ISSN 2286-4822
www.euacademic.org

EUROPEAN ACADEMIC RESEARCH
Vol. VIII, Issue 3/ June 2020

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

Effects of TCP Window Size and Transmission Range on the Throughput of Mobile Adhoc Data Network

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Abstract

In the recent wireless communication networks, such as Wi-Fi technology and cellular networks, communication between mobile hosts is coordinated by a centralized infrastructure such as access point or base station respectively. In such a centralized network, the exchange of data between a mobile host and the centralised infrastructure involves only one hop wireless link. Whereas in mobile ad-hoc data networks (MADNETs), there is no fixed infrastructure such as base stations or access points. MADNETs are traditionally multi-hop wireless networks. Each Independent node forwards packets to other nodes as well as discovers and maintains routes while in motion. It's mostly applicable in emergencies such as rescue operations, military applications and sharing of data in conferences. In this work, we carried out a Transmission Control Protocol (TCP) real-time measurements of a Mobile Ad-hoc Data Network (MADNET) at different transmission ranges with TCP window sizes of 64k and 256kb to verify the impact of increasing the window size at varying transmission ranges. We therefore explain the reduction in TCP throughput using our observations and analysis of the packet loss in our network setups. The reduction in the throughput was due to loss of TCP data and ACK-segment when the transmission range was increased. However, the throughput increased when the window size was increased at the same transmission range. Thus, for improved performance of MADNET, TCP window size should be increased and *the transmission range is kept below 10m as in our case depending on the transmitting power.*

Keywords: MADNET, TCP, throughput, Iperf, transmission range, Window size

1. INTRODUCTION

The advancement in wireless technology in recent times is one of the dominant factors in the present industrial revolution. As a result, industries have flooded the market with varieties of portable wireless devices with compatible wireless network functionalities making wireless networks an attractive hub in the research community today. In both Wi-Fi technology and cellular networks, mobile hosts communicate with a stationary access point or base station respectively. In such technologies, only one hop wireless link is needed for communications between a mobile host and a stationary host. However, in MANETs, there is no centralized infrastructure such as base stations or access points. Independent nodes forwards data to one another in a MANET while discovering and maintaining active routes. Thus, MANETs are multi-hop wireless networks by nature [7]. It's mostly applicable in emergencies such as rescue operations, military applications and sharing of data in conferences [1]. Mobile networks introduce an environment quite different from the one found in fixed networks due to scarce radio bandwidth and intermittent connectivity. Data services provided by W-WANs allow for a low link speed. Factors such as error losses, changing line rate and variable delays present additional challenges for efficient data transport [8]. The Transmission Control Protocol (TCP) is a popular transport layer protocol that provides reliable, ordered, and error-checked end-to-end data delivery between end hosts in the traditional wired network environment. The reliability of TCP is based on its capability of retransmitting lost packets. Thus, Packets will be retransmitted if the sender receives no acknowledgment within a certain timeout interval or receives duplicate acknowledgments. Due to the inherent reliability of wired networks, there is an implicit assumption made by TCP that any packet loss is due to congestion [8]. Consequently, TCP invokes its congestion control mechanisms to reduce congestion whenever any packet loss is detected.

2. RELATED WORKS

TCP over mobile adhoc data networks is a popular topic in the literature. Several studies have been carried out to investigate the cause of degradation of TCP throughput in wireless networks. Such factors include: TCP misinterpretation of packet loss or delay as congestion [16], network congestion [17], node mobility, position error and link distance [18], wireless link-layer contention for wired internet [19], etc.

The study in [2] investigated the multi-rate throughput characteristics of IEEE802.11g wireless LANs using real terminals. The results show that in simulation model based on the Rayleigh fading model, throughputs resemble a step function of the distance between a sender and receiver in all transmission rates. However, in real terminals, the throughput does not have steps but continuously decreases over the distance because there is radio interference. The result in the work shows the real terminals suffered from busy carrier effects due to radio interferences from other systems. The percentage of busy carriers was estimated to be 10% indoor and 121% outdoors.

S. Xu and T. Saadawi [3] focused on the optimization of real-time multimedia transmission over 802.11-based ad hoc networks in their study. The study proposed a simple and efficient cross-layer mechanism called a media-oriented rate selection algorithm (MORSA). This mechanism considers both the channel conditions and characteristics of the media for dynamically selecting the transmission mode. The main target of this mechanism is loss-tolerant applications such as VoD that do not require full reliable transmission. The proposed mechanism was first in a simple ad-hoc network that contains two wireless stations. These wireless stations communicate on a single channel. Station A is fixed and station B moves toward station A. Station B moves in 5m increments over the range of mobility (0m–200m) and is held fixed for a 60s transmission of CBR data towards station A. In each step, 30 000 CBR packets of size 2304 bytes (including physical layer FEC) are sent. The mean goodput of this single CBR connection between two wireless stations versus the distance between them for different transmission modes with and without media-oriented mechanism was compared. Since no payload FEC was used in the media-oriented protocol, the mean goodput is increased significantly compared to the standard transmission modes. Moreover, it was observed that the media-oriented mechanism achieved a 4Mbps mean goodput improvement at the highest rate mode with a reduction in coverage range.

Some TCP related problems over wireless links are the focus in [4]. The work is based upon simulations in ns-2 which demonstrated that TCP connections are unstable over wireless links. The study shows also that the TCP maximum window size has effects on the instability problem. The conclusion was drawn on the bases that the current version of the IEEE 802.11 MAC protocol does not function well in multi-hop ad hoc networks.

In [5], the performance of the practical network topology of RipEX units wireless communication module, based on Narrowband RF Networks for remote wireless communications is analyzed. A scenario with direct wireless transmission round- trip from the source S1 to the destination S5 and come back from source S1 with the presence of (RipEX units) Radio modem & Routers for relaying messages is considered. For multi-hop transmission with RipEX units, the results show that as the distance between the radio router nodes in round trip delay path increases with the round trip time (RTT). It was also observed that the RTT network decreases as throughput increases. In addition to these observations, the introduction of Forward Error Correction (FEC 3/4) can also promote a slight increase in RTT. Therefore, the study recommends that minimizing the number of transmitting nodes will improve system performance.

In [6] the analysis of the performance of TCP and UDP on a wireless link that is connected to a wire-line network is carried out. The performance of the TCP and UDP assuming three different traffic patterns were investigated. First, bulk transmission where the main concern is throughput. The Second was the real-time audio (using UDP) in the existence of bulk TCP transmission where the main concern is the packet loss for audio traffic. The last traffic pattern is the web traffic. Its main concern is the response time. The results show that increasing the packet size and the window size results in better link utilization. However, one might have expected that using

FEC to avoid the high error rate of the wireless link should have a detrimental effect on the system performance but the use of FEC does improve the system performance [6]. Another observation is that the use of RTS/CTS results in a decrease in system performance.

3. BASIC FUNCTIONALITIES OF TCP

Various literatures have established the TCP/IP protocol suite as the de facto standard for network communications today because it guarantees a reliable communication channel over an unreliable network. As a connection-oriented transport protocol that guarantees end-to-end reliable and ordered delivery of data packets over wired networks, it's widely used. Its design has some essential fundamental functionalities such as flow control, error control, and congestion control. In practice, these functionalities work with one another even though they have independent definitions of their own [8].

3.1 Flow Control

Modern data networks are designed to support a diverse range of hosts and communication mediums [10]. The crucial requirement for transmission of data from a sender to a receiver is that, regardless of the processing capability of the sender and the receiver and the available bit rate at the communication link, the buffers at the receiver side must not overflow [12]. This adaptation and a corresponding regulation concerning the amount of data sent are often referred to as Flow Control [9]. Data Link Control (DLC) achieves this through the flow control mechanism based on two approaches: Stop-and-Wait flow control and Sliding-Window flow control

3.2 Error control

Reliability in TCP is obtained by using error control mechanisms, which may include techniques for detecting corrupted, lost, out-of-order or duplicated segments [12]. Error control includes both error detection and error correction. Error detection and correction in TCP is achieved through the use of three simple tools: checksum, acknowledgment, and time-out. [11].

3.3 Congestion Control

Network congestion occurs when the network is over flooded with too many packets by the sender. When this happens, the network fails to handle the traffic properly, leading to poor quality of service (QoS). The typical symptoms of congestion are excessive packet delay, packet loss and retransmission [13]. TCP Congestion Control is a technique that prevents congestion or helps mitigate congestion after it occurs. Unlike flow control mechanism that employs sliding window (rwnd) at the receiver, the Congestion control mechanism uses congestion window (cwnd) at the sender. TCP implements four congestion control algorithms: slow start, congestion avoidance, fast retransmit, and fast recovery [14].

4. METHODOLOGY

In this study, we setup two mobile adhoc data networks (MADNET) A and B one at a time which differs only on the TCP window sizes. The two networks A and B have TCP window sizes of 64kb and 256kb respectively. In this study, the throughput of the networks were measured and recorded at the transmission ranges of 5m, 10m, 15m, 20m, and 25m. Hence, the impact of increasing transmission range and TCP window size on the performance of the MADNET was observed and analysed. The measurements were taken indoors to maintain a line-of-sight between the server at the same ground level as the client as shown in fig. 1.

4.1 Experimental Requirements

Two identical laptops were used in this study (Hp Compaq 2710p). Both of the laptops have the features as stated in table 1. We adopted Iperf as our network management and performance tool and configured its QoS on the computers. Iperf is a tool to measure maximum TCP bandwidth, throughput, delay, etc. It allows the tuning of various parameters and UDP characteristics. We took measurements of the throughput from the client to the server by transmitting data for 10 seconds (-t) with the TCP port set to 500. We used Iperf commands to configure PC1as the server (Iperf - s) and assigned it an IP of 169.192.2.300, and PC2 as the client (Iperf -c) with IP of 169.192.3.200. as shown in fig. 1.

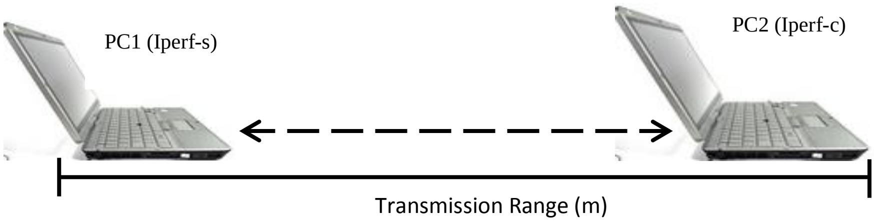

Figure 1. Experimental Setup

Table 1. Experimental Specification

Specifications	Value
Wireless Standard	IEEE 802.11g
Data Rate	54mbps
Frequency	1.2GHz
Radio Channel	6
Modulation	OFDM
RF Power	20dbm (maximum)
Operating System	Win 7
RAM	2GB
Subnet mask	255.255.255.0
Gateway	Disabled

5. RESULT

In each of the measurements, we kept the server (Iperf-s) stationary and the position of the client (Iperf-c) was been changed according to the transmission ranges above. In this study, each TCP connection was carried out for 10secs at 2secs interval. The total data transferred at the respective transmission range was got and recorded in the table below.

Table 2. Throughput of various Transmission Ranges at different TCP window sizes

Transmission Range (m)	Throughput of Network A	Throughput of Network B
5	20.9	23.1
10	20.2	22.4
15	21.2	21.1
20	20.8	22.2
25	19.9	22.0

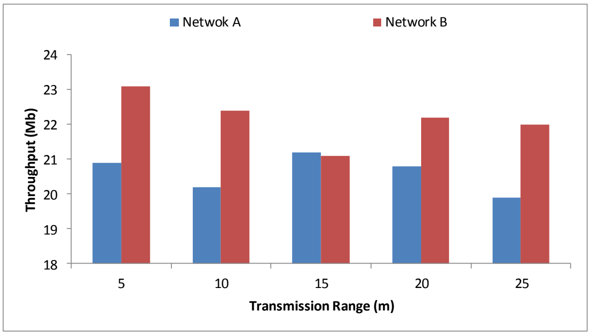

Figure 2. Bar Chart of Throughput as a function of Transmission Range for different TCP window sizes

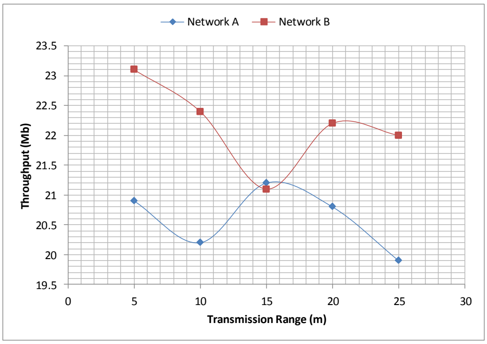

Figure 3. Throughput as a function of Transmission Range (m) at different TCP window sizes

6. DISCUSSION

Here, we describe the relationship between the transmission range and the amount of data transferred in both networks. In Figure 3, networks A and B gave similar response at the initial range of 0 to10m, showing a reduction in throughput in both networks. However, from 10m, their responses differed inversely with the transmission range till at 15m. Network A continued to upgrade in performance and recorded the maximum throughput (minimum packet loss) and the performance of network B continued to degrade until it recorded the minimum throughput (maximum packet loss). Moreover, the sizes of the TCP window as seen in table 2 is one of the dominant factors that determine the amount of data transmitted between the client and the server in our network setups. In figure 2, there was an increment in the TCP throughput as the TCP window size is increased at the same transmission range. Unlike [15], that showed that an increase in TCP window size led to increase in errors and decrease in TCP throughput because of the loss of TCP data and TCP ACK-segments. Moreover, there was a significant decrease in the data transferred as the transmission range increases in both networks A and B. On a general note, our result depicts that increase in transmission range has a reductive effect on throughput unlike the TCP window size, which improves the throughput when increased. We, therefore, conclude that a higher window size guarantees a better throughput characterized by little or no loss while keeping the transmission range as low as possible depending on the transmission power. The impact of the window size on the bandwidth with increasing transmission range could be verified in the future work. Subsequently, the relationship between the window size and bandwidth will be studied.

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