Angle Gap (AG) based Grouping Algorithm for Multi-Mobile Agents Itinerary Planning in Wireless Sensor Networks

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***Abstract*—Compared to the conventional wireless sensor networks (WSNs), Mobile Agent (MA) systems provide new capabilities for energy-efficient data dissemination by flexibly planning its itinerary for facilitating agent-based data collection and aggregation. Most of the existing work focus on the itinerary for single MA, however, it is obviously that using Multi-Mobile Agents(MMAs) will get benefits from the energy aspect. In this paper, we proposed a novel angle gap based grouping algorithm which could group the source nodes in a particular angle. Simulation will be performed to show the benefits from the algorithm.**

I. Introduction

Agent-based data collection and aggregation have been proved to be efficient in wireless sensor networks (WSNs).[1] While most of existing work focus on designing various single agent based itinerary planning (SIP) algorithms by considering energy-efficiency and/or aggregation efficiency[2][3][4][5], multi-agent based itinerary planning (MIP) solution is now promising.[6] According to the previous work[6], MIP algorithm design could be divided into four components: selection of visiting central location (VCL), Determining the source visiting set, determining a source-visiting sequence, and iterative algorithm.

In this paper, we focus on how to more efficiently group the source nodes, which is the key challenge in MIP. The nodes with relevant information should be included in the same group. In most of the cases, they are geographical neighbors. According to this feature, the paper[6] select a visiting central location (VCL) according to the node density(Gravity Algorithm) and group all the nodes in circle of radius R. However, this approach assumes that the relevant source nodes are arranged geographically distributed in several clusters, which limits the use of the algorithm in a wide range of applications. To address this problem, we provide a Angle Gap (AG) based grouping algorithm which could describe the group better.

II. Analysis

In this section, an example of MMAs itinerary planning is analyzed to show the benefits from the AG algorithm.

Figure 1 is the grouping result for VCL algorithm. According to the center and the radius, the sink will send 4 MAs to the corresponding source nodes. However, it is obviously that it will be more efficient if the MA visit the source nodes near the sink on the way back from collecting the data in the other nodes at once. Forasmuch, VCL grouping is not a good solution.

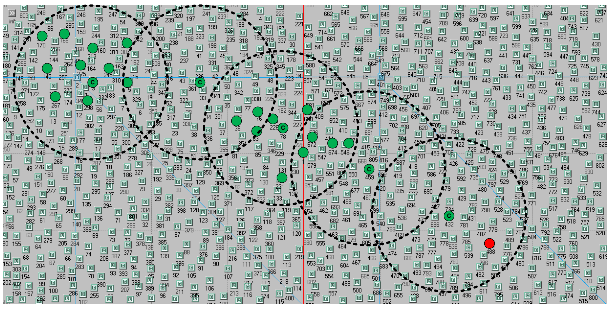

Fig. 1. Visiting Central Location Grouping

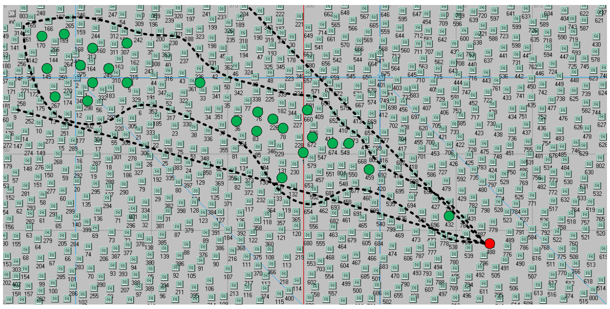

Fig. 2. Angle Gap Grouping

On the other hand, the Angle Gap (AG) based grouping could solve this type of problems easily. Figure 2 shows the grouping strategy for the sink. We assume that we could connect the sink and the source nodes with beelines, and the Angle Gaps $\Delta\theta$ between the beelines could become an important factor which describe the relations among source nodes. In our approach, the sink calculate the Angle Gap Factors (AGF) for each source node. The two nodes with minimum gap will be select as center nodes and the nodes within a particular Angle Gap threshold θ should be included in the group then. Additionally, with a iterative calculation, the source nodes near the group will be also included. From this approach, the sink will recognize all of the source nodes in the figure as a group.

III. Simulation

A. Simulation Setup

We implemented the proposed grouping algorithm as well as the existing VCL algorithm using OPNET Modeler and perform simulations.We choose a network where nodes are uniformly deployed within a 1000m * 500m field. To verify the scaling property of our algorithms, we select a large-scale network with 800 nodes. We assume that the sink node is located at the center of the field and multiple source nodes are randomly distributed in the network.

B. Simulation Result

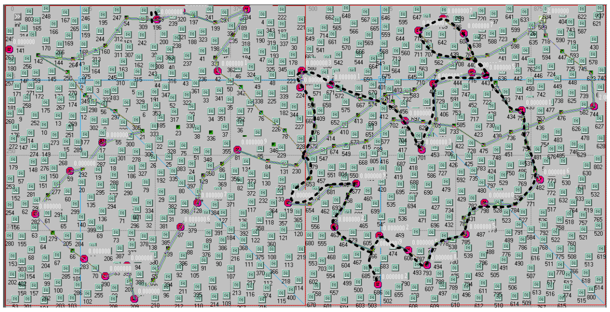

Fig. 3. Visiting Central Location Grouping Result

Figure 3 shows the result of the VCL algorithm. As has been indicated by the dashed line, the first itinerary covered a large circle area in the right part of the field. However, the source node at the right edge was not included. It means that another MA is required for this node individually. To all appearances, this grouping will decrease the benefit from using the MA since the travel of MA itself will cost energy of the network.

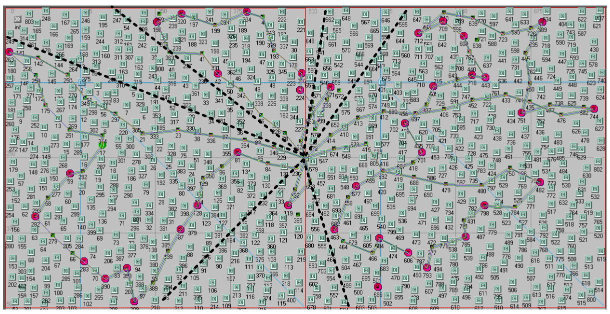

Fig. 4. Angle Gap Grouping Result

The result for AG algorithm is totally different. It is presented in Figure 4 that the whole surveillance field is divided into serval parts according to the AGFs between the source nodes. The problem occurred in the VCL scenario above would never appear in this scenario.

Another potential benefit from the AG grouping is that when the MMAs are sent simultaneously, the feature of the angle division could reduced the radio interference between multiple itinerary flows. Lower SIR could reduce transmission error, which implies smaller latency and longer network lifetime.

More of this, due to the nature of angle based, AG grouping could achieve much more benefits than that of VCL when the relevant source nodes are distributed in a straight line.

However, the new approach rise a new problem. Since the source nodes are not always deployed equably, there maybe some of them could not be included in a large group but stand alone. In Figure 4, the two nodes in individual groups are examples. To address this problem, we suggested that the algorithm should judge the number of remaining source nodes. If there are just small number of nodes to be visited, then one special MA will be sent for all of them.

C. Discussion

As the radius R is an important parameter in VCL algorithm, the efficiency of AG grouping will be heavily affected by the parameter of θ, the threshold of the Angle Gap. How to choose a appropriate θ is still an tough issue.Nevertheless, θ could be determined by the density of the network while the radius of the VCL algorithm couldn't.

Another issue of AG grouping algorithm is that selecting the sources node with minimum $\Delta\theta$ as the central location is not the best choice. Considering the density of the source nodes as VCL does could make it more reasonable.

IV. Conclusion

In this paper, we proposed a novel grouping algorithm for MMAs itinerary planning in wireless sensor networks. The new algorithm group the source nodes based on the information of angle gap, which is a more reasonable way. Simulations are performed to show the different results between the two grouping algorithms.

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