Source: Samsung Electronics Co. Ltd

**Title: [FS\_AMD] Discussion on 5GMS Aspects for Multi Access**

**Agenda Item: 8.9**

**Document for: Discussion and Agreement**

# **Introduction**

During SA4#127 meeting, a new study on Advanced Media Delivery (FS\_AMD) in document S4-240518 was agreed in SA4, and later in SA#103 meeting SP-240514. One of the topics of this study is Multi-CDN and Multi-Access Media Delivery. Specifically, the extract for scope of work related to Multi-Access Media Delivery in the agreed study item is as follows:

***Multi-CDN and Multi-Access Media Delivery****: …….. Further extensions include the ability for a client to use multiple access networks at the same time to support media delivery. Study of integration of different technologies into the Media Delivery System is of relevance to address content provisioning, content hosting, impacts on user plane reference points M2 and M4, and on media session handling at reference point M5 as well as potential benefits in terms of quality and resource usage.*

This contribution discusses some background information for Multi-Access related specification in 3GPP SA2, and further discusses some of the 5G media delivery features that may need to be studied with Multi-Access.

# **Background**

# **2.1 ATSSS (Access Traffic Steering, Switching, Splitting) Standardization in 3GPP**

Multi-access is specified by 3GPP SA2 as an optional feature ATSSS (Access Traffic Steering, Switching, Splitting) in the 5G System in clause 5.32 of TS 23.501 [23501]. Some of the key principles this defines 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 and the RAN/AN.

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:

- If conveyed over an MA PDU Session the application flow between the Media Session Handler and the Media 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 and the Media 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 an S-NSSAI, the same S-NSSAI is allowed on both the access networks.

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.

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

8. The ATSSS rules provided to the UE by the network contain information about the type of steering functionality to be used to distribute traffic across multiple access networks. Steering functionality is the functionality that can steer, switch, and split traffic across multiple access networks. From clause 5.32.8 of TS 23.501 [23501], supported steering functionalities include:

- 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 – Functionality that allows steering, switching, and splitting of traffic across two access networks based on information from IP layer and below.

9. The ATSSS rules provided to the UE by the network indicates which steering mode is to be applied to matching traffic for each Service Data Flow (SDF). 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.

# **2.2 Research and Literature**

The two main multi-access packet steering functionalities supported by the 5G System in Release 18 are multipath TCP (MPTCP) and multipath QUIC (MPQUIC). This clause presents some background research literature on these two functionalities and on the topic of multipath media streaming in general.

- [1] explores whether MPTCP benefits mobile media streaming, especially DASH, and concludes that MPTCP performs better than TCP when the bandwidth on the two paths is constant and in cases where a secondary link with low bandwidth is added to the highly variable primary link. However, the paper finds that when an unstable secondary path is added to a stable primary path, MPTCP performs worse. It concludes that MPTCP is sensitive to bandwidth fluctuation which may cause DASH to underperform.

- [2] presents a similar analysis to [1] that DASH benefits from the improved aggregated throughput provided by MPTCP; yet the inter-path throughput difference and intra-path throughput fluctuation have noticeable (negative) impact when using MPTCP, resulting in lower bit rates or frequent rebuffering even if high bandwidth paths are available.

- [3] presents a detailed survey of work related to multipath wireless streaming. Regarding DASH with MPTCP, one topic that [3] discusses is that the rate adaptation logic for DASH is on the client side while the MPTCP scheduler (for scheduling decisions related to packet selection and distributing them) is on the server side. [3] presents literature comparing MPTCP performance limitations (e.g., out-of-order packets, head-of-line blocking due to the ARQ mechanism, frequent throughput fluctuation and unnecessary fast retransmission, content-agnostic traffic scheduling) with the relatively simpler and cleaner MPQUIC in the context of adaptive media streaming.

- On the contrary, [5] compares MPTCP with MPQUIC for adaptive media streaming (DASH) in a Wi-Fi and LTE testbed environment and shows that MPTCP outperforms MPQUIC in terms of available bandwidth and number of video quality switches.

- [4] presents a survey of multipath transport protocols in the context of 5G Access Traffic Steering, Switching, and Splitting (ATSSS), the main enabler behind multi-access in the 5G System. It reviews current standardization activities (around multi-connectivity and ATSSS architecture) and multipath transport protocols covering core functionalities such as path management, scheduling, congestion control and reliable transfer. It discusses the integration of multipath transport with ATSSS to satisfy eMBB and URLLC service requirements.

# **2.3 Proposed Topics for study**

Based on standardization in 3GPP and background literature for multipath transmission, below are few study topics when analyzing multi-access for 5G media delivery:

1. Preferred steering functionalities for media delivery: As discussed in clause 2.1 of this document, TS 23.501 supports three different steering functionalities (MPTCP, MPQUIC, ATSSS-LL). There exists literature on pros and cons of some of these steering functionalities for video streaming. While most of the existing literature suggest MPQUIC over MPTCP for multipath video streaming, it is beneficial if SA4 looks more closely for advantages of each of the options, and potentially specify the preferred option(s).
2. Provisioning to impact traffic steering, switching, and splitting of 5G media delivery session traffic: In clause 2.1 of this document, it is observed that SMF, based on policy rules from PCF, creates or updates ATSSS and N4 rules and forwards them to UE and UPF respectively. In TS 26501, there are provisioning aspects over M1 (e.g., dynamic policy, QoS provisioning) because of which 5GMS AF interacts with PCF to enable those features. It can be studied if any provisioning enhancements on M1 are useful/needed to impact creation/modification of ATSSS and/or N4 rules (via PCF) thereby enabling network/Application Provider initiated traffic steering, switching, and splitting of 5G media delivery session traffic
3. QoS Management: TS 26.501 and TS 26.510 specify QoS specifications (M1QoSSpecification, M5QoSSpecification) for provisioning and dynamic policy. While these were specified keeping in mind a simple TCP transport for 5G Media Streaming session, it needs to be studied if any of the above QoS specifications are to be enhanced for a multipath transport with multiple accesses in context of generalized media delivery architecture being developed.
4. Traffic steering, switching, and splitting of 5G media delivery session traffic: It is to be studied whether 5G media delivery session traffic (M4 and M5 flows) can actually be steered, switched and split across multiple accesses and still guarantee the required QoS (M5 traffic is lightweight compared to M4, so expect lower impact to M5 traffic because of ATSSS), and if any conditions can be provisioned or configured for such processes to take place.
5. Possible enhancements to network assistance and reporting (metrics and consumption): It can be studied if current network assistance information and reporting information (for both metrics and consumption) can be enhanced for multiple accesses (e.g., possibly separate information for each access?).

# **Multi-Access for 5G Media Delivery**

### 3.1 Description

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. With ATSSS, a Multi-Access PDU Session (MA PDU Session) enables the exchange of PDUs between the UE and the UPF by simultaneously using one 3GPP access network and one non-3GPP access network. Clause 5.32 of TS 23.501 [23501] also describes steering functionalities and steering modes that can be used to distribute traffic across multiple access networks, and how policy rules ("ATSSS rules" acting between the network and the UE, and "N4 rules" between the network and the UPF) enable such distribution of application traffic across multiple access networks.

In the context of the generalized media delivery architecture, the application flow between the Media Session Handler and the Media AF at reference point M5 may span two different access networks if conveyed over an MA PDU Session. Similarly, an application flow between the Media Access Client and the Media AS at reference point M4 may span different access networks. To support the operation of media delivery sessions across multiple access networks, it is to be studied how the ATSSS architecture impacts media delivery features specified in TS 26.501 [26501], TS 26.506 [26506] and TS 26.502 [26502]. Specifically, the following can be studied:

- Impacts on provisioning procedures and whether any enhancements are useful/needed to enable media delivery session over multiple access networks.

- Impact on media session handling procedures, in particular dynamic policies, network assistance and reporting and whether these functionalities need to be enhanced to support multiple access networks.

Consequential impacts on stage-3 specifications are also studied.

### 3.2 Collaboration Scenario

Editor’s Note: Study collaboration scenarios between the 5G System and Application Provider for each of the key topics.

### 3.3 Architecture Mapping

Editor’s Note: Based on existing architectures, develop one or more deployment architectures that address the key topics and the collaboration models.

### 3.4 High-Level Call Flow

Editor’s Note: Map the key topics to basic functions and develop high-level call flows.

### 3.5 Gap Analysis and Requirements

The following potential open issues are identified:

1)

3) Possible enhancements to provisioning of the Media Delivery System at reference point M1 to impact access traffic steering, switching, and splitting across multiple accesses – Enhancements to M1 interface

4) QoS Management while transporting media delivery traffic over multiple access networks. Applicable stage 2 and stage 3 aspects related to impacts on the QoS specifications at reference points M1 and M5 resulting from the presence of multiple access networks.

5) Possible enhancements to dynamic policy, network assistance and reporting (metrics, consumption reporting) media session handling functionalities – Impacts to M5 interface

### 3.6 Candidate Solutions

Editor’s Note: Candidate solutions for identified key issue.

### 3.7 Summary and Conclusions

Editor’s Note: Conclusion at end of study of key issue.

# **References**

[1] Cyriac J,. Emir H., Mea W., Rittwik J., Shankarnarayanan, “Is Multipath TCP (MPTCP) Beneficial for Video Streaming over DASH?, IEEE Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunication Systems, 2016

[2] Jia z., Jiangchuan L., Cong Z., Yong C., Yong J., Wei G., “MPTCP+: Enhancing Adaptive HTTP Video Streaming over Multipath”, IEEE/ACM 28th Symposium on Quality of Service (IWQoS), 2020

[3] Samira A., Vanessa T., Christian E.R., Prakash K., Imed B., “A Holistic Survey of Multipath Wireless Video Streaming”, Journal of Network and Computer Applications, March 2023

[4] Hongjia W., Simone F., Giusepe C., Ozgu A., Anna B., “A Survey on Multipath Transport Protocols Towards 5G Access Traffic Steering, Switching, and Splitting”, IEEE Access, 2021

[5] Przylucki S., Czerwinski D., “The simulation study on the multipath adaptive video transmission”, International conference of Computational Methods in Engineering Science, 2019

# **Proposal**

We propose to add clause 3 of this contribution to the TR for the FS\_AMD study.