

# 3D Spectrum Sharing for Hybrid D2D and UAV Networks

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**Abstract**—In this paper, we study a three-dimensional (3D) spectrum sharing between device-to-device (D2D) and unmanned aerial vehicles (UAVs) communications. We consider that UAVs perform spatial spectrum sensing to opportunistically access the licensed channels that are occupied by the D2D communications of ground users. The objective of the considered 3D spectrum sharing networks is to maximize the area spectral efficiency (ASE) of UAV networks while guaranteeing the required minimum ASE of D2D networks. Using the tools from machine learning, we obtain the probability of spatial false alarm and the probability of spatial missed detection at the UAV, which helps us to characterize the density of active UAVs. Then, based on the Neyman-Pearson criterion, we further derive the coverage

data transmission need to be carefully designed. Due to the congested unlicensed spectrum, it is desirable for UAVs to transmit in licensed or shared spectrum [3]. Licensing spectrum for massive/broadband UAV communications is not feasible; rather, we consider spectrum sharing between UAVs and ground licensed users to be a viable option.

In the licensed band, device-to-device (D2D) communications enable mobile users that are close to each other to communicate directly [4], [5]. The D2D operation in the licensed band includes the underlay mode (using the same spectrum as cellular communications links) and the overlay mode (using