IMPROVE THE PERFORMANCE OF TRANSPORT LAYER OF TCP PROTOCOL IN WIRELESS SENSOR NETWORK

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ABSTRACT

The Wireless Sensor Network is a network of many sensor nodes with wireless channels to communicate with others. With no centralized control and specified network connection, it can transfer to the outside world. At the same time, both nodes are capable of acting as a source or sink node. These nodes have minimal processing power due to their small physical size, limiting the processor capacity and the battery's size. When they work together collectively, they can gather information about the physical environment. They get a transceiver to communicate with the virtual world and with the real world. The routing topology to be used for the network depends on the transmission capacity of its nodes. It also depends on the location of the node, which may differ from time to time.

This paper examines the characteristics of a wireless sensor network and analyzing the functionality of TCP protocol and its variables. It suggests using nodes near the sinks as proxy nodes to improve the WSN transport layer's efficiency. The results of the simulation show that the throughput increases.

Keywords: *TCP protocol, WSN, AODV, Network Simulator NS-2*

1. INTRODUCTION

The WSNs networks are data transmission systems that work together to collect and relay environmental data to a central node. In WSNs, Various studies have been performed on data link and network layer. [1-2]. However, there are a few studies on the transport layer, but the guarantees of collecting from many nodes to the main station are of significant importance under WSN limitations due to loss of energy, storage capacity, and noisy communication. Studies on wireless networks' transport layer concentrate primarily on two topics, namely, efficient data transmission and congestion management. Not enough attention has been paid to the transport layer's protocols, which achieves a high level of reliability in WSNs. TCP is the most common and transport layer protocols in networks. It can not be used for a sensor with restricted wireless connectivity capacity [3]. Therefore, to overcome this problem, TCP variables are added, the most common of New Reno and Vegas. In this paper, we propose the deployment of proxy nodes to enhance the transport layer protocol's efficiency in WSNs. The proposed method transfers data to the primary station nodes using the TCP protocol and the TCP variant. The research examines the output in the states: proxy nodes as neighbors of the sink.

Our results suggest that installing proxy nodes near the sink allows the network to detect packet loss or congestion before it transmits to the sink [4-5].

The rest of the paper describe as follows. Section 3 will explain some related protocols. Sector 5 will demonstrate some of the features of the proxy node used by WSNs. Section 6 will address the performance evaluation metrics and performance evaluation results, respectively. Finally, Section 7 will conclude the paper and offer some suggestions for our future work.

2. LITERATURE REVIEW

AR Rind, K Shahzad, MA Qadir [6], the proposed improved variants would allow the measurement of the combined effect of the parameters on TCP performance on both correlated and noncorrelated wireless networks. These improved variants of TCP include Tahoe, SACK, Reno, and NewReno.

The model results will optimize the performance, reduce correlated losses, allow evaluation over a variety of operating conditions, and allow the combined effects of forward error connection (FEC)/automatic repeat request (ARQ).

JJ Garcia-Luna-Aceves, C Parsa [7], these processes are grouped into three groups. The first sort is the end-to-end protocol, where the sender recovers the damage. The second category is the link-layer protocols with local reliability. The third category is the split-connection protocol, which breaks the end-to-end connection into two parts at the base station. These protocols avoid losses in wireless communication due to congestion losses.

L. S. Brakmo et al. [8], a new method for sensing and avoiding congestion management called TCP Vegas has been proposed. They evaluate the performance of Vegas in the wired network by assessing the performance of TCP Reno. They infer from their analysis. TCP Vegas has a high throughput. TCP Vegas involves upgrading an earlier TCP congestion management algorithm (Tahoe and Reno) that senses packet delay congestion rather than packet loss. The delay estimation scheme can be used as a way to detect congestion in terms of packet delay.

R Dunaytsev. [9], conduct a TCP performance analysis in wired-cum-wireless environments based on their survey of the current TCP performance-related issues in wired-cum-wireless environments. They say that TCP performs poorly in wireless environments in terms of achieved throughput due to insufficient bandwidth, power consumption, random loss, short flow, user mobility, and long RTT.

3. PROTOCOLS USED IN THE SIMULATION

3.1 Ad-Hoc On-Demand Distance Vector Routing (AODV)

AODV is a routing protocol based on a source implemented on-demand routing. This method of routing generates routes only when the source node is needed. This routing protocol is an extension of the DSDV and DSR routing protocols. AODV is designed to reduce the transmitted number by eliminating the "count to infinity" issue [10]. This problem is a sort of looping mechanism that each node regularly updates to each other. In the AODV, a node needs to connect to another node. It tests the routing table to decide the shortest route. When a path is not available on the network, a route discovery process is started that becomes On-Demand. In the route discovery process, the node sends a route request (RReq). This request is a type of control message that contains types of information such as the source IP address and destination nodes, the last known destination sequence, and the hop count [11-12].

3.2 TCP variants under WSN

The TCP original designed for wired connections. There is a small chance of high latency and data corruption due to external parameters for wired connections. Congestion is the critical cause of packet loss in a wired connection. Thus, TCP has been created by keeping the above parameters in mind. As wireless and heterogeneous networks develop due to the need for a secure protocol in the TCP/IP model of the Internet, TCP implements on-wired connections. Wireless links have a significant vector and high latency problem with a high bit error rate (BER). Thus, originally, unmodified old TCP tended to function poorly on wireless connections.

Research has begun in the TCP sector, and improvements have been made to increase the performance requirements. Variants of TCP came into being. TCP Tahoe has the first congestion control algorithm. Jacobson and Karels developed this algorithm in 1986. Several other algorithms are implemented based on the same theory suggested by Jacobson and Karels. After that, multiple enhancements and modifications are made to Tahoe, leading to the development and production of new TCP variants with various congestion window algorithms (Mo et al., 1999).

The efficiency of the TCP variant is directly impacted by its congestion control system, where the number of packets transmitted over network connections depends on the congestion control's work behavior and its role in traffic control.

The first TCP version, including its basic configuration, is based on a window-based flow control scheme. Tahoe presents the second generation of TCP models, with two new avoidance methods of congestion and rapid distribution. Reno is the third version of the first built-in series and is standardized in RFC 2011, where a fast recovery algorithm further extends the congestion control function. However, the versions of TCP, Tahoe, and Reno (and their variants) are not optimal for the connections' throughput and impartiality. Good research on TCP has also been carried out, and a variety of enhancement methods have been proposed[13].

The version of Vegas is a promising mechanism due to its high efficiency. A significant point is an underlying network assumed by Vegas. When the original TCP Vegas was proposed, the Random Early Detection mechanism not consider part of the operating network. Vegas may or may not be useful when the router equips with a RED mechanism. Thus, we support two box scheduling schemes, the RED router, and the conventional drop-tail router.

If the sender does not receive a response within a specified period, the sender forwards the data. Form of TCP that uses the AODV routing protocol in WSN

New Reno: -New Reno is a minor improvement from TCP-Reno. It can identify multiple packet losses and is thus much more useful than Reno in the case of multiple packet losses. New-Reno joins the fast retransmit as it encounters several duplicate packets but does not leave fast recovery until all incomplete data at the time of quick recovery is remembered.

VEGAS: -Vegas suggests congestion due to packet delay. TCP Vegas changes the scale of the window to the network congestion. It detects interference before packet interruption [14-15].

4. MAJOR TRANSPORT LAYER PROTOCOLS

The goal of the optimal transport layer is to control the congestion caused by the instability of traffic injected within the network, to restore packet loss due to congestive and queue overload, to ensure end-to-end reliability and service quality (e.g., to maintain tolerable bandwidth, packet loss ratio, and latency depending on the application), and to ensure the orderly delivery of packets in case of packaging.

If end-to-end reliability cannot be offered due to network constraints, the hop-to-hop reliability system is provided instead. The MAC layer is responsible for retrieving the loss of the packet due to a bit error. However, due to the queue overload that occurs in congestion, no packet loss can be restored. We present the Internet transport protocol, namely, TCP, before deducting the WSN transport layer model. [16].

TCP is a link-oriented protocol that establishes the connection (3-way handshake) between the sender and the receiver nodes before the actual packet communication starts. If introduced in WSN, where data could only be in the order of a few bytes, the 3-way handshake approach would become a burden with such a small amount of data. Also, except for a few instances, WSN is built as a multihop wireless network where its weak and error-prone radio channels determine each interhop link. Since TCP is an end-to-end protocol, the time to set up a TCP link between two end nodes, apart from each other, can be very high. It is difficult for sensor nodes, particularly ones far from the sink, to receive enough through-out to support WSN applications that require continuous data transmission. By comparison, the end-to-end solution has a slower response time in the event of congestion, resulting in a significant reduction in the number of sections. The drop in this section will be a waste of energy consumption.

TCP provides an end-to-end ACK and a retransmission approach to ensure stability, resulting in much lower throughput and increased transmission time.

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In addition to the individual restrictions, the TCP protocol does not have inherent cross-layer complex interactions, particularly the lower-layer protocols. Fortunately, the basic definition of TCP has affected the subsequent architecture of the transport layer protocols proposed to date. Having made to cover the particular characteristics of WSN, the requirements of the WSN transport layer can describe. Usually, the transport layer will be:

- be consistent with the application data flow of a model.
- have end-to-end reliability and control congestion;
- To be able to handle the model of variable reliability required by the requirement. For example, the application of temperature control may be tolerable for packet loss than the application of clandestine military surveillance. Any implementation may require the reliability of the kit, while others may need the reliability of the case,
- To be reasonably scalable as the sensor's network density increases;
- Be designed to manage effortlessly with other layers, such as MAC layers, programs, and networks.
- Use the minimum resources and minimize the use of control messages without compromising the required data throughput level.

By the above set of guidelines, a variety of transport control protocols has been developed for WSN. Some of them are relatively basic, while others follow a big deal of the specifications set out above. As described above, the management of congestion and/or the assurance of reliability is a core task of a transport control protocol that can provide upstream, downstream, or both. The transport layer protocols fall primarily into upstream congestion management, upstream reliability assurance, and downstream reliability assurance.

5. WIRELESS SENSOR NETWORKS

• If we concentrate exclusively on ad-hoc networks, the degradation of TCP efficiency in these networks is the product of the following differences [17]:

5.1 Effect of re-estimate of the route

Due to the node mobility in ad hoc networks, routes may be split, and new routes must be computed. The discovery of new routes takes longer than the timeout interval of the sender. This causes timeout at the sender and can invoke congestion control. Thus, after the new route discovery, the throughput would be reduced as TCP is in a slow start stage. In networks with high mobility, due to frequent breaking of previous routes and new routes, the overall throughput would be reduced.

5.2 Effect of the Partition of Networks

Network splitting or partitioning is a crucial concern in ad-hoc networks. The sender and the recipient should be in different partitions. In that case, the packets are not sent to the recipient. Sender times out and transmits packets back. Thus, packets are retransmitted repeatedly but do not reach the receiver as the receiver is in another partition. For each retransmission, the sender doubles the timeout interval before the full value is reached. Moreover, when the sender and receiver are connected, the missing packets are not transmitted by the sender until a significant delay.

5.3 Window of Congestion

• The TCP congestion window is described as an acceptable data rate for a particular path. As discussed above, the routes also change the relationship between the sender congestion window and the real appropriate route data rate in ad-hoc networks. The traffic jam window for a path can be too wide for a newer route, and the sender can communicate at a high rate resulting in network congestion.

Reliable transmission of data in WS is complicated due to the following features of these networks:

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• Decreased processing power and reduced connectivity of sensor nodes.

• Near location on land results in a loss. Alternatively, the fading of the signal resulting in asymmetrical connections.

• Energy storage of nodes includes idle nodes and only wake up when required.

• Heavy-duty sensor nodes that can cause congestion and channel contention.

• Traditional transport layer protocols are not appropriate for severely restricted WSNs with features that are very different from traditional wired networks, including the Internet.

6. EVALUATING THE PERFORMANCE OF WSNS

Methods for determining the efficacy of the WSN transport layer protocol would be as follows:

• **Energy Efficiency:** The energy required for the wireless network is supplied using a battery. WSNs applies in non-urban regions where the prospect of data collection with low consumption of energy see as a critical efficiency index. Energy consumption can be measured by calculating the total energy used in a network [18].

• **Congestion control**: Congestion could occur in a wireless network for many different reasons. Transport is also the relocation of the sensor node and corresponding communications resulting from various events [19-20]. Network congestion will lead to two serious outcomes: a buffer reduction in capacity and an increase in each packet's bandwidth cost. Decreasing congestion is, therefore, helpful to the achievement of reliability. In WSNs with a single node sink, a passive approach may be used to reduce congestion. When congestion occurs in the system, the sensor nodes minimize their notification process, allowing the congested nodes to exit their line and be freed.

• **Reliability**: It can check at both the packet's level and the level of the event. The packet-level determine by the proportion of packets delivered successfully to the final destination. An alternative method of calculating the packet level's efficiency is determining the end-to-end rate of loss of packet number. The lower rate of the loss, the higher is the network's efficiency. The event frequency reliability calculates by measuring the specific volume of data from the destination or event by the receiver. Not all messages need to be controlled by the receiver in this case. As long as the specified number of packets reaches the destination within a limited time, the case's reliability level is achieved [21].

6.1 Transport Protocols of Proxy Nodes

This paper aims to study the efficacy of the proxy in WSNs. There are variations in average total network capacity, average end-to-end delay, network splitting, and data transmission changes to the central station. The network separates into sections in the current framework. For every segment, one proxy node performs the central station's role in that segment, So the other nodes are transferring the sensor information to the node rather than sending it directly to the node of the sink. The proxy node is an intermediate node that acts as a sink—also, the primary node for transmitting sensors data as part of individual other nodes [22].

The proxy node can collect and distribute data from the sensor nodes to the entire network's central station. In this scenario, the system with 1000 * 1000 m2, and the number of nodes are 100 and 120. The proxy nodes are five nodes with the AODV routing protocol, and the moving nodes except the central node configure to match the proposed architecture. Network performance measurements, including progress in packet transfer, end-to-end delays, and packet receipt ratios for three transmission protocols, such as TCP and its variants (New Reno and Vegas), are then checked. The end-to-end communication method will upgrade the existing proxy node design. The leading network splits into different regions, which each of that node recognizes as the central server receiving packets from that area [23].

Initially, packets from each region start sending packets to a proxy node. After all, packets have been sent. The proxy node will send them to the central station. In this process, the obtained data is transmitted to the destination and may improve the central station's transmission time. It would reduce the loss of the packet. Several nodes are a key parameter in the structure of the network. This parameter's choice must be assumed never to make the complex circumstances of wireless networks more difficult. The number of nodes is determined based on the performance of the network and the area underused. The proposed structure assesses density; one node near the main central station should be the chosen proxy node [24-25].

6.2 RESULTS

We analyzed the impact of proxy presence on WSNs performance for different network sizes and node mobility. The role of proxy effects on TCP protocol performance is being studied. In terms of efficiency indicators, we considered the total network capacity and end-to-end latency, as follows:

- **End-to-end delay:** Delay has defined the packet needs the time to reach the destination. The delay depends on the network's many factors, including the number of variables, nodes, the transmission capacity of nodes, and network traffic setup.
- **Network total capacity:** The bit rate that has successfully accessed their destination with each source-destination pair, named throughput. The total amount of the throughput is the actual performance of the network [26].

The number of proxy nodes will determine how the transport protocol handles packets sent to the network. Here, we measured the performance with a network size of 100 nodes and 120 nodes. The study considers a device with a length of 1000 m and a width of 1000 m. The range of the radio transmitter is 100 m. This network is a wireless network where the nodes' location is assumed to be a different distribution. Network nodes are configured to transfer these packets to the central station, as shown in Figure 1, with 100 nodes and Figure 2 with 120 nodes. Nodes are supposed to be moving, and their position and velocity properties are being random. Thus, the network cannot be predicted over the period, As shown in the following table1.

Figure 1: Simulator of WSNs with proxy nodes (100 nodes)

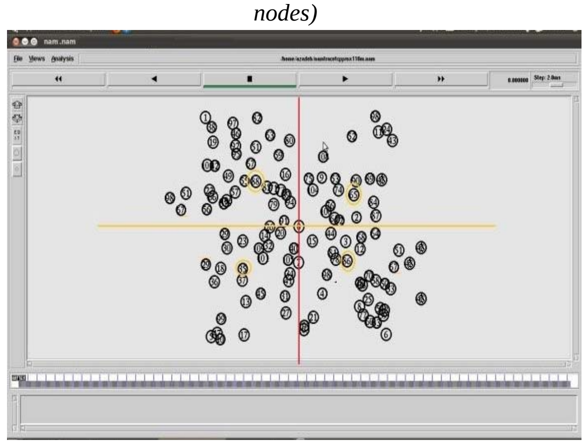
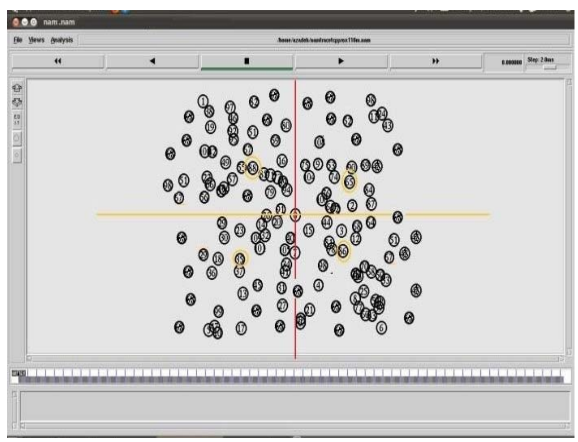


Figure 2: Simulator of WSNs with proxy nodes (120 nodes)



6.3 4.1 The Performance of WSN without proxy nodes

The results show that the number of nodes grows and traffic rises, the TCP and New Reno protocols' efficiency in the system without proxy decreases. The performance of these two protocols is also slightly different. The Vegas protocol displays a low efficiency compared to other transport protocols. In particular, The Vegas throughput is considerably lower than the others.

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The Vegas protocol protects packets against being lost to the system. That is why it restricts the amount of data delivered to the network. Inversely, the New Reno protocol sends back packets that are repeatedly lost. As a result, the Vegas Protocol has shown worse efficiency in terms of network latency. The difference between the end-to-end delay of the three protocols is not essential. It is noted that, due to its rapid resending process, the end-to-end delay of the Vegas is relatively low than other protocols. The Vegas protocol uses an efficient algorithm to check the delay of the software. It also overcame the issue of sufficient positive reception to locate lost packets. As a result, the Vegas protocol appears to be better than others regarding the end-to-end delay factor, which is highly essential for WSN applications.

As the number of nodes increases, the efficiency of the TCP is lower than other protocols, dropping dramatically. TCP's output is 308.18, while New Reno and Vegas are 306.32 and 149.76, respectively, for 100 nodes on the system. TCP performance decreased from 308.18 for 100 nodes to 291.05 for 120 nodes in the network. Moreover, concerning other criteria that the TCP has no better performance, this problem shows which TCP is ineffective for the network significantly when the network's density increases, while New-Reno increases from 306.32 393.41 and Vegas increase from 149.76. to 208.51, as illustrated in Table 1 and Table 2.

Table 1: The Results of Network Throughput and Delay Time without proxy

sport Protocol	No. of Nodes	without proxy	
		Throughput (Kbps)	End to End Delay (ms)
TCP	100	308.18	161.90
	120	291.05	111.96
New Reno	100	306.32	163.48
	120	393.41	194.66
vegas	100	149.76	91.83
	120	208.51	256.89

Table2: The Results of Network Throughput and Delay Time with proxy

sport Protocol	No. of Nodes	with proxy	
		Throughput (Kbps)	End to End Delay (ms)
TCP	100	361.23	191.664
	120	498.04	201.158
New Reno	100	367.02	172.372
	120	479.85	216.057
vegas	100	182.70	95.223
	120	225.43	244.405

6.4 The Performance of WSN with proxy nodes

Performance of transport protocols when different proxy nodes are located on a network. Comparing network latency efficiency in two non-proxy and proxy states shows that TCP and New Reno protocol improvements have occurred in network capacity. However, the Vegas Protocol is also underperforming. Besides that, as proxy nodes placed on the network, the Vegas protocol's performance indicates a small increase.

6.5 DISCUSSION

When the proxy state is contiguous to the sink node, the New Reno protocol's efficiency is more advantageous in terms of network performance than other protocols. However, applying proxy to the network data transfer method has boosted throughput and enhanced end-to-end latency. The Vegas does not have a good effect on network latency with the other protocols. However, both systems benefit from the efficiency of network.

Protocols has dramatically increased the end-to-end delay. This rise attribute to the fact that the information is first sent to the proxy node and then sent to the sink node. It adds up the transmission time but increases the other results. The end-to-end delay was much smaller than the other protocols in the Vegas protocol due to its rapid resending algorithm. Finally, the throughput is increased more than the delay time.

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7. CONCLUSION

The purpose of the present study was to analyze and implement a way of improving the transport protocol in WSNs. First, the efficiency of TCP was discussed in comparison to the NewReno and Vegas protocols. According to the simulation results, while the Vegas protocol behaves poorly of network output, it delivers much better performance than TCP and NewReno in terms of end-to-end delay.

Given the disadvantages of WSNs and the implementation of an appropriate transport protocol, the easy and standard methods applicable to every WSNs should be used. The proxy technique was the concept raised in this research. If we try to use the end-to-end send-and-receive approach, the chances are that packet transmission efficiency to the central station will decrease as nodes increase network traffic. However, in the proxy state, when packets send to the proxy node, it was quickly detected if a packet was congested or lost, as well as packet recovery or congestion prevention activity was used depending on the New Reno and Vegas transport protocol layout.

This section discussed the network's performance and efficiency, while the solutions suggested in the past were limited to problems with improving those parameters, such as avoiding congestion or recovering missing packets. Finally, we found that increasing the throughput of the TCP protocol and its variables while increasing the number of nodes from 100 to 120 will increase a little delay time.

Our future work involves testing other parameters, such as the congestion window, and increasing proxy nodes across the network.

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