

# Fuzzy Based Vertical Handoff Decision Controller for Future Networks

Mr. G. U. Mali

Department of E&TC, Vasantao More Polytechnic, Parola, India

**Abstract**— In Next generation wireless Networks, the received signals (RSS) from different networks do not have a same meaning since each network is composed of its specific characteristics and there is no common pilot signal. Then, RSS comparisons are insufficient for handoff decision and may be inefficient and impractical. A more complex decision criterion that combines a large number of parameters or factors such as monetary cost, bandwidth, and power consumption and user profile is necessary. Though there are a lot works available for vertical handoff decision (VHD) for wireless networks, the selection of best network is still challenging problem. In this paper we propose a Fuzzy based vertical handoff decision controller (FVHDC) Which performs handover decision based on the output of fuzzy based rules..

**Keywords**— Vertical handoff, Fuzzy based vertical handoff decision controller (FVHDC), Vertical handoff decision (VHD),(RSS)Received signal strength,3G and 4G,Vertical hand over(VHO)

## I. INTRODUCTION

In the previous generation i.e. 1G to 3G, they have limitation like limited data rate , upload data rate, download data rate, more handoff latency, less bandwidth and more network cost etc. All these limited and insufficient features which doesn't support today's requirement due to increase in demand for speed, multimedia support, high capacity, other resources and IP based services. This is where the fourth generation wireless communication comes to play. The main aim of 4G is to replace current core technology with a single universal technology based on IP. They have a potential to provide flash high data rates over wide area, global roaming facility, multimedia support, seamless transport end-to-end mechanism and better system with reduced cost.

Yet there are several challenges that inhibit the progress of 4G.the biggest challenge is how to implement handoffs in IP-based 4G networks with minimum handoff latency and packet loss. If handoff latency (i.e. the time spent in handoff) is too long, packet may get lost or disconnection may occur during the handoff which obviously degrades the Qos in 4G systems. When user moves from the coverage area defining one cell into that of another, the

system must provide the capability for that user to remain "in touch" while breaking the connection with one base station and establishing another connection with another base station. This operation is called a handoff., there are several reasons for handover failure are due to non-availability of traffic channel or stand-alone dedicated control channel at new station, far distance between two base transceiver stations, interference to smaller neighboring cell called "near far" effect even when phone still have excellent connection to its current cell and the channel used by the phone becomes interfered by another phone using the same channel in a different cell, the received signal strength (RSS) from different networks which do not have the same meaning since each network is composed of its specific characteristics and there is no common pilot signal. Then received signal strength (RSS) comparison are insufficient for handoff decision and may be impractical. The decision to decide best network may be based on statics factors such as the bandwidth of each network (capacity), usage charges of each network, power consumption of each network interface and battery level of mobile device. However, dynamics factor must be considered in handoff decision.

For the past year many researchers and scientist from all over the world have been working on to implement efficient handoff with minimum handoff latency for this they adapting new handoff methods, handoff algorithms etc. some researchers used vertical handoff decision algorithm for efficient vertical handoff and route selection algorithm for forward data packets to proper attachment point for minimize the latency. Also adopt the additive weighting (SAW) method to reduce overload and processing delay. Simulated annealing (SA) method to minimize the cost of wireless network, GPS handoff technique to detect direction of velocity of mobile terminal for efficient handoff, MAV algorithm to avoid the unnecessary handover, Qos vertical handoff scheme to trigger the handoff process not only basis on signal strength but also consider the Qos parameters too.

Here we propose a fuzzy based vertical handoff decision controller which performs handover decision based on output of fuzzy rules and formation of fuzzy rules are depends on network parameters like network load, available bandwidth, handoff latency etc. we consider

more than 16 latest parameters or factor for efficient vertical handoff. Then in that one network state monitor (NSM) measure throughput of current network periodically. Once throughput degraded handoff decision is triggered. In that situation on going function of current network will taken and intimate to best available network..First establish the connection with best network then cuts off the connection of current network. Therefore vertical handoff will perform almost no time and say there is negligible latency.

This paper is organized as follows. Section 2 provides a brief review of existing work related to vertical handoff. Section 3 describes the type of handoff and handoff details in 4G. Sections 4, main phases of vertical handoff explain. In Section 5, requirement or factors or parameters of vertical handoff mechanism is explained in details. Then sections 6 describe the example of situation of false vertical handoff, causes of vertical handoff and how to avoid the same. Section 7, describe in short the proposed fuzzy based vertical handoff decision controller. Section 8, gives the result and Section 9, finally gives a conclusion.

## II. RELATED WORK

Debabrata Sarddar et al have proposed a GPS based handoff technique to improve handoff probability in NGWS (Next Generation Wireless System). Using GPS they determined the direction of velocity of the MT (Mobile Terminal). Using GPS they ensured efficient hand-off. This method is efficient only if at different time interval the angles are stored in memory and compared for a specific time interval means for perfectness we required huge data with huge memory capacity. [1]. Wonjun Lee et al have proposed an MAV (Movement Aware Vertical handover) handover algorithm to exploit movement pattern for avoiding unnecessary handovers in the integrated WLAN and Mobile WiMAX networks. The MAV handover algorithm adjusts the dwell time adaptively and predicts the residual time in the cell of target base station (BS). Consequently, the adaptive dwell timer of MAV handover algorithm allows an MS (Mobile station) a better connection as long as possible. It mainly works on to avoid frequent handoff within short period by adopting dwell time. But it required to cover the detection technique of actual cell boundary also consider coverage based mechanism for efficient handoff [2]. Dong Ma et al have proposed a QoS-based vertical handoff scheme for WLAN and WiMAX interworking networks. This scheme is used to evaluate the real-time status of the overlay networks and make a handoff decision based on the information. By their proposal, a handoff process will not only be triggered by unaccepted signal strength but also by unsatisfied QoS parameters. In that they use

bandwidth estimation algorithm for handoff. But for effective handoff on the basis of Qos parameters we required latest parameter too for maintain Qos like network cost, load balancing etc. [3] P.Vetrivelan and P.Narayanasamy have proposed seamless media independent resilience triggering (SMIRT) framework will provide decision based on soft-handover for heterogeneous networks like Wi-Fi, WiMAX and LTE. It will provide seamless roaming across the heterogeneous networks through the media independent handover framework without user intervention .a call admission control (CAC) is another key factor that enables efficient system resource utilization. This CAC is always performed when a mobile initiate's communication in new or another cell, either through a new call or a handoff .In this mainly adaptive bandwidth allocation algorithm is used for adapt call when bandwidth is insufficient for call admission. But we need effective unique algorithm which cover every issue and take a effective decision within a short time also unnecessary handoff situation is not covered. [4].

Wang et al proposed policy enabled handoff that allows user to express policies and find out best network on the basis of dynamic and statics parameters of network and the cost function presented in that is very preliminary and cannot handled sophisticated configuration. Joon-myung kang, hong-taek ju2 and James won proposed Automatic Handover Management (AHM) provides solution for selecting best network on the basis of context information without user intervention. AHM perform the mainly four functions such as monitoring, analyzing, planning and executing .but it needs concrete context information as well as improvement required in AHM by optimizing context evaluation function[5].E.Stevens,Wong proposed vertical handoff decision algorithm for heterogeneous network which determine the condition under which vertical handoff performed. it uses the data like connection duration and signaling load for vertical handoff decision. It based on Markov decision process (MDP) to maximize expected total reward of connection and lower expected vertical handoff than another method like simple additive weighting (SAW) method and GRA (grey relational analysis)[6].A Dvir et al proposed an efficient decision handoff mechanism for heterogeneous network. A decision function considers all the available network and parameters like host velocity, battery status, current load on network etc.It defines the new system-wise entity when user in the area with overlapping access technology. Then entity performs the technology selection to optimize the system performance. In this we required to cover the parameters which detect the false situation also along with all latest parameter [7].

Mrs. Chandralekha et al proposed a theory for selection of best wireless network at the time of handoff based on set of predefined user preferences on mobile device. This method selects the best wireless network with reasonable performance rate. It needs to improve when it select the features from generated data. It should select very carefully. Because this one used as input to neural network in order to have high performance rate [7]. Goyal et al proposed a dynamic decision model for vertical handoff across heterogeneous network. It select best network among available networks based on dynamics factor like RSS, velocity of mobile node etc and statics factors. The dynamic algorithm has different phase. The priority phase is used to remove ineligible network, normal phase is used to accommodate user-specific preference. And last is decision phase is used to select best network. It needs to develop the functions which relate received signal strength (RSS) with velocity so that this function utilized with other factors for effective handoff. [8].

Arati Rana et al proposed a vertical handoff method which reduced a latency .When a mobile moves from its home to another location, it obtains a new care-of address by contacting the subnet of that particular network by analyzing the router advertisement that is periodically sent out by the access router. Then mobile node configures itself a new care-of address. After that the mobile needs to verify if there is any duplicate address in the same radio range. So it performs the DAD (Duplicate Address Detection) process for any duplicate addresses. If the mobile duplicate address, it has to reconfigure itself a new care-of address. Once a new care-of address is obtained, the mobile updates the home agent with its new care-of address.. Obtaining the new address from subnet then check for the duplication and if found then perform DAD operation is time consuming so latency get affected. Also to switch from one network to another it should be consider more parameters then due to latency connection may be lost if it is more so to avoid the disconnection latency should be as minimum as [9].

Dr.Sanjay Kadam et al proposed a requirement of vertical handoff mechanism. Vertical handoff will remain an essential component for 4G wireless networks due to switching of mobile users amongst heterogeneous networks. The 4G wireless networks create new handoff challenges due to multiple requirements for vertical handoff. The requirements include high bandwidth, low handoff latency, lower power consumption, minimum network cost, balanced network load, network security, user preferences, throughput and RSS of a switching network. Above proposed parameters are not sufficient for taking efficient decision of vertical handoff. Actually

it needs to consider lot many statics and dynamics parameters of network too [10].

Goyal et al. Proposed a dynamic decision model for VHO across heterogeneous wireless networks (ADDMVHO). This model makes the right VHO decisions by determining the “best” network at “best” time among available networks based on dynamic factors such as RSS and velocity of mobile station as well as static factors. A handoff Management Center (HMC) monitors the various inputs collected from the network interfaces and their base stations (BS) analyze this information and make handoff decisions. The dynamic algorithm has different phases. The Priority Phase is used to remove all the unwanted and ineligible networks from the prospective candidate networks. The Normal Phase is used to accommodate user-specific preferences regarding the usage of network interfaces. Finally, the Decision Phase is used to select the “Best” network and executing the handoff to the selected network .decision by this method is not so efficient and effective cause of less parameter so we need to consider more parameters [11].

Tokekar et al proposed handoff technique which depend on static and dynamic parameters. the static signal strength sometimes is not sufficient to trigger the handoff and therefore along with signal strength other information like network load, type of application, speed of mobile node (MN) may be consider. Vertical handoff process can be accomplished in three phases namely- Network discovery, Handoff decision and Handoff execution. Network discovery is a procedure to find appropriate network in such a way that the target network satisfies user preferences with required QoS. After successful discovery of appropriate network, next decisive factor which affects seamless vertical handoff is when to make a handoff Decision. Too early handoff results unnecessary handoff Whereas an outcome of late handoff is reduced QoS Finally, in this case actually handoff execution should be at right time means trigger of handoff decision will be done by considering all the parameters properly so Qos is not affected also unnecessary hand off should be avoided [12].

Jain et al proposed the vertical handoff decision depends on coverage area of the network along with the velocity of the mobile user and determined application-wise critical speed for particular coverage range of network during which handoff is beneficial. Mainly vertical handoff decision determined using velocity of mobile node and coverage range which reduces the number of unnecessary handoff and consequently improves QoS but only these factors are not sufficient to take a decision of vertical handoff that's why we should consider more and more parameters for proper vertical handoff decision. [13].

Here kolipaka et al proposed Interworking architecture of wireless mesh network and joint admission control combined with vertical handoff algorithm between WLAN and WIMAX. This algorithm can guarantee QoS support to the existing traffic flows in WLAN by transferring calls to other network to provide QoS to as many users as possible. so that with the proposed handoff scheme system throughput and end to end delay is improved. In that they mainly focus on Qos so need to focus on how we reduce number of handoff also and which type of parameters should considered for proper vertical handoff decision[14]

### III. HANDOFF IN 4G NETWORK

In fig 1.shows Two types of Handoff can be occurred in 4G.1) Horizontal handoff 2) Vertical handoff. Handoff between two base stations of the same system called horizontal handoff. Handoff between two BSs, belong to two different systems and two different gateway foreign agent ( GFA) called vertical handoff. Horizontal handoff is further classified into link layer handoff and intra-system handoff.

Horizontal handoff between two BSs, under the same foreign agent called link layer handoff. Horizontal handoff between two BSs that belong to two different FAs and both FAs belongs to the same system and hence to same gateway foreign agent (GFA) called intra system handoff. Here in this paper we cover the vertical handoff .

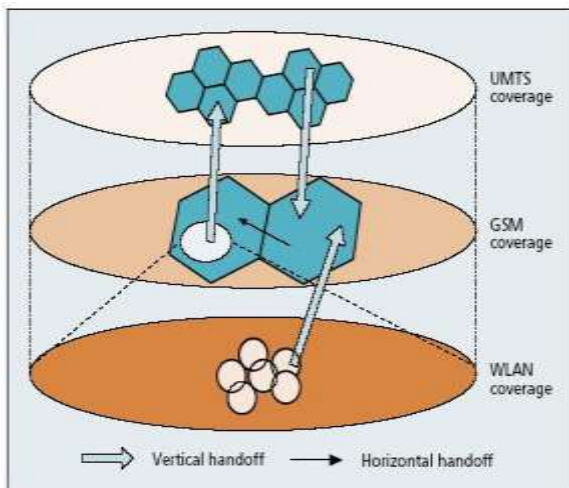


Fig 1: Hand off mechanisms

### IV. MAIN PHASES OF VERTICAL HANDOFF

Three main phases of vertical handoff (VHO) is system discovery, vertical handoff decision and vertical handoff<sup>5.2</sup> execution. During the system discovery phase, the mobile terminal determines which networks can be used. These networks may also advertise the supported data rates and Quality of Service (QoS) parameters .since the user are mobile. This phase may be invoked periodically. In the

vertical handoff decision phase, the mobile terminal determines whether connections should continue using the existing selected network or be switched to another network. The decision may depend on various parameters including the type of the application, Access cost , transmit power, and the user's preferences. During the vertical handoff execution phase, the connections in the mobile terminal are re-routed from the existing network to the new network in a seamless manner. This phase also includes the authentication, authorization and transfer of user's context information. Hence vertical handoff that is, handoff procedures between APs (Access points) of heterogeneous technology.

### V. REQUIRMENT FOR VERTICAL HANDOFF MECHANISM FOR 4G

In 4G we consider the following many important integral statics and dynamics factors for designing proper vertical handoff (VH) decision controller.

#### 5.1 BANDWIDTH,POWER CONSUMPTION, HANDOFF LATENCY AND ANTENNA SYSTEM

In order to provide seamless handoff for quality of service (Qos), there is a need to manage bandwidth requirement of mobile node during the movement. Bandwidth known as link capacity in a network. So high bandwidth i.e 100Mhz or above ensures lower call dropping and high throughput. .then we should improve energy efficiency also by considering factor who consumes the energy like user terminal, base station equipments. again power consume at the time of mobile switching or handoffs. During handoff, frequent interface activation causes much power consumption. also power consume during network discovery because of unnecessary interface activation. Delay can occur during handoff process. This delay called as handoff latency. it should be minimum typically it is 10ms. Handoff latency affect service quality of many applications of mobile users..then we can use multiple antenna system which is necessary to achieve higher data rates within available bandwidth. Normally key requirement for mobile communication is two antennas for uplink and two antennas for downlink. The use of MIMO improves the data rate. Today 2x2 to 8x 8 MIMO system can be use for 4G.so this factor should be consider for improve the data rates.

#### 5.2 NETWORK THROUGHPUT, NETWORK COST, NETWORK LOAD BALANCE AND NETWORK SECURITY.

Normally network throughput refers to the average data rate of successful data delivery over communication link. Maximum throughput is equal to TCP window size



divided by round-trip time of communication data packets .also Network cost to be minimized during vertical handoff decision (VHO).the new call and handoff call arrival rates can be analyzed using cost function. In future heterogeneous network can combine their advantages like data rates, coverage, high quality of service, bandwidth etc.In such case multi-interface terminals should switch

from one network to another network for better performance with maintain continuous connection. In that case network cost is very important factor and it must consider. We should balance the network load to avoid deterioration in quality of service. Variation in the traffic loads between cell will reduce the traffic carrying capacity. To provide a high quality communication service and enhance a high traffic-carrying capacity, network load should be balanced. Today we not only required the seamless handoff but also required the secure handoff for prevent and monitor the unauthorized access, misuse, modification and network resources. so for secure service we must improve the handoff policies for network security.

#### 5.3 RECEIVED SIGNAL STRENGTH (RSS), VELOCITY AND PREDICTIVE RESIDENCE TIME.

Signal strength defines in part the performance of network, amount of network bandwidth available and power present in signal. So to maintain connection, received signal strength (RSS) should not be below a certain threshold level in network during vertical handoff. For handoff initiation a measurement of received signal strength is very important. .Because of small cell area, when mobile terminal traveling at high speeds handoff back to the original network would occur very shortly afterwards. So velocity of mobile terminal should be considered during vertical handoff decision . Today rapidly increase the demand of higher data rate for high speed access of real time application, internet and other multimedia application. The predictive residence time is calculated based on node velocity and direction which are estimated based on some location update techniques.

#### 5.4 DATA RATE, UP LOAD DATA RATE AND DOWNLOAD DATA RATE

Generally the data rates should be as high as possible to maintain the required quality of service with continuous connection .so in 4G a data rate is four time faster than 3G typically it is 20 to 100Mbps. Up load data rate factor should be as high as possible typically it is 500Mbps.so that quality of service(Qos) will maintain in 4G and supports a real time application properly without breaking

the connection. Typically 500 Mbps on uplink mobility support up to 15km/h..Download data rates factor should be as high as possible so that quality of service (Qos) will maintain. Typically 1Gbps on downlink mobility support up to 15km/h . All of these are important statics and dynamics factors or parameters must consider while designing vertical handoff decision controller which is helpful to take accurate, proper and efficient vertical handoff decision.

## VI. EFFECT OF GEOGRAPHICAL TOPOLOGY FOR TRIGGERS FALSE VERTICAL HANDOFF

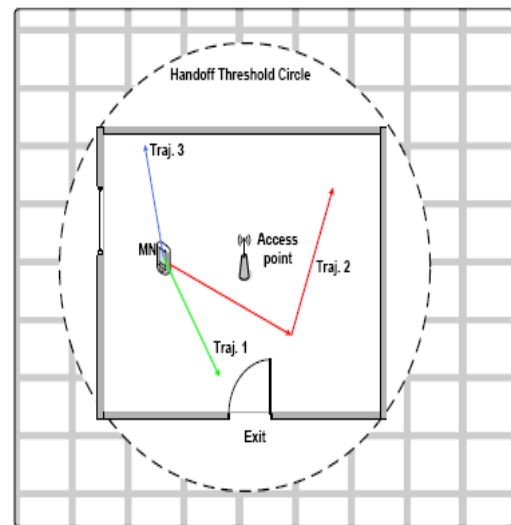


Fig 2: False Handoff triggers due to topological boundaries

In figure 2 in which a mobile node is located inside a closed environment and which move toward the boundary of Coverage in trajectory3. according to that received signal strength (RSS) starts to decrease as it will move towards the Coverage boundary. And if handoff based on only received signal strength (RSS), the mobile node experiences weak signal and start to prepare the vertical handoff process. but actual condition is that boundary of coverage threshold falls to close to but beyond the physical boundary like wall. The reality is that actual mobile node cannot experiences vertical handoff or handover but it experiences handoff due to physical boundary closes to actual coverage boundary so to avoid such condition we should consider lot many parameters and also improve the boundary detection algorithm for proper vertical handoff. It is essential to be considered to avoid false handoff while designing the vertical handoff decision controller for proper vertical handoff decision .

#### 6.1 AVOIDANCE OF UNWANTED VERTICAL HANDOFF

The main reason of unwanted handovers is the failure to recognize temporary coverage, unavailability of required

resources and congestion in new network. An unnecessary vertical handover actually in an increased signaling and delay. Sometime a new network can satisfy all the condition for vertical handover but for limited period of connectivity. Also 4G is a IP based technology then sometime vertical handover will be done but this new connection will not able to start VOIP connection and in this case handover considered to be unnecessary. This a very important consideration that help us to avoid unnecessary handoff which discuss in above topic and unnecessary losses regarding the connection with a network, interruption in real time application and multimedia application etc.

To avoid this a one condition should be satisfied by fuzzy based vertical handover decision controller is that mobile node should connected with new network for time period equal to the handover recovery period which already mention in topic called main phases of vertical handoff. This is the time in which the data received from new connection is equal to at least the amount that received from old connection the duration equal to the total handover procedure. Otherwise considered to be unwanted handover .

## VII. PROPOSED FUZZY BASED VERTICAL HANDOFF DECISION CONTROLLER

Basically a fuzzy based vertical handoff decision controller is a kind of systems which take current values of parameters of best network among available networks, compare them with the present network which already satisfy the standard values of parameters set by vertical handoff decision controller for vertical handoff decision. Following are the detail steps used to design the fuzzy based vertical handoff decision controller.

In implementing vertical handoff by using fuzzy logic first we need to create a system .we call this system as A systems A at mobile device which periodically provides the report about the entire available networks in the area and their respective QOS parameters like bit rates, signal strength, signal type, signal range and also the system need to detect the battery level of the mobile device to the original base station.

As the base station receives these parameters then it need to feed to our second module. we will call this as B. Once B receives all the parameters it will store in stack of data. Now all this data which is in stack need to be feed to fuzzy inference engine. We will call this module D where all the data are properly analyzed and set protocols for the fuzzy inference rules. In system D by using centroid method we create rules and set all the parameters in the inference engine.

One advanced technique we will use here with our unique module .we will cal this as C.Here in System C it retrieve

the data from the stack of System B and it will feed this to D to set the fuzzy rules, While doing this System C will perform a prototype matching for best data to be feed in using **Generic Algorithm**. Where Matching will be done in between all the stack data and the Latest best fuzzy data. So it will help us to provide best data for the System D.

Then we need to create a System Module. we will call this As E.this module called Knowledge base, Where all the inference rules need to be study carefully and set their bounds with the priorities like VL( very low), L( low),M( medium) , HM( high medium), H( high) and VH( very high).

Then again we need to create a System called Defuzzification. We will call this as F, where one best available network resource will be chosen and it will be passed to System B of the base station to weave vertical handoff.

In all the system modules from B to F, system functioning will perform in back ground on periodical basis at the base station. Once the Handoff Situation arises then all the information about the going on function will be taken from the **performing Network base station ( BST1)** and by using System F, The best available network base station ( **BST2**) is intimate with on going function of BST1 and resume all the functions with residuals.

BST2 First establishes a connection with the destination network and then cuts off the connection of BST1 and now BST2 becomes BST1 for the further vertical handoff. Here in the above all the proposed system the vertical handoff will perform in almost no time and therefore we can say there is neglible latency.

## VIII. RESULT

In wireless system the requirement for higher data rate exponentially increasing because of availability of smart phone at low cost. then number of user and their demand for better resources increases day by day so today 3G is not sufficient to meet all requirements.

Table 1:4G requirements

Technical Items	4G Requirements
Downlink peak data rates	1 G bps(low mobility 15km/hr)
Uplink peak data rates	500Mbps (low mobility 15km/hr)
Bandwidth	Scalable up to 100Mhz or above
Latency	10ms
Uplink peak spectral efficiency	15 bps/Hz
Downlink peak spectral efficiency	30 bps/Hz
Access scheme	OFDMA

<b>Switching design basis</b>	<i>Packet switching</i>
<b>Speed (data rate)</b>	<i>Data rate up to 20 to 100Mbps</i>
<b>Frequency band</b>	<i>2 to 8Ghz</i>
<b>Mobile top speeds</b>	<i>200 Km/hr</i>

Therefore we look for 4G wireless system which at least satisfied the following latest all requirements and below shown in the table.1 for better quality of service.

A fuzzy based vertical handoff decision controller take a proper decision by using the reference data as a latest requirements of 4G as shown in table1.

A decision controller on each BS or AP estimates and report the above parameters to the fuzzy module, which in turn make the Fuzzy rule set. Based on the output of fuzzy decision model, the best target network is selected.

A network state monitor (NSM) is used to monitor the status of the current network periodically to measure the throughput. The handoff decision is triggered whenever the throughput of the existing network is degrades. Here in this whenever the handoff situation arises that time Without breaking the connection with exiting network first establishing the connection with selected network and then cutoff the connection of previous or existing network. Hence proposed systems perform vertical handoff in almost no time and therefore we can say there is a negligible latency.

## IX. CONCLUSION

In this paper we discuss the handoff, types of vertical handoff, main phases of vertical handoff that points clear the vertical handoff process means how the vertical handoff process will executed and which steps are required to complete the vertical handoff process. so according to that we come to know where we loss the maximum time. And how we reduced the unnecessary steps which increase the latency.

After that we discuss the requirement for vertical handoff..Here actually we collect the parameters In the form of refine knowledge which positively supports to fuzzy based vertical handoff decision controller to take the accurate, efficient and proper decision without time consuming and maintaining the continuous connection with proper quality of service (Qos) on the level of 4G.

Then one important issue we also considered that is unnecessary handoff situation so not only we considered the handover situation but also considered unnecessary handover situation too so that unnecessary signaling .handoff, delay and over Burdon of frequently switch to new network will avoid.

Finally we proposed a fuzzy based vertical handoff decision controller who consider more than 15 parameters

and collect the pure and particular knowledge about exact situation of handover then and then it will make a future connection with new network without breaking the old connection. So that the problem of latency is also solved and call dropping probability will decrease. But we required more and more parameters to be integrated in controller so that our controller will perform the functions very accurate, proper with high speed.

## REFERENCES

- [1] Debarata Sarddar Kaushik Mandel, Tapas Jana, Utpal Biswas and M.K.Naskar "A Handoff Technique to Reduce False-Handoff Probability in next Generation Wireless Networks" (IJCSSE) International Journal on Computer Science and Engineering "Vol.02.No.03,2010,630-634.
- [2] Wonju Lee, Eunkyo Kim, Joongheon Kim, Inkyu Lee and Choonhwa Lee "Movement-Aware Vertical
- [3] Handoff of WLAN and Mobile WIMAX for Seamless Ubiquitous Access" IEEE Transactions on Consumer Electronics, Vol.53, No.4, November 2007.
- [4] Dong Ma and Maode Ma "A Qos-Based Vertical Handoff Scheme for Internetworking of WLAN and WIMAX" IEEE Global Telecommunication conference, "GLOBECOM" 2009.
- [5] P.Vetrivelan and P.Narayanansamy "SMIRT with Call Admission Control (CAC) Based Vertical Handover Decision for Seamless Mobility in Multi-Access 4G Heterogeneous Wireless Overlay Networks "in proceeding of the international multiconference of engineers & computer scientists 2012 vol1, IMECS 2012, march 14-16, 2012 HONGKONG
- [6] H.J. Wang, R. H. Katz & J. Giese, (1999) "Policy-Enabled Handoffs across Heterogeneous Wireless Networks", In proc. of ACM WMCSA.
- [7] Enrique Stevens-Navarro, Vincent W.S. Wong and Yuxia Lin, "A Vertical Hand off Decision Algorithm for Heterogeneous Wireless Networks", In Proc. Of IEEE Wireless Communication and Networking Conference (WCNC07)
- [8] A. Dvir, R. Giladi, I. Kitroser & M. Segal, February (2010) "Efficient decision handoff mechanism for heterogeneous network", International journal of Wireless and Mobile networks, Vol. 2, No. 1.
- [9] Mrs. Chandralekha & Dr. Prafulla Kumar Behera, November (2009) "Use of Adaptive Resonance Theory for Vertical Handoff Decision in Heterogeneous Wireless Environment", International Journal of Recent Trends in Engineering, Vol. 2, No. 3.

- [10] Arati Rana, Kamaljeet Kaur, Anuj Aggarwal  
"Wireless Network(3G &4G)" Department of  
computer Science, AIMT, Ambala, (Kurukshetra
- [11] Dr. Sanjay Kadam, "Requirements Of Vertical  
Handoff Mechanism In 4G Wireless Network  
"International Journal of Wireless & Mobile  
Networks (IJWMN) Vol.3, No.2 April 2011.
- [12] Pramod Goyal & S. K. Saxena, (2008) "A Dynamic  
Decision Model for Vertical Handoffs across  
Heterogeneous Wireless Networks", 677 ? 2008  
WASET.ORG, World Academy of Science,  
Engineering and Technology, Issue 41, pp 676-682.
- [13] Jain A, Tokekar S, "Optimization of vertical handoff  
In UMTS and WLAN heterogeneous networks,"  
IEEE International Conference on Emerging Trends  
in Communication, Control, Signal Processing &  
Computing Applications (C2SPCA) 2013.
- [14] Aabha Jain, Sanjiv Tokekar, "Application Based  
Vertical Handoff Decision in Heterogeneous  
Network," Elsevier 3rd International Conference on  
Recent Trends in Computing 2015 (ICRTC-2015).
- [15] Joint Admission Control and Vertical Handoff  
between WLAN and WIMAX in Wireless Mesh  
Networks for QoS 2nd IEEE International  
Conference on Engineering and Technology  
(ICETECH), 17th & 18th March 2016, Coimbatore,  
TN, India.