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A path switching scheme for SCTP based on round trip delays

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ABSTRACT

Due to the rapid development of network applications, today the Internet plays an important role in our everyday life. Users hope that the network is always speedy enough to help them access the Internet without any delay. But the real situation is far from the ideal case. In the future, network researchers will continuously improve the network speed, and try to develop networks that are robust, without any crashes or packet loss. In this paper, we propose an aggressive path switching scheme for SCTP. Before data transmission, the scheme selects the fastest path as the primary path to transmit packets. When the path fails or transmission quality is poor, this scheme evaluates alternate paths, and selects the one with the best quality as the new primary path to substitute for the original one. After that, packets are delivered through the new path. Several factors are considered in the evaluation, including bandwidth, encryption/decryption, size of the congestion window, retransmission policy, routing policy, etc.

1. Introduction

In recent years, many mobile and fixed hosts are increasingly equipped with multiple network interfaces [1] which provide two end nodes of a communication connection/association with multiple paths to enhance packet delivery reliability and service availability. This is an important issue particularly for those systems that need very reliable transmission support. Stream control transmission protocol (SCTP), which provides a multi-homing feature, is presently a protocol that meets the requirement of multiple network interfaces. That is why its importance both in wired and wireless communication is greater every day, and its applications have also been widely deployed and quickly developed. Leu [2] employed SCTP as a key mechanism of network mobility to achieve a seamless handover for delivering multimedia data. Noonan et al. [3] proposed a delay sensitive SCTP which evaluates voice traffic between multi-homed hosts and chooses the lowest delay path to demonstrate performance improvements.

To take full advantage of multi-homing, many current studies are addressing the issue of how to select the best network interface and transmission path to efficiently transmit packets. Dahal and Saikia [4] proposed a scheme, called Switch Path on Congestion, to determine whether a handover from the current primary path to an alternate path is necessary or not. Kelly et al. [5] introduced a delay-centric handover by periodically measuring path delays. Ribeiro and Leung [1] raised a minimum delay path selection scheme to select the lowest delay paths for both directions of communication between sender and receiver. Noonan et al. [3] proposed a scheme that offers the benefit of performing the handover based on measured path delays. Other modified SCTP versions can be found in [6,7]. Al-kaisan et al. [8] stated that congestion control algorithms are unable to prevent congestion collapse and unfairness created by applications that are unresponsive to network congestion.

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Generally, the above-mentioned approaches switch paths and improve SCTP performance all based on measured round trip time (RTT) and layer-four features, e.g., adjusting the size of the congestion window. However, our opinion is that SCTP improvement should not be limited to RTT measurements and transport layer functions, implying that the factors the current SCTP systems consider are only a part of SCTP's performance-affecting factors. It also means that the performance can be further improved. In fact, a packet travels through several network layers before it arrives at its destination. We consult the OSI model [9] as the reference model. When a transmission starts, packets flow from the application layer to the physical layer, and then go across switches/routers or mobile routers. When the packets arrive at the receiver, they go in the reverse direction from the physical layer to the application layer. This is a complicated transmission process in which the transport layer plays an important role in handling flow control. However, if other factors, like current network bandwidth and packet drop rates on intermediate nodes/routers between sender and receiver, can be involved [10], its performance will be further improved.

Hence, in this study, we develop a new path switching scheme for SCTP, called the *p*ath *s*election *a*nd *s*witching *p*rocess (PSASP), which when the current primary path fails or its transmission quality is poor chooses the best path for SCTP by evaluating mechanisms and activities that influence SCTP transmission efficiency, including the size of encrypted/decrypted data [6], size of the congestion window [11,12], retransmission policies [13], length of a routing path [14], a packet's RTT [4], network delays [1], hardware speed and bandwidth, etc., aiming to improve the performance of the SCTP protocol. These mechanisms and activities are dispersed in layers of the OSI model. For example, routing is a layer-three task, and hardware speed is a layer-one concern. In this study, we also formally analyze a path's delivery delay by dealing with these probable factors, and propose a path switching scheme based on evaluation results of the related mechanisms and activities. Further, among these factors, a factor may be affected by others. For example, current available bandwidth is affected by the size of the sender's congestion window. In other words, this is a complicated analytical task. Experimental results show that this scheme can truly select the best path. In the following, no matter the concerned facilities are routers or mobile routers, we call them routers to simplify the description.

The contributions of this research are as follows:

(1) The PSASP evaluates cross-layer mechanisms and activities to select a primary path for the SCTP.
(2) We derive PSASP's cost model, including the processing delay, transmission delay, propagation delay and queuing delay, each of which is evaluated based on the cross-layer mechanisms and activities.
(3) We calculate the total cost for the PSASP when k retransmissions have been experienced given a path's retransmission probability, $k = 0, 1, 2, \ldots, n$.

This paper is organized as follows. Section 2 introduces relevant background and related work. Section 3 describes our system architecture. The experimental results are presented in Section 4. Section 5 concludes this article and addresses our feature work.

2. Background and related work

2.1. SCTP

The SCTP inherits features and attributes from the TCP, but provides new features for users [15], including multi-homing, multi-streaming, heartbeat, four-way handshake, and chunk bundling.

(1) Multi-homing: with this, the SCTP establishes an association between sender and receiver before transmitting packets. An association often contains multiple paths, each of which is an ip-to-ip connection, i.e., this protocol needs multiple IPs. Initially the SCTP chooses a path as the primary path to transmit packets. When transmission quality is poor, it chooses the secondary path, known as alternate path, to substitute for the primary path. With multi-homing, SCTP transmission is more reliable than that of TCP and UDP.
(2) Multi-streaming: this divides a path into multiple subpaths, called streams. All streams are independent of each other in transmission. Before data transmission, SCTP defines a number of streams and assigns packets to streams for transmission to prevent the head of line problem [16].
(3) Heartbeat: this is implemented for each node to periodically send packets telling other nodes that it is still active. Through heartbeats, a node can know which paths are currently available.
(4) Four-way handshake: this is used to establish a connection. Before data transmission, the sender sends an INIT to the receiver. The receiver on receiving the INIT responds with an INIT-ACK which includes a state cookie and connection information, neither saving state information, nor allocating resources for the connection. Next, the sender replies with a corresponding COOKIE-ECHO to confirm the state cookie. After the confirmation, the receiver replies with a COOKIE-ACK. After that, an association is established and the sender can transmit data to the receiver. Meanwhile, the receiver allocates cpu time and memory capacity to the association.
(5) Chunk bundling: this is related to the SCTP packet format. A SCTP packet includes control chunks and data chunks. Control chunks carry information for SCTP controlling. Data chunks convey data messages. The SCTP can bundle several small chunks into a big one, or vice versa. However, the packet size cannot in any circumstance exceed the maximum transmission limit.