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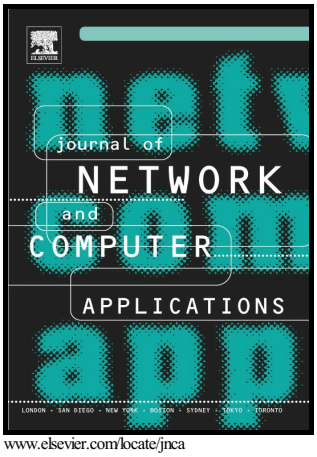

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Distributed Radio Resource Allocation for Device-to-Device Communications Underlaying Cellular Networks

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Abstract

Underlaying Device-to-Device (D2D) communications can increase the spectral efficiency of cellular networks when sharing part of the spectrum with cellular users. This requires radio resource allocation policies capable to limit and control the interference between D2D and cellular communications. Many of the proposed policies are centralized, and require the base station to decide which resources should be allocated to each D2D transmission. Centralized schemes can efficiently control interference levels, but their feasibility can be compromised by their complexity and signaling overhead. To address this constraint, this paper proposes DiRAT, a distributed radio resource allocation scheme for D2D communications underlaying cellular networks. With DiRAT, the D2D nodes locally select their radio resources from a pool created by the cellular network in order to control the interference generated to the primary cellular users. DiRAT includes a control mechanism to ensure that the user QoS requirements are satisfied. This study demonstrates that DiRAT can increase the network capacity while avoiding or limiting the degradation of the performance of the primary cellular users. DiRAT also significantly reduces the complexity and overhead compared to existing centralized and distributed schemes.

Index Terms
Device-to-Device, D2D, underlaying, radio resource management, radio resource allocation, distributed, centralized, network-assisted, cellular networks, 5G

1. INTRODUCTION

The design of future 5G cellular networks is driven by the massive growth in data traffic, and the requirement to handle and support very large numbers of connected devices with distinct QoS (Quality of Service) requirements. Device-to-device (D2D) communications will be one of the key technological components of 5G. D2D allows two devices in proximity to establish a direct communication with the support and control from the network. D2D communications can operate on cellular (inband) or unlicensed (outband) spectrum. Inband D2D communications include underlay and overlay modes. The overlay mode results in that a fixed portion of the cellular spectrum is dedicated only to D2D links. This eliminates the interference between D2D and cellular communications, but also limits the spectral efficiency gains that D2D communications can provide. In the underlay mode, D2D and cellular communications[1] share a portion of the cellular spectrum. Underlaying D2D communications can significantly increase the spectral efficiency (especially under high traffic loads [1]) if the radio resource management can limit and control the interference between D2D and cellular communications.

Many of the proposed radio resource allocation schemes for inband D2D communications underlaying cellular networks consider a centralized approach where the BS (Base Station) or eNB (enhanced Node B) takes the final resource allocation decision [2]. Centralized schemes can better control interference levels, but their signaling overhead and complexity can compromise their feasibility. This was actually highlighted in [1] where the authors formulate a centralized proposal as an integer linear programming problem, and show that there is no known polynomial-time algorithm for finding all feasible solutions since all possible combinations of concurrently active D2D links can grow exponentially with the total number of D2D links. The complexity and overhead can be reduced with distributed schemes, although the implementation of existing solutions can be still compromised by the signaling overhead or by the time required to achieve a solution to the problem. In addition, any reduction of overhead or complexity should not come at the expense of a significant reduction of the gains that can be achieved with D2D communications, or at the expense of degrading the performance of primary cellular users. In this context, this study proposes DiRAT, a novel network-assisted Distributed Radio resource AllocaTion scheme for D2D communications underlaying cellular networks. The proposed scheme has been designed with the objective to increase the network capacity without degrading the performance of the cellular users, and to significantly reduce the computational complexity and signaling overhead. To this aim, the D2D nodes locally select their radio resources from a pool of resources that has been previously created by the eNB in order to control the interference generated to the primary cellular users. DiRAT implements an additional control process at the eNB and D2D receivers that continuously evaluates if their QoS requirements are satisfied. If they are not, the eNB modifies the

[1] The terms ‘cellular communications’ or ‘cellular transmissions’ are used in this paper to refer to conventional cellular links between a mobile station and a base station.