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Adaptive Handoff Prediction and Appreciate Decision Using ANFIS between Terrestrial Communication and HAP

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Abstract

Adaptive handoff provides a cost-effective way to enhance the Quality of Service (QOS) of homogeneous and heterogeneous communication systems. Recent researches focused on handoff between Heterogonous communications systems. Therefore, handoff between terrestrial communication systems and High altitude platform using Neuro Fuzzy Interference system (ANFIS) is our proposed technique for enhancing the QoS. The proposed techniques used for accurate prediction and appreciated decision-based on Received Signal Strength (RSS), Velocity of the user, and the distance between the user from the cell center and the available channel in both terrestrial and HAP. HAP has been considered as a complementary BS to the terrestrial mobile system, giving coverage in shadow zones. HAPs can provide back-up services to areas which are uncovered by terrestrial systems, thus with the goodness of HAP, QoS improved. The

results show that ANFIS is a viable option for an appreciated hand-off decision and more sensitive for hand-off prediction.

Key words: ANFIS, QOS, HAP, Heterogeneous communication, Hand-off, prediction

I. Introduction

Wireless cellular communications provide communication services to mobile users (MUs) in the particular coverage area. Coverage area of network access is divided into many cells [1]. Each cell has a group of allocated channels. In wireless network environment, the key ingredients to provide an efficient ubiquitous communication with guaranteed high Quality of Service (QoS) is the design of intelligent hand-off techniques.

Hand-off is a common technique employed in all of the cellular communication systems (both in terrestrial communication and satellite communication) for ensuring uninterrupted connectivity with increased system capacity and enhance the QoS, typically when the user is moving from one cell to neighbor cell or faces a shadow zone in one cellular technology yet supported under other cellular system, operational in coexistence [2,3].The hand-off process determines the optimal threshold for sustained QoS for respective user in each cell and improves the capacity [4].The Hand-off algorithm can also exploit the unique characteristics of HAP which is coexisting with the terrestrial cellular system as a back-up system.

For making hand-off decision, the decision can be made based on various parameters. Taking more parameters in to consideration, that will make the decision more effective. The most cases of designing hand-off algorithms is based signal strength [5]. In this case, bit error rate (BER) and the timing advance can work as alarm condition indicators rather than hand-off algorithm inputs. In the particular, proper selection of the soft hand-off region and its associated parameters can avoid the ping-pong effect in hard hand-off [6]. In addition, while performing vertical hand-offs, these techniques do not take into account the QoS of an ongoing call to enhance the user satisfaction based on their preferences, location and/or application contexts. While performing hand-off decision., some factors should be taken in the consideration such as network available bandwidth, latency, security, usage cost, power consumption, battery status of MS, and user preferences [7].

Hand-off optimization became a very demanding task. The optimization standard depends on the desired overall performance of the whole wireless network system involved. The optimization methods can be done using artificial intelligent approaches for enhancing the hand-off rate [8-11]. The combination of fuzzy logic and neural network is ANFIS which can be used for taking an optimal hand-off and appreciate decision based on the input parameters.

A fuzzy logic rule base is known sensitivities of hand-off parameters such as delay, distance, RSS etc. The ANFIS used for the hand-off decision process in heterogeneous networks [12]. Using ANFIS allows achieving a balanced trade-off among different communication system characteristics in any particular and dynamic cellular environment. The procedures for designing a generic fuzzy logic based algorithm are outlined. Therefore, we have proposed an algorithm for an efficient hand-off between HAP and terrestrial mobile communication systems by using ANFIS. Further, in this contribution, HAP has been considered as a complementary layer for terrestrial mobile communication system. For superior decision making, the hand-off procedure has been augmented by using ANFIS and considering additional control parameters. In this research ANFIS has been used for making an optimal and efficient hand-off decisions based on four parameters viz. RSS from original cell, distance from original cell, Velocity, availability of channels in the neighbor cell, and availability of channels in HAP.

The rest of paper highlights the hand-off overview in the section II and HAP based Cellular Network Deployment in section III. Section IV describes the proposed technology also result presents in section V. Finally the conclusion presents in section VI.

II. HAND-OFF OVERVIEW

Traditional single-metric hand-off decision techniques, such as RSS, are not efficient and intelligent enough to minimize the number of unnecessary hand-offs, decision delays. Efficient hand-off techniques cost-effectively preserve and enhance the system performance and QoS [13].

Hand-off is a common technique employed by all wireless cellular networks. It has been proven vital importance for both for ensuring uninterrupted calls and enhancing the system capacity [14]. Hand-offs are expensive to execute, so avoiding unnecessary hand-offs should be considered. There are several hand-off techniques proposed in the literature depending on the type of the channel allocation technique used. Hand-offs can be classified as fixed [15], flexible [16] and dynamic[17]. These techniques are used for new connection and hand-off connection requests. Also the technique for predicting user mobility remains a very challenging task due to the fuzziness of human mobility patterns has investigated [18]. Hand-off is typically characterized some requirements which are: (1) hand-off latency and QoS provided [19]. Latency should be no more than a few 100 of milliseconds. On the other hand, the source should be nearly identical with a view to sustain QoS provided and the same wireless communication experience.

The process of hand-off used to determine the maximum number of calls that can be continuing in particular cells [20]. Fig.1 shows a simple hand-off scenario in which users travel from base station -A to based station-B. Initially, the user is connected to base station-A. The overlap between the two communication cells is the hand-off region. In hand-off region the mobile user may be connected to either base station-A or base station-B. At a certain time during the travel, the user of mobile is handed-off from base station-A to base station-B, when the user is closer to base station-B.

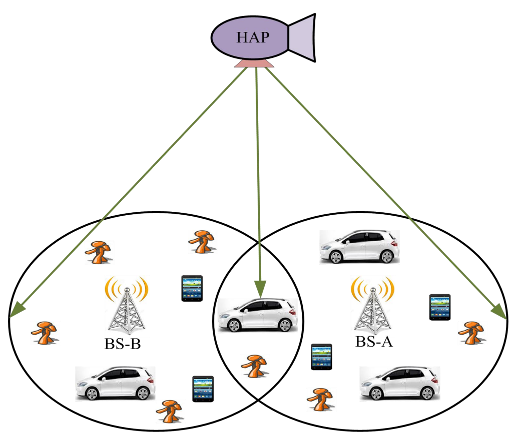

Fig.1 Hand-off Cellular System

There are several ways for classification of hand-off [21]. The classification is depending on type of network, number of entity and connection. It represents as vertical and horizontal hand-off, hard and soft hand-off, mobile -controlled, mobile - assisted, and network - controlled hand-off. Horizontal hand-off occurs when the users moves between different base stations of the same network. Moreover, vertical hand-off occurs when hand-off is required between different wireless networks. The second is the number of connection represented by hard and soft. In the case of hard hand-off, the users must drop its connection from the current network before it connects to a new access network. However, in soft hand-off the users can connect to more access network during the hand-off process. In addition, it also depends on entity and represented by network-controlled hand-off, mobile-controlled, network-controlled hand-off, mobile-assisted. Mobile-assisted hand-off is the mixed of mobile-controlled and network-controlled hand-off where the users make the hand-off decisions [22].

Hand-off includes three major steps i.e. hand-off initiation, channel assignment and execution [23]. Initiation phase, the decision to start the hand-off procedure is taken. The execution phase, a new channel allocated is carried out but the call will get dropped, if there is no channel available [23].

1. Hand-off decision / detection: a decision has to be made when exactly to initiate and perform a hand-off. This decision can be occurred by equipment of user or the base station.

2. Hand-off channel assignment: this phase has to manage the channels in view to ensure that there will be enough channels to minimize dropping call probability.

3. Hand-off execution: this phase of a hand-off procedure contains the protocols for reliable replaced of hand-off data. This is the signaling procedure required to inform the hand-off connection and base station about the new channel allocation.

There are several desirable features of hand-off technique such as should be fast, should be successful, should be maintained the planning cellular borders, should be minimized, chosen correctly minimal, and minimize the call drop.

III. HAP BASED CELLULAR NETWORK DEPLOYMENT

The HAP is expected to carry a set of antennas and other equipment as payload. This set of antennas cover a hexagonal area over the earth, by creating multiple cells. Fig.2 shows the hexagonal shaped cells as created by HAP using multi-beams.

In Fig.2, each cell is identified by a pair of coordinates [Nr, Nc] . Nr Specifies the number of concentric hexagonal ring or tier in which the cell is located, and Nc is the number of the cell within that tier, and it decreases clockwise. All tiers are disposed concentrically around the central cell as in Fig.2 depicts. At this step, the cell disposition has defined and hexagonal coverage of HAP is expected to provide with a set of antennas as payload.

Fig.2 dedicated one tier and two tier situations. In the case of one tier, 8 Km represents the separation distance between cells. Due to two tiers are used, the separation distance is 4 Km. therefore, increasing the number of tier leads to decrease the separation distance between cells. So number of cells at any tier is given by:

$$N_{cell} = 6XN_r \qquad (1)$$

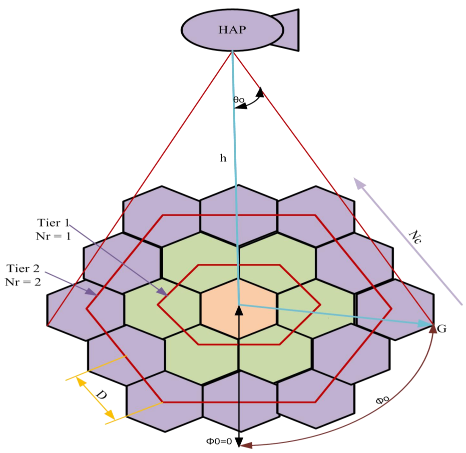

Fig.2 Cell Disposition and Parameters [24, 8]

In case of Nr=1, the total number of cells is six and one reference cell as given below.

$$N_{cell} = 6X1 + \text{refernce cell} = 7 \text{ cells} \qquad (2)$$

In case of Nr=2, the total number of cells in the first tier and cells at second tier as given below.

$$N_{cell} = 6X2 + \text{number of cell in first tier} = 19 \text{ cells} \qquad (3)$$

In case of Nr=3, the total number of cells in the second tier and cells at the third tier as given below.

$$N_{cell} = 6X3 + \text{number of cell in first tier} \qquad (4)$$

In case of one tier, the average number of served users for the configuration with is considered 661 [8]. Consequently, the service performance probability would be 661/ number of users. In case of two tiers, the average number of served users for the configuration with is considered 1774 [8]. Consequently, the service performance probability would be 1774/ number of users.

Next step is to define the azimuth and elevation angles from the HAP position to the center of cell for these antennas. Fig.2 shows all parameters are required for any cell, whose coordinates are [Nr, Nc], the HAP height and D is the separation between cells [26]. The expressions of the elevation θ_0 and the azimuth angle $\emptyset_0$ can be drived from:

$$\theta_0 = \arctan(\frac{G}{h}) \tag{5}$$

$$\emptyset_0 = \arcsin\left(\frac{(c'-1)D\sin(\frac{\pi}{3})}{G}\right) + (N_s - 1)\frac{\pi}{3} \tag{6}$$

Where h is the high altitude platform height and ground distance G is the distance from the cell center to the sub-platform point, which can be derived from:

$$G = \sqrt{(N_r.d)^2 + ((c'-1).d)^2 - 2N_r.d^2.(c'-1).\cos(\frac{\pi}{3})} \tag{7}$$

In this expression C is used to identify the cell's location with respect to the first cell along the side:

$$c' = N_c - (N_s - 1).N_r \tag{8}$$

Where Nsis an integer between one and six identifying the side of the hexagon:

$$N_s = 1 + \text{floor}[\frac{N_c - 1}{N_r}] \tag{9}$$

With all these parameters it is possible to define the antenna azimuth and elevation angles for all cells that comprise the hexagonal structure [24].

IV. PROPOSED TECHNOLOGY

The terrestrial cellular system shown in Fig. 3 with seven cells as 1, 2, 3 …..7. As user in cell2 moving to cell7, but there is no empty channel in cell7, hand-off will perform to HAP. On the other hand, when user in cell2 moves to out of terrestrial coverage, hand-off will be performed to HAP. Furthermore, user in cell7 got weak signals from cell7 and user still inside the cell in shadow zone; hand-off will perform to HAP. Therefore, HAP can cooperate with existing terrestrial communication system easily helps to enhance the QoS.

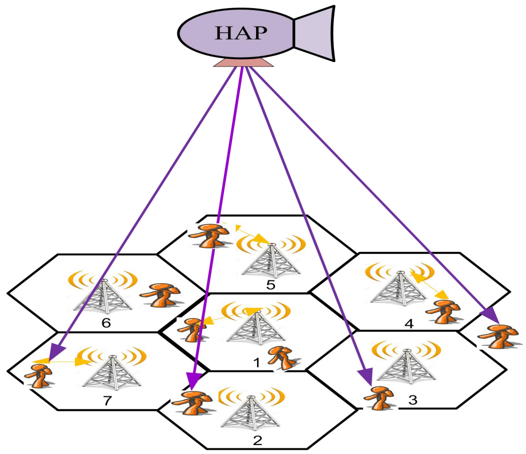

Fig.3 Concept of Hand-off from Terrestrial communication to HAP [28]

We focus on the hand-off of terrestrial systems and HAP (heterogonous). Then we proposed new techniques for adaptive hand off using ANFIS to select appreciate decision. The RSS, distance, velocity and available channel in terrestrial cells and HAP are considered as the input for estimate and select an appreciate hand-off decision. The proposed Fuzzy logic for hand-off is shown in fig. 4

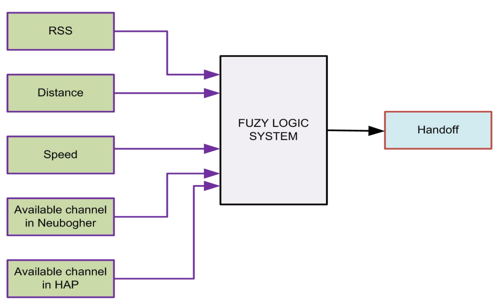

Fig.4 Proposed Fuzzy Logic based Hand-off Techniques

A fuzzy logic based ANFIS used the input parameters as data set for training and take appreciate hand-off decision. The features of ANFIS are indicating a method for the fuzzy logic procedure to learn information about the data set, based on the membership function parameters which have been given as shown in fig.5.

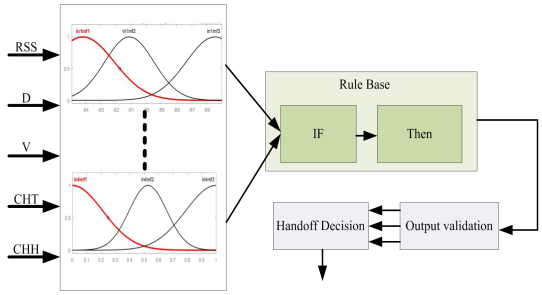

Fig.5 Hand-off decision using ANFIS

Neuro-adaptive learning models provide for the procedure of fuzzy logic to learn information about a data set. Using a given input and output data set. ANIFIS constructs a fuzzy inference system (FIS) whose membership function (MF) parameters are tuned (adjusted). Adjusting MF is by using either a back propagation algorithm alone or in combination with a least squares type of method. The parameters that have been considered associated with the MFs changes through the learning process. The proposed algorithm uses ANFIS for making hand-off decision. Fig. 6 represents the ANFIS structure.

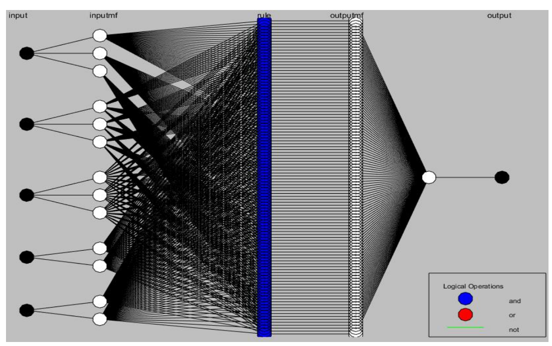

Fig.6 ANFIS Structure

There are 5 inputs variables as well as 3 and 2 membership functions as shown in Fig.6. Therefore 108 rules were considered. The output membership functions are 108 and one output. This is because ANFIS does not allow any rule sharing. In order to train the ANFIS 200 pairs of input, output data were generated. There are two selected options available for designing a FIS in the ANFIS editor. In this proposed work, we select grid partition method and hybrid algorithm is used for training the model.

V. RESULTS

Efficient hand-off technique enhances the performance of heterogeneous communication and provides high QoS. The simulation results for hand-off prediction and appreciate decision of hand-off between terrestrial cellular systems and HAP. HAP has been considered as a complementary BS to terrestrial mobile system, giving coverage in shadow zones. Hand-off techniques is used in heterogeneous wireless cellular systems to take the decision when and to which base station should receive hand-off call, then call should be continue without interruption. In this research ANFIS has been used for making an efficient hand-off decisions based on four parameters viz. RSS from original cell, distance from original cell, Velocity, availability of channels in the neighbor cell, and availability of channels in HAP. Also, it is shown that the proposed algorithm decreases the number of unnecessary hand-off and therefore hand-off rate is improved. ANFIS information is given in Table.1.

Fig.7 represents the surface plot of hand-off against RSS and distance. It is evident that the hand-off is low when the user approaching the serving cell. The value of hand-off is high for high distance between base station and user. Fig.8 represents the surface plot of hand-off against RSS and velocity of user. It is evident that the hand-off is low when the user approaching the serving cell. The value of hand-off is high for high velocity of user. Fig.9 represents the surface plot of hand-off against RSS and distance. It is evident that the hand-off is low when the user approaching the serving cell. The value of hand-off is high for no available channels in terrestrial communication system. Fig.10 represents the surface plot of hand-off against RSS and distance. It is evident that the hand-off is low when the user approaching the serving cell. The value of hand-off is not that much high because of the neighbor cells have free channels but still the availability of HAP has protect hand off to be occurs. Therefore, the capacity and QoS have enhanced and improved significantly.

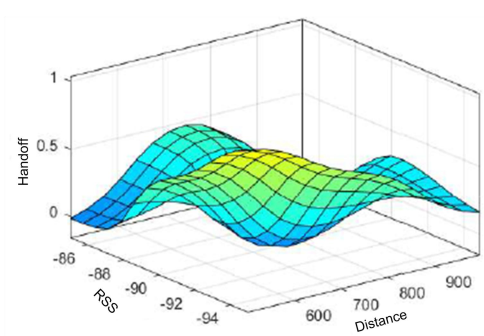

Fig.7 Surface plot of Handoff vs RSS and distance

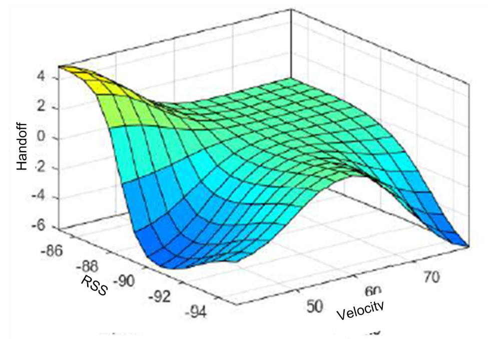

Fig.8 Surface plot of Hand-off vs RSS and Velocity

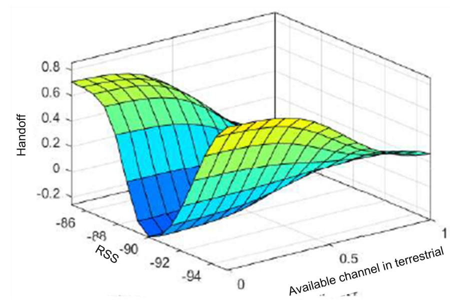

Fig.9 Surface plot of Hand-off vs RSS and available channel in terrestrial systems

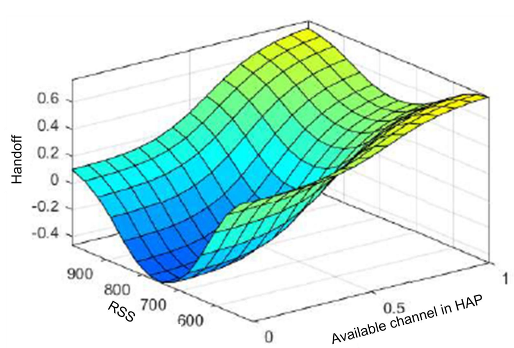

Fig.10 Surface plot of Hand-off vs RSS and available channel in HAP

Learning Algorithm	Hybrid
NO. of Nodes	250
Minimal training RMSE	0.074547
No. of linear parameters	108
No. of Non- Linear parameters	26
Total No. of parameters	134
No. of training data pairs	200
No. of rules	108

Table 1. ANFIS Information

VI. CONCLUSIONS

In this paper, we focused on a vertical hand-off decision between terrestrial communication systems and HAP. The prediction of hand-off using ANFIS based on RSS, velocity of the user, and the distance between the user from the cell center and the available channel in both terrestrial and HAP. Results have shown that the performance of proposed technique achieves some desirable features by making appropriated trade-offs in making hand-off decisions. HAP system can provide services to the subscribers staying at the corner of cells or at terrestrial coverage area which is influenced by shadowing. Effective hand-off technique is done based on ANFIS for the coexisting of HAP and terrestrial communication systems. Therefore, decision making by using ANFIS is highly adaptive and optimal.

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