Use of SCTP for Handoff and Path Selection Strategy in Wireless Network

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摘要

一般的應用程式都是使用 TCP 和 UDP 的傳輸協定來進行資料的傳輸，然而在無線網路中，使用者具有移動性，在移動的過程中會有換手的行程， IP 位置勢必會改變，這兩種協定需要再重新建立連線。Stream Control Transmission Protocol 是新的傳輸層協定，而 SCTP 的 DAR 機制可以不需再重新建立連線。目前已有許多學者從事 SCTP 協定之研究，其中也有學者對於 SCTP 的 DAR 換手進行效能分析。然而卻很少有研究於換手時能決定出選擇最好的路徑，一般只考慮訊號強度進行選擇。我們將設計一個路徑決策的系統，並結合 SCTP，找出在無線網路中最好的路徑出來再進行換手的行程，提昇檔案傳輸的效能。

關鍵詞：SCTP、DAR、無線網路、換手、Socket API。

Abstract

Wireless network comprises many Access Points (APs). When a user moves, its IP address may be changed. Applications have not supplied handoff by using TCP or UDP since the connection needs to be re-established while handoff. The Stream Control Transmission Protocol (SCTP) is a novel transport layer protocol. SCTP provides handoff with Dynamic Address Reconfiguration (DAR) mechanism. There are studies about the SCTP, and part of them are about the handoff with DAR of SCTP. They utilize the signal strength from AP to decide handoff by using DAR but can not select the best path. Therefore, in this paper we proposed the system that can decide handoff and select the best path in wireless network.

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Keywords: SCTP, DAR, Wireless Network, handoff, Socket API.

1. Introduction

Today, wireless networks provide users with mobility functions. Users can use some applications and transfer data anywhere at anytime. Users usually use Transmission Control Protocol (TCP). TCP has some limitations. For example, a user must handoff when it moves from AP 1 to AP 2 and in the overlapped region. TCP needs to re-establish a connection because TCP will abort the original connection after handoff. Therefore, new transport protocol is discussed to promote the transmission efficiency, especially focusing on path select, mobility management and handoff issues. For content users, applications expect faster, more reliable and more efficient transport protocol in wireless networks.

SCTP [5] standardized by the Internet Engineering Task Force (IETF) is a transport layer protocol. SCTP introduces many characteristics, including multi-homing, multi-streaming, chunk bundling, selective acknowledgments (SACK) and heartbeat. Like TCP and UDP, SCTP belongs to the transport layer in the IP architecture. Additionally, SCTP is achieved through the concept of association, which is a set of transport layer connections between the same pair of endpoints, each connection being routed over one of the available interface. SCTP creates the IP list after establishing association. The SCTP association is established by four-way handshaking to avoid the security issue in TCP. Figure 1 shows the architecture of SCTP.

In wireless network, DAR [6] is extended by SCTP. DAR will allow SCTP stack to dynamically add an IP address to the IP list of SCTP association, to dynamically delete IP address from the IP list of SCTP association, and to request to set the primary address. The primary address is used by the source endpoint to communicate with the destination endpoint. Users do not need to re-establish association because the DAR in SCTP will not abort the association after handoff.

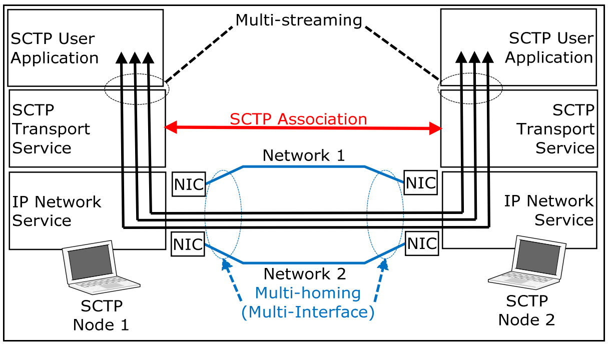

Figure 1. Architecture of SCTP.

In this paper, we designed and implemented the path selection system of SCTP which chose the best transmission path in wireless network.

2. Related Backgrounds

2.1 Dynamic Address Reconfiguration

DAR was standardized by the IETF in September 2007. DAR supports Seamless Handoff in transport layer. DAR defines two new chunks and several new parameters. New chunks are Address Configuration Change Chunk (ASCONF) and Address Configuration Acknowledgment Chunk (ASCONF-ACK). The new parameters include Add IP Address, Delete IP Address and Set Primary Address. Therefore, Mobile Node (MN) can use ASCONF and ASCONF-ACK chunk to achieve handoff.

Figure 2 and Figure 3 show the concept and the procedure of DAR, respectively. It is assumed that the MN initiates the association with the Correspondent Node (CN). For SCTP association, the MN uses IP 1 and the CN uses IP 3. When the MN moves from AP 1 to AP 2, it arrives at the overlapped region and the MN gets IP 2 from AP 2. The MN sends an ASCONF (Add IP Address, IP2) message to the CN to add IP 2 to the SCTP association. The CN responds an ASCONF-ACK to the MN upon receiving ASCONF from the MN. The IP lists of the MN and the CN therefore keep IP 1 and IP 2 addresses. While the MN continues to move toward AP 2 and the signal form AP 2 becomes strong enough, the MN needs to change to the new IP address for the SCTP association. The MN sends an ASCONF (Set Primary, IP 2) message to the CN. The CN responds ASCONF-ACK to the MN upon receiving an ASCONF from the MN. As the MN progresses to move toward AP 2, if the signal form AP 1 becomes too weak to support communications, the MN must delete IP 1 from the IP list by sending an ASCONF (Delete IP 1) message to the CN. The CN responds ASCONF-ACK to the MN upon receiving an ASCONF from the MN.

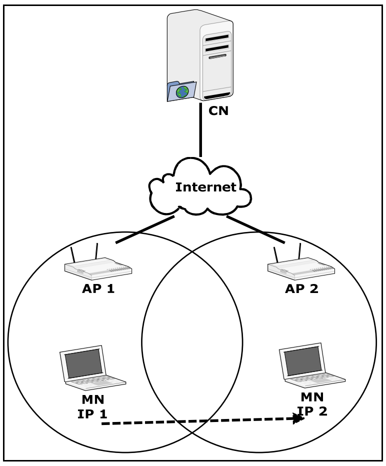

Figure 2. Handoff environment of SCTP.

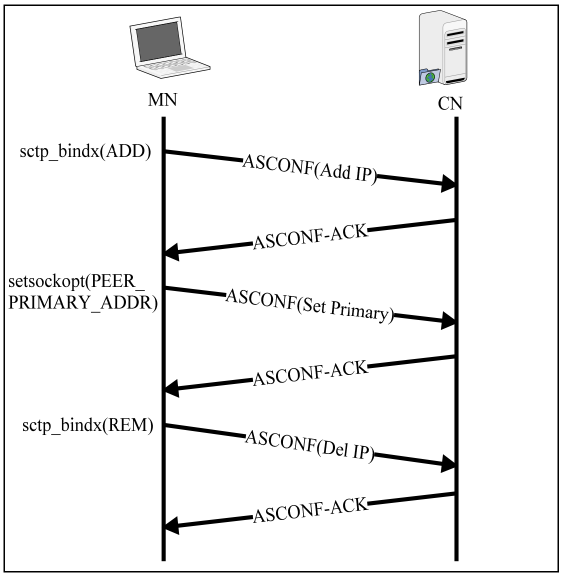

Figure 3. Handoff procedure of SCTP

2.2 SCTP Application Programming Interfaces (APIs)

SCTP sockets API [7] is still under working in the state of draft. SCTP sockets API has provided a standard mapping of the Internet Protocol suite to many operating systems. SCTP sockets API is extended from TCP socket and UDP socket because SCTP keeps lots of characteristics of TCP and UDP, and provides some new features. SCTP sockets API has two kinds of socket styles. The first one is one-to-many style. It is a set of semantics which is similar to that defined for connectionless protocols, such as UDP. The second one is one-to-one style. It supports a similar semantics as sockets for connection-oriented protocols, such as TCP.

DAR uses the sctp_bindx() and the setsockopt() functions in SCTP sockets API. The sctp_bindx() function uses two kinds of parameters, where SCTP_BINDX_ADD_ADDR adds new IP addresses to the IP list and SCTP_BINDX_REM_ADDR removes IP addresses from the IP list. The setscokopt() function uses SCTP_PEER_ADDR_PARAMS parameter to change the primary IP address.

3. Related Works

In the study of S. J. Koh et al. [3], they focused on the addition of IP, deletion of IP and change of primary IP with DAR in wireless network. They compared signal strength from AP and decided the conditions to add IP, delete IP and change primary IP. They defined “aggressive” and “conservative” criteria to trigger DAR. They analyzed the performance of their system by using the Network Simulator 2 (NS2) [10]. In their simulations, they set the MN with two mobility patterns, cross-over and random modes, at the overlapped region. They combined triggering rules with mobility patterns and compared the file delivering time.

In the study of D.P. Kim et al. [2], they conducted the implementation of DAR for SCTP by using Linux Kernel Stream Control Transmission Protocol (lksctp) [8]. A small test network was constructed in their test environment, which consisted of one router and two APs. The MN used a Network Interface Card (NIC) to support the SCTP single-homing feature. On one hand, the MN was equipped with two different NICs to support the SCTP dual-homing feature. They conducted the experimental analyses of SCTP handoff for single-homing and dual-homing as well as the file delivering time.

S. Lahde et al. [4] developed the system with DAR of SCTP in heterogeneous communication environments. The system comprised three main components, The HO engine, HO server and Link Monitor. The HO Engine provided handoff to applications upon receiving handoff message from the HO Server. The HO Server obtained the network information from the Link Monitor to make the handoff decision. The Link Monitor measured the quality and characteristic of each available link. In their experiments, they simulated different networks by using NIST Net emulation [9]. They measured throughput and end-to-end delay of the system during handoffs.

Those researches discussed handoffs by using DAR of SCTP in wireless network, and made the handoff decision according to the signal strength only. Those researches can not find the best path for transmission. In this paper, we proposed the handoff strategies with path selection in wireless network and conducted the implementation of the design.

4. System Design

The proposed system was defined at the overlapped region of signal of APs. The system selected the best path by using DAR in SCTP which could increase the application’s throughput in wireless network. Figure 4 shows the system module in this research which comprises six main components. The Initial module provides the initialization of the system at the beginning. In addition, the Initial module chooses the best signal strength among APs for the primary path at the beginning by using the Detect Network module. The Detect Network module measures the signal strength from each AP and the quality of each available path by cyclic delivery of Heartbeat packets. The Network List module stores the state information of the network from the Detect Network module. The Handoff Resolution module decides the condition to change path after calculating and comparing data from the Network List module. The DAR module performs DAR in SCTP and controls the Send/Receive module. The Send/Receive module conducts the data transfer.

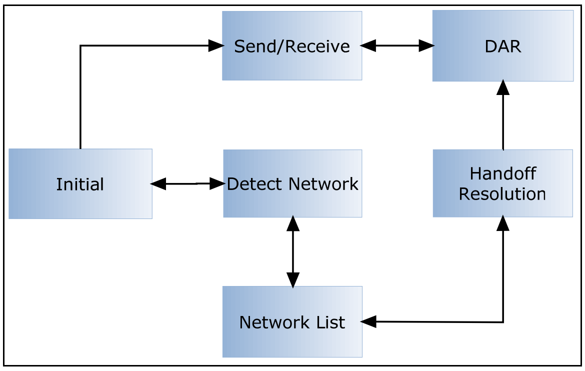

Figure 4. System Module

Figure 5 shows the handoff procedure of the proposed system. The MN obtains IP 2 from AP 2 when it enters the overlapped region between AP 1 and AP 2. The MN sends ASCONF (Add IP2) to the CN. The CN adds IP 2 in the IP list. The Detect Network module begins to record information of different paths to the CN by cyclic delivery of Heartbeat packets. The MN sends ASCONF (Set Primary IP 2) to the CN when the Handoff Resolution module decides to change the primary path. If the signal strength from AP 1 becomes too weak to support communications, the MN deletes IP 1 from the IP list by sending an ASCONF (Delete IP 1) message to the CN.

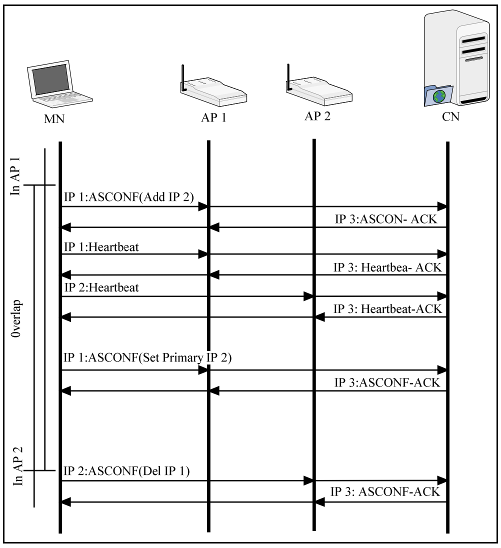

Figure 5. Handoff Procedure of system.

From our previous work, we have designed one path selection algorithm for handoff decision [1]. In this paper, we modified it little bit and conducted the path selection and handoff strategies according two formulas shown below. The Handoff Resolution module will execute these formulas. Formula (1) decides the path change when it is true. The *OPV* stands for the Original Path Value. The *NPV* stands for the New Path Value. The parameter α is the weight value decided by users. Formula (2) is designed to compute path value for every available link. The *OPV* takes the path value from formula (2). The *NPV* chooses the maximum value from formula (2) without *OPV* value. The *S.S.* stands for the signal strength of the corresponding AP. The *Ps* is the success ratio of the transmitted heartbeat packets. The *RTT* stands for Round Trip Time of the heartbeat packets. *S.S.*, *Ps* and *RTT* are metrics to measure the quality of transmission path. The β and the γ are weight values decided by users.

$$OPV < \alpha \cdot (NPV) \quad \text{.....................(1)}$$

$$S.S. \cdot \left[\beta \cdot (Ps) + \gamma \cdot \left(\frac{1}{RTT} \right) \right] \quad \text{.....................(2)}$$

5. Evaluation

5.1 Measurement environment

In the software system of our experimental environment, we used Socket API of SCTP to implement the system by lksctp 2.6.16-1.0.6. We used Linux Ubuntu 7.04 (Feisty Fawn) [12] as the operating system. We observed the packets by using Wireshark network protocol analyzer [11]. The system hardware list is shown in Table 1. We used Notebooks to represent the MNs and Servers to represent the CNs. We used PLANEX CQW-AP108AG for APs in the experiment. The network topology is shown in figure 2 with the MNs and the CNs. We used 802.11g Protocol for radio transmission in wireless network.

Table 1. Hardware of list.

	MN	CN
CPU	Intel Pentium 1.8 GHz (32bit)	AMD Dual Core 1.8GMHz (32bit)
RAM	512MB	2048 MB
NIC(s)	Intel PRO/Wireless 2200	NetXtreme 1 Gigabit Ethernet

In our experiments, we observed the handoff time using DAR of the proposed system. We used formula (3), shown below, to make the handoff decision.

$$1.2 \cdot (S.S._{AP1}) < S.S_{AP2} \ldots\ldots\ldots\ldots\ldots \ldots\ldots(3)$$

Formula (3) compares the signal strength between AP 1 and AP 2. The system requests an IP address from every AP. Each AP replies to the request from the built-in DHCP server. Then, the system conducts DAR in SCTP and follows formula (3) to make the decision of handoff. Figure 6 shows the observation of the SCTP packets by using Wireshark. The IP address of MN is ‘192.168.55.71’ from AP 1. The corresponding IP address of CN is ‘192.168.55.6’. At the beginning, ASCONF is to add IP address ‘192.168.55.81’ to IP list. Then, ASCONF is to change the IP address due to the handoff. The MN uses IP address ‘192.168.55.81’ to transfer data after receiving an ASCONF-ACK. Finally, ASCONF is delete IP address ‘192.168.55.71’ from IP list.

No.	Time	Source	Destination	Protocol	Info
3000	40.043213	192.168.55.71	192.168.55.6	SCTP	DATA
3001	40.066994	192.168.55.6	192.168.55.71	SCTP	SACK
3002	40.069220	192.168.55.71	192.168.55.6	SCTP	ASCONF
3003	40.070420	192.168.55.6	192.168.55.71	SCTP	ASCONF_ACK
3004	40.071865	192.168.55.71	192.168.55.6	SCTP	ASCONF
3005	40.073194	192.168.55.6	192.168.55.71	SCTP	ASCONF_ACK
3006	41.080102	192.168.55.81	192.168.55.6	SCTP	ASCONF
3007	41.080147	192.168.55.81	192.168.55.6	SCTP	DATA
3008	41.093043	192.168.55.6	192.168.55.81	SCTP	ASCONF_ACK
3009	41.281509	192.168.55.6	192.168.55.81	SCTP	SACK
3010	41.281576	192.168.55.81	192.168.55.6	SCTP	DATA
3011	41.281605	192.168.55.81	192.168.55.6	SCTP	DATA
3012	41.286645	192.168.55.6	192.168.55.81	SCTP	SACK
3013	41.286692	192.168.55.81	192.168.55.6	SCTP	DATA
3014	41.286717	192.168.55.81	192.168.55.6	SCTP	DATA

Figure 6. Packet flow of DAR

5.2 Measurement results

In our experiments, the MN sends a file with size of 2MB to the CN. We discovered that the DAR in SCTP will not conduct handoff unless the transmission queue of SCTP is empty. That means we need to clean up the queue in SCTP before using formula (3) to make DAR handoff. We define Wait Time, Handoff Time and Total Time in our experiments. The Wait Time is the latency for the transmitted packets in queue of SCTP to be cleaned up after handoff decide being made. The Handoff Time is the period from the last packet with old IP address being sent out to the first packet with new IP address being sent out. The Total Time is the summation of Wait Time and Handoff Time. We set packet size to be 128, 256, 1024, and 2048 bytes, exclusive the header files, for different experiments and sent them to the SCTP queue.

Table 2. Different packet size of handoff time.

Packet Size	2048	1024	256	128
Wait Time	0.2936	0.4900	0.4289	0.7391
Handoff Time	1.5205	1.0534	1.8392	1.2922
Total Time	1.8141	1.5134	2.2681	2.0313

(unit: second)

Table 2 shows the measurement result of handoff time. The transmitted packets in SCTP queue with bigger packet size are expected to be longer than those with smaller packet size. That means the Wait Time for bigger packet size should be larger than the smaller packet size. However, from our experimental results, we found that the packet size of 2048 bytes showed the least Wait Time compared with other smaller packet sizes. The reason for the least Wait Time is that the bigger packets have faster transmission rates. The packet size with 1024 bytes, however, has longer Wait Time as compared with the packet size with 256 bytes. The reason for the 1024-byte packet with longer Wait Time is believed to be due to the accumulation of more data in SCTP queue for transmission which causes more time to clean the queue, compared with that of 256-byte packet. On the other hand, the Handoff Time for packet sizes of 2048, 1024, 256 and 128 bytes are around 1.52, 1.05, 1.84 and 1.29 seconds, respectively. The Handoff Time was not affected by packet sizes. The Handoff Time may be affected by ASCONF delivering time and process scheduling of operating system.

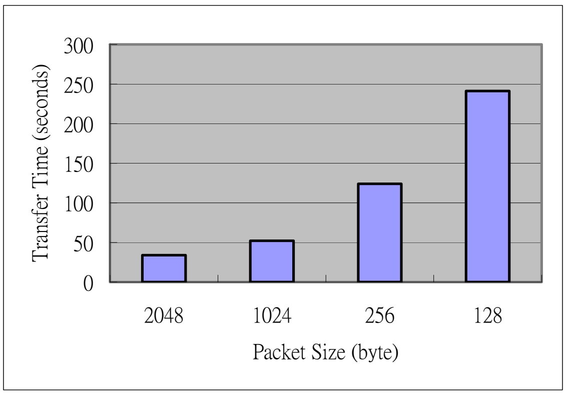

Figure 7. Transfer time with different packet sizes.

Figure 7 shows the transfer time, including handoff processing time, with different packet sizes. The transfer time for packet sizes of 2048, 1024, 256 and 128 bytes are around 34.0, 56.1, 124.1 and 241.3 seconds, respectively. The 2MB file spent least transfer time by using packets with 2048 bytes. The experimental results are believed to be due to the larger transfer rates with bigger packet sizes.

6. Conclusions

In this paper, we proposed the handoff strategies with path selection by using DAR in SCTP over wireless networks. We observed handoff time of DAR of our proposed system over Linux platform. We conducted the experimental analyses of DAR for the handoff time and file delivering time. From our experimental result, we found that the file delivering time for the 2048-byte packet size was the smallest. The reason for the least Wait Time is that the bigger packets have faster transmission rates. The packet size may affect the file delivering time; however, the handoff time of DAR will not affect the file delivery significantly.

In the future, we will continuously improve the throughput of our designed system. We will further conduct related experiments to make the result more complete. For example, we will measure and compare the throughput of file transfer for the mechanisms with and without best path selection. In addition, we will conduct our system with two or more wireless NICs to further improve the overall throughput of the designed system.

7. Acknowledgements

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