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Hopfield Neural Network for Dynamic Channel Assignment in Mobile Multimedia Networks

Jyoti Balkrishna Patil[1], Dr. Sunil Bhutoda[2]

[1]Research Scholar, Department of Computer Science, P. K. University, Shivpuri, M.P.
[2]Professor, Department of Computer Science, P. K. University, Shivpuri, M.P.

ABSTRACT

To maximize coverage, cellular networks are often laid out in a hexagonal configuration, which consists of sets of continuous, non-overlapping cells. Channel reuse is essential for efficient management of limited frequency resources in mobile networks, and these cells form the basis of the geographic model for such networks. Nevertheless, network performance can be negatively impacted by co-channel interference, which is introduced by channel reuse. The fundamental motivation for this study is to discover a middle ground that may satisfy the demanding standards of mobile multimedia networks. To address this issue of dynamic channel allocation, the Hopfield Neural Network (HNN) is utilized. One type of artificial neural network, HNN updates neuron states and computes the weighted sum of inputs using auto-associative memory. By balancing hard and soft allocation strategies, the energy function of the HNN is used to optimize channel allocation in the mobile network, thus mitigating interference.

Keywords: Channel Allocation, Neural Network, Cellular, Multimedia

INTRODUCTION

A variety of services, including phone, video, gaming, and data communication, are made possible by mobile multimedia networks, which have become an essential component of today's telecoms infrastructure. The demand for mobile multimedia services has skyrocketed due to the widespread availability of smartphones, tablets, and other portable devices. Problems with resource management have become more apparent as a result of this increase in demand. The term "channel allocation" describes the procedure by which mobile customers are given specific channels to transmit data, video, or voice. Because of factors such as user mobility, bandwidth constraints, and the diverse quality of service needs of multimedia applications, channel allocation in mobile multimedia networks is notoriously difficult. Allocation becomes even more complicated when dealing with multimedia traffic, which is inherently dynamic and frequently demands low packet loss, low latency, and high data rates. As a result, satisfying users, optimizing network performance, and accommodating varied applications all depend on well-designed channel allocation algorithms.

The limited amount of radio spectrum is the primary obstacle to channel allocation. The amount of radio frequency spectrum available for use in wireless communication is a constraint. Because of the high data transfer demands of multimedia applications, efficient management of this limited resource is of the utmost importance. The goal of channel allocation is to enhance system efficiency, minimize interference, and maintain the needed quality of service (QoS) by assigning different users or devices within a network to different channels (frequency bands or time slots). Handling the available bandwidth, improving resource use, guaranteeing customer pleasure, and balancing trade-offs between system capacity and service quality are all aspects of this complex topic.

Centralized, distributed, and hybrid strategies are several ways to categorize dynamic channel allocation techniques. A single controller or base station handles channel allocation for the whole network in centralized DCA methods. Global resource optimization is possible with this approach, but it might not scale well, particularly in big networks with many users. Furthermore, the network becomes susceptible to compromise in the event that the central controller is compromised due to the single point of failure introduced by centralized systems. In contrast, dispersed DCA methods enable base stations or individual devices to autonomously allocate channels according to local data. Although this approach makes things more stable and scalable, it might not allocate resources optimally because it doesn't take global data into account. In order to strike a balance between centralized and distributed decision-making, hybrid methods integrate the best of both worlds.

Nevertheless, there are several difficulties with channel allocation in mobile multimedia networks. Because users are constantly on the move, there are a lot of handovers, in which devices migrate from one base station or access point to another. Particularly for multimedia applications that are sensitive to delay, it is vital to ensure a solid connection and uninterrupted service during handovers. Poor channel allocation during handovers can result in buffering, dropped connections, and an overall worse user experience. In order to solve this problem, researchers have created predictive handover algorithms. These algorithms can tell when a user is going to leave a base station's coverage area and then pre-allocate channels in the next cell to make sure the transfer goes smoothly.

REVIEW OF LITERATURE

Mahmood, Maha et al., (2019) Because of the massive volume of data transmitted via the Internet, the area of Multimedia Information Retrieval (MIR) has become increasingly vital. Raw data or its components are two ways to describe multimedia data. Data structures having various properties, including images, music, video, and text, make up raw multimedia data. Semantic gap, or the discrepancy between how a notion is understood by humans and how it may be expressed in a language understood by machines, is the main obstacle to machine intelligence representation (MIR). Using a variety of algorithms through a two-stage process (training and testing) is the goal of this research.

Singh, Sunil & Vidyarthi, Deo. (2019) The cellular network architecture is the subject of much research on radio channel allocation. The nodes in the network must be careful with the limited resources known as channels. It is common practice for neighboring cells to lend or borrow channels during channel allocation. Only one lending or borrowing operation is used by the majority of the existing channel allocation algorithms. Cognitive radio has made it feasible to use the channels in an opportunistic way. The services that are available through the channels are typically categorized as either real-time or non-real-time. In this case, non-real-time services are given less priority than real-time ones. In addition, the new handoff services are prioritized above the call ones. By combining the concepts of cognitive radio with multi-channel lending/borrowing, this study suggests a new heuristic technique to improve channel utilization for these services. The suggested model's performance is evaluated by simulation, which shows the efficient use of channels in relation to dropped and blocked services.

Kumar, Sanjeev et al., (2016) Mobile multimedia communication systems have bandwidth constraints. However, channel allocation is essential for cell resource management and network optimization. This problem must be fixed to reduce blocked and dropped calls. This research introduces dynamic channel allocation using hopfield neural networks and handoff calls to move traffic. Enhancing the system's capacity. The Hopfield algorithm generates a new energy function that distributes incoming and outgoing call channels using traffic mobility data. We also investigated traffic mobility with an error-back propagation neural network model for intercell handoff calls and continuous service availability to improve QoS. Our system decreases call handoff dropping and blocking more than static or dynamic channel allocation systems.

Kumar, Sanjeev & Kumar, Krishan. (2014) One of the difficult difficulties with providing quality of service (QoS) in mobile multimedia network communication systems is call admission control (CAC). One definition of CAC is a system that limits access to a network depending on the resources that are available. If there are sufficient idle resources to meet the quality of service needs of the new call without compromising the quality of service for already approved calls, then the call is admitted. Otherwise, it is rejected. This article offers an overview of various CAC methods that are utilized in mobile multimedia networks. These schemes make use of soft computing techniques such as genetic algorithms, fuzzy logic, and artificial neural networks. Many factors utilized in mobile multimedia networks can be adjusted via soft computing. Our objective is to assess and contrast the most effective aspects of soft computing as it pertains to mobile multimedia networks in order to enhance the capacity of current CAC approaches. Additionally, this research delves into the future directions of artificial neural networks, fuzzy logic, and genetic algorithms, exploring their untapped potential. Topics covered include Genetic Algorithms (GA), Artificial Neural Networks (ANNs), Fuzzy Logic (FL), and Soft Computing (SC).

Omid, Moradi. (2010) Radio spectrum is a scarce resource in mobile wireless communication systems. But it has been demonstrated that the system capacity can be enhanced by the efficient utilization of existing channels. To enhance service quality while minimizing the likelihood of call blocking or dropping, a channel assignment system assigns channels to calls or mobiles in a certain way. It is well-known that channel assignment is an optimization problem that is NP-hard. A novel channel-assignment technique based on a tweaked Hopfield neural network is presented in this article. The channel-assignment problem is carried out via a modified discrete Hopfield network and is expressed as an energy-minimization problem. The algorithm determines an energy function and specifies the proper weights for the connections between neurons. When the constraint conditions are not met, each neuron receives inhibitory support from the interconnection weights, and when they are met, each neuron receives excitatory support. Seven benchmark issues with total frequencies ranging from 73 to 533 will be used to test the algorithm. All seven tasks were outperformed by this new method and its companions, the suggested regular interval initialization and updated interconnection weights.

Model of Mobile/Cellular Networks

The geographical model is likely comprised of a series of continuous, non-overlapping cells, as shown in Figure 1. All of these cells should come together to make a hexagonal parallelogram. A random selection is made at time t to determine which cell will serve as the host and receive future calls. There has been no change to anything else in the entire network. The interference that happens when multiple channels are in operation at once is closely related to channel reuse, which is an inherent aspect of cellular networks. Less co-channel interference is an additional perk of a greater reuse distance. On the other side, with more cells ending up in each cluster, reuse efficiency decreases with increasing distance between reuses. So, when deciding on a frequency reuse pattern, it's important to think about how much co-channel interference there will be and how effective the reuse will be. The specification specifies the minimum reuse distance as the smallest normalized distance between cells sharing a channel. An interference zone radiates from the host cell in all directions. The cellular model considers the network's call volume at instant t instead of the initial conditions.

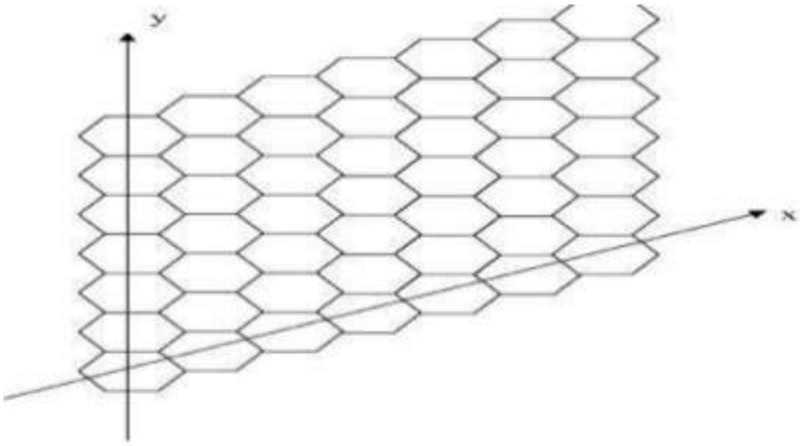

Figure 1: Mobile Network System

Representation Of The Problem

The proposed method considered least interference channel assignment. This challenge involves selecting a channel from a limited pool. The system with m cells has a solution M = 1,m2 mn}. C channels in the accessible frequency range have identical bandwidths.

O = c1, c2,... CMAX represents these channels' consecutive numbering.

Hopfield Neural Network

The late Dr. John J. Hopfield designed a Hopfield Neural Network (HNN) in 1982. Recurrent and totally connected networks exist. HNN depicts itself via auto-associative memory, another neural computing model. Additionally, HNN illuminate the human memory process. Artificial neurons are the fastest and easiest HNN construction method. The AI neurons' input capacity is N.

For every input i, weight wi exists. Additionally, they make something. No adjustments will be made to the neuron's output until new data arrives. The neuron is updated using these steps:

To complete the computation, it is necessary to calculate the weighted sum of all inputs, ∑i wixi, after determining their values, xi.

The weight value of each neuron can be approximated by combining the total inputs from several neurons with the threshold function.

The equation S = $wiba$ + xi

The position of ab represents neural states.

The neuron threshold rule and threshold THD automatically update neuron states, as shown by.

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

Having more than zero weighted inputs sets the neuron's output state to one. When the weighted inputs are less than zero, use -1.

Neurons can keep their output state until updated.

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

Formulation of HNN EnergyFunction

Energy function definition and explanation E shows that the HNN model may discover dynamic channel allocation issues.

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

In HNN, "X" represents the input vector for channel assignment, "b" represents the velocity bias determined by constraints, and "W" is the symmetric weight matrix.

The DCA HNN model can design and describe the channel allocation problem. The literature review discusses DCA techniques and shows how an energy function can characterize the CPA in mobile multimedia networks with random mobility traffic load distribution. We developed a new energy function for mobile network DCA channel allocation.

This function allocates hard or soft channels.

CONCLUSION

In an era characterized by the increasing demand for varied multimedia services, channel allocation is an intricate yet critical procedure in mobile multimedia networks that guarantees the efficient use of limited resources. The continual development of mobile multimedia networks relies heavily on channel allocation. Future networks will need to incorporate safe, adaptive, and efficient channel allocation algorithms to meet the growing demand for bandwidth-intensive, real-time multimedia applications while keeping users happy.

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