Dynamic Tracking Protocol for Maneuvering Targets in Sensor Network

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Abstract

Target tracking is one of the most important applications in wireless sensor networks (WSNs). Energy efficiency is one of the most important design goals for target tracking. We propose and evaluate a distributed, energy-efficient, light-weight framework dynamic clustering algorithm for target localization and tracking in wireless sensor networks. Since radio communication is the most energy-consuming operation, this framework aims to reduce the number of messages and the number of message collisions, while providing refined accuracy. The tracking protocol is also adaptive to the target velocity to ensure high accuracy with minimum power consumption. We envision a hierarchical sensor network that is composed of a static backbone of sparsely placed high-capability sensors which will assume the role of a gateway upon triggered by certain signal events and moderately to densely populate low-end sensors whose function is to provide sensor information to their gateway upon request. A cluster is formed when the activation message is received from the gateway. All the active nodes send their data to the next predicted node. The last active node (source node SN) at certain hop count sends its data to the gateway. The election of reference node is based on the data received no overhead due election. Acoustic signal strength detected by the active nodes exceeds a pre-determined threshold introduce a back off time proportional to its value. This back off time reduces collision rates. Using NS2 and Matlab to introduce the accuracy of target location, total power consumption for different proposed protocols, the effect of changing frequency rate at different target speeds and the drop ratio for different protocols.

Keywords: *Wireless sensor networks; target tracking; energy consumption; Reporting frequency*

1. Introduction

Wireless sensor networks are systems of small, low-powered networked sensing devices deployed over an interested area to monitor interested events and perform application specific tasks in response to the detected events. One of the most significant and elementary application is localization and tracking moving targets. The type of interested signals includes temperature, sound, light, magnetism and seismic vibration. A sensing modality is determined based on the types of targets to be tracked.

We study the issue of tracking mobile targets using wireless sensor networks. The whole tracking process is divided into the positioning stage and the tracking stage. In the process of target tracking, a lot of factors [13] affect energy consumption, which includes the number of moving targets, the speed of moving targets, data reporting frequency, tracking data accuracy, data collection frequency, and so on. Obviously, as design goals, the sensor nodes surrounding the moving target should be able to promptly provide reliable status information about the moving target and the area around it in an energy efficient way, and the sensor nodes should report this information to the sink in a fast and energy efficient way. In this paper, we propose a Dynamic target Tracking Protocol (DTP) for single-target tracking in WSNs. In summary, the key contributions of this paper are as follows:

- The active node group which consists of sensor nodes in the tracking state can track the target dynamically by using the node state transition mechanism and weight calculation mechanism.
- The sensor nodes should participate in tracking target or not depends on the received activation message.
- The data reporting frequency can be adjusted according to the velocity of the target to reduce unnecessary data transmission and improve the energy efficiency.
- Dynamic election of the source node (that collect the data from detected node and send it to the gateway) based on the information included in the received message.

The rest of the paper is organized as follows: Section 2 summarizes some existing target tracking protocols in WSNs. Section 3 discusses the basic ideas behind the proposed DTP protocol, including node state transition, node weight calculation, the initialization and reconstruction of the communication. The system architecture is discussed in Section 4. Section 5 includes the calculation of the main system parameters. We simulate and evaluate the proposed DTP protocol in Section 6. Section 7 concludes the paper.

2. Related Works

There are many dynamic clustering algorithms in Object Tracking Sensor Network (OTSN). However, there may be overlap area between two clusters which would cause redundant data and unnecessary data transmissions from the cluster head to base station. Thus, an algorithm is needed to reduce these unnecessary data transmissions. In-Sook Lee[8] proposed an algorithm to avoid redundant data and reduce energy consumption based on prediction result of moving objects. It also introduces an algorithm for cluster formation to minimize the overlap area of clusters. H. Yang [9] presents a Distributed Predictive Tracking protocol. The protocol uses a static clustering based approach for tracking mechanism. The speed of the target is a variable parameter which they use to evaluate its impact to the tracking quality. They assume high dense network and algorithm to avoid target lose in case of wrong prediction. The energy consumption of the tracking algorithm and communication cost is evaluated. Aysegul [10] proposed a Target tracking system that predicts future locations of the target and awakens the corresponding leader nodes so that the nodes along the trajectory self organize to form clusters to collect data related to the target in advance and thus reduce the target misses. The algorithm first provides detection of the target and forms a cluster with the neighboring nodes around it. After the selection of the cluster header, the coordinates of the targets is estimated using localization methods and cooperation between the cluster nodes under the control of the leader node. Two phase timer based are used in leader election algorithm which elects the node closest to the target as the leader node. Xiaofei[11] proposed a herd-based target tracking protocol. A sensor node has three states, namely, sleeping state, sensing state, and tracking state. Each sensor node is associated with a weight to be used to make a state transition among the three states. When a target moves into a monitoring area, a cluster node is selected as the herd head that is responsible for reporting the target information to the sink in the network. The sensor node can adjust the frequency of data reporting according to the velocity of the target. Khin [12] proposed a model to identify the lifetime of target tracking wireless sensor network. The model is static cluster based architecture and aims to provide two factors. First, it is to increase the lifetime of target tracking wireless sensor network. Secondly, it is to enable good localization result with low energy consumption for each sensor in the network. Xingbo Yu [2] proposes a quality aware information collection protocol in sensor networks for tracking applications. A sensor senses the environment and communicates its readings to the server periodically. A grid based network topology was simulated to evaluate the performance of their adaptive tracking protocols. They used four separate protocols to compare the total energy consumption in the sensor network over the period of tracking. The protocol explores trade-off between energy and application quality to significantly reduce energy consumption in the sensor network thereby enhancing the lifetimes of sensor nodes.

Most tracking protocols addresses target localization. In many cases, however, targets are not cooperative with sensors, e.g., enemy vehicles and unregistered victims in disaster areas. In the non-cooperative cases, however, the absence of the original signal strength information prevents the use of absolute distance estimates. Instead, one can estimate the original signal strength by collecting and analyzing a number of sensing data, which often requires non-linear optimization techniques. Qianyu Ye [3] addresses the measurements and accuracy of location calculation. In many circumstances, it is difficult to obtain the distance from the observation nodes to the surveillant target. As a result, using distance as a factor to determine the target location is not always feasible. They proposed a target tracking algorithm based on the sensing information which is in proportion to or in inverse proportion to the exponent of distance. The proportions of sensing information on different sensors are used to draw the loci of the target. The target location can be approximated by these loci. Zhijun Yu [7] proposed tracking protocol for acoustic target tracking in wireless sensor networks. The location of the target is calculated depending on time difference of arrival (TDOA) calculation. The distributed processing algorithm is based on mobile agent computing paradigm and sequential Bayesian estimation. To decrease the wireless communications, they proposed to represent the belief by parameterized methods such as Gaussian approximation or Gaussian mixture model approximation. They presented an attraction force function to handle the mobile agent migration planning problem, which is a combination of the node residual energy, useful information, and communication cost. Jeongkeun Lee [1] proposed light-weight localization algorithm, dubbed Ratiometric Vector Iteration (RVI) that is based on relative distance ratio estimates rather than absolute distance estimates. Vinodkrishnan [4] presents a wireless sensor network protocol, Trail that supports distance-sensitive tracking of mobile objects for in-network subscribers upon demand. Information about closer objects is required more often and more quickly than that of farther objects. Livio

[5] presents localization platform that exploits a single-hop WSN, based on a Microchip MCU and a Cypress RF device, to tracking its moving nodes. Specifically, the nodes of the network are divided in three sets. The algorithms adopted to manage the network and to localize moving nodes are discussed. A working prototype based upon the hardware platform, software and protocol described in this paper has been deployed and tested, and some results are shown. Guanghui [6] considered the issue of how to track mobile targets with certain level of *quality of monitoring* (QoM), while conserving power. They addressed the target tracking problem by taking into account of both the *coverage* and the *QoM*. Also studied analytically whether or not the detection/observation made by a single sensor suffices to tracking the target in a reasonably populated sensor network. In particular, for the sake of determining the relay area, the scheme requires that each sensor node knows its own position, and a localization algorithm has to be included. This may increase both the computational and communication overhead. In [18] Adaptive Target Tracking Protocol (ATTP) has been proposed which at each time step, employs two helpful tools. First, an extended Kalman filter (EKF)-based estimation technique to predict the tracking error and second, an energy consumption model to estimate energy consumption based on different number of nodes and sampling time intervals. After that by using these estimations selects the best number of nodes and sampling time interval according to an objective function which is defined based on tracking accuracy and energy consumption. In [19] proposed a new noise model for distance measurement to account for both additive noises and multiplicative noises. Also they discussed how to numerically obtain the necessary noise statistics using the least square (LS) method. Second, proposed a new measurement conversion method using maximum likelihood estimation. This method is based on the triangulation idea, commonly used in global positioning systems (GPS), and recently extended to sensor localization in wireless sensor networks. But here they applied maximum likelihood estimation to obtain a good linear estimate of the target position in the Cartesian coordinates and an approximate covariance matrix of the converted measurement noise. Finally, the converted measurement and noise covariance matrix are then used in a standard Kalman filter to update the target state estimate recursively. In our previous work [20] the different tracking parameters were introduced and how it affects on tracking accuracy. In this paper the power reduction using network structure and MAC protocol are introduced and also two cluster head election algorithms to reduce power consumption.

3. The Dynamic Tracking Protocol

Tracking protocols in general address certain application civilians or military. According to required application the network topology, sensor types and required accuracy is designed. In our tracking protocol the application is tracking small vacuolar its speed changing between zero to 20m/sec. The network topology is similar to that proposed in [14,15,12] and presented in section 4. The architecture aims to design and implement a wireless sensor network that enables energy efficient detection and tracking of events.

The network includes four gateways at the network corners, and acoustic nodes. Each gateway includes dual photo sensor. These gateways guard the network sides. The sensor nodes have two states sleep or active. They are sleep but during the detection operation gateways activate the nodes near the target trajectory. These activated nodes start to activate other nodes. After certain hop count the calculated data is sent to the gateway which this node belong to. The node which sends the data is Source Node (SN).

The proposed tracking protocol achieves dynamic election of SN based on the information in the received message. This method reduced overhead election in communication and time, but introduces redundancy, as more than one SN can be elected. The tracking protocol activates only the near nodes to the targets trajectory. Nodes are normally in sleeping mode. The four gateways at the corners of the monitoring area are in sensing state all the time. At the detection of a target the two gateways surround the target start to activate *n* nodes. These nodes start to calculate the RSS between them and the target. Each active node starts to activate at least 2 of its neighbor depending on their ID. We propose two cases of activation and also two cases of SN election. These cases are introduced in section 3.2.

The Tracking protocol is summarized in the following steps:

1- The target passes the monitoring area from one side.
2- The two gateways at this side start the activation of the acoustic sensor nodes as in algorithm 1
3- The activation message includes target calculated distance from the acoustic node, the active nodes ID (includes its ID and other nodes), the initial time step (tracking resolution) and the initial reporting frequency
4- At the reception of this activation message, acoustic nodes turn into active mode.
5- Each active node knows its neighbor and active nodes.
6- According to the RSS which is translated to estimate distance, it sends activation message according to two cases:

a. Activation message is sent to its entire neighbor near at this distance including pervious active nodes, RSS, time step and reporting frequency decremented by one.
b. Activation message is sent to only acoustic nodes in sleeping mode including pervious active nodes, RSS, time step and reporting frequency decremented by one.

7- When the hop count of frequency reporting reach zero. The decision of the SN which sends all target data to its gateway has two cases:
   a. The last activated nodes send their data. Where any previous activated nodes are rejected from the SN as there are newer nodes than them.
   b. The last activated nodes and higher weighting factor send their data.

8- The gateway updates the time step for higher quality if necessary and reporting frequency according to the target speed. The estimate positions of the target are calculated.

9- The updated message is sent to the next predicted active nodes.

10- The active nodes return to sleeping mode as the RSS is decreasing and reaches its minimum threshold.

3.1 The Gateway

There are four gateways at the corner of the network topology. Each gateway has a photo sensor with dual beam. Gateways are powerful node and active all the detection time. The network is divided into four clusters each cluster join one of the gateways.

The functions of the gateway:

- In sensing mode all time.
- Start the activation of sensing the nearest nodes to the targets
- Define the period SN state to send data
- Define the recovery process
- Includes localization algorithm to do the processing
- Define the election period to the SN (in case of target stop moving)

The network distribution is uniform has N nodes. The probability of finding n_s nodes near the target for RSS s , gateway1and2 *gd1,gd2* is .

(1)

1

For acceptable accuracy as introduced in [20] n_s nodes is considered at n_s =5. Number of nodes near the target with received signal s and beam length r. if the network dentistry is ¢

$$N_{active} = \int_{r}^{r} \int_{s-r}^{s+r} ¢\, dxdy \qquad (2)$$

The two gateways which the target inter the monitoring area from their side start to calculate at least 5 nodes. These nodes satisfy the iteration of algorithm1. This algorithm may run at one gateway if the target is passing in its cluster or in both gateways in case passing between them.

Algorithm 1

d_{thresh}=0.25r.
Switch cluster
Case one cluster
While n_{active}< 5
Calculate the nodes satisfy this relation

$$\left|d_{gd1,n} - d_{tar}\right| \le d_{thesh} \oplus \left|d_{gd2,n} - d_{tar}\right| \le d_{thesh}$$

If n_{active}<5
d_{thresh}= d_{thresh}+5;
End;
End;
Case between clusters
While n_{active}< 5
Calculate the nodes satisfy this relation

$$\left|d_{gd1,n} - d_{tar}\right| \le d_{thesh} and \left|d_{gd2,n} - d_{tar}\right| \le d_{thesh}$$

If n_{active}<5
d_{thresh}= d_{thresh}+5;
End;
End;
End;

The format of the activation message sent to the active nodes by gateway

Nodes ID in sensing mode	Time the sensing mode starts To each node	Resolution: count decremented by each received node and time step decrements occur

The first field includes the ID of all active nodes by the gateway or SNs. The second field is the time it starts sensing mode. The third field stats the resolution of the tracking. The time step is time between successive detection. The resolution is the reporting frequency. The count here means after how many hop count it needs the data.

3.2 Sensor Nodes

Initially, we assume that each sensor has its own localization and stationary awareness. The sensing area of a sensor is shaped as a circle with a radius r centered at the location of the sensor. We also assume that sensors can directly communicate with the neighboring sensors within a radius at least *2r* because the communication range is twice more than the sensing range. The system uses uniform distribution for sensor placement. All sensor nodes have the same initial power, receiving, transmitting, sleeping and sensing power. The nodes have two states active and sleep state as described in table 1. They are initially set at the sleep modes and turned to active modes only when there is a target. Therefore, they can save their energy and make their life time long.

Table 1: Modes of Sensor Nodes

Processing Mode	Active Mode	Sleeping Mode
Tasks perform in the corresponding mode	All parts of the sensor are fully powered. Sensor performs sensing the environment, processing, receiving packet from cluster head, and transmitting RSS value to source node and then to gateway.	It is energy saving mode. Sensor only listens an interrupt to go active mode.

Addition of nodes in the detection process:

The two gateways around the target send the target position to the activated nodes. The nodes change its state from sleep to active mode. The RSS of the target is measured. According to its value and pervious calculated target position it can estimate the target direction. Each active node knows:

1- The active nodes at their time step and previous time steps
2- The first target position calculated by gateways
3- The RSS of each activated nodes
4- Estimated target direction

There are two cases in node addition. Each active node estimates the new nodes which going to be activated. In the first case of nodes addition includes new and previous activated nodes. In the second case neglects the previous activated nodes. So the activation messages are reduced and they reach zero in case of slow speed or target stop.

The number of included active nodes has a limit. At reaching the limited size the nodes with minimum RSS are removed to add the newer nodes with higher RSS. The limit of number of nodes included is $l_{act,node}$

$$l_{act,node} = \overline{N}_{active} \times 0.25 \times f_{rep} \qquad (3)$$

Where $\overline{N}_{active}$ the mean of estimated active node, and f_{rep} is the reporting frequency which is calculated in section 5.3

Format of the message of active sensing nodes

Nodes ID sensing mode	Time the sensing mode starts to each node	The distance of the target	Resolution count decremented by each received node and time the decrements occur	SN_{ch} ID and the Time it is elected

It has two more fields, the estimated distance of the target and ID of the SN_{ch} with its election Time. There are two methods proposed to elect SN as cluster head (SN_{ch}). The energy consumption of each of them is calculated and also the redundancy of each method is introduced.

The election of SN_{ch}

The election of SN_{ch} is a self decision based on the data received from the incoming message. The SN_{ch} election introduces redundancy in their number. The number of SN_{ch} depends on the estimated target velocity, distance, its kinematic mode, number of neighbors (network connectivity) and time step.

$$\text{Network connectivity} = ¢ \times \int_{y_i}^{y_i+r} \int_{x_i}^{x_i+r} dxdy \qquad (4)$$

Where ¢ is the network density, (x_i, y_i) is the node position. In the proposed topology in section 4.1 which is a square connectivity are 4 for hexagon topology are 6 and increased for dense network. Increasing connectivity increase accuracy but in our proposed protocol increase redundancy of SN numbers. To overcome redundancy in case of dense network a weighting factor is introduced and discussed in details. Connectivity also affects the calculation of $\overline{N}_{active}$. It has maximum value 4 if we neglecting the estimated direction of the target and 2 including estimated direction.

The first case

The SN_{ch} is elected as the last activated node. In case the sensor nodes send activation to its entire neighbor near the target, which are 4 in our topology. To activate the entire four nodes that means the target is on the active node. But for actual case only two of them is activated

The second case without weighting factor

The probability of choosing more than SN_{ch} depend on target velocity. The slow target stays in the same detection region for time. As result know new active node are introduced and all old active node becomes SN_{ch} as the hop count reach zero.

The detection region is a circle quadrate of radius r. for linear motion the target moves distance $v\Delta T$ at each time step. The distance between the first detection (d_{RSS}) and departure from the detection region r is r-d_{RSS}. The redundancy number of SN_{ch} N_{rd} for network connectivity Net_{conn} is calculated as follow.

$$N_{rd}\, v\Delta T \approx (r - d_{RSS})Net_{conn}$$

$$N_{rd} \approx \frac{(r - d_{RSS})Net_{conn}}{v\Delta T} \qquad (5)$$

In case of nonlinear motion the traveled distance inside the detection region is the line integral over the pass. The maximum redundancy in the first case for both kinematic models is equal to the connectivity. In the second case for both kinematics differs according to target parameters.

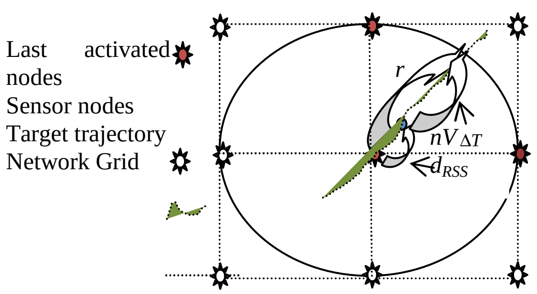


Fig. 1 The Election f SN_{ch}

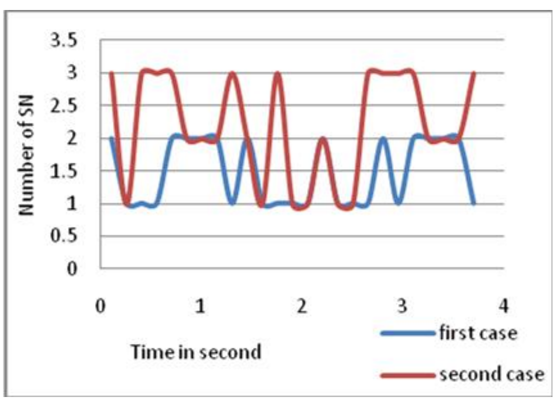


Fig. 2 the redundancy of SN_{ch} in the two cases of reporting algorithms

Second case with weighting factor

At the activation of new sensor node, its activated node sends to each pair different weighting factor. This factor is random value from 1 to 10 as the target direction is unknown to the activated node. The sent values must be different. Each active node start to compare its weighting factor with the other nodes since they are included in the same received message.

The weighting factor is neglected by the node in case if target received signal is double the threshold value. The node considers itself a SN_{ch}.

The introduced SN for both first and second case of DTP simulation runs for ΔT =0.5 sec, r=15m and v=20m/sec shown in figure 2. The maximum number of redundancy of SN_{ch} in first case is 2 while the second case introduces 3.

4. System Architecture

In this section, the proposed wireless sensor network topology is presented in figure 3. Models introduced in tracking process as Localization model and target kinematics is included in this section.

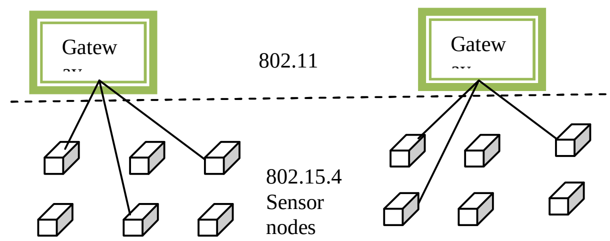


Fig. 3 the system architecture of the network

4.1 Network Topology

The network topology is grid with 100 nodes as introduced in figure 4. The monitoring area is *100mX100m*. There are four gateways at the corner. The beam length is 15*m*. Each node has two states sensing modes (active) and sleeping. The nodes can communicate with their neighbors and know the distance between them. The gateway at the corners is active all the time while all other nodes are sleeping until they receive activation message. The gateway has photo detectors, dual beam detection. It's rang out is 30~60 m. Their response time starts from 50 msec. Each active node calculates the distance between it and the target using Received Signal Strength (RSS).

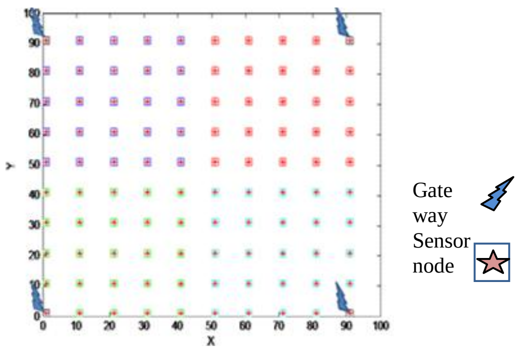


Fig. 4 Network topology has four clusters for each gateway

4.2 Localization Model

The fundamental principle applied in the energy-based approach is that the signal strength (i.e., energy) of a received signal decreases exponentially with the propagation distance:

$$s_i = a \,.\, \|x - x_i\|^{-\sim} + Q_i \qquad where \quad 0 < i < N$$

(6)

S_i is the received signal strength by the i^{th} sensor node and $a \in \Re$ is the (unknown) strength of an acoustic signal from the target, $x \in \Re^2$ is the target position yet to be determined, $x_i \in \Re^2$ is the known position of the i^{th} sensor, i ~ s the (known) attenuation coefficient, and Q_i is the white Gaussian noise with zero-mean and $\pm^2$ variance . We consider eXtreme Scale Mote measured values to evaluate our algorithm. In [16] for acoustic signal less than 1.38 $«w/m^2$, range more than 20*m* and event duration more than 2.3*sec*.

The estimated distance d_{RSS} has an error d_{err}.

$$d_{RSS} = d_{act} + d_{error} \tag{7}$$

The introduced error must be less than the change of *RSS* which proportional to the change of target position. To avoid activation of wrong nodes we assume that

$$\Delta RSS \propto v\Delta T \tag{8}$$

$$2d_{error} \prec \frac{1}{2} v\Delta T$$

$$d_{error} \prec 0.25 v\Delta T \tag{9}$$

Where v is target velocity, ΔT time step.

4.3The Target Models

Two kinematics models are introduced for quick maneuver detection. Constant Velocity Model (CV). This model is the most commonly used. The target is assumed to move with nearly constant velocity. Coordinated Turn Rate Model (CT) where set of accelerations modeled are those in the direction normal to the velocity, which model constant turns μ . The nonlinear model is the case of considering a fifth state ω instead of constant value.

For notational simplicity, $x_t \cong \{x_t, \dot{x}_t, y_t, \dot{y}_t\}$ refers to the state (coordinates and the velocities).

All models are in the generic state-space form

$$x_{t+1} = F\, x_t + G\, u_t \tag{10}$$

$$F_{CV} = diag\begin{bmatrix} 1 & \Delta T \\ 0 & 1 \end{bmatrix}, \quad G = diag\begin{bmatrix} \dfrac{\Delta T^2}{2} \\ \Delta T \end{bmatrix}$$

$$F_{CT} = \begin{pmatrix} 1 & \dfrac{\sin \mu\Delta T}{\mu} & 0 & -\dfrac{1-\cos\mu\Delta T}{\mu} \\ 0 & \cos\mu\Delta T & 0 & -\sin\mu\Delta T \\ 0 & \dfrac{1-\cos\mu\Delta T}{\mu} & 1 & \dfrac{\sin\mu\Delta T}{\mu} \\ 0 & \sin\mu\Delta T & 0 & \cos\mu\Delta T \end{pmatrix} \tag{11}$$

Where $u_t \sim N(0, diag(\pm_x^2, \pm_y^2))$.

5 System Parameters

Performance improving of the tracking protocol depends on calibration of some parameters. These parameters control accuracy and reduction of power consumption and so increase the network life time.

5.1 Time step calculation ΔT

The minimum value of time step is the T_{cycle} as calculated by Jeongkeun Lee [1]. The maximum value is calculated depending on the estimated target velocity v where the target can be seen by the node when passing by at least once. The inter node distance d_{in} for sensing rang r is $\dfrac{r}{\sqrt{2}}$

$$v = \frac{current\ position - previous\ position}{\Delta T}$$

$$r\sqrt{2} \cong 2\Delta T v \tag{12}$$

$$\Delta T \cong \frac{r}{v\sqrt{2}}$$

5.2 The window size and backoff time

The window size w_{size} here includes the mean time delay in processing, queuing, carrier sense time and transmission. The back of time T_{bf} is a random variable normal distribution proportional to the RSS at each node.

$$T_{bf} = f(\text{«}) - f(RSS) \quad where \quad f(x) = N(\text{«} = Rss_{\max}, \pm = 0.2) \tag{13}$$

To reduce energy consumption, the time step must be varied according to target velocity.

$$T_{cycle} \leq \Delta T \leq \frac{r}{v\sqrt{2}} \quad (14)$$

5.3 Reporting frequency

After localizing the target, the SN is obliged to report the estimated location to the sink node. Usually, the sink is a gateway connecting the sensor network to subscribers. Therefore, reporting to the sink normally incurs multi hop message relaying and multiple transmissions which depend on the hop distance between the SN and the gateway. If the target is stationary or moves around within a small area, the estimated location does not change notably as time goes by and the same location estimate (or possibly with small deviation) is repeatedly reported to the gateway. In these cases, it is not necessary and even wasteful to report (almost) same location estimates repeatedly. Rather than reporting every time leader performs localization, we propose to dynamically schedule a reporting frequency considering the target's kinematics. The reporting frequency is a hop count decremented each ΔT that avoids clock synchronization. The maximum communication rang is R_{max} .The network cluster diagonal is for regular shape topology has maximum side length *l* number of regular clusters *ch* is

$$d_{\max} = \frac{2l\sqrt{2}}{ch} \quad (15)$$

The reporting frequency f_{rep} is proportional to the target velocity and maximum travelled distance without reporting.

$$f_{rep} = \frac{v}{traveled\ \text{distance}}, \quad \text{traveled distance} = n_{hop} v \Delta T;$$

where n_{hop} maximumhop count between gateway and SN

$$n_{hop} \approx \frac{d_{\max}}{R_{\max}}$$

$$f_{rep} = \frac{1}{n_{hop}\Delta T} = \frac{R_{\max}}{d_{\max}\Delta T} \quad (16)$$

Considering these parameters time step weighting factor backoff time and reporting frequency increase the QOS and minimize power consumption.

5.4 The Energy Model

A sensor consumes energy in three ways: the energy used to run circuitry, the energy used to send radio transmission and energy used in computational. The energy used to run circuitry is proportional to the number of bits in the message. Say that the message length is *k* bit, define E_{elec} be the energy per bit. Then the energy used to run circuitry is $E_{elec}k$. This energy is the same for receiver and transmitter [17]. The energy for transmitter to send *k* bits over distance *d* is $£_{amp}\ k\, d^{\sim}$, where $£_{amp}$ is the energy constant for the radio transmission and ~ is the path loss exponent. The total energy for a receiver to handle a *k*-bit message is

$E_{Rx}(k) = E_{elec}k$ =24 «w *for 2.5msec* (18)

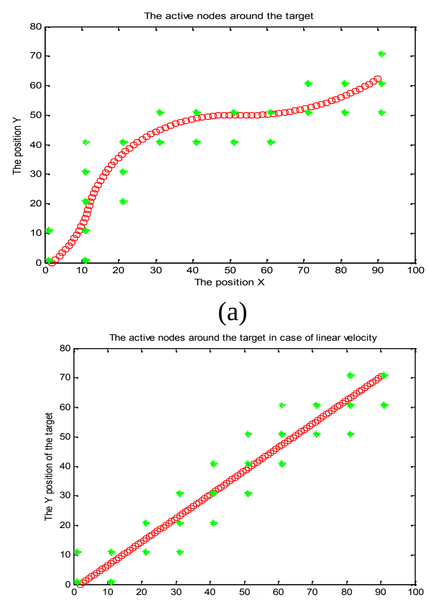
The total energy for a transmitter to send a *k*-bit message over distance *d* is,

$E_{Tx}(k;\ d) = E_{elec}k + £_{amp}\ k\, d^{\sim}$ =48 «w *for 2.5ms*ec (19)

The computational energy for acoustic sensor [16] with parameters number of samples256 and sampling frequency 8,192 *hz* and expected covered path length 2,300*ms* results an average power of 370 «*w*.

6 Performance Evaluations

The network topology is described in section 4.1. The sensor nodes communicate using MAC protocol (IEEE 802-15.4). Nodes start sensing mode by receiving a signal from the cluster head or its neighbor and end sensing mode as there is no detection. All nodes have the same type. Starting energy is 1000 joule, Idle power 0.01 watt, Sleep power 0.001 watt and Sending power 0.2 watt.In figure 5 the target trajectory for two kinematics model with velocity 20m/sec. The green points are the activated node near the target during the monitoring time.



(a)

(b)

Figure 5 (a) the nonlinear motion trajectory surrounded by the activated nodes, (b) the linear motion trajectory surrounded by active nodes both has velocity of 20m/sec

The total power consumption in the two cases without including the weighting factor are introduced in figure 6. The accumulation of power consumption in first case increase with time. Second case introduces less power consumption.

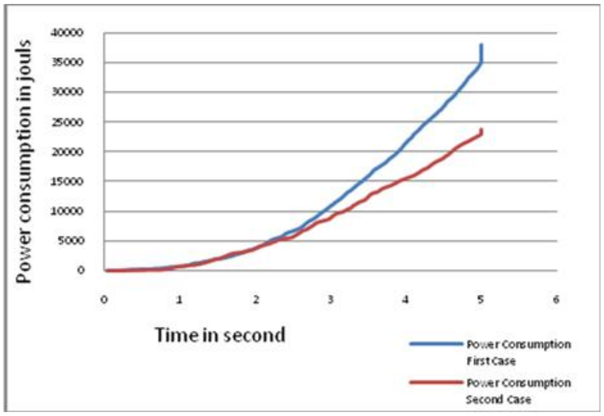


Fig. 6 total power consumption including gateways communication

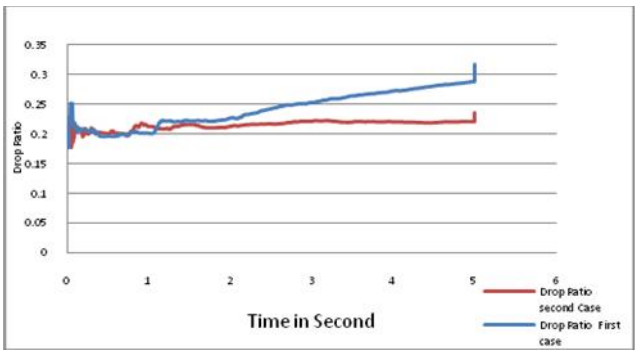


Fig. 7 Total dropping rations without considering the backoff time

The dropping ratio of the second case also is less which also introduces reduction in power consumption.

7 CONCLUSION

Target tracking is an application dependent protocol. As it depends on the problem formulation as environment, network topology, types of sensor nodes included in network (same type or different types) and targets type. The proposed DTP minimize power consumption using cross layer as it benefits from MAC protocol. Also the relation between different parameters as target velocity, sensing beam, network connectivity, sensing time step, reporting frequency and target hit are joined in a simple equation to give a relative design value. Two election algorithms are introduced. In first election algorithm SN_{ch} is elected as the last activated node. In second case the sensor nodes send activation to its entire neighbor near the target, which are 4 in our topology. At the activation of new sensor node, its activated node sends to each pair different weighting factor. This factor is random value from 1 to 10 as the target direction is unknown to the activated node. For both algorithms the impact on redundancy in SN_{ch} is simulated.The second algorithm has minimum power consumption and also introduces less packet drop ratio. In this paper the main objective is high accuracy with minimum power consumption. The tracking protocols benefits from the other sensor network protocols to reduce power consumption and also reduce packet drop ratio. In the future work changing reporting frequency and introducing multi target from the same type to evaluate the power consumption and redundancy rate.

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