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**Max-min Fairness Rate Control in Wireless Networks: Optimality and Algorithms by Perron-Frobenius Theory**

**Abstract:**

Rate adaptation and power control are two key resource allocation mechanisms in multiuser wireless networks. In the presence of interference, how do we jointly optimize end-to-end source rates and link powers to achieve weighted max-min rate fairness for all sources in the network? This optimization problem is hard to solve as physical layer link rate functions are nonlinear, nonconvex, and coupled in the transmit powers. We show that the weighted max-min rate fairness problem can, in fact, be decoupled into separate fairness problems for flow rate and power control. For a large class of physical layer link rate functions, we characterize the optimal solution analytically by a nonlinear Perron-Frobenius theory (through solving a conditional eigenvalue problem) that captures the interaction of multiuser interference. We give an iterative algorithm to compute the optimal flow rate that converges geometrically fast without any parameter configuration. Numerical results show that our iterative algorithm is computationally fast for both the Shannon capacity, CDMA, and piecewise link rate functions.

**Existing System:**

The wireless network presents a significant challenge to resource allocation techniques as the algorithms need to capture temporal interaction among multiple users, operation in unlicensed spectrum, a different mix of rate scheduling at the MAC layer with coding and modulation techniques at the physical layer that shapes the achievable rates. In wireless networks, compounding the difficulty is the strong dependency between the physical layer implementation and interference coupling across multiple links due to the nonconvexity of rate functions. Achieving end-to-end flow rate fairness in a wireless network is thus a challenging nonlinear problem even for a fixed number of flows and links.

**Proposed System:**

We cast the solution of the classical max-min rate fairness optimization as computing a Perron- Frobenius eigenvector obtained through an iterative power method algorithm with general fixed-point mapping. Previous work utilized the classical linear Perron-Frobenius theorem to link the optimal solution of the max-min SINR problem to the Perron- Frobenius eigenvector and proposed power method algorithm with linear fixed-point iterations.

However, the general optimal solution to a more complicated link rate functions remains open, and we tackle it by utilizing the nonlinear extension of the Perron-Frobenius theorem. the special case when the link achievable data rate is given by the Shannon capacity formula, we provide an alternate Perron-Frobenius theoretic characterization (linear Perron-Frobenius theorem and generalized Perron-Frobenius theory for the pencil matrix) of the problem. Inspired by the seminal work, we find that although the fixed-point iteration does not satisfy the conditions for a standard interference function (with increasing monotonicity replaced with decreasing monotonicity), its convergence is proved in the paper.

For the general case, we solve the weighted max-min flow rate fairness problem subject to affine power constraints for a large class of physical layer link rate functions. We show that this problem can be decoupled into two subproblems on fairness – one at the network layer and one at the link layer - whose optimal value and solutions can be characterized using nonlinear Perron-Frobenius theory and nonnegative matrix theory. Geometrically fast convergent algorithms with no parameter configuration are proposed to compute the optimal solution.