Distributed Resource Allocation for Underlay Device-to-Device Communications in 5G Cellular Networks

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I. Introduction

Device-to-device(D2D) network consists of device pairs communicating directly with each other. In underlay mode of operation, the device pairs reuse the resources that are being currently used by conventional devices (Cellular User Equipments (CUEs)). This reuse results in increasing the network capacity, and the direct short range communication results in enhancing performance in terms of data rates, reliability, and energy efficiency, as long as the interference arising from the reuse is properly taken care of. Efficient channel and power allocation schemes for the D2D tier is one way of ensuring that the CUEs are not adversely affected while reaping the advantages of reuse of resources.

II. Motivation and Problem statement

Resource allocation schemes can be classified into centralized and distributed schemes. Centralized schemes which require channel state information (CSI) between every device pair to be known at the base station (BS), results in signaling overhead for CSI acquisition. Pilot contamination will result in incorrect CSI values during the acquisition phase. Hence, distributed schemes, involving little-to-no intervention from the BS as well as negligible information exchange among devices, are the unequivocal choice for future networks. We study the resource allocation in an underlay D2D network and explore the effectiveness of game models and learning algorithms in providing light weight, scalable, and energy efficient distributed solutions for the next generation ultra dense networks. We aim for schemes which do not require information exchange between device pairs and which guarantee necessary quality of service (QoS) for device pairs as well as CUEs. Such schemes are helpful in reducing the computational overhead on the BS and employing a D2D network in an adhoc fashion. The impediment to using such algorithms is the sub-optimality in performance due to the limitation in the amount of information that is available to a device.

III. Proposed Solutions

The joint channel and power allocation problem in an underlay D2D network was initially modeled as a multi-agent learning problem with discrete strategy sets and partially distributed learning algorithms, Fictitious Play (FP) and Fading Memory Joint Strategy Fictitious Play with Inertia (FMJSFP-I), were suggested to determine the channel index and power level to be used by each device pair to maximize the sum rate of the D2D tier. Since these algorithms required information exchange among the device pairs, the distributed joint channel and power allocation problem was then reformulated as an interference mitigation game. A fully distributed Stochastic Learning Algorithm (SLA) was then proposed to learn the channel index and transmit power level.

To ensure the QoS of the CUEs, the resource allocation problem was then modeled as a Stackelberg game with pricing. At the leader level, the BS sets prices for the channels to ensure the QoS of the CUEs. We compared our scheme to an available hybrid scheme and found that our scheme works better in terms of providing a higher sum rate for the D2D tier while ensuring the QoS of the CUEs. We also compared it to an exhaustive search scheme to determine the optimal allocation that maximizes the sum rate of the D2D tier.

In our current work we further extend our previous work where we used the Stackelberg game with pricing for resource allocation for D2D tier while ensuring the QoS of the CUEs. On comparing with the exhaustive search scheme, it was found that our scheme falls behind, giving only half the optimal sum rate. In order to overcome this shortcoming, we reformulated our problem as a rate maximization problem instead of weighted aggregate interference minimization. In future we plan to extend our work to multicell scenarios where we can provide QoS guarantees to D2D pairs also.

IV. References

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