Handover for Dense Small Cells Heterogeneous Networks: A Power-Efficient Game Theoretical Approach

Mohanad Alhabo, Li Zhang, Naveed Nawaz

***Abstract*—In this paper, a non-cooperative game method is formulated where all players compete to transmit at higher power. Every base station represents a player in the game. The game is solved by obtaining the Nash equilibrium (NE) where the game converges to optimality. The proposed method, named Power Efficient Handover Game Theoretic (PEHO-GT) approach, aims to control the handover in dense small cell networks. Players optimize their payoff by adjusting the transmission power to improve the performance in terms of throughput, handover, power consumption and load balancing. To select the desired transmission power for a player, the payoff function considers the gain of increasing the transmission power. Then, the cell selection takes place by deploying Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS). A game theoretical method is implemented for heterogeneous networks to validate the improvement obtained. Results reveal that the proposed method gives a throughput improvement while reducing the power consumption and minimizing the frequent handover.**

***Keywords*—**Energy efficiency, game theory, handover, HetNets, small cells.

I. Introduction

THE tremendous increase of the number of devices connected to the cellular network has led to the demand for network coverage and capacity improvement. The small cells (SCs) deployment is a good solution to tackle this demand [1]. In general, the dense SCs deployment is considered as one of the key technologies of the fifth generation (5G) networks. The massive deployment of SCs help in traffic offloading from the macrocell (MC) base stations, however, this technology faces several challenges such as interference and handover causing an increase in power consumption. Different researches focusing on the problems associated with the handover (HO) have been done in the literature.

In [2], [3], [4], we presented different HO techniques to manage the problems associated with HO in heterogeneous networks (HetNets). This involves the reduction of the unnecessary HO, minimizing the HO failure and enhancing the throughput and load balancing. Results show a good performance compared to the existing HO methods in the literature. Authors in [5] proposed a HO technique for the purpose of load balancing HetNets in which the user equipments (UEs) are offloaded from the congested base stations by using the effect of interference. The technique utilizes an altered A3 HO event considering the interference and cell load. Results show an improvement in throughput and load distribution. Authors in [6] proposed two modified weighted TOPSIS techniques for HO management. The first technique considers the entropy weighting, while the other technique utilizes a standard deviation weighting strategy. It has been shown that the two techniques have reduced the frequent handovers and improved the throughput.

In [7], authors proposed a power consumption method that finds a compromise between energy consumption and traffic load. This method enhanced the energy efficiency by utilizing a greedy technique to make the cell switches between idle and active modes. In [8], a technique that allows a cell to adjust its power according to the load is proposed. Authors in [9] presented a HO technique which considers the energy efficiency problem in HetNets. The Analytical Hierarchy Process (AHP) is deployed to acquire the weights of each HO attribute while a Grey Rational Analysis (GRA) is utilized to choose the optimal cell. Results reveal a minimization in the frequent HOs and HO failure. Authors in [10] presented an energy efficiency technique where the cells switch to sleep mode when they are light-loaded cells targeting to reduce the energy consumption. Authors in [11] proposed a technique taking into account the UE association and power control in HetNets where a joint optimization problem is formulated by deploying a log-utility model. Results reveal an enhancement in the energy efficiency. Authors in [12] presented a bargaining game for power coordination in HetNets. Results show that this technique has improved the energy efficiency. In [13], authors proposed a sleeping mechanism for SCs to minimize the power consumption. At MC edge, a SC switches to sleep mode and the resulted coverage gap is compensated by the nearby range expanded SCs. The UEs associated with the sleeping SCs will be switched to the MC. Results reveal an enhancement in the energy efficiency. However, the unplanned sleeping for SCs at the MC edge could result in a HO failure. Moreover, switching the UEs from a sleeping SC to the MC may cause an increase in the signalling overhead, due to the unnecessary HOs, and result in underutilizing the SCs causing an unbalanced load. Additionally, most works in literature neglected to consider the UE's mobility in dense small cell HetNets. Therefore, in this work we propose a game theoretical solution, PEHO-GT, using a dynamic transmission

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power for the cells to improve the power efficiency. A cell selfishly competes to transmit power. The payoff function takes into account the profit from increasing the cell transmission power (the utility function) and the cost caused by power consumption. The game is solved by proving the existence of Nash equilibrium. Then, the cell selection happens by using TOPSIS method. The proposed PEHO-GT method is then evaluated in terms of power consumption, average SC load, unnecessary handover and throughput. The remainder of this paper is organized as follows. Section II gives the system model. Section III provides the proposed game theoretic method, game solution and TOPSIS technique. Section IV illustrates the results. While, Section V gives the conclusion.

II. System Model

Two-tier HetNet model is considered in this paper. A single MC is deployed with dense SCs under the MC coverage area. The set of all cells in the network $S = \{0, 1, 2, \cdots, N_{sc}\}$. Where 0 is the MC, covering a radius of $500m$, and N_{sc} is the total number of SCs, uniformly distributed and covering a radius of $100m$ each. In order to assure the overlapping between SCs, the minimum distance constraint is considered. The minimum distance between MC and SC is set to $75m$ and the SC to SC site distance is set to $40m$ [1]. Users are distributed uniformly and they follow a Gauss mobility model which can be expressed using two parameters: velocity, V_{ue}, and direction, θ_k. These two parameters can be expressed as Gaussian distribution and are updated by [14]

$$V_{ue} = \mathcal{N}(v_m, v_{std}), \tag{1}$$

$$\theta_k = \mathcal{N}(\theta_m, 2\pi - \theta_m \tan(\frac{\sqrt{V_{ue}}}{2})\Delta t), \tag{2}$$

where v_m is the mean velocity of the UE, v_{std} is the standard deviation of the UE velocity, θ_m is the previous direction of the UE, Δt is the period between two updates of the mobility model, and $\mathcal{N}(x, y)$ is a Gaussian distribution with mean x and standard deviation y. The propagation model between the MC and a UE is expressed as

$$PL_m = 128.1 + 37.6 \ \log_{10}(d_m) + \xi^*, \tag{3}$$

where d_m represents the distance between a UE and the MC in kilometres, and ξ^* is a Gaussian distribution random variable with zero mean and 12 dB standard deviation [15].
The propagation model between a SC and a UE is expressed as

$$PL_{sc_i} = 38 + 30 \ \log_{10}(d_{sc_i}) + \xi^*, \tag{4}$$

where d_{sc_i} is the distance between a UE and SC i in metres. The downlink signal to interference plus noise ratio (SINR) received from cell k is

$$SINR_{bs_k} = \frac{P^r_{bs_k \to ue}}{\sum_{bs \in S, bs \neq bs_k} P^r_{bs \to ue} + \sigma^2}, \tag{5}$$

where $P^r_{bs_k \to ue}$ is the downlink received power from cell k, σ^2 is the noise power and the term $\left(\sum_{bs \in S, bs \neq bs_k} P^r_{bs \to ue}\right)$ represents the summation of the downlink power from the interfering cells.

The data rate at UE received from cell k is expressed by Shannon capacity as

$$T^r_{bs_k} = BW \log_2(1 + SINR_{bs_k}). \tag{6}$$

Assuming that all UEs in cell k hold the same quality of service (QoS) requirement in terms of packet arrival size. Therefore, the load on cell k can be expressed as

$$L_{bs,k} = \sum_{\forall\ UEs} \frac{packet\ arrival\ rate \cdot mean\ packet\ size}{T^r_{bs_k}}. \tag{7}$$

III. Power Efficient Handover Game Theoretic (PEHO-GT) Approach

A. Handover Game Formulation

In this paper, the PEHO-GT method is formulated mathematically by deploying game theory. Players in the game compete to transmit at higher power. A strategy taken by one player in the game influences the payoff of other players. The following rules control the game:

- All cells in the game can transmit power at a range of $\left[0,\ P^{t^{max}}_{bs}\ \right]$.
- All cells in the game share a density specific metric D_{bs}.

The game is expressed as $\Gamma = \left\{S, (A_k)_{k \in S}, (\Omega_k)_{k \in S}\right\}$, where S represents the number of players, A_k is the set of actions for player S_k and Ω_k represents its payoff. The game components are illustrated as:

1) Players: are the base stations in the network, $(S_1, \cdots, S_k, \cdots, S_n)$, $\forall k \in S$.
2) Actions (Strategies): a player has set of strategies $A = (A_1, \cdots, A_k, \cdots, A_n)$, $\forall k \in S$, where $A_k = \left[0, P^{t^{max}}_{bs,k}\right]$ is the action set for player S_k, and therefore, $A = \Pi^n_{k=1} A_k$.
3) Payoff function: is the cost for player S_k to transmit power at $P^t_{bs,k}$. In this work, the payoff function is expressed utilizing the gain (utility) and the cost functions as:
   - Utility function U_k: is the gain of player S_k for playing the action a_k. In this work, we deployed an exponential utility function [16] where its second derivative is negative and it has a strict concave property

     $$U_k(a_k) = \lambda\left(1 - e^{-P^t_{bs,k}}\right), \tag{8}$$

     where λ is a predefined weighting factor and $P^t_{bs,k}$ is the transmission power of player S_k. A player intends to increase its transmission power to maximize its utility.
   - Power cost function $E_k(a_k, a_{-k})$: power consumption is considered as an influential problem in ultra-dense SCs networks. Therefore, we introduce the power consumption cost function as follows

     $$P_k(a_k, a_{-k}) = \alpha\ D_{bs}\ P^t_{bs,k}, \tag{9}$$

     where α is a predefined weighting factor for power cost and D_{bs} is the network density metric [17] which is expressed as

     $$D_{bs} = \frac{\mid S \mid \pi R^2_{sc}}{\pi R^2_m}, \tag{10}$$

     where R_{sc} and R_m are respectively the SC and MC radius.

The payoff function for player S_k $\forall k \in S$ is expressed as

$$\Omega_k(a_k, a_{-k}) = \lambda\big(1 - e^{-P^t_{bs,k}}\big) - \alpha\ D_{bs}\ P^t_{bs,k}, \quad (11)$$

where $\lambda > 0$, so that the second derivative of $\Omega_k(a_k, a_{-k})$ will always be negative, i.e., concave function.

The solution of the non-cooperative game $\Gamma = \{S, (A_k)_{k\in S}, (\Omega_k)_{k\in S}\}$ can be obtained by reaching the optimal transmission power for each player, i.e., reaching the Nash equilibrium. This means that all players in the game reach optimal action $o^*_k = P^{t^*}_{bs,k}$ where no player can enhance its payoff function by changing its action where $o^*_k = \big[P^{t^*}_{bs,1}, \cdots, P^{t^*}_{bs,k}, \cdots, P^{t^*}_{bs,n}\big]$.

Theorem 1. *The game $\Gamma = \{S, (A_k)_{k\in S}, (\Omega_k)_{k\in S}\}$ is a concave n-person game which has at least one Nash equilibrium.*

Proof: The action set $A_k = \big[0, \cdots, P^{t^{max}}_{bs,k}\big]$ for player S_k is closed and bounded $\forall k \in S$ which means that A_k is a compact set.

Assume that the two points $x,\ y \in A_k$ and $\zeta = [0, 1]$ where $A = \Pi^n_{k=1} A_k$. The action vector A_k is convex $\forall k \in S$ if for any $x,\ y \in A_k$ and $\zeta = [0, 1]$, $\zeta x + (1 - \zeta)y \in A_k$.

Let the Hessian matrix H of the differentiable payoff function $\Omega_k(a_k, a_{-k}) = \lambda\big(1 - e^{-P^t_{bs,k}}\big) - \alpha\ D_{bs}\ P^t_{bs,k}$ be as follows

$$H = \begin{bmatrix} \frac{\partial^2\Omega}{\partial P^{t^2}_{bs,1}} & \frac{\partial^2\Omega}{\partial P^t_{bs,1} P^t_{bs,2}} & \cdots & \frac{\partial^2\Omega}{\partial P^t_{bs,1} P^t_{bs,n}} \\ \frac{\partial^2\Omega}{\partial P^t_{bs,2} P^t_{bs,1}} & \frac{\partial^2\Omega}{\partial P^{t^2}_{bs,2}} & \cdots & \frac{\partial^2\Omega}{\partial P^t_{bs,2} P^t_{bs,n}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial^2\Omega}{\partial P^t_{bs,n} P^t_{bs,1}} & \frac{\partial^2\Omega}{\partial P^t_{bs,n} P^t_{bs,2}} & \cdots & \frac{\partial^2\Omega}{\partial P^{t^2}_{bs,n}} \end{bmatrix}. \quad (12)$$

Using the second derivative of Ω_k, it is clear that H is negative definite at $P^t_{bs,k}$ utilizing the leading principle minor of H, which means that it reaches a local maximum at $P^t_{bs,k}$ [18] as shown in (13). Therefore, the payoff function Ω_k is strictly concave in A_k, $\forall k \in S$.

$$\Omega''_k = \begin{cases} -\lambda e^{-P^t_{bs,k}} & \text{for main diagonal elements} \\ 0 & \text{otherwise} \end{cases} \quad (13)$$

where $(\Omega''_k < 0)$ to meet the strict concave condition.

Theorem 2. *The non-negative weighted sum $\omega(P^t_{bs,k}, q)$ is diagonally strictly concave if the symmetric matrix $\big[\ G(P^t_{bs,k}, q) + G'(P^t_{bs,k}, q)\big]$ is negative definite $\forall k \in S$, where q is a positive vector $q = [q_1, q_2, \cdots, q_n]$ [19].*

Proof: The non-negative weighted sum $\omega(P^t_{bs,k}, q)$ can be defined as the summation of Ω_k, that is

$$\omega(P^t_{bs,k}, q) = \sum_{k=1}^{n} q_k \Omega_k(P^t_{bs,k}),\ \forall k \in S,\ q_k \geq 0 \quad (14)$$

For each fixed q, a related mapping $g(P^t_{bs,k}, q)$ is defined as the gradients $\nabla_k \Omega_k(P^t_{bs,k})$, that is

$$g(P^t_{bs,k}, q) = \begin{bmatrix} q_1 \nabla_1 \Omega_1(P^t_{bs,1}) \\ q_2 \nabla_2 \Omega_2(P^t_{bs,2}) \\ \vdots \\ q_n \nabla_n \Omega_n(P^t_{bs,n}) \end{bmatrix}, \quad (15)$$

where $g(P^t_{bs,k}, q)$ is the pseudo-gradient of $\omega(P^t_{bs,k}, q)$ and $\nabla_k \Omega_k(P^t_{bs,k}) = \lambda e^{-P^t_{bs,k}} - \alpha\ D_{bs}$, $\forall k \in S$.

When the symmetric matrix $\big[\ G(P^t_{bs,k}, q) + G'(P^t_{bs,k}, q)\big]$ is negative definite, then $\omega(P^t_{bs,k}, q)$ is diagonally strictly concave [19]. Therefore, we can express the Jacobian matrix $G(P^t_{bs,k}, q)$ of $g(P^t_{bs,k}, q)$ with respect to $P^t_{bs,k}$ as follows

$$G(P^t_{bs,k}, q) = \begin{bmatrix} q_1 \frac{\partial^2\Omega}{\partial P^{t^2}_{bs,1}} & q_1 \frac{\partial^2\Omega}{\partial P^t_{bs,1} P^t_{bs,2}} & \cdots & q_1 \frac{\partial^2\Omega}{\partial P^t_{bs,1} P^t_{bs,n}} \\ q_2 \frac{\partial^2\Omega}{\partial P^t_{bs,2} P^t_{bs,1}} & q_2 \frac{\partial^2\Omega}{\partial P^{t^2}_{bs,2}} & \cdots & q_2 \frac{\partial^2\Omega}{\partial P^t_{bs,2} P^t_{bs,n}} \\ \vdots & \vdots & \ddots & \vdots \\ q_n \frac{\partial^2\Omega}{\partial P^t_{bs,n} P^t_{bs,1}} & q_n \frac{\partial^2\Omega}{\partial P^t_{bs,n} P^t_{bs,2}} & \cdots & q_n \frac{\partial^2\Omega}{\partial P^{t^2}_{bs,n}} \end{bmatrix}. \quad (16)$$

Clearly, the symmetric matrix $\big[G(P^t_{bs,k}, q) + G'(P^t_{bs,k}, q)\big]$ is negative definite $\forall P^t_{bs,k} \in S$, therefore, the non-negative weighted sum $\omega(P^t_{bs,k}, q)$ is diagonally strictly concave. This means that the game $\Gamma = \{S, (A_k)_{k\in S}, (\Omega_k)_{k\in S}\}$ has a unique Nash equilibrium (Theorem 2 [19]).

B. Handover Game Solution

The optimal game solution for each player S_k can be obtained by selecting an action that maximizes its payoff function $\Omega_k(P^t_{bs,k})$. The optimal transmission power $P^{t^*}_{bs,k}$ $\forall k \in S$ is in the range $0 \leq P^t_{bs,k} \leq P^{t^{max}}_{bs,k}$. Therefore, the optimization problem can be expressed as

$$\begin{aligned} \underset{P^t_{bs,k} \in A_k}{\text{maximize}} \quad & \Omega_k(P^t_{bs,k}, P^t_{bs,-k}), \\ \text{subject to} \quad & P^t_{bs,k} \geq 0, \\ & P^t_{bs,k} \leq P^{t^{max}}_{bs,k},\ \forall k \in S. \end{aligned} \quad (17)$$

The above nonlinear optimization problem can be solved by defining the Lagrangian function $\mathcal{P}_k$ and the Lagrangian multipliers u_k and v_k for player S_k, $\forall k \in S$ as

$$\mathcal{P}_k = \Omega_k\big(P^t_{bs,k}, P^t_{bs,-k}\big) + u_k P^t_{bs,k} + v_k\big(P^{t^{max}}_{bs,k} - P^t_{bs,k}\big). \quad (18)$$

The Karush-Kuhn-Tucker (KKT) conditions [20] of the maximization problem for player S_k are

$$u_k,\ v_k \geq 0,$$
$$P^t_{bs,k} \geq 0,$$
$$P^{t^{max}}_{bs,k} - P^t_{bs,k} \geq 0,$$
$$\nabla_{P^t_{bs,k}} \Omega_k(P^t_{bs,k}, P^t_{bs,-k}) + u_k \nabla_{P^t_{bs,k}}(P^t_{bs,k}) +$$
$$v_k \nabla_{P^t_{bs,k}}(P^{t^{max}}_{bs,k} - P^t_{bs,k}) = 0,$$
$$u_k(P^t_{bs,k}),\ v_k(P^{t^{max}}_{bs,k} - P^t_{bs,k}) = 0.$$

The above problem is solved as:

- When $P^t_{bs,k} = 0$ and $v_k = 0$

$$\lambda e^0 - \alpha\ D_{bs} + u_k = 0$$

$$u_k = \alpha\ D_{bs} - \lambda$$

The solution $P^t_{bs,k} = 0$ is feasible, if the condition $(u_k > 0)$ holds:

$$\alpha\ D_{bs} \geq \lambda$$

- When $P^t_{bs,k} = P^{t^{max}}_{bs,k}$ and $u_k = 0$

$$\lambda e^{-P^t_{bs,k}} - \alpha\ D_{bs} - v_k = 0$$

$$v_k = \lambda e^{-P^t_{bs,k}} - \alpha\ D_{bs}$$

The solution $P^t_{bs,k} = P^{t^{max}}_{bs,k}$ is feasible, if the condition ($v_k > 0$) holds:

$$\alpha\ D_{bs} \le \lambda e^{-P^t_{bs,k}}$$

- When $u_k = 0$, $v_k = 0$ and $(0 < P^t_{bs,k} < P^{t^{max}}_{bs,k})$

$$\lambda e^{-P^t_{bs,k}} - \alpha\ D_{bs} = 0$$

$$e^{-P^t_{bs,k}} = \frac{\alpha\ D_{bs}}{\lambda}$$

$$P^t_{bs,k} = \ln\left(\frac{\lambda}{\alpha D_{bs}}\right).$$

Thus, the game solution for player S_k, $\forall k \in S$, is the optimum transmission power $P^{t^*}_{bs,k}$ which can be written as

$$P^{t^*}_{bs,k} = \begin{cases} 0 & \text{if condition } A \\ P^{t^{max}}_{bs,k} & \text{if condition } B \\ \ln\left(\frac{\lambda}{\alpha D_{bs}}\right) & \text{otherwise} \end{cases} \quad (19)$$

where conditions A and B are respectively:

$$\alpha D_{bs} \ge \lambda, \quad (20)$$

$$\alpha D_{bs} \le \lambda e^{-P^t_{bs,k}}. \quad (21)$$

The optimum transmission power $P^{t^*}_{bs,k}$ is the Nash equilibrium and the solution of the game.

C. Cell Selection

The transmission power for each base station has been adjusted in the game part. Now, we deploy multiple criteria HO technique, that is TOPSIS [21], to choose the best HO target. The criteria used in TOPSIS are: data rate, UE velocity and cell load. The three criteria are all weighted according to the standard deviation (SD) weighting technique [22]. The SD technique finds the weight of each metric in terms of the standard deviation, metrics with small standard deviation are assigned smaller weights and vice versa. Base stations are ranked based on TOPSIS and the highest ranked one is selected as a HO target. Base stations selection according to TOPSIS procedures is detailed in our previous work [6].

IV. Performance and Results Analysis

The proposed PEHO-GT method is implemented, evaluated and compared against the conventional method, in which there is no ability for the base stations to adjust their transmission power, in terms of power consumption, average SC load, unnecessary HO probability and throughput. Each cell in the network dynamically adjusts its transmission power based on PEHO-GT method. Then, TOPSIS technique is deployed for cell selection. Simulation parameters are shown in Table I.

TABLE I
Simulation Parameters

Parameter	Value
Radius of MC	500 meters
Radius of SC	100 meters
Number of SCs	50
Bandwidth	20 MHz
Transmission power of MC	46 dBm
Transmission power of SC	30 dBm
Velocity of UE	{0, 10, 20, 40, 60, 80, 100} km/h
(*packet arrival rate · mean packet size*)	180 kbps
(λ, α)	(14, 7)

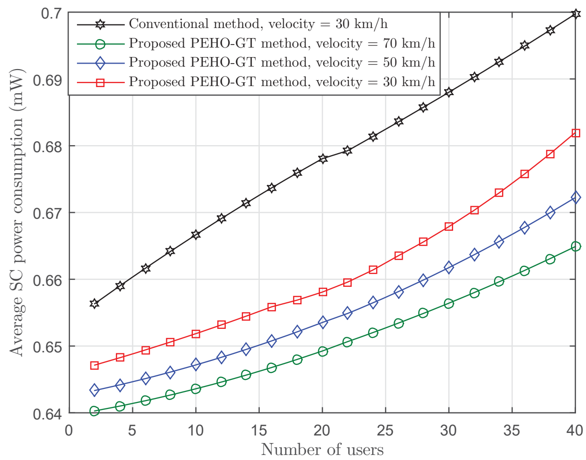

Fig. 1 Average SC power consumption

A. Power Consumption

Fig. 1 shows the average SC power consumption with respects to the number of users. At 30km/h velocity, the PEHO-GT method outperformed the conventional method at all user densities. For instance, when there is 10 users, the PEHO-GT has a 2.25% reduction in the average SC power consumption compared to the conventional method. Obviously, in PEHO-GT method, the higher the velocity the lower power consumption because more SCs will boost their transmission power when slow UEs reach their coverage area. Besides, low power consumption for higher velocities owes to the connection of UEs to MC and the reduction of the transmission power of SCs.

B. Average Load

Fig. 2 depicts the averaged SC load with respect to the number of users for different velocities. It can be noticed that for all velocities the PEHO-GT method has outperformed the conventional one as the latter does not optimize the transmission power prior to HO. Clearly from Fig. 2, the averaged SC load is the lowest for the PEHO-GT method, at 70km/h, because most of the fast moving UEs are associated with the MC due to reducing/deactivating of the SC transmission power. The opposite is happening with low velocity of 30km/h because more UEs will be connected to the SC and the load increases with the increase in the number of UEs.

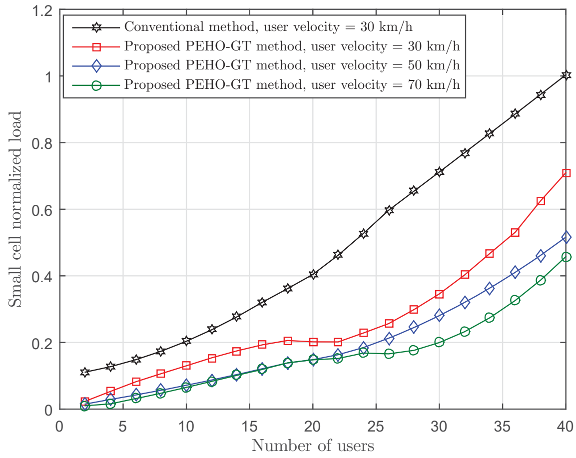

Fig. 2 Small cell average load

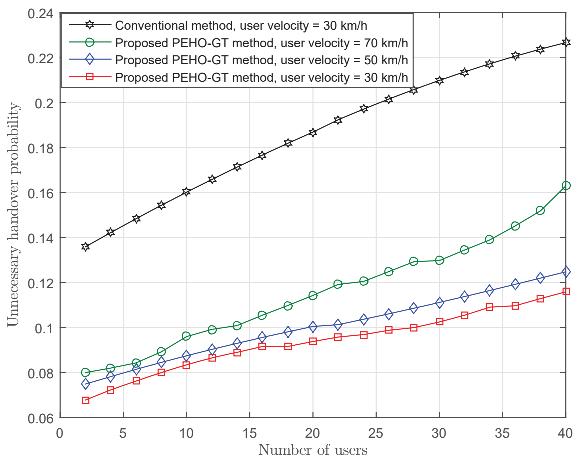

Fig. 3 Unnecessary handover probability

C. Unnecessary Handover

The probability of unnecessary HO with regards to the number of UEs is shown in Fig. 3 for different velocities. The unnecessary HO is defined, when the UE begins a HO to cell k and departs the cell after one second. Clearly, the PEHO-GT method has outperformed the conventional one at all velocities. For example, when there is 10 users and the velocity is 30km/h, the PEHO-GT has about 47.8% reduction in the unnecessary HO probability. Generally, with the PEHO-GT, the lower the velocity the lower the unnecessary HO because fast moving users will cause frequent HOs.

D. Throughput

The averaged SC throughout is shown in Fig. 4 for different number of users. For PEHO-GT, the average SC throughput for fast moving users is the lowest compared to the lower speed users because the former tend to choose the MC while the latter tend to choose the SC. In general, the average SC throughput for all number of users sharply goes down after a 40km/h velocity because the fast users associate with the MC and few number of users connect to the SC.

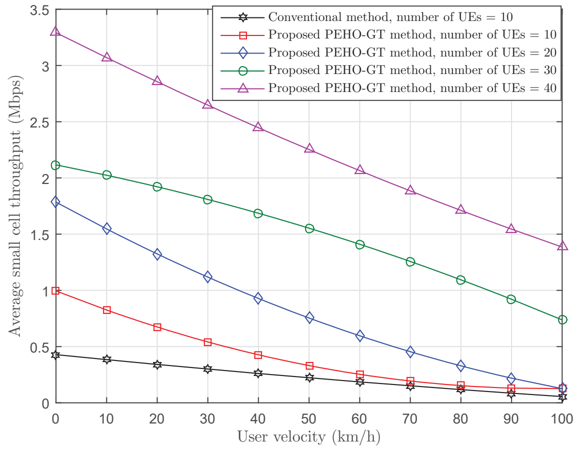

Fig. 4 Average SC throughput vs. UE velocity

V. Conclusion

In this work, we deployed game theory method to optimize the transmission power of the SCs targeting to reach the optimal power for all cells in the network. The payoff function for each player (each cell) is mathematically formulated using utility (gain) and cost functions. The cost function includes the effect of SC density. The proposed PEHO-GT method is solved mathematically by finding the Nash equilibrium. The cell selection is then done by using TOPSIS method to select the proper cell. Additionally, the proposed method is implemented, evaluated and compared with the conventional method where the power optimization policy is not used. Results show that the proposed PEHO-GT method outperformed the conventional in terms of power consumption, SC average load, unnecessary HO and throughput. For instance, with 30km/h velocity and 10 users, the proposed PEHO-GT method has an enhancement of 2.25%, 36.6%, 47.8% and 83% over the conventional method in terms of power consumption, average SC load, unnecessary HO, and average SC throughput respectively.

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