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Design of a Cross-Layer Loss Discrimination Mechanism for DCCP in Wireless Environments

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Abstract

DCCP, or Datagram Congestion Control algorithm, is a transit layer algorithm that ensures dependable data transfer despite the presence of unstable connections. DCCP includes a congestion management device that modifies the packet transmission rate based on the status of the network. When it comes to bottleneck losses and cellular connection failures, however, DCCP does not make any distinctions. caused by fading, which causes extra rate changes. In this article, we suggested a method to improve DCCP's usage of available capacity in a cellular network. We used a cross-layer loss separation method to split out the effects of crowding loss from those of fading. The true fading loss rate can be inferred thanks to the cross-layer based method that identifies frame loss in the data connection layer in real-time. After that is done, the transit layer packet loss will not include the fading loss. Once the originator has determined the congestion loss rate accurately, they can use the DCCP rate control process to make transmission rate adjustments that are reflective of the actual congestion condition along the transmission route. Our simulation findings indicate that when the fading loss rate in a wireless network ranges from 5% to 15%, DCCP with our suggested CCID 3 rate control algorithm can detect fading loss and increase transmission rates by between 4.7% and 15.5%.

1. Introduction

A new transit layer system called Datagram Congestion Control system (DCCP) is being developed to increase the amount of data that can be sent in real time for services like video on demand and VoIP over the Internet. When the transit layer is unstable, DCCP can be used to perform congestion management. Congestion, three in-built CCID 2, CCID 3, and CCID 4 are the management systems that are in use at the moment. At the moment of link establishment, a congestion control strategy can be chosen and changed flexibly, for instance from CCID2 to CCID3, based on the feature discussion of both DCCP destinations. However, DCCP runs into problems when trying to adjust to the wifi network setting. Inappropriate transmission rate decrease occurs in DCCP congestion control systems for primarily two causes. To begin, wireless traffic gridlock at an Access Point (AP). This indicates that there is Intense rivalry for the AP's assigned networks. In this case, the AP's capability may be exceeded by the aggregate bandwidth requirements of the attached mobile nodes. The AP's cache is where inbound data should be briefly kept. However, the AP's cache may overrun and some packets should be discarded if the inbound packet arrival rate is greater than the AP's operation rate. So-called cellular gridlock causes a severe slowdown in transfer efficiency. Second, a mistake in signal propagation due to fading happened over cellular networks. Multipath fading and signal loss both contribute to fading errors. Packet transport security is compromised, and transmission speed drops, due to signal fading mistake. When signal fading error happens, the mobile node drops messages because it was unable to receive a portion of the broadcast packet. We constructed and ran a simulation of a wireless network in which a signal fading mistake was introduced to show its devastating effects. Decline due to ageing in specific. As shown in Fig. 1, DCCP suffers performance drops in the presence of wireless fading loss. The CCID 3 congestion management method is used in the planned experiment over a wireless network, and the fading loss rate is the chance of a message being lost due to a fading signal. Since there is no fading impact on the network at launch, the wireless signal fading loss rate is equivalent to zero, and the DCCP's transmission rate is 34.8KB/s. The network was then given a diminishing loss effect. The average transmission rate falls to 31KB/s when the fading loss rate reaches

5%. In addition, we doubled the previous diminishing loss rate from ten percent to forty percent. As the amount of wireless fading rises, it is clear that the transmission rate declines significantly. The results of this trial show that slowing down the pace at which data is sent has no bearing on the problem of network overcrowding. An important take away from the experiments is that DCCP's rate control system decreases the transfer rate even when there is no overcrowding in the cellular network.

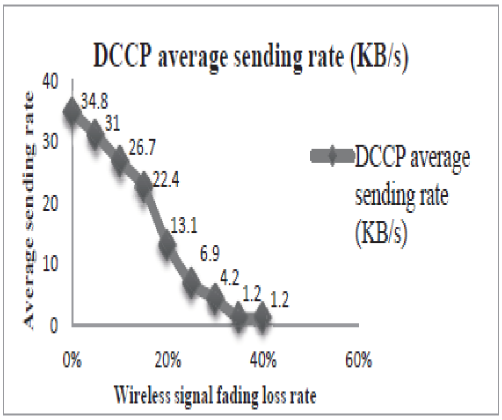

Fig. 1. Experiment result for DCCP over wireless links

To evaluate the effectiveness of the DCCP CCID 3 congestion management method, the rate of dropped messages is measured. DCCP keeps a log of all data bits it receives and discards. For a DCCP link that supports ECN (Explicit Congestion Notification), a message is recognized as a period of gridlock. Packets dropped in the wireless network realm due to fading are still counted as losses in the reception list, which is used to determine the loss event rate. DCCP CCID 3 uses the TCP-Friendly Rate Control algorithm to accomplish TCP fairness and a seamless transfer rate by adjusting the packet transmitting rate based on monitored network circumstances like RTT (Round Trip Time) and loss event rate. Here is the rate-controlling equation:

$$X = \frac{S}{RTT^* \sqrt{\frac{2p}{3}} + tRTO^* \left(3\sqrt{\frac{3p}{8}}\right)^* p^* \left(1+32p^2\right)}$$

Where X is the data-transfer speed, S is the packet-size indicator, RTT is the round-trip time, tRTO is the restart limit, and p is the loss-occurrence frequency. Loss event rate is determined by tracking and updating the receipt history list with each packet's arrival. A rise in the lost occurrence rate as assessed by the DCCP In order to instantly change the transmitting rate, the receiving mechanism transmits a confirmation to the sending mechanism. Otherwise, the recipient would have to transmit a response during each RTT interval. When overcrowding causes packet loss in a cable network, the DCCP adjusts the transmission rate to compensate for the loss. Because DCCP can't tell the difference between congestion loss and signal fading loss in a wireless network, it overestimates the loss event rate p and reduces the transmitting rate of packets more than required. To boost DCCP CCID 3's functionality over wireless networks, this article incorporates a cross-layer loss detection method into DCCP. The suggested cross-layer based method makes use of the data connection layer's information to separate crowding loss from fading loss. Since DCCP is able to differentiate between fading loss and overcrowding loss, it can modify its transfer rate accordingly. This paper's final sections are structured as follows. In Section 2, we provide an overview of the literature concerning DCCP in wireless networks and the various loss detection methods that have been proposed. In Section 3, the recommended framework and loss classification system are detailed. The outcomes and evaluations of computer performance are presented in Section 4. The final thoughts are presented in Section 5.

2. Related work

Mechanisms for managing the rates of streaming services across a variety of networks are the subject of current research. Rate management is difficult to implement because the loss situation can shift quickly. And To maintain a consistent transfer rate, an effective rate change approach should adapt to the network. Condition. There are a lot of potential answers to the problem, but DCCP and SCTP are two of them. To [1] compare DCCP with other video streaming algorithms over a cellular network. Both DCCP and SCTP are protocols that operate at the transport layer. The DCCP has been demonstrated to be an effective method for this streaming service has a higher rate than SCTP and less delay and fewer interruptions. Also, UDP. To maintain Quos in video streaming during handoff, [2] proposes using predictive rate control. For DCCP to quickly modify its data transmission rate. The focus of this research was to determine if there was a correlation between transmission latency and CCID 3 transmission frequency. Any time a mobile gateway transitions between different wirelesses LANs, each of which could have vastly it can rapidly adjust the sending rate in response to variations in the latency of the sensing messages. The higher bit error rate in wireless fading has an effect on the efficiency of congestion control strategies. Wireless Internet Access without the Wires! The authors of [3] discuss the difficulty of implementing DCCP over a cell phone network. Investigated the potential for modifying the traffic strategy. The ECN was used by the authors of [4] [5] to the present holdup in travel. The combined ECN marks communications as potentially important when the network is busy. When wireless links are saturated, DCCP transmission rates are capped to prevent overflow. ECN setup is necessary for the decision of whether or not to mark a communication is made by routers and queue capacity monitoring. In [6], an A cross-layer strategy was proposed, and it makes use of the physical layer data's ARQ ACKs.

3. The Proposed Mechanism

In this Section, we presented the proposed control architecture and control scheme.

Architecture

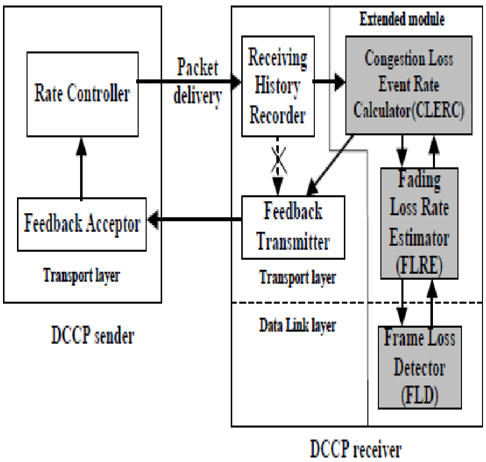

Fig. 2. The system architecture with cross-layer loss discrimination in DCCP

The loss differentiation algorithm is built into the network to distinguish between overcrowding loss and fading loss. The Dynamic Congestion Control Procedure. Our expanded system layout for CCID 3 is shown in Fig. 2. The added components are greyed out. Both the DCCP originator and receiver sides originally participated in the rate-control procedure. This section explains the receiver's perspective. Rate Controller is in charge of data transfer on the DCCP sender's end. Price change. Equation (1), in which loss and other factors are used to determine the transmission rate, is used by the rate controller. P and RTT, two measures of the frequency of events, are supplied by Feedback Acceptor. Acceptor of Feedback gets the bargaining From the DCCP recipient, Rate receives data and the loss event rate, which it then passes on to Information.

Controller. When a new file is received by a DCCP recipient, the Receiving History Recorder records the event and changes the receiving list. Losses are counted in terms of frequency. The Feedback Transmitter then receives the data on how often outages occur. At each RTT interval, the Feedback Transmitter will transmit the DCCP source a packet of data describing the loss rate during that time. The Feedback Transmitter will announce an increase in the expected loss event rate if it is greater than the previous estimate. Note regarding Immediate Changes to Transfer Rate Notification. Congestion Frame Loss Detector, Fading Loss Rate Estimator, and Loss Event Calculator are examples of the new, larger components in Fig. 2. (FLD). CLERC needs to deduct the proportion of losses attributable to fading. CLERC requests the presumed fading loss. Rate from FLRE after receiving the calculated loss event rate from the Receiving History Recorder. Therefore, the rate of loss events caused by network congestion can be calculated using Equation (3). Communicates with the recipient to get a response. The proposed technique of loss separation is built into FLRE and FLD, and it can be used with any number of levels. FLRE is responsible for converting frame loss rates from the data link layer to fading loss rates at the TDL. When CLERC requests it, FLRE determines the rate of dimming. That is, substituting the frame loss density (FLD) into the equation (2). In the physical layer, FLD monitors the frames' loss rate and communicates it to FLRE via the data link layer.

The Cross-layer Loss Discrimination Scheme

We presented the cross-layer loss discrimination procedure and the reasoning method from the frame loss rate to the packet fading loss rate in order to provide a short introduction to the loss discrimination process used in FLRE and FLD. The packet distribution process begins with the payload's arrival at the network port. Supervisor, where they are passed on to higher levels for review before being accepted or transmitted. If a packet's data capacity exceeds the Maximum Transmission Unit (MTU) of the connection between two neighbouring nodes, the payload will be broken down into multiple frames. The receiver gathers all of the packet's associated frames and reconstructs it from scratch. Fig. 3 is a diagram of the process.

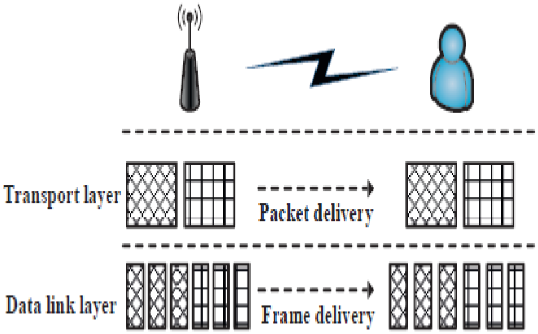

Fig. 3. The abstract packet delivery configuration over wireless links.

Frame loss in the data link layer effects packet loss in the transit layer because if one frame is damaged during transfer and cannot be deciphered, the remaining frames pertaining to the same packet cannot be reunited to the original packet effectively. The percentage of data loss due to fading can be deduced from the probability of a frame being lost based on the following formulas:

$$1-P_{fadingloss}=\left(1-P_{frameloss}\right)^{k} \quad (2)$$

$$\left(1-p\right)=\left(1-p_{c}\right)*\left(1-p_{e}\right) \quad (3)$$

$$p_{c}=1-\frac{\left(1-p\right)}{\left(1-p_{frameloss}\right)^{k}} \quad (4)$$

When neither overcrowding nor fading happens in the connection, Eq. (3) guarantees that a message will be transmitted to the target node. This holds true for both conventional and cellular networks. If, for example, an

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originator sends 100 messages via a direct connection to an AP, and the AP passes these messages were transmitted over a wireless network to the final relay point, but only 70 of them made it. We calculated a 10% fading loss rate over the cellular connection and assumed overcrowding only on the cable route. Using Eq. 1, we find that the overcrowding loss rate along the transmission route is roughly 1-(1-0.3)/(1-0.1) = 0.22. (3).

4. Simulation Results

We applied the DCCP extensions in NS2 to test their functionality and ensure that the DCCP enhancements suggested in this article are technically feasible. With these new capabilities, DCCP CCID 3 can differentiate between crowding loss and fading loss, adjusting its transfer rate accordingly. In addition, it needs to make sure that the When contending with TCP traffic, DCCP's enhanced rate control keeps things equitable.

Simulation Environment

We used NS2 to run simulations of DCCP's new features. The intended wireless emulation environment includes (1) a packet-sending wireless AP and (2) a packet-receiving wireless AP in order to analyze the loss separation scheme. The characteristics of the network setting are as shown in Table 1.

Table 1. Parameters for simulation environment

Parameter	Value
Wireless Bandwidth	2Mb
Packet size	1500 byte
Fading loss rate	Domain I : 10%
	Domain II : 5%-15%

Domain I and Domain II illustrate two distinct network scenarios. Domain I's fading loss rate (1) is held constant at around 10%, while Domain II's fading loss rate (2) is raised from 5% to 15%. The goal of Domain I am to test the loss detection algorithm in a controlled setting to see if it can detect diminishing loss. In Domain II, we hope to see if the enhanced DCCP is responsive to the dimming situation's variability and rapidly adjusts the transfer rate. The trial contrasted the enhanced DCCP to the initial DCCP in terms of transmission rate and volume. Parallel TCP traffic rate was also monitored to test for TCP-fairness in the new DCCP.

Performance Analysis

Figures 4 and 5 show transmitting rate graphs and total output for the original DCCP and the enhanced DCCP with loss detection, respectively. Figure 4(a) depicts the case of a 10% fading loss rate, where the suggested scheme's average transmitting rate of 34.6 KB/s is 28.6% greater than the baseline. The standard DCCP has an average transmission speed of 26.9 KB/s. In addition, the suggested scheme's standard variation in transmitting rates is 0.26KB/s, while the original DCCP's is 1.66KB/s. In contrast to the original DCCP, which experiences rate fluctuation due to the highly variable fading effect, the enhanced DCCP maintains a much more stable transmitting rate by filtering out the fading loss rate. Throughput for the suggested system is shown in Fig. 5(a), where it is seen to be 786Kbps, an increase of 8.1% over the throughput of the initial DCCP of 728Kbps.

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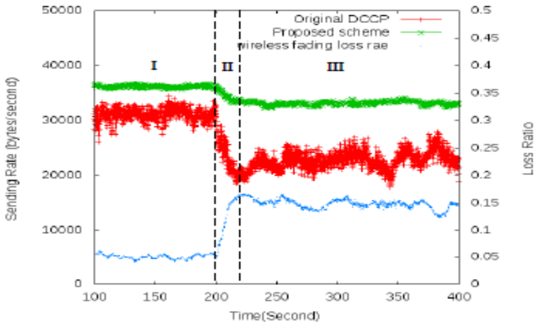

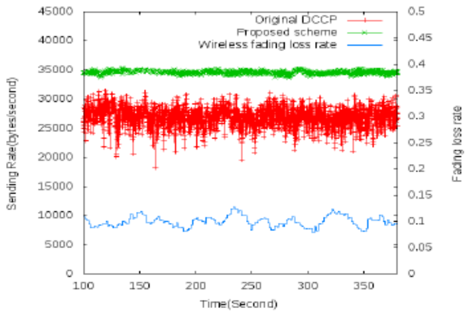

Fig.4. (a) sending rate variation in Domain I; (b) sending rate variation in Domain II.

In Fig. When the diminishing loss rate increases from 5% to 15%, as described in section 4(b), the original DCCP fails at the 200-second point. Because of fading, judgment breaks down, and the transfer rate drops. The competition lasted for a total of three halves. Time intervals, labelled I, II, III, etc., where I is the first 100 seconds, II is the second 200 seconds, and so on. Third Interval, from the 220th to the 400th second. Intervals I and III are represented by the figures situations where DCCP experiences continuous diminishing losses, as shown in Fig. Second Interval (4a) illustrates a situation in which DCCP adjusts the data rate in light of the growing fading effect. In The usual transmitting speeds for the original DCCP and the proposed system are 31.11.09 KB/s and 36.21.09 KB/s, respectively. With the proposed technique, transmission speeds can be increased by 16.3 percent, or 0.22 KB/s. Changeover in the Third Act:

When contrasting the average sending rate of the original DCCP (22.81.56 KB/s) with that of the proposed method (33.20.31 KB/s), respectively, with the latter demonstrating a 45.6% improvement in transfer effectiveness. The acceleration of the rate of declining return is responsible for a superior DCCP system maintains a steady transfer rate and is immune to fading loss. The proof, however, in Fig. After the 200th second, the posting rate of the proposed strategy stabilizes at a lower value, as shown in Figure 4(b). The issue occurs because the intensity of the fading impact can influence the estimated RTT at the recipient. Sender. DCCP's flow (rate) and round-trip time (RTT) are influenced by the automated repetition request (ARQ) feature of the physical layer. The data transmission rate is calculated using Eq. (1). Interval II sees a sharp uptick in the deteriorating loss, and the Transfer rates on the original DCCP dropped and became unreliable over time, while those on the Improvements were made to the DCCP algorithm to allow it to detect and account for fading losses in wireless connections. The resulting plots have been depicted in Figure. 5(b), demonstrating the usefulness of loss separation. For an increase of about 15.5% in throughput speed.

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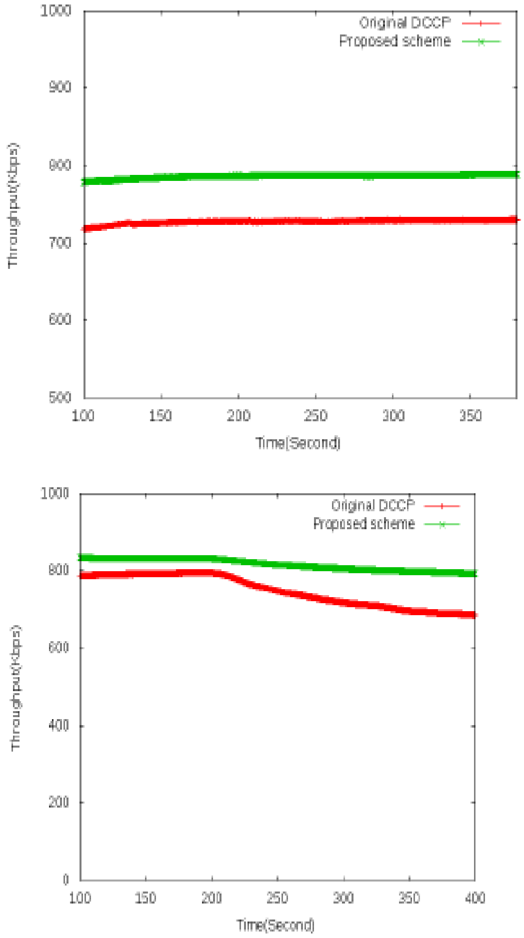

Fig.5. (a) throughput variation in Domain I; (b) throughput variation in Domain II

Figure 6 depicts a performance evaluation of the classic DCCP, the enhanced DCCP system, and two independent TCP processes. The results show that the throughput of a TCP flow transmitted using the suggested scheme is unaffected by the scheme's implementation, and is equivalent to the throughput of a TCP flow transmitted using the original DCCP. Therefore, it is clear that the suggested DCCP method does not consume all available network capacity or slow down the TCP traffic. The highest transmitting rate is proportionate to the packet size, and since the rate control method in DCCP CCID 3 adjusts its transmission rate based on the expected network state, this is the case. To fill up the leftover capacity, the enhanced DCCP does not simply raise the transmission rate indefinitely.

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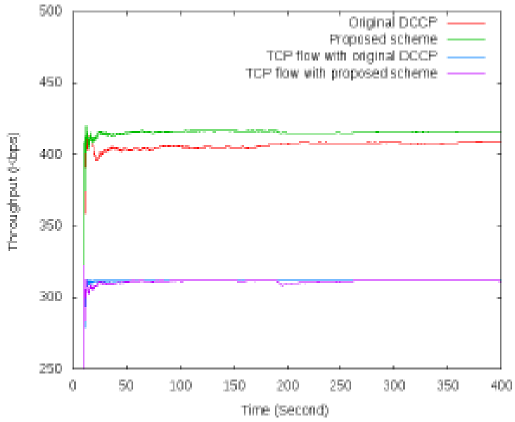

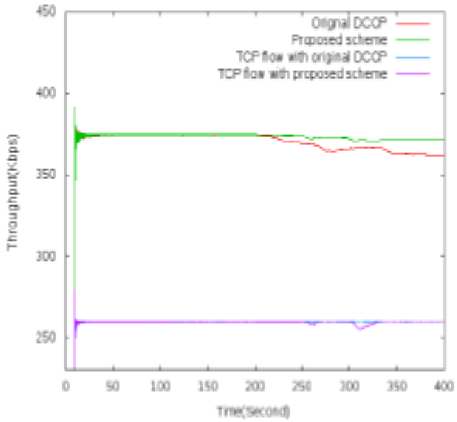

Fig.6. (a) TCP-fairness evaluation in Domain I; (b) TCP-fairness evaluation in Domain II

5. Conclusion

Incorrect rate transmission rate change for DCCP CCID 3 due to fading impact over wireless network leads to loss of wireless network capacity. In order to eliminate the fading impact on the DCCP congestion management, this work incorporates a cross-layer based loss classification algorithm into DCCP. The suggested using the data link layer information, DCCP implements a method to deduce the fading loss. We have tested the efficiency of the suggested method in a computer exercise. Our suggested cross-layer based loss detection strategy over the wireless environment has been shown in simulations to increase transfer rates by up to 45.6% and throughputs by up to 15.5%.

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