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Time-to-Think: Optimal Economic Considerations in Mobile Edge Computing

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***Abstract*—In this poster, we study the problem of maximizing profit level and minimizing network price for Mobile Edge Computing platform, while proposing an optimal economic model. This exposes the tradeoff between profit level of network operators and network price of Edge Users (EUs), which is captivated by both the operators and EUs, and allows the operator to handle an optimal economic specification design. We consider the problem of maximum profit with minimum network price problem (MPP) as optimization problem, and present heuristics to obtain the upgrade series optimally. Preliminary outcome presents that the proposed model increases the profit level by 20 % and reduces network price by 30% compared to general edge and cloud platform.**

I. Introduction

Due to rapid growth of wireless technologies and mobile computing, Mobile Edge Computing (MEC) provides an important platform for Internet-of-Things and other applications [1], [2]. MEC assists to improve the profit levels of both mobile network operators and edge-users (EU) by increasing the utilization of available resources and decreasing the network price. The MEC standard introduces the efficient and unique integration of between the virtualization function of cloud computing platform and mobile access network [3]. The evolution of MEC bridges the cloud computing capabilities nearer to mobile edge devices. This type of integration efficiently brings down the core centralized computational power to mobile edge. As mobile devices operate at the close proximity of the MEC platform, it enables low-latency and higher bandwidth utilization for different real-time applications and services. The MEC platform efficiently analyzes the real-time service with minimum network price and service delay. In MEC, the most important and essential problem is where and when to offload the services from mobile edge devices. To offload the online services, the mobile devices generally invest their individual resources, such as, communication and computational power, and exhibit themselves to probable security and privacy threats by disseminating their individual information. Therefore, the mobile devices would not be involved in offloading their computational services, unless they gain a fulfilling profit and reward to remunerate their computational power consumption and possible privacy violation. Hence, it is requisite to model an efficient incentive offloading scheme to achieve the maximum involvement from mobile edge devices, while providing maximized profit. Therefore, the MEC platform lacks an optimal economic model with minimum pricing abstraction or agreement. As the present models are not adaptive to the changing behavior of the network conditions and also the priority levels of different real-time applications. To overcome this limitation, we propose an optimal economical model for MEC. However, this is one of the preliminary work of designing an optimal economic model for MEC.

II. Optimal Economic Model

We now present an optimal economic model for MEC as shown in Figure 1. MEC platform primarily rely on Mobile Edge Severs (MES) to orchestrate the resource utilization. To maximize the resource utilization, the MEC server needs to frequently update the data offloading price $\mathcal{P}_{off}^{t}$ and profit model $\mathbb{P}_i$ as the network conditions change in terms of traffic flows $I_{ij} \in (0, 1)$. As it provides an efficient synchronous feature, therefore the updated economic policy is resulted into significant development in network price and profit level. The

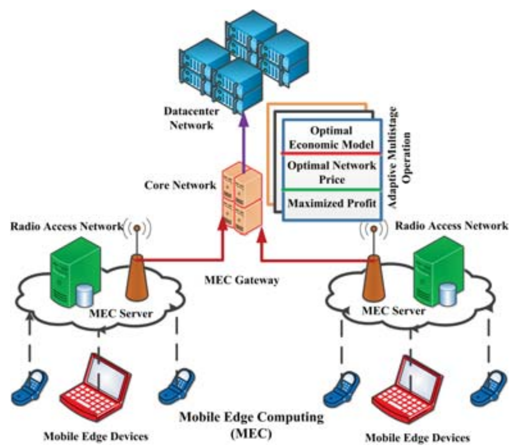

Figure 1: Optimal economic model for MEC

present model strives to find an optimal data price policy through numerous stages, each of which promises that there may exist individualistic flexibility in pricing policy based on the network conditions. This approach allows the network to utilize its full functionalities, which necessitates resolving a sequence of Linear Programming (LP) with profit and scalability challenges. As each MEC updates its pricing policy adaptively with change in network conditions, the transition of data pricing policy from the initial to final stage may result in increase of profit margin. Here, the profit level of EUs is designed based on Quality-of-Experience of EUs.

III. Optimization Model

Problem Formulation: We present an optimization model to provide optimal price and profit both for EUs and MES, where the MESs are connected to heterogeneous data

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centers. Basically, the optimization program aims to determine optimal price for N EUs with different priority levels based on their applications. Such that the maximum profit can be achieved during the process of data and computational offloading. We model the optimal profit model for MEDs with different priority levels as constraints so as to reduce the overcharged policies. The formulated as a joint optimization problem for economic model in MEC, which is:

$$\text{Minimize} \overbrace{\sum_{t\in\mathcal{T}}\sum_{i=1}^{N}\mathcal{U}_i^t}^{\text{utility value}} = \sum_{t\in\mathcal{T}}\Bigg[\overbrace{\sum_{i=1}^{N}\sum_{j=1}^{M} I_{ij}\frac{\beta_i^t}{\beta_{max}}(\frac{\mathbb{T}_i^e-\mathbb{T}_i^s}{\mathbb{T}_i^e})}^{\text{traffic execution price}} \tag{1}$$

$$+\underbrace{\sum_{i=1}^{N}\sum_{j=1}^{M}(\mathcal{P}_{off}^t I_{ij}}_{\text{data offloading price}} + \underbrace{\sum_{i=1}^{N}\mathcal{P}_O^t I_{ij})}_{\text{other prices}} - \underbrace{\sum_{i=1}^{N}\frac{\mathbb{P}_i^t}{\mathbb{P}_{th}^t}}_{\text{profit model}}\Bigg],$$

$$\text{subject to} \quad I_{ij} \geq I^{th}, i\in N, j\in M, \tag{2}$$

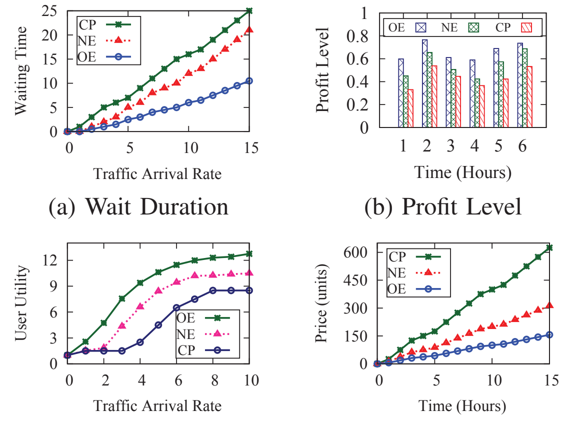
$$\sum_{t\in\mathcal{T}}\mathcal{P}_{off}^t \geq \mathcal{P}_{off}^{th}, \mathcal{P}_O^t \geq \mathcal{P}_O^{th}, \tag{3}$$

$$\mathbb{P}_i^t \leq \mathbb{P}_i^{th}, i\in N, t\in\mathcal{T}, \tag{4}$$

where M denotes the number of MESs, $\mathcal{P}_O^t$ denotes the other pricing factors like hardware price and datacenter management price, $\mathbb{T}_i^s$ and $\mathbb{T}_i^e$ denote traffic execution start and end time respectively, and β_i^t and β_{max} denote the actual and maximum scaling factor respectively. Equation (1) represents the joint optimization problem of the economic model. The traffic flows I_{ij} is to be greater than the threshold traffic flow as shown in Equation (2). Equation (3) represents the offloading price $\mathcal{P}_{off}^t$ is be greater than the threshold price $\mathcal{P}_{off}^{th}$. Equation (4) represents the profit model $\mathbb{P}_i^t$ is to be lesser than the threshold profit model $\mathbb{P}_i^{th}$. $\mathbb{P}_{th}^t$ denotes threshold profit.

***Algorithm Design and Implementation**:* Specific to the designed integer program, we try to model an efficient heuristics for MPP. Here, we present an optimal profit model for network operators based on the QoE of EUs. This only needs resolving one LP and which provides less complexity than normal MEC platform (NE) and cloud platform (CP). We further propose an optimal economic model (OE), which improves upon the result of total network price and profit level of network operators. We model a prototype for our algorithms using CloudSim [4] for the performance improvement. We run our framework on a system with an Intel core-i5 processor, 1.7 GHz CPU. We also adopted same kind of environment in [5]. We assume that MESs charge their optimal data unit prices for $7/GB$ and unit discount price $2/GB$ for 72 hours of usage. We also consider the maximum traffic is 20 GB and traffic arrival rate of 5 Mb/s. The origin and destination of flows are considered random in nature. The default bandwidth is set to 24 Mbps and the average waiting time is set to be 20 s. The bandwidth utilization is 10 Mb with 1 ms service delay and queue size is 1 Mb.

***Preliminary Results**:* We study the optimal network price of EUs and profit level of network operators using the proposed framework. Figure 2(a) presents the wait duration of executing real-time services with variation of different data traffic flows. OE can effectively decreases the waiting duration



(a) Wait Duration (b) Profit Level

(c) Utility (d) Price Charged

Figure 2: Analysis of optimal economic model

by 12% and 8% compared to NE and CP. Furthermore, Figure 2(b) shows the profit level of network operators using OE increases by 10% and 25% than NE and CP, which increases with the variation of time. Figure 2(c) shows the user utility for edge devices, where OE outperforms both NE and CP by around 3% and 6%. On the other hand, we focus at network price, it is described as the total price incurred for different operations perform on MEC and reconfigured the prices based on the network conditions from the first to last stage. We see from Figure 2(d) that OE is nearly 30% than NE and CP. The existing NE and CP schemes are not adaptive to the changing behavior of network conditions and also priority levels of different applications.

IV. Conclusion

Here, we considered the problem of maximizing the profit level of network operators and minimizing the network price for EUs during service period. We proposed an efficient heuristic algorithm to model the optimization. Initial results show that our proposed model provides maximized profit level and minimized network price. Detailed studies of the rigidity of the proposed problem and the approximation limits of algorithms are left as future work.

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