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A Novel Approach to Enhance TCP Throughput in Wireless Sensor Networks

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Abstract

Wireless sensor network add a new wireless structure have been designed to improve the performance of the new communications. Performance of wireless sensor network has a vital dependency to the transport protocols. TCP is a connection oriented and reliable protocol of transport protocol which is developed for wired networks because of some unique characteristics of wireless sensor network like poor resources, poor channel bandwidth and noisy channels and node mobility, performance of TCP is degraded. 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 a bout problem that cause this degradation. On the other hand TCP wrongly assumes congestion is the main reason of each packet lost, while packet lost may happen because of wireless sensor networks limitations that is mentioned above. The propose model modify TCP congestion detection module to distinguish between congestion and non congestion situation. It evaluated by simulated results and throughput enhancement verified by NS2.

Keywords Wireless sensor networks; TCP; Throughput

Introduction

Wireless sensor network consisting of a large number of distributed sensor nodes is widespread to controlling and monitoring environmental conditions and in recent years many applications in various fields of industrial, military, agricultural, and medical and other oil industry is allocated. Hence a lot of research is done to enhance their performance.

A sensor network has 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 is caused Routing algorithms be one of main challenging. 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 another main challenging. These problems cause decreasing the wireless sensor network performance. This paper addresses a modified version of TCP congestion avoidance mechanism to improve performance over error prone channels of sensor network.

TCP is a reliable and connection oriented protocol of transport layer. But this protocol is not suitable for sensor networks because of their low bandwidth and error prone channels and node movement. There are 2 ways to enhance TCP performance

- Developing another protocol which is compatible with sensor network characteristic.
- Modifying TCP to enhance performance.

TCP nature tend 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 lost is happened TCP inherently call congestion avoidance algorithm [5] to decrease congestion window rate. In wired network when packet is lost, TCP consider congestion is occurred but packet lost could due to noisy channel or poor bandwidth in wireless sensor network [6,7]. Wrong decision of TCP to determine congestion cause degrading TCP congestion window rate mistakenly.

Our propose mechanism focus on above problem. When TCP could distinguish between packets lost due to congestion are packet lost without congestion, congestion window is not unduly decreased. New model modify TCP congestion avoidance mechanism. It use the static aggregate transmitting rate instead of packet lost as a point of congestion and enhance the throughput of TCP connection in wireless sensor networks.

The rest of paper investigates related works are presented. Then a scenario is simulated by ns2 and problem is explained by simulation results. In the fourth section proposed model is described and the throughput of proposed model is evaluated. Last section of paper is conclusion.

Related Work

Recent research has many attempts 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 consists of:

- Congestion avoidance

- Congestion notification
- Congestion detection

Modify congestion detection sub module [8-11]. They use buffer occupancy as a point to detect 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 [12]. 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].

Problem Overview

TCP is one of transport layer ptotocol.it is responsible for transmitting data reliable mode. It is a connection oriented protocol. There is a 3 handshake connection set up phase before sending TCP flows to establish connection and connection 4 way handshaking closing phase after sending data to terminate connection.

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

But some of TCP characteristics like end to end reliably and congestion avoidance mechanism degrade WSN performance parameters like throughput. Actually when packet lost is happened, TCP imagine it is due to congestion and reduce the congestion window according to its congestion avoidance mechanism. TCP reaction is inherently in wired network which there is no link failure and each packet lost is indication of congestion. But in WSN packet lost may occur because of many reason like: poor link bandwidth, link failure and etc. TCP has a low throughput since it assume each packet lost is only due to congestion and reduce its transmission rate when packet lost is detected.

Figure 1, shows throughput of TCP flow when node 4 as TCP source sends TCP flow to node 5 as a TCP receiver according to Table 1 parameters.

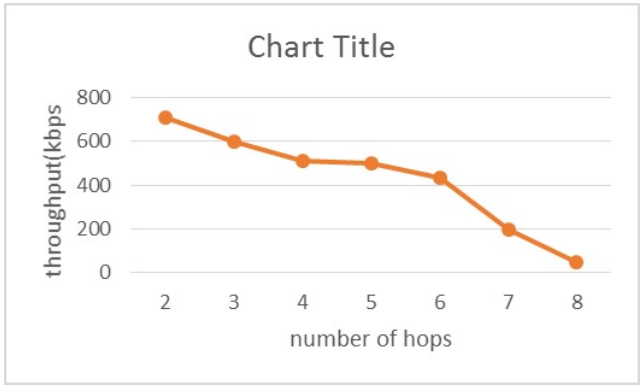

Figure 1: TCP connection throughput.

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

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 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 is 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. Packet is dropped when receiving rate is lower than $R_{Aggregate}$.

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.

Simulation

Ns is a discrete event simulator targeted at networking research which developed by the University of California at Berkeley and the VINT project [7]. Ns 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.

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

Table 1: Simulation configuration.

Simulation results

Simulation is done using NS2simulator version 2.31 according to Table 1 parameters. Topography size is 500 * 500 meter 2. Number of sensor nodes are 25 with random motion. Simulation is run 10 times for 200 seconds. Sent packet simultaneously after 2.5 seconds.

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.

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 = (total number of bits)/ (t_{end} - t_{first})

Which t_{first} is sending time of first packet and tend is receiving time of last packet.

Figure 2 show the throughput of TCP connection according to our proposed model.

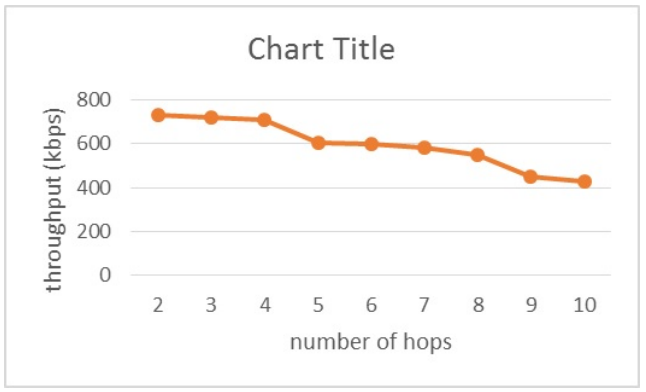

Figure 2: Throughput of TCP connection according to proposed model.

Figure 2, obviously shows how are 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 packet lost which 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 which caused TCP has a poor performance targeting wireless sensor network is described. Some research to enhance TCP performance is analyzed. The proposed model modified the congestion notification sub module. A rate limiter is developed. 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 lost is not sign of congestion. By happening every packet lost TCP Destination not call congestion avoidance module and the transmission rate is not decreased. Results shows proposed model enhance TCP connection throughput.

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