ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 6, June 2015

Energy and Traffic Aware Vertical Handoff in Heterogeneous Wireless Network

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Abstract: The next generation mobile networks have the development trend of integration of cellular networks and Wireless Local Area Networks (WLAN).Considering the heterogeneous environment, Universal Mobile Telecommunication System (UMTS) of cellular technology and WLAN (over IEEE 802.11) are the most promising networks. Integration of these two networks facilitate user for the seamless communication. Handoff decision making is the main challenging issue in the integration of UMTS and WLAN networks.Efficient vertical handoff algorithms are required to maintain the acceptable level of quality and seamless connectivity in heterogeneous wireless environment. Various metrics have been considered such as bandwidth, energy, traffic, distance, monetary cost to make handoff decision.A novelhandoff decision making algorithm using fuzzy rule for meeting the requirements of heterogeneous networks is proposed in this paper.WLAN and UMTS are considered as two integrated network entities.Handoff decision metrics for the proposed algorithm are energy, traffic and cost. The algorithm allows the mobile terminal to have the seamless connection with most energy efficient and cost effective network weighted with the handoff metrics such as energy, traffic and cost.

Key terms: WLAN, UMTS, Heterogeneous Wireless Networks, Vertical Handoff.

I. INTRODUCTION

In case of coverage unavailability, WLAN facilitates user switching to the low bandwidth overlay service of General Packet Radio Service network (GPRS). Various wireless networks such as UMTS, WLAN, WiMAX (Worldwide Interoperability for Microwave Access) have progressed to facilitate communication over a link [1]. Different versions of WLAN are available such as IEEE 802.11 a/b/g/n providing higher bandwidth with data rates of 11Mbps to 54Mbps. UMTS is termed as “Large Coverage Network” which gives data rates up to 2Mbps. UMTS uses WCDMA (Wireless Code Division Multiple Access) as access technology. With their individual characteristics of coverage, bandwidth, energy, traffic, security, cost and cost, every technology facilitates user to use the most efficient access network in heterogeneous environment. With the integration of complementary wireless technologies such as WLAN hot-spots and UMTS cellular network efficient and seamless communication can provided to the user. Handoff decision mechanism is the key element of the vertical handoff, which implies to decide whether to carry out the handoff.In addition to received signal strength the following metrics have been used in order to take the decision as to when to initiate handoff and which access network to be chosen in heterogeneous wireless system: service type (conversational, streaming, background and interactive), networks conditions, system performance, user preference (such as preferred network operator, preferred technology type) and cost of service[1]. Proposed algorithm is anovel fuzzy rule based handoff decision making algorithm which uses various parameters namely Received Signal Strength (RSS), energy, traffic and cost.

Now a day’s number of mobile users is served in wireless network, sustaining quality of service while maintaining the ongoing connection is a necessary task. Energy efficiency is one of the major issues and signal strength of the network is calculated from the energy itself. Traffic is also a key factor to be considered of because of the increasing number of mobile users in the present day technology.

II. RELATED WORK

An algorithm for vertical handoff decision for UMTS and WLAN proposed by Ram Kumar Singh et al [6] is divided into two parts: first part is Fuzzy logic based handoff initiation algorithm and second is an access network selection algorithm. It determines whether to continue with an existing service or begin another service by initiating a vertical handoff and dynamically selects the optimum network connection from the available access network technologies.In order to take better decision for handoff it is proposed to use different handoff metrics such as data rate, network coverage and perceived Quality of Service (QoS) in addition to RSSI.

FUZZY-Technique for Order Preference by Similarity to Ideal Solution (FUZZY-TOPSIS) based vertical handoff decision mechanism is proposed in [2]. Two methods, which are, FUZZY rule based mechanism and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) are united. Handoff metrics such as bandwidth, end-to-end delay, bit-error rate and jitter are used to make the decision for handoff. Simulation results are thencompared with simple additive weighting (SAW),

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ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
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TOPSIS, multiplicative exponent weighting (MEW) and Fuzzy and showed that considered parameters shows better results for Fuzzy-TOPSIS method. Vertical handoff using Stream Control Transmission Protocol (SCTP) in UMTS and WLAN network is proposed in [8]. UMTS/WLAN vertical handoff is supported by using mSCTP. UMTS/WLAN handoff delay and overall throughput are the two critical performance metrics evaluated using simulation.

Enrique Stevens-Navarro and Vincent W.S. Wong [9] provides comparison of different vertical handoff decision algorithms, namely Simple Additive Weighting (SAW), Multiplicative Exponent Weighting (MEW), Grey Relational Analysis (GRA) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Different attributes such as bandwidth, delay, packet loss rate, and cost are considered for each of the algorithm. Slightly higher bandwidth and lower delay results obtained for GRA while MEW, SAW, and TOPSIS provide similar performance.

Location aware vertical handoff decision algorithm for heterogeneous access network is proposed by Farhan Qamar et al [7] applies threshold criterion for signal level and distance separately. Heterogeneous environment is considered of the networks WLAN, EDGE and CDMA.

Various handoff metrics such as bandwidth, velocity, distance, monetary cost are used to process handoff request. Simulation results from the existing methods show that MEW, SAW and TOPSIS provide similar performance to all four traffic classes. GRA provides a slightly higher bandwidth and lower delay for interactive and background traffic classes [2].Bandwidth has been considered as major factor for handoff in most of the techniques. Energy is also a prime requirement for handoff to be considered of along with bandwidth. Some methods have also considered energy as well as traffic alone to initiate handoff. In this paper multiple base station are considered with number of mobile users.Because of increasing global competition among the wireless service providers, cost is also an important parameter to be considered of. Proposed algorithm considers energy of the node, network traffic and cost for handoff.

III. PRELIMINARY OF VERTICAL HANDOFF

The three phases of Vertical handoff are: 1. System discovery phase 2. Handoff decision phase 3. Handoff execution phase System discovery phase continuously monitors the state of the network and need to carry out handoff. Thehandoff decision phase decides whether the mobile terminal is able to continue with the ongoing connection with the existing network or switch to another network. It needs to decide when to carry out the handoff and to determine the best network for the handoff. Third step selects the best network from the decision taken in the previous phase. Consider mobile devices 1, 2, 3, 4, 5 and 2 laptops that support both UMTS and WLAN access capabilities [1]. UMTS network serves mobile devices 1, 2, 3 and 4 and WLAN network serves mobile device 5 and 2 laptops.

Mobile terminal 3 starts moving away from the node B, and approaching WLAN network and it detects the failing of the UMTS network coverage. When it comes to the coverage area of the WLAN network,overlapping area, it may tempt to switch to WLAN network to delight in the higher bandwidth service.When the signal strength of WLAN network is better than the UMTS network it will switch over to the WLAN network. Similarly, for the mobile device 5, operating in a WLAN, moves out of the coverage area of WLAN, the mobile device detects failing of WLAN coverage and with the better signal strength switches to UMTS network.

IV. PROPOSED SYSTEM

In heterogeneous networks, even after the handoff, vertical handoff required to be more efficient while sustaining the Quality of Service for different traffic classes such as conversational, streaming, background and interactive. The algorithm for the proposed fuzzy rule based handoff decision mechanism for the best network to be selected is shown in figure 2and considers two networks i.e. WLAN and UMTS. A fuzzy rule based handoff decision making system is proposed which considers Mobile-Controlled Handoff and some assistance from the network. Two handoff scenes are considered to roamin heterogeneous networks, i.e. handoff from UMTS to WLAN and from WLAN to UMTS. RSS of the mobile node for the current network is continuously monitored and the condition of the handoff. According to the handoff metrics, a threshold level is assigned to each of the network. The first step is, when the mobile node experiences RSS going below the threshold level, it starts searching networks in the surrounding environment. In the second step, for the available network set, the parameters considered are checked for the handoff. The proposed fuzzy rule based decision mechanism considers energy, cost and traffic for the handoff. Third step selectsthe best network. Finally the mobile node is switched to the best network selected in the decision module. Assume the low region points Figure 3 are as follows{Low_1, Low_2,Low_3}; Medium region points as{Med_1, Med_2, Med_3}; and for high region as{High_1, High_2, High_3}, In thefuzzification process, ifX is the input value and falls in the low region then the membership value for low region will be calculated as explained below:

$$\Delta 1 = X - Low\_1,$$
$$\Delta 2 = Low\_2 - X$$
$$S2 = \frac{-1}{Low\_2 - Low\_3}$$

If (($\Delta 1 \leq 0$) or ($\Delta 2 \leq 0$)) then the membership value of the low region will be
Low_Mem = 0
else
Low_Mem = min($\Delta 2$*S2,Max)

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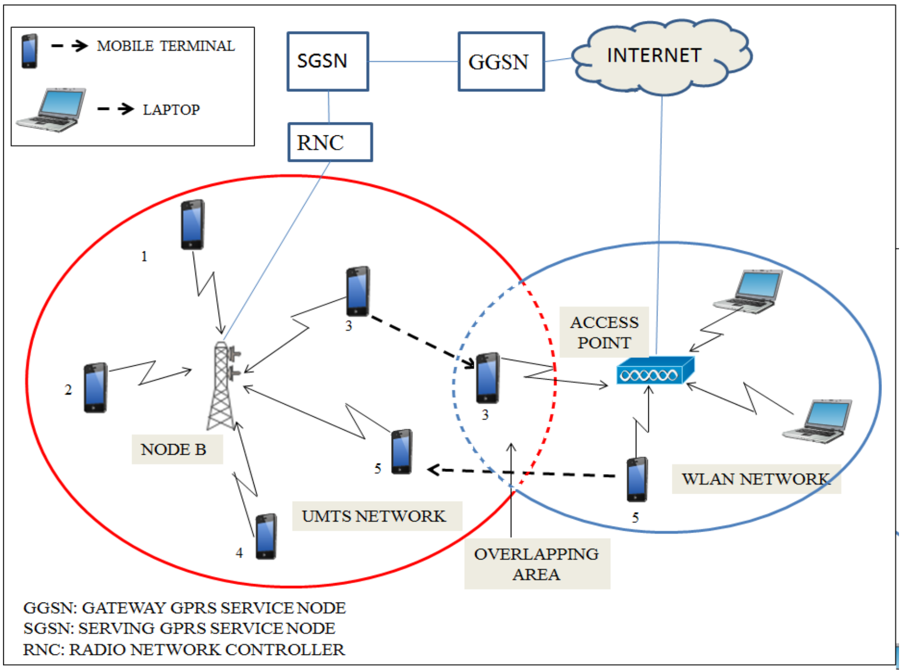

Fig 1. Vertical Handoff Scenario

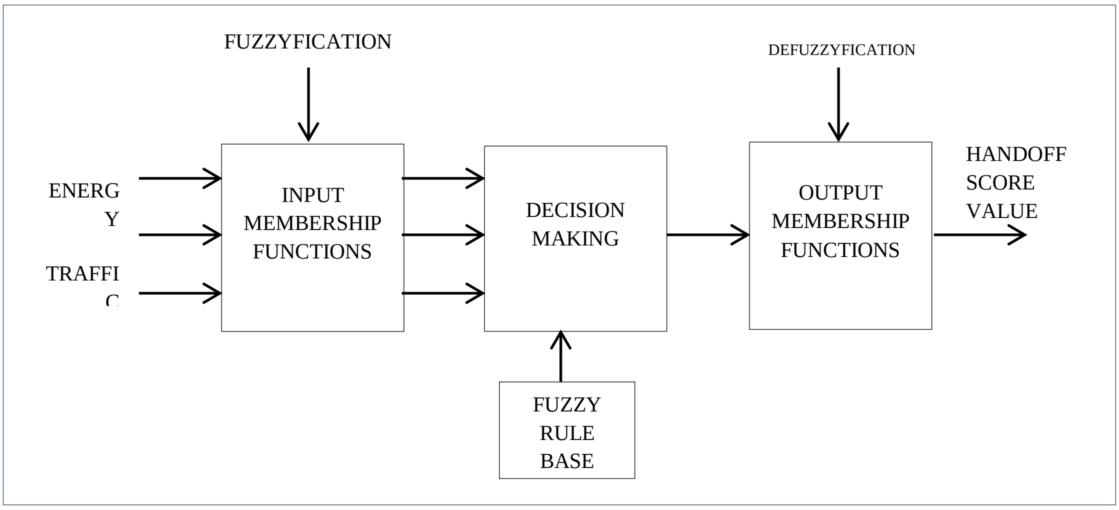

Fig 2. Block diagram of Fuzzy Logic System

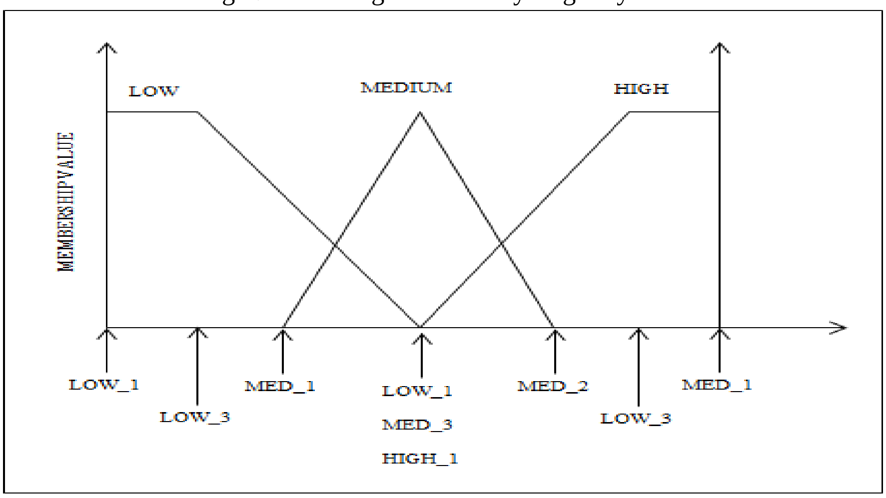

Fig 3. Fuzzy Membership Functions

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ISSN (Print) 2319-5940

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If X falls in the medium region then the membership value for medium region will be calculated as follows:

$$\Delta 1 = X - Med\_1,$$
$$\Delta 2 = Med\_2 - X$$
$$S1 = \frac{1}{Med\_3 - Med\_1}$$
$$S2 = \frac{-1}{Med\_2 - Med\_3}$$

If ((Δ1≤ 0) or (Δ2≤ 0)) then the membership value of the low region will be
Med_Mem = 0
Else
Med_Mem = min(Δ1*S1,Δ2*S2,Max)

If X falls in the medium region then the membership value for medium region will be calculated as follows:

$$\Delta 1 = X - High\_1,$$
$$\Delta 2 = High\_2 - X$$
$$S1 = \frac{1}{High\_3 - High\_1}$$

If ((Δ1≤ 0) or (Δ2≤ 0)) then the membership value of the low region will be
High_Mem = 0
Else
High_Mem = min(Δ1*S1,Max)

With 3 inputs and 3 membership regions, number of rules that can be used are 3*3*3 = 27. Each rule is associated with a membership value and will also have output membership values. With the help of the centroid method of defuzzification, the output handoff score value is calculated as

$$X^* = (\sum A_N C_N) / \sum C_N$$

whereC_N= [C_1, C_2, C_3, . . . , C_{27}] givesthe center value of each effected output region, and A_N= [A_1, A_2, A_3, . . . , A_{27}] gives the affected areas of output regions. By using the above proposed method, the handoff score is calculated for given set of input parameters and then the network with highest handoff score value is selected.

The system flow for fuzzy rule based mechanism that gives the decision regarding the best network to be selected is displayed in Fig 4. Input is taken from the parameter values of the network and handoff score is calculated. Whenever a mobile terminal operating in UMTS network senses a new WLAN network,it begins handoff initiation and chooses whether the mobile terminal should handoff to WLAN on the basis of the input parameters which are energy, traffic and cost of the target WLAN network. RSSI indicates the network availability of the target WLAN network. The fuzzification module takes input as the crisp values of the parameters selectedwhich are then transformed into fuzzy sets via membership functions.Fuzzy Inference Engine takes these fuzzy sets as input where a set of IF-THENrules is applied to obtain decision sets. these decision sets are then converted to crisp values With the use of defuzzification process which is used to determine whether the handoff is necessary.

Fuzzy sets are assigned to each of the input parameters; for example, the fuzzy set values for energy, traffic and cost consists of three linguistic terms: Low, Medium, and High.These sets are mapped to corresponding triangular Membership Functions. The fuzzy IF-THEN rules can be:

- IF energy is low, and traffic is high, and cost is high, THEN handoff factor is low.
- IF energy is low, and traffic is medium, and cost is high, THEN handoff factor is low.
- IF energy is high, and traffic is low, and cost is low, THEN handoff factor is high.
- IF energy is medium, and traffic is low, and cost is low, THEN handoff factor is high.

Handoff score is then calculated after the defuzzification process to determine whether handoff is required.

VI. SYSTEM IMPLEMRNTATION

This section discusses the scenario generated in NS2 to depict UMTS to WLAN handover and the results. Simulations performed are considering traffic/CBR. Handoff is performed from base station 1 to base station 2 which is an Access Point (AP). The parameters considered are traffic, cost and energy. The scenario consists of two UMTSbase stationsand a WLAN access point. It is assumed that one Mobile Node(MN), equipped with multiple interfaces, is connected to UMTS before it goes through the WLAN coverage area. MT starts in a UMTSbase station and after some time itstarts to move in the direction of the center of the WLAN (AP), and in its way a WLAN network isdetected. Figure 5 shows that there is one Access Points(APs) and two Base Stations arranged alternatively and all areconnected to the correspondent node (CN) through therouter. At the start of simulation the MN is under UMTS coverage area, transfer of data will take placefrom MN to CN through Base Station1. MN starts moving towards WLAN and finds it better, so vertical handover takes place from UMTS to WLAN and MT starts sending data without any loss.

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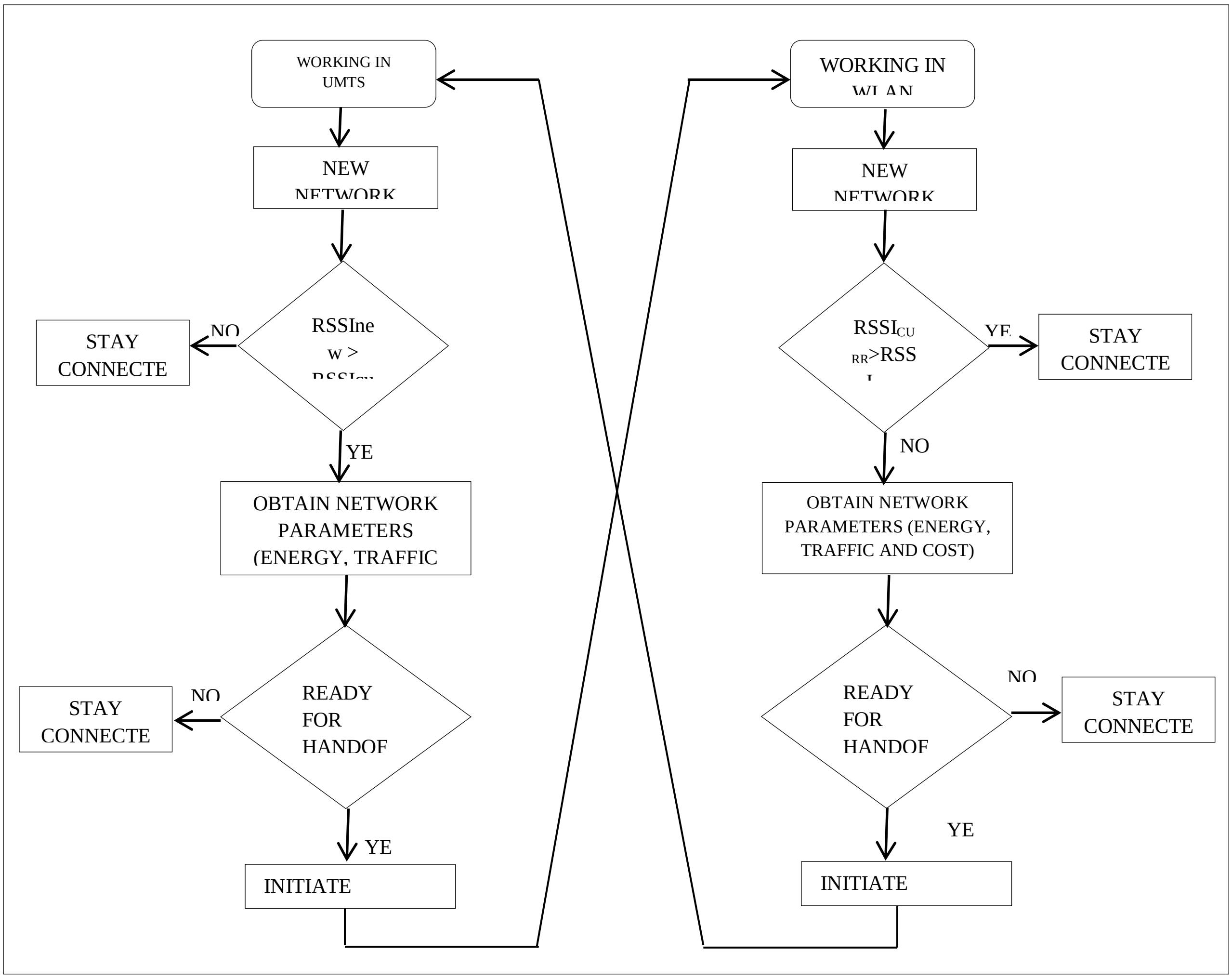
Fig 4. Fuzzy rule based handoff decision mechanism.



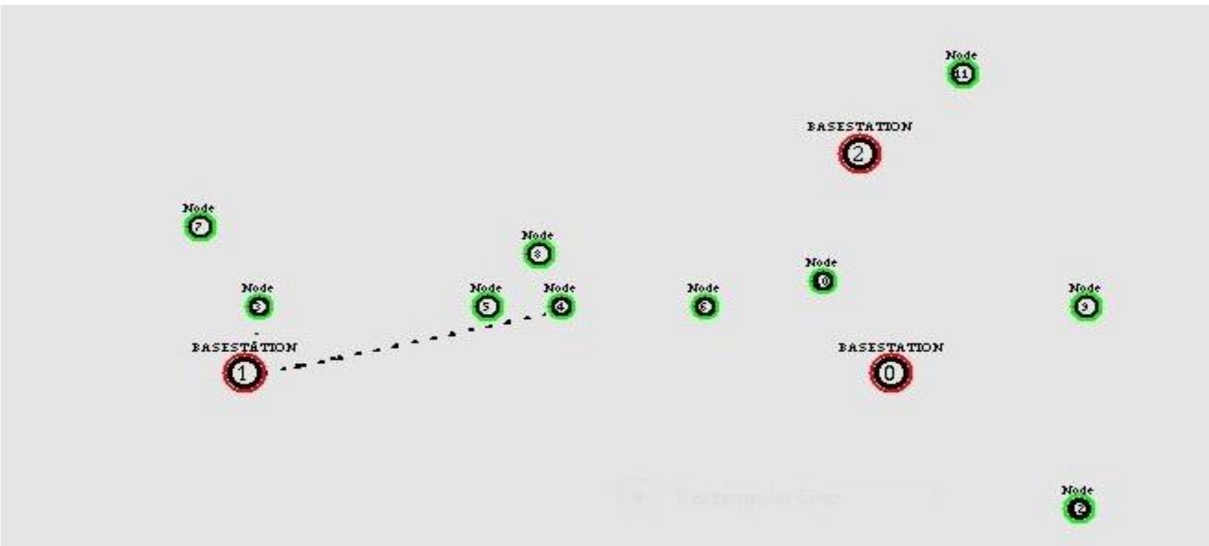


Fig 5. Handoff scenario with 2 base stations and an access point before handoff

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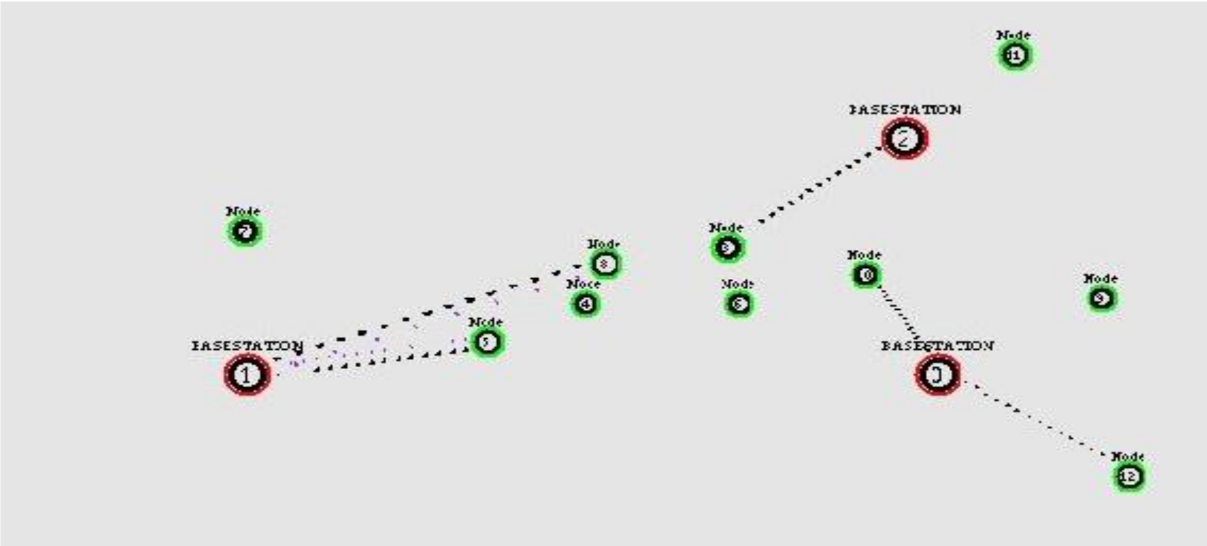

Fig 6. Handoff scenario with 2 base stations and an access point after handoff

VII. RESULTS

The results obtained are calculated for the performance parameters throughput, end to end delay and packet delivery ratio. The received signal strength of the mobile node 3 is calculated at every instant and shown in figure 7. It shows that when the mobile node is in UMTS network it has good signal strength. As it starts moving away from the UMTS base station the RSS starts decreasing. As it comes to the WLANnetwork and finds that the RSS of WLAN access point is better than UMTS base station it performs handoff.

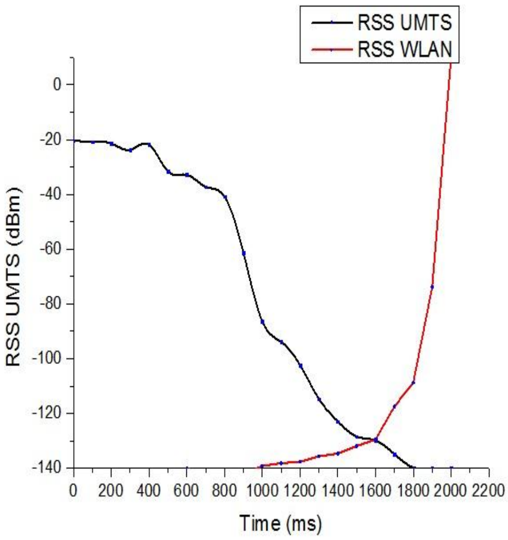

Fig 7 RSS of node 3 for UMTS to WLAN

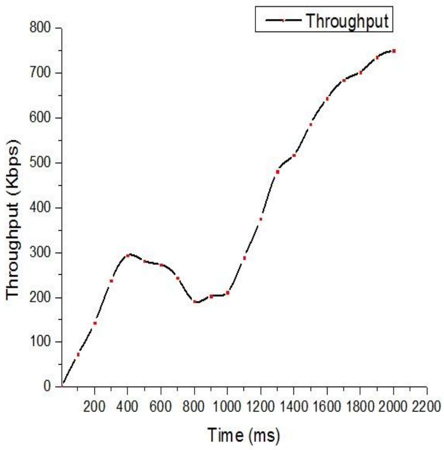

Fig 8 Throughput for UMTS to WLAN vertical handoff

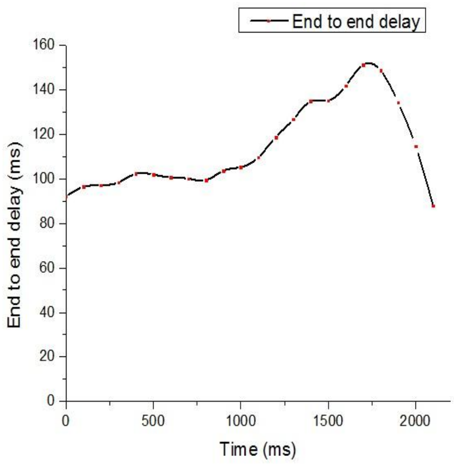

Fig 9 End to end delay for UMTS to WLAN vertical handoff

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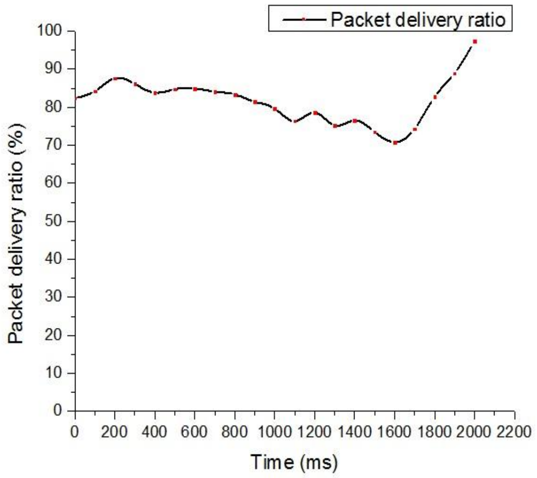

Fig 10 Packet delivery ratio for UMTS to WLAN vertical handoff

Throughput, end to end delay and packet delivery ratio metrics are calculated and shown in figure 8, figure 9 and figure 10 respectively.

VIII. CONCLUSION

This paper proposes a fuzzy rule based decision algorithm based on the UMTS and WLAN radio heterogeneous network model. The criteria of energy, traffic and cost is considered to make a better decision of handoff using membership functions. The performance parameters evaluated are throughput, end to end delay and packet delivery ratio. From the results it can be said that vertical handoff shows better results for throughput and packet delivery ratio and slightly lagging in end to end delay.This algorithm can also be applied to the other heterogeneous networks. The performance of the proposed algorithm can be improved by considering some more parameters also.

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