ICIC Express Letters
Volume **12**, Number **7**, July **2018**

ICIC International ©2018 ISSN 1881-803X
pp. 731–736

AN OPTIMAL RESOURCE ALLOCATION SCHEME FOR D2D COMMUNICATIONS UNDERLAYING 5G-BASED CELLULAR NETWORKS

Chongdeuk Lee

Division of Electronic Engineering
Chonbuk National University
567 Baekje-daero, Deokjin-gu, Jeonju-si, Jeollabuk-do 54896, Korea
cdlee1008@jbnu.ac.kr

Received November 2017; accepted February 2018

Abstract. *As with 4G-based cellular networks, 5G-based cellular networks have an effect on a heavy traffic. A heavy traffic not only causes resources interference but also wastes buffer cache resources and link resources in 5G-based cellular networks. In this paper the objective of the optimal resource allocation scheme is to reduce the waste of resources and to fairly schedule the traffic requests of CUE (cellular user equipment) and DUE (D2D user equipment) to the resources. To realize this objective, this paper proposes a novel traffic detection based resource scheduling scheme called TDRAS (traffic detection-based resource allocation scheduling) scheme. The proposed TDRAS analyzes the forwarded active traffics or non-active traffics from CUEs and DUEs and detects whether the analyzed traffics are heavy traffic causing interference. Such detected traffic types reduce interference and stably allocate cache and link resources. We show through simulation analysis whether the proposed scheme allocates resources optimally.*
Keywords: 4G-based cellular networks, 5G-based cellular networks, CUE, DUE, Traffic detection

1. **Introduction.** Recently, the 5G-based cellular network has become a hot issue in the communication environment, and the 5G system develops NRAT (new radio access technology) through core functions of 3G and 4G system and convergence network of WLAN (wireless local area network). In order to guarantee 5G-based communication service, various technologies such as cellular technology, handoff technology, GSM (global system for mobile communications) technology, WCDMA (wideband code division multiple access) technology, small cell technology must be provided [1,2]. Especially, since the 5G-based communication service is based on the D2D communication network, the optimal resource allocation algorithm in the D2D communication network is very important in guaranteeing the gigabit communication service. However, until now, standardization and international standards for 5G mobile communication services have not been presented, and 5G communication technologies after 2020 are expected to evolve into 100Gbps communication technology, which is 1000 times faster than 4G-LTE technology. In particular, the optimal resource allocation technique underlaying D2D communication is a technology capable of actively responding to changes in mobile communication environments and business models and is a very important technology for guaranteeing gigabit communication services [3]. Under the 5G-based cellular network environment, the success of gigabit communication services is to reuse limited radio frequencies and to minimize the waste of radio resources. If it does not adequately reuse the limited frequency and radio resources, then this not only lowers the communication quality of service (QoS), but also causes serious communication overhead. One solution for effectively operating and managing limited frequency and radio resources is the D2D-based resource allocation scheme [4,5]. D2D

DOI: 10.24507/icicel.12.07.731

communication technology was an important technology for inter-device communication underlaying the existing 4G LTE communication technology environment, and this technology will so be an important scheme for insuring gigabit communication service and improving communication service in 5G-based cellular network environment. Thus, D2D communication technology offers the advantage of reusing frequency resources and radio resources without constructing additional infrastructure in a cellular network. However, D2D communication underlaying a 5G-based cellular network causes significant mutual interference between the cellular link and D2D link due to a large number of communication devices, unlike 4G cellular communications [6,7].

In order to solve this interference problem, [8] proposed an algorithm that minimizes the interference between the D2D terminal and the cellular terminal by using statistical techniques. This algorithm is a technique for reducing the size of interference by using statistical techniques. However, this algorithm has a problem that it is difficult to measure the size of different interference for each resource. [9] proposed a time hopping algorithm to minimize resource interference between a cellular terminal and a D2D terminal. This algorithm is a relatively efficient technique to mitigate interference between D2D links, but it is difficult to group D2D link resources. In addition, these algorithms are a 4G LTE based communication technique, and when the number of terminals is rapidly increased, resource interference due to user traffic occurs very seriously.

As a result, they cause link degradation and resource interference. Therefore, this paper proposes an optimal resource allocation scheme to reduce link degradation and guarantee D2D communication service under 5G-based cellular networks. The proposed scheme ensures optimal resource allocation for both cellular and D2D links and allows fair scheduling of limited resources. The proposed paper is expected to be applied to 5G mobile communication services and IoT (Internet of things), and we believe that it will further accelerate the evolution of 5G cellular technology.

The rest of this paper is as follows. In Section 2, the system model for the proposed scheme is described. Section 3 describes the main results. Finally, conclusions are described.

2. **System Model.**

In this section, we consider a 5G-based cellular network consisting of N CUEs and M DUEs for optimal resource allocation, and also we consider link pairs for D2D-Tx and D2D-Rx to forward the traffics from the 5G-based cellular networks to the evolved Node B (eNB). In the 5G-based cellular network, the eNB has buffer cache resources and link resources for analyzing and storing traffic types. The proposed system model is shown in Figure 1.

In the system model, D2D terminals have a link pair of D2D-Tx and D2D-Rx, and it is assumed that the transmitting and receiving terminals exist within a certain distance. In this process, due to heavy traffic, it meets C2D (cellular-to-D2D) link interference, D2D-to-cellular link interference, and D2D link interference. In order to reduce these interference, we propose a resource scheduling scheme to allocate the optimal resource according to the traffic type.

2.1. **Resource allocation scheduling.**

The resource allocation scheduling process is to fairly allocate buffer cache resources and link resources to DUE and CUE traffic regardless of distance, for which we apply the scheduling threshold α. The resource allocation scheduling process is shown in Figure 2, and the scheduling threshold α is a measure for filtering heavy non-active traffic.

Figure 2 shows the resource allocation scheduler for s1 in Figure 1, where s1, s2, and s3 each have RBs (resource blocks). In Figure 2, it is necessary to detect the traffic types transmitted from UE1, UE2, and UE3 to find the cause of resource interference.

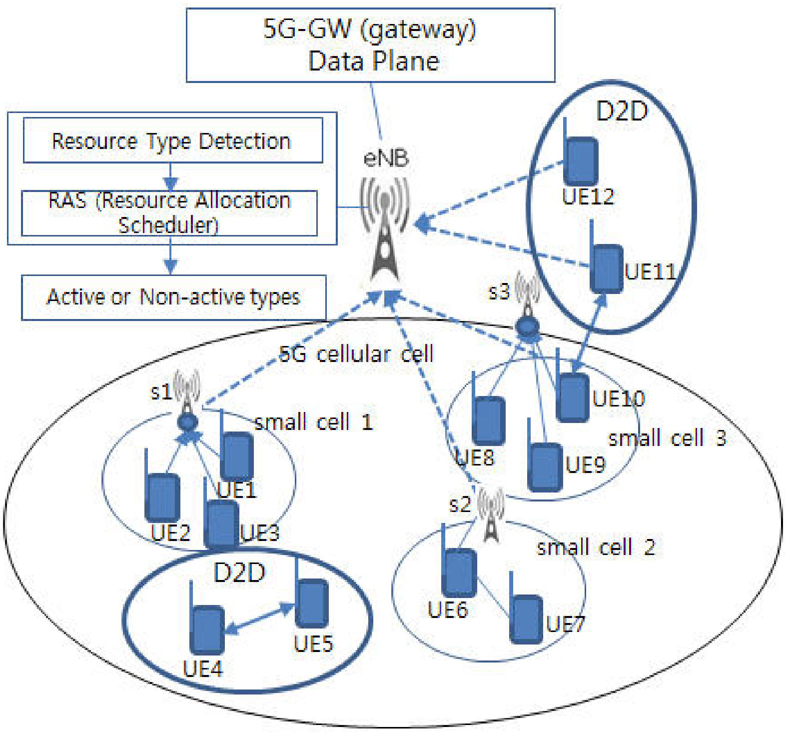

FIGURE 1. System model

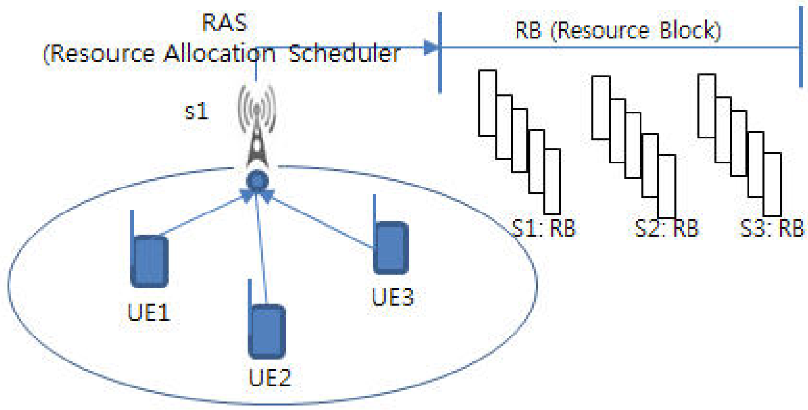

FIGURE 2. Resource allocation scheduling process

Therefore, the RB index for detecting the RB corresponding to the cellular link in S1 is defined as Equation (1) [7].

Definition 2.1.

$$K^* = \arg\max_{k \in 1,2,\ldots,N} \begin{cases} \min \alpha_{\text{DUE-eNB}}^{\text{filtering}} \\ n \in 1, 2, \ldots, N \end{cases} \tag{1}$$

Here $\alpha_{\text{DUE-eNB}}^{\text{filtering}}$ is the scheduling threshold α for filtering traffic that does not satisfy the RB between D2D and 5G cellular cells. And N represents the number of cells in the 5G cellular cell.

2.2. **Non-active traffic control.** If the resource allocation scheduler RAS does not properly control non-active traffic, non-active traffic causes resource interference problems in the buffer cache and link, which results in poor link quality. To overcome this problem, we consider burst time and buffer cache capacity for the resource allocation scheduler. For this, we assume the burst time and the buffer utilization rate between the buffer queue occupancy $[Q_{\min}, Q_{\max}]$ and the two points $\{(Q_{\min}, Q_{\max}), C_{NA}(N)\}$, $\{(Q_{\min}, Q_{\max}), C_A(N)\}$.

From the viewpoint of empirical analysis, non-active traffic has a large buffer occupancy rate and a long burst time, while active traffic has an effective buffer occupancy rate and short burst time. Therefore, the optimal resource allocation procedure considering buffer occupancy rate and burst time is as follows.

Non-active traffic control procedure
Input: $\overrightarrow{P}$, $[Q_{\min}, Q_{\max}]$ and $\{(Q_{\min}, Q_{\max}), C_{NA}(N)\}$, $\{(Q_{\min}, Q_{\max}), C_A(N)\}$.
Output: active traffics generated by RAS
Initial $\overrightarrow{P} = 0$
// $\overrightarrow{P}$ is the newly entered active traffic or non-active traffic.
while active traffics do
for $i = 1$ to N do
$K^* = \arg\max_{k \in 1,2,\ldots,N} \begin{cases} \min \alpha_{\text{DUE-eNB}}^{\text{filtering}} \\ n \in 1, 2, \ldots, N \end{cases}$
end for
counter = 0
for $i = 1$ to N do
if $(\alpha < 0.6)$ then
$N_A = 1$
// N_A is the number of active traffics
counter = counter + 1
end if
end for
if $(\alpha > 0.7)$ then
// α is the scheduling threshold
return N_A
end if
end while

If $C_{NA}(N) > Q_{\max}$, then non-active traffics are controlled and consequently only active packets remain in the buffer queue. Thus, this process prevents the consumption of link resources, and this effectively allocates resources.

2.3. **Link rate.** If the resource allocation scheduler RAS fails to control non-active traffic, the resource interference degrades link quality. In this paper, we consider transmission delay T_d and transmission rate T_r between C2D, D2C, and D2D to guarantee link rate. In a 5G-based cellular network, since the quality of the radio link is variable with burst time and size, it is assumed that the most recently measured result is more important than the previously measured result. This means that $\frac{T_d(t_2)}{T_r(t_2)}$ is more important than $\frac{T_d(t_1)}{T_r(t_1)}$ when the time interval is $0 \leq t_1 \leq t_2 \leq t$. Therefore, in order to guarantee the link quality for active traffic which causes less resource consumption, we measure the link rate $L(t_j)$ based on the statistical information $\frac{T_d(t_j)}{T_r(t_j)}$ in each time interval t_j, and the link rate $L(t_j)$ is defined as Equation (2).

Definition 2.2.

$$L(t_j) = (1 - \alpha) \times L(t_{j-1}) + \alpha \times \frac{T_d(t_j)}{T_r(t_j)} \tag{2}$$

Here t_j is the current time. Then, $P_i = P_i \times L(t_j)$ is updated, and the stability of the radio link and the degree of resource interference are determined according to α. If α is close to 1, it keeps the most recent resource information. On the other hand, if α is close to 0, the link quality degrades and resource interference greatly increases.

3. **Main Results.** In this section, we have performed a simulation analysis on CUEs and DUEs. In order to perform the simulation, we performed the simulation by setting the moving speed of the CUEs to 3km, 3 eNBs, and the bandwidth from 300MHz to 3.4GHz. It is assumed that there are 5 RBs each in the cellular band, and 80 CUEs and 30 DUEs are assumed in each cell. It is assumed that there are 5 RBs in each of the cellular bands, and each cell has 30 CUEs and 10 DUEs. CUE and $DUE - T_x$ were assumed to be uniformly distributed in the network, and $DUE - R_x$ was assumed to have a maximum distance of $D_{\max} = 20$m. In order to measure the link loss, we apply signal power to CUE and DUE, and the signal power of CUE is limited to -50dB and the signal power of DUE is limited to -20dB. Non-active traffic control rate was measured based on active traffic and non-active traffic, and we used the scheduling threshold α. We limited the maximum number of retransmissions to three times. We considered the burst time and buffer occupancy rate between the buffer queue occupancy $[Q_{\min}, Q_{\max}]$ and the two points $\{(Q_{\min}, Q_{\max}), C_{NA}(N)\}$, $\{(Q_{\min}, Q_{\max}), C_A(N)\}$. Figure 3 shows the average traffic control rate for non-active traffic when the scheduling threshold α is applied. As shown in Figure 3, if the number of non-active traffic increases for each traffics, the mutual interference increases proportionally.

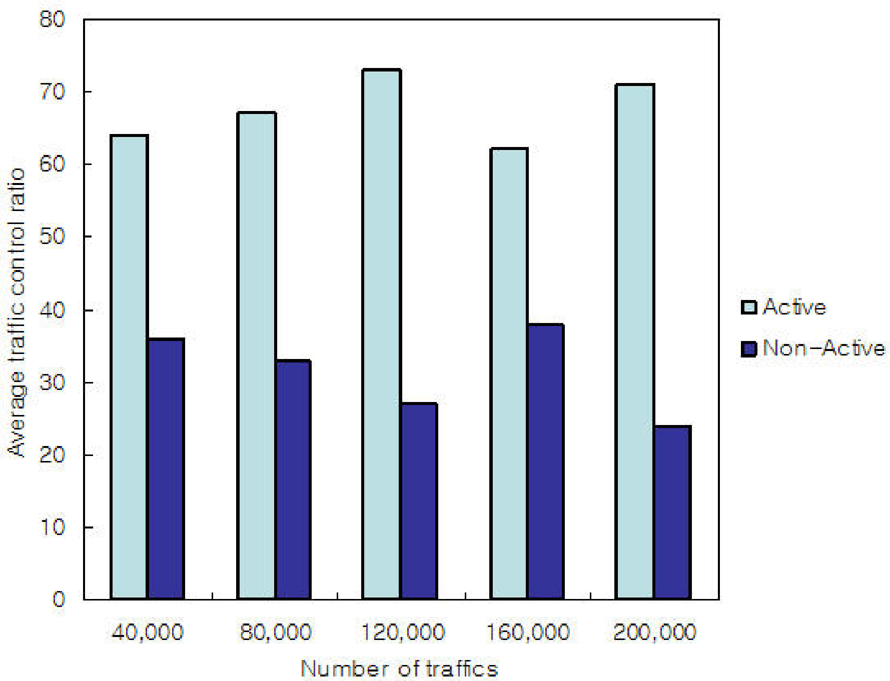

Figure 3. Non-active traffic control ratio

Figure 4 shows the simulation results for 200,000 active and non-active traffics with three groups when α is 0.3 or more, α is 0.5 or more, and α is 0.7 or more. As shown in Figure 4, when α is less than 0.5, it affects the buffer queue, and it can be seen that the average link transmission rate is decreased.

4. **Conclusions.** Under the 5G-based cellular network, traffic interference is expected to increase even more due to the numerous device users. In this paper, we proposed a novel traffic detection based resource allocation scheduling (TDRAS) scheme to realize 5G communication service by reducing traffic interference in 5G-based cellular networks. The proposed TDRAS provides fair access to eNBs regardless of their location between CUE and DUEs by identifying active traffic and non-active traffic. The proposed TDRAS allowed the buffer cache resource to control non-active traffic more flexibly when traffic congestion occurs on link resources. In order to control non-active traffic, we applied the

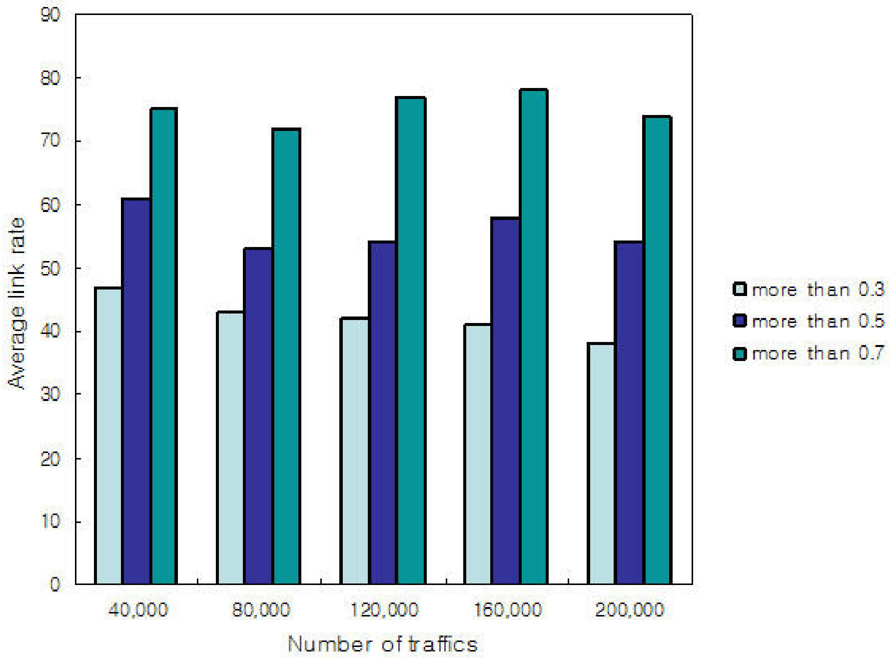

FIGURE 4. Average link rate

scheduling threshold α to control the traffics generated by eNB. Simulation results show that the proposed TDRAS effectively controls non-active traffic that causes resource interference. For future study, we will continue to work on applying the proposed technique to real 5G cellular network environments.

Acknowledgment. This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2017R1A2B4006687).

REFERENCES

[1] ITU-R, IMT vision-framework and overall objectives of the future development of IMT for 2020 and beyond, *The 22nd Meeting of Working Party 5D*, 2015.
[2] G. Misra, A. Agarwal, S. Misra and K. Agarwal, Device to device millimeter wave communication in 5G wireless cellular networks (A next generation promising wireless cellular technology), *International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES)*, pp.89-93, 2016.
[3] G. A. Safdar, U. R. Masood, M. Muhammad, M. A. Imran and R. Tafazolli, Interference mitigation in D2D communication underlaying LTE-A network, *IEEE Access*, vol.4, pp.7967-7987, 2016.
[4] G. Yu, L. Xu, D. Feng, R. Yin, G. Y. Li and Y. Jiang, Joint mode selection and resource allocation for device-to-device communications, *IEEE Trans. Communications*, vol.62, no.11, pp.3814-3824, 2014.
[5] L. Yang and W. Zhang, Interference coordination for 5G cellular networks, *SpringerBriefs in Electrical and Computer Engineering*, pp.1-11, 2015.
[6] Y. Zhang, F. Li, M. A. A. Mohamed and X. Luan, A resource allocation scheme for multi-D2D communications underlaying cellular networks with multi-subcarrier reusing, *Applied Science*, vol.7, pp.1-16, 2017.
[7] H. M. Kim, G. M. Kang and O. S. Shin, Resource allocation scheme for multiple device-to-device communications in a multicell network, *Journal of the Institute of Electronics and Information Engineers*, vol.53, no.9, pp.1316-1323, 2016.
[8] S. Xu, H. Wang, T. Chen, Q. Huang and T. Peng, Effective interference cancellation scheme for device-to device communication underlaying cellular networks, *Proc. of IEEE Vehicular Technology Conference*, pp.1-5, 2010.
[9] Q. Ye, A. S. Mazin, C. Caramanis and J. G. Andrews, Resource optimization in device-to-device cellular systems using time-frequency hopping, *IEEE Trans. Wireless Communications*, vol.13, no.10, pp.5467-5480, 2014.