

# Research and Comparison of Laser Radar Vehicle Self-organizing Network Routing Strategy

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**Abstract:** In this paper, an optimized and innovative routing strategy<sup>[1, 2]</sup> is proposed for the current poor quality of the laser radar vehicle self-organizing network communication. First, a plurality of users' quality evaluation indicators is selected to establish a routing optimization mathematical model. Then, the mathematical model is solved, analyzed and improved by using the ant colony algorithm. Finally, the innovative optimized routing strategy is compared with the classic laser radar self-organizing network and gets more researches and analyses. The results show that the innovative optimized routing scheme proposed can establish an optimal node communication route quickly and easily, which can improve the communication quality effectively indeed both from theoretical research and simulation analysis.

**Keywords:** Lidar communication, Vehicle self-organizing network, Routing, Ant colony algorithm.

## 1. Introduction

On the one hand, the accidents of frequent traffics and the congestion of driving roads have led to increasingly severe traffic safety situations. On the other hand, the demand for services such as in-vehicle entertainment, real-time navigation and so on has extremely increased. For the reason that, vehicle mobile self-organizing network came into being as one of the significant foundations in intelligent transportation system<sup>[3]</sup>. It is a new wireless self-organizing network applied to traffic roads, which can realize multi-hop wireless communication<sup>[4]</sup> among traffic units. In addition, the increasingly mature lidar system technology has already made an excellent base for the network.

The fundamental purpose of communication is to convey the message, for which routing is just provides the best path. Based on the research of the traditional routing strategy in vehicle self-organizing network, this paper proposes an innovative and optimized laser radar vehicle self-organizing network routing, which effectively improves the rate and the accuracy of data transmission and reduces the packet loss rate of the network.

## 2. Basic Knowledge and Theory

### 2.1 Lidar Communication System

A lidar communication module<sup>[5, 6]</sup> consists of two parts, which are laser radar transmitters and laser radar receivers and both of them use duplex communication. The laser radar transmitter part mainly includes a laser light source, a radar component and a transmitting optical system and the laser radar receiver majorly comprises a photoelectric radar detector, a main amplifier and a receiving optical system. In this paper, the laser signal whose wavelength is 1550nm is used to conduct two-way signal transmission through the atmosphere. Its working principle is shown in Fig. 1.

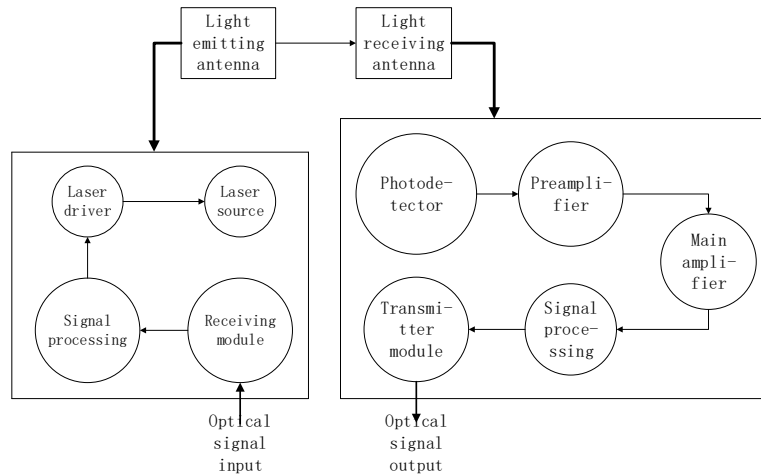


Fig. 1 The working principle of the lidar communication system

### 2.2 Vehicle Self-organizing Network

Vehicle self-organizing network [7, 8] is the application of the traditional mobile ad-hoc network on the road, which is special relatively.

In the laser radar vehicle self-organizing network based on the existing researches, the working frequency is changed into  $1.9355 \times 10^{14}$  Hz by redefining and improving the physical layer and the MAC layer as the network in this paper uses the laser carrier whose wavelength is 1550nm for communication.

### 3. Mathematical Model of Lidar Communication Routing

The routing of the laser radar communication means establish an optimal information transmission path between the sending node and the receiving node, which must try the best to satisfy the service quality requirements for users.

According to the characteristics of the laser radar communication, this paper chooses the bandwidth and the delay as the standard of service quality for users. Suppose  $s$  represents the source node and  $d$  represents the target node in signal transmission, then the mathematical model [9, 10] of the laser radar communication routing could be defined as follows:

$$Cost(s, d) = \sum_{(a,b) \in P(s,d)} C(a, b) \tag{1}$$

The corresponding constraints are:

$$Min_{(a,b) \in P(s,d)} B(a, b) \geq B \tag{2}$$

$$\sum_{(a,b) \in P(s,d)} T(a, b) \leq T \tag{3}$$

In the above formula,  $B$  represents the minimum bandwidth and  $T$  represents the time delay.

### 4. Improvement of Ant Colony Algorithm

Ant colony algorithm [11, 12] is a search algorithm derived from ant colony hunting behaviors. The network can be seen as a directed graph, whose optimal path is a minimum length path from the start point to the end point.

The convergence rate of the standard ant colony algorithm is slow relatively so that it is difficult to find the optimal solution of the corresponding problem. In order to improve the performance, the improved solutions are put forward as follows:

- (1) Improvement of node probability selection and calculation

The probability that node i chooses node j is:

$$P = \begin{cases} \arg \max_{k \in allowed_i} (\tau_{ik})^\alpha (\eta_{ik})^\beta, q \leq q_0 \\ p_{ij}^k(t) = \frac{(\tau_{ij})^\alpha (\eta_{ij})^\beta}{\sum_{s \in allowed_i} (\tau_{is})^\alpha (\eta_{is})^\beta}, q > q_0, j \in allowed_i \end{cases} \quad (4)$$

The meanings of related parameters is shown in Table 1.

Table 1 Meanings of parameters

Symbol	Meaning	Symbol	Meaning
$\tau$	Pheromone	$\eta$	Heuristic information function
$\alpha$	Pheromone factor	$\beta$	Heuristic factor
$q_0$	Constant	$q$	Random variable

(2) Improvement of dynamic update method

$$\beta(i) = b^{1/i} \quad (5)$$

In Formula 5, b is a constant and i represents the current number of iterations.

(3) Improvement of pheromone update method

The local update method is:

$$\begin{cases} \tau_{ij} = (1 - \rho)\tau_{ij} + \rho\tau_{ij} \\ \forall \tau_{ij} = Q / l_k \end{cases} \quad (6)$$

In Formula 6, Q means the size of the pheromone, ρ means the volatility of the pheromone and  $l_k$  means the path length.

The global update method is:

$$\tau_{ij}(t+1) = (1 - \rho)\tau_{ij}(t) + \rho\tau_{ij}(t) \quad (7)$$

$$\forall \tau_{ij}(t) = \begin{cases} Q / l_{gbest}, (i, j) \in gobaoptimalpath \\ 0, otherwise \end{cases} \quad (8)$$

Also,  $l_{gbest}$  represents the current optimal path length.

## 5. Steps of Routing Establishment

- ① Make an integral analysis for the lidar vehicle self-organizing network and select the corresponding constraints.
- ② Set up the mathematical model and the objective function is defined as follows:

$$through\_put = \sum_{i=1}^M (\beta_{s,d_i} \times t_{s,d_i}) \quad (9)$$

In Formula 9,  $\beta_{s,d_i}$  is used to judge if there is a successful route between node s and node d and  $t_{s,d_i}$  means the data transfer volume between node s and node d.

- ③ Initialize the parameters and place each ant to the source node of the signal transmission.
- ④ Calculate the next node selection probability and carry out the forward operation.
- ⑤ Conduct update of the pheromone on each path partly.
- ⑥ Conduct update of the pheromone on each path globally.
- ⑦ Try the best to get the optimal route between the source node and the target node according to the path with the strongest pheromone intensity.

## 6. Experiments and Analyses

### 6.1 Simulation Parameter Setting

It makes a comparison between the routing strategy of this paper and the tradition so that the results are comparable and more convincing. The parameter settings are shown in Table 2.

Table 2 Network parameters

Parameter	Value	Parameter	Value
Number of transmitters	1	Number of receivers	1
Simulation area	1500m of the road	Number of nodes	50
Communication radius	250m	Size of packets	1024bit
Speed of nodes	[30, 80](m/s)	Simulation time	300s

### 6.2 Results and Analyses

As can be seen from Fig. 2 that the throughputs of the two routing strategies are into a steady state eventually with the simulation time increasing. In addition, the throughput of this paper is larger than the tradition as the constraints on service quality requirements of the users are taken into account fully.

From Fig. 3, the packet loss rate of this paper is always lower than the tradition, which improves the success rate of data transmission and could satisfy the communication quality requirements of the users.

In Fig. 4, it displays that the new routing strategy of this paper is more stable, more reliable and faster, which can meet the real-time communication requirements.

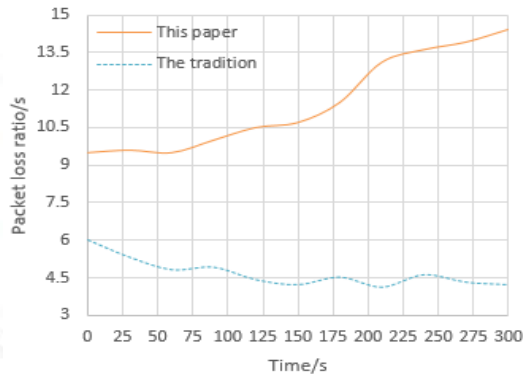
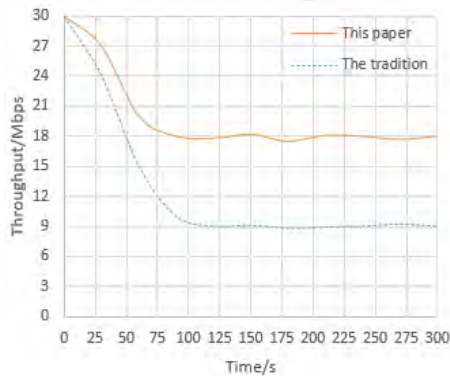


Fig. 2 Comparison of throughput

Fig. 3 Comparison of packet loss ratio

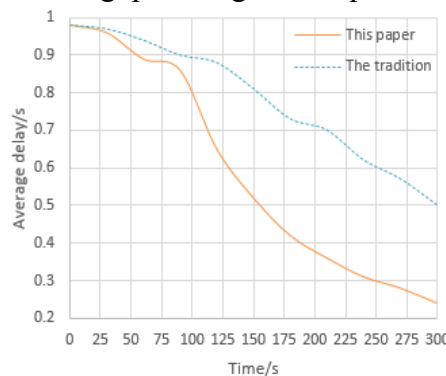


Fig. 4 Comparison of average delay

## 7. Summary

The new routing strategy this paper proposed in laser radar vehicle self-organizing network can solve some current problems. At the same time, the research can indeed satisfy the service quality requirements of the users with reducing the packet loss rate and speeding up the efficiency of data transmission, which provides a new direction for the network of this paper.

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