Cluster-based Target Tracking and Recovery Algorithm in Wireless Sensor Network

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Abstract- **From the various issues related to WSN, energy efficiency is considered as one of the important issue. For one of the most killer application such as object tracking where the continuous reporting of object is required consumes more energy of network. As well, recovery mechanism has to be run to locate the target exact position in case of object loss. In this work we are proposing energy and time conserving recovery technique.**

Keywords- Clustering; Dynamic clustering; Prediction; Target tracking; Target recovery; Wireless sensor network;

I. INTRODUCTION

The fast evolutions in wireless sensor network, it is potential to implement the wireless sensor network technology (WSNs) in different in several eventualities. Such WSNs is collection of thousands of little coordinating device known as sensor nodes deployed in a in a very physical environment for sensing various events such as speed, light, temperature etc. A wireless sensor nodes are square measure battery operated. Such sensor node carries restricted and customarily irreplaceable battery power sources. Therefore, the first of WSNs must on power conservation. Due to such limitations, Sensor nodes might ends up into energy depletion and network failure. Therefore, to save energy it is very important for WSN to operate energy efficiently.

In vast number of WSN applications, target tracking is one in all-important application [1]. The sensors nodes in the vicinity (area) of an incident should be able to continuously monitor it and report to the sink. A various traditional target-tracking techniques for Wireless Sensor Networks use a centralized approach. In traditional target tracking strategies, one node at a time typically performs sensing by resulting in heavy computation burden, less accuracy and additional energy consumption wherever WSNs every node has terribly restricted power. Even if the more than one node performs sensing and node fails due to battery drainage then target can not detected. Hence, next predicted nodes that were purported to be active for tracking target might not have the trace of target, inflicting loss of target.

In this paper, we have a tendency to propose energy efficient and quick recovery mechanism (RM) to recover the lost target throughout tracking exploitation using dynamic clustered network.

Rest contents of the paper are organized as follows:

- Section II: Related works of existing cluster- based tracking techniques and recovery mechanisms.
- Section III: Challenges in recovery mechanism
- Section IV: Network scenario
- Section V: Target tracking
- Section VI: Proposed recovery technique
- Section VII: Conclusion

II. RELATED WORKS

Wireless Sensor Network implementation has several design challenges such as limited energy, communication failure, deployment, network lifetime, accuracy and secure communication etc. Dividing the network into groups of node as a cluster can considered as a solution to handle these challenges [2]. The light source, based tracking for terrain observation during night using clusters is mentioned in [3].

DELTA is one of the distributive algorithm which tracks the article solely only at constant speed by dynamic clustering and selection of Cluster Head based on light measurement. The advantage of DELTA is that the communication range of the sensor is higher than their sensing range. However, the main dispute of this method is that it can deal with constant speed only, and varying speed is not considered.

Energy efficient approach, RARE [4] reduces the quantity of node involving in tracking. It consists of two sub algorithms, first is RARE-Area that ensures nodes with qualitative received data, and second is RARE-Node that reduces the unnecessary nodes participating in target tracking. For multiple moving targets tracking, a tree-based approach STUN considers leaf nodes to track the targets as presented in [5]. Low-Energy Adaptive Clustering Hierarchy [6] reduces the energy consumption of every node.

In LEACH, sensor network divided into small components is known as clusters and selects one in all as cluster-head.

LEACH uses random selection and rotation of the cluster-heads to distribute randomly the energy consumption within the network. LEACH performance can be divided into two parts first is Setup phase and another second is Steady phase. Within the setup phase clusters network will formed and a cluster head is selected for every cluster. In the second phase, data is sensed and is sent to the central base station. As nodes are depleted of energy, all the approaches of WSN ought to have less communication between one another to conserve energy. Many tracking algorithms have already been developed [7]-[9].

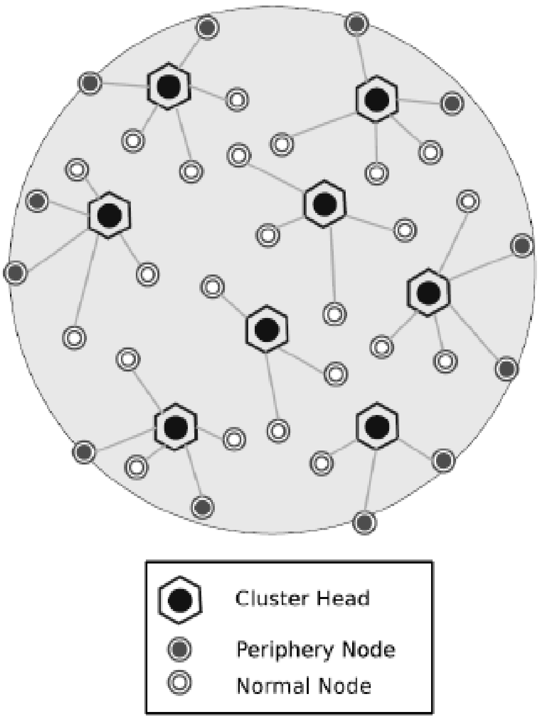

Figure 1 Cluster- Based Sensor Network Architecture for Target Tracking [10]

Recovery mechanism for target recovery using static clustered (as in figure 1) WSN is mentioned in [10], which is consists of four phases: (a) loss of target – when target's current location is not known, current CH declares target is lost and recovery mechanism is initiated, (b) search – current CH waits for some time to receive acknowledgement from downstream that is. From next single hop clusters to reduce the chances of false initiation of recovery algorithm, (c) active recovery – this phase consists of three levels throughout recovery (d) sleep – once target is found, clusters that square measure taking part presently in tracking stay awake and remainder of them move to sleep state. However, RM presented in [10] requires large number of nodes to be in active state throughout recovery.

In this paper, we are proposing a dynamic clustered WSN that provides energy efficient recovery approach that ends up with less communication overhead and less number of active CHs for successful recovery. Multi-hop, multi-cluster network architecture for wireless domains should be able to configure itself dynamically with the changing network. Mostly, the cluster heads are performs formation of clusters and maintenance of the configuration of the network. A cluster head provides resource allocation to all its members. The dynamic nature of any target or mobile nodes, their connection or disconnection to and from clusters disturbs the *stability* of the network. Hence, cluster heads reconfiguration is necessary. Rather than waking up all single hop clusters [10] or all double hop clusters during recovery, this approach will find single or double hop clusters nearest to target's next predicted location for saving time and energy of network.

III. CHALLENGES IN RECOVERY MECHANISM

Sometimes network fails to trace the target's trajectory accurately attributable to several reasons as follows:

1. Node Failures
2. Network Failure
3. Deployment
4. Localization Errors
5. Synchronization
6. Data Aggregation
7. Data Dissemination
8. Prediction Errors
9. Uncertain change in target's velocity/direction
10. Hardware malfunction

1. Node Failures:

Sensor nodes are battery operated and generally irreplaceable. So, even single node failure causes network failure.

2. Network Failure:

The failure of network occurs due to communication breaks, overload of data, physical disasters etc.

3. Deployment:

Setting up an executive sensor network in a real time or real world environment [11] is a Deployment. Sensor nodes can be deployed either by placing them sequentially in a sensor field or at random by dropping it from height. Various deployment issues are [12, 13]:

3.1. Node dies due to either by normal battery discharge or due to short circuits.

3.2. Network congestion occurs due to many parallel data transmissions made by several sensor nodes simultaneously. So that even if the two nodes may very close to each other but still each one can not communicate due to physical interference in the real world instead nodes that are far away from each other may communicate.

3.3. Low data yield is also one of the common problems in deployment. Low data yield occurs when network delivers insufficient amount of information.

3.4. Self-Configured sensor networks is needed due to random or distributed deployment of sensor nodes in real world environment without human participation.

4. Localization Errors:

When target enters into the area of interest of sensing nodes, distance between target and nodes can calculate by them. These distances help during localization of target. Hence, the larger difference between calculated distance and actual distance will result in localization error.

5. Synchronization:

For real time data collection, the clock synchronization is an important in sensor networks. Time Synchronization supports to maintain events synchronization between nodes in the network by providing common time scale for local clocks of nodes in the network. Global clock synchronization also require for some applications are navigation guidance, environment monitoring, vehicle tracking etc.

In sensor network, need to properly coordinate and collaborate to perform a complex task such as data fusion in which the data collected from number of sensor nodes and aggregated to generate a meaningful result. Lack of synchronization between sensor nodes then results into the inaccurate data estimation.

6. Data Aggregation:

The main objective of the sensors nodes is to periodically sense the data from the surrounding environment process it and transmit it to the sink or base station. Thus, a method for combining the sensed data into accurate and high quality information is required and this is accomplished through Data Aggregation.

Data Aggregation is the process of collecting or aggregating data from multiple sensors and estimating the desired output by eliminating the redundant data and then providing fused information to the base station. Therefore, there are some issues for data aggregation as to obtain complete and up to date information from neighboring nodes, improving clustering techniques for data gathering, eliminating redundant data transmission etc.

7. Data Dissemination:

To obtain required data, the queries for the data routed from node to node in the sensor network. Data dissemination is a two step process. In which initially node broadcasts its interests to its neighbors periodically and then through the whole sensor network. In the second step, the nodes having requested data will reply back to the source node with data.

The key difference between data aggregation and data dissemination is that, in data dissemination, all the nodes even the base station also can request for the data but in data aggregation periodic data transition of the aggregated data will occur is to the base station.

8. Prediction Errors:

To save the energy, not all clusters should be awake all time. In such condition, advanced warning message should be generated by operating cluster heads for its upstream and downstream cluster heads. To do so current CH need to predict future location of target. In this prediction process, minor errors can lead to target loss, since the target's trajectory may be lost due to a cluster not being woken up in advance.

9. Uncertain change in target's velocity/direction:

Sudden change in target trajectory may not be handles by monitoring nodes and prediction errors will generate. Some of the applications such as military require reliable and credible target tracking. To overcome such problems quick, time saving and energy efficient recovery mechanisms needed.

10. Hardware malfunction [15]:

Another attribute leads to a lost of target is the inbuilt hardware parts of sensor node which may causes malfunction or the battery is weakening. In such conditions, routine maintenance checks must be providing to confirm the integrity of the system that is not possible.

IV. NETWORK SCENARIO

Overall architectural model for target-tracking system is shown in Figure 1, wherever the fundamental components are sensor nodes, that are deployed initially. Once moving target comes into the vicinity of boundary node, boundary sensor nodes initiates the continuous sensing.

The target-tracking algorithm initiates tracking of target. The energy saving operations performs by maintaining various states by sensor nodes. Dynamic clustering algorithm also applied for power consumption. Finally, the tracking information from every node further sent to the other user nodes. The proposed strategy for target tracking and recovery in wireless sensor networks there are various modules. The detailed explanation of every module is as follows.

The proposed technique assumes the following properties for network modeling.

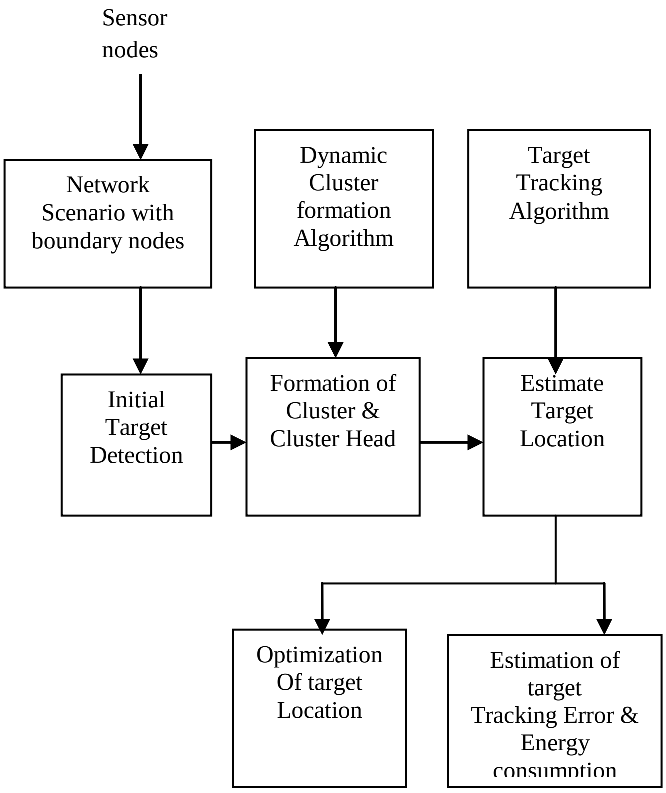

Figure 2. Architecture of target tracking system

1. The sensor nodes are limited energy and stationary.
2. All sensor nodes are having constrained energy with a uniform initial energy.
3. Boundary nodes get selected as per boundary node selection procedure [14].
4. Cluster head selection will be depending on energy level of sensor and average energy level of network.
5. The sink node is located some where in the network for data collection from every cluster-head.
6. Continuous data delivery assumed for network.
7. Dynamic cluster heads selection will perform based on the remaining energy level of every sensor node and entire sensor networks. Every sensor node sends their energy information to the base station.

V. TARGET TRACKING

Tracking algorithm [10] for target performs two steps:

i. Localization

ii. Prediction

1) Localization: Boundary nodes exchange their information with one another to identify the nodes who also have detected the target. Such three nodes found then trilateration mechanism is initiated. Otherwise, wake message send by boundary nodes to its single hop neighbors to perform localization. The boundary node nearest to target sends this information to CH to perform prediction.

2) Prediction: The next predicted location of target depends on current and previous locations of target. Predictions are going to be performed by Current CH as follows:

• Predict target's next location.
• Find member nodes in the area of predicted location.
• Node nearest to target's predicted location will wake up only. If no node is present in the vicinity, then only single hop CH wake up, this will become current CH for further tracking.

VI. PROPOSED RECOVERY TECHNIQUE

In the clustered based tracking network, CH is itself accountable to predict next location of target and establish various next CH to handle further tracking process. In static cluster based network, probability of CH failure is more than the failure of local (member) nodes as it because of communication overhead. The proposed recovery mechanism follows three steps (Figure 3 shows flowchart of tracking and recovery):

1. Announcement of lost of target
2. Recovery
3. Sleep

1) Announcement of lost of target: As continuous target moves far from current cluster, current Cluster Head sends warning massage to wake up to the next predicted or selected CH. If CH is failed due to any of the reason such as Node Failures, Network Failure, Localization Error or Prediction Errors, then no acknowledgement will receive by current CH from selected CH. Current CH waits for acknowledgement for some period and finally target lost situation can be announced by current CH. This step is same as described in [10].

2) Recovery: As loss of target occurs, current CH initiates true recovery process immediately. Detail of recovery method is as given below:

Synonyms:
NL: Next locations of target
PL: Predicted locations
SCH: Single hop CH

Steps:
Current CH:
1. Wake up all member nodes.

2. Predict few NL based on previous PL.

3. As CH has information about its SCHs, it finds one of them that is not fail and nearest to NL.

4. Wake up this SCH.

5. If (any of NL is in vicinity of selected SCH) Selected SCH:
   a. Wake up all member nodes.
   b. Become current CH.

c. Locate target using trilateration and start tracking.
d. Send acknowledgement to current CH.
Else
a. Make selected SCH as current CH temporarily.
b. Follow step 1-5 until the target will recover.

3) Sleep: Once target recovered, only currently tracking nodes stay active and remaining will go in sleep mode, same as in [10].

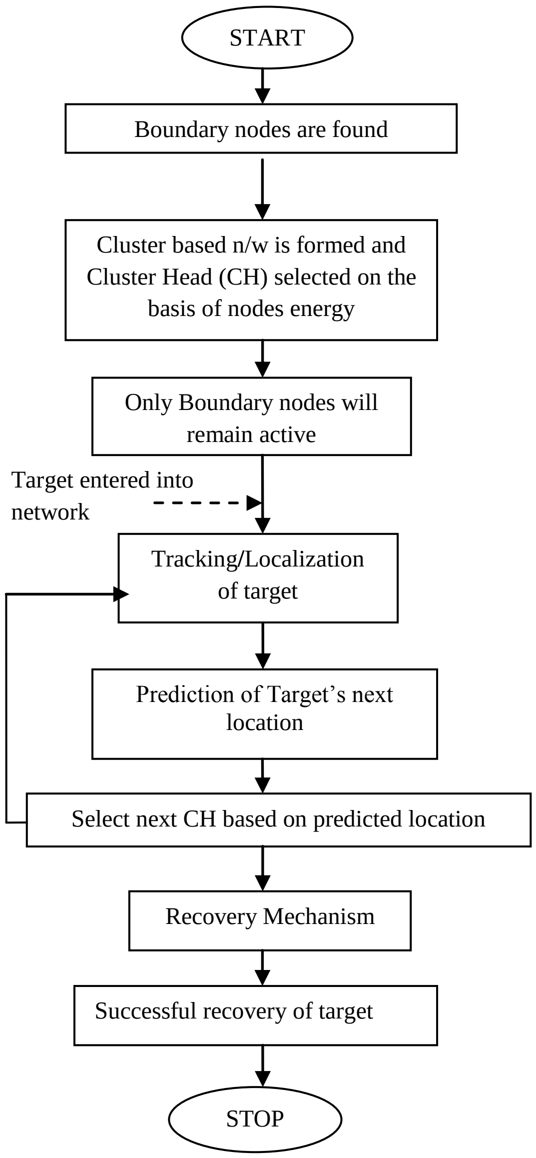

Figure 3: Target Tracking and Recovery Flowchart

VII. CONCLUSION

This paper focused on the various problems of loss of target trajectory in a target tracking wireless sensor network. For WSNs to be used effectively and reliably, by considering energy and time saving issue for target tracking, quick and additional correct recovery mechanisms has been given in this paper.

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