+3*
Maximum packet loss rate	octet s*
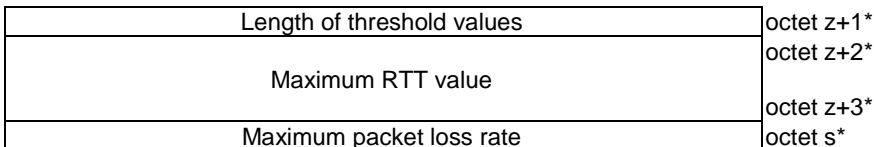
Figure 6.1.3.2-5: Threshold values

Table 6.1.3.2-1: ATSSS parameter contents including an ATSSS rule

ATSSS rule ID (octet 6)
The ATSSS rule ID specifies the identity of the individual ATSSS rule on which the ATSSS rule operation in octet 7 is applied.

ATSSS rule operation (octet 7)
The ATSSS rule operation is encoded as follows:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	Add or replace ATSSS rule
0	0	0	0	0	0	1	0	Delete ATSSS rule

All other values are spare.

If "Add or replace ATSSS rule" is indicated, the ATSSS rule with identity as indicated in ATSSS rule ID and contents as indicated in the following octets of the ATSSS rule parameter is added to the set of ATSSS rules. If an ATSSS rule with the same ATSSS rule ID does not exist in the set of ATSSS rules, a new rule is created and added. If an ATSSS rule with the same ATSSS rule ID exists in the set of ATSSS rules, the old rule is replaced with the new ATSSS rule. If "Delete ATSSS rule" is indicated, the ATSSS rule with identity as indicated in the ATSSS rule ID parameter is deleted from the set of ATSSS set of rules and octets a+5 and onwards of the ATSSS rule parameter are ignored. If no ATSSS rule with identity as indicated in the ATSSS rule ID parameter exists in the set of ATSSS rules, the Delete ATSSS rule operation is successful without changes to the set of ATSSS rules.

Precedence value of an ATSSS rule (octet 8)
The precedence value of an ATSSS rule field shall be used to specify the precedence of the ATSSS rule among all ATSSS rules. This field shall include the binary encoded value of the precedence value in the range from 0 to 255 (decimal). The higher the value of the precedence value field, the lower the precedence of the ATSSS rule is.

The traffic descriptor length field (octets 9 to 10) indicates length of the traffic descriptor field.

Traffic descriptor (octets 11 to f)
The traffic descriptor field is, as defined in table 5.2.1 in 3GPP TS 24.526 [5], of variable size and contains a variable number (at least one) of traffic descriptor components (NOTE 3). Each traffic descriptor component shall be encoded as a sequence of one octet traffic descriptor component type identifier and a traffic descriptor component value field. The traffic descriptor component type identifier shall be transmitted first.

Traffic descriptor component type identifier
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	Match-all type
0	0	0	0	1	0	0	0	OS Id + OS App Id type (NOTE 1)
0	0	0	1	0	0	0	0	IPv4 remote address type
0	0	1	0	0	0	0	1	IPv6 remote address/prefix length type
0	0	1	1	0	0	0	0	Protocol identifier/next header type
0	1	0	1	0	0	0	0	Single remote port type
0	1	0	1	0	0	0	1	Remote port range type
0	1	0	1	0	0	1	0	IP 3 tuple type
0	1	1	0	0	0	0	0	Security parameter index type
0	1	1	1	0	0	0	0	Type of service/traffic class type
1	0	0	0	0	0	0	0	Flow label type
1	0	0	0	0	0	0	1	Destination MAC address type
1	0	0	0	0	0	1	1	802.1Q C-TAG VID type
1	0	0	0	0	1	0	0	802.1Q S-TAG VID type
1	0	0	0	0	1	0	1	802.1Q C-TAG PCP/DEI type
1	0	0	0	0	1	1	0	802.1Q S-TAG PCP/DEI type
1	0	0	0	0	1	1	1	Ethertype type
1	0	0	0	1	0	0	0	DNN type
1	0	0	1	0	0	0	1	Destination FQDN
1	0	0	1	0	0	1	0	Regular expression
1	0	1	0	0	0	0	0	OS App Id type
1	0	1	0	0	0	0	1	Destination MAC address range type

All other values are spare. If received they shall be interpreted as unknown.

Length of access selection descriptor (octet f+1)
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	1	1	If the steering mode is smallest delay
0	0	0	0	0	1	0	0	If the steering mode is not smallest delay and steering mode additional indicator is not included
0	0	0	0	0	1	0	1	If the steering mode is not smallest delay and steering mode additional indicator is included

All other values are spare.

Steering functionality (octet f+2)
The steering functionality field shall be encoded by one octet (octet f+2) as follows
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	UE's supported steering functionality (NOTE 2)
0	0	0	0	0	0	1	0	MPTCP functionality
0	0	0	0	0	0	1	1	ATSSS-LL functionality

All other values are spare.

If the UE does not support the received encoded steering functionality in the ATSSS rule, the UE shall ignore the ATSSS rule.

Steering mode (octet f+3)
The steering mode descriptor field shall be encoded by one octet (octet f+3) as follows:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	Active-standby
0	0	0	0	0	0	1	0	Smallest delay
0	0	0	0	0	0	1	1	Load balancing
0	0	0	0	0	1	0	0	Priority based

All other values are spare.

Steering mode information (octet f+4)
If the steering mode is defined as active-standby, octet f+4 shall be defined as follows:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	Active 3GPP and no standby
0	0	0	0	0	0	1	0	Active 3GPP and non-3GPP standby
0	0	0	0	0	0	1	1	Active non-3GPP and no standby
0	0	0	0	0	1	0	0	Active non-3GPP and 3GPP standby

All other values are spare.

If the steering mode is defined as smallest delay, Steering mode information shall not be included.

If the steering mode is defined as load balancing, octet f+4 shall be encoded to show the percentage of the SDF traffic transmitted over 3GPP access and non-3GPP access as follows:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	100% over 3GPP and 0% over non-3GPP
0	0	0	0	0	0	1	0	90% over 3GPP and 10% over non-3GPP
0	0	0	0	0	0	1	1	80% over 3GPP and 20% over non-3GPP
0	0	0	0	0	1	0	0	70% over 3GPP and 30% over non-3GPP
0	0	0	0	0	1	0	1	60% over 3GPP and 40% over non-3GPP
0	0	0	0	0	1	1	0	50% over 3GPP and 50% over non-3GPP
0	0	0	0	0	1	1	1	40% over 3GPP and 60% over non-3GPP
0	0	0	0	1	0	0	0	30% over 3GPP and 70% over non-3GPP
0	0	0	0	1	0	0	1	20% over 3GPP and 80% over non-3GPP
0	0	0	0	1	0	1	0	10% over 3GPP and 90% over non-3GPP
0	0	0	0	1	0	1	1	0% over 3GPP and 100% over non-3GPP

All other values are spare.

If the steering mode is defined as priority-based, octet f+4 shall be encoded as:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	3GPP is high priority access
0	0	0	0	0	0	1	0	non-3GPP is high priority access

All other values are spare.

Steering mode additional indicator (octetz)
The steering mode additional indicator provides information to adjust the traffic steering. The following operations exist.

LBPAO (load balancing percentages adjustment operation) (octet z, bits 2 to 1) is set as follows:
Bit

2	1	
0	0	No additional operation
0	1	Autonomous load-balance operation is allowed
1	0	UE assistance operation is allowed
1	1	spare

Maximum RTT value (octets z+2 to z+3)
If the steering mode is defined as load balancing or priority based (octet f+3), the maximum RTT value field indicates binary encoded value of the maximum RTT in miliseconds (NOTE 4).

Maximum packet loss rate (octet s)
If the steering mode is defined as load balancing or priority based (octet f+3), the maximum packet loss rate field indicates the allowed percentage of packet rate lost as follows (NOTE 4):
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	0	0% packet loss rate
0	0	0	0	0	0	0	1	1% packet loss rate
					to			
0	1	1	0	0	1	0	0	100% packet loss rate

All other values are spare (NOTE 5).

NOTE 1: For "OS Id + OS App Id type", the traffic descriptor component value field does not specify the OS version number or the version number of the application.
NOTE 2: This value shall be set by the SMF if the UE supports only one steering functionality, i.e. only "ATSSS Low-Layer functionality with any steering mode". The SMF knows the UE's supported steering functionality during the MA PDU session establishment.
NOTE 3: Traffic descriptor components of an ATSSS rule are not required to be the same as the traffic descriptor components, defined in table 5.2.1 in 3GPP TS 24.526 [5].
NOTE 4: If the value is received for a steering mode other than load balancing or priority based, it shall be ignored.
NOTE 5: In this release of the specification if received, it shall be interpreted as value 100.

6.1.4 Network steering functionalities information

6.1.4.1 Definition of network steering functionalities information

6.1.4.1.1 MPTCP Functionality with any steering mode and the ATSSS-LL functionality with only the active-standby steering mode

In order for the UE to support the MPTCP functionality, the UE shall support the TCP extensions for multipath operation specified in IETF RFC 8684 [8].

When the UE indicates support for MPTCP functionality with any steering mode and the ATSSS-LL functionality with only the active-standby steering mode and the network accepts to enable these functionalities for an MA PDU session

of IP type in the UPF as specified in the clause 5.32.2 of 3GPP TS 23.501 [2], then the network shall provide the following information to the UE:

    a)   two "link-specific multipath" IP addresses/prefixes used only by the MPTCP functionality in the UE, one associated with the 3GPP access and another associated with the non-3GPP access;

    NOTE: It is possible that the network provides the "link-specific multipath" IP addresses/prefix that is not routable via N6 (e.g. IPv6 link local address).

    b)   the IP address, port number and the type of one or more MPTCP proxies in the UPF; and

    c)   one or more ATSSS rules including an ATSSS rule for non-MPTCP traffic. The ATSSS rule for non-MPTCP traffic shall be composed of a precedence with value "255", a "match-all type" traffic descriptor, an "ATSSS-LL functionality" steering functionality and an "active-standby" steering mode.

In this release of the specification, the UPF shall support the Transport Converter as specified in IETF RFC 8803 [9].

In this release of the specification, the UE shall support the client extensions specified in IETF RFC 8803 [9], and only client-initiated multipath connections via a Transport Converter are supported.

The UE shall use the "link-specific multipath" addresses/prefixes to establish subflows over non-3GPP access and over 3GPP access.

When the MA PDU session is Ethernet type, the network shall not enable the MPTCP functionality with any steering mode and the ATSSS-LL functionality with only the active-standby steering mode.

6.1.4.1.2   ATSSS-LL Functionality with any steering mode

When the UE indicates ATSSS-LL capability with any steering mode and the network accepts to enable this functionality for an MA PDU session of any supported type, then the network shall enable ATSSS-LL functionality with any steering mode in the UPF as specified in the clause 5.32.2 of 3GPP TS 23.501 [2] and provide one or more ATSSS rules to the UE.

In an ATSSS capable UE, the following ATSSS-LL requirements apply:

    a)   for an MA PDU session of Ethernet PDU session type, the ATSSS-LL functionality with any steering mode is mandatory; and

    b)   for an MA PDU session of IPv4, IPv6, or IPv4v6 PDU session type, if the UE does not support:

        1)   the MPTCP functionality with any steering mode and the ATSSS-LL functionality with only the active-standby steering mode; and

        2)   the MPTCP functionality with any steering mode and the ATSSS-LL functionality with any steering mode,

    then ATSSS-LL functionality with any steering mode is mandatory.

6.1.4.1.3   MPTCP functionality with any steering mode and the ATSSS-LL functionality with any steering mode

In order for the UE to support the MPTCP functionality, the UE shall support the TCP extensions for multipath operation specified in IETF RFC 8684[8].

When the UE indicates support for MPTCP functionality with any steering mode and the ATSSS-LL functionality with any steering mode and the network accepts to enable these functionalities for an MA PDU session of IP type in the UPF as specified in the clause 5.32.2 of 3GPP TS 23.501 [2], then the network shall provide the following information to the UE:

    a)   two "link-specific multipath" IP addresses/prefixes used only by the MPTCP functionality in the UE, one associated with the 3GPP access and another associated with the non-3GPP access;

    b)   the IP address, port number and the type of one or more MPTCP proxies in the UPF; and

    c)   one or more ATSSS rules.

In this release of the specification, the UPF shall support the Transport Converter as specified in IETF RFC 8803 [9].

In this release of the specification, the UE shall support the client extensions specified in IETF RFC 8803 [9], and only client-initiated multipath connections via a Transport Converter are supported.

The UE shall use the "link-specific multipath" addresses/prefixes to establish subflows over non-3GPP access and over 3GPP access.

When the MA PDU session is Ethernet type, the network shall not enable the MPTCP functionality with any steering mode and the ATSSS-LL functionality with any steering mode.

6.1.4.2 Encoding of network steering functionalities information

The network steering functionalities information contains:

    a) addressing information for the ATSSS capable UE supporting MPTCP fiunctionality; and

    b) addressing information and type for the MPTCP proxy;

and is encoded as shown in figure 6.1.4.2-1, figure 6.1.4.2-2 and table 6.1.4.2-1:

8	7	6	5	4	3	2	1	
UE 3GPP IP address type								octet a+1
UE 3GPP IP address								octet a+2 ⋮ octet k-1
UE non-3GPP IP address type								octet k
UE non-3GPP IP address								octet k+1 ⋮ octet l-1
Length of MPTCP proxy information								octet l
MPTCP proxy information value 1								octet l+1 ⋮ octet m+2
MPTCP proxy information value 2								octet n ⋮ octet o
MPTCP proxy information value n								octet p ⋮ octet s
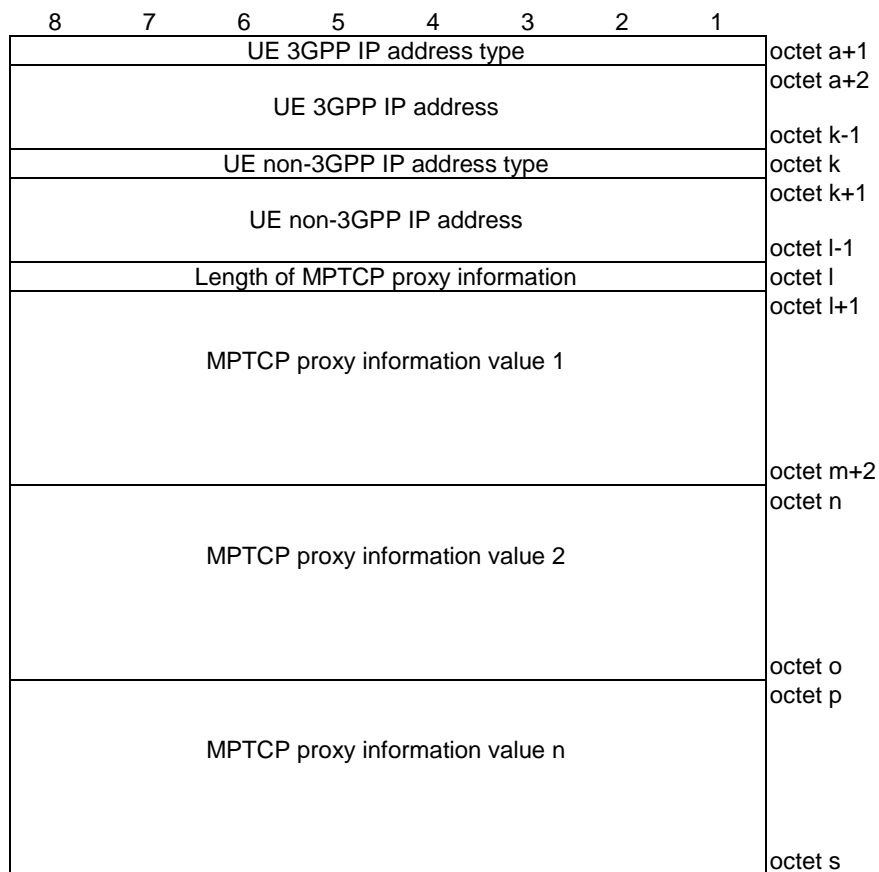
Figure 6.1.4.2-1: Network steering functionalities information including UE IP addresses and MPTCP proxy information

MPTCP proxy IP address type	octet l+1
MPTCP proxy IP address	octet l+2 ⋮ octet m-1
MPTCP proxy port	octet m octet m+1
MPTCP proxy type	octet m+2
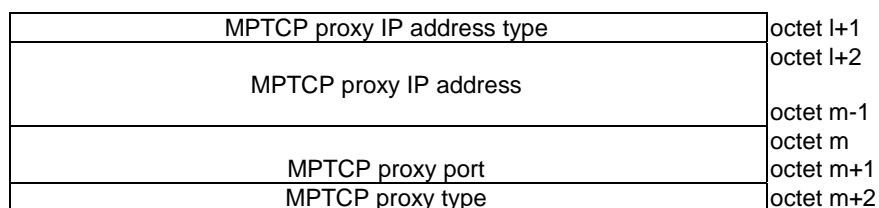
Figure 6.1.4.2-2: MPTCP proxy information

Table 6.1.4.2-1: UE IP addresses and MPTCP proxy information

UE 3GPP IP address type (octet a+1) is set as follows:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	IPv4
0	0	0	0	0	0	1	0	IPv6
0	0	0	0	0	0	1	1	IPv4v6

If the UE 3GPP IP address type indicates IPv4, then the UE 3GPP IP address field contains an IPv4 address in 4 octets.

If the UE 3GPP IP address type indicates IPv6, then the UE 3GPP IP address field contains an IPv6 address in 16 octets field and 1 octet prefix length field. The IPv6 address field shall be transmitted first.

If the UE 3GPP IP address type indicates IPv4v6, then the UE 3GPP IP address field contains two IP addresses. The first UE 3GPP IP address is an IPv4 address in 4 octets and the second UE 3GPP IP address is an IPv6 address field in 16 octets followed by 1 octet prefix length field.

UE non-3GPP IP address type (octet k) is set as follows:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	IPv4
0	0	0	0	0	0	1	0	IPv6
0	0	0	0	0	0	1	1	IPv4v6

If the UE non-3GPP IP address type indicates IPv4, then the UE non-3GPP IP address field contains an IPv4 address in 4 octets.

If the UE non-3GPP IP address type indicates IPv6, then the UE non-3GPP IP address field contains an IPv6 address in 16 octets field and 1 octet prefix length field. The IPv6 address field shall be transmitted first.

If the UE non-3GPP IP address type indicates IPv4v6, then the UE non-3GPP IP address field contains two IP addresses. The first UE non-3GPP IP address is an IPv4 address in 4 octets and the second UE non-3GPP IP address is an IPv6 address field in 16 octets followed by 1 octet prefix length field.

MPTCP proxy IP address type (octet l+1) is set as follows:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	IPv4
0	0	0	0	0	0	1	0	IPv6
0	0	0	0	0	0	1	1	IPv4v6

If the MPTCP proxy IP address type indicates IPv4, then the MPTCP proxy IP address field contains an IPv4 address in 4 octets.

If the MPTCP proxy IP address type indicates IPv6, then the MPTCP proxy IP address field contains an IPv6 address in 16 octets.

If the MPTCP proxy IP address type indicates IPv4v6, then the MPTCP proxy IP address field contains two IP addresses. The first MPTCP proxy IP address is an IPv4 address in 4 octets and the second MPTCP proxy IP address is an IPv6 address in 16 octets.

MPTCP proxy type (octet m+2) is set as follows:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	Transport converter

All other values are spare.

6.1.5 Measurement assistance information

6.1.5.1 Definition of measurement assistance information

The measurement assistance information is transmitted by the network to the UE.

If the UE is only capable of supporting MPTCP functionality with any steering mode and the ATSSS-LL functionality with only the active-standby steering mode, the network may send measurement assistance information for the UE to send access availability/unavailability to the UPF. In this case, the UE and UPF shall not perform RTT measurements using PMF, the UE and UPF shall use the RTT measurements available at the MPTCP layer.

The measurement assistance information is defined in 3GPP TS 23.501 [2] and it contains:

a) addressing for the PMF in the UPF according to:

1) if the PDU session is IP type, the measurement assistance information contains IP address for the PMF with an allocated port number associated with the 3GPP access network and another allocated port number associated with non-3GPP access network for access performance measurements over the QoS flow of the default QoS rule, and optionally a QoS flow list according to figure 6.1.5.2-3 and figure 6.1.5.2-4 with the allocated port numbers to perform measurements over the QoS flows of non-default QoS rules; and

2) if the PDU session is Ethernet type, the measurement assistance information contains a MAC address associated with the 3GPP access network and another MAC address associated with the non-3GPP address network for the PMF for access performance measurements over the QoS flow of the default QoS rule, and optionally a QoS flow list according to figure 6.1.5.2-3 and figure 6.1.5.2-5 with the MAC addresses to perform for measurements over the QoS flows of non-default QoS rules; and

b) an indicator to report the availability and unavailability of an access network.

6.1.5.2 Encoding of measurement assistance information

The measurement assistance information contains addressing information for the PMF in the UPF and is encoded as shown in figure 6.1.5.2-1 and figure 6.1.5.2-2 and table 6.1.5.2-1 and table 6.1.5.2-2.

8	7	6	5	4	3	2	1	
PMF IP address type								octet a+1
PMF IP address								octet a+2
								octet b-5
PMF 3GPP port								octet b-4
								octet b-3
PMF non-3GPP port								octet b-2
								octet b-1
0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	APMQF	AARI	octet b
QoS flow list								octet b+1*
								octet c*
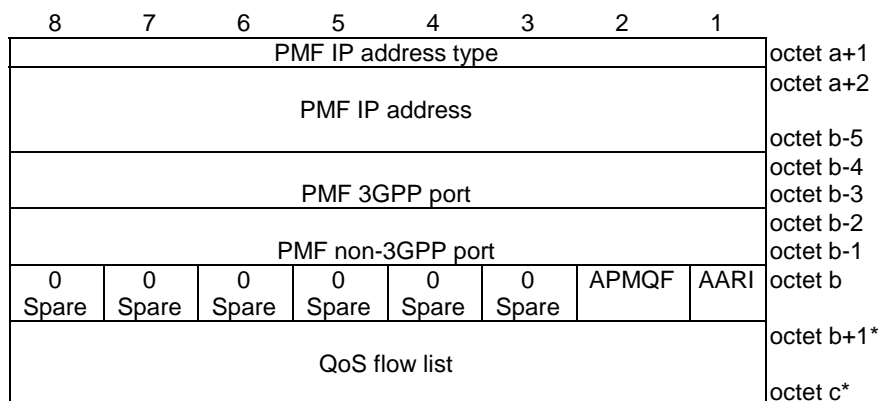
Figure 6.1.5.2-1: ATSSS parameter contents including one PMF IP address information

Table 6.1.5.2-1: PMF IP address type

PMF IP address type (octet a+1) is set as follows:
Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	IPv4
0	0	0	0	0	0	1	0	IPv6
0	0	0	0	0	0	1	1	IPv4IPv6

All other values are spare.

If the PMF IP address type indicates IPv4, then the PMF IP address field contains an IPv4 address in 4 octets.

If the PMF IP address type indicates IPv6, then the PMF IP address field contains an IPv6 address in 16 octets.

If the PMF IP address type indicates IPv4IPv6, then the PMF IP address field contains two IP addresses. The first PMF IP address is an IPv4 address in 4 octets and the second PMF IP address is an IPv6 address in 16 octets.

PMF 3GPP port (octets b-4 – b-3) is allocated port number associated with the 3GPP access network and is dedicated for the QoS flow of the default QoS flow.

PMF non-3GPP port (octets b-2 – b-1) is allocated port number associated with the non-3GPP access network and is dedicated for the QoS flow of the default QoS flow.

AARI (access availability reporting indicator) (octet b, bit 1) is set as follows:
Bit

1

0   Do not report the access availability (NOTE)

1   Report the access availability

APMQF (access performance measurements per QoS flow indicator) (octet b, bit 2) is set as follows (NOTE 2):
Bit

1

0   Perform access performance measurements using default QoS rule.

1   Perform access performance measurements using non-default QoS rule.

QoS flow list is according to figure 6.1.5.2-3, figure 6.1.5.2-4 and table 6.1.5.2-3.

NOTE 1:	Even if AARI is set to "Do not report the access availability" during the MA PDU session establishment procedure, the UE still needs to perform access availability or unavailability report procedure over an access immediately after the MA PDU session is established to enable the UPF to determine the UDP port of the PMF in the UE or the UDP port and the IPv6 address of the PMF in the UE, as specified in clause 5.4.2.1.1.
NOTE 2:	If APMQF is set to "Perform access performance measurements using default QoS rule", the UE shall use octets b-4 and b-3 for PMF 3GPP port and octets b-2 and b-1 for PMF non-3GPP port and the UE shall ignore the QoS flow list, if provided. If APMQF is set to "Perform access performance measurements using non-default QoS rule" the UE shall use the information provided by the QoS flow list to perform the access performance measurements using the QoS flow of the non-default QoS rule.

8	7	6	5	4	3	2	1	
PMF 3GPP MAC address								octet a+1
								octet a+6
PMF non-3GPP MAC address								octet a+7
								octet a+12
0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	APMQ F	AARI	octet a+13
QoS flow list								octet a+14*
								octet b*

Figure 6.1.5.2-2: ATSSS parameter contents including one PMF MAC address information

Table 6.1.5.2-2: PMF MAC address type

PMF 3GPP MAC address contains a 6 octet MAC address associated with the 3GPP access network and is dedicated for the QoS flow of the default QoS flow. PMF non-3GPP MAC address contains a 6 octet MAC address associated with the non-3GPP access network and is dedicated for the QoS flow of the default QoS flow. AARI (access availability reporting indicator) (octet a+13, bit 1) is set as follows: Bit **1** 0   Do not report the access availability (NOTE 1) 1   Report the access availability APMQF (access performance measurements per QoS flow indicator) (octet a+13, bit 2) is and set as follows (NOTE 2): Bit **1** 0   Perform access performance measurements using default QoS rule. 1   Perform access performance measurements using non-default QoS rule. QoS flow list is according to figure 6.1.5.2-3, figure 6.1.5.2-5 and table 6.1.5.2-3.
NOTE 1: Even if AARI is set to "Do not report the access availability" during the MA PDU session establishment procedure, the UE still needs to perform access availability or unavailability report procedure over an access immediately after the MA PDU session is established to enable the UPF to determine the MAC address of the PMF in the UE as specified in clause 5.4.2.1.2. NOTE 2: If APMQF is set to "Perform access performance measurements using default QoS rule", the UE shall use octets a+1 through a+6 for PMF 3GPP MAC address and octets a+7 and a+12 for PMF non-3GPP MAC address and the UE shall ignore the QoS flow list, if provided. If APMQF is set to "Perform access performance measurements using non-default QoS rule" the UE shall use the information provided by the QoS flow list to perform the access performance measurements using the QoS flow of the non-default QoS rule.

8	7	6	5	4	3	2	1	
Length of QoS flow contents								octet 1
QoS flow 1								octet 2
								octet k
…								octet k+1*
								octet m-1*
QoS flow n								octet m*
								octet n*
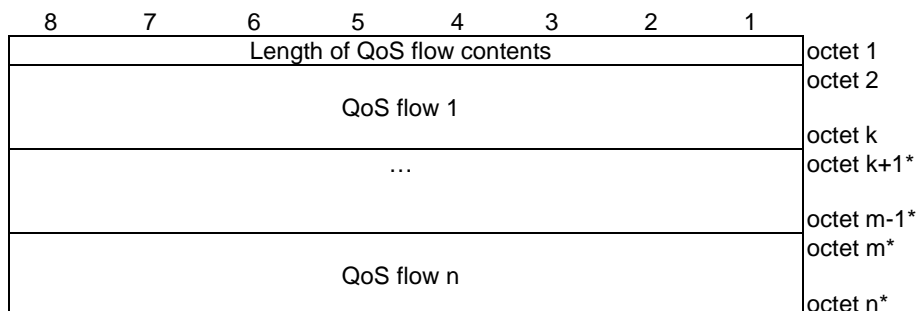
Figure 6.1.5.2-3: QoS flow list information element

8	7	6	5	4	3	2	1	
0 Spare	0 Spare	QFI						octet p
PMF 3GPP port								octet p+1 octet p+2
PMF non-3GPP port								octet p+3 octet p+4
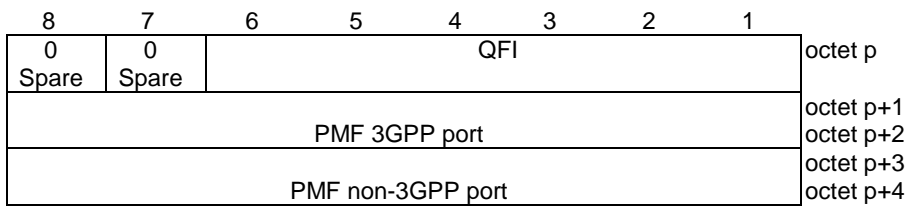
Figure 6.1.5.2-4: QoS flow – IP address

8	7	6	5	4	3	2	1	
0 SpareI	0 Spare	QFI						octet p
PMF 3GPP MAC address								octet p+1 octet p+6
PMF non-3GPP MAC address								octet p+7 octet p+12
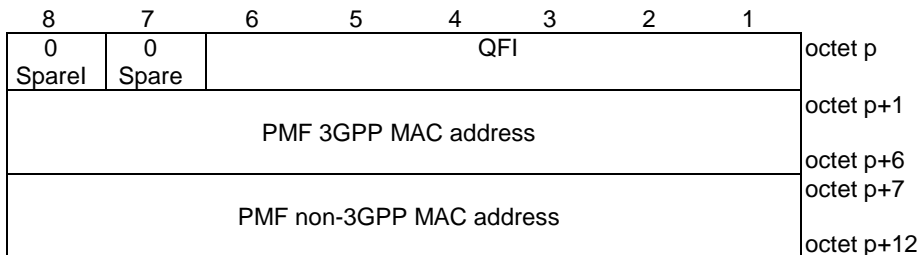
Figure 6.1.5.2-5: QoS flow – MAC address

Table 6.1.5.2-3: QoS flow

QFI is defined in Table 9.11.4.12.1 of 3GPP TS 24.501 [6].

PMF 3GPP port contains a 2 octet port number, associated with the 3GPP access network for the target QoS flow.

PMF non-3GPP port contains a 2 octet port number, associated with the non-3GPP access network for the target QoS flow.

PMF 3GPP MAC address contains a 6 octet MAC address, associated with the 3GPP access network for the target QoS flow.

PMF non-3GPP MAC address contains a 6 octet MAC address, associated with the non-3GPP access network for the target QoS flow.

6.1.6 ATSSS PCO parameters

6.1.6.1 General

Clause 6.1.6 specifies PCO parameters used for ATSSS.

6.1.6.2 ATSSS request PCO parameter

The purpose of the ATSSS request PCO parameter is to provide UE parameters for MA PDU session management.

The ATSSS request PCO parameter container contents are coded as shown in figure 6.1.6.2-1 and table 6.1.6.2-1.

The ATSSS request PCO parameter container contents may be one or more octets long. If the ATSSS request PCO parameter container contents is longer than one octet, octets other than the first octet shall be ignored.

8	7	6	5	4	3	2	1	
0 Spare	0 Spare	0 Spare	0 Spare	ATSSS-ST				octet 1
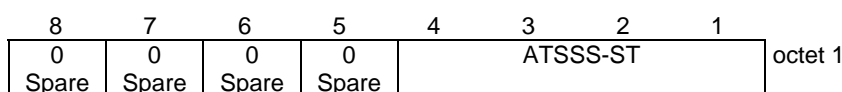
Figure 6.1.6.2-1: ATSSS request PCO parameter container contents

Table 6.1.6.2-1: ATSSS request PCO parameter container contents

Supported ATSSS steering functionalities and steering modes (ATSSS-ST) (octet 1, bits 1, 2, 3 and 4) (see NOTE) This field indicates the 5GSM capability of ATSSS steering functionalities and steering modes. Bits **4 3 2 1** 0 0 0 1 ATSSS Low-Layer functionality with any steering mode supported 0 0 1 0 MPTCP functionality with any steering mode and ATSSS-LL functionality with only active-standby steering mode supported 0 0 1 1 MPTCP functionality with any steering mode and ATSSS-LL functionality with any steering mode supported All other values are reserved. All other bits in octet 1 are spare and shall be coded as zero.
NOTE: If the ATSSS request PCO parameter is included in the PDN CONNECTIVITY REQUEST message with the request type information element set to "handover", the ATSSS-ST field is ignored.

6.1.6.3 ATSSS response with the length of two octets PCO parameter

The purpose of the ATSSS response with the length of two octets PCO parameter is to provide network parameters for MA PDU session management.

The ATSSS response with the length of two octets PCO parameter container contents are coded as shown in figure 6.1.6.3-1 and table 6.1.6.3-1.

The ATSSS response with the length of two octets PCO parameter container contents may be one or more octets long. If the ATSSS response with the length of two octets PCO parameter container contents is longer than as indicated in the figure 6.1.6.3-1, the octets after the last field of the figure 6.1.6.3-1 shall be ignored.

8	7	6	5	4	3	2	1	
0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	MAII	NSFII	octet 1
Network steering functionalities information length								octet 2* octet 3*
Network steering functionalities information								octet 4* octet n*
Measurement assistance information length								octet n+1* octet n+2*
Measurement assistance information								octet n+3* octet m*

Figure 6.1.6.3-1: ATSSS response with the length of two octets PCO parameter container contents

Table 6.1.6.3-1: ATSSS response with the length of two octets PCO parameter container contents

Network steering functionalities information indicator (NSFII) (octet 1, bit 1)
This bit indicates whether the network steering functionalities information length field
and the network steering functionalities information are included.
Bit
1
0   Network steering functionalities information length field and network
          steering functionalities information field not included.
1   Network steering functionalities information length field and network
          steering functionalities information field included.

Measurement assistance information indicator (MAII) (octet 1, bit 2)
This bit indicates whether the measurement assistance information length field and the
measurement assistance information field are included.
Bit
2
0   Measurement assistance information length field and the measurement
          assistance information field not included.
1   Measurement assistance information length field and the measurement
          assistance information field included.

All other bits in octet 1 are spare and shall be coded as zero.

The network steering functionalities information length field indicates length of the
network steering functionalities information field.

The network steering functionalities information field is coded as specified in
figure 6.1.4.2-1, figure 6.1.4.2-2 and table 6.1.4.2-1.

The measurement assistance information length field indicates length of the
measurement assistance information field.

The measurement assistance information field is coded as specified in figure 6.1.5.2-1
and table 6.1.5.2-1, figure 6.1.5.2-2 and table 6.1.5.2-2.

6.2 Encoding of performance measurement function (PMF) protocol (PMFP)

6.2.1 Message functional definitions and format

6.2.1.1 General

The following PMFP messages are specified:

- PMFP echo request;

- PMFP echo response;

- PMFP access report;

- PMFP acknowledgement;

- PMFP UAD provisioning;

- PMFP UAD provisioning complete;

- PMFP UAT command;

- PMFP UAT complete;

- PMFP PLR count request;

- PMFP PLR count response;

- PMFP PLR report request; and

- PMFP PLR report response.

6.2.1.2 PMFP echo request

6.2.1.2.1 Message definition

The PMFP ECHO REQUEST message is sent by the UE to the UPF or by the UPF to the UE to initiate detection of RTT.

See table 6.2.1.2.1-1.

Message type: PMFP ECHO REQUEST

Significance: dual

Direction: UE to UPF or UPF to UE

Table 6.2.1.2.1-1: PMFP ECHO REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP echo request message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2
	RI	Request identity 6.2.2.5	M	V	1
70	Padding	Padding 6.2.2.6	O	TLV-E	3-1000

6.2.1.3 PMFP echo response

6.2.1.3.1 Message definition

The PMFP ECHO RESPONSE message is sent by the UPF to the UE or by the UE to the UPF as response to an PMFP ECHO REQUEST message to enable detection of RTT.

See table 6.2.1.3.1-1.

Message type: PMFP ECHO RESPONSE

Significance: dual

Direction: UE to UPF or UPF to UE

Table 6.2.1.3.1-1: PMFP ECHO RESPONSE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP echo response message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2
	RI	Request identity 6.2.2.5	M	V	1
70	Padding	Padding 6.2.2.6	O	TLV-E	3-1000

6.2.1.4   PMFP access report

6.2.1.4.1   Message definition

The PMFP ACCESS REPORT message is sent by the UE to the UPF to inform the UPF about access availability or unavailability.

See table 6.2.1.4.1-1.

> Message type: PMFP ACCESS REPORT

> Significance: dual

> Direction: UE to UPF

Table 6.2.1.4.1-1: PMFP ACCESS REPORT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP access report message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2
	Access availability state	Access availability state 6.2.2.3	M	V	1/2
	Spare half octet	Spare half octet 6.2.2.4	M	V	1/2

6.2.1.5   PMFP acknowledgement

6.2.1.5.1   Message definition

The PMFP ACKNOWLEDGEMENT message is sent by the UPF to the UE to acknowledge reception of a PMFP ACCESS REPORT message.

See table 6.2.1.5.1-1.

> Message type: PMFP ACKNOWLEDGEMENT

> Significance: dual

> Direction: UPF to UE

Table 6.2.1.5.1-1: PMFP ACKNOWLEDGEMENT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP acknowledgement message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2

6.2.1.6 PMFP UAD provisioning

6.2.1.6.1 Message definition

The PMFP UAD PROVISIONING message is sent by the UE to provide UE assistance data to the UPF.

See table 6.2.1.6.1-1.

Message type: PMFP UAD PROVISIONING

Significance: dual

Direction: UE to network

Table 6.2.1.6.1-1: PMFP UAD PROVISIONING message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP UAD provisioning message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2
	DL distribution information	DL distribution information 6.2.2.8	M	V	1

6.2.1.7 PMFP PLR count request

6.2.1.7.1 Message definition

The PMFP PLR COUNT REQUEST message is sent by the UE or the UPF to initiate a PMFP PLR measurement procedure.

See table 6.2.1.7.1-1.

Message type: PMFP PLR COUNT REQUEST

Significance: dual

Direction: both

Table 6.2.1.7.1-1: PMFP PLR COUNT REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP PLR count request message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2

6.2.1.8 PMFP PLR count response

6.2.1.8.1 Message definition

The PMFP PLR COUNT RESPONSE message is sent by the UE to the UPF or the UPF to the UE to acknowledge reception of a PMFP PLR COUNT REQUEST message.

See table 6.2.1.8.1-1.

Message type: PMFP PLR COUNT RESPONSE

Significance: dual

Direction: both

Table 6.2.1.8.1-1: PMFP PLR COUNT RESPONSE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP PLR count response message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2

6.2.1.9 PMFP PLR report request

6.2.1.9.1 Message definition

The PMFP PLR REPORT REQUEST message is sent by either UE or UPF to request the report of the counting result.

See table 6.2.1.9.1-1.

Message type: PMFP PLR REPORT REQUEST

Significance: dual

Direction: both

Table 6.2.1.9.1-1: PMFP PLR REPORT REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP PLR report request message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2
	Additional measurement indication	Additional measurement indication 6.2.2.9	O	TV	1

6.2.1.9.2 Additional measurement indication

This IE is included in the message by either UE or UPF when the restart counting for another PLR measurement is required.

6.2.1.10 PMFP PLR report response

6.2.1.10.1 Message definition

The PMFP PLR REPORT RESPONSE message is sent by either UE or the UPF to respond the PMFP PLR REPORT REQUEST message and report the counting result.

See table 6.2.1.10.1-1.

   Message type: PMFP PLR REPORT RESPONSE

   Significance: dual

   Direction: both

Table 6.2.1.10.1-1: PMFP PLR REPORT RESPONSE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP PLR report response message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2
	Counting result	Counting result 6.2.2.10	M	V	4
	Additional measurement indication	Additional measurement indication 6.2.2.9	O	TV	1

6.2.1.10.2   Additional measurement indication

This IE is included in the message by either UE or UPF to indicate whether to accept the request of restart counting for another PLR measurement in the PMFP PLR REPORT REQUEST message.

6.2.1.11   PMFP UAT command

6.2.1.11.1   Message definition

The PMFP UAT COMMAND message is sent by the UE to the UPF in order to terminate the UE assistance operation to the UPF.

See table 6.2.1.11.1-1.

   Message type: PMFP UAT COMMAND

   Significance: dual

   Direction: UE to network

Table 6.2.1.11.1-1: PMFP UAT COMMAND message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP UAT command message identity	Message type 6.2.2.1	M	V	1

6.2.1.12   PMFP UAT complete

6.2.1.12.1   Message definition

The PMFP UAT COMPLETE message is sent by the UPF to the UE.

See table 6.2.1.12.1-1.

   Message type: PMFP UAT COMPLETE

   Significance: dual

   Direction: network to UE

Table 6.2.1.12.1-1: PMFP UAT COMPLETE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP UAT complete message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2

6.2.1.13 PMFP UAD provisioning complete

6.2.1.13.1 Message definition

The PMFP UAD PROVISIONING COMPLETE message is sent by the UPF to the UE as response to PMFP UAD PROVISIONING message.

See table 6.2.1.13.1-1.

Message type: PMFP UAD PROVISIONING COMPLETE

Significance: dual

Direction: network to UE

Table 6.2.1.13.1-1: PMFP UAD PROVISIONING COMPLETE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	PMFP UAD provisioning complete message identity	Message type 6.2.2.1	M	V	1
	EPTI	Extended procedure transaction identity 6.2.2.2	M	V	2

Editor's note [WI: ATSSS-Ph2, CR#96]: Whether a backoff timer can optionally be provided by the UPF to protect itself from continuous PMFP UAD PROVISIONING resending when the UE request is not accepted is FFS.

Editor's note [WI: ATSSS-Ph2, CR#96]: Whether an indication of whether the UPF aligns the DL traffic distribution based on the UE request is provided in the message is FFS.

6.2.2 Encoding of information element

6.2.2.1 Message type

Message type is a type 3 information element with length of 1 octet.

Table 6.2.2.1-1 defines the value part of the message type IE used in the PMFP.

Table 6.2.2.1-1: Message type

```
Bits
8  7  6  5  4  3  2  1
0  0  0  0  0  0  0  1        PMFP ECHO REQUEST message
0  0  0  0  0  0  1  0        PMFP ECHO RESPONSE message
0  0  0  0  0  0  1  1        PMFP ACCESS REPORT message
0  0  0  0  0  1  0  0        PMFP ACKNOWLEDGEMENT message

0  0  0  0  0  1  0  1        PMFP PLR COUNT REQUEST message
0  0  0  0  0  1  1  0        PMFP PLR COUNT RESPONSE message
0  0  0  0  1  0  0  1        PMFP UAD PROVISIONING message
0  0  0  0  0  1  1  1        PMFP PLR REPORT REQUEST message
0  0  0  0  1  0  0  0        PMFP PLR REPORT RESPONSE message
0  0  0  0  1  0  1  0        PMFP UAT COMMAND message
0  0  0  0  1  0  1  1        PMFP UAT COMPLETE message
0  0  0  0  1  1  0  0        PMFP UAD PROVISIONING COMPLETE
                             message

All other values are reserved
```

6.2.2.2 Extended procedure transaction identity

The purpose of the extended procedure transaction identity information element is to enable distinguishing up to 10000H different bi-directional message flows. Such a message flow is called a transaction.

Extended procedure transaction identity is a type 3 information element with length of 2 octet.

The extended procedure transaction identity information element is coded as shown in figure 6.2.2.2-1 and table 6.2.2.2-1.
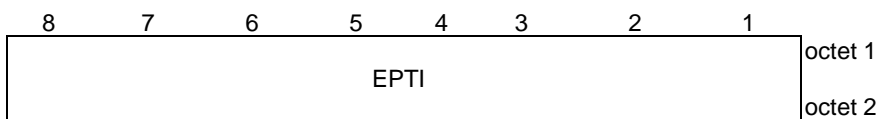
Figure 6.2.2.2-1: Extended procedure transaction identity information element

Table 6.2.2.2-1: Extended procedure transaction identity information element

```
EPTI (octet 1 to octet 2)
Binary encoded EPTI value.
EPTI values between 0000H and 7FFFH indicate a UE-initiated transaction. EPTI
values between 8000H and FFFFH indicate a UPF-initiated transaction.
```

6.2.2.3 Access availability state

The purpose of the access availability state information element is to provide information about availability of access.

The access availability state is a type 1 information element.

The access availability state information element is coded as shown in figure 6.2.2.3-1 and table 6.2.2.3-1.
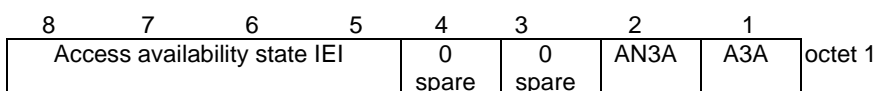
Figure 6.2.2.3-1: Access availability state information element

Table 6.2.2.3-1: Access availability state information element

Availability over 3GPP access (A3A) (octet 1, bit 1)
Bit
1
0 3GPP access not available
1 3GPP access available
Availability over non-3GPP access (AN3A) (octet 1, bit 2)
Bit
2
0 non-3GPP access not available
1 non-3GPP access available

6.2.2.4 Spare half octet

This information element is used in the description of messages when an odd number of half octet type 1 information elements are used. This element is filled with spare bits set to zero and is placed in bits 5 to 8 of the octet unless otherwise specified.

6.2.2.5 Request identity

The purpose of the Request identity information element is to enable association of a PMF ECHO RESPONSE message with one of PMF ECHO REQUEST messages sent within one RTT measurement procedure.

The Request identity is a type 3 information element with length of 1 octet.

The Request identity information element is coded as shown in figure 6.2.2.5-1 and table 6.2.2.5-1.

| 8	7	6	5	4	3	2	1	
Request identity value								octet 1
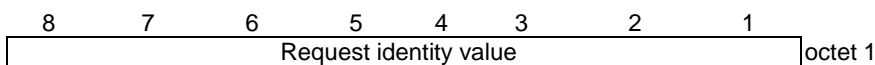
Figure 6.2.2.5-1: Request identity information element

Table 6.2.2.5-1: Request identity information element

Request identity value (octet 1)
Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 0 \
to } Request identity value
1 1 1 1 1 1 1 1 /

6.2.2.6 Padding

The purpose of the Padding information element is to extend the PMFP message to length requested by upper layers.

The Padding information information element is coded as shown in figure 6.2.2.6-1.

The Padding information is a type 6 information element with a minimum length of 3 octets.

8	7	6	5	4	3	2	1	
Padding IEI								octet 1
Padding length								octet 2
								octet 3
0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	octets 3
								octet n

Figure 6.2.2.6-1: Padding information element

6.2.2.7 Void

6.2.2.8 DL distribution information

The purpose of the DL distribution information information element is to provide a DL traffic distribution that can be applied by the UPF for all DL traffic that applies to the UE-assistance operation.

The DL distribution information is a type 3 information element with length of 2 octets.

The DL distribution information information element is coded as shown in figure 6.2.2.8-1 and table 6.2.2.8-1.
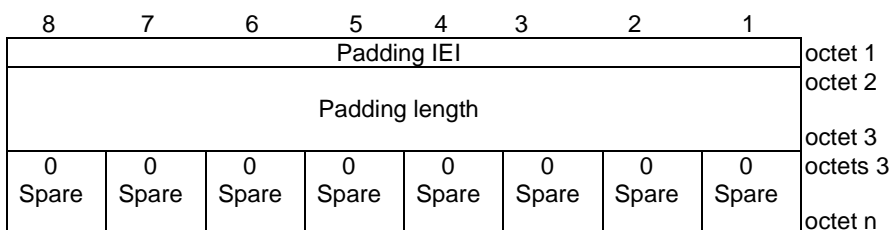
8	7	6	5	4	3	2	1	
DL distribution information IEI								octet 1
DL distribution value								octet 2
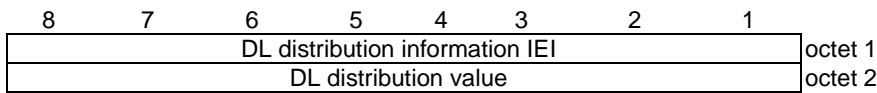
Figure 6.2.2.8-1: DL distribution information information element

Table 6.2.2.8-1: DL distribution information information element

```
DL distribution value (octet 2)

Bits
8  7  6  5  4  3  2  1
0  0  0  0  0  0  0  1    100% over 3GPP and 0% over non-3GPP
0  0  0  0  0  0  1  0    90% over 3GPP and 10% over non-3GPP
0  0  0  0  0  0  1  1    80% over 3GPP and 20% over non-3GPP
0  0  0  0  0  1  0  0    70% over 3GPP and 30% over non-3GPP
0  0  0  0  0  1  0  1    60% over 3GPP and 40% over non-3GPP
0  0  0  0  0  1  1  0    50% over 3GPP and 50% over non-3GPP
0  0  0  0  0  1  1  1    40% over 3GPP and 60% over non-3GPP
0  0  0  0  1  0  0  0    30% over 3GPP and 70% over non-3GPP
0  0  0  0  1  0  0  1    20% over 3GPP and 80% over non-3GPP
0  0  0  0  1  0  1  0    10% over 3GPP and 90% over non-3GPP
0  0  0  0  1  0  1  1    0% over 3GPP and 100% over non-3GPP
All other values are spare.
```

6.2.2.9 Additional measurement indication

The purpose of the additional measurement indication information element is to indicate whether to restart counting for another PLR measurement.

The additional measurement indication is a type 1 information element.

The additional measurement indication information element is coded as shown in figure 6.2.2.9-1 and table 6.2.2.9-1.

8	7	6	5	4	3	2	1	
Additional measurement indication IEI				0 spare	0 spare	0 spare	ACR	octet 1
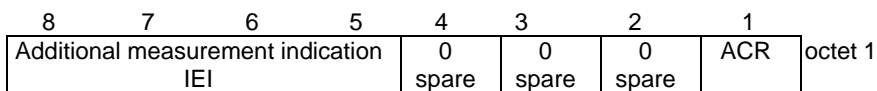
Figure 6.2.2.9-1: Additional measurement indication information element

Table 6.2.2.9-1: Additional measurement indication information element

```
Restart counting (RC) (octet 1, bit 1)
Bit
1
0          Restart counting is not to be performed
1          Restart counting is to be performed

Bits 2 to 4 are spare and shall be coded as zero.
```

6.2.2.10 Counting result

The purpose of the counting result information element is to indicate the number of the counted packets.

The counting result is a type 3 information element with length of 5 octet.

The counting result information element is coded as shown in figure 6.2.2.10-1.

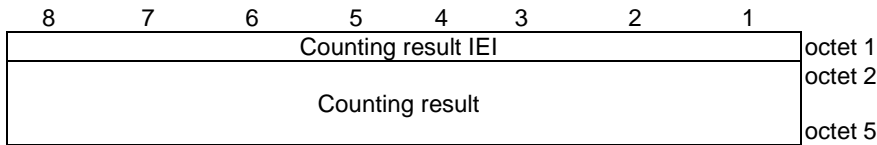| 8	7	6	5	4	3	2	1	
Counting result IEI								octet 1
Counting result								octet 2
								octet 5

Figure 6.2.2.10-1: Counting result information element

Table 6.2.2.10-1: Counting result information element

Counting result (octet 1 to octet 5) Binary encoded counting result value.

6.3 Encoding of 3GPP IEEE MAC based protocol family

Ethertype of the 3GPP IEEE MAC based protocol family is XYZ.

Editor's note: ethertype of the 3GPP IEEE MAC based protocol family will be assigned by IEEE.

The MAC client data field of a MAC frame as specified in IEEE 802.3 [12] with the length/type field set to the ethertype of the 3GPP IEEE MAC based protocol family contains a 3GPP IEEE MAC based protocol family envelope. The 3GPP IEEE MAC based protocol family envelope is encoded as shown in figure 6.3-1 and table 6.3-1.

8	7	6	5	4	3	2	1	
Protocol subtype								octet 1
Protocol data								octet 2
								octet x
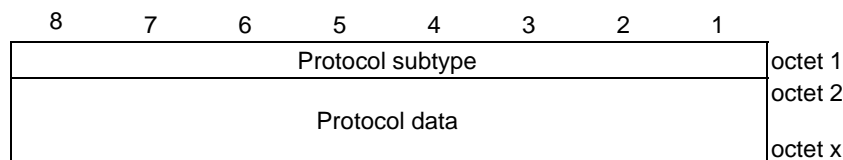
Figure 6.3-1: 3GPP IEEE MAC based protocol family envelope

Table 6.3-1: 3GPP IEEE MAC based protocol family envelope

Protocol subtype (octet 1) The protocol subtype field identifies protocol of the protocol data field. Bits **8 7 6 5 4 3 2 1** 0 0 0 0 0 0 0 1   Performance measurement function protocol (PMFP). All other values are reserved. Protocol data (octets 2 to x) If the protocol subtype field is set to "Performance measurement function protocol (PMFP)", the protocol data field shall be encoded as a sequence of a two octets PMFP message length field and a PMFP message field. The PMFP message length field shall indicate the length in octets of the PMFP message field. The PMFP message field shall contain a PMFP message as specified in clause 6.2.1.
NOTE: A sending entity shall not set the protocol subtype field to a reserved value. A receiving entity shall ignore a 3GPP IEEE MAC based protocol family envelope if the protocol subtype field is set to a reserved value.

7 List of system parameters

7.1 General

The description of timers in the tables of clause 7 should be considered a brief summary. The precise details are found in clause 5, which should be considered the definitive descriptions.

7.2 Timers of performance measurement function (PMF) protocol (PMFP)

Timers of PMFP are shown in table 7.2-1 and table 7.2-2.

Table 7.2-1: Timers of PMFP – UE side

TIMER NUM.	TIMER VALUE	CAUSE OF START	NORMAL STOP	ON THE 1st, 2nd, 3rd, 4th EXPIRY (NOTE 1)
T101	1s	Transmission of the first PMFP ECHO REQUEST message	A PMFP ECHO RESPONSE message received for each sent PMFP ECHO REQUEST message	Abort of the procedure.
T102	NOTE 2	Transmission of PMFP ACCESS REPORT message	PMFP ACKNOWLEDGEMENT message with the same EPTI is received	Retransmission of PMFP ACCESS REPORT message
T103	1s	Transmission of PMFP PLR COUNT REQUEST message	PMFP PLR COUNT RESPONSE message with the same EPTI is received	Abort of the procedure.
T104	1s	Transmission of PMFP PLR REPORT REQUEST message	PMFP PLR REPORT RESPONSE message with the same EPTI is received	Abort of the procedure.
T105	1s	Transmission of PMFP UAT COMMAND message	PMFP UAT COMPLETE message with the same EPTI is received	Retransmission of PMFP UAT COMMAND message
T106	1s	Transmission of PMFP UAD PROVISIONING message	PMFP UAD PROVISIONING COMPLETE message with the same EPTI is received	Retransmission of PMFP UAD PROVISIONING message
NOTE 1: Typically, the procedures are aborted on the fifth expiry of the relevant timer. Exceptions are described in the corresponding procedure description.				
NOTE 2: Initial timer value is 500 milliseconds. The timer value doubles after each timer expiry, until set to 4 seconds.				

Table 7.2-2: Timers of PMFP – UPF side

TIMER NUM.	TIMER VALUE	CAUSE OF START	NORMAL STOP	ON THE 1st, 2nd, 3rd, 4th EXPIRY (NOTE 1)
T201	NOTE 2	Transmission of the first PMFP ECHO REQUEST message	A PMFP ECHO RESPONSE message received for each sent PMFP ECHO REQUEST message	Abort of the procedure.
T203	1s	Transmission of PMFP PLR COUNT REQUEST message	PMFP PLR COUNT RESPONSE message with the same EPTI is received	Abort of the procedure.
T204	1s	Transmission of PMFP PLR REPORT REQUEST message	PMFP PLR REPORT RESPONSE message with the same EPTI is received	Abort of the procedure.
NOTE 1: Typically, the procedures are aborted on the fifth expiry of the relevant timer. Exceptions are described in the corresponding procedure description.				
NOTE 2: The value of this timer is network dependent.				

8　Handling of unknown, unforeseen, and erroneous PMFP data

8.1　General

The procedures specified in the clause apply to those messages which pass the checks described in this clause.

This clause also specifies procedures for the handling of unknown, unforeseen, and erroneous PMFP data by the receiving entity. These procedures are called "error handling procedures", but in addition to providing recovery mechanisms for error situations they define a compatibility mechanism for future extensions of the PMFP.

Clauses 8.1 to 8.8 shall be applied in order of precedence.

Detailed error handling procedures in the network are implementation dependent and may vary from PLMN to PLMN. However, when extensions of PMFP are developed, networks are assumed to have the error handling which is indicated in this clause as mandatory ("shall") and that is indicated as strongly recommended ("should").

Also, the error handling of the network is only considered as mandatory or strongly recommended when certain thresholds for errors are not reached during a dedicated connection.

For definition of semantical and syntactical errors see 3GPP TS 24.007 [13], clause 11.4.2.

8.2　Message too short or too long

8.2.1　Message too short

When a message is received that is too short to contain a complete message type information element, that message shall be ignored, c.f. 3GPP TS 24.007 [13].

8.2.2 Message too long

The maximum size of a PMFP message is 65535 octets.

8.3 Unknown or unforeseen extended procedure transaction identity (EPTI)

8.3.1 Extended procedure transaction identity (EPTI)

The following network procedures shall apply for handling an unknown, erroneous, or unforeseen EPTI received in a PMFP message:

   a) In case the network receives a PMFP ECHO RESPONSE message in which the EPTI value does not match any EPTI in use, the network shall ignore the PMFP message.

The following UE procedures shall apply for handling an unknown, erroneous, or unforeseen EPTI received in a PMFP message:

   a) In case the UE receives a PMFP ECHO RESPONSE message, a PMFP UAD PROVISIONING COMPLETE message, a PMFP UAT COMPLETE message or a PMFP ACKNOWLEDGEMENT message in which the EPTI value does not match any EPTI in use, the UE shall ignore the PMFP message.

8.4 Unknown or unforeseen message type

If the UE or the network receives a PMFP message with message type not defined for the PMFP or not implemented by the receiver, it shall ignore the PMFP message.

   NOTE: A message type not defined for the PMFP in the given direction is regarded by the receiver as a message type not defined for the PMFP, see 3GPP TS 24.007 [13].

If the UE receives a message not compatible with the PMFP state, the UE shall ignore the PMFP message.

If the network receives a message not compatible with the PMFP state, the network actions are implementation dependent.

8.5 Non-semantical mandatory information element errors

8.5.1 Common procedures

When on receipt of a message,

   a) an "imperative message part" error; or

   b) a "missing mandatory IE" error;

is diagnosed or when a message containing:

   a) a syntactically incorrect mandatory IE;

   b) an IE unknown in the message, but encoded as "comprehension required" (see 3GPP TS 24.007 [13]); or

   c) an out of sequence IE encoded as "comprehension required" (see 3GPP TS 24.007 [13]) is received;

the UE shall ignore the PMFP message and the network shall:

   a) try to treat the message (the exact further actions are implementation dependent); or

   b) ignore the message.

8.6 Unknown and unforeseen IEs in the non-imperative message part

8.6.1 IEIs unknown in the message

The UE shall ignore all IEs unknown in a message which are not encoded as "comprehension required" (see 3GPP TS 24.007 [13]).

The network shall take the same approach.

8.6.2 Out of sequence IEs

The UE shall ignore all out of sequence IEs in a message which are not encoded as "comprehension required" (see 3GPP TS 24.007 [13]).

The network should take the same approach.

8.6.3 Repeated IEs

If an information element with format T, TV, TLV, or TLV-E is repeated in a message in which repetition of the information element is not specified in clause 6.2.1, the UE shall handle only the contents of the information element appearing first and shall ignore all subsequent repetitions of the information element. When repetition of information elements is specified, the UE shall handle only the contents of specified repeated information elements. If the limit on repetition of information elements is exceeded, the UE shall handle the contents of information elements appearing first up to the limit of repetitions and shall ignore all subsequent repetitions of the information element.

The network should follow the same procedures.

8.7 Non-imperative message part errors

8.7.1 General

This category includes:

a) syntactically incorrect optional IEs; and

b) conditional IE errors.

8.7.2 Syntactically incorrect optional IEs

The UE shall treat all optional IEs that are syntactically incorrect in a message as not present in the message.

The network shall take the same approach.

8.7.3 Conditional IE errors

NOTE: In this release of specification, there are no conditional IEs.

When upon receipt of a PMFP message the UE diagnoses a "missing conditional IE" error or an "unexpected conditional IE" error, or when it receives a PMFP message containing at least one syntactically incorrect conditional IE, the UE shall ignore the message.

When the network receives a message and diagnoses a "missing conditional IE" error or an "unexpected conditional IE" error or when it receives a message containing at least one syntactically incorrect conditional IE, the network shall either:

a) try to treat the message (the exact further actions are implementation dependent); or

b) ignore the message.

8.8 Messages with semantically incorrect contents

When a message with semantically incorrect contents is received, the UE shall perform the foreseen reactions of the procedural part of clause 5.4. If, however no such reactions are specified, the UE shall ignore the message.

The network should follow the same procedure.

Annex A (informative):
Registration templates

A.1 IEEE registration templates

A.1.1 IEEE registration templates for ethertype values

A.1.1.1 IEEE registration templates for ethertype value for 3GPP IEEE MAC based protocol family

Editor's note: MCC is requested to apply in IEEE-RA for allocation of an ethertype value according to this template.

Registration URL:

http://standards.ieee.org/develop/regauth/ethertype/index.html

Registry:

ethertype

Detailed description:

This application requests allocation of an ethertype value for 3GPP IEEE MAC based protocol family, as specified in IEEE 802 [11].

Protocol description:

The MAC client data field of a MAC frame as specified in IEEE 802.3 [12] of the 3GPP IEEE MAC based protocol family is formatted as follows:

- octet 1 of the MAC client data field is the protocol subtype field.

- remaining octets of the MAC client data field are the protocol data field.

The protocol subtype field set to one identifies the performance measurement function protocol specified in 3GPP TS 24.193.

3GPP TS 24.193 enables assignment of further protocols to values of the protocol subtype field.

Assignment quantity:

1

Additional comments:

1) Does the company requesting the assignment have any existing Ethertype assignments?

Yes.

1a) Does the existing use of the original assignment support sub-typing?

No.

1b) Does the current applicant know who is currently responsible for maintenance of the previously assigned Ethertype?

Yes.

1c) Has the company considered using sub-typing of the older Ethertype for the new use under application?

Yes. Sub-typing of the older Ethertype for the new use under application is not possible.

1d) Given the above, why is a new Ethertype needed?

See detailed description for the new use under application.

2) Has the new protocol been developed and tested in accordance with clause 9 and especially clause 9.2.3 and Figure 12 of IEEE Std 802-2014 [11], IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture?

The 3GPP IEEE MAC based protocol family has been developed as follows:

- the first octet of the MAC client data field of a MAC frame as specified in IEEE 802.3 [12] of the 3GPP IEEE MAC based protocol family contains the protocol subtype field.

- the MAC client data field of the MAC frame of the 3GPP IEEE MAC based protocol family does not contain a protocol version field. If a protocol identified by an existing protocol subtype field value is modified in a backward-compatible way, there is no need to indicate a protocol version. If a protocol identified by an existing protocol subtype field value needs to be modified in a backward-incompatible way, a new protocol subtype field value will be assigned to the modified protocol.

The 3GPP IEEE MAC based protocol family has not been tested.

3) Have the full provisions of Figure 12 for the "Protocol identification field" in the prototype protocol been preserved in the final version of the protocol for which the new EtherType is being requested?

The first octet of the MAC client data field of a MAC frame as specified in IEEE 802.3 [12] of the 3GPP IEEE MAC based protocol family contains the protocol subtype field.

The MAC client data field of the MAC frame of the 3GPP IEEE MAC based protocol family does not contain a protocol version field. If a protocol identified by an existing protocol subtype field value is modified in a backward-compatible way, there is no need to indicate a protocol version. If a protocol identified by an existing protocol subtype field value needs to be modified in a backward-incompatible way, a new protocol subtype field value will be assigned to the modified protocol.

This is preserved in the final version.

4) What provisions have been made for maintaining and assigning sub-types going forward within your company? Please provide an example of the first 10 bytes/octets as an example.

3GPP TS 24.193 enables assignment of protocols to values of the protocol subtype field. A sending entity shall not set the protocol subtype field to a reserved value. A receiving entity shall ignore the MAC client data field, if the protocol

subtype field is set to a reserved value. 3GPP TS 24.193 so far contains an assignment for the performance measurement function to value one of the protocol subtype field.

For the performance measurement function protocol:

- value of octet 1 of the MAC client data field is set to one.

- values of octet 2 and octet 3 of the MAC client data field contain the length of the performance measurement function protocol message.

- value of octet 4 of the MAC client data field is set to the message type of the performance measurement function protocol.

- value of octet 5 and octet 6 of the MAC client data field is set to the extended procedure transaction identity of the performance measurement function protocol, enabling distinguishing of procedures running in parallel.

- values of octet 7 and later octets of the MAC client data field depend on the message type of the performance measurement function protocol.

Annex B (informative):
Change history

						Change history	
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2019-02	CT1#115					TS skeleton and scope are provided by C1-191625 and C1-191704 respectively.	0.0.0
2019-04	CT1#116					Includes the following contributions agreed by CT1 at CT1#116: C1-192468, C1-192471, C1-192472.	0.1.0
2019-05	CT1#117					Includes the following contributions agreed by CT1 at CT1#117: C1-193488, C1-193489, C1-193769, C1-193770.	0.2.0
2019-09	CT1#119					Includes the following contributions agreed by CT1 at CT1#119: C1-194735, C1-194736, C1-194738, C1-194740, C1-194934, C1-194938, C1-194941, C1-194975, C1-195119, C1-195123, C1-195161, C1-195162.	0.3.0
2019-10	CT1#120					Includes the following contributions agreed by CT1 at CT1#120: C1-196191, C1-196712, C1-196746, C1-196748, C1-196749, C1-196750, C1-196751, C1-196752, C1-196753, C1-196947.	0.4.0
2019-11	CT1#121					Includes the following contributions agreed by CT1 at CT1#121: C1-198239, C1-198709, C1-198712, C1-198713, C1-198714, C1-199036.	0.5.0
2019-12	CT#86	CP-193150				Presentation for information at TSG CT	1.0.0
2019-12	CT#86	CP-192387				A title updated	1.0.1
2020-03	CT1#122-e					Includes the following contributions agreed by CT1 at CT1#122-e: C1-200461, C1-200630, C1-200789, C1-200807, C1-200928, C1-200929, C1-200988, C1-201000, C1-201009, C1-201014, C1-201036.	1.1.0
2020-05	CT1#123-e					Includes the following contributions agreed by CT1 at CT1#123-e: C1-202124, C1-202533, C1-202642, C1-202661, C1-202679, C1-202818.	1.2.0
2020-06	CT1#124-e					Includes the following contributions agreed by CT1 at CT1#124-e: C1-203050, C1-203051, C1-203075, C1-203076, C1-203077, C1-204002, C1-204015, C1-204016.	1.3.0
2020-06	CT#88e	CP-201173				Presentation for approval at TSG CT	2.0.0
2020-07	CT#88e					Version 16.0.0 created after approval	16.0.0
2020-09	CT#89e	CP-202153	0001	1	F	Correction on the necessity of ATSSS Container IE	16.1.0
2020-09	CT#89e	CP-202153	0003	1	F	Clarification on whether UP resources are established on 3GPP and non-3GPP accesses	16.1.0
2020-09	CT#89e	CP-202153	0004	1	F	Handling of MA PDU session after an inter-system change from N1 mode to S1 mode	16.1.0
2020-09	CT#89e	CP-202153	0005	1	F	ATSSS rule with steering functionality not supported by the UE	16.1.0
2020-09	CT#89e	CP-202153	0006	1	F	Clarification on MAI for PMFP	16.1.0
2020-09	CT#89e	CP-202153	0007	1	F	PMFP messages transported over default QoS flow	16.1.0
2020-09	CT#89e	CP-202153	0008	1	F	RFC for draft-ietf-tcpm-converters	16.1.0
2020-12	CT#90e	CP-203179	0010	1	F	Clarification on receipt of MA PDU session release command	16.2.0
2020-12	CT#90e	CP-203179	0011	3	F	Clarifications on using DRB/IPSecSA as indication to MA PDU session UP resources establishment	16.2.0
2020-12	CT#90e	CP-203179	0012	1	F	IEI value for the Padding IE	16.2.0
2020-12	CT#90e	CP-203179	0014		F	Correction for PMFP messages sent via Ethernet PDU session	16.2.0
2020-12	CT#90e	CP-203179	0015	1	F	Correction for EPTI length	16.2.0
2020-12	CT#90e	CP-203179	0017		F	Correction for PMFP timer values	16.2.0
2020-12	CT#90e	CP-203179	0018		F	Support of regular expression in ATSSS rules	16.2.0
2020-12	CT#90e	CP-203179	0020	1	F	Transport Converter procedure	16.2.0
2020-12	CT#90e	CP-203179	0022		F	Clarification on non-allowed area applied to wireline access	16.2.0
2020-12	CT#90e	CP-203179	0023	1	F	Introduction of IP 3-tuple type	16.2.0
2021-03	CT#91e	CP-210109	0026	1	F	Numbering the timers used in PMFP	16.3.0
2021-03	CT#91e	CP-210109	0028	1	F	Fix support of network-requested UP reactivation	16.3.0
2021-03	CT#91e	CP-210133	0027	1	D	Correction on establishing user plane resources	17.0.0
2021-04	CT#91e					Restoration of corrupted figures	17.0.1
2021-06	CT#92e	CP-211131	0040	1	A	MA PDU session for LADN not supported	17.1.0
2021-06	CT#92e	CP-211131	0045	2	A	Addition of ATSSS Rule ID and individual rule modification	17.1.0
2021-06	CT#92e	CP-211138	0031	1	B	Support for MA PDU Session with 3GPP access in EPC	17.1.0
2021-06	CT#92e	CP-211138	0029	3	B	Introduction of performance measurement for a certain target QoS flow and UE assistance data provisioning	17.1.0
2021-06	CT#92e	CP-211138	0036	1	B	Support of UE assistance data in PMFP	17.1.0
2021-06	CT#92e	CP-211138	0037	1	B	PMFP message transport associated with QoS flow	17.1.0
2021-06	CT#92e	CP-211138	0038	1	F	EPS interworking if UE supporting 3GPP access leg in EPC of an MA PDU session	17.10
2021-06	CT#92e	CP-211138	0030	3	B	Support of packet loss rate measurement	17.1.0
2021-06	CT#92e	CP-211150	0034		F	Enable report the availability and unavailability of an access network	17.1.0
2021-06	CT#92e	CP-211150	0035		D	Correction on EPTI	17.1.0
2021-06	CT#92e	CP-211150	0041		F	5G-RG and hybrid access	17.1.0
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2022-09	CT#97e	CP-222138	0097	1	F	Support MAC address range type in ATSSS container	17.6.0

History

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