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TRACKING OF MOVING OBJECT IN WIRELESS SENSOR NETWORK

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Abstract - A Wireless Sensor Network is a collection of sensor nodes distributed into a network to monitor the environmental conditions and send the sensed data to the Base Station. Wireless Sensor Network is one of the rapidly developing area in which energy consumption is the most important aspect to be considered while tracking, monitoring, reporting and visualization of data. An Energy Efficient Prediction-based Clustering algorithm is proposed to track the moving object in wireless sensor network. This algorithm reduces the number of hops between transmitter and receiver nodes and also the number of transmitted packets. In this method, the sensor nodes are statically placed and clustered using LEACH-R algorithm. The Prediction based clustering algorithm is applied where few nodes are selected for tracking which uses the prediction mechanism to predict the next location of the moving object. The Current Location of the target is found using Trilateration algorithm. The Current Location or Predicted Location is sent to active Cluster Head from the leader node or the other node. Based on which node send the message to the Cluster Head, the Predicted or Current Location will be sent to the base station. In real time, the proposed work is applicable in traffic tracking and vehicle tracking. The experiment is carried out using Network Stimulator-2 environment. Simulation result shows that the proposed algorithm gives a better performance and reduces the energy consumption.

Keywords *- Wireless Sensor Networks; LEACH-R; tracking; prediction; trilateration*

I. INTRODUCTION

Wireless Sensor Networks (WSN) is group of heterogeneous sensor nodes which are small, low cost, placed randomly and conn0ected by wireless media to form a sensor field. The sensors are spatially distributed to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to the Base Station (BS). WSN has the ability to dynamically adapt to changing environments.

Object tracking is one of the challenging and non trivial applications for Wireless Sensor Network in which network of wireless sensors are involved in the task of tracking a moving object. Several factors are considered when developing algorithms for tracking moving objects include single vs. multiple targets, stationary vs. mobile nodes, target motion characteristics, energy efficiency and network architecture. Object Tracking is widely used in many applications like military application, commercial applications, field of surveillance, intruder application and traffic applications.

There are various metrics for analysing object tracking such as cluster formation, tracking accuracy, cluster head life time, miss rate, total energy consumed, distance between the source and object, varying speed of the target, etc. The open issues in object tracking are detecting the moving object's change in direction, varying speed of the target, target precision, prediction accuracy, fault tolerance and missing target recovery. In all tracking process, more energy is consumed for messages or data transmission between the sensor nodes or between the sensor and sink.

In a target tracking application, the sensor nodes which can sense the target at a particular time are kept in active mode, while the remaining nodes are to be retained in inactive mode so as to conserve energy until the target approaches them. To continuously monitor mobile target, a group of sensors must be turned in active mode just before target reaches to them. The group of active sensor nodes varies depending on the velocity of moving object and the schedule by cluster head. The sensor nodes detect the moving object and transmit the information to the sink or the base station.

The traditional target tracking methodologies make use of a centralized approach. As the number of sensors increases in the network, more messages are passed on towards the base station and will consume additional bandwidth. Thus, this approach is not fault tolerant as there is single point of failure and lacks scalability. Moreover in traditional target tracking methods, sensing task is usually performed by one node at a time resulting in less accuracy and heavy computation burden on that node. In WSN, each node has very limited power and consequently traditional tracking methods based on complex signal processing algorithm are not applicable.

Therefore, the object tracking algorithm should be designed in such a way that it result in good quality tracking with low energy consumption. The good quality tracking extends the network lifetime and achieves a high accuracy. In order to obtain an energy efficient tracking with low energy consumption, an assumption is made that all the sensor nodes have same energy level. Because, even if a sensor node fails, other sensor node can take the responsibility and carry out the tracking process.

The remainder of this paper is structured as follows: Section II discusses related work. Section III presents the proposed system, section IV discusses about the performance evaluation and conclusion remarks are given in section V.

II. RELATED WORK

In general, the tracking algorithm is mainly based on the network architecture-Tree based, Cluster based and Prediction based algorithm. Tree-based methods organize the network into a hierarchy tree. Some examples are STUN (Scalable Tracking Using Networked Sensors), DCTC (Dynamic Convoy Tree-based Collaboration) and OCO (Optimized Communication and Organization). H. T. Kung *et al.* [6] have proposed STUN where cost is assigned to each link of network graph, which is computed from the Euclidean distance between the two nodes. Construction of the tree is based on the costs. The leaf nodes are used for tracking the moving target and then sending collected data to the sink through intermediate nodes. Distance travelled by the tracking object is limited (bounded) here.

Wensheng Zhang [14] has proposed DCTC algorithm, dynamically constructs a tree for mobile target tracking and depending on the target location, a subset of nodes participate in tree construction. The tree in the DCTC is a logic tree and does reflect the physical structure of the sensor network. Sam Phu Manh Tran *et al.* Have proposed, OCO [11] is a tree-based method for target tracking that provides self organizing and routing capabilities with low computation overhead on sensor nodes. Authentication and other security features are not considered in OCO.

Li-Hsing Yen *et al.* have proposed, Mobility Profiling Using Markov Chains [7] which estimates the mobility profile (link between nodes and weight of each link) from the historical statistics. By this the problem of energy consumption for update the location information to the sink is reduced, while passing message between the sink and sensor nodes (directly). Cannot get the accurate speed and direct of the objects (random value) and up-to-date information may not be available in the sink.

Some of the examples for Cluster based tracking are RARE, Dynamic Clustering Tracking Algorithm DCTA and Adaptive Dynamic Cluster-based Tracking (ADCT). Wei-Peng Chen *et al.* have proposed, Dynamic clustering algorithm [13] for acoustic target tracking in WSNs, constructs a voronoi diagram for CHs and nearest CH to target in each interval time is the CH that the target is placed in its cell. This CH is selected as active CH. Then active CH broadcasts a packet and nodes that receive this packet reply and send the information that have sensed from target for it. Active CH, calculates current target's location and sends it to the sink. Conflict may occur when more than one CH has the same pre-determined threshold, which lead complication in CH selection.

A cluster-based algorithm for tracking proposed by Khin Thanda Soe has proposed [5] consists of three main phases, target detection, acoustic source localization and target state estimation and tracking. Olule, E. *et al.* have proposed [10] is based on two algorithms, RARE-Area (Reduced Area REporting) and RARE-Node (Reduction of Active node REdundancy). RARE-Area reduces number of nodes participating in tracking and RARE-Node reduces redundant information.

Dan Liu, Nihong Wang *et al.* have proposed, Dynamic cluster based algorithm [2] wake up or slept the sensing nodes though predicting the moving track of the target, reduce the number of tracking nodes to minimize network energy consumption. Selecting the optimal nodes to conduct the tracking task along the predicted moving track though the energy consumption of communication function will guarantee load balancing and extend the network lifetime.

Examples of prediction-based algorithm are PES (Prediction-based Energy Saving), DPR (Dual Prediction-based Reporting) and DPT (Distributed Predicted Tracking) .These methods focus on reduction of energy consumption by keeping most of nodes in sleeping mode.

Yingqi Xu *et al.* have proposed, DPR [17] ,where the next location of target is calculated at both sensor nodes and sink. When the difference between real location and predicted location is acceptable, no update message send to sink and therefore the number of packets transmitted decrease.DPR reduces the energy consumption of radio components by minimizing the number of long distance transmissions between sensor nodes and the base station with a reasonable overhead. In DPR, both the base station and sensor nodes make identical predictions about the future movements of mobile objects based on their moving history. Error in sensor detection and communication collisions in network is not recoverable.

H. Yang *et al.* have proposed, Distributed Predictive Tracking [DPT] [16], uses separate algorithms for nodes and CHs. The CH uses the target descriptor to identify target and predicts its next location. The protocol uses a clustering based approach for scalability and a prediction based tracking mechanism to provide a distributed and energy efficient solution. The protocol is robust against node or prediction failures which may result in temporary loss of the target and recovers from such scenarios quickly and with very little additional energy use. To achieve low miss rate, the DPT algorithm should be extended.

Mohammad-Taghi Abdizadeh *et al.* have proposed, Adaptive Prediction-based Tracking (APT) [9] scheme is proposed that enables tracking in the sensor network to achieve a certain level of self cognition for modifying the tracking time interval for movement patterns with acceleration, which results in significantly decreasing the network power consumption and achieving a smaller miss probability.

Guojun Wang *et al.* have proposed, Two-level cooperative and energy-efficient tracking algorithm (CET) [4] reduces energy consumption by requiring only a minimum number of sensor nodes to participate in communication, transaction, and perform sensing for target tracking in wireless sensor networks. It is expected that only the nodes adjacent to the target are responsible for observing the target to save the energy consumption and extend the network lifetime as well by using a wakeup mechanism and a face-aware routing.

III. PROPOSED SYSTEM

The proposed work is an energy efficient prediction-based method in a clustered network which consists of nodes at same energy level and range of communication. Initially the nodes are clustered using LEACH-R (LEACH- Reward) protocol in which a node is selected as a Cluster Head (CH). When a target enters the wireless sensor network, the CH that detects the target becomes active while other nodes are in sleep mode. Then the active CH selects three sensor nodes of its members for tracking in which one node is selected as Leader node. The selected nodes sense the target and current target location is calculated using trilateration algorithm.

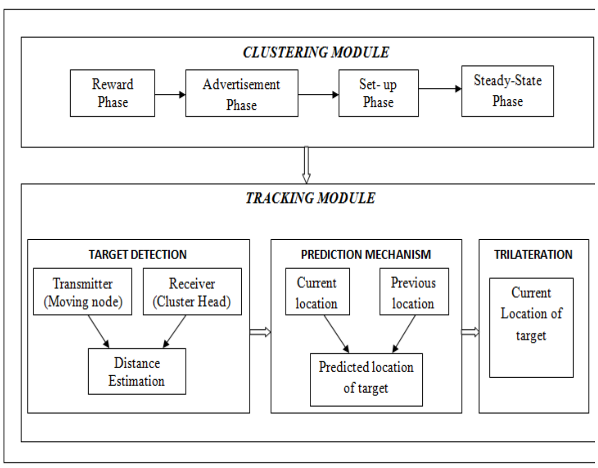

Figure 1: Architecture Diagram

In this algorithm three sensor nodes are selected each time in which two nodes calculates its distance from the moving object and sends the data to the leader node. The localization of the moving object is done by leader node whereas in previous methods it's done by CH.

Using prediction based clustering method energy consumed in the network will be reduced since the transmission power of the nodes is directly proportional to the distances. The three nodes selected for tracking are close to each other, thus the energy consumed for sending a data between the nodes is lower than sending a data from one of the selected nodes to its CH. In LEACH-R, a reward value is calculated by each CH every time in order to eliminate the cluster that has no members and thereby save the energy.

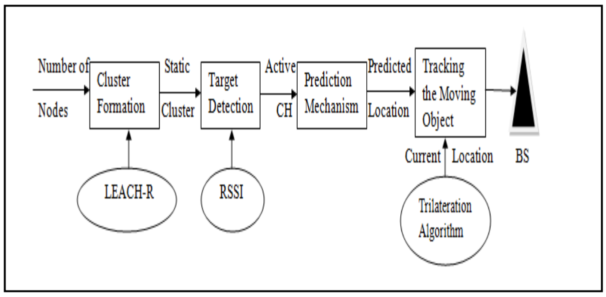

Figure 2: Block Diagram

A. Clustering Of Nodes

Clustering is a technique used to extend the lifetime of a sensor network by reducing energy consumption.The LEACH-R (Low-Energy Adaptive Clustering Hierarchy-Reward) algorithm, involves four phases are as follows

Reward Phase - Reward Calculation

Advertisement - Elections and membership

Set- up phase - Schedule creation

Steady state phase - Data flow between the nodes

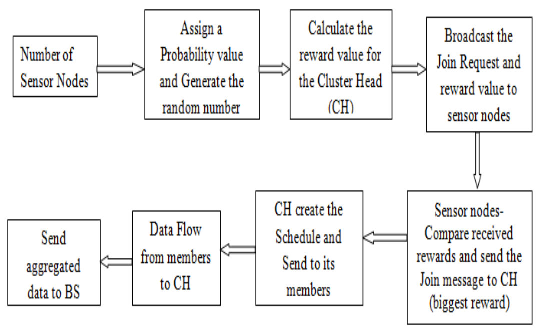

Figure 3: Flow Diagram for LEACH-R

In LEACH-R, each sensor nodes generate a random value x between 0 and 1 which is compared with the probability value P. If the x is less than P, then the node announce itself as CH and calculate its reward values as

$$Reward_i = Old\ Reward_i + Cluster\ member + Energy + Distance\ from\ BS$$

The relation consist of 4 parts, first is the old reward value assigned for the node. Second part is the members in the cluster. Third part is the energy of the node and last is the distance of the node from the BS.

While broadcasting the reward value is also sent along with the join request. The members join with the CH that has biggest reward by comparing the reward values. Then the CH creates a TDMA schedules for its members and send it to its cluster members. The data flow occurs between members and CH. In LEACH, the cluster that doesn't have members is also considered and schedule is created. By using reward value the CH that doesn't have any members is removed and energy is saved.

B. Target Detection

The target detection is done using Received Signal Strength Indicator [RSSI] method. It estimates the distance between two sensors by measuring the power of the signal transmitted from sender to receiver. Theoretically, the signal strength is inversely proportional to squared distance, and a known radio propagation model can be used to convert the signal strength into distance. The main advantage is its low cost, because most receivers are capable of estimating the received signal strength. In some cases, there may be inaccuracies of distance estimation due to noise and interference.

But, considering its low cost, it is possible that a more sophisticated and precise use of RSSI (e.g., with better transmitters) could become the most used technology of distance estimation. In the Figure3.4, a sender node sends a signal with a determined strength that fades as the signal propagates. The bigger the distance to the receiver node, the lesser the signal strength when it arrives at that node.

C. Prediction Mechanism

A prediction-based algorithm uses a prediction mechanism that predicts the next location of target is a linear prediction method. This mechanism with current and previous location of target, predicts next location of target.

Using (x_i,y_i) and (x_{i-1},y_{i-1}) ,co-ordinates of nodes i and i-1 at time t_i and t_{i-1} the target's speed *v* and the direction is calculated .The predicted location (x_{i+1},y_{i+1}) of the target after the given time *t* is calculated using the target speed and direction. If the predicted location is within the current cluster, then the active CH selects the three nodes which are nearest to the location. If the predicted location is placed out of the current cluster, active CH selects nearest CH to that location as next active CH and gives the tracking task to the new active CH.

D. Trilateration Algorithm

After receiving the distance message from two other selected nodes, the leader node calculates current location of moving object using trilateration algorithm. Trilateration algorithm forms relation between three nodes and by solving three formed relations the coordinate of target (x,y) is obtained.

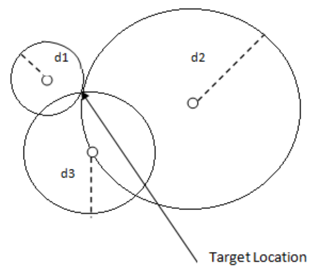

Figure 4: Trilateration Algorithm

In Lateration, the mobile nodes are localized using overlapping circles as shown in Figure 3.5. The circumference radii are equal the estimated distance among nodes.

E. Tracking Of Moving Object

In general, tracking system track the moving targets in a WSN by sensing capability of sensors (like acoustic, vision, thermal). Since sensor nodes have limited battery power and replacement of battery is impossible, energy saving is an issue in tracking process.

Input : Number of nodes

Output : Current location of the Moving Object

Steps 1 : Initially the nodes are clustered using LEACH-R.

Steps 2 : The moving object is detected by the sensor using RSSI and the CH which is close to moving object becomes the Active CH.

Steps 3 : The Active CH uses the prediction mechanism and predict the next location of the moving object as (x_{i+1},y_{i+1}).

Steps 4 : If the predicted location is within the cluster members, then the active CH selects the three nodes to calculate the current location using trilateration algorithm.

Steps 5 : Else if the predicted location is outside the current cluster, then the CH near to the predicted location becomes Active CH and Step 4 is followed.

IV. PERFORMANCE EVALUATION

A. Energy Consumption

In the proposed algorithm the energy consumed is reduced since only activated nodes in the network is involved in tracking and rest of nodes remain in standby mode. Figure 5 show the graph comparing the energy consumption before and after the proposed algorithm.

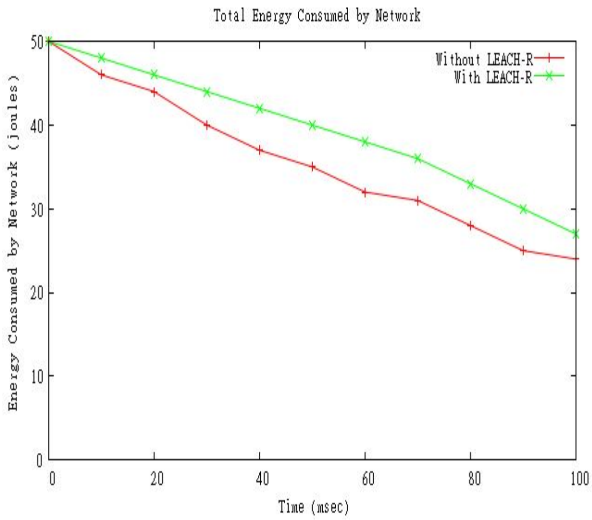

Figure 5: Energy Consumed

B. Number of Alive Nodes

The number of alive nodes decreases as the time increases. In the proposed algorithm, there is a steady decrease in the number of alive nodes.. Figure6 show the comparison by taking time versus number of live nodes as (x,y) co-ordinates.

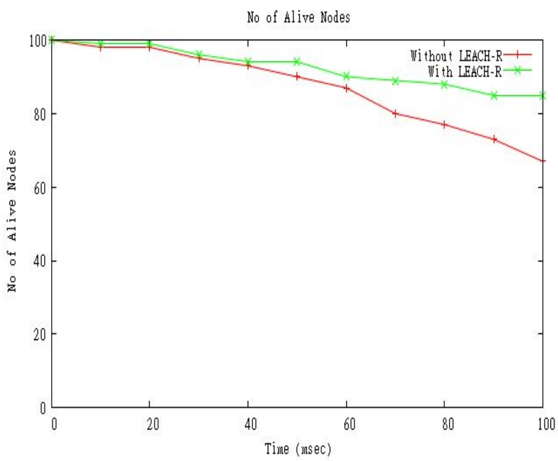

Figure 6: Number of Alive Nodes

C. Network Lifetime

The network lifetime is directly proportional to the number of nodes in the network. Figure 7 show the increase in the network lifetime as number of nodes in the increase.

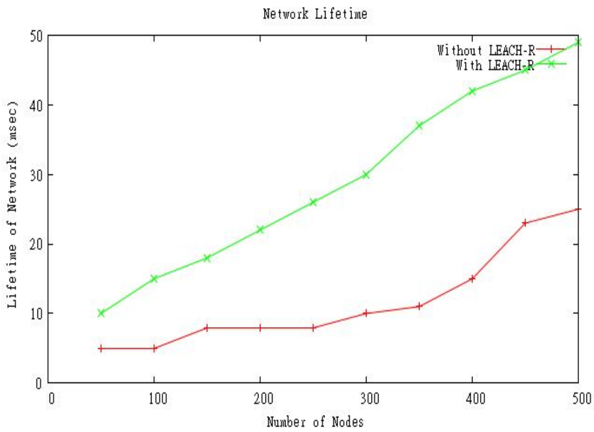

Figure 7 : Network Lifetime

V. CONCLUSION

In this paper, a system is developed in such a way that target tracking in WSN is done in efficient way using an energy efficient prediction- based clustering algorithm. Energy efficient prediction-based Clustering algorithm, reduces the average energy consumed by sensor nodes and thereby increase the lifetime of the network. The tracking of the moving object is accurately done.

Future Work:

As a future enhancement, the tracking algorithm can be extended for multiple targets by forming dynamic clustering. Dynamic cluster reduces overlapping between the inter-clusters and also avoid duplication and unwanted transmission of data. By this method, the tracking accuracy is increased and reduces energy consumed in the network. Then the received data can be analysed and visualized using an effective visualization tool.

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