Efficient Scheduling Algorithm for drone power charging

Mehedi Tajrian
Dept. of Computer Engineering, Ajou University
tajrian1100@gmail.com

Jai-Hoon Kim
Dept. of Cyber Security, Ajou University
jaikim@ajou.ac.kr

Abstract— **Drones are opening new horizon as a major Internet-of-Things (IoT) player which is a network of objects. Drone needs to charge itself during providing services from the charging stations. If there are lots of drones and one charging station, then it is a critical situation to decide which drone should get charged first and make order of priorities for drones to get charged sequentially. In this paper, we propose an efficient scheduling algorithm for drone power charging (ESADPC), in which charging station would have a scheduler to decide which drone can get charged earlier among many other drones. Simulation results have showed that our algorithm reduces the deadline miss ration and turnaround time.**

1. Introduction

One of the most exciting developments in today`s world is drone. They are being used for several applications in surveillance, disaster management, search and rescue, environment monitoring, deliveries, photography, agriculture, security, and more [1]. As a constraint device, drones have power consumption [2] and have chance to have delivery latency. If there is only one charging station, it is difficult to handle the situation and decide which drone should get charged itself first, among many drones [3].

We established an algorithm ESADPC by which drones would have a priority set defined by the charging station to decide which drone can get charged earlier among many other drones from a charging station. With the help of programming we show that,

(i) ESADPC is more efficient than the existing EDF and FCFS algorithm,
(ii) Turnaround time is reduced as compared to FCFS and EDF
(iii) drones can have a better organized queue for getting charged from the charging station,
(iv) human controlling system can be altered,
(v) Probability of missing deadline is minimized.

2. Related Works

There are many priority algorithms like First come first serve (FCFS), Shortest job first (SJF) and Earliest deadline first (EDF) [4]. Let us assume two drones A and B where B has a big battery which needs more time to get charged compared to A. But B comes little earlier than A and B has short deadline than A. According to SJF algorithm [4], drone A will get charged first. In this case, B have to wait until drone A finishes its charging. But B can have short deadline to deliver its work. So, B can have *starvation* problem. According to FCFS and EDF algorithms [4], drone B will get charged first. In this case, it is going to be very large waiting time for A which is injustice to it as it has small battery and need less time to get charged. So, A can have longest waiting problem.

3. Proposed Mechanism

Assuming there are lots of drones coexisting in a service area, giving same or different type of service. There is one charging station located in the service area from where drones can charge by their own help as shown in Figure 1.

Figure 1: Considering the situation of many drones, their destination and one charging station.

We established algorithm ESADPC, by which drones would have priority binding by the charging station to decide which drone can get charge earlier among many from a charging station depending on their battery size, how far the delivery destination and deadline for service. We proposed our algorithm only for the delivery drones which have already got their delivery order and may need to get charge during passing the delivery path, not for the drones which are waiting on charging station.

- Firstly, the charging time, deadline time and transportation time will be taken randomly.
- Then scheduler will check and calculate the summation of charging time and transportation time, will subtract the summation result from deadline time for each drone. The calculation result is the laxity time for each drone. Which drone has shortest laxity time, will get highest priority to power up.
- Then the scheduler will calculate the priority where,

  Priority = (laxity time + charging time) / 2
- Then the scheduler will finally have the highest priority drone which has the smallest value for this calculation.

So, after calculating the priority scheduler will have a queue of highest prior drones for powering up. As a drone need to complete its delivery service before the deadline, its transportation time and charging time should be less than deadline time.

Charging time + transportation time < deadline time

Figure 2 shows the time limits for charging time, transportation time and deadline time.

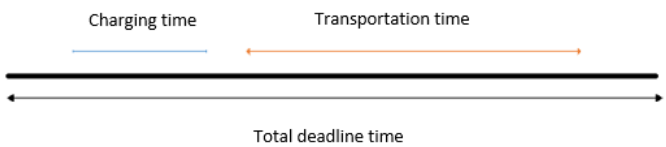

Figure 2: The time limits for charging time, transportation time and deadline time.

4. PROPOSED ALGORITHM

The pseudo code of ESADPC is given bellow:

ESADPC -ALGORITHM

1 Input max_ndrone // taking the limit of maximum number of drones

2 takes charging_time, deadline_time, transportation_time randomly for each drone
//where charging time + transportation time < deadline time

3 laxity_time = deadline_time – (charging_time + transportation _time)

4 priority = smallest value of { (laxity_time + charging_time) / 2 }
// creating the priority queue of drones depending on the smallest value holding drone among all.

5. SIMULATION

Consider an isolated system consisting of a charging station and many drones need to get charged. Drones come up to this charging station at random times, wait their turn for charging, are charged and then leave as shown in Figure 3.

Figure 3: Illustration of the situation of drones` arrival at charging station and departure after charging.

For the simulation of our algorithm, we used C programming language. Here, the condition is, the result of charging time + transportation time should be minimum than deadline time. We calculated Deadline miss ratio depending on how many drones are missing their deadline.

$$\text{Deadline miss ratio} = \frac{\text{Number of drone missed deadline}}{\text{Total number of drones}}$$

Turnaround time is the total time between drones arrival in charging station, waiting for charge and completing the charging.

$$\text{Turnaround time} = \text{Waiting time} + \text{Charging time}$$

According to ESADPC and other algorithms, the drone which has highest priority, will get charged first and will not have any waiting time. Then it`s turnaround time = only it`s charging time. So, when there is only one drone the turnaround time will be same for all algorithm.

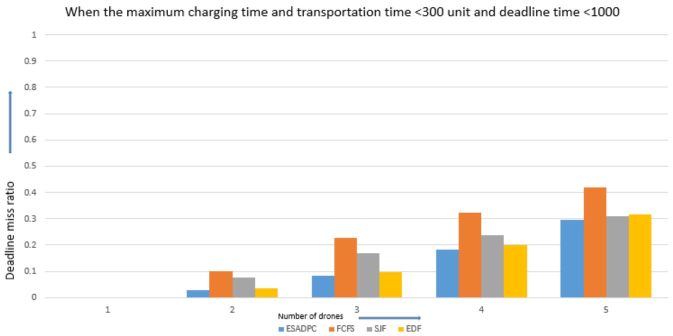

Figure 4: Deadline miss ratio when maximum charging time and transportation time is not more than 300 unit and deadline time is not more than 1000 unit.

In Figure 4, we can observe when maximum charging time and transportation time is below than 300 units and deadline is below than 1000 units, ESADPC shows lowest deadline miss ratio comparing with other algorithms, for 2 to 5 drones. FCFS shows highest deadline miss ratio followed by SJF as second highest and EDF as third. In Figure 5, ESADPC shows low turnaround time comparing with other algorithms but not comparing with SJF for 2 to 5 drones.

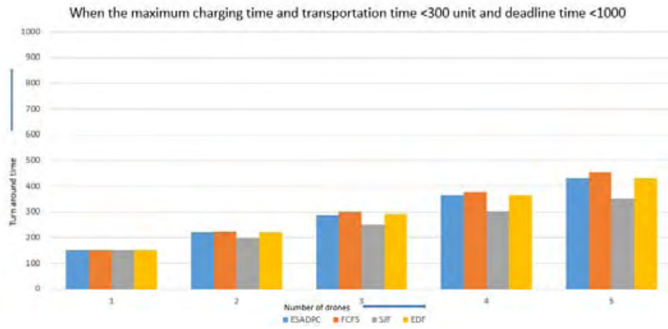

Figure 5: Turnaround time when maximum charging time and transportation time is not more than 300 unit and deadline time is not more than 1000 unit.

We can see after the simulations that ESADPC shows the lowest deadline miss ratio and turnaround time compared to FCFS and EDF. But SJF has lowest turnaround time for a very obvious reason as the priority for SJF depends on the charging time which is one of two main parameters of calculating turnaround time. For SJF the priority queue builds by the ascending order of charging time of drones. So, SJF has the highest probability to have the lowest turnaround time.

6. CONCLUSION

Drones are opening new horizon as a major Internet-of-Things (IoT) player which is a network of objects. To make sure that no drone will miss their deadline because of getting charged, there should be a well-organized queue when there is a single charging station. ESADPC provides a simple solution of this problem and make sure after analyzation and simulation that there is less probability to miss deadline for all the drones using ESADPC. By the help of ESADPC collision among drones can be minimized, time can be saved, the role of human management can be altered. It is a better solution comparing with FCFS and EDF algorithms.

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REFERENCE

[1] H. Shakhatreh, A. Sawalmeh, A. Al-Fuqaha, Z. Dou, E. Almaita, I. Khalil, N. S. Othman, A. Khreishah and M. Guizani, “Unmanned Aerial Vehicles: A Survey on Civil Applications and Key Research Challenges.” arXiv:1805.00881v1 [cs.RO], 19 Apr 2018.

[2] T. S. Alemayehu and J. H. Kim, “Efficient Nearest Neighbor Heuristic TSP Algorithms for Reducing Data Acquisition Latency of UAV Relay WSN.” Wireless Personal Communications. Vol. 95, Issue 3, pp. 3271–3285, August 2017.

[3] F. P. Kemper, K. A. O. Suzuki, J.R. Morrison, “UAV Consumable Replenishment: Design Concepts for Automated Service Stations.” Journal of Intelligent & Robotic Systems, Vol. 61, Issue 1–4, pp 369–397, January 2011.

[4] A. Silberschatz, P.B. Galvin, and G. Gagne, “Operating Systems Concepts with Java.” John Wiley and Sons, Inc., Eighth edition, Chapter 5 pp. 183-239, 2010.