A hybrid frequency allocation algorithm based on IFR3+tx-ITL development

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Abstract: Communication technologies are developing rapidly and various frequencies are being used in daily life. The aim of this paper is to prove a new frequency allocation algorithm for 37-cell networks to enhance the utilization of communication frequencies. It is shown that the hybrid algorithm has a larger channel capacity compared to the traditional stand-alone algorithm, which is conducive to improving frequency utilisation.

Keywords: Frequency Allocation, Channel Capacity, Algorithms.

1. Introduction

In the field of frequency allocation algorithms, there is a great need to propose a new, more efficient frequency allocation algorithm. It has been shown that the application of hybrid algorithms is feasible and, to some extent, significantly improves channel capacity [1,2]. The significance of this research is to open up ideas for the development of frequency allocation algorithms to make enhancements. The study uses MATLAB simulations to focus on the feasibility analysis of a hybrid algorithm developed based on the IFR3 and tx-ITL algorithms. Unlike existing research, this study sets the size of the user cluster to a 37-cell network model, the model can be referenced in Figure 1.

2. Experimental procedure

2.1 Algorithm analysis

The three main frequency allocation algorithms used in this study are Integer Frequency Reuse (IFRN), Water-filling and Transmit Interference Temperature Limit (tx-ITL).

2.1.1 Integer Frequency Reuse (IFR)

The IFR algorithm is a basic frequency allowance algorithm where the capacity C_n identical to the capacity c_n of each cell can be deliberated from the noise power σ and the Transmit power, P_n and P_m, from the nth base station and the mth fundamental station [3,4]. $h_{m,n}$ indicates those channels that generate interferences with the object cell, as well as k and l represent the distance between two cells that affect each other The relevant key variables are as follows

(1) Multiplexing factor that determines the number of frequency multiplexes
(2) Overall channel capacity of the network
(3) Channel capacity per cell

$$N = k^2 + kl + l^2 \tag{1}$$

$$C_{total}=\sum_n Cn \tag{2}$$

$$C_{n=log_2}\left(1+\frac{|h_{m,n}|^2 P_n}{\sum_{m\neq n} \rho_{m,n}|h_{m,n}|^2 P_m+\rho^2}\right) \tag{3}$$

2.1.2 Water-filling & Transmit Interference Temperature Limit(tx-ITL)

The water-filling method is a more intelligent frequency allocation algorithm that limits the use of noisier channels by setting a "horizontal plane", represented by $\frac{1}{\lambda}$ [5]. The meaning of $|H[f]|$ is the interference that the channel has while the meaning of p is the gap between interference and water-level. The key formulas in the method are as follows: Transmitted power per frequency;The value of

$\frac{1}{\lambda}$ in the horizontal plane is the solution of the following equation satisfying;Channel capacity for the water-filling method where N_c means the number of frequency channels：

$$P_f = \left(\frac{1}{\lambda} - \frac{\sigma^2}{|H[f]|^2}\right) \tag{4}$$

$$\sum_{f=1}^{N_c} \left(\frac{1}{\lambda} - \frac{\sigma^2}{|H[f]|^2}\right) = p \tag{5}$$

$$C = max_{\{P_f\}} \sum_{f=1}^{N_c} log_2(1 + \frac{P_f|H[f]|^2}{\sigma^2}) \tag{6}$$

The tx-ITL is an optimised water injection method. Compared to the water injection method, the tx-ITL possesses a variable S_k that can control the interference, which makes the water injection method more intelligent [6]. Transmit power per cell where $c_k[n]$ means inverse noise ratio and w_k means water-level in tx-ITL, Overall transmit power:

$$p_k[n] = \begin{cases} (w_k - c_{k[n]})^+ \ if \ c_k[n] \le S_k \\ 0 \ if \ c_k[n] \ge S_k \end{cases}, \forall n \tag{7}$$

$$P_k = \sum_{n=1}^{N} (w_k - c_k[n])^+ \tag{8}$$

2.2 Comparison of the IFR3+tx-ITL fusion algorithm with a single conventional algorithm

2.2.1 Contrast of the two algorithms at variable SNR

The SNR is one of the main reasons for the size of the channel capacity, and in the research process, standalone algorithms tend to be very sensitive to the SNR [7]. In contrast, the hybrid algorithm is not as sensitive to SNR as the standalone algorithm. After improving the SNR by a factor of 3, the channel capacity generated by the hybrid algorithm does not fluctuate relatively significantly, indicating that with less SNR, the hybrid algorithm can still generate approximately equal channel capacity, which saves resources to a certain extent. The corresponding data are detailed in Figure 1.

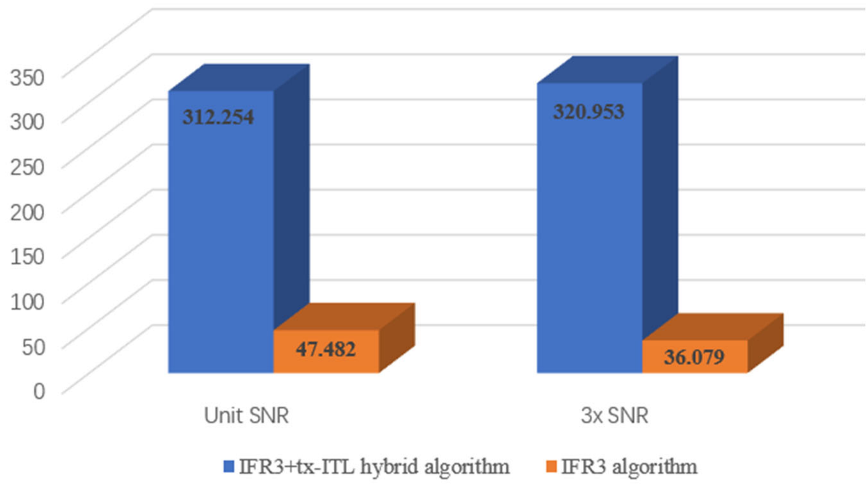

Figure1. The dissimilarity in channel capacity produced by the above algorithms at 3x SNR

2.2.2 Contrast of the two algorithms at variable bandwidths

Channel capacity increases with bandwidth. In hybrid algorithms, the bandwidth brings much more gain to the channel capacity than in standalone algorithms. The main reason for this phenomenon is that hybrid algorithms are more efficient at multiplexing, which allows the increased bandwidth to be used to greater effect [8,9]. The hybrid algorithm did not increase the size of the channel capacity by the same order of magnitude as the standalone algorithm when the bandwidth became three times larger during the study. The data are detailed in Figure 2.

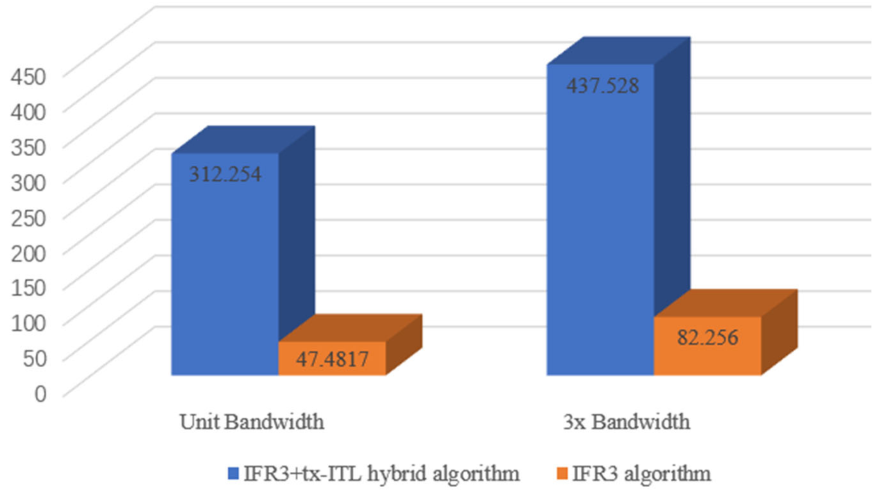

Figure2. 3x bandwidth capacity for both algorithms

3.Conclusion

Through the study, it is found that the hybrid algorithm developed based on IFR3 and tx-ITL can significantly increase the channel capacity and it allows for a higher utilisation of frequencies compared to the traditional stand-alone algorithm. Hence, the idea of a combination approach to develop new frequency allocation algorithms is viable. A frequency allocation algorithm developed in a hybrid manner is not simply a crude addition of two algorithms to achieve a result of 1+1=2. Instead, the idea is to embed one algorithm into the other to achieve a 1+1>2 effect. With such a treatment, the advantageous parts of both algorithms can be represented very thoroughly; The hybrid algorithm, in other words, preserves only the strengths of both algorithms. The paper's contribution is to validate the viability of the hybrid method and to inform future work on the exploitation of frequency allocation algorithms and to fill a gap in the field of efficient algorithms for subsequent algorithm development work. The shortcoming of the current research is that the algorithm is not streamlined in design, which leads to a system that takes a lot of time to compile in code. The design of the algorithm ought to be refined in future research, for instance by altering the structure of the algorithm and the programming language.

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