International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 5, Issue 4, April 2016 ISSN 2319 - 4847

Key Performance Indicators of major TCP Routing Protocols Deployed in MANETs

Aniket Deshpande[1] , Dr. Ashok Kaushal[2]

[1]Research Scholar, Faculty of Engineering and Technology, Mewar University,
NH-79, Gangrar, Chittorgarh, Rajasthan – 312901, India

[2]Research Supervisor, Faculty of Engineering and Technology, Mewar University,
NH-79, Gangrar, Chittorgarh, Rajasthan – 312901, India

Abstract

Mobile Ad-Hoc networks have fascinated lately as the means of provision of connectivity of the continuous network to mobile computing device irrespective of the corporeal location. Recent studies primarily focused over the routing protocols that are required in this very environment. In the research analysis, the effects of the link breakage will be analyzed because of the impact mobility has on the performance of TCP. Via simulation, it will be demonstrated that the output of the TCP drops significantly in the course of movement of the nodes. It can be due to various reasons, such as the difference amongst the congestion and link failure. The analysis various types of protocols will be presented on the basis of the path asymmetry, high bit error, route failure, network partition, TCP Congestion window size, energy constraint, intra-flow and inter-flow contention, multipath routing, and interaction between TCP and Media Access Control (MAC).

Keywords: Mobile Ad-Hoc Networks performance, Routing protocols for MANETs, Network congestion, Comparison of routing protocol behaviour in MANETs.

1. INTRODUCTION

This study, focused on behavior and performance of various TCP based routing protocolsin Ad-Hoc Networks, will incorporate the comparative assessment of the various types of TCP basedrouting protocols used in the Ad-Hoc network with respect to multiple parameters affecting the end-to-end delivery of packets. The protocols in consideration include End-to-End Approach Protocol, Detection of Out of Order Delivery Protocol, feedback-Scheme Protocol and Adaptive Back-off Response Approach protocol. Each of these protocols responds uniquely to various parameters that affect the behavior of TCP over Ad-Hoc Networks that is documented in this study. The study documents the comparative response of these protocols to various performance-based parameters followed by recommendations on the scope of further study on this topic.

2. KEY TCP MOBILE AD-HOC NETWORKS PROTOCOLS IN THE CONSIDERATION

2.1End to End Approaches Protocol

There are two types of approaches that have been deployed for the detection of the network congestion over the Internet i.e. feedback from that of the intermediate gateways and end-to-end measurement within the network [6]. Normal TCP includes end-to-end measurement of RTT (Round trip time) along the loss of a packet in the detection of congestion. RED/ ECN facilitates congestion notification via immediate size monitoring of the queue at the gateways of the network.

End-to-end approaches require no support of the network. The end nodes i.e. the sender or receiver can recognize the state of the network by measuring the parameters of appropriate traffic. For instance, out of order delivery or high volume implies route change. A heuristic is hired in order to distinguish between the congestion and the route failures without depending over the feedback from the various other nodes of the network. When timeouts transpire consecutively, it can be marked as to be evidence of a route loss [1]. The unrecognized packet is again transmitted; however, the RTO remains immobile until the route is reinvented and the retransmitted packet is accredited.

The end-to-end protocol as defined by the name, defines the protocol between the ends regarding the channel of communication. The most prominent service provided by the end-to-end protocol is to deliver process-to-process channels of communication for the processes of applications. An application running over an operating system is defined as the “process” [7-9]. There may be various application procedures operating simultaneously on a single host, with the assistance of process-to-process channels, any of the processes of applications running over any Internet hosts can connect with each other.

2.2TCP DOOR (Out of Order Delivery Event Protocol)

TCP detection of Out-of-order and Response, commonly known as DOOR, is an end-to-end approach. DOOR approach may not include collaboration of the intermediate nodes. OOO events are understood as a sign of the catastrophe of the route. Either the detection of events of OOO is successful by the means of a sender-based or the mechanism based on the receiver [8]. The sender-based mechanism includes the constant assets of the sequence number of ACK in order to detect OOO events. In case of the fraud packet of ACK, these ACKs will have the similar sequence number, in order to fulfill the additional needs of the sender for the detection of OOO events. This information is a single byte option included in ACKs known as ADSN (ACK Duplication Sequence Number). The ACK Duplication Sequence Number is broadcasted and is also incremented with every ACK duplicate. The mechanism based on the receiver, however, needs an additive two bytes option of TCP, in order to perceive the OOO events, known as TPSN (TCP Packet Sequence Number) [2]. The TPSN is transmitted and incremented with all the packets, which includes the retransmission of the packets. If the receiver indicates an OOO event, it ought to inform the sender via setting a bit of specific option, known as the OOO bit, in the pack header of ACK [10]. When the TCP sender identifies an OOO event, it takes the subsequent two-rejoinder actions, i.e. incapacitating congestion control and control of instant recovery throughout the evasion of congestion.

For the detection of OOO, the information ordering is included to the TCP ACKs data packets of TCP. OOO exposure is performed at both ends, i.e., the sender recognizes the acknowledged packets that are out of order and the receiver perceives the packets of out-of-order data packets. In case of the receiver noticing OOO, it informs the sender with respect to the scenario that it is the sender who takes into accounts congestion control actions [8]. Once the sender of the TCP knows the condition of OOO, it may take any of the two responsive actions, which include, temporarily incapacitating the control of the congestion and instantaneous control in the avoidance of congestion [1]. The first action is referred to, whenever the condition of the OOO id sensed, the sender of TCP will keep the respective variables of the state, which includes RTO and the size of the congestion window constant with respect to the time period. Another action includes that if in between the past time period, the sender of the TCP has entered already into the state of the avoidance of congestion, and it can recover instantly regarding the state prior to the avoidance of such congestion.

OOO can be detected, however, only after the recovery of the route from the failures. Consequently, TCP-DOOR is less responsive and accurate than the feedback based approach, which has the ability to detect, if errors of the route or congestion occur, and thus, send the report to the sender in the initial stages [3]. Additionally, it may not perform sound with the multi-path routing, reason being; the routing of the multi-path may cause the OOO as well [5]. Hence, it can be summarized that TCP-DOOR can perform as a second source against the feedback-based method in order to enhance the TCP performance of an ad-hoc network, in case of the unavailability of the latter option.

2.3Feedback Scheme Protocol

In the recent architecture of the Internet, there exists no rate feedback from the network to the sources of traffic. TCP can be used to achieve network traffic control, as it is integrated in the end systems. TCP forms the source traffic by regulating the size if the transmission window according to the estimate of the status of the network. The strength of the respective end-system approach to control of the traffic is the ease of deployment and flexibility. Novel algorithms of TCP can be used gradually in the Internet deprived of the prerequisite of any progression in the core of the network [2]. The chief drawback is that sources cannot learn the precise states of the network, which have resulted in lessening the optimum outcome.

It is evident that consideration of route failure as invoking as congestion and invoking congestion control is not an advisable option, as route failure and congestion control are incongruent phenomenon that need to be handled independent of each other. Therefore, a scheme has been proposed that acknowledges the source regarding the failure of the route to ensure that it does not invoke congestion control unnecessarily and refrain from sending any additive packets until the restoration of the route. Feedback schemes regarding TCP have been already proposed in the form of ECN (Explicit Congestion Notifications) for the fixed networks and EBSN in the category of cellular networks [5-8]. Ad-hoc networks do not have a consistent backbone. Therefore, a feedback approach is proposed for the management of the route failures in the context of the ad-hoc networks referred to TCP-F or TCP-feedback that is described below.

A single bulk session of data transfer is considered, in which, a source MH (Mobile host) is sending the packets to the destination MH. Once the layer of the network at the intermediate MH identifies the disruption of the route because of the mobility of the following MH with respect to the route, it explicitly sends a RFN (Route Failure Notification) packet towards the resource and records of the very event. Every intermediate node that obtains the packet of RFN invalidates that specific route and prevents received packets envisioned for that destination from passing via respective route [5]. However, if the intermediate route is aware of an alternate source regarding the destination, this alternative route can be deployed in order to support any further communication and the RFN is castoff. Else, the intermediate node propagates the RFN directly towards the source.

The deployment of the feedback nurtures various interesting issues.Effect of the multiple failures over the similar route, it is always possible that the failure of the multiple routes occur independently along various links with respect to the routes. It is not considered as the serious concern in case of TCP-F, because the source will then be receiving an RFN from the adjacent FP and behaves in a respective manner. Communication, however, will then resume only afterward the source receives an RRN from that FP (Failure point), which indicated that the route has been stowed [2].
The effect of the congestion over the mechanism of feedback, there exist a possibility that in the crowded network, RRN and RFN packets may be delay or lost. This is not the concern, however, since the basic TCP will detect the congestion at the source and invoke congestion control [5-9]. The very behavior has been required as the attempt is made only to recognize the packet loss because of the congestion from that because of the failure of the route.
Though there exists the possibilities of the failure over multiple connections of an end-to-end transport, a single transport connection is considered in analyzing of simulation. In real life situations, however, there may exist a number of transport connections that include the similar link orroute [10]. Thus, a single link or route failure is a possibility in order to affect a number of transport connections.

2.4Adaptive Back-off Response Approach Protocol

MANET (Mobile ad hoc Network) suffers from provisional route changes and link failures. In addition to it, TCP accomplishes offensively when most packets are lost because of the congestion. Various researches that have taken place for improving the performance of the over MANET need feedback from the lower layers. Various attempts have been made for the improvement of layered TCP. Yet, another enhancement is not content [7-10]. Therefore, an algorithm has been proposed in which the back-off counter is solid only when the volume of the ongoing transmission is generated.

An approach has been deployed in order to perform the adaptive back off response approach protocol, for TCP, retransmits the primogenital-unrecognized packet and adds the RTO (Retransmit Time Interval). The procedure is repeated until an ACK has been received for the retransmitted packet. Therefore, retransmission timeout interval can be very wide; however, the routes may have been regenerated few years back. The wasted time can be utilized in sending the packets. It is to be noted that the respective approach did not rely over feedback from the lower layers of the network [6]. The palpable trade-off is that an approach of the feedback-based is more precise than any of the other technique.

3. Comparison of Protocols through Various Parameters

3.1Interaction between Media Access Control (MAC) and TCP

A model has been presented for the cooperative design of congestion control and MAC (Media Access Control) for the network for ad-hoc wireless. By means of a contention matrix and graph, a resource has been formulated and allocated in the network; a resource allocation in the network has been formulated as a problem of utility extension with the limitations that arise from the contention regarding access of the channel. Two algorithms have been presented that are distributed spatially and fester vertically into the double layer where MAC and TCP jointly solve the delinquent of the system [10]. The first is known as the primal algorithm, in which the layer of MAC located at the link establishes the congestion prices based over local rates of the aggregate source. Whereas the sources of TCP regulate, their rates based over the aggregate prices in the respective paths.
The second is the dual sub gradient algorithm, in which the MAC sub-algorithm is executed via flows of the scheduling link-layer rendering to the link congestion prices. Properties of the global convergence of the following algorithm have been proved [3]. This is termed as the introductory step towards the systematic approach in order to jointly design the algorithm of TCP congestion control and the MAC algorithms, but more specifically in order to establish the interaction between them more transparent.

3.2Route Failures

The router failures with respect to the wired networks appear very rarely. In MANET it appears in a frequent manner. The primary cause of route failure is the mobility of the node. Another factor that may lead to the failure of the router is the failure of the link because of contention over the wireless channel that counts as the main cause of performance of TCP [1]. Moreover, within the Ad-hoc networks, the routing protocols that depend upon broadcasting Hello messages in order to recognize the reachability of the neighbors, can suffer from the communication grey zones. Within these zones, data messages cannot be replaced, however, broadcast control frames and hello messages designate the reachable neighbors. Therefore, on sending the data messages, failures can be confronted by the routing protocol [8]. The origin of the problem is the rate of heterogeneous transmission, fluctuations of the wireless links, lack of acknowledgement regarding the broadcast messages.

3.3High Bit Errors

Bit error is defined as the occurrence of errors in the transmission lines to the total number of bits sent [10]. The protocol that works better in order to reduce the high bit error is the Adaptive Back off Response Approach Protocol.

3.4Path Asymmetry

Route asymmetry relates to the distinctive paths are deployed for the TCP ACKs and TCP data. Path asymmetry can be aobject of the used routing protocol. Route asymmetry augments routing outlays and loss of the packet in the context of high degree mobility. The reason behind this being that, when nodes displace by the distinctive reverse and forward routes, it increases the probability of the route crash practiced by the connections of TCP [6]. Regarding the satellite networks, research had been going on in order to improvise the performance of TCP, however, the satellite networks are out of fashion, and therefore the Ad-hoc networks have attained more attention. The adaptive-delayed ACK is however, being proposed in order to reduce the channel contention, by reducing the number of TCP ACK transmitted.

3.5Network Partition

A positive transmission between multiple stations is referred to as the undirected edge. The primary reason for the occurrence of MANET is the mobility of the node. One more factor that may conclude towards the partition of the network is the energy limiting operations of nodes [9]. An illustration of the network partition is mentioned in the figure below. In the figure, the dashed lines are represented as the contacts among the nodes. When the node D goes far from the C node, this result in the network panel in to dual components.

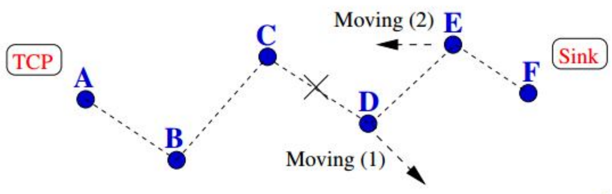


Figure 1 Illustration of Network Partitions

3.6TCP Congestion Window Size

By tuning the TCP of the sender to the maximum window size (about four packets), the entire versions of TCP perform in a similar way. In addition to it, the author has investigated the performance of the various version of TCP with the help of the delayed-ACK option. Accordingly, the sink TCP will send one packet of TCP ACK for each of the two received packets [1-3]. The mentioned option will reduce the contention over the wireless channels, due to the ACK packet and data share the identical channel of the wireless. Simulating the chain of multi-hop with the option of delayed ACK, the improvement has been monitored of about 15 per cent to 32 per cent.

3.7Energy Constraint

Due to the carriage of the batteries by each node of the mobile have restricted power supply, therefore the power of processing is limited. It has been regarded as the foremost issue in the course of ad-hoc networks, because every node is performing as an end system along with the router, with the insinuation that additive energy is needed in order to forward and relay packets [2]. Power saving strategies has been examined at various levels of the mobile device in addition to the transmission of the physical layer, applications and the operation systems. Power control can be used jointly with transport or routing agents in order to augment the performance of the Ad hoc networks. Communication of power restraints have also revealed the concern regarding the cooperation between the two nodes, however, nodes cannot contribute win the procedures of forwarding and routing, in order to save the power of the battery.

3.8Multipath Routing

The purpose of the multipath routing objective is to increase the availability of the path of TCP links with the deployment of multipath routing. Researchers have found that the original multipath routing depreciates the performance of TCP, because of the accuracy in the measurement of average RTT and the delivery of the out-of-order packet. Therefore, the new variation regarding the multipath routing called the backup path routing has been introduced [5]. This proposed routing maintains various paths form the destination source, however, only singular path at a time. In case of the breakage of the current path, it may quickly switch towards a substitute path. Two schemes have been proposed for the selection of the path. The major option is to select the shortest-hop path as the shortest-delay path or selecting the maximally disjoint path as an alternative.

3.9 Intra-flow and Inter-flow Contention

There exist several problems between the interaction of the contentions for the MAC layer and the congestion of traffic flow for the reliable service, which includes TCP traffic. The key idea is to differentiate transmission of the packet. In a more precise manner, opportunities of better transmission are generally assigned to backlogged or urgent packets [7]. This may include those who are conventional by the nodes of the downstream or the one accumulated at the congested nodes.

4. COMPARISON CHART

Below mentioned chart clarifies the performance measuring parameters with respect to the above-mentioned routing protocols. The criteria of the evaluation conducted using NS2 simulation tool is also mentioned.

Table 1: Comparison chart for the performance of TCP Routing Protocols in the MANETs

Performance Measuring Parameters	TCP based Routing Protocols used in MANETs			
	End-to-end Approaches Protocol	**TCP DOOR (Out of Order Delivery Event Protocol)**	**Feedback Scheme Protocol**	**Adaptive Back off Response Approach Protocol**
Interaction between Media Access Control (MAC) and TCP	3	3	2	2
Route Failures	2	1	1	1
High Bit Errors	2	2	2	2
Path Asymmetry	3	2	2	3
Network Partition	3	2	2	3
TCP Congestion Window Size	2	3	3	2
Energy Constraint	3	2	2	2
Multipath Routing	3	2	3	2
Intra-f1 and Inter-f1 Contention	3	3	2	2

Criteria	1=Low	2=Medium	3=High

5. CONCLUSION

It can be concluded that based on the analysis of above-mentioned parameter, different protocols are profound in different parameters. Therefore, various protocols can be used in order to combat congestion in the ad- hoc network depending on the challenges observed. However, a hybrid approach combining two or more of these above protocols is expected to have wider positive coverage on most of these performance impacting parameters and hence most optimal for the future work towards identifying and developing such a blend.

6. FUTURE WORK

The procedure of optimizing and measuring the performance of end-to-end approach protocol is under a number of conditions. These include energy constraints, TCP congestion window size, intra-flow and interflow congestion, and interaction between MAC and TCP. Researches are also in progress over the behavior of the TCP connection and the protocol. In addition, the working has been started on improvising the performance of TCP in the context of the metropolitan-area packet network of relay. The system consists of multiple wireless hops from the base station in order to host the mobile and operates at bandwidth of approximately 100Kbits/s. The future wireless networks are likely to be heterogeneous, wherein each host will be connected simultaneously to the various other wireless interfaces that have the capability to interfere with each other. The problems regarding the improvising of TCP performance, handoff and routing in the typical heterogeneous network, depicting the interference influence over the quality of the connection, and the network-characteristics support application are challenging one substantial practical value. Hence a right blend combining two or more of these protocols with suitable enhancement is definitely the way forward to ensure wider adaptability and stability in performance of TCP over Mobile Ad-Hoc Networks.

References

[1] Bade, S., Kumar, M., &Kamat, P., A Reactive Energy-Alert Algorithm for MANET and Its Impact on Node Energy Consumption. International Journal of Computer Applications, 2013, 71(18). Data retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.403.2141&rep=rep1&type=pdf

[2] Bhardwaj, P. K., Sharma, S., &Dubey, V. Comparative Analysis of Reactive and Proactive Protocol of Mobile Ad-Hoc Network. International Journal on Computer Science and Engineering (IJCSE), 2012, 4(07). Data retrieved from http://www.enggjournals.com/ijcse/doc/IJCSE12-04-07-171.pdf

[3] Devaraj, S. A., Anita, R., & Christa, J. J. Comparative analysis of random based mobility models using TCP variant in MANETs. In Communication and Network Technologies (ICCNT), 2014 International Conference on (pp. 324-329). IEEE Data retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=7062778

[4] Dixit, A., Singh, S., & Gupta, K. Comparative Study of P-AODV and Improved AODV in VANET, 2015. Data retrieved from http://ijarcsms.com/docs/paper/volume3/issue1/V3I1-0079.pdf

[5] Kaur, D., & Kumar, N. Comparative Analysis of AODV, OLSR, TORA, DSR and DSDV Routing Protocols in Mobile Ad-Hoc Networks. International Journal of Computer Network and Information Security (IJCNIS), 2013, 5(3), 39. Data retrieved from http://www.mecs-press.org/ijcnis/ijcnis-v5-n3/v5n3-5.html

[6] Mannan, N., Khurana, S., & Rani, M. Comparative Analysis of Reactive Protocols in Mobile Ad-Hoc Networks. International Journal of Computer Science and Engineering, 2014, 233-237. Data retrieved from http://www.ijcseonline.org/pub_paper/IJCSE-00242.pdf

[7] Martinez, F. J., Toh, C. K., Cano, J. C., Calafate, C. T., & Manzoni, P. A survey and comparative study of simulators for vehicular ad hoc networks (VANETs). Wireless Communications and Mobile Computing, 2011, 11(7), 813-828 Data retrieved from http://onlinelibrary.wiley.com/doi/10.1002/wcm.859/full

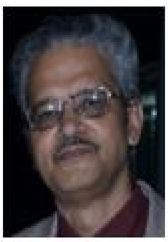
[8] Ros, F. J., Ruiz, P. M., &Stojmenovic, I. Acknowledgment-based broadcast protocol for reliable and efficient data dissemination in vehicular ad hoc networks. Mobile Computing, IEEE Transactions on, 2012, 11(1), 33-46. Data retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5677542

[9] Sreenivasa, B. C., Prakash, G. C., &Ramakrishnan, K. V. Comparative analysis of ADTCP and M-ADTCP: Congestion Control Techniques for improving TCP performance over Ad-hoc Networks. arXiv preprint arXiv:, 2012, 1209.2507. Data retrieved from http://arxiv.org/abs/1209.2507

[10] Umamaheswaran, S., Kumar, N., &Biswas, P. K.. A survey of routing protocol design patterns for mobile ad hoc networks. In Emerging Technology Trends in Electronics, Communication and Networking (ET2ECN), 2014 2nd International Conference on (pp. 1-6). IEEE. Date retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=7044988

AUTHOR

Aniket Deshpande is pursuing his PhD in Computer Science and Engineering at Mewar University, Chittorgarh, Rajasthan, India under the guidance of Dr. Ashok Kaushal. He received his Master of Technology in Computer Science and Engineering from Dr. MGR Educational and Research Institute, Chennai, Tamil Nadu, India in 2004. Prior to that he completed his Bachelor of Engineering in Computer Technology from Nagpur University in 2000. Network Infrastructure Optimization has been his key area of interest for last many years and is currently working with Riverbed Technology as a Senior Solution Consultant.



Dr. Ashok Kaushalcompleted his Master of Technology in 1983 from Lviv Polytechnic National University, Ukraine followed by Ph.D. in 1987 from National Technical University of Ukraine (formerly Kyiv Polytechnic Institute) in Computer Technology.He has extensive Industry experience and is also presently working as a Research Supervisor and Visiting Faculty at Mewar University. Additionally, he is also working as a Freelance consultant with special interests in Geospatial Technologies (GIS) including recent advances in ICT, Electronics & GIS including Cloud Computing, Crowdsourcing, Big Data, Smart Phones, Digital Wallet, RFID, Mobile Computing ecosystem with Applications in eGovernance and Surveillance including Smart Cities.