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Power Control in LTE-Advanced Networks for Device to Device Communication

Ravindra S [1], Dr. Siddesh G K [2]

Research Scholar, Dept. of ECE, DSCE, K.S.Layout, Bengaluru, India[1]

Professor, Dept. of ECE, JSSATE, Uttarahalli-Kengeri Rd, Bengaluru, India[2]

ABSTRACT: Device to device communication systems will be able to handle voice and data services in an efficient manner. To provide efficient transmission, power control mechanisms play a very important role in LTE-A networks. For D2D communication, D2D discovery signals and cellular signals are multiplexed. This multiplexing is responsible for In-band Emission Interference (IEI). In-band Emission Interference degrades discovery range of device to device user equipments and hence throughput of cellular user equipments. In this paper, a utility function based uplink power control algorithm is developed for D2D communication in LTE-Advanced networks. Based on the mode selected, transmit power levels are iteratively calculated to meet the Quality of Service (QoS) requirements of all users. A high received power signal at device user equipment indicates strong In-band Emission Interference. The simulation results demonstrate the effectiveness and superiority of our proposed method in terms of power consumption.

KEYWORDS: D2D, IEI, QoS, OFDMA, SCFDMA.

I.INTRODUCTION

The peak data rates of LTE-Advanced networks include 1 Gbps in downlink and 500 Mbps in uplink, bandwidth scalability up to 100 MHz [2]. Single Carrier- Frequency Division Multiple Access (SCFDMA) and Orthogonal Frequency Division Multiple Access (OFDMA) techniques used for uplink and down link transmission. LTE-Advanced systems are designed for high speed internet and data rate. In this process, every user face battery drain problem in the UE. Hence the main issue is power drain problem and power control in user equipments is a challenging task. All mobiles are too competitive to get signal from base station and hence uplink power control is a major task. One mobile creates interference to the other mobile by increasing its uplink power [1] to maintain high data rate. Due to this each user equipment creates interference to all other user equipments and finally cell edge user equipments never connect to the base station. When the user equipments switches from one generation to other, network providers bear a large amount of money to install separate equipment for each generation on the same tower [6],[7]. This creates unnecessary load on cellular tower.

An optimum power control mechanism is required to avoid the above said problems. There are two types of power control algorithms: centralized and distributed. In centralized power control, a network center can simultaneously compute the optimal power levels for mobile stations in the network. In distributed power control, the power calculations are done within the mobile stations by determining the transmitter power of base station. The delay and complexity are much lower and more scalable in distributed power control than centralized power control. One of the major goal in LTE-Advanced system is to support higher downlink cell-average and cell-edge throughput. Water filling and game theory methods focus on intra-cell power control for each resource block, and these two methods are much more complex [4].

In order to reduce the complexity of the power control method, we need a method that considers only the cell level and each cell can decide the transmission power independently. This type of power control method has been proposed before, such as using different transmission power levels considering the traffic load [10], and smart discontinues transmission (DTX) [3]. The conventional method does not consider the UE distribution in neighboring cells. If there is no or only a few cell edge UEs in the neighboring cells, power reduction in the cell will not yield a improvement in performance. In order to address this problem, we propose a scheme that accurately estimates the transmission power of each cell considering the loss and improvement. In this paper, an uplink distributed power control algorithm is

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proposed for LTE-Advanced networks based on the utility function. Our paper will take the objective of control the uplink power in LTE-A relay networks and maximize the user's utility. The transmit power is based on the UE measurements without impact on the network capacity. Utility concept has been widely used to solve resource optimization problem in networks.

The major technical contribution of the paper is as follows:

- We propose a method that calculates the optimum power level of the base station and the D2D distance
- If the D2D distance is in region of proximity, the BS power will not be utilized by the UEs
- eNB based open loop power control is assumed based on the path loss between the eNB and the UE
- An uplink distributed power control algorithm is proposed for LTE-Advanced networks based on the utility function

The paper is organized as follows:

Section II describes about the system model for power control. Section III describes the power control analysis and Power control algorithm. Section IV gives simulation results. The last Section leads to the conclusion of the paper.

II.SYSTEM MODEL

We consider a scenario of one cell with one BS and multiple users. As shown in Fig.1, we have two kinds of users, i.e., D2D users that have direct data transmissions and traditional cellular users that work in the uplink mode. Each user is equipped with a single omni directional antenna and is distributed uniformly in the cell. The two users in a D2D pair satisfy the distance constraint of D2D communication and different D2D pairs can have communicating demands at the same time. Fig.1 illustrates a scenario in which cellular users work in uplink and share their resources with D2D pairs.

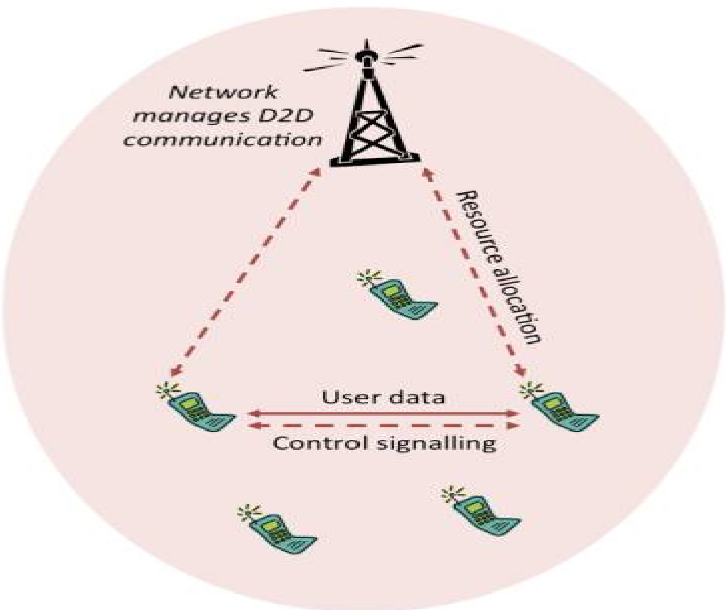

Fig. 1 D2D scenario of one cell with one BS and multiple users

In this paper, we consider small cell scenario 2a in which the macrocell and small cells use separate frequencies. For the macrolayer, macrocell sites are deployed within a hexagonal grid and each cell site is divided into three sectors. For the small cell layer, a small cell cluster is dropped uniformly and randomly within the macro geographical area. Small cells are uniformly and randomly dropped within the cluster area [5]. The UEs are uniformly distributed within the small cell cluster. This means that some UEs are outdoor UEs and others are indoor UEs. Each UE is dropped without mobility during the entire simulation.

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A scenario of resource sharing within a cellular network is as follows: one CU (user 1) and one D2D pair (user 2 and user 3) are sharing the same channel resources. User 2 is a transmitter while user 3 is a receiver of the D2D pair. The two users in a D2D pair are staying close enough to meet the requirement of the maximum distance constraint of D2D communication, in order to guarantee the quality of D2D communication [8]. When user 1 transmits data to the base station, the base station suffers the interference from the D2D transmitter (i.e., user 2). Also the D2D pair (i.e., user 2 and user 3) is in communication while the receiver (i.e. user 3) suffers the interference from the CU (user 1) and the other D2D transmitters.

III. POWER CONTROL ANALYSIS

The cellular users and D2D users in uplink transmission share the same number of available RBs. We assume that each radio base station is occupied by one cellular user and can be shared with multiple D2D pairs. There are two kinds of interference due to channel resource sharing. One is that base station receives from D2D transmitters and another is that the D2D receivers receive from cellular users. The signal to interference noise ratio (SINR) is considered as an important indicator for BS to D2D link quality.

LTE-A network model is considered with M base stations (eNB) and each base station with N users as shown in Fig.1. Each user equipment is covered by one or more base stations and the nth user will connect to the mth base station to transmit the data with power level of Pnm and data rate of γ_{nm}. Let the Gaussian noise variance to be σ 2, the channels are modeled by a path loss exponent δ at a distance of l_{nm} meters for nth user and frequency flat Rayleigh fading function h_{nm}, then the SINR at user n , From [1] the expression γ_{nm} can be expressed as,

$$\gamma_{nm} = P_{nm}\, l_{nm}^{-\delta}\, h_{nm}^{2} / \sigma^{2} \qquad (1)$$

The DUE SINR from [3] is given by

$$SINR_{DUE}^{k} = (P_{DUE}^{k} |h_{DUE}^{k}|^{2})/(IEI^{k} + \sigma^{2}) \qquad (2)$$

The target transmit rate between nth user and mth base station is rnm, then the utility function in [9] can be expressed as,

$$U_{nm}(P_{nm}) = r_{nm} - \beta_{nm} P_{nm} - \phi_{nm} P_{nm} \qquad (3)$$

Where $r_{nm} = \gamma_{nm}\, \alpha_{nm}$, $\alpha_{nm} = [(P_{DUE}^{k} |h_{DUE}^{k}|^{2})/(IEI^{k} + \sigma^{2})]/ P_{nm}$, P_{DUE}^{k} is the power transmitted by the DUE, $|h_{DUE}^{k}|^{2}$ is the channel gain between target D2D pair, IEI^{k} is the interference due to IEI from the CUEs, β_{nm} is a positive parameter of utility function and ϕ_{nm} is a positive congestion cost parameters [5], [2], which are called as the pricing parameters. Table I shows the parameters of β nm and ϕnm [1] used to find the power level.

TABLE I

PARAMETERS OF β nm and ϕnm

β nm	n=1	n=2	n=3	n=4	n=5
m=1	0.2	0.3	0.4	0.5	0.6
m=2	0.25	0.35	0.45	0.55	0.65
ϕnm	n=1	n=2	n=3	n=4	n=5
m=1	0.65	0.72	0.75	0.81	0.85
m=2	0.7	0.73	0.82	0.85	0.89

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The final optimal power level allocated to each user is expressed as

$P^{*}_{nm} = [C_m/\{(\beta_{nm}+\phi_{nm})\ln 2\sum_{n\in N}(\alpha_{nm}/(\beta_{nm}+\phi_{nm})\ln 2)\}]-(1/\alpha_{nm})$ (4)

Where Cm is the total capacity of m[th] base station and is given by $C_m = (1-\lambda m)\sum_{n\in N}(\alpha_{nm}/(\beta_{nm}+\phi_{nm})\ln 2)$

Algorithm1: Power Control Algorithm

Step 1: Initialize $P^{k}_{DUE,}|h^{k}_{DUE}|$, IEI^{k} and σ

Step 2: Find $SINR^{k}_{DUE} = (P^{k}_{DUE}|h^{k}_{DUE}|^2)/(IEI^{k}+\sigma^2) = \gamma_{nm}$

Step 2: Obtain α_{nm} using $\alpha_{nm} = r_{nm}/\gamma_{nm}$

Step 3: Calculate Cm using $C_m = (1-\lambda m)\sum_{n\in N}(\alpha_{nm}/(\beta_{nm}+\phi_{nm})\ln 2)$

Step 4: The final optimal power level allocated to each user is calculated using

$P^{*}_{nm} = [C_m/\{(\beta_{nm}+\phi_{nm})\ln 2\sum_{n\in N}(\alpha_{nm}/(\beta_{nm}+\phi_{nm})\ln 2)\}]-(1/\alpha_{nm})$

IV. SIMULATION RESULTS

This section gives simulation results for an LTE-Advanced network with single cell which is covered by a base station. The users of the cell are assumed to be uniformly distributed over the entire network and have same communication environment, propagation loss, capacity and traffic loads. The simulation parameters considered in this paper are tabulated in Table II.

TABLE II

SIMULATION PARAMETERS

PARAMETERS	VALUE
Number of Cells M	3
Number of Users N	15
Number of Users In Each Cell	5
Propagation Path Loss	0.8
AWGN Power	-83DBM
Neighbour Cell Power Interference	-10.3 DBM
Capacity of Cell M	10^5 BPS
Positive Parameter	β nm
Probability Parameter	ϕnm

In this simulation we compared the performances of the proposed power control algorithm with the conventional method and the simulation results shows that when the UEs number increases the optimal power level is high in the proposed method compared to the other method i.e. for 5 mobile users in the cell the optimal power level is 10mW

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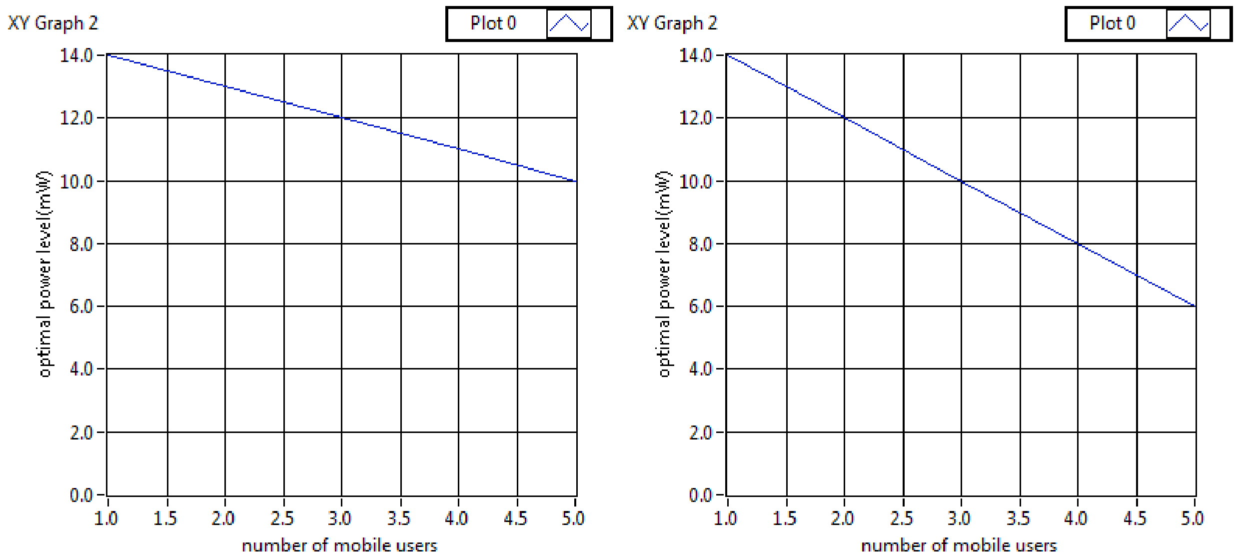
(Fig. 2 (a)) in the proposed method and it is 6mW (Fig. 2 (b)) in the conventional method. Hence the proposed technique can be used to control power in LTE-A networks for D2D communication.



(a) (b)

Fig. 2 Optimum power level versus number of mobile users (a) Proposed method (b) Conventional method

V. CONCLUSION

This work helps to control power for D2D communication system in LTE-A networks. The LabVIEW tool is used to find the solutions to the power allocation problems. Simulation results show that the proposed power control algorithm offers lower complexity and effectively maintain high power levels even when the mobile user equipments in the cell increases. In this paper we assumed an LTE-Advanced network with single cell which is covered by a single base station and each radio base station is occupied by one cellular user and can be shared with multiple D2D pairs.

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