Utility Maximization for Resource Sharing in Mobile Edge Computing

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Abstract

Mobile Edge Computing (MEC) is a technology to provide Cloud Computing nearby end-users as the edge network. In this paper, we propose a framework for resource sharing between multiple service provider to improve the performance of MEC. Firstly, we introduce scenario of the resource sharing in MEC. Secondly, we proposed a framework to maximize social benefit and fairness of each agent in the network. Then, we design heuristic optimization for solving the maximization problem of social utility.

1. INTRODUCTION

Smart devices such as mobile phone, wearable device has become an indispensable part of people's daily life [1]. Nowadays people are using smart devices not only for communicating, working, text, also entertainment, and running many complicated applications such as video analysis, Virtual reality, or Augmented reality, etc., Many smart devices has run out of the resource because of heavy computation task which required more resource than current device have. In order to solve this problem, many authors have proposed to offload solution [2], [3]. By using offloading service through Cloud server, the outage problem is solved but faced delay problem. The central cloud is far away from the end-user and the bandwidth always low. It affects the performance of task completion. Therefore, a distributed approach is preferable than central cloud server. MEC is one of the distributed approaches that allow end-users to offload computation, data etc., MEC provides computation, communication, and storage to end-user with low latency, low cost, and efficiently. The deployment of MEC is at the edge of the network. It extends the central cloud proximity to the end-user [4]. By using MEC, offloading service can be improving accuracy, quality of service, and reduce delay. There are several works focused on data offloading but most of them are compatibility with the cellular network [5], [6]. However, the popularity of devices is growing with double-digit has led to the exponential data offloading which exceed the capabilities of MEC [4]. The model of resource sharing is proposed to avoid this changeling. Resource sharing has been efficiently solution to avoid overload in many research [2], [3], [4]. In this paper, we introduce the resource sharing in Mobile Edge Computing, which allows one

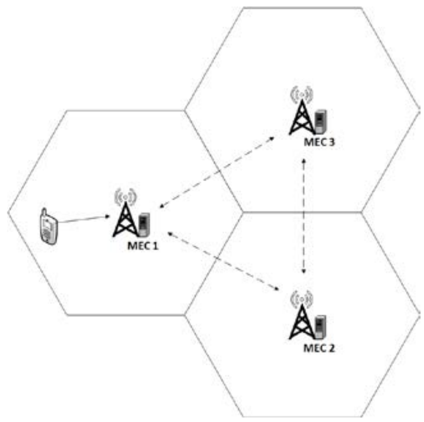

Figure 1. System model

MEC used resource available from its neighbors. The resource here is considering as computational, memory, storage, and network. In which, multiple MEC belong to multiple SP have different amount of demanding. Some of the MEC has run out of resource because of huge demand from its users. On the other hand, some MEC is less user connected and have idle resource to share.

2. SYSTEM MODEL AND PROBLEM FORMULATION

In this section, we will introduce the system model and problem formulation of resource sharing in MEC. In this system model, we consider a set of mobile users and a number of MEC server belong to different Service provider(SP). Each user can only communicate with its SP's MEC server. On the other hand, each SP can share resource with each other. For example, MEC 1 belong to SP A, and MEC 2 belong to SP B, with some constraint SP A can exploit available resource from MEC 2 to served its subscriber. And when a mobile user has a task to offload. It will send offloading demand to its service provider. The computational can be considered as a heavy task like image processing, or video rendering, etc., which required more resources and power to complete. However, the limitation of physical resources, or battery capacity does not support to accomplish the task or accomplish in weak performance. Then it is better to use offloading service. On the MEC server side, the more demand from UEs will exceed its capabilities. The SP need to decide whether to offload nearby MEC from the other MEC server or Cloud Server. Then the problem can be separate in two phases: the first phase is UEs and its SP, the second phase is among the SP. In the Fig. 1 user A has demand to offload but exceed its SP MEC 1. The MEC 1 will decide to offload nearby MEC of the other SP such as: MEC 2, MEC 3. In the first phase, the end-users will make a decision whether to offload or not. By calculation its utility by using offloading service. In this phase we will design an optimization based on the condition of execution time, the cost of offloading, and the total utility of the system to get an optimal solution for the UE side as well as the MEC side. In the second phase is the problem of resource sharing among MEC. Each MEC have a policy to sharing resource like: payment for each unit of resource, sharing capacity, etc., and served its subscriber. Whenever both phase is not available the task offload by user will forwarded to central Cloud server. Then our objective is combined of two different part: maximize the utility of task offloading, balancing the resource sharing among MEC. Let N_m is the set of users belong to SP m, e.g. m=1 is the set of user belong to SP 1. Each $i \in N_m$ has a computation task to offload define as $T_i = \{s_i, t_i, p_i\}$, where s_i is the size of task, t_i is the worst time execution, and the budget of incentive payment p_i . We assume that among the MECs, there are some MEC have available resource to share for the other that exceed capability because of the dense user denoted as $\beta = \{1,2,\ldots, B\}$ and a set of MEC that over resource is $\kappa = \{1,2,\ldots, K\}$ such that $\beta \cap \kappa = \varnothing$. We then formulation problem as follow

$$\max: \sum_{i=1}^{N}\sum_{b=1}^{B}\left(f_i(T_i) - f_{ib}(T_i)\right) + \sum_{b=1}^{B}\sum_{k=1}^{K}\left(f_{bc}(T_b) - f_{bk}(T_b)\right) \quad (1)$$

$$s.t.: \quad c_m(T_i) \le p_i, \quad (2)$$

$$\Pi(T_i) \le \Gamma_b, \quad (3)$$

$$\Pi(T_b) \le \Gamma_k, \quad (4)$$

$$\eta(T_i) \le t_i, \quad (5)$$

$$(2),(3),(4),(5) \forall i \in N, \forall b \in B, \forall k \in K$$

The constraints number (1) is represented for the payment under user’s budget. The second constraint is guarantee the computational offload compatible with MEC resource capacity. Where the $\Pi(\bullet)$ is the mapping function from computation to resource capacity. The constrain number (5) is the quality of services that executing time always less than worst case execution. The objective function is maximizing utility for end-use as well as MEC server. The optimization problem is non-convex, non-smooth, and NP-hard then we proposed a heuristic solution to solve.

3. EVALUATION

In this section, we will propose a heuristic solution for the optimization and simulating the results by using numerical method.

Algorithm 1: Maximizing total utility(MTU)

1. *Initial information for any N, β, and κ*
2. *Calculate the objective (1) by random selection*
3. *Compare with current solution by random another selection.*
4. *Project the solution to constrain (2), (3), (4)*
5. *The algorithm will stop when the total utility does not change when new selection has come.*
6. *Return results.*

For the simulation set up, we use the cost function as follow [2], and generate a virtual network follows the Fig. 2. Number of SP is 3, user is 100.

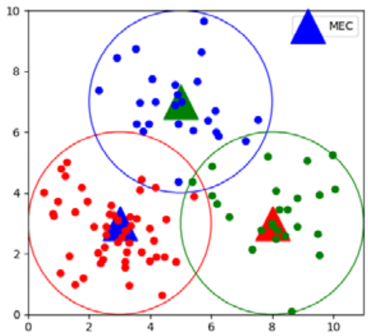

Figure 2: Network setup

In the Figure 2, the simulation result shown that the proposed algorithm has achieved better utility than greedy algorithm. But in this algorithm the worst case become exhausted search. In the future we will improve more to reduce the complexity.

4. CONCLUSION

Resource sharing can help the offloading service reduce the overload, improving quality of service. It will fulfill the MEC utilization. This study shows us a novel model for resource sharing in MEC. Simulations have shown that proposed scheme significantly enhances the performance and achieves higher utility than greedy method. Finally, improving performance of algorithm is required. Currently, it is just a heuristic approach and the worst case till exhausted search.

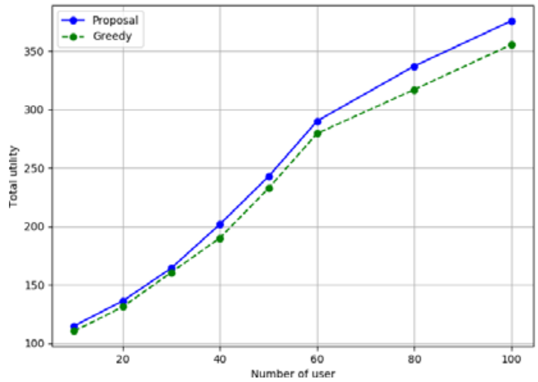

Figure 3: Total utility

5. ACKNOWLEDGEMENT

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