Design an Algorithm for Vertical Handover Strategies in Heterogenous Wireless Network

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Abstract: **A heterogenous wireless network consists of different wireless access standards. To transfer data seamlessly vertical handoff (VHO) plays a major role. Seamless continuity is the main goal in 4G wireless networks. When a mobile terminal is in overlapping area, for service continuity handoff mechanism is mainly used while moving in heterogenous wireless networks. Vertical Handoff decision (VHO) is based on received signal strength (RSS) signals. While taking VHO decision, user mobility is an important factor. VHO is required only at lower speeds and higher speed user velocity may cause unnecessary handovers that can reduce system capacity and Qos level. UE velocity makes the HO decision, we can reduce the transmission cost and transmission time. Wireless access standards: Wi-Fi, Wimax, LTE.**
This algorithm is simulated in NS2 and its performance is evaluated in terms of user velocity and handover numbers. This approach leads to improvements in the end user experience.

***IndexTerms*–Heterogeneous wireless network(HWN), Vertical Handoff(VHO), Horizontal Handoff(HHO), Receiver Signal Strength(RSS), VHO decision algorithm, User equipment velocity.**

I. INTRODUCTION

A mobile moves into a different cell, at that time a conversation is in progress, the MSC automatically transfers the call to a new channel belonging to the new base station referred to as handoff (HO).HO can be classified into:

- Vertical HO
- Horizontal HO

The handoff between access networks with different link layer technologies is defined as vertical handoff (VHO) whereas handoff between different access points within the same link layer technology is defined as horizontal handoff (HHO) [5].The considerations for vertical handover include:

- The VHO supported device must contain a dual card that enables connection between different wireless standards.
- Various handover metrics are considered to decide the wireless standard that can support handoff efficiently.

The different metrics includes:

- Receiving signal strength(RSS)
- User velocity

In order to achieve seamless vertical mobility it is essential to consider the mobility pattern of the user which can be obtained from the LTE System. Received signal strength (RSS) is a parameter which is to be considered for accurate HO prediction. A mobile node chooses an access point (AP) which offers maximum signal strength. HO is initiated when the corresponding RSS from an AP falls below a threshold value due to the various fading effects. The RSS threshold is fixed based on mobile node (MN) location and velocity information. Thus the combination of mobility pattern and RSS reduces the unnecessary handoffs. The main reasons for unnecessary HOs are: [2], [3]

- Network congestion.
- Unable to identify temporary coverage.
- Scarcity of required resources.

Among these problems, identifying the temporary coverage is one of the main problems faced by the heterogeneous network. That means the mobile node remain connected to the temporary coverage network at least for a minimum amount of time called HO recovery period. If a VHO occur before HO recovery period, all the optimal resources and favourable network conditions provided by the new network for establishing the new connection does not get successfully utilized. This will also cause large signalling overhead and delay.

Monetary cost, offered services, network conditions and user preferences are the other additional factors considered besides RSS and user velocity. This paper considers the influence of other users requesting HO, i.e., considering the collision among different users when they try to access the same APs or base station. This will degrade the overall network performance due to higher congestion delays and dropped call probability. So, in order to improve the performance of the heterogeneous network an objective function is developed which considers all the above mentioned parameters and through the optimization of this objective function system performance can be improved. The new VHO scheme involves two steps: [1]

- Picking HO candidates: It is purely based on the parameters such as RSS, velocity and user type.
- Optimization of objective function**:** The objective function comprises different factors which the network operators concern, for e.g.: load, cost, battery life time etc. This paper considers mainly the parameters load and cost and generalizes the objective function.

Due to ever growing demand for packet-based mobile broadband systems, the 3GPP [11] has introduced LTE (LongTerm Evolution) specifications [14] as the next step of the current 3.5G cellular networks. An enhanced access network (i.e., the E-UTRAN, Evolved-UMTS Terrestrial Radio Access Network) and an evolved core network have been defined[12].

Overview of Wimax and Wi-Fi and LTE System

In this paper we consider the network that integrates both Wimax and Wi-Fi and LTE access standards. The Wimax and WiFi are considered due to their high bandwidth availability and ease of networking.

- *Wimax:* The Wimax is a wireless Ethernet standard(802.16). It provides wide range of user mobility and It is accessible everywhere. The operation of Wimax is same as that of Wi-Fi, but Wimax can operate at higher speed. Also the coverage area of Wimax is large therefore it can support large number of users. The coverage area is about 400m at 3.5GHz with a data rate of 20Mbps [10].
- *WCDMA:* Global GSM community developed this technology to support third generation (3G) mobile services. It is use in radio leg of both UMTS an HSPA networks. It is spread spectrum modulation technique, which uses channels whose bandwidth is much greater than that of the data to be transfered. It uses CDMA as an underlying channel access method.

- *Wi-Fi:* A well developed wireless technology of presentday which uses high frequency radio signals for data transmission. Wi-Fi(802.11) operates in 2.4GHz band with a data rate of 11Mbps and a coverage area of about 70-80meters.It can also operate in the 5GHz band which offers a maximum data rate of 54Mbps and uses OFDM based air interface[10].

- *LTE:* The LTE radio access is based on Orthogonal Frequency Division Multiplexing (OFDM) and provides a highly flexible bandwidth (from 1:4 to 20 Mhz). Both frequency division duplex (FDD) and time-division duplex (TDD) multiple access techniques are supported [14]. Radio resources are distributed among users in a time-frequency domain. The eNB schedules radio resources among uplink/downlink flows at the beginning of each sub-frame.
  LTE-Sim supports all six channel bandwidths (i.e., 1.4, 3,5, 10, 15, and 20 MHz) available for the LTE system and the cellular frequency reuse. Finally, TDD and FDD are handled by the Frame Manager.

II. SYSTEM DESCRIPTION

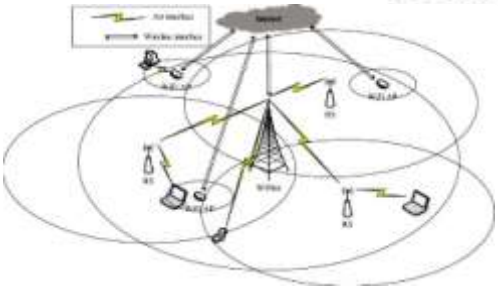

Fig.1. System Description

We consider a heterogeneous network with Wimax and Wi-Fi as the sub networks with one Wimax BS and three Wi-Fi APs. The number of BS is always selected as one except in the case of highly dense urban environment. The number of user equipment in the particular network is assumed as ten. Figure1 is the grammatical representation of the simulation model. The inner circle with larger radius represents the Wimax service range and the other three circles with equal radius represent the Wi-Fi service range.

III. VERTICAL HANDOFF ALGORITHM (VHO)

The VHO scheme is explained using flow chart as given below [1]

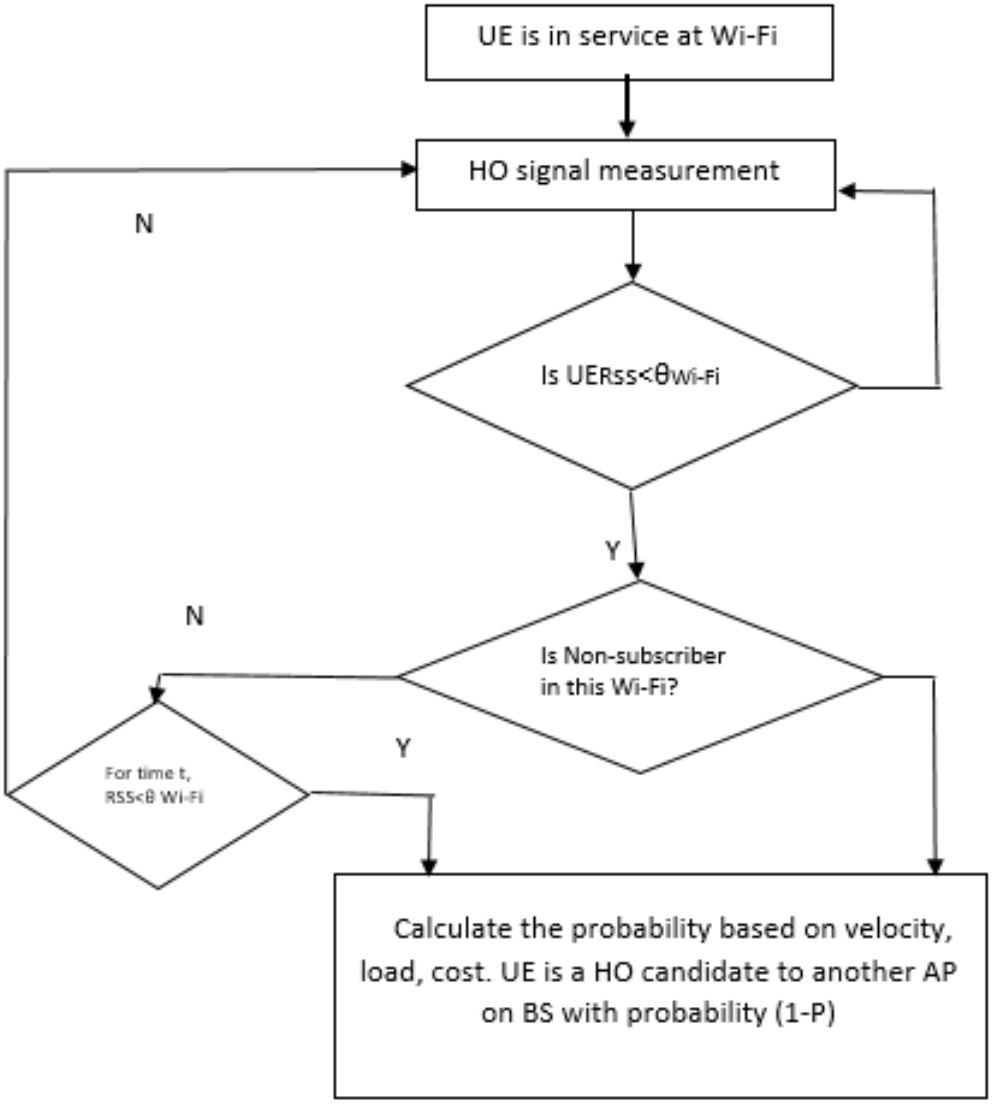

Fig 2. Flowchart for picking HO candidates in Wi-Fi

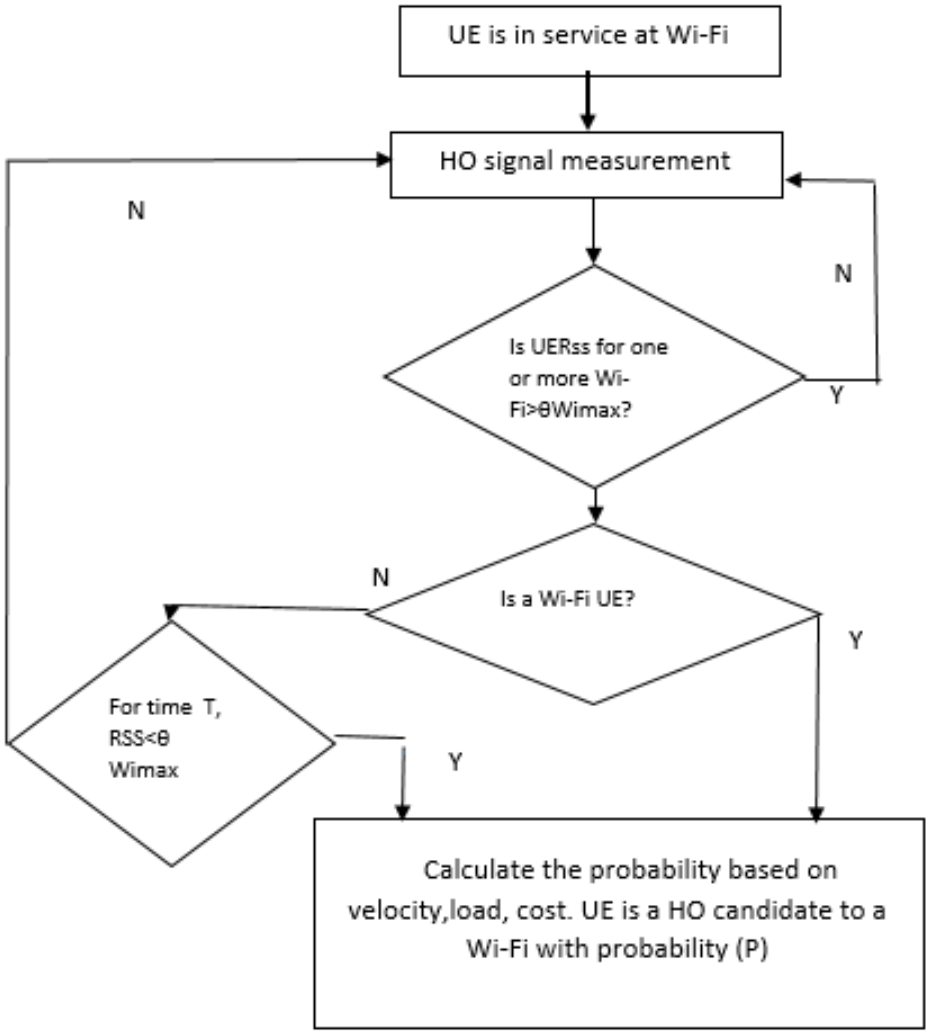

Fig.3. Flowchart for picking HO candidates in Wimax

As shown in the flowchart, a UE requesting HO can either belongs to a BS or an AP. For a UE in service at a BS, HO may occur if the RSS from one or more AP exceeds a specific threshold, say Wimax or it may also happens when in service at an AP, the User Equipment RSS falls below a threshold them it is called as Wi-Fi. If the above conditions satisfy, then the network checks whether the UE is its subscriber or not. This is done to ensure QoS of the subscribers, i.e., the subscriber belongs to a particular BS or AP gets a higher priority than the non-subscribers. This is achieved by introducing a time duration T,such that if the HO requesting UE is under the service of corresponding network(a subscriber), the UE can remain in the network for a time duration T till RSS< (Wi-Fi or Wimax). If the HO requesting UE is a non-subscriber to the current network, then the network immediately performs HO and releases the resources for the subscribers. To avoid the unnecessary HO, probability of HO is measured by considering some parameters such as velocity of the UE, maximum load that a particular network can tolerate. For a high speed UE, the probability of remaining in the BS is high, if the other constraints such as bandwidth availability and service cost offered by the network also satisfy.

IV. ESTABLISHED NODES

For the simulation purpose, there are 17 nodes, which are divided into following specifications. There are nodes from 0 to 17, where 0 node defines Server, node 1,2,4 defines nodes of Wi-Fi, node 3 define node of Wi-Max and Remaining nodes as a mobile users.

```
[root@localhost source]# ns packet1.tcl
num_nodes is set 17
warning: Please use -channel as shown in tcl/ex/wireless-mitf.tcl
INITIALIZE THE LIST xListHead
Loading connection pattern...
Loading scenario file...
   Node      -     Specification
 -------------------------------
     0       -     Server
     1       -     WIFI  - AP1
     2       -     WIFI  - AP2
     3       -     WIMAX - BS
     4       -     WIFI  - AP3
Starting Simulation...
channel.cc:sendUp - Calc highestAntennaZ_ and distCST_
highestAntennaZ_ = 1.5,  distCST_ = 550.0
SORTING LISTS ...DONE!
[root@localhost source]#
```

Dynamic decision process

Priority Phase: (Network Discovery)

1. Add all the available network into candidate list.
2. Scan all the networks and their Received Signal Strength (RSS)
3. Record the velocity of the mobile station (MS)
4. Remove the networks which do not satisfy the required RSS and velocity criteria.
5. Calculate and assign the priorities of all the candidates networks based on the difference between RSS and its threshold value RSST.
6. Continue with normal Phase

Normal Phase: (Network Analysis)

7. Collect current system status from SM component and determine the weight factors.
8. Collect information on every wireless interface in the candidate list.
9. Calculate the static score "S" using a *Cost function* for every network.
10. Continue with Decision Phase.

Decision Phase: (Network Selection and Execution)

11. Calculate a dynamic *score "DScore"* by multiplying the *priority* of each candidate network its static score "S".
12. Select the network with the highest value of "DScore".
13. Handoff all the current information to the "Selected network" if different from current network.

6.1 System Monitor

This module is responsible to monitor the current battery level of the mobile station and record the user preferences for various networks based on the current battery level, offered bandwidth, usage charges and power consumption by their interfaces. These preferences arepassed on to the Network Analysis module which converts them into the respective weight factors to calculate the score function.

6.2 Network Analysis

The analysis of the network is based on a score function S. the S can

be defined as a function of the following parameters: the offered bandwidth (Bn), power consumption of using the network access device (Pn) and the usage charge of the network (Cn)-

Sn= f(Bn, Pn, Cn) (1)

We can imagine that such a score function is the sum of some normalized form of each parameter. Normalization is needed to ensure that the sum of the values in different units is meaningful.

In general, suppose that there are k factors to consider in calculating the score, the final score of the interface i will be a sum of k weighted functions.

Si=1,*k*,*I*,*I*, *j*,*j*,*w f*
= Σ
0<Si<1,1*k*,*j*,*j*,*w*
= Σ
=1 ……..(2)

In the equation, wj stands for the weight of factor j and fi,j represents the normalized score of interface i for factor j.

For our model –

Si= wbfb,i + wp fp,i + wc fc,i……... (3)

Where

- - 52 - -

fb,i = eα
i / eM , αi≥0 & M≥αi……..(4)
fp,i = 1/eβ
i , βi≥0…… (5)
fc,i = 1/eγ
i ,γi≥0 ……..(6)

The coefficients α*i*, β*i*, γ*i* can be obtained via a lookup table or welltuned functions as below:

αi = Min(xi ,M)/M ;M= 2Mbps ……...(7)
βi =2/yi ; yi: hours ……..(8)
γi =zi / 20 ; zi : Rs./min ……..(9)

In Eq. 3, we used the inversed exponential equation for *fp,i* and *fc,i* to bound the result between zero and one (i.e. these functions are normalized), and properly model users preferences. For *fb,i*, a new term *M* is introduced as the denominator to normalize the function, where *M* is defined as the maximum link capacity among all available interfaces. Note that, the properties of bandwidth and usage cost/power consumption are opposite (i.e. the more bandwidth thebetter, whereas lower cost/power consumption is preferred).

6.3 Network Discovery

The object of this module is to identify all the Candidate Networks from all the available networks and assign them Priority. A *candidate network* is the network whose received signal strength is higher than its threshold value and its velocity threshold is greater than the velocity of mobile station.

The priority is based on the difference between received signal strength and its threshold value (i.e. RssDiff). We have taken it sobecause higher the RssDiff means that the MS is more nearer to theBS of that network and hence the MS can stay for more time in thecell of the respective network before asking for another handoff. Thus

- - 53 - -

we are able to reduce the unnecessary handoffs and improve the overall performance of the system.

Let N= {n1,n2,n3……nk} is the set of available network interfaces,
VT={vt1,vt2,vt3,…….vtk} is the set of threshold values of velocities for a mobile station for the respective networks.
RSST={rsst1,rsst2,rsst3,…….rsstk} is the set of threshold values of received signal strengths of respective networks.
RssDiff={RssDiff1,RssDiff2,…….rssDiffk} is the set of values of difference between the received signal strength and its threshold value.
CN = { } is the set of all eligible candidate networks into which the handoff can take place.
P={0,1/k,2/k,…..j/k,…1} is the set of priority values for jth network,

where j=1..k
The network base station (BS) and mobile station (MS) is observed for the RSS and Velocity respectively at the specified time intervals and the decisions are taken as below to select the candidate networks:
Let *the MS is currently in network ni* **Then**
If *RSSi < rssti* **then**
For all nj where j ≠ i
If *(RSSj > rsstj and vi < vtj)* **then**
{CN} = {CN} U {nj}
RssDiffj=RSSj-rsstj
The priory is assigned to all the networks as below-
Let there are n candidate networks out of k available networks then
- - 54 - -
For *j=1 to k* **Do**
If *j is not a candidate network* **Then**
Pj=0
Else if *j is the only candidate network* **Then**
Pj=1
Else if *network is at ith position in an ascending order sorted set of RssDiff* **Then**
pj=i/k;
Using above rule based the Network Discovery module filter the eligible networks from the all available networks.

6.4 Dynamic Decision

This module is responsible to take final decision of selecting a particular candidate networks from a set of candidate networks decided earlier by network discovery (ND) module. A dynamic score "***DScore***" is calculated for each network i as below-
DScorei = Si * pi (10)
Where Si is the score calculated by the NA module and pi is the priority decided by the ND module for the ith network.
A candidate networks which has highest corresponding value of"***DScore***" is selected as the "best" network to handoff.

6.5 Handoff Manager and Executor

This module is responsible for executing the handoff decisions. It handoff all the current transmissions to the network interface selected by the Dynamic Decision Module if the selected network is different from the current network. This handoff can be implemented based on any handoff Implementation techniques as described earlier in chapter 4. However, this model is more suitable to perform "Soft Vertical Handover" using application layer approaches like USHA

V. RESULTS AND DISCUSSION

NETWORK PERFORMANCE EVALUATION & RESULTS ANALYSIS

Performance Evaluation

The performance of the network is evaluated by following scenarios:

- WiFi + Wimax
- Wi-Fi + Wimax + LTE
- WiFi
- Wimax
- LTE

A network is considered that is covered by one BS and three APs. Remaining users are distributed in the network and are assigned velocities in the range. The threshold is set, The Wimax range is set to be 500m and the Wifi range is set in the range [200m 400m] and their corresponding frequencies are 5GHz and 2.5GHz respectively. The maximum tolerable system bandwidth is assigned.

Results analysis:

- Call Dropping
- Comparison delay
- Performance under Diff. Packet Loss

- Overall packet delivery ratio
- Overall throughput

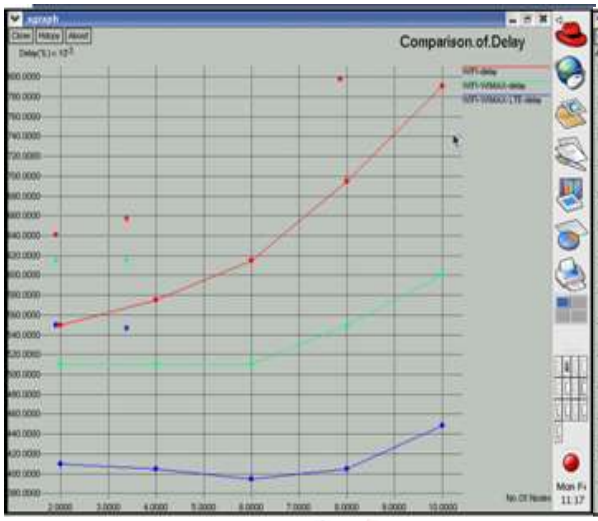

Fig.4. Comparison of Delay Wi-Fi, Wimax, LTE

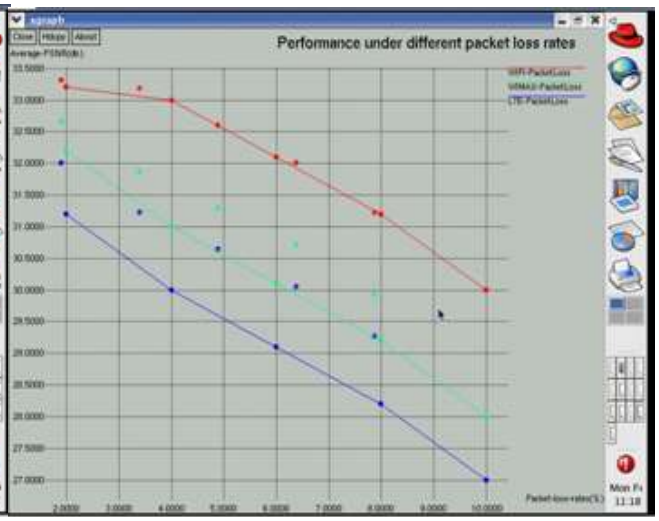

Fig.5. Performance under packet loss rates

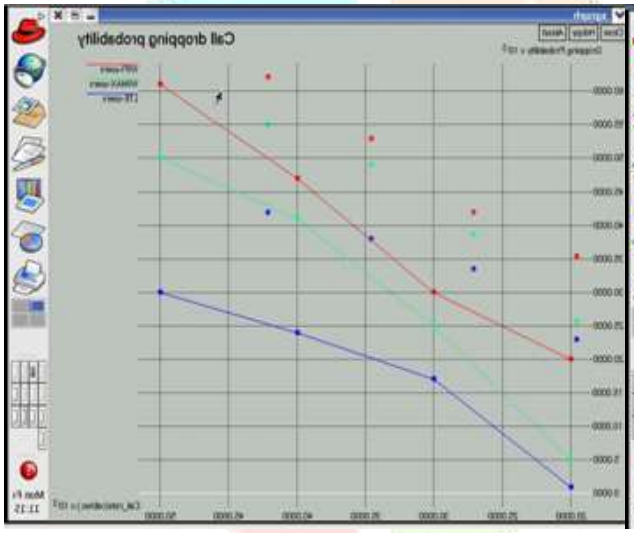

Fig.6. Call drop probability Wi-Fi, Wimax, LTE

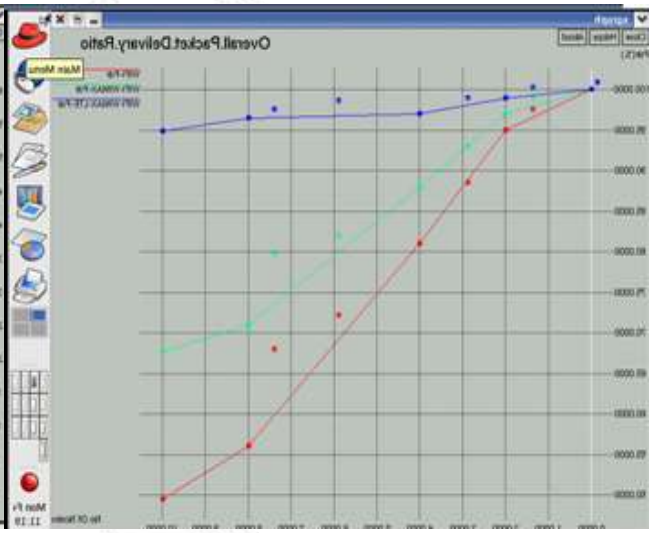

Fig.7. Overall Packet delivery ratio

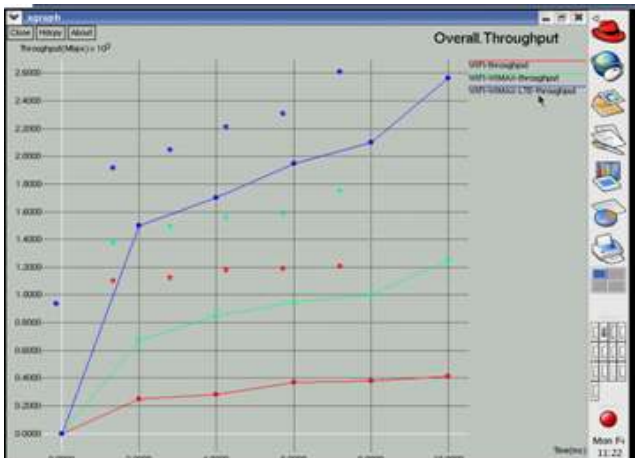

Fig.8. Overall Throughput

In the above figures, HO prediction is done on the parameters RSS and velocity. In the second scenario we propose a new VHO scheme considering an optimized objective function along with RSS and velocity. For that we are considering Wi-Fi , Wimax or LTE Network. The following result is obtained.

VI. CONCLUSION

In this paper an open source framework to simulate LTE networks, namely *LTE-Sim*, has been proposed. Features covered by this simulator will allow both researchers and practitioners to test enhanced techniques for improving 4G cellular networks, such as new physical functionalities, innovative network protocols and architectures, high performance scheduling strategies, and so on. The open nature of this software can allow people interested in research in this field to contribute to the development of the framework, furnishing a reference platform for testing and comparing new solution for LTE systems.Effectiveness of the developed simulator has been verified with several simulations to study the scalability and the performance of the framework. Such as the Wi-Fi, Wimax and LTE comparatively represented in above graphical representation.

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