ARPN Journal of Engineering and Applied Sciences

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OPTIMIZING THE VERTICAL HANDOFF DECISION MAKING ALGORITHM in 4G

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ABSTRACT

This article focuses on improving the vertical handover scheme in the heterogeneous networks. There are three main steps involved in this process which are: Handover necessity estimation, Handover target selection and Handover triggering condition estimation. The first step helps us in finding out whether a handover is necessary to the other access point, the second one helps in finding out the best suited candidates for the handover process. Third step helps us in triggering the handover process at the correct moment. 4G networks are expected to improve the communication process by improving speed and services offered by provider. This method is designed so as to reduce the handover failure and the unnecessary handovers. Along with this it is also supposed to enhance user satisfaction by involving user in decision making.

Keywords: handover necessity estimation, handover target selection, handover triggering condition estimation, probability density function.

INTRODUCTION

In the fast developing world with new technologies being invented everyday it is necessary to keep users satisfied. Proposed work aim to remain always connected and remains connected to the best network [1].Our work focuses on to improve the existing vertical handoff decision making algorithm. Input is taken in the form of transmitted power, handover delay, cell radius and power consumption level of the user. If the handoff is necessary then it chooses the best network available according to the algorithm [2]. It keeps monitoring the device in order to update the information dynamically. Handover is the process of maintaining a user's active session when a mobile terminal changes its connection point of the access network [3]-[6]. Earlier algorithms used to take handover decisions based only on the RSS value taken periodically and thus they didn't use to consider the user's choice of networks while making an assumption that there existed only type of access technology. However in a heterogeneous environment several other reasons like more bandwidth or security could perhaps be the cause to trigger handover [7].

Background

A number of studies and survey on vertical handover decision (VHD) algorithms. However, the focus of this paper is quite narrow and only covered cost function, bandwidth and received signal strength (RSS) based VHD algorithms [7],[8]. Existing System lacked in enough details for implementation and dynamic system has not been proposed for evaluation of parameters which led to increase in handover failures. The other problem in a cell was, if a MT received signal from an adjacent wireless local area network (WLAN) cost with low and high throughput then there was a tendency for handover to occur to that WLAN irrespective of whether it is required or not [9], [10].In this paper we tend to focus our attention on a scheme that tries to take into consideration the user preferences and thus increase user satisfaction level, reducing the handover failure rate and also the unnecessary handovers.

MATERIAL AND METHODS

Vertical handover decision marking process

The following steps are involved for the vertical handover decision making process. The steps as follows:

Step1: Initial checking of the handoff necessity

A. Network model

Wireless networks range from i = 1 to N. B_i is the total bandwidth and b_i denotes the bandwidth currently available for use.

New call blocking probability

The mean number of request arrivals per unit time is denoted by λ_i and undergoes Poisson distribution. The call holding time has an exponential distribution with mean $1/\mu_i$. Now we can find the equation of this by using the Erlang-B model.

$$P_i = \frac{\left(\frac{\lambda_i}{\mu_i}\right)^{Bi}}{B_i!}\left(\sum_{n=0}^{B_i}\frac{\left(\frac{\lambda_i}{\mu_i}\right)^{n}}{n!}\right)^{-1} \quad (1)$$

Dynamic call blocking probability

Now in order to calculate the dynamic call blocking probability we can substitute B_i with b_i to make it more of a dynamic equation. With the changes in the equation its performance is greatly enhanced as compared to the previous equation.

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$$P_i = \frac{\left(\frac{\lambda_i}{\mu_i}\right)^{bi}}{b_i!}\left(\sum_{n=0}^{b_i}\frac{\left(\frac{\lambda_i}{\mu_i}\right)^{n}}{n!}\right)^{-1} \tag{2}$$

B. Minimum guarantee function

It is the first step in the pre handoff decision. In a vertical handoff decision there are many factors that influence the decision making process. Some of them are cost, bandwidth, velocity etc. Thus a minimum guarantee function is designed so as to calculate the minimum value that is needed of each possible candidate for the handover process.

$$M_n = F(b_n - b_{th}).F(RSS_n - RSS_{th}).F(V_n - V_{th}).$$
$$F(T_n - T_{th}).F(P_n - P_{th}).F(C_n - C_{th}) \tag{3}$$

whereas, V stands for velocity of Mobile network, T indicates the estimated time the mobile network will stay in a particular network, P indicates the battery power and C indicates the network cost involved. The value with subscript n are the values of the different networks where n ranges from 1 to N and the values with the subscript th indicate the threshold value required for each parameter. The function F is a unit step function which gives a value zero for negative parameters; hence if for a particular network the value of available resource is less than the threshold value then it gives a zero value.

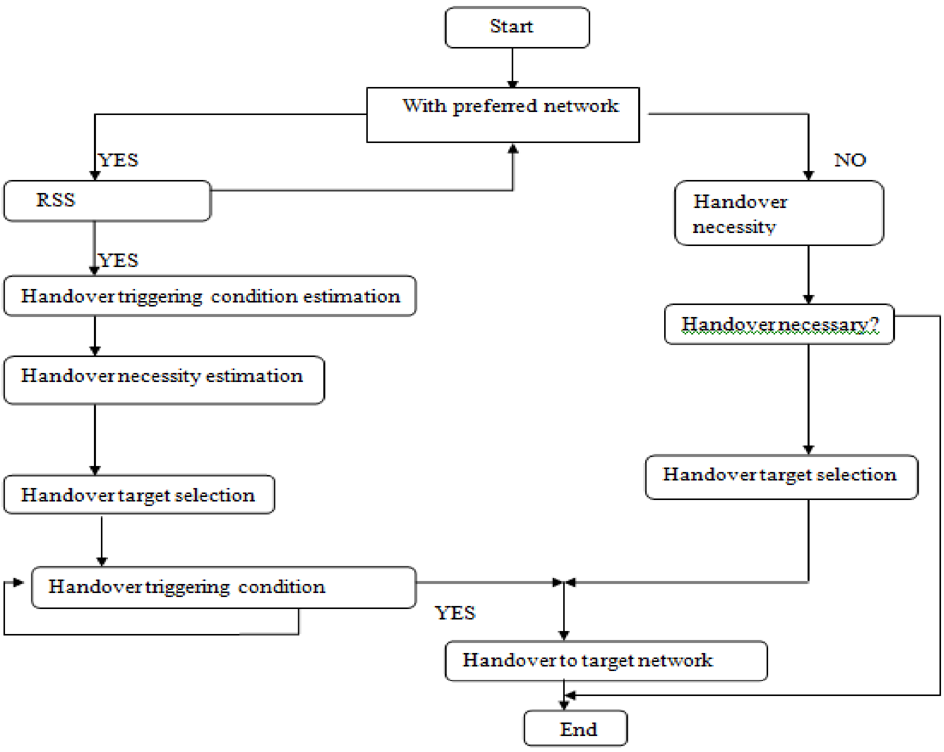

Figure-1. Flow diagram of vertical handover decision making.

Step 2: Handoff Necessity Estimation (HNE)

Predicting travelling time using RSS and velocity

The algorithm involves few assumptions which are Circular geometry forms WLAN cells. A constant speed is maintained by the MT in a uniform motion. The movement can be designed using log-distance path loss model. The equation of unnecessary handover is given by

$$P_u = \begin{cases} \frac{\pi}{2}\left[\sin^{-1}\left(\frac{v(\tau_i+\tau_o)}{2R}\right) - \sin^{-1}\left(\frac{vT2}{2R}\right)\right], & 0 \le T2 \le (\tau_i+\tau_o) \\ 0, & (\tau_i+\tau_o) < T2 \end{cases} \tag{4}$$

$$T2 = \frac{2R}{v}\sin\left(\sin^{-1}\left(\frac{v(\tau_i+\tau_o)}{2R}\right)\right) - \frac{\pi}{2}P_u \tag{5}$$

For the failed handover the probability function is given as

$$P_f = \begin{cases} \frac{\pi}{2}\left[\sin^{-1}\left(\frac{v\tau_i}{2R}\right) - \sin^{-1}\left(\frac{vT1}{2R}\right)\right], & 0 \le T1 \le \tau_i \\ 0, & \tau_i < T1 \end{cases} \tag{6}$$

VOL. 13, NO. 3, FEBRUARY 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

$$T1 = \frac{2R}{v}\sin\left[\sin^{-1}\left(\frac{v\tau_i}{2R}\right) - \frac{\pi}{2}P_f\right] \quad (7)$$

where $\alpha + \beta = \chi$.

Step 3: Handover Target Selection (HTS)

According to the user the different inputs are assigned weights according to their requirement, there are different levels of priorities assigned such as high, medium, low and none. There are a few assumptions on which this method is based. P_w indicates power level of battery which ranges from 0 to 1 meaning low and full battery respectively. The weight factors of the four inputs are W_b, W_s,W_m and W_p indicating bandwidth, security and power level. The sum of all these weights is equal to one. High, medium, low and none are indicated by i_h,i_l, i_m and 0. All these values range between 0 and 1. Different level of priorities are N_h N_l N_m and N_n where the summation of these four is equal to 3. The weight of these priority levels after adjusting are W_{ih},W_{im}, W_{il}, W_{in}.

The objective is to find W_b,W_m, W_s, W_p based on gathered data.

$$W_{ih} = \frac{I_h P_w}{N_h I_h + N_m I_m + N_l I_l} \quad (8)$$

$$W_{im} = \frac{I_m P_m}{N_h I_h + N_m I_m + N_l I_l} \quad (9)$$

$$W_{il} = \frac{I_l P_l}{N_h I_h + N_m I_m + N_l I_l} \quad (10)$$

$$W_{in} = 0 \quad (11)$$

Cost factor calculation

In order to find lowest cost of the network, different weights are assigned to it. The cost function expression as follows:

$$C_i = \frac{W_b\left(\frac{1}{B_i}\right)}{\max\left(\left(\frac{1}{B_1}\right),...,\left(\frac{1}{B_n}\right)\right)} + \frac{W_m M_i}{\max(M_1,...,M_n)} + \frac{W_p P_i}{\max(P_1,...,P_n)} \quad (12)$$

Step4: Handoff Triggering Condition Estimation (HTCE)

The handover triggering condition estimation has an important role to play as in that it should not start the handover too early so as to reduce the WLAN usage nor too late so as to cause connection to break. A Circular network service is assumed and with the help of different parameters and the threshold value is calculated.

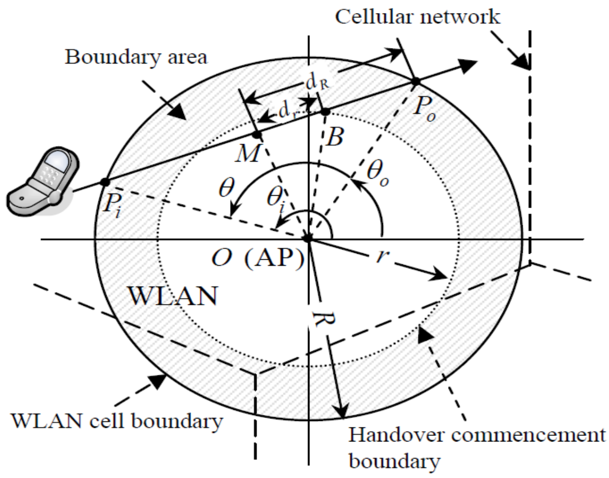

Figure-2. Diagram of WLAN for triggering condition of handover.

P_i and P_o are the points where the MT enters and leaves respectively. The middle point of WLAN is indicated by M. Boundary area refers to dashed area. In Figure-2, a MT is going through an area where both cellular and WLAN services are available. R and r are the radius of outer and inner circles respectively. d_R stands for half length of trajectory segment inside outer circle whereas d_r stands for the same for the inner circle. The intersection and inner circle is denoted by B. Where M is the point after which RSS of access point (AP) starts degrading.MT measures WLAN RSS quite often and finds out its moving receiver RSS. The value of r and RSS at point B is found by the Handover Triggering Condition (HTCE) algorithm. A handover takes place when the value of received strength drops below the threshold or the required level.

The condition for handover as follows:

$$d_R = \sqrt{\left(\frac{1}{2}R^2(1-\cos\theta)\right)} \quad (13)$$

$$d_r = \sqrt{\left(r^2 - \frac{1}{2}R^2(1+\cos\theta)\right)} \quad (14)$$

When MT is travelling away from WLAN and the value of RSS degrades below the threshold value indicating that MT is past M point. Time consumed from point B to P_o is C_1 and C_2 is from M to P_o.

$$t_b = \frac{1}{v}(d_R - d_r), C_1 \quad (15)$$

$$t_b = \frac{1}{v}d_R, C_2 \quad (16)$$

$$tb = \frac{\left(\sqrt{\left(\frac{1}{2}R^2(1-\cos\theta)\right)} - \sqrt{\left(r^2 - \frac{1}{2}R^2(1+\cos\theta)\right)}\right)}{v}, C1 \quad (17)$$

 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

$$tb = \frac{\sqrt{\left(\frac{1}{2}R^2(1-\cos\theta)\right)}}{v}, \text{C2} \quad (18)$$

$$P_b = G(r) = \begin{cases} 1, & R<r \\ 1-\frac{1}{\pi}\cos^{-1}\left(\frac{2r^2}{R^2}-\frac{(R^2-r^2-v^2\tau_o^2)^2}{2v^2\tau_o^2R^2}-1\right), & R-v\tau_o \le r \le R \cap C1 \\ 0, & r < R - v\tau_o \cap C1 \\ \frac{1}{\pi}\cos^{-1}\left(\frac{1-2v^2\tau_o^2}{R^2}\right), & C2 \end{cases} \quad (19)$$

The value of r can be found using below equations when P_b ranges from 0 to 1.

$$r = G^{-1}(P_b) - C_a R \quad (20)$$

$$= \sqrt{\left(v^2\tau_o^2 + R^2 - v\tau_o R\sqrt{(2[1-\cos(\pi-\pi P_b)])}\right)} - C_a R \quad (21)$$

G(r) has an inverse function which is denoted as $G^{-1}(P_b)$ and channel adjustment input is denoted by C_a.

$$C_a = \begin{cases} \frac{10\%}{v} & \text{if } v > 3.6\text{km/h} \\ 10\% & \text{else} \end{cases} \quad (21)$$

RESULTS AND SIMULATION

Table-1shows the list of simulation parameters. In section we have analysed the different methods to optimize the VH in heterogeneous network.

Figure-3 compares the fixed RSS threshold method, hysteresis based method and HNE methods based on the number of handover failures. In Figure-3, at 80 Km/h velocities, the number of handover failure for hysteresis based method is 850, Fixed RSS method is 600 and HNE method is 198. This shows that, Fixed RSS method has 29.4% of reduction in the number of handover failures when compared to hysteresis based method. Similarly, in HNE method 79.6% reduction in number of handover failures when compared to hysteriss based method and 67 % reduction in number of handover failure when compared to Fixed RSS method. So, HNE method reduced the number of handover failures.

Figure-4 compares the fixed RSS threshold method, hysteresis based method and HNE methods based on the number of unnecessary handovers. In Figure-3, at 80 Km/h velocity, the number of unnecessary handover for hysteresis based method is 2000, Fixed RSS method is 1500 and HNE method is 490. This shows that, Fixed RSS method has 25% of reduction in the number of unnecessary handover when compared to hysteresis based method. Similarly, in HNE method 75.5% reduction in number of unnecessary handover when compared to hysteriss based method and 67.3 % reduction in number of unnecessary handover when compared to Fixed RSS method.

This shows that, if number of had over failure is reduced the number of unnecessary handover also reduce. This is the relations between Figure-3 and Figure-4.

Table-1. Simulation parameters.

Parameter	Symbol	Value
WLAN radius	R	150m
AP transmit power	P_{tx}	20dBm
Distance between AP and reference point	d_{ref}	1m
Path loss exponent	β	3.5
Standard deviation of shadow fading	σ	4.3dB
Handover delay from cellular network to WLAN	Γ_i	2s
Handover delay from WLAN to cellular network	Γ_o	2s
Tolerable handover failure probability	P_f	0.02
Tolerable unnecessary handover failure probability	P_u	0.04
Path loss at reference point	PL_{ref}	40 dB

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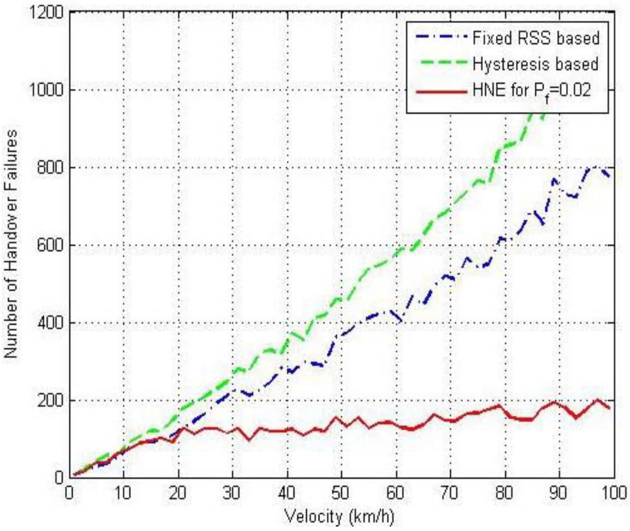

Figure-3. Graph between total number of handover failures versus velocity comparing the three methods.

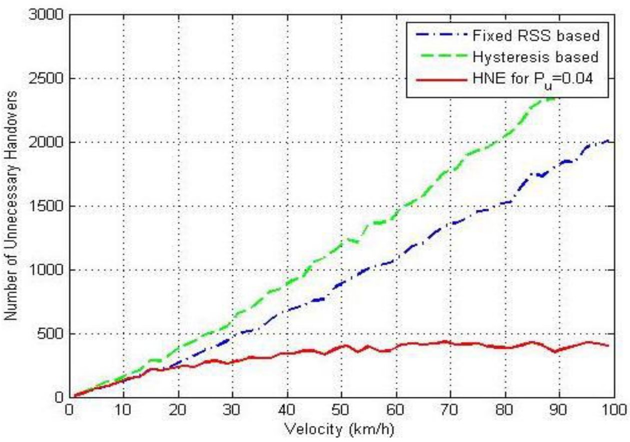

Figure-4. Graph between the number of unnecessary handovers and velocity comparing the three methods after simulation.

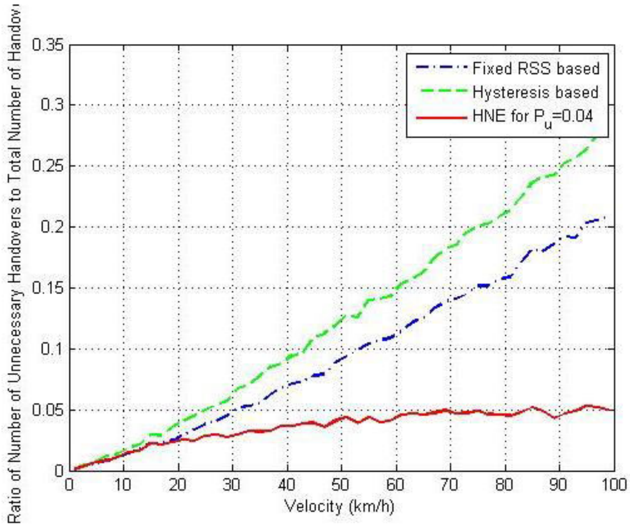

Figure-5. Ratio of unnecessary handovers to total handovers.

Figure-5 shows relationship between the ratio on number of unnecessary handover to total number of handover and velocity. Form Figure-5, it shows that HNE provides better performance in terms of unnecessary handover when compared to Fixed RSS method and hysteresis method.

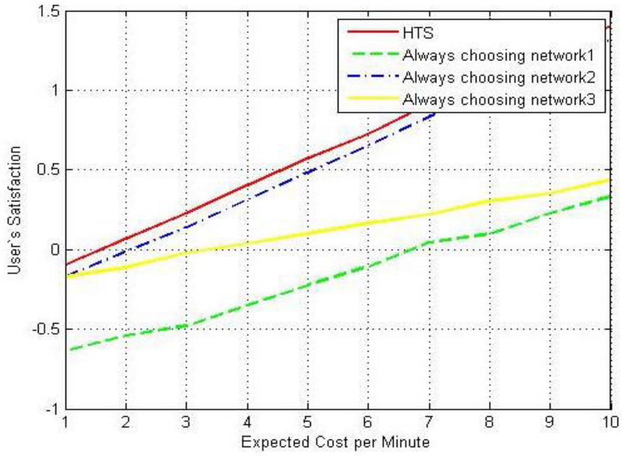

Figure-6. Satisfaction of user's based on cost.

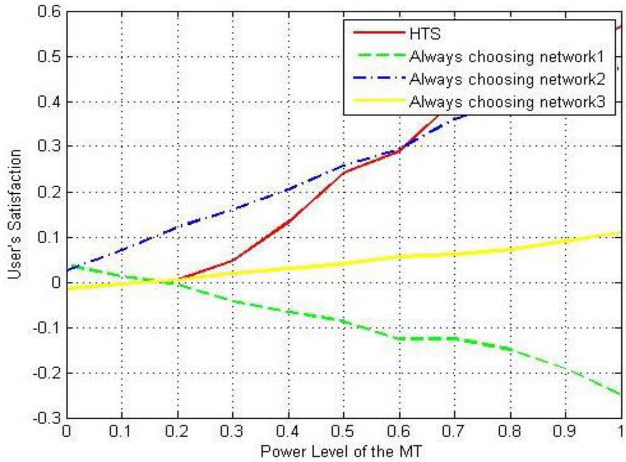

Figure-7. Satisfaction of user's based on power.

Figure-6 compares the HTS with other networks in terms of user's satisfaction. HTS has been able to achieve the highest user satisfaction among the other networks irrespective of what budget user selects. This is due to reduce the number of handover failure; HTS provides higher user's satisfaction.

The effect of different MT power level on user satisfaction can be seen in Figure-7. At power level up to 0.6mW people who choose network 2 have greater user satisfaction as compared to people who choose HTS. This is mainly due to the fact that in order to increase battery life the HTS prefers network 3 to save battery but since the power consumption factor is not taken into account while finding user satisfaction thus network 2 has better user satisfaction at that power level. The above 0.6 mW the HTS can be selected.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

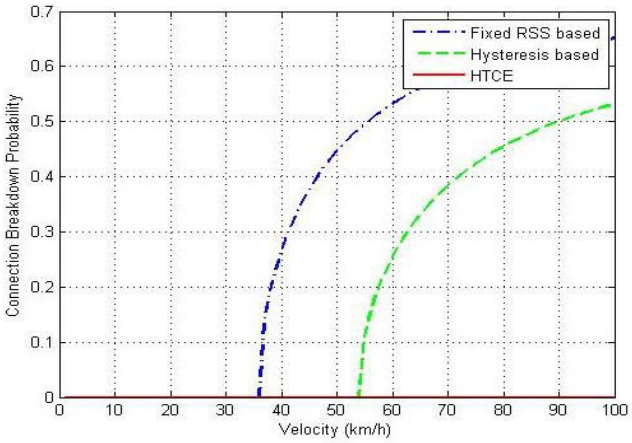

Figure-8. Comparing the three methods on the basis of connection breakdowns Probability with respect to velocity.

Figure-8 shows the connection breakdown probability for the fixed RSS based threshold method ($R2_{fixed}$ = 130m), HTCE and hysteresis based method ($R2_{hyst}$= 120m). As the velocity increases the probability still remains the in the case of HTCE as it is designed to keep the probability below preset level even as velocity may increase. This is due to reduce the number of handover failure HTCE provides low breakdown probability.

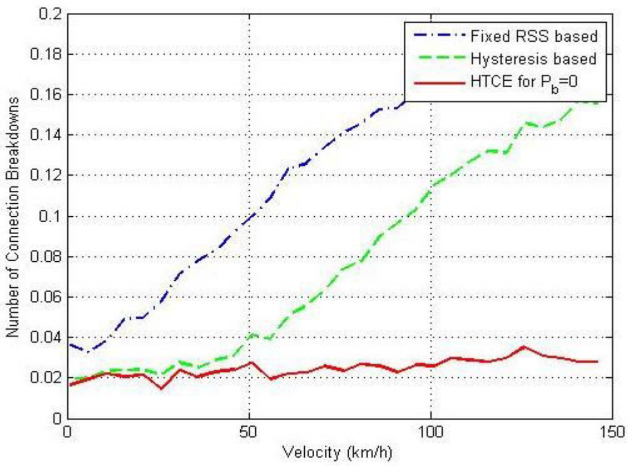

Figure-9. Comparing connection breakdown with respect to velocity for the three methods.

Figure-9 shows us the number of connection breakdowns with respect to velocity. As we can see from Figure-9 the total number of connection breakdowns still remains low for HTCE even at high speeds.

5. CONCLUSIONS

In this paper, in order to optimize the VH mechanism in heterogeneous network, HNE, HTS and HTCE method has been proposed. Based on this method, number of failure handover is reduced at certain extent and connection breakdown probability also reduced. Due to which, users can select the best network and user satisfaction also increased. It is concluded that, above three methods are optimized the VH in the heterogeneous network environment.

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