Maximum Energy-Efficiency Approach for Resources Allocation in LTE-A System by Using Battery Deposit Service (BDS)

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Abstract- ***The long-term evolution (LTE) is the newly adopted technology which enhances capacity and coverage for current mobility networks, which experience a constant traffic increase. LTE communication system based on a redesigned physical layer and an orthogonal frequency division multiple access (OFDMA) modulation. In this paper, proposed the Energy Efficient (EE) resource allocation approach in OFDMA downlink networks that based upon heterogeneous services used in Device to Device (D2D) communication. In this approach we consider End to End Energy Consumption technique i.e. energy consumption of both transmitter and receiver. We formulated the problem of EE resource allocation as a mixed combinatorial and non-convex optimization problem. An evolutionary method based on Binary quantum-behaved particle swarm optimization (BQPSO) is proposed to solve the formulated problem. The simulation results show that the proposed algorithm not only can improve system energy efficiency but also can guarantee heterogeneous Quality of service (QoS) requirement.***

Keywords: Long Term Evolution, D2D communication, Battery Deposit Service, Resources allocation, energy-efficient resource allocation algorithm.

I. INTRODUCTION

The LTE-A (5G) cellular wireless networks are envisioned to overcome the fundamental challenges of existing cellular networks, for example, higher data rates, excellent end-to-end performance, and user-coverage in hot-spots and crowded areas with lower latency, energy consumption, and cost per information transfer. To address these challenges, LTE-A systems will adopt a multi-tier architecture consisting of macro cells, different types of licensed small cells, relays, and device-to-device (D2D) networks to serve users with different quality-of service (QoS) requirements in a spectrum and energy-efficient manner.

In this paper, we have studied energy efficiency from the device and network perspective. We will look at the problem from the network as well as device point of view. The multi-hop communications reduce the total transmission power in cellular wireless network. Our aim is to formulate the EE resource allocation when D2D relay is enabled. The problems we consider include selection of relay, resource allocation and power control. These optimization problems have binary decision variables, and thus exponential search spaces. This problem directly is not optimizing for real-time operations. Therefore, we need to develop faster algorithms to cope with LTE runtime requirement (sub frame level, which is 1 ms). The problem of joint optimization of relay strategies andresource allocation has been considered in the past. However, past works mainly focus on maximizing rate, and therefore maximum power is always used. In the context of LTE, quality of service (QoS) is provided in term of minimum guaranteed bit rate. As a result, it is more applicable to consider energy efficiency, minimizing transmission power while satisfying this rate requirement as well as select fixed rate by fixed Modulation and Coding Scheme (MCS). A prominent work in this direction is [Ng and Yu, 2007]. The authors consider the problem of maximizing a utility function, concave in rate of each data stream, by relay selection and resource allocation. The solution in [Ngand Yu, 2007] bases on the assumption that the amount of schedulable resource is abundant Even though this assumption may be appropriate for the number of OFDM tones; it cannot be applied to the number of resource blocks,

The unit schedulable resource in LTE. Furthermore, [Ng and Yu, 2007] proposes to use an exhaustive search for the optimal relay strategy. This approach limits the application of their solution in real-time operations. The majority of existing work use Shannon's formula to calculate the achieve- able rate of the UEs. Even though it makes the problem simpler because of the convexity of Shannon's formula, it is unrealistic. In real LTE networks, the UEs are assigned a Modulation and Coding Scheme (MCS) for each transmission. The achieved rate of the UEs is a function of their assigned MCS. The introduction of MCS adds another dimension to the variables of the optimization problem, which makes the search space much larger. As a result finding real-time algorithms becomes more challenging. In the context of downlink transmission for femtocells, the authors of [Lopez-Perez et al., 2014] propose to separate and fixed MCS from the resource allocation problem. We follow this idea in our work.

II. BATTERY DEPOSIT SERVICE

BDS is a technique for battery optimization of smartphones. It is based on reduction in energy consumed by communication over network. This will be achieved by utilizing cooperative device-to-device communication is shown in Fig.1. The system is designed to allow users with higher battery level to carry traffic of users with lower battery level, thereby reducing the chances of user running out of battery early. It is proposed to be implemented in form of a proximity service (ProSe) [7] under D2D communication architecture underlying LTE-A technology. BDS addresses the issue of increasing smartphones' battery life by reducing power consumption in network communications. This approach is made effective by redistributive the existing energy in network to increase usage time of battery power.

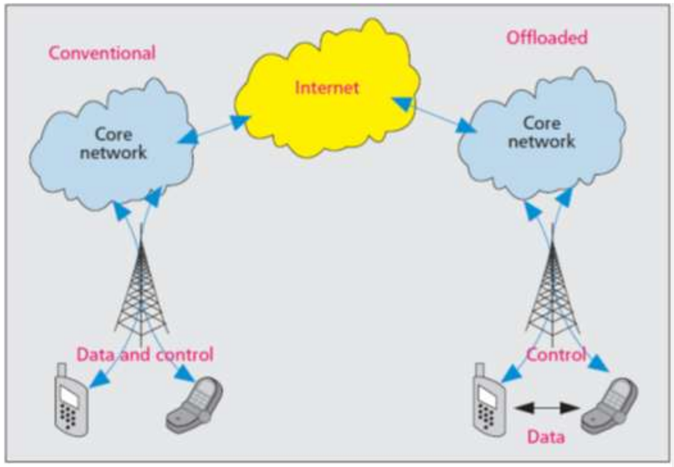

Fig.1 A conventional cellular and D2D network scenario

In [9], the notions of valued battery and valueless battery have been introduced as the amount of the smartphone battery when the user is active without having any access to power source or the amount smartphone battery remaining after the usage period, when the user have access to some power source, respectively. A method of developing cooperation between users is followed which allows them to spend their valueless battery power to save somebody else's valued battery power, thereby decreasing their probability of outage. The device-to-device cooperative relay underlying cellular networks is the physical mechanism used for "distributing" battery. This scheme helps in increasing the quantity of valued battery power in the network, henceforth reducing the cases of UEs running out of battery early.

The concepts of depositing and withdrawing the battery have been used to explain the fact that the benefits of helpers need not to be reciprocal or immediate. This means that a user who receives help can repay, at a later time, to some other user than the one who helped him. In this way BDS will be beneficial to large number of users.

III. RELATED WORK

A.UPLINK SCHEDULING AND POWER CONTROL IN LTE

In LTE, the UEs transmit data to the eNodeB on physical uplink shared channels (PUSCH). The eNodeB sends control messages to the UEs on physical downlink control channels (PDCCH). The UEs with uplink data send buffer status reports (BSR) to the eNodeB, indicating how much and what type of data they need to transmit. The eNodeB takes into account buffer status of all served UEs in allocating PUSCH resource. With dynamic scheduling, resource allocation is done for every sub frame (1ms). To notify the UEs of the resource assignment, the eNodeB sends uplink grants using downlink control information (DCI) messages on PDCCH. DCI format 0 is used for uplink grants of single transport block, while format 4 is used for uplink grants of multiple transport blocks. Also included in the DCI are the modulation and coding scheme (MCS), and transmission power control (TPC) messages. The DCI is sent 4 sub frames prior to the actual uplink transmission to allow time for the UEs to process these uplink grants. In LTE, a UE's uplink transmission power (in dBm) is controlled by equation (4.1) (see [Baker, 2011, 3GPP, 2011c]).

$$P = P0+\alpha PL+\Delta TF+f(\Delta TPC) +10\log10 (M)$$

The per-resource block (RB) power control consists of two components: a basic open-loop operating point and a dynamic offset. M is the number of allocated RBs. P0 is a semi-static nominal power level set by the eNodeB.PL is the path loss compensation component, where controls the degree of compensation. PL is derived from the downlink Reference Signal Received Power. It includes shadowing but not fast fading. The dynamic control of UE uplink transmission power is designed to be an offset from the base operating point. This offset depends on two factors: the allowed modulation and coding scheme (TF stands for Transport Format) and a UE-specific transmitter power control (TPC) command.

B. D2D COMMUNICATIONS UNDERLAYING LTE

Proximity services and public safety usage are the main drivers for development of D2D in LTE. The target for release 12 is discovery and communication for public safety. Even though D2D communications have not been fully standardized in 3GPP, some features have been agreed upon [3GPP, 2014a]. D2D operations will be considered in two modes: in-coverage (Mode 1), and out-of-coverage (Mode 2). A D2D link is considered in Mode 1 if both UEs are connected to the cellular networks and Mode 2 otherwise. We focus on Mode 1 in our work. For Mode 1, the time/frequency resource for D2D communication (for discovery, scheduling, and data) are configured by the eNodeB. A new DCI format will be used to relay this scheduling information to the UEs. This new DCI format will have the same size as DCI format 0. It is also agreed that, at least in the beginning, D2D communication will occupy the uplink frequency (FDD) or uplink sub frames (TDD). For Mode 1, the eNodeB has the flexibility to optimize system performance. In this chapter we will consider system performance in term of minimizing UE uplink transmission power.

In this work we consider a single cell with N UEs. All UEs are assumed capable of D2D. The objective is to design a cooperative relay system that reduces the overall transmission power on the uplink. Inactive UEs are allowed to receive data from active UEs through D2D connections, decode and forward to the eNodeB. Currently, the eNodeB schedules uplink based on buffer status reports and channel quality from the UEs. We add one more dimension to this decision process: relay selection. Ideally, relay assignment can be done every subframe (1ms). However, the overhead for signaling such assignment will be too excessive. In fact, the current consideration for a D2D transmission time interval is 2 frames (20 ms) [3GPP,2014b]. As a result, in our design, the relay selection is carried out at a large time scale. During such a period, each UE keeps record of at most one relay. If the relay is inactive, the eNodeB signals the UE to transmit through therelay. Resource allocation and power control can be done on a per-sub frame basis to cope with fast fading.

C.RELAY SELECTION

To select a relay for each UE such that the total transmission power is minimized. For fairness, each UE can only choose at most one other UE as relay and each UE only serves as relay for at most one other UE. Since the relay selection problem is considered in a large time scale, average channel statistics can be used. This design also allows time for the eNodeB to aggregate D2D channel information. The freshness requirement of this channel information is not stringent, thus the control signaling overhead can be kept low. Consequently, we will assume that the eNodeB knows the average channel statistics of all D2D links. In addition, operating at a large time scale allows us to use Shannon capacity formula, instead of discrete MCS levels, to determine the average UE rate. We
consider orthogonal resource allocation and assume no inter-cell interference.

D.RESOURCE ALLOCATION AND POWER CONTROL

During each subframe, let us denote the set of UEs with non-empty buffer by A, the set of UEs with empty buffer by I. Consider an active UE n 2 A with relay m. If the relay is inactive, i.e. m 2 I, n always use the relay instead of direct transmission. As a result, at the beginning of each frame, the eNodeB knows how much D2D resource is needed. In this section, we formulate the resource allocation and power control problem. It can then be applied separately for D2D relay and for cellular uplink. In LTE, the unit for resource allocation is RB pair. Each RB pair consists of one RB per slot. For localized allocation, the two RBs occupy the same frequency. Let us denote by K the number of RBs for each slot. K depends on the system bandwidth and how much frequency resource is allocated for D2D communication

versus cellular uplink. Orthogonal resource allocation is used such that each RB is only allocated to 1 link. Let s = 1; : : : ; S be the allowable MCS levels. Each MCS consists of a modulation order (e.g. QPSK), and an effective code rate (e.g. 3/4). In LTE, each UE only uses one MCS per transmission. Without considering HARQ between several transmissions, the rate of each UE is therefore a function of the MCS level and the number of allocated RBs. For each MCS s, there is a corresponding required SNR s to achieve some predetermined packet error rate (e.g. 10%). These SNR requirements are usually obtained by simulation. In this work, we will use the MCS values, and the corresponding required SNR, from Table 4.1, introduced in [Lopez-Perez et al., 2014]. Let the allocation variable xn;k;s = 1 denotes that RB k and MCS s are assigned to UE n; xn;k;s = 0 otherwise. The rate of UE n is

$$rn = \sum_{s=1}^{s}\sum_{k=1}^{k} Xn,k,s\ \Phi s$$

Where ϕs is the per-RB rate of MCS s. For normal cyclic prefix, each RB consists of 7 OFDM symbols and 12 subcarriers. Without accounting for reserved reference and control elements, each RB has 84 resource elements. Since the duration of a slot is 0.5 ms, we can calculate ϕs for each MCS s, as noted in Table1.

Table1 Modulation and Coding schemes

	Modulation	Code rate	SNR(dB)	Eefficiency (bits/symbol)	Rate1 (Mbps/RB)
MCS1	8 QAM	1/2	2.88	1.00	0.168
MCS2	8QAM	3/4	5.74	1.50	0.252
MCS3	16QAM	1/2	8.79	2.00	0.336
MCS4	16QAM	3/4	12.22	3.00	0.504
MCS5	64QAM	2/3	15.88	4.00	0.672
MCS6	64QAM	3/4	17.50	4.50	0.756

In LTE, demodulation reference signals (DM-RS) and sounding reference signals (SRS) are transmitted by the UEs to help the eNodeB estimate the channel gains. In this work we will assume that the eNodeB knows the channel gains on all RBs for all UEs. We also assume that the UEs are capable of using different transmission power on different RBs. Furthermore, we do not consider infeasible cases, i.e. there are always enough RBs to satisfy QoS requirement of the UEs. The resource allocation and power control problem can be formulated as the following Mixed Binary Linear Program

$$\textbf{(RAPC)} \quad \min_{Pn,k,s,Xn,k,s,yn,s} \sum_{n=1}^{n}\sum_{s=1}^{s}\sum_{k=1}^{k} P_{n,k,s}$$

$$\frac{Pn,k,s\ Gn,k}{\sigma^2} \geq X_{n,k,s\gamma_s}$$

$$\sum_{s=1}^{s} y_{n,s} = 1$$

$$X_{n,k,s} \leq y_{n,s}$$

$$\sum_{n=1}^{n}\sum_{s=1}^{s} X_{n,k,s} \le 1$$

$$\sum_{s=1}^{s}\sum_{k=1}^{k} X_{n,k,s}\Phi_s \ge R_n$$

$$P_{n,k,s} \ge 0$$

$$X_{n,k,s} \in \{0,1\}$$

$$y_{n,s} \in \{0,1\}$$

Here Pn;k;s is the transmission power of UE n on RB k for MCS s, Gn;k is the channel gain for UE n on RB k, the binary variable yn;s = 1 if MCS s is assigned to UE constrain(4.16) ensures that the SNR requirement for assigned MCS is met.

Constraints (4.17) and (4.18) ensure that each UE is assigned only one MCS. Constraint (4.19) ensures that each RB is assigned to at most one UE. Constraint (4.20) ensures the required rate of each UE. Constraints (4.21), (4.22), (4.23) indicate the domain of the decision variables. The decision variables of (RAPC) are 3-dimensional. Their large search spaces make solving the optimization problem time consuming, not appropriate to a real- time operation. Since the channel conditions do not change significantly sub frame by sub frame, the MCS levels do not need to be updated that frequently. As a result, we can consider a sub-problem of (RAPC) where the MCS is predetermined. This sub-problem is only 2-dimensional and can be solved in real time. We provide a heuristic algorithm to search for the best MCS. This heuristic algorithm is carried out at a larger time scale (e.g. frame level). For every sub frame within each such large time scale, the eNodeB solves the sub-problem to obtain resource assignment and power allocation.

E.RAPC for fixed MCS

When MCS s is selected for UE n, the SNR requirement and the per-RB rate can be associated to the UE so that $\Upsilon_n = \Upsilon_s$ $\Phi_n = \Phi_s$(RAPC) reduces to

(S-RAPC)

$$\min_{P_{n,k}X_{n,k}} \sum_{n=1}^{N}\sum_{k=1}^{K} P_{n,k}$$

$$\frac{Pn,k\,Gn,k}{\sigma^2} \ge X_{n,k}\Upsilon_n$$

$$\sum_{n=1}^{N} X_{n,k} \le 1$$

$$\sum_{k=1}^{K} X_{n,k}\Phi_s \ge R_n$$

$$P_{n,k} \ge 0$$

$$X_{n,k} \in \{0,1\}$$

Similar to the relay selection problem (RS), here we also observe that the assignment variable xn;k is the most important. Once xn;k is determined, we can obtain Pn;k by solving for equality in (4.24). For a fixed MCS, the rate of each UE is proportional to the number of allocated RBs. We can easily see that the rate requirement can be equivalently written as

$$\sum_{k=1}^{K} X_{n,k} = \left[\frac{R_n}{\Phi_n}\right]$$

Let us denote $D_n = \left[\frac{R_n}{\Phi_n}\right]$as the required number of RBs for UE n. (S-RAPC) is equivalent to the minimum-cost flow problem for the graph illustrated in Figure 4.2. The circular nodes represent the UEs, while the squared nodes represent the RBs. Each link is annotated with a (capacity, cost) pair. The links from the source s to the UEs have capacity equal to the required number of RBs Dn. All other links have capacity 1. The link between UE n and RB k has cost.

$$P_{n,k} = \frac{\gamma_n \sigma^2}{G_{n,k}}$$

The total flow of the network is$\sum_{n=1}^{N} D_n$

Similar to the minimum weighted matching on a bipartite graph, minimum-cost flow is a well-studied problem. Algorithms with polynomial time complexity as well as fast practical implementation have been developed.

To determine the best MCS levels for all UEs.In previous work used heuristic algorithm but in aur work we will used fixed MCS. We observe that if MCS s satisfies the rate requirement of UE n using only one RB, then all MCS higher than s will not be selected. This is because an MCS higher than s will require higher transmission power. Therefore, we first used the best MCS levels for all UEs i.e. 8-QAM modulation scheme will further reduce data rate, thereby reducing the battery usage and hence will increase the overall efficiency of the system.

TABLE- 2 PARAMETERS FOR SIMULATION

Parameters	Values
Cell Radius	500m
No. of UEs	500

Mean data inter-arrival time (*Barr)*	30s
Mean burst size *(Bmean)*	7800 bytes
Speed	0.1-3m/s
Pause duration	0-300s
Walk duration	30-300s
Path loss compensation factor (*α)*	0.8
Constant energy cost factor	15mJ
Communication battery budget	300J
Base power (*Po)*	69dBm
Maximum transmit power (*T)*	24dBm
Modulation order QAM 8	8
Modulation order QAM 16	16
Modulation order QAM 64	64
Code rate	1/3
Carrier frequency	2GHz
No. of Resource Blocks/subframe (*NRB*)	100
eNode B antenna height	25m
UE antenna height	1.5m
No. of walls for indoor NLOS	1
Cooperation threshold *γ1,γ2*	0.3,0.3
Cooperation path loss threshold	110dB
Cooperation radius	30m
SNR (Eb/No) (*E)*	3.3dB
Noise Margin (*K)*	3dB
Processing Gain (*PG)*	27.95db
Handoff gain (*H)*	5dB
Log Normal fade margin (*L')*	11.3dB
Cell Antenna gain (*G)*	10dB
Cable Loss (*C)*	2dB

F. SIMULATION RESULTS

The proposed model has been implemented as an event-driven simulation in MATLAB environment. The simulation is initialized with UEs located at uniformly random locations within a hexagonal cell and having a random battery level. In this paper, for EE resources allocation approach Modulation and Coding Scheme (MCS) values have been used. For each MCS s, there is corresponding required SNRs to achieve some predetermined packet error rate (e.g. 10%). These SNR requirements are usually obtained by simulation. In this work, we will use the MCS values, and the corresponding required SNR and rate, from Table 2, introduced in [6] with respect to BDS. In previous work, for choose maximum modulation scheme used heuristic algorithm. The results of comparison shows that choose, 8-QAM serves to be a much better option considering the requirements of low data rate and symbol error rate and a much greater battery usage time. Therefore for EE resources allocation and power control we can used 8QAM MCS for each UEs but based upon condition applied for it because selection of relay and power control of LTE network. Figure 2 shows the plot of the Effect of Modulation Schemes on Transmission Power for both theoretical values and practical values obtained from simulation. The graph shows that 8 QAM takes less transmission power as compared to 16 QAM and 64 QAM in D2D system and UE system.

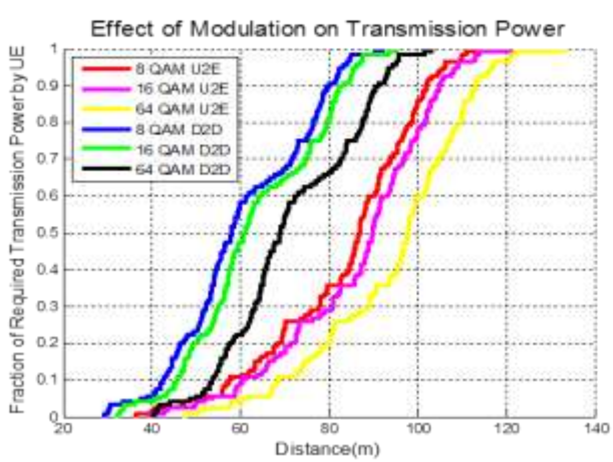

Fig.2 Plot of the Effect of Different Modulation Schemes onTransmission Power

Figure 3 shows the plot of the Symbol Error Probabilities of 8, 16 and 64 QAMs for both theoretical values and values obtained from simulation. The graph shows that the Symbol error Rate (SER) increases with increase in modulation order. Thus 8-QAM is having least SER.

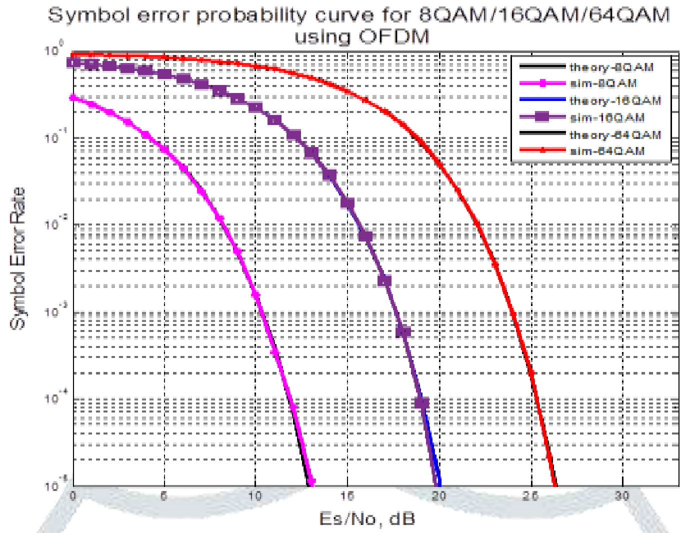

Fig.3 Symbol Error Probability curve for 8QAM/16QAM/64QAM

Figure 4 shows the plot of the Probability of Survival with Different Modulation Schemes. The graph shows that the Probability of Survival increases with decreases in modulation order. Thus 8QAM is having more Probability of survival

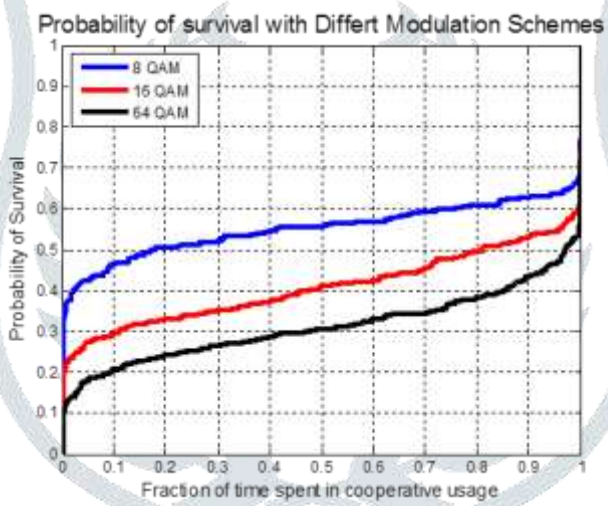

Fig.4Plot of Probability of Survival with Different Modulation Schemes

IV.CONCLUSION

In this paper we have introduced a mechanism to enable device-to-device relay in LTE networks. We show that with proper relay selection, resource allocation and power control, D2D relay can significantly reduce the transmission power of the UEs We formulate the relay selection, resource allocation and power control, we separate out MCS selection. We show that with a fixed MCS, the resource allocation and power control problem can be equivalently seen as a minimum-cost flow problem, which also has fast algorithms. We compare the performance of our modulation and coding scheme and choose the best modulation and coding scheme i.e. 8QAM.

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