FUZZY LOGIC BASED HANDOVER DECISION SYSTEM

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ABSTRACT

With the development of wireless communication technology, various wireless networks have been deployed. Heterogeneous networks will be dominant in the next generation wireless networks. In such networks, providing a seamless handoff by selecting the appropriate network is one of the key issues. In order to be always best connected for various applications, the network selection procedure, in heterogeneous multi-access environment during vertical handover decision is intended to choose the most suitable network for mobile user. In this paper, a handoff decision scheme is proposed that will help to choose the correct network and fuzzy logic is applied to deal with the imprecise information of some criteria and user preference.

KEYWORDS

Fuzzy Logic, Handoff Decision, Heterogeneous Wireless Environment, Mobile Node.

1. INTRODUCTION

Next generation wireless network is a network of emerging various networks such as CDMA2000, Wireless LAN and WCDMA into all IP-based networks that will make it globally available. This technology is a very complex technology of integrating different new techniques, and services for a higher speed wireless internet access. The main concern of the next-generation wireless networks is the integration of heterogeneous wireless technologies. This integration invokes some challenges, such as handover decision making and mobility management. Provisioning of seamless handover is one of the key topics in next generation wireless networks. Vertical handover decisions evaluate candidate NAPs based on different standards. Making a suitable handover decision according to different standard based parameters of access points in heterogeneous wireless networks is providing a scope of research. Wireless network technologies are different from each other usually in terms of bandwidths, frequencies, latencies, and etc. Currently, no single technology simultaneously provides a low latency, high bandwidth, and cost-effective services to all mobile users. So as to enable seamless communications in wireless environment, providing support for well-organized handoff between the various technologies will play a crucial role.

Handoff is described as a process of transferring an ongoing call or data session from one access point to another in wireless networks. It can also be defined as the process of changing the communication channel (frequency, modulation scheme, data rate, spreading code, or combination of them) associated with the current connection while a call is in progress. Traditional handoff process, called horizontal handoff, takes place to provide a seamless service when a user moves between two adjacent cells. Generally, horizontal handoff is based on only single parameter such as RSS (Received Signal Strength), SNR (Signal-to- Noise Ratio), etc.,

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and initializes when received signal strength indicator (RSSI) or SNR drops below a specified handoff threshold. It is also performed between two access points each of which has same network technology. On the other hand, vertical handoff process takes place between different technologies. Because the next generation wireless systems involve a mixture of various technologies, it is obvious that, traditional handoff mechanisms will not be sufficient. Using only one metric for vertical handoff decision making is not efficient since existing networks overlap with each other. Considering more performance metrics, such as; data rate, monetary cost, user's speed, and etc., as well as RSS more realistic performance results can be achieved for these heterogeneous structures. In general, the vertical handoff process is divided into three steps. First, a mobile node must know which wireless systems are reachable. This step is called system discovery. The next step is handoff decision, in which the mobile node evaluates vertical handoff parameters associated with a new wireless system (network) to make handoff decision. If the mobile node decides to handoff to other network, the last step will proceed. The last step is handoff execution. If the mobile node decides to perform vertical handoff, it executes the vertical handoff procedure to be associated with a new wireless system. Note that a handoff execution means a successful handoff to the other network. Consequently, in heterogeneous wireless networks, it is critical to design an efficient vertical handoff algorithm for providing seamless connection. Artificial intelligent algorithms based on fuzzy logic, neural networks or neuro-fuzzy systems are some of the approaches to solve vertical handoff problems.

2. STATE OF ART

Various approaches have been developed and proposed in order to facilitate and to improve the vertical handover decision. The authors in [1] proposed an interworking model that integrates a WiMAX network, a UMTS network and a WLAN in an IMS compatible architecture. Their primary focus was to replace the RAN part of the UMTS network with a WiMAX network and to place an IMS core on top of both technologies to manage sessions. Using a cost model they evaluated the performance of proposed architecture. In [2] authors present a vertical handoff scheme for providing seamless services between Wi-Fi and WiMAX networks. They provide a low latency handoff scheme, including horizontal handoff and vertical handoff. In homogeneous networks, an Mobile Node can detect its movement and forecast the handoff, which alleviates the communication cost between the MN and its Access Point (AP). In heterogeneous networks, the vertical handoff scheme uses the velocity to be an important metric to trigger handoff. In [3] X. Haibo et al. develop a novel handover scheme, which is completely controlled by Mobile Terminal, for the next generation heterogeneous wireless networks. To improve the performance of the handover scheme, a network discovery algorithm with fuzzy logic and a network selection algorithm using MCDM based on vague sets are derived respectively. Ali Çalhan & Celal Çeken [4] developed an adaptive fuzzy based handoff decision system which combines parameters such as data rate, cost and RSSI in order to get training elements to ANFIS. With the training element of ANFIS from fuzzy based system, the rules and the membership function can be properly tuned to optimize the handoff performance. In [5] authors have presented an algorithm which will help to evaluate the decision for handoff in heterogeneous WWAN and WLAN network. The result for various values of the input parameters (Bandwidth, RSSI and Network) and its corresponding output Handoff Decision is evaluated. So by evaluating the value of Handoff Decision, decision can be made whether a handoff is performed or not. In [6] authors proposed a vehicular heterogeneous network comprised of WLAN and cellular systems. They shown that in order to minimize the cost of communications or alternatively minimize the communication time, use of VHO is an appropriate choice in lower speeds, whereas it would be better to avoid VHO and stay in the cellular network at higher speeds. Manoj Sharma & Dr. R.K.Khola [7] proposes an intelligent approach to find out the vertical handover decision in multi network environment. The Sugeno Fuzzy Inference system is used to find the decision for vertical handover. The inference use the crisp input values for network parameters such as available bandwidth, network load and signal strength. The value of these network parameters are generated by event generator and are feed fuzzy inference system. The output of the fuzzy system is handover decision. [8] Propose the FUN-HODS algorithm to process the handover decision in heterogeneous wireless networks. Fuzzy normalization not only includes the advantage of imprecise data dealing, but also enables the comparison of different parameters in heterogeneous networks. It can make choosing a NAP easier and raise performance. In [9] authors proposed a method for network selection in heterogeneous wireless environment. A method for Rss prediction is proposed. With the help of Rss prediction, handoff procedure can be started in advance. QoS, bandwidth & Cost are the parameters on which the handover decision is taken. The algorithm proposed for the optimal network selection is based on TOPSIS method. In [10] authors have proposed a new call admission control scheme for heterogeneous networks, where the users' relative preference for the WLAN changes adaptively based on the available resources in the WLAN and the location distribution of the cellular users. [11] Proposes a vertical handover algorithm that considers some network parameters including signal strength, cost and unused bandwidth. The handover decision is based on the weight vector for each of the input parameter and membership function of each parameter.

3. PREDICTION OF RECEIVED SIGNAL STRENGTH (RSS)

Here an algorithm is proposed which is used for predetermination of reverse signal strength. The algorithm will help to reduce the call dropping probability in vertical handoff with the help of predetection of signal. In this vertical handoff algorithm, the Predictive Received Signal Strength (PRSS) is used to decide when to start a vertical handoff. If and only if the PRs in the networks fit to the Reverse Signal Strength (RSS) thresholds of the networks, then vertical handoff procedure will be triggered. Thus, it will help in pre determination of reverse signal strength. In this the Mobile Terminal (MT) samples the RSS periodically in the procedure of moving. With a few sampled RSS's stored in the database of MT, PRSS can be achieved. This can be achieved as following:

$$r(t+1) = \gamma(t).I(t) + \upsilon(t)$$

$$= [\gamma 1(t) \quad \gamma 2(t)][r(t) \quad r(t-1)]^T + \upsilon(\mathrm{t}) \qquad (1)$$

in which, t is the current time; $I(t)$ is the input signal matrix at t , $I(k)$=[$r(k)$ $r(k-1)$]; $\gamma(t)$ and $\vartheta(t)$ describe the predict index matrix at the time t. We adopt the LMS algorithm to reach the optimal predicted index, that is, γ and ϑ are optimal to guarantee the error square minimal between the prediction values of (t +1) and t. The index formulations are present as following:

$$\gamma(t+1) = \gamma(t) + \mu.e(t).I(t)$$

$$\upsilon(t+1) = \upsilon(t) + \mu.e(t) \qquad (2)$$

in which, $e(t)=d(t+1)-r(t+1)$, μ is the fixed step size. An example of RSS prediction is shown in Figure 1 for a particular wireless environment [12]. The algorithm is simple and accurate to predict the RSS trend of future time.

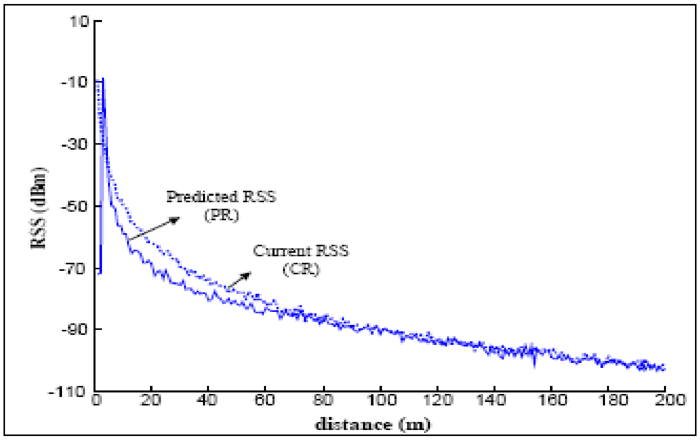

Fig. 1The curves of Predicted RSS and Current RSS

4. PROPOSED FUZZY LOGIC BASED HANDOFF DECISION SYSTEM.

Fuzzy logic based Vertical Handoff Decision Algorithms can be applied to the handoffs initiated by mobile nodes (MNs). For instance, when a MN moves in an area covered by Wireless Local Area Network (WLAN) and Wireless Wide Area Network (WWAN), it will detect a new wireless link or suffer severe signal degradation of the current link. In such situations, fuzzy logic based handover is used to select an optimized network for the MN. The advantage of fuzzy logic based algorithms is the ability to take multiple parameters into account and give the best possible solution for handoff decision, especially when the nature of the problem exhibits uncertainty. Figure 2 shows the block diagram of the proposed fuzzy logic based handoff decision system.

We consider an overlay wireless network composed of WLAN and WWAN, Suppose that WWAN covers the entire service area providing lower data rate and WLAN only covers some portions of the service area providing higher data rate. The vertical handoff decision is triggered when any of the following events occurs: (a) the MN detects a new wireless link; (b) there is severe signal degradation of the current wireless link; (c) a new service request is made; (d) resources of some network are insufficient and resource balancing is required.

Here an algorithm is proposed which is used to find out the handoff decision in WWAN and in WLAN network. As we know that WLAN is faster high bandwidth, lower cost, and short distance access technology and WWAN is slower, higher cost, long range and always connected access technology. The natural trend is to use high bandwidth WLAN's in hotspots and switch to WWAN's when the coverage of the WLAN is not available or the network condition in the WLAN is not good enough. Vertical handoff between WWAN and WLAN enables seamless terminal, personal and network mobility. Since the WWAN could be always on and the WLAN is optional, the main objective of the handoff from WWAN to WLAN is to improve the QoS. A user connected to a WWAN system would like to move into a WLAN area and to change the connection to WLAN to obtain a higher bandwidth service at lesser cost.

In this proposed algorithm the following network parameters are chosen for vertical handover decision model: Predicted RSS (PRSS), Available bandwidth (B), and Users Preference (UP). There may be some other parameters such as Delay, jitter, error rate, battery level etc. which can also be used to decide the network selection.

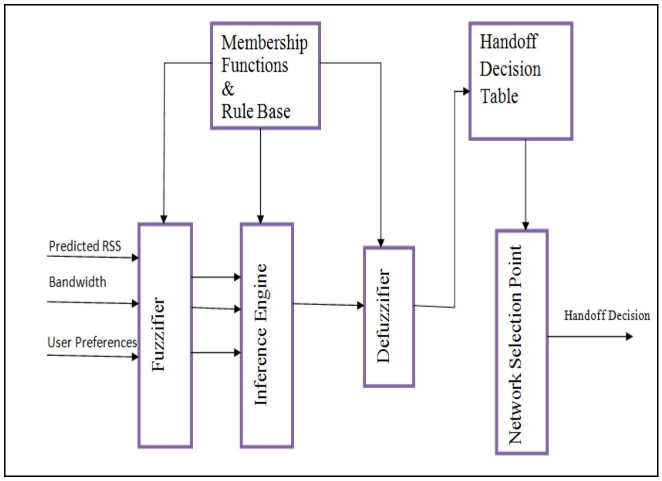

Fig. 2 Block diagram of the proposed fuzzy logic based handoff decision system

In order to compare the attributes of different values and different units of measurement it is necessary to use the process of normalization. Normalization is needed to ensure that the values in different units are meaningful.

$$N(x) = \frac{x - x_{\min}}{x_{\max} - x_{\min}} \qquad (3)$$

Where x=PRSS, B &UP. In (3), PRSS, B and UP denote the original values; N (PRSS), N (B), and N (UP) are the normalized values.

After the inputs have been collected originally, they are mapped into the normalized values by the normalized functions (3). Each of the normalized input parameters is assigned to one of three fuzzy sets by membership functions. The membership functions (MFs) of PRSS, B, and UP are shown in Fig. 3-5.

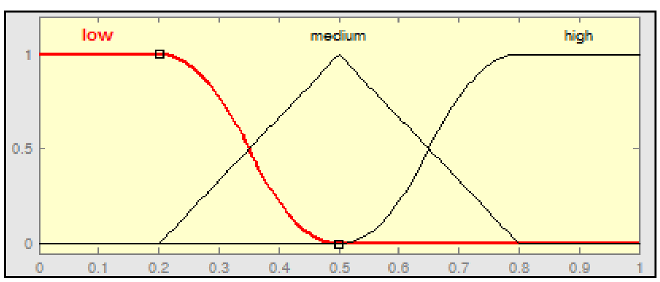

Figure 3 Membership function for input variable PRSS.

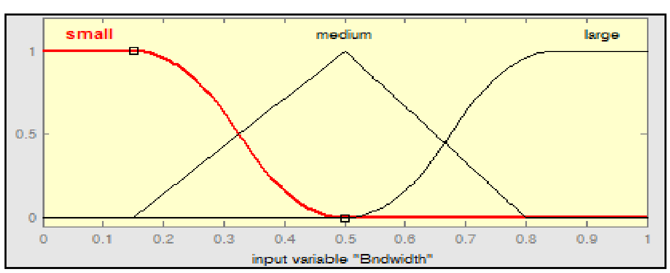

Figure 4 Membership Function for input variable Bandwidth

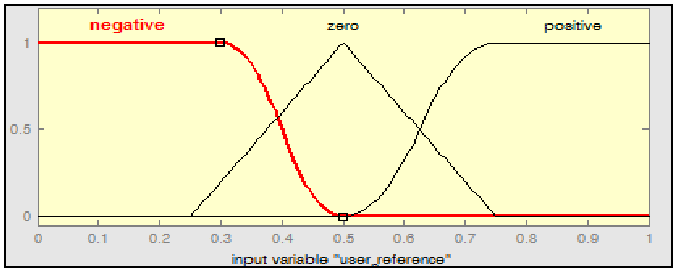

Figure 5 Membership Function for input variable User Preference

5. RESULT & DISCUSSION

The multimode mobile node associated with the WWAN monitors at repeated intervals and measures the RSSI of the nearby WLAN's to see whether or not a better high data rate WLAN service is available. Fuzzy logic algorithms can be implemented in the mobile node as a handoff decision engine to provide rules for decision making. The input parameters are fed into a fuzzifier, which transforms them into fuzzy sets. Next the fuzzy sets are feed into a fuzzy inference engine where a set of fuzzy IF-THEN rules is applied to obtain fuzzy decision sets. The output fuzzy decision sets are aggregated into a single fuzzy set and passed to the defuzzifier to be converted into a precise quantity during the final stage of the handoff decision. The fuzzy inference engine is based on the Sugeno fuzzy inference system, whose computational performance is more efficient than the Mamdani system. Some of the IF-THEN rules are shown in Table 1.

Table 1: IF-THEN fuzzy rules

IF			THEN
Bandwidth	**RSS**	**User_Preference**	**Handoff Decision Value**
small	low	negative	very_low
small	medium	positive	medium
medium	high	zero	high
medium	high	positive	very_high
large	high	zero	very_high
large	high	positive	very_high

The range of handoff factor is from 0 to 1. The larger the handoff factor is, the higher the possibility to handoff to WLAN.

The handoff decision scheme can be given as-

• If the output is less than 0.45, then the MN chooses WWAN. If the current access network is WLAN then the MN makes a handoff; otherwise, no handoff.

• If the output is more than 0.7, then the MN chooses WLAN. If the current access network is WWAN, then the MN makes a handoff; otherwise, no handoff.

• If the output is between 0.45 and 0.7, then the MN stays in the current access network. This could reduce the unnecessary handoffs.

Table – 2 shows the result of handoff decision for various values of Bandwidth, network Area and RSSI.

Table 2 Results for various input values and its corresponding output decision.

S.No	**Bandwidth; N(B)**	**PRSS; N(PRSS)**	**User Preference; N(UP)**	**Handoff Decision value**	**Conclusion**
1	0.30	0.5	0.5	0.357	Handover to WWAN if current network is WLAN otherwise no handoff.
2	0.6325	0.8735	0.6928	0.966	Handover to WLAN if current network is WWAN otherwise no handoff.
3	0.5241	0.6084	0.4157	0.488	There will be no handoff and avoid unnecessary handoff.
4	0.5241	0.8012	0.5241	0.758	Handover to WLAN if current network is WWAN otherwise no handoff.

Table 2 shows the different cases of handoff decision values according to the fuzzy logic based handoff algorithm. When the MN is inside WLAN, the outputs are more than 7 and the MN chooses to handoff to WLAN. This is because the network conditions of WLAN are relatively good and is more attractive. When the MN is leaving the WLANs, the outputs sharply decrease and the MN executes handoffs to the TD-SCDMA network.

Figure 6 shows the fuzzy inference rules based on the Sugeno fuzzy inference system.

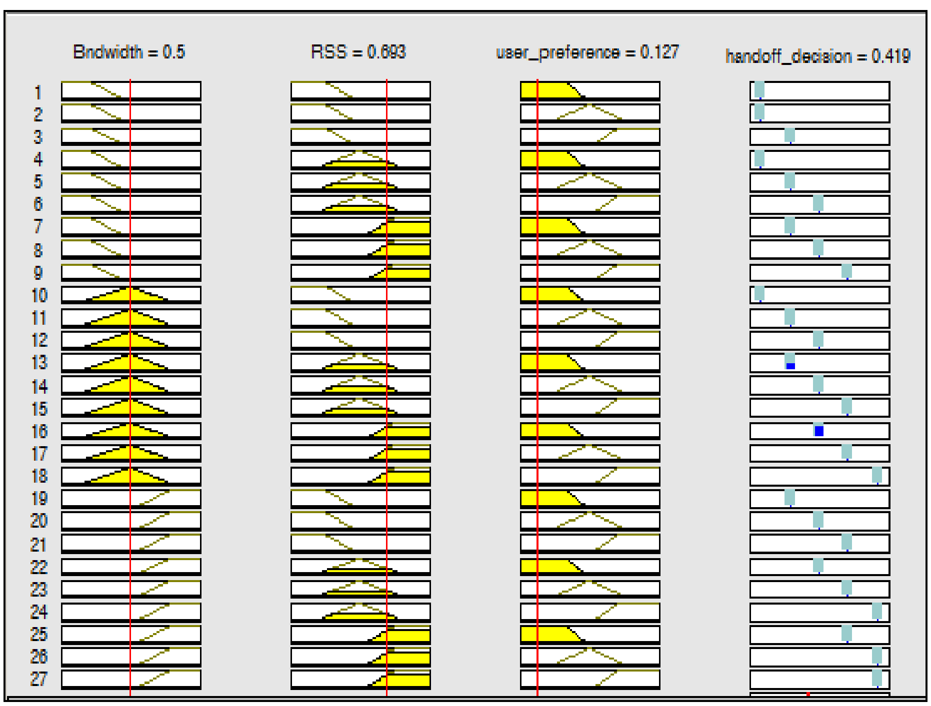

Fig. 6 The fuzzy inference rules based on the Sugeno fuzzy Inference system

6. CONCLUSION

In this paper, a vertical handoff decision criterion is proposed which is based on the input parameters of Predicted RSS, Bandwidth and users preference. Based upon these input parameters the value of handoff decision is calculated by the handoff decision algorithm. For the handoffs initiated by MN s, fuzzy logic based VHDA is employed to select the most appropriate network for the MNs. Afterward, the selected MNs are handed over to other nearby BSs. The simulation results show that the VHDA can make accurate handoff decisions, help to balance the network resources and improve the performance of the networks.

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