Using SCTP to improve the network efficiency under asymmetric transmission link

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摘 要

隨著網路科技的快速發展，如何快速有效的傳遞資料成為廣泛討論的議題。以目前相當普及的 ADSL 技術為例，消極的加大網路頻寬，將需耗費大量的成本，因此有效的利用路徑切換的策略，適當的選擇最佳的網路傳輸路徑，讓資料傳輸得到最大的效能，則是另一種頻寬解決方案。因此我們利用 IETF 在 2000 年所提出的新一代之傳輸協定 SCTP，利用其中的 Multi-homing、路徑偵測機制(HEARTBEAT)與區塊綁定(Chunk bundling)等特性，並進行適當修改後，提出一個新的有效路徑選擇運作機制，使資料能夠在較有利的網路傳輸路徑上進行傳輸，藉此提升網路傳輸效能。

關鍵詞：SCTP, ADSL, Multi-homing, Heartbeat

Abstract

The networking technology develops rapidly in these years. It is important to transfer the data rapidly and efficiently. One of the approaches is to transmit data through different paths efficiently when there are many choices of paths to the users. To maximize the effective bandwidth utilization rate, we will let the data transmission achieve the best efficiency. In this paper, we use the new transmission protocol SCTP proposed by IETF in 2000. We use the characteristics of Multi-homing 、 HEARTBEAT and Chunk bundling in SCTP to provide a new efficient path selection under asymmetric transmission link.

Keywords: SCTP, ADSL, Multi-homing, Heartbeat

1. Introduction

The rapid growth of Internet and interactive multimedia applications, Internet is deeply in people's life. Through the increase of various services, the growth of the amount of data transmission bursts out comparing to the past on the Internet. The speed of 56K modem is not sufficient to use. The telecommunication companies are positively building new generation of High Speed Networking to face the new time of service and appliance of Broadband Network. The Asymmetric Digital Subscriber Lines (ADSL) which comes from the technique of DSL is mainly used.

The requirements amount of internet server in general families is downloading. There for Asymmetric Digital Subscriber Lines (ADSL) passed by American National Standards Institute (ANSI) has become the most popular standard. The main character is to use the original phone lines as the transmission media without rebuilding new lines and it divided asymmetrically on the bandwidth. It applies asymmetric transmission speed of upload and download.

However, ADSL not only fits in with home users but also fits in with middle scale industries because of the lower build up fees and remain cost compare to dedicated line. Industries can achieve their needs of bandwidth by setting many ADSL lines and combining them. If they use different Internet Service Provider (ISP), they also have the characters of back up lines.

Stream Control Transmission Protocol (SCTP) was made as RFC 2960[10] in October of 2000. The main characteristics of SCTP such as (1) Multi-streaming, (2) Chunk bundling, (3) Multi-homing, (4) Four-way handshake to make connections, etc.. The figure1 is SCTP protocol structure.

Otherwise SCTP has the characters of Selective Acknowledgments (SACK) and detect mechanism (HEARTBEAT). SACK is mainly used as a receiver to confirm when it receives the data packet. When the data packets have gaps, the SACK chunks will back to sender and ask for resending data. The mechanism of HEARTBEAT

is that there are many transmission paths connect the node and it will send HEARTBEAT (HB) packet to the idle paths in a period to ask the situation of the path. There are 30 seconds between HB packets. When SCTP node finds out the primary transmission path breaks off, it will change the backup path as the primary path automatically [2].

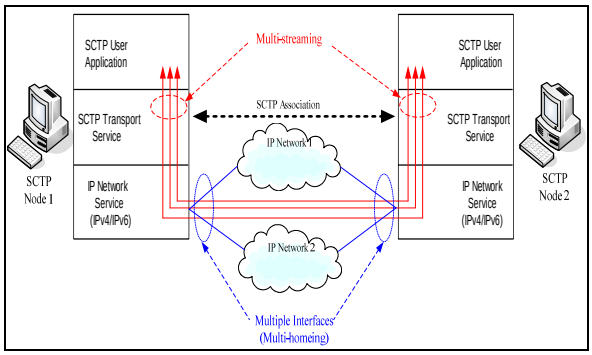

Figure 1、 The SCTP protocol structure

This paper has five chapters. The first chapter is introduction and the background. The second chapter is discussions about the relative studies of SCTP's exchange mechanism. The third chapter introduces our method of exchange paths under ADSL environment. The fourth chapter is a result which our simulation and analysis. The last chapter is conclusion of the paper and the development in the future.

2. Related Work

SCTP applies a reliable and perfect transmission mechanism especially under the high missing rate internet environment. Add up with multiple transmission paths and use the File Transfer Protocol (FTP) [1] to send data. It can satisfy the users who hope to complete the data transmission fast, and avoid the break down during the transmission process. However, how to choose the best transmission path to send data to achieve the best transmission efficiency is what we are going to discuss.

In the RFC-2960[10] defines that nodes can to achieve that in the same association we can have many IP addresses through many interfaces at the same time. When the primary transmission path breaks down, it can quickly change the path to keep sending data without rebuild the new connection. But the mechanism of path exchange only happens when the path breaks down happened. It doesn't consider the congest control mechanism. Although the mechanism can lower the internet congest but it makes the problem of lower transmission efficiency.

Shigeru Kashihara [11] and other scholars also bring out that to calculate the bottleneck bandwidth and the latency as the condition of choosing path. They use the "The packet pair method" method which K.Lai [8] brought out in 2001. The method will get each path's bandwidth. At the same time, they make users to modify HB packet size (60bytes) in order to get the more precise BBW value of path. The conditions are: 1.) choose the primary path in accordance with the sufficient bandwidth. 2.) When the primary path and the backup path both satisfy or dissatisfy with the need of bandwidth, the path select further consideration utilize SRTT and bandwidth of each path. When one of the two conditions satisfies, exchanges the path to find out the best transmission path.

However, the method may make unnecessary path exchange and exchange delay. And when it counts the time of delay, it needs to send two bigger and reformed HB packets, then get the optimistic time of path delay. It will make the whole Internet create extra overhead.

John Fitzpatrick[7,8] and other scholars direct SCTP protocol using ITU (International Telecommunication Union) G.701 E-model (R=Ro-Is-Id-Ie+A) to measure the path quality of service (QoS) in Voice over Internet Protocol. It's comparing with ITU G.800 Mean Opinion Score (MOS) which subjectively measures the QoS parameter. Using the QoS parameter makes a choice to switch path that can improve the VoIP QoS to exploit SCTP's Multi-homing characteristic.

However, the E-model just use HB packet to measure RTT parameter in each path. For this reason, it can't obtain the condition in real network. So they modify the HB packet size to 80 bytes and deliver many packets to detect the path. However, this mechanism will make more loading on the internet.

Therefore we proposed a method that can avoid extra overhead and the network resources wasting. It will proceed path detect and path switch mechanism real time and effective to improve the efficacy of transmission.

3. The proposed strategy

Due to the requirement of file transmit in

real time is not quite high. Therefore users want to get bigger bandwidth to download or upload files. It makes the data transmit faster and shorten the transmit time. Use ADSL as an example, because the bandwidth limited by ISP from user end to the network server provider. We assume the backbone is quite large between ISPs. Therefore the transmission bottleneck bandwidth (BBW) will result in download bandwidth of client end or upload bandwidth of server end. The useful bandwidth will reduce when the numbers or types of download data or upload data increases.

Therefore we proposed a new path switch mechanism. When users supply the SCTP protocol and have many ADSL lines simultaneously. According utilize the characteristic of Heartbeat in SCTP protocol. It will detect the useful bandwidth immediately without sending extra bigger packet to each path. When the bandwidth reduces in primary path, the mechanism can detect and select the best backup path to process data transmit real time. To proceed data transmit with maximum transmission bandwidth, to get the best efficiency in file transmit.

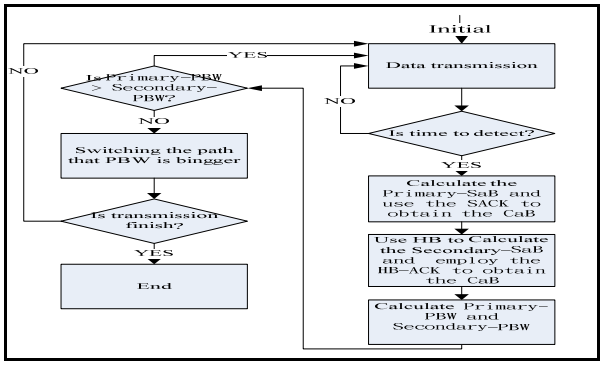

Figure 2、The Process flow of proposed strategy

The SCTP protocol can bound many transmit path in the same association when setting up at the beginning. The data transmit according a primary path at beginning, the HB packet will proceed path detect in backup path. But the original SCTP proceed to switch path only when the primary path cutting off. Therefore we proposed a new path switch strategy that modifies the path switch strategy of SCTP. The new strategy will real time detect the bandwidth of each path and to computer available bandwidth that as the basis of route where data are transmitted of the choice. It modify some as follows：

1.）SCTP will cyclic detect and computer the available upload bandwidth(Server available Bandwidth, SaB) form endpoint B to ISP in primary path interface. Furthermore, use SACK packet to receive the available download bandwidth (Client available Bandwidth, CaB) from ISP to endpoint A. The SaB and CaB are parameters of select path.
2.）Modify the cycle of HB packet delivering on detecting backup path on the standard SCTP to match the primary path by detecting the interval between the rest of useable bandwidth. It is also computer the available upload bandwidth form endpoint B to ISP(SaB) and using HB-ACK to receive the available download bandwidth from ISP to endpoint A(CaB) of each backup path.
3.)The data transmit end use the parameter from the formula(1) to find out each path's Most small Path Bandwidth (SPB).
4. ）And use the formula(2) to Compare the weight (PBW_{new}) of each path.
5. ）Finally set primary path according to which is the maximum weight from each path.

$$SPB=Min(SaB,CaB) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$PBW_{new}=\alpha PBW_{old}+(1-\alpha)*SPB \ (0 \leqq \alpha \leqq 1) \quad .(2)$$

The SaB is detection path available upload bandwidth in Server. The computer is utilizing the maximum upload bandwidth minus using upload bandwidth at a unit time. In addition, the CaB is detection path available download bandwidth in Client. The parameter of SPB which is small path bandwidth chose form SaB and CaB. The parameter of PBW_{new}(Path Bandwidth Weight-new) is the weight of path available bandwidth now, and the PBW_{old}(Path Bandwidth Weight-old) is the weight of path available bandwidth last time.

In order to avoid result surplus path switch and produce extra delay due to the parameter size of SPB. Therefore we calculate present the available bandwidth weight value (PBW_{new}) on each path. The computer of PBW_{new}, we use the parameter PBW_{old} multiply by α and combine with the parameter of SPB. Finally we get present path weight (PBW_{new}). When the weight of backup path is greater than primary path, transmit path will switched.

The Figure2 is a flow chart of paths switch mechanism. When finishing setting up the

SCTP's association, the data transmit from Server. It also judge whether reaches the route detect time. If it has not expired the detect time, the Server continues carrying on the transmission of the data. If the data has expired the detect interval time, the Server will detect and computer the available bandwidth with each path in the same association. Then compare the weight of each path. If the weight of primary path is not lesser than other backup path's weights (Primary-PBW_{new}> Secondary-PBW_{new}), it does not switch transmit path, data transmit still follows the original path. On the other hand switch primary transmit path. At the same time, if the data is not complete transmitted, the data transmit will be through with the new primary path.

Therefore we proposed method on path switch utilize the characteristics, Multi-homing and heartbeat of SCTP, moreover modify some mechanism in SCTP. The method can switch transmit path in good time when bandwidth reduces in primary path and the association does not need to be setting-up again, In order to reach better throughput.

4. Performance Analysis

This paper is building the network environment by our method. The users of both sides have many ADSL circuit to transmit data. It compares to the efficiency on the FTP that combine with traditional transmission protocol or our proposed strategy. The Experiment structure chart of this research in Figure3. Both end users (Client、Server) support SCTP transmission protocol and have two ADSL circuit with different bandwidth to ISP. Between two end points are through backbone of ISP. When finish setting up the association with Client and Server. The data transmits from Server to Client.

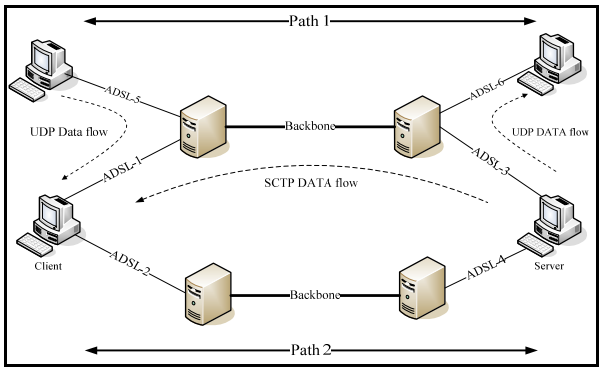

Figure 3、The Experimental setup

We simulate using Network Simulation Version 2(NS-2)[12] in Linux Fedora core 2. Description of the detailed experimental environmental parameter in Table 1, the simulation environmental in Client and Server both have many transmission paths, the experiment computes when the Primary transmit path (ADSL-3、ADSL-1) commit influences on other UDP flow, what influences on data transmission will we meet.

Description on different simulation situation parameter is in Table 2. In the experiment, Simulation situation I and Simulation situation II is to compare each path of Server and Client, when the main transmit path commit influences on other UDP flow in server or client. According to the differences of parameters from simulation situation I and simulation situation II, we can get the changes of throughput results, separately describe on Figure 4 and Figure 5. Figure 6 is to compare the changes of TSN in SCTP and our proposed method in scenarios I. In Figure 7, will be experiment compare influence of throughput in different detect interval. According to situation parameter from simulation situation I. The α value is established as 0.6.

Table 1、The NS-2 experimental environment

Operation System	Fedora core 2
Simulate Software	NS-2 ver.2.28
Simulate Time	40 Sec
SCTP Data flow Start and stop time	1 Sec, 35 Sec
Backbone bandwidth	100Mbits
ADSL-1 and ADSL-2 Download bandwidth	3Mbits
ADSL-3 Uplink bandwidth	2Mbits
ADSL-4 Uplink bandwidth	1Mbits
ADSL-5 and ADSL-6 Double link bandwidth	5Mbits

Table 2、 Experimental scenarios

Scenario Ⅰ	
UDP Data flow Start and Stop time with ADSL-3	5 Sec, 15 Sec
Detect Interval	1 Sec
Scenario Ⅱ	
UDP Data flow Start and Stop time with ADSL-1	15 Sec, 25 Sec
Detect Interval	1 Sec

In Figure 3 Experiment structure, the SCTP data have been transmitted since the first second according to Path 1. At fifth second and 15th second, Path 1 has other interference with the UDP flow, makes Path 1's bandwidth decrease. At tradition SCTP transmit protocol, Path1 is not breach, therefore the transmit path does not switch. So the throughput is reduced. Then we proposed path switch strategy can prompt to detect the change of bandwidth with transmit path and switch transmit path, to improve the transmit efficiency.

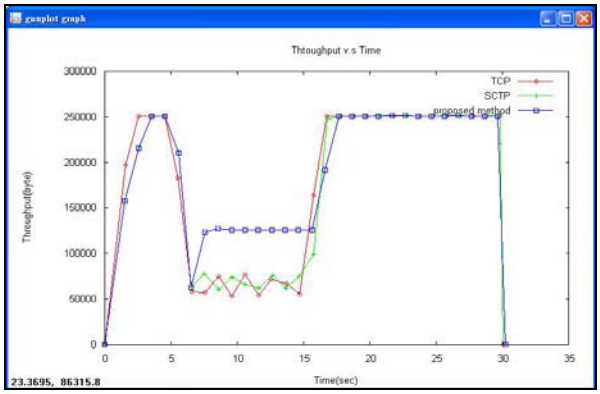

Figure 4、Change of throughput for different protocols (Interfere with ADSL-3)

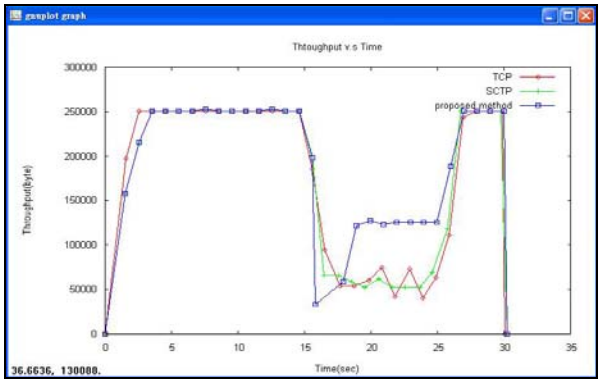

Figure 5、Change of throughput for different protocols (Interfere with ADSL-1)

In Figure 4 and Figure 5, X axis and Y axis represent simulation time and throughput respectively. In Figure 4, the UDP data flow had started in Path1 (ADSL-3) at the fifth second, Path1's bandwidth decreased, our method will switch transmission path to Path2. Until the UDP flow had ended at 15th second. The transmission path will switch to Path1.

The same situation in Figure 5, the UDP flow had started in Path 1 (ADSL-1) at the 15th second, Path1's bandwidth reduced, our method will switch transmission path to Path2. Until the UDP flow had ended at 25th second. The transmission path will switch to Path1.

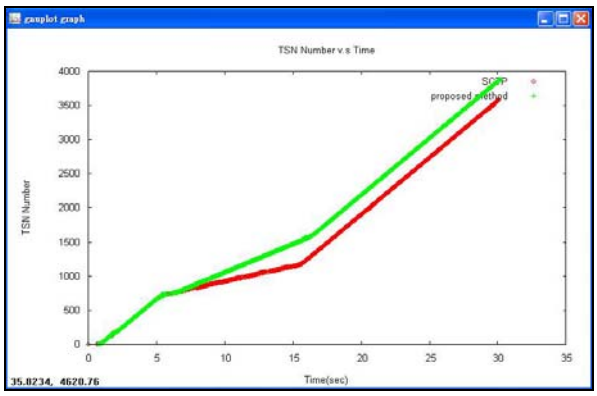

Figure 6、Change of TSN for different protocols (Interfere with ADSL-3)

In Figure 6, X axis and Y axis represent simulation time and TSN Number respectively. Because the Path1 commit other interference with UDP data flow, then the usability bandwidth reduced. At tradition SCTP, the congested control and retransmission mechanism will retard the TSN Number in receiver. It will restore until 15th second the interference had ended. Due to our method can fast detect the change of bandwidth and switch the transmission path. So our method can improve the transmit efficiency.

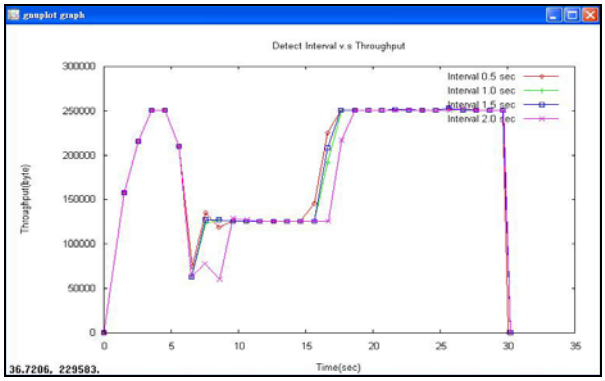

Figure 7、Change of throughput in different detected intervals (Interfere with ADSL-3)

In Figure 7 is our proposed path switch strategy, the experiment that computes the influence of the data transmitted in different detect interval. The X axis and Y axis represent simulation time and throughput respectively. The bandwidth detect intervals are 0.5 second、1.0 second、1.5 second、2.0 second respectively. According to the experiment, we can get a result that bandwidth detect interval is 0.5 second has better throughput.

5. Conclusions

For the traditional data transmission using FTP over TCP, because it only allows one connection for one address, the transmission can be blocked if the transmission link is broken. To switch to different transmission paths, the session will be re-established which results in unnecessary delay and decrease of the transmission efficiency. On the other hand, SCTP with multi-homing functionality allows multiple addresses to be related to the same association. This will reduce the unnecessary delay as in the case of TCP. However, the path switch only occurs when the primary path breaks according to the default SCTP mechanism. Therefore, we proposed the automatic detection of the transmission condition for different paths and provided the mechanisms to decide the optimized path switch. This design, especially for the asymmetric transmission link, increased the transmission efficiency.

References

[1] A. Bhushan, B. Braden, W. Crowther, E. Harslem, J. Heafner, A. McKenzie, J. Melvin, B. Sundberg, D. Watson and J. White, *"The file transfer Protocol"*, ***IETF RFC 0172***,June 1971

[2] A. Caro, P. Amer, and J. Iyengar, *"Retransmission Policies with Transport Layer Multihoming"*, ***IEEE International Conference on Networks*** ,pp.255-260, 2003

[3] A. Caro et al., *"SCTP：A Proposed Standard for Robust Inernet Data Transport"*, ***IEEE Computer***, pp.56-63,2003

[4] J. Funasaka,; K.Ishida, H. Obata, and Y. Jutori,*" A study on primary path switching strategy of SCTP"*, ***IEEE International Conference on Autonomous Eecetralized Systems***, pp.536-541,2005

[5] J. Fitzpatrick and J. Murphy, "SCTP based Handover Mechanism for VoIP over IEEE 802.11b Wireless LAN with Heterogeneous Transmission Rates," ***IEEE Department of Electrical and Computer engineering at ICC 2006***, June 12 2006.

[6] J. Fitzpatrick, J. Murphy and S. Murphy, "An approach to transport layer handover of VoIP over WLAN," ***IEEE Consumer Communications and Networking Conference***, Volume 2, January 2006.

[7] J. Postel, *"Transmission Control Protocol"*, ***IETF RFC 793***, January 1980.

[8] K. Lai and H. Baker, *"A Tool for Measuring Bottleneck Link Bandwidth"*, ***Proc. USENIX symposium on Internet Technology and Systems***, March 2001.

[9] L.H. Chang, B.Y. Ho, "Effective Path Selection using SCTP for Asymmetric Network," ***The 2nd Workshop on Wireless, Ad Hoc, and Sensor Networks (WASN 2006)***, August 10, 2006.

[10] R. Stewart, et al., *"Stream Control Transmission Protocol"*, ***IETF RFC 2960***, October 2000.

[11]S. Kashihara, T. Nishiyama,.K. Iida, H. Koga, Y. Kadobayashi, and S. Yamaguchi,*" Path selection using active measurement in multi-homed wireless networks"*, ***IEEE International Symposium on Applications and the Interne (SAINT2004)***, pp.273-276,2004

[12]The Network Simulator version 2 - ns-2 http://www.isi.edu/nsnam/ns/