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Vertical Handoff Algorithm for Vehicle Heterogeneous Network Based on Motion Trend Prediction

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Abstract. In this paper, a vertical handover algorithm based on motion trend prediction is proposed for the problem that the speed of vehicle in the heterogeneous IoV (Internet of Vehicles) is fast, which leads to the high switching failure rate and "ping-pong effect". In the heterogeneous IoV environment composed of LTE and WiMAX, the duration of the current base station coverage is calculated by predicting the movement trend of the vehicle. According to the time, the vehicle node is divided into narrow mobile node and wide mobile node. For narrow mobile nodes, the network selection method based on load balancing is adopted to decide the handoff. For the mobile nodes, handoff decisions are carried out by using the multiple attribute vertical handoff algorithm based on Fuzzy Analytic Hierarchy Process (AHP). The simulation results show that the algorithm can reduce the number of handover, improve the switching delay and improve the throughput of the system in two kinds of simulation scenarios with different vehicle quantity and different vehicle speed.

Keywords: Analytic Hierarchy Process, heterogeneous IoV, motion trend, multiple attribute decision, vertical handoff

1 Introduction

With the deep integration of a variety of wireless networks, the future car network is an important feature of a variety of wireless network integration, complementary advantages for the user terminal to provide the best service. The characteristics of various wireless networks vary, for example, the transmission rate, cost, coverage and other aspects of the gap [1]· When the number of handoff is too much, the terminal business will have a great impact. So how to ensure effective switching is the focus of this paper.

Some handover algorithms have been proposed in the literature [2-9]. Cheelu et al. [2] proposed an intelligent VHO decision strategy targeting to maximise user satisfaction without compromising on quality of service for non-real time mobile based services. The proposed strategy applies consumer surplus value (CSV)-based pricing scheme and also a prediction system to[1] approximate network performances at various intervals. In [3], a Kalman filtering and fuzzy logic approach to reducing handoff initiations was proposed, The algorithm take several metrics such as received signal strength (RSS), data rate, velocity of mobile terminal, and traffic load are considered as criteria to initiate handoff from WLAN to the cellular network. In [4], an individualization service oriented fuzzy vertical handover algorithm was proposed; the handover performance is improved from the following two aspects. Firstly, in the network discovery phase, the candidate networks are sifted by predicting the network loads in handover execution. Secondly, in the handover decision phase, different membership functions are designed according to the different QoS requirements of each application class. Kaleem et al. [5] present

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a novel multi-criteria VHO algorithm, which chooses the target NAT based on several factors such as userpreferences, system parameters, and traffic-types with varying Quality of Service (QoS) requirements. In [6], a multi-attribute vertical handoff decision algorithm based on mobile trend quantization is proposed, The algorithm quantifies the motion trend of the terminal and predicts the motion path of the terminal by moving trend parameter, compared with the algorithm that does not specifically consider the trend of terminal motion, the algorithm reduces the switching failure rate, thus improving the network performance. Kong et al. [7] proposed a prediction vertical switching algorithm is proposed in the vehicle heterogeneous network. The algorithm uses the Markov chain to predict the change of the network state. The fuzzy logic method is used to determine the attribute weight. Finally, the optimal target network is defined by defining the revenue function, the average blocking rate and packet loss rate of the vehicle terminal are effectively improved, and the ping-pong effect is reduced. When the terminal moves to a new network coverage area, the efficiency of the algorithm is reduced due to the lack of historical mobile information. In [8] the vertical switching decision algorithm of the fuzzy control system is proposed, The network parameters and the service type are taken as the decision factors, and the fuzzy control system is introduced in parallel with the analytic hierarchy process (AHP), The time of switching decision is shortened and select the best network for users. Wang et al. [9] proposed a vertical handoff method based on Bayesian decision in Internet of Vehicles (IoV) is to use Bayesian decision algorithm to select the best access network. Although the above research has achieved good research results, however, there is a lack of research on the influence of the number of vehicle nodes, the distribution of vehicle nodes, the terminal speed on handover decisions and the network performance in heterogeneous IoV.

In this paper, a vertical handoff algorithm based on motion trend prediction is proposed, which divides the vehicle nodes into narrow mobile nodes and wide mobile nodes according to the duration of the terminal coverage in the current base station. For narrow mobile nodes, a network selection method based on load balancing (LBNS) is used to decide the handoff. For the wide mobile node, the multi-attribute vertical handover algorithm based on fuzzy analytic hierarchy process (AHP) is used to decide the handoff. The algorithm uses the interference-to-noise ratio (SINR), switching delay; communication cost and available bandwidth attribute of different access networks and then use the fuzzy hierarchical method to determine the weight of each attribute, and finally use the simple weighted sum (SAW) method to judge whether to connect to the target network.

The main innovations of this paper are as follows: (1) According to the duration of terminal coverage under the current base station terminal classification, take different vertical switching strategy for different terminals. (2) Considering the influence of the number of vehicle nodes and the distribution of vehicle nodes on handover decisions in heterogeneous IoV.

2 Vertical Switching Algorithm Based on Motion Trend Prediction

2.1 Vehicle Motion Area Prediction

Since the terminal is not uniform during the course of motion, so generally take a period of time the average speed of the terminal to study. Using the speed measurement function of the terminal itself, samples are sampled in the periodic T to obtain N sampling speed values, and the mean values of these sampling values are taken. The average speed of the terminals in the period T can be obtained.

$$\overline{V} = \frac{1}{N}\sum_{j=0}^{N-1} V_j, j = 0,1,\cdots,N-1 . \quad \textbf{(1)}$$

V_j in the formula (1) represents the jth sample value.

As shown in Fig. 1, point A indicates that the terminal has a network switch here, and point B indicates the location where the terminal arrives at A after a period of time Δt . The calculation of the network duration can be expressed as:

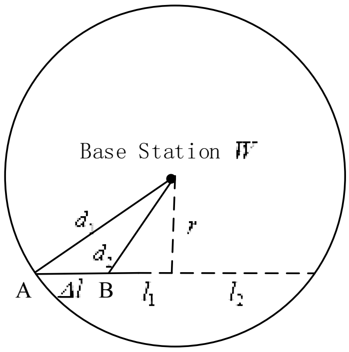

Fig. 1. Duration prediction model

$$\begin{cases} d_1^{\ 2} = r^2 + (\Delta l + l_1)^2 \\ d_2^{\ 2} = r^2 + l_1^{\ 2} \end{cases} . \quad \textbf{(2)}$$

In formula (2), $l_1 = \frac{d_1^{\ 2} - d_2^{\ 2} - \Delta l^2}{2\Delta l}$, $\Delta l = \overline{V}\Delta t$. Because of $l_2 = l_1 + \Delta l$, the predicted network duration is:

$$t_c = \frac{2l_2}{\overline{V}} = \frac{d_1^{\ 2} - d_2^{\ 2} + \overline{V}^2 \Delta t^2}{\overline{V}^2 \Delta t} . \quad \textbf{(3)}$$

Compare t_c with the preset duration threshold δ, when $t_c < \delta$, Indicating that the vehicle nodes in the current base station coverage movement time is short, and frequent access to multiple base station coverage, then these nodes are classified as wide mobile vehicles, On the contrary, when $t_c \geq \delta$, then the node in the current coverage of the base station within a long time, this part of the node classified as narrow mobile vehicles.

2.2 Network Handoff Decision Algorithm for Narrow Moving Node

For a narrow mobile vehicle, assuming that the current terminal accesses the LTE network, the LTE network performance is good for the duration of the current base station coverage, the factor that affects the node handover is the network condition of the LTE base station. It is only necessary to consider the switching between the current LTE base station and the WiMAX network for such nodes. And the current base station load conditions and the terminal in the process of movement by the building block will affect the base station network situation.

For a narrow mobile node i, assuming that its current motion is within the coverage of the LTE network and has been connected to the LTE network. If the current access network performance degrades, the terminal first determines whether the network performance is degraded by the blockage of the building. During the waiting time wt, if the network performance recovery that the reasons for the decline in network performance is caused by the blockade of the building, continue to maintain the current connection, do not switch. If the current access network performance is not restored within the waiting time, the LTE network will be compared with the WiMAX network to select the better target network connection. Comparing the performance of LTE and WiMAX networks by calculating the load condition of the current base station, and as a switching criterion. In the formula (4), ρ_B is the load condition of the current base station, $NL_{sch(i)}(t)$ is the load condition of the optimal target network that the node m can access, and ρ_φ is the condition hysteresis threshold, and the value of the ρ_φ is 0.2. When $\rho_{diff} > \rho_\varphi$, on behalf of the WiMAX network is better than LTE network, node m performs handover connected to the WiMAX network; on the contrary, when $\rho_{diff} \leq \rho_\varphi$, on behalf of the WiMAX network performance and excellent network performance than LTE or both are almost the same, do not execute handover, continue to maintain the current network connection.

$$\rho_{diff} = \frac{NL_{sch(i)}(t) - \rho_B(t)}{\rho_B(t)} . \quad \textbf{(4)}$$

2.3 Network handoff Algorithm for Wide Mobile Node

Wide mobile node is characterized by its movement in a single base station coverage duration is short, frequent movement leads to more switching times. In this paper, a multi-attribute decision algorithm based on fuzzy analytic hierarchy process (AHP) is proposed for network switching of wide mobile nodes. Suppose that the LTE network has m base stations (BS), and that the WiMAX network has n access points (AP), and all candidate base stations and access points form a collection $H = \left\{BS_1^{\ L}, BS_2^{\ L}, \cdots, BS_m^{\ L}, BS_1^{\ WM}, BS_2^{\ WM}, \cdots, BS_n^{\ WM}\right\}$, Each time the terminal selects a base station from the set H to connect.

The vertical switching algorithm of the wide mobile vehicle node includes three parts: decision attribute analysis, determination attribute weight and handover decision.

2.3.1 Decision Attribute Analysis

Factors affecting the switching decision are: Signal and Interference Noise Ratio (SINR), switching delay, communication costs, available bandwidth.

(1) *SINR:* The SINR value $\gamma^L_{BS_{j,i}}$ received by the node i from the LTE base station BS^L_j is expressed as [10]

$$\gamma^L_{BS_{j,i}} = \frac{G^L_{BS_{j,i}} P^L_{BS_{j,i}}}{P^L_0 + \sum_{k=1,k\neq j}^{m} G^L_{BS_{k,i}} P^L_{BS_k} + G^L_{BS_{j,i}} \alpha (P^L_{BS_j} - P^L_{BS_{j,i}})} . \quad \textbf{(5)}$$

Where $P^L_{BS_j}$ is the total transmit power of BS^L_j; $P^L_{BS_{j,i}}$ is the transmission power of BS^L_j to node i; $G^L_{BS_{j,i}}$ is the channel gain between node i and base station BS^L_j; α is the orthogonal factor, the value is 0.4; P^L_0 is the thermal noise power, the value is -99dBm; The SINR value $\gamma^{WM}_{BS_{j,i}}$ received by the node i from the WiMAX base station BS^{WM}_j is expressed as [11]

$$\gamma^{WM}_{BS_{j,i}} = \frac{\sum_{k=1}^{s_i} G^{WM}_{BS_{j,i}} P^{WM}_{BS_{j,k}}}{P_B + \sum_{k=1,k\neq j}^{n} \sum_{s=1}^{n_k} G^{WM}_{BS_{k,j}} P^{WM}_{BS_{k,s}}} . \quad \textbf{(6)}$$

Where $P^{WM}_{BS_{j,k}}$ is the transmit power of the WiMAX base station; $G^{WM}_{BS_{j,i}}$ is the channel gain between node i and WiMAX base station BS^{WM}_j; P_B is the background noise power, the value is -86dBm.

In order to obtain a data rate equal to that received from the WiMAX base station, $\gamma^{WM}_{BS_{j,i}}$ can be converted to the equivalent SINR value $\gamma'^{WM}_{BS_{j,i}}$ received by the node from the LTE base station

$$\gamma'^{WM}_{BS_{j,i}} = \Gamma^L_{BS} \left[(1 + \frac{\gamma^{WM}_{BS_{j,i}}}{\Gamma^{WM}_{BS}})^{\frac{W^{WM}_{BS}}{W^L_{BS}}} - 1 \right] . \quad \textbf{(7)}$$

Where W^L_{BS} and W^{WM}_{BS} represent the bandwidth of the LTE and WiMAX networks, respectively, and Γ^L_{BS} and Γ^{WM}_{BS} represent the difference between the gain and the coding gain of the channel capacity in the LTE and WiMAX networks, respectively.

(2) *Handoff delay:* From the literature [12] we can see that the node to perform a switching delay is:

$$\tau_{d,VHO} = 4\left(\tau_{mr} + \tau_{ra} + \tau_{ai}\right) + \overline{\tau_H} + \overline{\tau_W} + \tau_{VHO,e} \,. \tag{8}$$

Where τ_{mr} the delay between the node and the base station, τ_{ra} is is the delay between the base station and the gateway GPRS support node (GGSN), τ_{ai} is the delay between GGS and the information server (IS), $\overline{\tau_H}$ and $\overline{\tau_W}$ are the average delay for scanning high-speed downlink packets (HSDPA) and WiMAX channels, $\tau_{VHO,e}$ is the average switching delay [13].

(3) *Other attributes:* Let S_i be the SINR vector consisting of $\gamma^{L}_{BS_j,i}$ and $\gamma^{WM}_{BS_j,i}$; τ_i be the switching delay vector for the node to switch to the alternate network; C_i represents each alternative network, communicating with the node i, sending a normalized cost vector for each bit, and U_i representing the available bandwidth of each alternative network. According to the above 4 decision attributes, the attribute matrix A_i is

$$A_i = \left[S_i \quad \tau_i^{-1} \quad C_i \quad U_i\right]^T . \tag{9}$$

2.3.2 Determine the Attribute Weights

In this paper, we use the following steps to determine the attribute weight: First, according to the fuzzy analytic hierarchy process to determine the importance of each attribute, and then build the fuzzy decision matrix, finally, we derive the weight vector w corresponding to the network attribute.

First, a hierarchical model is constructed according to the decision criterion and the alternative network. Assuming that the element E on the previous layer is associated with the element $e_1, e_2, \cdots, e_p$ in the next layer $(L1)$, the fuzzy decision matrix P can be represented as

$$P = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1p} \\ r_{21} & r_{22} & \cdots & r_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ r_{p1} & r_{p2} & \cdots & r_{pp} \end{bmatrix} . \tag{10}$$

In equation (10), $0 \le r_{ij} \le 1$, $r_{ij} + r_{ji} = 1$. r_{ij} is an important measure of degree of e_i is more important than e_j, indicating that e_i and e_i have a "$\cdots$ is more important than $\cdots$" ambiguity relationships when e_i and e_i are compared with element E. We can assign the value to r_{ij} in 0.1~0.9, $r_{ij} \ge 0.5$ means that e_i is more important than e_j, $r_{ij} < 0.5$ means e_j is greater than e_i, $r_{ij} = 0.5$ means that e_i and e_j have the same importance. Let the weight of element $e_1, e_2, \cdots, e_p$ be $\omega_1, \omega_2, \cdots \omega_p$, the relationship between e_i and ω_i is as follows:

$$\sum_{i=1}^{p} \omega_i = 1,\ \omega_i > 1 . \tag{11}$$

When the element e_i is more important, the corresponding weight value ω_i is also larger.

If the matrix P is the consistency matrix, there is the formula (12) [14]

$$r_{ij} = 0.5 + \mu\left(\omega_i - \omega_j\right),\ i, j = 1, 2, \cdots, p . \tag{12}$$

Among them, μ represents the decision maker's attention to each attribute. Through formula (12) and formula (13), we can get the weight $\omega_1, \omega_2, \cdots \omega_p$ corresponding to the element $e_1, e_2, \cdots, e_p$, that is:

$$\omega_i = \frac{1}{p} + \frac{1}{\mu p}\left(\sum_{k=1}^{p} r_{ik} - 0.5p\right)\left(i = 1, 2, \cdots p\right) . \tag{13}$$

At the same time if the matrix P meet the consistency, then [12]

$$\left|\omega_i - \omega_j\right| = \frac{1}{|\mu|}\left|\varepsilon_{ij}\right|,\ i,j = 1,2\cdots,p\ . \tag{14}$$

Where ε_{ij} is the difference between the i-th row and the j-th row of P. From (15), we can see that the value of $|\mu|$ determines the value of $\left|\omega_i - \omega_j\right|$, and $\left|\omega_i - \omega_j\right|$ reflects the importance of decision maker's importance to the decision attribute. Therefore, several sets of weights can be obtained through different numerical values, and a set of weights satisfying the decision maker is selected from them.

In the case of streaming media services defined by 3GPP, for example, using the HSDPA channel to transmit video streams from an LTE base station, the available bandwidth attributes in the decision attributes have an important effect on the outcome of the decision. The fuzzy decision matrix J is obtained by comparing the relative degree of judgment results with each other

$$\mathbf{J} = \begin{array}{c} \\ e_1 \\ e_2 \\ e_3 \\ e_4 \end{array}\begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{bmatrix} 0.5 & 0.5 & 0.2 & 0.5 \\ 0.5 & 0.5 & 0.2 & 0.5 \\ 0.8 & 0.8 & 0.5 & 0.8 \\ 0.5 & 0.5 & 0.2 & 0.5 \end{bmatrix} \end{array}. \tag{15}$$

Where e_1 、 e_2 、 e_3 、 e_4 are SINR, switching delay, communication cost, available bandwidth respectively. Using the consistency judgment theorem of literature [11], it can be concluded that matrix J is consistent. In the formula (14), let μ = 0.4, we can get the weight value of each attribute $\omega_1 = 0.0625$ 、 $\omega_2 = 0.0625$ 、 $\omega_3 = 0.8125$ 、 $\omega_4 = 0.0625$.

2.3.3 Switching Decisions

SAW is the most commonly used multi-attribute decision making method. SAW algorithm is through the weight of all attribute values and determine the best target network, as shown in equation (16):

$$S_{SAW}^{*} = \arg\max_{i\in M} \sum_{j=1}^{N} \omega_j r_{ij}\ . \tag{16}$$

In equation (16), r_{ij} is the attribute value of the jth attribute of the i-th network, which is the element in the attribute matrix A_i ; ω_j represents the importance weight vector assigned to each attribute; N represents the set of attributes, and M ($M \le m+n$) represents the collection of alternative networks.

The candidate network with the largest value of S_{SAW}^{*} is the pre-switched target network. Then the decision strategy is: when the terminal before the decision has access to network corresponding to S_{SAW}^{*}, then no need to switch; otherwise, switch to network corresponding to S_{SAW}^{*}.

3 Experimental Results and Analysis

3.1 Simulation Scenarios and Parameter Settings

The simulation scenario is a heterogeneous network composed of LTE and WiMAX, as shown in Fig. 2. The LTE network covers all the scenes. In the simulation range, 400 terminal nodes are randomly generated, and the position of these nodes will change from time to time, in which their moving speed does not exceed 80km/h, the moving direction, i.e., the movement angle, satisfies the uniform distribution in [0,2π]. LTE and WiMAX network system parameters shown in Table 1. Where h is the base station antenna height and r is the cell radius.

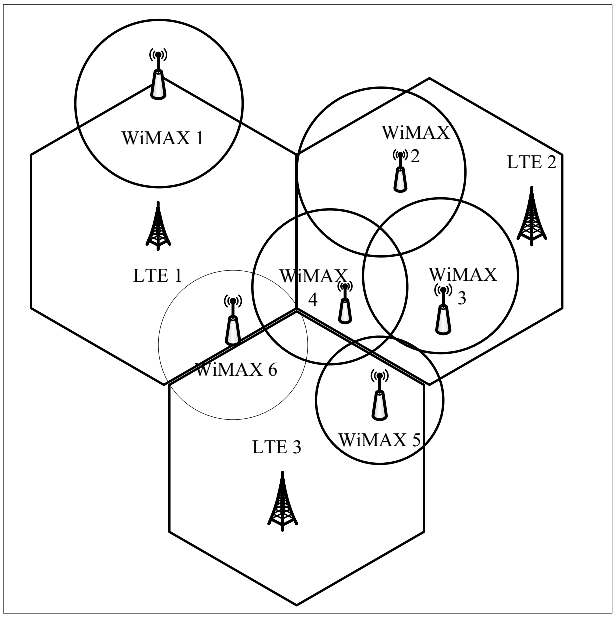

Fig. 2. Simulation scenarios

Table 1. System parameters

Base Station	f / Ghz	W_{BS} / Mhz	P_{BS} / dBm	Γ / dBm	R / km	h / m
LTE	2.0	5	40	16	1.2	15
WiMAX	2.5	10	46	1	1.0	15

3.2 Simulation Results

3.2.1 Investigation Index

In this paper, the network performance is evaluated by three aspects: network delay, throughput and numbers of handover, compared with the vertical switching algorithm which is based on the received signal strength (RSS), multi-attribute decision making (MADM) [15] and Bayesian decision (BDT) [7].

3.2.2 Switching Delay Analysis

Fig. 3 shows the switching delay graphs for four switching strategies in different vehicle node simulation environments. As shown in Fig. 3, as the number of vehicle nodes increases, the delay of all four switching strategies increases. The biggest increase is RSS-based network switching strategy. When the number of vehicle nodes changes from 50 to 300, the delay increases from less than 200 ms to more than 700 ms, and its growth rate approaches 500 ms. The reason for this result is that under the same simulation conditions, the density of the vehicle nodes increases with the increase of the number of nodes, and the distance between the vehicles becomes smaller. When the vehicle is moving, the vehicle in the WiMAX is switched from the LTE base station and its RSS changes constantly, and finally, the working channel of the WiMAX vehicle is also switched frequently. At the same time, it can be seen from the figure that compared with the RSS algorithm, the switching delay based on the MADM switching algorithm and the BDT switching algorithm and the algorithm in this paper are slow. And the delay of this algorithm is obviously lower than the other two algorithms, because the total load of the network increases as the number of vehicle nodes increases, and the MADM and BDT-based algorithms do not consider the possibility of network overload. Only consider a variety of network attributes and the theoretical probability of network switching as the basis for switching decision. In this paper, in order to reduce the possibility of network congestion, the load balancing method is used to select the appropriate access network for the newly connected vehicles. This process is time-consuming, so the delay is slow and the MADM and BDT switching algorithms are delayed relatively slightly higher than the algorithm in this paper.

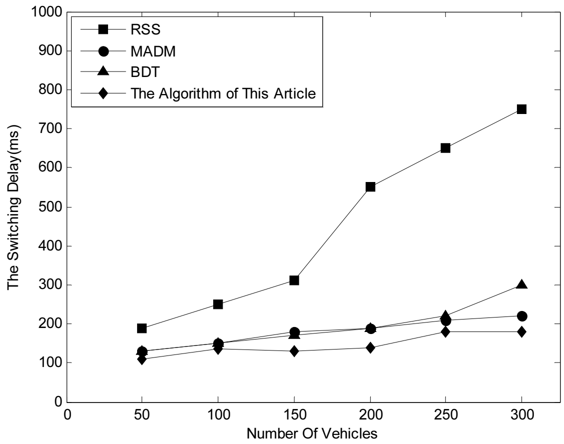

Fig. 3. The switching delay varies with the number of vehicles

Fig. 4 shows the switching delay graphs for RSS, MADM, BDT, and switching strategies in different vehicle node speed simulations. It can be seen from the figure that the four switching algorithms with the increase in speed, the switching delay are showing an increasing trend. At the same speed, compared with the other three algorithms, the switching delay based on RSS switching algorithm is the largest; the maximum values reaches 995ms, which also leads to the user can not get the best network experience. When the vehicle speed is 5m/s, the delay based on MADM, BDT and the switching strategy is distributed below 400ms, but when the vehicle speed reaches 30m/s, the delay based on MADM switching strategy reaches 755ms, and its growth trend significantly higher than the other two strategies, users still can not get a good network experience. In addition, when the vehicle speed is greater than 20m/s, the switching delay of the BDT-based switching algorithm is higher than that of this algorithm. When the vehicle speed changes from 5m/s to 30m/s, the delay increases from 350.3 ms 632.9 ms, and the highest switching delay of this algorithm is only 351ms. Therefore, compared with the other three algorithms, the switching delay of this algorithm has certain advantages, which ensures that users can obtain a relatively stable network experience. In this paper, the switching algorithm is based on the duration of the vehicle within the base station to analyze and predict the vehicle movement, and through the network duration of the terminal classification, for different types of terminals using different algorithms to switch the decision to reduce the vehicle speed on network performance caused by the impact.

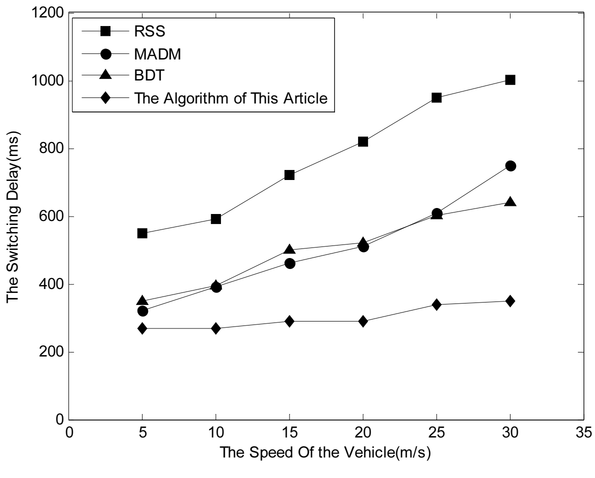

Fig. 4. Comparison of switching delay at different speeds

3.2.3 Network Throughput Analysis

Fig. 5 shows the comparison of the network throughput of the four switching strategies in the simulation environment of different vehicle nodes. It can be seen that the RSS-based switching algorithm has the least throughput and low growth rate compared to the other three switches, which also shows that RSS's load capacity is weak. Network throughput based on MADM, BDT based and the algorithm in this paper has the same throughput when the number of nodes is 50, however, with the increase of the number of vehicle nodes, the network throughput of this algorithm is higher than that of the other two algorithms. When the vehicle node reaches 30, it has the highest network throughput, which means that the algorithm has the strongest with the load capacity. This is because the algorithm uses the LBNS method to select the appropriate network of newly connected vehicles, the strategy can not only balance the network load, but also can reduce the network congestion rate, reduce the packet loss rate, can satisfy the communication needs of the vast majority of heterogeneous vehicle network terminal.

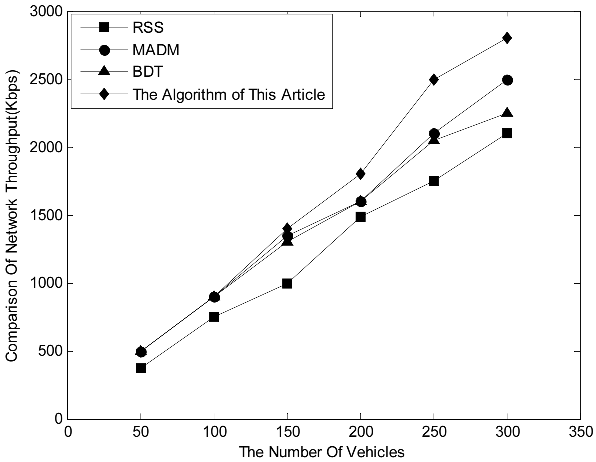

Fig. 5. Comparison of network throughput as the number of vehicles changes

Fig. 6 shows the four switching algorithms for network throughput as the vehicle speed changes. It can be seen from the figure that the network throughput of the four switching strategies decreases with the speed of the vehicle. Compared with the other three switching algorithms, the throughput of RSS-based switching algorithm is the largest, indicating that its robustness is weak. Compared with the BDT algorithm and the proposed algorithm, the network throughput of MADM handover algorithm fluctuates greatly, which indicates that the network performance is affected by the vehicle speed. In this paper, the network throughput of the algorithm is more obvious than that of the BDT switching algorithm. However, at the same speed, the throughput of this algorithm is still higher than that of the BDT switching algorithm. Compared with the other three algorithms, the network throughput of this algorithm has some advantages in the low speed and even high speed vehicle movement environment.

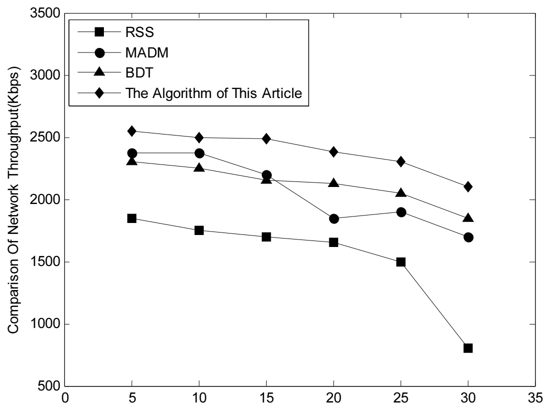

Fig. 6. Comparison of network throughput at different speeds

3.2.4 Switching Quantity Analysis

Fig. 7 shows the number of network switching times for terminals at different vehicle nodes. As can be seen from the figure, under the same number of vehicles, RSS has the highest number of network switching and with the increase in the number of vehicle nodes, the largest increase. This is because a variety of different access technology to form a heterogeneous vehicle network, and each network RSS standard is not the same, when the vehicle location changes, RSS value changes. The switching rate of handover strategy based on BDT is significantly higher than that of MADM-based algorithm. Compared with the other three switching algorithms, the growth trend is relatively gentle of this algorithm, and the number of handover is always the lowest. This is because the algorithm uses the LBNS method to select a candidate network with low network load, which reduces the number of handover and reduces the switching failure rate. This method is applicable to the high load capacity of the vehicle environment.

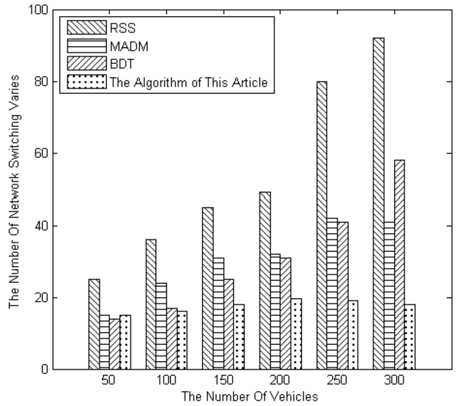

Fig. 7. the number of network switching varies with the number of vehicles

Fig. 8 shows the four switching algorithms for network switching times as vehicle speed changes.

As shown in the figure, the switching times of the four methods show an increasing trend with the increase of the speed of the vehicle nodes. And at the same speed, RSS switching strategy of the network switching times are higher than the other three strategies. So the RSS switch algorithm switch too fast, can not make users get a good network experience. MADM switching strategy of the number of switching growth rate is higher than the other two strategies, the maximum number of switching for 59.8 times, and when the vehicle speed is greater than 20m / s, the switching frequency become significantly faster. The number of handover of the algorithm in this paper and b BDT algorithm are relatively flat, and the number of network switching in this algorithm is obviously lower than that of BDT. This is because this article according to the duration of the network classification of nodes, different nodes using the switch algorithm is not used. This can not only reduce the number of switching between WiMAX and LTE, limit the unnecessary switching of nodes, and reduce the switching failure rate due to the switching caused by the terminal repeatedly entering the coverage of the same base station.

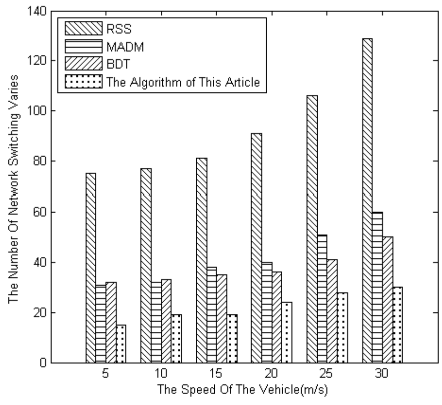

Fig. 8. The number of network switching times at different speeds

4 Conclusion

In this paper, a vertical handoff algorithm based on motion trend prediction is proposed. Firstly, the duration of the current base station coverage is calculated by predicting the trend of the vehicle movement. The vehicle nodes are divided into narrow mobile nodes and wide mobile node. For narrow mobile nodes, the network selection method based on load balancing is adopted to decide the handoff. For the mobile nodes, handoff decisions are carried out by using the multiple attribute vertical handoff algorithm based on Fuzzy Analytic Hierarchy Process (AHP), The algorithm uses the interference and noise ratio (SINR), switching delay, communication cost and available bandwidth attribute of different access networks as the factors influencing the decision, and establishes the attribute matrix according to the network attribute. The fuzzy hierarchy method is used to determine the weight of each attribute, and finally the use of simple weighted sum (SAW) method to determine whether the connection to the target network. The simulation results show that compared with the three switching algorithms based on RSS, MADM and BDT, the ping - pong effect is reduced, the network delay is improved obviously, and the system throughput is improved. But also confirmed the number and distribution of nodes in the heterogeneous car network, the vehicle speed has a great impact on the terminal communication performance. How to balance the allocation of system resources between the handover request and the new call request for a better user experience is the focus of the next step.

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