IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 5, No 3, September 2011
ISSN (Online): 1694-0814
www.IJCSI.org

Improved Datagram Transport Protocol over Wireless Sensor Networks- TCP Fairness

Senthil Kumaran .M [1] and Dr. R. Rangarajan [2]

[1] Professor/CSE
Muthayammal Engineering College
Rasipuram, India.

[2] Dean/ECE
Dr. Mahalingam College of Engineering & Technology
Pollachi, India.

Abstract

TCP connections have small bandwidth-delay product and frequent packet loss in wireless sensor networks due to route breakages and radio interference. Datagram transport protocol provides a reliable end-to-end transport protocol over wireless sensor networks. This paper deals with improvement of TCP Fairness as Fairness in wireless sensor networks plays a major role to have maximum fair share of available bandwidth among the nodes, thus energy is consumed. A distributed adaptive max-min algorithm has been proposed in order to improve the fairness in WSNs. The proposed scheme incorporates two techniques: a fixed-size window-based flow-control algorithm and a cumulative bit-vector-based selective ACK strategy. Security has got the major impact over WSNs and that has been overcome by logical Tunneling. The simulation results show the improvement in terms of fairness, throughput and delay and packet loss using Network Simulator NS-2.

Keywords: *Fairness, Congestion Control, Bandwidth Delay Product, Dynamic Source Routing*

1. Introduction

Recent advances in wireless communication technology and portable devices have generated much interest in wireless sensor networks (WSNs). A WSN is a collection of wireless devices moving in seemingly random directions and communicating with one another without the aid of an established infrastructure. It is characterized by low variable bandwidths, high variable delays, significant non congestion-related packet losses, and occasional communication blackouts due to route breakages. Under such operating conditions, the traditional reliable transport-layer protocol TCP, which is used widely in the wired network, is not suitable for WSNs. The proposal of this work is carried out in the direction of analyzing congestion control algorithm and the strategy used to guarantee reliable delivery. Bandwidth-delay products (BDPs) represent the maximum amount of unacknowledged data that are allowed in flight at any moment in the network. When the amount of traffic injected by a source exceeds the BDP of the connection, the excessive packets that are queued in the network lead to undesirable queuing delays and congestions. Correspondingly, the network cannot be fully utilized when the total packets in the network are less than the BDP. As such, the BDP plays an important role in the design of a congestion control algorithm for the effective usage of network resources. For a window-based transport protocol like TCP, the transmission window size must be carefully adjusted for networks with different BDP values. TCP was originally designed for a general wired network where the BDP is not very large and packet losses rarely occur. However, with the emergence of various types of networks such as high-speed and satellite networks, TCP can no longer guarantee good bandwidth utilization. It is desirable that the system knows the BDP for each connection in advance so that it can limit the amount of traffic pumped into the network and maintain the optimum throughput.

In traditional wired networks, the TCP source is unaware of the available BDP and dynamically determines it by creating congestion during the transmission. However, in WSNs, the BDP of a path can be determined in advance by using routing protocols such as DSR (Dynamic Source Routing Protocol) and AODV (Adhoc On Demand Vector Routing Protocol). This allows the transport layer to intelligently set its transmission window before connection establishment. In this improved DTPA, the transmission window is fixed at a small value, which is as low as several packets. This proposed mathematical model calculates the optimum transmission window size, and its value has been found to be equal to the

BDP of the path plus 3. More effort should be put into the ability of the scheme to quickly detect and recover the lost packets.

The currently prevalent Reno variant of TCP employs a cumulative ACK scheme, through which packet losses are detected with at least three duplicate ACKs, i.e., four identical ACKs without any other intervening packets. Using this technique, networks with high packet losses cause TCP to rely heavily on time-outs to detect packet losses, which degrades the TCP performance significantly. The deficiency of TCP Reno's ACK scheme has led to the design of the selective ACK (SACK) scheme, through which the ACK packet can carry both the negative and positive information of packet transmissions. In addition, the TCP option may be used to carry other information such as time stamp. As such, the number of usable SACK blocks is further reduced, and the TCP SACK scheme is unsuitable for use in networks with frequent packet losses. In the proposed scheme, cumulative bit-vector based SACK scheme is deployed, through which each bit in the vector represents the reception status of one packet. The bit value and the bit position in the vector are used to predict packet losses. Hence, each ACK packet can acknowledge a wide range of packets by using small overheads. Correspondingly, this transport protocol essentially becomes a datagram-oriented protocol.

2. Literature Review

Various solutions have been proposed to provide reliable packet delivery in WSNs in recent years. Most of the existing proposals in WSNs focus on the modification of congestion control algorithms in the transport protocol. These proposals can be divided into two categories i.e., non-TCP variants and TCP variants. The schemes in [5] [6] and [7] belong to non-TCP variants, where the source adjusts the transmission rate based on explicit feedback from intermediate nodes along the path. Although relatively accurate congestion information can be obtained, the algorithms in these schemes cannot retain the end-to-end semantics of a transport protocol. Moreover, they require complicated mathematical computation and incur excessive network overhead.

In contrast with non-TCP variants, the majority of the proposals are modified versions of the legacy TCP protocol. In [8] and [9], the strategies proactively detect incipient congestion by relying on some measured metrics at the source, such as the variation of the measured round-trip times (RTTs) and short-term throughput, since packet loss information alone cannot provide an accurate congestion indication. In [10] [11] and [12], the authors attempt to minimize the contentions between data and ACK packets by adaptively reducing the number of ACK packet transmissions in the network. The drawback of these TCP variants is that they still adopt the AIMD congestion control algorithm with unnecessary large transmission windows. Chen et al. [13] propose a scheme where the TCP sender limits the size of its maximum transmission window to the BDP of the path in multi-hop networks. However, the small transmission window leads to high AIMD costs, and the TCP source is also unable to detect the packet loss

3. Improved DTPA-TCP Fairness Scheme

The improved DTPA works on the basic principle of DTPA that utilizes selective acknowledgement scheme and in addition uses max-min fairness algorithm to improve the TCP fairness criteria.

A. Strategies in Flow Control Scheme

In this paper the congestion control is done in the WSNS uses datagram based technique, fixed window flow control and cumulative bit vector SACK strategy.

1) Datagram-Based Technique:

In case of datagram based technique, each datagram is sequenced. The sequence number in each data header does not represent the highest byte of that data like in TCP. With a datagram protocol, the IP fragmentation of a packet is highly undesirable during the transmission, because the fragmentation cause inefficient resource usage due to the incurrence of a higher MAC overhead. The loss of a single fragment requires the source to retransmit all of the fragments in the original datagram, even if most of the fragments are received correctly at the destination. Datagram is small enough to avoid fragmentation.

2) Cumulative Bit Vector based SACK:

ACK header illustrates the new ACK strategy. H is the highest sequence number of the datagram that has been received. There is a bit in the header named L to indicate the existence of an out-of-order data. The L flag is turned on whenever an out-of-order segment arrives, which implies that there may be missing packets. The vector field consists of k bits representing the receiving status of a set of earlier packets. Let ai be a single bit that indicates the arrival status of the packet with sequence number H_i. Use the L flag for the realization of a cumulative acknowledgment mechanism. If the L flag in a received ACK packet is turned off, this means that the transmission is in a normal status, without data packet losses or out-of-order transmissions. Hence, an acknowledgment of sequence number H indicates that all datagram up to H have been received.

3) Fixed Window Flow Control:

Improved DTPA employs a sliding window transmission technique. Given the number of hops n, the window size is fixed at

$$w(n) = BDP(n) + \alpha(n)$$

where $\alpha(n)$ is a small value used to guarantee that there are enough packet transmissions and ACK arrivals at the source in case of packet losses. For instance, with $w = BDP = 1$, the source cannot detect the packet loss through the ACK, because there is only one packet transmission, and it is the one that is missing. A mathematical model is developed to calculate the throughput of a single DTPA flow over an n -hop ad hoc network. The throughput is derived as a function of packet loss rate, path length n, and transmission window size w (n). Determine an appropriate transmission window with which the throughput of an n -hop chain can be maximized.

DTPA relies on the path length information provided in routing protocols such as DSR and AODV to determine the BDP of a path. In DSR, the header of each IP packet carries the instantaneous hop count information. In AODV, each route table entry at the source also contains the hop length. The hop count information provided by these routing protocols can be passed on to the transport layer so that DTPA can intelligently set its transmission window. Find the BDP of a path so that DTPA can be compatible with more routing protocols. The strategy guarantees that the network pipeline is at least fully utilized and that there is no heavy congestion and contention in the networks.

4) Retransmission Mode:

Derive a mechanism for deciding on whether to retransmit the lost packet. DTPA source decides to retransmit a packet by either the receipt of ACKs or a time-out event. The source DTPA depends on the L flag and the bit vector in the ACK header to detect the possible packet losses. It keeps a retransmission buffer for storing the incoming ACK information with a turned-on L flag on a per-connection basis**.** For a time-out event, the DTPA source assumes that there is no outstanding packet in the network. Since the transmission window is fixed at a value greater than one, besides retransmitting those lost packets recorded by the retransmission buffer. The source also transmits new packets if the transmission window allows. In DTPA, the Retransmission Time-Out (RTO) timer works in the same way as that in TCP. Except that it does not exponentially increase itself in the event of retransmission, because the time-out event here implies a window’s worth of packet losses rather than a heavy congestion in the system.

5) Performance Metrics for Improved DTPA:

Throughput:

Similar to TCP, the behavior of the DTPA protocol is regarded as a cyclic evolution. It defines one cycle as the interval between the end of one time-out event and the end of the next time-out event. The cycles form a renewal process due to the independent packet losses. The cycle duration is a random variable that is further divided into two non overlapping components at the time when the time-out occurs. It define the DTPA throughput for an n-hop static linear chain

Fairness:

Significant TCP unfairness in ad hoc networks has been revealed. TCP unfairness is mainly attributed to the unfairness of the MAC protocol, which results from the nature of shared wireless medium and location dependency. To solve the TCP unfairness in wireless sensor networks, adaptive max-min fairness algorithm is used in our DTPA model. Fairness criteria for DTPA flows in wireless sensor networks are compared with improved DTPA. In multi-level scheduling for wireless ad-hoc networks the max-min fair allocation of the fair shares is made at the lower-most layer (MAC layer). It mainly lays down the framework to calculate the fair shares that would achieve max-min fairness in an ad-hoc network. Then design distributed algorithms that allow each node to determine its max-min per-link fair share in a global ad-hoc network without knowledge of the global topology of the network.

4. Experimental Performance of Improved DTPA

The simulation of the improved DTPA model is carried out in NS-2 simulator to validate the analytical model and evaluate the performance of DTPA with improved DTPA. The simulations using static topologies interoperate with other WSN DSR and AODV to handle the mobility issues. In the simulation scenarios, all nodes communicate with identical half-duplex wireless radios with a bandwidth of 1 Mbps. The radio propagation model uses free-space attenuation at near distances and an approximation to two-ray ground at a far distance by assuming specular reflection off a flat ground plane. DSR is used as the routing protocol for improved DTPA. The packet size is set to 512 bytes, and fragmentation does not take place during transmission.

To validate the analytical model, we run a DTPA flow over the n-hop static linear chain defined in the model. Each simulation is run for 500 seconds. The data and ACK packets are discarded with probability by the receiving node rather than being dropped. Fig. 1 shows the throughput comparisons between the AODV and DSR-DTPA (improved) simulation and results of the proposed improved DTPA model for different number of nodes. With Fig1 the throughput of the DSR-DTPA model increase when compared to that of the AODV model of transmission.

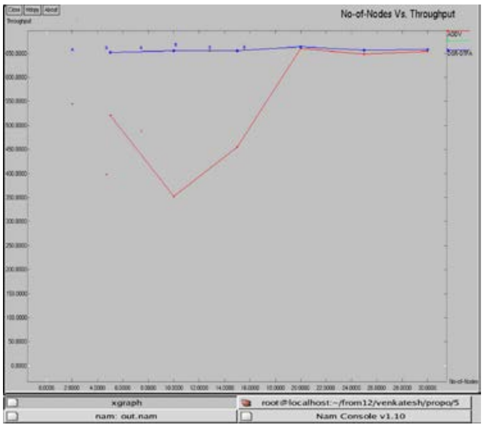

Fig. 1 Comparison of AODV with DSR-DTPA (improved) Number of nodes Vs throughput

The node variation is plotted against the packet loss rate of each transport layer packet as shown in Fig 2. Both results show that the delay decreases with even in the nodes being increased and also noted that delay for DSR-DTPA is less compared to that of the AODV routing protocol. The results from the analysis of the proposed model match closely with the simulations. It can be seen that the delay do not have a significant impact on the number of nodes being increased (Fairness criteria) with throughput performance in multihop wireless sensor networks, as the improved DTPA throughput always increases with number of node variations.

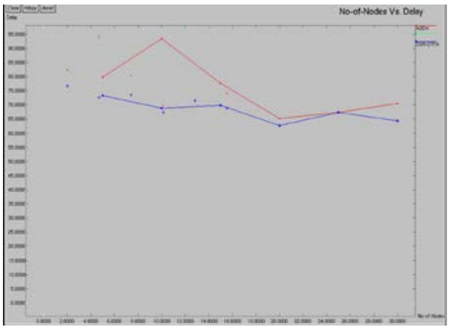

Fig. 2 Comparison of AODV with DSR-DTPA (improved) Number of nodes Vs Delay

Comparing to AODV, the throughput, average RTT, average maximum IP queue size and the number of retransmissions can, respectively, be improved by up to 35 percent. Using a small transmission window, the CWL source sends a limited amount of packets into the networks so that it cannot detect packet losses via the reception of enough ACK packets. The source has to heavily rely on time-out events to detect and retransmit the lost packets, and correspondingly, the CWL goes back to a slow-start phase, with its transmission window dropped to one, which results in throughput degradation. As such, improved DTPA scheme can be utilized in a general ad hoc network for efficient fairness in transmission.

5. Conclusion and Future Work

The improved DTPA model proposed in this work had a reliable Datagram Transport Protocol over wireless sensor networks with better fairness in multi-hop increased node transmission. As the BDP of a path in WSNs is very small, any AIMD-style congestion control algorithm is costly and is hence not necessary for wireless sensor networks. On the other hand, a strategy for guaranteeing reliable transmissions and recovering frequent packet losses plays a more critical role in the design of a transport protocol. With this basis, our scheme incorporates a fixed-window-based flow control and a bit-vector-based SACK strategy with which the ACK packets contain a vector of bits representing the reception status of the set of packets that were transmitted earlier.

With NS-2 simulator, improved DTPA model is evaluated and shown that results improves the network throughput, average RTT, and decreased average delay in the network, and number of retransmissions by up to 35 percent as compared to the AODV. Since DTPA employs a window-based congestion control coupled with an ACK technique similar to TCP, it is believed that DTPA also experiences severe unfairness among competing flows in wireless sensor networks. Hence, in order to provide fairness for DTPA flows in wireless sensor networks, max-min algorithm is deployed in improved DTPA. This solution can be extended to evaluate fairness with large number of nodes in WSNs.

REFERENCES

[1]. Xia Li, Peng-Yong Kong and Kee-Chaing Chua, “DTPA: A Reliable Datagram Transport Protocol over Ad hoc Networks”, *in IEEE Transactions on Mobile Computing*, October 2008.

[2]. M. Mathis, J. Mahdavi, S. Floyd, and A. Romano, “TCP Selective Acknowledgement Options”, *IETF RFC 2018*, 1996.

[3]. R. Kettimuthu and W. Allcock, “Improved Selective Acknowledgment Scheme for TCP,” *in Proceedings International Conference on Internet Computing (IC ’04)*, pp. 913-919, 2004.

[4]. H.-S. Wilson So, Y. Xia, and J. Walrand, “A Robust Acknowledgement Scheme for Unreliable Flows,” *in Proceedings IEEE INFOCOM ’02*, vol. 3, pp. 1500-1509, 2002.

[5]. G. Anastasi, E. Ancillotti, M. Conti, and A. Passarella, “TPA: A Transport Protocol for Ad Hoc Networks,” *Proc. 10th IEEE Symp. Computers and Comm. (ISCC ’05)*, pp. 51-56, 2005.

[6]. K. Chen, K. Nahrstedt, and N. Vaidya, “The Utility of Explicit Rate-Based Flow Control in Mobile Ad Hoc Networks,” *in Proceedings IEEE Wireless Comm. and Networking Conference (WCNC ’04)*, no. 1, pp. 1904-1909, 2004.

[7]. H. Zhai, X. Chen, and Y. Fang, “Rate-Based Transport Control for Mobile Ad Hoc Networks,” *in Proceedings IEEE Wireless Communications and Networking Conference (WCNC ’05)*, pp. 2264-2269, 2005.

[8]. K. Sundaresan, V. Anantharaman, H.-Y. Hsieh, and R. Sivakumar, “ATP: A Reliable Transport Protocol for Ad Hoc Networks,” *IEEE Transactions on Mobile Computing*, vol. 4, no. 6, pp. 588-603, November 2005.

[9]. Z. Fu, B. Greenstein, X. Meng, and S. Lu, “Design and Implementation of a TCP-Friendly Transport Protocol for Ad Hoc Networks,” *in Proceedings 10th IEEE International Conference on Network Protocols (ICNP ’02)*, pp. 216-225, 2002.

[10]. S. EIRakabawy, A. Klemm, and C. Lindemann, “TCP with Adaptive Pacing for Multihop Wireless Networks,” *in Proceedings ACM MobiHoc ’05*, pp. 288-299, 2005.

[11]. A. Singh and K. Kankipati, “TCP-ADA: TCP with Adaptive Delayed Acknowledgement for Mobile Ad Hoc Networks,” *in Proceedings IEEE Wireless Communication and Networking Conference (WCNC ’04)*, no. 1, pp. 1679-1684, 2004.

[12]. R.Oliveira and T. Braun, “A Dynamic Adaptive Acknowledgement Strategy for TCP over Multihop Wireless Networks,” *Proc. IEEE INFOCOM ’05*, pp 1863-1874, 2005.

[13]. E. Altman and T. Jimenez, “Novel Delayed ACK Techniques for Improving TCP Performance in Multihop Wireless Networks,” *in Proceedings Eighth International Conference on Personal Wireless Communication (PWC ’03)*, pp. 237-253, 2003.

[14]. K. Chen, Y. Xue, and K. Nahrstedt, “On Setting TCP’s Congestion window Limit in Mobile Ad Hoc Networks,” *Wireless Communication. and Mobile Computing*, vol. 2, no. 1, pp. 85-100, 2002.