UAV ASSISTED MEC

A PROJECT REPORT

Submitted by

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CERTIFICATE

Certified that this project report titled “**UAV ASSISTED MEC**” is the bonafide work of “**JIBON KUMAR BORGOYARY [Roll No:GAU-C-17/276], GOBINDA MALAKAR [RollNo:GAU-C-17/255], NICHOLAS BASUMATARY [RollNo:GAU-C-16/254], BRUNO LYNGDOH BORO [RollNo:GAU-C-16/244], PARTHA PROTIM BORAH [RollNo:GAU-C-17/L-402]**”, who carried out the project work under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

The rapid growth and demand of Internet of Things (IoT)(Internet of Things) devices and technologies are demanding more and more computation. As the technology is advancing the demand for real time data and fast computation is required. This is achieved by pushing the servers to the edge of networks and is called Edge Computing. But Edge Computing is not capable of handling the versatile demands of computation. So to further improve the Quality Of Service a more versatile architecture is required which is Mobile Edge Computing assisted with Aerial and other mobile objects capable of providing service. But the moving object has limited battery capacity hence when it visits the nodes it loses some amount of energy. By placing some charging points, we tried to increase the service time of the Mobile Edge Server and designed an algorithm to find a path to serve all the IoT nodes in a particular area such that the Mobile Edge Computing (MEC) is never stuck in any area without sufficient charge to travel at all.

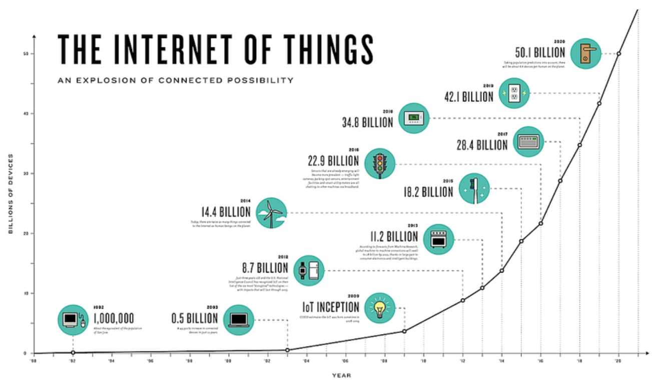

Figure 1: Graph Showing The Rapid Growth and Demand of IoT

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ABBREVIATIONS

MEC	Mobile Edge Computing
UAV	Unmanned aerial vehicles
IoT	Internet of Things
TSP	Travelling Salesman Problem

CHAPTER 1

INTRODUCTION

The rising computation-intensive applications are a unit triggering a revolution of mobile applications and may considerably improve the standard of expertise of mobile users. However, they impose a good challenge on devices that commonly have an occasional computation capability and finite battery capability. The evaluation of mixed reality(MR), augmented reality(AR), virtual reality(VR) and video analysis in mobile devices are vastly increasing but for limited computation Power and storage capacity they are facing so many issues. To resolve these issues MEC comes with a little computation power and storage capacity yet sufficient enough is deployed to serve edge devices with low or no computation and storage capacity at all. Especially in the IoT era MEC provides a great level of computing service to the billions of IOT nodes to be deployed. Seeing that most of the IoT nodes are power-constrained and with limited computation capability can offload the task to the MEC to expand the battery life and achieve a better computing efficiency. But some IoT nodes are placed in some challenging areas like hills, forests, deserts, mountains locations. In these scenarios MEC can't reach the IOTs. But MEC serves with mobility such as a Unmanned aerial vehicles (UAV) are the practical choice for some commercial applications due to their simplicity in deployment and low maintenance cost. The UAV is also capable of covering the area which was not covered by the Base Station.

As we know that the UAV has limited battery capacity and thus cannot provide service continuously so we put some charging stations within that particular area of service. The UAV enabled MEC can continue to provide service to the IoT nodes with the capability of charging while continuing its path. Here our aim is to find a path that covers all the IoT nodes in a designated area such that the UAV is never stuck in without sufficient charge to carry on its service.

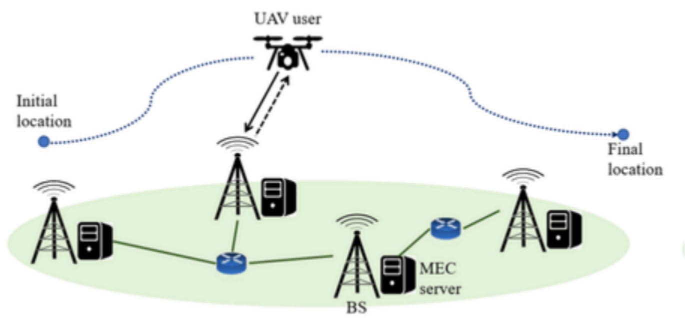

Figure 1.1: UAV assisted MEC with Charging Stations

CHAPTER 2

MOTIVATION

The evaluation of IOT devices is vastly growing. In the previous few years, numerous public and personal studies researchers began making an investment, a considerable quantity of sources for the development of human-friendly unmanned aerial vehicles (UAVs), or 'drones'. These gadgets right now observed a fantastic deployment within the society commencing an incredible quantity of recent possibilities as beneficial gear to deal with plenty of societal challenges, including agriculture and woodland analysis, figuring out belongings boundaries, surveying production sites or corridors for roads and railroads, flooding and coastal erosion assessments, constructing records management, catastrophe making plans and handling, surveys in far off or undeveloped areas, and the shipping of goods.The opportunities of digitalisation and technology improvement cope with societal demanding situations including making societal sectors and domain names extra ecosystem friendly, green and competitive.

Regardless of enormous Advancement in the field of Drones, they still rely on human supervision and have limited freedom of control and ability to complete only part of task's as mentioned above. This project will work on solving one of the major issues while operating an UAV i.e Longevity of the Batteries, by deploying multiple Charging Stations between it's area of Service. Such that The UAV does not die out on Batteries before reaching another Charging Stations, so that it can charge itself up Again and continue to provide its service for a longer time period.

CHAPTER 3

CHALLENGES IN UAV ASSISTED MEC

1. **Resource Allocation in Multiple-user Multiple-UAV Scenarios**

   Although several studies have been conducted in coming up with resource allocation schemes , those schemes were chiefly proposed for networks with either one UAV or one user. Since the operation time and battery of the UAV are restricted and usually an oversized variety of users ought to be served within the geographical coverage space, it's necessary however difficult to design economical resource allocation schemes for UAV-enabled MEC networks with multiple users and multiple UAVs. The matter of grouping users with UAVs is often associated with integer non-convex optimization drawbacks. Moreover, the trajectories of multiple UAVs ought to be conjointly optimized in order to expand the coverage space and improve the computation performance, creating the problem even tougher.

2. **Security Issues**

   To the most effective of our data, there are no studies on the security problems in UAV-enabled MEC networks. As mentioned previously, physical-layer security techniques pro- vide a promising direction or pursuit in UAV-en- abled MEC networks.

3. **Computation Efficiency**

   Since a UAV incorporates a limited energy support from battery, computation efficiency is of essential importance in UAV-enabled MEC networks. However, it's highly challenging to tackle the computation efficiency issues due to the noncompliant fractional forms, especially when the binary computation mode is considered.

CHAPTER 4

PROPOSED WORK

The work proposed have been elaborated in this section. Two Algorithms have been proposed to find a path for a UAV equipped with an MEC Server to cover an area in absence as well as in presence of time window. The IoT node devices with some bits of data to be calculated are distributed in the area and charging points have been distributed across the area. The Charging points are placed such that UAV can go to home or any IoT node either directly in one-go or through intermediate Charging point(s).

4.1 Conditions

1. All the positions of IoT nodes are none
2. All the positions of Recharging stations are none
3. All IoT nodes as well as Recharging stations are stationary
4. All IoT nodes as well as Recharging stations are within the area A x B
5. Maximum Computaion bits of each IoT node is 20-byte
6. The MEC Server always charges fully whenever it is in a Recharging station
7. The MEC server is always fully charged before starting its journey
8. MEC server uses fixed percent charge to compute 1 byte
9. MEC server uses fixed percent charge to travel 1 unit distance
10. MEC server can always move from a charging station to another directly in one go
11. MEC server have enough capacity to travel from atleast one charging station to the home/starting position in one go
12. Time taken to travel 1 unit distance by UAV is fixed
13. Time taken to charge 1% of max capacity is fixed
14. Time taken to compute 1 byte is fixed

4.2 Contribution-1

To find a path for a MEC server equipped to a UAV to cover a area of 100m x 100m with n number of IoT nodes and k number of Charging Stations (n » k) distributed across the area whose location area known. The path is such that the MEC Server returns back to the point from where it started and visited all the IoT nodes and recharge itself whenever necessary and its found using a greedy approach. There is no time window for providing service to the IoT node(s) and a single UAV can complete this task using the Algorithm-1.

4.2.1 Variables:-

VARIABLE NAME	MEANING
n	Number of IoT nodes
k	Number of Charging Stations
computing$_{energy}$	Charge used in % per byte computation
travel$_{energy}$	Charge in % used per unit dist travelled
max$_{bits}$	Assumed max computation bits in a node
station	List of Recharging Stations
path	Path or trajectory of MEC server
P	Current Position
P1	Nearest IoT node from P
S	Nearest Recharging station from P
S1	Nearest Recharging station from P1
C	Current Charge
C1	Discharge if path chosen is P to S
C2	Discharge if path chosen is P to S via P1
U	Unvisited IoT nodes
home	Initial and final position of MEC Server

Table 4.1: Variables and Parameters

4.2.2 Algorithm-1

Greedy algorithm to find the desired Path

Steps:

1. P = home , C = 100
2. If Current Position P is not a station then
    - Find nearest IoT-node from P (i.e. P1)
    - Find nearest Recharge station from P (i.e. S)
    - Find nearest Recharge station from P1 (i.e. S1)
    - If C > C2 then
        - goto P1
        - update charge C
        - store path
    - Else if C < C2 then
        - goto S
        - update charge C
        - store path
3. If P is at Recharging station then
    - Find nearest IoT-node from P (i.e. P1)
    - Goto P1
    - update charge C
    - store path
4. Continue 2 and 3 till all nodes are visited
5. G to the nearest Charging Station from home that can be visited from P
6. if C is not enough to return home
        - store path
        - update charge
    - else go to home directly and store path
7. Continue 5 till P is not home
8. End

4.3 Contribution-2

To find a path for a MEC server equipped to a UAV to cover a area of AxB with n number of IoT nodes and k number of Charging Stations (n » k) distributed across the area whose location area known. The path is such that the MEC Server returns back to the point from where it started and visited all the IoT nodes and recharge itself whenever necessary And every IoT node has its own time window in which it is available for receiving service from MEC server

4.3.1 Algorithm-2

Steps:

1. Sort the unvisited nodes according to initial time of window in ascending order in U.
2. If P == home (Current position is home)
   (a) If vehicle can go to node in U (before the window closes) and have enough charge left to visit a charging station after completing all the task at that node. Then go to U and remove that node from U.
   (b) If vehicle does not have enough charge to do step (2.a) but have sufficient time to do the above task.
   Then vehicle will check if it can visit to the nearest charging station from that node and complete the task at the given time. If it can be done then vehicle will visit that charging station.
   (c) If (2.a) and (2.b) can't be done then it means there are no more nodes left that can be visited in the given time. Store the path and repeat steps 1 to 5 with remaining unvisited nodes.
3. If P == station (Current position is station)
   (a) If vehicle can go to node in U (before the window closes) and have enough charge left to visit a charging station after completing all the task at that node. Then go to U and remove that node from U.
   (b) If vehicle does not have enough charge to do step (3.a) but have sufficient time to do the above task.
   Then vehicle will check if it can visit to the nearest charging station from that node and complete the task at the given time. If it can be done then vehicle will visit that charging station.
   (c) If (3.a) and (3.b) can't be done then it means there are no more nodes left that can be visited in the given time. And the vehicle will return home.

4. If P == node (Current position is a node)
   (a) If vehicle can go to node in U (before the window closes) and have enough charge left to visit a charging station after completing all the task at that node. Then go to U and remove that node from U.
   (b) If vehicle does not have enough charge to do step (4.a) but have sufficient time to do the above task. Then vehicle will check if it can visit to the nearest charging station from that node and complete the task at the given time. If it can be done then vehicle will visit that charging station.
   (c) If (4.a) and (4.b) can't be done then it means there are no more nodes left that can be visited in the given time. And the vehicle will return home.
5. Continue steps 2 to 4 until U is not empty (all nodes are visited)
6. End

CHAPTER 5

SIMULATION

Simulation of the Proposed work have been graphically shown in this section. And the information of the simulation environment have been included. The IoT nodes and Charging points are distributed in an area of 100m x 100m for simulation purpose.

5.1 System Used

Processor	Intel(R) Core(TM) i5-8300H CPU
RAM	8.00 GB DDR4
System type	64-bit Operating System, x64-based processor
OS	Windows 10
Programming language	Python 3.7
IDE	Spyder
GPU	NVIDIA GeForce GTX 1050 Ti GDDR5 4GB
Storage	1TB 5400 rpm Hybrid HDD (FireCuda) with PCIE NVME 128GB M.2 SSD

Table 5.1: system used

5.2 Simulation Results for Algorithm-1

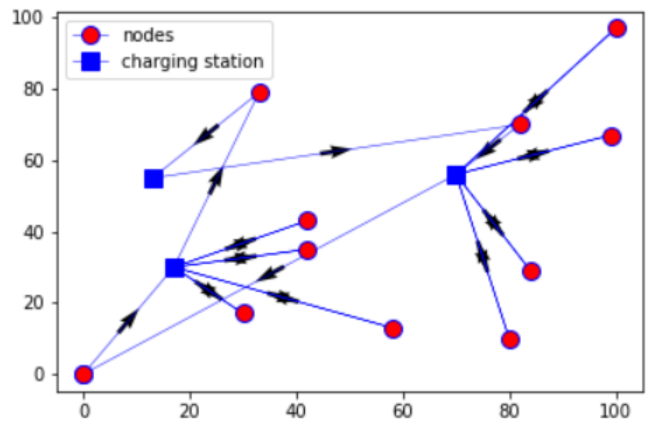

Figure 5.1: Simulation result 1

No. Of Nodes = 10
No. of Charging Stations = 3

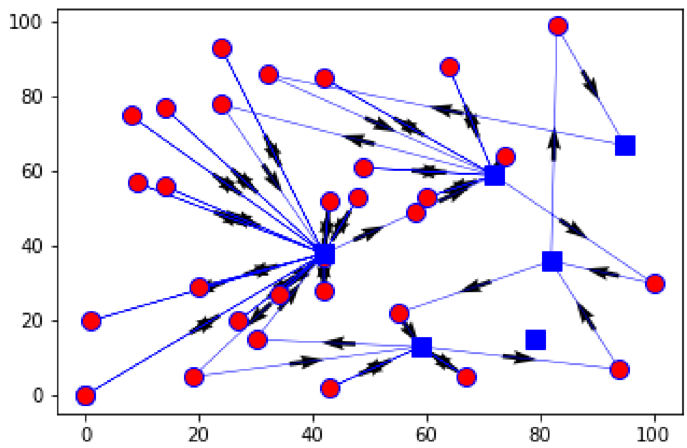

Figure 5.2: Simulation result 2

No. Of Nodes = 30
No. of Charging Stations = 6

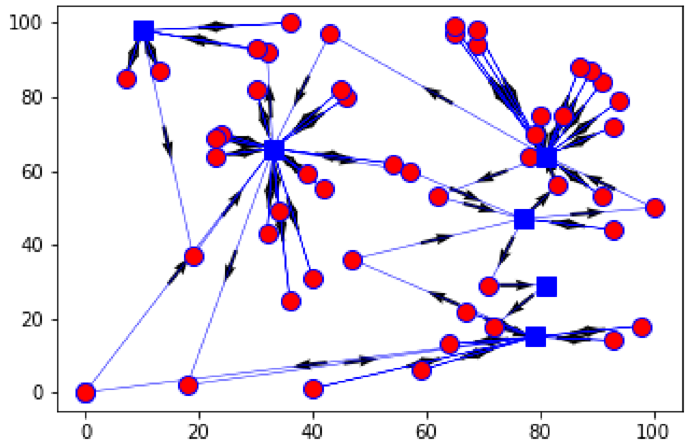

Figure 5.3: Simulation result 3

No. Of Nodes = 50
No. of Charging Stations = 6

CHAPTER 6

CONCLUSION

The increasing number of IoT devices and their deployment to remote areas is handled by using an MEC server. An area with dimension A x B in which IoT nodes are present are served using UAV equipped with MEC-Server capable of recharging itself in the Recharge station placed in that particular area of along its way. Algorithm-1 is capable of finding a path to cover all IoT nodes in a particular area such that the MEC server is nerver stuck in any part of area due to a lack of Charge in absence of time window. The Algorithm-2 is capable of finding path to cover all the IoT nodes in presence of time window (provided sufficient number of UAVs are available) such that the MEC server is nerver stuck in any part of area due to a lack of Charge. The simulation results have been shown for the proposed algorithms.

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CHAPTER 7

APENDIX 1

7.1 Cloud Computing

Cloud computing is an on demand computing service over the internet which is usually paid. It provides services such as storage, applications and processing power. It is a very promising service as the owner doesn't have to own their own computing infrastructure or data centers. They can simply rent a cloud service provider and manage their business or any work and get away from all the troubles of maintaining and owning an IT infrastructure.
Cloud computing can be classified into the following parts-

1. **Infrastructure-as-a-Service (IaaS)**

   Cloud infrastructure services, referred to as Infrastructure as a Service (IaaS), are self-service models for accessing, monitoring, and managing remote data center infrastructures, like reason (virtualized or vacant metal), storage, networking, and networking services (e.g. firewalls). rather than having to buy hardware outright, users should buy IaaS supported consumption, like electricity or different utility requests.

2. **Platform-as-a-Service (PaaS)**

   Cloud platform services, or Platform as a Service (PaaS), are used for applications, and alternative development, whereas providing cloud parts to software. What developers gain with PaaS may be a framework they will hinge on to develop or customize applications. PaaS makes the event, testing, and preparation of applications fast, simple, and efficient. With this technology, enterprise operations, or a third-party supplier, will manage OSes, virtualization, servers, storage, networking, and also the PaaS software itself. Developers, however, manage the applications.

3. **Software-as-a-Service (SaaS)**

   Cloud application services, or software as a Service (SaaS), represent the most important cloud market and are still growing quickly. SaaS uses the net to deliver applications that are managed by a third-party seller and whose interface is accessed on the clients' facet. Most SaaS applications are often run directly from an online browser with none downloads or installations needed, though some need plugins.

But since the geographical location of the cloud server and an end user can be very huge, thus the latency of service becomes a non-negligible problem. The data policies also play an important role for the location of the data centre, as a result the cloud vendors have to set up regional data centre networks to allow organizations to keep their data in their own region.

7.2 Mobile Edge Computing (MEC)

Mobile edge computing is an emerging technology in the 5G era, it gives the cloud and IT services within the closeness of mobile users. it gives access to the cloud server inside or vicinal to the base station. MEC has a huge amount of computation power and storage space allocated at the network edges, it provides the sufficient capacity to do the high level computation and latency-critical task in mobile devices.

Multi-access edge computing or previously known as mobile edge computing is a type of edge computing. It extends the cloud computing services by pushing the servers towards the edge of the network. This greatly reduces the latency as compared to cloud computing because the end user is very close to the server as compared to that in cloud computing servers.

Due to the developments in the field of Virtual Reality (VR), Augmented Reality (AR) Enterprise Mixed Reality (MR), cloud gaming, multiplayer games, real time detections, real time video analysis the demand of least possible latency for service is required.

But the MEC servers are fixed and thus cannot exploit the mobility to move closer to the terminal devices or end users.

7.3 UAV Assisted MEC

Unmanned aerial vehicle (UAV) communication has attracted wide attention in the mobile edge computing (MEC) system due to its high-flexibility and simple operation auxiliary communication mode it is the new popular field of study that bring a better MEC experience with a potential .In this approach the MEC servers can be equipped to a UAV or any other moving object to provide MEC service to a small sections of area.UAVs forward the tasks onto a cloud center or base station for processing, thereby shortening the implementation time of tasks. However, the offloading links of an UAV-assisted MEC system acquire a radio broadcasting mode.Several eavesdroppers might be present in the environment to eavesdrop the data sent by users and UAVs, thereby causing significant effects on the secrecy performance.

7.4 Travelling Salesman Problem (TSP)

It is an ultimatum to find the most shortest and efficient way from a list of Destination Which is to be chosen by a person.If in an specific area there are some nodes are given so that a person find the minimum shortest path to visit the all nodes and the nodes are visited only once and return back to the starting node,there are obviously many different routes are from but choose the one which gives the minimum distance, Using Travelling Salesman Problem (TSP) we find the minimum path to visit all the nodes only once and the minimum way of returning back to the starting node.