3GPP TSG-SA WG4 Meeting post #129e S4aI240177

Electronic Meeting, 26th September–24th October 2024 Revision of S4aI240168

Title: [FS-AMD WT 3b]: Application Considerations with Multi-access media delivery

Agenda Item: 2.6

Source: Samsung Electronics Co Ltd.

Introduction

Document S4aI240132 on the topic of Multi-access media delivery was endorsed during the SA4 Post 129e meeting. This document adds on top of the above document and discusses application considerations with different ATSSS functionalities specified in TS 23501. The present document proposes few gaps and a candidate solution to fill those gaps based on the above application considerations, and discusses some pending work that is still to be completed.

Background and motivation

The input for the application considerations discussed in this document are taken from IETF RFCs and accepted drafts that are adopted into our 3GPP specifications. Specifically, the following are the aspects extracted from the above specifications that are used for discussion to progress the study of this topic:

* Configuration information from the application layer to the lower layers when applications use multipath delivery based on MPTCP and MPQUIC functionalities
* Information exposed to the application layer from lower layers during multipath delivery

Based on the above discussion, high level call flows are presented, and a couple of gaps are identified and documented. A candidate solution to extend existing APIs in our 5GMS System is proposed.

Text proposal

The following textual changes to TR 26.804 **CR0013** are proposed.

\* \* \* \* First change \* \* \* \*

## 2 References

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[MPTCPAPP] IETF RFC 6897: "Multipath TCP (MPTCP) Application Interface Considerations", March 2013

[MPQUICAPP] IETF Draft: "Multipath Extension for QUIC", draft-ietf-quic-multipath-10, July 2024

\* \* \* \* Second change \* \* \* \*

#### 5.15.1.3 Multi-access using ATSSS

##### 5.15.1.3.1 Background Specification for ATSSS architecture

Clause 5.32 of TS 23.501 [23501] describes ATSSS (Access Traffic Steering, Switching, and Splitting) an optional feature supported by the UE and 5G Core network for multi-access. Some of the key principles this feature defines that are relevant for our study are:

1. The ATSSS feature enables a *Multi-Access PDU Connectivity Service* allowing for the exchange of PDUs between the UE and a Data Network by simultaneously using one 3GPP access network and one non-3GPP access network via two independent N3/N9 tunnels between a PDU Session Anchor UPF (PSA UPF) and the RAN/AN.

NOTE 1: The limits on the number and type of access network refer to Release 18 and may differ in subsequent releases.

2. The Multi-Access PDU Connectivity Service is facilitated by a *Multi-Access PDU (MA PDU) Session* that may have User Plane resources on two access networks. In the context of the generalised media delivery architecture specified in TS 26.501 [15]:

- If conveyed over an MA PDU Session, the application flow between the Media Session Handler and the Media AF (e.g., 5GMS AF) at reference point M5 may use two different access networks.

- If conveyed over an MA PDU Session, the application flow between the Media Access Client (e.g., Media Player or Media Streamer) and the Media AS (e.g., 5GMS AS) at reference point M4 may use two different access networks.

3. The UE is supplied with policy rules ("ATSSS rules") by the network for deciding how to distribute uplink traffic across multiple access networks. Similarly, the UPF anchor is supplied with policy rules ("N4 rules") by the network for deciding how to distribute downlink traffic across the two N3/N9 tunnels and the two access networks. The network entity configuring ATSSS rules and N4 rules is the SMF. The SMF may map PCC rules from the PCF to create these ATSSS and N4 rules.

4. The UE indicates its support for ATSSS (steering functionalities and steering modes) in the *PDU Session Establishment Request* that is sent to request a new MA PDU Session.

5. If the UE requests a network slice instance, the same S-NSSAI is allowed to span both access networks.

NOTE 2: Support for QoS when PDUs are conveyed over a PDU Session belonging to a network slice that spans non-3GPP access network is unknown.

6. For QoS support, the same 5G QoS model used for conventional PDU Sessions also applies to MA PDU Sessions, i.e. QoS Flow is the finest granularity of QoS differentiation. However, QoS Flow is access-agnostic: the same network QoS applies to each of the different access network comprising the MA PDU Session, i.e. the same QoS is available across two different paths in different access networks. The network (SMF) may provide QoS rules to the UE via one access network that are used for both the 3GPP access network and non-3GPP access network.

- In the context of the generalised media delivery architecture, application flows at reference point M5 and/or M4 using a MA PDU Session may have similar network QoS as when they are transmitted via the 3GPP access network alone.

NOTE 3: Support for PDU Session QoS when PDUs are conveyed over a non-3GPP access network is unknown.

7. The network may provide Measurement Assistance Information to the UE and/or UPF to assist them in determining which measurements (packet round-trip time measurements, packet loss rate measurements) are to be performed before deciding how to distribute traffic across the two access networks.

8. The ATSSS rules provided to the UE by the network contain information about the type of steering to be used to distribute traffic across multiple access networks. This allows traffic to be steered, switched and split across multiple access networks. From clause 5.32.8 of TS 23.501 [23501], the supported steering mechanism defined in this release are:

- *Higher-layer MPTCP (Multipath TCP) functionality* – The UPF provides MPTCP proxy functionality. Corresponding MPTCP functionality in the UE may communicate with the MPTCP proxy in the UPF to distribute and aggregate traffic across multiple access networks.

- *Higher-layer MPQUIC (Multipath-enabled QUIC) functionality* – The UPF provides MPQUIC proxy functionality. The corresponding MPQUIC functionality in the UE may communicate with the MPQUIC proxy in the UPF to distribute and aggregate traffic across multiple access networks.

- *ATSSS-LL (ATSSS Low-Layer) functionality* – The UPF allows steering, switching, and splitting of traffic across two access networks based on information from the IP layer and below.

9. The ATSSS rules provided to the UE by the network indicate which steering mode is to be applied to matching traffic for each Service Data Flow (SDF). The steering mode determines how the matching traffic is to be distributed across 3GPP and non-3GPP access networks. Supported steering modes in Release 18 include:

- *Active-Standby:* Used to steer matching SDF packets onto one access network (the "Active access") when this is available, and onto another (the "Standby access") when the Active access is unavailable.

- *Smallest Delay:* Matching SDF packets are steered to the access network with smallest packet round-trip time.

- *Load-Balancing:* Used to split the delivery of SDF packets between both the access networks if both of them are available.

- *Priority-based:* Used to steer SDF packets onto an access network with a higher priority.

*- Redundant:* Used to duplicate SDF packets on both access networks if both of them are available.

Figure 5.15.1.3-1 illustrates the traffic steering mechanisms defined in this release by TS 23.501 [23501] and their respective functionalities.



Figure 5.15.1.3-1: Traffic steering mechanisms and their functionalities
in an illustrative UE model specified in TS 23.501 [23501]

For access traffic steering, switching, and splitting procedures, the UE may be provided with up to five different IP addresses by the network:

* one IP address/prefix for the Multi-Access PDU session (allocated regardless of type of steering functionality).
* two IP addresses/prefixes, one bound to each access network, called the “MPTCP link-specific multipath” addresses (if UE and network agree on using MPTCP steering functionality).
* two IP addresses/prefixes, one bound to each access network, called the “MPQUIC link-specific multipath” addresses (if UE and network agree on using MPQUIC steering functionality).

NOTE 1: The MPTCP link-specific multipath addresses and the MPQUIC link-specific multipath addresses may not be routable via N6.

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

To support the operation of media delivery services specified in TS 26.501 [26501], TS 26.506 [26506], and TS 26.502 [26502] with multi-access, there is a need to first document clear potential issues to split, steer, and switch the M4 application flows of these media delivery services based on methods specified in ATSSS architecture.

##### 5.15.1.3.2 Application considerations for multipath TCP

RFC 6897 [MPTCPAPP] specifies two classes of application:

* *Legacy Applications:* These applications are unaware of MPTCP, and therefore use the existing TCP sockets API to interface with the MPTCP layer. This is the default case.
* *MPTCP-aware applications:* These applications are aware of MPTCP functionality, and use an enhanced MPTCP API to interact with the MPTCP layer.

[MPTCPAPP] describes a basic API that is a simple extension of TCP’s interface for MPTCP-aware applications. Following are some of the application interface capabilities with the basic API for an MPTCP-aware application while using MPTCP.

* The application may be able to request to turn on or turn off the usage of MPTCP.
* The application may restrict MPTCP to bind to a given set of IP addresses. The application possesses the capabilities to add a set of new local addresses to an existing MPTCP connection, or to remove a local address from an existing MPTCP connection.
* The application may be able to obtain information on the pairs of addresses used by the MPTCP subflows.
* The application may explicitly configure send and receive buffer sizes via the sockets API (SO\_SNDBUF, SO\_RCVBUF). These socket options can be used with MPTCP to affect the buffer sizes of the MPTCP connection.
* The application may be able to retrieve the local connection identifier for the MPTCP connection.

[MPTCPAPP] also describes requirements on an advanced MPTCP API in its annex, including design considerations, MPTCP usage scenarios and application requirements. Following are some of the potential requirements on an advanced API beyond the features of the basic API listed above available to the application to interface with the MPTCP layer.

* The application may obtain usage information and statistics about all subflows (e.g., the ratio of traffic sent via this subflow).
* The application may request a change in the number of subflows in use, thus triggering removal or addition of subflows. Requesting establishment of a specific subflow to a provided destination, or a request for termination of specific existing subflow may be possible.
* The application may be able to inform the MPTCP implementation about its high-level performance requirements, e.g., in the form or a profile.
* The application may be able to indicate the communication characteristics of the connection (e.g., expected amount and data rate to be sent over MPTCP connection, expected duration of connection etc.). Similar heuristics may be used by the application to manage (create new, or terminate existing) MPTCP subflows.
* The application may be able to specify preferable subflows or subflow usage policies. This could change the behaviour of MPTCP scheduler.
* The application may be able to specify redundancy levels (e.g., specify whether TCP segments are to be sent on one path or more than one path in parallel).
* The application may be able to register for callbacks to be informed when there are changes to subflows of the MPTCP connection.

[MPTCPAPP] also discusses performance improvements for applications resulting from the use of MPTCP. The obvious performance improvement is throughput because the applications is able to pool more than one path between two MPTCP endpoints. Another obvious improvement is application resilience because if one path fails, the other paths are able to carry all the traffic, and if necessary any lost packets on a path may be retransmitted over one or more of the other available paths. However [MPTCPAPP] also discusses two potential problems for applications using MPTCP, especially if they are applications with real-time requirements:

* If the delays of different MPTCP subflows of an MPTCP connection differ, the jitter perceivable to an application may appear higher as the data is spread across multiple subflows. Although MPTCP ensures in-order delivery to the application, the data delivery could be more bursty than with a single-path TCP connection.
* Some middleboxes may refuse to pass MPTCP data segments due to the presence of TCP options, or they may strip TCP options. In this case, MPTCP falls back to regular TCP operation. Although this is not a problem (because the corresponding application session is still ultimately usable for data exchange), there may be additional delays when the first handshake fails.

##### 5.15.1.3.3 Application considerations for multipath QUIC

[MPQUICAPP] specifies a multipath extension for QUIC version 1 to enable simultaneous usage of multiple paths for a single QUIC connection. [MPQUICAPP] also specifies the capabilities of an MPQUIC-aware application to interface with the MPQUIC implementation on the host/device.

* The application using the QUIC multipath extension may use algorithms to define and handle the number of active paths and how they are used to send QUIC packets.
* The application using the QUIC multipath extension may handle the IP addresses and the actual decision process to set up or tear down paths.
* The application using the QUIC multipath extension may specify the maximum number of paths for a QUIC connection by setting the initial\_max\_path\_id parameter or by sending a MAX\_PATH\_ID frame. The application may later revise the maximum number of paths for a QUIC connection.
* The application using the QUIC multipath extension may define strategies to keep one or more paths alive by sending PING frames on those paths before the idle timeout expires.
* The application using the QUIC multipath extension may use the capabilities of the MPQUIC implementation to mainain separate congestion state for each path to avoid sending more data on a given path than congestion control for that path indicates.

According to [MPQUICAPP], an MPQUIC endpoint may use multiple IP addresses simultaneously for a connection. The multipath extension for QUIC supports the following scenarios:

* The client uses multiple IP addresses, and the server listens on only one IP address.
* The client uses only one IP address, and the server listens on multiple IP addresses.
* The client uses multiple IP addresses, and the server listens on multiple IP addresses.
* The client uses only one IP address, and the server listens on only one IP address.

\* \* \* \* Third change \* \* \* \*

#### 5.15.3.2 ATSSS mapping into 5GMS architecture

Figure 5.15.3.1-1 shows the detailed collaboration scenario for multi-access media delivery using different ATSSS steering functionalities described in clause 5.15.1.3 of the present document.



Figure 5.15.3.1-1: Multi-access media delivery using different ATSSS steering mechanisms

In figure 5.15.3.1-2, the UE and the network may negotiate the use of one or more ATSSS steering mechanisms:

1. If the UE and the network agree on using the low-layer steering mechanism (ATSSS-LL) as specified in clause 5.32 of TS 23.501 [23501]:

a. The 5GMS Client and the 5GMS AS are unaware of multi-access media delivery.

b. Traffic steering, switching, and splitting decisions at the UE and UPF are based on information at IP the layer and below.

c. A data switching function in the UE decides how to steer, switch, and split M4 flows across the 3GPP and non-3GPP accesses based on provisioned ATSSS rules and local conditions (e.g., signal loss conditions).

d. Any type of traffic, including the TCP traffic, UDP traffic, Ethernet traffic, etc. from the 5GMS Client may be steered, switched, or split.

2. If the UE and the network agree on using the high-layer MPTCP Steering mechanism as specified in clause 5.32.6.2.1 of TS 23.501 [23501]:

a. The 5GMS Client and the 5GMS AS may be unaware of multi-access media delivery.

b. Traffic steering, switching, and splitting decisions at the UE and UPF are based on information at the IP layer and above.

c. The network enables an MPTCP proxy in the UPF for the multi-access PDU Session.

d. The network allocates three IP addresses/prefixes to the UE – one for the multi-access PDU Session and two additional IP addresses/prefixes called “MPTCP link-specific multipath” addresses associated with each of the 3GPP and non-3GPP Accesses. The “MPTCP link-specific multipath” addresses may not be routable via N6.

e. TCP application flows at reference point M4 from the Media Stream Handler of the 5GMS Client in a UE allowed to use MPTCP functionality are sent to the MPTCP proxy over the two access networks using the two link-specific multipath addresses, and the MPTCP proxy functionality in the UPF uses the multi-access PDU Session IP address/prefix to communicate with the 5GMS AS in the DN.

f. Any non-MPTCP traffic from the 5GMS Client is routed over either the 3GPP Access or the non-3GPP Access based on a received ATSSS rule for non-MPTCP traffic as specified in clause 5.32.2 of TS 23.501 [23501].

3. If the UE and the network agree on using the high-layer MPQUIC Steering mechanism as specified in clause 5.32.6.2.2 of TS 23.501 [23501].

a. The 5GMS Client and the 5GMS AS may be unaware of multi-access media delivery.

b. Traffic steering, switching, and splitting decisions at the UE and UPF are based on information at the IP layer and above.

c. The network enables an MPQUIC proxy in the UPF for the multi-access PDU Session.

d. The network allocates three IP addresses/prefixes to the UE – one IP for the multi-access PDU Session and two additional IP addresses/prefixes called “MPQUIC link-specific multipath” addresses associated with each of the 3GPP and non-3GPP Accesses. The “MPQUIC link-specific multipath” addresses may not be routable via N6.

e. A QoS Flow selection and steering mode selection component in the Media Stream Handler of the 5GMS Client determines the number of multipath QUIC connections to be set up for the application flows at reference point M4. Each QUIC connection carries one QoS flow (based on QoS rules) i.e. each multipath QUIC connection carries the UDP traffic mapped to a single QoS flow

f. QUIC-based UDP application flows at reference point M4 from the Media Stream Handler of a 5GMS Client are sent over the two access networks to the MPQUIC proxy using the two link-specific multipath addresses with multiple QUIC paths, and the MPQUIC proxy functionality in the UPF uses the multi-access PDU Session IP address/prefix to communicate with the 5GMS AS in the DN.

Table 5.15.3.2-1 provides a description of whether the 5GMS Client and/or 5GMS-Aware Application is aware of multi-access media delivery for each of the steering functionalities supported in this release.

Table 5.15.3.2-1

|  |  |  |
| --- | --- | --- |
| Steering functionality | Application awareness | Application transparency |
| ATSSS-LL | No | Yes |
| MPTCP | Yes. 5GMS Client or 5GMS-Aware Application may use API as described in clause 5.15.1.3.2 to control MPTCP behaviour. | Yes. 5GMS Client or 5GMS-Aware Application may use just the standard TCP sockets API as described in clause 5.15.1.3.2 to be transparent with MPTCP functionality. |
| MPQUIC | Yes. 5GMS Client or 5GMS-Aware Application may use API as described in clause 5.15.1.3.3 to control MPQUIC behaviour. | TBD |

\* \* \* \* Fourth change \* \* \* \*

#### 5.15.4.2 Multi-Access media delivery using ATSSS

From clause 5.32 of TS 25.501 [23501] and clause 4.22.3 of TS 23.502 [23502], a Multi-access PDU Session may be set up in one of three different ways:

1. The UE may set up a Single Access PDU Session over one access network, and then register over another access network and request a Multi-access PDU Session to be set up using both the access networks.

2. The UE may indicate its capability for ATSSS, and request the setting up of a Multi-access PDU Session to begin with.

3. The UE may request to set up a Single-Access PDU Session, but the network may transparently set up a Multi-access PDU Session instead.

For simplicity, for the high-level call flows for 5G Media Streaming with multi-access media delivery, the first option above is used. Figure 5.15.4.2-1 shows a high-level call flow for a 5G Media Streaming session over a Multi-access PDU Session that uses two different access networks: a 3GPP access and a non-3GPP access.

Assumptions:

- The 5GMS Client is unaware of the UE ATSSS steering functionality.

- 5G Media Streaming session is set up over 3GPP access first before the UE switches to a Multi-Access PDU Session to use both the access networks.



Figure 5.15.4.2-1: 5G Media Streaming session with multi-access media delivery

The steps are as follows:

1. The UE sets up a Single-Access PDU Session over the 3GPP access using the PDU Session establishment procedure specified in clause 4.3.2 of TS 23.502 [23502]. The 5GMS entities on the UE set up a 5G Media Streaming session over the Single-Access PDU Session as specified in clause 5.2 of TS 26.501 [26501].

2. The Media Stream Handler in the 5GMS Client of the UE interacts with the 5GMS AS for M4 media streaming over 3GPP access.

3. UE requests setting up a Multi-Access PDU Session spanning both the 3GPP access network and the non-3GPP access network with the SMF as specified in claue 5.32 of TS 23.501 [23501]. This request includes UE capabilities for ATSSS multi-access delivery and the UE’s preferred steering functionalities.

4. A decision is made by the SMF to switch the Single-Access PDU Session of the UE to a Multi-Access PDU Session. (The SMF may interact with the PCF to make this decision.)

5. The SMF sends updated ATSSS rules to the UE as specified in clause 5.32 of TS 23.501 [23501].

6. The SMF updates the forwarding behaviour of the UPF for the Multi-Access PDU Session by sending updated N4 rules for multi-access delivery to the UPF. Based on the the received N4 rules, the UPF activates the required steering functionality.

7. The UE-internal component processing the received ATSSS rules activates the UE ATSSS Steering Functionality in the UE.

Editor's Note: The actual name of the UE-internal component processing ATSSS rules is to be clarified, and the figures are to be updated

8. If the highest priority rule in the received ATSSS rules indicates steering of traffic towards a specific access nework (e.g., 3GPP access), then:

- In the uplink direction, the M4 media flows from the Media Stream Handler are sent to the UE ATSSS Steering Functionality, which then forwards the media flows to the UPF over the 3GPP access network, and the UPF forwards the media flows to the 5GMS AS.

- In downlink direction, the M4 media flows from the 5GMS AS are sent to the UPF, which then forwards them to the UE ATSSS Steering Functionality over the 3GPP access network, which then forwards them to the Media Stream Handler in 5GMS Client.

9. If the high priority rule in the received ATSSS rules indicates switching of traffic towards a specific access network (e.g., from 3GPP access to non-3GPP access), then:

- In the uplink direction, the M4 media flows from the Media Stream Handler are sent to the UE ATSSS Steering Functionality, which then forwards the media flows to the UPF over the non-3GPP access, and the UPF forwards the media flows to the 5GMS AS.

- In the downlink direction, the M4 media flows from the 5GMS AS are sent to the UPF, which then forwards the media flows to the UE ATSSS Steering Functionality over the non-3GPP access network, which then forwards them to the Media Stream Handler in 5GMS Client.

10. If the highest priority rule in the received ATSSS rules indicates splitting of traffic between two access networks (e.g., 3GPP access and non-3GPP access), then:

- In the uplink direction, the M4 media flows from the Media Stream Handler are sent to the UE ATSSS Functionality. The UE ATSSS Steering Functionality then splits the M4 media flow traffic according to the criteria defined in the ATSSS rules and distributes it between both the 3GPP access and the non-3GPP access networks when forwarding it to the UPF. The split M4 flows arrive at the UPF where the ATSSS Steering Functionality in the UPF aggregates the split M4 traffic, and then forwards the aggregated M4 flows to the 5GMS AS.

- In the downlink direction, the M4 media flows from the 5GMS AS are sent to the ATSSS Steering Functionality in the UPF. The ATSSS Steering Functionality in the UPF then splits the M4 media flow traffic according to the criteria defined in the N4 rules and distributes it between both the 3GPP access and non-3GPP access networks when forwarding it to the UE. The split M4 flows arrive at the UE. The UE ATSSS Steering Functionality aggregates the split M4 traffic, and then forwards the aggregated M4 flows to the Media Stream Handler in the 5GMS Client of the UE.

Figure 5.15.4.2-2 shows a high-level call flow for a 5G Media Streaming session over a Multi-access PDU Session that uses two different access networks: a 3GPP access and a non-3GPP access, when the 5GMS-Aware Application is aware of ATSSS Functionality in the UE.



Figure 5.15.4.2-2: 5G Media Streaming session with multi-access media delivery when the 5GMS-Aware Application is aware of ATSSS Functionality in the UE

The steps are as follows:

1. A 5G Media Streaming session over a Multi-Access PDU Session is set up as described in steps 1-7 of Fig 5.15.4.2-1 of the present document. This includes setting up ATSSS Functionality in the UE for multi-access media delivery.

2. The 5GMS-Aware Application receives information from the UE ATSSS Steering Functionality that multi-access delivery is being activated. The UE ATSSS Steering Functionality may provide information to the 5GMS-Aware Application about the multipath connection and associated subflows/paths.

3. The 5GMS-Aware Application configures the UE ATSSS Steering Functionality. The configuration information is based on the application configuration information described in clause 5.15.1.3.2 of the present document.

4. The Media Stream Handler in the 5GMS Client interacts with the 5GMS AS using multiple access networks as described in steps 8–10 of figure 5.15.4.2-1 of the present document.

Figure 5.15.4.2-3 shows a high-level call flow of the Dynamic Policy procedure for 5G Media Streaming before and after activation of multi-access media delivery.

Figure 5.15.4.2-3: Dynamic Policy Procedure for a 5G Media Streaming Session with multi-access delivery

The steps are as follows:

1. A 5G Media Streaming session over a Multi-Access PDU Session is set up, and M4 media flows are exchanged by the Media Stream Handler in the UE and 5GMS AS over an access network (e.g., 3GPP access) as described in steps 1–2 of figure 5.15.4.2-1 of the present document.

2. The Media Session Handler in the UE 5GMS Client instantiates a Dynamic Policy in the 5GMS AF to be applied to 5G Media Streaming session as described in clause 5.7.4 of TS 26.501 [26501]. In some cases, a QoS specification may be provided which contains the desired QoS information.

3. The 5GMS AF interacts with the PCF on behalf of the 5GMS Client (directly if the 5GMS AF is deployed in the Trusted DN, or via the NEF if 5GMS AF is in the external Data Network) to facilitate the application of the requested Dynamic Policy.

4. The M4 media flows are transferred between the Media Stream Handler and 5GMS AS over 3GPP access with the requested dynamic policy.

5. A multi-access media delivery session is set up using 3GPP access and non-3GPP access networks as described in steps 3–7 of figure 5.15.4.2-1 and steps 2–3 of figure 5.15.4.2-2 of the present document. The 5GMS-Aware Application may or may not be aware of multi-access media delivery.

6. M4 media flows are transferred over the 3GPP accesss and non-3GPP access, as described in steps 8–10 of figure 5.15.4.2-1.

7. The Media Session Handler interacts with the 5GMS AF to modify the Dynamic Policy as described in clause 5.7.4 of TS 26.501 [26501] so that it applies to the multi-access 5G Media Streaming session.

- If the M4 media flows are exchanged by the Media Stream Handler in the UE and 5GMS AS exclusively over the 3GPP access (as a result of using the high priority rule in the received ATSSS rules reflecting either a traffic steering or traffic switching decision to the 3GPP access), the requested QoS specified in the Dynamic Policy instance may be succesfully applied.

- If the M4 media flows are exchanged by the Media Stream Handler in the UE and 5GMS AS exclusively over the non-3GPP access (as a result of using the high priority rule in the received ATSSS rules reflecting either a traffic steering or traffic switching decision to non-3GPP access), the requested QoS specified in the Dynamic Policy instance may be succesfully applied if the non-3GPP access can guarantee and provide the required policy treatment.

- If the M4 media flows are exchanged by the Media Stream Handler in the UE and 5GMS AS over both the 3GPP access and the Non-3GPP access (as a result of using the high priority rule in the received ATSSS rules reflecting a traffic splitting decision to both 3GPP access and non-3GPP access), the requested QoS specified in the Dynamic Policy instance may be succesfully applied if the non-3GPP access can guarantee and provide the required policy treatment to the traffic it carries.

\* \* \* \* Fifth change \* \* \* \*

#### 5.15.5.2 Multi-Access media delivery using ATSSS

The following potential open issues are identified in the specific case where multipath delivery is not transparent to the 5GMS-Aware Application:

1. There is no specification related to informing the 5GMS-Aware Application of multiple paths when the UE is using ATSSS-based multipath media delivery.
2. There is no specification related to configuration of multiple paths by 5GMS-Aware Application when the UE is using ATSSS-based multipath media delivery.

In addition, the existing procedures for Dynamic Policies do not allow the 5GMS Client to request policy treatment over a specifc access network if the M4 flows are exchanged using multiple access networks. This is due to the fact that the currently specified data model parameters for dynamic policy procedures (as described in clause 5.15.1.4 of the present document) do not allow for identification of specific paths if multiple paths are possible between the UE and the 5GMS AS. Specifically, the sourceAddress and destinationAddress parameters of IPPacketFilterSet used in the Application‌Flow‌Description type (as described in clause 5.15.1.4 of this present document) both use the IP addresses of the Multi-Access PDU Session (as described in clause 5.15.1.3.1 of present document) assigned to the UE and UPF Steering Functionalities.

For identification of specific path, it is required that either the MPTCP link-specific multipath addresses or the MPQUIC link-specific multipath addresses be used, but these addresses are not routable via N6 (see clause 5.15.1.3.1 of present document), so these IP addresses are not candidates for use during the Dynamic Policy instantiation request that is to be sent to the 5GMS AF over N6.

This is an issue if one of the paths is a problematic path in a multipath environment as described in clause 5.15.1.3.2 of the present document. However, according to clause 5.32.4 of TS 23.501 [23501], traffic splitting for GBR QoS Flows is not supported. So, if M4 media flows are transported as GBR QoS Flows, then traffic splitting of M4 media flows using ATSSS is not supported in this release, and the study needs to be revisited in a future release.

Editor's Note: The Rel-18 ATSSS specification does not support traffic splitting for GBR QoS Flows between 3GPP and Non-3GPP accesses. The ATSSS specification work in future releases is to be monitored, and referenced here when there is an update.

\* \* \* \* Sixth change \* \* \* \*

#### 5.15.6.1 Multi-access downlink media streaming using CMMF

This candidate solution includes approaches where a 5GMSd Client accesses and downloads, via reference point M4d, CMMF-encoded media objects [CMMF – reference included within CR adding clause 5.19], and possibly original source media (e.g., MPEG-DASH or HLS media segments), over multiple access networks simultaneously from a single 5GMSd AS. CMMF (discussed in detail within clause 5.19.6.3) enables multi-access capabilities through application-layer implementations of the 5GMSd Client without requiring lower-layer (e.g., network, transport, etc.) multi-access integrations.

In this solution, multiple different CMMF-encoded bitstreams/objects (or representations) of the source media are stored/cached within a single logical 5GMSd AS. A CMMF-enabled 5GMSd Client requests and downloads a different CMMF-encoded representation (stripe) of the required original source media over each of the access networks available to it. These (potentially partially) received CMMF bitstreams/objects are decoded by a CMMF decoder in the 5GMSd Client yielding the required original source content once enough information has been received over all of the available access networks.

Unlike other multi-access technologies such as MPTCP, MPQUIC, ATSSS, etc., the responsibility to set up, request, and steer the delivery of content across each available access network rests with the application layer (e.g., Media Player) in this solution. For example, a Media Player sets up multiple HTTP connections in parallel, each one bound to a different network interface (each assigned with an IP address appropriate to that network). Requests to a single 5GMSd AS for different CMMF-encoded representations (stripes) of the original source media are sent from each of the HTTP connections over the different access networks. The HTTP response from the 5GMSd AS to each of these requests is routed appropriately over the appropriate access network, following standard network-layer/IP routing rules and procedures.

As mentioned above, traffic steering over each access network may be performed by the application layer (e.g., Media Player); and multiple policies can be defined/implemented based on the desired outcome. For example, a best-effort policy may evolve downloading as much CMMF-encoded content from each available access network until the CMMF decoder can successfully decode the required media. Networks that have lower latency, higher bandwidth, etc. will naturally contribute more to the download than those with higher latency, lower bandwidth, etc. Another policy may preference delivery of content from one access network over another. In this case, a schedular may be implemented so that requests of CMMF-encoded content made to the Application Server can be throttled over one access network so that the majority of the download is completed on the other(s).

Integration of CMMF within the 5GMS System is discussed in detail within clause 5.19.6.3.

\* \* \* \* Seventh change \* \* \* \*

#### 5.15.6.2 Multi-Access media delivery using ATSSS

To address the gaps identified in clause 5.15.5.2, it is proposed to extend the media stream handling client API exposed by the Media Stream Handler to the 5GMS-Aware Application at reference point M6 and to the Media Session Handler at reference point M11 as follows:

1. For the 5GMS-Aware Application to configure the following multipath delivery parameters:

- Enable/disable multipath media delivery.

- The number of MPQUIC paths or MPTCP subflows in the multipath delivery connection.

- Add new or remove existing MPQUIC path or MPTCP subflows to/from the multipath delivery connection

- Which media application flows are mapped onto which MPQUIC path or MPTCP subflow.

These objectives may be achieved by modifying the Configurations and settings API specified in clause 13.2.4 of TS 26.512 [16].

2. For the 5GMS-Aware Application to be informed of the following:

- Connection endpoint information to each of the MPQUIC path or MPTCP subflow.

- Status information of multipath delivery connection.

 These objectives may be achieved by modifying the Dynamic Status Information specified in clause 13.2.6 of TS 26.512 [16] for this purpose is TBD.

Editor's Note: Detailed formats of the above information are to be developed in conjunction with study progress documented in clause 5.24 of present document.

\* \* \* \* End of changes \* \* \* \*