

Research on Destination Network Selection Based on Trajectory Trend

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ABSTRACT

The terminal will switch between different networks to maintain the network service required by the terminal device during the mobile process, and the unreasonable or inaccurate choice of the destination network will lead to the mobile device to switch between multiple networks for many times, resulting in the deterioration of the overall network service quality and the decline of user experience. Based on the trajectory trend, this paper comprehensively considers the terminal moving trajectory and the base station location, reasonably refers to network parameter factors, and combines the analytic hierarchy process to select the destination network, so as to improve the accuracy of network selection, reduce the number of switching times, reduce the efficiency of switching and improve the network utilization.

KEYWORDS

Network selection, Moving trajectory, Trajectory trend, Analytic hierarchy process

1. INTRODUCTION

In the era of the Internet of everything in the current complex network environment, the characteristics of various networks are very different. In the complex network environment, in order to ensure the stability and efficiency of network services, the mobility management of terminals needs higher requirements. The Control/Data Separation Architecture (CDSA) [1] for ultra-dense cellular networks is an enhanced network architecture. Under CDSA architecture, CP is responsible for coverage preparation, and DP is responsible for data transmission, thus reducing the overhead of DP. In order to ensure the stable service provided to users, a large number of small areas will be arranged under the CDSA architecture. When the end user moves between these small areas, a large number of switches will be generated. The trigger time decision of the switch, the choice of the network destination of the switch, the number of switching times and the service condition of the network after the switch jointly affect the network experience of the end user. It is also related to the utilization rate of the whole network, so network switching has always been a hot research topic. At present, many literatures have proposed their own algorithms for selecting the destination network for network switching. Literature [2] uses Long short-term memory (LSTM) and Multi-Layer Perception (MLP) to predict factors related to handover delay, signal transmission cost and handover failure rate to carry out network handover research. In this paper, predictive and non-predictive methods are compared, and the predictive algorithm outperforms the non-predictive algorithm when the prediction accuracy reaches the minimum accuracy, and the choice between predictive and non-predictive methods is made according to the switching requirements of the mobile network. Reference [3] LSTM predicts the user's future location and then uses the location prediction results for network selection. However, it is mentioned in literature [4] that the mobile trend of the terminal is used as one of the reference factors for switching, the mobile trend, signal strength and network bandwidth are comprehensively

considered, and the trend judgment is carried out by using the speed decomposition method on the mobile trend, the signal strength and bandwidth are normalized, and then the network selection judgment is carried out by weighting each parameter. In literature [5-7], switching decisions are made for devices that pass through the network coverage in a straight line, and the resident time in the network is directly predicted according to the relationship between speed, distance and time, so as to select the switching target network. Literature [8] also uses LSTM learning to analyze the user's past movements to predict the user's position at the next moment, and then uses the location prediction result as the switching decision condition, essentially using the dwell time as the decision condition. Literature [9] reduces the number of target candidate networks by combining the residence time of target cell and the device moving direction Angle. Both references [10] and [11] conduct periodic sampling of terminal speed and obtain average speed according to the periodic sampling results. The difference is that the former adaptively adjusts and updates the cycle time of the candidate target network cluster according to the size of the average speed, while the latter uses the average speed to predict the resident time. Literature [12] and [13] both introduce the concept of stable period for device mobility. The former sets a fixed stable period for the resident time to perform the first network screening during the stable period, while the latter evaluates the resident time and related value function during the stable period to decide whether to perform switching. Literature [14,15] predicted the speed at the next moment by speed prediction, then multiplied the predicted speed result with the sampling time to get the terminal moving distance, then vector superimposed the obtained moving distance with the current terminal position to get the position at the next moment, and made network selection decision according to the position result.

There are some shortcomings in the above algorithms for network selection decision of mobile terminal. Therefore, in this paper, the randomness of terminal movement is integrated into the switching decision process. In the aspect of switching selection, the first network selection is carried out by calculating the tendency of the terminal relative to the target base station, and then the signal strength, signal-to-noise ratio, network bandwidth, delay and packet loss rate are selected, and the final destination network selection is carried out by combining the analytic hierarchy process. Finally, by comparing the switching frequency, switching failure rate and overall network bandwidth utilization of the proposed switching algorithm with those based on resident time and radial velocity combined with entropy weight method, we can see that the proposed algorithm has certain improvements in reducing switching frequency, reducing failure rate and improving network utilization.

2. SYSTEM MODEL AND SWITCHING PROCESS

This paper designs signal detection and recording module, track recording module, switch trigger module, network selection module and switch execution module. When the terminal is moving, the signal detection module always detects the signal strength of the service network; the trajectory recording module records the current terminal movement trajectory; the switching trigger module determines whether to trigger network switching by judging the change of signal strength and the position of the terminal; the network selection module performs the first network selection for trajectory trend calculation and the second network selection by using analytic hierarchy process. The switching execution module switches to the destination network after network selection. The specific network switching process is shown in Figure 1 below

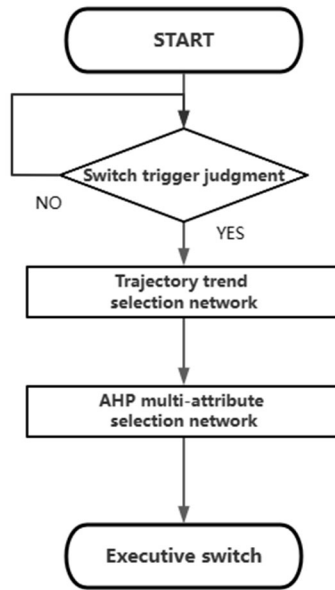


Fig.1 Flowchart of switching execution

3. REFERENCE FACTOR SELECTION OF DESTINATION NETWORK DECISION

3.1. Primary decision factor and secondary decision factor

3.1.1. Trajectory trend of initial decision factor

Since the terminal is related to the user's movement, the randomness of the movement is very large, which makes it more difficult to select the network for switching according to the mobile characteristics. However, the trajectory of the moving process can reflect the mobile trend to a large extent. Therefore, the key reference factor is to select the movement trajectory of the network for the purpose of network switching for the mobile terminal. The moving trajectory can reflect the past and current moving state of the terminal, and the short-term trajectory recorded in real time reflects the moving trend, which plays a key role in the choice of destination network. Besides, unlike the speed, the trajectory has high requirements on the judgment of size and direction, and the trajectory is more stable than the speed. The reference trajectory can make a more accurate measurement of the terminal's movement trend.

3.1.2. Quadratic decision factor signal strength, signal-to-noise ratio, available bandwidth, packet loss rate and delay

When selecting the destination network, it is necessary to ensure as much as possible that the destination network after switching can provide the terminal with high-quality services, which includes providing the terminal with more network resources, lower delay and more stable services. Therefore, the traditional reference signal strength is far from enough, and the difference in signal strength is very small in the ultra-dense network. In addition, the signal strength increases and decreases with the movement of the terminal, which has little impact on the network selection decision. Therefore, various network factors are considered at this stage. In this paper, multiple factors such as signal strength, bandwidth, delay and packet loss rate are selected. In this paper, the application type of the terminal is taken as the basis, and the emphasis of the current terminal application type on the network service factor is analyzed and calculated by using the analytic hierarchy process, and different weight combinations are selected to calculate each parameter

3.2. Trajectory trend calculation and analytic hierarchy process to calculate the weight of each attribute

3.2.1. Initial network screening is carried out by trajectory trend calculation

In this paper, the tendency of the terminal trajectory to each base station is calculated through the following formula (1) and (2)

$$L_{ij} = \sqrt{(TX_i - BX_j)^2 + (TY_i - BY_j)^2} \quad (1)$$

$$Q_j = \sum_{i=0}^{l-1} ((L_{(i+1)j} - L_{ij}) \div L_{(i+1)j}) \times \alpha_i \quad (2)$$

The above formula (1) is the distance formula(TX_i TY_i), Is the i th trace point in the trajectory of the terminal moving process, (BX_i BY_i) Is the location coordinates of the surrounding reachable network base station. L_{ij} Is the distance between the position coordinates of each terminal in the first terminal trajectory sequence and the surrounding JTH network base station,Then L_{ij} is taken as the input parameter of equation (2) and combined with the recorded time of each trajectory, that is, the time of distance change, multiplied by different weights α_i ,The trend of the recorded trajectory sequence relative to each base station is obtained. The calculated Q_j is the value of the terminal's tendency to each network base station.

According to Q_j for the first purpose of network screening, the networks obtained after the first calculation are the networks that are most likely to enter the future. The following is to select the network that meets the current terminal demand among the networks that are most likely to trend, so that the useless calculation can be reduced through the first time.

3.2.2. Analytic hierarchy process analyzes the weight of each index to make the final network decision

In this paper, the path loss of signal strength in free space is as follows (3)

$$:R_{UE} = P_{SBS} - (32.5 + 20\log_{10}F + \log_{10}d) \quad (3)$$

F is the transmit frequency of the base station, d is the distance between the base station and the terminal, R_{UE} is the received power of the terminal, and P_{SBS} is the transmit power of the base station.

SNR SNR is calculated as follows (4) :

$$SNR = 10\lg \frac{P_{BS}}{P_n} (dB) \quad (4)$$

P_s is the signal power of the destination network base station received by the terminal, and P_n is the total power received by the terminal from the surrounding.

The packet loss rate D is calculated as follows(5):

$$D = \frac{In - Out}{In} \times 100\% \quad (5)$$

In indicates the total amount of data sent and Out indicates the total amount of data lost.

After the terminal accesses the destination network, the average bandwidth B_{ue} that can be obtained is calculated as follows (6):

$$B_{ue} = \frac{B_{Bs}}{N + 1} \quad (6)$$

B_{ue} is the total bandwidth of the destination network, N the number of terminals accommodated in the current network.

After all the required factors are calculated, the selected factors are normalized through the following formula (7), which is used as the calculated input value of the quadratic decision.

$$C_{\{S,B,t,p\}} = \frac{C_{current} - C_{min}}{C_{max} - C_{min}} \quad (7)$$

Then select different weights according to the service type of the current terminal

Table 1 Importance of parameters to network selection ration

Scale	Meaning
1	Both are equally important
3	The former is slightly more important than the latter
5	The former is obviously more important than the latter
7	The former is strongly more important than the latter
9	The former is more important than the latte
2,4,6,8	Median value of relative importance

The following formula (8) decision matrix A is established according to the relative importance matrix:

$$A = \left\{ \begin{bmatrix} a_{11} & a_{11} & \dots & a_{1n} \\ a_{11} & a_{11} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \right\} \quad (8)$$

Then, the corresponding weights of each attribute factor are calculated according to the following formula (9).

$$W_i = \frac{1}{n} \sum_{m=1}^n \frac{a_{ij}}{\sum_{k=i}^n a_{kj}} \quad (9)$$

The weight vector of each network attribute factor is obtained: $W = [W_1 \ W_2 \ \dots \ W_j]$, Then the consistency check is carried out on the matrix, and after passing the consistency test, the final network is selected by the product of each factor and the weight of each factor:

$$B_i = W_1 \times S + W_2 \times B + W_3 \times T + W_4 \times P \quad (10)$$

$$B = \text{Max}(B_i) \quad (11)$$

The resulting network B is the final selected destination network.

Table 2 Comparison of the relative importance of session classes and table of weights of each factor

Session-class	SNR	Bandwidth	Signal strength	Delay	Packet loss rate	Eigenvector	Weight value(%)
SNR	1	0.125	3	0.167	0.25	0.435	6.251
Bandwidth	8	1	0.125	0.333	5	1.108	15.906
Signal strength	0.333	8	1	0.111	0.333	0.629	9.039
Delay	6	3	9	1	6	3.959	56.848
Packet loss rate	4	0.2	3	0.167	1	0.833	11.956

Table 3 Comparison of the relative importance of download classes and the weights of each factor

Download class	SNR	Bandwidth	Signal strength	Delay	Packet loss rate	Eigenvector	Weight value(%)
SNR	1	0.167	3	0.2	0.143	0.428	5.964
Bandwidth	6	1	7	7	0.333	2.502	34.899
Signal strength	0.333	0.143	1	0.333	0.125	0.288	4.019
Delay	5	0.143	3	1	1	1.165	16.247
Packet loss rate	7	3	8	1	1	2.787	38.871

4. CONTRAST EXPERIMENT

In this paper, Python was used to construct a virtual network environment for handover simulation, and the effectiveness of the handover method was verified by comparing the handover algorithm based on entropy weight method. The parameters of the network environment constructed in this paper are shown in Table 4 below.

Table 4 Simulated network parameters

parameter	numerical value
DBS radius /m	50~200
CBS radius /m	500
bandwidth /mbit	65-100
Number of service terminals on the network	50~100
delay /ms	0~10

The performance of the proposed algorithm is tested by comparing it with the method based on resident time and radial velocity and using entropy weight method to determine the change of switching times with the increase of moving distance under three different trajectories. The following figures 5 show the switching times of the proposed method and the entropy weight method respectively in the moving process of the three tracks A1, A2 and A3 with different total lengths. Due to the randomness of the moving, the switching consideration based on the entropy weight method is very affected by the reference value, so more switching is generated. In this paper, switching consideration from the trajectory greatly reduces the influence of moving randomness on network selection decision, and reduces the number of network switching to a certain extent.

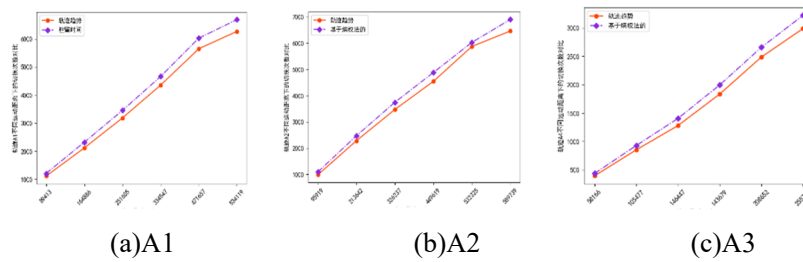


Fig.5 The number of track switching under A1, A2 and A3

FIG. 6 shows the handover failure rate of terminals in the moving process of three tracks A1, A2 and A3 with different total lengths. As can be seen from the results shown in the figure, the proposed algorithm can effectively reduce the handover failure rate in the same network environment to a certain extent, and carry out more reasonable destination network selection.

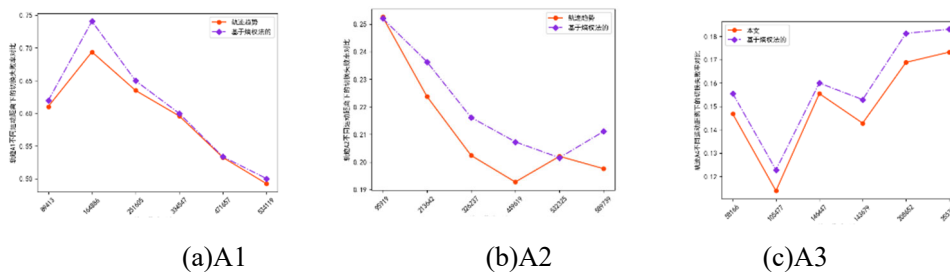


Fig.6 failure rate of track switching under A1, A2 and A3

When a small number of users move over the network, a single user can obtain more network resources. However, with the increase of the number of users and the emergence of crossover in the mobile process, when the destination network selection is unreasonable and multiple users choose the same network, the users in the current network will get fewer network resources, and many idle resources in the network selected by fewer users are not fully utilized. This leads to a lot of network resources wasted. Figure (7) below shows the comparison of the network resource utilization of a large number of terminals using two switching algorithms in the random movement process of the network. The method in this paper comprehensively considers the terminal's own mobile and network conditions, thereby obtaining a higher network utilization rate and reducing the waste of resources.

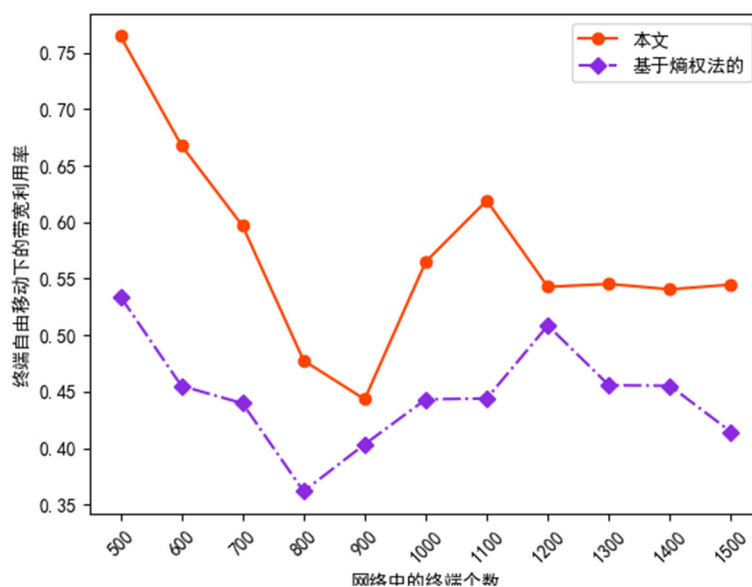


Fig.7 Comparison of bandwidth utilization

5. CONCLUSION

This paper studies the switching frequency, switching failure rate and network resource utilization of terminals in the switching process of heterogeneous networks, and establishes a simulation environment for comparative analysis to verify that the network selection method based on trajectory trend combined with analytic hierarchy process can reduce the number of network switching and reduce the switching failure rate. Select a more reasonable network for the terminal to improve the utilization rate of network resources to a certain extent. The trajectory of this paper is collected through the real time of the terminal movement process, and the weight obtained by the analytic hierarchy process is analyzed and calculated according to the laziness of each network parameter by the terminal application type, which has good application value.

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