**SA WG2 Meeting #139 S2-2004236rev01**

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**Source: Huawei, HiSilicon, InterDigital Inc., Apple?**

**Title: Solution for KI#2: Edge relocation based on MPTCP**

**Document for: Approval**

**Agenda Item: 8.3**

**Work Item / Release: FS\_enh\_EC / Rel-17**

***Abstract of the contribution:*** *This contribution proposes a solution to KI#2 on Edge relocation based on the usage of MPTCP.*

# 1 Introduction

This solution addresses Key Issue #2 on Edge relocation.

In TR 23.748, Key Issue #2 on Edge Relocation lists aspects to be considered in potential solutions. In this paper, we are focusing on the following aspects:

*- How to handle coordination of change of the Edge Application Server and PSA to support seamless change, e.g. preventing packet loss. This should consider the already specified mechanisms in TS 23.502 [3] clause 4.3.6.3 "Notification of User Plane Management Events"*

# 2 Discussion

Due to the nature of UE mobility, EAS, PSA or both may need to be relocated accordingly due to e.g., path optimization requirements on low latency services, e.g. V2X services, load balancing or service availability upon system failure.

Although Rel. 16 UPF with ULCL capabilities may enable UE IP to remain unchanged during UE mobility, this is usually not the case should the EAS IP change during EAS relocation, which implies a re-initiation of TCP or UDP socket on UE side, causing service interruption.

This paper provides a solution to address KI#2, specified in subclause 5.2 and in particular:

“*Coordination of change of the Edge Application Server and PSA to support seamless change, e.g. preventing packet loss”*,

*“it should consider the already specified mechanisms in TS 23.502 [3] clause 4.3.6.3 "Notification of User Plane Management Events"*” and

*“Change of the DNAI depending on the location of the UE to better serve the UE. This may imply EAS IP address change but in some cases the old EAS may be kept as long as the UE transaction is not over“.*

This solution enables the change of PSA, in coordination with the EAS relocation, by re-using some concepts of the MA-PDU session and path-switching mechanism based on the MPTCP option that was defined during the ATSSS study.

This contribution proposes that the ATSSS mechanism, defined in TS 23.501, section 5.32, supporting a MA-PDU session using MPTCP functionality be enhanced to enable coordinated EAS relocation as depicted in Figure 1.



**Figure 1.: Enhance ATSSS-based Non-roaming and Roaming with Local Breakout architecture**

The following summarizes aspects of the current Rel.16 MPTCP-based ATSSS functionality that are used, as well a summary of the proposed enhancements:

***Aspects of the solution aligned with MPTCP-based ATSSS functionality:***

Similar with the ATSSS feature defined in R16, the PSA UPFs providing communications towards the EASs are enhanced to support MPTCP proxy functionality. The MPTCP functionality in the UE communicates with an associated MPTCP Proxy functionality in the local PSA UPFs, by using the MPTCP protocol. Then the connection between the UE and EAS in the transport layer is split, by the MPTCP proxy functionality, into an MPTCP subflow between the UE and PSA UPF and a normal TCP connection between the PSA UPF and the EAS.

As supported by the ATSSS feature defined in R16, the network allocates one IP address/prefix (i.e. IP@1) to UE for the PDU Session and two additional IP addresses/prefixes (i.e. IP@2a and IP@2b). These two IP addresses/prefixes are used only by the MPTCP functionality in the UE and each of them may not be routable via N6. The MPTCP functionality in the UE shall use these two additional addresses/prefixes to establish subflows between the UE and local PSAs, and the MPTCP Proxy functionality shall use the IP address/prefix of the PDU session for the communication with the final destination (i.e. EAS1 or EAS2).

***Aspects of the proposed solution that differ from MPTCP-based ATSSS functionality:***

The current Rel.16 MPTCP-based ATSSS functionality allows an MPTCP session to be associated to one PSA. In contrast, the solution proposed in this contribution enables an MPTCP Session on the UE to be associated to multiple PSAs (i.e. multiple MPTCP Proxys) creating two MPTCP subflows of one MPTCP session over two different PSA UPFs, as depicted in Figure. 1

Having a sub-flow (IP@2a) with a first PSA1 and then establishing another sub-flow (IP@2b), for the same MPTCP session, with a target PSA2 enables the support of PSA change, without impacts on the UE application layer. The path switching is implemented in the transport layer based on the MPTCP mechanism. The mechanism is depicted in Figure 2

In addition, the SMF is enhanced to enable the transfer of MPTCP session context from the PSA1 to PSA2 via the N4 interface.



**Figure 2: MPTCP functionality in UE and MPTCP proxy functionality in PSA UPF**

***Two-phase coordinated PSA-EAS relocation mechanism***

The Edge Application Server may be relocated as well due to UE mobility and the change of PSA.

In order to have a coordinated change of PSA and EAS, a 2 phases mechanism is proposed, i.e. a preparation and completion phase, as illustrated in figure 3. Coordinating the PSA change and EAS relocation allows an efficient relocation, transparent to the UE’s application layer.

Once the decision to change the PSA is taken in the network, the AF is informed. Based on this information, a decision may be taken from an entity out of the 3GPP scope to relocate the EAS. A first phase is defined where the EAS relocation (e.g. select the target EAS, transfer UE’s application context, etc) is started (1a). During this phase, the 3GPP network also prepares the PSA change, e.g. selects the target PSA2 (1b), instantiates MPTCP Proxy if not already running, transfers the UE’s MPTCP context to the target PSA2 (1c), and establishes a sub-flow between the UE and the target PSA2, etc.) (1d). This preparation phase enables the last phase, i.e. the relocation completion, to be finalized very quickly, without disturbing the data exchange.

This completion phase, (e.g. enabling the usage of the MPTCP sub-flow to the target PSA2, establishment of a TCP session toward the target EAS, etc.) may then finalize the PSA change and EAS relocation very quickly, without disturbing the data exchange (2).



**Figure 3: EAS relocation with change of the DNAI due to UE’s mobility**

# 3 Proposal

It is proposed to add the following solution in TR 23.748.

First change

## 6.0 Mapping of Solutions to Key Issues

|  |  |
| --- | --- |
|  | Key Issues |
| Solutions |  | 2 |  |  |
| x |  | x |  |  |
|  |  |  |  |  |
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Next changes (all new text)

## 6.X Solution #X: EAS relocation coordinated with PSA change

This solution is for Key Issue #2 on Edge relocation.

### 6.X.1 Description

This solution addresses KI #2 and enables the change of PSA, in coordination with the EAS relocation, by re-using some concepts of the MA-PDU session and path-switching mechanism based on MPTCP that was defined during ATSSS study.

As defined in TS 23.501, section 5.32, the support of MA-PDU session is enabled using MPTCP functionality, i.e. MPTCP on the UE and MPTCP Proxy on the PSA. In summary, the UE and the UPF may establish 2 MPTCP sub-flows (or data paths) from 2 different ANs (e.g. 5G and WiFi). The MPTCP Proxy on the UPF establishes a TCP session with e.g. the destination server. DL data is sent from the server to the UPF via the TCP session. The MPTCP Proxy uses one of the MPTCP sub-flows to forward data to the UE. The same is done in the UL direction, i.e. UE sends data using either of the MPTCP sub-flows and the MPTCP Proxy forwards this data to the server via the TCP session. This is illustrated in Figure 6.X.1.1-1 extracted from TS 23.501, section 4.2.10.



Figure 6.X.1-1: Non-roaming and Roaming with Local Breakout architecture for ATSSS support

In this contribution the ATSSS mechanism for MA-PDU session using MPTCP protocol is enhanced to enable an MPTCP Session on the UE to be associated to multiple PSAs (i.e. multiple MPTCP Proxys). Having a sub-flow with a first PSA1 and then establishing another sub-flow, for the same MPTCP session, with a target PSA2 enables the support of PSA change.

The Edge Application Server may be relocated as well due to UE mobility and the change of PSA. In order to have a coordinated change of PSA and EAS, a 2 phases mechanism is proposed, i.e. a preparation and completion phase. Coordinating the PSA change and EAS relocation allows an efficient relocation, transparent to the UE’s application layer.

### Once the decision to change the PSA is taken in the network, the AF is informed. Based on this information, a decision may be taken from an entity out of the 3GPP scope to relocate the EAS. A first phase is defined where the EAS relocation (e.g. select the target EAS, transfer UE’s application context, etc) is started. During this phase, the 3GPP network also prepares the PSA change, e.g. selects the target PSA2, instantiates MPTCP Proxy if not already running, transfers the UE’s MPTCP context to the target PSA2, and establishes a sub-flow between the UE and the target PSA2, etc.). This preparation phase enables the last phase, i.e. the relocation completion, to be finalized very quickly, without disturbing the data exchange.

### The completion phase, (e.g. enabling the usage of the MPTCP sub-flow to the target PSA2, establishment of a TCP session toward the target EAS, etc.) may be triggered upon receipt of AF response to a Late Notification and it may then finalize the PSA change and EAS relocation very quickly, without disturbing the data exchange.

Two MPTCP proxies does not share receive window.

Editor’s Note: It is FFS wheter it is compliant to IETF MPTCP architecture.

Editor’s Note: It is FFS how two MPTCP proxies share the MPTCP control block defined in RFC8684.

### 6.X.2 Procedures

#### 6.X.2.1 PSA change and EAS relocation coordination

Figure 6.X.2.1-1 illustrates the procedure for PSA change and EAS relocation coordination. It is assumed that the AF is interacting with the source and target EASs, or with another entity interacting with those EASs. The AF then interacts with 5GC NFs to coordinate the PSA change and EAS relocation.



Figure 6.X.2.1-1: PSA change and EAS relocation coordination

1. UE establishes an MA-PDU session with MPTCP steering mode.
2. UE is assigned with an IP address (IP@2a), which is associated with PSA1, to be used with MPTCP functionality. IP@2a is allocated by PSA1, and provided by the SMF via SM NAS message.
3. An MPTCP sub-flow is created, using IP@2a on UE’s side. The MPTCP Proxy on PSA1 establishes a TCP session with the EAS1. Data is exchanged from the UE to the PSA1 over the MPTCP sub-flow. PSA1 forwards this UL data to the EAS1 over the TCP connection. The reverse is done in DL direction, i.e. EAS1 sends data for the UE over the TCP connection with PSA1. MPTCP Proxy forwards this data to the UE over the MPTCP sub-flow.
4. UE moves. SMF decides to insert/change UL CL and allocate another UPF/PSA2. The AF, which has previously registered to UE mobility events, is informed that the UE has moved and that a new PSA has been selected. This triggers the EAS relocation preparation phase. AF informs SMF that EAS relocation is in preparation phase.
	1. The AF interacts with the source and target EASs, or to another entity interacting with the EASs, to start the EAS relocation. EAS may stop or slow-down data transmission. This is at the application level and specified only to illustrate the relocation coordination. The interaction between the AF and EASs is out-of-scope of 3GPP.
5. SMF interacts with PSA1 to obtain the MPTCP context related to the MPTCP session with the UE. The MPTCP context includes e.g. security keys, tokens, MPTCP session sequence number. Information related to the sub-flow on PSA1 is not transferred to PSA2 since this sub-flow may not be used by PSA2.
6. SMF provides the obtained MPTCP context and UE’s PDU Session IP address to the selected PSA2 for PSA change.
7. SMF provides a new IP address (IP@2b) to the UE which is associated with PSA2. The IP address (IP@2b) is allocated by PSA2.
8. MPTCP Proxy on PSA2 receiving the already existing MPTCP context establishes a new sub-flow with the UE, using IP@2b. The sub-flow is created using the MP\_JOIN option with B=1, indicating to the UE that the subflow should be treated as backup path and it should not be used to send data, unless there are no usable subflows. The sub-flow is created in advance, during the relocation preparation phase. At this point, UE has two sub-flows associated to the same MPTCP session. The first sub-flow is with PSA1 and the second sub-flow is with PSA2.
9. AF informs the SMF that the EAS relocation is completed and provides the information to reach the target EAS. This triggers the relocation completion phase. SMF informs PSA2 to complete the PSA change. SMF provides PSA2 with the information to reach the target EAS. SMF also informs PSA1 to complete the PSA change and the MPTCP Proxy on PSA1 updates the MPTCP sub-flow’s priority by cleanly retiring its use using the “REMOVE\_ADDR” option indicating that this sub-flow shall not be used or terminates the sub-flow. The MPTCP session may be silently discarded on PSA1, allowing the UE to preserve the MPTCP session.
10. PSA2 establishes a TCP session with the target EAS. This TCP session is associated with the MPTCP session and sub-flow toward IP@2b.
11. MPTCP Proxy on PSA2 completes the change of PSA by changing the MPTCP sub-flow’s priority MP\_PRIO option with B=0. This means that the UE may start using this sub-flow.
12. SMF informs the AF that UE’s PSA change is completed.

### 6.X.3 Impacts on Existing Nodes and Functionalities

Editor’s note: Further evaluation on possible impacts on SMF and UE is needed.

SMF:

* Send PSA relocation indication to AF
* Receive EAS relocation preparation completed indication from AF
* Send PSA relocation preparation to UPF
* Send PSA relocation completion to UPF
* Query UPF/PSA to get MPTCP Session context
* Send MPTCP session context to target UPF/PSA

UPF acting as a source local PSA:

* Save MPTCP Session context locally
* Terminate the initial sub-flow with initial PSA when PSA relocation is completed

UPF acting as a targe local PSA:

* Create a new “backup” MPTCP sub-flow to be associated with the saved MPTCP Session
* Change MPTCP subflow ’s priority using MP\_PRIO option B=0 to activate the MPTCP subflow

End of changes