An Approach Using Dynamic Deferred Acknowledgement to Improve TCP Performance in Multi – Hop Wireless Networks

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Abstract

The network communication protocol designed for sending data packets over the Internet is the Transmission Control Protocol. This paper proposes an approach to improve the performance of TCP in Multi – Hop Wireless Networks. The approach aims to minimize the number of acknowledgements using Delayed Acknowledgement mechanism. The performance of TCP is reduced due to the generation of acknowledgement for each of the incoming data packet. The TCP performance wanes chiefly when the ACK and data packets encounter and impact one another as they traverse the same path. The performances of TCP in Multi – Hop Wireless Networks are affected due to contention and collision. Transmission Control Protocol performance can be improved by decreasing the number of acknowledgements using Delayed Acknowledgement mechanism. A receiver with an adaptive Delayed Acknowledgement mechanism is proposed to improve the performance of TCP in Multi – Hop Wireless Networks. A Delayed Acknowledgement (DAK) Algorithm is proposed to improve the Transmission Control Protocol throughput compared to the regular Transmission Control Protocol. The proposed approach is simulated in Network Simulator – 2 (NS – 2). The simulation results illustrate the efficiency of our approach in terms of packet loss.

Keywords : *Delayed Acknowledgement, Multi – Hop Wireless Networks, TCP, Throughput.*

1. Introduction

A Multi – Hop Wireless Network is a collection of mobile hosts with wireless network interfaces, which form a temporary network without the need of central administration or fixed infrastructure. The mobile hosts are free to move and can dynamically self – organize themselves into an arbitrary and temporary network. These nodes not only forward and receive packets, but they also act as routers and have the ability to accomplish route maintenance and route recovery. Multi – Hop Wireless Networks have some benefits like :

- It can extend the coverage area.
- It can improve the connectivity.
- It can also enable higher data rates.
- Multiple paths are available that can be used to improve the robustness of the network.

TCP is a connection – oriented protocol. It sends the data packets as an unstructured stream of bytes. TCP uses sequence numbers and acknowledgement messages, which can provide information to the sending node about the delivery of packets transmitted to the destination node. If, the data packets have been lost during the transmission from source node to destination node, TCP can re – transmit data packets until either of the conditions have been achieved :

- Timeout period has been reached.
- Until the data packets have been successful delivered.

TCP only recognizes the receipt of duplicate messages and will discard them appropriately. If sending node is transmitting too fast and receiving node is unable to receive the data packets, TCP can employ any of the flow control mechanisms to slow down the data transfer rate.

TCP services should be reliable and flow – controlled. However, TCP service is much more complex than UDP, which only provides the Best Effort service. To implement the service in TCP, it uses a number of protocol timers that could ensure reliable and synchronized communication between the sender and the receiver. This end – to – end conversation determines how the two characteristics of TCP operate :

- Performance
- Error handling

The performance of TCP is dependent on algorithms and techniques such as flow control and congestion control.

Flow control is the rate at which data packets are transmitted between sender and receiver. Congestion control is the method for implicitly interpreting the transmission rate. TCP implements a window based flow control mechanism. TCP's flow control is governed by maximum allowed window size advertised by the receiver. The policy followed by sender is to send new packets only after receiving acknowledgement for the previous packet. Besides, the receiver's advertised window, *awnd*, TCP's congestion control introduces two new variables for the connection :

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- Congestion Window (*cwnd*)
- Slowstart Threshold (*ssthresh*)

The congestion window (*cwnd*) is a counterpart to advertised window (*awnd*). *awnd* prevents the sender from overrunning the resources of the receiver. Congestion window (*cwnd*) prevents the sender from sending more data packets than the network can accommodate current load conditions.

The performance of TCP is degraded in wireless networks as compared to wired networks; because TCP was developed for wired networks. The packet loss in wired networks is assumed to be due to congestion only. This assumption fails in case of wireless networks, as the error rates in wireless networks may be an order of magnitude larger than wired networks. Hence, when data packets are dropped or corrupted on wireless link, the congestion control mechanism of sender kicks in and as a result (of reduction in congestion window size) the throughput decreases significantly.

The factors affecting the performance of TCP in Multi – Hop Wireless Networks are due to :

- Mobility
- Energy Efficiency
- Medium Contention and Collision
- Channel Error

The main objective of this paper is to improve the performance of TCP throughput in Multi – Hop Wireless Networks by delaying the acknowledgements of receiving the data packets in the network. Section I gives an introduction to the Multi – Hop Wireless Networks. Section II is about the related work in the area of research. Section III describes the proposed algorithm. Section IV is about the results based on simulations. Finally, Section V concludes the gain achieved in TCP performance for Multi – Hop Wireless Networks.

2. Related Works

This section presents the various methods proposed to improve the performance of TCP in Multi – Hop Wireless Networks.

A dynamic delayed TCP ACK mechanism that aims to adjust the number of delayed ACKs was hypothesized by Yang et al. It is called AP – DDA and regards four parameters such as the gage of congestion window, its sending situation, TCP sending states and also the special data packets. These could either be the retransmitted packets or out – of – order ACKs. The AP can estimate the gage of the window, establish the TCP state and also determine current sending state of the current window. Despite giving a considerable throughput, the shortcoming is the hardship in expanding which demands an alteration of the AP design.
Chen et al., posited TCP – DCA scheme in which the number of hops or the path length becomes a basis to select different delay windows. They recorded that the best TCP throughput gain happens when the ACK's are limited and an optional delay window size is present at the receiver.

Beizhong et al., suggested that the best TCP throughput can be gained by making the receiver wait until the ACK layoff disregarding the number of in – order packets received. The layoff is due to a large delay window.

3. TCP Performance In Dynamic Delayed Acknowledgement

Several solutions have been worked out by researchers to improve TCP performance. However, most of these were directed towards lowering the number of ACKs to minimize their encounter with data packets.

The objective of TCP – DAK is to maximize or minimize the number of ACKs by automatically detecting the network condition. The new protocol designed will automatically regulate the ACKs by adjusting the *cwnd* size, inter – arrival time of the packets, and their loss events.

The adjustment of the delay window will allow ACK to be generated by receiving the *dwnd* of the packets. In this way, the receiving node will be able to adjust itself to different values of delay imposed by the wireless channel.

The un – acknowledged data packet arrival count is maintained by TCP – DAK with ack – count variable 'k' which records values from 0 to current *dwnd* size.

TCP – DAK sends information to the sender about orderly arrival of packets or packet losses by generating ACKs after which the ack – count variable is set to '0'. Inter – arrival times of the TCP packets help TCP – DAK learn about the network condition that is an essential factor to set the delay window. This also helps avoid dependency on any definite feedback from the intermediate nodes on the path.

4. Simulation Results And Discussion

The parameter settings for the simulation experiments are shown in Table 1. The simulation was done using NS2 simulator.

Table 1 : Simulation Parameter

Parameters	Value
Simulation Area	1500 * 1500 m^2
Simulation Time	300 s
Transmission Range	250 m
Routing Protocol	AODV / DSR
TCP Traffic Type	FTP Generic
Packet Size	512

The performance metrics that are analyzed for evaluation include throughput, data packets sent by the sender and acknowledgements received by the sender. After extensive

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simulations, the inferences from the simulations depict the main reasons for TCP performance degrades due to generating acknowledgements for all the incoming packets.

In this paper, the interaction between the data packets and acknowledgements has been studied through the simulation and the simulation results indicate the performance of TCP degrades for generating acknowledgements for each incoming packet. Instead of that, delay the acknowledgements for all packets using TCP – DAK.
The wireless network topology was created with sender, receiver and lots of intermediate nodes. FTP generic is used to transfer the packet, and TCP is used to provide reliable packet delivery. The simulation was performed in various scenarios such as normal transmission and packet loss transmission. In this paper, the interaction between the data packets and acknowledgement was studied in various scenarios like normal transmission and packet loss transmission.

Simulation was done for the above topology in normal transmission and the observations are shown in Table 2. The simulations were done to analyze the ratio of the data packets sent and acknowledgements received.

Table 2 : TCP's Parameter Value for Normal Transmission

Number of Data Packet Sent by the Sender	Number of Data Packet Received by the Receiver	Total number of ACK only Packet Sent by Receiver	Duplicate ACK Packet Received by the Sender
106	101	54	46
232	223	109	89
346	335	136	111
451	439	153	121
578	561	201	155
688	669	224	172
808	784	263	203

The graph obtained for the above topology is shown in Figure 1. The simulations were done to analyze the ratio of data packets sent and acknowledgements received. It was found that approximately for every three packets an acknowledgement was sent.

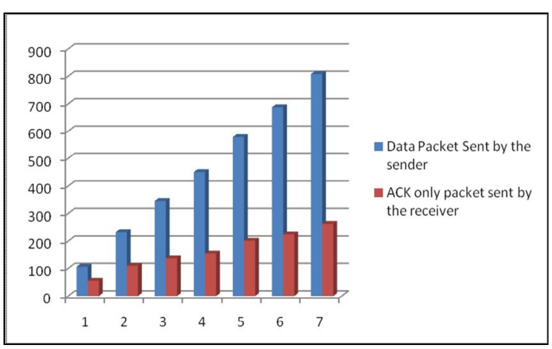

Figure 1 : TCP's Parameter Analysis for Normal Transmission

Simulation was done for the above topology in packet loss transmission and the observations are shown in Table 3. The simulations were done to analyze the ratio of data packets sent and the acknowledgements received. Manual Fault was created in the Node configuration with Static Type and analysis is performed to find the various TCP's parameters during the transmission.

Table 3 : TCP's Parameter Value for Packet Loss Transmission

Number of Data Packet Sent by the Sender	Number of Data Packet Received by the Receiver	Total number of ACK only Packet Sent by Receiver	Duplicate ACK Packet Received by the Sender
100	100	14	0
202	200	89	30
303	282	92	31

The graph for the above topology is shown in Figure 2. The simulations were done to analyze the ratio of the data packets sent and the acknowledgements received. A packet loss was created by fault node configuration option in NS2. A fault was created at the interface between node and node. The time at which the fault occurs was set as 10s to 20s. Accordingly, packet loss occurred at 10s, then the number of packets sent and the acknowledgements vary depending on the duration of the fault. In this case, the number of duplicate acknowledgements also increased, and indicated that the number of transmissions has also increased.

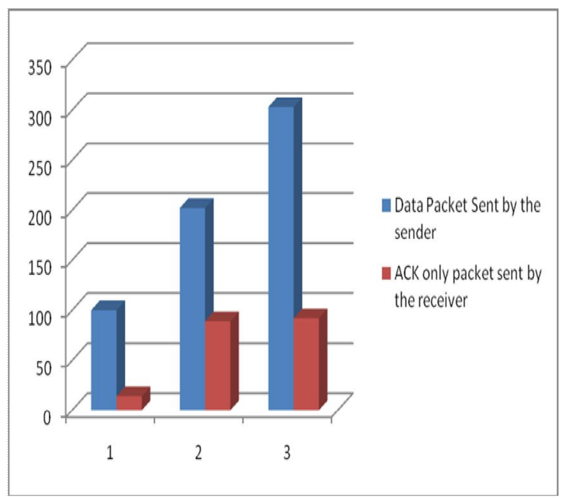

Figure 2 : TCP's Parameter Analysis for Packet Loss Transmission

5. Conclusion

To develop a TCP receiver that has a self – adjusting capacity to maintain the data to ACK ratio is the main focus of this research work. The work centrally aims at designing a TCP receiver that functions for large sensor networks. The protocol design does not require changes at intermediate nodes and also does not expect any feedback from the network which makes its deployment much easier than existing protocol.

In the future, TCP performance analysis can be done, for varying load, varying mobility, varying hop lengths and varying packet error rate in different wireless topologies such as 802.11, 802.15 and 802.16 using TCP – DAK.

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