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A Comparative Analysis and Classification of TCP Solutions for MANET

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Abstract— Mobile-Ad hoc networks are qualify by a lack of infrastructure, and by a random and quickly varying network topology; thus the need for a rich dynamic routing protocol that can adapt such an environment. In general, with the high mobility environment and high load network traffic, network performance perhaps took down causing packet loss or increase overhead. TCP optimization in mobile ad hoc networks MANETs is a challenging issue because of some unequaled characteristics of MANETs. Packet losses in MANETs are primarily due to congestion and frequent link losers but in case of wireless networks packet losses are accruing mainly due to congestion. Aims of this article is to Comparative analysis of transport layer perspective, it is very important to regard Transmission Control Protocol (TCP) as well for MANETs because of its broad application, and also demonstrates the several parameters comparison of Transmission Control Protocols solutions for Mobile ad-hoc wireless network

Keywords— MANET, TCP-F, TCP-ELFN, TCP-BuS, ATCP and Split-TCP.

I. Introduction

Congestion is situation in a computer network when the number of outstanding packets becomes difficult to handle by the internetworking devices. An intermediate device like router, switch has a limited amount of memory-buffer and processing capabilities. Congestion occurs when we force a network and its devices to work beyond their capacities. When a router is supplied more than of its capacity to process, router suffer from an traffic jam kind of situation which is called congestion. As a result, Router may discard few packets which is the side effect of it[1]. The transport layer is responsible for end-to-end connection establishment, end-to-end packet data delivery, congestion control and flow control[2,3,4]. There exist simple, unreliable and connectionless transport layer protocols such as UDP and reliable, end-to-end, byte-stream-based and connection oriented transport layer protocol such as TCP for wired network[5].In this paper we design the issues and challenges in designing a transport layer protocol for ad hoc wireless networks, and also explore the TCP variants for an adhoc networks.

II. TCP CONGESTION CONTROL

1. Tcp congestion control consists of:
   - slow start(SA)
   - congestion Avoidance(CA)
   - Fast retransmit/fast recovery
2. The endpoint node concludes that congestion exists when an increase in end-to-end delay is observed.
3. Retransmission can further aggravate congestion since more packets are injected into the network.

Issues in designing a TCP for MANET:

- Induced traffic: due to traffic through neighboring links
- Induced throughput unfairness
- Separation of congestion control,
- reliability and flow control
- Power and bandwidth constraints
- Misinterpretation of congestion
- Completely decoupled transport layer
- Dynamic topology[6].
- Network partition: Due to node mobility and energy constrained operation
- Routing failures: Due to repeated transmission failure from link layer contention

Why does TCP fail in MANETS

1. TCP misinterprets route failures as congestion: It reduce the sending rate.
2. TCP misinterprets wireless errors as congestion: It will incorrect the execution of congestion control -> performance drops.
3. Intra- flow and inter-flow contention: It is mainly increased delay, unpredictability, and unfairness.
4. Delay spike causes TCP invoke unnecessary retransmission: The problem in performance drops and many unnecessary retransmissions.
5. Inefficiency due to the loss of retransmitted packet: Performance drops significantly under some high loss environment like MANETs.

Solution topology of TCP for MANET

We want to choose solutions which maintain close connection to TCP. Upper layer in the OSI model affected by choice of transport layer protocol. The solution for TCP over ad hoc wireless networks can further be classified into split approaches and end-to-end approaches. The end-to-end approach can be classified as TCP-LFN, TCP-F, TCP-BuS and ATCP.

TCP over ad hoc wireless network

Since TCP is widely used today and efficient integration of an ad hoc wireless network with the internet is paramount wherever possible, it is essential to have mechanisms that can improve TCP's performance in ad hoc wireless networks. This would enable the seamless operation of application level protocols such as FTP,SMTP and HTTP across the integrated ad hoc wireless networks and the internet[7].

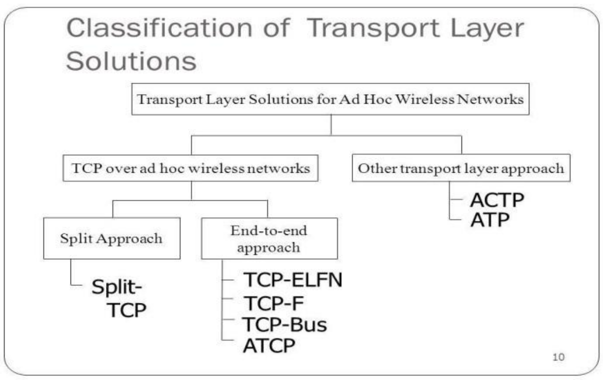

Figure 1: Classification of transport layer solutions

TCP-Feedback(TCP-F): It was introduced in 1998, TCP-F allows the source to be informed of a route disconnection as a result of node. When a link in a route is broken, the upstream node the detects the disconnection will send a Route Failure Notification(RFN) message back to the source. Upon receiving this message, the source enters SNOOZE state. When the TCP source enters SNOOZE state, it performs the following:

1. The source stops transmitting all data packets ie, be it new or retransmitted data.
2. The source freezes all its timers, the current cwnd size, and values of other state variables, like the retransmission timer value.

3. When the route repair complete message is received, data transmission will be resumed and all timers and state variable will be restored.

This approach has the accompanying better elements: common and unknown validation for vehicle-to-vehicle and vehicle-to-roadside interchanges, vehicle unlinkability, specialist following capacity and high computational effectiveness.

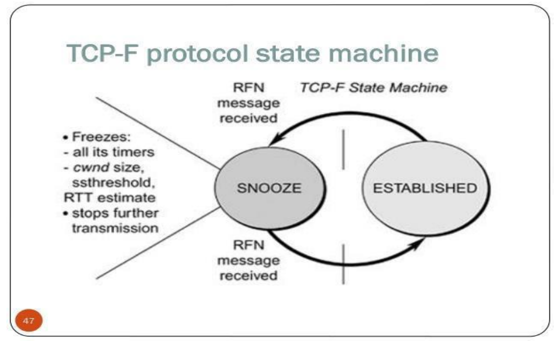

Figure-2: TCP-F state for manet

TCP-ELFN: The uses of TCP with Explicit Link Failure Notification(TCP-ELFN) for improving TCP performance in adhoc wireless networks. This is similar to TCP-F, except for handling of ELFN and the use of TCP probe packets for detecting the route establishment. ELFN message is similar to "host unreachable" message of ICMP – Internet Control Message Protocol. On receiving ELFN message, source enters into freeze – standby mode by pausing transmission. Source periodically get information about route reestablishment. If acknowledgement of probe message is received, TCP leaves the standby mode and resumes transmission. Route failure message of DSR- Dynamic Source Routing algorithm is piggybacked to carry route failure message information for TCP. ELFN message contains source and destination addresses and port numbers as well as TCP segment's sequence number. ELFN performs poor when load is high because of probing based nature [8].

TCP-BUS: BuS Stands for Buffering Capability and Sequencing Information. TCP BuS uses a reactive ABR – Associative Based Routing protocol. But the TCP-BuS is more dependent on the routing protocols compared to TCP-F and TCP-ELFN. It was proposed with Associativity-Based Routing (ABR) protocol as the routing scheme TCP BuS is based on following five improvements [9].

1. Explicit notification: Explicit notification are used to differentiate between network congestion and route failure as a result of mobility. The node that detects a route disconnection sends an Explicit route Disconnection Notification(ERDN) message back to the source. The source than stop the transmission. When the route reconfiguration or repair process is completed, an Explicit Route Successful Notification(ERSN) message is sent back to the source via the pivoting node.

2. Extension of timeout values: It is necessary to account for the time needed for route reconfiguration or repair. In TCP-BuS, timeout values for buffered packets at the source and nodes along the path to the pivoting node and doubled.

3. Selecting Retransmission: In TCP, retransmission of lost packets on the path due to congestion relies on a time out mechanism.

4. Avoidance of unnecessary requests for fast retransmission: There may be loss of some packets in the path from PN to Destination. There are already few next packets which are buffered in the path from source to PN. On new route establishment, destination informs source about the lost packets. The buffered packets reach to the destination before those retransmitted lost packets. Because of out-of order delivery, destination generates duplicate acknowledgements for fast retransmissions. Source avoids such unnecessary fast retransmission [10].

5. Reliable transmission of control messages.

ATCP: Ad hoc TCP similar to TCP-F and TCPELFN, ad hoc TCP(ATCP) also uses a network layer feedback mechanism to make the TCP sender aware of the status of the network path over which the TCP packets are propagated. Based on the feedback information received from the intermediate node, TCP sender changes its state to the persist state, congestion control state, or the retransmit state[11]. Adhoc TCP has four states: Normal (Connected), Congestion Control (Congested), Persistent (Disconnected) and Retransmit (Loss). Adhoc TCP listens to ICMP – Internet Control Message Protocol messages to put sender TCP in persistent state (freeze state until a new route is established). Adhoc TCP listens ECN – Explicit
Congestion Notifications to put sender TCP in congestion control state. On occurrence of 3 duplicate acknowledgements or RTO time out, sender TCP enters into the retransmission state [12].

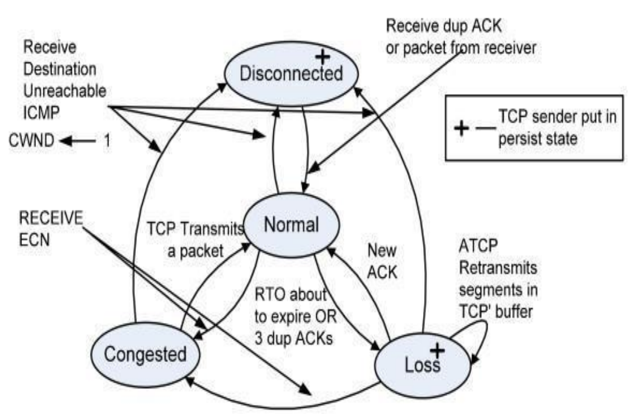

Figure-3: State transition diagram for ATCP

Split TCP: One of the major issues that affects the performance of TCP over ad hoc wireless networks is the degradation of throughput with increasing path length. The short connections generally obtain much higher throughput than long connections. Split-TCP provides a unique solution to this problem by splitting the transport layer objectives into congestion control and end-to-end reliability. This split-TCP splits a long TCP connection into a set of short concatenated TCP connections with a number of selected intermediate nodes as terminating points of these short connections[13].

III. COMPARISON OF TCP SOLUTIONS FOR AD-HOC NETWORKS:

The following Table.1 compares how various issues are handled in the Transmission Control Protocol extensions[6,14].

Table 1: Comparison of TCP solutions for Ad-hoc Wireless Networks

Issues	TCP-F	TCP-ELFN	TCP-BUS	ATCP	Split-TCP
Packet loss due to BER or collision	Same as TCP	Same as TCP	Same as TCP	Retransmit the lost packets without invoking congestion control	Same as TCP
Path breaks	RFN is sent to the TCP sender and state changes to snooze	ELFN is sent to the TCP sender and state changes to standby	ERDN is sent to the TCP sender, state changes to snooze, ICMP DUR is sent to the TCP sender and ATCP puts TCP into persist state	Same as TCP	Same as TCP
Out-of-order packets	Same as TCP	Same as TCP	Out-of-order packets reached after a path recovery are handled	ATCP reorders packets and hence TCP avoid sending duplicates	Same as TCP
Congestion	Same as TCP	Same as TCP	Explicit messages such as ICMP source quench are used	ECN is used to notify TCP sender. Congestion control is same as TCP	Since connection is split, the congestion control is handled within a zone by proxy nodes
Congestion window after path reestablishment	Same as before the path break	Same as before the path break	Same as before the path break	Recomputed for new route	Proxy nodes maintain congestion window and Handle congestion.

Explicit path break Notification	Yes	Yes	Yes	Yes	No
Explicit path establishment notification	Yes	No	Yes	No	No
Dependency on routing Protocol	Yes	Yes	Yes	Yes	No
End-to-end semantics	Yes	Yes	Yes	Yes	No
Packets buffered at intermediate nodes	No	No	Yes	No	Yes

CONCLUSION

In this paper, the major challenges involved in the design of a TCP and the various parameter comparison of transmission control protocol solution for ad-hoc wireless networks were described. The major goal is providing TCP in Adhoc wireless network the protocol should maintain end- to-end connections, end-to-end delivery of data packets, flow control and congestion control and also it should have a well defined cross-layer interaction framework for effective, scalable and protocol-independent interaction with lower layers. A perfect combination of all the three congestion control feedbacks – packet loss, packet delay and explicit notifications by intermediate routers improves the TCP performance drastically. Here can do work on congestion control on MANET by different variants.

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