A Survey on Trajectory Optimisation and Joint Resource Allocation for Multi-UAV-Assisted Multi-Access Mobile Edge Computing

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Abstract—

We have a vast range of search possibilities available to us in the modern world, making it challenging to choose what we actually need. The suggestion system is essential in addressing these issues. A recommender system is a framework that filters data using a variety of algorithms and then recommends the user the information that is most pertinent to them. Systems for recommendations are useful customisation tools that are frequently current and based on the preferences of current customers. These systems have proven to be quite beneficial in a variety of e-commerce, educational, entertainment, media, book, film, and product-related fields. This study examines a variety of recommendation techniques, their benefits and drawbacks, and several performance metrics. We have read a number of articles, evaluated their methodology, important aspects of the algorithm used and possible directions for future research.

Keywords: collaborative, hybrid, content-based, recommendation system, machine learning.

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I. INTRODUCTION

The Internet of Things (IoT) is an emerging technology that enables the connection of different devices, sensors, and actuators to the internet. This technology has enabled the creation of smart homes, smart cities, and Industry 4.0. One of the key challenges in IoT systems is resource allocation and trajectory optimization. Resource allocation involves the allocation of computing, storage, and communication resources to different IoT devices to optimize performance, while trajectory optimization involves the optimization of the path followed by an IoT device to achieve a specific goal. In this paper, we will discuss Trajectory optimisation and joint resource allocation in IoT systems.

Both "smart" and the Internet of Things are utilised. Because it is intelligent, it is used in many different industries, including smart homes, smart surroundings, smart cities, shopping, hospitals, and many more, as shown in Fig. 1. It can experience security, data storage, privacy, and other difficulties because it has uses in many different businesses. Allocating resources is a big challenge. As the IoT expanded into heterogeneity (the ability for numerous devices with different interfaces to interconnect), resource allocation became a critical problem in the IoT ecosystem. This study discusses the problem of resource allocation in the IoT.

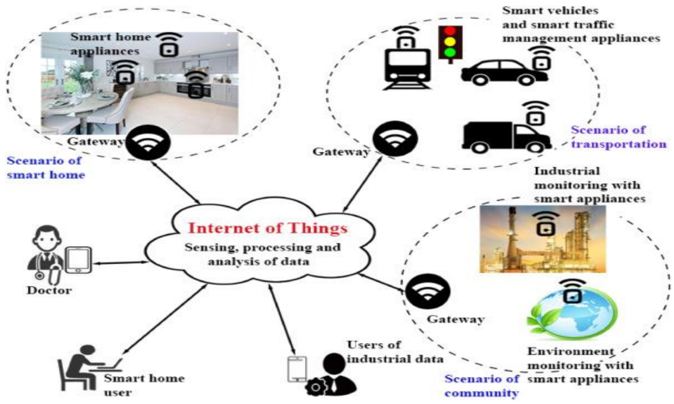

Figure 1. The IoT situation right now

II. LITERATURE SURVEY

A UAV-Enabled MEC

Recently, the UAV-enabled MEC network has been extensively investigated [13]–[19]. Considering the low-power ground IoT devices and the limited onboard energy storage of UAV, it is of great importance dedicating to the energy consumption minimization problems in the UAV-enabled MEC networks. To this end, X. Zhang et al. in [13] propose an efficient iterative algorithm to jointly optimize the trajectory design and resource allocation aiming to minimize the weighted sum energy consumption of users and UAVs in the UAV-enabled MEC system. Considering the stochastic offloading scheme, J. Zhang et al. in [14] adopt the Lyapunov optimization technique to optimize the same objective. Simulation results show that the proposed scheme can save more energy compared with that only considering the energy consumption of users. In addition, compared with the scheme that only minimizes the energy consumption of UAV, more backlogs of the task queues can be processed by tasking both the energy consumption of users and UAV into consideration.

Furthermore, by simultaneously considering the amount of completed task bits and energy consumption, the energy efficiency problems in the UAV-enabled MEC are investigated in [16]–[18]. To be specific, the energy efficiency of smart mobile devices (SMDs) in a multi-UAV assisted MEC system is investigated in [17], where an iterative optimization algorithm based on the Dinkelbach's method is proposed to tackle the formulated fractional programming problem. Different from [17], The UAV's energy efficiency is maximized in [16] jointly enhancing the UAV trajectory, the user transmit power, and computation load allocation. Moreover, the node mobility estimation has been adopted in [16] to design a proactive UAV trajectory when the knowledge of user trajectory is limited, which offer valuable insights on UAV optimal trajectory design for providing on-demand edge computing service for remote IoT nodes.

B. RIS-Assisted Networks The general definition of RIS is first given in [20]. In order to realize the vision of smart radio environment (SRE), RIS is regarded as a key enabler, which has received increasing research attentions from both industry and academia. For example, NTT DOCOMO designs a kind of smart glass, which can dynamically control the response of the impinging radio waves. Another practical example of RIS is called RFocus, which is designed by Massachusetts Institute of Technology (MIT), USA [21]. The elements of RFocus can adjust the reflect signals toward specified direction and locations. Although the smart glass and RFocus have provided some design insights for the development of RIS, the research of RIS is still at an early stage [22]. In academia, aiming to theoretically exploiting the benefits of RIS, there are much literature dedicates to the optimization problems in the RIS-assisted networks. For instance, in the RIS-assisted MEC networks, during a given mission period, the total completed task-input bits is maximized in [23]– [25]. From the simulation results, it can be observed that the computational performance of the MEC system is greatly improved with the aid of RIS. In order to minimize the energy consumption of all users in the RIS-assisted MEC, the phase shift, size of transmission data, transmission rate, power, transmission time and the decoding order are jointly optimized in [26]. Besides, the latency minimization and energy efficiency maximization problems in the RIS-assisted MEC are investigated in [27] and [28], respectively. In the RIS-assisted UAV networks, the RIS can be deployed for overcoming the blockages and enhancing the achievable rate. To this end, in [29], the sum rate of users in the downlink is maximized by jointly optimizing UAV's trajectory, the phase shift of RIS, the allocation of THz sub-bands, and the power control. As expected, the largest sum rate is achieved by the proposed joint optimization algorithm. In addition, in order to guarantee the secure communication between the UAV and the legitimate user, the average secrecy rate is maximized by an iterative algorithm in [30]. Similarly, the secure transmission problem is investigated in the UAV and RIS assisted mmWave networks, where the near-optimal positions of RIS and UAV are obtained by an exhaustive searching method [31]. Besides, in order to overcome the highly dynamic stochastic environments and reduce the computational complexity, the machine learning (ML) approaches have been utilized in the RIS assisted UAV networks. For instance, in [32], a decaying deep Q-network (D-DQN) based algorithm is proposed to minimize the energy consumption of the UAV by jointly optimizing the phase shift of RIS, UAV trajectory, decoding order, and power allocation. Simulation results show that the proposed D-DQN algorithm can strike a balance between accelerating training speed and converging to the local optimal, as well as avoiding oscillation. Furthermore, with the aim to maximize the energy efficiency of the UAV, the joint trajectory-phaseshift problems are tackled by the Double DQN (DDQN) and Deep Deterministic Policy Gradient (DDPG) algorithms in [33]. It can be seen that the the energy effectiveness of UAV is able to be greatly improved with the aid of RIS.

Resource Allocation

The area of resource allocation in IoT has seen a lot of research. Different researchers had provided various reviews and distribution methods. Some had provided a method for a hybrid resource allocation technique in a network, while others had employed scheduling algorithms for dynamic allocation. Different perspective of researchers has been explained below: Krishnapriya.S, Jobby P.P, 2015 [16] – Both "smart" and the Internet of Things are utilised. Because it is intelligent, it is used in many different industries, including smart homes, smart surroundings, smart cities, shopping, hospitals, and many more, as shown in Fig. 1. It can experience security, data storage, privacy, and other difficulties because it has uses in many different businesses. Allocating resources is a big challenge. As the Internet of Things (IoT) expanded into heterogeneity (the ability of multiple devices with different interfaces to interconnect), resource allocation became a critical problem in the IoT ecosystem. This study discusses the problem of resource allocation in the IoT.

Y. Choi, Y. Lim, 2016 [17] – cites resource management as a significant obstacle to IoT cloud computing. Meeting a user's Service Level Agreement (SLA) is the key concern with resource allocation in the CC.A SLA is characterised as a QoS agreement between a service provider and an end user. So, it suggests a winner determination technique in order to boost the providers' profit and lessen the SLA violation limits. It demonstrates that this mechanism produces much better results than ones that are presently in place. J. Li, Q. Sun, G Fan, 2016 [18] – Researchers covered methods to increase network utilisation in this report. The growth of IoT has a significant impact on network performance because more and more devices are connecting to the internet every day. Therefore, LTE-based IoT communication is used for uplink scheduling in order to guarantee better network performance. It suggests a resource allocation strategy for an uplink SC-FDMA that is QoS limited. Finally, a simulation model is employed to demonstrate how this technique enhances network data rate performance. Y. Viniotis, A. Singh. 2016 [19] – IoT message broker service definition. It functions as sort of a sender-to-receiver intermediate module and is controlled by SLA. SLA does not provide any more information about the message other than its volume. Researchers had introduced a brand-new, two-step SLA approach in this. Although it is comparable to the current one, it also gives providers more power to enforce it. Additionally, they looked at the simulation results to see if the suggested solution agreed with the current one and they also analysed other system parameters. I. Avgouleas, N. Pappas, Di Yuan, E. Fitzgerald, V. Angelakis, 2016 [20] – In this article, the author names an issue known as Service to Interface Assignment (SIA). According to this, it gets more challenging to assign services to each device with diverse and non-exchangeable resources as the number of IoT devices grows and they all employ various technologies. A mathematical approach known as Mixed Integer Linear Programming (MILP) is suggested to resolve this issue. This demonstrates that the entire cost of employing interface resources has decreased along with the need for worth service. M. Dong, K. Ota, G. Wang, Z. Zhou, L. T. Yang, 2016 [21] In this study, efforts are made to prevent energy loss and to preserve the quality of service, both of which are impacted by network communication. Device-to-device (D2D) communication makes it possible to create connection between user equipments. In this paper, the D2D architecture is also defined. Its main goal is to have the best throughput and service. But interference and spectrum reuse lead to a decline in service quality. A hybrid resource allocation mechanism built on the Cloud Radio Access Network (C-RAN) has been provided to address this issue. In order to ensure QoS, it also included a centralised interference mitigation mechanism. It happens in the baseband unit pool. The outcome of the simulation verifies the algorithm's effectiveness.

RECOMMENDATION SYSTEM TECHNIQUES

Resource Allocation:

Resource allocation in IoT systems involves the allocation of computing, storage, and communication resources to different IoT devices. The goal of resource allocation is to optimize the performance of the IoT system while minimizing the use of resources. Resource allocation in IoT systems is a challenging problem because of the large number of IoT devices and the heterogeneous nature of the resources. One approach to resource allocation in IoT systems is to use machine learning algorithms. Machine learning algorithms can learn the resource usage patterns of IoT devices and allocate resources accordingly. Another approach is to use optimization algorithms to allocate resources. Optimization algorithms can find the optimal resource

allocation that minimizes resource usage while maximizing performance.
Under resource allocation, there are four primary tasks., shown in Fig 2. Planning, task mapping, task scheduling, and communication scheduling are all included.

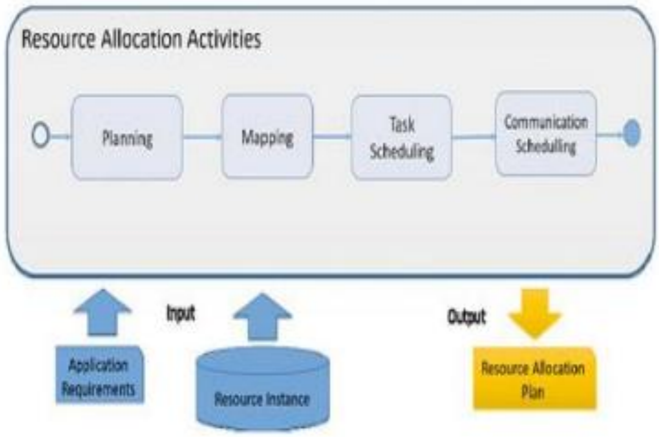

Figure. 2 Resource Allocation Activities

a) Planning: It is the initial step in the resource allocation process. This phase involves assessing the entire IoT ecosystem to see whether the resources are adequate for the application. The planning step determines which task is assigned to a certain tyre together with the necessary resources because IoT consists of numerous tyres [7].
b) Task Mapping: Task mapping is the next phase of resource allocation. Each node in this is given a specific task to complete, and occasionally nodes combine to complete a single task. Task duplication should be avoided.
c) Task Scheduling: Task scheduling comes next after task mapping. It is important for resource allocation. The ideal order for resource allocation is found through scheduling with consideration for time constraints [13]. To reduce waiting time, it chooses which task should be completed first.
d) Communication Scheduling: The scheduling of communication is the last stage of resource allocation. It is carried out for the task execution activities on the communication channels [14]. Effectiveness is required in order to make use of the proper channel capacity.

Resource Allocation Needed

Millions of smart things make up the IoT ecosystem, and resource allocation is necessary for these smart objects to successfully communicate and function. Reasons for allocating resources include: a) Resource allocation must be done in order to preserve Quality of Service (QoS). b) To control the system's peculiarity so that it does not compromise its dependability. c) To cut down on the amount of time devices sit idle as they wait for a resource to be allocated. d) To ensure proper resource utilisation and dynamic resource scheduling [15]. e) To cut back on energy usage

Trajectory Optimization:

Trajectory optimization in IoT systems involves the optimization of the path followed by an IoT device to achieve a specific goal. The goal of trajectory optimization is to optimize the path followed by an IoT device to come to a specific goal while minimizing the use of resources. One approach to trajectory optimization in IoT systems is to use machine learning algorithms. Machine learning algorithms can learn the optimal path followed by an IoT device to achieve a specific goal. Another approach is to use optimization algorithms to optimize the path followed by an IoT device. Optimization algorithms can find the optimal path that minimizes the use of resources while achieving the goal.

III. PROPOSED SYSTEM

IOT are small devices which sense data from it nearby environment and report to centralized server from further processing and this IOT can be anything like smart phones, sensors or any other devices which runs on battery and perform communication using internet. Due to limited battery this IOT cannot perform heavy computation task and need to offload this heavy computation task to nearby Mobile Edge Computing networks, if this edge network far away then IOT cannot offload task to edge servers. To overcome from this issue UAV (Unmanned aerial vehicle) was introduced which moves on fixed altitude nearer to IOT locations so IOT can easily offload to nearby UAV to get processed result.
All existing techniques were using SINGLE ACCESS UAV where all IOT will send or offload task to single UAV which leads to more energy consumption and get more delay in response.

To overcome from above issue author of this paper employing Multi UAV Assisted Mobile Edge Access where single IOT can offload task between multiple UAV and those UAV will process task and send result back to IOT. Here by diving task between multiple UAV and selecting only those UAV which are free for communication can reduce energy consumption and can get response faster.

In propose multi-UAV-assisted multi-access MEC model by allowing each IoT user to offload task bits to multiple MEC servers deployed at UAVs simultaneously for parallel computing, whichcan effectively reduce the energy consumption of users and UAVs. The weighted sum energy consumption of UAVs and usersis minimized by jointly optimizing the bit allocation, transmit power, CPU frequency, bandwidth allocation and UAVs' trajectories. Due to the non-convexity of the formulated problem, it is decomposed into two sub-problems and a joint resource allocation and trajectory design algorithm is proposed by alternative optimization.

Following modules are used to offload task

1)Communication Model: using this module vector will be created with values 0 and 1 and if user offloading task then vector will be filled with 1 else 0 and by using this vector system can know communication load on each UAV

2)Computation: to ensure all user/IOT task must be computed so Mobile EDGE CPU frequency will be assigned to each IOT request

3)UAV Model: using this module UAV will move from fixed altitude location and by using this locations IOT will find nearer UAV for task offloading

4)Joint Resource Allocation and Trajectory Optimization: Based on vector of load the resource will be jointly allocated between multiple UAV'S. Each IOT will optimized UAV trajectory (movement) by analysing vector load.

To implement this project we have designed IOT UAV simulation which consists of following modules.

1) Generate IoT Network: using this module we will create virtual IOT and UAV devices. Each UAV will move from its location to another location to receive offload request from IOT devices
2) IoT Task Offloading: using this module we can select any IOT which will offload task to multiple nearby UAV'S which will process request and send result back to IOT. For each request energy consumption will be calculated based on single and multiple UAV access
3) Energy Graph: using this module we will plot energy consumption graph between existing single UAV access and propose multiple UAV access.

IV. Conclusions

Resource allocation and trajectory optimization are two key challenges in IoT systems. Resource allocation involves the allocation of computing, storage, and communication resources to different IoT devices to optimize performance, while trajectory optimization involves the optimization of the path followed by using an IoT gadget achieve a specific goal. Machine learning and optimization algorithms can be used to address these challenges. These algorithms can learn the usage patterns of IoT devices and optimize the allocation of resources and the path followed by IoT devices. Future research should focus on developing more efficient resource allocation and trajectory optimization algorithms for IoT systems.

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