Routing Using Messengers in Sparse and Disconnected Mobile Sensor Networks

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Abstract—Sparse mobile sensor networks, such as those in the applications of ecology forest and modern battlefield, can frequently disconnect. Unfortunately, most existing routing protocols in mobile wireless networks mainly address connected networks, either sparse or dense. In this paper, we study the specific problem for dynamic routing in the sparse and disconnected mobile sensor networks utilizing messengers. We propose two routing discovery protocols: Genetic Fuzzy Straight Line Moving of Messengers (GFSLMM) and Genetic Fuzzy Flexible Sharing Policy of Messengers (GFFSPM). A preliminary simulation shows the efficiency of our protocols.

Index Terms—Mobile Sensor Networks (MSN), Minimum Spanning Tree (MST), Dynamic Source Routing Protocol (DSR), Ad Hoc On Demand Distance Vector Routing (AODV), Genetic Algorithm (GA), Fuzzy Inference System, Disjoint Mobile Sensor Networks (DMSN), Straight Line Moving of Messengers (SLMM), Flexible Sharing Policy of Messengers (FSPM), Genetic Fuzzy Straight Line Moving of Messengers (GFSLMM) and Genetic Fuzzy Flexible Sharing Policy of Messengers (GFFSPM).

1 Introduction

Rapid progress of wireless communication and distributed embedded sensor and actuator technologies has lead to the thriving of the applications of mobile sensor networks (MSN) which range from natural ecosystem to security monitoring, especially in inaccessible terrains or disaster relief operations [1].

Mobile sensor network is a dynamic sensor network with a large number of static sensor nodes and mobile nodes and wireless communication between them. These mobile nodes can be mobile vehicles (cars or buses) which are loaded with sensors. In a habitat monitoring scenario, animals can perform the role of mobile vehicles [5]. The MSN possess the self-organizing and cooperative ability to detect record, collect, process, predict and estimate some events of interest [1].

The first application we consider here is to monitor basic forest ecology. UCLA used infrared imagers to track forest temperatures and heat patterns [8]. But it is not cost-effective to study the entire ecology environment change by deploying lots of sensor nodes in the entire forest to form a dense connected network and maintaining the entire network. So a feasible way is to attach sensors to the trained or observed animals.

The second application we present here is the modern Battlefield which demands critical surveillance information system of the enemy site and the most rapid and precise decision support system. Mobile wireless sensors, scattered in targeted zones, form the MSN. They are able to quickly and secretly gather infor-
mation about the location and environment and periodically relay this information back to the command, control, and communication center [6].

Since sensor nodes inherently have limited power, short-distance communication and prone to failure, in the above two applications, it is difficult to form a globally connected topology. For sparse/disconnected networks, [2][5][7] proposed mobility-based approaches. [2] assumes network topology is relatively stable and the information about network partitions are conveyed by out-of-band means. [5] assumes that the sensor networks in the bottom tier are fixed. All the assumptions allow ignoring the inherently and highly dynamic nature of the distributed dynamic environment. Our previous work [7] was mostly devoted to implementing the agents-based simulator for the problem. We proposed two solutions, one based on straight line moving of messengers and the other based on flexible sharing policy of messengers. However, we did not give the problem formulation for it and show the feasibility topologically. These previous work will be described in details in section 2.

This paper deals with the distributed dynamic environment. We propose solution and show feasibility. Because the uncertainty of dynamic environment and wireless communication, we propose to employ the genetic fuzzy system in the previous two solutions.

The problem and solution method are as follows. Because the use of a long range radio consumes excessive energy, we employ the mobile vehicle (cars, buses, people, or animals with sensors) as the messenger. Once network partitions are generated, the autonomous routing discovery and maintenance based on messengers will be invoked in delay-tolerant sparse/disconnected mobile sensor networks. Through SLMM and FSPM based on the messengers, the information of the available network partitions can be shared. And then, in our problem model, we set every one of network partitions to be a vertex and find the cut-edges in the minimum spanning tree (MST) which connects these partitions and meets the condition of the minimum distance weight. The minimum distance weight represents the minimum total energy consumption in the process of the moving. Furthermore, distributed and dynamic characters of the specific applications make the problem more challenging and interesting. With the advent or moving of targets, the network partitions, as vertices in the MST, are changing. On the consequence, new MST should be built and new cut-edges should be discovered. So the problem is focused on the discovery and rebuilding of the dynamic MST with the tradeoff between the delay and real-time availability of network partitions information. Additionally, after MST is constructed, the problem is simplified and the currently existed techniques can be applied [3]. Our goal is to design an energy efficient, decentralized, scalable and flexible approach to share the information of network partitions and rebuild the MST for the distributed dynamic application environment in the delay-tolerant range when network partitions change. Figure 1 shows Process of building topology in disconnected network partitions. It can be iteratively operated. And every network partition can be composed of the hierarchy of subnetwork partitions no matter whether there has been a MST in it. The iterative