Comparative Study of RMST and STCP protocol for QoS Provisioning in WSN

Nasser-Eddine Rikli
King Saud University (KSU)
Riyadh, KSA
nrikli@ccis.ksu.edu.sa

Saleh Ibrahim AL-Eidan
King Saud University
Riyadh, KSA
saleidan@tvtc.gov.sa

Abstract— *Advancements in technologies, semiconductor industry and communications resulted in construction of wireless sensors. Wireless sensors are self-managing and sensing devices having the capability to communicate with each other and sink node wirelessly. The sink node can then take decision according to the application they are being used for; upon the reception of messages from node.*

Generally, transport control protocols provides reliable data transfer with congestion control and recovery support. This support is very important in wireless networks where data is more likely to be lost than wired network. In wireless sensor networks (WSN), there are limited resources like energy, memory, and signal strength. Therefore in WSN, QoS is very important in order to reduce the impact of data loss and data reliability.

This paper provides a comparative study on STCP and RMST transport layer protocol in order to study their effect on QoS. We used throughput, packet drop rate, delay and scaling in sensor nodes and source nodes is studied.

Index Terms—**QoS, STCP, RMST**

I. INTRODUCTION

Research in WSN has increased a lot due to its smaller size and potential benefits. Basic functionality of WSN is to collect the state of some physical system and transmit it to its users via wireless network. Most commonly the applications of WSN are home monitoring, health systems, surveillance, agriculture and buildings. WSN uses radio frequency and are low cost devices. Figure 1 shows different examples of WSNs.

Figure 1: Example of WSNs

The deployment of sensor nodes doesn't need to pre-engineered or designed that make it potential candidate for disastrous area like flood area or infrastructure destroyed due to volcanic eruptions, but in these sort of situations self-organizing algorithms are required.. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities. Sensor nodes are equipped with processing device thus instead of sending raw data, we can send processed data or at least partially processed data

In WSN, QoS has to be supported when it is used in applications like cyber physical system for achieving the communication reliability and integrity. QoS support is very necessary in cyber-physical system and in future its demands will increase [1]. Each user has their specific requirements on QoS according to their application. QoS can have specific attributes like reliability, availability, integrity, security, timeliness and robustness. To evaluate the QoS of some algorithm the potential metrics can be packet loss rate, delay jitter and many others [1] [2] [3].

Delay is the period of time which data takes from the departure of a data packet from the source node to reach the destination node. Throughput is the number of bits/packets transmitted successfully within a certain period of time. Packet loss rate is the percentage of data packets facing lost within the process of transmission

Major challenges that QoS provisioning in WSN limitations are providing support for mixed traffic, dynamic network topology and resource constraints like limited transmission power, bandwidth, number of radio channels.

II. TRANSPORT LAYER FOR WSN

The transport layer protocols are key for reliable data transport with energy conservation. Transport control protocols, are very important for reliable data dissemination and energy-conservation for WSNs in the transport layer. Congestion control only requires transport layer support but energy conservation involves lower layers too [5]. To provide congestion control in WSN, the resource limitation must be considered. Thus the design of protocol must be scalable and simple to save all resources that will help in increasing life of a network. There are some general factors that effect the transport control protocol for sensor networks.

- Congestion control and reliability should be provided at first, traffic towards sink is higher than

other nodes[38]. So, we can use hop-by-hop technique for congestion control and loss recovery as it will reduce the memory requirement and it also ease the reliability.

- It should have less packet drop rate to conserve energy.
- For connection between nodes connectionless protocol must be used in order to decrease the traffic and conserve energy.
- It should provide fair throughput for each sensor node so that each event at each node gets reported.
- Cross-Layer optimization can be made at transport layer, in order to recognize the exact fault of pack loss (Either it is from congestion, or route failure)

III. RMST AND STCP

RMST (Reliable Multi-Segment Transport) is responsible for providing reliable hop by hop transmission from source to sink; It works in cooperation with network and MAC layer protocols to achieve its goals. Reliability refers to reliable delivery of fragments sent by base station [4] [5]. There are two modes in RMST, caching (caching is done along the transmission path to reduce power loss) and non-caching (MAC layer is used to reduce the load of transport layer).Figure 2 shows RMST flow chart.

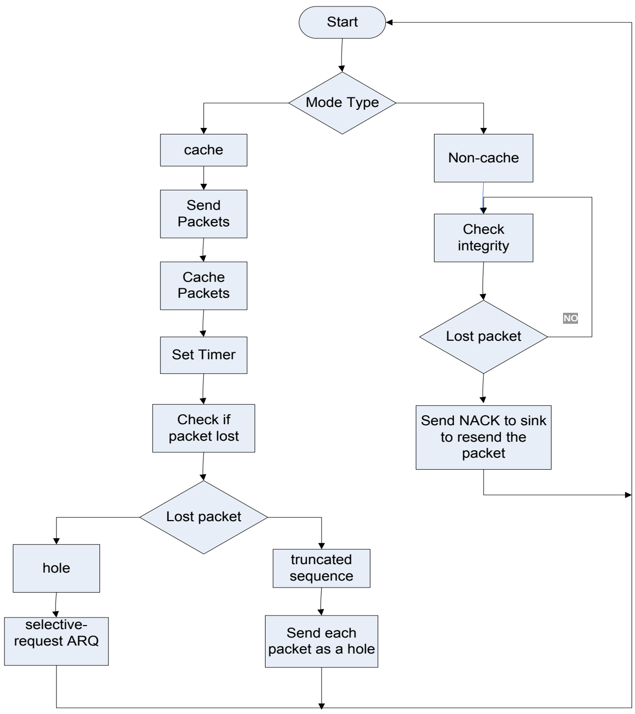

Figure 2: RMST flow chart

STCP (Sensor Transmission Control Protocol) on the other hand is a transport layer protocol that provides end to end delivery of data [5] [7]. In STCP, all nodes are strictly synchronized with base station through clock. The packets in STCP take key part in maintaining congestion control. Figure 3 shows STCP flow chart.

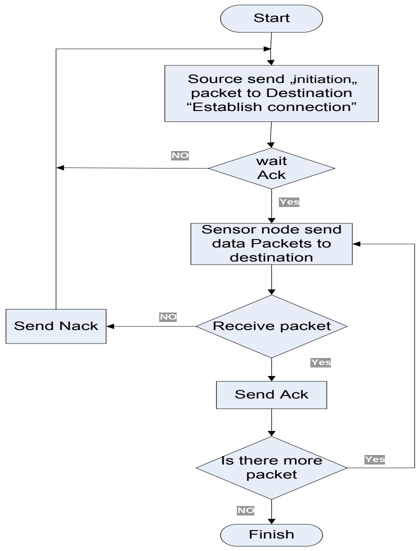

Figure 3: STCP flowchart

IV. SIMULATION MODEL DESIGN

In our experiments we have used wireless sensor nodes in multiple ways like a WSN as sensor node, a sink and a source.

Sensor Node: A node that is capable of performing some computation and has processing unit to perform computation.

Source Node: A node that is responsible for generating the messages based on the data received from other nodes. It also forwards the data.

Sink Node: A node that is waiting for events to occur for which it is designed for and after recording the events it forwards the data.

Environment Model: We assumed that the environment nodes detect the environment target in the wide area space, where we use a two-dimensional model (x-y plane) which is a square space of 1000m x 1000m. We used 30, 60 and 90 number of nodes to compare our models.

Sensor, User Node Model: While Environment node generate data packets and forwards to the sensor nodes, sensor nodes then delivers these packets to the user node. The sensor node and user node model consists of: 1) Wireless Channel. 2) Radio propagation model with Two Ray Ground. 3) Network interface with Wireless Physical module. 4) MAC layer with the 802.11 type. 5) Interface queue with Drop Tail - priority queue. 7) Link layer. 8) Omni-directional Antenna. 9) Interface queue length with maximum 50 packets in the interface queue 10) Energy model with (transmission, receiver and idle power. 11) Routing protocol.

Communication Model: To receive the detected data from the environment nodes via the sensor channels, the sensor nodes need to attach to the sensor agents to communicate with

sensor channels. For the communication between the sensor nodes and the user node via wireless channel, the sensor nodes also need to attach with the UDP agents.

A. Simulation Parameters

We set our simulation NS2 [8] we set an initial sensor node Battery Life to 500mW. Whenever the nodes transmit the data it needs power to transmit, in our assumption we made it 0.660mW so the left Battery life will be (Old Battery life – transmitted power (0.660mW)). Whenever the nodes receive the data it needs power to receive, in our assumption we made it 0.395mW so the left Battery life will be (Old Battery life – received power). Whenever the node is idle it means it is waiting for certain event that also requires power so at each time interval (mille second) we decrease the Battery Life by 0.035mW. Thus new Battery Life will be (Old Battery life – Idle power (0.035mW)). If the Battery Life is zero node dies.

Maximum transmission power of sensor node is set to 40 meter in our experiment. We chose the Constant Bit Rate so that we can test our protocols for streamed traffic. We chose a high CBR to test the major capability of network and effect on QoS.

B. Performance Metrics

The following metrics are considered when analyzing the performance of our protocols:

Throughput: It is a measure of the amount of data transmitted from the source to the destination in a unit period of time (second).

$$Throughput = \frac{\text{Total Data Bits Received}}{\text{SimulationTime}}$$

Packet Drop Rate (PDR): Represents the number of packets lost per unit time.

$$PDR = \frac{\text{Number of packets Drop}}{\text{SimulationTime}}$$

End-to-End Delay: The end-to-end delay is measured as the interval between the generation of a data packet at source and the reception of that packet at the sink. The end-to-end delay shows the average amount of time it takes for the network to deliver a data packet from a particular source node to the sink.

V. Experiments And Results

We have made a comparison between the results of RMST and STCP, with different types of tests, test a: one source one sink, test b: multi-source multi-sink and multi-source one sink. In each test of these tests, we have made a comparison between the performance measures of RMST and STCP. Also we study the effect of increasing the number of source nodes and sensor nodes on these performance measures.

A. Comparison between RMST and STCP results

Throughput:

Figure 5 shows the comparison between RMST and STCP throughput for sink , the red line depicts the RMST and green one defines STCP. The throughput of RMST is higher than STCP.

Figure 4: RMST and STCP throughput for sink(1)

Packet Drop Rate (PDR):

Figure 6 shows the comparison between RMST and STCP PDR for sink, the red line for RMST and green line is for STCP. The packet drop rate (PDR) of STCP is higher than the RMST.

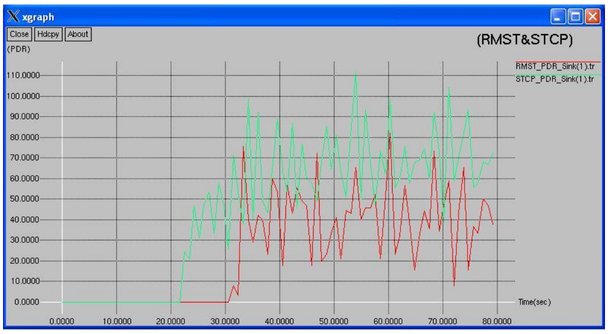

Figure 5: RMST and STCP PDR for sink

End to End Delay

Figure 7 shows the comparison between RMST and STCP End to End delay for sink, the red line for RMST delay and green line is for STCP delay. The RMST has lower delay than STCP.

Figure 7: RMST and STCP E2E delay for sink.

B. Effect of increasing the number of source nodes and sensor nodes in performance metrics

By applying the same setting of our NS2 simulation and assumptions as discussed and presented previously, except that the number of source nodes and the number of sensor nodes will be changes as we will explain,(multi sources-one sink).

We will increase the number of senor nodes to thirty, sixty and ninety, we will also increase the number of source nodes from one to twelve respectively. At each run of our simulation we will record the performance measures (Throughput, packet drop rate and end to end delay). First RMST Results (multi sources-one sink)

Figure 8 shows the results of throughput measure for different number of sensor nodes. The network has higher throughput value when only one source sends, they use available bandwidth. No congestion will appear thus it will cause high throughput. *The throughput value decreases as number of source node increase.*

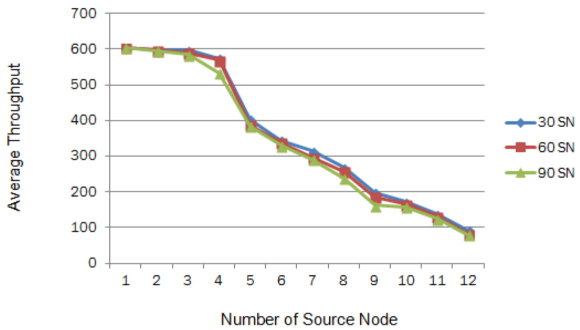

Figure 8: RMST Average Throughput (30,60,90) SN

Figure 9 shows the results of PDR ,it shows that the PDR equal to zero when only one source node send, and then the PDR increase as the number of source node increase because more sender sending the data means that there are more chances of collisions.

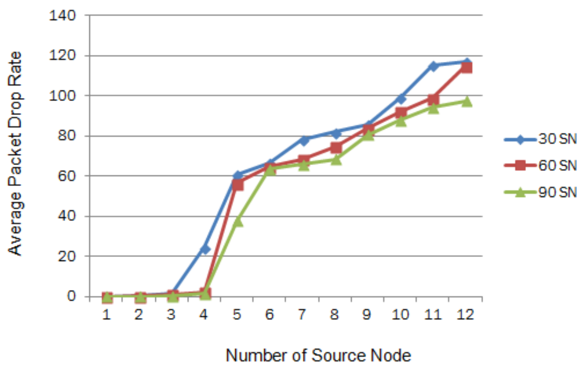

Fig 9 RMST: Average PDR (30,60,90)SNs

Figure 10 shows the Average Packets E2E Delay, when the number of source nodes increase the delay increases. The average E2E delay for ninety SNs is lower than sixty and thirty SNs (best) because if we increase the number of SNs the connectivity will increase, thus the E2E delay decreases when we increase the number of SNs.

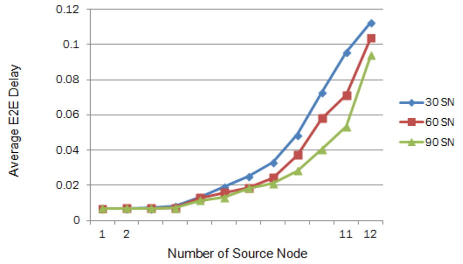

Fig 10: RMST: Average Packets E2E Delay (30,60,90)SNs

STCP results (multi sources-one sink)

Figure 11 shows the results of throughput measure for different number of sensor nodes. The network has higher throughput value when only one source sends, they use available bandwidth. No congestion will ppear thus it will cause high throughput. The throughput value decreases as number of source node increase.

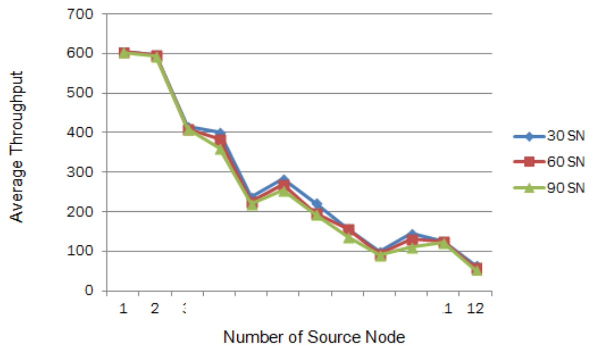

Fig 11 STCP: Average Throughput (30,60,90)SNs

Figure 12 shows the results of PDR, it shows that the PDR equal zero when only one source node send, and then the PDR increase as the number of source node increase because more sender sending the data means that there are more chances of collisions.

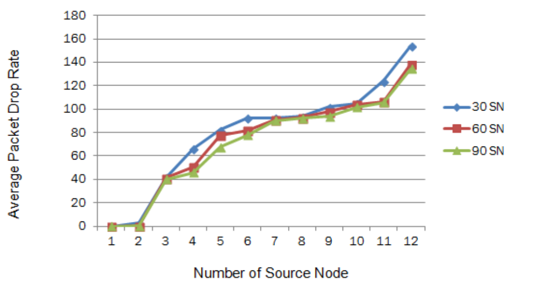

Fig 12 STCP: Average PDR (30,60,90)SNs

Figure 13 shows the Average Packets E2E Delay, when the number of source nodes increase the delay increases. The average E2E delay for ninety SNs is lower than sixty and thirty SNs (best) because if we increase the number of SNs the connectivity will increase, thus the E2E delay decreases when we increase the number of SNs.

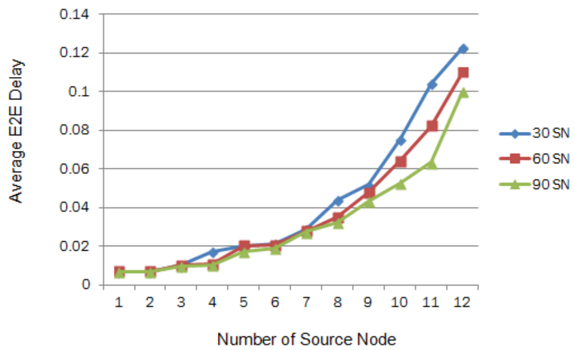

Fig 13 STCP: Average Packets E2E Delay (30,60,90)

VI. CONCLUSION

The objective of our paper was a comparative study on RMST and STCP transport control protocols. Based on that, some suggestions were investigated two transport protocols of wireless sensor networks. We used standard performance measures such as throughput, packet drop rate and the delay were used in comparison. As we saw, the RMST has better throughput than STCP, also RMST has less PDR than STCP, also RMST has less E2E delay than STCP. Also as we saw in the effect of increasing the number of source nodes and increase the number of sensor nodes on the performance measure as shown in table 1.

Table 1: Effect of increasing the number of sensor nodes and sources

Performance Metrics	Number Of Sensor Nodes	Number Of Sources
Average throughput	Decrease	Decrease
Average PDR	Decrease	Increase
Average E2E delay	Decrease	Increase

We propose the following as a future work:

- Investigate node mobility.
- Investigate different traffic types.
- Investigate packet level priority.
- Investigate in the loss detection of the reliability algorithm, as explained below.

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