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Resource Allocation for Heterogeneous Wireless Access

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Abstract: ***Preparation of high-speed railways around the world in recent years, high-speed trains are enjoying more and more necessary role in people's travelling. Meanwhile, folks are additional needing to get wireless access services than ever before, even after they are move by high-speed trains. These along drive and raise in demand for high-speed railway broadband wireless communications and necessitate the event of a communication system for high-mobility users. A two-hop below that, under which, passengers communicate with base stations (BSs) via a mobile relay (MR) is used.The resource allocation downside in the downlink OFDMA system as a capability improvement downside for the MR subject to the total capability constraint of native users. In previous work constant power and subcarrier allocation (CPSA) polices were used. Here, the mix of the passengers and native users in order to avoid the frequency variation, OPSA system will apply for this method. Frequency would even have a significant impact on the choice of cell size. Finally, to keep up the frequency RRH are deployed in numerous areas. Thus, the stronger resource allocation within the downlink of same OFDMA system is provided.***
Keywords: Resource allocation, OFDMA, mobile relay, intercarrier interference, Christian Johann Doppler unfold.

I. INTRODUCTION

WITH the deployment of high-speed railways around the world in recent years, high-speed trains are playing an increasingly important role in people's travelling. Meanwhile, people are more eager to get wireless access services than ever before, even when they are travelling by high-speed trains. These together drive an increase in demand for high-speed railway broadband wireless communications and necessitate the development of a communication system for high-mobility users. However, current cellular systems, like 3G, LTE, or LTE-Advanced, are only powerful in providing high-data-rate wireless access services for low-mobility. When users move with a high velocity (>120 km/h), the achievable data rates of those systems drop significantly. Recently developed systems for high-speed railways can support wireless services. For instance, Thalys in Europe can provide maximum data rates 4 Mbps for the downlink and 2 Mbps for the uplink using Wi-Fi and satellite [1].

Shinkasen N700 in Japan can support data rate 2 Mbps for both downlink and uplink via leakage cable [2]. A radio-over-fiber distributed antenna system for WiMax bullet trains was developed and tested by Industrial Technology Research Institute to support data rates 3 Mbps and 2 Mbps for downlink and uplink, respectively [3]. However, the achievable rates of those systems are relatively low (2~4 Mbps) compared to the estimated demand (37.5 Mbps) in the future [2]. Besides, these systems are dedicated and costly, and might not be suitable for widespread deployment. A more promising and economic approach is to extend the current cellular system to support high-speed railway broadband wireless communications.

There are several tough problems for the application of OFDMA cellular systems in high-speed railway scenarios. First, radio signals have a significant penetration loss when passing through the alloy carriages of high-speed trains. According to [2], the penetration loss can be larger than 20 dB. Second, there will be frequent handoffs due to the high speed of trains, and a significant number of handover failures could occur with many passengers hand off simultaneously. Third, the high velocity of trains could also bring serious Doppler spread effect. For instance, the Doppler spread is 833 Hz with a carrier frequency of 3 GHz and a velocity of 300 km/h[4]. This would break the orthogonality of subcarriers of OFDM and introduce inter-carrier interference (ICI). Fourth, the environments that the train passes are various, including scenarios like viaducts, plains, urban areas, hilly areas, etc. Channel statistics in those different environments are usually different, and thus require adaptive resource allocation policies in order to optimize the transmission. Fifth, channel fading statistics of high-speed trains and local users are quite different. Therefore, resource allocation schemes should be redesigned to meet both the requirement of passengers in high-speed trains and that of local users.

There are several works dedicated to determination these issues. An example, to take care of the penetration loss drawback, a two-hop design during which an access point (AP) put in within the train cabin is a mobile relay (MR) was projected in [1], [2]. During this two-hop design, passengers communicate with BSs via the MR. By putting antennas of the MR outside the train cabin; the high-penetration loss is avoided. Moreover, the design may cut back the speed of relinquishing failures since it's solely necessary to take care of relinquishing the MR instead of that of many passengers. Besides, there are projected schemes aimed toward reducing the relinquishing failure supported this design, like those in [5], [6].For the third drawback, many ICI cancellation ways for OFDM in high-mobility situation are projected, e.g., [7]–[9]. As for the fourth drawback, some comes were allotted to live the high- speed railway channels in several environments. e.g.[10]–[12].

To the most effective of our information, there aren't any previous works that studied resource allocation considering each high-speed train users and native users. We discover that though works addressing with resource allocation in OFDMA systems are made,(see [13], [14] for the surveys), they systematically assume that users within the system are quasi-static(or in low- mobility).Completely different from these works, we have a tendency to contemplate this drawback within the state of affairs during which high-speed train and plenty of native low-mobility users (native users for brief during this paper) exist. For the train, we have a tendency to use the two-hop design as in [1], [2] to attack the cluster relinquishing and high-penetration loss drawback. With this design, we will read all passengers within the train joined massive user portrayed by the MR.

This scenario distinguishes itself from traditional ones in the following aspects: first, the train usually transports several hundreds of people. To provide wireless services for those people, the large user represented by the MR requires a much larger amount of resources than individual local user. Second, the instantaneous CSI of the MR is not available to the BS due to rapid time variations while that of local users can be more accurately tracked. Therefore, resource allocations for them are based on different CSI. Third, the MR is subject to time-varying ICI due to its high-mobility as well as geographic movement, while the ICI of local users can be ignored. Considering the differences between the MR and local users, we allocate system resources over two timescales. We aim at maximizing the capacity of the MR while satisfying the sum capacity requirement of local users.

Our main contributions are as follows:

1). We tend to purpose the joint power and subcarrier allocation drawback for an OFDMA downlink system within the situation with a passing high-speed train and plenty of native users. This situation is totally different from ancient ones since channel statistics of the train and native users are different, and so ought to be treated otherwise.

2). By assumptive excellent ICI cancellation, we tend to the drawback of increasing the capability of the MR given the add capacity constraint of native users as an optimization problem. We tend to prove the existence and individualism of optimum solutions. Besides, we also propose an efficient algorithm to find the optimal solution. The capacity obtained by the optimal solution is the upper bound of the transmission rate of the MR.

3). By treating the ICI as Gaussian noise, we reformulate the MR capacity maximizing problem. We derive a closed form expression for the ICI term at the MR using the two-path Doppler spread model. Based on the expression, we then prove the existence and uniqueness of optimal solutions in this case as well. The optimal solution is obtained using the same algorithm as in contribution.

4). By comparing the upper and lower bounds for the achievable transmission rate of the MR, we find that ICI cancellation is not always necessary for the MR considering its complexity. We suggest that practical ICI cancellation be applied only when the gap between the upper and lower bounds is large, since only in this situation can ICI cancellation provides valuable rate gain.

5). We discuss implementation issues of the proposed power and subcarrier allocation policies. By dividing the coverage area of a BS, we show that we can actually utilize constant power and subcarrier allocation (CPSA) polices instead of the OPSA policy based on the region the train passes. Besides, we provide a way to calculate the approximate statistical average capacity as the train travels through numerous cells, which can be used to select appropriate cell sizes.

II. LITERATURE REVIEW

Dense little cell networks were investigated in several works with various things. For examples, in [11], authors developed a model of a man-made system that mechanically turns on/off relying on traffic demands. Assuming stochastic traffic arrivals, an optimization-based scheme for the Energy Efficient resource management in Pico-transceiver Hetnets was planned in [12].

The work of [13] studied the matter of determinative the number of deployed antennas; transmit power levels and optimum BS density for EE maximization in dense tiny cell networks with vast MIMO technique. An EE improvement framework that minimizes small cells' energy under the guarantee of minimum average user rate or fast user rate was thought-about in [14]. [15] Investigated WSEE and NEE maximization problems in multicarrier wireless networks. However, the approach in [15] can't be applied to OFDMA systems since it doesn't take into consideration the OFDMA principle that particular resources block (RB) will solely be allocated to one user.

There exist several works considering joint subcarrier and power allocation in OFDMA systems. In, an energy optimization rule was

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planned for dense OFDM networks, considering the load factor of OFDM systems. For EE resource allocation in OFDMA systems, an algorithm of power diminution was planned. In, a resource allocation algorithmic rule for EE optimization was studied in typical OFDMA systems. An EE optimization scheme for both RB and power allocation was investigated for MIMO-OFDMA systems in [19]. [20] Studied resource allocation for EE in MIMO OFDMA wireless networks. However, DT and DS constraints weren't considered. Reference studied the WSEE maximization problem under the DS constraint only. In, EE resource allocation was considered with both DS and DT services. Generally, these works considered conventional OFDM systems where there is one BS, i.e. the intercell interference doesn't exist. Thus the approaches in these works are not straightforwardly applicable to OFDM Hetnets, particularly for dense readying, wherever co-tier and cross-tier interference have to be compelled to to be fastidiously controlled.

Resource allocation for OFDM Hetnets was studied in [8], .specially, [8], planned spectral efficiency (SE) frameworks that maximize throughput under constraints of users' power. Recently, a joint allocation of RB and power for EE maximization was proposed in which only includes DS constraints. Therein, the intercell interference is assumed to be zero. The assumption is quite strong in practical implementation. Power minimization only with DS constraints was thought-about in An interference aware EE scheme was developed for both tiers in OFDMA femtocell Hetnets in which didn't include DT constraints. Reference proposed a power minimization transmission method for the two-tier LTE macro-femtocell network. To the best of our knowledge, resource allocation for EE maximization in OFDMA-based femtocell Hetnets under DS and DT constraints has not been addressed previously.

III. PROPOSED APPROACH

In this section, we tend to the system model, which has the network model, the channel model and also the transmission model.

A. Network Model

The network consists of multiple cells, and every cell includes a single BS, as shown in Fig. 1. We focus on the cell of BS1; we discuss resource allocation in one cell, and ignore interference caused by neighboring cells. Where there are'M'native users (moving speed less than 10 km/h And denoted by user m = 1, 2... M) And a passing high-speed train (moving speed larger than 120 km/h and denoted by user 0). The radius of the coverage space of BS1 is R m. The bandwidth of the system is B Hz, which is divided into N subcarriers, and denoted as = {0, 1... N−1}. The total available power for these subcarriers is P W. We discuss resource allocation in one cell, and ignore interference caused by neighboring cells. Besides, since the boundary areas between two cells are usually small, for convenience of analysis, we consider that one BS serves a circular space.

As in Fig. 1, the railway is located at a vertical distance dv from BS1. The train travels with a constant velocity v when passing through the cell of BS1.

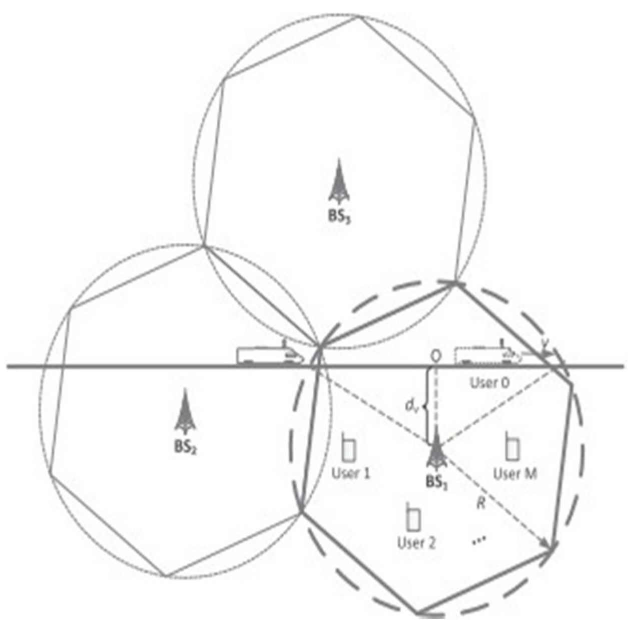

Fig. 1. Network model. [2]

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B. Resource Allocation for Native Users

It was verified in [19] that the optimal power and subcarrier allocation policy to maximize the sum capacity of an OFDMA system is initial to pick out for every subcarrier the user with the most effective CSI and then allocate the power using water filling among the subcarriers. However, this approach may be quite unfair when users are located at different positions. By continuously choosing the user with the most effective CSI for every subcarrier, the BS would starve farther users since their channels may be continuously worse than nearer users. Thus so as to keep up a definite degree of fairness and at constant time to utilize variations of CSI, we tent to propose scheme by that once sleuthing the CSI of every native user, the BS multiplies the CSI by the corresponding path loss of that user to mitigate the result of large-scale attenuation. The trail loss will be calculable by sleuthing the CSI of many past slots and making an average. Then the BS allocates power and subcarriers based mostly alone on tiny scale fading of native users. It may be conceived that in a very longer fundamental quantity (e.g., a programming period), all users would have a good share of system resources since they need constant same small-scale attenuation statistics. Besides, it absolutely noted in [19] that once the amount of users within the system is massive, easy equal power allocation among subcarriers will acquire performance with marginal distinction with water-filling. Since an outsized variety of users within the system is assumed, we have a tendency to adopt the simple equal power allocation to cut back process quality.

Then the ability and subcarrier allocation policy for native users is initial to settle on the user with the simplest small-scale weakening CSI for every subcarrier p, i.e., allocating subcarrier p to the user arg maxm |Hm (p, p)(l)| (choose the user randomly when more than one user has the same largest CSI), and then to allocate the power equally among the subcarriers.

Since in several slots, statistics of CSI of native users are the same, we have to tendency to omit the slot index in Hm (p, p) (l). Let |Hmax (p)| denote the random variable |Hmax (p)| = maxm |Hm (p, p)|. Moreover, channel statistics of every subcarrier is that the same in our model. Thus, once the amount of slots L is giant during a programming amount, the sum capacity of native users with all system resources may be approximated by the applied mathematics average

$$
\begin{aligned}
C_{\mathrm{sum}} &= \sum_{m=1}^{M} \frac{1}{L} \sum_{l=1}^{L} \sum_{p\in\Omega} \frac{B b_{m,p}(l)}{N} \log\left(1+\frac{|H_m(p,p)(l)|^2 \frac{P}{N}}{d_m^{\alpha} N_0 \frac{B}{N}}\right) \\
&= \sum_{m=1}^{M} \frac{N}{M}\frac{B}{N} \mathbb{E}\left(\log\left(1+\frac{|H_{\max}(p)|^2 P/N}{d_m^{\alpha} N_0 B/N}\right)\right)
\end{aligned}
$$

Similarly, the left aspect of constraint (11a) becomes

$$
\sum_{m=1}^{M} \frac{|\Omega_U(i)|}{M} \frac{B}{N} \mathbb{E}\left(\log\left(1+\frac{|H_{\max}(p)|^2 P_U(i)/|\Omega_U(i)|}{d_m^{\alpha} N_0 B/N}\right)\right).
$$

Where |U (i)| is that the variety of subcarriers in U (i).

C. Resource Allocation for the MR

Since the BS can't obtain the CSI of the MR, it will solely apportion the ability power equally among the subcarriers for the MR. The fading statistics of every subcarrier in different slots at the MR are the same, thus we are able to omit the slot index within the channel gain H0(p,p)(l) still. Moreover, the fading statistics of various subcarriers are also the identical. Then, in every programming period, time average of can be expressed as

$$
C_0(i) = \frac{B|\Omega_0(i)|}{N} \mathbb{E}\left(\log\left(1+\frac{\frac{|H_0(p,p)|^2 P_0(i)}{(d_v^2+(vi\tau_{sp})^2)^{\frac{\alpha}{2}}|\Omega_0(i)|}}{P_{\mathrm{ICI}}(i)+N_0 B/N}\right)\right)
$$

The ICI term then becomes

$$
P_{\mathrm{ICI}_0}(i) = \sum_{n\in\Omega_0(i), n\neq p} \frac{|H_0(n,p)|^2 P_0(i)}{\left(d_v^2+\left(vi\tau_{sp}\right)^2\right)^{\frac{\alpha}{2}} |\Omega_0(i)|}
$$

Denote the ICI of subcarriers allocated to the MR,

$$
P_{\mathrm{ICI}_U}(i) = \sum_{n\in\Omega_U(i)} \frac{|H_0(n,p)|^2 P_U(i)}{(d_v^2+(vi\tau_{sp})^2)^{\frac{\alpha}{2}} |\Omega_U(i)|}
$$

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IV. SIMULATION AND NUMERICALRESULTS

In this section, various simulations are conducted to substantiate our theoretical analysis.

A. Resource Allocation for the Case without ICI

1) *Power and Subcarrier Allocations:* We tend to plot the OPSA policy without ICI in Fig. 2.where users are divided into five groups equally, and every cluster is found at a similar distance from the BS. During this figure, two sum capacity requirements of native users $\rho = 0.7$ and $\rho = 0.5$ are presented. One will observe that because the MR comes nearer to the BS from the cell edge, the ability allotted to the MR decreases whereas its allocated range of subcarriers will increase. This agrees with the discussions in Section II. Once the MR is moving toward the BS, it's received SNR increases and the MR moves bit by bit from power-limited region into bandwidth-limited region. Therefore, less transmit power whereas a lot of subcarriers are needed to optimize its capacity. This method reverses once the MR travels far from the BS. It indicates that there's a tradeoff between power allocation and subcarrier assignment for the MR given the sum capacity constraint of native users. Moreover, one can see that when the add capacity constraint of local users decreases, both the power and subcarriers allocated to the MR increase. Besides, it must to be noted that during this process, the allocated power and subcarriers for native users always make their add capacity requirements satisfied, which is approximately 17.64 Mbps for $\rho = 0.7$ and 12.60 Mbps for $\rho = 0.5$.

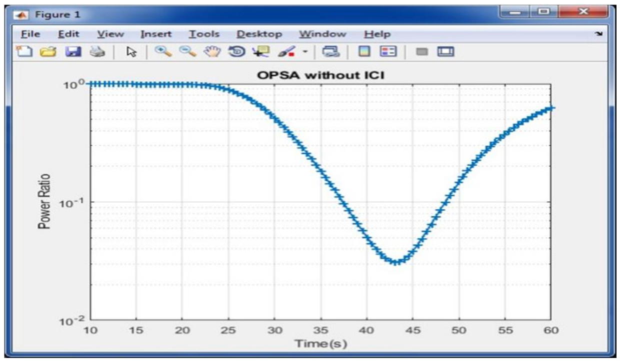

Fig. 2 OPSA without ICI

2) *Capacity of Different Power and Subcarrier Allocation Policies:* The capacity versus time curve of the MR obtained using Alg. 1 is shown in Fig. 4. For comparison, we also plot three constant power and subcarrier allocation policies (denoted as CPSA in this figure). CPSA-PL, CPSA-BL, CPSA-I denote the corresponding constant power and subcarrier allocation policies with $\{\eta(i), \beta(i)\}$ chosen at the time when the train is farthest from the BS, nearest to the BS and somewhere which lies between, respectively. One can observe that CSPA-PL is about optimum only when the MR is in the power limited region as it achieves a capacity which agrees with that obtained by OPSA, however, when the MR leaves that region; it performs much worse than OPSA. CSPA-BL obtains a close to optimum performance within the bandwidth-limited region, however performs unhealthy within the power- limited region. CSPA-I achieves near optimal performance in the intermediate region. In the other two regions, CSPA-I has a performance which lies between CPSA-PL and CPSA-BL. Nevertheless, this figure explicitly shows the advantage of OPSA over CPSA and the benefit of allocating resources by considering the efficiency of power and bandwidth.

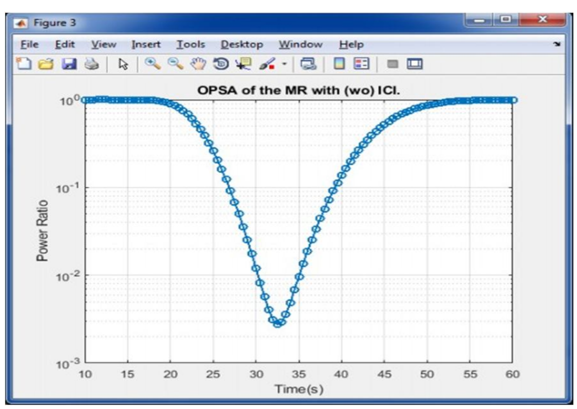

Fig. 3 OPSA of the MR without ICI

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3) *Effect of Number and Position of Local Users:* Number and position of local users have an impact on the capacity of the MR. To illustrate the effect of user positions, we use the extreme example that all users are located at the same distance from the BS. Besides, ρ = 0.7 for all these curves. Fig. 6 is OPSA with different numbers and positions of local users. Fig. 6 is the corresponding capacity of the MR. As can be seen from Fig. 5, when the position is fixed, for instance, dm = 1 km, the power allocated to the MR when the number of local users is 500 is significantly larger than that when the number is 50, and the number of subcarriers is slightly smaller. This can be explained from the perspective of power and bandwidth efficiency of local users. When the number of users becomes larger, the channel gain for each subcarrier |Hmax(p)| becomes larger, therefore, the efficiency of power decreases while that of bandwidth increases. Consequently, more subcarriers while less power should be allocated to them. Thus the allocated power to the MR becomes larger while the subcarriers become less.

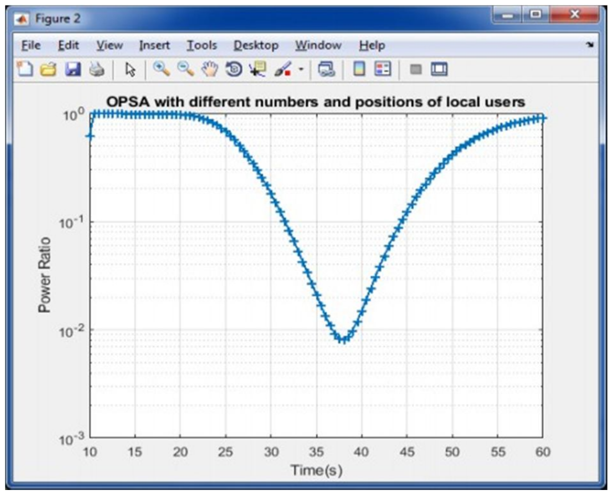

Fig 4 OPSA with different numbers and positions of local Users

B. Throughput Comparison Graph

Fig 5 shows that the throughput comparison graph of Number of total user equipment's and the total throughput in Bits/sec/Hz. Here, consider the heterogeneous networks in the overall process. There is a throughput comparison between the OPSA and proposed OPSA with RRH deployment. In existing OPSA term there is a low level of power can be used but in this work the low power can be applied in the RRH deployment area also. So, the proposed throughput is best than that of the existing system.

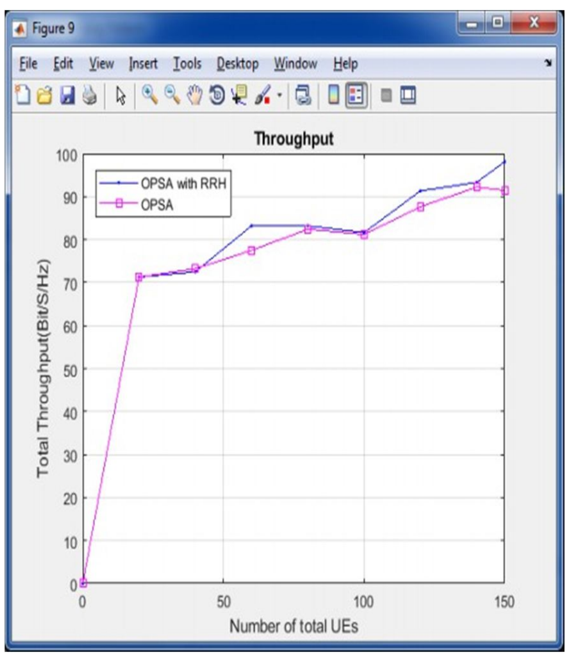

Fig. 5 Throughput Comparison Graph

V. CONCLUSION

Thus, the deployment of high-speed railways around the world in recent years, high-speed trains are playing an increasingly important role in people's travelling. Meanwhile, people are more eager to get wireless access services than ever before, even when they are travelling by high-speed trains. These together drive an increase in demand for high-speed railway broadband wireless communications and necessitate the development of a communication system for high-mobility users. A two-hop architecture, under which, passengers communicate with base stations (BSs) via a mobile relay (MR) is employed. The resource allocation problem in the downlink OFDMA system as a capacity optimization problem for the MR subject to the sum capacity constraint of local users.In previous work constant power and subcarrier allocation (CPSA) polices were used. Here, the combination of the passengers and local users in order to avoid the frequency variation, OPSA system can apply for this process. Frequency would also have a significant impact on the decision of cell size. Finally, maintained the frequency RRH are deployed in different areas. Thus, a better resource allocation in the downlink of same OFDMA system is provided.

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