A priority based model to increase TCP throughput over WSN

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Abstract: Wireless sensor networks (WSNs) are a popular wireless technologies to access the internet and growth of using TCP/IP model indicates many applications is supported by TCP to connect mobile nodes over wireless links. Development of new wireless networks like wireless sensor networks makes it essential to improve TCP's Performance. TCP is initially developed for wired networks where each packet loss is assumed to be due to congestion. TCP are lead to performance degradation in WSN where such environment imposes packet loss due to error prone channels and node mobility. TCP works on the assumptions that each packet loss is the sign of congestion. However packet losses are due to many reasons likes' poor resources, random bit error rate, poor channel bandwidth and noisy channels and node mobility in wireless sensor networks. In presence of these unique characteristics of wireless sensor network, TCP performs poorly in WSN, because it treats every packet loss is as a result of congestion. TCP invokes congestion avoidance algorithm and decreases its transmission rates by reducing congestion window. In this paper, a simulation based performance analysis is presented in the term of TCP throughput. The throughput decay of TCP are evaluated in wireless sensor networks and discuss about problem which causes this degradation. The proposed model modify TCP congestion detection module which packet losses due high bit error rate of wireless link should be distinguished from packet losses across congestion. It evaluated by simulated results and throughput enhancement verified by NS2.
[Mohammad Mehdi Hassani. **A priority based model to increase TCP throughput over WSN.** *Life Sci J* 2017;14(3):54-57]. ISSN: 1097-8135 (Print) / ISSN: 2372-613X (Online). http://www.lifesciencesite.com. 9. doi:10.7537/marslsj140317.09.

Keywords: wireless sensor networks, TCP, throughput

1. Introduction

WSNs, as a new wireless network have been designed to improve the performance of the new communications. TCP supports many applications on the internet due to its reliable data delivery ability. Wireless sensor network (consisting of a large number of distributed sensor nodes) is widespread to controlling and monitoring environmental conditions and many applications in various fields of industrial, military, agricultural, and medical and other oil industry is allocated in recent years. Hence a lot of research are done to enhance their performance.

A sensor network has a multi hop adhoc architecture. It means the source node could transmit to destination node by the aid of intermediary node. Each node can be either as a router to determine the path, or a source/destination node [1].

Node movement creates big problem for routing algorithms. This multi hop communication uses proactive routing algorithm like DSDV [2] or reactive routing algorithm like AODV [3] and DSR [4]. Furthermore the resource limitation and having error prone wireless channel are their main challenging. These problems cause decreasing the wireless sensor network performance. This paper addresses a modified version of TCP congestion detection mechanism to improve performance over error prone channels of sensor network.

TCP is a reliable and connection oriented protocol of transport layer that performs effectively in wired networks. But this protocol suffers from performance degradation because WSNs are prone to packet losses due to noisy links and node movement initiate congestion. in WSN. Congestion. Hence it is necessary to redesign and optimize TCP congestion control mechanism. There are 2 ways to enhance TCP performance.

1- Developing another protocols which are compatible with sensor network characteristic.

2- Modifying TCP to enhance performance.

TCP nature tends to own as much as available resources, hence few remaining resources are not enough for routing algorithm operation like discovering or maintenance path. Lack of enough resources affect TCP performance. Meanwhile, when packet loss is happened, TCP inherently invokes congestion avoidance algorithm [5] to decrease congestion window rate. In wired network, when packet is lost, TCP mistakenly considers congestion is occurred but packet loss could occurs due to noisy channel or poor bandwidth in wireless sensor network [6]. In the presence of high bit error rate of wireless channels, TCP treats the same way as in wired network. It reduces the window size and this wrong assumption of congestion results unnecessary reduction of transmission rate.

Our proposed model focuses on new strategy to detect the cause of packet losses. When TCP could not distinguishes between loss of packet due to congestion and loss of packet without congestion, congestion window is not unduly decreased. New model modifies TCP congestion avoidance mechanism. It use the static aggregate transmitting rate instead of packet loss as a point of congestion and enhance the throughput of TCP connection in wireless sensor networks.

The paper is organized as followed: in section 2 related works are presented. Section 3 describes the NS2 simulator implementation of TCP in WSN. A scenario is simulated by NS2 and problem is explained by simulation results. In section 4 proposed model is described and it is implemented in NS2. and the throughput improvement are demonstrated by simulation results.

2. Related work

Recent research has many attempt to overcome the limitation of TCP by modifying this protocol or developing new protocol targeting wireless sensor networks.

The modification done on congestion module. Congestion module consist of:

1- Congestion avoidance
2- 2- congestion notification.
3- Congestion detection.

While many approaches have been proposed for enhancing TCP throughput by modifying Congestion detection sub module [8, 9, 10 and 11], there are some approaches which use buffer occupancy to initiate congestion [12]. Congestion The maximum buffer threshold is determined. When buffer size be more than threshold, congestion is detected. The channel status is another sign of congestion.

Congestion notification one of the important steps to inform neighboring node for analysis and decision making by them. This notification is either explicit [12, 13] or implicit [14]. congestion avoidance means decreasing transmitting rate to avoid congestion. Rate adjustment is a congestion avoidance mechanism and it is refer to regulating transmission rate in a centralized or distributed manner. In a centralized [15, 16] and in a distributed manner rate adjustment don by each hop [17].

3. Problem overview

Congestion is happened when network traffic exceeds the available resource capacity like bandwidth. It is responsible for transmitting data in reliable manner. TCP is a most common connection oriented protocol of transport protocol. There is a 3 handshake connection set up phase before sending TCP flows to establish connection and 4 way handshaking closing phase after sending data to terminate connection.

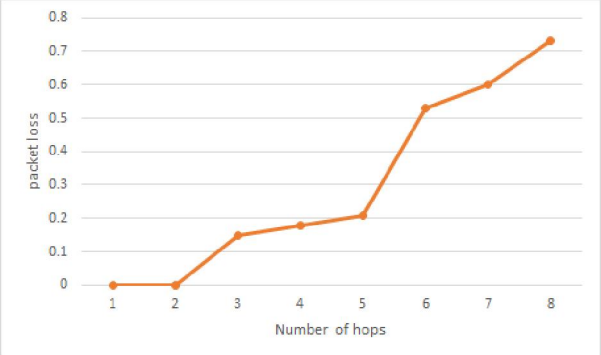

Fig. 1: Packet loss rate as a function of number of mobile nodes

It provides reliable service because of sending acknowledgement after delivery of packet by destination.

But lack of ability to adopt its congestion control algorithm is the main problem of TCP in WSN. There are many reasons to occur packet loss. Fig.1 shows the packet loss rate as a function of number of hops. As number of hops is increased this rate is dramatically increased. Each packet loss means a TCP segment is lost and when consecutive TCP segments are lost, TCP invokes congestion control algorithm, hence TCP congestion window is decreased. Congestion is the main reason of packet losses in wired network, but in a WSN, it happen often due to noisy channels with high bits error rate rather than congestion. When packet losses happen, TCP considers it as a sign of congestion and the wrong decision leads it to throughput degradation.

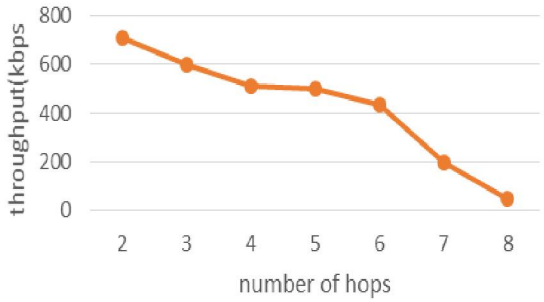

Fig. 2: TCP connection throughput

But some of TCP characteristics likes end to end reliably and congestion avoidance mechanism degrade WSN performance parameters like throughput. Actually when packet lost is happened, TCP considers it is due to congestion and reduces the congestion window according to its congestion avoidance mechanism. TCP has been inherently designed for

wired network which there is no link failure and each packet loss is indication of congestion. But in WSN packet loss may occur because of many reason like: poor link bandwidth, link failure and etc. TCP throughput is decreased since it assumes each packet loss is only due to congestion.

Fig. 2, shows throughput of TCP flow when node 4 as a TCP source sends TCP flow to node 5 as a TCP receiver according to Table I parameters.

This degradation of throughput is due to false detection of packet losses as a congestion situation.

4. Proposed model

As it is observable in former section, throughput degradation is due to detection of congestion is according to packet losses, while in many situation packet lost occur due to link failure. Hence it is needed to some modification to TCP congestion module. Instead of packet lost as a congestion detection identification, one aggregate uplink packet rate ($R_{aggregate}$) is determined at each destination. When throughput is less than $R_{Aggregate}$, congestion is happened. Actually this a rate limiter which done on receiving packets.

The rate limiter allows to send packet to another node when throughput is upper than $R_{Aggregate.}$ this parameter sets statically. The proposed mechanism indirectly regulates the TCP throughput according to following algorithm. Packet is dropped when receiving rate is lower than $R_{Aggregate}$.

Let $R_{Aggregate}$ the estimated throughput coming to the mobile node.

If (throughput (upstream throughput) > $R_{Aggregate}$) Congestion is happened and R_{UP}= Min ($R_{Aggregate}$, R_{UP})

Else

R_{UP}= Max ($R_{Aggregate,}$ R_{UP})

Now TCP easily could distinguish between packet lost which happened because of congestion or due to link failure. If packet lost is occurs when data rate is lower than $R_{Aggregate,}$ it demonstrates congestion otherwise it is not due to congestion.

5. Simulation tools

Ns2 is a discrete event simulator targeted at networking research which is developed by the University of California at Berkeley and the VINT project [7]. Ns2 provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks.

It is needed some modification on TCP protocol of NS2 to allow us implementing our propose model.

5.1 Simulation results

Simulation is done using NS2 simulator version 2.31 according to Table I parameters. Topography size is 500 * 500 meter^2. Number of sensor nodes are 25 with random motion. Simulation is run 10 time for 200 seconds. Packets are sent simultaneously after 2.5 second.

CBR traffics are generated using TCP sources. Source sends 500 bytes packet at the rate of 512 Packet s per second. Routing protocol is DSR. There are 10 wireless channels.

Table I: simulation configuration

Number of nodes	2.4, 8….
Number of TCP connections	1
Area	500 * 500
Connection type	TCP
Traffic type	CBR
Traffic rate	512
Window size	32
Simulation time	200 sec
Routing algorithm	DSR
Link bandwidth	10 kbps
$R_{Aggregate}$	750 kbps
Link error rate	0.1
NS2 simulator version	2.31

There are N upstream TCP connection and N TCP downstream TCP connection (packets are sent from sink to nodes). Downstream TCP throughput (TH_{down}) and upstream TCP throughput (TH_{up}) are calculated according to simulation results as followed:

$$Throughput = \frac{total\ number\ of\ bits}{t_{end} - t_{first}}$$

Which t_{first} is sending time of first packet and t_{end} is receiving time of last packet. Fig. 3 shows the throughput of TCP connection according to our proposed model.

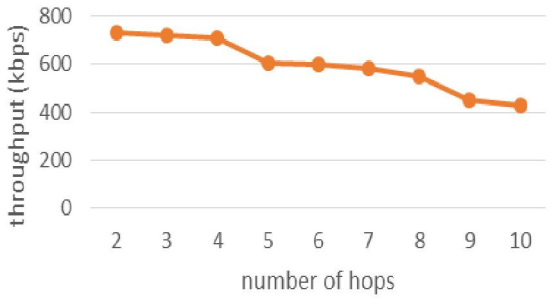

Fig. 3: throughput of TCP connection according to proposed model

Fig. 3, obviously shows how our proposed model enhance TCP connection throughput. Using rate limiter insist of traditional congestion detection module is the best reason for this enhancement. When TCP could distinguish between packets loss which is happened due to congestion from packet lost due to

link failure or node movement, TCP congestion windows is not decreased.

Conclusion

In this paper, main reasons of decreasing TCP throughput targeting wireless sensor network is described. Some research to enhance TCP performance is analyzed. The proposed model modified the congestion notification sub module by developing a rate limiter. The main task of this rate limiter is congestion detection. When the transmission rate is lower than $R_{Aggregate}$, congestion is detected, otherwise every packet loss is not sign of congestion. By happening every packet loss, congestion avoidance module is not called by TCP Destination and the transmission rate is not decreased. Results shows proposed model enhance throughput of TCP connection.

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