# *Optimal Scheduling with a Reliable Data Transfer Framework for Drone Inspections of Infrastructures*

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# Presenter

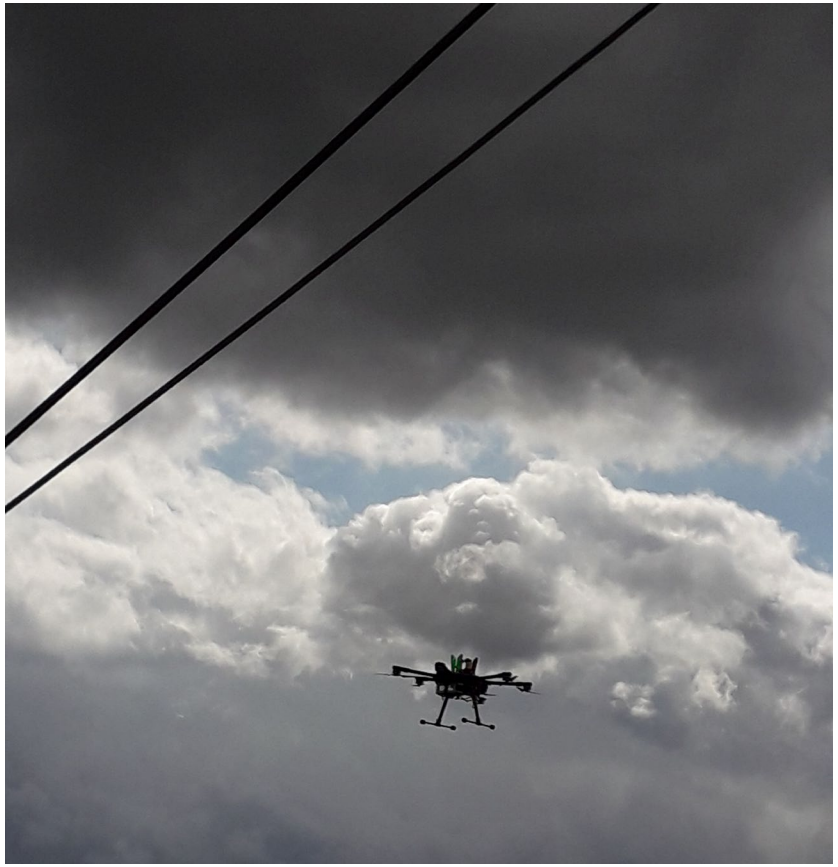
- Golizheh Mehrooz:  Ph.D. Research Fellow at IMADA SDU (2019-2021)
- My main responsibility in drones4Energy project is to design and implement a cloud infrastructure for monitoring and controlling autonomous inspection drones. The aim of the project is to build a collaborative, autonomous, and continuously operating drone system that will be offered to powerline operators to inspect the power grid accurately, frequently, and autonomously. In this regards, I have already published 6 papers.

# Agenda

- Introduction
- Background
- Data Transfer framework for Internet of Drones applications
- Rosbridge data analyze
- Optimal Scheduling with Extended TSP solver
- Multi drone scheduling analyze
- Conclusion

# Introduction

- With the development of new technologies, drones have received an increasing amount of attention in various areas for automatizing labor-intensive tasks [1]. Likewise, new EU regulations for drone inspections have eased the process of obtaining permission for inspecting the special case of linear infrastructures such as power pylons [3].
- In this regards, designing a cloud-based platform ,which includes a python package for the optimal routing and scheduling solution for inspection drones, will improve the inspection speed, cost, accuracy, and safety.
- In this paper, we have designed and implemented an optimal routing and scheduling with a reliable communication link for analyzing data in the cloud.



# Introduction

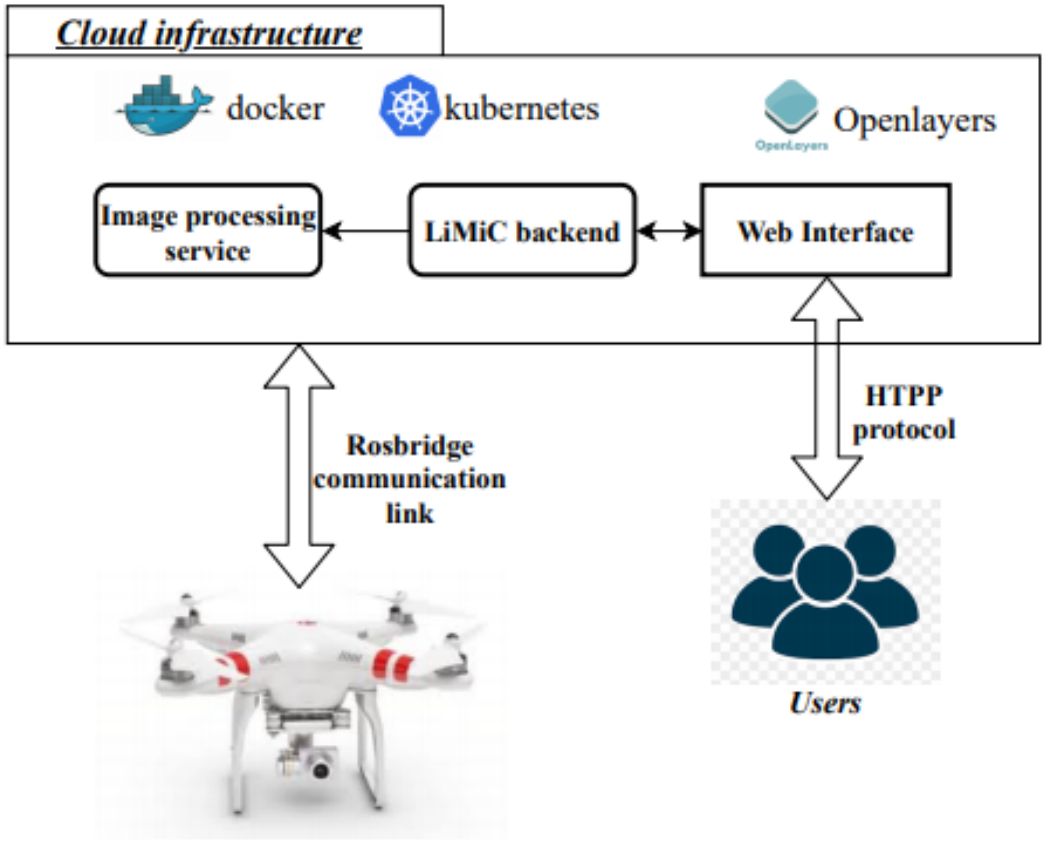
- In [2], the authors designed and implemented a web interface for controlling and monitoring drone flight. We have used Rosbridge as a communication link between the cloud and the drone. We have analyzed the communication delay in the framework. However, We have not measured the communication delay for transferring large data such as images. Additionally, We have not considered the scheduling problem for multi-drones.
- In the work presented in this paper, we extended the previous work [2][3] by considering the scheduling problem (extending LiMiC) and analyzing delay time for transferring large data such as images.

# Background

- A considerable amount of research has been conducted in order to navigate the drone and  transfer data between the drone and the cloud server.
- In these scenarios, the data collected should be transferred to the cloud server, where they can later be aggregated and analyzed using specialized data processing algorithms Internet of Things.
- In the work presented in this paper, we propose a novel IoD data transfer framework for cloud-based applications. Data includes either navigational data for controlling drones or the images to be analyzed in the cloud by using customized machine learning algorithms.
- Furthermore, An optimal scheduling algorithm based on extended OR-Tools as a TSP solver for inspection drones along the linear infrastructure.

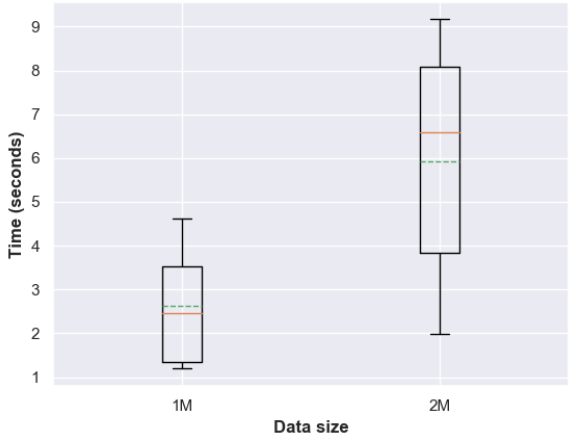
# Data Transfer framework for Internet of Drones applications

A variety of research and publications have been undertaken on different Internet of Drones applications (IoD) for establishing a communication link between drones and cloud server. In this regard, the widely used IoD protocols are Rosbridge, and HTTP.

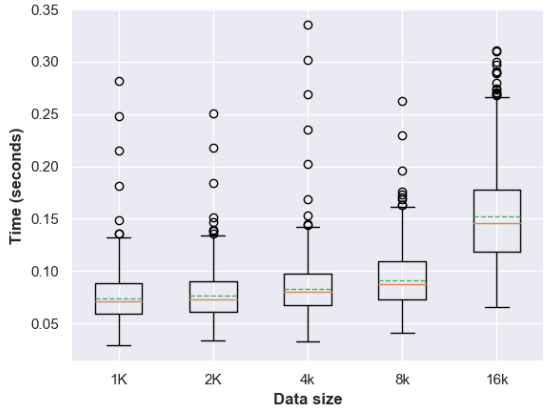


# Rosbridge data analyze

- As clearly can be seen in Figure the average time for transferring data in the range of 1KByte to 8Kbyte range from 0.07 to 0.09 seconds. Therefore, there is only a slightly and statistically likely insignificant difference for transferring data in this range. However, the time for transferring 16KByte data is close to double the time for transferring 8KByte.




- On the other hand, there is a significant increase in the delay for transferring 1MByte data compared 2Mbyte data from 2.5 seconds to 6 seconds on average.
- The wireless network communication performance can also be considered as an important factor for this non-linear significant increase in this data range.



# Optimal Scheduling with Extended TSP solver

OR-Tools offer two general approaches for scheduling problems such as the ***first solution strategies*** and the ***meta-heuristic strategies***.

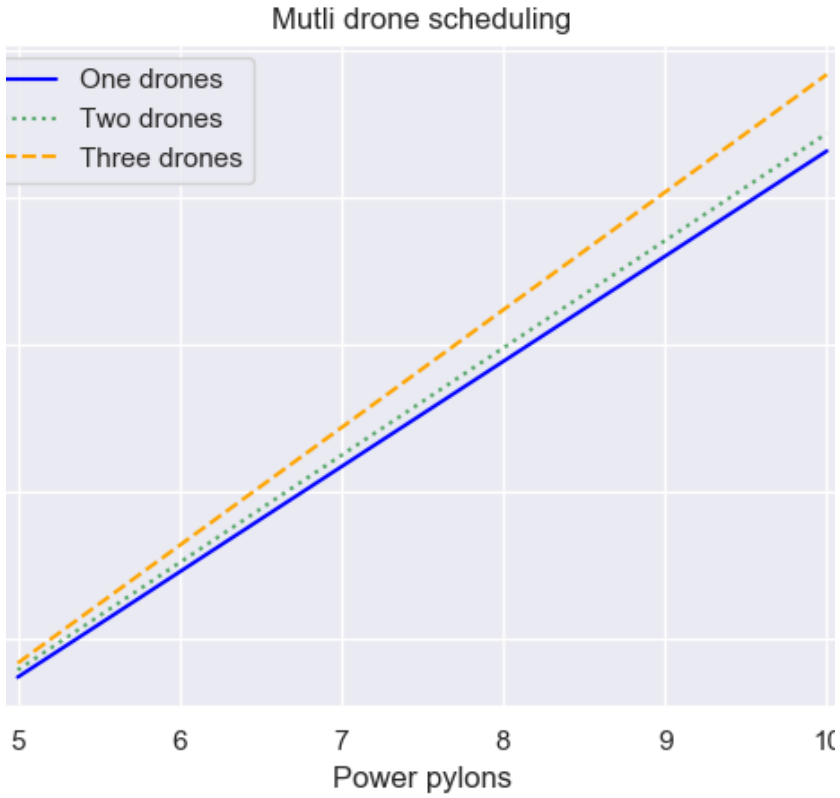
The first solution strategies are designed to find a single path between all points. This approach is a fast method for finding the optimal route.

The meta-heuristic strategies are slower than the first solution strategies in general but more reliable at finding the optimal route. The advantage of using the meta-heuristic strategies is that, its potential to avoid local minima, which the first strategies often end up in.

# Multi drone scheduling analyze

- We have also performed multi-drone scheduling by using the meta-heuristic strategies. We considered 5-10 power pylons on Fyn (Denmark). As can be observed in this figure, there is a linear relationship between the time and number of the power pylons.

- By increasing the number of power pylons calculation, time is also increased to a similar degree. However, there is a slight difference of scheduling times to be noted for different numbers of drones. We can, thus, conclude that the calculation time increases linearly with the number of power pylons. The reason is, unsurprisingly, that data matrix for solving the scheduling problem for 10 power pylons has more rows and columns compared with the data matrix with 5 power pylons.



# Conclusion

- This paper proposed an algorithm for optimal scheduling and a communication link between the drones and the cloud server for IoD applications of linear infrastructure inspection. Rosbridge is designed as a communication link between the cloud server and the ROS. We analyzed the Rosbridge communication delay time by measuring the transfer time and delays for different data sizes.
- The cloud server has been designed based on containerizing applications by using Docker and includes LiMiC. The LiMiC has been extended for solving the optimal routing and scheduling problem. We have implemented an optimal scheduling algorithm with the extended OR-Tools algorithm as a TSP solver for inspection drones along linear infrastructures.

# References

[1]: E. Es Yurek and H. C. Ozmutlu, “A decomposition-based iterativeoptimization algorithm for traveling salesman problem with drone,”Transportation Research Part C: Emerging Technologies, vol. 91, pp.249 – 262, 2018

[2]: G. Mehrooz and P. Schneider-Kamp, “Web application for plan-ning, monitoring, and controlling autonomous inspection drone,”10thMediterranean conference on embedded computing, 2021

[3]: G. Mehrooz and P. Schneider-Kamp, “Optimal path planning for droneinspections of linear infrastructures,”6th International Conference onGeographical Information Systems, Applications and Management, May2020