A Review of Various Approaches to Improve Usage of TCP in Mobile Ad-Hoc Networks

Aniket Deshpande\(^1\), Dr. Azad Kumar Shrivastava\(^2\)

\(^1\)Research Scholar, Mewar University, Chittorgarh, Rajasthan, India
\(^2\)Professor and Research Supervisor, Mewar University, Chittorgarh, Rajasthan, India

\(^1\)anik.deshpande@gmail.com

Abstract

Transmission control protocol is a connection oriented and reliable transport layer protocol. Initially TCP was mainly used for in wired networks but due to its efficiency was adopted initially for wireless and subsequently for Ad-Hoc Networks as well. Since TCP was originally designed to be meant for Wired Networks, it faced severe performance degradation when deployed in the wireless world. The reason for those performance failures included causes and effects such as route failures, channel losses and channel contention issues. This review is all about TCP working process with challenges of deploying TCP over wireless ad-hoc networks such as route failure and network partition, hidden and visible node problem, cross layer technique and improved inter layer communication. Finally, based on deriving best practices from the past works, authors have recommended for their own improvisation that is expected to address these limitations.

Keywords: Transmission control protocol, Route Failure, Network Partition, Cross Layer technique, Inter-Layer communication and Congestion Control.

1. Introduction

Wireless ad hoc network is a new mobile network infrastructure that can be used when the deployment of wired network is expensive and time-consuming [5]. Ad hoc networks consist of a set of mobile hosts communicating among themselves using wireless links, without the use of any other communication support facilities. The topology of an ad hoc network changes every time an MH’s movement results in the establishment of new wireless links or link disconnections [1]. This applies to battlefield, emergency rescue operations, and large-scale wireless conferencing situations where all the nodes are mobile. In such networks, each host acts as a router to forward packets sent by the source to the receiver [16]. Recently, several proposals on efficient routing protocols were suggested for wireless ad hoc networks. However, reliable data transmission problem has not yet been examined thoroughly. Transmission Control Protocol is widely used in the current Internet as the reliable end-to-end transport protocol. However, earlier research works had confirmed that TCP cannot be directly applied to wireless networks due to the presence of the time-varying link characteristics and node mobility issues. If a TCP source does not receive the acknowledgement packets from the destination in a timely fashion, timeout events for the transmitted segments will occur. TCP
assumes that congestion has occurred within the network and initiates the congestion control procedures [5] [17].

2. Working mechanism of TCP

TCP performs poorly in wireless ad hoc networks. The main reason for this poor performance is a high level of packet losses and a resulting high number of TCP re-transmission time-outs. First, a node drops a packet if it cannot forward the packet to the next hop of the route on which the packet is to be relayed, as the next hop node has moved out of transmission range. A second reason for packet loss is congestion in the shared medium [4]. TCP relies on packet loss as an indication of network congestion and triggers efficient congestion control algorithms once congestion is detected. However, it is well-known that TCP is not efficient in ad hoc networks. In addition to congestion, a transport protocol in an ad hoc network must handle mobility-induced disconnection and reconnection, route change-induced packet out-of-order delivery for mobile hosts, and error/contention-prone wireless transmissions [2] [19] [20]. TCP facing some problems in wireless ad-hoc networks like as link failure, channel contention and high BER. The performance of TCP degrades due to these above-mentioned factors. The research community have been suggested some approaches to improve the performance of TCP in wireless ad hoc network. By exchanging the data among different layers in cross layer design, the performance of wireless networks was improved.

3. Challenges of TCP in wireless Ad-Hoc Networks

The Key challenges faced by TCP in Wireless Ad-Hoc Networks as identified by various authors in the past include:

- Wireless channel
- MAC Layer
- Node Mobility
- Routing Protocol
- Congestion Window
- Path Asymmetry [21]

Contention is a fundamental problem in multi-hop wireless ad hoc networks and one of the main factors contributing to poor TCP performance in such networks. In Ad-Hoc wireless networks, adjacent nodes impede each-other as they contend for access to the shared wireless channel. Furthermore, packets in ad-hoc networks are typically forwarded through multiple hops en-route from source to destination; resulting in interference patterns not seen in centrally managed wireless networks such as wireless LANs or cellular networks. Self-contention, a key form of contention, has received little attention to date [7]. The ad-hoc network refers to the local network once the different devices are connected. [1]. However, this type of network affects the performance of a protocol for TCP or transmission control, which is the central element of network communication. TCP manages the transfer of data packets between computers and allows the exchange of data between two residents [8] [22] [23].
A lot of research to mitigate the performance problem of TCP, related to the wireless mobile environment is happening and as a result, several versions have emerged. Earlier attempts to address this problem can be broadly divided into two groups. The first group does not attempt to change or modify the TCP protocol, instead exploits methods such as injecting, removing or delaying TCP packets based on a superior understanding about what is happening at the link layer. These mechanisms provide solutions at the Link Layer (LL), by hiding the deficiencies of a wireless channel from TCP. The features of TCP are as follows,

- Reliable
- Point to point
- Error Control
- Stream data transfer
- Connection Oriented
- Flow control

4. Route Failure and Network partition

This section reviews the performance issues associated with the hidden and invisible nodes for TCP deployed in Ad-Hoc Networks.

Oliveira et al [6] have experimented the use of fuzzy logic theory for assisting the TCP error detection mechanism in such networks. An elementary fuzzy logic engine was presented as an intelligent technique for discriminating packet loss due to congestion from packet loss by wireless induced errors. The architecture of the proposed fuzzy-based error detection mechanism was also introduced and discussed. The full approach, for inferring the internal state of the network, relies on Round Trip Time (RTT) measurements only

One of the main reasons for the poor performance of formal TCP version used in wired networks over wireless networks was that the, packet loss in wireless networks was not only due to congestion there were other problem inherent to wireless network which could cause packet loss. Kumar et al [9] have presented a neural network-based congestion control technique for reliable data transfer over MANET, which recognizes and capture the mobility behaviour of node. The captured mobility behaviour was used to identify the cause of packet loss, in order to take action which increases the reliability of underlying MANET.

5. Hidden and Invisible Node Problem

This section reviews the challenges associated with the hidden and invisible nodes.

The ACK based approach provide congestion control mechanism and give the guarantee of reliability. The most data streams were flowed from sensor nodes to sink in WSNs, so congestion occurs at the sink. Then the transport protocol for WSNs should have mechanism for packets loss recovery such as ACK and Selective ACK used in TCP protocol so as to guarantee reliability. WSN only need to correctly receive packets from a certain area not every sensor node in particular area, or some ratio of successful transmission from a sensor node [15].
Attacks could be categorized as internal and external attack. External attack was carried out by nodes which were not part of any network. Internal attacks were processed by nodes which were in network and more server and hard to detect as compared to the external attacks such as black hole attacks, grey hole attacks, DOS, DDOS, Vampire attack. In passive attack the attacker only listens the communication channel to know the confidential information was being transferred without altering or disrupts the operation of the network. In an active attack attacker could alters, drop or destroys the data being exchanged. Nilesh et al [14] have proposed Vampire attacks and DDoS attacks exhaust the resources available to a network. Both the attacks drain the energy of nodes.

Mobile Ad hoc Networks (MANETs) was a wireless technology that plays an important role in several modern applications which include military, civil, health and real-time applications. Providing Quality of Service (QoS) for this application with network characterized by node mobility, infrastructure-less, limitation resource was a critical issue and takes greater attention. However, transport protocols effected influential on the performance of MANET application. Das et al [11] have analysed the performance for TFRC, UDP and TCP transport protocols in MANET environment. In order to achieve high accuracy results, the three transport protocols were implemented and simulated with four different network topology which were5, 10, 30 and 50 nodes, respectively using well known Network Simulator (NS-2.35). Moreover, Constant Bit Rate (CBR) considered as a traffic source and On-demand Distance Vector (AODV) as the routing protocol. For evaluation performance, QoS metrics such as end-to-end delay, packet delivery ratio, throughput and jitter were measured.

6. Cross Layer Techniques

This section reviews the cross-layer techniques and their advantages and limitations.

Mobile ad hoc networks (MANETs) were collection of mobile nodes connected together without any infrastructure and central management. Congestion control was an important problem in MANETs and TCP congestion control mechanisms were incapable of managing special characteristics of the wireless channel in ad hoc networks. Moreover, several network layers were involved and adjusting each parameter on those layers could affect the other ones. A cross-layer approach was proposed by Suraki et al [12] in transport, network, and MAC layers in which Fuzzy Logic System was used in intermediate and destination nodes as a dynamic tool for controlling the congestion problem in MANETs. In the network layer, DSR routing algorithm was used and messages exchanged among nodes were put into the ACK packets. The simulation results show that in this method, end-to-end delay was reduced more for UDP packets and less for the TCP packet.

TCP- Transmission Control Protocol was a connection oriented and reliable transport layer protocol. TCP was initially used for process-to-process communication in wired networks. When TCP was used with wireless networks, especially with the wireless mobile Ad-Hoc networks, a significant amount of performance degradation could be noticed. The main reasons were route failures, channel losses and channel contention issues. Molia and Agarwal [13] have presented an approach on cross-layer approaches to improve TCP’s performance. In
cross-layer approaches, the lower layers provide feedback – decision making information to the transport layer. Transport layer uses this information to differentiate congestion loss and non-congestion loss. Approaches were classified into three categories for route failures, channel losses and channel contention issues.

Ahmed and Sarfaraz [26] have proposed a technique, deviating from the traditional network design, toward enhancing the cross-layer interaction among different layers, namely physical, MAC and network. The Cross-Layer design approach for Power control (CLPC) would help to enhance the transmission power by averaging the RSS values and to find an effective route between the source and the destination.

### 7. Improved Inter-Layer communication and Control

This section reviews the improved interlayer communication approach to solve the problem of TCP performance degradation due to route failure.

Mamata et al [25] have proposed an inter-layer communication-based quality of service architecture that uses an optimized algorithm at the network layer as part of the QoS platform, another fast channel access mechanism implemented in MAC layer with a real time scheduler that uses Rate Monotonic algorithm for event driven task scheduling in the QoS platform. These components perform the functionalities of delay, power and jitter management in the channel during real-time data transmission, specifically they have considered video file transfer during simulation in NetSim Ver 8.3.

Chinta et al [24] have proposed an interlayer collaboration model for TCP performance improvement in mobile and wireless environments. They specifically target the case where a mobile act as a TCP sender. ILC-TCP was an end-to-end approach and does not need any special support from the base station infrastructure. ILC-TCP was evaluated against the normal TCP in various scenarios. Performance results suggest that ILC-TCP performs better than the normal TCP in many scenarios involving long disconnections, frequent disconnections and in the scenarios where a mobile host moves at considerable speeds.

The reason for congestion in wireless networks was as follows:

- **Insufficient link bandwidth**
- **Greedy network application**
- **Slow processors**
- **Sender overflows the network**
- **Poor design of network**

### 8. Summary of Comparative Analysis of TCP over Ad-Hoc Networks

The comparison is made with respect to the proposed method, objectives, performance metrics, and limitations has been summarized in the below table 1.
Table 1: Comparison Table for usage of TCP in wireless ad hoc networks

<table>
<thead>
<tr>
<th>Ref. No.</th>
<th>Proposed Method</th>
<th>Objectives</th>
<th>Performance Metrics</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1]</td>
<td>TCP-Feedback (TCP-F)</td>
<td>To analyse the problem of maintaining reliable end to end communication in ad hoc networks</td>
<td>Throughput, Window size, Sequence Number, TCP timeout</td>
<td>During a route failure occurs, a number of packets and/or acknowledgments may be lost</td>
</tr>
<tr>
<td>[3]</td>
<td>Delayed ACK Method</td>
<td>To improve the performance of Multi-hop wireless Networks</td>
<td>Throughput, Window size</td>
<td>Delay, loss probability is high</td>
</tr>
<tr>
<td>[4]</td>
<td>Signal strength-based link management</td>
<td>To reduce the packet losses due to mobility in Ad-Hoc networks</td>
<td>TCP goodput, False link failures, Packet loss</td>
<td>Congestion of network</td>
</tr>
<tr>
<td>[5]</td>
<td>TCP-BUS approach</td>
<td>To improve the TCP performance of ad hoc networks</td>
<td>Delivery rate, Congestion window size</td>
<td>Congestion and route failure</td>
</tr>
<tr>
<td>[6]</td>
<td>Fuzzy logic</td>
<td>To the improve the TCP Error detection in Ad-Hoc networks</td>
<td>Bit error rate, Correctness</td>
<td>Packet loss due to congestion</td>
</tr>
<tr>
<td>[12]</td>
<td>Fuzzy cross layer control Technique</td>
<td>To control the congestion problem</td>
<td>Throughput, Packet delivery ratio</td>
<td>Less transmission rate</td>
</tr>
</tbody>
</table>

9. Conclusion

In this review paper, the research effort is analysed based on route failure and network partition, hidden and visible node problem, cross layer technique and improved inter layer communication. This study has identified the current situation of the investigation regarding the improvement and usage of TCP performance in wireless ad hoc networks; furthermore, the study area proposes to develop the new challenges. The new challenge is to propose an efficient approach to overcome the drawback by improving the performance metrics such as throughput, delivery ratio, Error rate, congestion control and packet loss.

References


