Throughput-oriented Power Allocation Scheme Based on Convex Optimization for Cache-Enabled FiWi Access Network in 5G IoT Scenario

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*Abstract*—This paper presents an energy-saving wireless power allocation scheme based on convex optimization in cache-enabled FiWi access networks. Experiments indicate that the proposed scheme improves the global throughput when confronted with large-scale access terminal sets in 5G IoT scenario.

Keywords—FiWi access network, throughput, convex optimization

# Introduction

To cope with the demands brought by the numerous emerging applications such as autonomous vehicles and telemedicine, FiWi becomes the most widely applied access technology with the significant performance of long transmission distance and flexible access ability. In 5G IoT scenario, the sharp increase in the number of access terminals would put higher requirements on the throughput as well as energy consumption in FiWi access networks, which increases the difficulty of solving global optimal power allocation solutions.

The proper distribution of wireless transmit power for different access user devices has been proved to be a NPC problem and has caught the attention of many researchers [2]. The present researches are mainly focused on the wireless access domain [3, 4], which take advantages of several different dynamic programming algorithms and realize the breakthrough of throughput, compared with the fixed and manual assignment methods. However, the influence from the optical transmission domain has not been paid much attention in above studies. In addition, the state-of-the-art caching mechanism of FiWi access network is not fully utilized in giving more impressive achievements.

Motivated by the drawback above, convex optimization, which has the capacity of multi-objective optimization, is regarded to be suitable to involve the constraint from optical domain and caching mechanism into the solving process, in order to achieve a more optimal solution in power allocation.

In this paper, we propose an energy-saving power allocation scheme based on convex optimization (PA-CO) to improve the overall throughput in the scenario of massive access terminal sets in 5G IoT. The proposed PA-CO jointly considers the constraint imposed by optical domain and cache and dynamically adjusts the wireless transmit power distribution to achieve maximum throughput. Meanwhile, PA-CO has the ability to decrease power allocation latency because of the good convergence capacity of convex optimization algorithm. The experiments and simulations demonstrate that the proposed method can improve the total throughput to 91% with large-scale access terminal sets dramatically compared with the method based on fixed power assignment.

# Mathematical Formulation

In this section, we prove that the optimization problem of throughput in cache-enabled FiWi access network can be mathematically formulated as a convex problem in a global view. Therefore, it can be inferred that with a fixed caching file selection strategy, the solving of global optimal solution can be converted to the local optimal solution of power allocation in the wireless access domain.

The architecture of the cache-enabled FiWi access network considered in this paper is shown in Figure 1. Passive optical network (PON) is adopted in the ﬁber transmission domain. Signals are issued by optical line terminal (OLT) through the feeder ﬁber to an optical splitter, which is further connected to multiple optical-network unit-base stations (ONU-BSs) by distribution fibers.

As the interface of optical and wireless domains, each ONU-BS is cache-enabled. The ONU-BSs are indexed by a set *N*= {1, 2, ···, *n*, ···, *N*}. In the coverage area of ONU-BS*n*, the set of user equipment (UE) associated with it is denoted by *Φn*. We index UE by an index set *J* = {1, 2, ···, *j*, ···, *J*}. We assume that all the ONU-BSs in system adopt orthogonal frequency-division multiple access (OFDMA) to transmit data. For each sub-channel from *ONU-BSn* to *UEj*, the maximum bandwidth is denoted by *Pnj*, and the Rayleigh channel gain is denoted by *gnj*, which is assumed to follow the

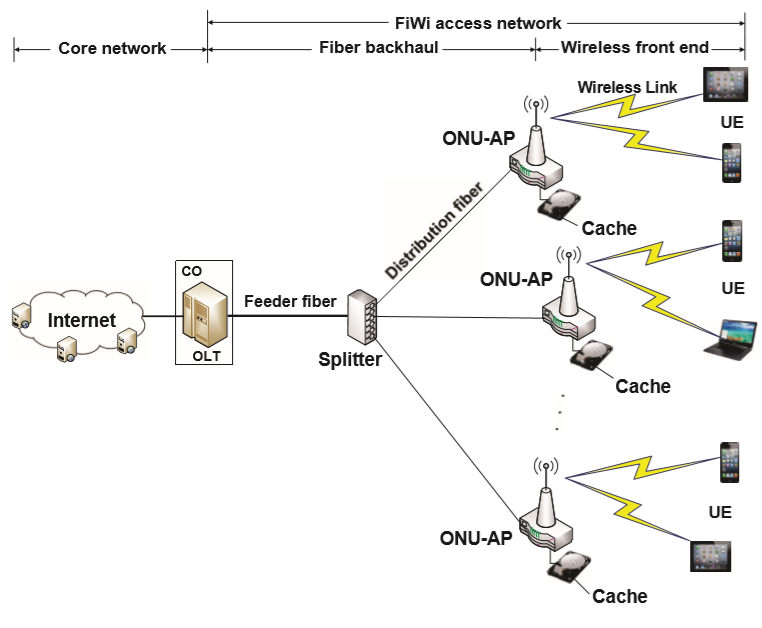


Figure 1. FiWi access network architecture with caches at ONU-APs

exponential distribution.

Let

|  |  |
| --- | --- |
|  | (20) |

then we have

|  |  |
| --- | --- |
|  | (21) |

which represents that when the allocated wireless transmit power is considered as an independent variable, the objective function of Problem P1 is decreasing and strictly concave.

Let

In the case of Problem P1, we have

The Lagrangian of P1 can be given as

|  |  |
| --- | --- |
|  | (18) |

where λ,µ ∈ , ∈are Lagrangian multipliers.

The KKT Conditions of Problem P1 is expressed as

where (8a) is a necessary condition for an optimal solution, (8b), (8c) and (8d) represent the complementary slackness, and (8e) represents the dual feasibility.

has three independent functions performed simultaneously. The first is caching mechanism. It means to store a certain number of files that may be requested by the UE in advance, which is designed to reduce the satisfaction delay on the UE side and to release the backhaul pressure of fibers. The second is the interaction mechanism with the core network. When the file requested by UE is not pre-cached, the ONU-BS requests and receives the file from the core network through fiber backhaul. The third is the interaction mechanism with UE. The ONU-BS performs photoelectric conversion and transmits wireless signals carrying different files to different UE under its jurisdiction.

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# Conclusion

put in cache-enabled FiWi access network can be mathematically formulated as a convex problem in a global view. Therefore, it can be inferred that with a fixed caching file selection strategy, the solving of global optimal

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*a**b* 

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