Social-aware Spectrum Sharing and Caching Helper Selection Strategy Optimized Multicast Video Streaming in Dense D2D 5G Networks

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***Abstract*—The expected explosion of video traffic in 5G ultra-dense networks will pose many challenges to the Internet service providers, e.g., degraded capacity and unfair quality of service (QoS). The most efficient solution is resource allocation that does not require any network architecture changes. This paper proposes a social-aware spectrum sharing and caching helper selection (SSC) strategy that exploits the resources of the mobile users (MUs), i.e., downlink spectrum resources for sharing and caching storage resources for multicasting, to offload the videos in dense device-to-device (D2D) 5G networks. Particularly, we consider physical and social attributes of the MUs to formulate an SSC optimization problem. The SSC problem is solved to optimally control: 1) which MUs, namely sharing mobile users (SUs), that share the downlink spectrum resources and 2) which MUs, namely caching mobile helpers (CHs), that cache the requested videos for D2D multicast communications by reusing the shared downlink spectrum resources. The objective is to maximize the system capacity while satisfying the constraints on capacity fluctuation amongst the receiving mobile users (RUs) and target signal to interference plus noise ratio at the SUs, to guarantee the RUs and the SUs high QoS fairness. Simulation results are shown to demonstrate the benefits of the SSC strategy.**

***Index Terms*—5G ultra-dense networks, caching and clustering, D2D multicast communications, resource sharing, social-aware networks, video applications and services.**

I. Introduction

In 5G ultra-dense networks, the number of mobile users (MUs) is expected to grow rapidly, i.e., exceeding 12 billion connected devices, and the video applications and services (VASs) will occupy up to 79% of the mobile data traffic by 2022 [1], while the network resources are of scarcity. The Internet service providers (ISPs) face the challenges of how to provide the MUs with high quality of VASs by efficiently exploiting the available resources of networks. This way, by the so-called resource allocation, the ISPs can further satisfy the MUs' demand while do not require to change the network architectures, and thus at a low cost.

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Recently, device-to-device (D2D) communications assisted caching (D2DC) technique has been introduced to 5G networks as a promising solution to bring the VASs closer to the MUs. It not only provides high quality in the direct vicinity of transmissions but also improves the resource efficiency in terms of spectrum sharing and caching storage for D2D communications [2]–[6]. The D2DC technique enables the sharing mobile users (SUs) that have available downlink spectrum resources to share their resources with the caching mobile helpers (CHs) that have cached the requested videos for establishing D2D communications between the CHs and the receiving mobile users (RUs). The videos are then streamed from the CHs to the RUs over D2D communications. Since the D2DC can offload the videos by direct D2D communications, it also mitigates the congestion at the backhaul links of macro base station (MBS) and small-cell base stations (SBSs). It is obvious that the D2DC technique quite meets the common interest-sharing nature of MUs when they are in close vicinity, e.g., offices, concert or meeting halls, stadiums, campuses, and even in case of emergency communications. In the so-called local VASs, the performance of D2DC can be improved by considering the clustering, selecting, and multicasting techniques as well as social relationships between the MUs [7].

In the context of local VASs, it is reasonable that the CHs are willing to share the videos with others who have the same interests. The local VASs further require clustering technique that groups the MUs into separated clusters. In each cluster, there are two types of MUs including the CHs and the RUs; the CH, which has proper physical and social attributes with the RUs, are selected for multicasting the requested videos to the RUs. It is noted that the RUs are normally served by the MBS if the requested videos have not cached in any CHs in a cluster or if the quality of received videos multicasted from the CHs is worse than that done from the MBS. The problems here are: 1) how to control the process of donwlink spectrum resource sharing and CH selection and 2) how to exploit the broadcast nature of wireless environment and the physical and social attributes between the MUs, to gain the best social-aware spectrum sharing and caching helper selection (SSC) strategy. The objective of the SSC strategy is to maximize the video multicast capacity delivered to the RUs while providing the RUs and the SUs with a high fairness in quality of service (QoS), i.e., guaranteeing the RUs low capacity fluctuation caused by multicasting and limiting the interference impact on the SUs due to sharing the downlink spectrum resources with the CHs for D2D multicast communications.