International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
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Research Paper
Available online at: www.jrrset.com
UGC Approved Journal No: 45483
Volume 6, Issue10 Pages 56-64

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

MOVING OBJECT TRACKING SYTEM FOR WIRELESS SENSOR NETWORKS

Dr.S.Tamil, H. A. Abdus Samad, M. A. Sameer, Mukram Ali, A. Haseeb
Department of Electronics and Communication Engineering,Shadan College of Engineering and Technology HYD,T.S,INDIA

Abstract— An important issue of wireless sensor networks is object tracking, which typically involves two basic operations: update and query. This issue has been intensively studied in other areas, such as cellular networks. However, the in- network processing characteristic of sensor networks has posed new challenges to this issue. In this paper, we develop several tree structures for in-network object tracking which take the physical topology of the sensor network into consideration. The optimization process has two stages. The rapid progress of wireless communication and embedded microsensing MEMS technologies has made wireless sensor networks possible. In light of storage in sensors, a sensor network can be considered as a distributed database, in which one can conduct in-network data processing. The first stage tries to reduce the location update cost based on a deviation-avoidance principle and a highest- weight-first principle. The second stage further adjusts the tree obtained in the first stage to reduce the query cost. The way we model this problem allows us to analytically formulate the cost of object tracking given the update and query rates of objects. Extensive simulations are conducted, which show a significant improvement over existing solutions.
Index Terms—Object tracking, in-network processing, sensor network, data aggregation, mobile computing

1 INTRODUCTION

THE rapid progress of wireless communication and embedded microsensing MEMS technologies has made wireless sensor networks possible. Such environments may have many inexpensive wireless nodes, each capable of collecting, processing, and storing environmental informa- tion, and communicating with neighboring nodes. In the past, sensors are connected by wire lines. Today, this environment is combined with the novel ad hoc networking technology to facilitate intersensor communication [11], [12]. The flexibility of installing and configuring a sensor network is thus greatly improved. Recently, a lot of research activities have been dedicated to sensor networks [4], [5], [6], [7], [8], [9], [13], [14].

Object tracking is an important application of wireless sensor networks (e.g., military intrusion detection and habitat monitoring). Existing research efforts on object tracking can be categorized in two ways. In the first category, the problem of accurately estimating the location of an object is addressed [1], [10]. In the second category, in- network data processing and data aggregation for object tracking are discussed [8], [15]. The main theme of this paper is to propose a data aggregation model for object tracking. Object tracking typically involves two basic operations: update and query. In general, updates of an object's location are initiated when the object moves from one sensor to another. A query is invoked each time when there is a need to find the location of an interested object.

Location updates and queries may be done in various ways. A naive way for delivering a query is to flood the whole network. The sensor whose sensing range contains the queried object will reply to the query. Clearly, this approach is inefficient because a considerable amount of energy will be consumed when the network scale is large or when the query rate is high. Alternatively, if all location information is stored at a specific sensor (e.g., the sink), no flooding is needed. But, whenever a movement is detected, update messages have to be sent. One drawback is that when objects move frequently, abundant update messages will be generated. The cost is not justified when the query rate is low. Clearly, these are trade-offs.

In [8], a Drain-And-Balance (DAB) tree structure is proposed to address this issue. As far as we know, this is the first in-network object tracking approach in sensor networks where query messages are not required to be flooded and update messages are not always transmitted to the sink. However, [8] has two drawbacks. First, a DAB tree is a logical tree not reflecting the physical structure of the sensor network; hence, an edge may consist of multiple communication

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hops and a high communication cost may be incurred. Second, the construction of the DAB tree does not take the query cost into consideration. Therefore, the result may not be efficient in some cases.

To relieve the aforementioned problems, we propose a new tree structure for in-network object tracking in a sensor network. The location update part of our solution can be viewed as an extension of [8]. In particular, we take the physical topology of the sensor network into consideration. We take a two-stage approach. The first stage aims at reducing the update cost, while the second stage aims at further reducing the query cost. For the first stage, several principles, namely, deviation-avoidance and highest- weight-first ones, are pointed out to construct an object

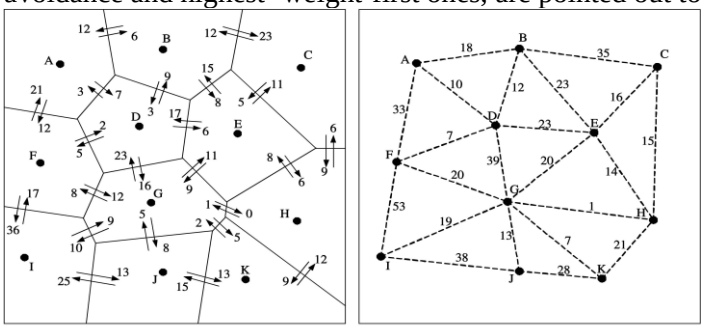

Fig. 1. (a) The Voronoi graph of a sensor network. The arrival and departure rates between sensors are the numbers associated with arrows. (b) The graph G corresponding to the sensor network in (a). The number labeled on each edge represents its weight.

tracking tree to reduce the communication cost of location update. Two solutions are proposed: Deviation-Avoidance Tree (DAT) and Zone-based Deviation-Avoidance Tree (Z-DAT). The latter approach tries to divide the sensing area into square-like zones, and recursively combine these zones into a tree. Our simulation results indicate that the Z-DAT approach is very suitable for regularly deployed sensor networks. For the second stage, we develop a Query Cost Reduction (QCR) algorithm to adjust the object tracking tree obtained in the first stage to further reduce the total cost.

The way we model this problem allows us to analytically formulate the update and query costs of the solution based on several parameters of the given problem, such as rates that objects cross the boundaries between sensors and rates that sensors are queried. We have also conducted extensive simulations to evaluate the proposed solutions. The results do validate our observations.

Several other tracking-related problems have also been studied, but they can be considered independent issues from our work. The authors in [14] explored a localized prediction approach for power efficient object tracking by putting unnecessary sensors in sleep mode. Techniques for co- operative tracking by multiple sensors have been addressed in [1], [3], [10], [15]. In [3], a dynamic clustering architecture that exploits signal strength observed by sensors is proposed to identify the set of sensors to track an object. In [15], a convoy tree is proposed for object tracking using data aggregation to reduce energy consumption.

The rest of this paper is organized as follows: Prelimin- aries are given in Section 2. DAT, Z-DAT, and QCR algorithms are presented in Section 3. Performance studies are conducted in Section 4. This paper concludes with Section 5.

2 PRELIMINARIES

We consider a wireless sensor network deployed in a field for the purpose of object tracking. Sensors' locations are already known at a special node, called sink, which serves as the gateway of the sensor network to the outside world. We adopt a simple nearest-sensor model, which only requires the sensor that receives the strongest signal from the object to report to the sink (this can be achieved by [3]). Therefore, the sensing field can be partitioned into a Voronoi graph [2], as depicted in Fig. 1a, such that every point in a polygon is closer to its corresponding sensor in that polygon than to any other. In practice, a sensor under our model may represent the clusterhead of a cluster of reduced-function sensors. In this work, however, we are only interested in the reporting behavior of these clusterheads.

Our goal is to propose a data aggregation model for

object tracking. We assume that whenever an object arrives at or departs from the sensing range (polygon) of a sensor, a detection event will be reported (note that this update message are not always forwarded to the sink, as will be elaborated later). Two sensors are called neighbors if their sensing ranges share a common boundary on the Voronoi graph; otherwise, they are nonneighbors. Multiple objects may be tracked concurrently in the network, and we assume that from mobility statistics, it is possible to collect the event rate between each pair of neighboring sensors to represent the frequency of objects travelling from one sensor to another. For example, in Fig. 1a, the arrival and

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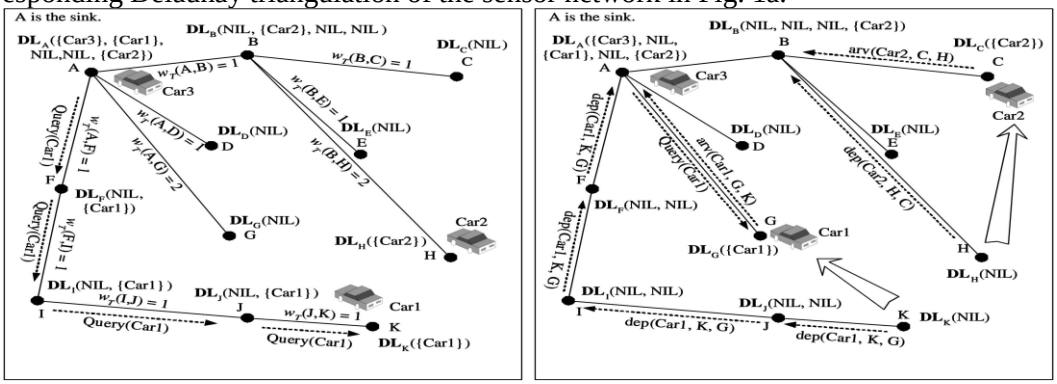
departure rates between sensors are shown on the edges of the Vonoroi graph. In addition, the communication range of sensors is assumed to be large enough so that neighboring sensors (in terms of their sensing ranges) can communicate with each other directly. Thus, the network topology can be regardedasanundirectedweightedgraphG ¼ ðVG; EGÞ with VG representing sensors and EG representing links between neighboring sensors. The weight of each link ða; bÞ2 EG, denoted by wGða; bÞ, is the sum of event rates from a to b and b to a. This is because both arrival and departure events will be reported in our scheme. In fact, G is a Delaunay triangulation of the network [2]. Fig. 1b shows the corresponding Delaunay triangulation of the sensor network in Fig. 1a.



(a) (b)

Fig. 2. (a) An object tracking tree T , where the dotted lines are the forwarding path of a query for Car1. (b) The events generated as Car1 moves from sensor K to G and Car2 moves from H to C.

In light of the storage in sensors, the sensor network is able to be viewed as a distributed database. We will exploit the possibility of conducting in-network data aggregation for object tracking in a sensor network. Similar to the approach in [8], a logical weighted tree T will be constructed from G. For example, Fig. 2a shows an object tracking tree T constructed from the network G in Fig. 1b. Movement events of objects are reported based on the following rules. Each node a in Twill maintain a detected listDLa ¼ ðL0; L1; ... ; LkÞ suchthatL0isthesetofobjects currently inside the coverage ofsensoraitself,and Li;i ¼ 1; ••• ; k, is the set of objects currently inside the coverage of any sensor who is in the subtree rooted at the ith child of sensor a, where k is the number of children of
a. When an object o moves from the sensing range of a to that of b (ða; bÞ2 EG), a departure event depðo; a; bÞ and an arrival event arvðo; b; aÞ will be reported by a and b, respectively, alone the tree T . On receiving such an event, a sensor x takes the following actions:

- If the event is depðo; a; bÞ, x will remove o from the proper Li in DLx such that sensor abelongstothe ith subtree of x in T . If x ¼ a, o will be removed from L0 in DLx. Then x checkswhethersensorbbelongs to the subtree rooted at x in T or not. If not, the event depðo; a; bÞ is forwarded to the parent node of x in T .
- If the event is arvðo; b; aÞ, x will add o to the proper Liin DLxsuch that sensor b belongs to the ith subtree of x in T . If x ¼ b, o will be added to L0 inDLx. Then x checks whether sensor a belongs to the subtree rooted at x in T or not. If not, the event arvðo; b; aÞ is forwarded to the parent node of x in T .

The above data aggregation model guarantees that, disregarding transmission delays, the data structure DLi always maintains the objects under the coverage of any descendant of sensor i in T . Therefore,searchingthe location of an object can be done efficiently in T ; a query is only required to be forwarded to a proper subtree and no flooding is needed. For example, Fig. 2a shows the forwarding path of a query for Car1 in T . Fig. 2b shows the reporting events as Car1 and Car2 move and the forwarding path of a query for the new location of Car1.

3 TREE CONSTRUCTION ALGORITHMS

This section presents our algorithms for constructing efficient object tracking trees. In Section 3.1, we develop algorithm DAT targeted at reducing the update cost. Then, in Section 3.2, based on the concept of divide-and-conquer, we devise algorithm Z-DAT to further reduce the update cost. In Section 3.3, algorithm QCR is developed to adjust the tree obtained by algorithm DAT/Z-DAT to further reduce the total cost.

TABLE 1
Summary of Notations

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$dist_G(u,v)$	The minimum hop count between u and v in G.
$dist_T(u,v)$	The sum of w_Ts of edges on the path connecting u and v in T.
$w_G(u,v)$	The event rate between u and v.
$w_T(u,v)$	The weight of edge (u,v) in T. $(= dist_G(u,v))$.
$lca(u,v)$	The lowest common ancestor of u and v.
$p(v)$	The parent of v in T.
$Subtree(v)$	Members of the subtree rooted at v.
$root(v)$	The root of the temporary subtree containing v during the construction of T.
$q(v)$	The query rate of v.
$neighbors(v)$	Neighbors of v.
$children(v)$	Children of v.

● Equation (2) contains the factor wT ðu; vÞ. Its minimal value is 1 when u 6¼ v. Consequently, it is desirable that each sensor's parent is oneofitsneighbors. Only the tree in Fig. 3d satisfies this criterion. By selecting neighboring sensors as parents, the average value of distT ðu; lcaðu; vÞÞ þ distT ðv; lcaðu; vÞÞ in (1) can be minimized. For example, the average values of distT ðu; lcaðu; vÞÞ þ distT ðv; lcaðu; vÞÞ are 3.591, 2.864, and 2.227 for the trees in Fig. 3a, Fig. 3c, and Fig. 3d, respectively.

● Equation, an edge ðu; vÞ with a higherwGðu; vÞ should be included into T as early as possible andpðvÞ should be set to u if distGðu; sinkÞ < distGðv; sinkÞ, and vice versa. We call this the highest-weight-first principle.

Based on above observations, we develop our algorithm DAT. Initially, DAT treats each node as a singleton subtree. Then we will gradually include more links to connect these subtrees together. In the end, all subtrees will be connected into one tree T . The detailed algorithmisshownin Algorithm 1, where notation rootðxÞ represents the root of the temporary subtree that contains x. To begin with, EG is sorted into a list L in a decreasing order of links' weights. Based on the third observation, algorithm DATwill examine edges in L one by one for possibly being included into tree T . For each edge ðu; vÞ in L being examined by algorithm DAT, ðu; vÞ will be included into T only if u and v are currently located in differentsubtrees. Also, ðu; vÞ will be included into T only if at least one of u and v is currently the root of its temporary subtree and the other is on a shortest path in G from the former node to the sink (these conditions are reflected by the if statements in lines 5 and 7). An edge in G passing these checks will then be included into T . Note that without these conditions, deviations may

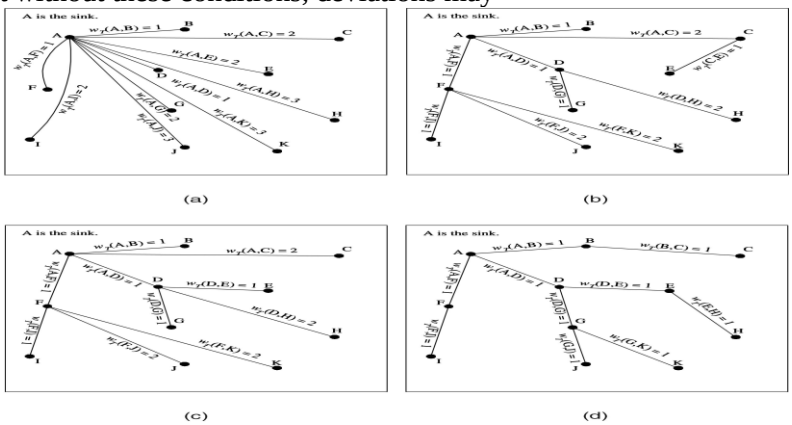

Fig. 3. Four possible location tracking trees for the graph in Fig. 1(b).

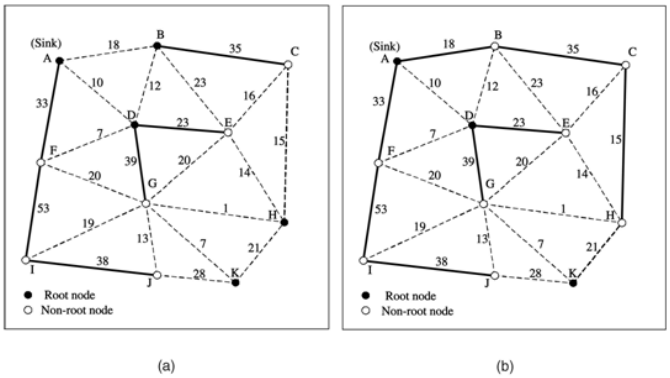

Fig. 4. Snapshots of an execution of DAT. Solid lines are those edges that have been included into T .

occur. It can be seen that T is always a subgraph of G and wT ðu; vÞ¼ 1 for all ðu; vÞ2 ET . For example, Fig. 4a is a snapshot of an execution of DAT. When ðF; GÞ is examined by DAT, it will not be included intoTbecause neitherFnor G is the root of its temporary subtree. Another snapshot is shown in Fig. 4b. When ðB; DÞ is examined, it will not beincluded into T . Although D is the root of its temporary subtree, B is not on the shortest path from D to A,

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i.e., distGðD; AÞ 6¼ distGðB; AÞþ 1. ðA; DÞ will be then examined after ðB; DÞ. ðA; DÞ can be included into T , because D is the root of its temporary subtree and A is on the shortest path from D to A.

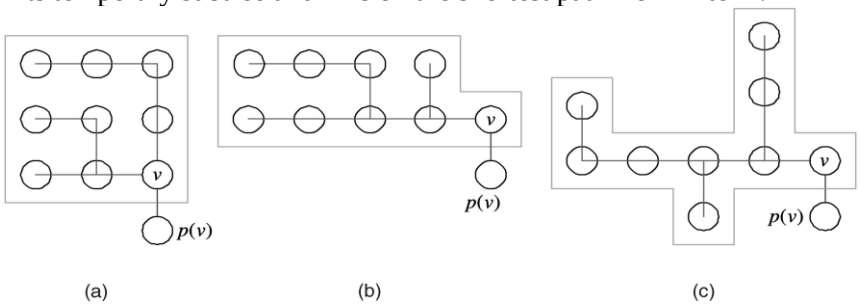

Fig. 5. Possible structures of subtrees with nine sensors.

3.2 Algorithm Z-DAT (Zone-Based Deviation- Avoidance Tree)

Theorem 2. If G is connected, the tree T constructed by algorithm DAT is a connected deviation-avoidance tree rooted at the sink.

Proof. First, we show that T is connected. Each sensor is the root of a singleton subtree in the beginning and we will prove that only one senor will be the root in the ending. Since G is connected, when a sensor x sink is the root of a subtree (i.e., x ¼ rootðxÞ), it always can find a neighbor- ing sensor y such that distGðx; sinkÞ¼ distGðy; sinkÞþ 1.the perimeter that bounds the sensing area of sensors in each

Hence, edge ðx; yÞ can be included into T , and x will not be the root anymore. By repeating such arguments, T will be connected and rooted at the sink. Second, we show that T is a deviation-avoidance tree. This can be derived from two observations. First, when an edge ðu; vÞ is included into T , DAT will choose v as the child of u if distGðv; sinkÞ is larger than distGðu; sinkÞ, and vice versa. Therefore, if the path from the sink to sensor u is one of the shortest paths, the path from the sink to sensor v is also one of the shortest paths. Second, assuming distGðv; sinkÞ¼ distGðu; sinkÞþ 1,DAT will include ðv; uÞ only whenvitself is the rootofasubtree.This total event rate that objects may move across the line. Then we pick the line with the lowest total event rate as its final location. After all horizontal lines are determined, we then further partition the sensing field into 22 regions by using ð2 — 1Þ vertical lines. Following the adjustment as above, each vertical line is also allowed to moveleftandright within a distance no more than 6 units and the one with the lowest total event rate is selected as its final location.

After the above steps are completed, the sensing field is divided into 22 square-like zones. First, we run DAT on the sensors in each zone. This will result in one or multiple subtrees in each zone. Next, we will merge subtrees in the above 22 zones recursively as follows: First, we combine these zones together into 2 × 2 larger zones, such that each guarantees that all descendant nodes in SubtreeðvÞ will

not deviate from their shortest paths to the sink. Hence, the theorem follows. Tu larger zone contains 2 × 2 neighboring zones. Then, we merge subtrees in these 2 × 2 zones by sorting all interzone edges (i.e., edges connecting these 2 × 2 zones) according to as the average number of queries that refer to objects within the sensing range of v per unit time in statistics.

Suppose that an object x is within the sensing range of v. When x is queried, if v is a nonleaf node, the query message is required to be forwarded to v since pðvÞ only indicates that x is in the subtree rooted at v. On the other hand, if v is a leaf node, the query message only has to be forwarded to pðvÞ because sensor pðvÞ knows that the object is currently monitored by v. The following equation givesQðT Þ by taking into account the number of hops that query requests and query replies have to travel on T .

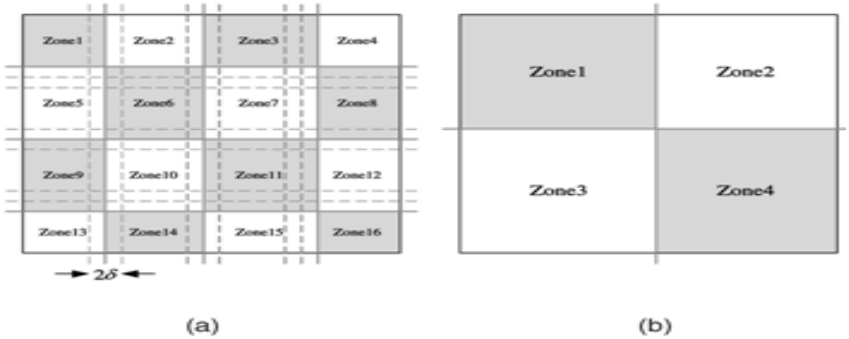

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Fig. 6. An example of the Z-DAT algorithm with 2 ¼ 4. (a) In the first iteration, we divide the field into 2 × 2 zones and adjust their boundaries according to 6. (b) In the second iteration, each 2 × 2 neighboring zones is combined into a larger zone.

To summarize, Z-DAT is similar to DAT except that it examines links of EG in a different order. By partitioning the sensing field into zones, each subtree in T is likely to cover a square-like region, thus avoiding the problem pointed out in

Fig. 5. Also, by using the parameter 6 to fine-tune the lowest-

Based on the above observations, QCR tries to adjust the tree T obtained by DAT or Z-DAT. In QCR, we examine T in a bottom-up manner and try to adjust the location of each node in T by the following operations.

Theorem 3. If G is connected, the tree T constructed by algorithm Z-DAT is a connected deviation-avoidance tree rooted at the sink.

Proof. Z-DAT will examine all links of G, but in a different order from DAT. However, the proof of

3.3 Algorithm QCR (Query Cost Reduction)

The above DAT and Z-DAT only try to reduce the update cost. The query cost is not taken into account. QCR is designed to reduce the total update and query cost by adjusting the object tracking tree obtained by DAT/Z-DAT. To begin with, we define the query rate qðvÞ of each sensor v

The derivation of (4) is in Appendix A. If the amount

of reduction is positive, we replace T byT 0. Otherwise, we keep T unchanged. Fig.7illustrates this operation.

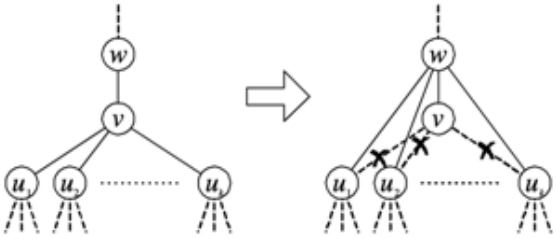

Fig. 7. Making a nonleaf node v a leaf node.

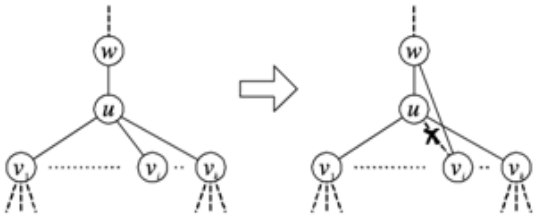

Fig. 8. Connecting a leaf node vito pðpðviÞÞ.

2. If a node v is a leaf node, we can make pðvÞ closer to the sink by cutting v0s link to its current parent pðvÞ and connect v to its grandparent pðpðvÞÞ. Let T 0 be the new tree. We derive that

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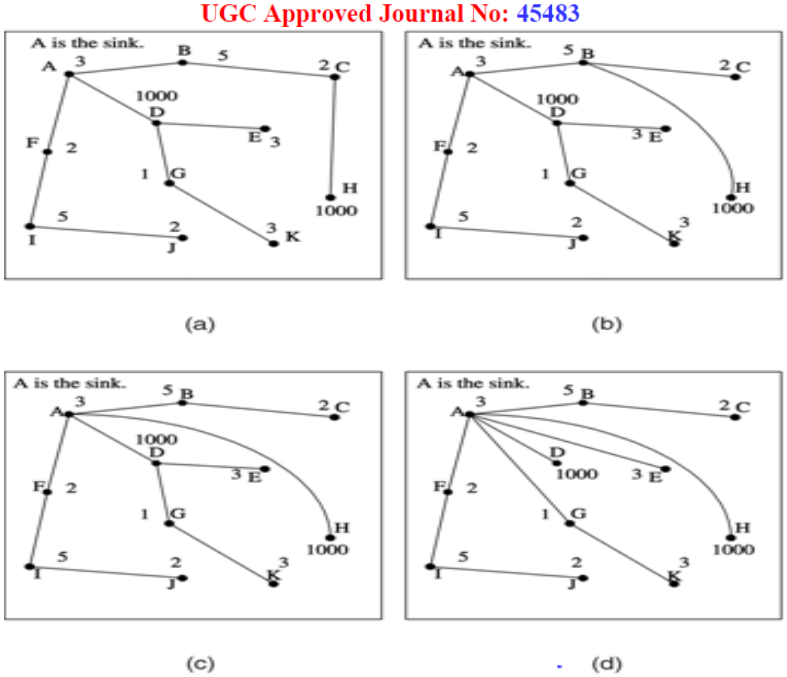

Fig. 9. An execution example of algorithm QCR.

Fig. 9d. Overall, the cost is reduced from 7,121 to 5,150, 3,180, and then 1,338 after each step, respectively.

4 SIMULATION RESULTS

The derivation of (5) is in Appendix A.Ifthe amount of reduction is positive, we replace T byT 0. Otherwise, T remains unchanged.Fig.8illustrates this operation.

Note that (4) and (5) allow us to compute the reduction of cost without computing U T 0 and Q T 0 . This saves computational overhead. Also note that T is examined in a bottom-up manner in a layer-by-layer manner. Nodes that are moved to an upper layer will have a chance to be reexamined. However, to avoid going back and forth, nodes that are not moved will not be reexamined.

For example, suppose that we are given a DAT tree in Fig. 9a (which is constructed from Fig. 1b), where the number labeled on each node is its query rate. When examining the bottom layer, we will apply Step 2 to sensors H, J, and K and obtain reductions of 1,974, -62, and -6, respectively. Hence, only H is moved upward as shown in Fig. 9b. When examining the second layer, we will apply Step 1 to sensor G and I and apply Step 2 to sensors C, E, and H. Only when applying to sensor H, it will result in a positive reduction of 1; 970. This updates the tree to Fig. 9c.

We have simulated a sensing field of size 256 256. Unless otherwise stated, 4,096 sensors are deployed in the sensing field. Two deployment models are considered. In the first one, sensors are regularly deployed as a 64 64 grid-like network. In the second model, sensors are randomly deployed. In both models, the sink may be located near the center of the network or one corner of the network.

Finally, sensors B, D, and F are examined. Only D has a

determined by an exponential probability positive reduction of 1,842. Thus, D will become a leaf and all its children are connected to D’s parent as shown in

where C isapositive constantanddisthe totalnumber of levels. In fact, the above behavior only formulates how

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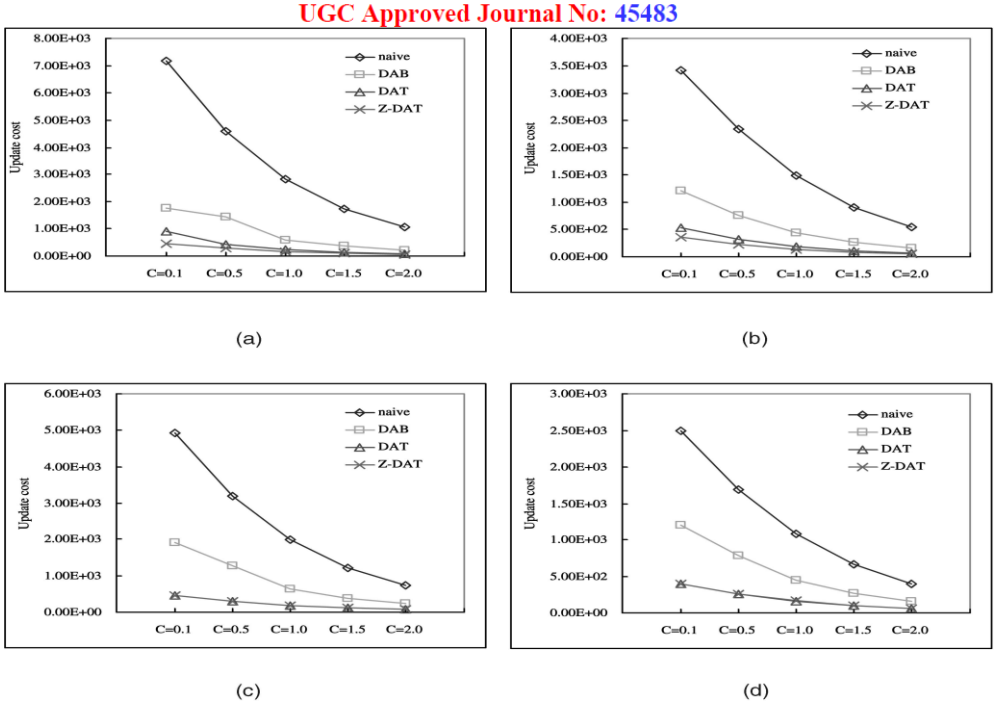

Fig. 10. Comparison of update costs. In the Z-DAT scheme, 2 8 and 6 0. (a) Regular deployment, sink at a corner. (b) Regular deployment, sink at the center. (c) Random deployment, sink at a corner. (d) Random deployment, sink at the center.

5 CONCLUSIONS

In this paper, we have developed several efficient ways to construct a logical object tracking tree in a sensor network. We have shown how to organize sensor nodes as a logical tree so as to facilitate in-network data processing and to reduce the total communication cost incurred by object tracking. For the location update part, our work can be viewed as the extension of the work in [8], and we enhance the work by exploiting the physical structure of the sensor network and the concept of deviation avoidance. In addition, we also consider the query operation and formulate the query cost of an object tracking tree given the query rates of sensors. In particular, our approach tries to strike a balance between the update cost and query cost. Performance analyses are presented with respect to factors such as moving rates and query rates. Simulation results show that by exploiting the deviation-avoidance trees, algorithms DAT and Z-DAT are able to reduce the update cost. By adjusting the deviation-avoidance trees, algorithm QCR is able to significantly reduce the total cost when the aggregate query rates is high, thus leading to efficient object tracking solutions.

APPENDIX A

In this appendix, we show how to derive (4) and (5). To begin with, we present two implicit facts used in the following derivations. First, according to Theorem 1, we can conclude that if the members of Subtree v are not changed, the number of messages transmittedon edge

REFERENCES

1 J. Aslam, Z. Butler, F. Constantin, V. Crespi, G. Cybenko, and D. Rus, “Tracking a Moving Object with Binary Sensors,” Proc. ACM SenSys Conf., Nov. 2003.

2 F. Aurenhammer, “Voronoi Diagrams—A Survey of a Funda- mental Geometric Data Structure,” ACM Computing Surveys, vol. 23, no. 3, pp. 345-405, Sept. 1991.

3 W.-P. Chen, J.C. Hou, and L. Sha, “Dynamic Clusteringfor Acoustic Target Tracking in Wireless Sensor Networks,” Proc. IEEE Int’l Conf. Network Protocols (ICNP), Nov. 2003.

4 D. Ganesan, R. Cristescu, and B. Beferull-Lozano, “Power-Efficient Sensor Placement and Transmission Structure for Data Gathering under Distortion Constraints,” Proc. Int’l Workshop Information Processing in Sensor Networks (IPSN), 2004.

5 C.-F. Huang and Y.-C. Tseng, “The Coverage Problem in a Wireless Sensor Network,” Proc. ACM Int’l Workshop Wireless Sensor Networks and Applications (WSNA), Sept. 2003.

6 C. Intanagonwiwat, R. Govindan, and D. Estrin, “Directed Diffusion: A Scalable and Robust Communication Paradigm for Sensor Networks,” Proc. Sixth Ann. Int’l Conf. Mobile Computing and Networking (MobiCOM), Aug. 2000.

7 Vishal V Lodhi, Amairullah Khan, Puranik “Dynamic Resource Management of Cognitive Radio Networks Via Fuzzy Logic Technique” International Journal of Engineering Research & Technology (IJERT), Volume.2. Issue.12. pp. 205-2711 in December 2013.

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A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Research Paper
Available online at: www.jrrset.com
UGC Approved Journal No: 45483

8 Amairullah Khan Lodhi, Ingole Snehal Diliprao, Kale Sindhu Subhas "Wavelet-Based Texture Feature For Content-Based Image Retrieval" International Journal of Engineering Technology & (IJETAE), Volume.3. Issue.12. in December 2013.

9 A. K. Lodhi, Apeksha L. "Wide Band Speech Coding and It's Application" International Journal of Engineering Research and Technology, Volume.2. Issue.6. in October 2013.

10 Lodhi A.K., Honrao Sachin B. "Solar Energy Based Automated Irrigation System" International Journal of Electronics Communication and Computer Engineering (IJECCE), Volume.4. Issue.5. pp. 205-2711 in September 2013.

11 Amairullah Khan Lodhi, Sachin R Gaikwad, Pushpak Khapke "Wireless Power Transmission" International Journal of Emerging Technology and Advanced Engineering (IJETAE), Volume.2. Issue.13. pp. 584-587 in May 2013.

12 AK Lodhi, G Parveen Baburao Kamble "Automatic Restaurant Order System Using ZigBee" Excel Journal of Engineering Technology and Management Science, Vol.1, Issue.3, in December 2012.

13 Amairullah Khan Lodhi, Syed Abdul Sattar, M. A. Nayeem "Efficient Low Power Design in FPGA's by Enumerating the State Machine Encoding" Global Journal of Computer Application and Technology (GJCAT), Volume.1. Issue.2. pp. 166-170 in May 2011.

14 Amairullah Khan Lodhi, M. S. S. Rukmini, Syed Abdulsattar "Energy Efficient Wireless Sensor Networks: A Survey on Energy-Based Routing Techniques" IEEE 3rd International Conference on Electrical, Electronics, Communication, Computation Technologies, and Optimization Techniques (ICEECCOT), conducted by GSSSIETW, Mysuru, on14th & 15th Dec 2018.

Amairullah Khan Lodhi, M. S. S. Rukmini "Energy-Efficient Routing Protocol for Node Lifetime Enhancement in Wireless Sensor Networks" International Conference on Modern Technology in Engineering Research & Management (ICMTERM–2019), conducted by Siddhartha Institute of Engineering and Technology, Hyderabad, on 1st & 2nd May' 2019