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A STUDY OF CHANNEL ALLOCATION IN MOBILE MULTIMEDIA NETWORKS USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

Through the use of artificial intelligence, CAC systems have the ability to optimize resource allocation, minimize congestion, and improve overall network performance. It is possible to make admission control choices that are more informed and adaptable by using machine learning models such as neural networks and decision trees. These models are able to accurately estimate the influence that admitting a new call would have on the quality of service (QoS) of the network. In order to investigate AI-enhanced CAC schemes, it is necessary to conduct a comprehensive examination of the different machine learning algorithms and the extent to which they may be used to real-time network management. In addition, it is essential to take into account the computational complexity and resource needs of AI-based CAC implementations in order to guarantee that they are practically feasible in mobile contexts that are limited in resources. Furthermore, the research includes an analysis of the trade-offs that exist between accuracy and computing efficiency. The objective of this study is to find a balance that is capable of satisfying the demanding standards that are imposed by mobile multimedia networks. Additionally, this investigation involves the possible integration of artificial intelligence-driven CAC with new technologies like as 5G networks and edge computing. Artificial intelligence (AI) and these technologies might work together to provide new opportunities for dynamic admission control that takes into account the context of the situation. This would further improve the flexibility and efficiency of mobile multimedia networks. This article offers a glance into the complex realm of CAC schemes, highlighting the revolutionary influence that approaches including artificial intelligence may have on the optimization of mobile multimedia networks. By incorporating artificial intelligence into CAC systems, there is the potential to meet the developing difficulties that are brought about by the growing demand for multimedia services. This would pave the way for network management solutions that are more intelligent and adaptation-oriented.

KEYWORDS: Channel Allocation, Mobile Multimedia Networks, Artificial Neural Network, quality of service, network management solutions.

INTRODUCTION

Over the course of the last several years, there has been a steady increase in the number of people interested in mobile communication and multimedia facilities. On the other hand, due to the limited amount of useable bandwidth that is necessary for the transmission of data and communication between the mobile device and the Base Station (BS) of the mobile multimedia network, the productivity in bandwidth utilization becomes a key concern in the process of bandwidth planning. Channel allocation is a term that is often used to describe this issue. A channel allocation system's objective is to identify an effective bandwidth allocation of channels to the cell while simultaneously meeting both the traffic need and the channel restrictions. This is the overall purpose of the scheme.

As a result of the restricted frequency spectrum and the growing demand for mobile communication services, the topic of optimum channel allocation has become an increasingly critical issue. It has been shown that this is a problem that requires Np full optimization. In an effort to find a solution to this problem, several heuristic techniques, such as neural networks, particle swarm optimization, and genetic algorithms, have been used. After doing the evaluation, it was discovered that a few of the researchers have used HNN for the purpose of developing applications related to wireless communication. For the most part, they have used Fixed Channel Allocation (FCA) systems to implement least interference frequency allocation implementations.

An application of the concept has been made to a cell model that was chosen at random. Consequently, the purpose of this chapter is to provide an innovative and effective dynamic channel allocation strategy that makes use of Hopfield Neural Networks (HNN) in order to search for a conflict-free channel allocation in such a way that demand has been satisfied. A total of four benchmark issues were used for the simulations procedure, and the results demonstrated that the HNN was capable of successfully lowering the call rejection ratio.

CHANNEL ALLOCATION PROBLEM

It is known to as the Channel Allocation Problem (CAP), and it is the process of assigning a channel from a given pool of channels to a caller in such a manner that the constraints of the allocation matrix are satisfied and overall interference is reduced.

Constraints in CAP

Within the realm of mobile multimedia networks, there are primarily three categories of restrictions, which are outlined in the following [AUDH11].

Adjacent Channel Constraint

According to the Adjacent Channel Constraints (ACC) protocol, it is not possible to allocate the same channel to certain pairs of radio cells at the same time. Channels should be placed in such a way that the frequency distribution across channels in a specific cell is maximized in order to lower anti-correlation coefficient (ACC).

Co-Channel Constraints

When using Co-Channels next, it is not possible to allocate the frequency spectrum to radio cells that are next to one another together.

Co-Site Constraint

The sole condition that must be met for a pair of channels to be used in the same cell is that there must be a minimum frequency space between them.

In order to solve the issue of channel allocation in mobile multimedia networks, a great number of heuristic techniques have been developed. These approaches make use of Artificial Neural Networks (ANN), Particle Swarm Optimization (PSO), Fuzzy Logic (FL), and genetic algorithms (GA) [SHRE16], [SHAR17].

When it comes to mobile multimedia networks, this chapter provides an introduction to the dynamic channel assignment (DCA) system. Because of the restricted frequency range and the growing demand in multimedia services, the problems associated with the optimum channel allocation have grown more critical over time. A channel allocation strategy, on the other hand, plays a vital part in dealing with the accessible channels in each cell, which is necessary for making the most efficient use of the channels that are available in a system.

MOBILE/CELLULAR NETWORK MODEL

As seen in Figure 4.1, the geographical model is thought to be a collection of cells that are not overlapping one another and are continuous. These cells are supposed to have a hexagonal structure and together generate a parallelogram. At time t, a single new call comes at any one cell, which is referred to as the host cell. All other circumstances in the whole network stay unchanged. It is unavoidable for channels to be reused in cellular systems, and at the same time, this phenomenon is directly connected to interference between channels being used simultaneously. Additionally, the co-channel interference level will decrease in proportion to the length of the reuse distance. On the other hand, a longer distance between reuses results in a greater number of cells in each cluster, which in turn leads to a poorer efficiency of reuse. As a result, the frequency reuse pattern need to be chosen by taking into account both the quantity of co-channel interference and the effectiveness of the reuse. By establishing a minimum reuse distance, which is the least permitted normalized distance between two cells that are able to utilize the same channel at the same time, a minimum reuse distance is established. This establishes an area of interference that extends up to cells in every direction from the host cell towards other cells. When working on the cellular model, the model does not take into account the circumstances at the beginning of the process; rather, it takes into account the situation at an intermediate time instant t, which is when a particular number of calls are currently being supplied by the network.

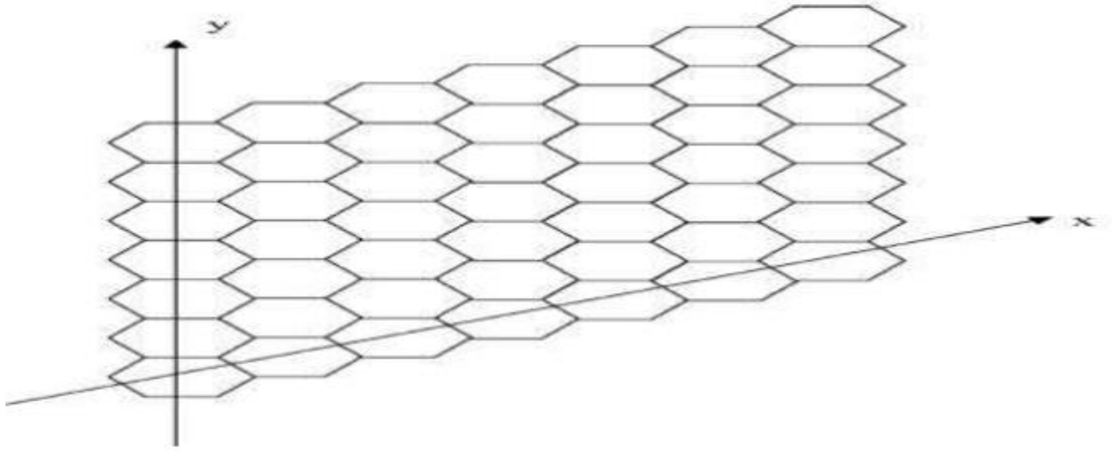

Figure 1 Mobile/ Cellular Network Model

Problem Representation

One of the problems that the suggested model took into consideration was the least interference channel assignment issue, which involves assigning a channel from a pool that has a restricted channel set. A system of m cells is represented by the equation M = 1,m2 mn}. There is an equal division of the available frequency spectrum into the number of channels C, each of which has an equal bandwidth. These channels are numbered in a sequential manner as C = c1,c2,...cmax}.

Channel Allocation Matrix And Vector Solution

Let us designate the total number of cells and channels in networks by the symbols M and C. For this particular network design, a matrix A with dimensions of $M \times C$ is referred to as the channel allocation matrix [VIDY05], [MORA11]. The components of this matrix are denoted by the notation $(i, j)h$.

$$A_{ij} = \begin{cases} 1 & \text{if channel } j \text{ is currently being used in cell } i \\ 0 & \text{otherwise} \end{cases}$$

$$\forall\, i = 1,2, \ldots \ldots \ldots, M, j = 1,2, \ldots \ldots . C$$

Let's say that M is equal to four, C is equal to ten, and that Channel 3,4 is now being used in cell 1, Channel 6 in cell 2, Channel 1 in cell 3, and Channel 3,7 in cell, respectively. Please see below table 1 the channel allocation matrix that has been created.

Table 1 Channel Allocation Matrix

		Channels									
		1	2	3	4	5	6	7	8	9	10
Cells	1	0	0	1	1	0	0	0	0	0	0
	2	0	0	0	0	0	1	0	0	0	0
	3	1	0	0	0	0	0	0	0	0	0
	4	0	0	1	0	0	0	1	0	0	0

We are willing to acknowledge that the new call request has been lodged at cell k, which is currently in the process of processing [traf(k)–1] calls. Here, "traf(k)" refers to the total traffic load (including incoming and outgoing) in cell k at timest. No calls are still pending, and no calls that are in progress have been terminated throughout the whole system. In situations when it is conceivable to reassign channels to ongoing calls in cell k, our challenge is to assign available channels to the incoming call instead of reassigning channels to the calls that are already in progress. [VIDY05] A acceptable arrangement is a vector of channel numbers, denoted by X, of length traf(k), which indicates a set of channels that are assigned to the traf(k) number of calls that are being received at cell k at the time-instant in question.

For every appropriate arrangement, the information on the new channel assignment in cell k is stored in a vector with a length of C and a value of 0 and 1; for instance, if M is equal to 4, C is equal to 10, and a suitable solution is then V is equal to [1 1 0 0 0 0 1 0 0 0]. Therefore, it is clear that V is a balanced function of X, also known as a one-to-one function.

Hopfield Neural Network

In 1982, Dr. John J. Hopfield came up with the idea for a sort of artificial neural network known as a Hopfield Neural Network (HNN). This type of network is either recurrent or completely linked. Through the use of an auto-associative memory, HNN is a representation of an additional neural computational paradigm. Human neural networks (HNN) also provide a paradigm for comprehending human memory. In its most basic form, HNN is constructed using artificial neurons [HOPF82]. A total of N inputs are available to these AI neurons. There is a weight wi that is connected with each and every input i. There is also an output from them. The current state of the output is preserved until the neuron is updated with new information. The following procedures are executed in order to bring the neuron up to date: The calculation involves determining the value of each input, denoted as xi, and calculating the weighted sum of all inputs, denoted as ∑i wixi.

By using the threshold function and the total inputs obtained from various neurons, it is possible to estimate the weight value of each neuron, which is represented by

$$ui = wij\ vj + xi$$

Where vj shows the states of neurons.

There is a natural update to the state of each neuron, which is accomplished with the help of the neuron threshold rule and the threshold THD, as shown by

$$v_i = \begin{cases} 1, & if\ U > THD \\ 0, & otherwise \end{cases}$$

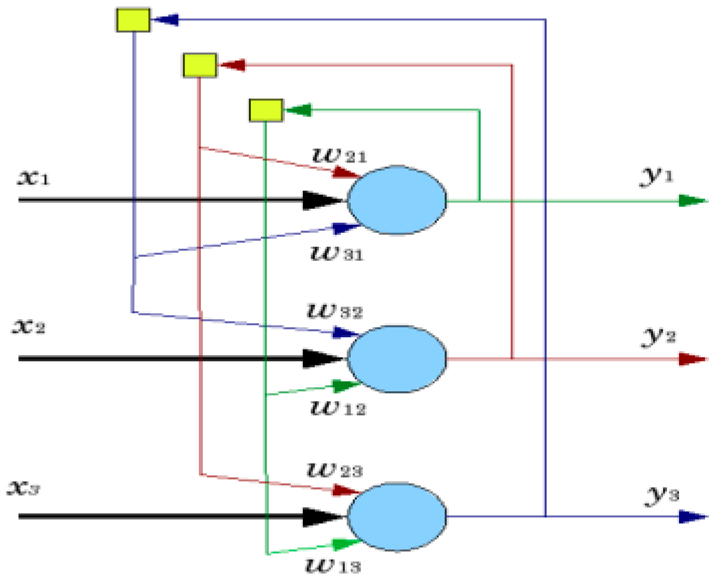

Figure 2 Architecture of Hopfield Neural Network

A value of one is assigned to the neuron's output state if the total of the weighted inputs is greater than zero or equal to zero. In cases when the weighted input total is less than zero, it is assigned the value -1.

It is possible for a neuron to keep its output state until it is updated once more.

$$y = \begin{cases} 1 & \sum w_i x_i \geq 0 \\ -1 & \sum w_i x_i \leq 0 \end{cases}$$

Formulation of HNN Energy Function

An explanation of the energy function formulation Regarding the determination of the problems associated with dynamic channel allocation, E demonstrates the effectiveness of the HNN model. Several articles, including [LAZA00], [CALA06], [MORA11], and [PAND16], have been written on the formulation of the HNN energy function (E), which is shown here.

$$E = \frac{1}{2} x^t \, W x + \, b^t \, x$$

Where

x Input vector for channel assignment;

b Bias vector identified by constraints;

W Symmetric weight matrix for HNN.

Formulating and capturing the channel allocation issue is accomplished by the use of the HNN model in DCA. According to the literature review, a number of different DCA strategies have been provided in detail, and it demonstrates how an energy function may be used to describe the CPA in mobile multimedia networks that are subject to random mobility traffic load distribution. There is a novel energy function that tackles the challenges of channel allocation for mobile network DCA approaches. This function is a representation of the hard and soft channel allocation scheme. The following is a representation of the formulation of the energy or fitness function: [BATT01], [MONS09], and [SUBR12].

$$\boldsymbol{E} = \frac{A}{2}\sum_{j=1}^{C}\sum_{\substack{i=1\\ i\neq k}}^{M}(V_{k},j\,.A_{i,j}.Interf(i,k)) + \frac{B}{2}\left[\sum_{j=1}^{M}(V_{k,j}) - Traf(k)\right]^{2}$$
$$-\frac{C}{2}\sum_{j=1}^{C}\sum_{\substack{i=1\\ i\neq k}}^{M}\left(V_{k,j}\,.A_{i,j}\,.\frac{1-Interf(i,k)}{Dist(i,k)}\right)$$
$$-\frac{D}{2}\sum_{j=1}^{M}(V_{k,j}\,.A_{k,j}) + \frac{F}{2}\sum_{j=1}^{C}\sum_{\substack{i=1\\ i\neq k}}^{M}(V_{k,j}\,\,.A_{i,j}\,.[1-Res(i,k)])$$
$$+\frac{G}{2}\sum_{j=1}^{C}[Free_{j}\,\,.(1-V_{k,j}) - H]$$

where

M Total cells used in the system.

C Total available channels in the system.

H Total available handoff guard channels.

Ai, Allocation table elements denote 1 if channel j is assigned to cell i, 0, Otherwise.

k The number of cells that are used in the cancellation or arrival of a call. Traf(i) is the available channel that was requested at cell i.

Vk, Assignment of the cell of interest.

Dist(i, k) Adjacent cell distance between cell i and k.

Interf(i, k) Channel compatibility matrix set to 1 if the assignment of a

It is not possible for the channel in cell i to be compatible with the identical channel in cell u, 0 unless otherwise specified.

The channel reuse matrix is denoted by the notation Res(i, k), and its value is 1 if cells i and k belong to the same result pattern, and 0 otherwise.

CONCLUSION

The purpose of this study is to propose a dynamic channel allocation model that is based on HNN for the purpose of making effective use of channels in mobile multimedia networks. Evaluation of the channel allocation issue has been accomplished by the development of an HNN model. Over the course of four benchmark issues, the model has been evaluated. Having tested the model with a number of different population sizes, we have discovered that a population size of one hundred provides the best response. It has been observed that the Cell-Based Call Rejection Probability (CCRP) has reduced, and this trend continues to decline as the number of iterations increases. When compared to other algorithms, such as the Genetic approach (GA), this approach converges relatively more quickly with a less number of iterations. As a result, it would save time and enhance the amount of channels that are used by the wireless system.

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