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Modeling Effective Spectrum Vertical Handoff Schemes for K-Tier Heterogeneous Wireless Integrated Networks Sinrbased Vertical Handoff in K-Tier Heterogeneous Wireless Network

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Abstract: *Wireless communication is the transfer of power or information between two or more points that are not connected by an electrical conductor. In the same way wireless network is the method through which we used wireless data connection between nodes. Heterogeneous network shows the use of multiple types of access nodes in wireless network consists of devices using different underlying Radio Access Technology (RAT). Effective spectrum vertical handoff strategies for heterogeneous wireless networks are presented in the thesis. A heterogeneous network consists of multiple tiers of available wireless networks, framed as K-tier heterogeneous wireless network (KHWN). A typical KHWN adopted in the thesis consists of Global System for Mobile communication (GSM), Universal Mobile Telecommunications System (UMTS) and Long Term Evolution (LTE). The handoff scheme considers the Receiving Signal Strength (RSS) and Signal to Interference and Noise Ratio (SINR) with the cost as the key parameters for vertical handoff decision making process. The key parameter RSS is estimated through a proposed path loss model based on local terrain and is observed to be better as compared to the earlier empirical models. Following this a VHO scheme is proposed for voice and data communication. Subsequently this SINR and a KHWN consisting of multi-tier with the four types of services, voice call, video streaming, web browsing and telemetry are considered. In this multi-hierarchy decision making criteria the best suited Analytical and Hierarchical Process (AHP) is applied, for the decision making process in VHO. The proposed scheme of vertical handoff provides higher than the earlier algorithms of Combined SINR based Vertical Handoff (CSVH) and Multi-dimensional SINR based vertical handoff (MSVH). Also the unnecessary VHO are controlled by the proposed scheme. The result shows that the proposed scheme provides low cost trace and overall system throughput with a control of unnecessary handoffs for all kinds of services within the KHWN. It improves the handoff decision accuracy and performance.*

Keywords: *Vertical handoff scheme, k-tier heterogeneous wireless network, receiving signal strength, signal to noise and interference ratio, radio access technology, throughput*

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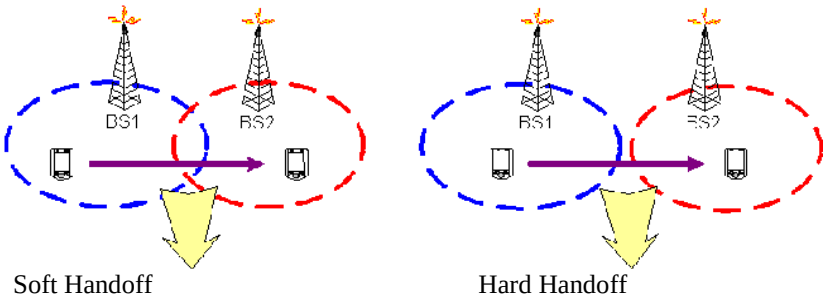
I. Introduction

The swift growth in wireless communication technology has changed human living standards. The mobile wireless industry started way back in 1970's with the first generation of mobile communication technology called 1G. Large size phone, frequent call drops and a limited mobility were the main drawbacks of this generation systems. In early 90's the popular Global System for Mobile Communication (GSM) designated as second generation (2G) was introduced. Due to higher demand for data services on wireless communication, the evolution led to third generation (3G) wireless communication technologies, Heterogeneous network shows the use of multiple types of access nodes in wireless network consists of devices using different underlying Radio Access Technology (RAT). There are two basic handoff techniques, Network Controlled Handoff (NCHO) and Mobile Controlled Handoff (MCHO). If the MS is measured to have a weaker signal in its existing cell, while a stronger signal is available in the neighboring cell, a handoff decision can be made by the network to switch the user to new BS from the old cell. MCHO is the highest degree of handoff decentralization, thereby enabling very fast handoff, typically on the order of 0.1ms as used in higher generations of networks



Soft Handoff Hard Handoff

A hard handoff is one in which the channel in the serving cell is first released and only then the channel in the target cell is engaged. the connection to the source is broken before, the connection to the target is made. Such handoff process is also known as break-before-make. Hard handoffs are intended to be instantaneous in order to minimize the disruption to the call. A soft handoff is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. A soft handoff is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell Handoff occurring within the same network is known as horizontal handoff. The concern of horizontal handoff is to maintain the on-going call, with the change of connectivity due to the movement of a mobile node. The concern of horizontal handoff is to maintain the on-going call, with the change of connectivity due to the movement of a mobile node. Handoff occurring within heterogeneous networks is known as vertical handoff. Vertical handoff is deferent from horizontal handoff. The access technology used is also changed along with the IP address, because the mobile nodes move deferent access network which uses deferent access technology.

II. VHOS Techniques Available

The present vertical handoff decision algorithm of the heterogeneous network is summarized, and existing problems and the future research direction are discussed [1, 8, 6].It is seen that the traditional handoff algorithm based on predefined path loss model with RSS is not suitable for heterogeneous wireless network with deferent kinds of user services at deferent terrain across all locations. The decision algorithms which take into consideration, the comprehensive network and decision factors, appeared to provide better handoff performance and improved user satisfaction index with better QoS [20, 21]. On the other hand, Next Generation Wireless Network (NGWN) is of complex structure resulted from the integration of heterogeneous wire-less networks. In these networks, the design of an effective vertical handoff balancing algorithm to improve the comprehensive performance of the whole system is a very important issue [4, 8, 9].

2.1. RSS based VHOS in k-tier heterogeneous wireless network

In this chapter we propose the VHOS between each tier of the network, after getting the proficiency and accuracy in the RSS measurement in each network of the KHWN domain. In the literature study we found most of the RSS estimations are based on selected empirical and statistical model with the local terrain data of Indian urban as well as sub-urban environments [2, 10]. The proposed statistical model aligns in accordance to the pre-set data, considering roof height, road width as normal random variables, by taking the real data of Indian urban and sub-urban terrain. The have parameters are modelled statistically, with the terrain information on, road width and roof top height, with height of base station, distance from base station. The model is validated by comparing the simulated results with the measurement campaigns carried out in urban and suburban regions [11]. From the path loss model the RSS has been estimated which gives a better performance [3]. The results of RSS for all networks considered are quite exciting and demonstrated in the simulation results of chapter-3. The new integrated KHWN concept is incorporated to achieve mobility within deferent tiers of networks using a VHOS based on the results of the RSS.

2.2 SINR and cost based vertical handoff in k-tier heterogeneous wireless network

The previous studies for vertical handoff in heterogeneous wireless networks such as combined SINR based vertical handoff (CSVH), multi-dimensional adaptive SINR based VHO algorithms (MASVHO) and multi-attribute vertical handoff algorithm with predictive SINR using grey model GM (1,1) use SINR, user required bandwidth, user traffic cost, utilization of each access network, and user preference [12,13]. However, all these techniques are applied to WLAN and WCDMA networks. Applying these methods for VHOS in KHWN and considering all types of traffics independently, it is found that the results provide less throughput with no remarkable reduction in traffic cost [5, 14, 15]. Hence we are motivated to propose VHOS for KHWN to provide seamless vertical handoff with multi attribute QoS [18]. The proposed method is superior to the existing methods in following performance indices.

1. SINR,

2. Bandwidth,
3. User traffic cost from k-tier access networks,
4. User preference criterion to make handoff decision,
5. Hysteresis buffer time.

The proposed VHOS deals with deferent traffic types, provides high system level throughput, as achieves low cost traffic. The result of the proposed SINR and cost based VHOS (SCVHOS) with the previous methods CSVH and MASVHO. The simulation results demonstrate the most optimal performance of the proposed scheme.Here we will show SINR based vertical handoff in k-tier heterogeneous wireless network. Simulation result and conclusions have been shown.

2.2.1 Vertical handoff in heterogeneous wireless network

The prime objective of VHO is to achieve mobility within heterogeneous wireless networks. The heterogeneous wireless network consists of multiple wireless technologies to provide diversified services to the mobile users. Mobility management addresses the key issues of location management and handoff management. Location management tracks the UE for successful information delivery.

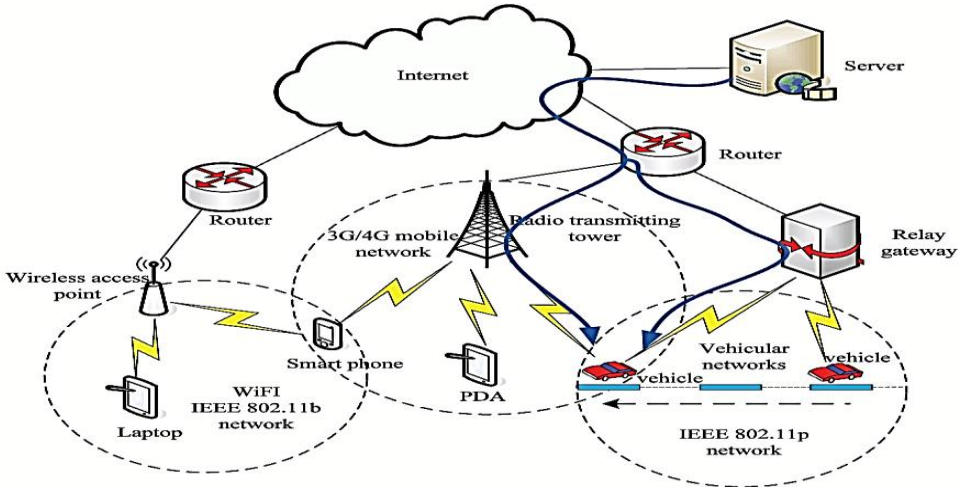


Fig.1 Multiple services provided by HWN

2.2.3 **SINR and cost based vertical handoff in k-tier heterogeneous wireless network**

The method finding of path loss for the local terrain with the estimation of RSS for all tiers of networks and proposing VHOS is discussed in the present chapter. Considering the same heterogeneous k-tier wireless network it is very much interesting toextend for SINR and cost basedVHOS.

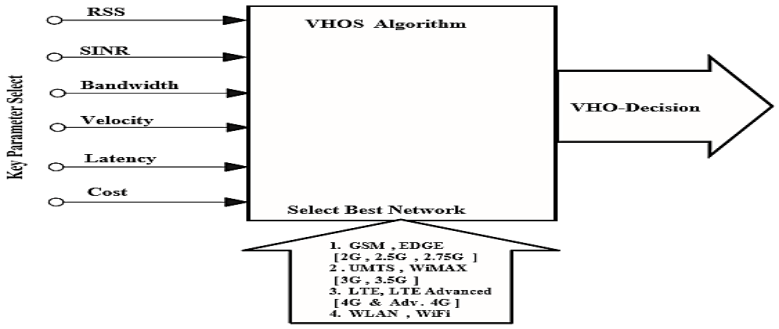


Fig. 2 Key parameters for VHOS

2.2.4 Heterogeneous Network Scenario

The LTE and WLAN networks are modeled considering the transceivers as per 3GPP standard. The UE's represents the end user's receiver and thee_{NB} ande_{APi}, represents the transceivers of LTE and WLAN respectively. The coverage of both the networks is taken a subiquitous for all the UEs. Considering n and m number of transceivers for the LTE and WLAN respectively are present in the networks and collecting all these transceivers into a matrix B, the transceivers can be represented as

$B = [e_{NB};e_{AP}]$

Where $e_{NB}= [e_{NB1}, e_{NB2}\ldots e_{NBn}]^T$

and $e_{AP}= [e_{AP_1}, e_{AP_2}, \ldots e_{AP\ m}]^T$

Thus, there are m+ntransceiverswheree_{NBi} isthei$_{th}$ transceiver of LTE and$e_{AP\,1}$is the j_{th} transceiver of WLAN. The indexing has been done from 1 to m + n in the set of B. The best possible transceiver channel, which is having best SINR, is assigned to the user equipment UE by the KHWN with the help of an algorithm

2.2.5 Signal to Interference and noise ratio

In heterogeneous wireless networks, signal propagation and the positioning of network transmitters and receivers are the key parameters which contribute to estimate the SINR. The availability and quality of the throughput of a transceiver depend upon the SINR value of the KHWN.The Shannon's The orem provides an upper bound to the capacity of a link, in bits per second (bps). The the orem is stated as

$$R_i^k = W \log_2\left(1 + \frac{\gamma_i^k}{\Gamma}\right) \quad 1$$

Where,$R_i^k$is the maximum achievable data rate, W is the bandwidth, ki is the SINR received at the UE k when associated with the transceiver Bi and is the dB gap between the encoded M-QAM and [capacity coding gain] [18]. Thus, the maximum achievable data rate for any LTE and WLAN link can be represented as (R^k_{eNBi}) and (R^k_{eAPi}) respectively. Since there is a relation between the data rate and SINR, hence SINR can be used to choose the transceiver from the KHWN. Similar toEquation 1 relation between SINR and data rate for individual LTE and WLAN in KHWN can be given as

$$R^k_{e_{NBi}} = W^k_{e_{NB}} log_2\,(1 + \frac{\gamma^k_{e_{NB}}}{\Gamma^k_{e_{NB}}}) \quad 2$$

$$R^k_{e_{APi}} = W^k_{e_{AP}} log_2\,(1 + \frac{\gamma^k_{e_{AP}}}{\Gamma^k_{e_{AP}\,k}}) \quad 3$$

The $\gamma^k_{e_{NB}}$ and$\gamma^k_{e_{AP}}$ are the receiving SINR. Assuming the same down link data rate for all co-existed networks and using (2) and (3), the relationship between and$\gamma^k_{e_{APi}}$ is given as

$$\gamma^k_{e_{NBi}} = \Gamma((1 + \frac{\gamma^k_{e_{APi}}}{\Gamma^k_{e_{APi}}}\left(\frac{W^k_{e_{APi}}}{W^k_{e_{NBi}}}\right) - 1) \quad 4$$

Similarly $\gamma^k_{e_{APi}}$ can be evaluated from$\gamma^k_{e_{NBi}}$.

The received SINR from e_{NBi^k} for i ($\gamma_{e_{NB}}$) no of UEs is converted to equivalent SINR of (γ_{AP}) to get the same received data rate.

2.2.6 Cost and Bandwidth

Considering the set of SINR values *S* for all e_{NB}s and e_{AP}s, can be represented as

$$S = \left(S_{e_{NB,i}} \cup S'_{AP,i}\right) \quad 5$$

For a required band width R_i for a user i, the minimum receiving SINR from $e_{NB}$and $\gamma_{min,\,i}$can be calculated from the relationship equation 5. Let C be the system cost vector in order to directly associate the cost value with the SINR value, the cost per bit is converted to cost per SINR (C_{SINR}).

Let W be the network available bandwidth vector. So the attribute matrix is as following:

$$R_a = \left[{}^{S-\gamma_{min}}_{U}\ {}^{1/C_{SINR}}\right] \quad 6$$

2.2.7 Vertical Handoff Scheme

Considering the findings of SINR and cost from the above discussion, the parameters can be set for VHOS in the KHWN. In this assumption we have considered the LTE and WLAN as the two tires of the networks as a part. So the VHOS decision making process can be set for the above assumption. We have also considered the four types of traffics in the decision making process.

- Voice
- Video Streaming
- Web browsing
- Telemetry

To rank the important decision parameters the decision making process made hierarchical, as shown in the figure 2 The previous study suggests that the AHP method is best suited for such decision making process. [18, 19]

Following this method we have taken the over all score of a target network among KHWN, determined by the weighted sum of all the absolute values obtained from the hierarchy of the network SINR, cost and bandwidth.

In AHP the Saaty's 9 point method deals with the pair wise comparison matrix. The selected network where,

- $A^*$is the comparison matrix

$$A^* = argmax \sum_{j=1}^{N}, W_{f_j r_{ij}}$$

- N - is the number of parameters
- m - denotes the number of candidate networks is KHWN
- r_{ij} value of the attributes
- j - the element of the attribute matrix
- W_{fj} denotestheweightfactor

Which indicates the importance of each attribute?

By applying the AHP method we use the eigenvalue method evaluate the relative weights of decision elements. Considering the high priority elements x_0 as the criteria and its dominant level below (D_L) has the elements, $x_1, x_2, x_3, \ldots, x_l$

The relative magnitude factorsin D_L are estimated through AHP pairwise comparison based on the judgments which are ranked on a Saaty9-point scale [16]. The results of the comparison are reciprocal of the numbers. The AHP comparison matrix M_{AHP} is consider which is a square matrix.Now we can calculate the eigenvector vector of the matrix M_C with the maximum eigenvalue valueλ_{max}.

According to the demand of traffic within KHWN between LTE and WLAN, the four types of traffic access classes of voice, video streaming, web browsing and telemetry. These four types of traffic access techniques can be represented by Matrix in AHP model as matrix M_{C1}, M_{C2} M_{C3} and M_{C4} respectively. For all classes the attributes are set according to the requirement and the AHP 9 point scale.

$$M_{c_1} = \begin{matrix} \\ c_1 \\ c_2 \\ c_3 \end{matrix} \begin{matrix} \begin{matrix} c_1 & c_2 & c_3 \end{matrix} \\ \begin{bmatrix} 1 & 1/9 & 1 \\ 9 & 1 & 9 \\ 1 & 1/9 & 1 \end{bmatrix} \end{matrix} \qquad 8$$

TheM_{C1} is the comparison matrix for conversational traffic of the KHWN. Similarly for video streaming M_{C2}, for web browsing M_{C3} and for telemetry M_{C4} are represented as follow:

Table 1: Represented consistency ratio

Traffic Type	SINR	COST	Bandwidth	CR
Voice	0.0909	0.8082	0.0909	0
Video Streaming	0.0704	0.1782	0.7514	0.0158
Web browsing	0.7143	0.1429	0.1428	0
Telemetry	0.7085	0.0603	0.2311	0

$$M_{c_2} = \begin{bmatrix} 1 & 1/3 & 1/9 \\ 3 & 1 & 1/5 \\ 9 & 5 & 1 \end{bmatrix} 9$$

$$M_{c_3} = \begin{bmatrix} 1 & 9 & 5 \\ 1/9 & 1 & 1/5 \\ 1/5 & 5 & 1 \end{bmatrix} \qquad 10$$

$$M_{c_4} = \begin{bmatrix} 1 & 5 & 5 \\ 1/5 & 1 & 1 \\ 1/5 & 1 & 1 \end{bmatrix} \qquad 11$$

Given in the above the decisions for each types of traffic specified throughеach type of networks, now we need to take decision for which is the best alternative for VHOS. So the pair wise comparison method of multi criteria decision making process using AHP has been adopted [98]. Here we attempted to determine the relative importance of each attributes. Applying the right principal eigenvector of matrix given the judgment with pairwise comparison and the approximation of the eigenvalue denoted byλ_X the consistency index can be calculated as

CI = (λ_X -n)/(n-1), so the consistency ratio CR can be evaluated CR = CI=RCI where random consistency index (RCI) is the average value of CI according to Saaty scale [17]. The well acceptance scale

value for CR is CR < 0:1 for which the matrixes are consistence as shown in table 1. The decision matrixes are considered to be consistence as we get the *CR* value less than 0.1. We have considered 4 types of traffic classes and the SINR, cost and bandwidth as the basic parameters for VHOS decision making process, which we got to be consistence as presented.

2.2.8. VHO decision process

The proposed VHOS is considered with three parameters

- QoS for each types of access
- Available number of choices of Networks forms the KHWN.
- Considered Hysteresis time buffer to avoid unnecessary handoffs

Hysteresis time defined as H_t is the buffer time for a VHO to trigger. The VHO triggers when the following condition satisfies.

$$\begin{cases} \mathrm{SINR}_{\text{current network}} > \mathrm{SINR}_{\text{predefined threshold}} \\ \text{and if} \\ \text{cost function value, of target network} < \text{cost value of current network} \end{cases}$$

The buffer hysteresis time included for determining the VHOS process H_t ifthe above criterion satisfies then the VHO can be triggered, considering the H_t If the hand of flatency is h_l and the number of evaluations N then the VHOS triggering time can be represented as

$$\mathrm{VHOS_t} = \frac{h_i}{e^{\mathrm{Ntarget}\ -\mathrm{Ncurrent}\ -1}} \quad 12$$

The N_{target} and$N_{current}$ are the cost function values of the current and target net- work, which can be dynamically changed over short period of time interval. So the H_t is modified as below, to achieve an adaptive VHO, which can deal with the dynamic KHWN.

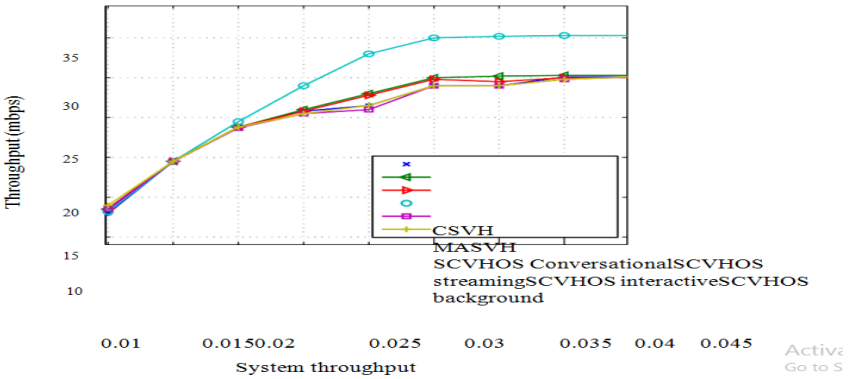


Figure3: The simulation result based on traffic through put, with the services like voice, video streaming web browsing and telemetry are demonstrated in this plot, and also the results are compared with the CSVH and MASVH type schemes environment. Considering the total evaluation count as 'n' and current evaluation is k.So the process will execute the same till k=N. So considering k = 0, h_1= 0

$$\emptyset = e^{N_{current}} - e^{N_{target}} \quad 13$$

$$\emptyset_k = \frac{h_l}{n} + \frac{h_l}{n(\emptyset_k - 1)} \quad 14$$

$$H_{t_k} = h_l \left(\frac{\emptyset_k}{n(\emptyset_k - 1)}\right) 15$$

The process executed until k = N

forφk >1 evaluating equation (15)we get

$$H_t = \sum_{K=0}^{N} \left[\frac{h_l}{N} + \frac{h_l}{N(\emptyset_k - 1)}\right] \quad 16$$

The simulation studies were conducted to get the best suited overall system through put and lowest traffi for access of voice, video streaming, web browsing and telemetry within KHWN for LTE and WLAN networks. Figure 3 shows the over all system through put from which it is seen that system through put is balanced in each type of traffic considering the attributes of bandwidth.

Average cost to user traffic of the algorithms

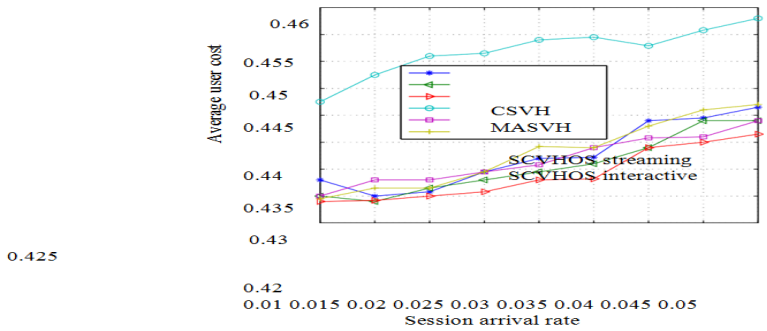


Figure 4: The simulation result based on traffic cost, with the services like voice, video streaming web browsing and telemetry are demonstrated in this plot, and also the results are compared with the CSVH and MASVH type schemes. The highest through put was seen for streaming videos as the through put requirement is more. The cost for each access technique has been represented in the Figure 4, where, the cost is seen to be lower than the earlier schemes of CSVH.

III. Result And Discussion

The performance of SINR and Cost based Vertical Hand off Scheme (SCVHOS) was evaluated concentrating on the download traffic, as the download traffic normally require higher bandwidth in case of video streaming, web browsing andtelemetry. The SCVHOS performance is simulated with respect to cost and the overal lsystem throughput as demonstrated in Figure 3. The performance is compared to the combined SINR based vertical handoff (CSVH) and multi-dimensional adaptive SINR based vertical handoff (MASVH) (k = 4) algorithms shown in Figure 2. The VHOS for KHWN remains a challenging problem in order to provide voice, data, and multimedia seamlessly in each tier of the network. The proposed VHOS using SINR, Cost and Bandwidth are taken as QoS criterion for VHOS in next generation cellular networks LTE and WLAN. The proposed scheme of VHOS achieved QoS better than the earlier algorithms of CSVH and MSVH. In addition to that, here modified hysteresis time is applied in order to reduce the ping pong VHO. From the simulation studies it is seen that the result achieved here is better than that of earlier methods. The number of VHOs considerably reduces as

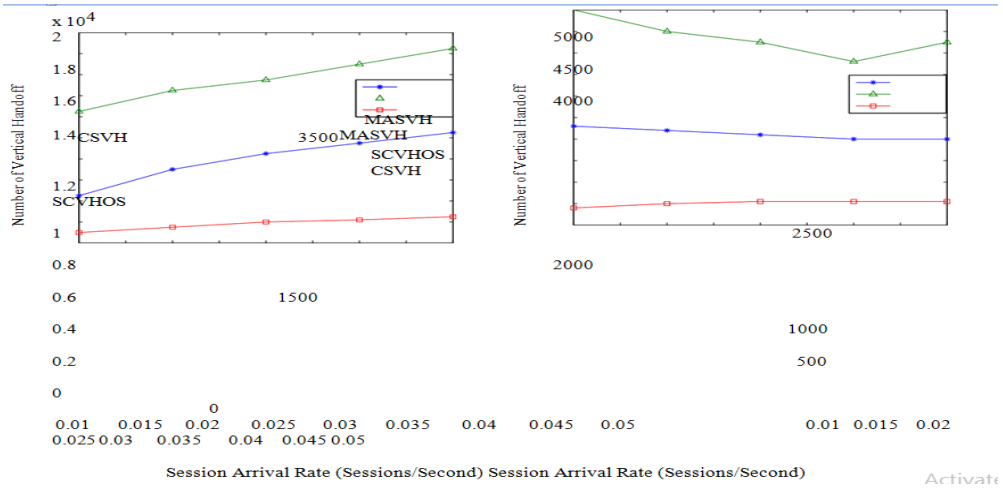
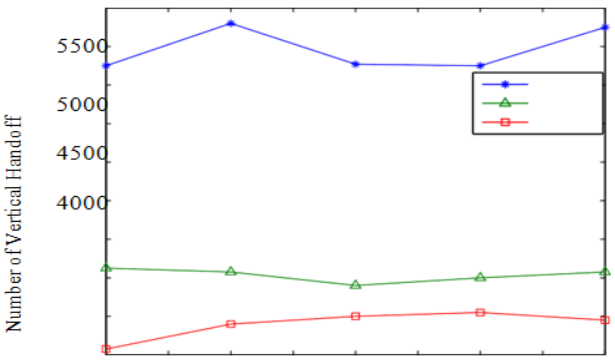


Fig.5 Number of VHO for Voice **Fig.6** Number of VHO for Video Streaming



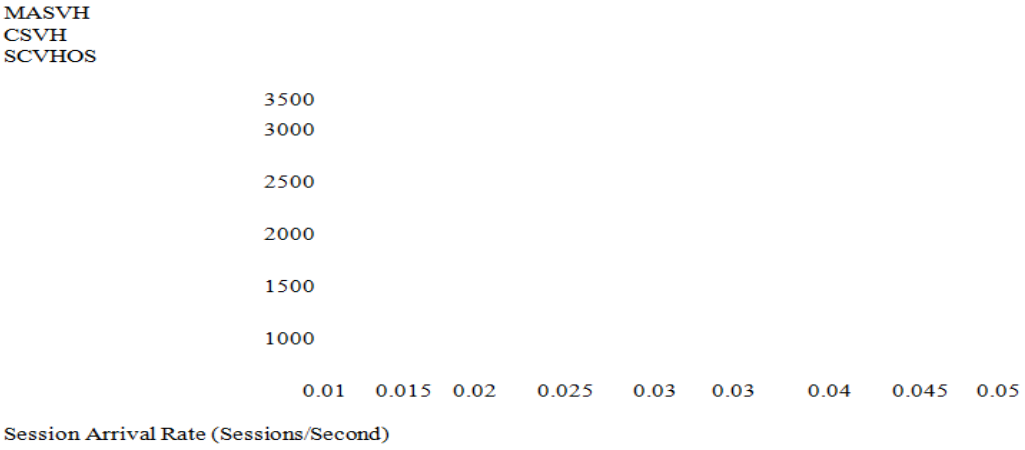


Fig.7 Number of VHO for web browsing.

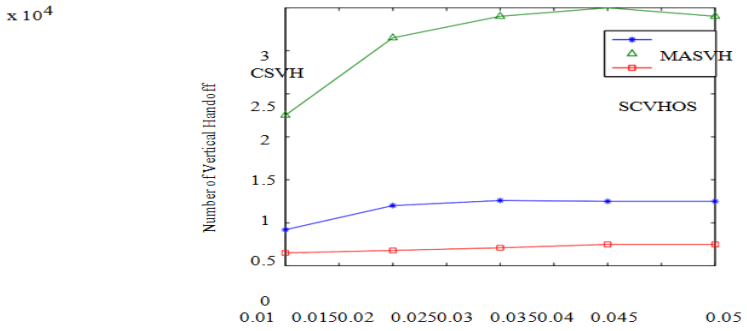


Fig.8 Number of VHO for Telemetry

IV. Conclusion

The vertical hand off schemes for heterogeneous networks were proposed based on some estimated RSS and SINR earlier, which did not take in to account the inputs of local terrain with multiple tiers of heterogeneous wireless networks and the quality of service. In order to improve the vertical hand off schemes for k-tier heterogeneous wireless networks, the present work proposes some novel VHOs techniques.

A comprehensive study of VHO and VHO algorithms is presented in this report. These algorithms are categorized into four groups as RSS, bandwidth, cost function and combination based algorithms. VHO algorithms reported in standard literature lack a comprehensive consideration of various network parameters, like user mobility and user preferences.There search project presented in this thes is add these issues and provide an integrated solution to the VHO process for near optimal performance. The framework for VHO is provided considering the most robust method of calculatingthepathlossthroughlocalterrain. Proposed local terrain based RSS method for KHWN improves the quality of receiving signals and hand off. The basic parameters of SINR and traffic cost are then considered as the key parameters for VHOS. Based on these parameters, the VHOS is proposed with the best suited analytical hierarchical process AHP for vertical hand off within the KHWN environment. The results found are observed to offer better quality of through put, cost effective traffic, and lower ping pong hand off sandal somulti-tier supported.

V. Scope For Future

Perceiving the proposed VHOs in comparison to the existing algorithms, several ideas and improvements have been devised that may help form the basis of future work to be carried out in this research area. The work presented here is carried out in the analytical and simulation environment. So the work has a scope to be extended for an environment, with more real time constraints.Further similar schemes have a scope for being proposed for fifth generation or beyond networks. If the Light Fidelity (LiFi) network is implemented then the hand off will be essential for mobility. The hand off is really an ever challenging process with the evolution of wireless communication standards.

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Abhishek Singh

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