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ARTIFICIAL INTELLIGENCE BASED MULTI-CRITERIA VERTICAL HANDOFF MECHANISM (AI-VHOM) IN WIRELESS NETWORKS

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Abstract

IEEE 802.11 based wireless networks (WLAN) has emerged as an accelerated distribution method and been deployed in a wide manner across the globe especially in the last decade. Mobility support is usually the primary motivation in these methods. Seamless handoff is one of the significant challenges in mobile networks, especially for real-time streaming applications, which has a strong requirement for timely delivery of information like Voice over IP(VoIP).Roaming initiates handoffs between different access interfaces and dissimilar networks, providing the need for an effective handoff technique in a heterogeneous environment. Novel handoff strategies are discussed in this paper and are used as a base for developing a unique Artificial Intelligence based framework of Vertical Handoff Mechanism for multiple criteria (AI-VHoM). The need for vertical handoff can be generalized as the transference of control from one network technology to another with a purpose of attaining better service with quality. Optimising the vertical handoff is a candid issue of research, which leads to poor network signaling, interruption in services, an unbalanced network load and power loss of the device. In this paper, the proposed AI-VHoM addresses this issue effectively and significantly improves Quality of Service (QoS). Traditionally, the vertical handoff function is measured by weighing a single criteria – Received Signal Strength. The combination of artificial intelligence considering multiple criteria in a heterogeneous wireless network, which is the future yields significant results for seamless handoffs without performance deterioration, decreasing the influence of dissimilar, unprecise and contradictory measurements arising from different sources.

Keywords— Vertical handoff, Wireless Networks, Artificial intelligence, Multi-criteria, Heterogeneous Networks

1. Introduction

The growth and popularity of the IEEE 802.11 networks have given a scope for the real – time data driven technologies like VoIP. This technology integrates voice and data over wireless infrastructure. The reduced cost of voice usage over Internet and the popularity of the wireless technology has gained an advantage to implement these technologies in today's IP network. The major benefit of the wireless networks is the mobility facilitating users to roam freely across various networks.

The IEEE 802.11 architecture includes the Stations (STA) comprising of all the devices and equipment connected to the wireless LAN. A station can either be a *Wireless Access Point* (WAP), which often are the routers that constitute the base station or a *Client*, which are workstations, laptops, printers, mobile phones or devices. Each station possess a wireless network interface controller. The *Basic Service Set* (BSS) comprises of the group of stations communicating at the physical layer. The communication can be infrastructure based, where devices communicate with other devices through access points or it can be ad-hoc, where the devices communicate in a peer-to-peer basis. The *Extended Service Set* (ESS) consists of all the connected BSS and the *Distribution System* (DS) connects the access points in the ESS.

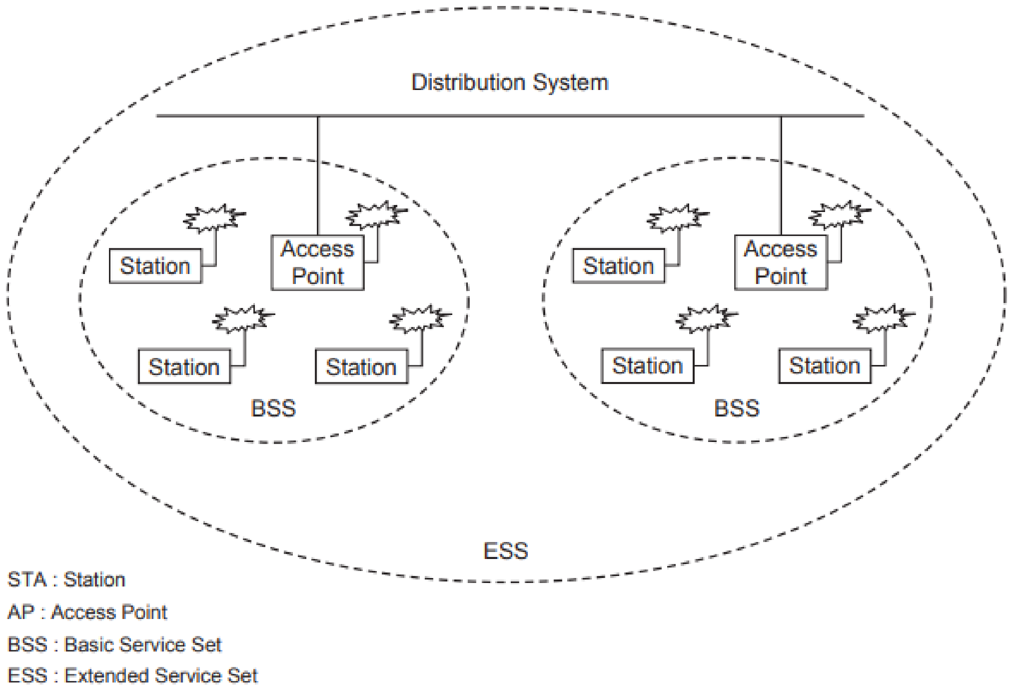

Fig. 1 IEEE 802.11 Wireless LAN Architecture

We consider 802.11 infrastructure networks in which Access Points (APs) convey traffic between associated clients and the wired part of the network. Examples of such networks are university campuses, convention centres, airports, and corporation intranets. Because APs have a limited range, we can extend coverage in a larger area by deploying multiple APs, for example one AP in every office in the case of an enterprise Wi-Fi network, thus resulting in a densely deployed network. APs are interconnected through a Distribution System (DS), generally a wired network to enable inter-AP communications. A station can join the wireless network by associating with an AP. When a station moves away from its AP, the signal of the AP falls off. If it drops below a certain threshold, the station starts searching for a new AP to associate with, initiating the MAC layer handoff process, until the new association takes place. During the handoff, the station neither receives nor sends data packets. This disruption in communications may take a long time that real-time applications like Voice over IP (VoIP) cannot tolerate.

The critical problem in applications such as VoIP over wireless LAN is the delay in voice packets due to handoffs as the user is in roaming state, transferring control from one radio coverage region to another. Other associated issues that requires attention are the security and channel capacity. This paper proposes an exclusive architectural framework using artificial intelligence to achieve seamless vertical handoffs. The major implications is that we have

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introduced changes only on the client side, which provides us certain limitations, which are to be addressed in the future work.

Usually during the roaming state, the Layer 2 (L2) or Layer 2 and Layer 3 (L3) handoffs goes undetected in the subnet, as the Mobile Node (MN) goes from one Access Point (AP) to another. In IPv6 deployment, the routers systematically send multicast Router Advertisement (RA) messages in a fixed time period to announce their availability, which might be a possible solution for the identified issue. But the frequency of RA is normally in the order of minutes, hence it becomes a challenge for a MN to learn about the subnet change in a periodical fashion. The other challenge is that when the L3 handoff has taken place, the MN has to stand by to obtain a new IP address for that subnet through Dynamic Host Configuration Protocol (DHCP). The above exception is unacceptable for real time applications and needs to be addressed. Even if the MN has received the new IP address, at the time of L3 handoff, then an additional notion of informing its IP address change to its Correspondent Node (CN) has to be carried out.

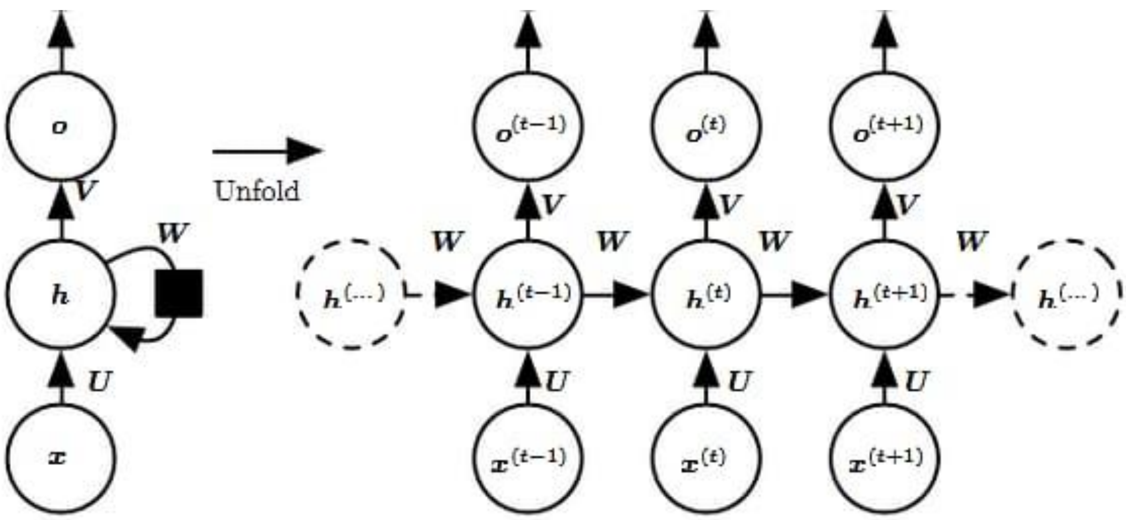

Fig. 2 – Recurrent Neural Network (RNN)

The traditional handoff management in the WLAN environment has been dependent on the decision algorithm and the handoff mechanism. Instead of the MN noticing its new IP address and increasing the client side extra efforts, we thought of devising a scheme of self-learning architecture applicable for the WLAN frameworks. Artificial intelligence in a mobile environment enables the network to learn from the user’s behaviours and about the status of

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the network, altering its learning to suit the dense time-varying WLANs. The selective features are extracted using the convolutional neural network (CNN) and the recurrent neural network (RNN). Thus the concept of the artificial intelligence based vertical handoff mechanism for multi-criteria can improve the data rate and provide scope for seamless handoff outperforming the existing methods.

In the rest of the paper, we detail the background and related work in Section II, and the proposed artificial intelligence based multi-criteria vertical handoff mechanism (AI-VHoM) framework in Section III, the implementation of the framework in Section IV, its performance comparison with existing methods in Section V. Finally, we evaluate the limitations, possible future work and conclude in Section VI.

2. BACKGROUND AND RELATED WORK

Handoff or handover is the process of transferring an ongoing call or data from one channel to another channel connected to a network. The handoff strategies are mainly classified as Horizontal (intra-system) handoff and vertical (inter-system) handoff. Vertical handoff is concerned with the overlapping of wireless networks. The important factors of these handoff strategies are in identifying a new base station and also in allocating the voice and control signals corresponding to the new base stations. Hence the handoffs are an integral part of the mobile networks and are performed frequently undetected by the user. For the smooth transitioning, it is necessary to consider the optimum signal at which the handoff must be initiated.

2.1 Handoff Strategy in Wireless and Mobile Communications

With regard to the 4G and 5G systems, mobility management has emerged as a major concern due to the widespread demand for the amalgamation of variety of wireless technologies and internet, alongside the rapid growth of the number of users. Mobility management is achieved through the integration of location management and handoff management. Location management is the process of finding the physical location of the user so that the calls directed to that user can be routed to that location. The goal of location management is to find a proper balance between the quality of service, signalling overhead and the latency. Handoff management is the process through which a MN keeps its connection active when it moves from one AP to another.

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The whole vertical handoff management process consists of three stages: ***Handoff initiation, Handoff Decision and Handoff Execution.***The handoff initiation is triggered by either a mobile device, a network agent or the changing network conditions. A new station is selected during the initiation phase, along with the information about the radio link and the execution of a decision algorithm. The best network and the perfect time for handoff are identified during the handoff decision phase. In the handoff execution phase, the mobile terminal features and the user profile will be shared to the new network during mobility, there executing the handoff process. Fig.2 depicts the overall handoff management process.

2.2 Types of Handoffs

Based on the behaviour of a mobile terminal for responding to a new connection, handoffs are divided into two types: Hard Handoffs and Soft Handoffs. A hard handoff is a scheme where the user's connection is entirely broken with an existing base station before establishing a connection with a new base station. A soft handoff is a scheme where the user is simultaneously connected to two or more base stations during a call.

Based on the control of the handoff decision, handoffs are divided into four types: Network Controlled Handoff (NCHO), Mobile Controlled Handoff (MCHO), Mobile Assisted Handoff (MAHO) and Network Assisted Handoff (NAHO). Figure 2.2 depicts the classification of handoffs based on various factors. If the control agent on the network side is responsible for the handoff decision, then it is called as network controlled handoff (NCHO); if the control agent is on the mobile terminal, then it is called as mobile controlled handoff (MCHO); if the control agent on the network side is assisted by the mobile terminal, then it is called as mobile assisted handoff (MAHO); if the control agent on the mobile terminal side is assisted by the network for sending and receiving primary information, then it is called as network assisted handoff (NAHO).

Based on the type of initiation, handoffs are divided into forced handoffs and user handoffs. When difficult network conditions arises, forced handoffs are initiated. Due to user preferences, the user handoffs are initiated.

2.3 Issues

Due to the above conflicting critical requirements at times of high traffic conditions or when

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channels are unavailable to any of the nearby base stations, unexpected excessive delay might occur. The decision on when to perform the handoff is based on the drop of the measured signal. It is to be assured that the signal drop is not because of momentary fading; hence these situations must be monitored by the base station for a certain period of time, before the handoff is initiated.When the measured signal drop is actually due to the user moving away from the base station, then the handoff is to be initiated.

Figure 2.3 depicts the scenario where the signal drops below the minimum acceptable level to maintain the channel live and yet the handoff is not initiated. Such situations occur when there is an unexpected delay in initiating a handoff or when the threshold is too meagre for the handoff in the systems.

Thus the time taken for initiating a handoff relies on a number of factors such as:

Transmitted Signal Strength: The number of handoffs increases when the signal strength is varying rapidly thereby paving way for forced handoffs.

2.4 Motivation for Vertical Handoff Mechanism

The term heterogeneous network in the wireless scenario denotes the different access technologies. They facilitate flexible and diversified wireless network access by fusing cellular networks, wireless LANs and adhoc networkswith the Internet.

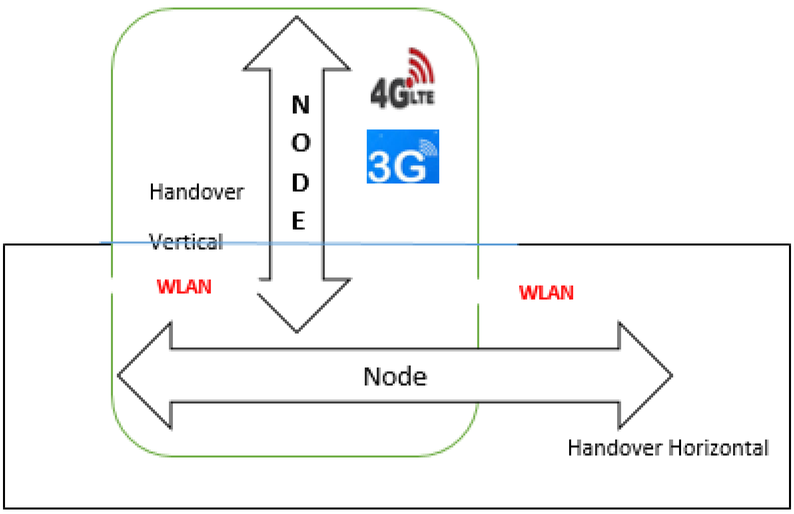

Fig.3 – Horizontal and Vertical Network Setup

The alternate of the heterogeneous networks is the homogeneous networks, where the handoff initiation and handoff decision phase are considered to be a single phase together

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termed as handoff initiation phase. As the handoff occurs between different cells of the same wireless technology, there is no necessity to "choose the best network" in a homogeneous environment. If the signal strength drops below a certain threshold value, then immediately horizontal handoff is initiated.

2.5 Challenges

The next generation heterogeneous networks aids an interoperability environment that necessitates seamless mobility management. To facilitate seamless communication, handoff schemes are designed in a way to permit users to roam across several networks. Facilitating efficient connection with a selected wireless network without the delay being faced by the user, remain to be a major concern in the heterogeneous networks. The recent research works have concentrated on providing directional assistance in choosing the optimal network through a few strategies during the handoff decision phase. But, an effective handoff scheme providing the required QoS measures and the best resource utilization remains to be under research. Moreover, our literature review reveals that there are various metrics that establishes an optimal network for selection such as bandwidth, bit error rate, signal strength, cost, power consumption, etc. The identified criteria might be best suited in a horizontal handoff environment but are inadequate to implement vertical handoff because of the contrasting system characteristics. Hence, it is essential to design a vertical handoff scheme that considers a multi-criteria and achieves the required QoS measures.

The vertical handoff schemes are usually classified into either mobile-controlled or network-controlled processes. The existing mobility management schemes to achieve the required QoS are mobile-controlled.

2.6 Related Work

Through an extensive literature study, the handoff mechanisms can be broadly classified into proactive, reactive and hybrid handoff schemes. A reactive strategy deals when the mobile user device if forced to make a handoff due to service failure, whereas a proactive strategy involves the user device ready with the next available network. A hybrid scheme involves both the proactive and reactive strategies to enhance the decision process.

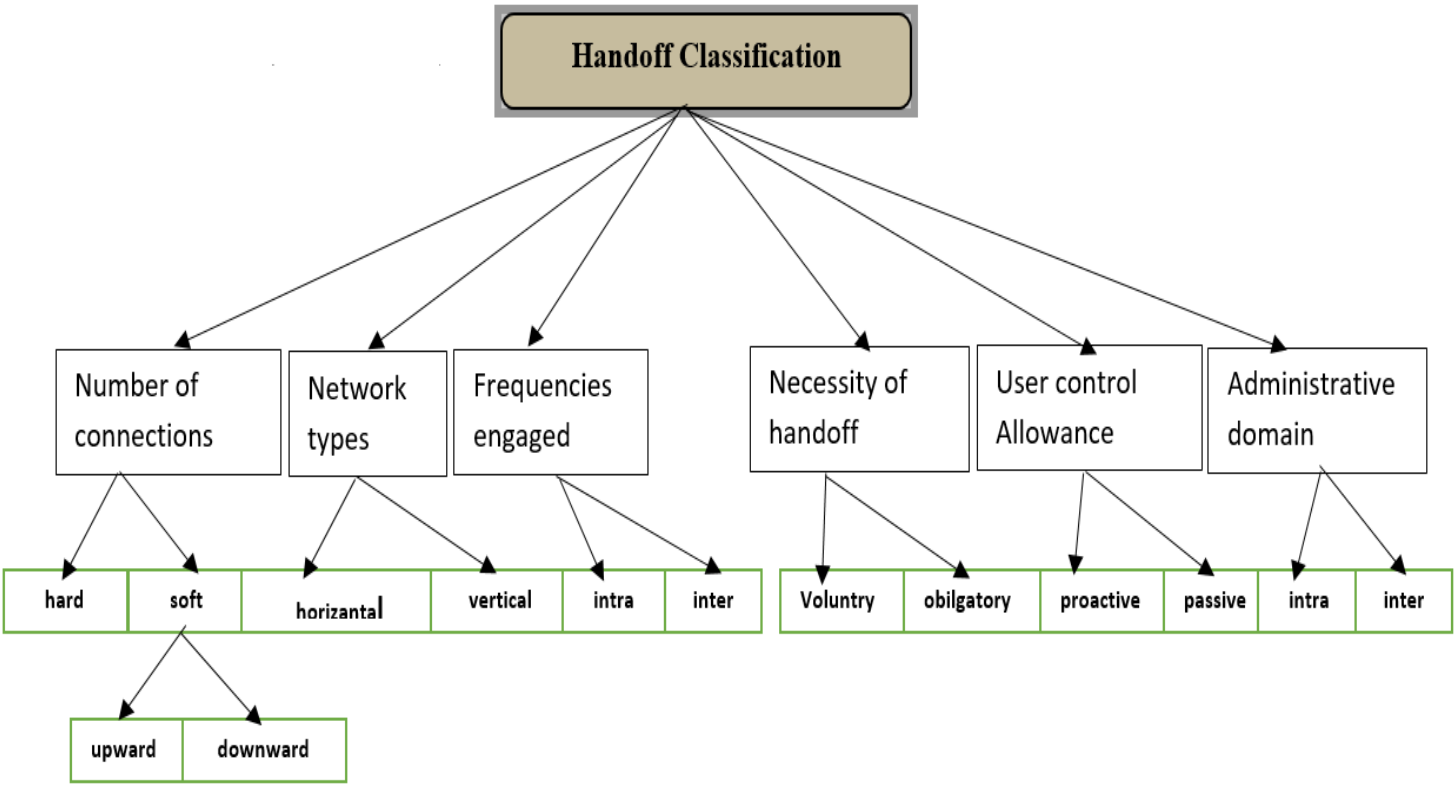

Fig. 4 – Classification of Handoff Schemes

Categories	Handoff approach	backup channel	Bandwidth Utilization	Delay of handoff	Disadvantages
Proactive handoff schemes	STBC	no and full backup	Average	Minimum	Bandwidth Underutilization No ongoing
	Fuzzy Based	No backup	Maximum	Can be Maximum	Sensing Mechanism Increased Handoff delay
	SHCP	no and full backup	Average	Minimum	Increased waiting time Bandwidth underutilization
	FAHP	Full backup	Minimum	Minimum	Bandwidth Underutilization No ongoing

	DFHC	No backup	Maximum	Maximum	Improved waiting time, Improved Handoff delay
	M/G/1 Queuing based	No backup	Maximum	Maximum	Handoff processing time is not completed
Reactive handoff schemes	Zigbee scheme	No backup	Maximum	Maximum	False alarm probability Cannot work under multipath Fading and shadowing conditions
Hybrid Handoff Scheme	Hybrid Scheme	No Backup	Average	Can be Maximum	Improved waiting time, Improved Handoff delay

Table 1 – Properties of Handoff Schemes

Further, they can also be grouped into Received Signal Strength (RSS) centred strategies and Consumer centred strategies. Traditional handoff schemes are based on the value of RSS. It works based on the rules for handoff decision, which rely on the differentiation of RSS of current network, the next new network, and threshold and hysteresis values. RSS centred schemes does not take the mobile user preferences, mobile terminal context data, network context data and application requirements into consideration. The major limitation is that while designing an efficient handoff scheme, the decision cannot be wholly depend on only the RSS value. Other parameters should also be taken into account.

The Consumer Centred Strategies (CCS) facilitates vertical handoffs which includes algorithms providing prime focus on the consumer preferences. Cost and QoS are the important factors affecting user preferences. The study of various vertical handover schemes have been made and the pros and cons of each have been analysed during the literature survey. Several policies have been proposed to satisfy the cost or the Qos requirement, but fails to find a balance in satisfying both the needs.

Thus an effective handoff scheme must include a network selection process module, which receives report about the network and user preferences from a network monitoring module and a user-centric module. The cost priority policy and the QoS priority policy are segments of the network selection process module.

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3. PROPOSED FRAMEWORK

The aim of the proposed scheme is to lower the handoff failures and achieve the targeted QoS measures through network-controlled handoff by considering multi-criteria in heterogeneous networks. The first phase of the proposed framework establishes the multi-criteria that needs to be considered for selection of an appropriate network. Artificial Intelligence based schemes are employed to learn about the network automatically. Using the Artificial Intelligence based Multi-Criteria Decision Making (MCDM) methods, the metrics are evaluated and are ranked. The decision variable is set, thereby enabling the decision of an efficient network for mobility.

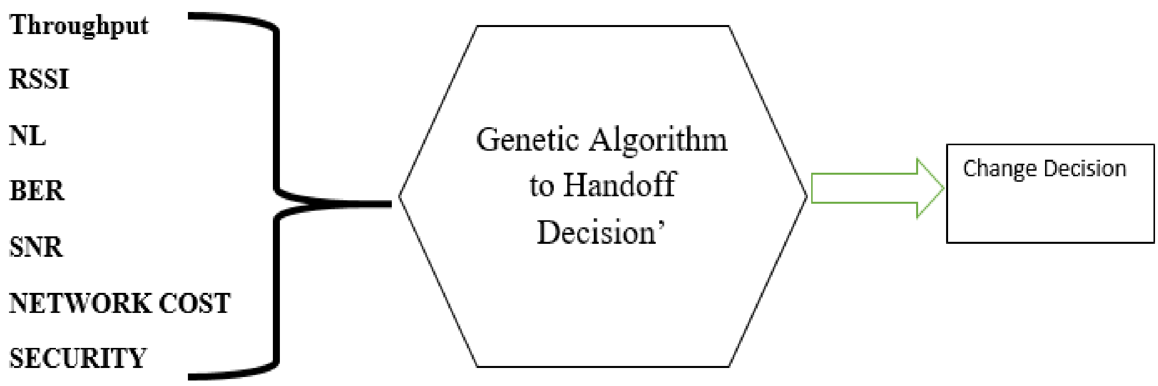

Fig. 5 – Multi-Criteria Environment

The second phase is to initiate the vertical handoff with the optimal networks satisfying the conditions laid. The third phase is to decide an optimal network satisfying the multi-criteria and is live. The last phase is the execution of the handoff with the ideal candidate network. The proposed framework is implemented and tested in a fuzzy-TOPSIS (Technique for Order of Preference by Similarity for Ideal Solution) and is compared to the existing schemes. Thus the proposed framework Artificial Intelligence based multi-criteria Vertical Handoff Mechanism (AI-VHoM) achieves seamless handoff using the AI schemes and tends to remove the ping pong effect.

3.1 Measurement of Handoff and Initialization

This is the initial stage at which the Mobile Node (MN) identifies an optimal network within its coverage thereby gaining information about all the neighbouring networks within its range.

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The entire process happens under three stages as specified in the IEEE 802.11 framework: i) Scanning ii) Authentication iii) Reassociation. During the scanning phase, the mobile node is responsible to find optimal APs and the procedure can happen either actively or passively. If it's an active process, the MN broadcasts a probe request message to each of the channel in the network and waits for the probe timer. If no response is received before it times out, then the MN assumes that there is no AP within its range and thus moves on to probe the next channel. In case if the channel is not hidden, then the MN waits for the timer to reach the MaxChannelTime. Here the timing interval is set between 20ms and 40ms.

If it's a passive process, then the wireless network card is on a standby mode to receive the beacon type messages which are sent by the Aps regularly in the interval of 100ms in each of the channel. Practically, the 802.11 standard allows 14 channels, whereas in Latin America, 11 channels are used, thereby allowing more time than a second of latency for scanning, which are particularly favourable for real-time applications in WiFi networks. If the MN is successful in identifying the potential AP, then it must process to authenticate and associate.

If the system is open (Open System), then there is no necessity for authentication and the system can support any host without authentication. Else, the system will only consider the MNs which is aware of the password (Shared Key). The last stage is the association phase which includes exchange of messages between the Access Point and Mobile Node: the request for association and the response for association. When the MN receives the response, it is associated with the AP and is prepared to send and receive data.

3.2 Handoff Decision

Performance of the handoff is directly dependent on the efficiency of the handoff decision algorithm. Various schemes for the handoff decision have been studied under the literature review which include RSS based strategies, CSS based strategies, QoS based and multi-criteria based. This is the critical stage at which the user device decides about the network or channel to which it is going to connect with during roaming or mobility. The normal functioning of the decision making algorithm includes the data which is received from the network, processing of the received information and the decision about which network the connection has to be established next. The multi-criteria based on which our system is built includes the Received Signal Strength Indicator (RSSI), throughput, the Signal to Noise Ratio (SNR), the power levels of the signals in the wireless network, the network load indicating the channel capacity, Bit Error Rate (BER) and the traffic congestion which

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plays yet another crucial role in determining the network. The BER is calculated by comparing the ratio of the number of bits of data that have been received and is altered because of noise or interference to that of the total number of bits transmitted within a particular time interval. Throughput is the measure of quantity of data received successfully within a channel. The SNR is the ratio between the power of the signal transmitted to that of the power of noise that manipulates it. Also included is the user preferences consisting of cost and security of the network.

3.3 Decision based on Multi-Criteria

The RSS based algorithms are easy to execute, as they are based on the received signal strength, which is a unique criteria. But the disadvantage is that when the node tends to find a network nearby, immediately the RSS is triggered and hence it is too sensitive to changes. It is usual for the RSS to be used in a horizontal handoff scheme as it is the only parameter that is subject to changes. The best example for this scheme is the “Greatest Potential” algorithm, as it shifts to the network with the highest RSS and in theory suffers from a meagre packet loss. But the major setback is that these algorithms suffer from the pingpong effect.

The pingpong effect is due to the needless handoffs thereby increasing the handoff rate which is the number of handoffs during a data session. There has been efforts to minimize the pingpong effect using the criteria of thresholds. In a few case, attempts have been made to use the Received Signal to Noise Interference (RSNI) to reduce the number of handoffs. There are a few algorithms based on bandwidth, which is influenced by the theory to shift to networks with better bandwidth in order to gain better throughput in a vertical handoff environment. These bandwidth schemes have already been tested and found fruitful in the Vehicular Adhoc Networks (VANET).

3.4 Artificial Intelligence

Neural networks schemes of Artificial Intelligence have been widely used in the process of decision making in heterogeneous networks. In the literature review, a scheme have been proposed including the artificial back propagation neural network, which makes use of the RSS factors, traffic intensity in the candidate networks and overlooking the training of the network. The major drawback of this scheme is the delay due to the training of the network. In yet another scheme, a middleware based on Recurrent Neural Network (RNN) has been employed to choose the ideal network based on user preferences. The concern over this scheme is that the latency is huge during the implementation of handoff because of the size of

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the signaling packets and the time taken for training. A recent approach included a neural network framework with RSSI and speed of the mobile network as input criteria, thereby lowering the number of needless handoffs.

Hence taking most of the criteria into consideration to train the network and to learn the network information automatically without any latency effects, the multi-criteria decision making algorithms are utilized in the proposed system. The criteria included for decision making are the optimal factors of user preferences. Fuzzy TOPSIS algorithm is used to fix the significance or rank of the criteria under consideration. The significant advantages of this fuzzy TOPSIS for multi-criteria decision making in a heterogeneous environment is evident from the performance results and comparison.

3.5 Framework

Dual Mode Card: The mobile terminal working in a vertical handoff environment must include a dual mode card to accommodate for both WLAN and UMTS cellular networks.

Interworking Architecture: The interworking architecture in a vertical handoff environment deals with the tight coupling and loose coupling between the WLAN and UMTS networks. The tight coupling scheme also includes the Wireless Access Gateway (WAG) and Packet Data Gateway (PDG) elements. Hence the data transmissions from WLAN Access Points to a particular node on the Internet happen through the core network of UMTS. Loose coupling is opted when the WLAN is not facilitated by the cellular network but instead by some private users. In that case, the data transmission in WLAN does not occur through cellular networks.

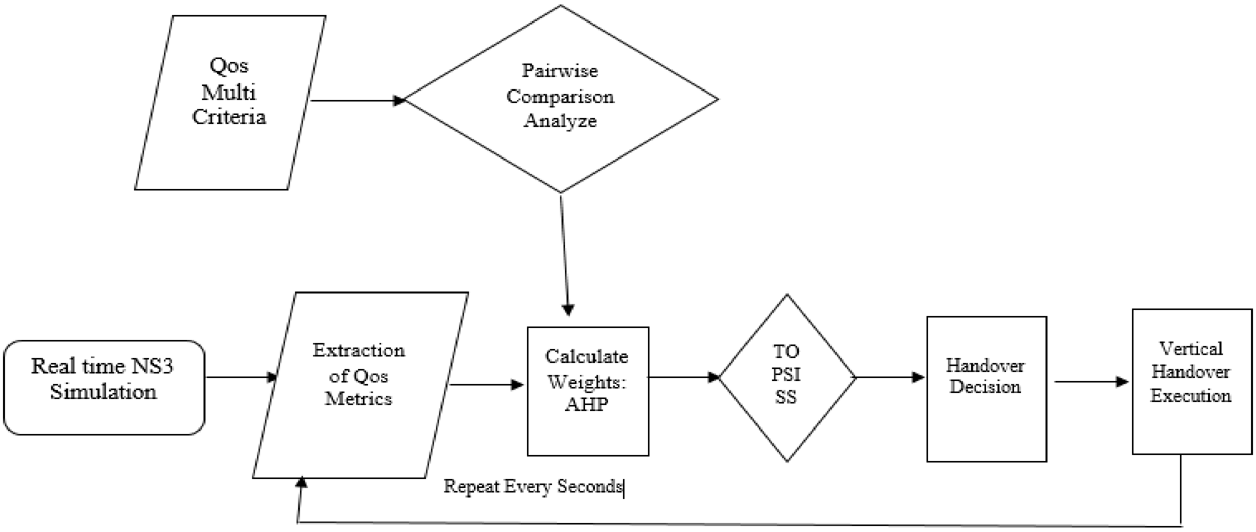

Fig. 6 – AI-VHoM Framework

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3.5.2 Handoff Criteria:

In traditional handoff mechanisms, the handoff decision is based solely on RSS between the proximity of the two cells and at times, may also be based on call drop rate due to the resource management issues. The issue is much more challenging in a heterogeneous vertical handoff environment, as varied wireless networks having incomparable signal strength parameters are to be considered like the WLAN and UMTS. Hence the multi – criteria decision making unit is employed to make the handoff decision process reliable.

3.5.3 Handoff Decision Algorithm:

Hence to utilize the potential of artificial intelligence to train and learn about the network, a fuzzy Technique for Ordering Preference by Similarity to Ideal Solution (TOPSIS) algorithm for Multi-Criteria Decision Making (MCDM) is included to assign weights for each of the criteria considered. A numerical exploration demonstrates the possibility of the proposed method with enhanced performance.

3.6 AI-VHoM– Working

The handoff procedure implies the management of the framework invoking the handoff decision algorithm. The goal of the efficient handoff decision algorithm is to choose the nest possible network based on multi-criteria. The proposed model analyses the weights of each of the criteria and the performance is analysed through a network simulation of the NS-3. The real-time and pairwise comparison is applied to the QoS Multi-Criteria. The fuzzy TOPSIS algorithm is used to assign and calculate the weight vectors so as to gain the relative importance of each of the criteria or user preferences. The fuzzy TOPSIS algorithm is used to make the final handoff decision based on the weight vectors. The real-time handoff decisions are tested and evaluated for every 5s. A fixed set of weights yields a particular quality or merit degree for each channel in the network; these merit values keeps changing if we consider a different set of weights into account. The result of the MCDM scheme is to fix on the best merit value scheme, which will facilitate seamless vertical handoff decision. It is evident that more combinations of the weights, facilitates higher chances of getting better merit values.

The vertical handoff decision problem can be expressed in the matrix form X, where each row ‘i’, correlates to the potential network and each column ‘j’ correlates to a criteria. The matrix of available networks is subject to the multi-criteria. The evaluated criteria are indicated in varied measurement units, thus indicating the need to normalize the values.

Moreover, the weighted values are fixed to each criterion based on its importance with regard to the user preferences. Fuzzy TOPSIS allows for comparison and for a choice of pre-set criteria. In our system, the fuzzy TOPSIS is used to calculate the weight vector w, which denotes the significance of the criteria with respect to user preference and QoS parameters. If fuzzy TOPSIS provide a results $w_j > 0$, which indicates the weight or importance of the j thcriteria, given that Xj=Y j=1 wj = 1. Weight computing is performed through a sequence of comparisons between the criteria pairs.

Importance	**Definition**	**Explanation**
1	Equal importance	Two parameters contributes equally
3	Moderate importance of one over another	Experience favored 3 times one than another
5	Strong importance	Experience favored 5 times one than another
7	Very strong importance	A parameters is favored and dominant in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed

Table.2 – The importance assigned through weighted vectors

4. PERFORMANCE COMPARISON

4.1 Simulations

The numerical exploration is done using the simulation environment to analyse the AI-VHoM framework. WLAN and UMTS are the two cellular networks on the network side. The advantage of these networks are that they are ideal combination to deliver seamless and

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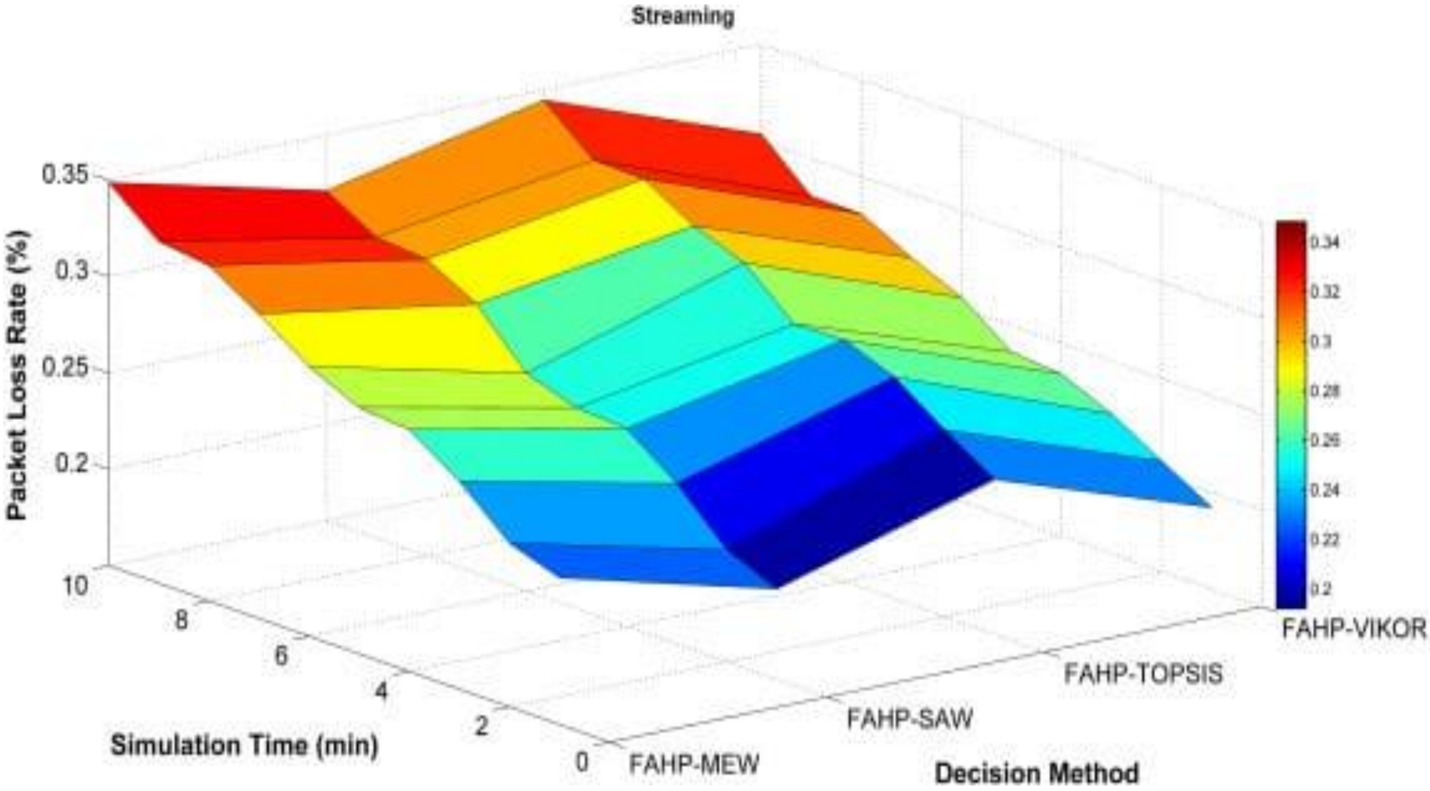
affordable services to the user and also that they are open IEEE wireless standards build to best suit the needs of IP-based applications. A multi-criteria QoS parameter set is considered. Different weighted vectors have been assigned to the multi-criteria through the fuzzy TOPSIS method. The simulation is run for 10 min; 100,000 packets are sent from the source and the decision is made every 5s as to test against real-time application needs. In case, if there are n different channels available in the network, the mobile terminal applies the decision algorithm continuously and hence need to perform no.of criteria pairs x n computations, to choose the best network. To compute the time T for the mobile terminal to choosethe



potential network, the complexity of the algorithms $O(n^2) = \max(O(TOPSIS))$.

Fig. 7 – MCDM Framework Comparison

It has to be ensured that for high quality and seamless handoff, the packet delay must be kept below 150 ms. If we predict that the mobile terminal executes one billion functions per second, then the average running time of each time the algorithm is called, is around 250ns. So we can conclude that the time to identify the rank of all the available networks is approximately equal to 1ms for the real time applications in heterogeneous set up.

4.2 Results

In-order to evaluate the performance of AI-VHoM framework, the number of lost packets and

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the end-to-end delay are chosen as the decision criteria during the simulation. The criteria tend to vary with the change in the decision making algorithms. The Figure 7 depicts the end-to-end delay and the packets loss that occurred during the vertical handoff in heterogeneous environment. The figure also depicts the performance of the various criteria and the importance of the weighted vectors allocated to the criteria. With regard to delay, the weights offer a much improved performance against the packet loss. The artificial intelligence based decision scheme eliminates the pingpong effect and assigning the new weights frequently increases the probability of transmitting the lost packets once again. It is shown that the number of lost packets are very less when compared to the original 100,000 packets thereby making the AI-VHoM favourable for real-time applications.

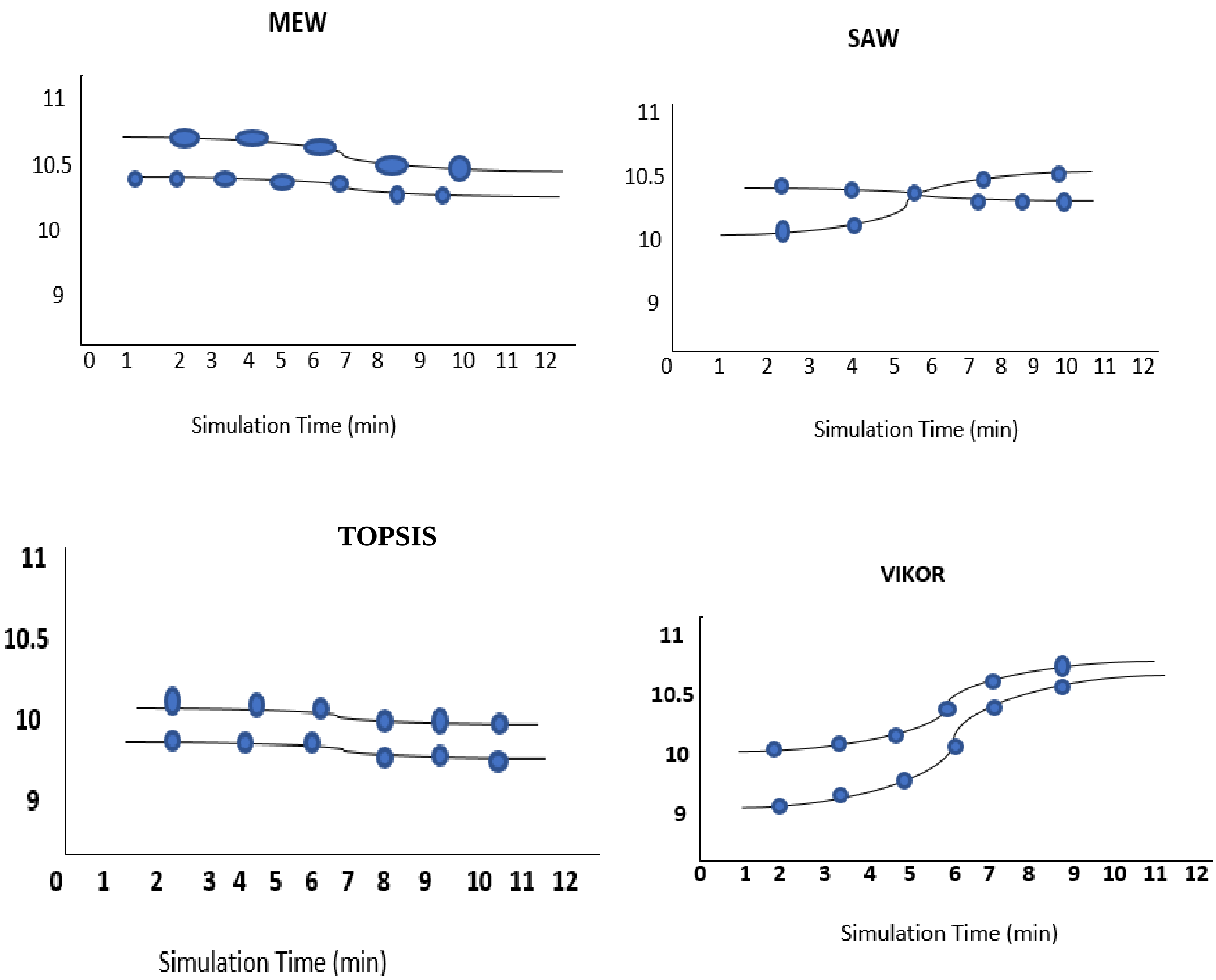

Fig. 8 – Comparison of Delay Time

The results show thatthe fuzzy TOPSIS allowing MCDM showed an improved performance with regard to delay and packet loss

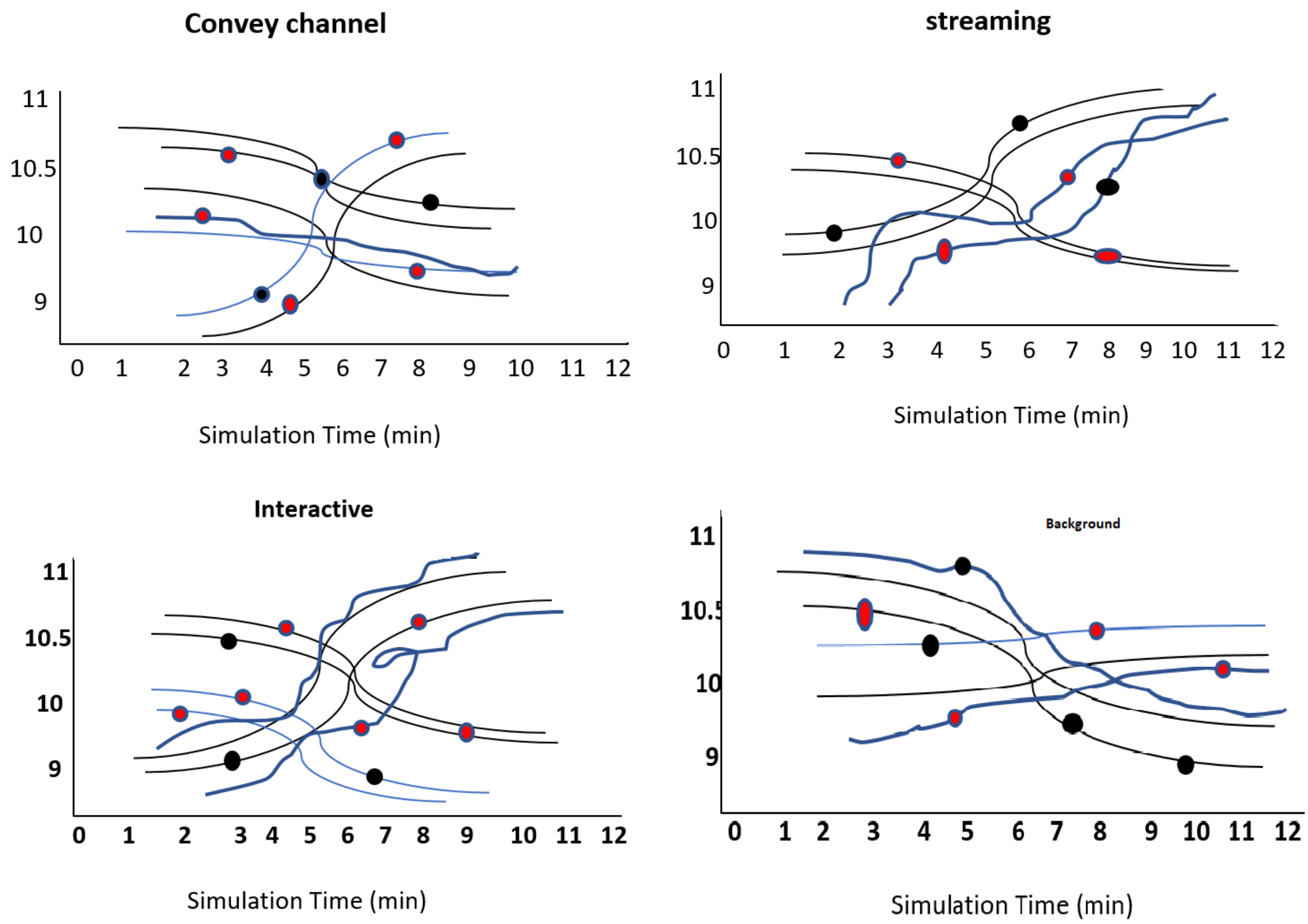

Fig. 9 – Comparison of Packet Loss vs Delay Time

5. CONCLUSION

With regard to the resource management in the heterogeneous wireless network, the artificial intelligence based multi-criteria vertical handoff mechanism provides users with the satisfaction of meeting the QoS requirements and user's preferences. In this paper, a novel framework incorporating the advantages of Multi-Criteria Decision Making (MCDM) and

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fuzzy TOPSIS have been implemented and analysed in NS3 simulation platform. In addition, the weights assignment and ranking the importance of weights was left to the artificial intelligence based handoff decision algorithm which eliminated the need for frequently learning about the network thus improving the system enhancement with reduced packet loss and latency enabling a seamless handoff.

The real time simulation included the WLAN and UMTS cellular network environments. The criteria considered were throughput, jitter, BER, SNR, RSSI and delay. The packet loss was kept to a minimum possible levels and BER associated with it also has considerably reduced. For the future, it can be aimed to reduce the packet loss to negligible level and concentrate on the security aspects during the vertical handoff as the users are more vulnerable to security attacks during mobility or roaming.

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