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Performance Evaluation of Handover Algorithm of Next Generation Wireless Heterogeneous Networks by Modeling Wrong Decision Handovers

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Abstract

The universal coverage of wireless networks is obtained by the integration of various wireless network technologies such as 2G, 3G and 4G etc. The integration of different networks formed as a heterogeneous wireless network which provides high data rates to the different network users. As of now, in 4G systems, the new user requires easy access with high data rates. In order to provide flexible accessibility among various networks, the heterogeneous system faces hard issues of portability support. If the user needs the continuous connection without any interruption when roaming between different wireless networks is possible by the technique handover. In such systems, wrong decision handover is a serious problem which effects the performance of the system by degrading the quality of service. These wrong decisions are the combination of missing and unnecessary handovers. In this paper, both are taken into consideration and performance of proposed model of five wireless heterogeneous networks is estimated by calculating the probability of wrong decision handover based on bandwidth based handover algorithm among heterogeneous wireless network. The proposed heterogeneous network is more effective in minimizing the probability of wrong decisions.

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I. INTRODUCTION

The forth coming generation wireless networks integrates the fourth generation wireless networks LTE, WiMAX and the third generation wireless networks UMTS, GPRS and EDGE in order to provide the user requirements [1]. The integration of these systems can give the best accessibility of systems to the end user [2]. The integration of the networks gives the consistent portability to the clients by methods for handover/handover [3]. It is nothing but transferring an active call from present network to another network. If the handover is happened between the various networks, which is called as vertical handover or vertical handover [4] [5]. When it is happened between similar networks then it is called as horizontal handover [6] [7].

The handover between the heterogeneous wireless networks relies upon a few parameters such as Received Signal Strength (RSS), Multiple Attributes Decision Making Based, cost function, Bandwidth based and so forth. In RSS based handover calculation, the handover is started when the quality of the signal at mobile node from the network1 is less than the threshold value and quality of the signal from the network2 is more prominent than the threshold value then the mobile node is handover from network1 to network2 [8]. For Multiple Attributes Decision Making Based is a Simple Additive Weighting Based in which various variables are assigned with various loads which can be balanced by

TEST Engineering & Management
January - February 2020
ISSN: 0193 - 4120 Page No. 14024 - 14031

network state [9]. Therefore, it is conceivable to ensure QoS necessity and improve the presentation of the entire system whereas in Cost function based [10], the type of the cost function is fixed for everyone, once the function is characterized adjusting the value is difficult dependent on various client requirements for various applications.

The upcoming generation wireless networks consider other handover parameters such as bandwidth, SNR (signal to noise ratio) and delay for developing new handover algorithms which provides better accessibility between the wireless networks [11]. Particularly, handover algorithm based on bandwidth is suitable for designing various applications of upper link layers [12]. Previously, the handover probability algorithm based on bandwidth for five heterogeneous wireless networks is implemented [13]. So, this paper focuses on a mathematical model for wrong decision handover probability by considering both unnecessary handover probability and missing handover probability based on the bandwidth based handover probability algorithm for five heterogeneous wireless networks [13]. The effect of wrong decision handover probability is estimated for different traffic load values.

II. HANDOVER PROBABILITY ANALYSIS FOR HETEROGENEOUS NETWORK BASED ON BANDWIDTH

Handover probability is the probability of Mobile Node (MN) to moves out from its existing wireless network. Handover probability calculation gives the information about occurrence of the handover to the MN. Probability of MN staying at network nwk is denoted by P_{nw_k}, where k=1, 2...N. The handover probability of MN is defined as,

$$P(HO) = \sum_{k=1}^{N} \sum_{\substack{m=1 \\ k \neq m}}^{N} P_{nw_k} P_{nw_k/nw_m} \quad (1)$$

Here, the five heterogeneous wireless networks considered as nw_1, nw_2, nw_3, nw_4 and nw_5. The handover algorithm for these networks is developed by the five state Markov model as shown in the below Figure1.

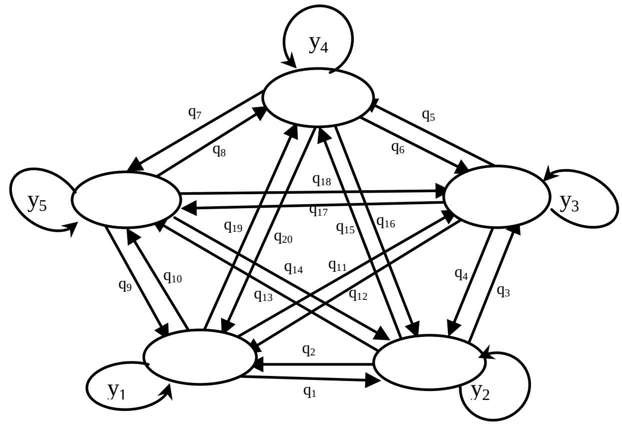

Figure 1. Five state Markov model

$MV_{nw_m/nw_k}^{(t)}$: MN will shift from network nw_k to network nw_m at time τ.

$SY_{nw_k}^{(t)}$: MN remains at current network nw_k at time τ.

P_{nw_m/nw_k} : Probability of MN moves from network nwk to nw_m at time τ i.e. $P(MV_{nw_m/nw_k}(\tau))$

P_{nw_k/nw_k} : Probability of MN stays at network nwk at time τ i.e. $p(SY_{nw_k}(\tau))$

$\Psi_{nw_k,nw_m}(r,\tau)$ represent the bandwidth available from the network nw_k is greater or equal to r and network nw_m available bandwidth is less than r at time τ.

Here, the desired heterogeneous wireless network is the integration of five wireless networks which is modelled as a five state Markov model. As the MN is switching between nw_1 to nw_2; nw_2 to nw_3; nw_3 to nw_4; nw_4 to nw_5 and nw_5 to nw_1 similarly for the remaining combinations as shown in Figure 1. In this, q_1 and q_2 are representing the probabilities of MN to move from nw_1 to nw_2, nw_2 to nw_1, and the

TEST Engineering & Management
January - February 2020
ISSN: 0193 - 4120 Page No. 14024 - 14031

probabilities of the MN to stay at nw_1, nw_2 are $(1-q_1-q_{11}-q_{19}-q_{10})$, $(1-q_2-q_{15}-q_3-q_{13})$ respectively for the remaining nodes and these can be represented with y_1, y_2, y_3, y_4 and y_5 respectively. If the mobile node wants to stay at the present network then the probability of MN to stay at its present network nw_1 is,

$$P_{nw_k} = (\text{Summation of incoming probabilities}) \;/\; (\text{Summation of total probabilities at that node}) = \frac{\sum_{\substack{m\neq k\\ m=1}}^{5} P_{nw_k/nw_m}}{\sum_{m=1, m\neq k}^{5} \left(P_{nw_k/nw_m} + P_{nw_m/nw_k}\right)} \tag{2}$$

The change of bandwidth process of network k, k = 1, 2, 3, 4, 5. is modelled with $M/M/A_k$ process. The incoming rate of requests for channels is denoted with a Poisson distribution having parameter λ_k, k = 1, 2, 3, 4, 5. and the rate by which the channels are serviced or cleared follows an exponential distribution with parameter μ_k, k = 1, 2, 3, 4, 5. And the occupied channel probability is represented by $\Pi_{k,x}$, k = 1, 2, 3, 4, 5. x = 0, 1, · · ·,. By using queuing theory,

$$\mu_{k,x} = \begin{cases} x\mu_k, & x \le A_k \\ 0 & \text{Otherwise} \end{cases} \tag{3}$$

$$\Pi_{k,x} = \Pi_{k,0}\, t_{lk}^{x} / x!,\; 0 < x \le A_k$$

x= no. of occupied channels

$$\Pi_{k,0} = \frac{1}{\sum_{x=0}^{A_k} t_{lk}^{x}/x!}, \quad k = 1, 2, 3, 4, 5. \tag{5}$$

A_k, is the network k available bandwidth. Then, the probability of available bandwidth is,

$$P\{a_k = m\} = \Pi_{A_k - m} \quad m = 0, \cdots, A_k,\; k = 1,2,3,4,5. \tag{6}$$

The probability of available bandwidth a_k, k = 1, 2,3,4 and 5 being greater than r and less than A_k–r is,

$$P\{a_k > r\} = \sum_{k=0}^{A_k - r} \Pi_{k,x}, k = 1, 2, ..N \quad P_{nw_k/nw_m}, k = m = 1,2,3,4,5. k \neq m \tag{7}$$

A. Handover Probability Algorithm for Heterogeneous Wireless Networks

In this paper probability of wrong decision handover is calculated and analyzed based on the bandwidth based handover algorithm. In this bandwidth based handover algorithm, MN wants to move out of its current network when the bandwidth of the other network is greater than the existing network at threshold l_{th}.

Algorithm: Bandwidth Based Handover Algorithm.
Begin
Get network available bandwidth A_1, A_2, A_3, A_4 and A_5 threshold l_{th}.

If a MN is at nw_1.
If $a_2 - a_1 \geq l_{th}$, the MN moves to nw_2
Else if $a_3 - a_1 \geq l_{th}$, the mobile node moves to nw_3
Else if $a_4 - a_1 \geq l_{th}$, the mobile node moves to nw_4
Else if $a_5 - a_1 \geq l_{th}$, the mobile node moves to nw_5
Similarly, for the nw_2, nw_3, nw_4 and nw_5
End

The bandwidth available at each network changes dynamically with respect to the number of users using the networks with time to time, so in order calculate handover probability only stable state is considered such that the time period t does not affect the any results.

With independent assumptions of bandwidth for these five networks A_1, A_2, A_3, A_4 and A_5 then,

$$P_{nw_k/nw_m} = P\{a_k - a_m \geq l_{th}\} = \sum_{k=0}^{A_k} \sum_{\substack{m=0, k\neq m\\ k-m \geq l_{th}}}^{A_m} \Pi_{k, A_k - m} \Pi_{m, A_m - k}$$

$$\text{where } k \neq m, k = m = 1,2,3,4,5 \tag{8}$$

Assume, Bandwidth=A_k=A, Traffic load= $t_{lk} = t_l$

Let $P_{nw_k/nw_m} = P, k \neq m, k = m = 1,2,3,4,5$

January - February 2020
ISSN: 0193 - 4120 Page No. 14024 - 14031

Probability of handover P(HO) is

$$P(HO) = P_{nw_1}(P_{nw2/nw1} + P_{nw3/nw1} + P_{nw4/nw1} + P_{nw5/nw1}) + P_{nw_2}(P_{nw1/nw2} + P_{nw3/nw2} + P_{nw4/nw2} + P_{nw5/nw2}) + P_{nw_3}(P_{nw1/nw3} + P_{nw2/nw3} + P_{nw4/nw3} + P_{nw5/nw3}) + P_{nw_4}(P_{nw1/nw4} + P_{nw2/nw4} + P_{nw3/nw4} + P_{nw5/nw4}) + P_{nw_5}(P_{nw1/nw5} + P_{nw2/nw5} + P_{nw3/nw4} + P_{nw4/nw5}) = 10 \times P \quad (9)$$

III. PROBABILITY OF WRONG DECISION HANDOVER ANALYSIS

Probability of wrong decision handover is combination of Probability of Unnecessary Handover (U_{nw_m/nw_k}) and Probability of Missing Handover (M_{NW_k}).

$$P(WDHO) = \sum_{k=1}^{N}\sum_{\substack{m=1\\k\neq m}}^{N} P\left\{U_{nw_m/nw_k}\right\} + \sum_{k=1}^{N} P\left\{M_{nw_k}\right\} \quad (10)$$

Unnecessary Handover denotes the events that a MN wants to move out of current network to other network, but the new network does not satisfy the bandwidth requirement of the mobile node in next time period. Where A_k and a_k is the maximum capacity and available bandwidth of network k, k = 1, 2, · · · N

MN is in nw_k and MN wants to move to nw_l at time τ_1, but $a_k \geq r$, and $a_m < r$ at time τ_2, $\tau_2 > \tau_1$. This condition is called as Unnecessary Handover.

Missing Handover denotes that a MN want to stay at the current network, but the current network not satisfy the bandwidth requirement next instant.

MN is in nw_k and MN wants to stay in nw_k at τ_1, but $a_m \geq r$, and $a_k < r$ in τ_2, $\tau_2 > \tau_1$. This process is called as Missing Handover.

Consider, Five wireless networks N=5 then,

$$WDHOP = U_{NW_1/NW_2} + U_{NW_1/NW_3} + U_{NW_1/NW_4} + U_{NW_1/NW_5} + U_{nw_2/nw_1} + U_{nw_2/nw_3} + U_{nw_2/nw_4} + U_{nw_2/nw_5} + U_{nw_3/nw_1} + U_{nw_3/nw_2} + U_{nw_3/nw_4} + U_{nw_3/nw_5} + U_{nw_4/nw_1} + U_{nw_4/nw_2} + U_{nw_4/nw_3} + U_{nw_4/nw_5} + U_{nw_5/nw_1} + U_{nw_5/nw_2} + U_{nw_5/nw_3} + U_{nw_5/nw_4} + M_{nw_1} + M_{nw_2} + M_{nw_3} + M_{nw_4} + M_{nw_5} \quad (11)$$

In which, $P\{U_{nw_m/nw_k}\}, P\{M_{nw_k}\},\ k = m = 1,2,3,4,5,\ k \neq m$ is given in the following:

$$P\left\{U_{nw_m/nw_k}\right\} = P_{nw_k} P_{nw_m/nw_k} \times P\left\{\Psi_{nw_k,nw_m}(r, t+\Delta) / MV_{nw_m/nw_k}(\tau)\right\}$$

$$P\left\{M_{nw_k}\right\} = P_{nw_k}(1 - P_{nw_m/nw_k}) \times P\left\{\Psi_{nw_m,nw_k}(r, t+\Delta) / SY_{nw_k}(\tau)\right\} \quad (12)$$

It is necessary to get $P_r\{\Psi_{nw_k,nw_m}(r,\tau+D) / MV_{nw_m/nw_k}(\tau)\}$ and $P_r\{\Psi_{nw_m,nw_k}(r,\tau+D) / SY_{nw_k}(\tau)\}$ in order to get WDHOP expression. For easiness of notation, time indication τ and $\tau+\Delta$ are abbreviated for time instants in the following

$$P\{\Psi_{nw_k,nw_m}(r,\tau+\Delta) / MV_{nw_k/nw_m}(t)\} = \sum_{m=l_{th}}^{A_m} P\{A_k \geq r / A_k \leq m - l_{th}\} P\{A_m = l\} \times \sum_{k=0}^{A_k} P\{A_m < r / A_m \geq k + l_{th}\} P\{A_k = k\} \quad (13)$$

$$P\{\Psi_{nw_m,nw_k}(r,\tau+\Delta) / SY_{nw_k}(t)\} = \sum_{k=0}^{A_k} P\{A_m \geq r / A_m \leq k + l_{th}\} P\{A_k = k\} \times \sum_{m=l_{th}-1}^{A_m} P\{A_k < r / A_k > m - l_{th}\} P\{A_m = m\} \quad (14)$$

Where k=m=1,2,3,4 and 5; $k \neq m$

Let s be the variable, the functions which are used for evaluating the unnecessary and missing handover probabilities are defined as,

$$\begin{aligned}
f_1(r,s) &= P\{a_1 \geq r \text{ at } \tau+\Delta / a_1 \leq s \text{ at } \tau\} \\
g_1(r,s) &= P\{a_2 < r \text{ at } \tau+\Delta / a_2 \geq s \text{ at } \tau\} \\
f_2(r,s) &= P\{a_1 < r \text{ at } \tau+\Delta / a_1 > s \text{ at } \tau\} \\
g_2(r,s) &= P\{a_2 \geq r \text{ at } \tau+\Delta / a_2 < s \text{ at } \tau\} \\
h_1(r,s) &= P\{a_2 \geq r \text{ at } \tau+\Delta / a_2 \leq s \text{ at } \tau\} \\
c_1(r,s) &= P\{a_3 < r \text{ at } \tau+\Delta / a_3 \geq s \text{ at } \tau\} \\
h_2(r,s) &= P\{a_2 < r \text{ at } \tau+\Delta / a_2 > s \text{ at } \tau\} \\
c_2(r,s) &= P\{a_3 \geq r \text{ at } \tau+\Delta / a_3 < s \text{ at } \tau\}
\end{aligned} \quad (15)$$

Similarly, d_1 (r, s), e_1(r, s), d_2(r, s) and e_2 (r, s) for network3 and network4, v_1 (r, s), x_1(r, s), v_2(r, s) and x_2(r, s) for network4 and network5. y_1(r, s), z_1(r, s), y_2(r, s) and z_2(r, s) for network5 and network1.

January - February 2020
ISSN: 0193 - 4120 Page No. 14024 - 14031

$$P\{\Psi_{nw_1,nw_2}{}^{(r,\tau+\Delta)}/MV_{nw_2/nw_1}{}^{(\tau)}\} = \sum_{m=l_{th}}^{A_2} f_1(r, m-l_{th})P\{A_2=m\} \times \sum_{k=0}^{A_1} g_1(r,k+l_{th})P\{A_1=k\}$$

$$P\{\Psi_{nw_2,nw_3}{}^{(r,\tau+\Delta)}/MV_{nw_3/nw_2}{}^{(\tau)}\} = \sum_{w=l_{th}}^{A_3} h_1(r, w-l_{th})P\{A_3=w\} \times \sum_{m=0}^{A_2} c_1(r,m+l_{th})P\{A_2=m\}$$

$$P\{\Psi_{nw_3,nw_4}{}^{(r,\tau+\Delta)}/MV_{nw_4/nw_3}{}^{(\tau)}\} = \sum_{u=l_{th}}^{A_4} d_1(r, u-l_{th})P\{A_4=u\} \times \sum_{w=0}^{A_3} e_1(r,w+l_{th})P\{A_3=w\}$$

$$P\Psi_{nw_4,nw_5}{}^{(r,\tau+\Delta)}/MV_{nw_5/nw_4}{}^{(\tau)}\} = \sum_{v=l_{th}}^{A_5} v_1(r, v-l_{th})P\{A_5=v\} \times \sum_{u=0}^{A_4} x_1(r,u+l_{th})P\{A_4=u\}$$

$$P\{\Psi_{nw_5,nw_1}{}^{(r,\tau+\Delta)}/MV_{nw_1/nw_5}{}^{(\tau)}\} = \sum_{k=l_{th}}^{A_1} y_1(r, k-l_{th})P\{A_1=k\} \times \sum_{v=0}^{A_5} z_1(r,v+l_{th})P\{A_5=v\} \quad (16)$$

Similarly, for $P\{\Psi_{nw_1,nw_3}{}^{(r,\tau+\Delta)}/MV_{nw_3/nw_1}{}^{(\tau)}\}$, $P\{\Psi_{nw_2,nw_4}{}^{(r,\tau+\Delta)}/MV_{nw_4/nw_2}{}^{(\tau)}\}$, $P\{\Psi_{nw_3,nw_5}{}^{(r,\tau+\Delta)}/MV_{nw_5/nw_3}{}^{(\tau)}\}$, $P\{\Psi_{nw_4,nw_1}{}^{(r,\tau+\Delta)}/MV_{nw_1/nw_4}{}^{(\tau)}\}$ and $P\{\Psi_{nw_5,nw_2}{}^{(r,\tau+\Delta)}/MV_{nw_2/nw_5}{}^{(\tau)}\}$.

$$P\{\Psi_{nw_2,nw_1}{}^{(r,\tau+\Delta)}/S_{nw_1}{}^{(\tau)}\} = \sum_{k=0}^{A_1} g_2(r,k+l_{th})P\{A_1=k\} \times \sum_{m=l_{th}-1}^{A_2} f_2(r,m-l_{th})P\{A_2=m\}$$

$$P\{\Psi_{nw_3,nw_2}{}^{(r,\tau+\Delta)}/S_{nw_2}{}^{(\tau)}\} = \sum_{m=0}^{A_2} c_2(r,m+l_{th})P\{A_2=m\} \times \sum_{w=l_{th}-1}^{A_3} h_2(r,w-l_{th})P\{A_3=w\}$$

$$P\{\Psi_{nw_4,nw_3}{}^{(r,\tau+\Delta)}/S_{nw_3}{}^{(\tau)}\} = \sum_{w=0}^{A_3} e_2(r,w+l_{th})P\{A_3=w\} \times \sum_{u=l_{th}-1}^{A_4} d_2(r,u-l_{th})P\{A_4=u\}$$

$$P\{\Psi_{nw_5,nw_4}{}^{(r,\tau+\Delta)}/S_{nw_4}{}^{(\tau)}\} = \sum_{u=0}^{A_4} x_2(r,u+l_{th})P\{A_4=u\} \times \sum_{v=l_{th}-1}^{A_5} v_2(r,v-l_{th})P\{A_5=v\}$$

$$P\{\Psi_{nw_1,nw_5}{}^{(r,\tau+\Delta)}/S_{nw_5}{}^{(\tau)}\} = \sum_{v=0}^{A_5} z_2(r,v+l_{th})P\{A_5=v\} \times \sum_{k=l_{th}-1}^{A_1} y_2(r,k-l_{th})P\{A_1=k\} \quad (17)$$

Similarly, for $P\{\Psi_{nw_3,nw_1}{}^{(r,\tau+\Delta)}/S_{nw_1}{}^{(\tau)}\}$, $P\{\Psi_{NW_4,NW_2}{}^{(r,\tau+\Delta)}/S_{NW_2}{}^{(\tau)}\}$, $P\{\Psi_{nw_5,nw_3}{}^{(r,\tau+\Delta)}/S_{nw_3}{}^{(\tau)}\}$, $P\{\Psi_{nw_1,nw_4}{}^{(r,\tau+\Delta)}/S_{nw_4}{}^{(\tau)}\}$ and $P\{\Psi_{nw_2,nw_5}{}^{(r,\tau+\Delta)}/S_{nw_5}{}^{(\tau)}\}$.

Let l_k be the number of requests that leave network k during time interval Δ, and b_k be the number of requests that be acknowledged to network k during time interval Δ, k=1, 2, 3, 4, 5.Based on the queuing networks result, the leaving process of each server of M/M/N process is Poisson distribution with parameter λ/N, where λ is arrival rate of M/M/N system. When network k, k=1, 2, 3, 4, 5 has x available bandwidth, the occupied bandwidth is A_k-x, then the leaving rate of the network will be $\Lambda_k = \frac{\lambda_k \times (A-x)}{A}$, k = 1, 2, 3, 4, 5.

So we have

$$\xi(x,\ r,\ \Delta) = P\{b_k - l_k \le x - r \text{ during } \Delta\} = \sum_{i=0}^{A_k-x} \frac{(\Lambda_k\Delta)^i}{i!} e^{-\Lambda_k\Delta} \times \sum_{j=0}^{i+x-r} \frac{(\lambda_k\Delta)^j}{j!} e^{-\lambda_k\Delta} \quad (18)$$

$$\psi_k(x,\ r,\ \Delta) = P\{a_k - l_k > x - r \text{ during } \Delta\} = \sum_{i=0}^{A_k-x} \frac{(\Lambda_k\Delta)^i}{i!} e^{-\Lambda_k D} \times \left[1 - \sum_{j=0}^{i+x-r} \frac{(\lambda_k\Delta)^j}{j!} e^{-\lambda_k\Delta}\right] \quad (19)$$

For simplifying the above equations, the following functions $f_1(r, s)$, $g_1(r, s)$, $f_2(r, s)$, $g_2(r, s)$, $h_1(r, s)$, $c_1(r, s)$, $h_2(r, s)$, $c_2(r, s)$, $d_1(r, s)$, $e_1(r, s)$, $d_2(r, s)$, $e_2(r, s)$, $v_1(r, s)$, $x_1(r, s)$, $v_2(r, s)$, $x_2(r, s)$, $y_1(r, s)$, $z_1(r, s)$, $y_2(r, s)$, $z_2(r, s)$ are used. Some of the expressions are given below.

$$f_1(r,s) = \sum_{x=0}^{s} \Pi_{1,A_1-k}\xi_1(x,r,\Delta)$$

$$g_1(r,s) = \sum_{k=s}^{A_2} \Pi_{2,A_2-x}\psi_2(x,r,\Delta)$$

$$f_2(r,s) = \sum_{k=s+1}^{A_1} \Pi_{1,A_1-k}\psi_1(s,r,\Delta)$$

$$g_2(r,s) = \sum_{x=0}^{s-1} \Pi_{2,A_2-x}\xi_2(x,r,\Delta) \quad (20)$$

Same as the above equations $h_1(r, s)$, $c_1(r, s)$, $h_2(r, s)$, $c_2(r, s)$, $d_1(r, s)$, $e_1(r, s)$, $d_2(r, s)$, $e_2(r, s)$, $v_1(r, s)$, $x_1(r, s)$, $v_2(r, s)$, $x_2(r, s)$, $y_1(r, s)$, $z_1(r, s)$, $y_2(r, s)$, $z_2(r, s)$ are also modelled.

January - February 2020
ISSN: 0193 - 4120 Page No. 14024 - 14031

By placing these expressions into equation (16) and (17), $P\{\Psi_{nwk,nwm}(r,\tau+\Delta)/MV_{nwk/nwm}(t)\}$, $P\{\Psi_{nwm,nwk}(r,\tau+\Delta)/SY_{nwk}(t)\}$ are obtained. With these unnecessary and missing handover probabilities are derived from equation (12). The sum of unnecessary and missing handover probability is wrong decision handover probability obtained from equation (11).

IV. SIMULATION RESULTS FOR PROBABILITY OF WRONG DECISION HANDOVER IN HETEROGENEOUS WIRELESS NETWORKS

Here five heterogeneous wireless networks are considered for performing bandwidth based handover probability. The bandwidth of these networks are considered as $A_k = A$, k=1,2,3,4,5 then the probabilities of mobile node moving from network k to network m and mobile node moving from network m to network k are equal i.e. $P_{nw_k/nw_m} = P_{nw_m/nw_k} = P$, k=m=1,2,3,4,5,k≠m.

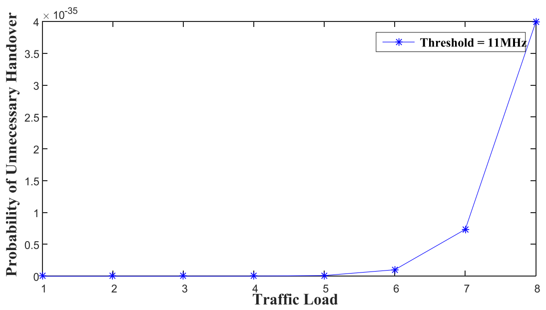

Figure 2: Probability of Unnecessary Handover vs. Traffic load for
Threshold =11MHz at Bandwidth =20MHz

Fig. 2 gives the how the probability of unnecessary handover varies with Traffic load at threshold value 11MHz. From the figure it is observed that unnecessary handover probability is presented for the various traffic loads is very less and is slightly increases with increase in the Traffic load value.

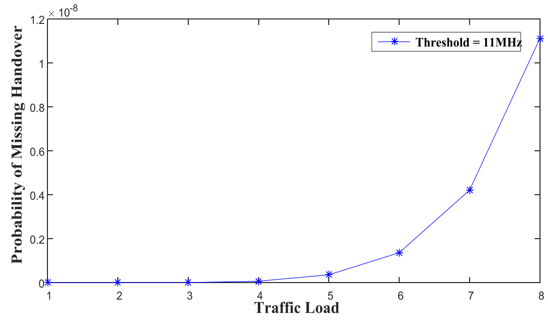

Figure 3. Probability of Missing Handover vs. Traffic load for Threshold = 11 MHz at Bandwidth =20 MHz

Fig. 3 gives the how the probability of missing handover varies with Traffic load at threshold value 11MHz. From the figure it is observed that missing handover probability is presented for the various traffic loads is less and is slightly increases with increase in the Traffic load value.

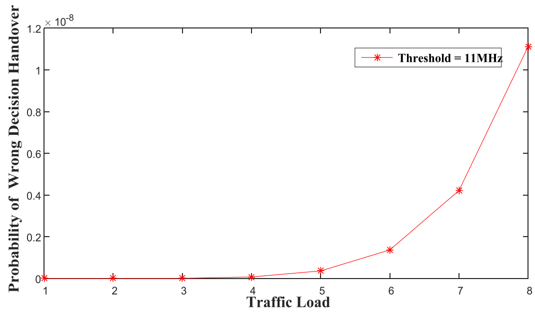

Figure 4. Probability wrong decision handover vs. Traffic load for Threshold =11 MHz at Bandwidth =20 MHz

Fig. 4 gives the how the probability of wrong decision handover varies with Traffic load at threshold value 11MHz. From the figure it is observed that wrong decision handover probability is presented for the various traffic loads is less and is slightly increases with increase in the Traffic load value. Probability of wrong decision handover is the combination probability of unnecessary and missing handovers. From Fig. 2 and Fig. 3, it is observed that missing handovers are more dominant than unnecessary because of that in Fig. 4, it is observed that probability of wrong decision handover is almost identical to the probability of missing handover.

Table.1: Handover Probabilities vs. Traffic load for Threshold =11MHz at Bandwidth =20MHz

S.No	Traffic Load	Probability of Unnecessary Handover	Probability of Missing Handover	Probability wrong decision handover
1	1	1.382X10^{-42}	4.963 X 10^{-15}	4.963 X 10^{-15}
2	2	9.052 X10^{-41}	5.624 X10^{-13}	5.624 X10^{-13}
3	3	1.074 X10^{-39}	9.449 X10^{-12}	9.449 X10^{-12}
4	4	9.248X 10^{-39}	7.279 X10^{-11}	7.279 X10^{-11}
5	5	1.014X 10^{-37}	3.634X 10^{-10}	3.634X 10^{-10}
6	6	1.008 X10^{-36}	1.369 X10^{-09}	1.369 X10^{-09}
7	7	7.35 X10^{-36}	4.215 X10^{-09}	4.215 X10^{-09}
8	8	3.99 X10^{-35}	1.112 X10^{-08}	1.112 X10^{-08}

Table 1 indicates that how the probability of unnecessary, missing and wrong decision handover probabilities varies with respect to traffic load. It is observed that as the traffic load increases all three are increases but this increment is in very low values.

CONCLUSION

In this paper, bandwidth based handover algorithm for five heterogeneous wireless networks is considered. For this, the mathematical model for probability of wrong decision handover is developed. For evaluating wrong decision handover, both unnecessary and missing handovers are considered. Handover algorithm performance is estimated by calculating the probability of wrong decision handover. The proposed mathematical model is achieved very less probability of wrong decision handovers, for example at traffic load is 8, the probability of wrong decision handover is 1.112 X10^{-08}. As the traffic load increases the probability of wrong decision handover increases in very less. So, handover algorithm based on bandwidth for five heterogeneous wireless networks gives the better handover decision with predication of probability of wrong decision handover and provides better network performance.

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