Implementation of Fuzzy Logic for Network Selection in Heterogeneous Wireless Network

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***Abstract*—In heterogeneous wireless network environment, the major challenging issue is to select the network depending upon the application. This paper employs Fuzzy Multiple Criteria Decision Making algorithm for network selection. This algorithm considers the following factors: Cost (C), Bandwidth (BW), Received Signal Strength (RSS), Velocity (V) and user Preference (P) for the network selection. In this heterogeneous environment, four networks are considered: UMTS, 802_3, 802_11 and 802_16. The proposed method finds Network Selection Function(NSF) that measures the efficiency in make use of radio resources by handover to a particular network. Fuzzy selects the network which has highest NSF. In this way network selection will be quite efficient compared to other methods.**

Keywords*— *NSF, Handover, Fuzzy Multiple Criteria Decision Making

I. INTRODUCTION

Heterogeneous networking is based on the principle that a mobile terminal may choose any one among multiple connectivity available based on some parameters. The main objective is to efficiently select a network for better transmission. In order to select the network it is necessary to analyse the network's performance [1]. By this networking the traffic in the transmission path can be avoided. The multimedia service is kept on increasing worldwide. While there has been a propagation of new wireless technology that gives a huge bandwidth. A mobile device is designed in multi-homed, multi-functioning wireless terminals to develop the maximum throughput of the heterogeneous wireless network [2]. The best network selection is more important to provide the ubiquitous service of different networks. Always Best Connected (ABC) method is used to select the suitable network depending up on the mobile users [3]. More number of techniques is available to overcome the multi-criteria problems, which includes the method Grey Relational Analysis (GRA) and Analytic Hierarchy Process (AHP) used vertical handover for network selection [4], technique for order preference by similarity to the ideal solution (TOPSIS), preference ranking organisation method for enrichment evaluations (PROMETHEE) and elimination and choice expressing reality (ELECTRE). Based on the application any of these methods can be employed.

Mobile terminals in heterogeneous wireless environment will select the network within the initial access and handover process. Mobile terminal is connected to the network in the most possible way by considering its QoS performance and energy consumption. Before selecting a network the things which are to be taken into account are network condition, QoS performance and energy consumption. The best balancing network is based on the performance and energy consumption. The energy consumption measurement is performed in real-time and non real-time applications [5].

In communication research field it is very tough to select the best network for Heterogeneous Wireless Networks, and it is also difficult to reduce the handoff number of vertical handoff. Hence a multiple attribute network selection algorithm is used to select the network based on Analytic Hierarchy Process (AHP) and synergetic theory [6]. It takes both the coordinates of objective attributes and different QoS requirements into consideration. The network performance will be better if the synergetic value is greater. The entropy of the system is considered to be less if the synergetic degree is high. The AHP method best selects the network by considering the above mentioned conditions.

A traditional way to select a target network based on the received signal strength (RSS) to meet the different requirements of both multimedia applications and different users. A hybrid analytic network process (ANP) and reverse TOPSIS (RTOPSIS) model to rank the candidate networks the values of compensatory information was used as input values[7].

A network selection mechanism for an integrated wireless local area network (WLAN) system to guarantee mobile users to always best connected (ABC) scheme was employed. The above mechanism is the process of balancing user preference, service application and network condition. Here this scheme comprises of three parts: first the availability of WLAN was detected, second an analytic hierarchy process (AHP) was applied to calculate the relative weights and the third to normalize parameters and to calculate decision-making index. The main advantage of this technique is it not only works for an integrated UMTS/WLAN system, but also be applicable to systems with more heterogeneity (e.g. WiMAX,

CDMA2000/UMTS, WLAN/GPRS/UMTS**).** Simulations reveal that this network selection technique can effectively decide the optimum network using trade-offs among network condition [8].

In this paper, the network selection is based on the fuzzy logic in Multi Criteria Decision Making. A handover algorithm concentrates on making a decision based on incomplete information and in a region of uncertainty. Fuzzy logic is a multi valued function and allows intermediate values to be defined and it is suitable for uncertainty.

The remaining paper is organised as follows: In section II proposed methodology is discussed, section III results are analysed and section IV concludes the paper.

II. METHODOLOGY

The method employed here is the fuzzy logic in multi Criteria decision making. Compared to other methods, the mathematical concepts are quite simple and easy in fuzzy reasoning. The information, data and the measurements of the input parameters are dissimilar and obtained from different sources in other methods where as in fuzzy this problem won't exists.

Multi-objective function is developed to select the network in a heterogeneous wireless environment. The multi-objective function consists of dominant parameters such as delay, bandwidth, packet loss and cost. These parameters particularly characterise the performance of voice, video and data services. The multi objective function is the summation of the product of the normalised weight of the parameter and average value of the parameters. In general the normalised weight of the parameter is equal to unity. With the help of this function the network can be selected.

TOPSIS method is a multi criteria decision analysis method which is based on the concept that value should be taken which have a shortest distance from the positive ideal solution and longest distance from the negative ideal solution. This method considers some parameters, identifying its weights, normalising those weights and finally calculating the distance between each value and the ideal value.

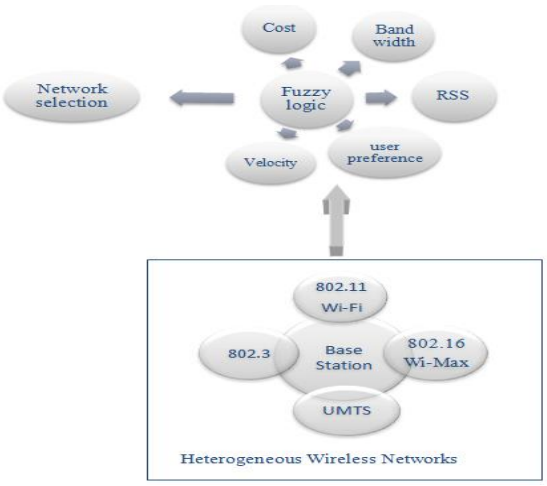

Fig 1 Network selection

The network selection process is carried out using the heterogeneous wireless network which cumulatively serves as base station. From this base station network it gets implemented by performing fuzzy logic technique. While implementation of this technique certain parameters should be considered they are cost, bandwidth, RSS, velocity and user preference. Therefore finally based on this implementation and performance analysis the network selection process is carried out.

The networking leads to the issue of handover, thus an effective and efficient handover process is important to select the user's connection from one cell to another cell, when the user moves from one location to another. In heterogeneous wireless environment the following four wireless networks are considered: UMTS, 802_3, 802_11, 802_16. The multi-objective function is defined for the QoS parameters. The normalised weights are assigned for all the parameters. The sum of normalised weight must be equal to unity. Weight coefficients are calculated by finding the entropy of attributes. Then the network parameters such as bandwidth, cost, received signal strength, velocity and user preference are collected. The normalized values of the above parameters are found. The fuzzy set function is collected. If the users prefer all the parameters equally form a fuzzy set or else set some threshold to optimize the parameters. Atlast by using the fuzzy set, select the suitable network.

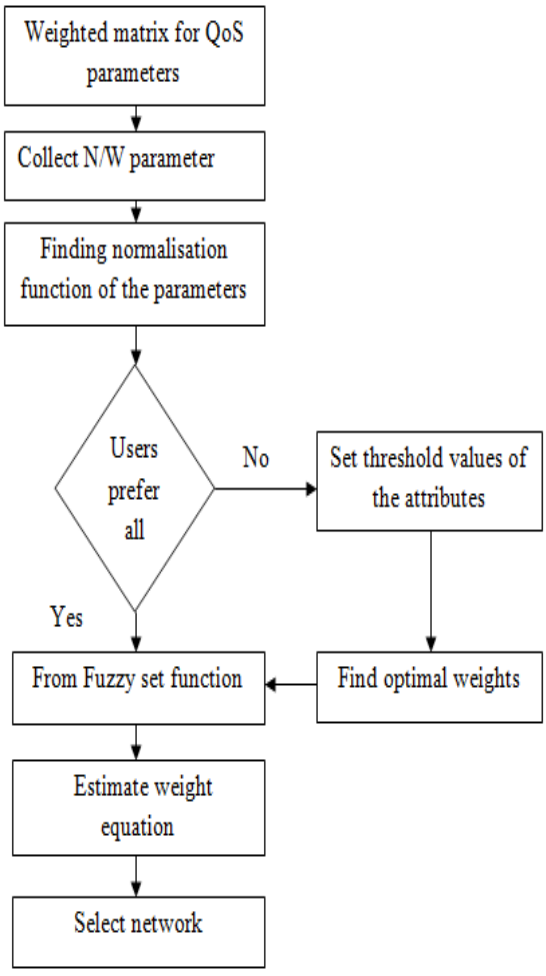

Fig 2 Block diagram of proposed method

The following are the equations employed in order to predict the efficient network. The normalized function equation (1) is given by,

$$N(a) = \frac{a - a_{min}}{a_{max} - a_{min}} \quad (1)$$

Received signal strength is the measure of power present in the received radio signal. The normalized function of received signal strength (RSS),

$$N(RSS) = \frac{RSS_a - RSS_{th}}{RSS_{max} - RSS_{th}} \quad (2)$$

Where RSS_a is the actual receiving signal strength

RSS_{th} is the threshold of the receiving signal strength

RSS_{max} is the maximum signal strength.

Usually while considering any method for network selection, at the user side cost will play a major role for selecting the network. The networks which provide efficient performances with low cost are usually preferred. The normalized function of cost (C) is given by,

$$N(C) = \frac{1 - C(a)}{C_{th}} \quad (3)$$

Where $C(a)$ is the current energy

C_{th} is the threshold of the energy.

Bandwidth is defined as the range of frequencies over which the gain is half of its maximum value. Bandwidth reuse is the efficient way by which the unused bandwidth can be employed for other purposes. The normalization function of Bandwidth (BW) is given by,

$$N(BW) = \frac{BW(a)}{BW_{max}} \quad (4)$$

Where $BW(a)$ is the required bandwidth of the mobile station,

BW_{max} is the maximum bandwidth that can be provided by the base station.

Velocity is the parameter which directly implies how much the speed of the network. Normalization function for velocity (V) is defined by equation (5),

$$N(V) = \frac{1 - V(x)}{V_{max}} \quad (5)$$

Where $V(x)$ is the current velocity

V_{max} is the maximum velocity.

Normalization function of user preference is given by

$$N(P) = \frac{P(a)}{P_{max}} \quad (6)$$

Where $P(a)$ is the selected to the user preference

P_{max} is the maximum user preference to the base station.

Here the below Table 1 shows the weighted value of various parameters based on fuzzy logic function between Wi-Fi and Wi-Max. The weighted values are calculated by considering the standard deviation of the parameter and the normalised standard deviation of all the parameters.

Table 1

	Mac802_11	Mac802_16
RSS	0.000347	0.004801
C	0.998175	0.995025
V	1	1
BW	0.99998	0.99994
P	0.018182	0.018182

III. SIMULATION RESULTS

In Fuzzy logic multi criteria decision making method, the delay will be lower compared to the previous method where fuzzy is employed. If delay is lower the network will be considered effective since the packets are delivered on time. The comparison is done between these methods as shown in Fig 3.

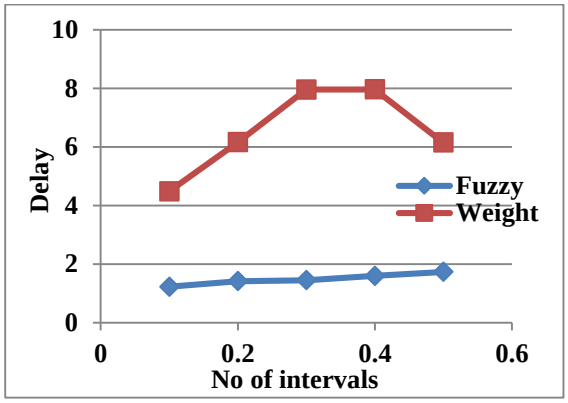

Fig 3 Delay Vs Intervals

Packet delivery ratio is defined as the ratio of the total number of packets successfully received to the destination to the total number of packets transmitted from the source. Usually the packet delivery ratio should be high which indicates that there is minimum packet loss. In this fuzzy logic technique, the packet delivery ratio is high compared to the weight estimation method as shown in Fig 4.

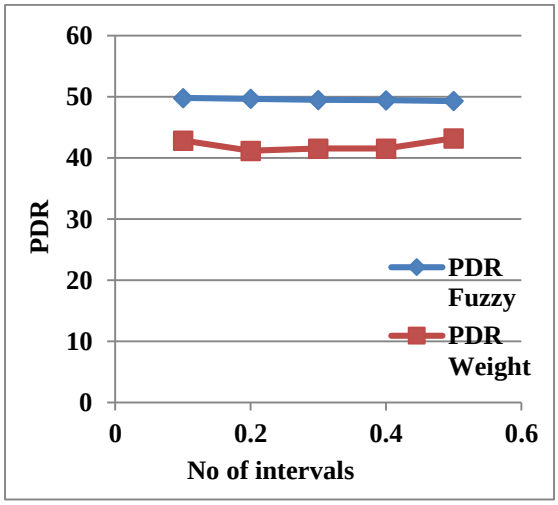

Fig 4 PDR Vs Intervals

In wireless networks, throughput is considered as the main factor to select the network and to analyse the performance of network. Throughput is defined as the total number of packets successfully transmitted to the receiver. In Fig 5 it is found that the throughput is high in fuzzy method.

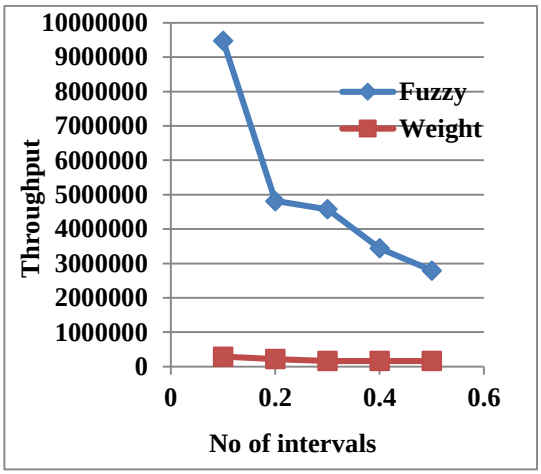

Fig 5 Throughput Vs Intervals

IV. CONCLUSION

In this paper, the fuzzy multi criteria decision making method is employed for network selection in heterogeneous wireless network. There are several techniques available currently in order to select a particular network in the heterogeneous environment. In fuzzy logic technique, the following parameters were considered: Cost, Bandwidth, Received Signal Strength, Velocity and user Preference. Based on the values of these parameters, network selection is done which will be very effective compared to the weighted QOS method where only certain parameters are considered.

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