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A review On Energy Efficient Resource Allocation in MIMO-OFDMA System Using Different Optimization Algorithm

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Abstract*- In today's wireless communication industry energy consumption is one of the main problems. In this paper a study on energy efficient resource allocation algorithms for long term evolution (LTE) cellular mobile systems is done. To be applicable in LTE systems, both multiple-input multiple-output (MIMO) orthogonal frequency-division multiple access (OFDMA) radio access network and resource blocks (RBs) for sub channel assignment are studied in this paper. In particular, an optimization problem concerning joint RB assignment, and power allocation is formulated to maximize the energy efficiency measured by "bits-per-Joule" metric, under per-user quality-of service (QoS) requirements in the form of user rate constraints. Here to improve the energy efficiency of resource allocation, Lagrange dual method is used. The RB assignment and power allocation on different sub channels is decoupled using dual decomposition. This results in increased computational complexity and time consumption. Optimization using harmony search algorithm can be used to overcome this problem. This article presents the comparison between different optimization algorithms. The proposed algorithm may be more applicable in LTE systems than existing schemes on energy-efficient resource allocation.

Keywords—Terms—Energy efficiency, Sub channel optimization,

I.INTRODUCTION

Due to the daily growth of users requirement on high data rate multimedia traffic, the Energy consumption of wireless communication has been dramatically increases. In recent years the result of enormous energy consumption is large amount of green house gas emission. (LTE) has been broadly acknowledged as the most promising standard for next-generation cellular systems to satisfy high-rate data transmission. However, high energy consumption With the most advanced techniques, 3GPP Long Term Evolution is still a major problem that has a large impact on the performance of LTE systems. As a result, many recent studies have focused on the energy-efficient design for LTE systems and relevant techniques, and 3GPP has also integrated green communication research as an important part into LTE standard documents Such evidence fully demonstrates the great . significance of green radio and energy-efficient design for LTE cellular systems.

To improve the energy efficiency of LTE cellular systems significantly from a holistic perspective, radio access networks should be considered as the top priority, because the access segment can account for over 75% of the total energy consumption for typical cellular mobile systems. Regarding radio access networks, most existing works have focused on energy-efficient power allocation for diverse wireless channels .

In this paper, we study the comparison between different optimization algorithms. And introducing a new algorithm to overcome the demerits of exsisting algorithms.

II. DIFFERENT OPTIMIZATION ALGORITHMS

A. JIOO Algorithm

For a downlink OFDMA network, EE and SE are ηEE def $= R/\zeta P + Pc$ and ηSE def $= R/B$ respectively.

EE is defined as transmitted bits per unit energy consumption at the transmitter side ,where the energy consumption includes transmission energy consumption (ζP times transmission time) and circuit energy consumption (Pc times transmission time) of transmitter in the active mode.

To obtain a high EE as well as a desirable SE and guarantee *quality-of-service* (QoS) for each user with the limited bandwidth and transmit power resource, it is reasonable to maximize EE under a satisfying minimum overall throughput requirement, $\check{R}$, and a series of (minimum) rate requirements,

$$\max_{\rho\in\varrho,\mathbf{P}\in\mathcal{P}} \eta_{EE} \left(= \frac{\sum_{k=1}^{K}\sum_{n=1}^{N} \rho_{k,n} r_{k,n}}{\sum_{k=1}^{K}\sum_{n=1}^{N} \rho_{k,n}\left(\zeta p_{k,n} + \xi r_{k,n}\right) + P_s} \right)$$

$$\sum_{k=1}^{K}\sum_{n=1}^{N}\rho_{k,n}r_{k,n} \geq \breve{R},$$

$$\sum_{n=1}^{N}\rho_{k,n}r_{k,n} = \breve{R}_k, \forall k \in \mathcal{K}_1,$$

$$\sum_{n=1}^{N}\rho_{k,n}r_{k,n} \geq \breve{R}_k, \forall k \in \mathcal{K}_2,$$

So here to improve the energy efficiency and spectral efficiency JIOO algorithm used. JIOO algorithm is Joint Inner and Outer Layer Optimization Algorithm.

Algorithm ***JIOO***

Input: initial value of SE: $\eta_{SE}^{(0)} = \frac{\breve{R}}{B}$

Output: optimal subcarrier and power allocation matrices, ρ_{opt} and P_{opt}, which result in the optimal EE, η_{EE}^{opt}

1. $\eta_{SE}^{(1)} = \eta_{SE}^{(0)}$, $d_1 \leftarrow \left.\frac{\mathrm{d}\eta_{EE}^{*}(\eta_{SE})}{\mathrm{d}\eta_{SE}}\right|_{\eta_{SE}=\eta_{SE}^{(1)}}$
2. **if** $d_1 \leq 0$
3. **then** (∗ Case 1 as shown in Figure 1 ∗)
   return current ρ and P as ρ_{opt}, P_{opt}, respectively
4. **else** (∗ Cases 2 and 3 as shown in Figure 1 ∗)
   $\eta_{SE}^{(2)} \leftarrow \eta_{SE}^{(1)}$, $\eta_{SE}^{(1)} \leftarrow \kappa\eta_{SE}^{(1)}$, $P_1 \leftarrow P^{*}(\eta_{SE}^{(1)})$,
   $d_1 \leftarrow \left.\frac{\mathrm{d}\eta_{EE}^{*}(\eta_{SE})}{\mathrm{d}\eta_{SE}}\right|_{\eta_{SE}=\eta_{SE}^{(1)}}$, where $P^{*}(\eta_{SE}^{(1)}) = \frac{B\eta_{SE}^{(1)}}{\zeta\eta_{EE}^{*}(\eta_{SE}^{(1)})} - \frac{P_c}{\zeta}$ and $\kappa > 1$, e.g., $\kappa = 2$
5. **while** $d_1 > 0$ && $P_1 < P_{max}$
6. **do** $\eta_{SE}^{(2)} \leftarrow \eta_{SE}^{(1)}$, $\eta_{SE}^{(1)} \leftarrow \kappa\eta_{SE}^{(1)}$, $P_1 \leftarrow P^{*}(\eta_{SE}^{(1)})$,
   $d_1 \leftarrow \left.\frac{\mathrm{d}\eta_{EE}^{*}(\eta_{SE})}{\mathrm{d}\eta_{SE}}\right|_{\eta_{SE}=\eta_{SE}^{(1)}}$
7. **while** no convergence (∗ bisection search ∗)
8. **do** $\eta_{SE}^{opt} \leftarrow \frac{\eta_{SE}^{(1)}+\eta_{SE}^{(2)}}{2}$, $P_{opt} \leftarrow P^{*}(\eta_{SE}^{opt})$,
   $d_{opt} \leftarrow \left.\frac{\mathrm{d}\eta_{EE}^{*}(\eta_{SE}^{opt})}{\mathrm{d}\eta_{SE}}\right|_{\eta_{SE}=\eta_{SE}^{(1)}}$, where $P^{*}(\eta_{SE}^{opt}) = \frac{B\eta_{SE}^{opt}}{\zeta\eta_{EE}^{*}(\eta_{SE}^{opt})} - \frac{P_c}{\zeta}$
9. **if** $d_{opt} > 0$ && $P_{opt} < P_{max}$
10. **then** $\eta_{SE}^{(2)} \leftarrow \eta_{SE}^{opt}$
11. **else** $\eta_{SE}^{(1)} \leftarrow \eta_{SE}^{opt}$
12. **return** current ρ and P as ρ_{opt}, P_{opt}, respectively

B. Suboptimal Subchannel Allocation

In the suboptimal sub channel allocation algorithm, equal power distribution is assumed across all sub channels. We define Hk,n = (h2k,n/N0(B/N)) as the channel to noise ratio for user *k* in sub channel *n* and Ωk is the set of sub channels assigned to user *k*. The algorithm can be described as

1) Initialization
   a) Set $R_k = 0$, $\Omega_k = \varnothing$ for $k = 1, 2, \ldots, K$ and $A = \{1, 2, \ldots, N\}$.
2) For $k = 1$ to K,
   a) find n satisfying $|H_{k,n}| \geq |H_{k,j}|$ for all $j \in A$;
   b) let $\Omega_k = \Omega_k \cup \{n\}$, $A = A - \{n\}$ and update R_k according to (2).
3) While $A \neq \varnothing$,
   a) find k satisfying $R_k/\gamma_k \leq R_i/\gamma_i$ for all i, $1 \leq i \leq K$;
   b) for the found k, find n satisfying $|H_{k,n}| \geq |H_{k,j}|$ for all $j \in A$;
   c) for the found k and n, let $\Omega_k = \Omega_k \cup \{n\}$, $A = A - \{n\}$ and update R_k according to (2).

The principle of the suboptimal sub channel algorithm is for each user to use the sub channels with high channel-to-noise ratio as much as possible. At each iteration, the user with the lowest proportional capacity has the option to pick which sub channel to use. The sub channel allocation algorithm is suboptimal, because equal power distribution in all sub channels is assumed. After sub channel allocation, only coarse proportional fairness is achieved. Here this algorithm is used for determine the optimal power allocation.

C. Gradient Assisted Binary Search Algogorithm

To find the optimal data rate vector for the multiple sub channel case and single sub channel transmission gradient assisted binary search algorithm is used.

Input: initial guess: $r_o > 0$

Output: optimal transmission rate: r^*

1. $r_1 = r_o$, $h_1 \leftarrow \left.\frac{dU(r)}{dr}\right|_{r_1}$, initialize $\alpha > 1$
2. **if** $h_1 < 0$
   (∗ seek r_1 and r_2 such that $r_1 < r^* < r_2$ ∗)
3. **then** $r_2 \leftarrow r_1$, $r_1 \leftarrow \frac{r_1}{\alpha}$, and $h_1 \leftarrow \left.\frac{dU(r)}{dr}\right|_{r_1}$
4. **while** $h_1 < 0$
5. **do** $r_2 \leftarrow r_1$, $r_1 \leftarrow \frac{r_1}{\alpha}$, and $h_1 \leftarrow \left.\frac{dU(r)}{dr}\right|_{r_1}$
6. **else** $r_2 \leftarrow r_1 * \alpha$ and $h_2 \leftarrow \left.\frac{dU(r)}{dr}\right|_{r_2}$
7. **while** $h_2 > 0$
8. **do** $r_1 \leftarrow r_2$, $r_2 \leftarrow r_2 * \alpha$, and $h_2 \leftarrow \left.\frac{dU(r)}{dr}\right|_{r_2}$
9. **while** no convergence
   (∗ seek r^* between r_1 and r_2 ∗)
10. **do** $\hat{r} \leftarrow \frac{r_2+r_1}{2}$; $\hat{h} \leftarrow \left.\frac{dU(r)}{dr}\right|_{\hat{r}}$
11. **if** $\hat{h} > 0$
12. **then** $r_1 = \hat{r}$;
13. **else** $r_2 = \hat{r}$
14. **return** $\hat{r}$

And multiple sub channel transmission BSSA Algorithm is using. BSSA is Binary Search Assisted Ascent.

Algorithm $BSAA(\mathbf{R}_o)$
(∗ algorithm for multi-subchannel transmission. ∗)
Input: initial guess: $\mathbf{R}_o$(default transmission rate can be used)
Output: optimal transmission rate vector: $\mathbf{R}^*$
1. $\mathbf{R} = \mathbf{R}_o$,
2. **while** no convergence
3. **do** use GABS to find the optimal step size μ^*;
4. $\mathbf{R} = [\mathbf{R} + \mu^* \nabla U(\mathbf{R})]^+$
5. **return** $\mathbf{R}$

D. Dinkle Batchs Method

Dinkle Batchs Method is a numerical energy efficient power allocation algorithm.

Data: λ_0 satisfying $F(\lambda_0) \geq 0$, tolerance Δ
$n = 0$;
while $|F(\lambda_n)| \geq \Delta$ **do**
 Use $\lambda = \lambda_n$ in (6) to obtain x_n^*;
 $\lambda_{n+1} = \frac{f_1(x_n^*)}{f_2(x_n^*)}$;
 $n{+}{+}$;
end

E. Iterative Spectrum Balancing

initialize $(\lambda_1, \cdots, \lambda_K)$.
repeat
 initialize $(S_1^n, \cdots, S_K^n)$.
 repeat
  for $k = 1$ to K,
   set $S_k^n = \text{argmax}_{S_k^n} \sum_{l=1}^{K} (w_l b_l^n - \lambda_l S_l^n)$.
  end
 until $(S_1^n, \cdots, S_K^n)$ converges
 update $(\lambda_1, \cdots, \lambda_K)$ using ellipsoid or subgradient method.
until $(\lambda_1, \cdots, \lambda_K)$ converges

ISB algorithm offers a significant complexity reduction with a small loss of optimality in many practical situations.

F. RA Algorithm

Resource allocation algorithm which provides Quality of Service (QoS) guarantees to users The algorithm is a modified proportional fair (PF) scheduling algorithm and it comprises two phases. In the first phase, users' minimum data rate requirements are met and in the second phase, remaining resources are allocated according to PF scheduling algorithm. It is a cell-level algorithm and its main advantages are the low implementation complexity and the capacity of maintaining higher ratio of QoS satisfied users.

1) **Initialization:**
 - Set $\mathcal{N} = \{1, 2, \ldots, N\}$, $\Phi = \{1, 2, \ldots, M\}$, $\mathcal{M} = \{\mu_1, \mu_2, \ldots, \mu_M\}$, $y_{jn} = 0$ and $p_{j,n} = P_t/N, \forall j, n$

2) **While** $\Phi \neq \{\}$:
 - Find user m and subcarrier n^*, with $r_{m,n^*} \geq r_{j,n}$, $\forall j, n$
 - If $R_m < \mu_m$
  - $y_{mn^*} = 1$
  - $R_m = R_m + r_{m,n^*}$
  - $\mathcal{N} \setminus \{n^*\}$
  - Calculate (1)
 - If $R_m \geq \mu_m$
  - $\mathcal{M} \setminus \{\mu_m\}$
  - $\Phi \setminus \{m\}$

3) **While** $\mathcal{N} \neq \{\}$:
 - Find subcarrier n' and user $m^* = \arg\max_m \frac{r_{m,n'}}{\psi_m}$

- $R_{m^*} = R_{m^*} + r_{m^*,n'}$
- $y_{m^*n'} = 1$
- $\mathcal{N} \setminus \{n'\}$
- Calculate (1)

G. Greedy Based Sub channel Pre processing Algorithm

1: Initialize $\mathcal{N} = \{1, 2, \ldots, N\}$, $\mathcal{M} = \{1, 2, \ldots, M\}$, and $\mathcal{N}_m = \emptyset, \forall m \in \mathcal{M}$;
2: **repeat**
3: Find $(m^*, n^*) = \arg\max_{m \in \mathcal{M}, n \in \mathcal{N}} \overline{h}_{m,n}$;
4: Update $\mathcal{N}_{m^*} = \mathcal{N}_{m^*} \cup \{n^*\}$, $\mathcal{M} = \mathcal{M} \setminus \{m^*\}$ and $\mathcal{N} = \mathcal{N} \setminus \{n^*\}$;
5: **until** $\mathcal{M} = \emptyset$

To effectively meet users' rate requirements, it is obvious that each user should be served by *at least one* RB; otherwise, there will be no frequency sub channel to carry the data needed for some users. Accordingly, we do a pre processing for sub channel assignment before solving *F*(*q*) = 0, using a *greedy* strategy as follows. For each user *m*, the average CSI of all *KJm* channels for MIMO transmission is calculated as

$$\overline{h}_{m,n} = (1/KJ_m) \sum_{k=1}^{K} \sum_{a=1}^{J_m} |\lambda_{m,k(n)}^{(a)}|^2$$

On each RB *n*. With all unassigned RBs, we then search for the (*m** *n**) with the best *hm,n* among all the users who have not been served by any RB and allocate RB *n*∗ to user *m**. This procedure repeats until each user has and only has one RB to use, which functions as a necessary condition for users' rate guarantees.

I. Associated Bisection Search and Ellipsoid Method

Initialize $q_u = 0$ and $q_l \gg 0$ satisfying $F(q_l) < 0$;
repeat
  Update $q_{\text{tmp}} = (q_u + q_l)/2$;
  Initialize $(\boldsymbol{\mu}(0), \gamma(0))$ and an initial ellipsoid $\mathbf{A}(0)$;
  repeat
    for each RB $n = 1$ to N **do**
      if $n \in \mathcal{N}$ **then**
        Calculate $p^{(a)*}_{m,k(n)}$ via (26) and obtain vector $\mathbf{T}_n$ by (27);
        Set $x_{m,n}$ and $p^{(a)}_{m,k(n)}$ according to (28) and (29);
      else
        Search for m^* which satisfies $n \in \mathcal{N}_{m^*}$;
        Solve $p^{(a)*}_{m,k(n)}$ by (26) for $m = m^*$;
        For $m = m^*$, set $p^{(a)}_{m,k(n)} = p^{(a)*}_{m,k(n)}$ and $x_{m,n} = 1$, otherwise $x_{m,n} = p^{(a)}_{m,k(n)} = 0$;
      end if
    end for
    Update dual variables $(\boldsymbol{\mu}, \gamma)$ and ellipsoid $\mathbf{A}$ by the ellipsoid method with subgradient in (30);
  until converge to the dual optimum $(\boldsymbol{\mu}^*, \gamma^*)$
  Update $q_u = q_{\text{tmp}}$ if $F(q_{\text{tmp}}) > 0$, else $q_l = q_{\text{tmp}}$;
until required accuracy $|F(q_{\text{tmp}})| < \epsilon$ (e.g., $\epsilon = 10^{-4}$)

II. PERFORMANCE COMPARISON OF VARIOUS ALGORITHMS

Conventional design of wireless networks mainly focuses on system capacity and spectral efficiency (SE). As green radio (GR) becomes an inevitable trend, energy-efficient design is becoming more and more important. These all algorithms is used to find the energy efficiency ,spectral efficiency and power calculations .but in ellipsoid method and JIOO algorithms are comparatively complexity and time consumption is very high.

JIOO algorithm was mainly used to determine the energy efficiency and spectral efficiency in downlink OFDMA networks. which is important for designing GR networks that require a better balance between EE and SE.

The Gradient Assisted Binary Search Algorithm is mainly used in frequency selective channels for energy efficient link adaptation. here the performance of this algorithm also poor .and complexity is also high. Dinkle batch method is another type of algorithm. in which the power is calculating efficiently and also it is a numerical energy efficiency calculation method. next is the resource allocation algorithm. This is used to allocate the resource blocks for each sub channel for the users. and also used to find the energy efficiency for resource blocks. Greedy algorithm for sub channel pre processing and Ellipsoid method are combined used to find the energy efficiency for MIMO-OFDMA system with lengranges dual method. So here the main disadvantages is computational complexity and time consumption very high. To overcome all demerits of those optimization techniques we have a new algorithm called search harmony algorithm. Harmony search is a music-based metaheuristic optimization algorithm. It was inspired by the observation that the aim of music is to search for a perfect

state of harmony. This harmony in music is analogous to find the optimality in an optimization process.

J. Harmony search algorithm

begin
  Objective function f(x), x=$(x_1,x_2, \ldots,x_d)^T$
  Generate initial harmonics (real number arrays)
  Define pitch adjusting rate (r_{pa}), pitch limits and bandwidth
  Define harmony memory accepting rate (r_{accept})
  while *(t<Max number of iterations)*
    Generate new harmonics by accepting best harmonics
    Adjust pitch to get new harmonics (solutions)
    if *(rand>r_{accept}), choose an existing harmonic randomly*
    else if *(rand>r_{pa}), adjust the pitch randomly within limits*
    else *generate new harmonics via randomization*
    end if
    Accept the new harmonics (solutions) if better
  end while
  Find the current best solutions
end

A further extension of the HS algorithm will be to solve multi objective optimization problems more naturally and more efficiently. In addition, the implementation of HS algorithm is also easier.

IV. CONCLUSION

The dramatic increase of network infrastructure comes at the cost of rapidly increasing energy consumption. which makes optimization of energy efficiency(EE)an important topic. since EE is often modeled as the ratio of rate to power. In this paper an overview of different optimization algorithms are compared. And we have a new optimization algorithm called search harmony algorithm. The main advantage of this algorithm is low computational complexity and giving high energy efficiency. Therefore, the proposed scheme shows significant performance improvement in terms of user rate requirement and SNR when compared to the competing schemes.

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