Cluster-based Tracking and Discovery of Target in Wireless Sensor Network

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Abstract: Energy potency is one of the vital issues amongst various issues associated with wireless sensor network. For one in every of the foremost killer application like object tracking, where the object consumes more energy for continuous reporting in network. Furthermore, recovery mechanism must be run to find the target actual position just in case of object loss. In this paper, we tend to square measure proposing an energy efficient and quick recovery mechanism.

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

1. INTRODUCTION

The fast evolutions in wireless detector network, it is potential to implement the wireless detector (sensor) network technology (WSNs) in numerous eventualities. Such WSN holds thousands of very little coordinating device called sensor/detector nodes deployed in a respective physical surroundings for sensing varied events like speed, light, temperature etc. A wireless detector nodes square measure unit of measurement battery operated. Such detector node carries restricted and typically irreplaceable battery power sources. Therefore, the primary of WSNs should on power conservation. In such situation, detector nodes may finishes up into energy depletion and network failure. Therefore, to save lots of energy it is important for WSN to work energy expeditiously. In huge range of WSN applications, target following is one altogether vital application [1]. The sensors nodes within the vicinity (area) of an incidence ought to be ready to unendingly monitor it and report to the sink. A varied ancient target following techniques for Wireless sensor networks use a centralized approach. In ancient target following methods, one node at a time usually performs sensing by leading to significant computation burden, less accuracy and extra energy consumption where WSNs each node has really restricted power. However, the quite one node performs sensing and node fails attributable to battery emptying then target cannot detected. Hence, next foretold nodes that were imagined to move for tracking target will not have the trace of target, inflicting loss of target. During this paper, we have got an inclination to propose energy economical and fast recovery mechanism (RM) to recover the lost target throughout tracking exploitation mis-treatment Clustered network.

Rest of the contents of the paper is 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: Simulation Results
- Section VII: Conclusion and Future Scope

2. 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 known as clusters and selects one in all as cluster- head. LEACH uses random selection and rotation of the cluster-heads to randomly distribute 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 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].

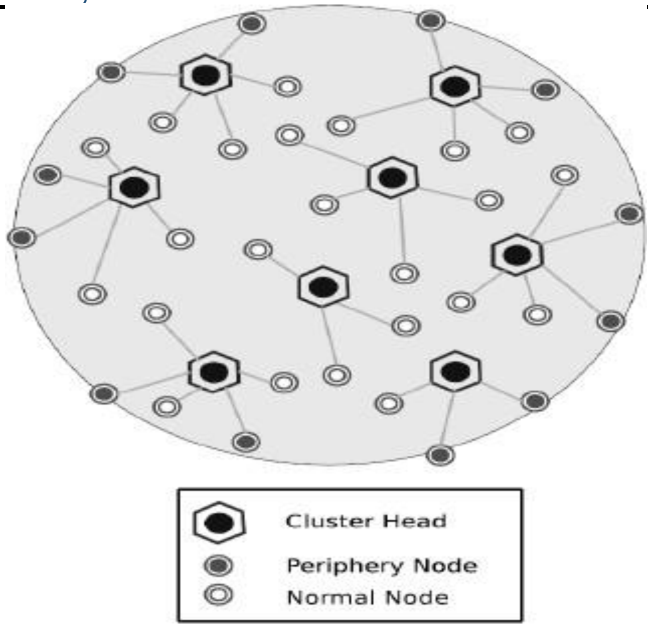

Figure 1Cluster- Based Sensor Network Architecture for Target Tracking [10]

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.

3. 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. Prediction Errors
7. Uncertain change in target's velocity/direction

1. Node Failures:

Sensor junctions are electric cell worked and ordinarily irreplaceable. In this way, even single junction inadequacy causes system failure.

2. Network Failure:

The inadequacy of system happens because of conveyance breaks, over-burden of information, physical disasters and so on.

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:

The point when target enters into the sensing range of junctions (nodes), difference between target and junctions can compute by them. These differences assist throughout confinement of target. Hence, the bigger distinction between computed distance and real distance will result in localization error.

5. Synchronization:

For real time knowledge assortment, the clock synchronization is a vital in sensing element networks. Time Synchronization supports to keep up events synchronization between nodes within the network by providing common measure scale for native clocks of nodes within the network. **C**lock synchronization additionally need for a few applications square measure navigation steering, setting watching, vehicle pursuit etc. In sensing element network, have to be compelled to properly coordinate and collaborate to perform task like knowledge fusion within which the information collected from variety of sensing element nodes and aggregate to get a meanin**g** result. Lack of synchronization between sensing element nodes then results into the wrong knowledge estimation.

6. Prediction Errors:

For energy conservation, no clusters should be awake all the time. In such situation, current cluster head for its upstream and downstream cluster heads should spread out advanced intimation message. Therefore, that current CH need to predict future location of target and forward it to next cluster. In this prediction process, if a cluster not being woken up in advance, the target's trajectory may be lost.

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

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

4. NETWORK SCENARIO

Overall architectural model for target-tracking system as 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.

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 [11].
4. Cluster head selection will be depending on energy level of sensor and average energy level of network.
5. The sink node is located somewhere in the network for data collection from every cluster-head.
6. Continuous data delivery assumed for network.

5. 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 if found, then trilateration mechanism 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.

6. 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 2 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 current CH. can announce target lost situation. 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:

Steps:

Current CH:

1. Current monitoring cluster head wake up all its member nodes.
2. Current monitoring cluster head predict few nearest location based on previous location.
3. As current cluster head has information about its all single hop cluster heads, out of them, cluster head finds one that is not fail and nearest to next predicted location.
4. Current CH wake up this predicted CH.
5. If (any of predicted location is in range of selected SCH) then Selected next CH:
    - Wake up all member nodes.
    - Temporary become current CH.
    - Localize target, using trilateration and tracking will initiate.
    - Send acknowledgement to current CH.

    - Else
        - Make selected SCH as current CH temporarily.
        - Follow step 1-5 until the target will recover.

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

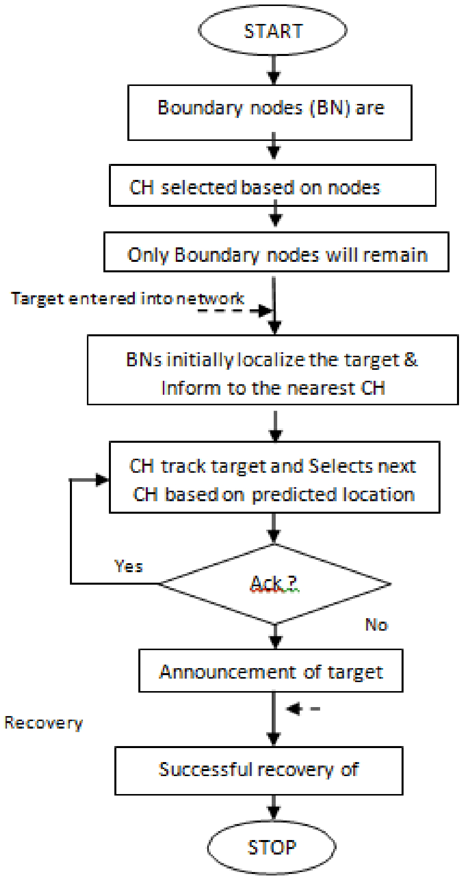

Figure 2: Target Tracking and Recovery Flowchart

7. SIMULATION RESULTS

To study Simulation based results of proposed recovery mechanism, VB .NET is used. In scenario, a cluster-based wireless sensor network consists of 120 nodes with radio range of 15 meter. Nodes are deployed in 1024X764 square meters field. The numbers of cluster heads are 9 and each has varying number of member nodes. This network has 50 boundary nodes active all time. Target is moving with constant velocity in random motion. Here, target enters the network from location (10, 200) and leaves at location (1020, 0). Cluster head will be selected depend on energy level and degree of nodes.

Parameters	Values
Number of nodes	120
Scenario Area	1024x764 sq. meter
Routing protocol	AODV
Radio Range	15 m
Initial Energy	100 J
Data packet size	500bytes
Data rate	2mbps

Table1. Simulation Scenario And Parameters

8. Recovery of Lost Target Track:

In wireless sensor network, target loss situation occurs mainly due to communication failure, node failure or due to sudden change in speed of target. This section presents the performance of the target recovery algorithm. Target entered into network at 3 sec and moves at a speed of 15 m/s in a zig- zag fashion.

1. Communication Failure:

Due to communication failure between cluster head, it is possible that prediction messages will not reach the concerned cluster head. As a result, the cluster is not woken up and the target's trajectory can be lost. Hence, the concerned cluster head initiates target recovery after a timeout interval. Figure 3 shows target recovery where two clusters could not be woken up due to network traffic. The target is lost at 16.43 s and recovered at 25.43 s. The target is again lost at 44.10 s and later recovered at 49.92 s.

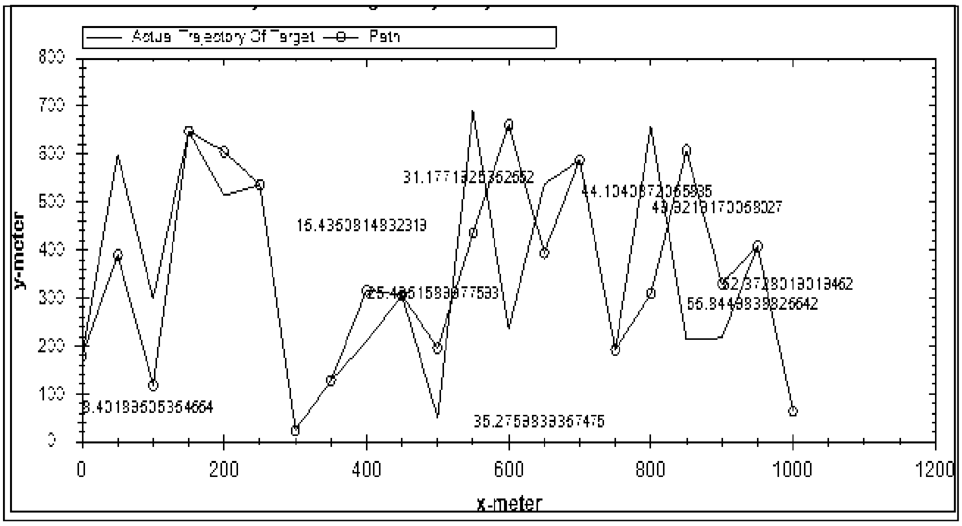

Figure 3: Recovery of lost target trajectory due to communication failure

2. Node Failure:

Node failure is a major reason for the loss of target trajectory. The nodes that can fail are normal nodes and cluster heads. Boundary nodes are assumed to not fail since these are needed for “boundary awareness”. Figure 4 shows the trajectory and the times at which it is lost and recovered. For instance, the target is lost at 16 seconds, recovered at 21 seconds; then lost and recovered again at 27 seconds.

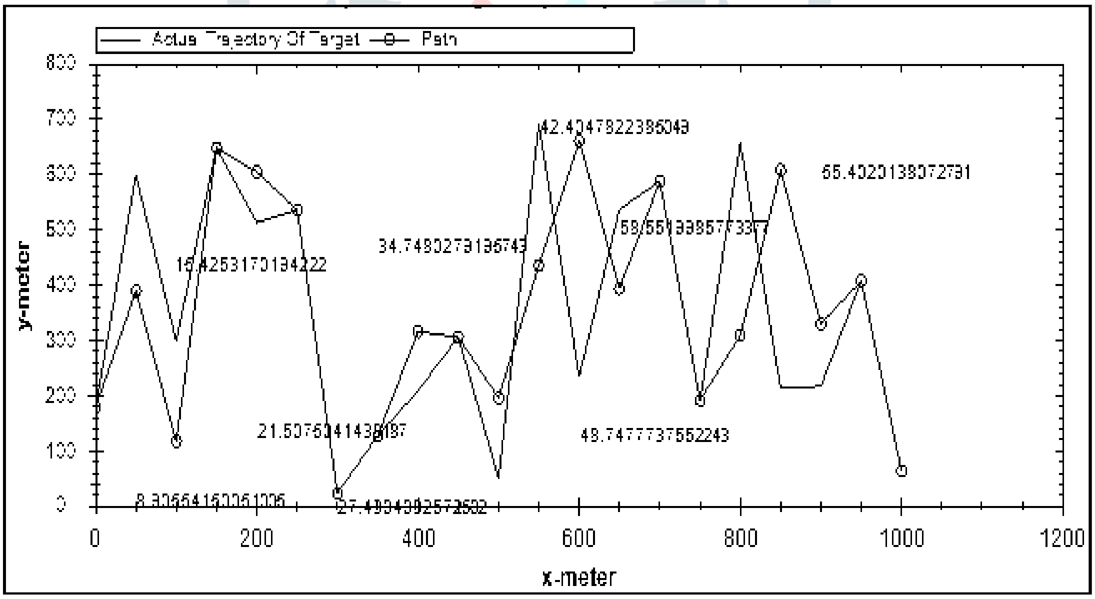

Figure 4: Recovery of lost target trajectory due to Node failure

3. Sudden change in speed of target:

The predicted position can be incorrect due to sudden change in direction and velocity of the target. This causes loss of target and recovery mechanisms are initiated. As shown in figure 5, the target was lost at 21.55 sec and recovered at 26.62 sec, with a recovery time of 5 second.

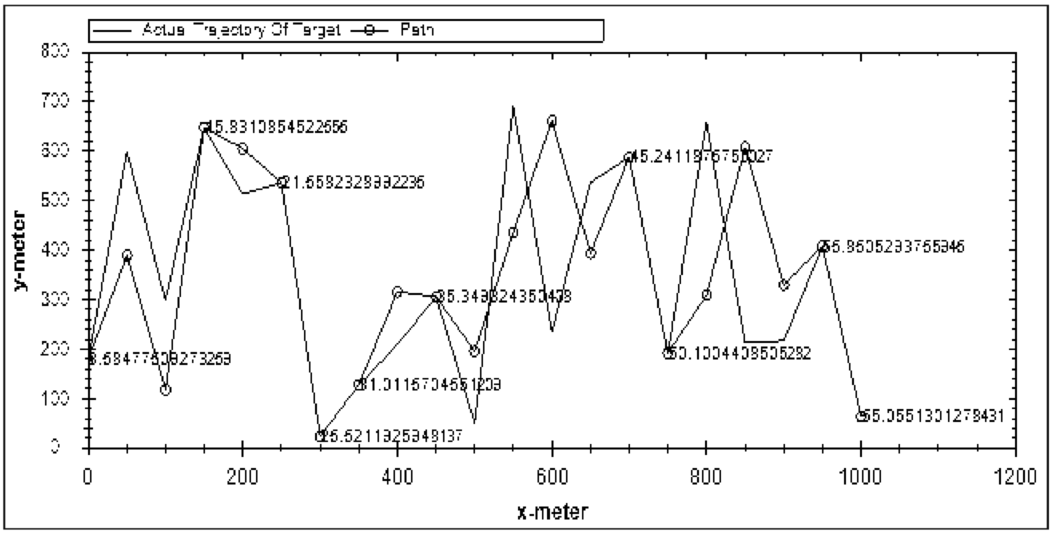

Figure 5: Recovery of lost target trajectory due to changing speed

Experimental simulation in figure 6 shows graphical analysis of energy consumed by network in case of target tracking, target loss and recovery of loss target by using proposed and existing clustering and tracking algorithms.

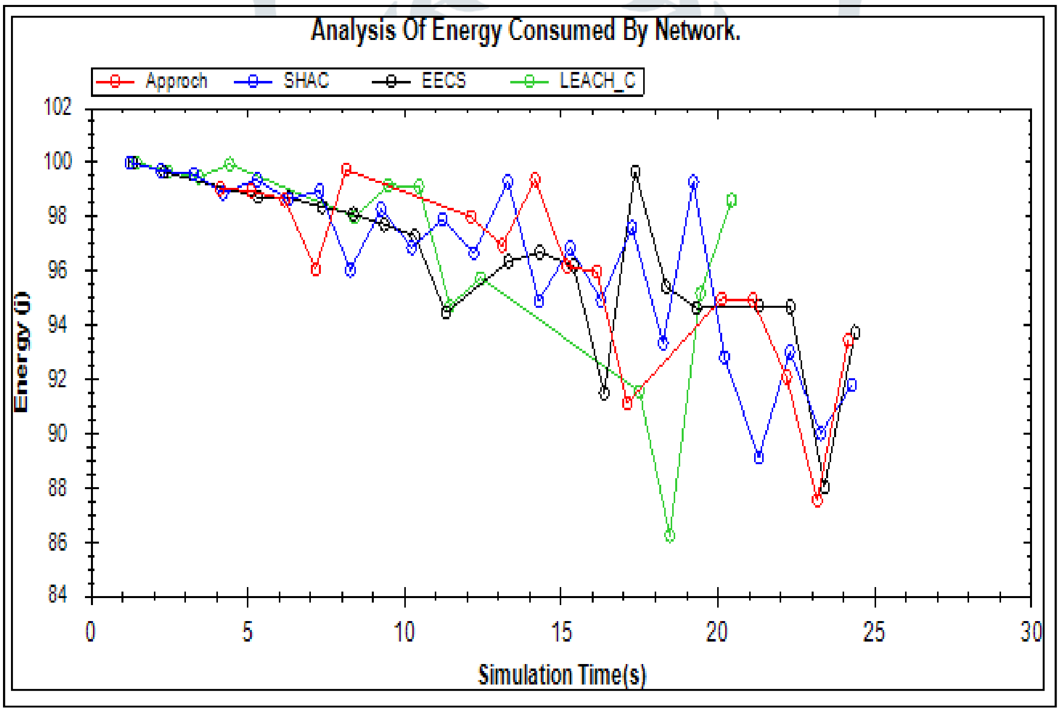

Figure 6: Energy consumed by network

8. CONCLUSION AND FUTURE SCOPE

Proposed target tracking and recovery technique is handling the problem of target loss situation in wireless sensor network. It is evident from results and comparison that the proposed approach is efficient in terms of time and energy because at different time, proposed tracking and recovery technique consumes less energy as compared to other as well recovery time is fast as compared to existing technique. A tracking and recovery mechanism is prediction based and evaluated using simulation experiments. The result shows the comparative analysis of energy consumption with other techniques like LEACH, SHAC etc. and recovery time due various situations of target loss. Proposed work extends lifetime of a network by 5%.

As working with this technique, recovery time to recover lost target is not sufficient. In future research we will focus on improving recovery time for lost target, which can discover target in much less time. In addition, we will work on having more than one base station for multiple moving target tracking and recovery for same algorithm.

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