SCTP-Cross Layer Mechanism Performance For EGPRS Data Handover in Variable Radio Transmission Conditions

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***Abstract* – In this paper we study the behavior of SCTP protocol with QoS_Measurement_Chunk extension [1] in wireless network. This extension contribute to improve the protocol performance in variable transmission conditions in radio environment. The SCTP QoS_Measurement_Chunk extension consists of cross-layer mechanism using the control chunk aspect used in SCTP. This chunk serves to inform the network about the transmission conditions variation on the radio interface. According to information supported by this chunk, sent by the mobile terminal to the GGSN, the network adapts its transmission flow by modifying the congestion control parameters (cwnd and ssthresh). This work considers a probabilistic variation of radio transmission conditions which aims a continuous quality degradation in order to trigger a handoff that activate the multihoming SCTP's feature.**

Keywords – QoS_Measurement_Chunk, SCTP, cross-layer mecanism, QoS random variation, Wireless

I. Introduction

In this paper we propose a modification of SCTP protocol related to the congestion control mechanism which consists of sending information on the radio link to the transport layer. This work is interested to the performance improvement following the dynamic change of the radio transmission conditions. These information can be used by the network to trigger the handover as in [2]. In our approach we consider SCTP protocol for its reliability and interesting transmission features, and it consists of creating a cross layer alternative that uses chunk control aspect in SCTP. We create a new control chunk named QoS_Measurement_chunk that is useful to carry radio transmission parameter to transport layer in order to adapt congestion control parameter to the radio transmission conditions. Here we study the behavior of the SCTP with QoS_Measurement_Chunk extension under variable radio quality parameters (coding scheme, BLER) in a random way. The simulated scenario aims a continuous quality degradation on the radio interface in order to better study the behavior of the suggested extension and to trigger a handover towards a new cell by using this new control chunk and the multihoming SCTP's feature.

Some wireless link characteristics (BLER, limited bandwidth, handovers due to mobility...) degrade the performance of transport protocols in wireless networks. Many studies have been made to give possible solutions for IP-based transport protocols over wireless networks. These solutions include TCP modifications, the use of SCTP and the implementation of link layer mechanisms like ARQ to improve TCP performance over wireless. In this paper we consider the possibility to study active interactions among the layers involved in the wireless access links (transport layer, RLC and MAC) and to define cross-layer mechanisms that take into account the efficiency requirements at different levels.

This study is focused on EGPRS network. We assume that an SCTP association is setup between the mobile and the GGSN. The SCTP association is setup at the PDP context activation and is maintained by the network when handover occurs. Only downlink transmission is considered and we suppose random change of the coding scheme and the corresponding BLER. Unlike, Mobile IP approaches, the mobile is not multihomed (it has a single IP address). The GGSN can be multihomed if required.

The paper is structured as follows. In section 2 we present a short description of SCTP's multihoming feature and the congestion control mechanism. We describe, in the third section, the considered simulation scenario. We detail our the QoS_Measurement_Chunk mechanism in section 4. Section 5 provides some simulation results and their interpretations. Finally, some conclusions and perspectives are drawn.

II. SCTP Multihoming Feature

One of the major features of SCTP is the management of "multihomed nodes", i.e. endpoints that have several transport IP addresses. To carry out a transmission towards a mulihomed node, the transmitter chooses at the association establishment one of the possible addresses which will correspond to the "primary path". The transmitter should not thereafter send data only over this primary path. If retransmissions are required it would be interesting to use another alternate path [3], to avoid packet losses related to problem on the primary path, and in other way to reduce the risks of congestion. SCTP must regularly control the multihomed node's addresses. For that it considers two possible states for each possible path : active or inactive [3]. The primary path is considered active, and the availability of the secondary addresses is controlled by the regular sending of HEARTBEAT chunks, which must be acknowledged by a HEARTBEAT ACK chunk.

SCTP association should with multihoming feature recover faster and provide better throughput as long as the alternate path is not affected by errors. SCTP's multihoming feature can be exploited to allow a mobile node to choose which wireless path is more suitable for communicating and then, to perform a data handover in the downlink.

III. Simulation Scenario

A. Simulation parameters

The simulated scenario is given by figure 1. We consider two EGPRS cells and we suppose that we have one mobile that probes a dynamic change of radio transmission conditions (coding scheme, BLER) over the first serving cell and then a handover data between these two cells. We consider an SCTP association between the mobile and its IP server (the fixed Host, directly connected to the GGSN).

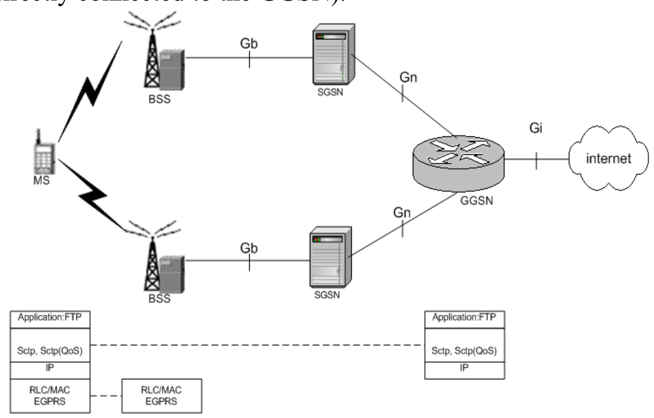

Figure 1.. Simulated Architecture

During the establishment of a PDP context between the mobile and the GGSN, an SCTP association is established between these two equipments. SCTP association is multi-homed on server IP side, and we activate one stream because we use a simple application FTP flow. On the other hand, the mobile has only one IP address (it does not change during the lifetime of the PDP context). The primary address of SCTP association corresponds to the IP address located on the same subnetwork as the SGSN with which the mobile established the PDP context. This address can be changed if the mobile changes of SGSN.

The primary link corresponds to server's primary address that is defined by the path : Server-GGSN-SGSN1-BSS1-MS. The alternate link is the one defined by the path : Server-GGSN-SGSN2-BSS2-MS.

On the radio interface we use a degradation process at level 2 (RLC/MAC) that simulates the decrease of link quality by changing the coding scheme used to transmit RLC blocks. First we consider a deterministic variation of the coding scheme and the corresponding block error rate (BLER). The table1 describes the change of the transmission parameters during a communication. The change of the coding scheme is conceived to degrade the transmission condition quality and to activate the radio handover towards the second cell.

Instant	**Coding scheme**	**BLER**
0sec	CS4	0.01
200sec	CS3	0.015
400sec	CS2	0.1
600sec	CS1	0.15
700sec	HO	
CS3 over second cell		0.015

Table 1. Transmission parameters change.

Second we consider a random change scheme of the coding scheme and the corresponding block error rate (BLER) given by the model in figure 2.

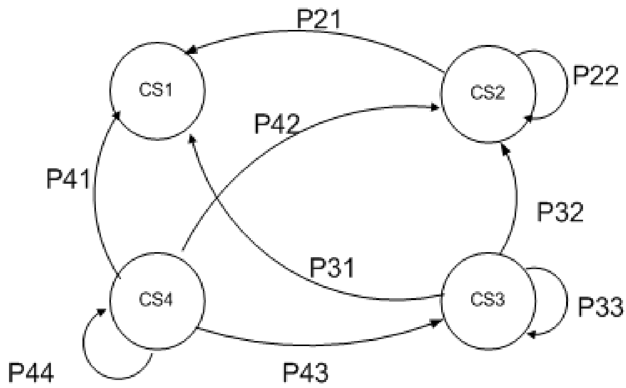

Figure 2..Transition model for coding scheme change.

Where :

Pij are the transition probabilities (from state i towards j). A state of this chain is defined by the coding scheme and the corresponding BLER.

P21=0.4, P22=0.6, P31=0.2, P32=0.5, P33=0.3, P41 = 0.1, P42=0.3, P43=0.4 and P44=0.2. The initial state is CS4, the time spent in each state is an exponential distribution random variable with averages 200sec, 400sec, 600sec and 800sec respectively with cs4, cs3, cs2 and cs1. The CS1 state is designed to be an absorbing state in order to be able to trigger a handover towards the second cell. We considered only the transitions which aim at the degradation of quality in order to better visualize the behavior of the suggested extension

The window size can vary at the RLC/MAC level from 64 to 384 blocks. A TBF can use up to 3 PDCH in downlink and 1 PDCH in uplink. Gb Interface is modeled with a duplex link of 64kbps transmission rate and 100ms propagation delay. Gi interface is modeled with a duplex link of 5Mbps transmission rate and 100ms propagation delay. The link between GGSN and the fixed host is a duplex link of 5Mbps transmission rate and 100ms propagation delay. The error model on the wired part, Gi interface, is uniformly distributed with a mean packet error rate of 1%.

Simulations are developed using NS2 by exploiting SCTP simulator developed by [4]. We use this SCTP simulator to which we added the functionality of Qos_Measurement_Chunk.

IV. Qos_Measurement procedure performance

At the establishment of the association, the mobile transmits to the GGSN (via the PDP context activation procedure) the capabilities of the radio bearer used by the mobile terminal. It communicates also the current coding schemes used for transmission on the air interfaces in the uplink and in the downlink. The GGSN is kept informed about any modification on the coding scheme used by opened TBF (typically due to the link adaptation procedure or to a handover). All this information are sent in Qos_Measurement_chunk which formats are given by figure 3 .

Chunk type	Chunk length
TLV : QoS_parameter	

Figure 3.. Qos_Measurement_chunk

The reception of a Qos_Measurement_chunk containing the information about the coding scheme used in the downlink just after the handover, will cause a recalculation of the cwnd in the new cell. The cwnd is performed as described in [1].

Another modification is in the calculation of the ssthresh after the transmission conditions change. The old value of the previous conditions is kept. That means that if the mobile is in congestion avoidance phase before coding scheme change, it will stay in this phase in the new cell with a updated value of cwnd. For handover if the mobile is in slow start phase in the old cell, it will stay in the slow start phase in the new cell but with a new value of cwnd instead of one or two MTUs.

The problem highlighted is the change of radio conditions and its impact on the flow transmission control at the transport layer. The losses on the radio interface are generally interpreted by transport protocol as congestion problems on the fixed part of the network. QoS_Measurement_Chunk is an approach that makes the possibility to information the transport protocol about the transmission parameters on the radio interface. This makes the possibility to adapt the flow of data transmission by an update of the parameters of congestion control mainly the size of the congestion window (cwnd) and the slow start threshold (ssthresh) (vs. Figure 4).

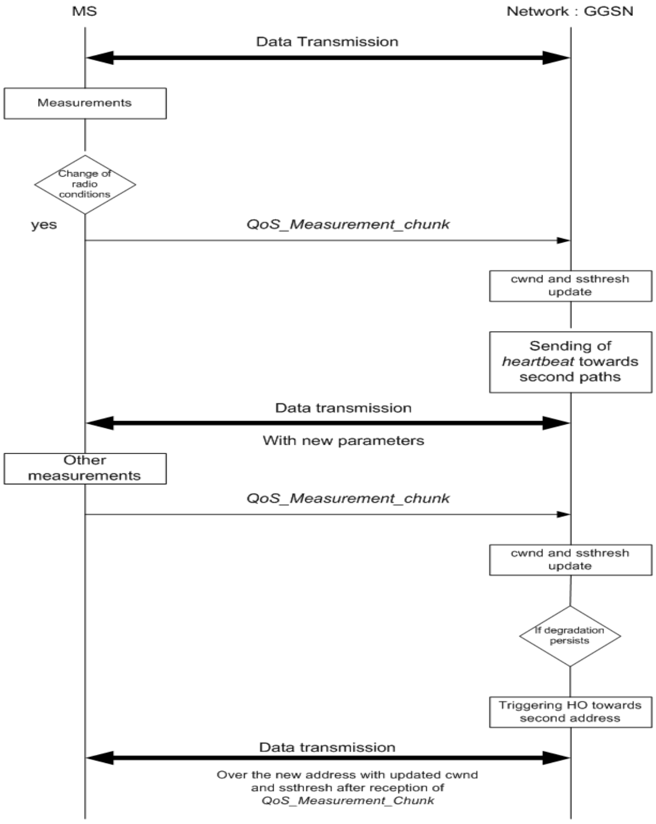

Figure 4. Qos_Measurement_chunk approach

The cwnd and ssthresh update is done according to their previous respective values and of the BDP of the radio link as it is described in [1]. QoS_Measurement_Chunk allows an instantaneous control of the transmission flow.

V. Simulation results and performance evaluation

Firstly we give simulation results that compare the performance of SCTP standard with SCTP QoS_Measurement_Chunk extension, in the case of deterministic change of radio transmission conditions. We notice that the throughput of the proposed extension is higher at the RLC/MAC level. Figure 5 illustrates the losses due to the degradation of the link quality (introduced by change of the pair (coding scheme , BLER)), followed by a cut of the connection with the first cell due to handover and the connection to the new cell. For the standard SCTP with the multihoming we notice that when changing from CS2 to CS1 we have a little transmission cut which corresponds to a retransmission timeout, whereas with the proposed extension there is no timeout production. This is due to the fact that cwnd in the proposed extension remains unchanged and keeps growing after the radio transmission conditions change. Which is confirmed by the evolution of TSN given by figure 6 and figure 7 for standard SCTP compared to SCTP with QoS_Measurement_Chunk. That explains that the evolution of cwnd (vs. figure 5) is better for the proposed extension and that the throughput increases also more rapidly for the proposed extension. We notice that dice the first coding scheme change the proposed extension performs better than the standard SCTP.

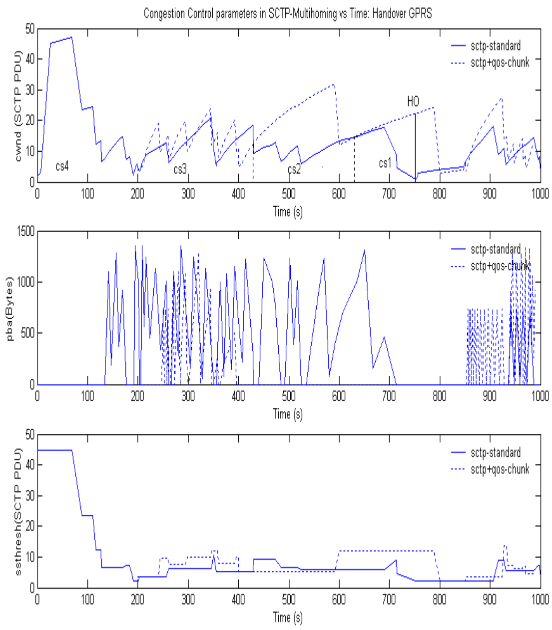

Figure 5. Congestion Control parameters with Standard SCTP compared to SCTP with QoS_Measurement_Chunk.

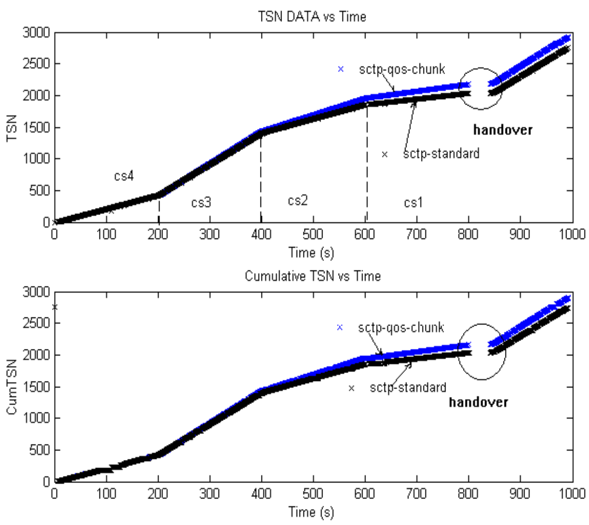

Figure 6. Variation of TSN and CumTSN with Standard SCTP compared to SCTP with QoS_Measurement_Chunk.

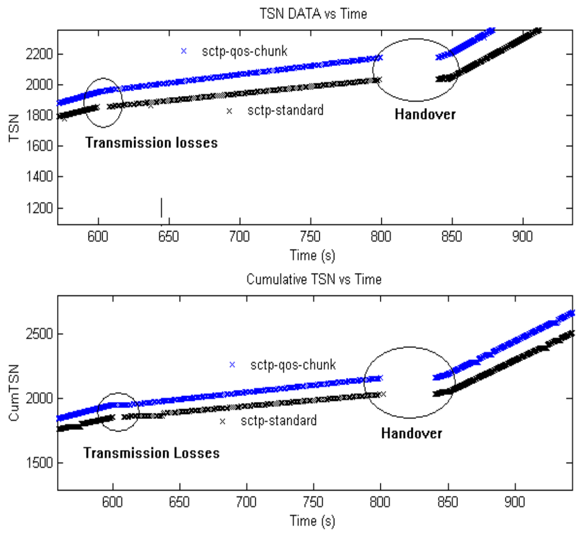

Figure 7. Variation of TSN and CumTSN with Standard SCTP compared to SCTP with QoS_Measurement_Chunk (zoom of figure 6).

With the first simulations we notice that the proposed extension for SCTP performs better than standard SCTP in variable transmission conditions. Secondly we consider only the suggested extension for SCTP in order to validate the behavior of the SCTP protocol with the QoS_Measurement_Chunk in the case of random change of the radio transmission quality parameters. We consider the random variation scheme described above in this paper.

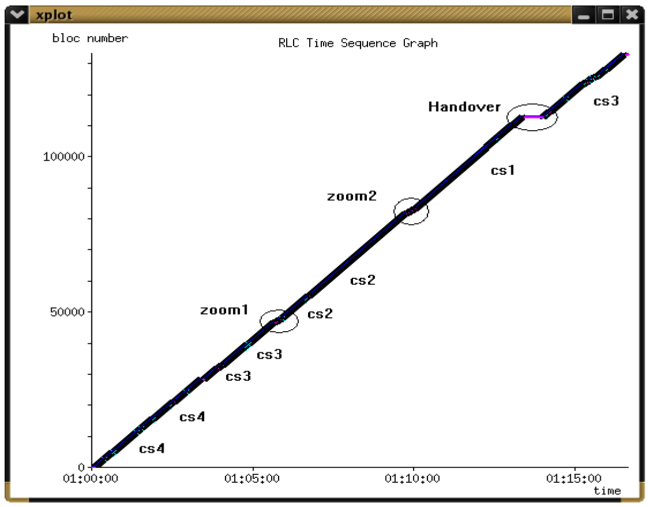

Figure 8. Variation of the RLC block Sequence Number with SCTP QoS_Measurement_Chunk.

In the end of the paper we provide the figures that illustrate the zooms.

We notice that the random variation of the transmission conditions over the radio interface (CS, BLER), carried to transport layer, does not cause losses of transmitted data. Performance evaluation of Qos_Measurement_chunk mechanism is studied at the SCTP level (vs figures 9 and 10)and at the RLC/MAC level (figure 8). We notice that the sequence number vary continuously in the time, i.e. we do not have a cut of the transmission flow caused by losses problems due to random transmission quality variations. The hypotheses of our suggested extension related to the congestion control are well checked what is illustrated by figure 9 that representes the cwnd and ssthresh variations. We identify the handover and we check well that cwnd after the change of radio link obeys to the formula given in section 4 (vs. figure 9). The goal to launch simulations taking account of random variations of the radio conditions is to validate the QoS_Measurement_Chunk SCTP's extension which is proven by the results obtained.

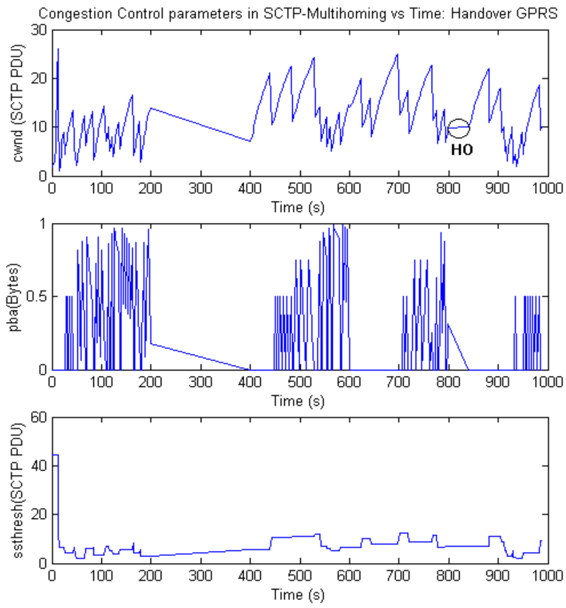

Figure 9. Congestion Control parameters with SCTP with QoS_Measurement_Chunk.

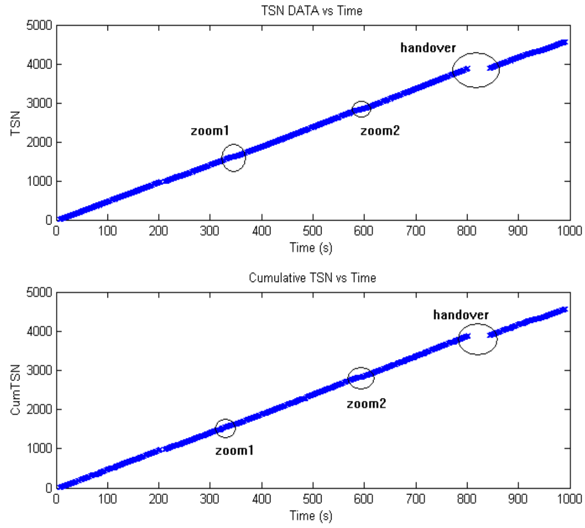

Figure 10. Variation of TSN and CumTSN with SCTP with QoS_Measurement_Chunk.

VI. Conclusion

This paper evokes the problem caused by the random change of radio transmission quality. In the first stage we consider a deterministic change scheme with which we compare the performance of the suggested extension to the standard SCTP. The QoS_Measurement_Chunk performs better than the standard SCTP which is verified at RLC/MAC level and transport level. The second stage consider the results given by the first simulations and consider a random scheme change of the radio transmission quality conditions. So, we study the behavior of the suggested extension in more realistic transmission conditions but we suppose a continuous degradation of the transmission quality in order to validate the QoS_Measurement_Chunk SCTP's modification. Creating a cross layer alternative consisting of carrying transmission parameters to the transport layer improve the transmission quality. This extension with the multihoming in SCTP, as it is proved by simulations, are used to ensure a powerful handover data (slow start isn't triggred on the new link). Up to here we haven't consider multistreaming SCTP's feature, a scheduling scheme study taking in account this feature will constitute our future work.

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