Neural Network in Intelligent Handoff for QoS in HAP and Terrestrial Systems

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Abstract—Recently, artificial neural networks have been utilized to improve handoff algorithms due to its ability to handle large data in fast processing. ANN helps in taking the handoff decision based on RSS, speed, traffic intensity, and directivity. RBF network is used for making a handoff decision to the chosen neighbor BS. Efficient handoff algorithm enhances the capacity and QoS of cellular systems. Handoff algorithm used in wireless cellular systems to decide when and to which BS to handoff in order that the services can be continued uninterrupted. HAPs considered as a complementary base station to mobiles in an obstacle position and the capacity of system is more efficient with the goodness of HAPs. As a revolutionary wireless system, HAPS can supply services for uncovered area improving total capacity of service-limited area by a terrestrial BS. This paper presents novel approaches for the design of high performance handoff algorithm that exploit attractive features. This paper proposes to combine HAP and terrestrial system in same coverage area. The tools of artificial intelligent utilized in this paper and simulations have done by using artificial neural network. The algorithms on artificial neural network are discussed in this paper.

Index Terms—HAP, RBF, handoff algorithm, ANN

I. INTRODUCTION

A handoff is the process of transferring a mobile station’s serving base station from one to another when the mobile station moves across the cell boundary. A properly designed handoff algorithm is essential in reducing the switching load of the system while maintaining the quality of service (QoS) of the call in progress and a low probability of blocking new calls. The handoff process determines the spectral efficiency and the quality perceived by users [1]. Efficient handoff algorithms cost-effectively preserve and enhance the capacity and Quality of Service (QoS) of communication systems. Handoff algorithm makes it possible to maintain link quality. The different path loss models have been used and then the received signal strength is calculated to determine the model that can be adopted to minimize the number of handoff studied in [2].

Cellular communications provides communication facility to users called (MSs). A service area is divided into a number of cells. Several such cells constitute a cluster. The available frequency spectrum is used in each cluster. Each cell in a cluster uses a fraction of the available channels in the spectrum allocated according to a channel assignment strategy and is served by (BS). Handoff is a common technique employed by all cellular systems both terrestrial [3] and satellite, which has been proven vital both for ensuring uninterrupted connections and increasing system capacity.

High altitude platform (HAP) is airplane or airship that operates at altitude 17-21km [4]. It is provide line of sight and better channel condition as well as high coverage area.

Figure 1. Concept of HAP cellar

It is possible to employ a combination of handoff techniques and a steering mechanism, to avoid interruptions on the link between the user and the platform as shown in Fig. 1. To do so, either the Customer Premises Equipment (CPE) should be able to keep track of the platform and/or the HAP itself should employ an antenna steering mechanism to maintain a constant coverage.

Recently, artificial neural networks (ANNs) have been applied to many diverse problems. Adaptive parameters such as user speeds, received signal strengths for pattern classification provide a multiple of criteria handoff algorithm [5]. Neural network is trained to predict a user’s transfer probabilities which represent the user movements [6]. A technique to recognize signal patterns of (mobile
station) MS using probabilistic neural network is introduced in Rayleigh fading channel [7]. This paper divided into seven parts: section I, gives brief introduction about handoff algorithm in HAP system; in section II, describes the desirable feature of handoff scenario. Cellular handoff system is covered in section III and section IV, describes handoff classifications. Neural network algorithm is described in section V. Comparison handoff approach as well as radial base function is described in section VII. Handoff algorithm describes in section IX and the result discussions are taken up in section X. Finally, section XI, conclusion of this work.

II. DESIRABLE FEATURES OF HANDOFF

A seamless handoff is typically characterized by two performance requirements [8]:

- The handoff latency should be no more than a few hundreds of milliseconds.
- The QoS provided by the source and target access networks should be nearly identical in order to sustain the same communication experience.

![Desirable Features of Handoff](image)

Fig. 2 describes several desirable features of handoff algorithms as mentioned in the literature [9]. Some of these features are described below:

- **Speed**: Handoff should be fast enough to avoid service degradation and/or interruption at the MS.
- **Reliability**: Handoff should be reliable such that the MS will be able to maintain the required QoS after handoff.
- **Successful**: Free channels and resources must be available at the target access network in order to make the handoff successful.
- **Number of Handoffs**: The number of handoffs must be minimized. Excessive number of handoffs results in poor QoS and excessive processing overheads as well as power loss, which is a critical issue in MSs with limited battery power.
- **Multiple Criteria Handoffs**: The target access network should be intelligently chosen based on multiple criteria.

III. CELLULAR SYSTEM HANDOFF

A handoff is the process of transferring a mobile station’s serving base station from one to another when the mobile station moves across the cell boundary. A properly designed handoff algorithm is essential in reducing the switching load of the system while maintaining the quality of service (QoS) of the call in progress and a low probability of blocking new calls cellular handoff system is shown in Fig. 3 which clears the benefited of HAP for handoff and provide QoS.

![Handoff Cellular System](image)

To reduce unnecessary handoffs and call dropping, an effective handoff algorithm using the neural network including the mobile-cell information is presented in Rayleigh channel. Handoff algorithms are distinguished from one another in two ways, handoff criteria and processing of handoff criteria. Conventional handoff algorithms are described as shown in Fig. 4 for various types of handoff algorithm.

![Handoff Algorithm](image)

IV. HANDOFFS CLASSIFICATION

Handoffs Classification can be classified in several ways depend on type of network technologies, upon the number of Bs/APS, based on the entity as shown in Fig. 5.

![Handoff Classification](image)
V. NEURAL NETWORK ALGORITHM

Recently, artificial neural networks (ANNs) have been applied to many diverse problems. ANNs are one tool of artificial intelligence (AI). An ANN is a massively parallel distributed processor that stores experimental knowledge; this knowledge is acquired by a learning process and is stored in the form of parameters of the ANN [10].

The ANN consists of a number of neurons arranged in a particular fashion. A nonlinear model of the artificial neuron is shown in Fig. 6. The three basic elements of neuron are weights, summing junction, and the activation function. Different activation functions include hard limit, linear, log-sig. threshold $\theta_k$ can be considered as one of the weight. The ANN consists of more than one neuron. The output of a neuron $k$ is given by:

$$u_k = \sum_{j=1}^{n} W_{kj} x_j$$

$$Y_k = f(u_k - \theta_k)$$

where $x_j$ ($j=1, \ldots, p$) are the input, $W_{kj}$ are weights, $\theta_k$ is the threshold, $f(.)$ is the activate function, and $Y_k$ is the output of neuron.

![Figure 6. Model of artificial neuron](image)

Characteristics of ANNs are massively parallel distributed architecture, ability to learn and generalize, fault tolerance, nonlinearity, and adaptivity. The learning in ANNs can be unsupervised or supervised. The ANN consists of a number of neurons arranged in a particular fashion. The three basic elements of a neuron are the synaptic weights (or weights), the summing junction, and the activation function. Fig. 6 explains the fundamental component of the ANN, an artificial neuron. Radial basis function Radial-basis functions (RBF) to the neural network as depicted in Fig. 4 for making handoff decisions. The basic structure consists of three layers: input layer, hidden layer and output layer [10]. The number of nodes used in the hidden layer is 20. This number was found after training he network and it made the errors converged.

VI. TRAFFIC INTENSITY

Traffic intensity is the average number of calls simultaneously in progress during a particular period of time. It measured in units of Erlangs. Thus 1 Erlang equals $1*3600$ call seconds.

$$I = \frac{N_c}{t/T}$$

VII. COMPARISON OF HANDOFF APPROACHES

The decision phase is the most important one in handoffs, the network performance, satisfactions, efficiency, flexibility, and complexity and reliability of the overall algorithm as shown in Table I.

The different combinations of these criteria can be used to perform handoff decisions: BW, SIR, Delay, response time, network coverage area, BER, RSS, Traffic load, and number of user as shown in Table II.

![Table I. Comparison of different handoff](image)

VIII. RADIAL BASED FUNCTION NETWORK

The RBFN consists of three different layers, an input layer, a hidden layer, and an output layer as shown in Fig. 7. The input layer acts as an entry point for the input vector; no processing takes place in the input layer. The hidden layer consists of several Gaussian functions that constitute arbitrary basis functions (called radial basis functions); these basis functions expand the input pattern onto the hidden layer space. This transformation from the input space to the hidden layer space is nonlinear due to nonlinear radial-basis functions. The output layer linearly combines the hidden layer responses to produce an output pattern. The rationale behind the working of the RBFN, a pattern-classification problem expressed in a high-dimensional space is more likely to be linearly separable than in a lower-dimensional space. The parameters of the...
RBFN weights (in the output layer) and the positions and spreads of the Gaussian functions. A complete learning procedure can be found in [10]. Basically, in a supervised learning mode, these RBFN parameters are changed according to a gradient descent procedure that represents a generalization of the least-mean-squares (LMS) algorithm.

Two distinct phases of learning in the RBFN are selection of centers of the radial basis functions and determination of linear weights. Some of the methods for the selection of RBF centers are random selection (based on the training patterns), unsupervised selection, and supervised selection. Some of the methods for linear weight determination are pseudo-inverse memory and LMS algorithm. These weight determination methods and a mapping between the hidden unit space and the output layer. This research utilizes a three-layer RBFN. The Neural Network Toolbox of MATLAB is used to train the RBFN.

Figure 7.  RBF neural network

Input nodes are \([x_1, \ldots, x_5]\) and the output equal to summation of hidden layer. The output decides whether the system needs handoff or not. \(Y_1\) and \(Y_2\) are equal to 00 that mean no handoff will be performance. If \(Y_1\) and \(Y_2\) are equal to 11, the system will handoff the mobile to chosen the base station. The output of the hidden layer

\[
W_{ij}(n) = [W_{i1}(n), \ldots, W_{i20}(n)]
\]

Initialize at the following, the center value \(\mu_i(0)\), the span value \(\delta(0)\), weight vector \(W_i(0)\), expect \(W_{i1}(0)=W_{i2}(0)=1\).

Calculate the output of the hidden layer by:

\[
Z_j = \exp((-((x_j-\mu_j(n))^2)\delta_j^2(n))^2)
\]

Calculate the output:

\[
Y_k = R\{\sum^M_{i=1} W_{ki}(n)Z_j \} , k=1, 2; M=20
\]

Calculate the error:

\[
e_k = d_k - y_k
\]

where \(d_k\in[0, 1]\) desired pattern

Update the weight:

\[
W_{ij}(n+1) = W_{ij}(n) - \tau_w e_kz_j
\]

where \(\tau_w\) is learning rate of weight

Update the center momentum:

\[
\mu_i(n+1) = \mu_i(n) + \tau_c \frac{2z_j}{\delta_j} (x_j-\mu_j(n)) \sum e_k w_{ij}(n)
\]

where, \(\tau_c\) is the learning rate of center.

Update span:

\[
\delta_j(n+1) = \delta_j(n) - \frac{2z_j}{\delta_j(n)} \ln\sum e_k w_{ij}(n)
\]

where \(\tau_s\) is learning rate of span. Repeat the steps until the mean square error convergence less than small number. The input to neural network are \(x_2\) is the direction of the user, \(x_2\) is signal strength of receiver from BS, \(x_3\) is signal strength received from target BS, \(x_4\) is the traffic intensity, and \(x_5\) is the mean time target of BS.

IX. HANDOFF ALGORITHM

After every small time interval, the simulator checked whether the position of the HAP had changed as shown in Fig. 8 and then initiated handoff if required.

![Figure 8. Handoff algorithm](image)

If the position of the platform has changed, then all users that have been affected must first be identified and be removed temporarily from the system. The users must then be added back into the system and connected to the new cell. This is to eliminate the case where users are being dropped from a cell that is waiting for some of its current users to be connected to another cell.

In this case the cell will have a number of channels available as soon as its handoff users release the channels they occupy. The point is to ensure that these channels are available for the new handoff users coming to the cell. The affected users are consisting a small proportion of the total number of users within a cell. Since the capacity is allocated on a case by case basis, the overhead will not be significantly high. There are major feature of handoff algorithm and several desirable feature of handoff algorithm should be fast, successful, the effect of handoff on the equality of services should be minimum, should be maintain the planning cellular borders to avoid congestion,
the number of handoff should be minimized, target cell should be chosen correctly minimal effect on new cell blacking, procedure should be minimize the number of connecting call drop outs by providing desired QOS.

X. RESULT

Radial-Basis function (RBF) network is used for making a handoff decision to the chosen neighbor BS. The neural inputs consist of the received signal strength from the serving and nearby base station (BS), user directions estimated an antenna array, traffic intensity, and traffic intensities. We considered that the effect of HAP movement is neglected because of steerable antennas are used. Positioning a mobile station (MS) is obtained by apply the timing advance concept. When mean arrival time is increase the handoff rate decrease smoothly as shown in Fig. 9. When traffic intensity increases, the handoff rate also increase as shown in Fig. 10. Fig. 9 and Fig. 10 show the important of using RBF to decide the handoff. In path loss propagation the handoff algorithm using the RBF network out performs. By using RBF network, handoff rate, blocking rate is lowest in any traffic intensity. We consider the signal strength, position, direction, and traffic intensity, the unnecessary handoff reduce.

In Fig. 11 clarify the relationship between speed of user and handoff portability rate. So that, if the speed increases the hand off probability will increase.

XI. CONCLUSION

A high performance handoff algorithm can achieve many of the desirable features by making appropriate tradeoffs. However, several factors such as topographical features, traffic variations, propagation environments, and system-specific constraints complicate the task of handoff algorithms.

Effective handoff algorithm based on RBF network in high altitude platform station cellular systems. HAPS system can provide services to the users staying at the corner of cells or at covered area influenced by shadowing. Besides the averaged received signal strength, user position and direction and traffic intensity are inputs of the neural networks. We use the RBF and BP to construct the networks. As the result is shown the hand off rate increase when traffic intensity increase and decrease when mean arrival time increase.

REFERENCES

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