Clustering techniques for Object Tracking in Wireless Sensor Networks: An Overview

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***Abstract*- In wireless sensor network energy efficiency, Data security & Network reliability are a few of the most important aspects to be considered while tracking, monitoring and reporting the data. In the object tracking continuous reporting of data is required, which consumes more energy of network. In this paper, the focus is mainly driven over the survey of the energy-efficient object tracking clustering algorithm(LEACH) for Wireless Sensor Network.**

Keywords—Wireless sensor networks, tracking, localization, RSSI, clustering, LEACH, TDMA.

I. INTRODUCTION

Due to the advancements in low cost embedded processors and wireless transmission technologies, wireless sensor networks have been commonly used in surveillance or monitoring of factories, health, military, and environment. Tracking of moving objects has attracted considerable attention and has found its applications in monitoring wildlife animals, tracking vehicles on the highway, military intrusion detection, and tracking in underground mining [2].

In object tracking important issue is to accurately localize objects and the process of locating objects is called localization. Tracking, which can be viewed as an extension of localization, is to track the paths of moving objects[1,2]. To improve the quality of tracking, sensors need to make accurate estimates of the location of targets. This accuracy of location consume lots of energy of nodes. These nodes of network has limited process power and low memory size. Battery replacement is impossible in many sensor networks due to the inaccessible or hostile environments. Therefore, energy efficiency is a critical issue in WSNs because of the restricted power supply [2].

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 [8]. On the other side if inactive or sleeping schedule is increase than the probability of the loosing object track is increase. So it is extremely important that the sleep scheduling for sensor nodes are made as accurate as possible [2]. To continuously monitor moving object, a group of sensors must be turned in active mode just before object reaches to them. Clustering is a technique used to extend lifetime of network by reducing the energy consumption [8]. The group of nodes called cluster and the node, which is in centre of the cluster, transfer the information to the base station is called cluster head. This group of active sensors varies depending on the velocity of moving object and schedule from cluster head. Ultimately, object tracking in course of maintaining the balance between network resources like energy, bandwidth, and overheads is challenging [4]. The purpose of this paper is to introduce and summarize the cluster-based object tracking algorithm currently used in sensor networks.

II. PRINCIPLE DESIGN

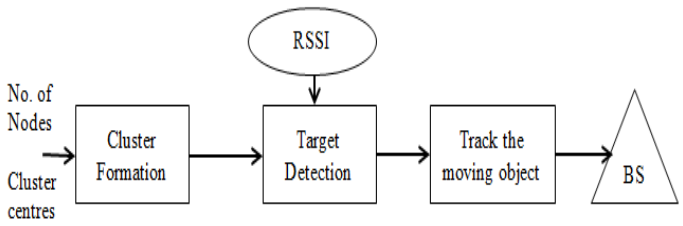

Fig 1: Basic block diagram of tracking system [10].

In the first step the cluster formation is generates with its cluster centers or cluster heads. Different formations are generated on their basic purpose.

In the second step the target is detected by using RSSI (Received Signal Strength Indication). It estimates the distance between two sensors by measuring the power of the signal transmitted from sender to receiver [10]. 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 [10]. The main advantage is its low cost, because most receivers are capable of estimating the received signal strength. But the bigger the distance to the receiver node, the lesser the signal strength when it arrives at that node [1].

In the third step target is track by the predicting next location of the object and assign cluster head with respective cluster. Prediction mechanism uses the object's previous location and current location to predicate the next location of object [10].

III. OVERVIEW OF EXISTING METHODOLOGY

Target tracking algorithms are classified in two main categories 1.Peer to Peer and 2.Hierarchical. The first category WSNs are known as flat or point-to-point networks. They are generally providing single-hop radio connectivity between the wireless nodes and are utilizing static routing over the wireless network. The main features of this category are [12]: the forwarding node only supports static routing and each node only communicates with its neighboring node(s) and network-wide consensus can be achieved through information exchange between neighbors. The second category (which is mainly discussed in this paper) is formed by mesh-based systems, which provide multi-hop radio connectivity between the wireless nodes. The sensors in the area, where an event is occurring, must be able to monitor it and report back to the base station. The base station has the capability to communicate with the outside world, and is usually accessible by the users. The important characterizations of this category are [12]: sensor nodes can support communications on behalf of other sensor nodes by acting as repeaters and the forwarding node can support data processing or information fusion on behalf of the senor nodes. Hierarchical Networks further classified in three categories 1.Naïve activation based tracking, 2. tree-based tracking, and 3.cluster-based tracking.

The cluster-based methods provide scalability and better usage of bandwidth than other types of methods.

Cluster-based method divides the network into clusters to support aggregated data processing [4]. A cluster consists of cluster head and member sensor nodes. When a sensor detects an object it automatically act as a CH. There is No need of declare election of cluster head. So message exchanges are not obtained. If more than one powerful sensor may detect the signal, multiple nodes are ready to become cluster head exist. So a decentralized approach has to be applied to ensure that only one Cluster Head is active in the neighbourhood of a target to be tracked with high probability [4].

Cluster based method is divided into two types [4]. 1.Static Clustering, and 2.Dynamic Clustering.

1. Static Clustering [9]

These clusters are formed statically at the time of network deployment. The attributes of each cluster, such as the size of a cluster, the area it covers, and the members it possesses, are static [4]. In spite of its simplicity, the static cluster architecture suffers from several drawbacks. First, fixed membership is not robust from the perspective of fault tolerance [9]. If a CH dies of power depletion, all the sensors in the cluster are useless. Second, fixed membership prevents sensor nodes in different clusters from sharing information and aggregating on data processing [9]. Finally, fixed membership cannot adapt to highly dynamic scenarios in which sensors in the region of high (low) event concentration may be instrumented to stay awake (go to sleep) [4].

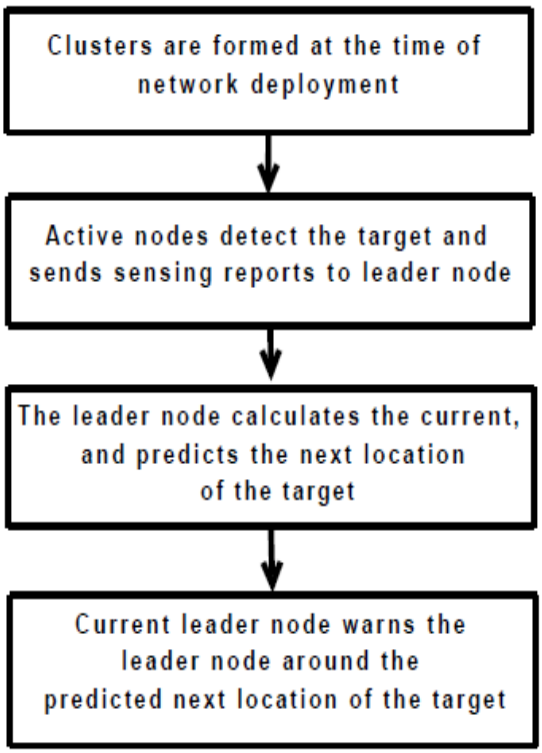

Fig 2: Flow Diagram of the Static Cluster Based Target Tracking [9].

2. Dynamic Clustering [9]

Dynamic cluster architectures, on the other side, offer several desirable features. Formation of a cluster is triggered by certain events of interest (e.g., detection of an approaching target with acoustic sounds). When a sensor with sufficient battery and computational power detects (with a high signal-to-noise ratio, SNR) signals of interest, it act as a CH. No declared leader (CH) election is required and, hence, no excessive message exchanges are obtained. As more than one "powerful" sensors may detect

the signal, multiple CHs may exist. A sensible, decentralized approach has to be applied to ensure that only one CH is active in the neighborhood of a target to be tracked with high probability. Sensors in the neighborhood of the active CH are "invited" to become members of the cluster and report their measurements to the CH [12]. Compared with the static clustering approaches, dynamic clustering networked sensors do not statically belong to a cluster and may support different clusters at different times [12]. Moreover, as only one cluster is active in the neighborhood of a target with high probability, redundant data is suppressed and potential interference and contention at the MAC level is mitigated [4].

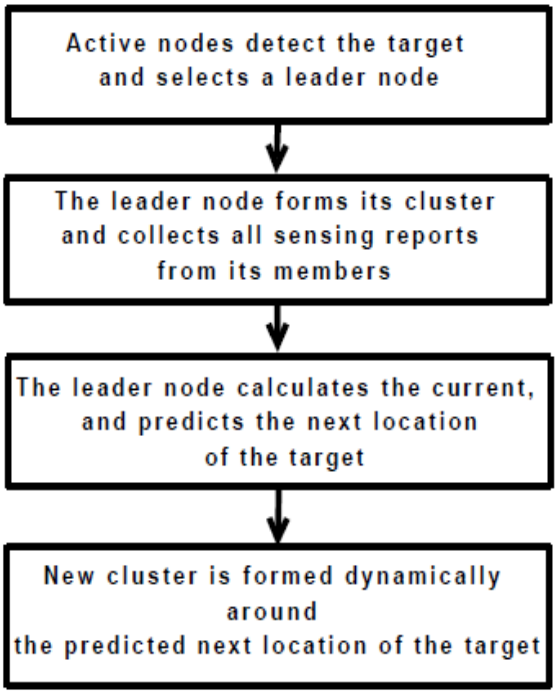

Fig 3: Flow Diagram of the Dynamic Cluster Based Target Tracking [9].

IV. LEACH METHOD

It is Dynamic Hierarchical Routing for sensor network, called Low Energy Adaptive Clustering Hierarchy (LEACH). A routing protocol is considered adaptive if certain system parameters can be controlled in order to adapt to current network conditions and available energy levels [4]. LEACH randomly selects a few sensor nodes as cluster heads (CHs) and rotates this role to evenly distribute the energy load among the sensors in the network. In LEACH, the CH nodes compress data arriving from nodes that belong to the respective cluster, and send an aggregated packet to the BS in order to reduce the amount of information that must be transmitted to the BS. LEACH uses a TDMA/code division multiple access (CDMA) MAC to reduce inter cluster and intra-cluster collisions [4]. However, data collection is centralized and performed periodically. Therefore, this protocol is most appropriate when there is a need for constant monitoring by the sensor network. A user may not need all the data immediately [16]. Hence, periodic data transmissions are unnecessary, and may drain the limited energy of the sensor nodes. After a given interval of time, randomized rotation of the role of CH is conducted so that uniform energy dissipation in the sensor network is obtained [16]. The operation of LEACH is separated into two phases, the setup phase and the steady state phase. In the setup phase, the clusters are organized and CHs are selected. In the steady state phase, the actual data transfer to the BS takes place [4]. The duration of the steady state phase is longer than the duration of the setup phase in order to minimize overhead. During the setup phase, a predetermined fraction of nodes, *p*, elect themselves as CHs as follows. A sensor node chooses a random number, r , between 0 and 1 [4]. If this random number is less than a Threshold value,T(n), the node becomes a CH for the current round. The threshold value is calculated based on an equation that incorporates the desired percentage to become a CH, the current round, and the set of nodes that have not been selected as a CH in the last (1/p) rounds denoted as G. it is given by

$$T(n) = (p/(1-p(\mathrm{mod}(1/p)))) \text{ if } n \in G$$

where *G* is the set of nodes that are involved in the CH election [4]. All elected CHs broadcast an advertisement message to the rest of the nodes in the network that they are the new CHs. All the non-CH nodes, after receiving this advertisement, decide on the cluster to which they want to belong [12]. This decision is based on the signal strength of the advertisement. The non-CH nodes inform the appropriate CHs that they will be a member of the cluster. After receiving all the messages from the nodes that would like to be included in the cluster and based on the number of nodes in the cluster, the CH node creates a TDMA schedule and assigns each node a time slot when it can transmit. This schedule is broadcast to all the nodes in the cluster [12]. During the steady state phase, the sensor nodes can begin sensing and transmitting data to the CHs. The CH node, after receiving all the data, aggregates it before sending it to the BS. After a certain time, which is determined a priori, the network goes back into the setup phase again and enters another round of selecting new CHs. Each cluster communicates using different CDMA codes to reduce interference from nodes belonging to other clusters [12].

V. CONCLUSION

Due to the scarce energy resources of sensor nodes, energy efficiency is becoming one of the main challenges in the design of object tracking protocols for WSNs. The ultimate objective behind the protocol design is to keep the sensors operating for as long as possible, thus prolonging the network lifetime. In this paper, we have surveyed and summarized recent research works focused mainly on the energy-efficient target tracking routing protocols for WSNs.

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