Finding Optimal Tour Length of Mobile Agent in Wireless Sensor Network

Anil Kumar Mahto

Department of Computer Science & Engineering

School of Engineering& Technology, Sharda University

Greater Noida, U.P., India

anil.fiem16@gmail.com

Ajay Prasad

Department of Information Technology

School of Engineering& Technology, Sharda University

Greater Noida, U.P., India

ajayprasadv@gmail.com

Hemkumar D.

Department of Computer Science & Engineering

School of Engineering& Technology, Sharda University

Greater Noida, U.P., India

1986.hem.kumar@gmail.com

Prity Kumari

Department of Computer Science & Engineering

Future Institute of Engg. & Management, WBUT

Kolkata, West Bengal., India

prity.kumari471@gmail.com

Abstract

Recently, research interest has increased in the design, development, and deployment of mobile agent systems in a wireless sensor network (WSN). Mobile agent systems employ migrating codes to facilitate flexible application re-tasking, local processing, and collaborative signal and information processing. This provides extra flexibility, as well as new capabilities to WSNs in contrast to the conventional WSN operations based on the client-server computing model. The MA collects data when it is in the proximity of a sensor node. This can be an alternative to multihop forwarding of data when we can utilize node mobility in a sensor network. To be useful, a MA approach needs to minimize data delivery latency. The major part of our work is about how to find out the minimal tour length of Mobile Agent in the Network for collecting the data from the sensor nodes**.**

Keywords: *Wireless sensor Network (WSN), Mobile Agent (MA), Base Station (BS), Travelling Salesperson Problem (TSP).*

1. Introduction

Wireless sensor networks (WSN) consist of a large number of small, energy- and resource-constrained tiny sensor nodes which have sensors and actuators to monitor and modify the state of our physical world. The nodes can communicate wirelessly and have sufficient computational resources to perform collaborative signal processing tasks[1]. A sensor network design is influenced by many factors, which include fault tolerance; scalability; production costs; operating environment; sensor network topology; hardware constraints; transmission media; and power consumption. These factors are important because they serve as a guideline to design a protocol or an algorithm for sensor networks. In other mobile and ad hoc networks, power consumption has been an important design factor, but not the primary consideration, simply because power resources can be replaced by the user. The emphasis is more on QoS provisioning than the power efficiency. In sensor networks though, power efficiency is an important performance metric, directly influencing the network lifetime. Application specific protocols can be designed by appropriately trading off other performance metrics such as delay and throughput with power efficiency. The main task of a sensor node in a sensor field is to detect events, perform quick local data processing, and then transmit the data. Power consumption can hence be divided into three domains: sensing, communication, and data processing.

Mobile Agent (MA):-

According to work presented in [3] The Mobile Agent is a special type of software or combination of Hardware &software which visits the network either periodically or on demand and performs data processing autonomously while migrating from node to node. Hence Mobile agent can be of two types-Hardware Mobile agent & Software Mobile Agent.

In mobile agent Paradigm the main aim is to move the computation to data rather than then data to the computation. So by using this paradigm the communication cost will be greatly reduce and the life time of the nodes will be comparatively more than the client server architecture in WSN.

Apart from battery life there is one more issue is in WSN i.e.; BANDWIDTH. Sensors are deployed on a low bandwidth wireless link. Hence the data movement should be as minimum as possible. Hence Mobile Agent based architecture is suitable for this scenario also. According to work presented in [4] Server-centered traditional C/S computing model, can be realized through remote procedure call (RPC), remote computing, code on demand, and etc. In RPC, client node initiates procedure call and passes parameter to server, then blocks for sever responding to client requirement and returning result to client nodes. Remote computing is extended from RPC. Client node sends its processing code and parameter to server, only making use of server's computing resource, the same as RPC, client node also has to wait for the result from server. In code on demand, client node downloads processing code for local execution from server through using local computing resource. Defects in traditional C/S computing model are as follows:

Aimless energy consumption(server's incapability of judging whether the data to be transmitted is invalid or not before data processing may result in transmitting massive data, irrelevant or useless, hence, waste bandwidth), Unbalanced network load(Which is caused by multiple clients transmitting data or requirement of service at the same time to server and may deteriorate network performance?), Low quality in fault-tolerance(When some resources or nodes become invalid temporarily, synchronous interact among nodes will bring about failure in computing procedure), Low security(For instance, multiple clients along different transmitting paths will do harm to carry out security control to data being transmitted).

Mobile Agent Computing Model:-

In mobile agent computing model, agent entity carrying execution code, running status, process result and access path by itself moves autonomously in network and interact with the outside in which self-governing and collaboration are emphasized. And it is characterized of asynchronous interact, moving as required and process by closest data resource, which help overcome the defects of C/S computing model. According to its own object and environment state, mobile agent computing model can compute through moving to nodes with corresponding resource. Communication and collaboration are carried out during the whole computing which can be divided into relatively independent multiple local sub computing process. As far as the realization of computation concerned, though mobile agent model can be realized through combination or adaptation of traditional distributed computing method, it is with following advantage] over traditional distributed computing method under circumstances of limitations on network:

(1) Decrease in the network data flow. Code transference, local process and result carrying of mobile agent realize the dramatically decrease in interact numbers between network nodes and data quantity transmitted through which bandwidth requirement, communication delay and quality of service (QOS) can be improved.

(2) Balanced load. Agent with the ability to adapt to changes of environment appropriately chooses moving tactics and data process methods according to the changing network load.

(3) Parallelism. Network can create multiple agents as required, which can move autonomously with parallel work for a common aim to improve computing efficiency and QOS.

(4) High quality in fault-tolerance. Agent can move asynchronously and autonomously. Long time link is not needed among network nodes. Node access and result returning can be fulfilled according to network status.

(5) Self-governing and collaborating. Mobile agent can aware the change of environment, interact with other agents, and take task-oriented action autonomously and collaboratively.

(6) Heterogeneity. Mobile agent, irrelevant to the environment of software and hardware, only depends on Mobile-Agent Environment.

Hence Mobile agent based Wireless Sensor network is much more efficient than the traditional Client server Architecture based Wireless sensor Network in terms of energy and bandwidth consumption.

2. Literature Survey

Energy consumption is critical and the processing ability, memory of sensor nodes are limited in wireless sensor networks. Mobile agent technology can decrease energy consumption and boost network performance. Inadequate deployment of mobile agents might lead to network failure due to constraint bandwidth.

According to work presented in [5] lots of Sensor Nodes (*SNodes*) and a Central Service Node (*CSNode*) are randomly distributed in *WSNs*. Task programs are updated dynamically due to limited memory of *SNodes*. *SNodes* are aware of energy consumption and usually remain in sleeping status; switch into working status when executing tasks; and automatically return to sleeping status after completing tasks. *CSNode* stores diverse *MAs* which can deal with the requests from *SNodes*. Once receiving a request from *SNodes*, *CSNode* initializes a *MA* according with the request; then the *MA* is dispatched to the node where the request is from and implements tasks; the *MA* returns results to *CSNode* after completing tasks; finally, the *MA* is destroyed locally.

While wireless sensor networks (WSNs) are typically targeted at large-scale deployment, due to many practical or inevitable reasons, a WSN may not always remain connected. There may be situations that a WSN is spatially separated into multiple sub networks. According to work presented in[6] that a WSN may become spatially separated into multiple sub networks. They discuss how to utilize a mobile mule to visit these sub networks to collect sensing data in an efficient way. Such separation may be due to several reasons like, the sensing field might be huge, such as farms or mountain areas. The traveling path of the mobile mule may reflect the data gathering latency and the energy consumption of the mule. Minimizing the perround total traversal time of the mule can be formulated as a *MPDG (*minimum-path data-gathering) problem, which is a generalization of the Euclidean Traveling Salesman Problem (ETSP).

A mobile agent model is an agent framework, which attempts to minimize traversal processing time regarding all destination nodes in the network. To minimize the processing time, the node with the optimal migration path among many destination nodes in the routing table is determined at the current node and the mobile agent migrates from the current node to the determined node.

Hence travelling path length of Mobile Agent is one of the major issues in the field of Mobile Agent Based Wireless Sensor Network. So which type of algorithm is suitable for finding the tour length of Mobile Agent.

3. Problem Statement

A mobile Agent will be scheduled from the base station to visiting the specific nodes in the WSN. The MA should visit the nodes in such a manner so that the total path travelled by the MA will be optimal. Hence main objective is “finding the Minimum Tour Length of a Mobile Agent in Wireless Sensor Network”.

A WSN deployed in a two dimensional square with ‘n’ number of nodes. Without loss of generality we consider that location of Base station will be decided by the user. From the Base station mobile agent will be scheduled to visit specified nodes.

Suppose X-coordinate and Y-coordinate of the respective node is given in the following table.

Table 1. Deployment of WSN

Node_Id	X-coordinate	Y-coordinate	Energy
1	42	68	0.5
2	35	1	0.5
3	70	25	0.5
:	:	:	:
:	:	:	:
n	X	y	0.5

Suppose the location of base station is node '2' and mobile agent have to visit node numbers (between 1 to n) 5, 6, 9, 24, 7, 4.Hence Mobile agent will be schedule from the Base station to visit all the desired nodes. Suppose one of the possible tour is (2-> 5->6->9->24->7->4->2).Here the length of the tour will be given by

length of the tour = D[2][5]+ D[5][6]+ D[6][9]+ D[9][24]+ D[24][7]+ D[7][4]+ D[4][2]

Hence we have to schedule the Mobile Agent in such a manner such that the length of the tour should me minimum.

4. Methodology

4.1 Travelling Salesperson Problem

Here the MA will be treated as a salesperson and nodes to be visited as cities.So the MA has to visit each node exactly once for collecting the data in such a manner so that the total path travelled by the MA should be minimum.

Issue with the TSP algorithm:-

In TSP algorithm for collecting the data by the Mobile Agent from the sensor nodes, Mobile Agent have to go to each node individually. But in Wireless Sensor Network the Mobile Agent can collect the data from the nodes which are in the specific range of the Mobile Agent. Hence travelling to each nodes individually by the Mobile agent is overhead. Hence TSP algorithm is not practically suitable for the WSN. Hence Ranged Based method is introduced for overcoming this issue.

4.2 Range Based Method for Tour Length calculation

Here MA will not go to each node individually for collecting the data, instead it will go to some specific nodes and collect the data from those nodes which are in the range of that MA. Again the MA will go to the next node and will collect the data from all those nodes who are in the range. Similarly it will visit the nodes till it not collect the data from all specified nodes.

4.2.1 Ranged Based Algorithm:-

Inputs- Grid size of the WSN (200x200), Total number of sensor nodes(200), Initial location of Mobile Agent is Base Station, Number of Nodes and node number (V1,V2,V3,…..Vn)to be visited is collected into an array, Range (R) of the Mobile Agent in which mobile agent can collect the data.

Algorithm-

Step1. Calculate the distance between the Base Station and the Nodes to be visited. Mobile agent will be scheduled to the node (suppose Vi) with minimum distance from base station. This node location will be the new location of mobile agent.

Step2. Hence the distance travelled by the mobile agent will be

Dist=Dist+Dist(MA,Vi).

2.1. Now calculate the distance from Vi to the every remaining unvisited node in the visiting array.

2.2. Compare the distance with the range (R)

If distance of any node from MA is less than R, then mark that node as a visit

Else the new location of MA will be the node nearest to the Vi,suppose Vj.

Vj = Vi;

Step3. Go to step 2 until all the nodes in the array marked as visited.

5. Result and Analysis

Wireless Sensor Network is deployed in 200 x 200 grid size with total 200 numbers of sensor nodes. Suppose the initial position of the Mobile Agent is at node id=1. The sensor nodes' id and other information from where data should be collected is stored into the Mobile Agent's memory. Now Mobile Agent is scheduled according to the algorithm Travelling Salesperson Problem (TSP) and Ranged based method and Improved Ranged based method. The distance travelled by the Mobile Agent for collecting the data from the sensor nodes for different scenario is calculated which is shown in Table-2.

Table 2. Comparison of TSP and RTSP

No of Nodes	TSP	RTSP R=10	RTSP R=20	RTSP R=30	RTSP (R=40)	RTSP R=50
5	457	425	425	425	370	366
10	604	589	589	589	534	520
15	765	669	669	642	567	520
20	1054	944	944	909	809	724
25	1094	1041	1041	921	819	713

30	1138	1057	1057	1012	896	713
35	1132	1189	1189	1031	838	713
40	1360	1291	1291	1111	866	761
50	1288	1174	1174	1182	859	819

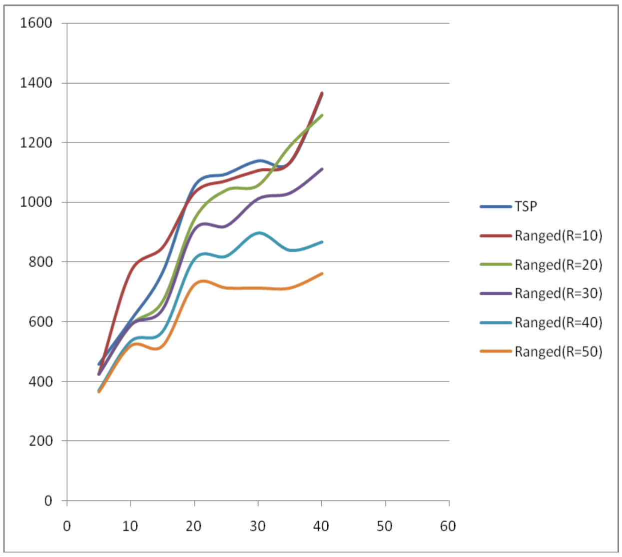

Figure 1 : comparison of TSP and RTSP based on table 2

From the table-2 and figure we can say that Ranged based method is efficient than Travelling Salesperson Problem.

6. Conclusion

Replacement of battery of a sensor node technique is under development. Hence saving energy of individual nodes by reducing the communication cost is a better option for increasing the life time of the network. In mobile agent Paradigm the main aim is to move the computation to data rather than then data to the computation. Optimal scheduling algorithm for mobile agent is very important for the success of the Mobile Agent technique in Wireless Sensor Network. Two algorithms (Travelling Salesperson Problem, Ranged Based Method) have implemented and results are observed for the same scenarios in. Based on the results in the previous section we can say that Ranged Based Method is the better algorithm than TSP algorithms.

References

1. I.F. Akyildiz, W. Su*, Y. Sankarasubramaniam, E. Cayirci "Wireless sensor networks: a survey" Broadband and Wireless Networking Laboratory, School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA 30332, USA Received 12 December 2001; accepted 20 December 2001.
2. A. Willig, IEEE, VDE/ITG, Wireless sensor networks: concept, challenges and approaches, Elektrotechnik & Informationstechnik (2006) 123/6: 224–231. DOI 10.1007/s00502-006-0351-1.
3. Rijubrata Bhaumik, Mobile Agent based Architecture for Wireless Sensor Networks, TKK T-110.5190 Seminar on Internetworking, 2009-04-27
4. Wang Jietai, Xu Jiadong, Yang Shaojun, "Research on Mechanism of Mobile Agent for Wireless Sensor Networks", 1-4244-1312-5/07 IEEE 2007.
5. Xue Wang, Sheng Wang, and Aiguo Jiang "Optimized Deployment Strategy of Mobile Agents in Wireless Sensor Networks" Proceedings of the Sixth International Conference on Intelligent Systems Design and Applications (ISDA'06).
6. Fang-Jing Wu, Chi-Fu Huang, and Yu-Chee Tseng "Data Gathering by Mobile Mules in a Spatially SeparatedWireless Sensor Network" 2009 Tenth International Conference on Mobile Data Management: Systems, Services and Middleware.
7. YonSik Lee, KwangJong Kim "Optimal Migration Path Searching using Path Adjustment and Reassignment for Mobile Agent", Fourth International Conference on Networked Computing and Advanced Information Management 2008 IEEE.