Abstract—Wireless sensor networks encompasses a wide range of applications which not only covers a strong infrastructure of communication but also highlights the broader aspects of security, surveillance, military, health care and environmental monitoring. Among these applications of wireless sensor networks target tracking is very essential which is installed in the required areas of surveillance for tracking any attacker/intruder and habitat monitoring. Bandwidth and power consumptions are the two inevitable constraints for meeting the demand of localization and energy levels. This paper focuses on target tracking in WSNs using clustering and prediction based protocol. Base station acts as the cluster formation manager and indicates when the moving target is witnessed.

Index Terms—Target tracking, intruder/attacker, clustering, prediction.

I. INTRODUCTION

Wireless sensor network is an assembly of special transducers with a capability of communication as well as monitoring and recording conditions at diverse locations. These multiple detection stations are called sensor nodes, each equipped with a sensor, transceiver and a power source. On the basis of sensed circumstances around, this specialized sensor is believed to act as electrical signal generator which entirely depends upon physical effects encountered. These sensors communicate via radio waves and differs from place to place from hundred to hundreds of thousands based on the requirement of the environment. Sensors deployed have small size, limited energy and low memory.

One of the most tremendous and vital applications of WSNs is target tracking that is very important issue with a wide spectrum of research and several applications. The concept is simple i.e. any moving target whether a person, vehicle or object can be tracked traversing in a WSNs with sensing capability of sensor nodes. Location and position of the moving object is constantly recorded, studied and compared each time unit with some reference point in order to declare the exact position and location of the target. It is similar to a feedback loop where a constant comparison is done between input and output. Therefore, it can be concluded that two critical tasks are involved in the object tracking management:

1) continuous supervision and 2) broadcasting, where continuous supervision is the monitoring of sensor nodes to keep a track of moving objects while broadcasting means to report that a moving object is detected to the relevant application running.

Clustering and prediction based protocols are presented in this paper, where the two critical parameters are distance and energy. In addition to these two parameters, the involvement of base station gives the true sense of tracking an intruder or a moving object in WSNs. Base station manages the prediction and clustering formation therefore it has maximum information about energy levels of each node in the network.

II. RELATED WORK

WSNs can be categorized under two main headings i.e. hierarchical and peer-to-peer. Inside hierarchical network, a mesh oriented multi hop radio based connectivity among or between wireless nodes is employed. This is shown in Fig. 1.

In this network the nodes of level 1 are backbone nodes while the nodes of level 2 are sensor nodes. Any event in the vicinity of the nodes can be detected as well as reported to the sink by the nodes, and the sink can further communicate to the outside world such as laptop, mobile etc.

The second category is peer to peer network in which, instead of a mesh based multi-hop radio connectivity there is flat single-hop radio connectivity among or between wireless nodes is deployed. This is shown in Figure 2.

Peer to peer or point to point network uses static routing on wireless networks. Every node is only able to communicate with its neighboring nodes and information can be exchanged between neighbors.
Hierarchical network can be further classified into four schemes as shown in Figure 3. These are Naïve activation based tracking, tree based tracking, cluster based tracking and hybrid approaches [1]. In Naïve activation based tracking scheme, every node of the network is in tracking mode all the time [6]. Each node sends its measured position of the target to the base station which further calculates and predicts the accurate position of the target on the basis of received information. This strategy is the simplest and offers best tracking results but has worst energy consumption as all the nodes are in tracking mode simultaneously, therefore reflects heavy computation and burden on base station. So this approach is not robust in case of link failure as well as in channel congestion scenario.

In tree based tracking protocols, the nodes in the network can be organized as a graph in which the vertices can be considered the nodes and the edges can be viewed as the connections, which indicate the communication between nodes in the network. Scalable Tracking Using Networked sensors (STUN) [2], [3] and Dynamic Convoy Tree-Based Collaboration (DCTC) [4] protocols are tree-based tracking approaches. In these schemes in addiction to nodes and vertices, a cost is also assigned to each communication. Leaf nodes are used for mobile target tracking and transmission of the collected data. Nodes then, send the information to sink through intermediate nodes.

Cluster based tracking approaches provides not only scalability in networks in both terms i.e. addition or removal of nodes but also it helps in better bandwidth usage. Wireless sensor networks divide the nodes into several clusters each having a boss or cluster head which is elected randomly or on specific criteria. Each cluster head is responsible for collecting data from the nodes in its cluster and send it to the base station. Cluster based tracking can be categorized into further three types: i) Static Clustering, ii) Dynamic Clustering, and iii) Space Time Clustering.

In static clustering, clusters are formed at the time of network formation. The size of cluster, area it covers as well as the members under one cluster remains constant throughout the network. This simple approach has many drawbacks, such as it is not fault tolerant and any failure of cluster head renders all the nodes in the network useless. Due to the fixed parameters, this approach does not work well in the dynamic environment where a node is needed to be in awake mode or sleep mode [9].

Dynamic clustering is useful in several ways. Formation of clusters is purely conditional on the events happening in the surroundings [10]. Sensors which are near the active cluster heads are invited to become members of the cluster and respond to the cluster head. In this approach, nodes can belong to different clusters at different times. As, only one cluster is activated on the basis of maximum probability in vicinity of a target. Therefore, the contention at MAC level is completely mitigated and redundant data is suppressed. Information driven sensor querying (IDSQ) [11], is one of the examples of dynamic clustering. Space time clustering is the third type of clustering technique in WSNs. [12] proposed this architecture in which clusters of space time neighboring nodes are organized dynamically and the information is propagated around on the basis of local messages in the space time cluster. Cluster head estimates the track of the target by this collected data.

The infrastructure of hybrid methods relies on more than one type of target tracking schemes. Distributed predictive tracking (DPT) and Hierarchical prediction strategy (HPS) are the examples of hybrid methods. In DPT the issue of scalability is resolved using clustering based protocol and prediction based method is adopted for efficient energy solution [7]. In HPS, a cluster is formed using Voronoi division and next location to be targeted is predicted using least square method [8].

Peer to peer networks as shown in Figure 3 can be classified into two classes which are: embedded filter based consensus and Alternating-direction based consensus. The first technique is a two steps method in which every time on exchanging the information among nodes an update step is resided. In a nutshell, each step of the algorithm comprises an exchange of information exchange and update process. Gaussian random parameters for decentralized estimation was established in [13] by Delouille et al for stationary environments and dynamic case was considered in [14] by Spanos. The second method of peer to peer networks is Alternating-Direction based consensus; in this technique simplicity and flexibility is confirmed due to the presence of single hop communications among sensors. The algorithm makes sure that the mean

![Figure 2: Peer To Peer Network](image)

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<tr>
<th>Target Tracking</th>
<th>Hierarchical</th>
<th>Peer to Peer</th>
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<tbody>
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<td>- Naïve activation</td>
<td>- Embedded filter based</td>
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<td>- Tree based tracking</td>
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![Figure 3: Categories of Target Tracking in WSNs](image)
square error is minimized. A degree of parallelization is achieved in alternating-direction based consensus. Sensor failure is handled by using a subset of “bridge” sensors, as described in [15-18].

III. Problem Statement
The main short coming of previous algorithms is that what if a target is there but it is missed by the nodes, i.e. target is lost due to several reasons. This paper designs a target recovery mechanism when a target is missed. Figure 4 shows the block diagram of steps involved in the target tracking algorithm.

IV. Methodology
This paper proposed a smart mechanism for target detection, prediction and recovery of a node is done using efficient energy clustering protocol.

A. Clustering
The main concept of clustering is to group the sensor nodes and collect information from neighboring nodes and send it to the base station. Information may include monitored environment or intruder tracking or an atmosphere where human access is not easily possible. Usually base station is outside the field area, which process the acquired data and reports to the user.

There are number of protocols for clustering having different pros and cons. This paper suggests the most energy efficient protocol known as LEACH (low energy adaptive clustering hierarchy) as proposed in [16]. This is TDMA (time division multiple access) MAC protocol which is designed for clustering in wireless sensor networks. The main focus of LEACH is pro-long the life span of a network by making it efficient in energy consumption. It is hierarchical protocol in which the sensor nodes collaborate or respond to cluster head and then it is the responsibility of the cluster head to further transmit the data to the base station. In every iteration of the protocol, there is a kind of polling mechanism in which each node waits and determines whether it will become the next cluster head or not. Nodes except cluster heads communicate via cluster heads in TDMA fashion. LEACH is an iterative process, in which each round begins with a set up phase, then the clusters are organized and nodes inform the specific cluster head to which head they belong then comes the data transmission phase where TDMA is used to exchange information between heads [17-20].

B. Target Detected
Target is detected using Received Signal Strength Indicator (RSSI). It calculates the distance between two sensors by measuring the power transmitted from sender to receiver. It is logarithmic ratio of power of received signal and reference power. It is known that power dissipates from a point source when it moves further and has inverse relation with distance, therefore, distance can be easily computed using this relationship. The main advantage of RSSI is low computational cost because most receivers are capable of estimating the received signal strength. Although in some cases inaccuracies of distance estimation is found but this can be improved by using RSSI with better transmission. The bigger the distance to the receiver node, the lesser will be the signal strength when it arrives. RSSI plays a significant role in deciding which link to use in order to make packet delivery optimal. Target localization can be optimized using other techniques showing best results.

C. Prediction
Next possible location of the target can be computed using prediction mechanism. As prior knowledge can help in determining the posterior position, similarly prediction method computes the next position of the target. This works in a linear fashion, for example at \( t^{th} \) instant, the co-ordinates of the target are \((x', y')\), and at \( t^{th+1} \) instant, co-ordinates may shift to \((x'^{t+1}, y'^{t+1})\) which is calculated using two important parameters like target speed and direction. If the predicted
location is within current cluster then cluster head informs the base station, else the command is given to the next nearest cluster head in vicinity of predicted co-ordinates of the target. After handing over the command, the current cluster goes to sleep mode in order to save as much energy as possible.

D. Target lost

Sometimes, a network fails to track the target properly and target is lost which has several possible reasons, following three can be few possible reasons behind target loss:

1. Failure of nodes or network

Sensor nodes are usually battery operated and when it comes to battery, there is a chance of low battery which in turns results in failure of sensors in the network. Network fails due to heavy traffic and physical malfunctioning

2. Error in target detection step

There is a possibility that measured distance is incorrect as the target enters the cluster and moves very fast so localization can be incorrect in such a scenario. This can also happen due to uncertain changes in target’s velocity and direction

3. Handing over the command

When the current location is estimated and found that target is not present in the current cluster, in such case, next command is handed over to next nearest cluster head. Due to energy issues, clusters involved in a network are not always in awake mode, this may result in target loss.

To handle such cases where target is lost there must be recovery mechanism as in real time applications, this can be hazardous.

E. Recovery Mechanism

As mentioned earlier, cluster head is responsible for predicting next location of the moving target and it keeps on sending warning messages to the next nearest cluster head in case when target is out of the reach of current cluster. It waits for the acknowledgment message, but if fails to receive any, then broadcast the target lost message to the entire network. This procedure is well described in [17]

Immediate steps shown in Figure 5 are taken by current cluster when it realizes that by any means a target in the network is lost.

V. CONCLUSION

This paper presents different network schemes and their further classification according to characteristics and capabilities of sensor nodes. It highlights the concept of clustering of nodes in the network. One of the main constraints of WSNs is power limitation which can be reduced to some extent by using energy efficient protocol LEACH for clustering. Localization of target can be achieved by received signal strength indicator. The method can be improved on the basis of experimental results on a network simulator by using different distance measuring schemes with different energy efficient protocols. The main objective of the paper was to introduce a mechanism for target tracking in wireless sensor networks as well as it discovers some of the scenarios in which target is lost and can be recovered.

![Figure 5: Steps taken by CH when target is lost](image_url)

REFERENCES