Performance Analysis of Vertical Handover Algorithm in Vehicular Ad-hoc Network using IEEE 802.21

Mr. U.Kumaran
Department of Computer Applications
Noorul Islam Centre for Higher Education, Kumaracoil, Tamilnadu, India
kumaran.u@rediffmail.com

Dr. M.K.Jeyakumar
Department of Computer Applications
Noorul Islam Centre for Higher Education,Kumaracoil, Tamilnadu, India
jeyakumarmk@yahoo.com

Abstract – Choosing or switching between heterogeneous networks according to the highest performance in terms of quality of service is largely inefficient in vertical handover. In fact a service may have unstable performance and require highly frequent vertical handover procedures. In this paper, a new vertical handover criterion is introduced along with a new handover decision strategy. In addition, handover decision is identified us a multiple attribute decision making (MADM) problem is applied to deal with some crucial criteria and user preference. For performance evaluation, four traffic class are considered. The subjective weight relations of decision elements are determined by Eigen value method of Analytic Hierarchy Process (AHP). Next, the rating method is employed to derive the objective weights of the evaluation criteria and on the basis, the comprehensive weight is obtained. Finally we use TOPSIS algorithm to make decision according to the attribute matrix and weight vector. The results show that our proposed scheme can achieve excellent performance according to the characteristics of the traffic by considering the relations of multiple attributions synthetically.

Key words – Vertical handover, AHP, Multiple attributes, TOPSIS.

I. INTRODUCTION

In recent advancement in wireless networking technologies, the mobile device users are expect to be always best connected. The growing in multiple access networks, more mobile terminals are supplied with multi-mode terminals, end users can able to connect to any available wireless network such as Wireless Fidelity (Wi-Fi), Universal Mobile Telecommunication System (UMTS), General Packet Radio Service (GPRS), Worldwide interoperability for Microwave Access (WiMAX) and Long Term Evolution (LTE) systems. These multi-mode terminals equipped with multiple radio interface, which is capable of communicating using any existing wireless access network protocol. In traditional homogeneous networks, the network selection process is purely based on received signal strength from serving node and neighboring access nodes. Heterogeneous networks involve a set of networks and each network having its own terminal parameters. Multiple attributes can be considered while selecting the best access network. A variety of access network characteristics has been identified as potential network selection criteria. In this context, user requirements can be translated into relative weights that a user assigns to each criterion (Eg. Bandwidth, delay, jitter, cost etc). Relative importance or weight of a criterion indicates the priority assigned to the criterion by the decision-maker while ranking the alternatives in a Multiple Attribute Decision-Making (MADM) environment. By introducing the weights of an attributes are related to the preferences of the end users. Once the criteria are identified and the preferences are fixed, it is necessary to define a mechanism that allows the terminal to evaluate candidate access networks to identify the most suitable one.

II. Proposed work

Vertical handover involves changing the data link layer technology used to access the network. Vertical handover processes are split into three phases

- Handover Initiation phase
- Handover Decision Phase
- Handover Execution Phase

Handover Initiation phase collects wireless network information. The information's collected from this phase is used for making decisions in the handover decision phase. The following information are collected during initiation phase

- *Availability of neighboring network links* such as Throughput, Packet loss ratio, Handoff latency, Received Signal Strength (RSS), Noise Signal ration (NSR), Signal to Interference Ratio (SIR), Bit Error Rate (BER), Distance, Location and QoS Parameters.
- *The device Status* such as Battery power, Speed, Resources and Service class
- *User Preferences* such as Budget and Service required

Handover Decision Phase based on the gathered information, this phase is in-charge of deciding when and where to trigger the handover. To make best decision the information gathered must be evaluated by many parameters obtained from different resources. Vertical Handover Decision Algorithm (VHA) is used to evaluate the parameters involved under each criteria.
Handover Execution Phase performs the actual transfer of the current session to the new access network takes place. This phase should also guarantee a smooth session transition process.

Decision in horizontal handover is different with decision of vertical handover, mainly because corresponding networks are different. The horizontal handover decision involves networks from the same link layer technology meanwhile vertical handover decision involves the network from different radio access technology (RAT). In horizontal handover, single parameter of RSS is sufficient to trigger handover, but in vertical handover, more parameters are needed to decide handover accurately. Wrong handover decision, however, causes the higher cost on the network side in terms of signaling and switching resource. Vertical handover decision algorithm using multi criteria is proposed as the handover decision, using single criteria (RSS) may result in inefficient handover and unbalanced load.

To decide vertical handover more accurately, more parameters are needed. In our study, we propose four attributes to decide vertical handover. Those attributes are Bandwidth, delay, jitter, and cost. The IEEE has been making significant efforts in order to develop a protocol which may be able to homogenize VHO processes among heterogeneous networks. In that sense the IEEE 802.21 standard has been released with the aim of regulating the handover process. The Media Independent Handover Function (MIHF) protocol, defined by the IEEE 802.21 standard, establishes the messages exchanged between peer MIH entities for handover, offering a common message payload across different networking media (802.3, 802.11, 802.16, Cellular). The standard refers as lower layers to the technology dependent components, and as upper layers to the requesting modules. Lower layers can be accessed by different functions to retrieve information to detect, prepare, and execute the VHO, while the upper layers demand that information; therefore, the latter are also referred to as Media Independent Handover User (MIHU). The MIHF offers to both lower and upper layers a Service Access Point (SAP) in order to exchange the service messages.

2.1 Proposed implementation

Vertical Handover Phases

I. Rating Attributes
II. Ranking Networks
III. Handover Execution

2.1.1 Phase I. Rating Attributes

Different attributes has to be consider to execute vertical handover in heterogeneous network. By adopting multiple attributes, need to determine their relative importance of the attribute. To rate the attributes, important network attributes are selected and assign weights to the various attributes.

Steps to Rate the identified attributes

Step 1: Adopt important critical attributes for rating attributes.
(Bandwidth, Delay, Jitter, Error Rate and Cost)
Step 2: To make it easier to judge the relative importance of the attribute, the network traffic is divided into four types based on IEEE 802.11 and IEEE802.16 std.
Step 3: To set the order of traffic application priority, network application priority is classified into priority levels from 1 to 7.
Step 4: The weight value are assigned to all of the attributes based on the four different traffic types and seven priority levels.
Step 5: The weighted ratio of the attributes are calculated
(add the weight values of each of the attributes together and divide the total by the value of the respective attribute).

2.1.2 Phase II Ranking Network

Steps to select suitable network

Step 1: Available network and their attributes are obtained via a nearby MIH Server
Step 2: Normalize the parameters of the candidate network
Step 3: Calculate the weighted ratios of the candidate network
(multiply the normalized weight values by weighted ratio of attributes)
Step 4: Determine the positive ideal solution and negative ideal solution
Step 5: Calculate the separation of each alternative from positive and negative ideal solution
Step 6: Calculate the combined weighted sum of ideal solutions
Step 7: Calculate the weighted sum of each candidate network
Step 8: Select optimal network (Highest score) to handover

2.1.3 Phase III Handover Execution

Handover Execution phase performs the actual transfer of the current session to the new access network. Traditionally received signal strength (RSS) is used to detect the signal strength of a nearby base station or access point. If the signal is weak and reaches a threshold value, a mobile node leaving its current base station or access point. By this time Phase I and Phase II procedures will be implemented to make handover preparations.

2.2 Vertical Handover Algorithm

Vertical handover algorithm is designed to enhance the performance in terms of number of handover and effective usage of network resources. To reduce the number of unnecessary handover (Ping-Pong effect), vehicle speed is also consider for handover.

```
Handover_Algo()
    BEGIN
      {
                        SET Traffic_Type;
                        SET Traffic_Weight;
                        WEIGHT_RATIO = CAL_RATIO(Traffic_Weight);
      While (! Handover)
                        {
```

```
                IF (Nearby BS's Signal >= NewBSThroshold) Then
                    Obtain New_BS_Parameter;
                    Save BS_Parameter_List;
                ENDIF;
                IF (Belongs to BS's Signal  <=HOThreshold) Then
                    Get BS_Parameter_List;
                    TARGET_BS_AP = TOPSIS(WEIGHT_RATIO, BS_Parameter_List);
        IF (NEARBY_NO_WIFI_AP_EXIST or Vehicle_Speed > 20 m/s) Then
                        Handover to Target WIMAX BS from Target_BS_AP;
        ELSE
                        Handover to Target WIFI  AP from Target_BS_AP;
                ENDIF;
                ENDIF;
              };
    };

CAL_RATIO()
    {
              SET TR_T=Traffic_Type ;
              SET TR_W=Traffic_Weight;
              Calculate WEIGHT_RATIO  from TR_W parameters;
        Return WEIGHT_RATIO;
    }END CAL_RATIO
TOPSIS(WEIGHT_RATIO,BS_Parameter_List);
    {
      Query BS_Parameter_List;
              Step 1: Normalize BS-Parameter_List;
              Step 2: Multipy normalized value with WEIGHT_RATIO;
              Step 3: Determine positive and negative ideal solutions;
              Step 4: Calculate the separation of each alternative;
              Step 5: Calculate the closeness coefficient of each alternative;
              Step 6: Select highest closeness coefficient value as TARGET_BS-AP;
                    return TARGET_BS_AP;
    } END TOPSIS()
```

2.3 Numerical Analysis of MADM methods

TOPSIS Method

Using TOPSIS method, first construct a decision matrix, and normalize the decision matrix.

TABLE 1: Normalized Decision Matrix

Traffic code	Bandwidth (mbps)	Delay (sec)	Jitter (sec)	Error (%)	Cost (rs/bps)
T1	0.136	0.273	0.227	0.091	0.273
T2	0.217	0.261	0.261	0.130	0.131
T3	0.231	0.077	0.077	0.538	0.077
T4	0.333	0.167	0.167	0.167	0.167

Then construct weighted normalize decision matrix. The following Table 2 presents the weighted normalized decision matrix.

TABLE 2: Weighted Normalize Decision Matrix

Network	Bandwidth (mbps)	Delay (sec)	Jitter (sec)	Error (%)	Cost (rs/bps)
N1	0.040	0.102	0.079	0.046	0.071
N2	0.085	0.156	0.091	0.053	0.068
N3	0.181	0.052	0.041	0.246	0.060
N4	0.131	0.037	0.116	0.101	0.035

Determine the positive ideal Solution A^+ and negative ideal solution A^- is as follows

	Bandwidth	Delay	Jitter	Error	Cost
A^+ =	{0.180	0.156	0.116	0.246	0.071}

	Bandwidth	Delay	Jitter	Error	Cost
A^- =	{0.040	0.037	0.040	0.046	0.035}

Then determine the distance between each alternative.
The positive ideal solution is given below

$$S_i+ = \begin{matrix} 0.252589399 \\ 0.216569393 \\ 0.129399387 \\ 0.196787804 \end{matrix}$$

Negative ideal solution is given below

$$S_i^- = \begin{matrix} 0.083734933 \\ 0.140754611 \\ 0.245703341 \\ 0.130202076 \end{matrix}$$

Finally the closeness (C_i) of the ideal solution is calculated and presented as follows

$$C_i = \begin{matrix} 0.24897 \\ 0.39391 \\ 0.655029 \\ 0.398184 \end{matrix}$$

From C_i , Network N3 is the best alternative network to connect the vehicle to maintain the service continuity by TOPSIS algorithm. The Ranking order of TOPSIS is N3, N4, N2, and N1

2.4 Analysis of Multi Attribute Decision Making in Vehicular Ad-Hoc Network

MADM problem involves a set of alternative network evaluated based on a set of attributes. Three multi attribute decision making algorithms Simple Additive Weighted Method, Multiplicative Exponent Weighted Method, Technique for Order Preference by Similarity to Ideal Solution Method are investigated and analyzed their performance.

Table 3: Analysis of multi attribute decision making algorithms

	SAW	MEW	TOPSIS
N1	0.532	0.504	0.249
N2	0.641	0.626	0.394
N3	0.896	0.888	0.655
N4	0.637	0.556	0.398

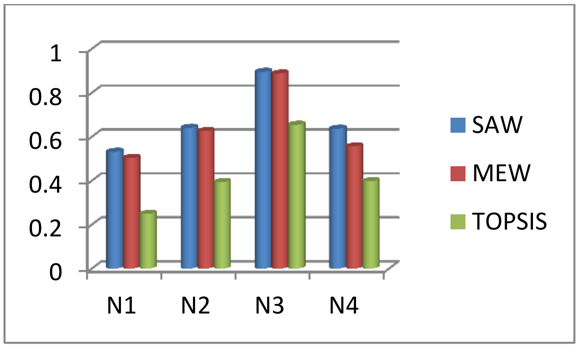

Figure 1: Performance analysis of MADM methods

2.5 Sensitivity of attributes are computed

To analyze the sensitivity of an attribute, the weight of the attribute is increased by a value. The change in the weight of one attribute affects the weight of other attributes.

Sensitivity Analysis

Table 4: Ranking order preferences before sensitivity analysis

Ranking Before Sensitive Analysis				
	N1	N2	N3	N4
SAW	0.532	0.641	0.896	0.637
MEW	0.504	0.626	0.888	0.556
TOPSIS	0.249	0.394	0.655	0.398

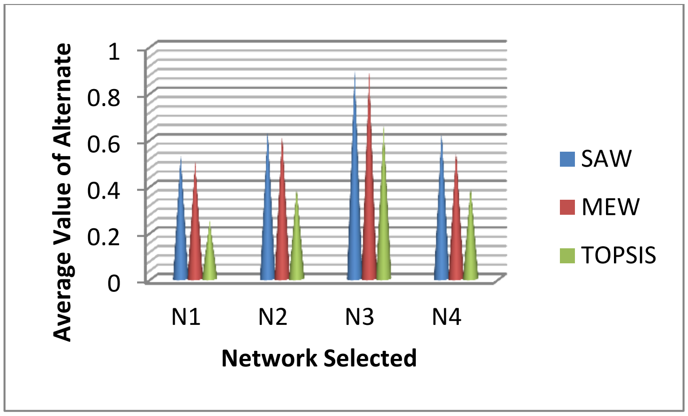

Figure 2: Ranking Order of alternative network before sensitivity analysis

Table 5: Ranking order preferences after sensitivity analysis

Ranking After Sensitive Analysis				
	N1	N2	N3	N4
SAW	0.524	0.607	0.861	0.726
MEW	0.503	0.593	0.852	0.642
TOPSIS	0.443	0.504	0.495	0.408

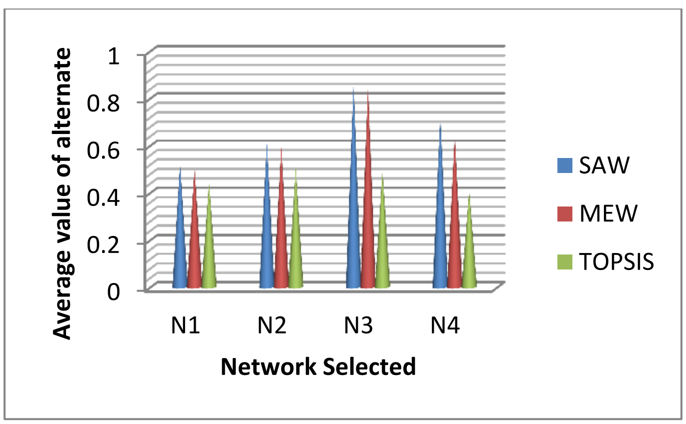

Figure 3: Ranking Order of alternative network after sensitivity analysis

III SIMULATION AND PERFORMANCE ANALYSIS

Table 6: Simulation Parameters

Parameters	Values
802.16 BS Bandwidth	45 Mb
802.11 AP Bandwidth	11 Mb
WiMAX BS radius	500 m
WiFi AP radius	50 m
Mobile node moving speed	5 m/s-20 m/s
Dynamic mobile nodes	26
WiMAX fixed mobile nodes	8-10
Simulation time	300 s
Packet transmission rate	1000kbs

Simulation carried out using NS2-NIST-(2.29) for calculating the packet drop ratio between vehicle node and correspondent node under four types of traffic services, using different vehicle speeds. The results of such simulations show that the Improved TOPSIS based handover method gives relatively lower packet drop ratios under all the four traffic types, when compared to the traditional NIST mobility handover method. In Improved TOPSIS handover method can allow the vehicle node to choose a best Base Station and hence the packet drop ratio is lower.

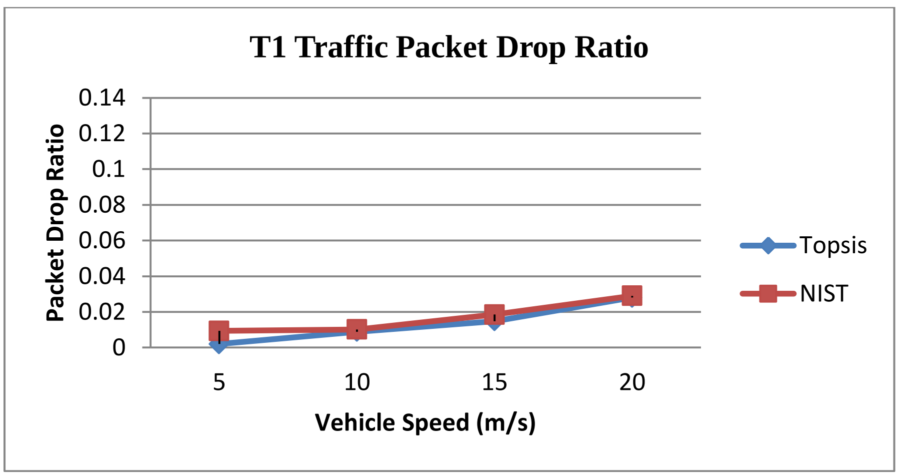

Figure 4: Packet Drop Ratio Performance for Traffic T1

The packet drop ratio performances of the two handover methods are conducted under Traffic T1. The length of the packet assigned is 300 bytes with the vehicle moving speed between 5 (m/s) – 20 (m/s). The simulation result shows that the TOPSIS handover method is little superior to the NIST handoff scheme.

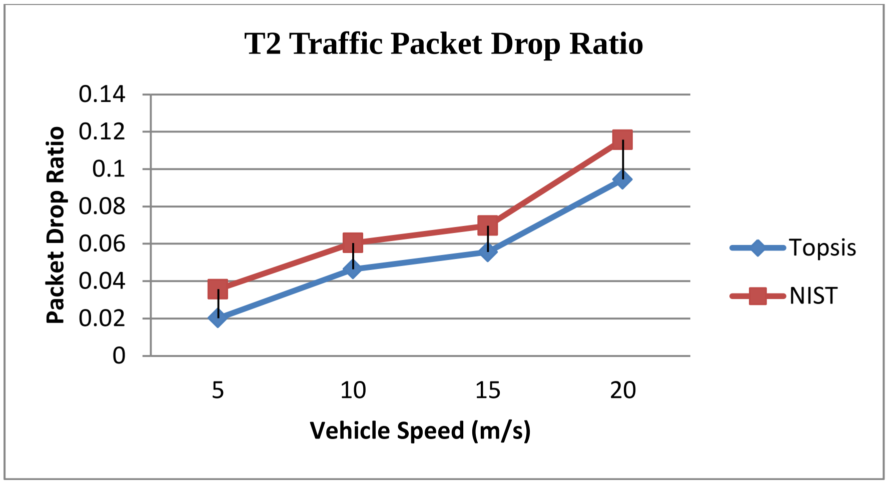

Figure 5: Packet Drop Ratio Performance for Traffic T2

The packet drop ratio performances carried out under Traffic T2. The packets length assigned is 2,000 bytes. The packet drop ratio performances illustrate that the TOPSIS handover method outperforms the NIST handover method.

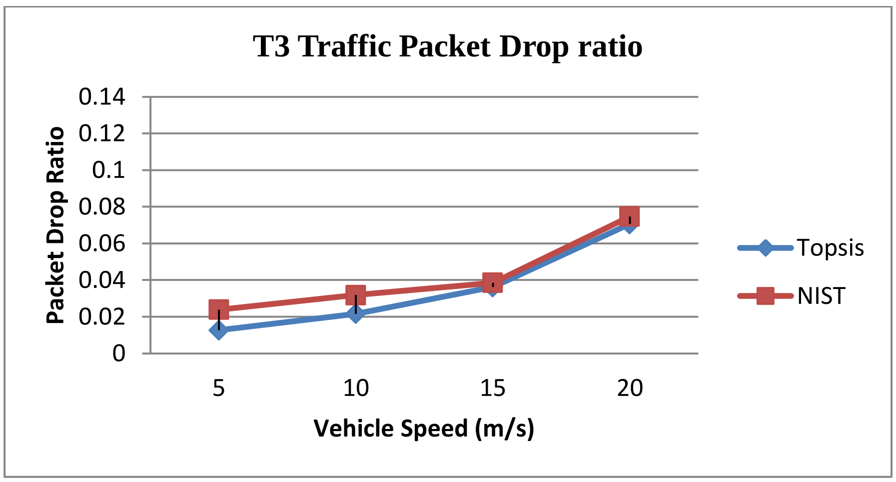

Figure 6: Packet Drop Ratio Performance for Traffic T3

The simulation conducted under Traffic T3. The packet length is set as 1000 bytes. In this time, the TOPSIS handover method performs slightly better than the NIST method, in terms of packet loss rates. This is because of Traffic T3 is best effort service requires less importance to other network conditions.

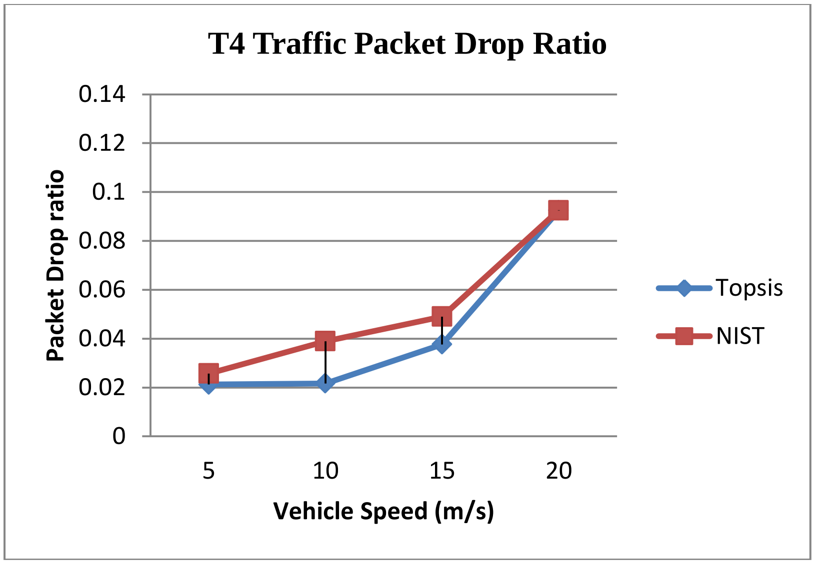

Figure 7: Packet Drop Ratio Performance for Traffic T4

The packet drop ratio performances made under the Traffic T4. The length of the packet assigned in this case is 1,500 bytes. The performance of the TOPSIS handover scheme in this Traffic is still superior to that of the NIST handover method.

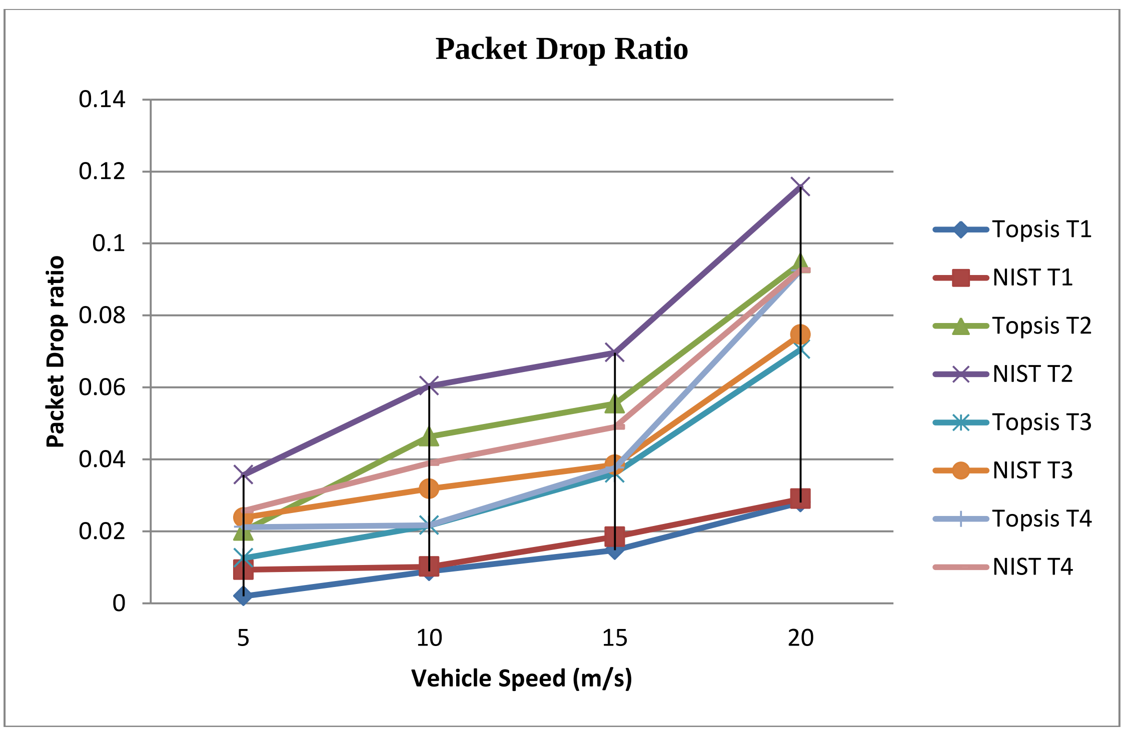

Figure 8: Comparison of Packet Drop Ratio between TOPSIS and NIST handover method

From the overall performance analysis of network under four different traffic services, we can find that when the vehicle moves at a high speed reaching 20 m/s, the packet drop ratios of both the TOPSIS and the NIST handover methods are rather high, showing little difference between them. Here is the reason why: the Wi-Fi AP covers a radius of 50 m in our experiment. This is to say that given the vehicle node's high moving speed at 20 m/s, it can remain within the area of the Wi-Fi AP for only a maximum five seconds. In other words, even if the vehicle node had handover to an AP with relatively good conditions, it was able to stay in the network for only a limited period of time. From Figure 8, we can see that the vehicle node, in transmitting packets over various types of traffic services, can cause a steady increment in packet losses, while increasing its own moving speed. We can also find that T1 traffic registers the lowest packet drop ratio in comparison with the other three types of traffic services. This is because the packets transmitted via T1 traffic are shorter ones being only 300 bytes long. The above situation is true for both handover methods. For the NIST handover method, the packet drop ratios of the four types of traffic services are such: T2 > T3 > T4 > T1. In terms of packet size, the packets transmitted over these four traffic types are in order 2000, 1500, 1000 and 300 bytes long. In other words, the larger the packets, the greater the packet drop ratios are. These situations also hold true for the TOPSIS handover method.

Table 7: Comparison of packet drop ratio between TOPSIS and NIST

Traffic	Speed (m/s)	TOPSIS (%)	NIST (%)	Improved Performance	Average ratio (%)
T1	5	0.002013	0.009353	0.00734	0.0033
	10	0.0089485	0.010174	0.001226	
	15	0.014832	0.018501	0.003669	
	20	0.028066	0.02903	0.000964	
T2	5	0.02014	0.035686	0.015546	0.016246
	10	0.04636	0.06042	0.01406	
	15	0.055541	0.069678	0.014137	
	20	0.09446	0.1157	0.02124	
T3	5	0.012597	0.023856	0.011259	0.006974
	10	0.021649	0.03184	0.010191	
	15	0.036166	0.038523	0.002357	
	20	0.070549	0.074637	0.004088	
T4	5	0.021206	0.025731	0.004525	0.0083
	10	0.021704	0.038935	0.017231	
	15	0.037664	0.049003	0.011339	
	20	0.092461	0.092564	0.000103	

The Table 7 show the comparisons of packet drop ratios that the TOPSIS handover method and the NIST handover method in the different types of traffic services. From this table, we can note that, for both handover methods, when the vehicle increases its speed, it can cause an increment in packet drop ratios, hence decreasing the degree of improvements. A description of packet drop ratios for each of the four traffic types is given below. The drop ratio for T1 traffic is relatively low, because the voice packets we set are shorter ones, being only 300 bytes long. As a result, the improvement rate in T1 traffic packet transmission for the TOPSIS handover method is significantly higher. In T2 traffic where we set longer packets of 2000 bytes for transmission, the improvement ratio is higher than that in T3 and T4. The TOPSIS handover method assigns a higher application priority to T2 traffic than T3 and T4 on purpose. The above experimental results prove that our handover scheme can allow vehicle node to make connection switches according to traffic application priority by applying the attribute rating method. This proof also helps to explain why the TOPSIS handover scheme's design to assign application priority on the principle of T1 > T2 > T3 > T4 is able to improve link service performance. Under that principle, lower priority applications do not need be given the priority to handover to a base station of better conditions, and vice versa. From our experiments, we find that, in comparison with the NIST handover method, the TOPSIS handover method's average improvement rate in the area of packet drop ratio for Traffic T1 is 101.6%, for Traffic T2 it is 38.85%, for Traffic T3 it is 37.2%, and for Traffic T4 it is 32.7%.

IV CONCLUSION

The traditional handover methods consider only RSS or just a few factors for making handover decisions. By proposing this novel handover method, the main aim is to provide an effective alternative to some similar MADM vertical handover methods, such as the SAW model that are included in this work for comparison. TOPSIS handover method adopts multiple critical attributes as criteria for making handover decisions. TOPSIS handover method aims to ensure that vehicular nodes can get better link service after connecting to new networks. Through this research and experiment, the aim is attainable by allowing vehicular nodes to select optimum handover networks according to their requirements for specific traffic applications. In this research TOPSIS handover method is compared with a MADM vertical handover model that comprises SAW and MEW, as well as the existing traditional NIST handover method. All such comparisons were carried out in a simulated heterogeneous wireless network environment. Final results indicate that the TOPSIS handover method can effectively reduce the rate of packet losses. With respect to jitter, we analyze jitter performances in packet transmission over T1 voice traffic and find the TOPSIS handover method also outperforms both the NIST and SAW handover models in terms of attaining relatively stable jitter changes. In T2 video traffic, we also see lower packet delay time. As for average throughput, the TOPSIS handover method works better than the NIST handover method and the SAW model, too. In total the performance indicators shows that the TOPSIS handover method renders better performances compared to both the traditional NIST handover method and the MADM SAW model.

REFERENCES

[1]. L.Mohamed, C.Leghris, A.Abdellah “Network selection decision based on handover history in heterogeneous wireless network” International Journal of Computer Science and Telecommunications. 3(2012). Pp.21-25.

[2]. Kaveh Shafiee, , Alireza Attar, and Victor C. M. Leung, “Optimal Distributed Vertical Handoff Strategies in Vehicular Heterogeneous Networks” IEEE journal on selected areas in communications, vol. 29, no. 3, march 2011, PP 534-544..

[3]. Gabriele Tamea, Mauro Biagi, and Roberto Cusani “Soft Multi-Criteria Decision Algorithm for Vertical Handover in Heterogeneous Networks” IEEE Communications letters, vol. 15, no. 11, november 2011, PP 1215-1217.

[4]. Dong Ma, and Maode Ma A “QoS Oriented Vertical Handoff Scheme for WiMAX/WLAN Overlay Networks” IEEE Transactions On Parallel And Distributed Systems, Vol. 23, No. 4, April 2012, PP 598-606

[5]. D.E. Charilas, and A.D. Panagopoulous “Multiaccess Radio Network Environments” in IEEE Vehicular Technologies. Vol. 5. No.4. Pp. 40-49. 2010.

[6]. Kumaran.u “Vertical Handover in Vehicular networks using Multiple Parameters” International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT) – July-2014.

[7]. M.A. Khan “Auction based interface selection with media independent handover services and flow management” in European wireless conference – 2010.

[8]. H. Pervaiz “A multi-criteria decision making (MCDM) network selection providing Qos differentiation to customers” in International conference on Multimedia computing and Information Technology – 2010.

[9]. Kumaran.u, M.K.Jeyakumar “Multi-Criteria Based Network Selection Strategy in Multi-Radio Access Network for Vehicular Communications” International Journal of Applied Engineering Research (IJAER)Vol. 10. Number 16. Aug.-2015, PP 37003 – 37008.

[10]. L.Mohamed, C.Leghris “A hybrid approach for network selection in heterogeneous multi-access environment” in NTMS 2011. Pp. 1-5.