Device-to-device (D2D) communications recently have attracted much attention for its potential capability to improve spectral efficiency underlying the existing heterogeneous networks (HetNets). Due to no sophisticated control, D2D user equipments (DUEs) themselves cannot resist eavesdropping or security attacks. It is urgent to maximize the secure capacity for both cellular users and DUEs. **This paper formulates the radio resource allocation problem to maximize the secure capacity of DUEs for the D2D communication underlaying HetNets which consist of high power nodes and low power nodes.** The optimization objective function with transmit bit rate and power constraints, which is non-convex and hard to be directly derived, is firstly transformed into matrix form. Then the equivalent convex form of the optimization problem is derived according to the Perron-Frobenius theory. A heuristic iterative algorithm based on the proximal theory is proposed to solve this equivalent convex problem through evaluating the proximal operator of Lagrange function. Numerical results show that the proposed radio resource allocation solution significantly improves the secure capacity with a fast convergence speed.

The goal of this paper is to optimize the radio resource allocation aiming to maximize the secure capacity of D2D communication underlaying HetNets. The non-convex objective function with several constraints are first transformed into matrix form. Then, the equivalent convex form is derived according to the Perron-Frobenius theory, which is based on the eigenvalue and eigenvector [20]. Note that the PerronFrobenius theory has been mainly used in homogeneous networks, there are lack of publications to use this theory to address the optimization issue in the D2D communication underlaying HetNets. To derive this Perron-Frobenius theory based equivalent convex optimization problem, the corresponding Lagrange function has been formulated and the proximal operator has been evaluated. Finally, a novel iterative algorithm based on the proximal theory has been proposed. The main contributions of this paper can be summarized as following:

• The optimization problem of radio resource allocation aiming to maximize the secure capacity in D2D communication underlaying HetNets has been addressed in this paper. To our best knowledge, previous works mainly take D2D communication as friendly jammer to improve the secure capacity of cellular users. Thus, only the performance of cellular users is optimized and the performance of D2D communication is ignored. Furthermore, previous works mainly focus on the traditional SE and do not focus on the secure capacity. Besides, when solving the optimization problem, previous works mainly try to simplify the interference between cellular users and D2D users by setting the interference with constant, which cannot take full advantage of the benefit of subcarrier reusing. This paper explores the resource allocation scheme for both cellular users and D2D users when they share the same subcarrier resource to maximize the secure capacity of D2D communication underlaying HetNets.

• To deal with the secrecy-optimized resource allocation problem, a non-convex objective function has been formulated. This non-convex objective function is hard to be directly derived. The existing works often simplify the interference into constant, and then the Lagrangian dual theory can be used. However, the interference in the D2D underlaying HetNets is often dynamical and should not be regarded as constant. To deal with this non-convex issue, the objective function is transformed to an equivalent convex optimization problem according to the Perron-Frobenius theory. Furthermore, to solve the equivalent convex problem, an iterative algorithm based on the proximal theory consisting of both outer and inner loop optimizations has been proposed to achieve the global optimal solution. • The SE performance of the proposed resource allocation solution has been numerically evaluated. Simulation results show that the proposed iterative algorithm can promptly converge and outperforms the baseline algorithms. The effects of the QoS and power constraints with various other comparisons have been shown to evaluate the performance gains of the proposals.

In this paper, the secrecy-optimized resource allocation for the device-to-device (D2D) communication underlaying heterogeneous networks (HetNets) has been researched. In the concerned system model, there densely exist high power node and low power node with D2D communication, therefore, the inter-tier interference is always severe, which leads to the secrecy-optimized maximization problem being non-convex. To solve this non-convex optimization problem, the primal non-convex optimization problem has been transformed into the convex issue with several steps. Firstly, the objective function with several constraints are transformed into a matrix form. Secondly, the equivalent convex form of the maximization problem for the matrix form is derived according to the Perron-Frobenius theory. Thirdly, the proximal operator of the transformed convex problem is evaluated. Then, a novel iterative algorithm based on the proximal theory to solve the equivalent convex problem is proposed. Simulation results have demonstrated that the secrecy capacity has a significant improvement and the proposed algorithm is effective and converges fast. Furthermore, comparing with four baselines, the proposal has a significant performance gain on the secrecy capacity of the whole network. In the future, the non-ideal CSIs should be considered to optimize the secrecy capacity. In addition, the advanced inter-tier interference in the physical layer and the dynamical queue characteristics in the upper layer should be jointly considered with the radio resource allocation to optimize the secrecy capacity in the D2D communication underlying HetNets.