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論 文 内 容 要 旨

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学位論文題目	A Study on Spectrum Sharing between Cellular and Wi-Fi Networks （セルラ／ Wi-Fi ネットワーク間の周波数共用に関する研究 ）		

内容要旨

In recent years, the amount of mobile traffic is growing rapidly and spectrum resources are becoming scarce in wireless networks. Under these predictions, it is clear that the wireless network capacity will not meet the exponential growth of traffic demand, such as high speed data communication, ultra reliable and low latency communication, cost effective wireless networks and so on. To overcome this problem, using cellular systems in the unlicensed spectrum has emerged as a promising and effective solution that can assist in exploiting the wireless spectrum in a more efficient way. In order to work in unlicensed bands, cellular systems, such as LTE, 5G New Radio need to coexist with legacy unlicensed technologies Wi-Fi (IEEE 802.11-based technology), Blue tooth and other systems. Consequently, providing fairness and a desired level of Quality of Service (QoS) between NR-U and Wi-Fi is a challenging issue.

In this dissertation, we propose an efficient channel assignment method for the heterogeneous wireless networks in unlicensed bands, based on Deep Reinforcement Learning (DRL) to overcome these challenges. For that, first of all we have implemented an emulator as an environment for spectrum sharing in densely deployed (eNBs) and Access Points (APs) in wireless heterogeneous networks to train the Double Deep Q Networks (DDQN) model. We considered that eNBs are established in an environment where APs are already densely deployed. Wi-Fi APs should be managed coordinately and eNBs should cooperate with them. For that, the agent (broker) is introduced to manage both APs and NBs in a centralized way. In this case, the agent controls the channel to maximize the throughput by assigning suitable channels to each AP and BS in the proposed environment. When training the DDQN agent, the optimal channel (action) is assigned to each AP/NB based on the highest average throughput (reward) which is obtained from the emulator.

The numerical results show that our proposed DDQN algorithm improves the average throughput from 25.5% to 48.7% in different user arrival rates compared to the random channel assignment approaches.

We evaluated the generalization performance of the trained agent, to confirm channel allocation efficiency in terms of average throughput (reward) in the proposed environment under the different user arrival

rates. Consequently, we can observe that the designed agent is trained enough to choose near-optimal action with high reward for any inputs in the short term.

In the first phase of this research, we analyzed related works which includes spectrum resources, mainly unlicensed spectrum, spectrum sharing techniques as well as coexistence between the cellular and Wi-Fi systems. In Particular, the spectrum sharing between cellular LTE and Wi-Fi systems are investigated which are based on the traditional method and machine learning methods.

In the next phase of this research, we developed an environment for spectrum sharing in densely deployed eNBs and APs in wireless heterogeneous networks. Furthermore, we propose an efficient channel assignment method for each Wi-Fi AP and cellular eNB of the environment in unlicensed bands, based on the DRL. This method is aimed to improve user's average throughput compared with other existing methods. For that, a single-agent DDQN based DRL scheme is employed for efficient channel assignment problems. Consequently, our trained agent is able to assign optimal action (channels) with high reward (average throughput) depending on the number of users and their location area information.

In the final part of our work, When building DDQN, we have examined impacts of the different hyper-parameter settings, different network architectures, and optimizers by experiments. The training accuracy of the designed DDQN has been validated for the on-line simulator when the training section is disabled. We evaluated the performance and the stability of trained agent, to confirm how well it has generalized to assign channels to maximum number of steps for an episode in the proposed environment under the different user arrival rates. Consequently, we can observe that the designed agent is trained enough to assign near optimal action with high reward for any inputs in the short term. Also, we can observe that from the validation result, the performance of the DDQN is impacted in terms of the user arrival rates and their location area index.