User Specific Algorithm for Vertical Handoff in Heterogeneous Wireless Networks

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Abstract-Selecting most optimal network to satisfy user requirements is very important for seamless mobility of users across heterogeneous wireless networks (HWNs). For overall network stability decision regarding when to perform vertical handoff and to which network is very crucial. In this paper we present an intelligent adaptive and user-centric network selection algorithm which uses Sugeno fuzzy inference system (FIS) to decide when to perform handoff. ANFIS is used to rank different wireless networks for VHO based on set of parameters along with user preferences on a mobile device. Our algorithm fulfills specific needs of users and simultaneously balance overall load of HWN. Simulation results demonstrate that our algorithm gives high network throughput and reduce packet drop rate and handoff latency.

Keywords- Adaptive neuro-fuzzy inference system (ANFIS), vertical handoff (VHO), Heterogeneous wireless networks (HWN) adaptive, user specific.

1 Introduction

Past few years has witnessed the development of varied range of mobile and wireless technologies, such as 3G cellular, satellites, WLAN, WiMax, WiFi and Bluetooth. These technologies differ in terms of bandwidth, security, and coverage area. Each of these technologies is tailored to meet particular user requirement. Integration of these technologies into heterogeneous wireless network (HWN) for flawless connectivity is a real challenge.

When user moves across different networks, its ongoing connection must be switched between different networks to provide seamless connectivity. This cross network transfer of ongoing call is called vertical handoff (VHO). VHO is one of the basic requirements for amalgamation of different network access technologies so as to use the best characteristic of different technologies at different point of time. Incorrect or very frequent handoffs may degrade QoS and too frequent handoffs may exhaust the resources of network [1]. So, whether a handoff is required or not and to which network is a critical decision for better-quality network performance.

Handoff is considered "seamless" if it can provide a continuous end-to-end data service without any disruption during the switchover with low latency and minimal packet loss. To achieve such type of seamless and efficient connectivity, there is an utmost need for intelligent VHO techniques. We present an intelligent and adaptive algorithm UIVH (User Specific Intelligent Vertical Handoff) for VHO in HWN. UIVH uses fuzzy inference system (FIS) to decide whether a VHO is required or not. Then ANFIS (adaptive neuro-fuzzy inference system) is used to select the best available wireless network for VHO based on set of parameters along with user preferences on a mobile device. UIVH fulfills user requirements and balance network load simultaneously.

2 Literature Review

A significant challenge in coordination of different wireless network technologies is selection of best available network and to perform smooth and seamless VHO among different types of technologies.

In [2], VHO decision algorithm is described as a fuzzy multiple attribute decision-making (MADM) problem. [2], uses network characteristics, user preference and cost to rank different networks.

Fuzzy neural joint radio resource management (JRRM) algorithm for HWN is presented in [3]. Firstly, it selects a suitable combination of cells, and then it selects the most appropriate Radio access technology (RAT) by means of appropriate inference rules and a multiple decision mechanism. This algorithm takes into consideration operator policies and user preferences for RAT selection.

In [4], a novel vertical handoff decision algorithm for overlay wireless networks that uses fuzzy logic-based normalized quantitative decision to select network is presented. In [5], a Trusted Distributed Vertical Handover Decision (T-DVHD) scheme for the 4G wireless networks to reduce processing delay is presented.

An intelligent handover model is presented in [6], to incorporate user preferences and QoS to provide best connectivity. However [6], does not address the issues of network selection optimization and handover delay reduction.

In [7], a novel vertical handoff algorithm for WLAN and CDMA is presented. Received signal strength (RSS) and distance are used to decide for handoff. Network selection is based on context information such as the dropping probability, blocking probability, grade of service (GoS), and number of handoff attempts. It does not address particular needs of user.

Handoff decision making process using a SOM algorithm in [8] is an adaptive inherent organizing technique but it does not guarantee finding the weight vector, corresponding to the network with the best parameter at a time.

In [9], Fast Handovers for Mobile IPv6 (FMIPv6) algorithm is presented to reduce handoff latency and minimize services disruption during handoff pertaining to MIPv6 operations such as movement detection, binding update and addresses configuration. However, it does not efficiently reduce signaling overhead (due to new messages introduced and exchanged for handoff anticipation) nor does it prevent packet loss (due to buffer space requirement).

In [10], a predictive RSS and fuzzy logic based network selection for vertical handoff in HWN is presented. [10], also presents the performance analysis of handoff mechanism with varying number of users.

In [11], a Handoff Protocol for Integrated Networks (HPIN) to enables QoS guarantee for real-time applications in heterogeneous IPv6-based wireless environments. HPIN is a one-suite protocol that performs network selection based on handoff score function. Moreover, HPIN performs fast handoff, localized mobility management, context transfer and access network discovery. To further alleviate packet loss, fast handoff schemes should support packet buffering and forwarding during handoff execution.

Detailed comparison between different VHO techniques can be found in [12].

In this paper an intelligent approach is used for VHO which uses packet buffering and fast VHO to reduce handoff latency and packet drop rate.

3 Tools Used

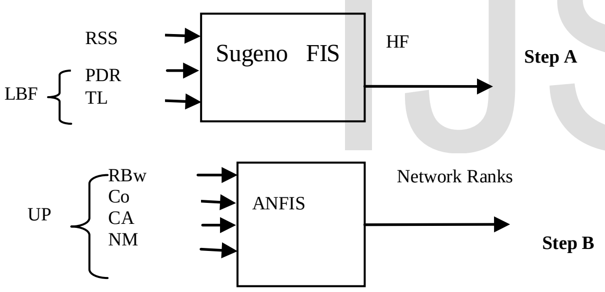

Fig. 1. Sugeno FIS and ANFIS for UIVH

UIVH use Sugeno FIS shown in Figure1. to decide whether handoff is required or not. Handoff decision is based on three parameters received signal strength (RSS), packet drop rate (PDR), and traffic load (TL). As PDR and TL plays significant role in deciding for handoff, thus UIVH controls network congestion and balance overall load of HWN. Ranks of available networks are generated using ANFIS in Figure1.This ranking is done to cater to specific needs of user in terms of required bandwidth (RBw), cost (Co), coverage area (CA) and node mobility (NM).

3.1. Input Parameters For SUGENO FIS

Input parameters used in FIS are stated below.

1) Received Signal Strength (RSS): This factor gives the strength of received signal from access point. Lower the value of RSS, more will be the need for handoff. Range of RSS is taken from -100db to 100 db.

2) Load Balancing Factor (LBF): This factor measures the network load. Higher the LBF, higher will be HF and thus more will be need for handoff. Two sub parameters contribute to LBF.

a) Traffic Load (TL): Higher value of TL signifies large number of users in current network. Further increase in number of users may lead to congestion thus reducing QoS of network. Higher the value of TL more will be need for handoff. Range of TL is taken from 0 to1.

b) Packet Drop Rate(PDR): Higher value of PDR signifies congestion in network. So, higher the PDR, higher will be HF. Range of PDR is taken from 0 to1.

Membership functions for input variables are shown in Figure 2a, 2b, 2c. Set of 27 rules shown in Figure 3. are used by FIS on inputs RSS, PDR and TL to obtain handoff factor (HF).

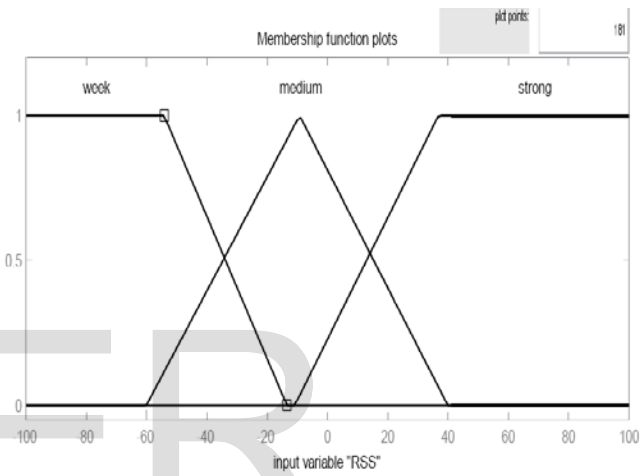

Fig. 2a. Membership Function for RSS.

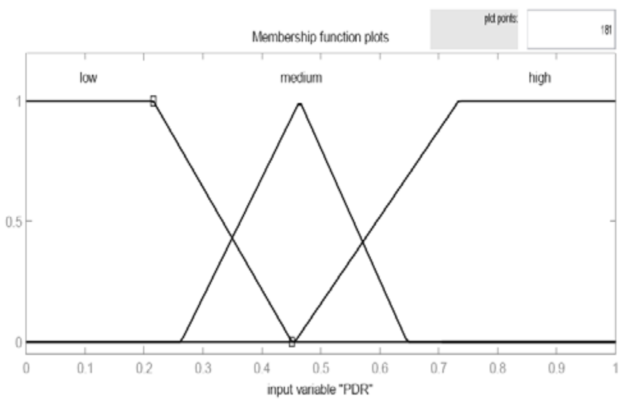

Fig. 2b. Membership Function for PDR.

ISSN 2229-5518

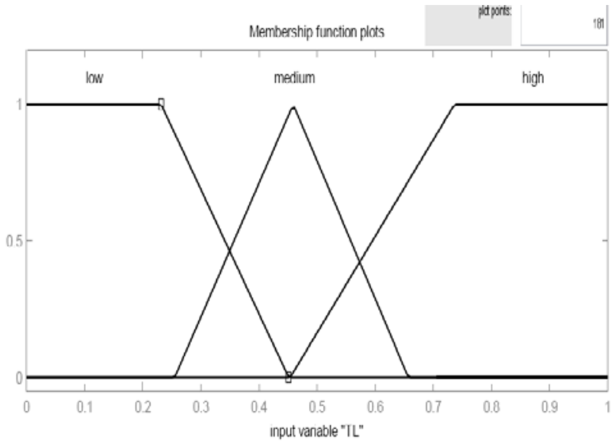

Fig. 2c. Membership Function for TL.

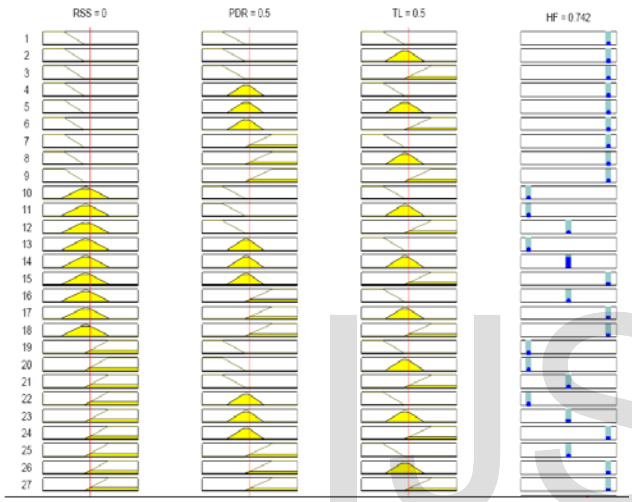

Fig. 3. Rules for Sugeno FIS

3.2. Input Parameters For ANFIS

Input parameters used in ANFIS are stated below:

1) User Preference (UP): This parameter enables user to choose best network from available networks depending upon its requirement. For example, File transfer will require high bandwidth whereas short queries may require less bandwidth. WLAN provides higher bandwidth and low usage cost but at the price of small coverage and cellular networks provide large coverage but at the price of low bandwidth and more usage cost. UP can be specified through four parameters

a) Required Bandwidth (RBw): It is the bandwidth required by user for particular application. It will be some fraction of Bw (bandwidth offered by network under consideration).

b) Usage Cost (Co): It gives the cost of using the network.

c) Coverage Area (CA): It gives area covered by network. If speed of mobile terminal is high then networks with wide coverage (cellular) will be preferred and vice versa.

d) Node Mobility (NM): It is the velocity with which the mobile terminal is moving. Higher the node mobility more will be the preference for network giving wide coverage like cellular networks otherwise mobile node will quickly move out of the range of chosen network.

4 User Specific Intelligent Vertical Handoff Algorithm

Efficient mobility management in the HWN requires intelligent and spontaneous VHO decision techniques. UIVH is a multi-criteria, intelligent and adaptive algorithm for efficient vertical handoff (VHO) in HWN. It very well caters to the needs of user and can adjust its decision to accommodate current network characteristics. The complete stepwise procedure of UIVH is depicted in form of flowchart in Figure 4. The implementation of UIVH is done in MATLAB. UIVH give optimal results for RSSth=-65 and HFth=0.7.

Detailed description of UIVH is given in our previous work in [13].

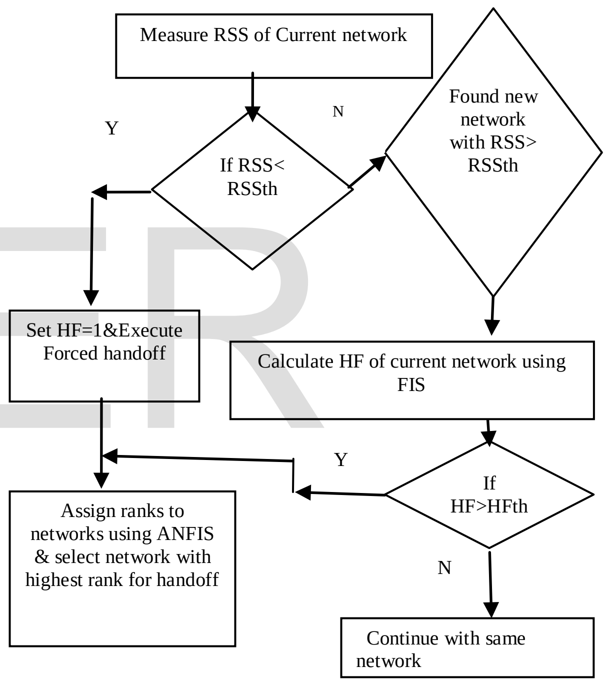

Fig. 4. Flowchart of UIVH

4.1. Assumptions

Packets arrive according to Poisson distribution with rate λ.

Base stations and access points have provision for storing certain number of packets in buffer space.

4.2 Performance Analysis

In HWN, the quality of service (QoS) may be defined by handoff latency (HL) and packet drop rate (PDR). Hence, we will analyze UIVH in terms of HL, PDR and throughput to evaluate its performance.

4.2.1. Handoff Latency

It is the time associated with the entire VHO entire process, including data collection, handoff decision, network selection and handoff execution.

$$HL=T1+T2+T3 \quad (1)$$

t1=time for HF decision using FIS
t2=time for ranking of network using ANFIS
t3=time for handoff execution (transfer of ongoing call from current network to new network)

4.2.2. Packet drop Rate

PDR is important parameters for user satisfaction. Higher value of PDR signifies congestion in network, which will degrade performance of networks. Thus VHO algorithms must explicitly address this issue. PDR depends upon buffer capacity of nodes in network and packet arrival rate. PDR can be calculated by formulae given in [12] which is calculated by the proportion of packets dropped due to BS and AP congestion

PDRvho= (1-Packetsrecieved)/packetssend (2)

PDR should be calculated solely for the VHO time period.

4.2.3. Throughput Ratio

Throughput ratio is measured as the ratio of the actual data rate to the requested data rate.

5 SIMULATION

This section evaluates the performance of UIVH by simulating HWN scenario where Universal Mobile Telecommunications System (UMTS), WLAN, WiFi and WiMAX overlay as shown in Figure 5.

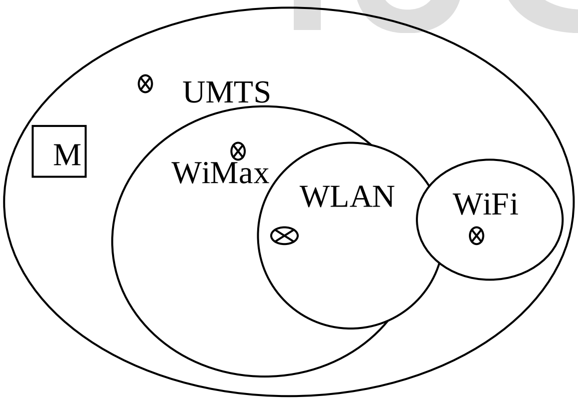

Fig..5. Simulation Scenario

There is one UMTS, one WiMax, one WLAN and one WiFi network and their coverage areas are shown in Figure 5. A user / MN with active sessions move between different networks and may enter the overlay of two or more networks. In this case user must decide when and where to execute a VHO to suit its requirements. If the request is accepted, the required bandwidth is assigned by the serving network.

For simulation ,we will consider the random walk mobility model described in [14].

TABLE1
Simulation Parameters

Parameters	Values
Data packet size	200 bytes
Buffer Capacity of Base Station	5 Mbps
Buffer Capacity of Access Point	2 Mbps
t3	5ms

5.1. Results and Discussion

In order to validate the performance efficiency of UIVH, it is compared with HPIN detailed in [11].The simulation results are shown in Figure 6-Figure 8.

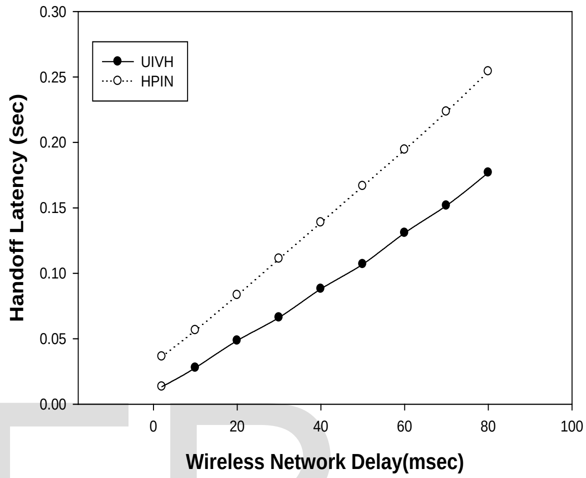

Fig. 6. Handoff latency vs wireless network delay

Handoff latency is less when wireless network delay is less and it increases gradually with increase in network delay. This is because time taken to perform various steps of VHO such as data collection, handoff decision, network selection and handoff execution depends upon network delay. As is evident from Figure 6, handoff latency in UIVH is much less than HPIN. Thus UIVH gives fast VHO as compared to HPIN. This proves the efficiency of UIVH. Since the maximal tolerable delay for interactive applications is approximately 200 ms. Hence, UIVH can very well handle these applications when the wireless link delay is less than 50 ms.

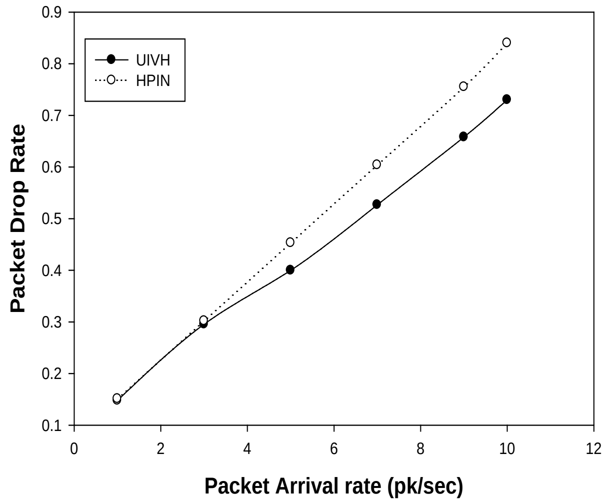

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Fig. 7. Packet drop rate vs. packet arrival rate

As is shown in Figure 7. , PDR is less for lower values of packet arrival rate and increases with increased arrival rate. This is due to the reason that in UIVH every BS and AP can buffer packets during VHO, which is missing in HPIN. As packet arrival rate increases, more and more packets need to be stored in buffer. Since buffer space is limited, so certain packets will be lost with increase in arrival rate. Since UIVH can balance network load more efficiently preventing too many packets from occupying the buffers. Due to this reason fewer packets are dropped in UIVH. It is also evident from Figure 7. that PDR is almost same in UIVH and HPIN for lower arrival rates . But for higher arrival rates, PDR is much less in UIVH as compared to HPIN. This is due to the reason PDR is proportional to handoff latency. As handoff latency is very less in UIVH this leads to fast execution of VHO as compared to HPIN. PDR is an important network congestion indicator. Lower values of PDR for UIVH signifies that it can efficiently control congestion of network.

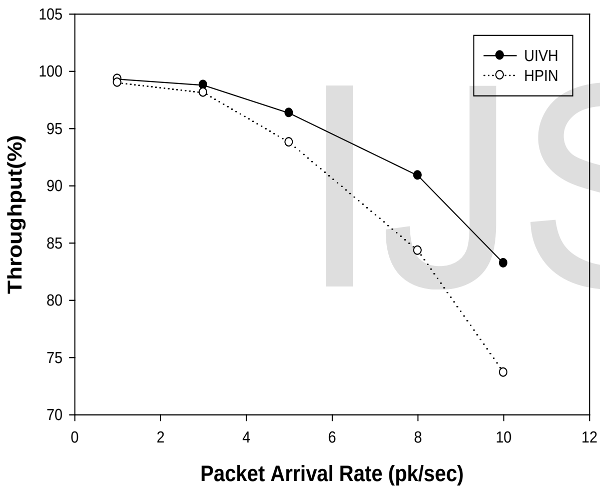

Fig. 8. Variation in throughput with packet arrival rate.

Figure 8 shows variations in throughput ratio with packet arrival rate. A significant gain in throughput can be achieved with UIVH as compared to HPIN. This is because UIVH can distribute load efficiently amongst all networks, leading to lower congestion. This results in lower handoff latency, less PDR and higher throughput. The performance of UIVH is better than HPIN in all conditions.

6 Conclusion

Flawless and efficient mobility management in 4G networks is very crucial and difficult task. In this paper an intelligent, multi-criteria and user-centric network selection algorithm UIVH is presented to optimize VHO across HWN. UIVH uses FIS to decide whether to initiate a handoff or not and ANFIS to select best available network. Presented algorithm uses PDR and TL in handoff decision leading to effective balance network load balancing and congestion control. UIVH is intelligent, adaptive and it caters to specific needs of users. Range of input parameters is chosen so as to incorporate the statistics of all the networks under consideration. ANFIS speeds up VHO decision and reduces packet loss and handoff latency. Simulation results demonstrate that UIVH improves network performance in terms of throughput, handoff latency, and packet loss and as compared to HPIN.

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