An Optimized Contention Resolution on Wireless Channel via Reinforcement Learning

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Abstract

This paper considers the classical contention resolution problem in a single hop wireless network with n users competing for an open-access wireless channel. The message of a user can be heard by all others if it is the only one transmitting in a time step, while all others listen simultaneously. In a distributed setting, a standard randomized solution guaranteeing fairness of channel access is to let all users transmit with a probability $1/n$ and listen otherwise in each time step. Thus, the expected number of successful transmissions of each user during T time steps is $\frac{1}{n} * (1 - \frac{1}{n})^{n-1} * T$, which asymptotically approaches $T/(ne)$ as n grows, but far from the theoretical upper bound T/n.

To close this gap and develop a learning-based solution for efficient and fair spectrum access, in this paper, a distributed Multi-Agent Reinforcement Learning (MARL) algorithm is proposed to optimize the usage of the wireless channel and guarantee the fairness of users. Specifically, different with the previous MARL works in most of which multiple agents either compete or cooperate with each other for the final reward, the multiple agents in our work have the competition and cooperation relationship simultaneously for a successful transmission. To handle this complex case, each agent in our algorithm uses a matrix to depict the efficiency and fairness of the recent channel utilization, and tunes its reward carefully according to its matrix and action in last time step. Also, the actor-critic framework is adopted in our MARL algorithm, which enhances the efficiency and correctness of our algorithm. Empirical results from our simulation studies show that with our learning algorithm, the number of successful transmissions of each user in T time steps becomes very close to the optimal bound T/n when T is sufficient large.

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