LM-4

A New TCP for Efficient Operations over Wireless Links

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1. Introduction

In recent years various wireless links have been incorporated into the Internet. Therefore, studies about TCP in wireless networks deserve special attention [1, 2, 3].

Wireless links often have higher link error rates than their wired counterparts. Because conventional TCP protocols are designed to be used in wired networks with low link error rates, they don't take link errors into account. That is, they assume that segment losses are solely due to congestion in networks [4]. For this reason, when the conventional TCP protocol is applied in wireless networks, performance of TCP declines very much [1, 3].

In this paper, we propose a new scheme to avoid performance degradation of TCP in wireless networks, which require link level retransmissions on wireless links and the modification of TCP-sender. This scheme doesn't pose problems on the implementation which existing ones do. In addition, experiments show this scheme yields higher performance than existing ones in the cellular network and in the satellite network.

2. Related Works

2.1 Snoop Scheme

Snoop [1] is the TCP-aware retransmission control on the wireless link. Snoop is implemented at the base station BS, where it observes TCP headers of packets which pass through BS. The idea is to keep any occurrence of packet loss due to link error transparent to the sender until timeout occurs.

Snoop has the following problems on the implementation.

1. Per-flow management is needed on BS. So BS has large overhead.
2. If IP encryption is used, this scheme is not usable.

Also TCP performance is affected owing to the following reasons.

1. Link error detection based on dupacks is not efficient.
2. If the round trip time between BS and TCP-receiver are large, timeout may occur.

2.2 Delayed Duplicate ACKs Scheme

Delayed Duplicate ACKs(DDA) scheme [2] uses link level retransmission (TCP-unaware retransmission). If the order of the segment arrival at the TCP-receiver is different from the order of the segment transmission at the TCP-sender, the TCP-receiver delays generating the third and subsequent dupacks for a certain optimal time d.

DDA scheme has problems on the implementation. It is difficult to estimate the optimal time d both dynamically and statically.

Also TCP performance is affected owing to the following reasons.

1. If time d is too large, throughput may decrease due to timeout.
2. If segment losses occur due to congestion, the error recovery is unnecessarily delayed for time d. As such, the benefits of using dupack vanish.

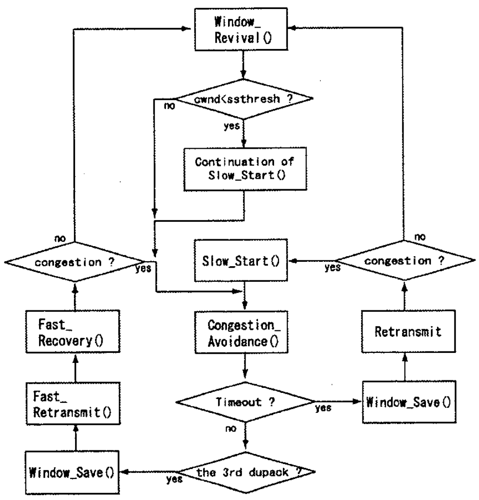

Figure 1: Flowchart of TCP-I&RW

3. Our Proposal

In this section, we propose a new end-to-end flow control scheme we named as "TCP Identification & Revivable Window (TCP I&RW)" to improve TCP performance in wireless where the wireless links support link level retransmission controls for link errors. TCP-sender in TCP I&RW places an identification tag for every data segment it sends. Like conventional TCPs, if a segment loss is detected, it first infers a congestion, lowers the sending rate and retransmits with a different identification tag. Sender figures out the actual cause of segment loss depending on identification response field in the ACKnowledgement corresponding to the retransmitted data. If the segment loss is due to link errors, sender revives its transmission rate to the value prior to the retransmission. As such, throughput degradation due to erroneous detection of congestion is avoided. This ensures an improved throughput for TCP over wireless links. Figure 1 shows the flowchart of TCP-I&RW.

4. Evaluation

We evaluate TCP-I&RW scheme (that is, TCP-I&RW with link level retransmissions) and other related flow control schemes using the ns-2 simulator [9]. We measure

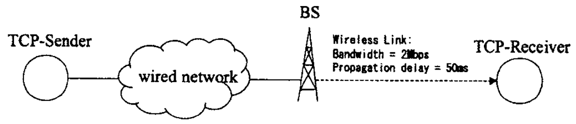

Figure 2: Simulation scenario for the cellular network

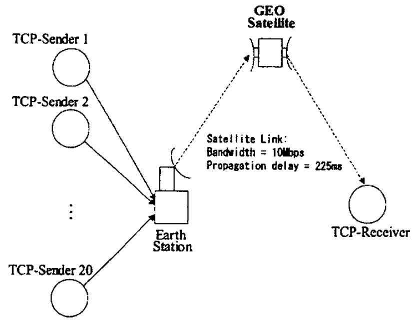

Figure 3: Simulation scenario for the satellite network

throughput (Figure 4) in cellular networks (Figure 2) and bandwidth utilization (Figure 5) over satellite links (Figure 3). The x-axis in Figures 4 and 5 indicate link error rate per segment. Other flow control schemes we compare with, are (1) TCP-Reno without link level retransmissions, (2) TCP-Reno with link level retransmissions, (3) Snoop scheme (TCP-Reno based) and (4) DDA scheme (TCP-Reno based).

The TCP-sender is assumed to be performing a bulk data transfer. Each TCP data segment contains 1000 bytes, while each TCP ACK contains 40 bytes. We use NAK-based selective repeat [10] as the link level retransmission on the wireless link. Each link level NAK contains 16 bytes. The wireless link has a priority scheduling queue which can hold at most 50 segments. That is, each link level NAK and each TCP data segment retransmitted by the wireless link has priority to send before other segments in the queue. TCP ACKs and link level NAKs are assumed not to be lost due to link error, because these are sufficiently small. The variable d which is a delay time of the third dupack of DDA scheme is statically set twice the propagation delay (i.e. round trip time) on the wireless link.

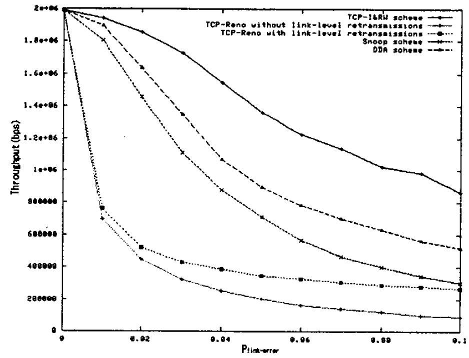

Figure 4: TCP throughput in the cellular network

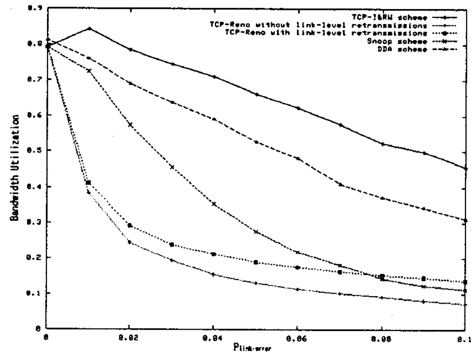

Figure 5: Bandwidth utilization on the satellite link

5. Conclusion

Results from our experiments for the cellular network and also for the satellite network show that our proposed new scheme can achieve better performance than existing well established ones. This proves TCP I&RW to be a strong candidate for deployment over wireless links.

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