

Dynamic Vertical Handoff Algorithm Using Media Independent Handover Service for Heterogeneous Network

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Abstract — Media Independent Handover (MIH) is a standard proposed by IEEE 802.21 working group to facilitate vertical handover support between heterogeneous networks. Currently, the implementation of the IEEE 802.21 standard supported in ns2, provided by National Institute of Standards and Technology (NIST) considers only the signal strength as a parameter to determine the destination network. Selecting a destination network using only RSS as indicator does not meet the needs of all users. For more accurate choice of destination network, vertical handoff decision should consider the values of different criteria of network as well mobile node. In this paper, we have proposed an improved handoff decision module including additional parameters which considers state of mobile node and network conditions during handoff decision in order to improve the performance. The simulation results shows that the proposed method achieves better performance in terms of throughput, handoff latency and packet drop over the basic handoff scheme. More over the proposed method helps to reduce the unnecessary handoffs by eliminating the ping-pong effect and thus increases overall system performance.

Index Terms — Heterogeneous Wireless Network, Vertical Handoff, Media Independent Handover, Handoff Decision Algorithm, NS2

I. INTRODUCTION

As wireless technologies gaining more popularity it is becoming increasingly important to have a vertical handoff solution [1]. A key requirement is the ability to select the best destination network. Generally, horizontal handoff decision considers parameters such as received signal strength indicator (RSSI), signal-to-noise ratio (SNR) and some link quality condition parameters [2]. Where as in case of vertical handoff, mobile users can move between different wireless access networks, and they will benefit from different network characteristics that cannot be compared directly. Therefore, the handoff decision algorithm becomes more difficult. An ideal Vertical Handover algorithm should consider several parameters for handoff decision. Few such parameters can include: Bandwidth, Latency, Received Signal Strength (RSS), Power Consumption, Network load,

Security, Throughput, Network cost and User preferences [1].

IEEE802.21 - Media Independent Handover (MIH) working group [3] developed a standard to provide a frame work to facilitate the vertical handover in the next generation heterogeneous wireless networks. It defines an abstract framework that optimizes and improves handover performance by providing information about the link layer technologies to the higher layers. The goal of provisioning is to achieve low-latency handovers and intelligence in network selection. However MIH does not consider factors to efficiently make handoff initiation and find an optimal target network [4]. Also the MIH framework is a general framework, but needs to be integrated with the specific access technologies and their mobility processes, allowing for a coherent inter-technology handover process. Hence an improved framework is needed to consider the values of different criteria to take a decision and make a better choice concerning the destination network during handover.

Vertical Handover Algorithms [5] involves two main things during a handover: Selecting best network and handover trigger. Network selection determines the best destination network, to which a mobile user can be handover. Handover decision may depend on various criteria to select destination network. Handover trigger indicates to the handover decision maker when the mobile's handover operation should be conducted. Hence it plays important roles as it decides initiation of switching of a mobile user to the selected destination network. During a handover, it is important to determine a proper handover triggering time. Otherwise ping-pong effect may occur when back and forth handover between two networks having similar conditions. Hence handover triggering time is carefully calculated to avoid ping-pong effect.

In this paper we have proposed an efficient vertical handoff method using MIH. The proposed method takes into account the user preferences, mobile node parameters, lower layer network information and make decisions depending on that information. A handoff

initiation method, which is proposed in this module, considerably reduces unnecessary handoffs and helps to increase overall system performance.

The remainder of this paper is organized as follows: Section II describes the related work. Section III describes proposed method. Section IV gives overview of simulation of proposed method using NS2 simulator. Section V describes the simulation results and we conclude in Section VI.

II. RELATED WORK

Various vertical handoff decision algorithms have been proposed recently. Due to the relevance of mobility interoperability in future networks, a significant amount of related work has been published by the academic community as well. In [1] a detailed survey on existing vertical handoff algorithm, their classification and comparison is given. A detailed introduction to MIH standard is given in [6][7]. In [8] authors provided a framework for the implementation of the MIH standard and evaluated its performance in integrated 802.11/802.16e networks through simulation. A mathematical model for analyzing the performance of MIH signaling is proposed in [9]. IEEE 802.21 based vertical handover schemes are proposed in [10] and [11]. Unfortunately, the proposals lack interaction between the MIH framework and the access technologies, QoS specificities. Furthermore, performance measurements are also not given [12] and standard should be extended to further facilitate seamless handover provision.

Deciding best target network is another important challenge in vertical handoff. From the literature it is found that Multi Attribute Decision Making (MADM) methods are widely used in handover decisions. Performance comparison among Simple Additive Weighting, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Grey Relational Analysis (GRA), and the Multiplicative Exponent Weighting (MEW) for vertical handoff decision is given in [13]. A context aware vertical handoff algorithm that considers both users and services requirements is proposed in [14]. A network selection algorithm based on Fuzzy Multiple Attribute Decision Making is proposed in [15]. The Network selection function is used to measure the efficiency in utilizing radio resources. Each network associated with parameters Received Signal Strength (RSS), Monetary cost(C), Band Width (BW), Velocity (V) and user preference (P). Even though there are a lot of vertical handoff algorithms in literature, these vertical handoff algorithms either lack in comprehensive consideration of various network parameters or the detailed implementation information.

III. PROPOSED WORK

For efficient vertical handoff algorithm, many network characteristics need to be considered for handoff decision. These include cost of service, security, power

consumption, network conditions, and network performance. In this proposed work, the vertical handoff decision algorithm considers the following aspects [16]:

- The state of the wireless access networks: This includes the available RSS, bandwidth, and cost of the service, network coverage.
- The state of the Mobile Node: This includes the velocity and Battery level of the MN.
- User Preference: This includes ranking of networks according to the user.
- The current condition of the system as well as its future possible evolutions.

Considering the above aspects, we propose a vertical handover decision algorithm using MIH. The algorithm includes two modules namely, handoff initiation module and handoff decision module.

Handoff Initiation module: The handoff initiation module plays important role as it helps to reduce unnecessary handoff and thereby enhancing throughput and user satisfaction. It is also called as pre-handoff decision phase. Handoff initiation module consists of two parts namely estimating the necessity of handoff and selecting potential target networks which are capable of providing basic guaranteed service to the user. Handoff necessity estimation phase checks whether there is a need for handoff by using parameters like velocity of the MN, coverage area of the serving network. For example, if MN's moving with very high speed, WLAN cannot support its speed. In this case handoff to larger coverage area network would be preferable. By considering velocity of MN it is obvious that unnecessary handoff can be eliminated. If there is need for handoff, then the list of candidate networks which are capable of providing basic guaranteed service to the user are sent to handoff decision module. In order to list the potential candidate network, we have used Minimum Guaranteed function as given in (1). Minimum guarantee indicates whether the minimum guarantee of MN is supported for every network i . According to [17] minimum guarantee function M_i for each network i can be given by,

$$M_i = F(B_i - B_{th}) \cdot F(RSS_i - RSS_{th}) \cdot F(V_i - V_{th}) \cdot F(T_i - T_{th}) \cdot F(P_i - P_{th}) \cdot F(C_i - C_{th}) \rightarrow \quad (1)$$

Where B_i is Available bandwidth, RSS_i is Received Signal Strength (RSS), V_i is velocity of MN, T_i is duration, P_i is battery power level and C_i is cost of service for network i . Also the parameters B_{th} , RSS_{th} , V_{th} , T_{th} , P_{th} and C_{th} indicates the pre-defined thresholds of available bandwidth, RSS, velocity, duration, battery power and cost of service for network i . The duration T_i denotes the estimated time MN will stay in a particular network i . By considering velocity of mobile node and coverage of the network, T_i can be predicted along with other parameters like moving pattern of MN, and the location information of MN [17].

The function $F(.)$ is a unit step function which is a discontinuous function whose value is zero for negative argument and one for positive argument. Hence, if there is any negative value in any of the term in (1) then M_i becomes zero. This indicates that for any particular

network i , if parameter value is lower than its threshold, the minimum guarantee function has zero value. Now, if M_i value is zero for a particular network i , then that network is not considered as a candidate network and if it is one it is included in the set of candidate networks S . Initially the set S is set to be empty at the beginning of every handoff decision. Hence set S contains candidate networks which are capable of providing minimum guaranteed service to MN and those which are not capable of providing minimum level of service to MN are eliminated from list candidate network. In this way handoff decision time also reduced. The set of candidate network S is then sent to handoff decision module.

Handoff Decision module: During handoff decision phase, the target network is selected from set of candidate network using (2). The vertical handoff decision problem is formulated as objective function H_i . In our proposed algorithm, dynamic weights used so that the objective function is adaptive to different metrics of several networks. The objective function H_i can be given as follows,

$$\text{Maximize } H_i(v) \rightarrow \quad (2)$$

Where $H_i(v)$ is the objective function evaluated for the network i and v is the input parameters. The objective function H_i can be mathematically expressed as:

$$\begin{aligned} H_i &= F(RSS_i, 1/C_i, B_i, 1/P_i, U_i, V_i) \\ H_i &= WR_i \times RSS_i + WC_i(1/C_i) + WB_i \times B_i + WP_i(1/P_i) \\ &+ WU_i \times U_i + WV_i \times V_i \rightarrow \quad (3) \end{aligned}$$

Where RSS_i , C_i , B_i , P_i , are normalized values of Received Signal Strength, Cost of service, Bandwidth, Power consumption, and U_i and V_i are the user preference and velocity of the MN. Normalization is needed to ensure that the sum of the values in different units is meaningful. The dynamic weights can be given by [18]

$$\begin{aligned} WR_i &= \frac{RSS_i - RSS_{th}}{RSS_{max} - RSS_{min}} & WC_i &= \frac{C_i - C_{th}}{C_{max} - C_{min}} \\ WB_i &= \frac{B_i - B_{th}}{B_{max} - B_{min}} & WP_i &= \frac{P_i - P_{th}}{P_{max} - P_{min}} \\ WV_i &= \frac{V_i - V_{th}}{V_{max} - V_{min}} & WU_i &= \frac{U_i}{n} \rightarrow \quad (4) \end{aligned}$$

For each network, H_i is consistently calculated and the network having highest value for H_i is chosen as the target network. Therefore, this objective function-based model estimates dynamic network conditions and includes a stability period to ensure that a handoff is worthwhile for each mobile. The flowchart of the proposed method is as given in fig.1.

The algorithm is executed whenever there is a Link-up Link down or Link Going Down trigger from MIH. If Link-up trigger occurs and Uplink id is WLAN then wait for small period of time in order to check whether signal strength is increasing or decreasing. This helps to reduce ping-pong effect [19]. Next step of the proposed method is calculating the M_i value for each network i . Let us consider that there are N networks available. In this step, the handoff initiation module evaluates whether the minimum guaranteed service to a user is supported for

every network i , M_i , for $i = 1, 2, \dots, N$. The set of candidate network contains networks whose M_i value is one. It is obvious that by introducing the duration into the minimum guarantee function, the ping-pong effect can be considerably eliminated. Thus, proposed approach reduces unnecessary handoffs while increasing network throughput, decreasing handoff delay, and avoiding connection dropping. In addition, the velocity is also considered in the first step to eliminate unnecessary handoff.

After the handoff initiation phase, according to the size of the candidate network set S , the propose decision algorithm generally falls into three cases [17]. The first case is that the set S is empty, and in this case MN remains connected to the current network. Secondly, there is only one member in set S . Here there may be further two scenarios. If sole network is the current network, MN stays in the current network; otherwise, MN decides to perform vertical handoff to target network. In the third case there are more than one network have been added into the set S . More specifically, there is more than one network, whose minimum guarantee function value is one. In this case MN uses objective function as given in (3) to select target network. After selecting the target network the traffic is rerouted from current network to target network.

IV. SIMULATION SETUP

The simulation is carried out in order to study the performance of the proposed method. For simulation purpose we have used ns2 with NIST's IEEE 802.21 add-on module. It consists of one UMTS, WiMAX base station and two WiFi access points as shown in the fig.2. The simulation is carried out for a period of 600 sec. MN is configured to use interfaces UMTS, WiFi, and WiMAX. Video traffic is created between CN and MultiFace node.

The mobility of a mobile node is fixed according to the path from point A to point B as shown in simulation scenario. Initially, when simulation starts MN connected to UMTS network and continues its communications with CN using UMTS network. As it moves it encounter WiFi Network and MN gets transferred to Wi-Fi and continues communication with CN. MN remains connected to WiFi as long as H_i value is high than all other network. When H_i for WiMAX becomes more than that of WiFi, MN will hand over to WiMAX network.

As soon as the new network becomes available, trigger for signal strength, user presences, Available bandwidth, velocity of MN, battery power level and cost of service for network i are generated to obtain the parameters and are forwarded to handoff initiation module to decide necessity of handoff.

To study the performance of the proposed method MN velocity is varied for different values ranging from 5 m/s to up to 35 m/s. The simulation is repeated number of times and average value is taken to improve the accuracy of the result. The simulation parameters are as given in the following table.

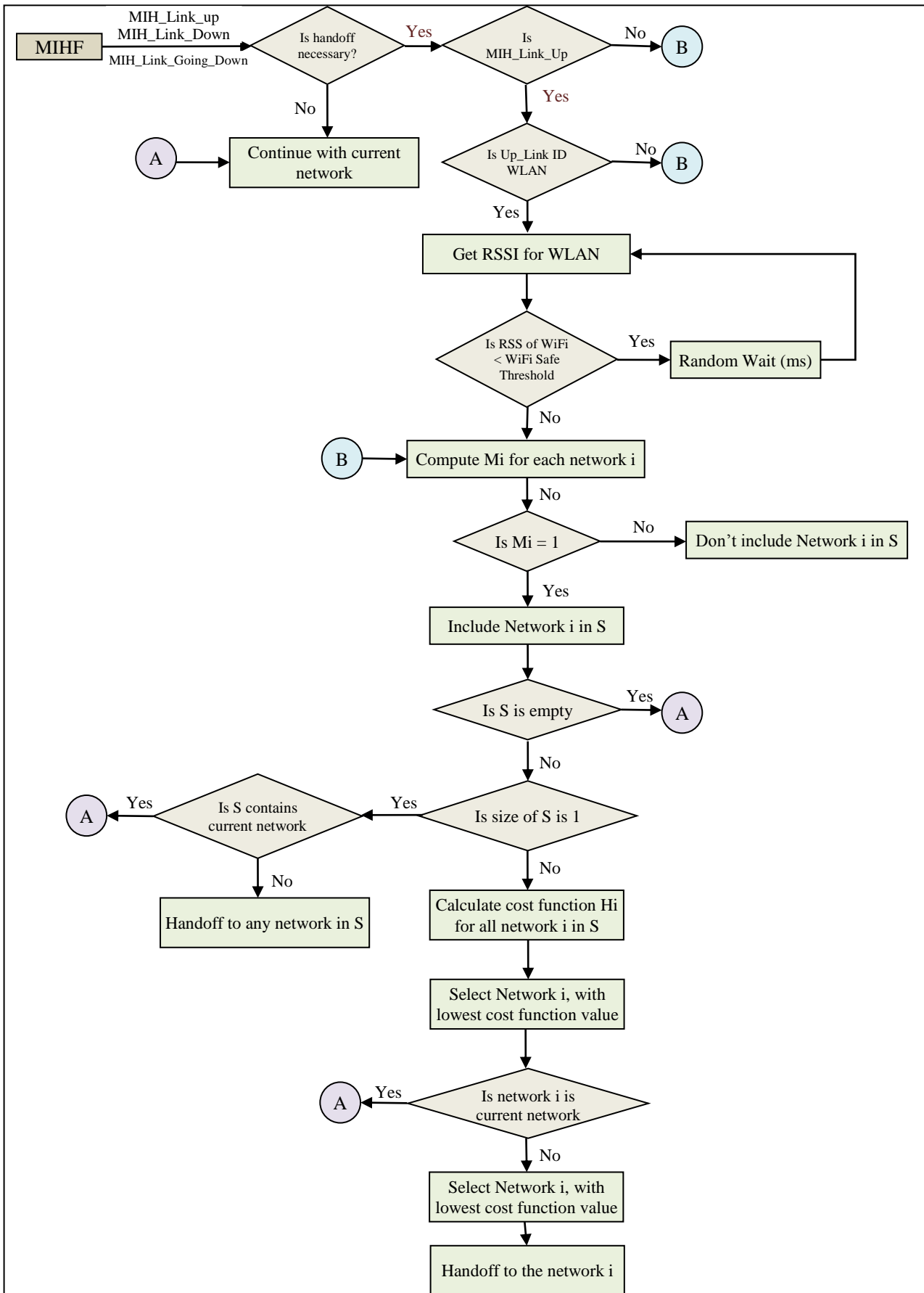


Fig. 1. Flowchart of proposed method

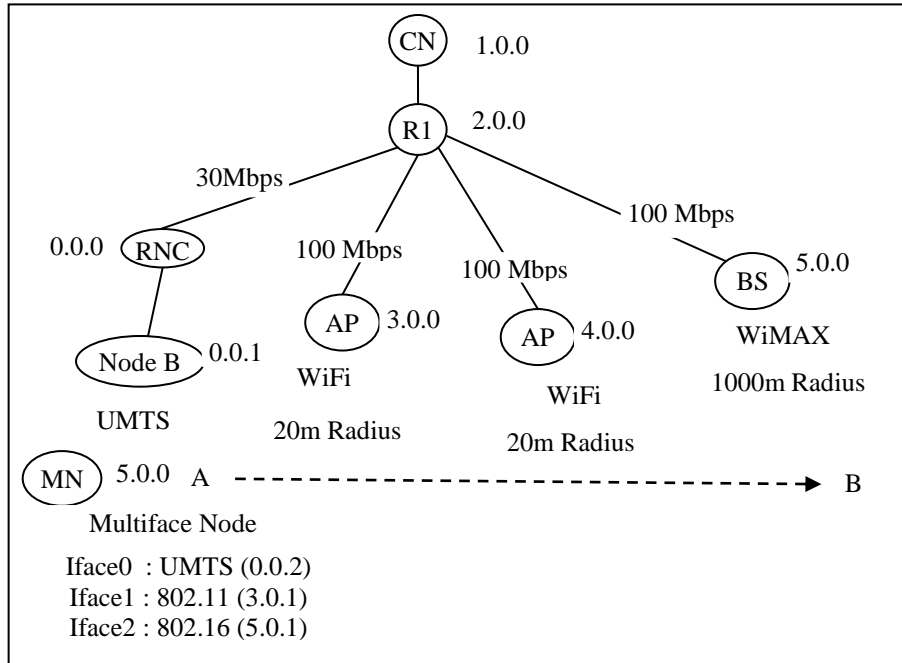


Fig. 2. Simulation scenario

Table 1. Simulation parameter values

Parameter	Value
Wireless Node	
Propagation model	TwoRayGround
routing protocol	DSDV
WiFi Configuration	
WLAN beacon interval (s)	0.1
MinChannelTime (s)	0.02
MaxChannelTime (s)	0.06
Data rate (Mbps)	11
RXThresh	6.12277e-09
WiMAX configuration	
RXThresh	1.26562e-13
Radius (m)	1000
ucd_interval (s)	5
dcd_interval (s)	5
modulation	OFDM_16QAM
Antenna model	OmniAntenna
UMTS Configuration	
Transport channel	Dedicated Channel (DCH)
llType	UMTS/RLC/AM – acknowledgment mode
DCD interval (s)	5
UCD interval (s)	5
Modulation	OFDM_16QAM
uplinkBW	384kbps
uplinkTTI	10ms
downlinkBW	384kbps
downlinkTTI	10ms
Mobility Model	
Velocity (m/s)	5 to 35
Path	Straight line
Application Traffic for Mobile Node	
Type	UDP video
Packet size (bytes)	1240

V. SIMULATION RESULTS

In this section, we present the simulation results. For scenario shown in fig.2, we have found the values for throughput, handoff latency and packet loss. This analysis of the system performance is needed to ensure that the proposed system is better than basic NIST module. The graph of handoff latency, throughput and packet drop is as shown in the following graph.

Handoff latency: The handoff latency is the amount of time from when the mobile is disconnected from the old base station to when the mobile receives the first packet from the new base station. This is nothing but the time interval between the first Link_Going_Down trigger generation and the HO_Complete generation. The graph of handoff latency versus speed of MN is as shown in the fig.3. The proposed model reduces handoff latency compared to basic NIST model. At lower velocity there is no much considerable difference in handoff latency. But as velocity of MN increases handoff latency also increases but less compared to NIST model.

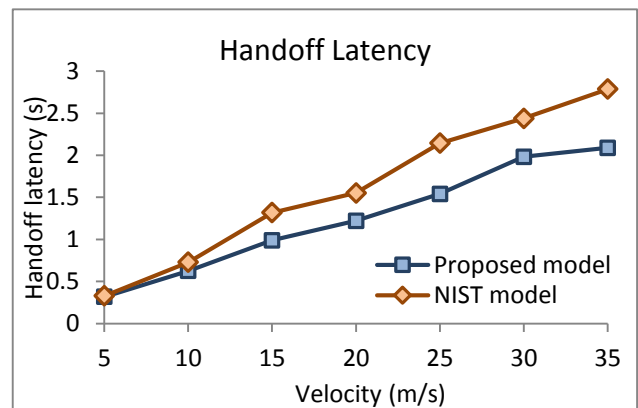


Fig. 3. Graph of Handoff latency v/s velocity

Throughput: The throughput is measured with respect to the speed of the mobile node. Fig.4 shows that the throughput measured has been found to slightly increase as the speed of the mobile node. Moreover proposed model give better throughput when compared to basic NIST module.

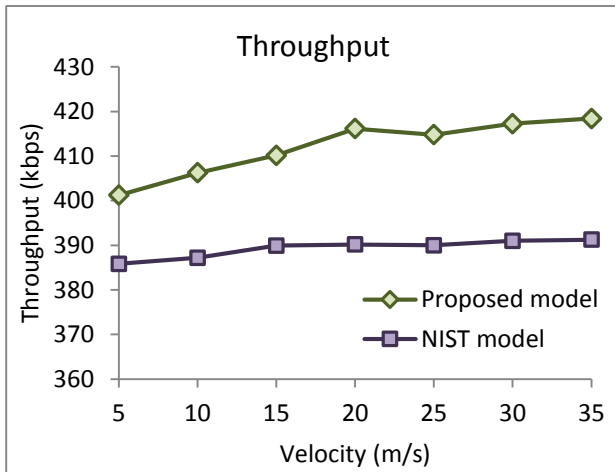


Fig. 4. Graph of Throughput v/s velocity

Packet drop: It is measure of average number of packet drops during the simulation. From fig.5 it is observed that the proposed method reduces packet drop considerably over basic NIST model. Packet loss values are higher in NIST model as shown in fig.5 as compared to the proposed model. Packet loss is almost null in proposed model for lower speeds.

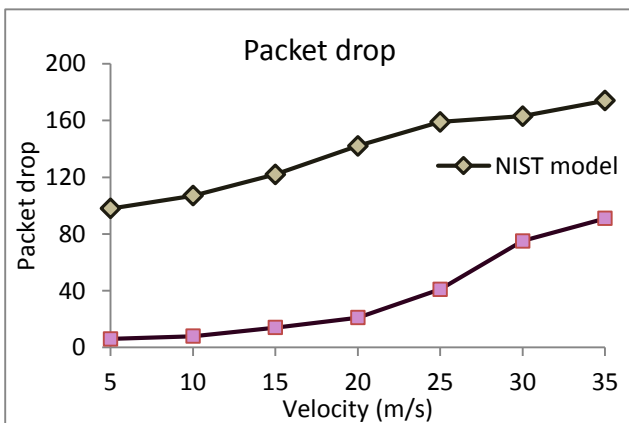


Fig. 5. Graph of Packet loss v/s velocity

VI. CONCLUSION

Seamless vertical handoff is key requirement for next generation network. Vertical Handoff decision to select destination network based on the Radio Signal Strength only is not always a good strategy. Hence there is a need for a new framework taking into account different parameters to guide network selection process during handover decision. In this paper a vertical handoff model formulated as objective function of multiple parameters with dynamic weights. The proposed model helps to reduce the unnecessary handoffs. The simulation is

performed using NS-2 simulator shows that the inclusion of additional parameters significantly improves the overall performance for mobile users. Simulation results demonstrate that proposed approach achieves improvement with respect to throughput, handoff latency and packet drop. Compared with basic NIST module the proposed approach has a slight increase in throughput, and decrease of latency and packet drop.

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