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• **Supplementary File** •

Secure Communication in Wireless Powered Communication Networks with Energy Accumulation

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Appendix A Proposed Algorithm for Solving the Problem (P1) With Given τ_1, τ_2

Let $\boldsymbol{\mu} = \{\mu_{m,k}, m = 1, \ldots, M, k = 1, \ldots, K\}$ denote the dual variables associated with the constraint in (6). With given $\boldsymbol{\tau}_1, \boldsymbol{\tau}_2$, the partial Lagrangian of the problem (P1) can be written as

$$L(\mathbf{P}, \mathbf{p}, \mathbf{q}, \boldsymbol{\mu}) = \sum_{m=1}^{M}\sum_{k=1}^{K}\omega_k \sum_{n=1}^{N} c_{k,n,m} - \sum_{m=1}^{M}\sum_{k=1}^{K}\mu_{m,k}\Bigg(\sum_{j=1}^{m}\tau_{2,j}\sum_{n=1}^{N}(p_{k,n,j} + q_{k,n,j}) - \sum_{j=1}^{m}\xi\tau_{1,j}\sum_{n=1}^{N}P_{n,j}g_{k,n,j}\Bigg). \tag{A1}$$

The dual function, $G(\boldsymbol{\mu})$, is obtained as the maximum function value of the following problem given by

$$\max_{\mathbf{P},\mathbf{p},\mathbf{q}} L(\mathbf{P}, \mathbf{p}, \mathbf{q}, \boldsymbol{\mu}) \quad \text{s.t. } (5), (8), (9). \tag{A2}$$

For solving the above problem, let $\mathbf{P}_m = \{P_{n,m}, \forall n\}, \mathbf{p}_m = \{p_{k,n,m}, \forall n, k\}, \mathbf{q}_m = \{q_{k,n,m}, \forall n, k\}$ and rewrite $L(\mathbf{P}, \mathbf{p}, \mathbf{q}, \boldsymbol{\mu})$ as $L(\mathbf{P}, \mathbf{p}, \mathbf{q}, \boldsymbol{\mu}) = \sum_{m=1}^{M} L_m(\mathbf{P}_m, \mathbf{p}_m, \mathbf{q}_m, \boldsymbol{\mu})$, where

$$L_m(\mathbf{P}_m, \mathbf{p}_m, \mathbf{q}_m, \boldsymbol{\mu}) = \sum_{k=1}^{K}\omega_k \sum_{n=1}^{N} c_{k,n,m} - \sum_{k=1}^{K}\sum_{j=m}^{M}\mu_{j,k}\tau_{2,m}\sum_{n=1}^{N}(p_{k,n,m} + q_{k,n,m}) + \sum_{k=1}^{K}\sum_{j=m}^{M}\mu_{j,k}\xi\tau_{1,m}\sum_{n=1}^{N}P_{n,m}g_{k,n,m}. \tag{A3}$$

The problem in (A2) can be decomposed into M subproblems, each for a slot as given by

$$\max_{\mathbf{P}_m,\mathbf{p}_m,\mathbf{q}_m} L_m(\mathbf{P}_m, \mathbf{p}_m, \mathbf{q}_m, \boldsymbol{\mu}) \tag{A4}$$

$$\text{s.t. } \sum_{n=1}^{N} P_{n,m} \leqslant P_{max}, \tag{A5}$$

$$p_{k,n,m}p_{k',n,m} = 0, \forall n, k \neq k', \tag{A6}$$

$$P_{n,m} \geqslant 0, p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0, \forall n, k, \tag{A7}$$

for $\forall m$. It is seen that $\mathbf{P}_m$ in the above problem does not coupled with other variables $\mathbf{p}_m, \mathbf{q}_m$, and is optimized by solving the following problem given by

$$\max_{\mathbf{P}_m} \sum_{n=1}^{N} P_{n,m}\sum_{k=1}^{K}\sum_{j=m}^{M}\mu_{j,k}g_{k,n,m} \tag{A8}$$

$$\text{s.t. } \sum_{n=1}^{N} P_{n,m} \leqslant P_{max}, \tag{A9}$$

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$$P_{n,m} \geqslant 0, \forall n, \tag{A10}$$

for $\forall m$. The problem in (A8) belongs to linear programming and its optimal solution can be easily obtained as

$$P_{n,m} = \begin{cases} P_{max}, & n = \arg\max_n \sum_{k=1}^{K} \sum_{j=m}^{M} \mu_{j,k} g_{k,n,m}, \\ 0, & n \neq \arg\max_n \sum_{k=1}^{K} \sum_{j=m}^{M} \mu_{j,k} g_{k,n,m}, \end{cases} \tag{A11}$$

for $\forall m, n$. To optimize $\mathbf{p}_m, \mathbf{q}_m$ in the problem in (A4), the problem can be decomposed into N subproblems, each for a subcarrier as given by

$$\max_{\mathbf{p}_m, \mathbf{q}_m} \sum_{k=1}^{K} \omega_k c_{k,n,m} - \sum_{k=1}^{K} \sum_{j=m}^{M} \mu_{j,k} \tau_{2,m} (p_{k,n,m} + q_{k,n,m}) \tag{A12}$$

$$\text{s.t. } p_{k,n,m} p_{k',n,m} = 0, \forall k \neq k', \tag{A13}$$

$$p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0, \forall k, \tag{A14}$$

for $\forall n$. From (A13), by solving K subproblems, each for a user k allocated with subcarrier n, the subcarrier is allocated to the user with the maximum objective function value. For $\forall k$ allocated with subcarrier n, the problem is

$$\max_{p_{k,n,m}, q_{k,n,m}} \omega_k c_{k,n,m} - \sum_{j=m}^{M} \mu_{j,k} \tau_{2,m} (p_{k,n,m} + q_{k,n,m}) \tag{A15}$$

$$\text{s.t. } p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0. \tag{A16}$$

This problem can be solved by solving the following two problems given as

$$\max_{p_{k,n,m}, q_{k,n,m}} - \sum_{j=m}^{M} \mu_{j,k} (p_{k,n,m} + q_{k,n,m}) \tag{A17}$$

$$\text{s.t. } p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0, \tag{A18}$$

$$\frac{h_{k,k,n,m}}{N_0 B} \leqslant \max_{k' \neq k} \frac{h_{k,k',n,m}}{N_0 B + q_{k,n,m} h_{k,k',n,m}}, \tag{A19}$$

and

$$\max_{p_{k,n,m}, q_{k,n,m}} \omega_k \log_2 \left(1 + \frac{p_{k,n,m} h_{k,k,n,m}}{N_0 B}\right) - \omega_k \max_{k' \neq k} \log_2 \left(1 + \frac{p_{k,n,m} h_{k,k',n,m}}{N_0 B + q_{k,n,m} h_{k,k',n,m}}\right)$$
$$- \sum_{j=m}^{M} \mu_{j,k} (p_{k,n,m} + q_{k,n,m}) \tag{A20}$$

$$\text{s.t. } p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0, \tag{A21}$$

$$\frac{h_{k,k,n,m}}{N_0 B} \geqslant \max_{k' \neq k} \frac{h_{k,k',n,m}}{N_0 B + q_{k,n,m} h_{k,k',n,m}}. \tag{A22}$$

It is noted that the solution of the problem with the maximum objective function value between the above two problems is the solution of the problem in (A15). It is also noted that the constraint in (A19) guarantees that $c_{k,n,m}$ is non-positive and the constraint in (A22) guarantees that $c_{k,n,m}$ is non-negative. The inequalities in (A19) and (A22) can be rewritten as $q_{k,n,m} \leqslant N_0 B \left(\frac{1}{h_{k,k,n,m}} - \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} \right)$ and $q_{k,n,m} \geqslant N_0 B \left(\frac{1}{h_{k,k,n,m}} - \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} \right)$, respectively. Thus, the problem in (A17) is feasible when $\frac{1}{h_{k,k,n,m}} \geqslant \min_{k' \neq k} \frac{1}{h_{k,k',n,m}}$ and its optimal solution is $p_{k,n,m} = 0, q_{k,n,m} = 0$. As for the problem in (A20), it is non-convex and can be rewritten as

$$\max_{p_{k,n,m}, q_{k,n,m}} f_1(p_{k,n,m}, q_{k,n,m}) - f_2(p_{k,n,m}, q_{k,n,m}) \tag{A23}$$

$$\text{s.t. } p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0, \tag{A24}$$

$$q_{k,n,m} \geqslant N_0 B \left(\frac{1}{h_{k,k,n,m}} - \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} \right), \tag{A25}$$

where

$$f_1(p_{k,n,m}, q_{k,n,m}) = \omega_k \log_2 \left(1 + \frac{p_{k,n,m} h_{k,k,n,m}}{N_0 B}\right) + \omega_k \log_2 \left(N_0 B \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} \right.$$
$$\left. + q_{k,n,m} \right) - \sum_{j=m}^{M} \mu_{j,k} (p_{k,n,m} + q_{k,n,m}), \tag{A26}$$

$$f_2(p_{k,n,m}, q_{k,n,m}) = \omega_k \log_2 \left(N_0 B \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} + p_{k,n,m} + q_{k,n,m} \right). \tag{A27}$$

It is seen that the objective function in (A23) has the form of difference-of-two-concave-functions (DC). Thus the problem in (A23) can be solved by the successive convex approximation (SCA) method. Let $p_{k,n,m}(t), q_{k,n,m}(t)$ denote the solution at the t-th iteration. Then, at the $t+1$-th iteration, $f_2(p_{k,n,m}, q_{k,n,m})$ is approximated by its first order Taylor expansion as

$$\begin{aligned} f_2(p_{k,n,m}, q_{k,n,m}) =& f_2(p_{k,n,m}(t), q_{k,n,m}(t)) + (p_{k,n,m} - p_{k,n,m}(t)) \\ & \times \left.\frac{\partial f_2(p_{k,n,m}, q_{k,n,m})}{\partial p_{k,n,m}}\right|_{p_{k,n,m}=p_{k,n,m}(t), q_{k,n,m}=q_{k,n,m}(t)} + (q_{k,n,m} - q_{k,n,m}(t)) \\ & \times \left.\frac{\partial f_2(p_{k,n,m}, q_{k,n,m})}{\partial q_{k,n,m}}\right|_{p_{k,n,m}=p_{k,n,m}(t), q_{k,n,m}=q_{k,n,m}(t)} \\ =& f_2(p_{k,n,m}(t), q_{k,n,m}(t)) + \frac{\omega_k (p_{k,n,m} - p_{k,n,m}(t))}{\left(N_0 B \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} + p_{k,n,m}(t) + q_{k,n,m}(t)\right) \ln 2} \\ & + \frac{\omega_k (q_{k,n,m} - q_{k,n,m}(t))}{\left(N_0 B \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} + p_{k,n,m}(t) + q_{k,n,m}(t)\right) \ln 2}. \end{aligned} \tag{A28}$$

Then, at the $t+1$-th iteration, $p_{k,n,m}(t+1), q_{k,n,m}(t+1)$ is obtained by solving the problem given by

$$\max_{p_{k,n,m}, q_{k,n,m}} f_1(p_{k,n,m}, q_{k,n,m}) - \frac{\omega_k (p_{k,n,m} + q_{k,n,m})}{\left(N_0 B \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} + p_{k,n,m}(t) + q_{k,n,m}(t)\right) \ln 2} \tag{A29}$$

$$\text{s.t. } p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0, \tag{A30}$$

$$q_{k,n,m} \geqslant N_0 B \left(\frac{1}{h_{k,k,n,m}} - \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} \right). \tag{A31}$$

It can be verified that the objective function in (A29) is concave and the constraints in (A30) and (A31) are affine. Thus, the optimal solution of the problem in (A29) can be obtained by setting the first derivatives of the objective function in (A29) with respect to $p_{k,n,m}, q_{k,n,m}$ to zero as given by

$$p_{k,n,m}(t+1) = \frac{N_0 B}{h_{k,k,n,m}} \left(\frac{\omega_k \frac{h_{k,k,n,m}}{N_0 B}}{\sum_{j=m}^{M} \mu_{j,k} \ln 2 + \frac{\omega_k}{N_0 B \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} + p_{k,n,m}(t) + q_{k,n,m}(t)}} - 1 \right)^+, \tag{A32}$$

$$\begin{aligned} q_{k,n,m}(t+1) = \max \Bigg(& N_0 B \left(\frac{1}{h_{k,k,n,m}} - \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} \right)^+, \\ & \frac{\omega_k}{\sum_{j=m}^{M} \mu_{j,k} \ln 2 + \frac{\omega_k}{N_0 B \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} + p_{k,n,m}(t) + q_{k,n,m}(t)}} - N_0 B \min_{k' \neq k} \frac{1}{h_{k,k',n,m}} \Bigg). \end{aligned} \tag{A33}$$

Since it have been proved that the SCA method converges to a local optimum [1], the problem in (A20) is solved by iteratively updating $p_{k,n,m}, q_{k,n,m}$ until convergence.

After $G(\boldsymbol{\mu})$ is obtained, the dual problem is given by

$$\min_{\boldsymbol{\mu} \succeq 0} G(\boldsymbol{\mu}). \tag{A34}$$

This problem can be solved by the ellipsoid method [2].

Appendix B Proposed Offline Algorithm

Algorithm B1 Proposed offline algorithm.

Initialize: $\{\tau_{1,m}\}, \{\tau_{2,m}\}$.
repeat
  Initialize: $\{\mu_{m,k}\}$.
  repeat
    for $m = 1$ to M **do**
      Obtain $P_{n,m}, \forall n$ by (A11).
      for $n = 1$ to N **do**
        for $k = 1$ to K **do**
          Initialize: $p_{k,n,m}(0), q_{k,n,m}(0), t = 0$.
          repeat
            Obtain $p_{k,n,m}(t+1)$ and $q_{k,n,m}(t+1)$ by (A32) and (A33), respectively.
            $t = t + 1$.
          until $|p_{k,n,m}(t) - p_{k,n,m}(t-1)| \leqslant \epsilon$ and $|q_{k,n,m}(t+1) - q_{k,n,m}(t)| \leqslant \epsilon$ are satisfied simultaneously, where ϵ denotes the error tolerance.
          Calculate the objective function value in (A20) by letting $p_{k,n,m} = p_{k,n,m}(t), q_{k,n,m} = q_{k,n,m}(t)$.
          if the objective function value in (A20) is larger than 0 **then**
            Let $p_{k,n,m} = p_{k,n,m}(t), q_{k,n,m} = q_{k,n,m}(t)$.
          else
            Let $p_{k,n,m} = 0, q_{k,n,m} = 0$.
          end if
          Calculate the objective function value in (A15).
        end for
        Denote the user with the maximum objective function value in (A15) as k^*, and assign the subcarrier n to the user k^* by setting $p_{k,n,m} = 0, q_{k,n,m} = 0, k \neq k^*$.
      end for
    end for
    Update $\{\mu_{m,k}\}$ using the ellipsoid method.
  until $\{\mu_{m,k}\}$ converges to the desired accuracy.
  Update $\{\tau_{1,m}\}, \{\tau_{2,m}\}$ by solving the problem in (10) using the interior point method.
until the weighted sum secrecy rate converges to the desired accuracy.

Appendix C Proposed Algorithm for Solving the Problem (P2) With Given $\tau_{1,m}, \tau_{2,m}$

The partial Lagrangian of the problem (P2) with given $\tau_{1,m}, \tau_{2,m}$ is written as

$$L(\mathbf{P}_m, \mathbf{p}_m, \mathbf{q}_m, \boldsymbol{\mu}_m) = \sum_{k=1}^{K} \omega_k \sum_{n=1}^{N} c_{k,n,m} - \sum_{k=1}^{K} \mu_{m,k} \left(\tau_{2,m} \sum_{n=1}^{N} (p_{k,n,m} + q_{k,n,m}) - \xi \tau_{1,m} \sum_{n=1}^{N} P_{n,m} g_{k,n,m} \right), \tag{C1}$$

where $\boldsymbol{\mu}_m = \{\mu_{m,k}, k = 1, \ldots, K\}$ is the dual variables associated with the constraint in (13). The dual function of the problem (P2) with given $\tau_{1,m}, \tau_{2,m}$ is obtained as

$$G(\boldsymbol{\mu}_m) = \max_{\mathbf{P}_m, \mathbf{p}_m, \mathbf{q}_m} L(\mathbf{P}_m, \mathbf{p}_m, \mathbf{q}_m, \boldsymbol{\mu}_m) \quad \text{s.t. } (12), (15), (16). \tag{C2}$$

The dual problem is then expressed as $\min_{\boldsymbol{\mu}_m \succeq 0} G(\boldsymbol{\mu}_m)$, which can be solved by the ellipsoid method. Thus, what remains is to solve the problem in (C2). The problem in (C2) for optimizing $\mathbf{P}_m$ is written as

$$\max_{\mathbf{P}_m \succeq 0} \sum_{n=1}^{N} P_{n,m} \sum_{k=1}^{K} \mu_{m,k} g_{k,n,m} \tag{C3}$$

$$\text{s.t.} \sum_{n=1}^{N} P_{n,m} \leqslant P_{max}. \tag{C4}$$

The optimal solution of the above problem can be easily obtained as

$$P_{n,m} = \begin{cases} P_{max}, & n = \arg\max_n \sum_{k=1}^{K} \mu_{m,k} g_{k,n,m}, \\ 0, & n \neq \arg\max_n \sum_{k=1}^{K} \mu_{m,k} g_{k,n,m}, \end{cases} \tag{C5}$$

for $\forall n$. The problem in (C2) for optimizing $\mathbf{p}_m$ and $\mathbf{q}_m$ is then decomposed into N subproblems, each for a subcarrier as

$$\max_{\mathbf{p}_m, \mathbf{q}_m} \sum_{k=1}^{K} \omega_k c_{k,n,m} - \sum_{k=1}^{K} \mu_{m,k} \tau_{2,m} (p_{k,n,m} + q_{k,n,m}) \tag{C6}$$

$$\text{s.t.}\ p_{k,n,m} p_{k^{'},n,m} = 0, \forall k \neq k^{'}, \tag{C7}$$

$$p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0, \forall k, \tag{C8}$$

for $\forall n$. The above problem can be solved by solving K subproblems, each for a user k allocated with subcarrier n, then selecting the result with the maximum objective function value. For $\forall k, n$, the problem is

$$\max_{p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0} \omega_k c_{k,n,m} - \mu_{m,k} \tau_{2,m} (p_{k,n,m} + q_{k,n,m}), \tag{C9}$$

which can be decomposed into two subproblems given by

$$\max_{p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0} - \mu_{m,k} (p_{k,n,m} + q_{k,n,m}) \tag{C10}$$

$$\text{s.t.}\ \frac{h_{k,k,n,m}}{N_0 B} \leqslant \max_{k' \neq k} \frac{h_{k,k^{'},n,m}}{N_0 B + q_{k,n,m} h_{k,k^{'},n,m}}, \tag{C11}$$

and

$$\max_{p_{k,n,m} \geqslant 0, q_{k,n,m} \geqslant 0} \omega_k \log_2 \left(1 + \frac{p_{k,n,m} h_{k,k,n,m}}{N_0 B}\right) - \omega_k \max_{k' \neq k} \log_2 \left(1 + \frac{p_{k,n,m} h_{k,k^{'},n,m}}{N_0 B + q_{k,n,m} h_{k,k^{'},n,m}}\right)$$
$$- \mu_{m,k} (p_{k,n,m} + q_{k,n,m}) \tag{C12}$$

$$\text{s.t.}\ \frac{h_{k,k,n,m}}{N_0 B} \geqslant \max_{k' \neq k} \frac{h_{k,k^{'},n,m}}{N_0 B + q_{k,n,m} h_{k,k^{'},n,m}}. \tag{C13}$$

The problem in (C10) is similar to the problem in (A17), and its optimal solution is thus $p_{k,n,m} = 0, q_{k,n,m} = 0$. Note that the problem in (C10) is feasible only if $\frac{1}{h_{k,k,n,m}} \geqslant \min_{k' \neq k} \frac{1}{h_{k,k^{'},n,m}}$. For the problem in (C12), its structure is similar to the problem in (A20) and thus can be solved by the SCA method. Following the procedures for solving the problem in (A20), $p_{k,n,m}, q_{k,n,m}$ can be obtained iteratively until convergence, where at the $t+1$-th iteration, $p_{k,n,m}(t+1), q_{k,n,m}(t+1)$ is updated as

$$p_{k,n,m}(t+1) = \frac{N_0 B}{h_{k,k,n,m}} \left(\frac{\omega_k \frac{h_{k,k,n,m}}{N_0 B}}{\mu_{m,k} \ln 2 + \frac{\omega_k}{N_0 B \min_{k' \neq k} \frac{1}{h_{k,k^{'},n,m}} + p_{k,n,m}(t) + q_{k,n,m}(t)}} - 1 \right)^{+}, \tag{C14}$$

$$q_{k,n,m}(t+1) = \max\left(N_0 B \left(\frac{1}{h_{k,k,n,m}} - \min_{k' \neq k} \frac{1}{h_{k,k^{'},n,m}} \right)^{+}, \right.$$
$$\left. \frac{\omega_k}{\mu_{m,k} \ln 2 + \frac{\omega_k}{N_0 B \min_{k' \neq k} \frac{1}{h_{k,k^{'},n,m}} + p_{k,n,m}(t) + q_{k,n,m}(t)}} - N_0 B \min_{k' \neq k} \frac{1}{h_{k,k^{'},n,m}} \right). \tag{C15}$$

The details for deriving (C14) and (C15) are omitted here for brevity.

Appendix D Proposed Online Algorithm

Algorithm D1 Proposed online algorithm.

Initialize: $\tau_{1,m}, \tau_{2,m}$.
repeat
  Initialize: $\boldsymbol{\mu}_m$.
  repeat
    Obtain $P_{n,m}, \forall n$ by (C5).
    for $n = 1$ to N **do**
      for $k = 1$ to K **do**
        Initialize: $p_{k,n,m}(0), q_{k,n,m}(0), t = 0$.
        repeat
          Obtain $p_{k,n,m}(t+1)$ and $q_{k,n,m}(t+1)$ by (C14) and (C15), respectively.
          $t = t + 1$.
        until $|p_{k,n,m}(t) - p_{k,n,m}(t-1)| \leqslant \epsilon$ and $|q_{k,n,m}(t+1) - q_{k,n,m}(t)| \leqslant \epsilon$ are satisfied simultaneously, where ϵ denotes the error tolerance.
        Calculate the objective function value in (C12) by letting $p_{k,n,m} = p_{k,n,m}(t), q_{k,n,m} = q_{k,n,m}(t)$.
        if the objective function value in (C12) is larger than 0 **then**
          Let $p_{k,n,m} = p_{k,n,m}(t), q_{k,n,m} = q_{k,n,m}(t)$.
        else
          Let $p_{k,n,m} = 0, q_{k,n,m} = 0$.
        end if
        Calculate the objective function value in (C9).
      end for
      Denote the user with the maximum objective function value in (C9) as k^*, and assign the subcarrier n to the user k^* by setting $p_{k,n,m} = 0, q_{k,n,m} = 0, k \neq k^*$.
    end for
    Update $\boldsymbol{\mu}_m$ using the ellipsoid method.
  until $\boldsymbol{\mu}_m$ converges to the desired accuracy.
  Update $\tau_{2,m}$ from (17) and $\tau_{1,m} = 1 - \tau_{2,m}$.
until the weighted sum secrecy rate converges to the desired accuracy.

References

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