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Improve Convergecasting in Collection Tree Protocol(CTP)

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Abstract - *Many Wireless Sensor Network(WSN) application depends on collection service to route data packets towards sink node. The Collection Tree Protocol is one of the tree based protocol used for data collection. 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 used Expected transmission ratio (ETX) metric for tree construction. It will indicate number of transmissions from a node to send a packet to destination and whose acknowledgment(ACK) is successfully received. The residual energy of the node is an important key factor, which plays a vital role in the lifetime of the network and hence this has to taken as one of the metric in the parent selection. To improve converge casting of CTP, energy constrain is introduced into the tree construction procedure. The revised tree construction procedure is implemented and simulation results are generated and analyzed using the performance metrics: packet delivery ratio(PDR) and duplicate packets received.*

Key Words: Wireless Sensor Networks, CTP, Packet Delivery Ratio

1. INTRODUCTION

A Wireless Sensor Networks(WSN) is an ad-hoc network with a number of sensors deployed across a wide geographical area. Once deployed, sensor nodes can capture data about some physical quantity, like temperature, atmospheric pressure. Sensor readings are then reported to sink node where they are further processed according to the application requirement. A sink can store received packets and forwarded them to external network using reliable and most possibly wired communication link. Node forwarded packets through routing tree up to at least one of sink node within the network. Each node selects one of its neighboring nodes as parent using metric such as link quality, energy of the nodes, hop counts. Parent node is responsible for handling packets coming from children and forwards them to the sink. Node collects information of its neighboring nodes for select the parent using regularly exchange message called beacons that contain information about metric..

CTP's main task is to perform data collection in wireless sensor network. CTP is a tree-based collection protocol. CTP provides for "best-effort any cast datagram communication to one of the collection roots in a network"[1]. In the collection tree protocol, nodes form routing tree topologies in which packets are forwarded to the sink, the root of the tree. A sink is typically connected to an external network to reporting the data that it collects and to a power source, thus it does not have energy constraints. The collection tree protocol supports the coexistence of multiple sinks in the network. Every node of the collection tree selects its parent from a list of candidate neighbours, sorted according to a performance metric that measures how likely is that the neighbouring node can forward the packet to the closest sink. In CTP, this metric is the Estimated number of Transmissions (ETX), which consist son the expected number of transmissions required to deliver the packet to a sink, counting eventual retransmissions. For definition, the sinks have an ETX equal to zero. The 1-hopETX measures the quality of the link that connects a node to its neighbour. Therefore, the ETX of a node, i.e. multi hop ETX, is recursively computed by summing of the 1-hop ETX to its parent. Every node of the tree is then in charge of forwarding packets received from its children, together with its own packets, to its parent.

A problem that can emerge in a CTP network is Routing Loops. CTP addresses loops through two mechanisms. First, every CTP packet contains a node's current gradient value. If CTP receives a data frame with a gradient value lower

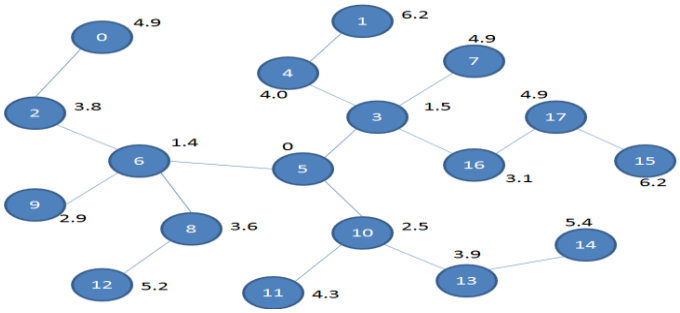


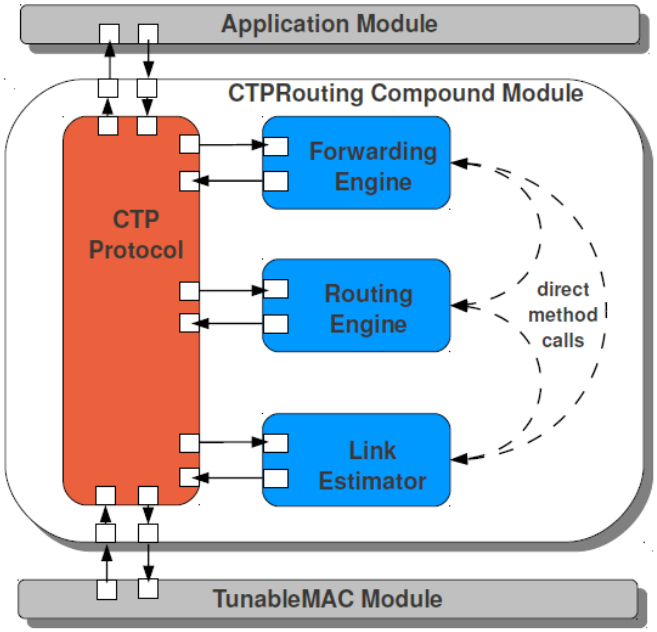
Fig. 1. CTP tree construction

than its own, then this indicates that there is an inconsistency in the tree. CTP tries to resolve the inconsistency by broadcasting a beacon frame, with the hope that the node which has sent the data frame will hear it and adjust its routes accordingly. If a collection of nodes is separated from the rest of the network, then they will form a loop whose ETX increases forever. Packet duplication is an additional problem that can occur in CTP. Packet duplication occurs when a node receives a data frame successfully and transmits an ACK, but the ACK is not received. The sender retransmits the packet, and the receiver receives it for

second time. This can have disastrous effects over multiple hops. For example, if each hop on average produces one duplicate, then on the first hop there will be two packets, on the second there will be four, on the third there will be eight, etc. [2]. Routing loop may cause a node to legitimately receive a packet more than once .In the remainder of this paper we will first provide some background information about CTP in section 2. We will then focus on the problems in CTP and propose some approaches to overcome those problems in section 3. In section 4, Implementation and compared simulation results of existing CTP and modified CTP is described.. Finally, 5 concludes the paper and proposes future works.

2. THE COLLECTION TREE PROTOCOL (CTP)

CTP uses routing messages (also called beacons) for tree construction and maintenance, and data messages to report application data to the sink.



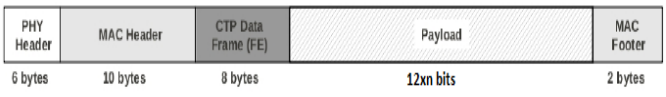
The basic architecture of CTP is shown in Figure 2. The main CTP Routing Compound Module includes three component of CTP which are Link Estimator, Routing Engine and Forwarding Engine and also includes CTP protocol module. CTP Protocol provides functionalities by managing incoming and outgoing messages between the CTP Routing compound module and its internal components. So only CTP Protocol module is connected to the input and output gates of the CTP Routing compound module. LE,FE and RE therefore interact with the CTP Protocol module to dispatch their messages to other internal or outer modules. In Figure 2 dotted lines are direct method calls. It means the internal modules of compound module may be used same set of functions. These function may be implemented in only one of the modules and used by the others through direct calls. Figure 2 also shows that CTP Routing module interacts with the application and physical layers through the Application and Tunable MAC modules, respectively.

A. The Problem

In Collection Tree protocol (CTP), tree is constructed based on Expected Transmission (ETX) count. In CTP, routing packets are used for tree construction and frequency of routing packets is sent is controlled by Trickle algorithm. In which after each successful transmission routing packet transmission interval is double. The node will not get the knowledge of the broken link until reception of the routing packet. Due to the breakage of the link, the network will suffer from higher data packet loss which increases packet retransmission. This happens because existing CTP does not consider energy of individual node for tree construction.

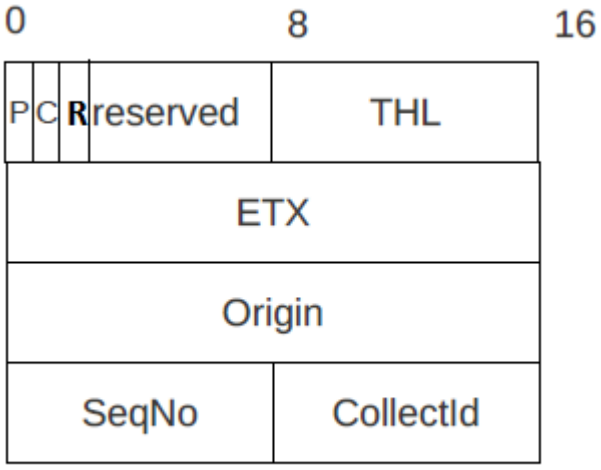
B. Proposed Approach

To overcome this problem, the tree construction is only based on the link quality and it does not consider the energy of the node[8]. So, the node changes its parent only when the link quality is bad and does not care about its parent's energy value which leads to rapid energy drain of parent node. In our algorithm, the routing table has additional entry of neighbor nodes residual energy and the beacon message also carries this information. The algorithm searches for the node with the highest residual energy and with minimum ETX from the routing table. If the node has high energy and minimum ETX, then that node will be taken as the parent node [7].In Existing CTP, the node will get knowledge of the broken link when beacon is received. But for saving energy of the node, the beacon transmission interval is increased after each successful packet transmission and the acknowledgement of that packet is received [5]. So, the node recognizes after longtime that the parent has ran out of energy and so the packet drop ratio is increased. To overcome this problem we define another approach which considers recovery packet. When then ode's energy value reaches below the energy threshold, then ode itself sends this recovery packet to its neighbour nodes to aware them about its energy reduction. By this approach the network lifetime and the packet delivery ratio can be increased and the number of packet retransmission can be decreased. Predicting node's death in advance with residual energy of neighbours is also reduced latency in recovering broken link[6].



CTP Recover Packet

n=no. of nodes



CTP Recover Packet

The format of recovery packet is shown in fig 6. This recover packet is same as data packet only difference is it includes node ID of neighbours node (n x 8 bits) with their energy(n x 6 bits) into payload. In CTP data frame which is field of recovery packet, includes 1bit R flag into reserved field which is shown in figure III-B. If R flag is set than node knows that this packet is recovery packet otherwise its data packet.

3. Simulation Results

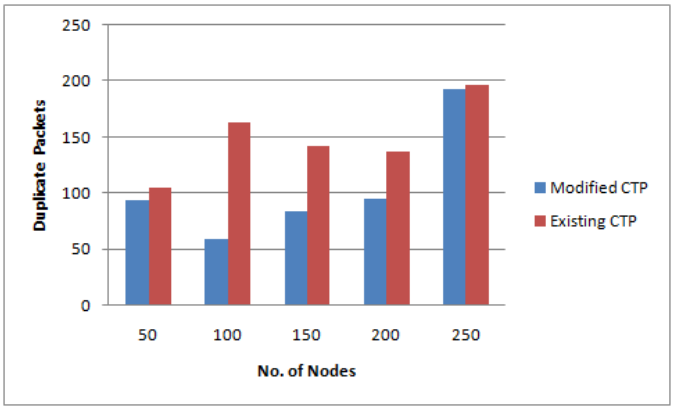
A. Duplicate Packets

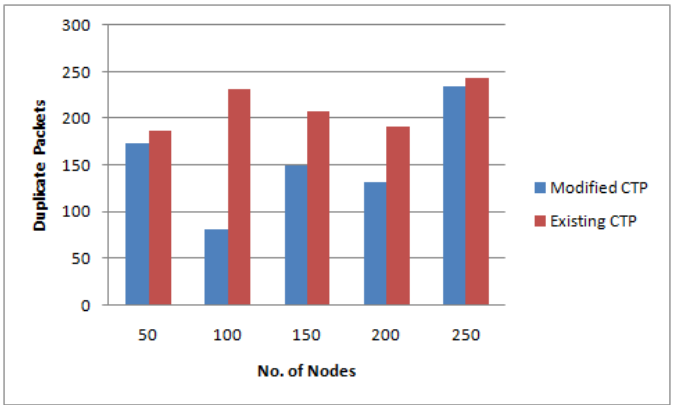
In this section, duplicate packets received are shown. We can see that number of duplicate packets received are less than the ones received in the existing CTP. This is because, In modified CTP nodes select their parent based on remaining energy of parent and link quality.

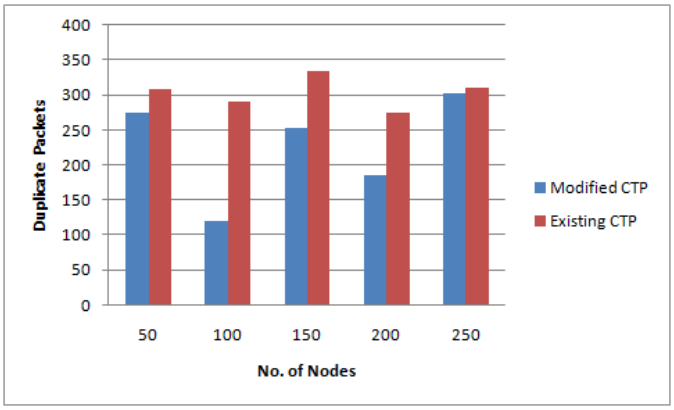
B. Packet Delivery Ratio

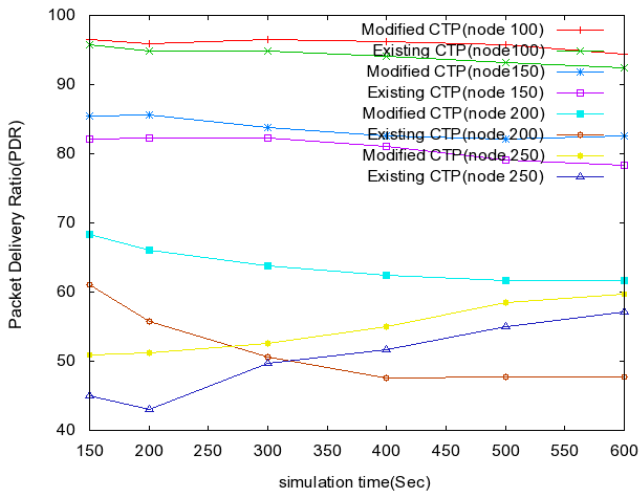
It is defined as the ratio of total number of packets that have reached the destination node to the total number of packets created at the source node.

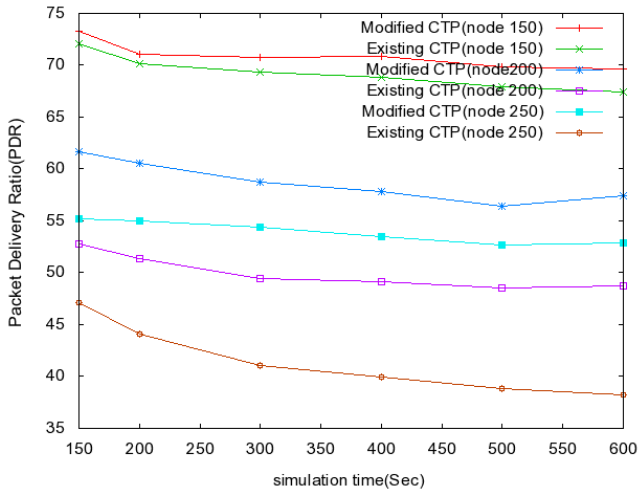
Figure 11 shows comparison of packet delivery ratio between Existing CTP and Modified CTP for field size 125x125.We can see from the graph that in modified CTP Packet Delivery ratio is higher than existing CTP. Here, increment in no. of nodes decreases the PDR because of congestion in network. Here, Figure 12 shows comparison of packet delivery ratio between Existing CTP and modified CTP for field size 175x175. We can see that as the number of nodes increase,











The graph shown in Figure 13 shows the packet delivery ratio of the nodes during different simulation times for field size 200x200. Here, we can see that modified CTP is better than existing CTP.

CONCLUSION

Energy is an important constraint in wireless sensor network. The residual energy of the node is an important key factor, which plays a vital role in the lifetime of the network and hence this has to taken as one of the metric in the parent selection. In this paper, we have analyzed tree construction procedure in existing CTP and found the rapid energy drain in parent node due to repetitive selection of the same nodes a parent without considering its energy value. To over come this problem, we have introduced energy constrain into the existing tree construction procedure. We have implemented the updated tree construction procedure and analyzed the simulation results. We have used data delivery ratio and duplicate packet reception as the performance metrics for analysis .The simulation results showed that our algorithm gives improved Packet delivery ratio(PDR) and reduced duplicate packet received. The another problem with the existing CTP is the late recognization of the link breakage which reduces the network life time and also increases the latency. To overcome this problem we have introduced a recovery packet to aware the node about its parent's energy value in advance. This approach can be implemented in future to improve the network life time, latency and Packet Delivery Ratio.

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