**3GPP TSG-WG2 Meeting #164 *S2-2409075***

**Maastricht, The Netherlands, August 19 – 23, 2024**

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| *CR-Form-v12.3* |
| **CHANGE REQUEST** |
|  |
|  | **23.501** | **CR** | **5493** | **rev** | **1** | **Current version:** | **19.0.0** |  |
|  |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network |  | Core Network | **X** |

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| --- |
|  |
| ***Title:***  | Support for MPQUIC-IP and MPQUIC-E steering functionalities |
|  |  |
| ***Source to WG:*** | Ericsson, Apple, CableLabs |
| ***Source to TSG:*** | SA2 |
|  |  |
| ***Work item code:*** | MASSS |  | ***Date:*** | 2024-08-09 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***Release:*** | Rel-19 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-17 (Release 17)Rel-18 (Release 18)Rel-19 (Release 19) Rel-20 (Release 20)* |
|  |  |
| ***Reason for change:*** | The FS\_MASSS study has agreed to enhance ATSSS to support MPQUIC using CONNECT-IP and CONNECT-Ethernet, by defining two new Steering Functionalities. This has not yet been captured in TS 23.501. |
|  |  |
| ***Summary of change:*** | Add support for two new Steering Funcitonalities for IP and Ethernet proxying using MPQUIC. |
|  |  |
| ***Consequences if not approved:*** | Missing functionality |
|  |  |
| ***Clauses affected:*** | 4.2.10, 5.8.5.8, 5.32.2, 5.32.4, 5.32.5.1, 5.32.6.1, 5.32.6.2.2, 5.32.6.3, 5.32.6.3.1, 5.32.6.3.X (new), 5.32.6.3.Y (new), 5.32.6.X (new), 5.32.8 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **X** |  Other core specifications  | TS/TR ... CR ...  |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ...  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

\*\*\*\* First Change \*\*\*\*

# 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 22.261: "Service requirements for next generation new services and markets; Stage 1".

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

[4] 3GPP TS 23.203: "Policies and Charging control architecture; Stage 2".

[5] 3GPP TS 23.040: "Technical realization of the Short Message Service (SMS); Stage 2".

…<snip>…

[189] IETF RFC 8285: "A General Mechanism for RTP Header Extensions".

[190] 3GPP TS 28.405: "Quality of Experience (QoE) measurement collection; Control and configuration".

[191] 3GPP TS 37.355: " LTE Positioning Protocol (LPP)".

[192] 3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management".

[193] IETF RFC 3168: "The Addition of Explicit Congestion Notification (ECN) to IP".

[194] 3GPP TS 33.503: "Security Aspects of Proximity based Services (ProSe) in the 5G System (5GS)".

[x] IETF RFC 9484: "Proxying IP in HTTP".

[y] IETF draft-ietf-masque-connect-ethernet: " Proxying Ethernet in HTTP".

Editor's note: The above document cannot be formally referenced until it is published as an RFC.

\*\*\*\* Next Change \*\*\*\*

### 4.2.10 Architecture Reference Model for ATSSS Support

In order to support the ATSSS feature, the 5G System Architecture is extended as shown in Figure 4.2.10-1, Figure 4.2.10-2 and Figure 4.2.10-3. The additional functionality that is supported by the UE and the network functions shown in these figures is specified in clause 5.32 below. In summary:

- The UE supports one or more of the steering functionalities specified in clause 5.32.6, i.e. the MPTCP functionality, the MPQUIC-UDP functionality, the MPQUIC-IP functionality, the MPQUIC-E functionality and the ATSSS-LL functionality. Each steering functionality in the UE enables traffic steering, switching and splitting across 3GPP access and non-3GPP access, in accordance with the ATSSS rules provided by the network. At least one of the ATSSS-LL functionality or the MPQUIC-E functionality is mandatory to support in the UE for MA PDU Session of type Ethernet.

NOTE x: The "MPQUIC-UDP functionality" is referred to as "MPQUIC functionality" in previous releases of this specification (that do not support the MPQUIC-IP functionality and the MPQUIC-E functionality).

- The UPF may support the MPTCP Proxy functionality, which communicates with the MPTCP functionality in the UE by using the MPTCP protocol (IETF RFC 8684 [81]), as defined in clause 5.32.6.2.1.

- The UPF may support the MPQUIC Proxy functionality, which communicates with the MPQUIC-UDP functionality, the MPQUIC-IP functionality, or the MPQUIC-E functionality in the UE by using the QUIC protocol (RFC 9000 [166], RFC 9001 [167], RFC 9002 [168]) and its multipath extensions (draft-ietf-quic-multipath [174]), as defined in clause 5.32.6.2.2.

- The UPF may support ATSSS-LL functionality, which is similar to the ATSSS-LL functionality defined for the UE. There is no user plane protocol defined between the ATSSS-LL functionality in the UE and the ATSSS-LL functionality in the UPF.

NOTE 1: ATSSS-LL or MPQUIC-E functionality is needed in the 5GC for MA PDU Session of type Ethernet.

- In addition, the UPF supports Performance Measurement Functionality (PMF), which may be used by the UE to obtain access performance measurements (see clause 5.32.5) over the user-plane of 3GPP access and/or over the user-plane of non-3GPP access.

- The AMF, SMF and PCF are extended with new functionality that is further discussed in clause 5.32.

Figure 4.2.10-1: Non-roaming and Roaming with Local Breakout architecture for ATSSS support

NOTE 2: The interactions between the UE and PCF that may be required for ATSSS control are specified in TS 23.503 [45].

NOTE 3: The UPF shown in Figure 4.2.10-1 can be connected via an N9 reference point, instead of the N3 reference point.

Figure 4.2.10-2 shows the 5G System Architecture for ATSSS support in a roaming case with home-routed traffic and when the UE is registered to the same VPLMN over 3GPP and non-3GPP accesses. In this case, the MPTCP Proxy functionality, the MPQUIC Proxy functionality, the ATSSS-LL functionality and the PMF are located in the H-UPF.

Figure 4.2.10-2: Roaming with Home-routed architecture for ATSSS support (UE registered to the same VPLMN)

Figure 4.2.10-3 shows the 5G System Architecture for ATSSS support in a roaming case with home-routed traffic and when the UE is registered to a VPLMN over 3GPP access and to HPLMN over non-3GPP access (i.e. the UE is registered to different PLMNs). In this case, the MPTCP Proxy functionality, the MPQUIC Proxy functionality, the ATSSS-LL functionality and the PMF are located in the H-UPF.

Figure 4.2.10-3: Roaming with Home-routed architecture for ATSSS support (UE registered to different PLMNs)

\*\*\*\* Next Change \*\*\*\*

#### 5.8.5.8 Multi-Access Rule

The following table describes the Multi-Access Rule (MAR) that includes the association to the two FARs for both 3GPP access and non-3GPP access in the case of supporting ATSSS.

Table 5.8.5.8-1: Attributes within Multi-Access Rule

|  |  |  |
| --- | --- | --- |
| Attribute | Description | Comment |
| N4 Session ID | Identifies the N4 session associated to this MAR. |  |
| Rule ID | Unique identifier to identify this rule. |  |
| Steering functionality(NOTE 5) | Indicates the applicable traffic steering functionality:Values "MPTCP functionality", "ATSSS-LL functionality", "MPQUIC-UDP functionality", "MPQUIC-IP functionality", "MPQUIC-E functionality". |  |
| Transport Mode | Identifies the transport mode (see clause 5.32.6.2.2.1) that should be used for the matching traffic, when the Steering functionality is the MPQUIC-UDP functionality, the MPQUIC-IP functionality, or the MPQUIC-E functionality. | The Transport Mode shall be included only when the Steering Functionality is the MPQUIC-UDP functionality, the MPQUIC-IP functionality or the MPQUIC-E functionality. In all other cases, the Transport Mode shall not be included. |
| Steering mode(NOTE 5) | Values "Active-Standby", "Smallest Delay", "Load Balancing", or "Priority-based" or "Redundant". |  |
| Steering Mode Indicator(NOTE 4) | Indicates either autonomous load-balance operation or UE-assistance operation if steering mode is set to "Load Balancing". |  |
| Threshold values(NOTE 3, NOTE 4) | A Maximum RTT and/or a Maximum Packet Loss Rate | The Threshold Values are applied by UPF as described in clause 5.32.8. |
| Per-Access Forwarding | Forwarding Action Rule ID | The Forwarding Action Rule ID identifies a forwarding action that has to be applied. |  |
| Action information | Weight | Identifies the weight for the FAR if steering mode is "Load Balancing" | The weights for all FARs need to sum up to 100 |
| (NOTE 1)(NOTE 2) | Priority | Values "Active or Standby" or "High or Low" for the FAR | "Active or Standby" for "Active-Standby" steering mode and "High or Low" for "Priority-based" steering mode |
|  | List of Usage Reporting Rule ID(s) | Every Usage Reporting Rule ID identifies a measurement action that has to be applied. | This enables the SMF to request separate usage reports for different FARs (i.e. different accesses) |
| NOTE 1: The Per-Access Forwarding Action information is provided per access type (i.e. 3GPP access or Non-3GPP access).NOTE 2: The Weight is treated as the default percentages if the Autonomous operation is allowed for the "Load Balancing" steering mode.NOTE 3: The Threshold Values may be provided when the Steering Mode is Priority-based, or when the Steering Mode is Load-Balancing with fixed split percentages or when the Steering Mode is "Redundant". If the Steering Mode is "Redundant", either a Maximum RTT or a Maximum Packet Loss Rate may be provided, but not both.NOTE 4: The Steering Mode Indicator and the Threshold Values shall not be provided together.NOTE 5: The Steering functionality "ATSSS-LL functionality" shall not be provided together with Steering Mode "Redundant". |

\*\*\*\* Next Change \*\*\*\*

### 5.32.2 Multi Access PDU Sessions

A Multi-Access PDU (MA PDU) Session is managed by using the session management functionality specified in clause 5.6, with the following additions and modifications:

- When the UE wants to request a new MA PDU Session:

- If the UE is registered to the same PLMN over 3GPP and non-3GPP accesses, then the UE shall send a PDU Session Establishment Request over any of the two accesses. The UE also provides Request Type as "MA PDU Request" in the UL NAS Transport message. The AMF informs the SMF that the UE is registered over both accesses and this triggers the establishment of user-plane resources on both accesses and two N3/N9 tunnels between PSA and the RAN/AN.

- If the UE is registered to different PLMNs over 3GPP and non-3GPP accesses, then the UE shall send a PDU Session Establishment Request over one access. The UE also provides Request Type as "MA PDU Request" in the UL NAS Transport message. After this PDU Session is established with one N3/N9 tunnel between the PSA and (R)AN established, the UE shall send another PDU Session Establishment Request over the other access. The UE also provides the same PDU Session ID and Request Type as "MA PDU Request" in the UL NAS Transport message. Two N3/N9 tunnels and User-plane resources on both accesses are established.

- If the UE is registered over one access only, then the UE shall send a PDU Session Establishment Request over this access. The UE also provides Request Type as "MA PDU Request" in the UL NAS Transport message. One N3/N9 tunnel between the PSA and (R)AN and User-plane resources on this access only are established. After the UE is registered over the second access, the UE shall establish user-plane resources on the second access.

- In the PDU Session Establishment Request that is sent to request a new MA PDU Session, the UE shall provide also its ATSSS capabilities, which indicate the steering functionalities and the steering modes supported in the UE. These functionalities are defined in clause 5.32.6.

- If the UE indicates it is capable of supporting:

- the ATSSS-LL functionality with any steering mode (as specified in clause 5.32.6.1);

 and the network accepts to activate this functionality, then the network may provide to UE Measurement Assistance Information (see details in clause 5.32.5) and shall provide to UE one or more ATSSS rules.

NOTE 1: As specified in Table 5.32.8-1 and in Table 5.8.5.8-1, the ATSSS-LL functionality cannot be used together with the Redundant steering mode. When the UE indicates it is capable of supporting the ATSSS-LL functionality with any steering mode, it is implied that the UE can support the ATSSS-LL functionality with any steering mode except the Redundant steering mode.

- If the UE indicates it is capable of supporting:

- the MPTCP functionality with any steering mode and the ATSSS-LL functionality with only the Active-Standby steering mode (as specified in clause 5.32.6.1); or

- the MPTCP functionality with any steering mode and the ATSSS-LL functionality with any steering mode (as specified in clause 5.32.6.1);

 and the network accepts to activate these functionalities, then the network provides MPTCP proxy information to UE, and allocates to UE (a) one IP address/prefix for the MA PDU session (as defined in clause 5.8.2.2) and (b) two additional IP addresses/prefixes, called "MPTCP link-specific multipath" addresses. Further details are provided in clause 5.32.6.2.1. In addition, the network may provide to UE Measurement Assistance Information and shall provide to UE one or more ATSSS rules. If the UE supports the ATSSS-LL functionality with only the Active-Standby steering mode, the network shall provide to UE an ATSSS rule for non-MPTCP traffic. The ATSSS rule for non-MPTCP traffic shall use the ATSSS-LL functionality and the Active-Standby Steering Mode to indicate how the non-MPTCP traffic shall be transferred across the 3GPP access and the non-3GPP access in the uplink direction.

- If the UE indicates it is capable of supporting

- the MPQUIC-IP with any steering mode (as specified in clause 5.32.6.1); or

- the MPQUIC-E with any steering mode (as specified in clause 5.32.6.1); or

- the MPQUIC-UDP and/or MPQUIC-E functionality(ies) with any steering mode and the ATSSS-LL functionality with only the Active-Standby steering mode (as specified in clause 5.32.6.1);

- the MPQUIC-UDP, MPQUIC-IP and/or MPQUIC-E functionality(ies) with any steering mode and the ATSSS-LL functionality with any steering mode (as specified in clause 5.32.6.1);

 and the network accepts to activate these functionalities, then the network provides MPQUIC proxy information to UE, and allocates to UE (a) one IP address/prefix for the MA PDU session (as defined in clause 5.8.2.2) and (b) two additional IP addresses/prefixes, called "MPQUIC link-specific multipath" addresses. Further details are provided in clause 5.32.6.2.2. In addition, the network may provide to UE Measurement Assistance Information and shall provide to UE one or more ATSSS rules. If the UE supports the ATSSS-LL functionality with only the Active-Standby steering mode, the network shall provide to UE an ATSSS rule for non-MPQUIC traffic. The ATSSS rule for non-MPQUIC traffic shall use the ATSSS-LL functionality and the Active-Standby Steering Mode to indicate how the non-MPQUIC traffic shall be transferred across the 3GPP access and the non-3GPP access in the uplink direction.

- If the UE indicates it is capable of supporting

- the MPTCP functionality with any steering mode, and at least one of the MPQUIC-UDP and MPQUIC-IP functionalities with any steering mode, and the ATSSS-LL functionality with only the Active-Standby steering mode (as specified in clause 5.32.6.1); or

- the MPTCP functionality with any steering mode, and at least one of the MPQUIC-UDP and MPQUIC-IP functionalities with any steering mode, and the ATSSS-LL functionality with any steering mode (as specified in clause 5.32.6.1);

 and the network accepts to activate these functionalities, then the network provides MPTCP proxy information and MPQUIC proxy information to UE and allocates to UE (a) one IP address/prefix for the MA PDU session (as defined in clause 5.8.2.2), (b) two additional IP addresses/prefixes, called "MPTCP link-specific multipath" addresses, and (c) two additional IP addresses/prefixes, called "MPQUIC link-specific multipath" addresses. Further details are provided in clause 5.32.6.2.1 and in clause 5.32.6.2.2. In addition, the network may provide to UE Measurement Assistance Information and shall provide to UE one or more ATSSS rules. If the UE supports the ATSSS-LL functionality with only the Active-Standby steering mode, the network shall provide to UE an ATSSS rule for non-MPTCP and non-MPQUIC traffic (i.e. the traffic for which neither the MPTCP, the MPQUIC-UDP nor the MPQUIC-IP functionalities are applied). The ATSSS rule for non-MPTCP and non-MPQUIC traffic shall use the ATSSS-LL functionality and the Active-Standby Steering Mode to indicate how the non-MPTCP and non-MPQUIC traffic shall be transferred across the 3GPP access and the non-3GPP access in the uplink direction.

NOTE 2: The "MPTCP link-specific multipath" addresses and the "MPQUIC link-specific multipath" addresses can be the same.

- If the UE requests an S-NSSAI, this S-NSSAI should be allowed on both accesses. Otherwise, the MA PDU Session shall not be established.

- The SMF determines the ATSSS capabilities supported for the MA PDU Session based on the ATSSS capabilities provided by the UE and per DNN configuration on SMF, as follows:

a) If the UE includes in its ATSSS capabilities "MPTCP functionality with any steering mode and ATSSS-LL functionality with only Active-Standby steering mode" (as specified in clause 5.32.6.1), then:

i) If the DNN configuration allows MPTCP and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL), including RTT measurement without using PMF protocol, the MA PDU Session is capable of (1) MPTCP and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL) in the downlink, and (2) MPTCP and ATSSS-LL with Active-Standby mode in the uplink.

NOTE 3: In this case, it is assumed that ATSSS-LL with "Smallest Delay" steering mode is selected for the downlink only when the UPF can measure RTT without using the PMF protocol, e.g. by using other means not defined by 3GPP such as using the RTT measurements of MPTCP.

ii) If the DNN configuration allows MPTCP and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL), but not RTT measurement without using PMF protocol, the MA PDU Session is capable of (1) MPTCP in the downlink (2) ATSSS-LL with any steering mode except Smallest Delay steering mode (i.e. any Steering Mode allowed for ATSSS-LL except Smallest Delay steering mode) in the downlink, and (3) MPTCP and ATSSS-LL with Active-Standby mode in the uplink.

iii) If the DNN configuration allows MPTCP with any steering mode and ATSSS-LL with only Active-Standby steering mode, the MA PDU Session is capable of MPTCP and ATSSS-LL with Active-Standby mode in the uplink and in the downlink.

Editor's note: [MASSS] The below bullets b) – g) for MPQUIC functionality need further updates to cover MPQUIC-IP and MPQUIC-E.

b) If the UE includes in its ATSSS capabilities "MPQUIC functionality with any steering mode and ATSSS-LL functionality with only Active-Standby steering mode" (as specified in clause 5.32.6.1), then:

i) If the DNN configuration allows MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL), including RTT measurement without using PMF protocol, the MA PDU Session is capable of (1) MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL) in the downlink, and (2) MPQUIC and ATSSS-LL with Active-Standby mode in the uplink.

NOTE 4: In this case, it is assumed that ATSSS-LL with "Smallest Delay" steering mode is selected for the downlink only when the UPF can measure RTT without using the PMF protocol, e.g. by using other means not defined by 3GPP such as using the RTT measurements of MPQUIC.

ii) If the DNN configuration allows MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL), but not RTT measurement without using PMF protocol, the MA PDU Session is capable of (1) MPQUIC in the downlink (2) ATSSS-LL with any steering mode except Smallest Delay steering mode (i.e. any Steering Mode allowed for ATSSS-LL except Smallest Delay steering mode) in the downlink, and (3) MPQUIC and ATSSS-LL with Active-Standby mode in the uplink.

iii) If the DNN configuration allows MPQUIC with any steering mode and ATSSS-LL with only Active-Standby steering mode, the MA PDU Session is capable of MPQUIC and ATSSS-LL with Active-Standby mode in the uplink and in the downlink.

c) If the UE includes in its ATSSS capabilities "MPQUIC functionality with any steering mode and ATSSS-LL functionality with any steering mode" (as specified in clause 5.32.6.1), and the DNN configuration allows MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL), the MA PDU Session is capable of MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL) in the uplink and in the downlink.

d) If the UE includes in its ATSSS capabilities "ATSSS-LL functionality with any steering mode" (as specified in clause 5.32.6.1) and the DNN configuration allows ATSSS-LL with any steering mode allowed for ATSSS-LL, the MA PDU Session is capable of ATSSS-LL with any steering mode allowed for ATSSS-LL in the uplink and in the downlink.

e) If the UE includes in its ATSSS capabilities "MPTCP functionality with any steering mode and ATSSS-LL functionality with any steering mode" (as specified in clause 5.32.6.1), and the DNN configuration allows MPTCP and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL), the MA PDU Session is capable of MPTCP and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL) in the uplink and in the downlink.

f) If the UE includes in its ATSSS capabilities "MPTCP functionality with any steering mode, and the MPQUIC functionality with any steering mode, and the ATSSS-LL functionality with any steering mode" (as specified in clause 5.32.6.1), and the DNN configuration allows MPTCP, MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL), the MA PDU Session is capable of MPTCP, MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL) in the uplink and in the downlink.

g) If the UE includes in its ATSSS capabilities "MPTCP functionality with any steering mode, and the MPQUIC functionality with any steering mode, and the ATSSS-LL functionality with only the Active-Standby steering mode" (as specified in clause 5.32.6.1), then:

i) If the DNN configuration allows MPTCP, MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL), including RTT measurement without using PMF protocol, the MA PDU Session is capable of (1) MPTCP, MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL) in the downlink, and (2) MPTCP, MPQUIC and ATSSS-LL with Active-Standby mode in the uplink.

NOTE 5: In this case, it is assumed that ATSSS-LL with "Smallest Delay" steering mode is selected for the downlink only when the UPF can measure RTT without using the PMF protocol, e.g. by using other means not defined by 3GPP such as using the RTT measurements of MPTCP or MPQUIC.

ii) If the DNN configuration allows MPTCP, MPQUIC and ATSSS-LL with any steering mode (i.e. any Steering Mode allowed for ATSSS-LL), but not RTT measurement without using PMF protocol, the MA PDU Session is capable of (1) MPTCP and MPQUIC in the downlink (2) ATSSS-LL with any steering mode except Smallest Delay steering mode (i.e. any Steering Mode allowed for ATSSS-LL except Smallest Delay steering mode) in the downlink, and (3) MPTCP, MPQUIC and ATSSS-LL with Active-Standby mode in the uplink.

iii) If the DNN configuration allows MPTCP and MPQUIC with any steering mode and ATSSS-LL with only Active-Standby steering mode, the MA PDU Session is capable of MPTCP and MPQUIC and ATSSS-LL with Active-Standby mode in the uplink and in the downlink.

 The SMF provides the ATSSS capabilities of the MA PDU Session to the PCF during PDU Session Establishment.

- The PCC rules provided by PCF include MA PDU Session Control information (see TS 23.503 [45]). They are used by SMF to derive ATSSS rules for the UE and N4 rules for the UPF. When dynamic PCC is not used for the MA PDU Session, the SMF shall provide ATSSS rules and N4 rules based on local configuration (e.g. based on DNN or S-NSSAI).

- The UE receives ATSSS rules from SMF, which indicate how the uplink traffic should be routed across 3GPP access and non-3GPP access. Similarly, the UPF receives N4 rules from SMF, which indicate how the downlink traffic should be routed across 3GPP access and non-3GPP access.

- When the SMF receives a PDU Session Establishment Request and a "MA PDU Request" indication and determines that UP security protection (see clause 5.10.3) is required for the PDU Session, the SMF shall only confirm the establishment of the MA PDU session if the 3GPP access network can enforce the required UP security protection. The SMF needs not confirm whether the non-3GPP access can enforce the required UP security protection.

- The UE indicates during MA PDU Session Establishment to the AMF whether it supports non-3GPP access path switching, i.e. whether the UE can transfer the non-3GPP access path of the MA PDU Session from a source non-3GPP access (N3IWF/TNGF) to a target non-3GPP access (a different N3IWF/TNGF). If the UE has indicated support for non-3GPP access path switching and the AMF supports non-3GPP access path switching, the AMF selects an SMF that supports non-3GPP access path switching, if such an SMF is available. If the AMF supports to maintain two N2 connections for non-3GPP access during the Registration procedure and the selected SMF supports non-3GPP path switching, the AMF indicates whether the UE supports non-3GPP path switching to the SMF. The SMF indicates support for non-3GPP path switching to the UE in the PDU Session Establishment Accept message.

NOTE 6: If the AMF selects an SMF not supporting non-3GPP access path switching, the non-3GPP access path switching can still be performed with the AMF triggering release of the old user plane resources before new user plane resources are established.

- After the MA PDU Session establishment:

- At any given time, the MA PDU session may have user-plane resources on both 3GPP and non-3GPP accesses, or on one access only, or may have no user-plane resources on any access.

- The AMF, SMF, PCF and UPF maintain their MA PDU Session contexts, even when the UE deregisters from one access (but remains registered on the other access).

- When the UE deregisters from one access (but remains registered on the other access), the AMF informs the SMF to release the resource of this access type in the UPF for the MA PDU Session. Subsequently, the SMF notifies the UPF that the access type has become unavailable and the N3/N9 tunnel for the access type are released.

- If the UE wants to add user-plane resources on one access of the MA PDU Session, e.g. based on access network performance measurement and/or ATSSS rules, then the UE shall send a PDU Session Establishment Request over this access containing PDU Session ID of the MA PDU Session. The UE also provides Request Type as "MA PDU Request" and the same PDU Session ID in the UL NAS Transport message. If there is no N3/N9 tunnel for this access, the N3/N9 tunnel for this access is established.

- If the UE wants to re-activate user-plane resources on one access of the MA PDU Session, e.g. based on access network performance measurement and/or ATSSS rules, then the UE shall initiate the UE Triggered Service Request procedure over this access.

- If the network wants to re-activate the user-plane resources over 3GPP access or non-3GPP access of the MA PDU Session, the network shall initiate the Network Triggered Service Request procedure, as specified in clause 4.22.7 of TS 23.502 [3].

- If the UE wants to move the non-3GPP user-plane resources of the MA PDU Session from a source non-3GPP access (e.g. source N3IWF or TNGF) to a target non-3GPP access (e.g. target N3IWF or TNGF), the UE initiates a Mobility Registration Update via the target non-3GPP access as described in TS 23.502 [3], clause 4.22.9.5. This procedure may also be used to move the non-3GPP user-plane resources of single access PDU Session(s).

NOTE 7: The UE can request activation of single access PDU Session(s) over the target non-3GPP access while performing Mobility Registration Update procedure according to the existing procedure.

- The SMF may add, remove or update one or more individual ATSSS rules of the UE by sending new or updated ATSSS rules with the corresponding Rule IDs to the UE.

A MA PDU Session may be established either:

a) when it is explicitly requested by an ATSSS-capable UE; or

b) when an ATSSS-capable UE requests a single-access PDU Session but the network decides to establish a MA PDU Session instead. This is an optional scenario specified in clause 4.22.3 of TS 23.502 [3], which may occur when the UE requests a single-access PDU Session but no policy (e.g. no URSP rule) and no local restrictions in the UE mandate a single access for the PDU Session.

A MA PDU Session may be established during a PDU Session modification procedure when the UE moves from EPS to 5GS, as specified in clause 4.22.6.3 of TS 23.502 [3].

The AMF indicates as part of the Registration procedure whether ATSSS is supported or not. When ATSSS is not supported, the UE shall not

- request establishment of a MA PDU Session (as described in clause 4.22.2 of TS 23.502 [3]); or

- request addition of User Plane resources for an existing MA PDU Session (as described in clause 4.22.7 of TS 23.502 [3]); or

- request establishment of a PDU Session with "MA PDU Network-Upgrade Allowed" indication (as described in clause 4.22.3 of TS 23.502 [3]); or

- request PDU Session Modification with Request Type of "MA PDU request" or with "MA PDU Network-Upgrade Allowed" indication after moving from EPC to 5GC (as described in clause 4.22.6.3 of TS 23.502 [3]).

The AMF indicates as part of the Registration procedure whether it supports non-3GPP access path switching. When the AMF does not indicate support of non-3GPP access path switching, the UE shall not perform the Mobility Registration Update procedure for non-3GPP access path switching, i.e. to switch traffic from a source non-3GPP access to a target non-3GPP access. The SMF indicates as part of the PDU Session Establishment procedure whether it supports non-3GPP access path switching. If the UE has one or more PDU sessions and at least one serving SMF for the PDU Sessions supports non-3GPP access path switching, the UE may include ("Non-3GPP path switching while using old AN resources") indication when the UE performs the Mobility Registration Update procedure for non-3GPP access path switching. If the UE is registered to different PLMNs over 3GPP and non-3GPP accesses, the UE shall use the capability received over non-3GPP access to determine whether to perform the Mobility Registration Update procedure for non-3GPP path switching and whether to include ("Non-3GPP access path switching while using old AN resources") indication.

NOTE 8: If the AMF receives ("Non-3GPP path switching while using old AN resources") indication from Mobility Registration Update procedure, and the serving SMF(s) for PDU Session(s) is not supporting non-3GPP access path switching, the non-3GPP access path switching can still be performed with the AMF triggering for each PDU Session the release of the old user plane resources before new user plane resources are established.

An ATSSS-capable UE may decide to request a MA PDU Session based on the provisioned URSP rules. In particular, the UE should request a MA PDU Session when the UE applies a URSP rule, which triggers the UE to establish a new PDU Session and the Access Type Preference component of the URSP rule indicates "Multi-Access" (see TS 23.503 [45]).

\*\*\*\* Next Change \*\*\*\*

### 5.32.4 QoS Support

The 5G QoS model for the Single-Access PDU Session is also applied to the MA PDU Session, i.e. the QoS Flow is the finest granularity of QoS differentiation in the MA PDU Session. One difference compared to the Single-Access PDU Session is that in a MA PDU Session there can be separate user-plane tunnels between the AN and the PSA, each one associated with a different access. However, the QoS Flow is not associated with specific access, i.e. it is access agnostic, so the same QoS is supported when the traffic is distributed over 3GPP and non-3GPP accesses. The SMF shall provide the same QFI in 3GPP and non-3GPP accesses so that the same QoS is supported in both accesses.

A QoS Flow of the MA PDU Session may be either Non-GBR or GBR depending on its QoS profile.

For a Non-GBR QoS Flow, the SMF provides a QoS profile to both 5G-ANs during MA PDU Session Establishment or MA PDU Session Modification procedure:

- During MA PDU Session Establishment procedure, the QoS profile to both ANs if the UE is registered over both accesses.

- During MA PDU Session Modification procedure, the QoS profile is provided to the 5G-AN(s) over which the user plane resources are activated.

For a GBR QoS Flow, the SMF shall provide a QoS profile to 5G-AN(s) as follows:

- If the PCC rule allows a GBR QoS Flow in a single access, the SMF provides the QoS profile for the GBR QoS Flow to the access network allowed by the PCC rule.

- If the PCC rule allows a GBR QoS Flow in both accesses and the Steering Mode is different from Redundant, the SMF decides to which access network to provide the QoS profile for the GBR QoS Flow based on its local policy (e.g. the access where the traffic is ongoing according to the Multi Access Routing rule).

- If the PCC rule allows a GBR QoS Flow in both accesses and the Steering Mode is Redundant, the SMF provides the QoS profile for the GBR QoS Flow to both access networks. Whenever the SMF recognizes that resources are not allocated in one access network, the SMF shall notify the PCF about the resource allocation failure and indicate the respective Access Type. Whenever the SMF recognizes that resources are not allocated in both access networks, the SMF shall release the resources for the GBR QoS Flow and report to the PCF about the removal of the PCC rule.

NOTE 1: The SMF knows about the allocation of resources in an access network from the interaction with the access network during GBR QoS Flow establishment/modification as well as during the release of resources by the access network.

For a GBR QoS Flow, traffic splitting is not supported. If the UPF determines that it cannot send GBR traffic over the current ongoing access e.g. based on the N4 rules and access availability and unavailability report from the UE as described in clause 5.32.5.3, the UPF shall send an Access Availability report to the SMF.

Based on the Access Availability report and if the Steering Mode is different from Redundant, the SMF decides whether to move GBR QoS Flows to the other access when one access is not available:

- if the PCC rule allows the GBR QoS Flows only on this access, the SMF shall release the resources for the GBR QoS Flow and report to the PCF about the removal of the PCC rule.

- if the corresponding PCC rule allows the GBR QoS Flow on both accesses and the other access is not available, the SMF shall release the resources for the GBR QoS Flow and report to the PCF about the removal of the PCC rule.

- if the PCC rule allows the GBR QoS Flow on both accesses and the other access is available, the SMF shall try to move the GBR QoS Flow to the other access. The SMF may trigger a PDU session modification procedure to provide the QoS profile to the other access and release the resources for the GBR QoS Flow in the current access.

- if Notification Control parameter is not included in the PCC rule for the GBR QoS Flow and the other access does not accept the QoS profile, the SMF shall release the resources for the GBR QoS Flow and report to the PCF about the removal of the PCC rule.

- if the Notification Control parameter is included in the PCC rule, the SMF shall notify the PCF that GFBR can no longer be guaranteed. After the other access accepts the QoS profile, the SMF shall notify the PCF that GFBR can again be guaranteed. If the other access does not accept the QoS profile, the SMF shall delete the GBR QoS Flow and report to the PCF about the removal of the PCC rule.

NOTE 2: The ATSSS rule for GBR QoS Flow only allows the UE to steer traffic over a single access so that the network knows in which access the UE sends GBR traffic. If the network wants to move GBR QoS Flow to the other access, the network needs to update ATSSS rule of the UE.

Based on the Access Availability report and if the Steering Mode is Redundant, the SMF behaves as follows:

- if both accesses are not available, the SMF shall release the resources for the GBR QoS Flow and report to the PCF about the removal of the PCC rule.

NOTE 3: The UPF can detect that both accesses are not available based on implementation specific means.

- when one of the accesses becomes unavailable while the other access is still available, the SMF shall neither release the resources for the GBR QoS Flow nor notify the PCF that GFBR can no longer be guaranteed (if the Notification Control parameter is included in the PCC rule).

NOTE 4: The access network will typically release the resources for a GBR QoS Flow if there is no traffic transferred for a certain amount of time and this will then trigger the SMF notification to PCF described above.

When the MA PDU Session is established or when the MA PDU Session is modified, the SMF may provide QoS rule(s) to the UE via one access, which are applied by the UE as specified in clause 5.7.1.4. The QoS rule(s) provided by SMF via one access are commonly used for both 3GPP access and non-3GPP access, so the QoS classification is independent of ATSSS rules.

The derived QoS rule generated by Reflective QoS is applied independently of the access on which the RQI was received. When any of the MPTCP functionality, MPQUIC-UDP functionality or the MPQUIC-IP Functionality is used in the UE, the UE shall use the IP address/prefix of the MA PDU Session and the final destination address to generate the derived QoS rule.

When any of the MPTCP functionality, MPQUIC-UDP functionality or MPQUIC-IP Functionality is enabled for the MA PDU Session:

- any QoS rules or PDRs that apply to the MA PDU Session IP address/prefix and port also apply (a) to the MPTCP "link-specific multipath" addresses/prefixes and ports used by the UE to establish MPTCP subflows over 3GPP and non-3GPP accesses , and (b) to the "MPQUIC link-specific multipath" addresses and ports used by the UE to transmit UDP flows over 3GPP and non-3GPP accesses; and

- any QoS rules or PDRs that apply to the IP address/prefix and port of the final destination server in DN also apply (a) to the IP address and port of the MPTCP proxy for corresponding MPTCP subflows that are terminated at the proxy and (b) to the IP address and port of the MPQUIC proxy for corresponding UDP flows that are terminated at the proxy.

NOTE 5: How these associations are made is left up to the UE and UPF implementations.

\*\*\*\* Next Change \*\*\*\*

### 5.32.5 Access Network Performance Measurements

#### 5.32.5.1 General principles

When an MA PDU Session is established, the network may provide the UE with Measurement Assistance Information. This information assists the UE in determining which measurements shall be performed over both accesses, as well as whether measurement reports need to be sent to the network.

Measurement Assistance Information shall include the addressing information of a Performance Measurement Function (PMF) in the UPF, the UE can send PMF protocol messages to:

- For a PDU Session of IP type, Measurement Assistance Information contains one IP address for the PMF, one UDP port associated with 3GPP access and another UDP port associated with non-3GPP access. PMF messages sent by UE to one of these UDP ports, shall be transmitted to UPF via the QoS Flow associated with the default QoS rule.

- For a PDU Session of Ethernet type, Measurement Assistance Information contains one MAC address associated with 3GPP access and another MAC address associated with non-3GPP access. PMF messages sent by UE to one of these MAC addresses, shall be transmitted to UPF via the QoS Flow associated with the default QoS rule.

NOTE 1: To protect the PMF in the UPF (e.g. to block DDOS to the PMF), the IP addresses of the PMF are only accessible from the UE IP address via the N3/N9 interface.

NOTE 2: After the MA PDU Session is released, the same UE IP address/prefix is not allocated to another UE for MA PDU Session in a short time.

If the SMF determines that access performance measurements per QoS Flow shall be applied for the MA PDU Session, then the Measurement Assistance Information shall also include a list of QoS Flows on which access performance measurements may be performed. For each QoS Flow in this list, the following information is included:

- The QFI of the associated QoS Flow.

- For a PDU Session of IP type, one UDP port associated with 3GPP access and another UDP port associated with non-3GPP access. PMF messages sent by UE to one of these UDP ports, shall be transmitted to UPF via the associated QoS Flow.

- For a PDU Session of Ethernet type, one MAC address associated with 3GPP access and another MAC address associated with non-3GPP access. PMF messages sent by UE to one of these MAC addresses, shall be transmitted to UPF via the associated QoS Flow.

The QoS rules and the N4 rules provided by SMF to UE and to UPF respectively shall include information (e.g. packet filters containing the UDP port or the MAC address associated with a QoS Flow), which enables the UE and UPF to route a PMF message to a specific QoS Flow.

The UE and the UPF may need to perform access performance measurements in order to estimate the Round-Trip Time (RTT) and/or the Packet Loss Rate (PLR) that an SDF is expected to experience when transmitted on a certain access type. Based on these measurements and the provisioned ATSSS rules in the UE and MAR rules in the UPF, the UE and the UPF decide how to distribute the traffic of an SDF across the two accesses.

If the UE and the UPF decide to initiate access performance measurements to estimate the RTT and/or the PLR for an SDF, the access performance measurements shall be performed either

(a) using the QoS Flow associated with the default QoS rule; or

(b) using the target QoS Flow, which is the QoS Flow that the SDF traffic is transmitted on.

When the access performance measurements are using the target QoS Flow, it is termed that "access performance measurements per QoS Flow" are applied for the MA PDU Session.

The UE shall indicate in its ATSSS capabilities that it supports access performance measurements per QoS Flow. Based on this UE capability and other information (such as local policy), the SMF determines whether access performance measurements per QoS Flow shall be applied for the MA PDU Session or not. If the SMF determines that access performance measurements per QoS Flow shall be applied for the MA PDU Session, then:

- The SMF determines a list of QoS Flows over which access performance measurements may be performed and provides this list to the UE (within the Measurement Assistance Information) and to the UPF.

- The UE and the UPF may initiate access performance measurements on one or more of the QoS Flows included in this list. The UE and the UPF shall be able to receive and respond to PMF messages sent on any QoS Flow included in this list.

- The SMF may update the list of QoS Flows over which access performance measurements may be performed during the lifetime of a MA PDU Session, e.g. when a new PCC rule that could benefit from PMF access performance measurements is bound to a QoS Flow.

NOTE 3: The SMF can e.g. add a QoS Flow into the list when at least one PCC Rule is bound to that QoS Flow that is using one of the Steering Modes where performance measurements via PMF are applicable, such as Lowest Delay Steering Mode or a Steering Mode where threshold values have been provided.

The UE shall perform access performance measurements per QoS Flow only when this is explicitly indicated in the Measurement Assistance Information, i.e. only when the UE receives the list of QoS Flows over which access performance measurements may be performed. Otherwise, the UE shall perform access performance measurements based on the QoS Flow associated with the default QoS rule. The UPF shall perform access performance measurements per QoS Flow only when this is explicitly indicated by SMF, i.e. only when the UPF receives the list of QoS Flows over which access performance measurements may be performed. Otherwise, the UPF shall perform access performance measurements based on the QoS Flow associated with the default QoS rule. In this case the UPF learns what QoS Flow to use as described in TS 29.244 [65].

The UE and the UPF may decide not to initiate access performance measurements using PMF over a certain target QoS Flow, when they already have access performance measurements for another target QoS Flow which they determine can be reused.

NOTE 4: How the UE and UPF determine that the performance measurements using a certain target QoS Flow apply to another target QoS Flow is based on implementation, e.g. AN resource to QoS Flow mapping in the UE or getting similar access measurements results with other QoS Flow.

When access performance measurements for an SDF are performed based on the target QoS Flow, the UE needs to be able to determine the QoS Flow a downlink packet arrives on. In order to enable this, the SMF shall include downlink Packet Filter information in the QoS rule provided to UE matching this SDF, unless Reflective QoS is used for the SDF.

NOTE 5: For example, if a QoS Flow requires to activate Reflective QoS, the SMF does not need to provide downlink QoS Flow information for the QoS Flow to minimize usage of packet filters. When a data packet is received over a QoS Flow, the UE can decide whether to check the downlink QoS Flow information based on the existence of SDAP header for the QoS Flow.

The addressing information of the PMF in the UPF is retrieved by the SMF from the UPF during N4 session establishment. If the UPF receives from the SMF, during N4 session establishment or modification procedure, a list of QoS Flows over which access performance measurements may be performed, the UPF allocates different UDP ports per QoS Flow per access for IP PDU sessions, or allocates different MAC addresses per QoS Flow per access for Ethernet PDU sessions. For IP PDU sessions, the UPF sends the PMF IP addressing information and the UDP ports with the QFI of the associated QoS Flow to the SMF. For Ethernet PDU sessions, the UPF sends the MAC addresses with the QFI of the associated QoS Flow to the SMF.

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

- Messages to allow for Round Trip Time (RTT) measurements, i.e. when the "Smallest Delay" steering mode is used or when either "Priority-based", "Load-Balancing" or "Redundant" steering mode is used with RTT threshold value being applied;

- Messages to allow for Packet Loss Rate (PLR) measurements, i.e. when steering mode is used either "Priority-based", "Load-Balancing" or "Redundant" steering mode is used with PLR threshold value being applied;

- Messages for reporting Access availability/unavailability by the UE to the UPF.

- Messages for sending UE-assistance data to UPF. Such messages may be sent from the UE to UPF only when the UE receives the UE-assistance indicator in an ATSSS rule, as specified in clause 5.32.8. Further details are provided in clause 5.32.5.5.

- Messages for sending Suspend Traffic Duplication and Resume Traffic Duplication from UPF to UE to suspend or resume traffic duplication as defined in clause 5.32.5.6.

Since steering modes can be different in up-link and down-link, the UE needs to be able to handle PMF protocol messages for RTT and PLR measurements received from UPF even if it is not using one of the steering modes associated with the RTT and PLR measurements (and vice versa).

The PMF protocol is specified in TS 24.193 [109].

The PMF protocol messages used for access availability/unavailability reports shall be sent on the QoS Flow associated with the default QoS rule. The PMF protocol messages used for access performance measurements shall be sent either on the QoS Flow associated with the default QoS rule, or on the target QoS Flow, as specified above.

The QoS Flow associated with the default QoS rule for MA PDU Session is Non-GBR QoS Flow.

The UE shall not apply the ATSSS rules and the UPF shall not apply the MAR rules for the PMF protocol messages.

When the UE requests a MA PDU session and indicates it is capable to support:

- the MPTCP functionality with any steering mode and the ATSSS-LL functionality with only the Active-Standby steering mode (as specified in clause 5.32.6.1); or

- one or more of the MPQUIC based Steering Functionalities with any steering mode and the ATSSS-LL functionality with only the Active-Standby steering mode (as specified in clause 5.32.6.1); or

- the MPTCP functionality with any steering mode, and one or more of the MPQUIC based Steering Functionalities with any steering mode and the ATSSS-LL functionality with only the Active-Standby steering mode (as specified in clause 5.32.6.1);

the network may send Measurement Assistance Information for the UE to send Access availability/unavailability reports to the UPF. In this case, the UE and UPF shall not perform RTT and PLR measurements using PMF as the UE and UPF can use measurements available at the MPTCP layer and/or at the MPQUIC layer.

\*\*\*\* Next Change \*\*\*\*

### 5.32.6 Support of Steering Functionalities

#### 5.32.6.1 General

The functionality in an ATSSS-capable UE that can steer, switch and split the MA PDU Session traffic across 3GPP access and non-3GPP access, is called a "steering functionality". An ATSSS-capable UE may support one or more of the following types of steering functionalities:

- Steering functionalities based on multi-path protocols:

- Steering Functionality that applies the MPTCP protocol (IETF RFC 8684 [81]) and is called "MPTCP functionality" (see clause 5.32.6.2.1). This steering functionality can be applied to steer, switch and split the TCP traffic flows identified in the ATSSS/N4 rules. The MPTCP functionality in the UE may communicate with an associated MPTCP Proxy functionality in the UPF, by using the MPTCP protocol over the 3GPP and/or the non-3GPP user plane.

- Steering Functionality called "MPQUIC-UDP" which applies the QUIC protocol (RFC 9000 [166], RFC 9001 [167], RFC 9002 [168]) and its multipath extensions (draft-ietf-quic-multipath [174]), and it is called "MPQUIC-UDP functionality" (see clause 5.32.6.2.2). This steering functionality can be applied to steer, switch and split the UDP traffic flows identified in the ATSSS/N4 rules. The MPQUIC-UDP functionality in the UE may communicate with an associated MPQUIC Proxy functionality in the UPF, by using the QUIC protocol and its multipath extensions over the 3GPP and/or the non-3GPP user plane.

- Steering functionality called "MPQUIC-IP" which applies the QUIC protocol (RFC 9000 [166], RFC 9001 [167], RFC 9002 [168]) and its multipath extensions (draft-ietf-quic-multipath [174]), see clause 5.32.6.2.X. This steering functionality can be applied to steer, switch and split IP traffic identified in the ATSSS/N4 rules. The MPQUIC-IP functionality in the UE may communicate with an associated MPQUIC Proxy functionality in the UPF, by using the QUIC protocol and its multipath extensions over the 3GPP and/or the non-3GPP user plane.

- Steering functionality called "MPQUIC-E" which applies the QUIC protocol (RFC 9000 [166], RFC 9001 [167], RFC 9002 [168]) and its multipath extensions (draft-ietf-quic-multipath [174]), see clause 5.32.6.2.Y. This steering functionality can be applied to steer, switch and split Ethernet traffic identified in the ATSSS/N4 rules. The MPQUIC-E functionality in the UE may communicate with an associated MPQUIC Proxy functionality in the UPF, by using the QUIC protocol and its multipath extensions over the 3GPP and/or the non-3GPP user plane.

- Steering functionalities based on data switching:

- A steering functionality called "ATSSS Low-Layer functionality", or ATSSS-LL functionality (see clause 5.32.6.3.1): This steering functionality can be applied to steer, switch and split all types of traffic, including TCP traffic, UDP traffic, Ethernet traffic, etc. ATSSS-LL functionality is mandatory for MA PDU Session of type Ethernet. In the network, there shall be in the data path of the MA PDU session one UPF supporting ATSSS-LL.

NOTE: Filters used in ATSSS rules related with a MA PDU Session of type Ethernet can refer to IP level parameters such as IP addresses and TCP/UDP ports.

The UE indicates to the network its supported steering functionalities and steering modes by including in the UE ATSSS Capability one of the following:

1) ATSSS-LL functionality with any steering mode.

 In this case, the UE indicates that it is capable to steer, switch and split all traffic of the MA PDU Session by using the ATSSS-LL functionality with any steering mode allowed for ATSSS-LL, as specified in clause 5.32.8.

2) MPTCP functionality with any steering mode and ATSSS-LL functionality with only Active-Standby steering mode.

 In this case, the UE indicates that:

a) it is capable to steer, switch and split the MPTCP traffic of the MA PDU Session by using the MPTCP functionality with any steering mode specified in clause 5.32.8; and

b) it is capable to steer and switch all other traffic (i.e. the non-MPTCP traffic) of the MA PDU Session by using the ATSSS-LL functionality with the Active-Standby steering mode specified in clause 5.32.8.

3) MPTCP functionality with any steering mode and ATSSS-LL functionality with any steering mode.

 In this case, the UE indicates that:

a) it is capable to steer, switch and split the MPTCP traffic of the MA PDU Session by using the MPTCP functionality with any steering mode specified in clause 5.32.8; and

b) it is capable to steer, switch and split all other traffic (i.e. the non-MPTCP traffic) of the MA PDU Session by using the ATSSS-LL functionality with any steering mode, as specified in clause 5.32.8.

Editor's note: [MASSS] The below bullets 4) – 7) for MPQUIC functionality need to be enhanced to support also MPQUIC-IP and MPQUIC-E

4) MPQUIC functionality with any steering mode and ATSSS-LL functionality with only Active-Standby steering mode.

 In this case, the UE indicates that:

a) it is capable to steer, switch and split the MPQUIC traffic of the MA PDU Session by using the MPQUIC functionality with any steering mode specified in clause 5.32.8; and

b) it is capable to steer and switch all other traffic (i.e. the non-MPQUIC traffic) of the MA PDU Session by using the ATSSS-LL functionality with the Active-Standby steering mode specified in clause 5.32.8.

5) MPQUIC functionality with any steering mode and ATSSS-LL functionality with any steering mode.

 In this case, the UE indicates that:

a) it is capable to steer, switch and split the MPQUIC traffic of the MA PDU Session by using the MPQUIC functionality with any steering mode specified in clause 5.32.8; and

b) it is capable to steer, switch and split all other traffic (i.e. the non-MPQUIC traffic) of the MA PDU Session by using the ATSSS-LL functionality with any steering mode that can be used with ATSSS-LL, as specified in clause 5.32.8.

6) MPTCP functionality with any steering mode, MPQUIC functionality with any steering mode, and ATSSS-LL functionality with only Active-Standby steering mode.

 In this case, the UE indicates that:

a) it is capable to steer, switch and split the MPTCP traffic of the MA PDU Session by using the MPTCP functionality with any steering mode specified in clause 5.32.8;

b) it is capable to steer, switch and split the MPQUIC traffic of the MA PDU Session by using the MPQUIC functionality with any steering mode specified in clause 5.32.8; and

c) it is capable to steer and switch all other traffic (i.e. the non-MPTCP traffic and the non-MPQUIC traffic) of the MA PDU Session by using the ATSSS-LL functionality with the Active-Standby steering mode specified in clause 5.32.8.

7) MPTCP functionality with any steering mode, MPQUIC functionality with any steering mode, and ATSSS-LL functionality with any steering mode.

 In this case, the UE indicates that:

a) it is capable to steer, switch and split the MPTCP traffic of the MA PDU Session by using the MPTCP functionality with any steering mode specified in clause 5.32.8;

b) it is capable to steer, switch and split the MPQUIC traffic of the MA PDU Session by using the MPQUIC functionality with any steering mode specified in clause 5.32.8; and

c) it is capable to steer, switch and split all other traffic (i.e. the non-MPTCP traffic and the non-MPQUIC traffic) of the MA PDU Session by using the ATSSS-LL functionality with any steering mode that can be used with ATSSS-LL, as specified in clause 5.32.8.

The above steering functionalities are schematically illustrated in the Figure 5.32.6.1-1, which shows an example model for an ATSSS-capable UE supporting the MPTCP functionality, the MPQUIC-UDP functionality and the ATSSS-LL functionality. The MPTCP flows and the MPQUIC flows in this figure represent the traffic of the applications for which MPTCP can be applied and for which MPQUIC can be applied respectively. The five different IP addresses illustrated in the UE are further described in clause 5.32.6.2.1 and in clause 5.32.6.2.2. When the MPTCP functionality and the MPQUIC functionality are both applied, the addresses (IP@1, IP@2) used for MPTCP may be the same as the addresses (IP@4, IP@5) used for MPQUIC.



Figure 5.32.6.1-1: Steering functionalities in an example UE model

Within the same MA PDU Session in the UE, it is possible to simultaneously steer different packet flows bydifferent steering functionalities. For the same packet flow, only one steering functionality shall be used.

All steering functionalities in the UE shall take ATSSS decisions (i.e. decide how to steer, switch and split the traffic) by using the same set of ATSSS rules. Similarly, all ATSSS decisions in the UPF shall be taken by applying the same set of N4 rules, which support ATSSS. The ATSSS rules and the N4 rules supporting ATSSS are provisioned in the UE and in the UPF respectively, when the MA PDU Session is established.

If the UE supports multiple steering functionalities, e.g. both the MPTCP functionality and the ATSSS-LL functionality, one or more of the MPQUIC steering functionalities and the ATSSS-LL functionality, or the MPTCP functionality, one or more of the MPQUIC steering functionalities and the ATSSS-LL functionality, it shall use the provisioned ATSSS rules (see TS 23.503 [45]) to decide which steering functionality to apply for a specific packet flow.

\*\*\*\* Next Change \*\*\*\*

#### 5.32.6.2 Steering Functionalities based on multi-path protocols.

\*\*\*\* Next Change \*\*\*\*

##### 5.32.6.2.2 MPQUIC-UDP Functionality

The MPQUIC functionality enables steering, switching, and splitting of UDP traffic between the UE and UPF, in accordance with the ATSSS policy created by the network. The operation of the MPQUIC-UDP functionality is based on RFC 9298 [170] "proxying UDP in HTTP", which specifies how UDP traffic can be transferred between a client (UE) and a proxy (UPF) using the RFC 9114 [171] HTTP/3 protocol. The HTTP/3 protocol operates on top of the QUIC protocol (RFC 9000 [166], RFC 9001 [167] , RFC 9002 [168]), which supports simultaneous communication over multiple paths, as defined in draft-ietf-quic-multipath [174].

The MPQUIC-UDP functionality in the UE communicates with the MPQUIC Proxy functionality in the UPF (see Figure 4.2.10-1) using the user plane of the 3GPP access, or the non-3GPP access, or both.

The MPQUIC-UDP functionality may be enabled for an MA PDU Session with type IPv4, IPv6 or IPv4v6, when both the UE and the network support this functionality. The MPQUIC-UDP functionality shall not be enabled when the type of the MA PDU Session is Ethernet.

Further details of MPQUIC are described in clause 5.32.6.X.

##### 5.32.6.2.X MPQUIC-IP Functionality

The MPQUIC-IP functionality enables steering, switching, and splitting of IP traffic between the UE and UPF, in accordance with the ATSSS policy created by the network. The operation of the MPQUIC-IP functionality is based on RFC 9484 [x] "Proxying IP in HTTP", which specifies how IP traffic can be transferred between a client (UE) and a proxy (UPF) using the RFC 9114 [171] HTTP/3 protocol.

The HTTP/3 protocol operates on top of the QUIC protocol (RFC 9000 [166], RFC 9001 [167], RFC 9002 [168]), which supports simultaneous communication over multiple paths, as defined in draft-ietf-quic-multipath [174].

The MPQUIC-IP functionality in the UE communicates with the MPQUIC Proxy functionality in the UPF (see Figure 4.2.10-1) using the user plane of the 3GPP access, or the non-3GPP access, or both.

The MPQUIC-IP functionality may be enabled for a MA PDU Session with type IPv4, IPv6 or IPv4v6, when both the UE and the network support this functionality.

Further details of MPQUIC-IP is described in clause 5.32.6.X.

##### 5.32.6.2.Y MPQUIC-E Functionality

The MPQUIC-E functionality enables steering, switching, and splitting of Ethernet traffic between the UE and UPF, in accordance with the ATSSS policy created by the network. The operation of the MPQUIC-E functionality is based on IETF draft-ietf-masque-connect-ethernet [y] "Proxying Ethernet in HTTP", which specifies how Ethernet traffic can be transferred between a client (UE) and a proxy (UPF) using the RFC 9114 [171] HTTP/3 protocol.

The HTTP/3 protocol operates on top of the QUIC protocol (RFC 9000 [166], RFC 9001 [167] , RFC 9002 [168]), which supports simultaneous communication over multiple paths, as defined in draft-ietf-quic-multipath [174].

The MPQUIC-E functionality in the UE communicates with the MPQUIC Proxy functionality in the UPF (see Figure 4.2.10-1) using the user plane of the 3GPP access, or the non-3GPP access, or both.

The MPQUIC-E functionality may be enabled when the type of the MA PDU Session is Ethernet. In case MPQUIC-E functionality is enabled for an Ethernet PDU Session Type, the SMF indicates PDU Session Type Unstructured or an IP based PDU Session type in the N2 information to NG-RAN, as described in TS 23.502 [3].

NOTE: The reason for indicating Unstructured PDU Session Type to NG-RAN in this case is to avoid that NG-RAN attempts to perform Ethernet header compression to the PDU.

Further details of MPQUIC-E is described in clause 5.32.6.X.

##### 5.32.6.2.Z Common functionality for MPQUIC-UDP, MPQUIC-IP and MPQUIC-E

5.32.6.2.Z.1 General

This clause provides further description of the MPQUIC-based steering functionalities, that are common to MPQUIC-UDP, MPQUIC-IP and MPQUIC-E.

The MPQUIC-UDP, MPQUIC-IP and MPQUIC-E functionality are composed of three components:

1) QoS flow selection & Steering mode selection: This component in the UE initiates the establishment of one or more multipath QUIC connections, after the establishment of the MA PDU Session and, for each uplink UDP flow for MPQUIC-UDP functionality), IP flow (for MPQUIC-IP functionality) and Ethernet flow (for MPQUIC-E functionality), it selects a QoS flow (based on the QoS rules), a steering mode and a transport mode (based on the ATSSS rules). This component in the UPF selects, for each downlink UDP flow, a QoS flow (based on the N4 rules), a steering mode and a transport mode (based on the N4 rules). The supported transport modes are defined below.

 In the UE, this component is only used in the uplink direction, while, in the UPF, this component is only used in the downlink direction.

2) HTTP/3 layer: Supports the HTTP/3 protocol defined in RFC 9114 [171] and the extensions defined in:

- RFC 9298 [170] for supporting UDP proxying over HTTP;

- RFC 9297 [172] for supporting HTTP datagrams; and

- RFC 9220 [173] for supporting Extended CONNECT.

 The HTTP/3 layer selects a multipath QUIC connection to be used for each traffic flow and allocates a new QUIC stream on this connection that is associated with the traffic flow. It also configures this QUIC stream to apply a specific steering mode.

 In the UE, the HTTP/3 layer implements an HTTP/3 client, while, in the UPF, it implements an HTTP/3 proxy.

3) QUIC layer: Supports the QUIC protocol as defined in the applicable IETF specifications (RFC 9000 [166], RFC 9001 [167], RFC 9002 [168]) and the extensions defined in:

- RFC 9221 [169] for supporting unreliable datagram transport with QUIC; and

- draft-ietf-quic-multipath [174] for supporting QUIC connections using multiple paths simultaneously.

When the MPQUIC-UDP functionality is applied, the protocol stack of the user plane is depicted in figure below.



Figure 5.32.6.2.2-1: UP protocol stack when the MPQUIC-UDP functionality is applied

Editor's note: The above figure might need changes (e.g. related with the mandatory use of TLS) based on the security work in SA WG3.

If the UE indicates that it is capable of supporting the MPQUIC-UDP, MPQUIC-IP and/or MPQUIC-E functionalities, as described in clause 5.32.2, and the network agrees to enable the corresponding MPQUIC functionality(ies) for the MA PDU Session then:

i) An associated MPQUIC Proxy functionality is enabled in the UPF for the MA PDU Session.

ii) The network allocates two IP addresses/prefixes, called "MPQUIC link-specific multipath " addresses/prefixes; one associated with 3GPP access and another associated with the non-3GPP access. In the UE, these two IP addresses/prefixes are used only by the MPQUIC functionality. Each "MPQUIC link-specific multipath" address/prefix assigned to UE may not be routable via N6. The MPQUIC functionality in the UE and the MPQUIC Proxy functionality in the UPF shall use the "MPQUIC link-specific multipath" addresses/prefixes for transmitting traffic flows over non-3GPP access and over 3GPP access. The MPQUIC Proxy functionality shall use the IP address/prefix of the MA PDU session for the communication with the final destination. In Figure 5.32.6.1-1, the IP@3 corresponds to the IP address of the MA PDU Session and the IP@4 and IP@5 correspond to the "MPQUIC link-specific multipath" addresses. The following UE IP address management applies:

- The MA PDU IP address/prefix shall be provided to the UE via mechanisms defined in clause 5.8.2.2.

- The "MPQUIC link-specific multipath" IP addresses/prefixes shall be allocated by the UPF and shall be provided to the UE via SM NAS signalling.

NOTE 1: After the MA PDU Session is released, the same UE IP addresses/prefixes are not allocated to another UE for MA PDU Session in a short time.

iii) The network shall send MPQUIC proxy information to UE, i.e. one IP address of UPF, one UDP port number and the proxy type (e.g. "connect-udp"). This information is used by the UE for establishing multipath QUIC connections with the UPF, which implements the MPQUIC Proxy functionality.

iv) After the MA PDU Session is established, the UE determines the number of multipath QUIC connections to be established with the UPF. The UE determines to establish at least as many multipath QUIC connections as the number of QoS flows of the MA PDU Session, i.e. one multipath QUIC connection per QoS flow. Each multipath QUIC connection carries the traffic mapped to a single QoS flow.

 For the downlink traffic to which the MPQUIC functionality is to be applied, the QoS rules provided to UE include downlink QoS information and the UE applies the downlink QoS information to establish multipath QUIC connections for the QoS flows used for the downlink traffic only.

v) During a QUIC connection establishment, the UE and UPF negotiate QUIC transport parameters and indicate (a) support of QUIC Datagram frames and (b) support of multipath. They indicate support of QUIC Datagram frames by providing the "max\_datagram\_frame\_size" transport parameter with a non-zero value (see RFC 9221 [169]) and they indicate support of multipath by providing the "enable\_multipath" transport parameter (see draft-ietf-quic-multipath [174]).

 In addition, during a QUIC connection establishment the QoS flow associated with this connection is determined. The UE sends all traffic of a QUIC connection over the QoS flow associated with this QUIC connection. This enables the UPF to determine the QoS flow associated with a QUIC connection and to select a QUIC connection for sending the downlink traffic of a QoS flow.

vi) After a QUIC connection establishment, the HTTP/3 client in the UE and the HTTP/3 proxy in the UPF negotiate HTTP settings and indicate support of HTTP Datagrams (see RFC 9297 [172]) and support of Extended CONNECT (see RFC 9220 [173]). To use MPQUIC proxying for a UDP traffic flow, the UE then sends a HTTP/3 CONNECT request (see RFC 9298 [170]) to the HTTP/3 proxy in the UPF. To use MPQUIC proxying for a IP traffic flow, the UE then sends a HTTP/3 CONNECT-IP request (see RFC 9484 [x]) to the HTTP/3 proxy in the UPF. To use MPQUIC proxying for an Ethernet traffic flow, the UE then sends a HTTP/3 CONNECT-Ethernet request (see IETF draft-ietf-masque-connect-ethernet [y]) to the HTTP/3 proxy in the UPF.

vii) The network may indicate to UE the list of applications for which the MPQUIC-UDP, MPQUIC-IP or MPQUIC-E functionality should be applied. This is achieved by using the Steering Functionality component of an ATSSS rule (see clause 5.32.8).

5.32.6.2.Z.2 Supported Transport Modes

The MPQUIC-UDP, MPQUIC-IP and MPQUIC-E functionalities support the following transport modes for transmitting a UDP flow between UE and UPF. The PCF selects which of these transport modes shall be applied for a UDP flow (SDF). The selected transport mode is provided to UE and UPF within the ATSSS rules and N4/MAR rules respectively.

- Datagram mode 2: This transport mode. It encapsulates UDP, IP packets and Ethernet frames, as applicable, packets within QUIC Datagram frames and provides unreliable transport with no sequence numbering and no packet reordering / deduplication. The transport mode is defined in RFC 9298 [170] for MPQUIC-UDP functionality, in RFC 9484 [x] for MPQUIC-IP functionality and in draft-ietf-masque-connect-ethernet [y] for MPQUIC-E functionality.

- Datagram mode 1: This transport mode is an extension of the mode defined in RFC 9298 [170], RFC 9484 [x] and draft-ietf-masque-connect-ethernet [y]. It encapsulates packets within QUIC Datagram frames and provides unreliable transport but with sequence numbering and with packet reordering / deduplication. It can be applied for any traffic flow. The details of the datagram mode 1, including the potential use of a Context ID (see RFC 9298 [170]), are considered in stage-3 specifications.

Editor's note: A reference to the applicable stage-3 specification needs to be added to the above paragraph, to point to the stage-3 details of Datagram mode 1.

- Stream mode: This transport mode is readily supported by the QUIC protocol. It encapsulates packets within QUIC Stream frames and provides reliable transport with sequence numbering and with packet reordering / deduplication. It can be applied for traffic flows where it is known that the application does not perform retransmissions.

NOTE 1: The Stream mode provides strict reliability and in-order delivery with re-transmissions and therefore can lead to melt down phenomena when reliable traffic (e.g. QUIC) is carried, or counteracts application decisions when UDP is selected to avoid reliability and/or in-order delivery. Therefore, it can be avoided for applications which perform their own reliability mechanisms.

NOTE 2: When a steering mode is supported by ATSSS-LL for a traffic flow (e.g. Active-Standby), one of the MPQUIC-UDP, MPQUIC-IP or MPQUIC-E steering functionalities can be selected if additional features, which are not supported by the ATSSS-LL steering functionality and PMF, are required for the traffic steering/switching/splitting of the traffic flow.

\*\*\*\* Next Change \*\*\*\*

#### 5.32.6.3 Steering Functionalities based on data switching

##### 5.32.6.3.1 ATSSS-LL Functionality

The ATSSS-LL functionality in the UE does not apply a specific protocol. It is a data switching function, which decides how to steer, switch and split the uplink traffic across 3GPP and non-3GPP accesses, based on the provisioned ATSSS rules and local conditions (e.g. signal loss conditions). The ATSSS-LL functionality in the UE may be applied to steer, switch and split all types of traffic, including TCP traffic, UDP traffic, Ethernet traffic, etc. The ATSSS-LL functionality does not support the Redundant Steering Mode.

The ATSSS-LL functionality may be enabled in the UE when the UE provides an "ATSSS-LL capability" during the PDU Session Establishment procedure.

Either the ATSSS-LL functionality or MPQUIC-E functionality is mandatory to support in the UE for MA PDU Session of type Ethernet.

Either the ATSSS-LL functionality or MPQUIC-IP functionality is mandatory to support in the UE for MA PDU Session with an IP-based PDU Session Type. In addition:

- When the UE neither supports the MPTCP functionality, the MPQUIC-UDP functionality, nor the MPQUIC-IP functionality, the ATSSS-LL functionality is mandatory in the UE for an MA PDU Session of type IP.

- When the UE supports the MPTCP functionality and does not support the MPQUIC-UDP functionality nor the MPQUIC-IP functionality, the ATSSS-LL functionality with Active-Standby Steering Mode is mandatory in the UE for an MA PDU Session of type IP to support non-MPTCP traffic.

- When the UE supports the MPQUIC-UDP functionality and does not support the MPTCP functionality, the ATSSS-LL functionality with Active-Standby Steering Mode is mandatory in the UE for an MA PDU Session of type IP to support non-MPQUIC traffic.

- When the UE supports both the MPTCP functionality and the MPQUIC-UDP functionality but not the MPQUIC-IP functionality, the ATSSS-LL functionality with Active-Standby Steering Mode is mandatory in the UE for an MA PDU Session of type IP to support non-MPTCP and non-MPQUIC traffic.

- When the UE supports the MPQUIC-IP functionality, the ATSSS-LL functionality is optional in the UE for an MA PDU Session of type IP.

The network shall also support the ATSSS-LL functionality as defined for the UE above. The ATSSS-LL functionality in the UPF is enabled for a MA PDU Session by ATSSS-LL functionality indication received in the Multi-Access Rules (MAR).

\*\*\*\* Next Change \*\*\*\*

### 5.32.8 ATSSS Rules

As specified in clause 5.32.3, after the establishment of a MA PDU Session, the UE receives a prioritized list of ATSSS rules from the SMF. The structure of an ATSSS rule is specified in Table 5.32.8-1.

Table 5.32.8-1: Structure of ATSSS Rule

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Information name | Description | Category | SMF permitted to modify in a PDU context | Scope |
| **Rule identifier** | Unique identifier to identify the ATSSS Rule | Mandatory | No | PDU context |
| Rule Precedence | Determines the order in which the ATSSS rule is evaluated in the UE. | Mandatory(NOTE 1) | Yes | PDU context |
| **Traffic Descriptor** | *This part defines the Traffic descriptor components for the ATSSS rule.* | Mandatory(NOTE 2) |  |  |
| Application descriptors | One or more application identities that identify the application(s) generating the traffic (NOTE 3). | Optional | Yes | PDU context |
| IP descriptors(NOTE 4) | One or more 5-tuples that identify the destination of IP traffic. | Optional | Yes | PDU context |
| Non-IP descriptors(NOTE 4) | One or more descriptors that identify the destination of non-IP traffic, i.e. of Ethernet traffic. | Optional | Yes | PDU context |
| **Access Selection Descriptor** | *This part defines the Access Selection Descriptor components for the ATSSS rule.* | Mandatory |  |  |
| Steering Mode | Identifies the steering mode that should be applied for the matching traffic and associated parameters. | Mandatory(NOTE 8) | Yes | PDU context |
| Steering Mode Indicator | Indicates either autonomous load-balance operation or UE-assistance operation if steering mode is set to "Load Balancing". | Optional(NOTE 6) | Yes | PDU context |
| Threshold Values(NOTE 9) | A Maximum RTT and/or a Maximum Packet Loss Rate. | Optional(NOTE 6) | Yes | PDU context |
| Steering Functionality | Identifies whether the MPTCP functionality, the MPQUIC-UDP functionality, the MPQUIC-IP functionality, the MPQUIC-E functionality or the ATSSS-LL functionality should be applied for the matching traffic. | Optional(NOTE 5)(NOTE 8) | Yes | PDU context |
| Transport Mode | Identifies the transport mode (see clause 5.32.6.2.2.1) that should be used for the matching traffic, when the Steering Functionality is the MPQUIC-UDP functionality, MPQUIC-IP functionality or MPQUIC-E functionality. | Optional(NOTE 7) | Yes | PDU context |
| NOTE 1: Each ATSSS rule has a different precedence value from the other ATSSS rules.NOTE 2: At least one of the Traffic Descriptor components is present.NOTE 3: An application identity consists of an OSId and an OSAppId.NOTE 4: An ATSSS rule cannot contain both IP descriptors and Non-IP descriptors.NOTE 5: If the UE supports only one Steering Functionality, this component is omitted.NOTE 6: The Steering Mode Indicator and the Threshold Values shall not be provided together.NOTE 7: The Transport Mode shall be included when the Steering Functionality is the MPQUIC-UDP functionality, MPQUIC-IP functionality or MPQUIC-E functionality. In all other cases, the Transport Mode shall not be included.NOTE 8: The Steering functionality "ATSSS-LL functionality" shall not be provided together with Steering Mode "Redundant".NOTE 9: If the Steering Mode is "Redundant", either a Maximum RTT or a Maximum Packet Loss Rate may be provided, but not both. |

The UE evaluates the ATSSS rules in priority order.

Each ATSSS rule contains a Traffic Descriptor (containing one or more components described in Table 5.32.8-1) that determines when the rule is applicable. An ATSSS rule is determined to be applicable when every component in the Traffic Descriptor matches the considered service data flow (SDF).

Depending on the type of the MA PDU Session, the Traffic Descriptor may contain the following components (the details of the Traffic Descriptor generation are described in clause 5.32.3):

- For IPv4, or IPv6, or IPv4v6 type: Application descriptors and/or IP descriptors.

- For Ethernet type: Application descriptors and/or Non-IP descriptors.

One ATSSS rule with a "match all" Traffic Descriptor may be provided, which matches all SDFs. When provided, it shall have the least Rule Precedence value, so it shall be the last one evaluated by the UE.

NOTE 1: The format of the "match all" Traffic descriptor of an ATSSS rule is defined in stage-3.

Each ATSSS rule contains an Access Selection Descriptor that contains the following components:

- A Steering Mode, which determines how the traffic of the matching SDF should be distributed across 3GPP and non-3GPP accesses. The following Steering Modes are supported:

- Active-Standby: It is used to steer a SDF on one access (the Active access), when this access is available, and to switch the SDF to the available other access (the Standby access), when Active access becomes unavailable. When the Active access becomes available again, the SDF is switched back to this access. If the Standby access is not defined, then the SDF is only allowed on the Active access and cannot be transferred on another access.

- Smallest Delay: It is used to steer a SDF to the access that is determined to have the smallest Round-Trip Time (RTT). As defined in clause 5.32.5, measurements may be obtained by the UE and UPF to determine the RTT over 3GPP access and over non-3GPP access. In addition, if one access becomes unavailable, all SDF traffic is switched to the other available access. It can only be used for the Non-GBR SDF.

- Load-Balancing: It is used to split a SDF across both accesses if both accesses are available. It contains the percentage of the SDF traffic that should be sent over 3GPP access and over non-3GPP access. Load-Balancing is only applicable to Non-GBR SDF. In addition, if one access becomes unavailable, all SDF traffic is switched to the other available access, as if the percentage of the SDF traffic transported via the available access was 100%.

- Priority-based: It is used to steer all the traffic of an SDF to the high priority access, until this access is determined to be congested. In this case, the traffic of the SDF is sent also to the low priority access, i.e. the SDF traffic is split over the two accesses. In addition, when the high priority access becomes unavailable, all SDF traffic is switched to the low priority access. How UE and UPF determine when a congestion occurs on an access is implementation dependent. It can only be used for the Non-GBR SDF.

- Redundant (without Threshold Values): It is used to duplicate traffic of an SDF on both accesses if both accesses are available. A Primary Access (either 3GPP access or Non-3GPP access) may be provided to the UE in the ATSSS rules and to the UPF in the N4 rules. If a Primary Access is provided, UE and UPF shall send all data packets of the SDF on the Primary Access and may duplicate data packets of the SDF on the other access. How many and which data packets are duplicated by UE and UPF on the other access is based on implementation. If the Primary Access is not provided to UE and UPF, the UE and UPF shall send all data packets of the SDF on both accesses. It can be used for GBR and Non-GBR SDF.

- A Steering Mode Indicator, which indicates that the UE may change the default steering parameters provided in the Steering Mode component and may adjust the traffic steering based on its own decisions. Only one of the following Steering Mode Indicators may be provided:

- Autonomous load-balance indicator: This indicator may be provided only when the Steering Mode is Load-Balancing. When provided, the UE may ignore the percentages in the Steering Mode component (i.e. the default percentages provided by the network) and may autonomously determine its own percentages for traffic splitting, in a way that maximizes the aggregated bandwidth in the uplink direction. The UE is expected to determine its own percentages for traffic splitting by performing measurements across the two accesses. The UPF may apply a similar behaviour when the autonomous load-balance indicator is included in an N4 rule.

- UE-assistance indicator: This indicator may be provided only when the Steering Mode is Load-Balancing. When provided by the network, it indicates that (a) 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, e.g. lower battery level), and that (b) the UE may inform the UPF how it decided to distribute the UL traffic of the matching SDF. In the normal cases, although with this indicator provided, the UE shall distribute the UL traffic as indicated by the network.

NOTE 2: Typically, the UE-assistance indicator can be provided for SDFs for which the network has no strong steering requirements. For example, when the network has no strong steering requirements for the default traffic of an MA PDU Session, the network can indicate (i) that this traffic must be steered with Load-Balancing steering mode using 50% - 50% split percentages, and (ii) that the UE is allowed to use other split percentages, such as 0% - 100%, if this is needed by the UE to optimize its operation (e.g. to minimize its battery consumption).

- Threshold Values: One or more threshold values may be provided when the Steering Mode is Priority-based or when the Steering Mode is Load-Balancing with fixed split percentages (i.e. without the Autonomous load-balance indicator or UE assistance indicator). One threshold value may be provided when the Steering Mode is Redundant. A threshold value may be either a value for RTT or a value for Packet Loss Rate. The threshold values are applicable to both accesses and are applied by the UE and UPF as follows:

- Load-Balancing Steering Mode with fixed split percentages (i.e. without the Autonomous load-balance indicator or UE assistance indicator): When at least one measured parameter (i.e. RTT or Packet Loss Rate) on one access exceeds the provided threshold value, the UE and UPF may stop sending traffic on this access, or may continue sending traffic on this access but should reduce the traffic on this access by an implementation specific amount and shall send the amount of reduced traffic on the other access. When all measured parameters (i.e. RTT and Packet Loss Rate) for both accesses do not exceed the provided threshold values, the UE and UPF shall apply the fixed split percentages.

- Priority-based Steering Mode: When one or more threshold values are provided for the Priority-based Steering Mode, these threshold values should be considered by UE and UPF to determine when an access becomes congested. For example, when a measured parameter (i.e. RTT or Packet Loss Rate) on one access exceeds the provided threshold value, the UE and UPF may consider this access as congested and send the traffic also to the low priority access.

- Redundant Steering Mode: When the measured Packet Loss Rate exceeds the provided threshold value on both accesses, the UE and UPF shall duplicate the traffic of the SDF on both accesses. When the measured RTT exceeds the provided threshold value on both accesses, the UE and UPF may duplicate the traffic of the SDF on both accesses based on implementation. When the measured parameter (i.e. either RTT or Packet Loss Rate) exceeds the provided threshold value on one access only, the UE and UPF shall send the traffic of the SDF only over the other access. When the measured parameter (i.e. either RTT or Packet Loss Rate) does not exceed the provided threshold value on any access, the UE and UPF shall send the traffic of the SDF only over the Primary Access. The Primary Access (either 3GPP access or Non-3GPP access) may be provided to the UE in the ATSSS rules and to the UPF in the N4 rules. If the Primary Access is not provided to the UE and UPF, UE and UPF shall select a Primary Access based on their own implementation (e.g. using the lowest RTT access or the lowest Packet Loss Rate access). If measurement results on an access are not available for a parameter, it is considered that the measured parameter for this access has not exceeded the provided threshold value. If a threshold value is provided when the Steering Mode is Redundant, the Steering Mode can only be used for Non-GBR SDF.

- A Steering Functionality, which identifies whether the MPTCP functionality, or the MPQUIC-UDP functionality, or the MPQUIC-IP functionality, or the MPQUIC-E functionality, or the ATSSS-LL functionality should be used to steer the traffic of the matching SDF. This is used when the UE supports multiple functionalities for ATSSS, as specified in clause 5.32.6 ("Support of Steering Functions").

- A Transport Mode, which identifies the transport mode that should be applied by the MPQUIC-UDP functionality, MPQUIC-IP functionality or MPQUIC-E functionality for the matching traffic. The transport modes supported by the MPQUIC-UDP functionality, MPQUIC-IP functionality and MPQUIC-E functionality are defined in clause 5.32.6.2.2.1.

NOTE 3: There is no need to update the ATSSS rules when one access becomes unavailable or available.

As an example, the following ATSSS rules could be provided to UE:

a) "Traffic Descriptor: UDP, DestAddr 1.2.3.4", "Steering Mode: Active-Standby, Active=3GPP, Standby=non-3GPP":

- This rule means "steer UDP traffic with destination IP address 1.2.3.4 to the active access (3GPP), if available. If the active access is not available, use the standby access (non-3GPP)".

b) "Traffic Descriptor: TCP, DestPort 8080", "Steering Mode: Smallest Delay":

- This rule means "steer TCP traffic with destination port 8080 to the access with the smallest delay". The UE needs to measure the RTT over both accesses, in order to determine which access has the smallest delay.

c) "Traffic Descriptor: TCP traffic of Application-1", "Steering Mode: Load-Balancing, 3GPP=20%, non-3GPP=80%", "Steering Functionality: MPTCP":

- This rule means "send 20% of the TCP traffic of Application-1 to 3GPP access and 80% to non-3GPP access by using the MPTCP functionality".

d) "Traffic Descriptor: TCP traffic of Application-1", "Steering Mode: Load-Balancing, 3GPP=20%, non-3GPP=80%, "Threshold Value for Packet Loss Rate: 1%", "Steering Functionality: MPTCP":

- This rule means "send 20% of the TCP traffic of Application-1 to 3GPP access and 80% to non-3GPP access as long as the Packet Loss Rate does not exceed 1% on both accesses, by using the MPTCP functionality. If the measured Packet Loss Rate of an access exceeds 1%, then the TCP traffic of Application-1 may be reduced on this access and sent via the other access".

e) "Traffic Descriptor: UDP traffic of Application-1", "Steering Mode: Load-Balancing, 3GPP=30%, non-3GPP=70%", "Steering Functionality: MPQUIC", "Transport Mode: Datagram mode 1":

- This rule means "send 30% of the UDP traffic of Application-1 to 3GPP access and 70% to non-3GPP access by using the MPQUIC functionality with the Datagram mode 1".

f) "Traffic Descriptor: com.example.app0, TCP", "Steering Mode: Redundant", "Steering Functionality: MPTCP":

- This rule means "traffic duplication is applied by the MPTCP steering functionality to the TCP traffic of application com.example.app0 and 100% of the traffic is duplicated over both accesses".

g) "Traffic Descriptor: com.example.app1, TCP", "Steering Mode: Redundant, Primary Access=3GPP, Threshold Value for Packet Loss Rate: 0.1%", "Steering Functionality: MPTCP":

- This rule means "traffic duplication is applied to the TCP traffic of application com.example.app1. If the measured PLR exceeds 0.1% on both accesses, all matched traffic is duplicated on both accesses. If the measured PLR exceeds 0.1% on one access only (either 3GPP or non-3GPP access), all matched traffic is sent over the other access only. If the measured PLR does not exceed 0.1% on any access, all matched traffic is sent over 3GPP access only as this is the Primary Access".

h) "Traffic Descriptor: com.example.app2, TCP", "Steering Mode: Redundant, Threshold Value for Packet Loss Rate: 0.1%", "Steering Functionality: MPTCP".

- This rule means "traffic duplication is applied to the TCP traffic of application com.example.app2. If the measured PLR exceeds 0.1% on both accesses, all matched traffic is duplicated and transmitted on both accesses. If the measured PLR exceeds 0.1% on one access only (either 3GPP or non-3GPP access), all matched traffic is sent over the other access only. If the measured PLR does not exceed 0.1% on any access, the UE or UPF selects the access based on their own implementation, e.g. the access with lower Packet Loss Rate to transmit all matched traffic".

\*\*\*\* End of Changes \*\*\*\*