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덤벨 네트워크에서 TCP 리눅스 변종의 혼잡 제어 알고리즘 평가

Congestion Control Algorithms Evaluation of TCP Linux Variants in Dumbbell

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요 약 덤벨은 조금 확장시키면 거의 모든 종류의 네트워크 실험에서 사용할 수 있는 가장 기본적인 토폴로지이다. 전송 제어 프로토콜인 TCP는 네트워크와 기지국 사이의 연결을 위해 사용되는 기본적인 프로토콜이다. TCP의 주요 목표는 기본적인 통신을 위하여 다른 애플리케이션에 서비스와 경로를 제공하는 것이다. 이로 인해 TCP는 통신 매체를 통해 많은 양의 데이터를 전송해야하기 때문에 심각한 혼잡 문제를 야기한다. 혼잡 문제를 계산하기 위해 다른 종류의 pre-cure 솔루션인 LBV와 DBV가 개발되었다. LBV은 만일 패킷들이 삭제되기 시작한다면, TCP 프로토콜을 통해 전달 될 예정인 데이터를 추적한다. 그때 TCP CUBIC은 그 손실을 알리기 위하여 LBV를 사용한다. 마찬가지로 DBV는 ACK 데이터가 그 설정된 데이터 속도 시간보다 지연되었을 때 사용되는 승인절차로 동작한다. TCP COMPOUND/VAGAS가 DBV의 예이다. 많은 알고리즘이 다른 TCP 변형에서 혼잡을 제어하기 위해 제안되었지만, 데이터 패킷들의 손실을 완전히 조절하지 못하였다. 이 논문에서, 혼잡 제어 알고리즘을 구현하였으며 그 결과를 덤벨 토폴로지를 사용하여 분석하였다. 그것은 일반적으로 TCP 트래픽을 분석하는 데 사용한다. 처리량의 공정성은 네트워크 시뮬레이터 (NS-2)를 사용하여 다른 TCP 변형에서 평가하였다.

Abstract Dumbbell is the most basic topology that can be used in almost all kind of network experiment within it or just by little expansion. While Transmission Control Protocol TCP is the basic protocol that is used for the connectivity among networks and stations. TCP major and basic goal is to provide path and services to different applications for communication. For that reason TCP has to transfer a lot of data through a communication medium that cause serious congestion problem. To calculate the congestion problem, different kind of pre-cure solutions are developer which are Loss Based Variant and Delay Based Variant. While LBV keep track of the data that is going to be passed through TCP protocol, if the data packets start dropping that means congestion occurrence which notify as a symptom, TCP CUBIC use LBV for notifying the loss. Similarly the DBV work with the acknowledgment procedure that is used in when data ACK get late with respect to its set data rate time, TCP COMPOUND/VAGAS are examples of DBV. Many algorithms have been purposed to control the congestion in different TCP variants but the loss of data packets did not completely controlled. In this paper, the congestion control algorithms are implemented and corresponding results are analyzed in Dumbbell topology, it is typically used to analyze the TCP traffic flows. Fairness of throughput is evaluated for different TCP variants using network simulator (NS-2).

Key Words : Acknowledgement, Congestion Window, Dumbbell Topology, Slow-start Threshold.

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I. Introduction

Dumbbell network are mostly used for connecting or making a networking for testing purposes of the networks. Dumbbell network topology has ranging in wireless or wired networking topologies as according to our usage, dumbbell topology is now implementable in almost every field of life from very simple networks to a complex and high level networking infrastructure designs. In other words, dumbbell topology has evolved as a key network to evaluate the traffic flows in TCP variants [1].

Transmission control protocol is responsible for end to end data delivery within a network and also having responsible or the reliable transferring of data, it's a connection oriented protocol unlike unified datagram protocol and having responsibility to make sure that the data has been transferred from one end to other end according to its destination address and sender requirements. In this process every decision taken by transmission control protocol on the basis of acknowledgement from the destination node.

Van Jacobson proposed algorithms for congestion avoidance and control: slow start (quickly fills the empty pipeline before the timeout), congestion avoidance (also called AIMD, obey Conservation of Packets algorithm) and fast re-transmit (duplicate acknowledgements if packet loss) [4].

When an acknowledgement received then the other packet of data will be transfer from source to destination node. Here are two mechanism used for getting send data and getting acknowledgement from destination to source node, stop and wait and sliding window which are commonly used by transmission control protocol for send or receive data. In stop and wait technique every packet will be sent after the acknowledgement of its predecessor packet, when its received then the next packet will be sent to the destination point, this sequence is going on until all packets or data transmission have been completed.

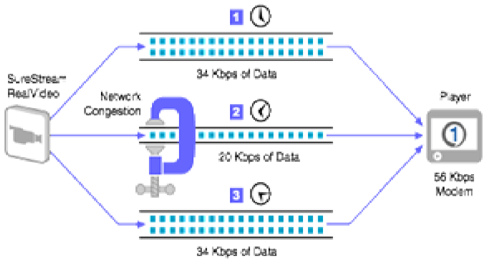

그림 1. 중간 혼잡
Fig. 1. Congestion in the Medium

On another hand the sliding window technique which means that a number of packets or the bundle of packets will be send to the destination point after the acknowledgement of the previous group of packets, if there is any frame missing in the previous group of packets then it will be send first then the next group or bundle of packets will being send. However transmission control protocol is core protocol for data transferring in the networks so he is many variants available for this protocol every variant of transmission control protocol having its own functionalities and properties according to the situation and network scenario, when we talk about the variants of transmission control protocol here are many name or them such as Reno, new Reno, high speed TCP, scalable TCP and many more [2].

In this research these main variants of transmission control protocol are being under study for the purpose of their performance evaluation according to their throughput, fairness, and convergence time. These thing will be conducted by the experimental study in network simulator by using the Linux operating system.

When any data is being to send in transmission control protocol its firstly perform handshaking between the source and destination nodes for the purpose to match their clock time and its ensure to the source node that the receiving node is ready to receive data from the source point, it is make possible by their handshaking and matching clock time of both nodes, while these functions in not executed in the user datagram protocol, its only send data to the destination point no matter it will received to the destination point or not.

II. TCP Variants

1. TCP Reno

The logic behind Reno is we get duplicate acknowledgements. Reno detects congestion as soon as it receives 3 duplicate acknowledgements. Without waiting for the time. Reno performs very well over TCP when the packet losses are small. But in multiple data loss, Reno does not perform well. The information about packet loss comes only after we receive 3 duplicate acknowledgements. But the information of the second packet loss comes only after receiving the acknowledgement of the re-transmitted packet i.e. one round trip time [3].

The equation which is used to increase the congestion window's size until the congestion is not detected.

Cwnd = cwnd + 1

When the congestion detected the congestion window size is increased as follow.

Cwnd = cwnd + 1/cwnd

2. TCP New-Reno

It does not exit the fast-recovery phase until all the unacknowledged data in the pipeline which was outstanding at the moment it entered the fast recovery phase is acknowledged. New-Reno suffers from the fact that it has to wait for one round trip time to detect every single packet loss. When the acknowledgement of the re-transmitted data is received, only then we can deduce which other segments of data was lost.

We can say that New Reno is an enhanced version of TCP RENO because its working same as Reno but it does not exit the fast recovery phase until the next acknowledgement is received.

When (New Reno) enters into the fast recovery phase it makes a note of the data which is outstanding. Next the speedy revival stage proceeds as in Reno. Yet when a new acknowledgement is established, afterward there are 2 potentials [5].

3. High Speed TCP (HSTCP)

High speed TCP was proposed to improve the performance of TCP connections by increasing the size of congestion window by the packet drop rate and an average congestion window. Whenever an acknowledgement is received, the congestion window is increased. HSTCP in fact suffers from the round trip time unfairness and TCP unfairness problems.

High speed TCP was projected to get better the presentation of TCP associations by raising the dimension of congestion window. HSTCP overcomes the current congestion control algorithms which limit the network resource utilization by making minor modifications. However TCPs" main aim is to transmit the data in an efficient manner with respect to time and packet drops. HSTCP retains the basic principles such as slow-start and time out with slight changes in it [6]. High speed TCP introduces a relation between the packet drop rate and an average congestion window. Whenever an acknowledgement is received, the congestion window is increased as shown below.

Cwnd = cwnd + $a(cwnd)/cwnd$

Whenever the congestion is noticed the cwnd is rationalized as revealed beneath

Cwnd = cwnd – b (cwnd)*cwnd

HSTCP performs as same as the standard TCP when the congestion window is small, the standards for 'a' and 'b' are 1 and 0.5 in the same way. Formerly the congestion window dimension is further than convinced threshold the window size (a) increases more aggressively than the standard TCP, while the value of (b) dips to 0.1 from 0.5. This behavior helps HSTCP to be compatible with standard TCP flows in networks and also to quickly utilize the available bandwidth in network with large bandwidth delay products [7, 8].

4. Scalable TCP (STCP)

Instead of splitting the congestion window size, every data loss decreases the congestion window by a small fraction until the data loss stops. Once the data loss stops, the rate is ramped at a slow fixed rate.

However, the increase and decrease rates in STCP are constant rather than HSTCP"s varying current window size. Whenever an acknowledgement is received, the cwnd is updated as the following equation.

Scalable TCP is alike to the HSTCP's violent boost and reduce algorithm. Scalable TCP amend the standard congestion control algorithms. Instead of halving the congestion window size, every data loss decreases the congestion window by a small fraction until the data loss stops [9]. Once the data loss stops, the rate is ramped at a slow fixed rate [10]. Though, the boost and decline rates in STCP are steady somewhat than HSTCP"s changeable present window size. When an acknowledgement is conventional, the cwnd is modernized as.

Cwnd= cwnd+ a

While congestion is noticed cwnd is reorganized as.

Cwnd=cwnd - (b*cwnd)

The standards of 'a' and 'b' are set to 0.01 and 0.125, the occasion fulfilled by STCP to twice its transfer speed at the basis is 70 round trip times for several speed and from now on the algorithm is scalable. Though, TCP-unfairness and RTT-unfairness problems are the major drawbacks like HSTCP [11].

III. Mock-up Setup and Tactic

The consequences in this paper are pedestal on the imitation done on NS-2, a separate occasion simulator. We have selected dumbbell topology for the study.

If a single connection may lost or damage, it refer to the breakage of communication channel and transferring of data, in this situation communication data cannot be travel from one node to another in any case. Since bidirectional relations are really apply by a sole wire [17].

1. High Speed TCP (HSTCP)

A Dumbbell topology is modeled with the network simulator-2 consisting of 8 hosts and 2 switches [12]. Any size of network can be chosen according to the experiment requirements, no of switches or user nodes can be increase or decrease according to network size, but the increment in the no of nodes may cause the complexity in the network and will create the chances of more noise in the all dedicated channels of the under studying network, Usually simple dumbbell network used of experiments purposes to see that how the under study network behave in simplest form of this topology. Each node have more concern with its neighboring nodes to communicate and transfer data to the core switches or any other node. [13].

2. Paths of Communication

DSR (Dynamic Source Routing) Protocol is a very easy and effective routing protocol designed especially for those networks that have multi-hop in MANETs. The third problem Broadcasting Storm is caused by DSR Protocol is remained for future work [14]. All nodes have dedicated link with other connected nodes and the core switches. The capacity of each communication channel between two nodes is manageable.

표 1. 관련 네트워크와 TCP 변형사용
Table 1. TCP Variant usage with Relevant Networks

TCP-Variants	Type of Network
New Reno	Wireless Network
Reno	Standard Network
Scalable High-speed	High-Speed Networks

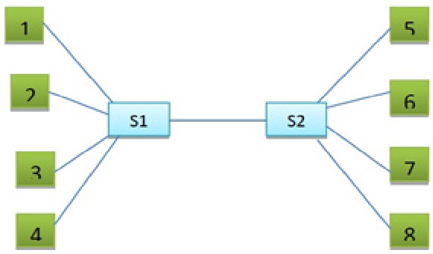

그림 2. 기본 덤벨 토폴로지
Fig. 2. Basic Dumbbell Topology

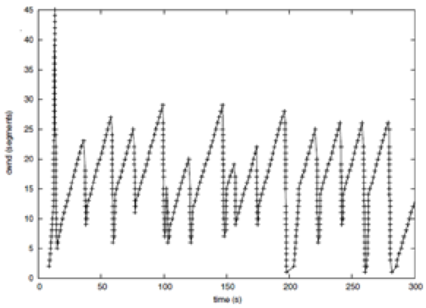

그림 3. 혼잡 윈도우 동작 - 리노
Fig. 3. Congestion window behavior - Reno

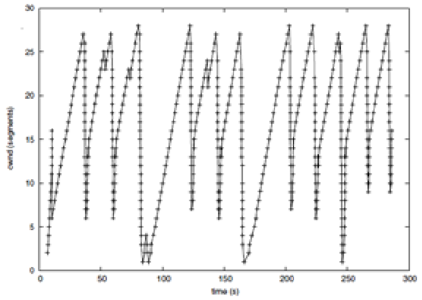

그림 4. 혼잡 윈도우 동작 - 새로운 리노
Fig. 4. Congestion window behavior - New Reno

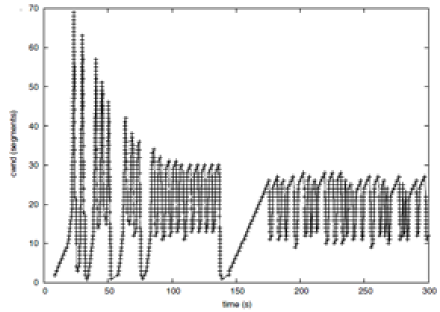

그림 5. 혼잡 윈도우 동작 - 확장
Fig. 5. Congestion window behavior - Scalable

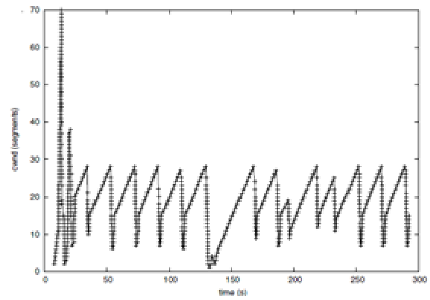

그림 6. 혼잡 윈도우 동작 - 높은 속도의 확장
Fig. 6. The behavior of congestion window - High-speed

표 2. TCP 변종의 처리량
Table 2. Throughput of the TCP Variants

TCP Variants	Throughput (Kbits/s)
Reno	393
New Reno	413
Scalable	440
High Speed	305

표 3. 패킷 손실의 세부 정보
Table 3. Packet Loss Detail

If Multiple packets Lost	TCP variants	Packets sent (%)	Packets Lost (%)
Worst	Reno	53.69%	46.31%
Better	New-Reno	68.06%	31.94%
Average	HSTCP	56.91%	43.09%
Average	STCP	54.55%	45.45%

3. Communication Traffic

When congestion happens, low priority packets are dropped at a faster rate (on average 10 times faster) than that for high priority packets [15, 16].The traffic flow in the dumbbell network is simulated and analyzed using different TCP variants. The results and analysis are depicted in the next section.

When given a situation where the amount of content due to be pushed through a connection is growing at a rate greater than it is possible to push through that connection, also known as a bottleneck, then there is no other solution than to drop packets. The TCP protocol is designed with a slow-start connection strategy so that excessive packet loss is cause the sender to throttle back and stop flooding the bottleneck point with data (using perceived packet loss as feedback to discover congestion).The data packets is be transmitted over a longer duration.[18].

IV. Experimental Results

We have executed to assess the presentation obtainable through the divergent of variants of the TCP realized in Linux version of 2.6. Showing in table 1, referring the complete record of the TCP Linux variants, represent-ting the type of network and the relevant variant of TCP which has been chosen for this network. Towards execute the under study experiment here are worn couple of tackle, equally liberally.

The set-up topology used for the primary imitation place is unabridged description for this complete scenario, wherever just the terminated node is linked towards the dependency system, whereas the other sided node remains straight linked to the global are network (internet).

Concerning to the channel throughput attained through the diverse alternatives in table 2. The standard throughput calculated more 15 minutes' extended associations. As of the consequences it appears evidently that all the variants approximately attain the similar presentation. Certainly, as of out experiments the satellite account do not take to any major development by admiration to the additional "typical" variants.

V. Results And Analysis

The traffic flow is determined using NS2 simulator. Table 2 demonstrate the throughput (in Kbps) get for every high-speed TCP variant in dumbbell network. Throughput reduces as we boost the figure of leap for all high-speed TCP variants as exposed in the table. Our studies demonstrate that all high-speed TCP variants constantly do healthier by dumbbell network.

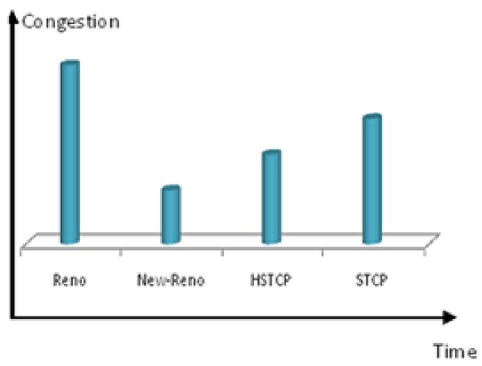

그림 7. 패킷 손실 분석
Fig. 7. Packet Loss Analysis

In this situation imitation mock-up utilize the package creation of transfer using file transfer protocol (FTP) means. FTP symbolizes a vastness data transport of huge size wherever the package mass and time of package production is set.

In our simulation the packet size is set to 1000 in all the cases. The table 3 depicts the results.

VI. Conclusion

We assess the presentation of high-speed TCP variants in provisions of throughput using dumbbell network. It is experiential that the presentation of TCP mainly depends on the congestion in the network. From our simulation results, the performance of TCP new Reno is much better for congestion control. In this study we have not considered other performance constraint such as Convergence and fairness speed, round trip time fairness and TCP fairness. Hereafter, we mean to learn the presentation of high speed tcp variants with overstated constraints to enhance the working capabilities of transmission control protocol in Dumbbell network.

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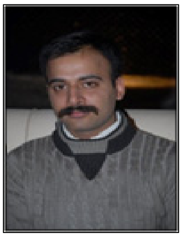

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