Standardization and Functionalities of ATSSS in 5G Networks

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***Abstract*—Access Traffic Steering, Switching, and Splitting (ATSSS) is a key capability introduced in the 3GPP 5G Core system to enable efficient use of multiple access networks, including both 3GPP and non-3GPP accesses. By leveraging multipath transport protocols and policy-based control, ATSSS allows operators to optimize traffic distribution, enhance service reliability, and improve user experience. This paper provides an overview of ATSSS standardizations in 3GPP, describes the technical descriptions, and discusses future directions.**

***Index Terms*—Access Traffic Steering, Switching, and Splitting, ATSSS, Mobile Core Network, 3GPP standard,**

I. Introduction

Access Traffic Steering, Switching, and Splitting (ATSSS) is a core capability introduced in the 5G System (5GS) architecture to enable the efficient and seamless utilization of multiple access technologies. ATSSS provides the ability to dynamically control the flow of user data across different access networks, including both 3GPP accesses (e.g., 5G NR) and non-3GPP accesses (e.g., WLAN), based on operator-defined policies and real-time network conditions. Through this mechanism, operators can enhance user experience by optimizing throughput, improving service reliability, and maintaining session continuity even under varying network conditions.

The ATSSS framework was first introduced in 3GPP Release 16, marking the beginning of multi-access traffic integration in the 5GS. In this release, 3GPP Technical Specification (TS) 23.501 defined the architectural framework for ATSSS, including policy-based access selection, traffic steering principles, and the integration of Multipath Transmission Control Protocol (MPTCP) as a transport mechanism [1]. 3GPP TS 23.502 detailed the operational procedures for steering, switching, and splitting traffic flows across accesses [2], while TS 23.503 specified the policy control aspects that govern ATSSS behavior through the Policy Control Function (PCF) [3].

Since its introduction, ATSSS has continued to evolve through subsequent 3GPP releases such as improved ATSSS-LL capabilities, finer policy granularity, and extended support for multipath QUIC. These continuous updates reflect the growing demand for seamless multi-access integration to meet the diverse requirements of emerging 5G and beyond services.

This research was supported by National Research Foundation (NRF) of Korea Grant funded by the Korean Government (MSIT) (No. RS-2024-00451909).

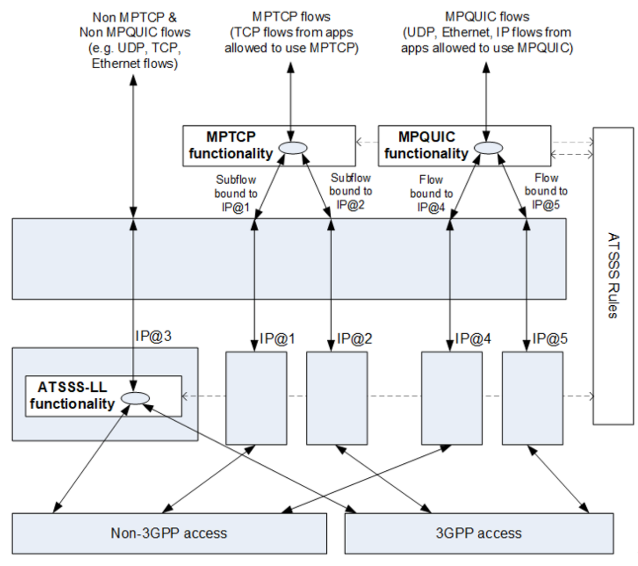

Fig. 1. Steering functionalities in ATSSS [1]

In this paper, Section II provides a technical explanation of the ATSSS framework. Section III discusses the future prospects of ATSSS.

II. ATSSS

The Access Traffic Steering, Switching, and Splitting (ATSSS) framework in the 5G System (5GS) enables multi-access integration by providing mechanisms to steer, switch, and split traffic between 3GPP access (e.g., NR) and non-3GPP access (e.g., WLAN), as illustrated in Fig. 1. To achieve this functionality, ATSSS coordinates flow identification, policy enforcement, and transport protocol configuration across both the control plane and the user plane.

For a multi-access (MA) Protocol Data Unit (PDU) service, the User Equipment (UE) can request the establishment of an MA PDU session when it is registered via one or both access networks. In this case, the PDU session request message includes an MA PDU request type. Upon receiving the request, the Access and Mobility Management Function (AMF) informs the Session Management Function (SMF), which then establishes the necessary user-plane resources. During session establishment, the UE provides its ATSSS capabilities, such as supported steering functionalities and steering modes.

Steering functionalities are realized differently depending on the transport protocol: TCP flows can leverage Multipath TCP (MPTCP), while UDP, IP, and encrypted traffic benefit from Multipath QUIC (MPQUIC). In addition, ATSSS-LL (Low Layer) provides support for all traffic types, but without relying on enhanced multipath transport protocols. This ensures that ATSSS functionalities can be applied universally across diverse services, even in scenarios where end-to-end multipath capabilities are not available.

Within this framework, several steering modes have been specified to control how user traffic is distributed across multiple accesses. In the Active–Standby mode, traffic is transmitted through the active access while a standby access remains idle but ready to take over in case of failure. The Smallest Delay mode directs traffic to the access with the lowest round-trip time (RTT), typically for non-GBR flows where latency minimization is crucial. The Load-Balancing mode distributes traffic across different accesses according to predefined ratios, also applicable to non-GBR services. In the Priority-Based mode, all traffic of a service data flow (SDF) is initially directed to the higher-priority access; if congestion occurs, traffic is split across both accesses, and if the preferred access becomes unavailable, the flow is switched to the lower-priority access. Congestion detection in this mode is implementation-specific. The Redundant (Without Threshold Values) mode duplicates traffic across multiple accesses, with implementation choices determining how many packets are duplicated and whether duplication occurs at the UE or UPF. Typically, traffic is sent primarily through one access, while duplication may occur over the other. Finally, the Redundant (With Threshold Values) mode applies duplication selectively, based on performance thresholds such as packet loss rate or RTT. This approach allows redundancy to be triggered dynamically for non-GBR flows when reliability or latency requirements demand it.

Beyond the definition of steering modes, additional indicators and parameters further refine how traffic distribution is executed. A steering mode indicator is used to signal which steering method is applied. In the case of load balancing, two further enhancements are possible. The autonomous load-balance indicator allows the UE to autonomously determine its own traffic-splitting ratios in the uplink direction, with the objective of maximizing aggregated bandwidth. By contrast, the UE-assistance indicator provides guidance from the network, instructing the UE to adjust its uplink distribution according to its internal state—for example, reducing reliance on a power-hungry access when operating with a low battery in order to minimize energy consumption. Threshold values can also be introduced for specific modes such as priority-based steering, load-balancing with fixed split ratios, or redundant transmission. These thresholds are applied in combination with measured performance parameters, such as RTT or packet loss rate, to determine how traffic should be steered or duplicated. For instance, in the redundant mode, traffic may be sent exclusively over the primary access under normal conditions, but duplicated over both accesses once the packet loss rate exceeds a defined threshold. Such mechanisms provide flexible, context-aware traffic management, enabling ATSSS to meet a wide range of application and service requirements.

Once the MA PDU session is established, the UE determines how to distribute uplink traffic across the available accesses based on both the network-provided ATSSS rules and local conditions, such as interface availability, packet loss, or user preferences. Downlink traffic distribution is determined by the UPF anchor in accordance with ATSSS rules received from the SMF (via N4 rules) and feedback from the UE over the user plane, including access availability status.

From a policy perspective, when dynamic Policy and Charging Control (PCC) is applied to the MA PDU session, the Policy Control Function (PCF) generates ATSSS-related PCC rules containing session control information. These rules define how uplink and downlink traffic should be distributed across the available accesses. The SMF translates PCC rules into ATSSS rules for the UE and N4 rules for the UPF. If dynamic PCC is not used, the SMF applies local policy for traffic distribution decisions.

Regarding Quality of Service (QoS), the 5G QoS framework for single-access sessions is also applied to MA PDU sessions, ensuring access-agnostic QoS control. The SMF provides the same QoS Flow Identifier (QFI) across both 3GPP and non-3GPP accesses. If the SMF detects that resources cannot be allocated on one access, it informs the PCF of the failure and identifies the affected access type. If resources cannot be allocated on either access, the SMF releases the session resources and reports the removal of the corresponding PCC rules to the PCF.

The network may also provide the UE with measurement assistance information to support decision-making for traffic steering in MA PDU sessions. This information specifies which measurements the UE should perform across both accesses and whether reports should be sent to the network (e.g., UPF). Measurements may include round-trip time, packet loss rate, and access availability, enabling adaptive and policy-compliant multi-access operation.

III. Conclusion

ATSSS represents a major step toward seamless multi-access integration in 5G networks, enabling operators to optimize connectivity across heterogeneous access technologies. With ongoing enhancements in QoS monitoring, AI-assisted decision-making, and support for NTN, ATSSS is poised to play a central role in beyond-5G and 6G systems. Future directions include the integration of context-aware policy adaptation, tighter coupling with application-layer requirements, and further protocol optimization for ultra-reliable and latency-sensitive services such as industrial automation and XR.

ACKNOWLEDGMENT

This research was supported by National Research Foundation (NRF) of Korea Grant funded by the Korean Government (MSIT) (No. RS-2024-00451909).

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