A Comparative Survey of Connectivity Models in Vehicular Networks

Mingzhou Liang, Ben Huang, Zhenguo Hou, Jinxiu Zhu, Xiaofeng Liu,Xin Su
College of IOT Engineering, Hohai University, Changzhou, China
China Construction Seventh Engineering Division CoRP, Ltd., Zhengzhou, China

三等奖

Abstract

Aim to provide the theoretical basis for the marine network we are about to present, we look at similar van networking (VANET) research and hope to be inspired from it. From this paper, the characteristics of VANET and the key parameter characteristics affecting its connectivity are summarized, and then the system models of the relevant literature are classified and various models are introduced. The connection probability of VANET under different system models is pointed out and analyzed. Finally, the interconnected probability characteristics of different models are compared by simulation analysis.

System Model

1. Scenarios

Analysis of the relevant literature shows that the researchers generally divide the car networking architecture into urban models and highway models, as shown in Figure 1.

- ●Urban Scenarios: Complex structure, high vehicle density and slower movement.
- ●Highway Scenarios: Simple structure, low vehicle density, fast vehicle movement, and fast network topology change.

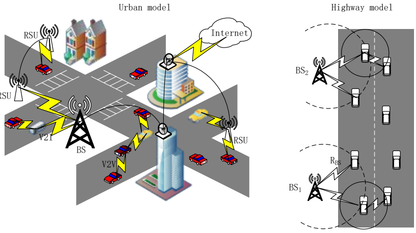

Fig1. VANET paradigm.

2. Urban Scenarios

For complex urban scenes, relevant literature tracks the actual vehicle trajectory data of 4000 taxis in Shanghai. Based on the data, the following three definitions are given ,

Definition 1 (Component):The component $C(t)$ is used to represent the network where each vehicle can reach any other vehicle at time t via a multi-hop connection.

Definition 2 (Component Speed):

$$V = \frac{1}{S}\sum_{n_i \in C} v_{n_i}$$

Where V represents the average speed, S represents the size of the component C.

2.1 Result

Through the analysis of the existing data, it is found that there is a two-way relationship between mobility and connectivity. When component speed V is greater than 20 m/s, mobility and connectivity are significantly reduced, and the probability of mobility network connectivity is very low. When V is less than 20 m/s, its network connection is linearly proportional to mobility.

$$S = \begin{cases} \alpha \cdot x^{\beta} & V \geq A \\ [S_{min}, S_{max}] & V \leq A \end{cases}$$

Where α, β, A are obtained from empirical data setting as $\alpha = 166.1, \beta = -0.4148, A = 20m/s$.

3. Highway Scenarios

3.1 Network Scenario and Mobile Model

Assumed that the study interval is [0, L].

Mobility: vehicle arrival and vehicle speed,

- ●Vehicle arrival
  - ➢Obey the Poisson distribution with parameter λ_0;
  - ➢Obey the exponentially distributed with parameterξ.
- ●Vehicle speed
  - ➢A wide sense stationary(WSS) random process with average speed μ_V;
  - ➢The speed is randomly selected and the interval $\mu_V \pm 20$.

3.2 Vehicle Distribution

■V2V

●The number vehicles follows the Poisson distribution, given by

$$P\{N(t) = n\} = \frac{(\rho L)^n}{n!} e^{-\rho L}$$

●Based on the progressive movement model, the vehicle position pdf,

$$f_X\{x_1, \dots, x_n\} = \frac{n!}{L^n}, 0 \leq x_1 \leq \cdots \leq x_n \leq L$$

■V2I

●Obey the Poisson distribution and related definitions, given by

$$p_Y(y) = \prod_{i=1}^{n} \frac{p_1(y_i)}{\int_0^L p_1(x)dx}, y = \{y_1, \dots, y_n : 0 \leq y_i \leq L\} e^{-\rho L}$$

3.3 Result

■V2V

●Hypercube model and geometric elements were used for analysis. We can get the probability of network link under the fixed number of nodes,

$$P_n(r_0) = \iint_{y_{n-1} \in D_{n-1}(r,L)} f_Y(y_1 \dots y_{n-1}) dy_1 \dots dy_{n-1}$$

●The average probability of the mobile VANET connection can be expressed by,

$$P_\rho(r_0) = \sum_{n=0}^{\infty} P_n(r_0) \frac{(\rho L)^n}{n!} e^{-\rho L}$$

■V2I

●Premise lemma

$$p_1(x) = 1 - \big(1 - g_b(x)\big)\big(1 - g_b(L - x)\big)$$

$$p_2(x) = 1 - e^{-\int_0^L g_v(\|x-y\|)\rho p_1(y)dy}$$

●Vehicle access probability

$$p_a(x) = 1 - \big(1 - p_1(x)\big)\big(1 - p_2(x)\big)$$

$$P_a = \frac{1}{L}\int_0^L p_a(x)dx$$

Simulation

1.Data

The data are derived from the corresponding literature.

Table1.Data description

Parameter	Description	Value
ρ	Vehicle density	0.1，0.01，0.005
r	Communication radius of vehicle	300,500m
R	Communication radius of instruction	1000m
p_f	The probability that the vehicle's communication radius is r_1	0.4,0.9

2.Result

Figure 2 shows the trend of the access probability changing with the base station interval. As the base station spacing increases, the access probability decreases gradually. However, when the probability of activity is 0.9, r=300, and the distance between the coastal base stations is 2500 meters, the access probability remains 1, indicating that the active probability can facilitate network connectivity. The communication radius plays the same role. At the same time, it also provides important reference value for our study of ocean networks.

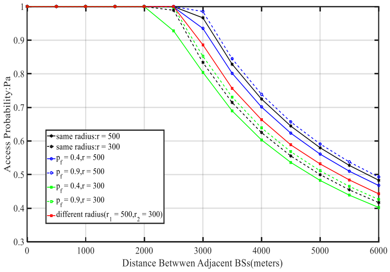

Fig2. Comparison of access probability of different references.

Conclusions

In conclusion, this paper studies the connectivity characteristics of VANET under different models. By analyzing and comparing the proposed models in the relevant literature, we compiled the similarities of different literatures in the research process, and also expounded their differences. Finally, the connectivity of references are simulated and compared, which not only verifies the accuracy of the proposed model, but also obtains key parameters such as vehicle transmission range, active vehicle probability and vehicle arrival rate. It plays a positive role in VANET connectivity and provides valuable research data for our future research.

Contact

Name：Mingzhou Liang
Phone：18827618543
Email：lmz_9586@163.com