# Chapter 2.9
# TCP Enhancements for Mobile Internet

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## INTRODUCTION

Transmission Control Protocol (TCP), the most popular transport layer communication protocol for the Internet, was originally designed for wired networks, where bit error rate (BER) is low and congestion is the primary cause of packet loss. Since mobile access networks are prone to substantial noncongestive losses due to high BER, host motion and handoff mechanisms, they often disturb the traffic control mechanisms in TCP. So the research literature abounds in various TCP enhancements to make it survive in the mobile Internet environment, where mobile devices face temporary and unannounced loss of network connectivity when they move. Mobility of devices causes varying, increased delays and packet losses. TCP incorrectly interprets these delays and losses as sign of network congestion and invokes unnecessary control mechanisms, causing degradation in the end-to-end goodput rate. This chapter provides an in-depth survey of various TCP enhancements which aim to redress the above issues and hence are specifically targeted for the mobile Internet applications.

## BACKGROUND

As wireless devices are becoming the fastest growing segments of the computer industry, the networking picture has changed radically in the last decade. Millions of people now want to access the Internet at any time from wherever in the world they may be. To allow this, mobile IP [PER96] has been developed to route packets to these mobile users. As a best effort type of protocol, mobile IP has fulfilled its task fairly well; but TCP [POS81] has to glue well to the mobile IP in order to provide the applications with an end-to-end and connection-oriented packet transport mechanism that ensures reliable and the ordered delivery of data. However, in the absence of wireless enhancements for TCP to work over mobile Internet, several known problems affect its performance [CAC95]. Nevertheless, most of the wireless data applications (e.g., FTP, Web, telnet, multicasting, etc.) use TCP as the default ***transport layer protocol,*** as they want to achieve reliable and guaranteed delivery of data. But TCP, having faced several problems specific to this network, poses a huge bottleneck to reaching a high goodput rate.

As a result, over the years TCP has been modified several times to improve its performance, and, hence, several important TCP versions have emerged, such as TCP-Tahoe [FAL96], TCP-Reno [FAL96], TCP-Vegas [BRA95], TCP-New Reno [FLO99], and TCP-SACK [FAL96],[MAT96]. However, all these mechanisms and various versions do not work the same, when called to work in diverse environments such as satellite networks, last hop wireless networks, and mobile ad-hoc networks. In [TSA02], [TIA05] authors have compared several TCP enhancing schemes for mobile/wireless networks. In [TSA02], Tsaoussidis and Matta have considered the effect of high BER, unexpected disconnection, and battery power for comparing various TCP enhancing schemes. They are of the opinion that the error detection mechanism must be able to classify different types of errors (e.g., congestion, transient wireless error, persistent wireless error, and handoff), and, based on the error classification, an appropriate recovery strategy must be employed that differs from congestion-oriented mechanisms employed by TCP. They argued for the importance of defining a new performance metric (e.g., energy efficiency) to measure protocol stability and fairness in last hop wireless networks. In [TIA05], Tian et al., have considered different application areas (e.g., cellular, satellite, ad-hoc, and heterogeneous networks) for TCP. But they concentrated on the effect of high BER and channel asymmetry on the performance of TCP in all four application areas.

## TCP IN MOBILE INTERNET

### Problem of Running TCP in Mobile Internet

The following characteristics have major impact on the performance of TCP in Mobile Internet [SAR06]:

- **High BER:** The bit error rate in wireless networks is much higher than those experienced in traditional wired networks. High BER results in a large number of packet drops. TCP treats these drops as congestion loss and starts congestion control procedures resulting in a degraded performance.
- **Limited spectrum:** Bandwidth is a scarcer resource in wireless networks than its wireline counterparts (e.g., the bandwidth of fast Ethernet is 100 Mbps, whereas GPRS has a bandwidth of 384 Kbps). So, sharing wireless bandwidth efficiently between mission critical and non-critical traffic is a very important task.
- **Handoff:** When a user leaves a cell and enters a new one, handoff takes place. During handoff, a mobile host may lose connection to the base station, and any data transmitted for the mobile host are lost. TCP treats this packet loss as congestion and slows down transmission rate resulting.
- **Unpredictable delay:** As a mobile user moves randomly, distance from a BS varies, resulting in temporally varied delay. This unpredictable delay is difficult for TCP to handle gracefully.
- **Frequent disconnection:** Mobile hosts often get disconnected (when in motion and/or discharged battery) without any warning. Transmission during this period causes huge packet drops leading to pseudo-congestion and hence degraded performance.
- **Limited energy:** Mobile devices are battery powered, and, hence, cannot afford too many