RADIO AWARE SCTP EXTENSION FOR HANDOVER DATA IN EGPRS

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ABSTRACT

SCTP is a transport protocol that is used in wired networks to transport PSTN signaling. It provides interesting features (namely multihoming and multistreaming) to enhance the performances of information transport over cellular networks air interfaces [1]. Some additional extensions have been defined to adapt SCTP in a wireless context (mSCTP) [2]. However current approaches do not take into account radio information in cell reselection/handover process. This study proposes a new extension for the SCTP protocol which aims at improving the transport performance in wireless environments. We define for that purpose a new control chunk (named Qos_Measurement_Chunk). It allows the emission of radio information from the mobile to the SCTP peer in the network. These information can be used by the SCTP layer to adapt the transmission rate to the current radio transmission conditions (particularly useful in handover/reselection situation). The combined use of Qos_Measurement_Chunk and of the multihoming feature provide a data handover with a performance improvement. The obtained simulation results are compared with the standard SCTP and present better performance in terms of data throughput in the access network.

Keywords – Handover, SCTP, Qos_Measurement_chunk, cwnd adaptation, flow control, cross layer optimization

I. Introduction

SCTP and some of its extensions have interesting features to provide better performance for 3G and B3G networks. Experimental extensions such as mSCTP [2] have been defined to provide a data handover. This extension has been defined for a mobile IP context. It relies on two new control chunks (ADDIP and DELETEIP) that makes it possible to add or delete dynamically IP addresses from SCTP association when cell switching occurs. In [3], the signal strength level is taken into account to decide when to add or delete a new IP address to the association (change of IP address corresponds to cell switching).

This work proposes a modification of SCTP protocol in order to send to the network any kind of information coming from layer 2 and/or physical layer. These information can be used by the network to trigger the handover as in [4]. This paper will only investigate the use of this information to improve the handover performance by modifying the congestion control mechanisms of SCTP. This approach requires a new type of SCTP control chunk denoted QoS_Measurement_chunk in the following. This chunk provides to the mobile node the possibility to inform the network about radio link quality (such as LLC error error rate, RLC/MAC block error rate, maximum capacity supported by the radio link...). In this study, we consider an 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 handover is triggered by the network. 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 organized as follows. In section 2 we present a short description of SCTP's multihoming feature and of the proposed solution of SCTP for ensuring mobility, mSCTP. QoS_Measurement_Chunk extension is described and detailed on the third section. We give simulation parameters and the simulated scenario in section 4. Section 5 provides some simulation results and their interpretations. Finally, some conclusions and perspectives are drawn.

II. SCTP Multihoming Feature and mSCTP Extension for Radio handover

A. Multihoming

SCTP multihoming provides redundancy between two distant nodes. Each node can be accessible via several IP addresses (and one single SCTP port) fixed at the setup of the association. The upper layer protocol (ULP) determines all IP addresses associated with SCTP association and they choose the primary path (one single path active at time). When the primary path becomes unavailable (following a congestion, or a significant data loss), SCTP sends all the traffic to one of the alternate addresses of the considered association. The reachability (or active state) of one destination address is probed with a heartbeat mechanism [4].

The Primary path is supposed to be inactive, if the transmitter cannot reach it after several expired RTO. In this case, SCTP packets will be transmitted towards another active address. The choice of the alternate IP destination address is insured by sending a Heartbeat Request chunk to its peer. SCTP peer's node must answer with a Heartbeat Ack chunk by indicating the backup IP address which will be active in the current association. A heartbeat chunk is sent periodically to the destination transport addresses in order to update their accessibility states.

SCTP association should with this feature recovers faster and provides better throughput as long as the alternate path is not affected by transmission errors. SCTP's multihoming feature

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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.

B. SCTP Congestion Control Mechanism

SCTP uses the same algorithms of congestion control as TCP [5]. The congestion control in SCTP is always applied to the whole association and not to individual streams. Congestion control in standard SCTP consists of [4] : slow start, congestion avoidance and congestion control.

Slow Start

Initially, the cwnd is set to 2*MTU If an entering SACK increments the Cumulative TSN Ack Point, cwnd must be incremented by the minimum of the total size of the buffered blocks previously acknowledged and of the path MTU of the destination.

Congestion avoidance

If cwnd > ssthresh, cwnd is updated by doing :

cwnd=cwnd +1*MTU by RTT, if the transmitter has cwnd or more bytes of suspended data for the corresponding transport address. In practice an implementation can carry out this in the following way :

1- partial-bytes-acked = 0

2- each time that cwnd > ssthresh, when a SACK that increments Cumulative TSN Ack Point is received, partial-bytes-ack increased by the total number of acked bytes

3- if partial-bytes-ack ≥ cwnd, and that before the reception of a SACK the transmitter has cwnd or more suspended data bytes, cwnd increased by MTU and

partial-bytes-acked = partial_bytes_acked – cwnd

4- As in Slow start, when the transmitter has no data to transmit to a given destination transport address, cwnd of that address must be adjusted to max(cwnd/2, 2*MTU) by RTO.

5- When all the transmitted data are acked by the receiver, partial-bytes-acked = 0.

Congestion Control

Upon the detection of packet losses indicated by SACK, an SCTP node must do the following :

$$ssthresh = max(cwnd/2, 2*MTU) \quad (1)$$

$$cwnd = ssthresh \quad (2)$$

Primarily a packet loss causes the reduction by half of the cwnd. When T3-rtx expires for an address, SCTP must execute Slow Start by:

$$ssthresh = max(cwnd/2, 2*MTU) \quad (3)$$

$$cwnd = 1*MTU \quad (4)$$

and ensures that there is no more than one SCTP packet that will be transmitted for this address until SCTP node receives the acknowledgment for a successful delivery of the data towards this address.

C. mSCTP

Mobile SCTP is based on the SCTP's multihoming feature and uses the possibility to add or delete dynamically new IP addresses to an existing association and to change the primary path. Mobile SCTP (mSCTP) uses ADDIP extension for that purpose. This extension consists in introducing two new chunk types [6] : Address Configuration Changes Chunk ASCONF and Address Configuration Acknowledgment ASCONF-Ack .

Mobile SCTP such as it is presented in [6] has some limitations in managing radio links during handover. Indeed, in mSCTP data packets are sent towards old IP address before the MN (Mobile Node) considers new IP address as the primary path for the association. This generates packet losses in the server side while the primary path change is not effective at the client and server level. Moreover, mSCTP does not manage mobility, it only takes care of describing how to change the primary path in the SCTP association. Additional mechanisms have to be provided to take care of user mobility (carried out by mobile IP in WLAN networks or by mobility management procedures in case of cellular networks).

III. QOS_MEASUREMENT PROCEDURE PERFORMANCE

A. Qos_Measurement_chunk

The extension consists in the following : when establishing the association, the mobile transmits to the GGSN (via the PDP context activation procedure) the capabilities of the radio bearer as well as the current coding schemes used for transmission on the air interfaces (uplink and downlink). The GGSN is kept informed about any change in the coding scheme used by opened TBF (typically due to the link adaptation procedure or to a handover). This information is sent in the Qos_Measurement_chunk which formats are given by figure 1 .

Chunk type	Chunk length
TLV : QoS_parameter	

Figure 1.. Qos_Measurement_chunk

Chunk type : 16 bits (unsigned integer)

Chunk length : 16 bits (unsigned integer)

QoS_Parameter : this field should include information about the current values of QoS transmission parameters over radio interface measured by the sender (Mobile Station) (it can be BLER, maximum rate...).

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B. Congestion control modifications

The proposed extension is a change of congestion control algorithms of standard SCTP that applies when a significant change of radio conditions occurs on the air interface. Indeed, the problem addressed here is the change of radio conditions and its impact on the flow transmission control at the transport layer. QoS_Measurement_Chunk approach makes it possible to notify the transport layer about the radio link transmission parameters. Consequently the transport layer may adapt the transmission data flow by updating size of the congestion window (cwnd) and the slow start threshold (ssthresh) (vs. Figure 2). The receiver side does not send an ACK after processing of a QoS_Measurement_Chunk, it is a measurement report.

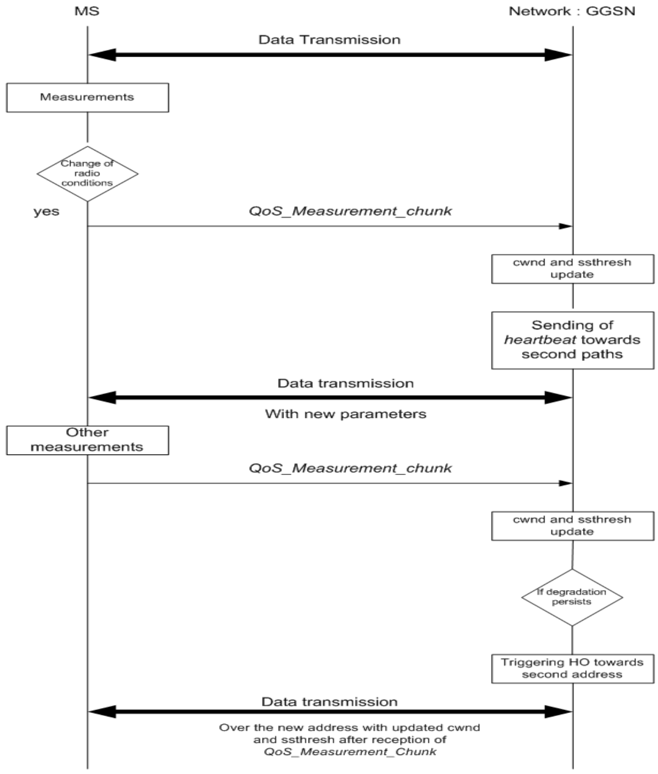

Figure 2. Qos_Measurement_chunk approach

For example, in case of handover, the reception of a Qos_Measurement_chunk after cell switching will trigger the computation of the new cwnd in the target cell. The cwnd value is determined as follows.

*cwnd(new)=cwnd(old)-C(Cs_old)*RTT+C(Cs-new)*RTT*, where

C(Cs_old) is the throughput provided with the old coding scheme and *C(Cs-new)* is the throughput provided with the new coding scheme.

Another change is in the calculation of the ssthresh after the transmission conditions change. The old value of the previous conditions is kept, meaning that if the mobile is in congestion avoidance phase before coding scheme change, it will remain in this phase in the target cell with an updated value of cwnd. These two modifications of standard SCTP congestion control can more generally be applied when the coding scheme used for transmission changes. Furthermore, in case of handover, a mobile in the slow start mode in the old cell, will stay in this mode in the target cell but with a value equal to the *cwnd(new)* instead of one or two MTUs. Another important point is the face that slow start is not systematically triggered when a handover occurs such as it is achieved in classical SCTP as it is specified in [4].

IV. SIMULATION CONTEXT

We have evaluated the performance of this scheme by simulating a scenario shown in figure 3. We consider two EGPRS cells and one mobile which triggers a data handover between the two cells. We consider an SCTP association between the mobile and its IP server (the fixed Host, directly connected to the GGSN).

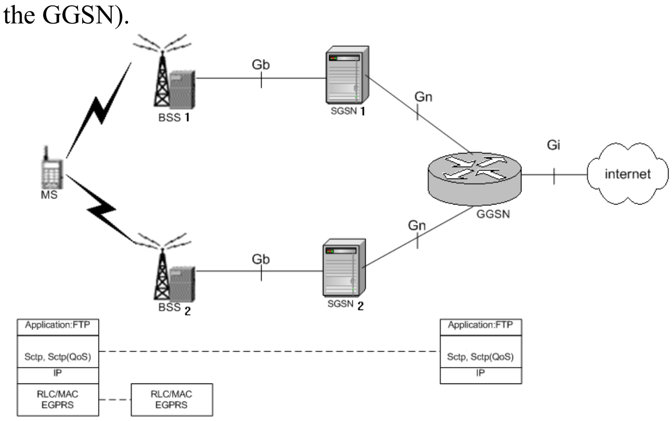

Figure 3.. Simulated Architecture

SCTP association is multihomed on IP server side, and we activate one single stream that transports a simple FTP flow. The problem of head of line blocking is not discussed here. 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 to another 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 (Errors uniformly distributed at RLC/MAC level with a 10^{-2} loss probability). Coding scheme can change from cs3 to cs1 in the performed simulations. The coding scheme used in the new cell is cs3 just after the handover). The window size can vary at the

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RLC/MAC level from 64 to 384 blocks. This degradation of throughput on the rate interface triggers the handover towards the new cell and then new radio conditions are taken into account for the alternate SCTP path. 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 Network Simulator NS2 by exploiting SCTP simulator developed by [7]. We use this SCTP simulator to which we added the functionality of Qos_Measurement_Chunk.

V. Simulation results and performance evaluation

Performance evaluation of Qos_Measurement_chunk mechanism is studied in the following, at the SCTP level and at the RLC/MAC level. The evolution of the RLC/MAC sequence number is given by the figure 4 for SCTP with Qos_Measurement_Chunk and by figure 5 for standard SCTP.

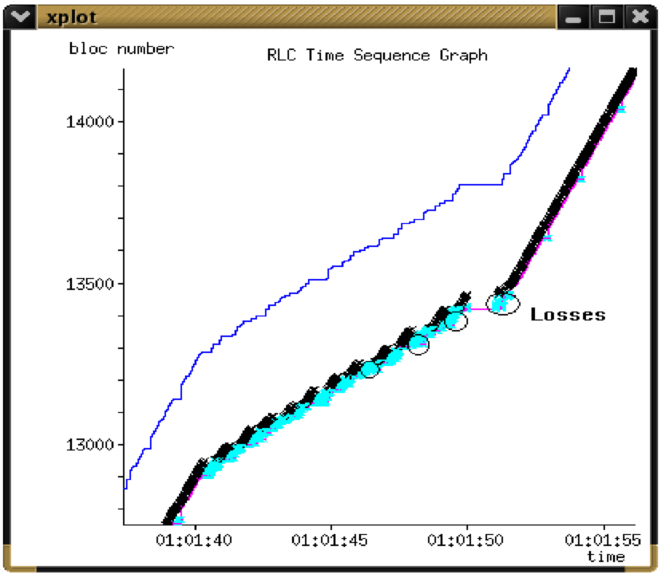

Figure 4. Variation of RLC/MAC sequence number in the case of SCTP with Qos_Measurement_Chunk

The Figures 4 and 5 illustrate the losses due to the degradation of the link quality (introduced by the error model), followed by a cut of the connection with the first cell due to handover and the connection to the new cell (area inside the circles of figure 4and 5). By comparison with the standard SCTP with the multihoming, we notice that the throughput of the proposed extension is higher at the RLC/MAC level (figure 4 and 5). This is also confirmed by the evolution of the TSN in figures 7,8 and9.

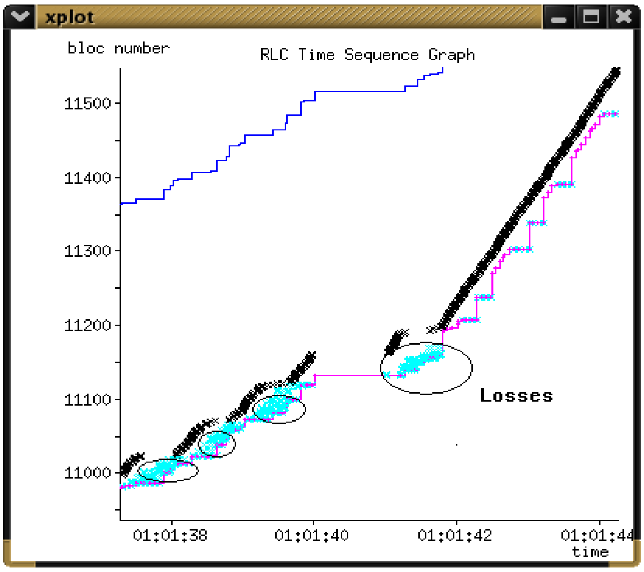

Figure 5.. Variation of RLC/MAC sequence number in the case of standard SCTP.

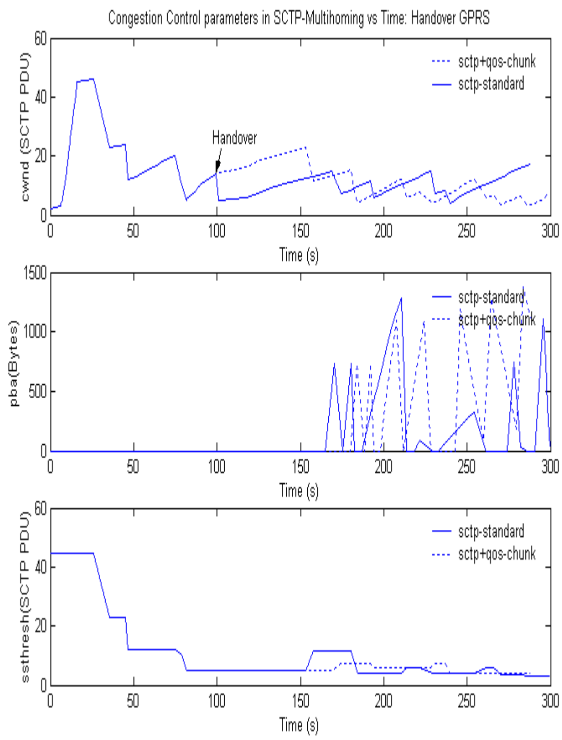

Figure 6. Congestion control parameters.

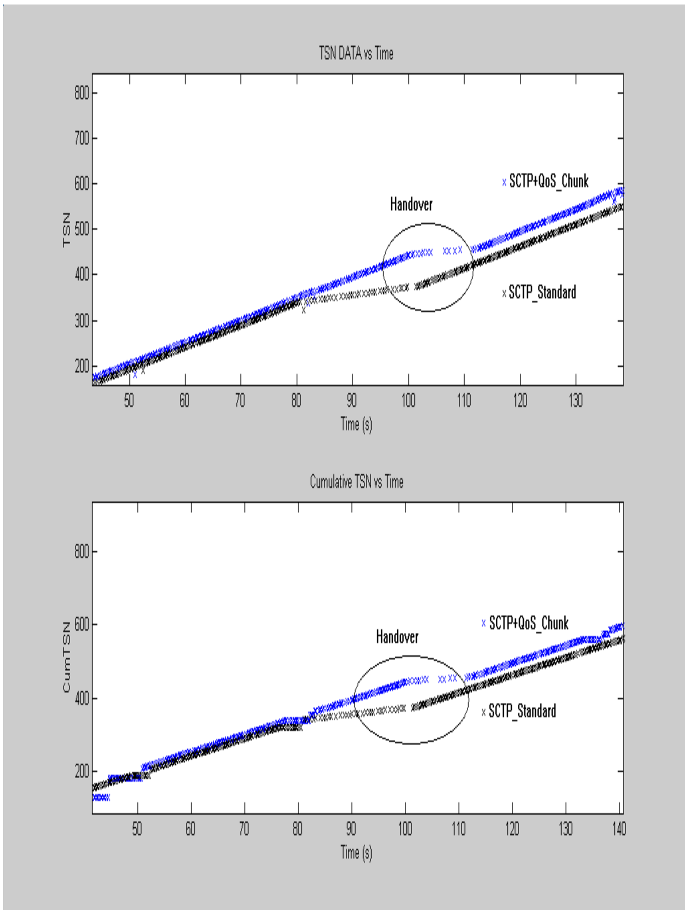

Figure 7. SCTP TSN variations.

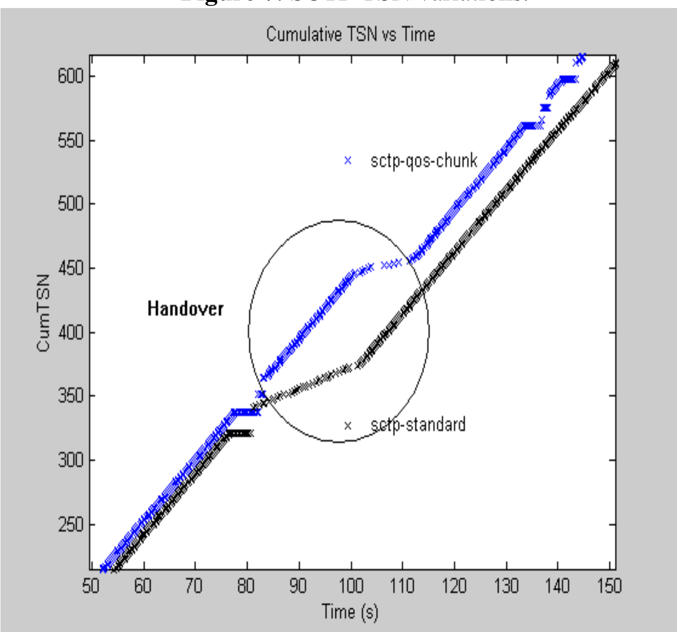

Figure 8. SCTP Cumulative TSN variations (zoom)

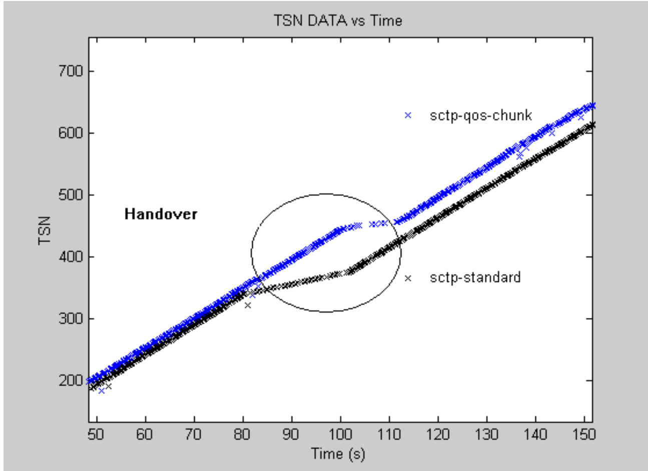

Figure 9. SCTP TSN variations (zoom)

VI. Conclusion

The modification introduced to SCTP protocol, suggested by this paper, is useful for a better adaptation of the transport protocol to radio environment. SCTP with its multihoming feature ensures better performance for data handover. The addition of a new chunk type (QoS_Measurement_chunk) makes the possibility to adapt the variation of cwnd according to the radio conditions.With QoS_Measurement_chunk procedure,we adapt cwnd and thus transmission flow to the radio environment conditions. The association does not execute slow start as the case of standard SCTP which slowed down the emission rate.With the extension proposed in this paper a data radio handover is performed better than the case of ordinary transport protocols, which is proved in this study in an homogeneous radio access technology. This feature will be particularly interesting in heterogeneous radio access technologies where we will have different radio quality parameters. This SCTP modification in a inter RAT context will be tackled in future investigations.

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