A Predictive Handover Initiation Mechanism in Next Generation Wireless Networks

SUDESH PAHAL[1], BRAHMJIT SINGH[2], ASHOK ARORA[3]
[1,2]Electronics and Communication Engineering, [3]Electrical Engineering
[1,3]MRIU, Faridabad, [2]NIT, Kurukshetra
INDIA
pahal.sudesh@gmail.com
brahmjit.s@gmail.com
ashok.mriu@gmail.com

Abstract: Next generation wireless networks are envisaged to be an integration of different wireless networks and demand the ability of users to move from one network domain to another network domain seamlessly. Also these networks require superior handover techniques to provide ubiquitous access to roaming users with maximum network resource utilization. In order to fulfill these requirements, it is essential to select an appropriate time to initiate handover. The handover procedure can be completed before link down only if we have prior information about necessity of handover as well as availability of target network. The link down event and link up event provide information about handover requirement and resource availability respectively. In this paper, a predictive handover initiation mechanism is proposed to select an appropriate time to start handover procedure. Also the prediction initiation time is made adaptive to avoid link failure in high velocity applications which was fixed in conventional algorithms. MATLAB Simulation results show that the proposed mechanism decreases the probability of false handover initiation by 25% and unnecessary handover probability by 35% when compared with existing handover mechanisms in different network overlapping environments.

Keywords: Handover; Prediction; Next generation wireless networks; GSM; WiMAX; Overlapping;

1. Introduction

Several wireless networks such as Bluetooth, WLAN, UMTS (Universal Mobile Telecommunication System), WiMAX and LTE (Long Term Evolution) have been emerged as individuals or integrated heterogeneous networks. These wireless networks have been designed for some specific service requirements such as coverage area, data rate and delay etc. In next generation of networks, users will be allowed to choose an optimum wireless network interface according to their requirement. While moving from one point to another, mobile users are required to switch from one network to another due to poor signal strength or specific user requirements. Due to rapid progress in wireless technologies, millions of multimedia applications have been introduced. Consequently, the shortage of wireless communication resources is becoming a critical issue. In order to utilize the resources of networks to their best, effective mobility management techniques need to be incorporated.

Mobility management [1][2] comprises of location management and handoff management. The previous one tracks the mobile for successful information delivery while the later one maintains active connections for roaming mobile terminals. Changing of wireless access technology can either be forced or unforced. In the former case, it entails the mobile terminal responding to changing network conditions such as signal strength resulting from the users movements. The later refers to the user changing the access network for better performance. Handover (HO) management is responsible for the service continuity of mobile users while moving from one BS (base station) to another BS. The handover between two BSs that belong to two different foreign agents (FAs) but both FAs belong to the same system or gateway foreign agent (GFA) is known as Horizontal HO. Vertical HO is the handover between two BSs under two different systems/GFAs. Vertical handover is a great challenge in heterogeneous networks. In order to facilitate vertical handover and internetworking among heterogeneous wireless networks, IEEE 802.21 Media Independent Handover (MIH) standard [3] defines various Media Independent Services (MIS). These services allow the mobile user to obtain dynamic information from heterogeneous networks. Thus Mobile node (MN) can acquire collective HO information like link quality about candidate networks from currently attached network which enables user to manage, control and configure link behavior related to handover. MIH also defines link triggers corresponding to the various link layer events. Link layer events such as link down and link up events changes as MN moves away from its point of attachment therefore link triggers can be generated to inform about these events to the corresponding entities. Service continuity and network resource utilization are challenging issues in heterogeneous networks while initiating a handover. Both of the above mentioned parameters are related to the HO initiation time. The delay in HO initiation time causes disruption in service while an early HO initiation results in wastage of resources of current network. The later situation arises mostly in network overlapping environments which gives us motivation for this research work.

In this paper, we propose a predictive HO initiation mechanism for next generation wireless networks. Using linear prediction technique, we predict the received signal strength of current network and target network which is used to find link down (LD) time of current BS and link up (LU) time of target BS. Then optimum HO initiation time is determined using LD and LU time according to different network overlapping and mobility conditions. The rest of paper is organized as follows: Section 2 describes the related work in this area. The system model used in this paper is introduced in section 3. In section 4, we present the proposed mechanism for HO initiation. Section 5 provides the performance evaluation of our solution with the help of simulation results. Finally, section 6 concludes this paper.

2. Related Work

A number of working groups such as IEEE 802.21, 3GPP and IEEE 802.16 have been involved in various activities related to handover [4]. An important step in mobility management is to collect information from various event sources from each layer and processing the collected events to a standardized trigger format. These triggers can be further used to feed handover decisions to enable seamless handovers assuming that the decisions are based on information available at MN. IEEE 802.21 media independent HO (MIH) provides facilities to exchange useful information between layers [5][6]. It also specifies a link going down (LGD) event which indicates that HO is about to happen. The outage probability is affected by HO trigger time thus the optimal HO decision can be taken using appropriate combination of design parameters [7]. Based on link quality, a number of methods have been proposed to estimate HO initiation time [8][9][10]. The threshold signal strength is predefined in most of the handover algorithms. But it causes ambiguity in handover decision as the handover conditions like channel parameters, user velocity and user preferences vary with time. An overview about handover initiation control techniques is given in [11]. It reviews different approaches and initiation techniques based on radio link measurements to detect HO requirement. An adaptive RSS threshold using estimation of boundary area is used to initiate HO in time [12]. The estimated distance gives the distance remaining to achieve HO which in turn estimates the handover failure probability. The authors in [13] proposed a timely fired link triggers to reduce handover required time in heterogeneous networks. The authors in [14] and [15] generated the link trigger using predictive signal strength and neighbor network information obtained from MIHF. However most of the previous work is based on predefined received signal strength (RSS) which is not suitable in various mobile networks. Chi Ma proposed a velocity optimized HO mechanism for WiMAX networks by using HO failure probability value to generate Link Going Down (LGD) trigger [16]. According to [17], the handover delay can be reduced by making threshold signal strength adaptive to velocity. The authors in [18] have used of data rate instead of signal strength to trigger handover. The distance travelled by user in target network area is predicted analytically in [19] which is used to find necessity of a handover. This reduces unnecessary handovers.

The HO algorithm based on least mean square prediction technique reduces HO requirement time in [20]. Mohanty presented an algorithm to select HO trigger time for reducing link failure probability for different HO delays [21]. However, the HO decision is made irrespective of MN in particular network causes network resource wastage. A method to reduce probability of false HO initiation with the help of GPS is suggested by the authors in [22]. None of the above mentioned algorithm considered different network overlapping situations. The authors in [23] and [24] made use of MN's trajectory to reduce false HO in overlapping cells. In [25], an auto regression model is used to select HO trigger time in varying network overlapping environment. However the link up time is determined based on predefined RSS threshold of target BS which may result in wastage of network resources in highly overlapping environment. Also the prediction initiation RSS is fixed which may cause early or late HO initiation for slow and fast users respectively.

In view of the above, a predictive HO initiation mechanism using linear prediction technique is proposed here. But different from above mentioned methods, this mechanism predicts RSS of current BS and target BS according to varying velocity and overlapping conditions. The handover before link down of current network is not desired hence it causes wastage of resources of current network especially, in highly overlapping environments. So, we do not consider link up time of target BS before link down time of current BS.

3. Procedure for predictive handover mechanism

In this section, we present procedure to find the appropriate HO initiation time by applying linear prediction. The signal strength to start prediction at current BS is to be defined before starting HO. The prediction initiation threshold (S_{init}) is made adaptive according to velocity of MN. The late prediction initiation may result in link failure in fast moving MNs.

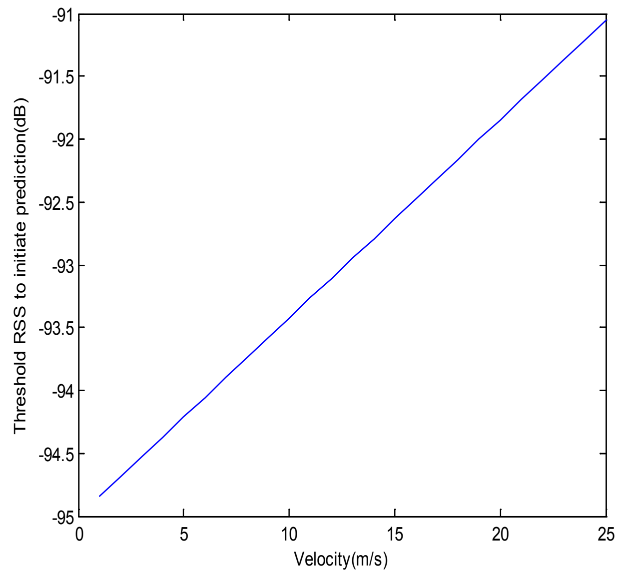

Figure 1. Variation of S_{init} with MN's velocity

Also an early prediction initiation seems to be unnecessary in slow moving MNs. The prediction threshold S_{init} is related to velocity according to equation (1).

$$S_{init} = \alpha_{lgdv} \times S_{th} \tag{1}$$

Where α_{lgdv} is the anticipation factor [16] and given as $\dfrac{1}{1-\frac{v}{v_1}\left(1-\frac{1}{\alpha_{lgdv1}^{\frac{1}{\beta}}}\right)}$

It has been evaluated experimentally by [16] that α_{lgdv1}=1.01 at v_1=1m/s. So we can find α_{lgdv} for different values of v. S_{th} is the minimum threshold signal strength to maintain a link. As the RSS of current BS reaches S_{init}, the prediction of RSS is started. The graph between S_{init} and velocity of MN in Fig. 1 shows that the prediction will start earlier for high velocities as compared to low velocities.

As a simpler one, forward linear predictor [26] is used to estimate RSS. Fig. 2 shows the linear prediction model in which RSS samples [$s(n)$, $s(n-1)$, ……$s(n-p+1)$] with an interval of T_s are fed as input signal. Initial prediction step K_0 can be determined by equation

$$K_0 = \frac{T_{HO} + \Delta H}{T_S} \tag{2}$$

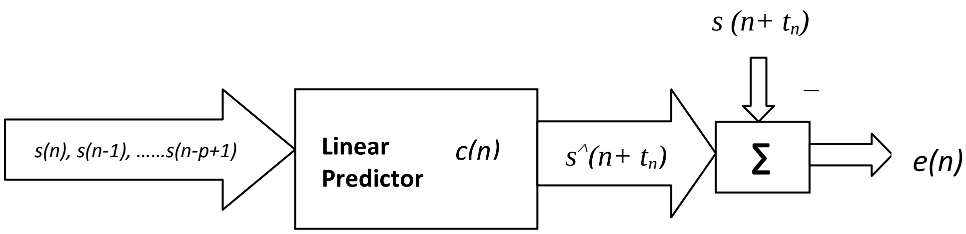

Figure 2. Linear Predictor Model

T_{HO}, the handover required time, is defined as the time required to prepare and execute HO and can be obtained by the method mentioned in [14]. ΔH and T_s are the marginal time (taken as 0) and sampling interval respectively. The predicted RSS for t_n time ahead obtained at the output is

$$s^{\wedge}(n+t_n) = \sum_{j=0}^{p-1} c(j)\, s(n-j) \qquad (3)$$

Where $c(j)$ is j^{th} linear prediction coefficient and p is the order of low pass filter. Note that p must be a scalar with a value less than the length of the input vector otherwise the block produces an error. The difference between actual RSS and predicted RSS is known as prediction error $e(n)$. The mean square error can be obtained by equation (4)

$$MSE= E[\{ s(n+t_n)- s^{\wedge}(n+t_n) \}]^2 \qquad (4)$$

The MN terminates the prediction process as the predicted RSS of current BS goes below the S_{th}. The time corresponding to this condition is named as Link Down time (t_{LD}) as the signal strength served by current BS is not sufficient to maintain the link. At this point, the MN must be able to connect to target network to continue its services. Thus the HO should be initiated at least T_{HO} time prior to t_{LD} so that HO procedure could be accomplished in time. The MN starts monitoring the predicted RSS of target BS at time $t_1=t_{LD}-T_{HO}$ with an interval of T_s. During this process, if the prediction result is less than S_{th} , the MN continues the prediction with next set of input samples until the predicted RSS is higher than S_{th}. At that time, the predicted Link Up time (T_{LU}) is said to be obtained. Triggering HO prior to T_1 seems to be unnecessary and causes wastage of network resources of current BS. The service is disrupted only for the time for which the target network is not having sufficient resources after T_1. Thus the time T_{LU} is assumed to be optimal time to initiate HO as sufficient signal strength of target network is available and current BS is approaching link down.

4. Simulation model

Consider the handover scenario of Fig. 3 in which the MN is moving away with the velocity 'v' from the Global System of Mobile Communication (GSM) network domain to the WiMAX network domain. The distance between two BSs is $D= R_1 + R_2 - L$ where R_1 and R_2 are radii of BS_1 and BS_2 respectively. L is the overlapping distance of two BSs. The received signal strength by MN from BS_i is

$$S_i(k) = P_t + G_t - L_t - PL_i(k) + G_r - L_r \qquad (5)$$

Where P_t is transmitted signal strength from a BS. G_t, L_t and G_r, L_r are antenna gains and losses of transmitter and receiver respectively. $PL_i(k)$ represents path loss component at K^{th} sampling distance from BS_i. The Okumura Hata propagation model [27] is considered for GSM network. The path loss equation is given by

$$Pl_i(k) = 69.55 + 26.16 \log f_i - 13.82 \log h_b - \alpha(h_m) + (44.9 - 6.55 \log h_b) \log d_i(k) \qquad (6)$$

For WiMAX network, extended version of Erceg model[28][29] is used and equation for calculating path loss in decibels is given by

$$Pl_i(k)=A+10\gamma \log10(d_i(k)/d_0)+Z_i(k)+PL_f+PL_{hms}+PL_{\theta ms} \qquad (7)$$

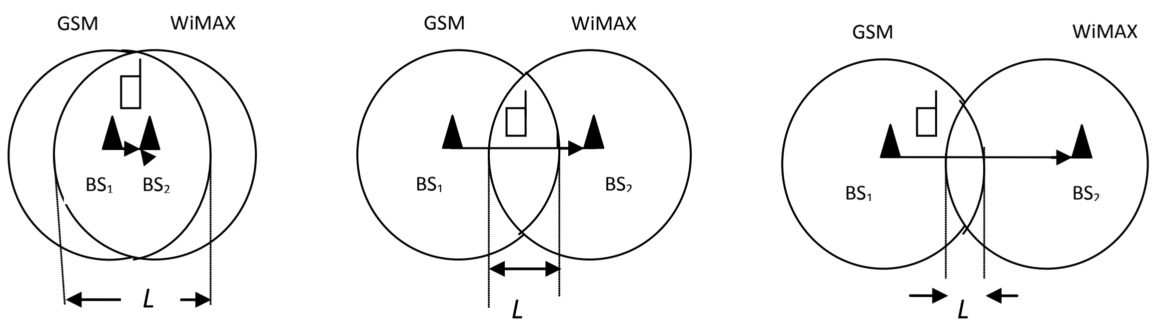

Figure 3. Handover Scenario

Where $d_i(k)$ is the distance between BS_i and MN at k^{th} Sampling instant in meters and $Z_i(k)$ is shadow fading component at k^{th} sampling instant, which is lognormally distributed and is described (in dB) as a Gaussian distribution with zero mean and standard deviation σ_i.

$$Z_i(k) = \rho_i Z_i(k-1) + \sigma_i \sqrt{1-\rho_i^{\,2}}\, \eta_i(0,1) \quad (8)$$

Where ρ_i is correlation coefficient of $\{Z_i(k)\}$. $\eta_i(0,1)$ are normal random variables with zero mean and unity variance. Parameter A represents the free space path loss and is given by

$$A = 20\log_{10}\frac{4\pi d_0}{\lambda} \qquad (9)$$

γ represents path loss exponent defined as

$$\gamma = a - bh_b + \frac{c}{h_b} \qquad (10)$$

$$PL_f = 6 \log \frac{f_i}{1900} \qquad (11)$$

$$PL_{hms} = -20\log\left(\frac{h_m}{2}\right) \text{ for Suburban areas} \quad (12)$$

$$PL_{qms} = 0.64 \ln\left(\frac{q}{360}\right) + 0.54\left(\ln\left(\frac{q}{360}\right)\right)^2 \quad (13)$$

Where f_i is the carrier frequency and h_b is the base station antenna height in meters. The empirical constants used in the above equations are well defined for suburban areas in Erceg model as given in Table 2. PL_f, PL_{hms}, PL_{qms} are correction factors corresponding to frequency f_i, MN height h_m, and MN antenna directivity q. PL_{qms} is often referred to as the antenna-gain reduction factor and accounts for the fact that the angular scattering is reduced owing to the directivity of the antenna. $\alpha(h_m)$ is the antenna correction factor for urban area in dB and is given by

$$\alpha(h_m) = 3.2\, [\log 11.75 h_m\,]^2 - 4.97 \qquad (14)$$

5. Simulation Results

In this section, the results obtained through Matlab simulation, based on simulation parameters given in Table 2, are analyzed. The results for RSS prediction and HO initiation trigger time are explained in subsection 5.1 and 5.2 respectively.

5.1 RSS Prediction

The threshold RSS for prediction initiation is calculated according to method given in section 3. The signal strengths of current and target BSs are predicted using linear predictor as discussed in section 3. Fig. 4 compares the actual and estimated RSS of both BSs. The maximum mean square error is 0.002 as illustrated in Fig. 5.

5.2 HO Initiation Trigger Time

Conventional Prediction Method 1: As proposed in [25], the RSSs of current BS and target BS are predicted to determine link down and link up time respectively.

According to [25], the link down time is the time when predicted RSS of current BS is lesser than the threshold while link up time is defined as the time when the predicted RSS of target BS is greater than the threshold. Then the HO trigger time is obtained by taking average of link up and link down time. This method may result in increase in the probability of unnecessary HOs in highly overlapping networks.

Conventional Prediction Method 2: This method only predicts the RSS of current BS to obtain the link going down trigger time [15]. It may result in service disruption due to unavailability of sufficient resources of target network as link up time is not considered.

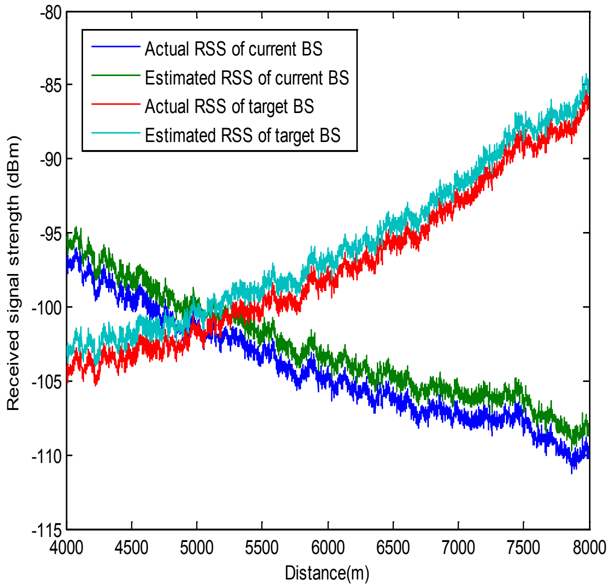

Figure 4 Comparison between Actual and Estimated received signal strengths of current and target network

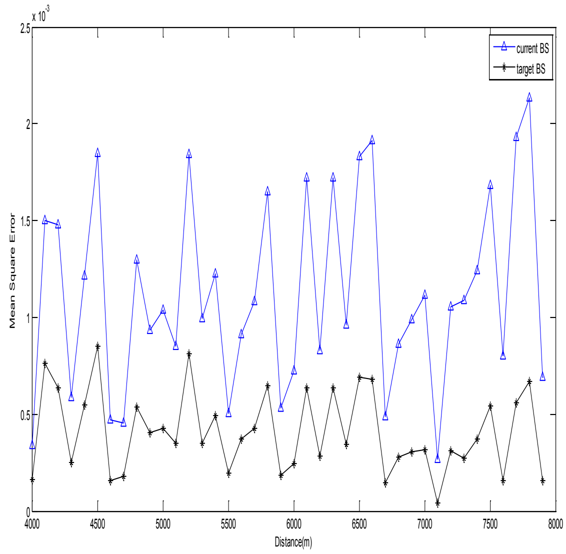

Figure 5 Mean Square Error of Predicted signal strength

Proposed Prediction Method: Firstly, the prediction of signal strengths is initiated according to the velocity of MN which was fixed in the conventional methods. Secondly, the link up time is considered only after determining the necessity of HO. The HO initiation trigger time calculated by the proposed mechanism is discussed in section 3.

The variation in HO initiation trigger time according to the overlapping distance of two BSs and velocity of MN is depicted by Fig. 6. The MN with higher velocity will cross the boundary of current BS earlier as compared to slow moving MN thus HO is required to be initiated earlier to complete HO procedure in time. In the proposed mechanism, the HO initiation trigger is generated earlier for high velocities of MN which in turn reduces the HO failure probability. Also the HO is not initiated falsely until the current network is deficient of resources (considered signal strength), even if the target network has sufficient resources. Thus in contrast to the HO initiation trigger in conventional prediction technique 1 (shown in Fig. 7), the HO initiation trigger time is constant irrespective of change in overlapping distance.

6. Result Discussion

In this section, the simulation results obtained for proposed and conventional methods are discussed. The probability of false HO initiation and probability of unnecessary HO are the two performance metrics that we investigate. The probability of false HO initiation P_f is defined as the probability of HO execution at a point where current network has RSS greater than threshold while target network has RSS lesser than threshold. In this case, HO is initiated before optimum time. According to Fig. 8 P_f shows almost no variation with velocity of MN but it has been reduced by 25% when compared with conventional prediction method 1 and 2. It is shown in Fig. 9 that the value of P_f is reduced and having constant value with respect to overlapping distance for proposed method in contrast to conventional methods where it increases with L. A higher value of P_f in conventional methods may cause HO failure due to insufficient RSS of target network at that instant. The probability of unnecessary HO P_{un} is the probability of triggering a HO without actual necessity of HO which may result in wastage of network resources. This situation arises when MN is to travel through an area close to the boundary of target network at higher velocity. In such cases, the MN goes out of target network coverage area even before completion of the HO procedure. It is depicted by Fig. 10 that P_{un} has been reduced up to 35% for all values of L when it is compared with the conventional prediction methods. In addition, the HO performance of the proposed HO mechanism in terms of P_{un} is better than the conventional methods for different velocities of MN as shown in Fig. 11. It is evident from Table 1 that the proposed method outperforms as compared to conventional methods in terms of availability and network resource utilization.

Table 1. Comparison between proposed and conventional methods

Method	Max (P_f)	Max(P_{un})
Conventional method 1	0.68	0.0040
Conventional method 2	0.7	0.0038
Proposed method	0.53	0.0033

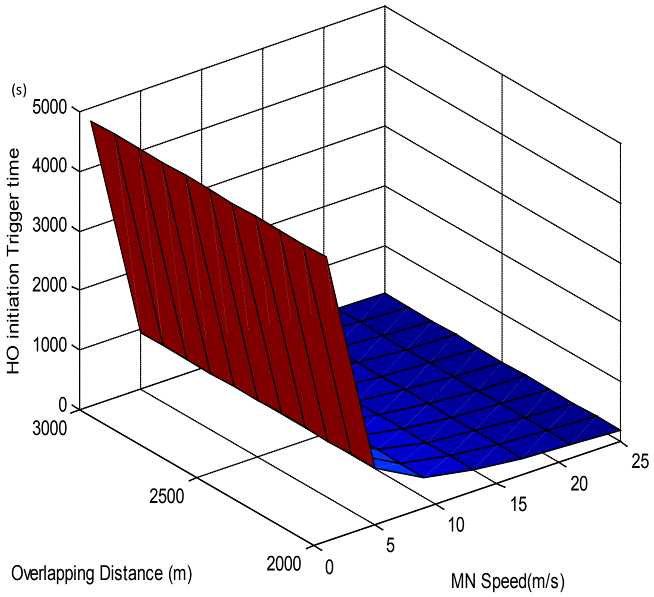

Figure 6. Handover initiation time versus Overlapping distance and velocity for proposed method

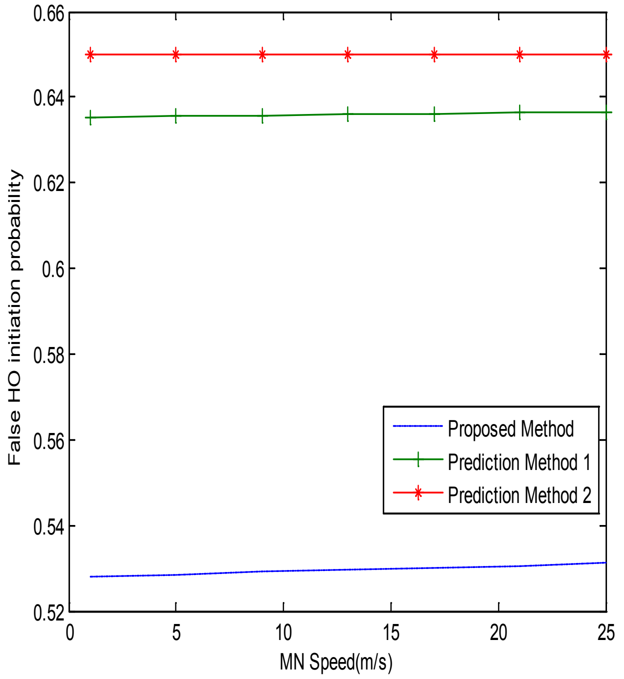

Figure 8. False HO initiation probability versus MN's velocity

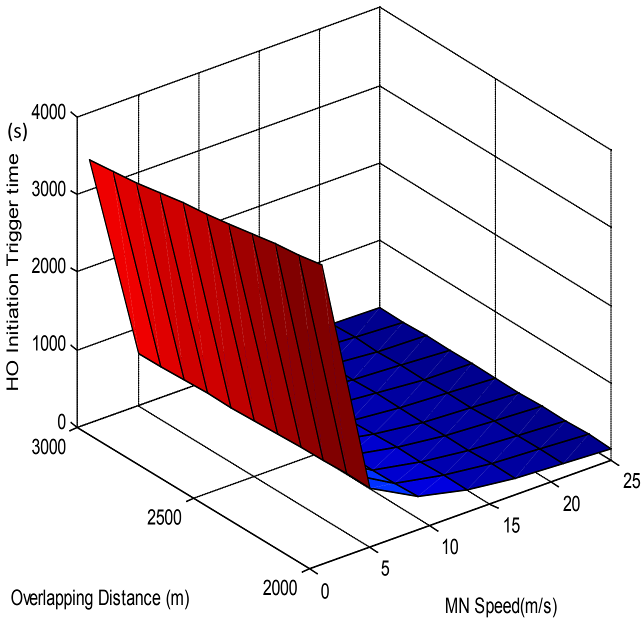

Figure 7. Handover initiation time versus Overlapping distance and velocity for conventional prediction method 1

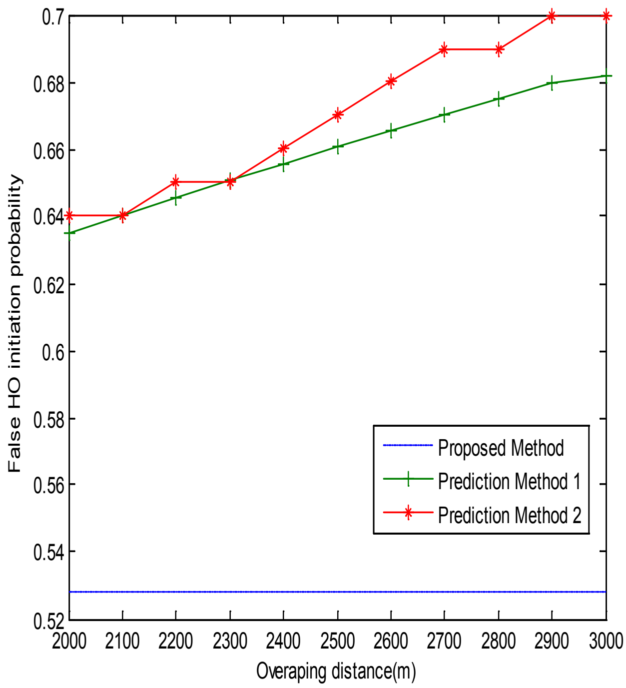

Figure 9. False HO initiation probability versus overlapping distance

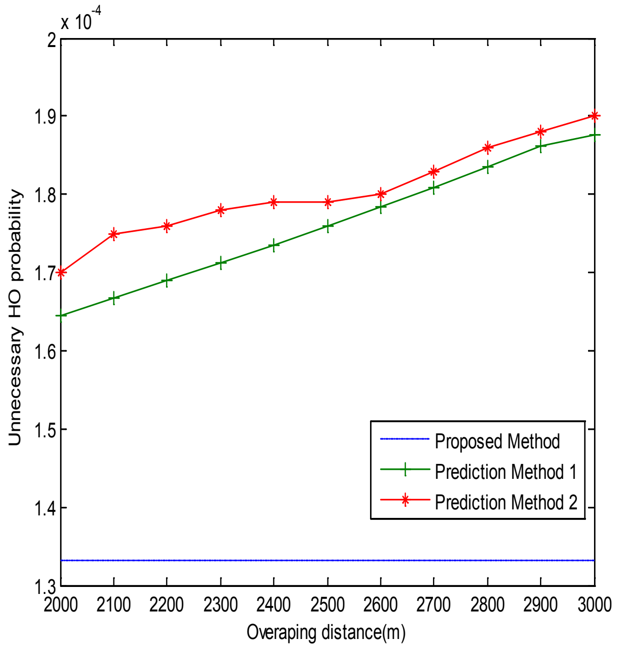

Figure 10. Unnecessary HO probability versus overlapping distance

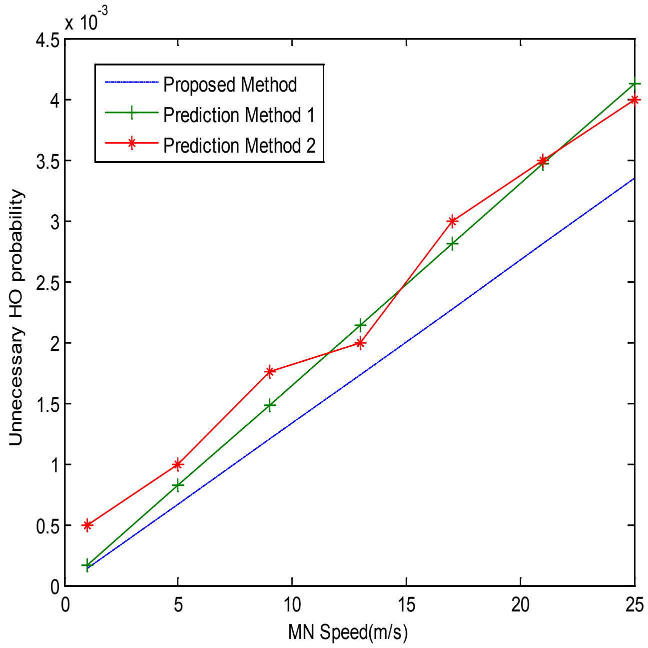

Figure 11. Unnecessary HO probability versus MN's Velocity

Table 2. Simulation Parameters

R_1=5000m	Radius of GSM cell	L_t= 3 dB	Transmitter antenna loss
R_2 =5000m	Radius of WiMAX cell	G_r= 0 dB	Receiver antenna gain
d_0=100m	Correlation distance	G_t= 8 dB	Transmitter antenna loss
P_t =43dBm	Transmitter power	σ_i =8 dB	Standard deviation of shadow fading
v=(1-25)m/s	Velocity of MN	h_b= 50 meter	Base station antenna height
$q = 10$	MN antenna directivity	h_m= 2 meter	Mobile station antenna height
ρ_i =0.35	Correlation coefficient	f_1 = 900 MHz	Carrier Frequency of GSM
G_t= 18 dB	Transmitter antenna gain	f_2 = 900 MHz	Carrier Frequency of WiMAX
T_s =10ms	Sampling time	S_{th} = – 100 dB	Threshold Signal Strength
a = 3.6	b(m) = 0.005	c(m^{-1}) = 20	

7. Conclusion

In this paper, we have proposed a predictive handover initiation mechanism in next generation wireless networks. The procedure for determination of appropriate HO initiation time with the help of predicted received signal strength is provided. The signal strength received from current base station and target base station is predicted using linear predictor with an acceptable mean square error. Then the predicted signal strengths are used to find link down time and link up time. The handover initiation trigger time with respect to overlapping distance and velocity of user is provided in simulation results. Also the prediction initiation time is varied with the velocity of MN to reduce the service disruption in high velocity conditions. The variation of probability of false HO initiation and probability of unnecessary HO with the overlapping distance and velocity is also studied. The numerical analysis and simulation results show that our proposed method can reduce the probability of false handover initiation up to 25% and probability of unnecessary handover up to 35%. The HO performance is better in varying overlapping conditions and different velocities of user. In future, application related parameters like throughput, packet loss rate and delay can also be analyzed for real time applications.

References:

[1] Qi Wang and Mosa Mi Abu-Rgheff, Multi-Layer Mobility Management Architecture Using Cross-Layer Signalling Interactions, *Personal Mobile Communications Conference, 2003. 5th European , IEEE*, 2003. Pp. 237 – 241.

[2] Lamia Chaari, Lotfi Kamoun, An overview of mobility management over IEEE802.16e, *ICT'09*, may 2009, pp. 334-339.

[3] IEEE 802.21, Media Independent Handover Services, IEEE Standard. *http://www.ieee802.org/21/.*

[4] Jaeho Jo and Jinsung Cho, Member, KSII, Cross-layer Optimized Vertical Handover Schemes between Mobile WiMAX and 3G Networks, *KSII Transactions on Internet and Information systems*. vol. 2, no. 4, August, 2008, pp. 171- 183,.

[5] K. Taniuchi, T. Corporation, IEEE 802.21: Media Independent Handover: Features, Applicability, and Realization. *Communications Magazine, IEEE,* 2009, 47, pp. 112-120.

[6] Weiyi Zhao,Jiang Xie, Inter-gateway Cross-layer Handoffs in Wireless Mesh networks, *IEEE proceedings "GlOBECOM" 2009,* pp. 1-6.

[7] Brahmjit Singh, Outage probability analysis in soft handover for 3g wireless networks. *3G and Beyond, 6th IEEE International Conference on*. 2005. Pp. 1 - 5

[8] L. Eastwood, S. Migaldi, Qiaobing Xie, V. Gupta, Mobility using IEEE 802.21 in a heterogeneous IEEE 802.16/802.11-based, IMT-advanced (4G) network. *IEEE Wireless Communications*, 15'2008, pp.26-34.

[9] Mhatre, V., Papagiannaki, K. Using smart triggers for improved user performance in 802.11 Wireless Networks, *ACM Mobisys'06*, 2006, pp. 246–259.

[10] Woon, S., Golmie, N., Sekercioglu, Y. A, Effective link triggers to improve handover performance, *IEEE PIMRC06*, 2006, pp. 1–5.

[11] Brahmjit Singh, Shakti Kumar, K K Aggarwal, Handover Initiation Control Techniques in Mobile Cellular Systems, *IETE Technical Review*, vol. 20. 2003, pp. 13-21.

[12] Azita Laily Yusof, Norsuzila Ya'acob, Mohd Tarmizi Ali, Handover Initiation Across Heterogeneous Access Networks for Next Generation Cellular Network, *2011 IEEE Symposium on Wireless Technology and Applications (ISWTA)*, September 25-28, 2011, Langkawi, Malaysia, pp. 9-12.

[13] S. Yoo, D. Cypher, N. Golmie, Predictive Link Trigger Mechanism for Seamless Handovers in Heterogeneous Wireless Networks, *Wireless Communications and Mobile Computing* 2008.

[14] Sang-Jo Yoo, D. Cypher, N. Golmie, Predictive Handover Mechanism based on required Time Estimation in Heterogeneous Wireless Networks, *Military Communications conference, MILCOM 2008*. IEEE, pp.1-7.

[15] Sang-Jo Yoo, David Cypher, Nada Golmie, Timely Effective Handover Mechanism in Heterogeneous Wireless Networks, *Wireless Pers Commun (2010)* 52, pp. 449–475.

[16] Chi Ma, Enda Fallon, Yansong Qiao, VOSHM - A Velocity Optimized Seamless Handover Mechanism for WiMAX Networks, *9th. IT & T Conference*, 2009.

[17] Caiyong hao, Hongli LIU, Jie zhan, A Velocity-Adaptive Handover Scheme for Mobile WiMAX, *Int. J. Communications, Network and System Sciences*, 2009, vol. 2, pp. 874-878.

[18] Sueng Jae Bae et. al., Handover Triggering Mechanism Based on IEEE 802.21 in Heterogeneous Networks with LTE and WLAN, *IEEE Conference ICOIN 2011*.

[19] Xiaohuan Yan, Nallasamy Mani, Y. Ahmet S¸ A Traveling Distance Prediction Based Method to Minimize Unnecessary Handovers from Cellular Networks to WLANs, *IEEE Communications Letters*, vol. 12, no. 1,January 2008, pp. 14-16.

[20] Miao Xiong, Jiannong Cao, Jun Zhang, Context- Aware Mechanism for IEEE 802.21 Media Independent Handover, *Proceedings of 20th International Conference on Computer Communications and Networks (ICCCN), 2011 IEEE,* pp. 1 - 6.

[21] S. Mohanty, I. F. Akyildiz, A cross-layer (layer 2 + 3) handover management protocol for next-generation wireless

systems, *IEEE Transactions on Mobile Computing*, October 2006, pp. 1347–1360.

[22] Thazin Ei, Wang Furong, Cross-Layer Handoff Management Algorithm on Heterogeneous Wireless Networks, *Information Technology Journal 7,vol.5,* 2008, pp. 820-824.

[23] Debabrata Sarddar et.al., A Handoff Technique to Reduce False-Handoff Probability in Next Generation Wireless Networks, *(IJCSE) International Journal on Computer Science and Engineering.* Vol. 02, No. 03, 2010, pp. 630-634.

[24] Debabrata Sarddar et.al., Minimization of Handoff Failure Probability for Next-Generation Wireless Systems" *International Journal of Next-Generation Networks (IJNGN)* Vol.2, No.2, June 2010, pp. 36-51.

[25] Jilei Yan, Linjing Zhao, Jiandong Li, A Prediction-Based Handover Trigger Time Selection Strategy in Varying Network Overlapping Environment, IEEE 2011.

[26] John G. Proakis, Dimitris G. Manolak, *Digital Signal Processing*, Beijing, Publishing house of electronics industry, 2007.

[27] Weiling Wu, Kai Niu, *Mobile Communication principle*, Beijing, Publishing house of electronics industry, 2005.

[28] V. Erceg et al., An Empirical Based Path Loss Model for Wireless Channels in Suburban Environments, *IEEE Journal on Selected Areas in Communications*. vol. 17, No. 7, July, 1999, pp. 686-687.

[29] V. Erceg, K. V. S. Hari, et al., Channel Models for Fixed Wireless applications, tech. rep., *IEEE 802.16 Broadband Wireless Access Working Group*, Jan. 2001.