Two Novel Handover Algorithms with Load Balancing for Heterogeneous Network

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***Abstract*—The demand for wireless resources is increasing at high pace. Heterogeneous networks (HetNets), i.e., network composed by base stations (BSs) with different coverage areas, are useful solutions to cope with this increasing demand. In this paper, we propose two handover (HO) algorithms. First HO algorithm is based on user equipment's (UE's) velocity, UE's position, UE's received signal strength (RSS) from BS and traffic load of BS. In the first phase of the first HO algorithm, UE employs parameters such as the distance of UE from its connected BS, velocity of UE and UE's RSS from its connected BS to determine the necessity of HO. If HO is needed, in the second phase, i.e., HO execution phase, UE selects the new BS based on the distance of UE from BS to which UE approaches, RSS and average traffic load of BS which is advertised through beacon signal. UE uses strength of received beacon signal as RSS. UE transmits the connection request signal to selected BS. Average traffic load means time average of traffic load. UE gets information of its position and its velocity via GPS. Second HO algorithm is based on only UE's RSS from BS and traffic load of BS. This HO algorithm has similar structure as the first one. However, in the first phase, only UE's instantaneous RSS and average RSS which means time average of RSS are employed to determine the necessity of HO by UE. In HOEP, UE selects the new BS based on instantaneous RSS, average RSS and average traffic load of BS. UE transmits the connection request signal to selected BS. A game-theoretic sleep mode algorithm is executed parallel to each HO algorithm in BS. The performance of the two proposed algorithms, such as total number of HOs, UE's throughput and system power consumption is evaluated by means of computer simulation.**

***Index Terms*—HetNet, handover, base station sleep mode algorithm, game theory, energy efficiency, mobility**

I. INTRODUCTION

The demand for wireless resources is increasing at high pace. Video streaming and social media are mainly responsible for this increase [1]. Consequently, traffic load and energy consumption in wireless cellular system are increasing accordingly and these urge the necessity of designing more energy and spectral efficient systems.

Heterogeneous networks (HetNets), consisting of macro cell base stations (MBSs) and small cell BSs (SBSs), are proven to be highly effective in increasing the wireless resources [2]–[4]. The total consumption energy in HetNets reduces when combined with sleep mode algorithms which adapt to traffic conditions in the network. In [3], a centralized sleep mode algorithm is proposed. It is shown that this algorithm can improve the energy efficiency in HetNets. However, if centralized approaches are used, the number of control signals increases with an increased information exchange between BSs. On the other hand, connecting all BSs to data processing centers, e.g. cloud radio access network (cloud-RAN), through high capacity backbone links, is an expensive solution and probably not yet suitable for some geographic areas. Sleep mode algorithms which rely on self-distribution control, do not need such information exchange through backhaul communication. In such algorithm, each BS decides independently to turn wake mode or sleep mode depending on its traffic load and consumption power.

In [5], an HO algorithm for HetNet is proposed. The HO method in [5] uses separate signaling mechanisms to identify the BS for connection and to trigger the handover. Our HO algorithm is implemented in parallel with a BS sleep mode algorithm to control the transmission power. UEs decide independently the BSs they want to connect to.

In this paper, we use the similar BS sleep mode algorithm as in [1], in which a non-cooperative, mixed strategy, game is used . Here, *sleep mode* refers to idle condition in which BS consumes power only for detecting user equipments (UEs). In strategic form games [6], each player, i.e., BS, selects its strategy (action) only to maximize its utility, i.e., a function which evaluates each player's outcome. In non-cooperative games, players decide their strategies independently without negotiating with other players. Later, we proposed two HO handover (HO) procedures in combination with the aforementioned sleep mode algorithm .

First HO algorithm is based on UE's velocity, UE's position, UE's received signal strength (RSS) from BSs and traffic load of BSs. The HO algorithm comprises of two different phases, i.e., HO necessity estimation phase (HONEP) and HO execution phase (HOEP). In HONEP, parameters such as the distance of UE with connected BS, velocity of UE and its RSS are employed to determine the necessity of HO. This phase helps reducing the unnecessary HOs and achieves a higher energy efficiency. After HONEP, if HO is needed, in HOEP, UE selects the new BS based on the average distance of UE and BS to which they approach, RSS and average traffic load of BSs which is advertised periodically through beacon signals. UE uses strength of received beacon signal as RSS. UE gets information of position and velocity via GPS.

Second HO algorithm is based on only UE's RSS and traffic load of BSs. Obtaining the information for UE's velocity and UE's position via GPS may be difficult. Therefore, we also propose this HO algorithm, which is only based on RSS and traffic load. This HO algorithm comprises of two phases, i.e., HONEP and HOEP, similar to the first HO algorithm. In HONEP, only UE's instantaneous RSS and average RSS are employed to determine the necessity of HO by UE. In HOEP, UE selects the new BS based on instantaneous RSS, average RSS and average traffic load.

The rest of this paper is organized as follows. In Section II, system model is described along with power consumption, load, and utility function. Section III discusses our proposed algorithm. Section IV provides the simulation results and the evaluation of our algorithms. Sections V concludes the paper.

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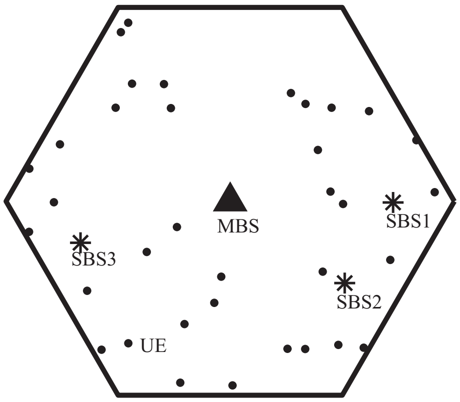

Fig. 1. HetNet topology.

II. SYSTEM MODEL

In this paper, we focus on the downlink transmission in HetNet, consisting of a MBS and several SBSs, $\mathcal{S} = \{1, ..., S\}$, which are distributed uniformly within the macro cell. Fig. 1 shows an example realization of such HetNet scenario. Each BS chooses its strategy (transmission power level) from Table I. Transmission power of sth BS is given according to:

$$P_s(t) = \xi_s(t) \cdot P_{sMAX}^{TX}, \tag{1}$$

where $\xi_s(t)$ is the transmission power level and P_{sMAX}^{TX} is the maximum transmission power of sth BS. In the following, we are going to explain the BS's energy consumption and load model along with the BS's utility which is a function of the two latter.

A. Consumption power

When one BS is in sleep mode, the BS consumes power only for detecting UEs in the macro cell. The consumption power of sth BS at time t is given by [7]:

$$P_s^{All}(t) = \begin{cases} \frac{P_{radio}+P_{base}}{\chi} = P_s^{Idle} \quad (sleep\, mode) \\ \frac{P_s(t)}{\eta\chi(1-\chi_{feed})} + P_s^{Back} + P_s^{Idle} \quad (wake\, mode), \end{cases} \tag{2}$$

with

$$\chi = (1-\chi_{DC})(1-\chi_{main})(1-\chi_{cool}), \tag{3}$$

where P_{radio}, P_{base} and P_s^{Back} are consumption power in radio frequency, baseband unit and backbone network. χ_{DC}, χ_{main}, χ_{cool} and χ_{feed} are losses in DC-DC conversion, main supply, cooling units and the feeder. η is the power amplifier's efficiency.

TABLE I
TRANSMISSION POWER LEVELS.

Identification Number of Strategy i	Transmission Power Level $\xi_s(t)$
1	0
2	1/3
3	2/3
4	1

Algorithm 1 : Sleep mode algorithm at BS [1].

```
**Initialization**: $\mathcal{S} = \{1, ..., S\}$;
**while do**
    $t-1 \rightarrow t$,
    BS's strategy selection: $a_s(t) = f\left(p_{s,i}(t-1)\right)$
    Calculation of average traffic load $\hat{\nu}_s(t)$ and broadcast to all UEs
    Calculation of traffic load $\nu_s(t)$, power consumption $P_s^{All}(t)$ and utility $u_s(t)$
    Update of average utility $\hat{u}_{s,i}(t)$, regret $\hat{r}_{s,i}(t)$ and probability distribution $p_{s,i}(t)$
**end while**
```

B. Traffic load

Signal to Interference plus Noise Ratio (SINR) of UE at point z is given by:

$$\varsigma_s(z,t) = \frac{P_s(t)g_s(z)}{\sum\limits_{\forall s' \in \mathcal{S}/s} P_{s'}(t)g_{s'}(z) + N}, \tag{4}$$

where $g_s(z)$ is UE's channel gain at point z and connected to sth BS. N is the noise variance.

Data rate of UE at point z is given by:

$$D_s(z,t) = w \log_2(1 + \varsigma_s(z,t)), \tag{5}$$

where w is the channel bandwidth.

Traffic load density of UE at point z is given by [8]:

$$\vartheta_s(z,t) = \frac{\kappa_s(z)v_s(z)}{D_s(z,t)}, \tag{6}$$

where $\kappa_s(z)$ is the packet arrival rate and $v_s(z)$ is the average packet size of UE at point s.

Traffic load, which indicates the utilization rate of BS's cell capacity is given by:

$$\nu_s(t) = \sum_{z \in \mathfrak{L}_s} \vartheta_s(z,t), \tag{7}$$

where $\mathfrak{L}_s$ is the set of all UEs connected to sth BS.

C. Utility

The smaller a BS's consumption power, $P_s^{All}(t)$ and traffic load, $\nu_s(t)$ are, the better condition for the BS is. Therefore, utility of sth BS consists of its consumption power, $P_s^{All}(t)$ and traffic load, $\nu_s(t)$ according to:

$$u_s(t) = -(\phi \cdot P_s^{All}(t)/P_{sMAX}^{TX} + \varphi \cdot \nu_s(t)), \tag{8}$$

where ϕ and φ ($\phi > 0, \varphi > 0$) are weighting factors of consumption power and traffic load. These figures define the influence of consumption power and load.

III. PROPOSED ALGORITHMS

We use the similar BS sleep mode algorithm in [1], as shown in Algorithm 1. The proposed algorithm, which is executed at UE is shown in Algorithm 2.

Algorithm 2 : Association algorithm at UE.

```
if UE isn't currently connected to any BS then
    UE chooses a new BS , $s(z,t)$ (HOEP)
else
    Decide whether to HO or not (HONEP)
    if HO is necessary then
        UE selects a new BS, $s(z,t)$ (HOEP)
    else
        UE doesn't change its BS
    end if
end if
```

Algorithm 3 : Strategy selection at BS.

```
Input:    $p_{s,j}(t-1)$ $(j = 1,2,3,4)$
Output:    $i$
Select $r$ $(0 < r < 1)$ randomly
if $p_{s,1}(t-1) > r$ then
    $i = 1$
else
    if $\sum_{j=1}^{2} p_{s,j}(t-1) > r$ then
        $i = 2$
    else
        if $\sum_{j=1}^{3} p_{s,j}(t-1) > r$ then
            $i = 3$
        else
            $i = 4$
        end if
    end if
end if
```

A. BS's strategy selection

Each BS has a set of strategies, $\mathcal{A}_s = \{a_{(s,1)}, ..., a_{(s,A)}\}$ and $a_s(t)$ is the strategy chosen by sth BS at time t. It selects its strategy with their strategies' probability distribution, $p_{s,i}(t-1)$ at time t according to:

$$a_s(t) = f(p_{s,i}(t-1)), \tag{9}$$

where f is the conversion function from probability distribution to strategy and is elaborated in Algorithm 3. As previously described, strategies define transmission power levels of BSs, $\xi_s(t)$. It should be noted that MBS selects its strategy only from $i = 1$ and $i = 4$.

B. Average traffic load

Each BS calculates itsaverage load, i.e., traffic load time average, according to:

$$\hat{\nu}_s(t) = \hat{\nu}_s(t-1) + n(t) \cdot (\nu_s(t-1) - \hat{\nu}_s(t-1)), \tag{10}$$

where $n(t)$ is the learning rate and indicates the impact of instantaneous value of load on average load. $n(t)$ is chosen in a way to make computation of average traffic load adequately slower than the UE association speed. If average traffic load changes rapidly, UEs change their connected BSs frequently. In this case, it may result in destabilizing the algorithm.

C. Computation of probability distribution

For ith strategy of sth BS, average utility, $\hat{u}_{s,i}(t+1)$, regret, $\hat{r}_{s,i}(t+1)$, and probability distribution, $p_{s,i}(t+1)$, are updated according to [1].:

$$\begin{aligned} \hat{u}_{s,i}(t+1) &= \hat{u}_{s,i}(t) + \iota_b(t+1) \cdot \mathbf{1}(t) \cdot (u_s(t) - \hat{u}_{s,i}(t)), \\ \hat{r}_{s,i}(t+1) &= \hat{r}_{s,i}(t) + \tau_s(t+1) \cdot (\hat{u}_{s,i}(t) - u_s(t) - \hat{r}_{s,i}(t)), \\ p_{s,i}(t+1) &= p_{s,i}(t) + \varrho_s(t+1) \cdot (G_{s,i}(\hat{r}_{s,i}(t)) - p_{s,i}(t)), \end{aligned} \tag{11}$$

with

$$\mathbf{1}(t) = \left\{ \begin{array}{ll} 1 & (if \quad a_s(t+1) = a_s(t)) \\ 0 & (if \quad a_s(t+1) \neq a_s(t)), \end{array} \right. \tag{12}$$

and

$$G_{s,i}(\hat{r}_{s,i}(t)) = \frac{\exp(\varepsilon_s \hat{r}_{s,i}(t))}{\sum_{i' \in \mathcal{A}_s} \exp(\varepsilon_s \hat{r}_{s,i'}(t))}, \tag{13}$$

where $G_{s,i}(\hat{r}_{s,i}(t))$ is the Boltzmann distribution and ε_s is the temperature parameter. $\iota_s(t)$, $\tau_s(t)$ and $\varrho_s(t)$ are learning rates which follow a form like $1/t^c$ (c: power parameter) and should meet the following criterion.

$$\begin{array}{ll} \lim_{t\to\infty} \sum_{m=1}^{t} \iota_s(m) = +\infty, & \lim_{t\to\infty} \sum_{m=1}^{t} \tau_s(m) = +\infty, \\ \lim_{t\to\infty} \sum_{m=1}^{t} \varrho_s(m) = +\infty, & \lim_{t\to\infty} \sum_{m=1}^{t} \iota_s^2(m) < +\infty, \\ \lim_{t\to\infty} \sum_{m=1}^{t} \tau_s^2(m) < +\infty, & \lim_{t\to\infty} \sum_{m=1}^{t} \varrho_s^2(m) < +\infty, \\ \lim_{t\to\infty} \frac{\tau_s(t)}{\iota_s(t)} = 0, & \lim_{t\to\infty} \frac{\varrho_s(t)}{\tau_s(t)} = 0. \end{array} \tag{14}$$

D. HO Algorithms at UE

Each UE receives the average traffic load, $\hat{\nu}_s(t)$, through beacon signals and RSS, $P_s^{RX}(t)$, from all BSs in the macro cell. UE uses strength of received beacon signal as RSS. The two proposed HO algorithms use this information for the HO decision process. In each algorithm, UE decides necessity of HO at first. Nextly, UE implements HO if HO is needed.

1) First proposed HO algorithm which uses the UE's position and velocity data:

Fig. 2 shows the geo-relational model of UE and its connected BS. In this figure, $v(t)(\geq 0)$ is the velocity of UE and $v_b(t)$ $(-\infty < v_b(t) < +\infty)$ is its velocity component in the direction of the connected BS. $d(t)$ is the UE's distance to its connected BS. UE gets data of its position and velocity via GPS and gets data of BSs' positions through beacon signals. In this algorithm, each UE decides about HO based on distance from its connected BS, velocity of UE and its RSS. Algorithm 4 shows the HONEP phase at UE. In HONEP phase, UE always searches for a new BS if UE is connected to MBS. This is because we want to prevent UE to keep connecting to MBS for long time. If UE is connected to SBS, UE implements HONEP as follows. If $d(t) > r_{SBS}$ (r_{SBS}: small cell radius) condition is met, UE searches for a new BS. The reason for this is that we want to prevent UE to keep connecting to BSs far from UE. If UE is connected to SBS and $d(t) \leq r_{SBS}$ condition is met, UE implements HONEP as follows. If $v_b(t) < 0$, $d(t) \leq d^{TH}$ (d^{TH}: distance threshold) and $P_s^{RX}(t) \leq P_1^{TH}$ (P_1^{TH}: RSS threshold 1) conditions are met, UE searches for a new BS.

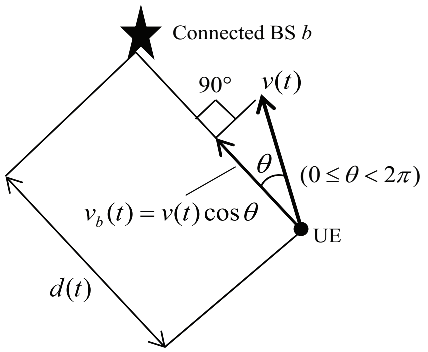

Fig. 2. Geo-relational model of UE and its connected BS

Algorithm 4 : First proposed algorithm; HONEP with using data of UE's position and velocity, at UE.

```
if UE is connected to MBS then
    Always search for a new BS using (15)
else
    (UE is connected to SBS)
    if $d(t) > r_{SBS}$ ($r_{SBS}$: small cell radius) then
        search for a new BS using (15)
    else
        if $v_b(t) < 0$, $d(t) \le d^{TH}$ ($d^{TH}$: distance threshold)
        and $P_s^{RX}(t) \le P_1^{TH}$ ($P_1^{TH}$: RSS threshold 1) then
            search for a new BS using (15)
        else
            Do not change current connected BS
        end if
    end if
end if
```

For new UE or whenever HO is needed, each UE at point z selects the BS, $s(z,t)$, based on the following criterion:

$$s(z,t) = \arg\max_{s\in\mathcal{S}}\{(\hat{\nu}_s(t)+\varsigma_s)^{-\varpi}\cdot P_s^{RX}(t)\cdot(d_s(t))^{-\lambda}\}, \tag{15}$$

where ς_s is offset of sth BS. ϖ ($\varpi > 0$) and λ ($\lambda > 0$) are coefficients which define the influence of average traffic load, $\hat{\nu}_s(t)$, and the distance between UE and sth BS, $d_s(t)$. UE transmits the connection request signal to selected BS.

2) Second proposed HO algorithm which does not use the UE's position and velocity data:

Obtaining the information for UE's velocity and UE's position via GPS may be difficult. Therefore, we also propose second HO algorithm, which is only based on RSS and traffic load. In this algorithm, at first, UE computes each BS's average RSS , which indicates time average of RSS from each BS, according to:

$$\hat{P}_s^{RX}(t) = \hat{P}_s^{RX}(t-1)\cdot(P_s^{RX}(t)/\hat{P}_s^{RX}(t-1))^{\gamma}, \tag{16}$$

where γ is learning rate and indicates the impact of instantaneous RSS, $P_s^{RX}(t)$. UE implements HONEP as shown in algorithm 5. In HONEP phase, UE always searches for a new BS if UE is connected to MBS. This is because we want to prevent UE from keep connecting to MBS for long time. If UE is connected to SBS, UE implements HONEP as following. If $\hat{P}_s^{RX}(t) < P_1^{TH}$ condition is met, UE searches for a new BS. The reason for this is that we want to prevent UE from keep connecting to BS far from UE. If UE is connected to SBS and $\hat{P}_s^{RX}(t) \ge P_1^{TH}$ condition is met, UE implements HONEP as follows; If $\hat{P}_s^{RX}(t) < P_2^{TH}$, $\hat{P}_s^{RX}(t) < \hat{P}_s^{RX}(t-1)$ and $P_s^{RX}(t) < P_2^{TH}(P_2^{TH}$ $(P_2^{TH} > P_1^{TH})$: RSS threshold 2)) conditions are met, UE searches for a new BS. UE being not connected to any BS or UE needing HO at point z, selects BS $s(z,t)$ to connect to based on the following criteria:

$$s(z,t) = \arg\max_{s\in\mathcal{S}}(\hat{\nu}_s(t)+\varsigma_s)^{-\varpi}\cdot\hat{P}_s^{RX}(t)\cdot\acute{P}_s(t), \tag{17}$$

with

$$\acute{P}_s(t) = \begin{cases} P_a & if\ s\text{th}\ BS\ is\ SBS\ and\ \hat{P}_s^{RX}(t) > \hat{P}_s^{RX}(t-1) \\ 1 & Otherwise, \end{cases} \tag{18}$$

where $P_a > 1$, ς_s is an offset and P_a is the inflation constant. UE transmits the connection request signal to selected BS.

Algorithm 5 : Second proposed algorithm; HONEP without using data of UE's position and velocity, at UE.

```
if UE is connected to MBS then
    Search for a new BS
else
    (UE is connected to SBS)
    if $\hat{P}_s^{RX}(t) < P_1^{TH}$ then
        Search for a new BS using (17)
    else
        if $\hat{P}_s^{RX}(t) < P_2^{TH}$, $\hat{P}_s^{RX}(t) < \hat{P}_s^{RX}(t-1)$ and
        $P_s^{RX}(t) < P_2^{TH}$
        ($P_2^{TH}$ ($P_2^{TH} > P_1^{TH}$): RSS threshold 2)) then
            Search for a new BS using (17)
        else
            Do not change current connected BS
        end if
    end if
end if
```

IV. COMPUTER SIMULATION

We used MATLAB software for this computer simulation. In this computer simulation, all UEs move around the macro cell during the whole simulation time. Simulation parameters are summarized in Table 2. UEs' velocities have a Gaussian distribution. Total simulation time is 10000s. Time interval of sleep mode algorithm and HO algorithm are 1 s. This indicates that the algorithm runs totally 10000 times. Time interval for calculating average RSS is 0.1 s. In the simulation results, proposed HO algorithm 1 indicates the HO algorithm based on UE's velocity, UE's position, UE's RSSs from BSs and traffic load of BSs. Proposed HO algorithm 2 indicates HO algorithm based on only UE's RSSs from BSs and traffic load of BSs. Fig. 3 shows the total number of HOs per 1 s *vs* different number of UEs. Total number of HOs in proposed HO algorithm 2 is bigger than the one in our proposed HO algorithm 1. This is mainly due to occurring of Ping-Pong effect in algorithms which rely more on RSS. Please note that Ping-Pong indirectly contributes to higher energy loss.

Fig. 4 shows the total consumption power in HetNet *vs* different number of UEs. We compare the results with the case that all BSs are in wake mode and communicate in maximum transmission power. The total consumption power both in proposed HO algorithm 1 and 2 is smaller than the case where all BSs are in wake mode. Therefore, we deduct that sleep mode algorithms works well in both cases of using proposed HO algorithm 1 and 2. For instance, assuming 40 UEs, total consumption power in proposed HO algorithm 2 is smaller than proposed HO algorithm 1. This is due to the effect of RSS in proposed HO algorithm 2 which is bigger than

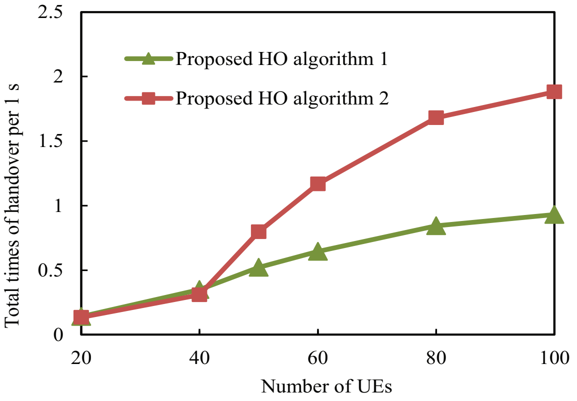

Fig. 3. Total number of HOs per 1 s *vs* different number of UEs at an average velocity of 4 km/h.

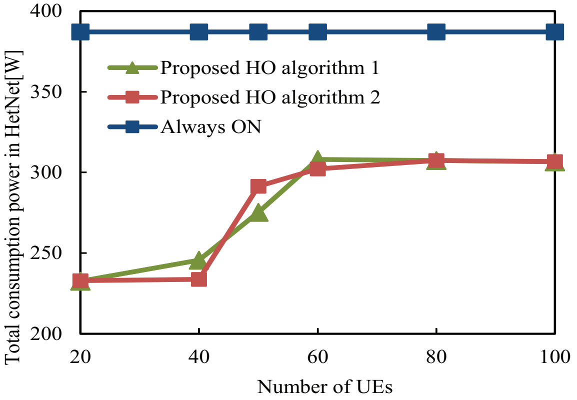

Fig. 4. The total consumption power in HetNet *vs* different number of UEs at an average velocity of 4 km/h.

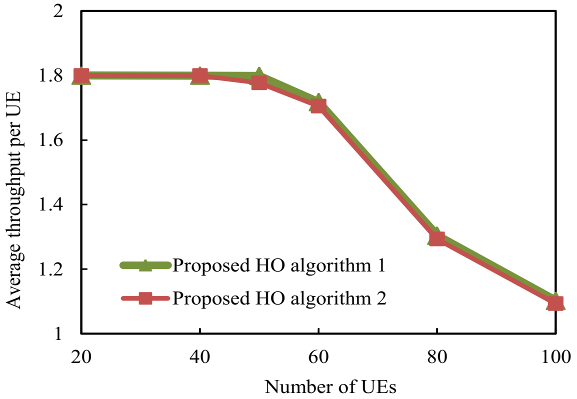

Fig. 5. The average throughput per UE *vs* different number of UEs at an average velocity of 4 km/h.

that the proposed HO algorithm 1. As a result, UEs select BSs with higher RSS more frequently. However, in the presence of 50 SBSs, total consumption power in proposed HO algorithm 2 is higher than proposed HO algorithm 1. This is because the effect of RSS in proposed HO algorithm 2 is smaller.

Fig. 5 shows the average throughput per UE *vs* different number of UEs. We observe that average throughput per UE in proposed HO algorithm 1 and 2 are almost the same, which implies that both HO algorithms do not depend on throughput.

The overall consumption power and throughput in both proposed HO algorithms are almost identical. However, the proposed HO algorithm 1 has slightly better performance than proposed algorithm 2 in terms of number of HOs. Therefore, when the position and velocity of UE are available via GPS, proposed HO algorithm 1 yields better performance.

TABLE II
SIMULATION PARAMETERS.

Parameter	**Value**
Network	
Noise Variance N	-168 dBm/Hz
Arrival Rate $\kappa_s(z)$	180 kbps
MBS	
Maximum Transmission Power P_{sMAX}^{TX}	46 dBm
Minimum MBS-SBS Distance	75 m
Cell radius r_{MBS}	250 m
SBS	
Number of SBSs	7
Maximum Transmission Power P_{sMAX}^{TX}	30 dBm
Minimum SBS-SBS Distance	40 m
Cell radius r_{SBS}	40 m
Path loss (d: distance of BS and UE (m)) (unit: dB)	
MBS - UE	15.3+37.6$\log_{10}$(d) [1]
SBS - UE	30.6+36.7$\log_{10}$(d) [1]
Algorithm Parameters	
Weighting Coefficients for Power Consumption and Traffic Load, ϕ, φ	10, 5
Learning Rate of Average Load $n(t)$	$1/t^{0.9}$
Learning Rate Exponents c for ι_s, τ_s, ϱ_s	0.6,0.7,0.8
Boltzmann Temperature ε_s	10
Power Threshold P_1^{TH}, P_2^{TH}	-60 dBm, -50 dBm
Distance Threshold d^{TH}	20m
Learning Rate of Average Power γ	0.93
Weighting Exponent of Traffic Load for BS Selection ϖ	1
Offset ς_s	0.5
Inflating Value P_a	7 dB

V. CONCLUSION

In this paper, two different types of handover (HO) algorithms were proposed. First HO algorithm is based on user equipment's (UE's) velocity, UE's position, UE's received signal strength (RSS) from BSs and traffic load of BSs. Second HO algorithm is based on only UE's RSS from BSs and traffic load of BSs. Each HO algorithm has two stages. In the first stage, each UE estimates the necessity of HO. If HO is needed, in the second stage, UE selects the BS to be connected to. Simulation result indicates that first HO algorithm outperforms second HO algorithm from number of HOs point of view. However the overall consumption power and throughput in both proposed HO algorithms are almost identical. As a result, the first HO algorithm performs better if UE can access its position and velocity information via GPS.

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