Study on Transport Layer Handover using SCTP

L. Budzisz, R. Ferrús, F. Casadevall
Dept. of Signal Theory and Communications

Universitat Politècnica de Catalunya (UPC)

C./ Jordi Girona, 1-3, Campus Nord, Barcelona, Spain

e-mail: [lukasz, ferrus, ferranc]@tsc.upc.edu, http://www.tsc.upc.edu/

Abstract—**In this paper we perform initial study of SCTP performance in order to evaluate the idea of soft handover in the transport layer. We discuss two different aspects: the influence of the point between two adjacent Access Points to trigger the handover, and a set of triggering rules based on radio signal strength. From the experiments on triggering rules it was shown that the best trade-off between average throughput and signalling overhead is achieved for a slow add-IP and fast change-IP.**

Key words: SCTP, handover, wireless networks, IP mobility, transport layer.

1. INTRODUCTION

The latest evolution and successful deployment of wireless local area networks (WLANs) has pushed into a strong demand to integrate them with the existing mobile networks such as Global System for Mobile Communications/General Packet Radio Service (GSM/GPRS), or third-generation (3G) Universal Mobile Telecommunications System (UMTS), and cdma2000. The main goal of this integration is to develop heterogeneous mobile data networks capable of supporting ubiquitous data services with very high data rates in hotspots. The most important technical challenges to develop such heterogeneous networks, also referred to as fourth-generation (4G) mobile data networks, are: seamless vertical handovers across WLAN and 3G radio technologies, security, common authentication, unified accounting and billing, WLAN sharing (by several 3G networks), and consistent Quality of Service (QoS) and service provisioning, to mention the most important ones.

One of most important aspects in the introduction of IP into a mobile communications network is the mobility management. The mobility management involves location management and handover management. Earlier works on the mobility management problem in heterogeneous networks proposed solutions either in network layer, as in case of Mobile IP or in application layer, i.e. SIP-based approach. However the already proposed solutions have several drawbacks, i.e. long handover latency, that recommend looking for a new proposal. In this new proposal, an important assumption should be made: the transport layer should support vertical handover in order to maintain the Internet end-to-end principle. The advantages of the transport layer approach are possibly wide scope of application, as there is no need for modification or adding any network component, and a possibility of fast adaptation of the flow and congestion control to existing network conditions.

1.1. New transport protocol - SCTP.

Conversely, TCP (Transmission Control Protocol) is not the only possible transport protocol solution for wireless networks. A new proposal for a general-purpose data transport (there is also an unreliable extension already available), called SCTP (Stream Control Transmission Protocol), has been defined in IETF's RFC 2960 [1]. SCTP was originally designed as a telephony signalling protocol over IP, however its capabilities let extend scope of use as a transport protocol for many traditional Internet services and applications such as these based on SIP or HTTP. Range of possible applications can be observed in many internet drafts discussing both signalling, and more general purposes.

SCTP provides a reliable, full-duplex connection and mechanisms to control congestion. SCTP’s connection is called association, and supports multiple streams within an association (multistreaming) and hosts with multiple network addresses (multihoming). SCTP associations are established in a four-way handshake (instead of a three-way as for TCP) in order to improve protocol security and make it resistant to blind Denial-of-Service (DoS) attacks. New features of SCTP that resulted in gaining so much interest are multihoming and multistreaming. Multihoming permits to use multiple IP addresses for the endpoints of the same association. So far, multihoming has been used for link redundancy only, but there is also a lot of research done to employ it to load balancing. Multistreaming allows SCTP to establish associations with *multiple streams* (streams are unidirectional data flows within a single association). The number of requested streams is declared on the association setup and valid during the entire association lifetime. Each stream is distinguished with the Stream Identifier field included in each chunk. Then, chunks from different streams can be concatenated inside one packet. To preserve order within a stream the Stream Sequence Number is used.

SCTP is still subject of a dynamic research in many areas; however this paper focuses on employing the SCTP's multihomming feature to perform transport layer seamless handover (TraSH).

1.2. Transport layer handover.

Idea of TraSH has been widely discussed recently [2], [3]. Proposed solutions include some modifications to the original version of the SCTP. This modified protocol version is also referred to, as a mobile SCTP (mSCTP). The main difference is a newly added extension for dynamic address reconfiguration, described in details in [4], that permits adding and/or deleting *dynamically* IP addresses to an *existing association*, as well as changing the *primary IP address* by means of new type of address configuration messages (ASCONF and ASCONF-ACK chunks). This approach fully supports end–to-end vertical handover in any type of heterogeneous wireless environment; nevertheless there is no particular concern about the performance improvement. Several IETF's drafts are devoted to develop the mSCTP: [5], [6].

Another scheme named cellular SCTP (cSCTP) was proposed in [7]. The cSCTP introduces to the mSCTP additional features in order to improve the performance during the handover process. New flag is used to indicate whether the mobile node has entered the handover phase and is possible to apply all the necessary changes of the IP addresses. During the handover phase both addresses are regarded as primaries and new congestion window (cwnd) is set for both to the half of the value of cwnd of the initial primary address.

As it was mentioned before, earlier works on the mobility management in the heterogeneous networks proposed solutions either in the network layer, as in case of Mobile IP or in the application layer, i.e. SIP-based approach. Table 1 shows a comparison of those different approaches to the mobility support.

Table 1. Mobility Support with mSCTP, MIP, SIP and RSerPool protocols.

Category	**mSCTP**	**Mobile IP**	**SIP**	**RSerPool**
Layer	Transport	Network	Application	Session
Location Management Support	No	yes	yes	yes
Handover Management Support	Yes	FMIP needed	supported with mSCTP	supported with mSCTP
Route optimization	provided basically	binding update needed	not provided	provided with. mSCTP
Network Support	not required	Required	not required	not required
Special Agents	No	Home Agent, Foreign Agent	SIP servers	ENRP server

2. Ns-2 simulation scenarios and parameters.

In order to establish well-defined operational conditions for testing the SCTP, a simple handover scenario, such as the one presented on the figure 1, has been analysed by means of the simulations carried out in the ns-2 simulator.

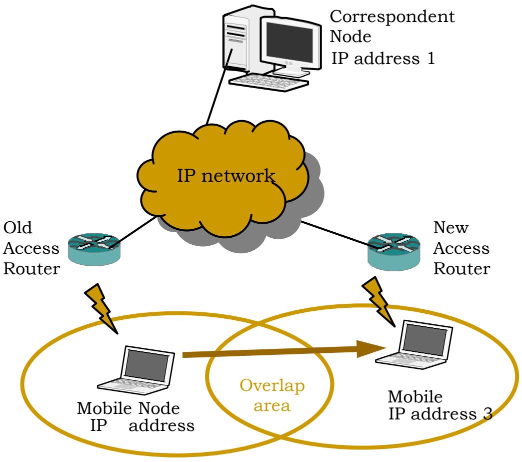

Figure 1: mSCTP for Soft Handover in Transport Layer – proposed simulation scenario.

In this scenario, the mobile user starts moving from one access point to the other, while maintaining an active SCTP association with the correspondent node. The decision of changing the network attachment point, as well as the execution of this process may have an important impact on the protocol performance and such analysis will form the scope of this paper.

Table 2 presents the most important parameters of the simulation scenarios.

Table 2. Scenario parameters.

Parameter	**Value**
Transmitted power, each AP	20 dBm
Noise level	-174 dBm/Hz
Wired line transmission delay	15 ms
Bandwidth of the wired networks	10 Mb/s
Distance between APs	162 m
Mobile node speed	2 m/s
Number of possible states for each M-QAM modulation	4, 16, 64, 256
Symbol transmission speed	1 Msymbol/s
Packet loss threshold	0,01
SCTP data chunk size	1468 Bytes

The simplest simulation model comprise of the symmetrical links when changing the attachment point from old AP to the new AP. Propagation path losses are accounted by a free space model plus a lognormal shadowing model with a standard deviation 5dB, and correlation distance of 10m. Under such constructed scenario, different decision functions, considering the relation of received signal strength from both APs, were evaluated. Figure 2 illustrates power received from each AP.

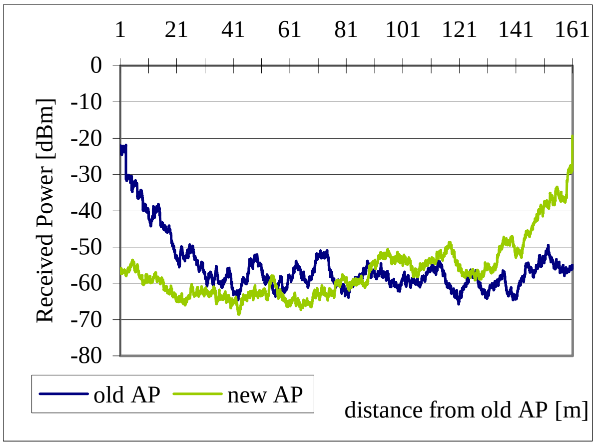

Figure 2: Received power from both APs

Radio channel transmissions are carried out at 8, 6, 4 and 2 Mbits/s data rates. A link adaptation algorithm assures the highest data rate among those, while providing a packet loss ratio below 1%. No channel coding is used so packet loss ratio is directly obtained from the radio channel bit error ratio (that depends on the M-QAM modulation, the observed signal to noise ratio) and the number of bits of a packet. Figure 3 shows available data rates for each AP for the desired packet loss ratio less than 1%.

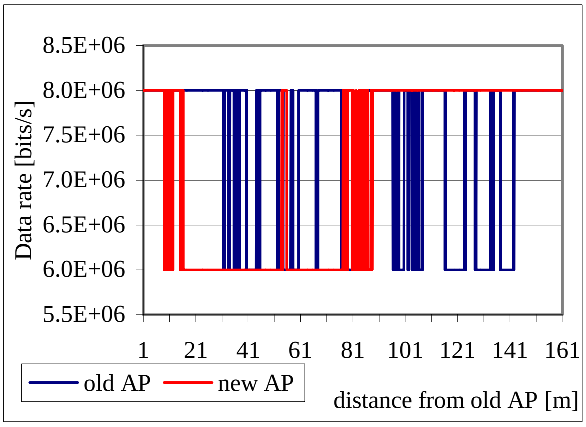

Figure 3: Available data rates at each AP

Next section presents the SCTP performance in two different situations: first, the change point is strictly determined and we look how the performance of the protocol changes in function of the distance from the old AP, followed by a study of triggering conditions influence.

3. Results and discussion.

3.1. Forced change point.

Within the presented scenario we analysed the average throughput rate, as well as the average congestion window (cwnd) size for the different points were handover was forced inside the overlap area. Each simulation was run 10 times to achieve the average performance.

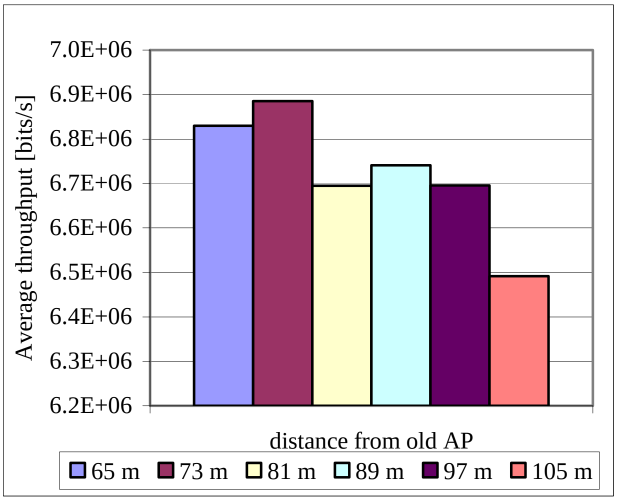

Figure 4: Average throughput rate for handover forced in function of the distance from old AP.

As shown in the figure 4, there is only a slightly difference in the average throughput, no matter where we take the decision to change the access point. However, it is necessary to take the decision early enough in order to avoid problems with the coverage from the old AP, as in the situation where handover is forced in the distance larger than the coverage radius (i.e. 105m from the old AP).

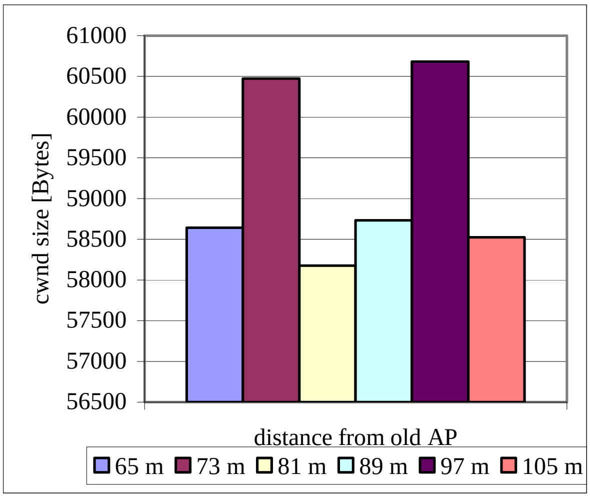

Figure 5. Average cwnd size in Bytes for handover forced in function of the distance from old AP.

Figures 5 presents the results obtained for the average congestion window size. The average cwnd size depends on whether in which phase of increasing cwnd the handover was invoked.

3.2. Different handover policies.

Very important feature in study of transport layer handover are triggering rules. We use standard relative signal strength criterion to determine when introduce a new IP address, change the primary IP or remove unnecessary IP address. Measurements are done each 20ms, and the following triggering levels are considered:

- Fast add-IP, if for 2 consecutive measures signal of a new AP is stronger than current, then a valid IP address for the new AP is added to the association.
- Slow add-IP, the same as before, but now within 4 consecutive probes meeting such criterion.
- Fast change-IP, changing primary IP address after 7 consecutive probes
- Slow change-IP, primary IP change with 10 probes threshold.

We also set thresholds levels for the Remove-IP address, which are 15 and 20 probes for fast and slow Remove-IP respectively. Figures 6 and 7 present the performance comparisons for each of mentioned triggering rules (thresholds are shown in the following order: Add-IP/Remove-IP/Change-IP). Each simulation was run 3 times to achieve the average performance.

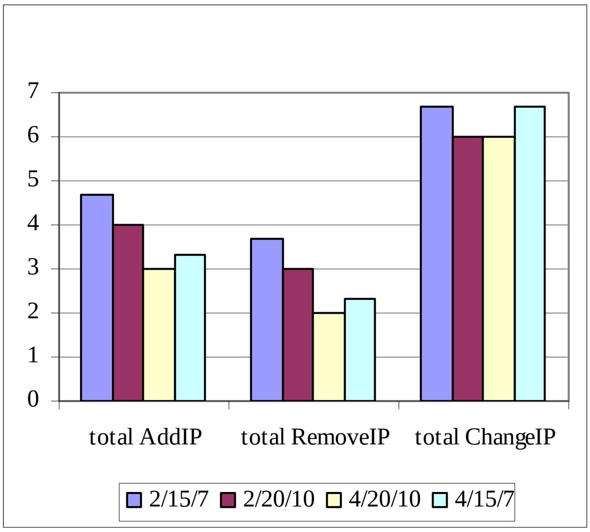

Figure 6. Average number of operations in the overlap area for different handover policies.

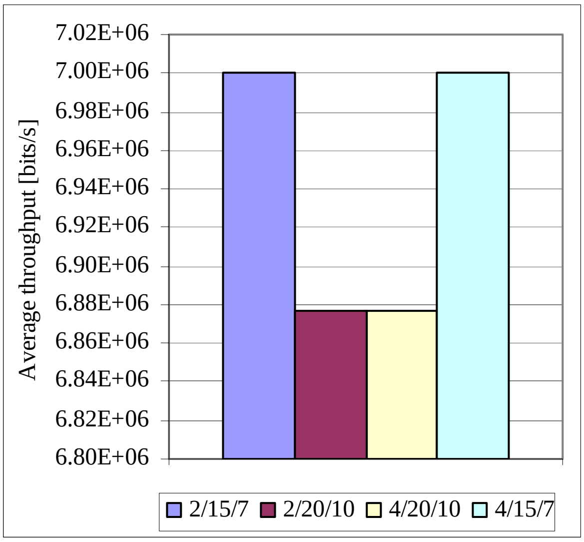

Figure 7. Average throughput rate for different handover policies.

Of course, there must be a trade off between desired throughput rate and signalling overhead caused by so called ping-pong effect invoking too many changes of AP. It seems that from the throughput point of view is better to force the change of the AP as fast as possible (Fast Change-IP obtain better throughput rate), however the signalling overhead is relatively high (number of generated Change-IP messages).

Moreover, in case of slow IP changes the fall in throughput rate is not that big considering the signalling overhead while maintaining the SCTP performance

4. CONCLUSIONS

In this paper we proposed initial study on SCTP performance in order to evaluate the idea of soft handover in the transport layer. We discussed two different aspects: the influence of distance from old AP to trigger the handover, and triggering rules. From the experiments on triggering rules it was shown that the best trade-off between average throughput and signalling overhead is achieved for slow add-IP and fast change-IP.

ACKNOWLEDGMENT

This work has been supported partially by the NoE NEWCOM from European Community and by TIC2004-00518 grant from CYCIT (Spanish National Science Council).

REFERENCES

[1] Stewart R., and Xie Q., et al., "Stream Control Transmission Protocol", IETF RFC 2960 (standard track), October 2000; www.ietf.org/rfc/rfc2960.txt.

[2] Koh S. J., Chang M.J. and Lee M., "mSCTP for Soft Handover in Transport Layer", IEEE Communication Letters, March 2004, pp.189-191.

[3] Ma L., Yu F., Leung V., and Randihawa T., "A New Method to Support UMTS-WLAN Vertical Handover Using SCTP", IEEE Wireless Communications Magazine, August 2004, pp.44-51.

[4] Stewart R., "Stream Control Transmission Protocol (SCTP) Dynamic Address Reconfiguration", IETF draft, September 2003; <draft-ietf-tsvwg-addip-sctp-08.txt>, work in progress.

[5] Riegel M., and Tuexen M., "Mobile SCTP", IETF draft, October 2004; <draft-riegel-tuexen-mobile-sctp-04.txt>, work in progress.

[6] Koh S. J., and Xie Q., "Mobile SCTP (mSCTP) for Internet Mobility ", IETF draft, March 2005; <draft-sjkoh-msctp-00.txt>, work in progress.

[7] Aydin I., Seok W., and Shen Ch.-Ch., "Cellular SCTP: A Transport-Layer Approach to Internet Mobility", Proceedings of the 12th International Conference on ICCCN, 20-22 October 2003, pp. 285 - 290.