Advanced Science and Technology Letters
Vol.111 (NGCIT 2015), pp.23-26
http://dx.doi.org/10.14257/astl.2015.111.06

Stratified Multi-objective Optimization Algorithm in Wireless Networks

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Abstract. Due to the cost, reliability and quality of communication equilibrium of the traditional FM radio network optimization algorithms during the construction , hierarchical multi-objective optimization algorithm is put forth.First, increasee FM wireless networks mobile node and select new-adding link waypoints' optimal vector set, then design a hierarchical optimization model, and then use hierarchical multi-objective optimization algorithm to solve the problems of VHF wireless networks.Finally, compared simulation experiment of stratified multi-objective optimization algorithm and Glid algorithm and violent search algorithm is conducted, and the experiment shows that: stratified multi-objective optimization algorithm is smaller than traditional optimization algorithms in areas such in the network nodes, the average communication jump and the average attenuation of communication after running 50 times, i.e. lower cost, better network reliability and communication quality.

Keywords: Path discrete, constraints, objective function, network node, WSN

1 Introduction

Different from the usual wired communication networks, wireless ad hoc networks can be laid easily and quickly without pre-infrastructure. Self-organizing wireless network's data link layer technology is one of the key technologies of self-organizing wireless networks. Based on TCP/IP protocol, FM radio network with self-organization is different from conventional WLAN, it use frequency hopping transmission and static TDMA MAC technology.This FH-TDMA transmission system helps ensure the reliability of the communication node and anti-jamming, It is easy to implement self-organizing network environment changes. But features and defects of FH-TDMA transmission system presents special requirements for FM channel link layer protocol's design [1-4].

ISSN: 2287-1233 ASTL

2 Models and Definition

A. Definition of Objective Function

Main objective of FM radio network planning is the cost of network construction, network reliability and quality of communication and get the optimum of the three through the use of appropriate network planning algorithm. To lower construction costs and obtain savings is an important goal of network planning when the communication needs and quality are satisfied .In building a VHF radio network, adding an additional vector waypoint means an increase in a communication vehicle. The reduction of the number of adding vector waypoints is particularly important to cost control. Therefore, the objective function is defined as the following:

$$f_1(x) = \frac{|s|}{m} \qquad (1)$$

Wherein, f_1 (x) represents the average number of required adding vector waypoints when connect a necessary network node; x represents an increase of a set of vector coordinates of the waypoint; | x | represents the increase in the number of vector waypoints; m indicates the number of necessary network nodes.

In the VHF wireless network, problems of arbitrary hop communication of any link between two necessary network nodes can let this link fail. Therefore, the fewer the average number of communication hops between the necessary network nodes, the higher the reliability of the network. The objective function is defined as the following:

$$f_2(x) = \frac{1 \le i \prec \sum_{1 \le i \le j} h_{ij}}{m(m-1)/2} \qquad (2)$$

Wherein, f_2 (x) represents the average number of communication hops between necessary network nodes, ; x represents an increase of a set of vector coordinates of the waypoint; h_{ij} (x) represents the shortest hops of the communications link between the necessary network node i and j. The communication attenuation between necessary network nodes directly determines the communication quality of the entire wireless network. Therefore, another objective function is defined as:

$$f_3(x) = \frac{1 \le i \prec \sum_{i \le j} l_{ij}}{m(m-1)/2} \qquad (3)$$

Wherein, f_3 (x) represents the average communication attenuation between the necessary network nodes; x represents an increase of a set of vector coordinates of the waypoint; l_{ij} (x) indicates the communication attenuation between the necessary network node i and j, if necessary, the network node i and j are needed to multi-hop for communication, the communication attenuation between them is the maximum of the multi-hop attenuation.

B. Hierarchical network Planning Optimization Model

Hierarchical network planning optimization mathematical model is:

$$s = \min_{x \in k} \left[p_k f_k(x) \right]_{k=1}^{l} \qquad (4)$$

Wherein, T represents the minimum solution of hierarchical multi-objective; Ps (s = 1,2,, L) for the first level of the mark, which means the corresponding objective function fs (x) (s = 1,2,, L) is the s priority level, and the relationship between the Ps satisfy s> s' Ps> Ps', which means that the s priority level "prior" to s' priority level.Under the condition of satisfying the constraint conditions. Firstly, get the minimal solution set of the objective function value of the second priority based on the minimal solution set of the objective function value of the first priority levels, and the rest can be done in the same manner. In general, multi-objective minimization of s+1 priority level should be done based on the solution set of the s priority level. In the last layer, solution set of Multi-objective minimization is the solution set of type (4).

In this paper, L = 3, i_e , three priority level's problem of hierarchical multi-objective minimization:

$$R = \min_{x \in j} \left[p_1 f_1(x), p_2 f_2(x), p_3 f_3(x) \right] \qquad (5)$$

In VHF radio network planning, the cost factor is at the highest priority, the next is reliability of the network, and the last one is the communication quality of the network .Therefore, function of the first priority level is supposed as the average number of required-adding waypoints vectors f1 (x) which is needed to connect a necessary network node , and the function of the second priority level is supposed as the average number of average communication hops f2(x) between necessary network nodes ,and the function of the first priority level is supposed as the average number of the average communication attenuation f3 (x) between necessary network nodes.

During the optimization process, partially focusing on certain optimization goals through a hierarchical approach can ensure that a more important optimal performance goal priority can be optimized firstly. Layering is usually not used alone, but more used in conjunction with other optimization algorithms.

C. Propagation model

For the planning wireless network, simulation and verification are conducted; communication attenuation between nodes is calculated by using Longley-Rice model. The communication attenuation through Longley-Rice model does not only consider the communication frequency and the distance between nodes, but also consider the terrain information, such as terrain irregularities, the average surface refractive and other factors. Therefore, attenuation communication by using Longley-Rice model can be a good fit the actual communication attenuation between nodes.

3 Conclusion

This paper studies how to increase certain mobile nodes as a relay node to constitute the optimal FM wireless network based on certain given necessary network nodes. To achieve the balance between network construction cost, reliability and quality of communication , we design a hierarchical optimization model and under the model

define the objective function of FM radio network planning .To solve the model,we propose a hierarchical multi-objective optimization approximation algorithm, which combines advantages of the greedy algorithm and dynamic programming , and it can achieve the approximate optimal solution which satisfies the constraints according to the priority level of the objective function . In addition, the article also analyzes the time complexity of the algorithm, and compares the algorithm with other wireless network planning algorithm on simulation .Simulation results show that the algorithm can find the solution which is similar or even equal to the optimal solution, and the planned network is much better than GLiD algorithms in terms of cost, reliability, and communication quality.

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