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An Improved Proactive Handover Prediction and Decision Algorithm for Wireless Mobile Networks

Vidhate Amarsinh*
Department of Computer Engineering
India

Devane Satish
Department of Information Technology
India

Abstract— Multimedia and video streaming applications are becoming more popular and used by most of the users because of advances in mobile devices and mobile wireless networks. Maintaining continuity of video stream in mobility, handover protocol plays a pivotal role. The important task of handover process is handover prediction and decision. This paper presents a novel approach by considering a traditional approach of received signal strength indicator and also includes other parameters to form a better handover prediction and decision mechanism which selects best new point of attachment to continue its services.

Keywords— Handover, handover prediction, handover decision, Fast MIPv6

I. Introduction

With the advancements of video streaming applications, an integration of mobility and information services has become an immediate issue in the modern world. The video streaming applications are span from traditional telecom services such as Voice over IP (VoIP) and video conference to entertainment and Video on Demand (VoD) [1].

For Each video application based on mobility has a specific quality of service (QoS) requirements. One such application is video streaming and the most challenging issues in supporting mobility for such application is the avoidance of flow interruptions when clients roam from one wireless locality to another. In order to provide uninterrupted services and maximum user-perceived quality, a successful video streaming solution needs to adapt to mobile handover scenarios. An efficient handover decision plays a vital role to subsidies the handover after-effects especially when the application is video streaming on move. The present handover decision typically considers only connectivity signal strength from various Point of Attachment (PoA) in the proximity [2] and selects next PoA based on that. The handover decision based only on Received Signal Strength Indicator (RSSI) can provide the next point of attachment but fails to confirm the suitability of that PoA for applications like video streaming.

The above issue motivated us to formalize the mechanism to select the best AP from the proximity, based on the application requirements. This paper provides a proposal for improving the handover decision making process by considering supplementary parameters along with RSSI as a main parameter. Our objective is to make handover decision so efficient that only the best PoA is selected. Our results prove the completeness of an objective which minimizes the issues like packet losses, false handover, unnecessary handover and improves Quality of Service (QoS) as well as Quality of Experience (QoE).

The rest of this paper is organized as follows. Section II discusses about the literature review. In section III we discuss about the handover prediction and decision mechanism. Section IV unfolds our proposal for an improved proactive handover prediction and decision algorithm to select the best PoA for the service continuity. Section V reports our simulation experimental results. Our concluding remarks along with future research note are given in Section VI followed by refrences.

II. Literature Review

Khatib Noaman Ashraf, Vidhate Amarsinh and Satish Devane [1] have presented the analysis for mobility management protocols along with a comparative study of signalling delay and handover latency. Pollini *et al.* [2] has suggested various approaches to take Handover (HO) decision as RSS with threshold, RSS with threshold and hysteresis and future prediction of RSS. Inclusion of Threshold and Hysteresis Margin reduces Unnecessary HOs, but still a wrong decision for HO may drop the call due to increase in HO delay. Especially hysteresis margin avoids ping-ponging effect. Prediction of the future RSS helps in reducing unnecessary HO as compared to threshold and hysteresis methods. But still RSS alone is not sufficient to take decision. Mobile IP [MIP] [3] is a first development in terms to provide IP handover to route the packets, which follows various improvements and extensions. The various extensions are Fast MIPv6 [4], Hierarchical MIPv6 [5], Proxy MIPv6 [6] and our own proposed model i.e. improvement to Fast MIPv6 [7].

Xiaohuan Yan *et al.* [8] and Jong-Hyouk Lee [9] have presented a comprehensive survey of the handover algorithms designed to satisfy various requirements based on parameters. To offer a systematic comparison, they have categorized the algorithms into four groups based on the main handover decision criterion used. Also, they have evaluated tradeoffs between their complexity of implementation and efficiency for various proposals. Ali Safa Sadiq *et al.* [10] states that RSS predictions of handover decisions do not perform well. It is a need to develop an intelligent approach to predict the handover decision process, thus yielding seamless handovers. They have proposed a Mobility and Signal Strength-Aware Handover Decision (MSSHD) approach to predict the handover decision in wireless networks. The Received Signal Strength Indicator and the direction of Mobile Node parameters are considered as inputs to the fuzzy inference system to predict the handover decision, and hence switching to the best preferable access point, resulting in reduced handover latency as well as the wireless access media delay.

A. Bhuvaneswari *et al.* [11] have considered that each application requires different QoS, so the network selection may vary accordingly. To achieve this goal and to select the best network for a mobile terminal when moving from one network to another, it is necessary to have a good decision making algorithm which decides the best network for a specific application that the user needs based on QoS parameter. They have considered various parameters like data rate, bandwidth, and coverage for the decision. Ravindra Agarwal and Amarsinh Vidhate [12] have stated that, many times the handover decision is taken not only based on Received signal strength (RSS) but also other factors like available bandwidth, total required bandwidth, expected delay, packet jitter, packet loss and cost per byte. They have analysed various handover decision techniques to understand the handover initialization reasons and proper handover trigger. P. Bellavista [13] *et al.* have considered that, with signal strength, other factors like handover awareness, QoS awareness and location awareness are also some of the crucial factors to be considered for handover decision. But more parameters introduce more delay, which may not be very suitable for applications like video streaming.

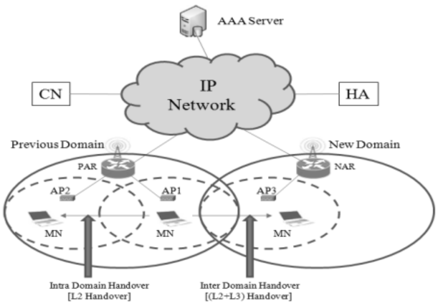
Roy S.D. *et al.* [14] have proposed received signal strength (RSS) based strategy for handover in heterogeneous networks which considers RSS and bandwidth. Further these strategies have been modified by considering averaging of RSS. For comparison purposes, the performance of the Vertical Handover (VHO) algorithm also considers hysteresis and dwell timer. Wireless Bandwidth estimation tool (WBest) [15] was designed for fast, non-intrusive and accurate estimation of available bandwidth in IEEE 802.11 networks. Anagha Raich and Vidhate Amarsinh [16] have presented the selection of the best path based on signal strength, RTT and packet losses. Yutao Ling *et al.* [17] have analysed vertical handover decision strategy using the parameters like network bandwidth, RSS and variation of RSS. The performance of this strategy has been analysed and it observes that it greatly reduces the handover call dropping probability than the current existing strategy. Qing He *et al.* [18] have proposed Cost function based strategy for providing ubiquitous access by considering RSS, network bandwidth, monetary cost and user preference as the handover decision parameter. For the handovers initiated by point of attachments, cost function based scheme is utilized to find out network selection function with lower values to select the target network. Vidhate Amarsinh and Satish Devane [19] have done an excellent research on selection of the best access point. The scheme decreases the probability of call blocking and call dropping.

T. Inzerilli *et al.* [20] have presented a novel location-based algorithm for managing soft mobile-controlled handover between wireless systems to reduce ping-pong effect. Huiling Jia *et al.* [21] suggested policy-enabled decision strategy using MAC layer sensing technique, designed to estimate the handover metrics in IEEE 802.11. Simulation results for the proposed handoff decision strategy overcome the drawback of unnecessary handovers. Yang *et al.*[22] has suggested that in order to provide multimedia QoS inside the integrated network environment, the vertical handover algorithm needs to be QoS aware, which cannot be achieved only by RSS based handover criteria. Even in achieving the best possible performance, only RSS as handover indicator is not a good solution. They have considered VHD between WLAN and WCDMA networks using SINR as a handover indicator. Joon-Myung *et al.* [23] have suggested that a user's personal preferences towards an access network could be another criteria to select a best satisfying network over only best connected network from the available networks.

Based on the literature survey, where many researches are claiming that received signal strength indicator (RSSI) is not the only criteria for the handover decision making for QoS based applications like video streaming. All the above identified issues are important causes to improve the QoS during handover. We undertake these issues as challenges and motivation to continue our research.

A handover or handover is a movement of a Mobile Node between two points of attachments (PoA), i.e., the process of terminating existing connectivity and obtaining new connectivity [1] [7].

Figure 1 shows handover in wireless mobile network. Handover Latency is the time interval during which a Mobile Node (MN) does not send or receive any packets during handover, as it is not connected anywhere. Handovers in IP-based Next Generation Wireless Network (NGWS) may involve changes of the PoAs at the link layer and routing



changes at the IP layer. Efficient mechanisms must ensure seamless handover, i.e., with minimal signalling overhead, minimum handover latency, lesser packet loss, minimum handover failure and maximum service continuity [7].

III. HANDOVER PREDICTION AND DECISION

In order to prevent the service interruptions while serving the video stream to MNs, the prediction of handover is imperative. It allows performing the required service management operations in advance with respect to the actual communication level client handover. The main aim of handover prediction depends on proactively moving the client to the exact predicted next wireless location. In this phase, the handover prediction is performed proactively based on data link monitoring using the Received Signal Strength Indication (RSSI) of clients. The handover decision is triggered when the roaming client encounters a change in its link state [2] [10].

A. Proactive Handover Decision

The proactive method of triggering the handover takes place in prior to the absolute loss of original clients signal. i.e. if the RSSI of the new client crosses the threshold (Preset) value, then the handover gets triggered. The signal strength goes down with distance. The mobile nodes are continuously scanning for new PoAs for better connectivity. The present mechanism adds hysteresis so that a ping-pong effect should not arise. T_{hp} is the hysteresis thresholds given for the handover prediction and decision whereas T_{hh} is the hysteresis thresholds for handover. Once the conditions are fulfilled, the mobile node is connected to the subsequent PoA. The present systems use hysteresis and threshold along with the RSS and hands the user to a new PoA only if the current signal level drops below a threshold and the target PoA is stronger than the current and linear during a given hysteresis margin.

The present study shows the proactive handover decision using the following conditions.
Let R_{PoAnew} be the RSSI value of visible PoA
Let R_{PoAold} be the RSSI value of current PoA.
Let T_{hh} be the threshold value of hysteresis for handover.
New PoA selection algorithm (Traditional)

If $R_{PoAnew} > (R_{PoAold} + T_{hh})$
Then
    Handover is triggered
    Handover Execution
End if

If more predictions are simultaneously enabled, then the proactive handover considers PoA with strongest RSSI value.

IV. IMPROVED PROACTIVE HANDOVER DECISION

A handover decision plays a vital role for the continuation of the data flow during mobility period. An intelligent selection of network parameters add to its right selection of PoA which lead towards a valuable contribution for the applications like video streaming and its video continuity during handover period. Various network parameters have been identified which are Received Signal Strength (RSS), Round Trip Time (RTT), Available Bandwidth, Packet loss ratio, Peak Signal to Noise Ratio (PSNR), Network Connection Time (Lifetime), Power Consumption, Monetary Cost, User preferences, Location and velocity of MN, Quality of Service (QoS) and QoE etc. There are other parameters also like, better coverage, lesser latency, lesser Carrier-to-Interferences Ratio(CIR), lesser Signal-to-Interferences Ratio (SIR), lesser Bit Error Rate (BER) etc., more security level, proper QoS class based on the applications, are some of the parameters to be considered for the selection process [11][12][13][16][17][18].

After the literature review, following parameters have been considered for selection of the best PoA for handover based on requirement of video streaming application to maintain quality of service intact.

- Received Signal Strength: Received Signal Strength (RSS) is the key factor for handover decision. RSS is an indication of the power level being received by the antenna. Therefore, the higher the RSS number, the stronger the signal. RSS is typically converted into predefined levels. Signal strength does not fade in a linear manner, but inversely as the square of the distance. RSSI denotes generally range from -20 to -100 dBm.

- Available Bandwidth: An estimation of available bandwidth before handover takes place to support video continuity plays an important role to select a potential PoA. It is generally known as the link capacity in a network. The best PoA selection is required towards seamless video continuity and counting in Mbps. the bandwidth is higher, it lowers the call dropping and call blocking probability.

- Return Trip Time (RTT): RTT is the length of time it takes for a signal to be sent plus the length of time it takes for an acknowledgment of that signal to be received. This time delay therefore consists of the propagation times between the sender and the receiver and counting in milliseconds.

- Packet Loss Ratio: Packet Loss Ratio (PLR) is the ratio of lost packet outcomes to total transmitted packets and counting number of packets. One of the major reasons for packet loss is the inadequate signal strength.

The sufficient indication of RSSI from the nearby PoAs, above the threshold gives a trigger to handover. But it is not adequate to handle applications like video streaming due to the variable nature of mobile networks in terms of bandwidth, delay, jitter and interference as discussed in review section. The following figure shows a scenario for improved proposal.

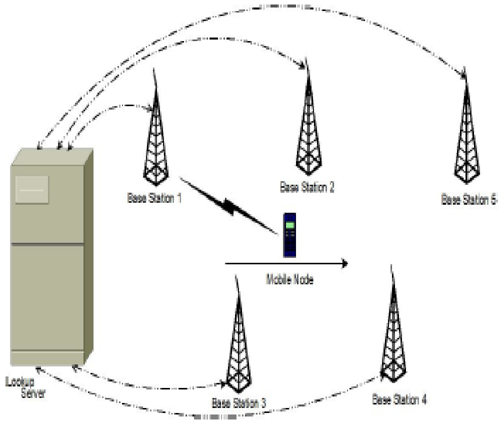


Figure 2: Scenario

Figure 2 shows a typical scenario where mobile node is connected to PoA_1 and moving towards the other end. We assume that, the Mobile Node is connected to video server or gateway through PoA_1 and running video streaming application. During the scanning process the mobile node is continuously scanning the signal strength from the available PoAs. When the user mobile node is in mobility, it has many options for point of attachment (PoA) to connect based on the availability of APs in that area. Figure 4 shows the scenario, where other POAs like PoA_2, PoA_3, PoA_4 and PoA_5 are the available PoA options. The traditional method selects either PoA_2 or PoA_3 having excellent signal strength, but its bandwidth is low, which may not be very suitable for the connectivity of video streaming. Our proposal considers multiple parameters to decide and it may choose PoA_4 whose RSSI is little weak, but bandwidth is more it can support as well as its packet loss ratio is also very low.

An Improved proactive method of triggering the handover takes place in prior to the absolute loss of original clients predefined threshold value i.e. when the score value of the function is the minimal of the score values of other PoAs. We have introduced a concept of Lookup server which is also a part of regional network domain. All the PoAs are sending information about the above mentioned parameters, periodically. We call it as footprints.

The Improved Proactive handover prediction & Decision algorithm is as follows:

Step 1: MN is connected to one of the PoAs.
Step 2: Lookup server is connected to all the PoAs.
Step 3: The footprints consisting of parameters like RSS, RTT, Bandwidth & Packet loss are sent to the lookup server periodically.
Step 4: when MN is losing connectivity due to loss of function value below threshold, then MN sends a request to lookup server to find out the best PoA available as per the need.
Step5: As Lookup server is having all the footprints and selection function, the outcome is the Best PoA and inform it to MN through old PoA.
Step 6: MN starts association / Reassociation function for further handover process.

The present study provides a policy for streaming video application on mobile devices based on above mentioned parameters. There are certain policies defined dynamically and based on the application requirements. We consider RSSI, Bandwidth, RTT and packet loss.

A proactive handover trigger function using the following conditions is defined below. The variables are RSSI, BW, RTT and λ. The function f_{RSSI} gives RSSI value, the function f_{BW} gives the bandwidth value, the function f_{RTT} gives the return trip time value and the function f_λ gives a packet loss value. The function f_{APi} is the function available at lookup server which takes values for each AP. This information is available to mobile node from the look up server by firing a lookup query.

$$f_{PoA_i} = \begin{array}{l}(W_{RSSI} * f_{RSSI}) * N_{RSSI} + (W_{BW} * f_{BW}) * N_{BW} + \\ (W_{RTT} * f_{RTT}) * N_{RTT} + (W_\lambda * f_\lambda) * N_\lambda\end{array}$$

Where value of 'i' varies from 1 to n (No. of PoAs)

Following are the normalization functions.

$$N_{RSSI} = \frac{RSSI - RSSI_{min}}{RSSI_{max} - RSSI_{min}} \qquad N_{BW} = \frac{BW - BW_{min}}{BW_{max} - BW_{min}}$$

$$N_{RTT} = \frac{RTT - RTT_{min}}{RTT_{max} - RTT_{min}} \qquad N_\lambda = \frac{\lambda - \lambda_{min}}{\lambda_{max} - \lambda_{min}}$$

To bring all these parameters to a common scale, weight have been defined to these parameters based on their importance and normalized later. The present policy is defined for video streaming application due to the stringent requirement of sufficient bandwidth and less packet loss. So we assume more weight for RSSI, however BW, RTT and packet loss are assigned less weight as follows,

$$W_{RSSI} = 70\%,\ W_{BW} = 10\%,\ W_{RTT} = 10\% \ \&\ W_\lambda = 10\% \qquad (2)$$

Where the sum all weights is 1.

$$W_{bw} + W_{RTT} + W_{RSSI} + W_\lambda = 1$$

The Best AP selection function is available at MN and it is defined as

$$f_{PoA_{Best}} = MIN(f_{PoA_1}, \ldots\ldots, f_{PoA_n})$$

All the scoring values are given to the best PoA selection function and the PoA having minimum score is selected as the best AP. The connection is immediately done after that.

V. Implementation and Simulation Results

For the simulation in NS2 [25], UDP Continuous Bit Rate (CBR) as well as Variable Bit Rate (VBR) traffic is introduced. The simulation topology considers limited handovers with 802.11 WLAN standards for implementations [26] and No Adhoc (NOAH) mode for the topology. NOAH is a wireless routing agent that (in contrast to DSDV, DSR) only supports direct communication between wireless nodes or between base stations and mobile nodes in case Fast Mobile IP is used. This allows simulating scenarios where multi-hop wireless routing is undesired.

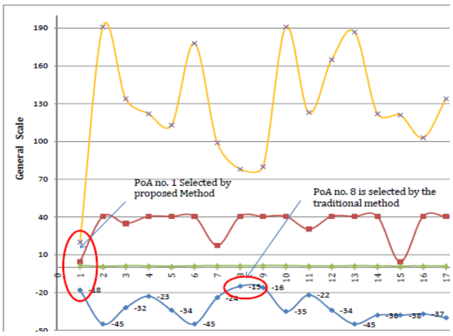


Figure 3: PoA selection by traditional & Improved Proposal

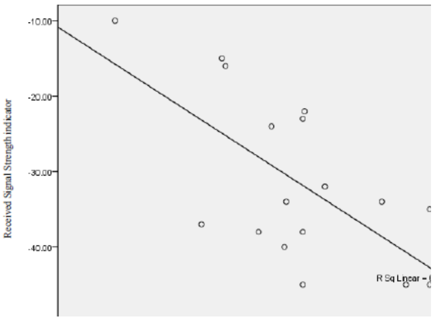


Figure 4: Correlation between RSSI and Packet Loss

In figure 3, PoA selection is shown with the help of traditional method and improved method. The PoA_8 is selected as it is getting maximum signal strength in that proximity, whereas PoA_1 is selected by the improved method. The reason is that, the RSS is more, RTT is least, available bandwidth is more and packet losses are less. The decision is taken by the decision function available at lookup server and the inputs available to the decision function in terms of footprints values.

In figure 4, correlation between RSSI and packet loss is shown which is equal to 0.417. It indicates an inverse relation between signal strength and packet loss. When the signal strength is good, the no. of packet losses is less. There is a similar relation between other parameters.

Table-1 Look Up Database					
Network ID	Timestamp	RSSI	Available bandwidth(ABW)	Round trip time (RTT)	Packet Loss (Λ)

Figure 5: Periodic footprint format

In figure 5, a periodic footprint format is shown. There are various parameters as a part of the footprint format. The respective table is shown as follows,

VI. FOOTPRINT VALUES AND FUNCTION VALUES

TABLE 1

PoA no.s	RSSI (dBm)	Available bandwidth (mbps)	RTT (ms)	Packet Loss (per second)	Function value
1	-18	1.45	4.5	20	-30268
2	-45	0.96	40.5	191	350389
3	-32	1.33	34.9	134	140787
4	-23	1.23	40.5	122	108252
5	-34	0.96	40.5	113	100460
6	-15	1.36	40.5	78	31339.8

There are various footprint values shown in the above table 1. The traditional method based on RSS, selects the PoA_6 and improved method selects PoA_1 based on the calculations and the minimum value out of that. The reason behind the selection is strong RSS, excellent bandwidth, lesser RTT and lesser packet loss.

VII. CONCLUSION AND FUTURE RESEARCH

Handover prediction and decision is one of the important phases of a successful handover process. Our proposal selects the best PoA from the available options and promotes video continuity due to the better decision making. In future, authors propose to apply various policies to variety of applications and design a dynamic decision policy based on the requirements of a user as well as a network.

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REFERENCES

[1] Ashraf K.N.,Amarsinh V. and Satish D.,“Survey and analysis of mobility management protocols for handover in wireless network,” IEEE 3rd International Advance Computing Conference (IACC), pp. 413-420,Feb.,2013.

[2] Pollini G.P., “Trends in handover design,” IEEE Communications Magazine,34(3)82-90,Mar 1996.

[3] D. Johnson, C. Perkins, and J. Arkko, “Mobility Support in IPv6,” IETF RFC 3775, June 2004.

[4] R. Koodli, “Fast Handovers for Mobile IPv6,”IETF RFC 4068, July, 2005.

[5] H. Soliman, C. Castelluccia, K. ElMalki, and L. Bellier, “Hierarchical Mobile IPv6 Mobility Management (HMIPv6),” IETF RFC 4140, August 2005.

[6] S. Gundavelli, K. Leung, V. Devarapalli, K. Chowdhury, and B. Patil, “Proxy Mobile IPv6,” IETF RFC 5213, August 2008.

[7] Vidhate Amarsinh and Satish Devane, “Improved Latency Handover in Fast MIPv6 for Streaming Video,” Springer-Verlag Berlin Heidelberg 2013, ICAC3 2013, CCIS 361, pp. 381–392, 2013.

[8] X. Yan, Y. Ahmet, and S. Narayanan, “A survey of vertical handover decision algorithms in Fourth Generation heterogeneous wireless networks,” Computer Networks, vol. 54, pp.1848–1863, 2010.

[9] Jong-Hyouk Lee, Jean-Marie Bonnin, Ilsun You, Tai-Myoung Chung, “Comparative Handover Performance Analysis of IPv6 Mobility Management Protocols,” IEEE Transactions On Industrial Electronics, vol. 60, no. 3, pp. 1077-1088, March 2013.

[10] Ali Safa Sadiq, Kamalrulnizam Abu Bakar, Kayhan Zrar Ghafoor, and Alberto J. Gonzalez, “Mobility and Signal Strength- Aware Handover Decision in Mobile IPv6 based Wireless LAN,” Proceedings of the international multiconference of Engineers and Computer Scientists, IMECS 2011, March 16-18, 2011, Hong Kong.

[11] A. Bhuvaneswari, “An Overview of Vertical Handover Decision Making Algorithms,” I. J. Computer Network and Information Security, 9, 55-62 August 2012 in MECS (http://www.mecs-press.org/).

[12] Ravindra R.Agrawal, Amarsinh Vidhate,“Optimized Heterogeneous Wireless Network with Scoring Methods,” International Conference & Workshop on Recent Trends in Technology, (TCET) 2012 Proceedings published in International Journal of Computer Applications (IJCA), Vol. icwet, number 8, pages-28-32, March 2012, Published by Foundation of Computer Science, New York, USA.

[13] Paolo Bellavista, Antonio Corradi and Luca Foschini,“Context-aware handover middleware for transparent service continuity in wireless networks,” Pervasive and Mobile Computing, Elsevier, Vol. 3,PP. 439–466,2007.

[14] Roy S.D., Anup, S.,“Received signal strength based vertical handover algorithm in 3G cellular network, Signal Processing,”IEEE International Conference on Communication and Computing (ICSPCC), 2012,vol., no., pp.326,330, 12-15 Aug. 2012.

[15] Mingzhe Li, Claypool, Mark Kinicki, Robert, “WBest: A bandwidth estimation tool for IEEE 802.11 wireless networks,” Local Computer Networks, 2008. LCN 2008. 33rd IEEE Conference on, v, pp.374-381, 14-17 Oct. 2008.

[16] Anagha R. Raich, Amarsinh Vidhate, “Best Path Selection Using Location Aware Modified AODV,” International Journal of Advanced Computer Research (ISSN (print): 2249-7277, ISSN (online): 2277-7970) Volume-3 Number-3 Issue-11 September-2013.

[17] Yutao Ling,Benshun Yi, Qiuping Zhu,"Vertical Handover Decision Strategy in Wireless Overlay Networks, Wireless Communications, Networking and Mobile Computing,"WiCom 09. 5th International Conference on wireless communication , vol., no., pp.1,3, 24-26 Sept. 2009.

[18] Qing He, "A novel vertical handover decision algorithm in heterogeneous wireless networks," IEEE International Conference on Wireless Communications,Networking and Information Security (WCNIS), 2010,vol., no., pp.566,570, 25-27 ,June 2010.

[19] Vidhate Amarsinh , Devane Satish, "Seamless video streaming using improved handover prediction and session handover in mobile networks," International Journal of Computer Engineering & Technology (IJCET), Volume 5, Issue 4, April (2014)

[20] T. Inzerilli, A. M. Vegni, A. Neri, and R. Cusani,"A Location-based Vertical Handover algorithm for limitation of the ping-pong effect",IEEE International Conference on Wireless & Mobile Computing, Networking & Communication, 2008.

[21] Huiling Jia and Peng Cheng and Zhaoyang Zhang and Shiju Li, "An Improved Adaptive Decision Scheme for Vertical Handover in Heterogeneous Wireless Networks," International Conference on Communications, Circuits and Systems Proceedings, vol. 3, pp.1816-1820,June 2006.

[22] Kemeng Yang and Gondal, I. and Bin Qiu,"Multi-Dimensional Adaptive SINR Based Vertical Handover for Heterogeneous Wireless Networks," IEEE Communications Letters, vol. 12, no.6, pp.438-440,June 2008.

[23] Joon-Myung Kang and John Strassner and Sin-seok Seo and James Won-Ki Hong,"personalized handover decisions for mobile services in heterogeneous wireless networks,journal Computer Networks,vol. 55,no.7,pp.1520-1532,2011

[24] Kristian Evensen, Andreas Petlund, Haakon Riiser, Paul Vigmostad, Dominik Kaspar1, Carsten Griwodz, Pål Halvorsen,"Mobile Video Streaming Using Location-Based Network Prediction and Transparent Handover,"21st international workshop on Network and operating systems support for digital audio and video ,Page(s) 21-26, ACM New York, NY, USA,2011.

[25] Kevin Fall, Kannan Varadhan, "The ns Manual," The VINT Project, A Collaboration between researchers at UC Berkeley, LBL, USC/ISI, and Xerox PARC, May 2010.

[26] 802.11 Wireless Networks: The Definitive Guide, 2nd Edition By Matthew Gast , Publisher: O'Reilly Media,, Released: April 2005.