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An Intelligent Vehicle Traffic Information System Mode and Evaluation

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Abstract: The investment of centralized traffic information system is large and data processing is too concentrate, the autonomous traffic information system based on vehicle-to-vehicle communication is mostly limited to information on safe driving, less involved with the research of the whole road network congestion information collection and transmission. This study puts forward an autonomous intelligent vehicle traffic information system mode which is for the whole urban road network and can collect and transmit information by itself. And then, based on the original information and integration processing model, it builds the corresponding self-diffusion transmission model for different roads, different driving direction vehicles and different information integration results. It also creates autonomous generation and dynamic update models of traffic congestion information for the whole road network. The traffic simulation and the evaluation results in a variety of situations show that IVTIS mode and models are reasonable and basically adapted to autonomous collection and quick transmission for traffic congestion information in urban road network.

Key words: ITS, VANET, SOTIS, IVTIS, traffic information, traffic congestion, autonomous collection, autonomous transmission

INTRODUCTION

Most of the existing urban traffic information systems use the centralized information collection, data processing and information transmission mode, they play a significant role on road traffic operation and management in their normal state. But it depends on a large number of fixed information collection, dissemination and communication facilities which cause the system to need excessive investment. At the same time, information processing focuses on data processing center too much, its comprehensive processing capacity is limited by the performance and scale of the relevant equipment. In addition, earthquakes and other natural disasters, fire or power cut, terrorist attacks and others will make system failure, traffic paralysis and other specific risk, the response capacity is relatively weak.

With the development of electronic communication technologies, domestic and foreign intelligence traffic experts concerns on traffic information system based on vehicle-to-vehicle communication and make some research results. The representative system modes are: The vehicle-road communication mode that the road side equipment provides information on safe driving and congestion to vehicles (Piao and McDonald, 2008; Baskar *et al*., 2008; Kurata *et al*., 2011; Tamaki *et al*., 2010); the vehicle-vehicle communication mode that transmitting the forward congestion information based on the opposite-direction vehicles (Narzt *et al*., 2010; John *et al*., 2008); SOTIS (Self-Organized Traffic Information System) which can collect and transmit information autonomously based on vehicle-to-vehicle communication (Wischhof *et al*., 2003, 2005; Yang and Recker, 2008) etc. In addition, the author of this study also puts forward an initial mode of intelligent vehicle traffic information system for autonomous collection and dynamic transmission of traffic congestion information in urban road network (Zhang and Zhao, 2012).

However, in the research of vehicle traffic information system based on vehicle-to-vehicle communication, there are a lot of researches on safe traffic information and the results, while the research and evaluation for traffic congestion information, especially for traffic congestion information autonomous collection, transmission and update in real time for large-scale road network, is relatively less. Currently, traffic congestion in the city is more serious, each country economy is relatively tight, intelligent vehicle traffic information system, which has less investment, strong autonomous property and high ability to deal with unexpected risks, is of great significance. Therefore, based on further research and

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improvement in the initial intelligent vehicle traffic information system mode, we focus on building the corresponding system models, simulating and evaluating the effect of autonomous collection, integration and transmission for the road network traffic congestion information in different simulation environment and specific factors, in order to verify and analyze the rationality and effectiveness of this system mode and its models.

DESCRIPTION OF IVTIS

This study puts forward the mode of the Intelligent Vehicle Traffic Information System (IVTIS): Intelligent vehicle traffic information system) based on vehicular *ad-hoc* network (VANET), the whole process is shown in Fig. 1.

Its main feature is that the vehicles in the road network collect the original traffic information autonomously after they pass through each road and transmit information with each other by VANET broadcast so that they expand or update the original collection information group owned by each vehicle and then they make the corresponding information integration and processing. At the same time, in order to reduce the amount of information transmission, the vehicle in IVTIS spreads the information in the form of simplified congestion information to the vehicles of the other roads, thus achieving that each vehicle can update its own road network congestion information in real time.

Different from the centralized traffic information system, information processing of IVTIS mode is carried out by each vehicle alone. Through the real-time exchange of congestion information between vehicles, each vehicle can generate automatically and update the road network congestion information in real time, in order to give real-time reference to drivers.

In addition, congestion information transmission in IVTIS mode is a radioactive diffuse transmission method, vehicles running in the road network spread the congestion information to the whole road network by the continuous VANET broadcast in relay style. In order to enhance the speed of information processing and communication, vehicular information terminal can use high performance processor and wireless communication device with parallel transceiver functions to achieve the traffic congestion information in the network environment, the rapid spread of results.

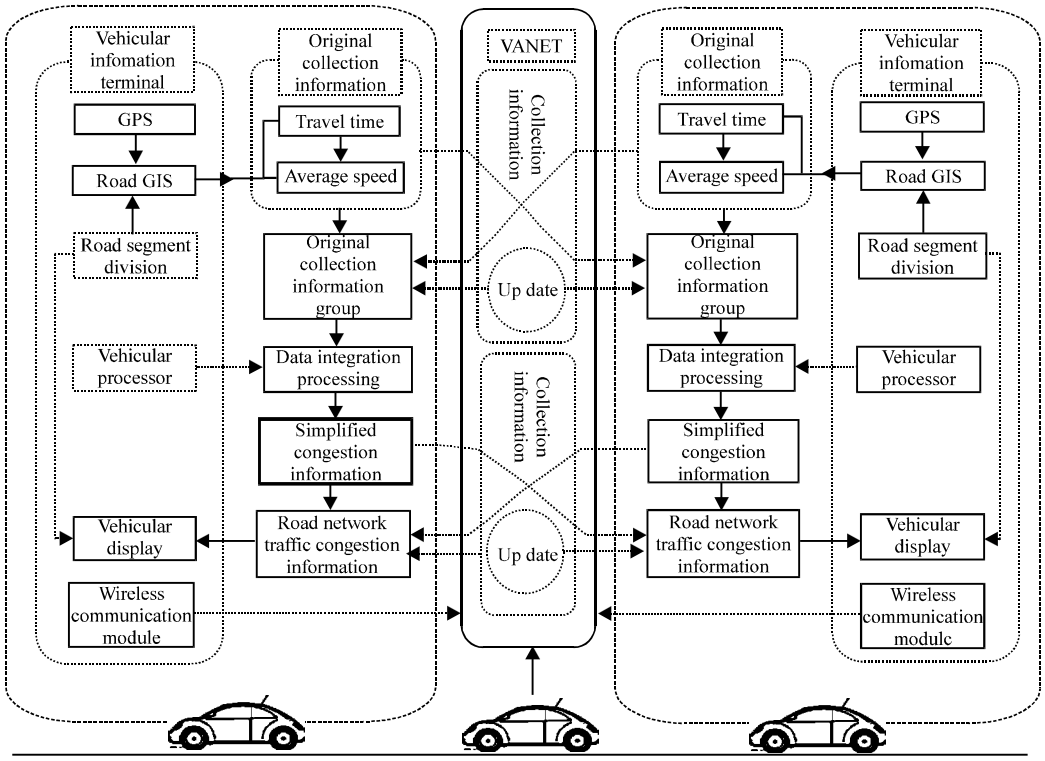

Fig. 1: Mode of IVTIS based on VANET

MODEL FOR IVTIS

Based on the above mentioned IVTIS mode, this study establishes the corresponding system models, its main models are as follows.

Mode for the collection of traffic congestion information: After a collection vehicle has passed through the road, we can get the time when the vehicle passed the start point and the end point of the road and the average travel speed (Eq. 1, 2) through the GPS positioning and road GIS and then we get the original collection information. At the same time, the vehicle will also receive the original collection information transited by others vehicles of the same collection-road. It will constitute an original collection information group and collection vehicle group (later known as the original collection vehicle group). By integrating the collection information group of the vehicle, you can calculate its average speed of the collection road (Eq. 3, 4):

$$T_p(i) = t_{p,2}(i) - t_{p,1}(i), \quad p \in E_k(i), \quad i \in \{1,2,\ldots,N\} \tag{1}$$

$$V_p(i) = \frac{L(i)}{T_p(i)}, \quad p \in E_k(i), \quad i \in \{1,2,\ldots,N\} \tag{2}$$

$$\bar{V}_k(i) = \frac{n_k(i) \cdot L(i)}{\sum_{p \in E_k(i)} T_p(i)} = \frac{n_k(i)}{\sum_{p \in E_k(i)} \frac{1}{V_p(i)}} \tag{3}$$

or

$$\bar{V}_k(i) = \frac{\sum_{p \in E_k(i)} V_p(i)}{n_k(i)} \tag{4}$$

Where:

$T_p(i)$: The travel time of the road i which the collection vehicle p pass through

$t_{p,1}(i), t_{p,2}(i)$: The moments at which the collection vehicle p pass through the beginning and end of the road i

$E_k(i)$: The group of the original collection vehicles of the road i. They are owned by the collection vehicle k

$V_p(i)$: The average travel speed of the road i. It is collected by the collection vehicle p

L(i): The length of road i

$\bar{V}^k(I)$: The average travel speed of the road i. It is gotten by collection vehicle k after the original collection information group of the vehicle is integrated and processed

$n_k(i)$: The vehicle numbers in $E_k(i)$

In order to reduce the amount of information in vehicle-to-vehicle communication and reduce the occupancy of communication resources during information transmission, according to the existing centralized traffic information system dividing the speed range of the road traffic congestion degree, the congestion degree of the collection road is divided into three categories in the form of the simplified traffic congestion information, (Eq. 5):

$$V'_k(i) = \begin{cases} 0 & \bar{V}_k(i) \geq V_2 \quad \text{(clear)} \\ 1 & V_1 \leq \bar{V}_k(i) < V_2 \quad \text{(slow)} \\ 2 & 0 \leq \bar{V}_k(i) < V_1 \quad \text{(congestion)} \end{cases} \tag{5}$$

Where:

$V'_k(i)$: The simplified traffic congestion information of the roadi. Itis gotten by collection vehicle k after information integration and processing

V_1, V_2: The speed upper limits respectively represent the congestion and slow of the road network which the vehicle is in

Model for the transmission of traffic congestion information: The traffic information which the vehicle p in a collection road transmits to others is divided into two categories: One is the original collection information group which is transmitted to the other vehicles which are in the same collection road (Eq. 6), it contains the original collection information collected by the vehicle p and received from the other vehicles in the same collection road; the other is the road-network congestion information which is transmitted to the other vehicles which are in the different collection road, it contains the congestion information of the collection road after vehicle p integrates its collection information (Eq. 7), the latest simplified congestion information about other roads received by VANET (Eq. 8) and the first releasing time after the integration of information. Put the two types of information together, the transmission mode that vehicles k in the collection road i releases its traffic information is shown in Eq. 9.

$$VF_k(i) = \{V_p(i) \mid p \in E_k(i)\}, \; i \in \{1,2,\ldots,N\} \tag{6}$$

$$D_k(i) = \{V'_k(i), t_{k,3}(i)\}, \; i \in \{1,2,\ldots,N\} \tag{7}$$

$$R_k(i) = \{V'_q(j), t_{q,3}(j) \mid q \neq k, j \neq i, j \in G_k(i)\}, \; i \in \{1,2,\ldots,N\}, G_k(i) \subseteq \{1,2,\ldots,N\} \tag{8}$$

$$A_k(i) = F_k(i) \cup D_k(i) \cup \{R_k(i) \mid G_k(i) \subseteq \{1,2,\ldots,N\}\}, \quad i \in \{1,2,\ldots,N\} \tag{9}$$

Where:

$F_k(i)$: The group of the original collection information of the road i. It is owned by the collection vehicle k

$D_k(i)$: The simplified traffic congestion information of the collection vehicle k after integration. It is about the road i

$R_k(i)$: The group of the traffic congestion information of the roads outside i. It is rebroadcasted by the collection vehicle k

$G_k(i)$: The group of roads, of which the vehicle k of the road i has the simplified traffic congestion information

$t_{k,3}(i), t_{q,3}(j)$: The moments at which the collection vehicle k of the road i and the collection vehicle q of the road j release the simplified traffic congestion information after the information integration and processing

$A_k(i)$: The group of all traffic information of the road i. The group is transmitted by the collection vehicle k

Generating model of the road network traffic congestion information: Each vehicle collects information by itself and integrates the information and receives the simplified congestion information released by the other vehicles continuously, then the vehicular terminal would generate the corresponding congestion information of the part of the road network. At the same time, with the passage of the time and the increase of the number of information exchange between each vehicle and the other vehicles, it will generate the own traffic congestion information of the whole road network (Eq. 10):

$$N_k(t) = D_k(i) \cup R_k(i) = \{ V_k'(t,j), t_k(j) \mid j \in \{1,2,\ldots,N\} \} \tag{10}$$

$$V_k'(t,j) = \begin{cases} V_k'(i);\ t_k(j) = t_{k,3}(i) & j = i \\ V_q'(j);\ t_k(j) = t_{q,3}(j), \quad (q \neq k, j \in G_k(i)) & j \neq i \end{cases}$$

$$t_k(j) \leq t$$

$$i,j \in \{1,2,\ldots,N\}, G_k(i) \subseteq \{1,2,\ldots,N\}$$

Where:

$N_k(t)$: The group of all traffic congestion information of the collection vehicle k at the moment t

$V'_k(t,j)$, $t_k(j)$: The collection vehicle k gets $V'_k(t, j,)$ (the simplified traffic congestion information of the road j) at the moment $t_k(j)$

Updating model of the road network traffic congestion information: As the vehicles running on the road network and VAN ternating constantly, each vehicle continuously transmits its own road-network congestion information with each other and also receives new traffic congestion information, the vehicle's own traffic congestion information is updating in real time. According to different situations, the dynamic updating models are as follows.

When the vehicle k and the vehicle k' belong to the same collection road i and the original collection vehicle group of the vehicle k' contains the collection vehicle which not belongs to the original collection vehicle group of the vehicle k, it should update the original collection vehicle group.

When: $E_k(i) \neq E_k(i)$

Then:

$$E_k(i) = E_k(i) \cup E_{k'}(i) \tag{11}$$

$$k \neq k',\ i \in \{1,2,\ldots,N\}$$

When the vehicle k and the vehicle k' belong to the different collection roads , or they belong to the same collection road i but the traffic congestion information which is transmitted by the vehicle k' is about the road j outside of i, it should be divided into three situations to update the information.

If the vehicle k and the vehicle k' both have the traffic congestion information of a road , it should update the information of the vehicle k according to the old and new of the traffic congestion information.

When $t_k(j) < t_{k'}(j)$

Then:

$$\begin{aligned} &V_k'(t,j) = V_{k'}'(t,j) \quad (= V_q'(j)) \\ &t_k(j) = t_{k'}(j) \quad (= t_{q,3}(j)) \end{aligned} \tag{12}$$

$$k' \neq k,\ q \neq k, j \neq i, j \in G_k(i) \cap G_{k'}(j),$$
$$G_k(i), G_{k'}(j) \subseteq \{1,2,\ldots,N\}$$

If the vehicle k does not have some traffic congestion information which the vehicle k' has, it should add this traffic congestion information to the vehicle k.

When $V'_k(t, j) = \phi$, $t_k(j) = t$

And:

$$V_{k'}'(t,j) = V_q'(j),\ t_{k'}(j) = t_{q,3}(j)$$

Then:

$$\begin{aligned} &V_k'(t,j) = V_{k'}'(t,j) \quad (= V_q'(j)) \\ &t_k(j) = t_{k'}(j) \quad (= t_{q,3}(j)) \\ &G_k(i) = G_k(i) \cup G_{k'}(j) \end{aligned} \tag{13}$$

$$k' \neq k,\ q \neq k, j \neq i, i \in G_k(i), j \in G_{k'}(j),$$
$$G_k(i), G_{k'}(j) \subseteq \{1,2,\ldots,N\}$$

Where:
$V'_k(t, j) = \phi$: The traffic congestion information of the road j ($j \neq i$) of the vehicle k is null.

Taking the timeliness of the traffic congestion information into accout, when the vehicle k has the congestion information of a road and doesn't update it in a prescribed time, it will discard this information automatically because this information loses its reference value.

When $t-t_k(j) = T_0$
Then:

$$V'_k(t,j) = \varphi,\ t_k(j) = t \tag{14}$$

$$j \neq i,\ j \in G_k(i),\ G_k(i) \subseteq \{1,2,\ldots,N\}$$
$$i \in \{1,2,\ldots,N\}$$

Where:
T_0: The predefined retention time of the traffic congestion information

TRFFIC SIMULATION OF IVTIS

In order to verify the IVTIS mode and the feasibility and rationality of the IVTIS model, this study carries out the traffic simulation in the different situations, then analyzes and evaluates the transmission effect of the traffic congestion information based on different evaluation indexes.

Traffic simulation platform: This study achieves the corresponding functions of the system models mentioned above through the secondary development platform of the traffic simulation software VISSIM. By using the list of objects (Links, Nodes, Vehicles, etc.) and the corresponding data reading and control method which are provided by the COM interface of VISSIM software, we embed the built system models into each vehicle during the simulation running at each step, so we give each vehicle functions such as original information collection, integration, transmission, network congestion information generation, dynamical update and so on.

Evaluation indexes and related terms: Firstly, this article defines the evaluation indexes and related terms that used to analyze and evaluate the dissemination effect of traffic congestion information:

- **Vehicle reception rate of traffic congestion information:** The ratio that the vehicles receiving the traffic congestion information to the vehicles in the traffic flow of every road segment in a certain period of time
- **Shortest transmission time of traffic congestion information:** Refer to the time that traffic congestion information is fast transmitted to every road segment or the corresponding location after the information is published
- **Maximum transmission rate of traffic congestion information:** Refer to the rate that traffic congestion information is fast transmitted to every road segment or the corresponding location after the information is published
- **Network coverage rate of traffic congestion information:** The ratio of the total road segment length that receiving traffic congestion information to the whole road network length in a certain time after the information is published
- **Network coverage time of traffic congestion information:** The shortest time that the traffic congestion information transmitted to all road segment of the whole road network
- **Intersection coverage time of traffic congestion information:** The shortest time that the traffic congestion information transmitted to all intersections of the whole road network
- **Packet loss rate:** Within the information broadcast range, the ratio of the vehicles that not receiving the traffic congestion information to all vehicles

Simulation evaluation of single way situation
Simulation environment setting:

- **Schematic diagram of simulation road:** As shown in Fig. 2, total length: 10 km, collecting road segment length: 1 km, speed limitation: 60 km h^{-1}, road segment 9 set speed bumps to simulate traffic jam (length: 400 m, traffic speed: 4-6 km h^{-1}); congestion speed scoping: V1 = 20 km h^{-1}, V2 = 40 km h^{-1}
- **Simulation time:** 35 min; setting congestion Start time: 15 min after the simulation begins; congestion information retention time: 15 min
- **Radio communication range:** 300 m; Information release interval: 1sec
- **Inflow of traffic:** To the right: 400, 800, 1200 veh h^{-1}, To the left: 0, 100, 300,600 veh h^{-1}; Vehicle randomly set out according to Poisson distribution

Simulation and evaluation: In this study, the right traffic flow in Fig. 3 as the main direction, it mainly focus on the simulation and analysis to the dissemination effect that the traffic congestion information spread to the rear road

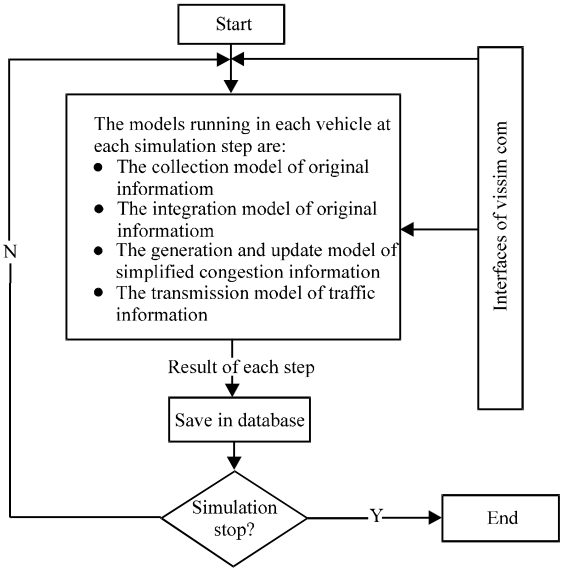

Fig. 2: Primary simulation program diagram based on the COM interfaces of VISSIM

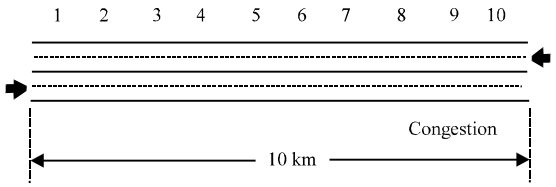

Fig. 3: Schematic diagram of simulation road

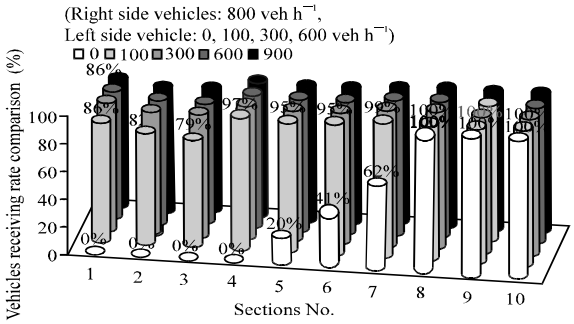

Fig. 4: Vehicle reception rate with different opposite-direction traffic flows

segment when the traffic flow of opposite direction and same direction are different, as well as the evaluation to the vehicle reception rate, the shortest transmission time and the maximum transmission rate of traffic congestion information. Finally, this study makes analysis to the impact that different packet loss rate on dissemination effect of congestion information.

Vehicle reception rate of traffic congestion information: Figure 4 is shown the vehicle reception rate of traffic congestion information in every road segment after the occurrence of congestion in the road 9 (Fig. 3). If defined the same direction traffic flow as the driving direction of vehicles traveling on congested road. In Fig. 4, for the one-way situation that there is no vehicles in opposite direction (left-moving vehicles to 0), due to the traffic congestion information only transmitted between the vehicles of the same direction, then the reception rate of the vehicles behind congestion road segment is relatively low, moreover with the increase of the distance from the congested road, the receiving rate is lower. ; While after the emergence of the opposite traffic flow, with the help of which the vehicles reception rate of the rear road segment has improved significantly and with the increase traffic flow of opposite direction the vehicle reception rate also gradually increased. Furthermore, when the traffic flow reaches a certain number (300 h^{-1} or more), the reception rate in each road segment basically tend to be stable.

Maximum transmission rate and the shortest transmission time of traffic congestion information:

- **Simulation evaluation of different opposite traffic flow**

Figure 5, 6, respectively are the comparison curves of the shortest transmission time and the maximum transmission rate when the same direction traffic flow is certain and the opposite direction traffic flow is different.

As shown in Fig. 5 when there are no opposite vehicles and the vehicles spacing is too large or too near, it is easy to cause spreading disconnection and congestion information temporarily unable to continue to transmit backward until the subsequent vehicles overtake and drive into the communication scope of front vehicles and the broken chain information is linked and continues to be propagated backward (seethe curvejumppart). When introducing and increasing the opposite traffic flow, the disconnection of information has been significantly improved and the shortest transmission time of traffic congestion information is significantly shortened. As the opposite traffic flow reached 300 vehicles or more, the shortesttransmission time is areroughlythesame.

Seen from Fig. 6, which corresponds to no opposite vehicles, because of the traffic congestion information emerge broken chain during dissemination process, the curves which is maximum transmission rate of traffic congestion information appear downwardjump and the overall transmission rate obviously decreases. On the

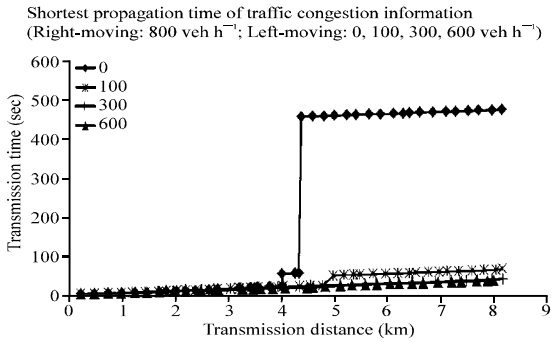

Fig. 5: Shortest transmission time with different opposite-direction traffic flows

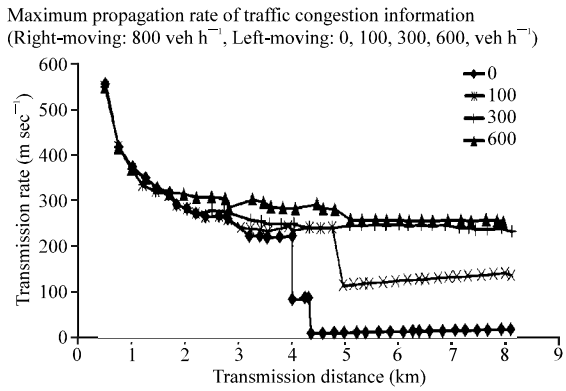

Fig. 6: Maximum transmission rate with different opposite-direction traffic flows

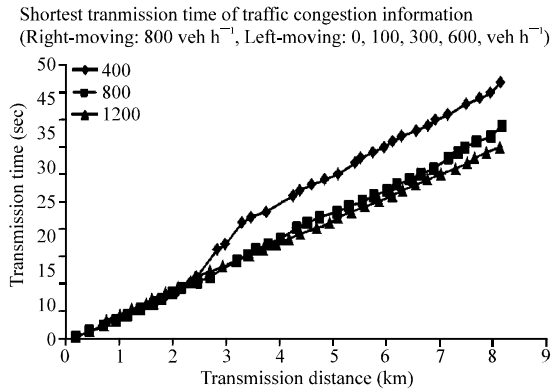

Fig. 7: Shortest transmission time with different same-direction traffic flows

other hand, after introducing and increasing the traffic flow of opposite direction, the maximum transmission rate tends to accelerate. As a whole, when it is closer to the congested road and the trafficdensity is higher and then the maximum transmission rate is relatively high, while with the transmission distance increases, the maximum transmission rate is gradually reduced andtends to be gentle.

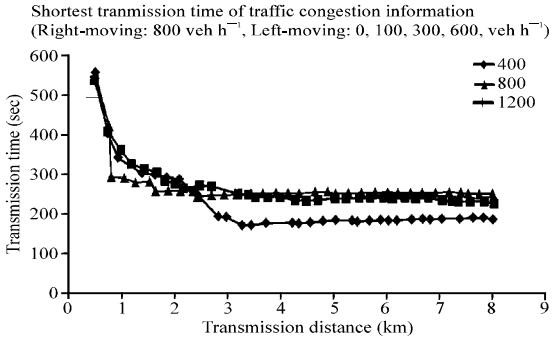

Fig. 8: Maximum transmission rate with different same-direction traffic flows

Evaluation that the opposing direction traffic is certain, the same direction traffic differs: Figure 7, 8, respectively are the comparison curves of the shortest transmission time and the maximum transmission rate of traffic congestion information as the opposing direction traffic (to the left) is constant, the same direction traffic (to the right) is different.

Seen from Fig. 7, with the right linetraffic increasing, the shortest transmission time of traffic congestion information trend to be shorter and when the traffic flow reaches up to 1200 veh h^{-1}, the shortest transmission time is reduced to 35 sec.

Correspond to Fig. 7 and 8; with the increase of traffic flow, the maximum transmission rate overall showed a trend of increase and when the traffic flow reaches up to 1200 veh h^{-1}, the maximum transmission rate of traffic congestion information transmitted to 9 km reaches 256 m sec^{-1}

Impact of the packet loss rate upon communicationeffect: Using multichannel transceiver and parallel processing terminal, the information packet loss rate: 0, 25, 50, 75 and 90%.

Due to vehicles based on VANET transmit information and suffer the radio interference and restrictions from various communication or road conditions that the congestion information is not necessarily transmitted to all vehicles within the communication range. So, this study will analyze the impact of the packet loss rate upon communicationeffect during the information dissemination process.

Figure 9, 10, respectively are impact curves of the packet loss rate upon the shortest transmission timeand the maximumtransmissionrate when vehicles transmit traffic congestion information. Seen from the result, under the given simulation condition, when packet loss rate is below 50% the impact is not particularly evident. While

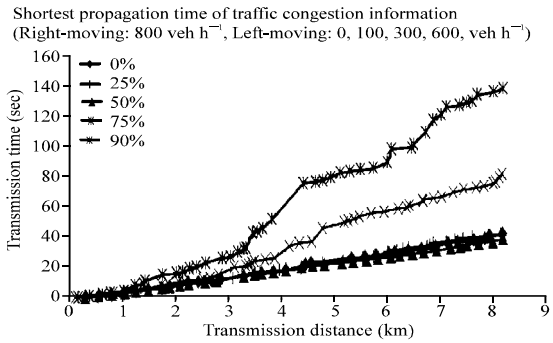

Fig. 9: Shortest transmission time with different packet loss rate

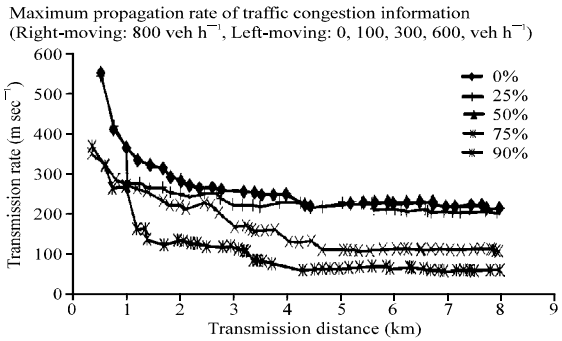

Fig. 10: Maximum transmission rate with different packet loss rate

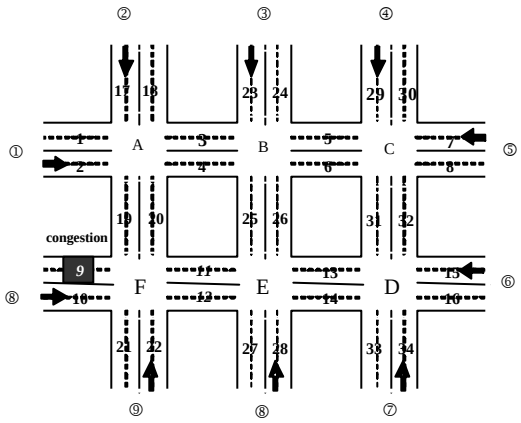

Fig. 11: Schematic diagram of network

the packet loss rate increases to 75% or even 90%, the shortesttransmission time increases substantially and the maximumtransmissionrate relatively declines. It can be seen from the two that when the packet loss rate of information dissemination is 50%, the shortest time of congestion information transmitted to the 9 km near requires only for 44 sec, as well as the maximumtransmissionrate up to 205 m sec^{-1}. On this basis, the speed of information transmissionbasically meets the requirements of information released of urban road network.

Simulation and evaluation of the road network

Simulation environment settings

- **Schematic diagram of road network:** It shown as the picture 11, All road sections are 950 m length, the width of intersection are 50 m, Synchronization signal (cycle: 90 sec); setting the section 9 as the congested area
- **Traffic flow input settings:**
- **Situation 1:** Entrance 5,6: 600 veh h^{-1}; others 400 veh h^{-1}
- **Situation 2:** Half of the traffic flow of the situation 1
- **Situation 3:** Twice of the traffic flow of the situation 1
- **Distribution of traffic flow:** Straight 50%, turn right 25%, turn left 25%
- **Other settings:** The same as Single road

Simulation and evaluation: The Transmission rate of Congestion information in road network is complex than single road; the traffic flow, distribution of traffic flow in each intersection. Traffic signals can caused uneven road network vehicle density and vehicle spacing, which have a good influence on the transmission rate of congestion information in road network. However, compared with the single, since there are many junctions in network, congestion information can spread around through many paths. So, that it can spread quickly.

Through single scenario simulation results we can know that, traffic flow have a significant impact to disseminate congest information. In this study, with the above simulation parameters, In order to verify and evaluate the rationality and applicability of IVTIS and its model in road network, we focus on analysis and evaluation of the transmission velocity in different traffic flows.

Receiving rate of congestion information: When traffic is Case 1, the reception rate of congestion information (statistical time 5 min) shown in Fig. 12. As can be seen with reference to Fig. 11, the vehicle that near the Congested road and on the rear sections (Section 11, 13; 19,17; 22 etc.) directly affected by congestion have a greater probability of receiving the traffic jam information. The vehicles of other sections receiving rate related to many factors, such as the distance to the congested road, traffic flow density, Frequency of signal and so on. On the whole, within 5 min of congestion information released, the rate of congestion information received by the vehicle except for a few sections (section 33) is above 90%.

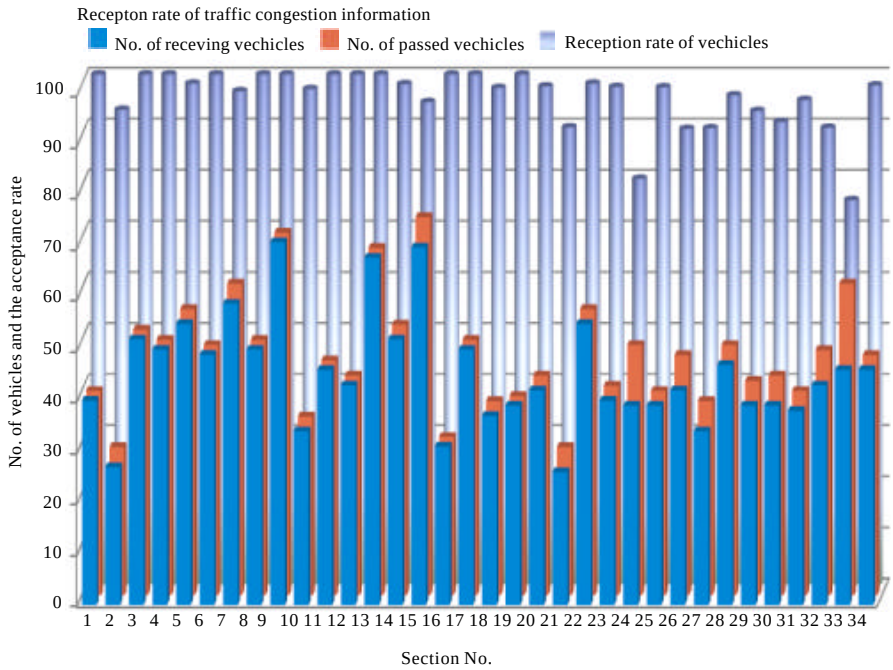

Fig. 12: Reception rate of each road section

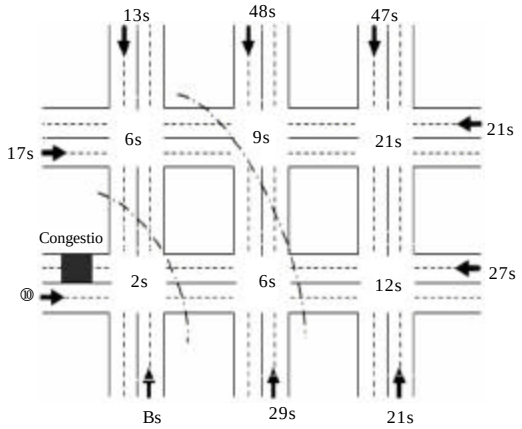

Fig. 13: Shortest transmission time of disseminating congestion information

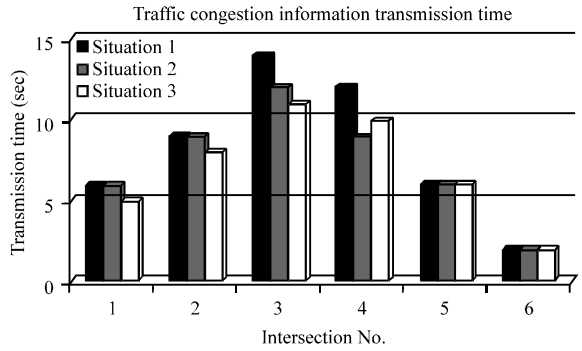

Fig. 14: Minimum transmission time of junction with different traffic flow

Minimum time of spreading congestion information: Figure 13 show that the shortest transmission time of disseminating congestion information to various junctions and entrances.

Figure 13 shows that, Traffic congestion information in the network is not only disseminated along a straight line direction, but also to use the intersection of a network of multiple transmission paths spreading out quickly. When some congestion information disseminated slowly or broken chain occurs, it can detour through other paths and spread rapidly to other junctions or sections. Shown in Fig. 13, as a whole, the shortest time of congestion information disseminated to the intersection is relatively much faster than network entrance. In order to analyze traffic flow on the impact of transmission time of congestion information, Fig. 14, 15 lists three traffic flow situations showing that the minimum time of the congestion information is Disseminated to the respective entrance and junction.

Figure 14, 15 shows that with the increase in traffic flow, the minimum time of congestion information disseminated the intersection and the entrance reduced. However, Traffic Flow Density the junction and vehicle spacing changed little due to signal control. Also, road network disseminate information choose multiple paths.

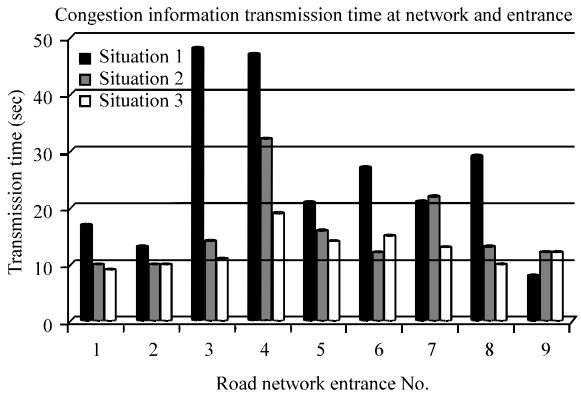

Fig. 15: Minimum transmission time of entrance with different traffic flow

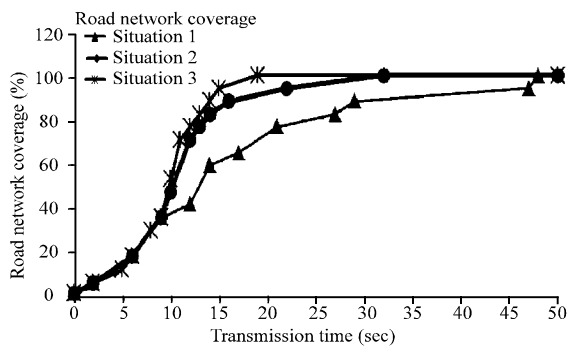

Fig. 16: Coverage rate of congested information at road network

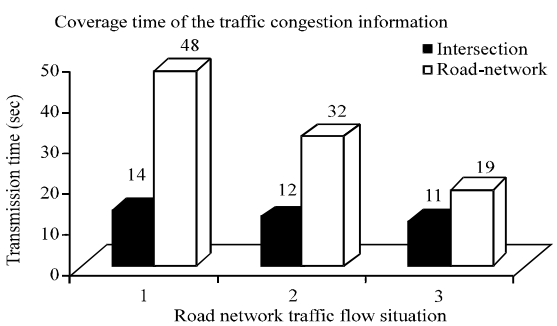

Fig. 17: Coverage time of congestion information spread to intersection and road network

So, it has a relatively small impact on the shortest time of disseminating information to the junctions. But dissemination of information between the entrance and neighboring junctions is the same with single-way case. With the increase in traffic flow, the broken chain phenomena gradually reduce so that the minimum time of spread to each entrance also significantly shorten.

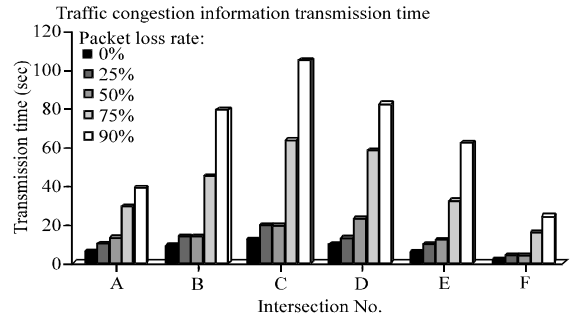

Fig. 18: Shortest transmission time when traffic congestion information reaches the road junctions in different packet loss rates

Coverage rate of congested information at road network: Figure 16 is comparison curves of road network coverage rate of traffic flow of jam information with different traffic flow. Seen from Fig. 16, with the road network traffic flow increases, the coverage rate of traffic congestion information increased under the same time, while the shortest time of covering the entire road network is reduced. For Situation 1 to Situation 3, after the release of the congestion information, network coverage rate was 40, 70, 76 at 12 sec and spread throughout the network is the minimum time of 48 sec Case 1, Case 2 were reduced to 32 and 19 sec Case 3.

Transmission time of traffic congestion information to intersection and network: Summarized in Fig. 15, 16, 17 is in different traffic flow situations, covering time of congestion information spread to network and Intersections. Figure 17 shows the congestion information is disseminated to the intersection faster than the road network. However, with the increase in network traffic flows, the difference of covered time between network and intersection become small and gradually become normal. Since the intersection is an important place for the driver to select driving route after receiving traffic Congestion information. Thus for urban road network, the coverage time of traffic congestion information is the key to reduce congestion in the road network. From the above we can see IVTIS model showed better results of dissemination.

Analysis of the influence which different packet loss rates have on the transmission effect of road-network congestion information: This study simulates and analyzes the influence degree, which different packet loss rates have on the transmission effect of road-network congestion information, in case 2 of the three kinds of network traffic flows.

Figure 18 and 19 show that, the time, which the traffic congestion information takes to reach each road junction

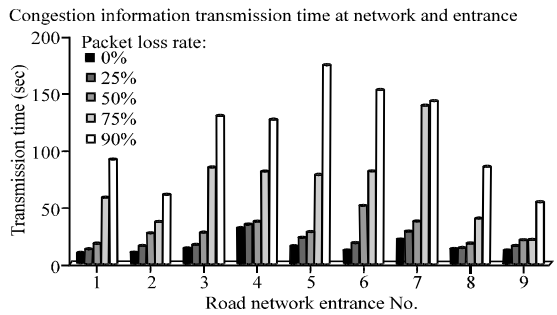

Fig. 19: Shortest transmission time when traffic congestion information reaches the road entrances in different packet loss rates

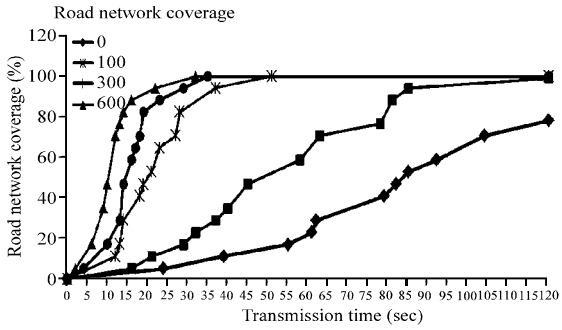

Fig. 20: Road network coverage of congestion information at different packet loss rate

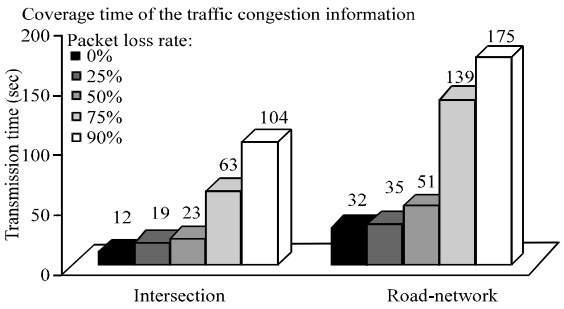

Fig. 21: Cover time of road network and junctions at different packet loss rate

and road-network entrance, increases with the increase of packet loss rate. And when the packet loss rate increases over 50, 75 and 90%, the time which the traffic congestion information takes to reach each road junction and road-network entrance increases obviously, while the change is relatively small when the packet loss rate is less than 50%.

Figure 20 shows, as the packet loss rate increases, the network coverage of congestion information is relatively lower. When the packet loss rate is less than 50% the change is not significant. The minimum time of congestion Information covering the entire road network is less than 50 sec. When the information packet loss rate increased to 75 and 90%, its network coverage has a substantial increase. But after congestion information is disseminated 120 sec, its road network coverage has reached 99 and 79%. This shows that if the information packet loss rate is not particularly large, network coverage of IVTIS mode is quite satisfactory.

Figure 21 shows, as the packet loss rate increases, the time of congestion information dissemination to the road network and the intersection o increases accordingly, especially when the information packet loss rate is greater than 75% change is very obvious. By comparing the coverage time of entrance road network, the former is much faster than the latter.

As mentioned above, in the urban road network, the coverage of entrance plays a key role in dissemination of congestion information. While by the simulation results can be seen, In IVTIS mode, the congestion information is covered quickly at entrance, showing a better result of dissemination (When the information loss rate is 50%, the minimum coverage time is 23 sec, while only 19 sec when is 25%). From this result we can see that at the general urban road network, especially urban road network composed of a lot of entrances, IVTIS model has certain validity.

CONCLUSION

In this study we further improve and perfect VANET-based intelligent traffic information system and construct corresponding IVTIS system model. Then we enables IVTIS model run in the simulation platform simulation by using the secondary development platform of traffic simulation software. On this basis, in order to evaluate reasonableness and validity of the IVTIS model. In this study, we comprehensively analyzed simulation results of single road and road network with different simulation conditions. We evaluate and analyze the received rate, Shortest transmission time, Maximum Velocity of Transmission,Road Network Coverage and some another Transmission efficiency indicators and the information packet loss rate effect on the dissemination of information. From the results we can know, IVTIS model and its system model is reasonable, which shows good self-collection and diffusion of information. However, the congestion information in the actual transmission process will be subject to a variety of complex factors. Then it will need further study and combined with the actual traffic data to Simulate. Through this improve and enhance the legitimacy and effectiveness of this system.

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