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Optimization of Collection Tree Protocol

Harleen Kaur
Assistant professor in CSE Department
Bhagwan Mahavir college of engineering,Surat
[1]harleenkaur.935@gmail.com

Prof. Gaurang Raval
Associate Professor in CSE Department
Institute of Technology ,Nirma University, Ahmedabad
[2]gaurang.raval@gmail.com

Abstract: Collection tree protocol is a tree based protocol which is mainly used for aggregation. It is minimum cost routing tree which selects the path having minimum cost routing gradient. It will generate one or more trees to root which is called base station. When any node has data it sends data up the tree which is forwarded to root.CTP will provide link quality estimation among nearby neighbours. It will indicate number of transmissions from a node to send a packet to destination and whose acknowledgment is successfully received. It sends data to root by choosing a next hop. CTP is having a problem of fast energy depletion which is caused by congestion in the network. Also energy level of the network is not highly scalable. Whenever a node in a network is failed it is not able to do the function and it should not effect on overall network. When more number of nodes are added in the network, congestion will take place and so it does not have an additional energy to choose an optimal path. In revised CTP, to enhance the energy level of a network RSSI is used in broadcast fault tolerant algorithm. RSSI means power received by antenna. CTP suffers a problem by disseminating data statically in network. So in revised CTP line mobility model is integrated which will send data dynamically to sink node.

***Keywords*:** CTP (Collection Tree Protocol),ETX(Expected Transmission), ACK(Acknowledgement),THL(Time Has Lived), RSSI(Received Signal Strength Indicator).

I. INTRODUCTION

CTP's main task is to perform data collection in wireless sensor network. It contains data packets which is unicast. It is having two features reliability and efficiency. CTP should be able to send a packet greater than 90 percent. It should send a packet towards destination with minimum amount of transmission. This protocol will make one or more routing trees to the root which is called base station having minimum cost. CTP is having a routing problem which will lead to routing loop and hence will have network congestion. Due to network congestion packet drops occur. Due to frequently changes in link quality it will have stale topology. It consists of two mechanisms which will deal this problem. The first is data path validation which will send packet to route dynamically and detect the problem when it is not making progress towards destination. It uses data packet transmission and reception methodology.

Second is adaptive beaconing which will send beacons faster when the topology is inconsistent due to which sender node which has send the data will hear it and it will adjust it route accordingly [1]. It make use of trickle algorithm which allows nodes to send very few control beacons when the topology is consistent and quickly detect the routing problem. It consists of routing metric called ETX(expected transmission). ETX of root is always 0 and ETX of node is defined as ETX of its parent plus ETX of link to its parent.

The collection of ETX value is known as gradient value. CTP always chooses path having minimum ETX value. If any node receives ETX value which is higher than its own then there will be routing problem and if node receives gradient value lower than its own then there will be routing inconsistency which is solved by broadcasting a beacon frame [1,2,3,4].

II. CTP ARCHITECTURE

It consists of three main modules:

A. Forwarding Engine: It forwards data packets to node and then ultimately it is forwarded towards root. Node will select the parent from routing table and will check the identifier of a current node and if the ETX of sender is greater than ETX of receiver than there will be routing inconsistency. For routing inconsistency data path validation and adaptive beaconing method is used[2,3].

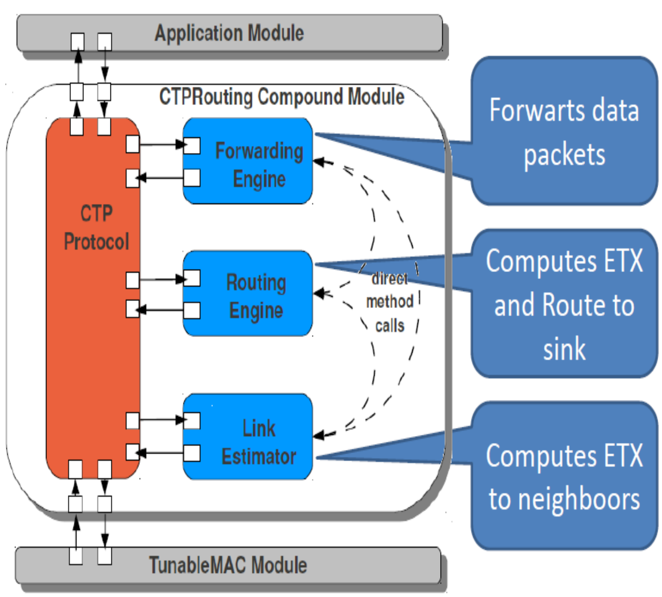

Fig.ure 1. CTP Architecture[2]

B. *Link Estimator:* is a module which is used to estimate the link of node using routing metric ETX. ETX of root is zero and ETX of node is defined as ETX of parent plus ETX of link to its parent[2,3,4].

C. *Routing Engine:* is a module which routes packet in the tree towards sink and maintains routing table containing list of neighbours from which node can select its parent. The information in the table is filled with the help of beacons which been transmitted. A node having an ETX and its value equal to n will be able to send data to sink with a total of n transmission. The rate at which beacons are sent are adjusted by trickle algorithm. The node will select its parent which is having lower ETX value. Each time a node receives any updation from its neighbour, it records its information in its routing table. It has two uses: first one is to select the parent and to select the minimum routing path. It has two functions: UpdateRouteTask in which parent is selected rapidly before a node will send its own beacon. SendBeaconTask broadcast the current route information to others[2,3].

D. *Structure of CTP:*

a. P-Routing pull-This bit allows nodes to request information from other nodes. If any node hears a packet with the P bit set, it should transmit a routing frame in the next transmission [3].
b. C: congestion notification-If a node transmits a CTP data frame it must set the C bit field on the next data frame [3].
c. THL: Time has lived-When a node generates a data frame it sets THL to 0.When a node receives a CTP data frame, it must increment the THL value and if a node receives a THL of 255,it increments to 0[3].
d. Origin: The originating address of the packet. A node forwarding a data frame must not modify the origin field [3].
e. Seqno: This field signifies the origin sequence number. The originating node sets this field, and a node forwarding a data frame must not modify it [3].
f. Collect id: This field signifies the higher-level protocol identifier. The origin sets this field, and a node forwarding a data frame must not modify it [3].
g. Data: This field signifies the data payload, of zero or more bytes. A node forwarding a data frames must not modify the data payload [3].

III. PROBLEM IN EXISTING PROTOCOL

The protocol is already available in Tiny OS and does the static tree generation from the given topology is able to disseminate data. It does not consider RSSI(received signal strength indicator), energy level of the network is not highly scalable. It does not have an additional energy to choose an optimal path [4]. Whenever a node in a network is failed it is not able to do the function, it should not effect on overall network.CTP is not a fault tolerant network because if more nodes are added in the network, congestion take place which will lead to packet drops if any node fails. So in previous approach byzantine fault tolerant algorithm using CTP is proposed. In this approach RSSI is integrated in broadcast fault tolerant algorithm and compare the results of these two implementation and also line mobility model is integrated in CTP in Castalia simulator, which will send data dynamically to sink node and observe the results [2, 4, 5, 6, 7].

IV. ALGORITHM

Broadcast fault tolerant algorithm using RSSI has been implemented in Tiny OS with the help of TOSSIM simulator. RSSI means power received by antenna. It is also used to determine amount of radio energy present in the radio channel. Once the network is cleared for sending the data to sender node, it will send its packet to destination and the packet is sent to destination hop by hop. Once the packet is reached to destination, it will measure its RSSI value and also the signal strength of wireless network at different power levels[5,8,9,10].

A. *First stage:* All motes locally broadcasts HELO packet using CTP. Base station finds total number of motes in a network [5,8,9,10].

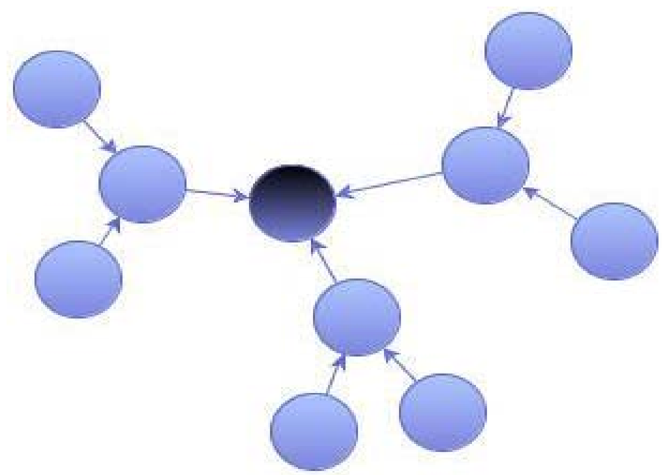

Figure. 2. Motes sending HELO packet to Base Station [5].

B. *Second stage:* Base station will send information to all motes[5,8,9,10].

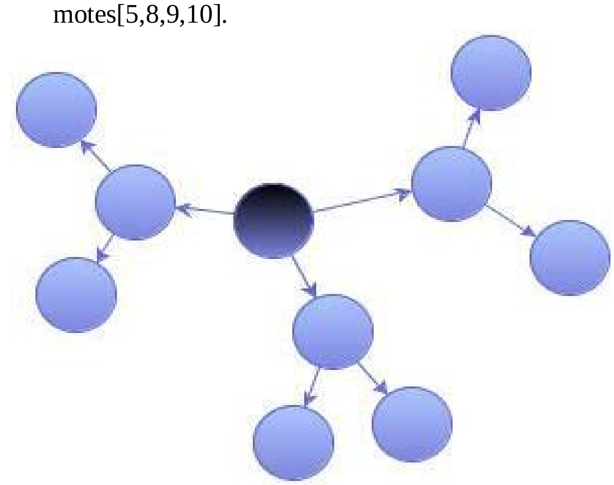

Figure 3. Base Station sending Number of Motes in the network to all motes[5].

C. ***Third stage:*** Each mote will sends HELO packet to its neighbour[5,8,9,10].

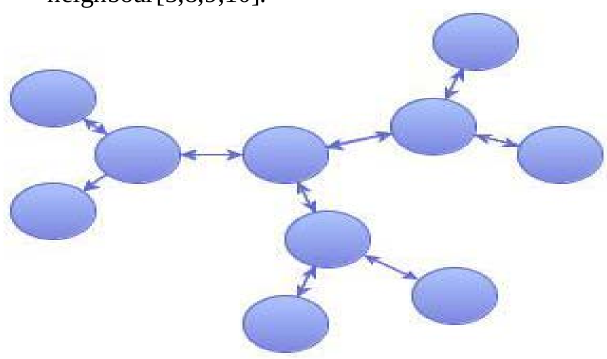

Fig.ure 4: Motes sending HELO packet to each other [5].

D. ***Fourth stage:*** After receiving HELO packet from neighbour motes send ACK packet to sender mote. After receiving ACK packet mote measures its RSSI value and stores all necessary information. Each mote also stores which mote can be selected as its parent [5,8,9,10].

E. ***Fifth stage:*** Information collected from the previous stage is sent to base station using FRNDS packet and base station processes this information and creates routing table [5,8,9,10].

F. ***Sixth stage:*** Base station sends pruned routing table to all motes [5,8,9,10].

G. ***Seventh stage:*** In this stage one node will be randomly selected and will disseminate INIT packet using pruned routing table [5,8,9,10].

H. ***Eighth stage:*** After receiving INIT packet, motes send ECHO packet. Motes keep counter of ECHO packets [5,8,9,10].

I. ***Ninth stage:*** If any node has received n-f ECHO packets in previous round then it establishes successful communication [5,8,9,10].

Pruning refers to deleting unnecessary entries from routing table. When routing table is constructed at base station, it sends the pruned routing table to all the motes in the network. When it forwards this table to motes, they will prune entries of motes which are at same level or higher level in the given graph. This will enable motes to communicate efficiently. Using this table each mote will know how much power is required to transmit a packet and for global broadcast to which mote it should send packet. This method will allow power efficient global broadcast in the whole wireless sensor network. As power is a very important resource in sensor networks and this approach uses the least power.

V. RESULTS

The algorithm was simulated which were in the range of 100 in number. The metric was power and charge consumed per node. Figure 5 shows the graph of charge versus time. Y axis in the graph indicates charge which is measured in mAh.

And X axis shows the time in seconds. As time increases the rate of charge also decreases. Here rate of charge decreases less in broadcast fault tolerant algorithm in multi-hop network using RSSI as compared to CTP.

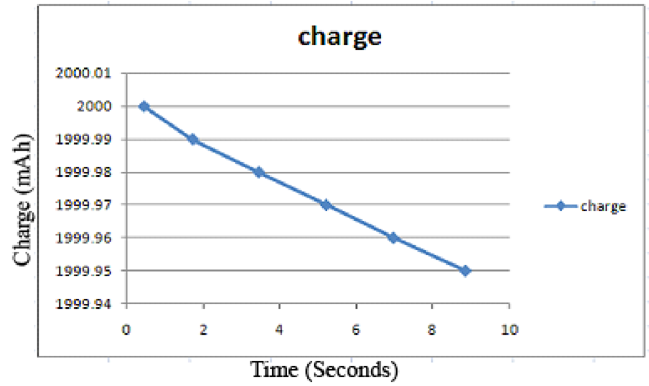

Fig.ure 5. Charge v/s Time

Figure 6 shows the graph of charge versus time. Y axis in the graph indicates charge which is measured in mAh. And X axis shows the time in seconds. As time increases the rate of charge also decreases. Here rate of charge decreases more in broadcast fault tolerant algorithm in multi-hop network using CTP without RSSI.

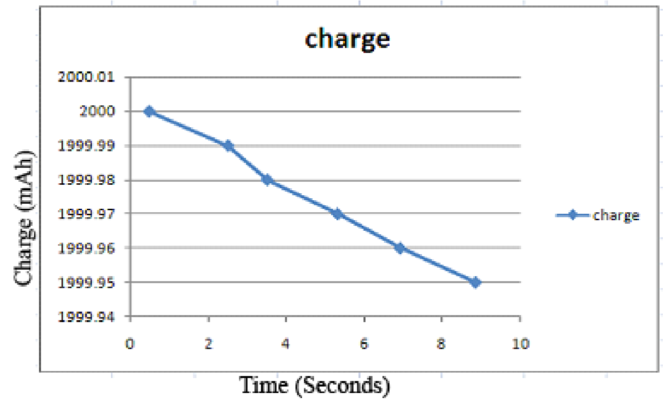

Figure 6. Charge v/s Time

VI. IMPLEMENTATION OF CTP OVER CASTALIA

CTP suffers a problem by disseminating data statically in network and so it is not able to send data to the node that it does not belong to its range. Mobility poses challenges in CTP to dynamically route data. So by integrating line mobility model in CTP it dynamically send data to sink node in Castalia simulator and evaluate the performance of CTP as applied in mobile wireless sensor network scenarios. It is a simulator for wireless sensor network. It is based on the OMNET++ platform [2].

Table I. Simulation Result of scenario upto 250 nodes

Number Of Nodes	Simulation Time(sec)	Field Size(x*y)	Radius(m)	Existing CTP(J)	Modified CTP(J)
50	200	100	25	16.997	13.257
100	200	150	25	20.395	16.732
150	200	200	25	23.793	20.395
200	200	250	25	27.191	23.577
250	200	300	25	30.58	26.98

Resource manager in Castalia defines the energy calculation and also defines the initial energy of a node. This module is declared in routing engine.cc file in CTP which calculates energy whenever a node sends data to the neighbour having minimum ETX value.

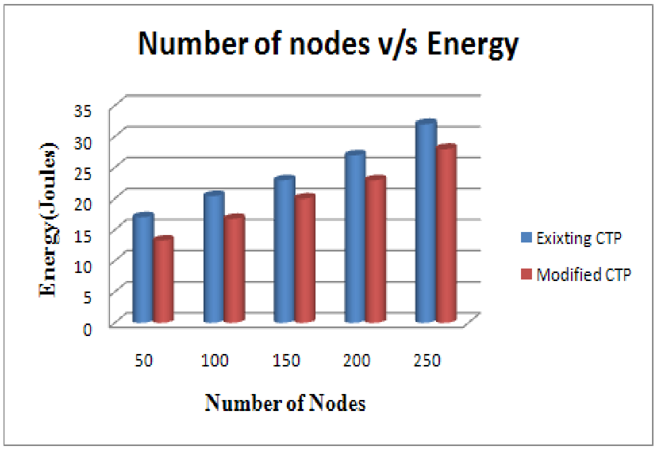

Fig.ure 7. Number of nodes v/s Energy

Figure 7 shows the energy which is measured in joules and is simulated from 50 to 250 nodes. It indicates that modified CTP consumed less energy than existing CTP. In an existing CTP packets are lost more due to network congestion then modified CTP.

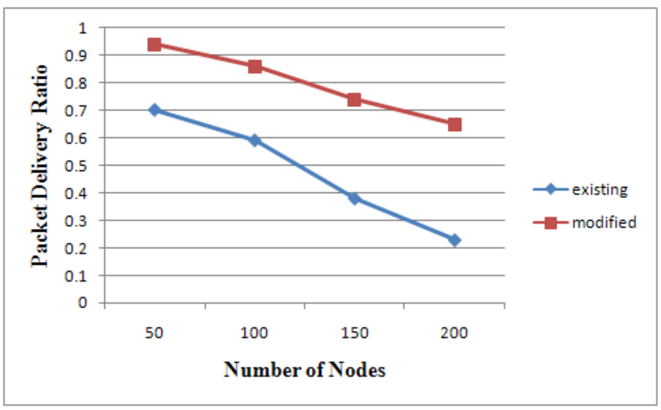

Figure 8. Packet delivery ratio

Figure 8 shows the graph of packet delivery ratio which is simulated from 50 to 250 nodes and indicates that modified CTP has higher packet delivery ratio than existing CTP by 32.3 percentage, because of communication radius is small the nodes are more closer to each other and so packets are delivered more to sink node.

VII. CONCLUSION

CTP consumed less energy than existing CTP. Energy is an important constraint in wireless sensor network. So to optimize energy in collection tree protocol, I have implemented broadcast fault tolerant algorithm on multi-hop networks using CTP and multi-hop networks using RSSI, then compare the results of these two different topologies. Collection tree protocol disseminates data statically so to dynamically disseminate data line mobility module is integrated in existing CTP protocol over Castalia wireless sensor network simulator. And compare the simulation results of an existing CTP and modified CTP which indicates that by including line mobility module it sends data to sink node dynamically and because of small communication radius between nodes, packet delivery ratio is higher in modified CTP by 32.3 percentage. Also modified CTP consumed less energy than existing CTP.

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