# MLPNS2021 Final Project Proposal

## A ML-based networks evaluation and prediction system

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## 1 Introduction to the Problem

Communication system reliability is a key point for Beyond Visual Line of Sight (BVLOS) Unmanned Aerial Vehicles (UAVs) applications, where the pilot has to remotely drive the drone relying on the real-time telemetry data and video feeds coming from the UAV. In order to achieve the maximum communication system reliability level for such applications, many wireless communication protocols must be adopted, together with a a powerful on-board central gateway able to handle different heterogeneous protocols and thus route data toward the most suitable one, ensuring redundancy and fail safe capabilities. Behind the physical implementation of the system, a strong network evaluation and selection mechanism must be implemented, in order to continuously determine the current link quality and switch to a stronger one if needed, or to predict the radio link quality attitude based on the flight direction direction and speed of the UAV, thus allowing the possibility to foresee and anticipate the network behavior, therefore which protocol chose.

## 2 Application of ML-techniques

During the flights, many data are collected every few seconds, depending also on the hardware APIs refresh rates. They refer to the different wireless communications protocols quality indexes, which values indicates both the radio signal level and the real communication protocols performance, together with the main drone parameters, such as the attitude, direction, speed and Global Navigation Satellite System (GNSS) position. Given the highly variable nature of radio signals, combined also with drones' speeds, which can easily reach tens of kilometres per hour, the data sample rate mush be high enough to detect even smaller signal variations, especially while travelling at high speeds, which are more critical in terms of network stability.

Such amount of data could be used in many different ways. First of all, after a flight all the collected data can be used as a data set to find a correlation between the drone flight parameters, such as the speed, direction, orientation, altitude and the main signal quality indexes, thus allowing to determine the best travelling speed and height in order to optimize the wireless protocol reliability during the next flights. Therefore, such data could also be used to create heat maps based on the signal quality over a geographical area, making easier to understand the network coverage of different protocols over a specific area and thus optimize the next flight path.

A more advanced application of different ML-techniques — which must be chosen properly — can be used to predict, combining both realtime in-flight data and previously collected datasets, to estimate the best network to chose during a certain time and geographical location of the ongoing flight. This attempt to estimate the most reliable network during the fly path could be very useful to prepare the system to handle the network change, thus avoiding fail safe or service interruptions.

## 3 Project Development

In the following, the different stages and project phases are described. Each phase is associated with a Work Package (WP), which is further divided in sub-tasks detailed as follows, while the final project timeline is shown in Table 1.

WP1 **Data Collection**: In-flight data collection over multiple interfaces and in different flight environments (countryside, sub-urban and urban, if regulations allow). Data shall be stored both locally (on the UAV computer board) and on a remote server, where they will be received almost in real-time. JSON and MySQL will be used for data storage.

WP2 **Data Munging**: Selection of the useful network quality index parameters of the different interfaces together with the main UAV telemetry data, with the aim to create a complete data set to whom apply ML and regression models, in order to find the aforementioned correlation and estimation. Data plotting through geographical heat maps and different kind of charts.

WP3 **ML model evaluation & implementation**: Study of the main existing ML algorithms and their possible application to the created data set. Implementation of the most suitable models using the right Python libraries. Execution of the models and preliminary results comparison, with the aim to determine the best algorithm. Choice of the most significant results and data to work on.

| Task | W1 | W2 | W3 | W4 | W5 | W6 |
|---|---|---|---|---|---|---|
| WP1 | | | | | | |
| WP2 | | | | | | |
| WP3 | | | | | | |
| WP4 | | | | | | |
| WP5 | | | | | | |

Table 1: Project deploy timeline.

WP4 **Finals results & validation**: Validation of the models performance through the available data set and traditional wireless communication theory, with the aim to determine if the estimation of the model respects the main physical laws ruling the world of wireless communications. In depth results comparison between the algorithms chosen and fine tuning of the best performing one. Further test of the model in a real environment, in order to check its prediction efficiency.

WP5 **Dissemination**: Detailed dissemination of the results achieved during the implementation and testing phase.

# 4 Motivations & Clarifications

Since my Ph.D. research activity focus is related to the implementation of a multi-interface system on a drone, able to combine together many different wireless communication protocols in order to guarantee seamless connectivity during BVLOS flights, in the last months I've been working on data collection and evaluation in order to determine which is the best network and its coverage in a certain environment. Therefore, I believe it could be interesting applying to such data more advanced data munging and evaluation techniques, in order to try to predict which could be the best wireless communication protocol during the flight path. This is not directly linked to my Ph.D. research activity, since, as telecommunication engineer, my topic is more related to data routing, multiple networks implementation and advanced antennas control, but I think it could be a nice exercise to apply what I learned during the ML course and thus try to estimate and compare the results to the more traditional network choice mechanisms. I know it is not an easy task, because my knowledge of the ML-world is still limited, but I think I could improve it by practicing on a real problem like this one.