An Efficient Mechanism for Mobile Target Tracking in Grid-based Wireless Sensor Networks

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Abstract

Wireless Sensor Networks (WSNs） is composed of sink and many sensor nodes. It has the great scope to monitor environment and the characteristics of wireless communications. Relatively, the advantages of sensor node bring themselves some restrictions. The greatest challenge among those is the constraints on energy. The most critical issue is how to minimize the energy consumption for keeping target tracking to devise the mobile target tracking mechanism in WSNs.

Therefore, we propose a solution on the basis of the advantages of Grid-based network which could determine where the target might be in the grids, and then those sensor node do track the target; others turn into sleep mode, this mechanism could efficiently reduce the energy consumption, and even prolongs the whole network's lifetime.

1. Introduction

In recent years, because of the great process of wireless communications technology, which makes wireless communications market and wireless communication applications are becoming increasingly popular. Thus a number of wireless network technology have been developed, including Wireless Sensor Networks (WSNs) [1][2], which attention of everyone most.

WSNs are often used to replace mankind with sensor nodes to obtain the information which is unable for human beings. Hence its applications is widespread, such fields in environmental, health, military and learning. The most influential factor is the restriction to energy. In order to solve the biggest problem, researchers have made various studies of wireless sensor network, and many of the literature also proffer the corresponding approaches in accordance with the mentioned problem. [6][7]

In the wireless sensor network environment, one of the very important tasks is the monitoring and tracking to target [5]. It makes the sensor node in monitoring can enter sleep mode in order to save energy after a period of time. But such an approach is still unable to achieve the better energy usage, the sensor node that does not track target in WSNs, will still stay in awaking phase and keep continuing consumption of energy.

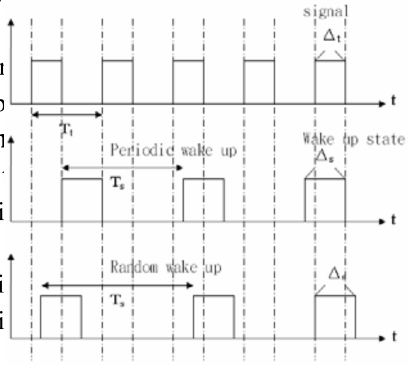
In this paper, "An Efficient Mechanism for Mobile Target Tracking in Grid-based Wireless Sensor Networks" fully utilizes the power of sensor node; through the decisions which sensor node should be wake up to track target. Under the premise of acceptable tracking error, we hope to be able to wake up the sensor node only when it needs to work in WSNs. The focus of this paper is to design a method in tracking target which can be applied in grid-based [8]. And under this framework, we hope to prolong the WSNs's lifetime by elected the less sensor nodes to track the target.

This paper is divided into five chapters; Chapter 2 will introduce the more common target-tracking technology in recent studies. Chapter 3 is about the method proposed in this paper. Chapter 4 is the simulations. Chapter 5 is this paper's conclusions and future works.

2. Related work

On the subject to tracking mobile target, most of the researches focus on how to save sensor node's limited energy[9-11], and they wish the entire WSNs can track the target for long by saving energy. Therefore, in the current study, the sensor nodes tracking target work usually is added the wake-up mechanism (schedule). The major purpose is saving the energy consumption with turning the sensor node working a span of time into sleep mode.

The wake-up mechanism (schedule) in tracking mobile target can be divided into two categories, namely: synchronous wake-up and asynchronous wake-up. We will detailed descript the way how the above two types of the wake-up mechanism (schedule) design. ntroduce synchro chronous wake-up 6].



2-1 Syn

In wake-up mechani [13] and random chart as shown i this two mechani

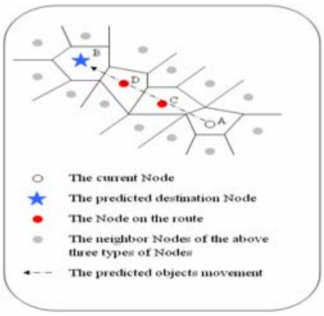
Figure 1：the periodic wake-up and random wake-up

In Figure 1, the Δ_t represents the length of time interval，the Δ_s represents the wake-up time length of the sensor node; the T_t represents the period of sending signal of target, T_s represents the wake-up period of sensor node.

In the Synchronous Wake-Up, either the periodic wake-up or the random wake-up, there is existing great shortcomings, the reason is that all sensor nodes have to be waked up each time, but in tracking mobile targets of the time, not all of the sensor node will sense the target.

2-2 asynchronous wake-up

In the asynchronous wake-up mechanism, it can be divided into two types: Based on record to predict location of tar of target, we have to PI ocol [16] described two mode of operation.



2-2-1 PES Pro

In order t will wake up the neighbo sor nodes in the meantin

Figure 2：PES Protocol

Such a method for tracking target, it is in accordance o determine which the se p. However, if the record it will likely cause too n ontrary, the enough info energy.

2-2-2 EST I

The ne itecture, as shown in Fi

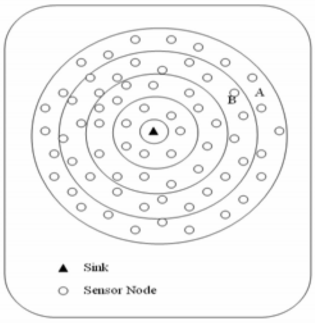
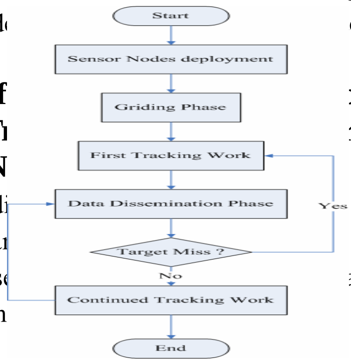


Figure 3： EST Protocol

Consideration to the energy, the limited number of sensor nodes in one level can sense the target. The most serious problem is the more external level, because of containing more the sensor nodes, the above situation is more obvious. For the tracking error, as compared with PES Protocol, EST Protocol wakes up more the sensor nod cking error rate.

3. An Eff bile Target Tr reless Sensor N



We di into three phases, nai Phase and Data Diss art of our mechanism

Figure 4： flowchart of the proposed method

3-1 Environment

All the sensor nodes are taken randomly and uniform deployment, the sink is in the Address as (0,0). After the randomly and evenly deployment, each of them will know its position, and the sensor nodes and the sink will not move.

In WSNs, we assume that the entire network is time synchronization. Under this environment, all the sensor nodes are equal in terms of sensing ability, computing ability, storage capacity and the maximum energy. We assume that in WSNs the target velocity (V_t) is fixed, and the initial target velocity is unknown. At the same time, the direction that the target moves to is random.

3-2 Griding Phase

Each edge of the grid we set to a variable R, and there is a head node in each grid. The sink will choose randomly a sensor node as the initial head node from each grid. ... each grid, they will ... re are two types of t... hich is the maximum ... ie general transmit r... d node or relay nod... e transmit range as (... nsor node is being ... 2 R as its transmit r...

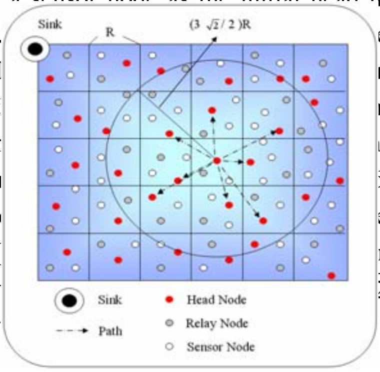


Figure 5： transmit range of the head node

3-3 Tracking Phase

Here are two parts according to the operation flow, namely: the first track work and the continued track work. In the lead preparation, the sink first will first send a Query_message (Query_mes) to the all the sensor nodes in entire WSNs. As the sensor nodes receive Query_mes , they begin to sensing. The Query_mes packet type as shown in the following Table 1: the field of Address (Xs, Ys) represents of the address information, the field of Tracking Interval represents the tracking internal of the target, and the tracking interval initial value is 0.

Table 1： the type of Query_mes

Address(X_s, Y_s)	Tracking Interval

Once the sensor node senses the target, it will record when it tracks the target, and sends a Detection_message (Det_mes) to the sink. The following Table 2 is the packet type of Det_mes: the field of Packet_typerepresents the name of pakeage, here it calls Det_mes, the field of Address(X_i,Y_i) represents the address of the sensor node, i, who is sending this packet, Sensor_type represents the receiver's identity, t_i represents the time when the i sensor node sense the target.

Table 2： the type of Det_mes

Packet_type	Address(X_i,Y_i)	Sensor_type	t_i

When the sink receive the Det_mes packet sent by sensor node, it computes the target's velocity (V_t) based on the information of the field of Address (X_i,Y_i) and field of t_i. The sink computers that the last tracking time interval is R/V_t.

3-3-1 First Tracking Work

In the first tracking work, the sink will replace the field value of Tracking Interval with R/V_t show in the Query_mes packet. And then the sink sends it to all the sensor node in entire WSNs. Once the sensor nodes receive this packet, they are doing the first tracking work. According to the tracking situation of all the sensor nodes in each grid, we find it can be divided into two situations.

Situation 1: There is more than one sensor node to sense the target in grids. Under this situation, while the sensor node is processing the target tracking, it shall send the Information_message (Inf_mes) packet to the head node existing in the same grid. The packet type of Inf_mes shown as the following Table 3: the Inf_mes is the field name of Packet_type, the H is the value of Sensor_type, Remain_energy$_i$ shows that the sensor node i' s remained energy.

Table 3： the type of Inf_mes

Packet_type	Address(X_i,Y_i)	Sensor_type	t_i	Remain_energy$_i$

The head node picks the time value is the lest from these packets, then it transmits a Time_message (T_mes) to the neighbor grids. The type of T_mes is shown as Table 4: T_mes is the field name of Packet_type, H is the value to Sensor_type field, Min_t_i represents the minimum time to sense the target in this grid.

Table 4： the type of T_mes

Packet_type	Address(X_i,Y_i)	Sensor_type	Min_t_i

If the head node receives the T_mes packet from the neighbor node, it will compare the time value of this packet with its minimum time value. If its minimum time value is not greater than the received time value, it is going to keep tracking the target.

If the head node ensure to continue tracking the target, the head node finds out the maximum value of the Remain_energy$_i$ field in the Inf_mes packet, and sets this sensor node to be the next head node of the grid in the next round. The head node transmits a Tra_message (Tracking_mes) packet to the neighbor head node and this new head node. In the situation 1, the first tracking work is over. From now on, we get into the continued tracking work. The type of theTracking_mes packet: the field name of Packet_type is Tracking_mes, H is the value to Sensor_type field, wake up Time represents the time to wake up all of the sensor nodes in the grid and the neighbor grids, as shown in Table 5.

Table 5: the type of Tracking_mes

Packet_type	Address(X_i, Y_i)	Sensor_type	Wake up Time

Situation 2: There is none of sensor node sensing the target. The sensor nodes transmit the Inf_mes packet to the head node of their grids, the value will be ∞ to the time field. At this point, the head node still chooses the relay node accordingly. When the relay node is chose, the head node notifies the sensor nodes of its gird put into the sleep mode except the relay node.

3-3-2 Continued Tracking Work

As the head node in the neighbor grids and the new one receive the Tra_mes, the neighbor head node indicates when the wake up time is. For the common situation, there would be only two situations in next tracking target, which are: the target is back to this gird again and the target is in the neighbor grid. It represents the target is lost when the new head node receives the Retracking_mes packet and time runs out. The sink would be notified the target is lost by this head node. The sink would wake up the all sensor node in entire WSNs and then return to the first tracking work. The below Table 6 is the packet type of Retracking_mes: Packet_type' s field name is Retracking_mes，H is the value to Sensor_type field，Time out means the head node notify the sink the time when the target lost, and the value to the Time out field: Wake up Time＋1/2(Tracking Interval)

Table 6: the type of Retracking_mes

Packet_type	Address(X_i, Y_i)	Sensor_type	Time out

We still can describe the continued tracking work with two situations

Situation 1: There is more than one sensor node to sense the target in grids. Same as the situation 1 in the first tracking work, the head node receives the Inf_mes packets sent by all of the sensor nodes in the grid. It picks the relay node accordingly, and transmits the T_mes packet to the head node in neighbor. Differ from the first tracking work, when the head node transmitted the T_mes packet, it need to replace the Wake up Time field with Wake up Time＋Tracking Interval.

In the executing period, if the head node receives the transmitted T_mes packet from the neighbor grid, it still needs to determine if the target tracking work is needed to process. Once the target tracking work can not proceed, the head node has to find out the new head node for the next round, and then the relative relay node's Inf_mes packet to this new head node. After that, the prior head node transmits the Inf_mes packet to this new head node and sends back the Response to its relay node. Then the new head node will notify the sensor nodes in the grid to be in the sleep mode except the relay node.

Situation 2: there is none of sensor node sensing the target. The head node finds the new head node to the next tracking round and notifies it, at the same time, finds out and notifies the relative relay node. And then this new head node is going to notify the all sensor nodes put into the sleep mode except the relay node

3-4 Data Dissemination Phase

When finishing each target tracking work, the head node transmits the Tra_mes packet to the head nodes in neighbor grid. They will send back an Ack_message (Ack_mes) packet. When the head node once receives the Ack_mes packet, it will pick the nearest neighbor head node to the sink. And then transmits the Target_message (Target_mes) packet to that head node. The packet type of Ack_mes and Target_mes are as below: in Ack_mespacket, the name of field Packet_type is Retracking_mes，the Address (X_i,Y_i)field represents the sensor node i' s address, H is the value to the field of Sensor_type, the name of the Packet_type field is Retracking_mes, H is the value to the Sensor_type field, the Address (X_t,Y_t) field means the sensor node i' s address, t_i is for the time when the time the sensor node I sense the target, as shown in Table 7 and Table 8.

Table 7: the type of Ack_mes

Packet_type	Address(X_i, Y_i)	Sensor_type

Table 8：the type of Target_mes

Packet_type	Address(X_i, Y_i)	Sensor_type	Address(X_t, Y_t)	t_i

4. Simulation Result

The following are the relevant parameters and the environment settings of WSNs when the simulation is operating:

- The scope of WSNs is 500m × 500m。
- The number of sensor nodes is 750, the deployment way is random with uniform distribution.

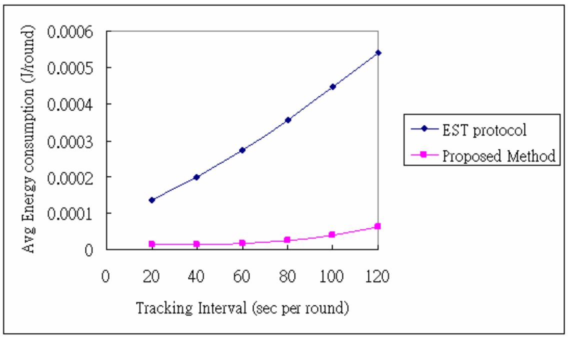


Figure 6：the average energy consumption

Figure 6 shows that for the whole WSNs, the average energy consumption of the mechanism proposed by this paper is much lower than EST protocol. That is because EST protocol's tracking sensor nodes for each round is more than our

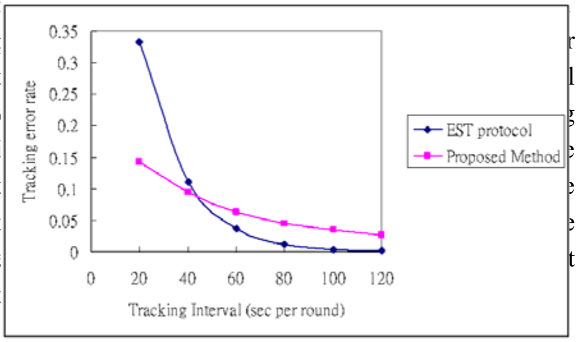


Figure 7：the rate of tracking error

We can find out in Figure 7 that the tracking interval is less than 40 second, the proposed mechanism's tracking errors is lower than EST protocol. As EST protocol does not wake up enough levels, most of them cannot sense where the target is, so it makes the higher rate of tracking error. When the tracking interval is more than 40 second, EST protocol wakes up a lot of levels, so the rate of tracking error becomes lower than our mechanism. However, EST protocol has slightly better performance in tracking error when tracking interval is more than 40 second.

5. Conclusion

In the related issues of WSNs, when the sensor nodes are facing many constraints, the most serious restriction is energy. So in order to make the WSNs achieve better performance, we need to overcome its inherent constraints on the technical conditions through the fine mechanism, also need to develop the hardware technology to enhance the efficacy. A better target tracking mechanism, not only be able to correctly sense the target information, but also has to efficiently control the average energy consumption of the WSNs to keep tracking target.

We present a mobile target-tracking mechanism adopted the grid-based frame in this paper. Avoiding the unnecessarily of energy consumption, the sensor node limited in a single grid to track target, let the rest do not need to track and turn into sleep mode. In addition, we take the surplus energy as a reference, make the sensor node with more energy become the head node of this grid. It will balance the remaining energy to the WSNs, and will further extending the reach of the WSNs' life time.

Through the results of our simulation, the tracking mechanism proposed in this paper can be at least five times to the EST protocol in total rounds, even up to 20 times. The above means that this paper presents an mechanism can effectively increase the target-tracking sustainability of the WSNs. On the aspect of average energy consumption, EST protocol is nearly 10 times than ours. The proposed mechanisms indeed can approach the whole networks' average energy consumption, and shows that presented mechanism performs better.

6. Reference

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