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Source:	**Siemens AG**
Title:	**Comments on Nokia's contribution on Impacts of enabling NSAPI/SAPI/PFI re-mapping on PS Handover Performance**
Agenda item:	**9.25**
Document for:	**Discussion/ Decision**

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1. INTRODUCTION

The PS Handover mechanism is being standardized in TSG GERAN [3GPP TS 43.129]. The primary goal of this procedure is to enable real-time services in GERAN *A/Gb mode*, but the handover mechanism would be applicable also to other PS services. Due to strict Quality of Service requirements on low latency and packet loss, real-time packet-switched (PS) services require a minimal service interruption of the data transfer during cell change. PS handover is defined following the GSM circuit-switched handover principle of allocating radio resources in the target cell prior to changing cell, such that it fulfils the QoS requirements for real-time services in [3GPP TS 23.107].

Changes to the PS handover mechanism have been proposed for discussion and approval in CT WG1#38 in the documents (C1-050754, C1-050755 and C1-050756).

The major disagreement point is the NSAPI/SAPI/PFI re-mapping issue that have been extensively discussed in GERAN until it was agreed not to support it in TSG GERAN#22 and recently brought up in TSG CT1 group as well as in TSG GERAN2.

The architectural/protocol impacts due to the re-mapping have been highlighted in the document C1-050082.

[Siemens: Firstly, the correct document number is C1-050582. Secondly, this document was sent on the CT1 mailing list as a late document, but it never appeared on the file server in Cancun or on the 3GPP file server and remained marked as 'not available' in the meeting report. Consequently, it was never treated during the meeting. If it had been opened, we would have given some

comments, since in our opinion e.g., from the two statements on page 3 of the contribution

"-> per MS per QoS class, one SAPI is related to one PFI"

"-> per MS per QoS class there can be no more than one SAPI utiliziung the same PFI"

the first one is misleading, it should rather read:

"-> one SAPI is related to one QoS class, and one SAPI is related to one PFI"

and the second one is wrong, since it is possible to have two different NSAPIs with the same QoS class using two different SAPIs, and the two SAPIs can use the same PFI. (If such a configuration would not be possible, the whole discussion would be pointless for us.)]

This discussion paper highlights the impact of supporting NSAPI/SAPI/PFI re-mapping on the performance of PS handover due to the proposed changes.

1. IMPACTS ON THE PERFORMANCE DURING PS HANDOVER DUE TO NSAPI/SAPI/PFI REMAPPING

The impacts on the performance of PS Handover due to re-mapping are listed below as follows:

- ***Throughput decline during PS Handover***

  During XID negotiation there are parameters that can impact the performance of the PS Handover. The change of the SAPI during PS Handover can lead to degradation of the PS Handover performance.

  E.g. MS is using SAPI=5 in the old cell for a certain packet flow and during PS handover the network orders MS to use SAPI=3 instead of SAPI=5, when re-mapping is applied.

  As a consequence, all packets already in LLC and RLC with SAPI=5 should be deleted because the receiving SGSN would not understand them. Due to this there will be packet drops at TCP level leading to reduced throughput. The loss of data is not negligible. In EGPRS RLC window sizes can be quite large (see TS44.060 chapter 9.1.9.2), e.g. for 2 uplink slots, the RLC window size can be 256. In a worst-case scenario with MCS-9 coding scheme, the RLC window size would be MCS-9_block_size * 256 = 74 octets * 256 = 18955 octets. With 2 uplink slots the theoretical maximum transfer speed in RLC is 118.4 kbits/s when MCS-9 is used. Discarding 18955 bytes results in 1.28 seconds transfer time. Thus a very large amount of data can be lost due to the change of SAPI.

  This problem will not exist if the MS and network utilizes the same SAPI value for the packet flow in the old cell as well as in the new cell.

  [Siemens: The text above has overlooked that in the target cell due to the reset also the LLC frame numbers are no longer valid. Furthermore, the ciphering mode in the new cell may be different - which also would require a re-ciphering of all buffered data packets. Besides that, after a reset to default values, the entity will anyway be forced to discard any compressed packets because the peer entity will no longer understand them.

  So, either a more 'intelligent' implementation can be found, which allows to change the frame numbers and to re-cipher the packets - and then changing

the SAPI isn't really a big issue. Or a simple solution is choosen and the buffer will be flushed. Then this implementation will discard packets that realistically correspond to an interruption time of the order of 100 – 200 ms. We don't doubt that in a worst case scenario the buffered data can correspond to 1.28 seconds of transmission time. However, in our understanding such a worst case would also mean that even without any handover we would have a delay of 1.28 seconds in the user data and this does not look like a conversational service.]

The problem is not relevant for the *Iu mode* to *A/Gb mode* PS handover, because even if MS receives a new SAPI value in this scenario, the 2G buffers are empty and there is no need to discard any packet data.

[Siemens: Here, Nokia's contribution overlooked that for *Iu mode* to *A/Gb mode* PS handover in principle the same problem exists with the data buffered in the RLC/MAC layer of the Iu mode protocol stack. The main difference is that in this case there is no easy way to adapt frame numbers or SAPIs or to do a re-ciphering. So probably flushing the buffer is the appropriate solution.]

- ***Degradation of the service from the user's point of view***

From user point of view the transmissions in GPRS level are started fast, but TCP slows down because packets have been lost and have to be retransmitted, or even worse, TCP goes to slow start. This will be seen as a degradation of the service from the user point of view.

[Siemens: In our understanding, as a rule, real-time services will use UDP instead of TCP.

For TCP we agree that it will suffer from packet loss during handover, but to put the blame for this on the SAPI re-mapping and not mention the reset of the LLC frame numbers – or other possible reasons for packet loss - does not look like a convincing argument.]

- ***Delay of the handover caused by the PS Handover Command segmentation*.**

Performing re-mapping at each SGSN change for all NSAPI/SAPI/PFI will result in RLC/MAC segmentation of the PS Handover Command, which will cause unwanted handover delays for PS services.

IF re-mapping is supported, there is a need to include the NSAPI and its newly assigned SAPI and PFI value in the NAS container for each and every PDP Context. This has to be done for all packet flows regardless of their QoS profile and regardless of whether there are resources allocated in the target cell.

[Siemens: This is not correct.

Firstly, a vendor change will not happen at every handover with SGSN change; therefore, re-mapping will not be necessary at each SGSN change.

Secondly, according to our stage 2 proposal in GERAN2 and also according to our CR to TS 24.008:

"For PDP contexts whose NSAPI is not included in the NAS container for PS HO information element, the MS shall continue to use the same LLC SAPI and PFI values."

I.e. NSAPI/SAPI/PFI only needs to be included, if the relation between them is actually changed. We assume that in a realistic handover scenarion this will be the case for 1 or 2 PDP conversational or streaming contexts, meaning

additional 3 or 5 octets (2 per NSAPI/SPAI/PFI triplett) instead of the 23 additional octets claimed by Nokia.]

The NAS Container shall be sent transparently through the air interface to the MS in the RLC/MAC message, i.e. PS Handover Command. The size of this message will obviously grow if re-mapping is supported, up to 23 additional octets, in addition to the radio interface parameters within the air interface handover message. Note that PFI always would have to be sent twice, as it will be included in the radio access container as well as in the NAS container.

Obviously the size of the PS Handover Command will increase if re-mapping is supported and segmentation will have to be applied at the RLC/MAC level as specified in 3GPP TS44.060. The size of PS HANDOVER COMMAND message influences significantly the performance of PS handover. Overlong handover commands will cause long interruptions due to retransmission of control block segments, which increases with the number of segments. When taking into consideration that the service interruption caused by the PS HANDOVER COMMAND message transfer is only a part of overall service interruption during PS handover, it is necessary to minimize it by keeping the PS HANDOVER COMMAND as small as possible. This will however not be possible if the NSAPI/SAPI/PFI re-mapping is to be supported. Additionally it has to be noted that the NSAPI/SAPI/PFI re-mapping will be sent for all PDP contexts regardless of whether a certain PDP context has received radio resource in the target cell or not. This leads to utilizing the PS Handover Command for changing some parameters that are not relevant for the handover procedure itself.

[Siemens: As explained above, this is wrong. Please note also that for PDP contexts with QoS traffic class 'interactive' or 'background', we do not see a need for a re-mapping during PS handover, since these contexts cannot be handed over anyway. So, a re-mapping via PDP context modification after the handover is sufficient. We do not have any problem, if Nokia wants to have this specified explicitly in the stage 2.]

- ***New round of XID negotiation in the target cell to change the default parameters***

  The NAS Container defined in the CR to 3GPP TS 24.008 limits the usage of the old XiD parameters to the re-mapping, i.e. old XiD parameters cannot be used in the target cell if re-mapping is supported. This means that the MS after processing the NAS container will have to start a new XiD negotiation procedure to change the default parameters for each of the received NSAPI/SAPI pair resulting in additional signalling with the core network and usage of the radio resources in the target cell.

  [Siemens: Yes, after a PS handover with the re-mapping a new XID negotiation will be necessary. But please note that according to our stage 2 proposal this XID negotiation will be started by the SGSN, not by the MS. Secondly, what would be the alternative? – It would mean that the SGSN has to stop the downlink transmission of user data until the MS has performed the routing area update and the SGSN has performed a PDP context modification in order to change the NSAPI/SAPI/PFI mapping and then afterwards an XID negotiation for the new SAPI. This would no longer be a handover but a normal routing area update.

  We see Nokia's point that the reset coming with the re-mapping affects all PDP contexts, i.e. with the solution proposed by Siemens there will be a slower start for all PDP contexts (please note that the transfer of user data is already possible during the SGSN-initiated XID negotiation, Nokia did not mention this). – With the Nokia solution, however, the alternative is that only one PDP context is handed over and for all other PDP contexts multiplexed on the same PFI we actually perform a routing area update with subsequent PDP context modification. – This is the trade-off on which we have to decide.]

- ***Data transfer is not possible any more on the old cell which leads to complete failure of PS Handover***

  If a failure occurs after the MS has processed the NAS container in the new cell, but before the RAU is completed, then falling back to previous cell as described in 3GPP TS43.129 does not work. The reason is that the old SAPI and PFI values have been overwritten at PS handover by the new SGSN. So, MS cannot by any means fall back to the old cell, where the resources would have been still available for the data flows. A dire consequence is that new failure handling procedures have to be defined for the air interface as well as for the Gb interface. However, independently of the new failure handling, the recovery of the data transmission will not be possible, leading to severe service degradation from the user's point of view.

  [Siemens: We agree that the case of a failed routing area update is not covered by our current CR to TS 24.008, but the problem has a wider scope and not only applies to the NSAPI/SAPI/PFI remapping, but also to the change of the ciphering algorithm (which the old SGSN also is not aware of) and also to the XID negotiation (the old SGSN does not know whether the MS performed a reset to default values or a reset to 'old XID parameters'). So removing the NSAPI-SAPI-PFI re-mapping from our CRs does not solve the problem.

  We discussed this internally only very briefly, but one possible solution would be that the MS stores the old parameters (old ciphering algorithm, old NSAPI-SAPI-PFI mapping, maybe also the old XID parameters), until the routing area update was accepted by the new SGSN. If the new SGSN rejects the routing

area update, the MS falls back to the old configuration and to RR idle, and performs a new routing area update when it finds a suitable cell.

But apart from that the comment from Nokia points to a more serious problem which until now GERAN did not address at all in the stage 2:

A 're-start' after a PS handover with a subsequent RAU (Routing Area Update) failure is not a soft landing but rather it corresponds to a loss of the radio connection in the CS handover case. (The main difference is that the PDP contexts may be kept a bit longer, so a 'connection re-establishment is still possible.) Therefore, a RAU Reject should be strictly avoided, if possible. But the stage 2, TS 43.129, does not contain any mechanism that would prevent a handover to an area where roaming restrictions apply.

For PS handover from Iu-mode to Iu-mode such a mechanism exists, but since it was not mentioned in TS 23.060 that this mechanism is essential for a correct operation of handover, and GERAN2 generated their message flows from TS 23.060 via paste, copy and modify, apparently no one detected this problem until now.

Note, that for a CS handover, the situation is slightly different, because there the location update is postponed until the RR connection is released. If it then turns out that there is a roaming restriction for the cell on which the MS is camping, it does not harm the CS call.]

2. CONCLUSION

This paper demonstrates the negative performance impacts of re-mapping NSAPI/SAPI/PFIs during PS handover in GERAN *A/Gb mode.* Re-mapping NSAPI/SAPI/PFI during PS handover has severe impact not only on the architectural/protocol level, but also on the performance of PS handover. The resulting degradation in PS handover due to re-mapping is the following:

- Not fulfilling the QoS requirements for the real-time services due to:
  - Decrease of throughput during PS Handover and service degradation;
  - Delay on the PS handover and user data transmission due to segmentation of the PS Handover Command message;
  - Additional signalling due to XID negotiation;
- Impossible PS Handover failure recovery in terms of data transfer.

[Siemens: With our responses to Nokia's argumentation we have shown that most of the arguments are not valid or the issues have not been well understood. Furthermore, and that is the important point, issues have been identified, that still have to be solved independent of the question of supporting the re-mapping or not. Therefore, we propose that TSG CT#28 should refer the entire topic back to CT1 for further considerations.]

REFERENCES

[1] ~~C1-050082~~C1-050582

[2] C1-050754, C1-050755 and C1-050756

[3] 3GPP TS 43.129

[4] 3GPP TS 24.008
[5] 3GPP TS 44.064
[6] 3GPP TS 44.065