Routing Protocol Based on Fuzzy Logic in Mobile Ad hoc Networks

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Abstract: Taxonomic Ad hoc network usages have been investigated in military services, conferences and transport and et al., environment, network performance is intensively affected by routing protocols. A variety of routing algorithms has been suggested and their performance has been studied. Among them, those algorithms that are based on nods position are noticeable and these methods have been emphasized on this article. Since fuzzy calculation has opened a new door to most of engineering fields a routing based on fuzzy logic is presented on this article. A fuzzy logic usage assures path reliability in specific of time.On the other hand, we present a combination of two distinct algorithms – proactive and packet request. Finally, a mathematical model is presented that approves improve ness compared to other methods.
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1. Introduction

Mobile wireless networks application has been examined in various military settings, conferences, rescue teams, transportation matters, etc. these nexuses have been practically utilized too. Great advancement of radio technology and the mass production of electronic circuits make it feasible to manufacture tiny electronic equipment with topnotch processing capability, reasonable price and low power consumption. There is no need to use topological structures in these infrastructures. The above fact and the other advancements caused the formation of ad-hoc networks. Mobile wireless networks which are manufactured by the name of Manets do not have any predefined topological structures. No concentrated control has been applied for routing these nexuses due to the aforesaid fact. Routing is done by each node. Thus each node carries out processing and routing functions. Routing methods can be classified in these networks in various manners. Two approaches known as preset and on-demand methods are utilized in this classification. Some messages are emitted periodically based on fixed intervals in the preset method to make the routing data compatible for each pair of nodes. Some tables are used to contain the routing data in this methodology. Thus sometimes they are also called table-driven methods. When a routing demand occurs, a specific direction is made from the departure point to the destination point in the table-driven methods. The above procedure is carried out through the beginning node and the routing detection process. When a specific route is established successfully the beginning node maintains it as long as required. There is another classification available for the above nexuses, which is as follows: flatrouting, hierarchical routing, and geographical position routing. Nodes are regarded as peers in the flat routing; none of the nodes are superior to other ones. Routing and processing occur in each note. Specific nodes are selected for hierarchical routing. The concept of clusters is used in the above methodology. Some of the basic nodes make the routing for the control clusters. Other nodes transfer data to the basic node of one's cluster so that routing will be carried out by them. Geographic position assisted routing uses the pertinent services. They use GPS systems to position the setting of equipment. It goes without saying that the required equipment and tools are manufactured in diverse sizes and precisions. We explicate the position-driven methodology at first. LAR Methodology will be elaborated afterwards. We will elucidate fuzzy calculations and logic laconically. We will propound our suggested method eventually. Position-driven routing methodology will be propounded afterwards. On-demand and table-driven protocols will be dealt with hereunder. [14, 1].

2. Position assisted routing methodology

The Packages are dispatched based on the geographical destinations in this methodology. Thus nodes should query the final destination of the package and receive the required data. Since ad hoc networks ply a fixed infrastructure, the position in which a distributed algorithm is used is a key design method for a specific service. Services should not be disconnected due to the malfunctioning of individual nodes. Scalability is an optimum feature of networks.

When routing is carried out based on position, nodes are dispatched based on the position of a package and the immediate position of the neighboring nodes. The destination position is situated in a closed header. If any of the nodes contains data about the precise position of the destination, the position may be updated in the package before dispatching. Unilateral emissions reveal the position of adjacent nodes. These radio waves are periodically dispatched by all the nodes, and they have data about the sender's node. Three chief strategies can be specified for position-assisted routing. In the first two strategies, one of the nodes sends a specific package to a greedy forwarding or flooding directed node in the adjacent zone, in a way that these nodes are nearer the destination as compared to the sending node.

The third strategy is used to form a hierarchy for scalability with plenty of mobile nodes. Hierarchical mechanisms use various types of ad hoc routing protocols in diverse hierarchical levels. (Thus position assisted routing is carried out in one level and non-position-based routing is executed in another level.

Table 1. collating table-driven and on-demand protocols

Table-driven	On-demand	Parameters
It is always available	It will be provided whenever needed	Routing data is available
It is mostly flat except in HSR and CGSR	Flat	Routing philosophy
It is required	It is not required	Periodic refreshing
Conveying data of new routes to other nodes	Redetection of routing	Manners of matching motions
It is bigger than the on-demand protocols	Routing activity can intensify it	the great mass of signals emitted
The shortest route is propounded as a qualitative criteria	The shortest route is mostly used and few units can provide Qos	Supporting Qos

We utilize the ensuing criteria to access special routing strategies. Communication complexity is the average number of one-step transferences which are indispensable to dispatch a specific node to another one. This will occur, if the destination position is known. Communication complexity must be equal to the number of steps in the shortest route between the departure and destination points.[3,4,5,9,10].

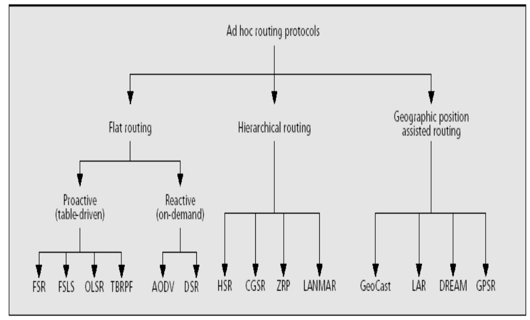

Figure 1. Routing methodology classification

3. LAR: Location-Aided Routing

As it is evident in LAR Schematic view the S departure point reveals the request in its route.S double node has two portions. One of them pertains the routing data. Suppose S node contains the data concerning Wd, Wd Position of node D at the moment of T0.When S node contains data about the routing detection, T1 is larger than T0. the distance from S node up to Xd, Xd is calculated. This matter has been depicted in DistS. The data of the above distance is inserted into the message. Xd, Xd positions are added to the message request in the routing. When an I node receives data from S dispatching node, node I calculates the pertinent distance from Xd, Xd. DistI has been depicted based on parameters A,B. if Adists + Bdist I is a valid relation, I node will send the request to its adjacent units. When I node forward the routing request, the message contains data about Xd, Xd Disti. The data received in Dist S is replaced by the data received in Dist I.

If DistS + DistI is a valid relation, I node will cast away the routing request.

When several K nodes receive the routing request from I node, (the message which was sent by s), they will do a task similar to what was described above. If K node has received this request previously, it will ignore it. Thus K node will calculate the pertinent distance from Xd, Xd which has been depicted by Disti. Routing request sent by I node contains Disti. If Disti + Dist K are correct, K node will dispatch the request to the adjacent units (unless K node is the destination point of the route).

Disti data is replaced by Dist K data prior to forwarding the request. If Disti + Distk is correct, K node will ignore the request, K node will forward I request message produced by S provided that it is nearer Xd, Xd. AB parameters are usually non-zero which are tuned to detect a possible route.[7,8,11]

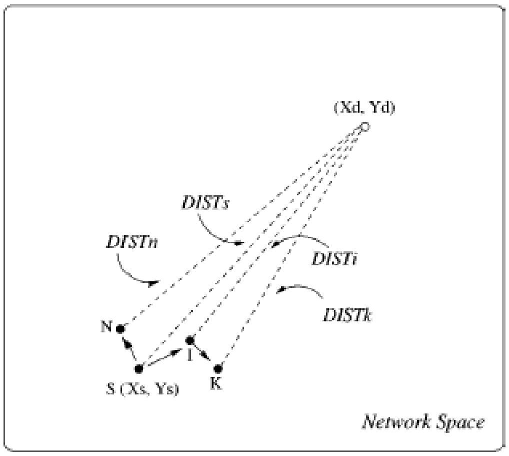

Figure 2. The schematic view of the LAR routing algorithm

4. Fuzzy numbers hypothesis

Professor Lotfizadeh presented the fuzzy logic hypothesis and the pertinent collections in 1965.[5] he emphasized the fact that the binary logic that Aristotle talked about does not match the precise reality of the actual world. We use fuzzy decision making instead of binary logic in our daily tasks. For instance, consider the ensuing sentence: If it is cold, I won't go to the factory. We never determine a specific point for weather coldness to see the realization of the above point. For instance, we do not mention the temperature of 3.9 degrees as a permitted temperature for going to work and the temperature of 4.1 degrees as a temperature which precludes us from going to work. It goes without saying that we will never use such precision in our daily decision makings. The above fact originates from the inexact realities of this world. The precision of the gauging tool can be problematic in the above example. We won't use any specific tool when dealing with that quandary. Plenty of mathematicians opposed to this view at first, nonetheless engineers embraced it PID controllers were rapidly replaced by fuzzy controllers. The above view had to be proposed in other math problem too. Fuzzy numbers and calculations were propounded subsequent to fuzzy logic and collections. Fuzzy numbers denote the fact that a specific number may be displayed in the space that it occupies not merely in a specific spot. For instance, number 2 can be regarded as 1.99 or 2.01 but not regarding 100 percent precision. Membership functions were obtained from fuzzy collections. They were propounded again. Membership functions represent the relationship between each element and the collection. If we intend to explicate this matter about the fuzzy collection, we have to pay attention to the ensuing instance. A group of people who are more than 180 centimeters tall.

This collection may contain all the people who are 180 centimeters tall onwards. Suppose there is a person who is 179 centimeters tall who could not be a member of the above community. There is also another person who is 125 centimeters tall and has the same situation. A membership mark is assigned to each member which ranges from zero to one. Thus all the people who are 180 centimeters tall have a membership number of 1 and the rest of them who are 180 centimeters or less are assigned a quantity ranging from zero to one. The above quantity will be zero for those who are less than 140 centimeters tall. The membership function of this collection has been depicted beneath.

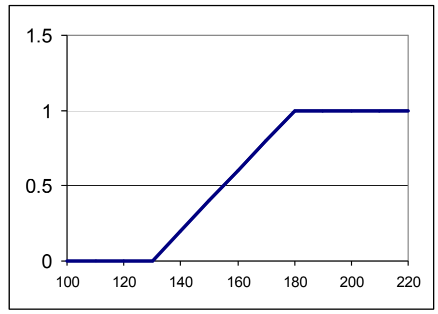

Figure 4. The membership function for the tall people

As you can see in the figure above, the quantity of this function is 1 for data more than 180 and zero for data less than 130. the above quantity can be calculated based on the linear functions (ranging from 130 to 180).

$$f(x) = \frac{x-130}{180-130}$$

The above function is one those which are available to depict the membership ranking of each data in a fuzzy collection. It goes without saying that other types of this function can be used to depict the membership ranking of a fuzzy set. You can see various types of these functions below.

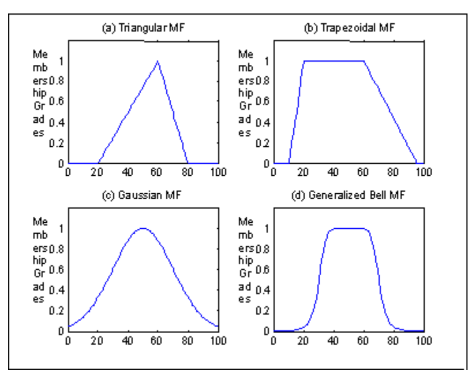

Figure 3. Various types of fuzzy membership functions

A triangular membership function can be used to depict a fuzzy number. Triangular membership function can be defined as Ta, b, c based on the criteria below.

$$T(a,b,c)\begin{cases} 0 & x \le a \\ \dfrac{x-a}{b-a} & a < x < b \\ 1 & x = b \\ \dfrac{x-b}{c-b} & b < x < c \\ 0 & x \ge c \end{cases}$$

You can see a sample in a2 picture. There are other types of membership functions for numbers, for instance, trapezoidal and Gaussian functions [6].

Four basic operations of adding, subtracting, multiplying and dividing are implemented in two methods to make calculations with fuzzy numbers. One of them is the Alpha shearing method and the other one is the principle of extension.

Removing fuzzy features since precise spot tools have been used to form our surroundings, each time a calculation is done with fuzzy decision making, the conclusion has to be converted to a non-fuzzy number to be applied in an actual environment. This stage is known as non-fuzzy making. Plenty of methods have been suggested in this regard for instance, gravitation point, average altitude, total average, etc. since calculation cost and delay are significant factors for routing, we have chosen a very simple method for this task.

5. FLA

Flar is a routing algorithm for based on fuzzy calculationsWe will deal with our suggested algorithm in this chapter. We will enumerate the essential hypotheses that we consider in this algorithm. We will deal with the routing methods for the suggested algorithm.

A. Essential Hypotheses

The following essential hypotheses will be available in this algorithm.

GPS Equipment has adequate precision. (Hence, they return X and y quantities distinctively and correctly as the node moves along it). The nodes motion pattern is fixed while samplings are made. The time intervals regarded for samplings are considered in a way that the nodes motion pattern will be fixed during these intervals.

The membership function which has been used for the position numbers is triangular and right angle.

There is a fixed interval between the two samplings and the consecutive sampling, to obtain information about the fixed position. These parameters are determined with regard to the GPS tool precision and the motion coefficient of nodes. The velocity of each node is constant.

B. Routing method

The second schematic view of LAR algorithm has been selected for this algorithm. Fuzzy calculations have been utilized to quantify and collate the interstice of each node up to the destination. Thus, the departure and destination data are inserted in the message, when a message is sent. This interstice is based on a non-fuzzy number. It is sent to the destination based on a fuzzy number in the message. The fuzzy extent is quantified for X and y position of each node.

Suppose tp is the time required to make consecutive updates of each node position. This is the time that each node has to request its position from the position-rendering unit. Since positions are regarded based on fuzzy extents, each time the position of a node is updated, two consecutive requests are sent to the service-rendering unit. Suppose ts is the interstice between two consecutive requests. Thus the following will apply for making fuzzy quantifications in the positions.

X1, y1 = the position obtained in the first request
X2, y2 = the position obtained in the second request
Ts = the time interstice between two sampling
Tp = the time interval between two pairs of sampling

$$\begin{cases} x_s = x_1 \\ x_E = x_1 + [(x_2 - x_1) \times \dfrac{t_p}{t_s}] \\ x_m \to x_m = x_s \end{cases}$$

$$\begin{cases} y_s = y_1 \\ y_E = y_1 + [(y_2 - y_1) \times \dfrac{t_p}{t_s}] \\ y_m \to y_m = y_s \end{cases}$$

Each of the middle nodes which receive the message uses the ensuing formula to quantify the interstice up to the destination.

$$D_{A-D} = \sqrt{(X_D - X_A)^2 + (Y_D - Y_A)^2}$$

Since Xa, Xd, Ya, and Yd are fuzzy interstices; the formula will be as follows for making calculations.

$$\sqrt{(a_{x_D} - c_{x_A})^2, (b_{x_D} - b_{x_A})^2, (c_{x_D} - a_{x_A})^2 + (a_{y_D} - c_{y_D})^2, (b_{y_D} - b_{y_A})^2 (c_{y_D} - a_{y_A})^2}$$

$$\sqrt{(a_{x_D} - c_{x_A})^2 + (a_{y_D} - c_{y_A})^2, (b_{x_D} - b_{x_A})^2 + (b_{y_D} - b_{x_D})^2, (c_{x_D} - a_{x_A}) + (c_{y_D} - a_{y_A})^2}$$

$$\sqrt{(a_{x_D} - c_{x_A})^2 + (a_{y_D} - c_{y_A})^2}$$

$$dm = \sqrt{(b_{x_D} - b_{x_A})^2 + (b_{y_D} - b_{y_D})^2}$$

$$de = \sqrt{(c_{x_D} - a_{x_A}) + (c_{y_D} - a_{y_A})^2}$$

Table 3. Collation of LAR and FLAR

Apparent feature	Output	Reservation counterweight	Routing counterweight	Supporting inactive period	Having no loops	Route reconstruction manner	Criteria	Method
Quantification of the routing counterweight	Relatively high	Intermediate	Relatively low	Yes	Yes	Local	Route velocity	LAR
Route stability during a specific period	Relatively high	A little more than LAR	Less than LAR	Yes	Yes	local	1. stability 2. route velocity	FLAR

The following method has been utilized to make the numbers obtained above into non-fuzzy format. X has been calculated based on Xe, Xm and Xs to simplify some tasks. The equations of the two middle lines have been calculated got the triangle and they have been equalized.

The intersection point of a triangle median can be calculated based on the ensuing relation.

The following method has been utilized to make the numbers obtained above into non-fuzzy format. X has been calculated based on Xe, Xm and Xs to simplify some tasks. The equations of the two middle lines have been calculated got the triangle and they have been equalized.

The intersection point of a triangle median can be calculated based on the ensuing relation.

The first median line:

$$(d_B, 1) - (\frac{d_E + d_S}{2}, 0)$$

$$(d_S, 0) - (\frac{d_B + d_E}{2}, 0.5)$$

The 2nd median line:

$$d_{y1} = \left[\frac{0.5}{\frac{d_B + d_E}{2} - d_S} (d - d_S) \right]$$

$$d_{y2} = \left[\frac{-1}{\frac{d_E + d_S}{2} - d_B} (d - d_B) \right] + 1$$

$$d = \frac{-2d_s^2 - 2d_B d_S + 2d_E^2 + 2d_E d_B}{6(d_E - d_S)}$$

These numbers are regarded as the interstice between the node and the destination. They are collated with the interstice which is available in the message. This is a non-fuzzy collation. If the interstice between the node and the destination is less than or equal to the interstice inserted in the message, the node will resend the pertinent message. Fuzzy method outdoes LAR Method in situations where nodes have a commensurate motion because FLAR tries to estimate a better position for each node. But LAR carries out this task based on the previous position it bears from the previous node.

As we said earlier the efficaciousness of this method depends upon the precision of the position-rendering tool and the extent of nodes motions.

6. Simulation

A. Simulator

We have used the Xsimulator which has been developed in the computer engineering college of Sharif Industrial University to simulate the suggested algorithm. The above simulator was established at first for the simulation of some networks. It was developed for sensor and ad hoc networks afterwards. This simulator has been developed based on C # language and a totally object-oriented manner. Plenty of features have been embedded in it to support various motions and positions [14].

B. Simulation Method

We have considered the ensuing scenario in the algorithm simulation.

Here we suppose that the there are 300 processing nodes in the pertinent settings. We have assumed automobiles moving in an expressway for the above scenario. The length of the expressway is 10 kilometers in this simulation. The carriage zone is

250 meters. 6 vehicles commute in each kilometer of the above extent. The above vehicles move in the oncoming directions. Considering the nature of this algorithm, it has been taken for granted that all of the above vehicles have position detecting equipment. The above assumption can't be wrong because GPS tools are being manufactured on a great basis and plenty of vehicles will possess the above equipment in the near future. Some of the parameters examined in these simulations pertain the belated delivery and number of packages. You can observe the above results in diagrams 1 and 2. belated delivery of packages has been depicted in diagram 1. the success of processing nodes to deliver the received packages has been depicted in diagram No 2 based on percents.

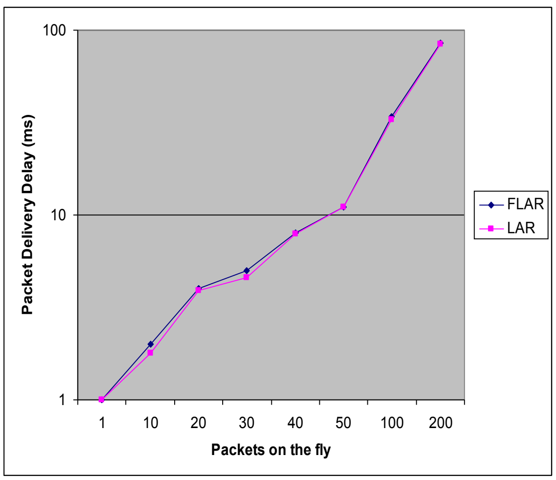

Figure 5. Belated delivery of packages

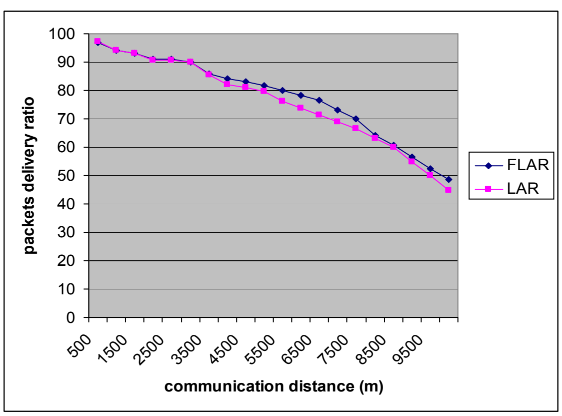

Figure 6. Successful delivery of the received packages in LAR and FLAR based on percentages

C. Simulation Results

You can observe and collate the success rate of FLAR and LAR in diagram 1. as you can see the belated delivery of LAR is a little less than FLAR. The delay in FLAR is due to the short-time calculations that it has to perform each time. although few calculations of this ilk are carried out, nonetheless they have their own effect when packages are being delivered.

You can see that the success rate of FLAR to deliver packages is considerably higher.

When the interstice between the message-exchanging nodes is little, LAR and FLAR variance is not noticeable. When we talk about intervals exceeding 3500 meters, FLAR Algorithm outdoes LAR Algorithm. This is a general similarity which can be used to ply these algorithms and the pertinent physical formulas to calculate the extant position of a node.

The extant position of a node is being portended in both methods. Some of the physical formulas can be utilized to calculate the position through this method.

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