University of Aveiro
Integrated Masters in Computer and Telematics
Informatics Engineering Project

Drone Relay

Aerial Drone platform for scenarios of limitation and emergency

Technical Report - Milestone 3

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Context of our project

Nowadays aerial drones are becoming very popular as they also become more accessible, in terms of usability and economics. Drones can have reduced size and good cost-benefit ratio which make them an excellent alternative for some specific objectives/missions. Some scenarios that benefit from the use of aerial drones are the surveillance of important individuals, monitoring public-gathering restrictions, monitoring forest areas or disaster areas, transferring lightweight high value objects, watching live video transmission, etc…

Taking all of that into account we decided to create an optimized relay to be integrated into a modular infrastructure, enabling the autonomous control and monitoring of a fleet of aerial drones in a mission context to manage many different situations.

The project is divided in three main parts, one onboard computer of the vehicle (drone), a ground station and a dashboard, everything will be explained in detail further up.

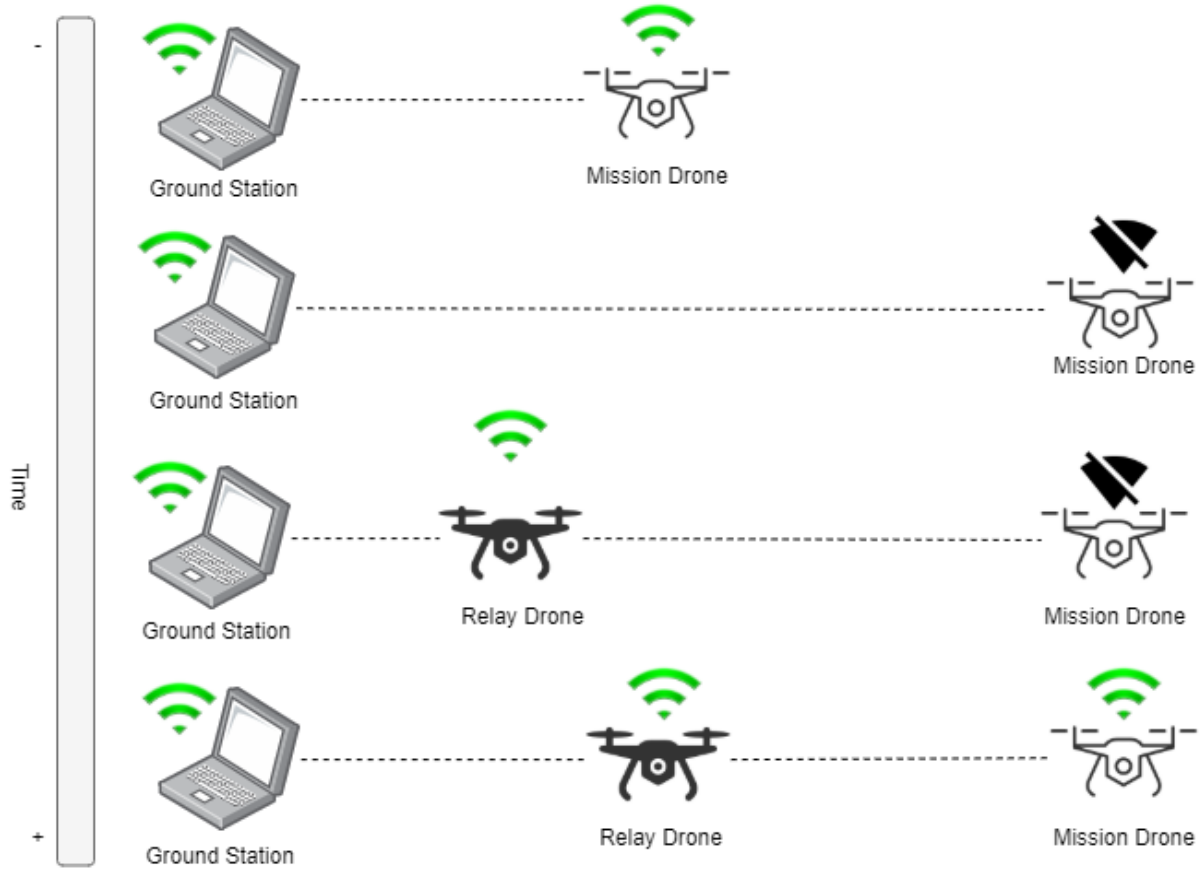

Figure 1: Relaying

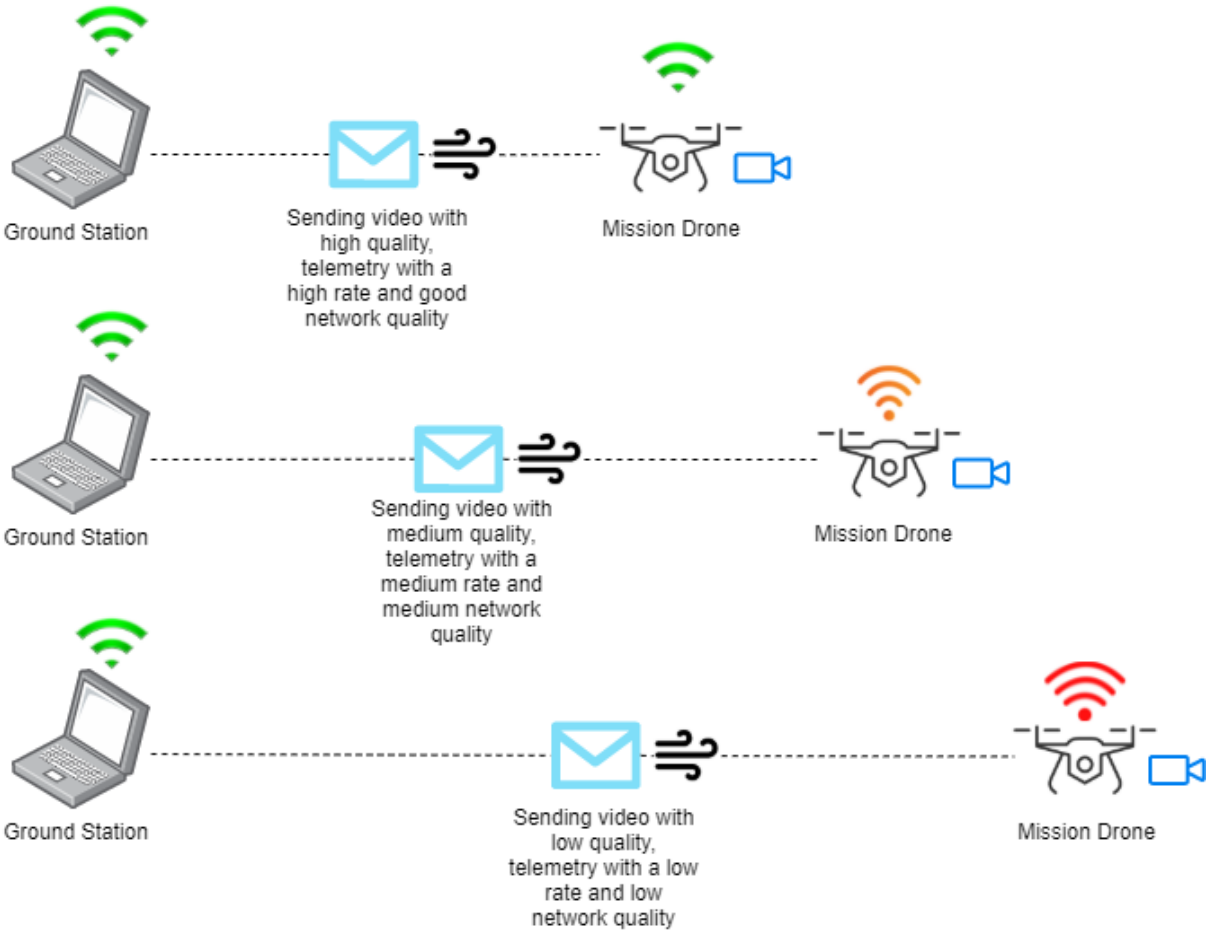

Figure 2: Camera quality, telemetry sending ratio and network quality

Conditions for making the prototype

For making this prototype, most of our work and testing was done in IT 2, as the material and tools needed were only available there.

Our prototype is divided into four main components which we demonstrate in the video and also explain in the below chapters what has been done regarding their development prior to this delivery.

For the Camera module, at this milestone, we aimed for the integration of this module with the drones, developing part of the automatic video quality change. At the moment the working version is displayed in the prototype video. A computer (ground station) was placed inside IT 2 and a group member walked outside holding a Nvidia Jetson to which the camera was attached, transmitting the video feed. We then used the dashboard to change the quality of the video in real time.

For the network sensor, at this milestone, we aimed for having it ready in this delivery/prototype, and so, a functional version has already been developed and tested, although as we will explain below, some improvements to this module can and will be made.

A version of both the network sensor and its simulated version can be seen in the prototype video, where for the simulated version we performed a mission on the simulator with two drones and retrieved the network quality parameters. For the “real” network sensor we connected a drone to the ground station and physically separated them to see how the network quality parameters change.

As for the last module, the relay algorithm, we have developed an initial version that has been going through multiple tests assisted by the simulator, JMavSim. Such a test can be seen on the prototype video, where two drones go on a mission and one drone works as a relay for both of them.

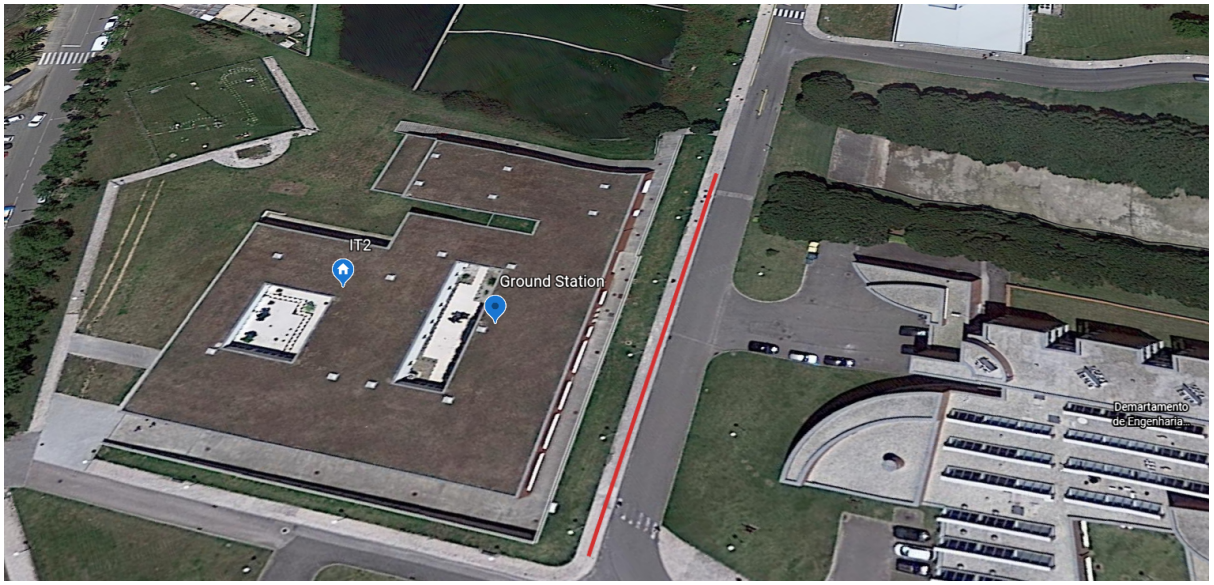

Figure 3: Course used to film the Camera module in the prototype video

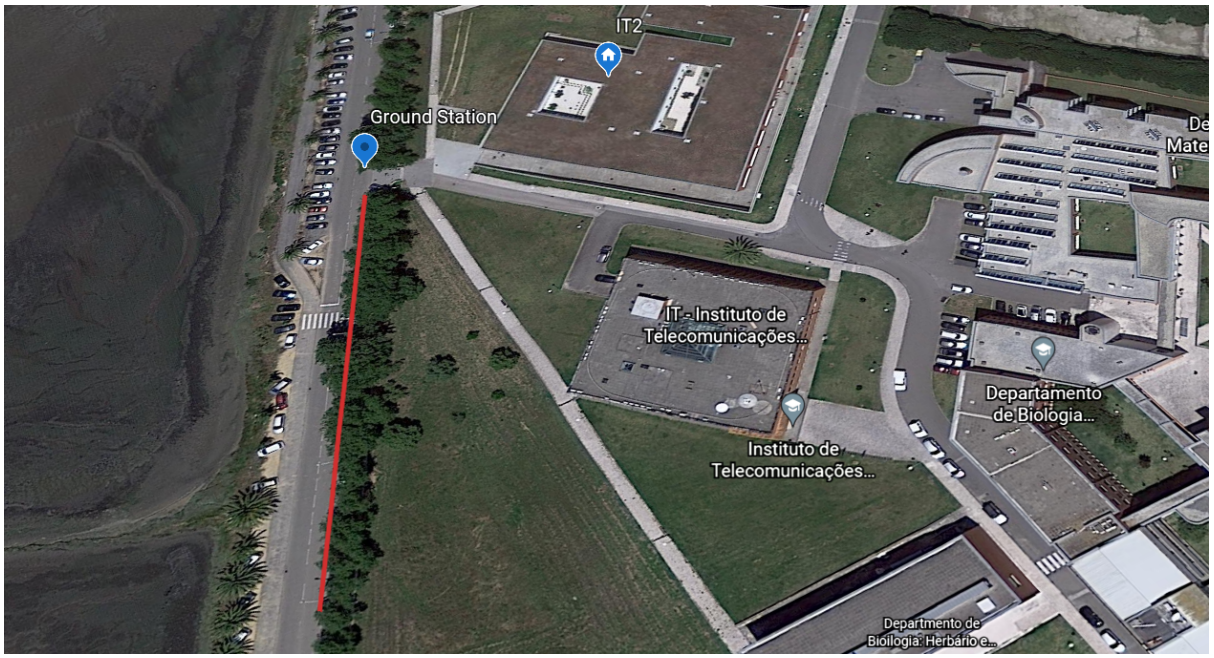

Figure 4: Course used to film the network module in the prototype video

Limitations for our prototype

This project had a few limitations that resulted from a couple of variables

- Drones were not 100% operational and only a couple of test flights for learning how to control the drones were performed.

- As most of the base components used for this project are still being developed and improved, a process of continuous integration and the waiting for new functionalities of external modules to our project is needed.

The last point was not considered so much as a limitation but rather a consequence of the constant evolution of the project as a whole.

Communication and work meetings

The communication between the group itself was done using *Discord*, both for text messages and voice meetings. We prefered to use it because we all already had experience on it and were familiar with it.

The communication between the group and the supervisors, professor Susana Sargento, professor Miguel Luís and mentor Margarida Silva was accomplished using *Slack NAP-IT* Aveiro for text messages and *Zoom* for meetings.

State of the project and planning

We will now explain the state our project is in by explaining with some degree of detail the steps that have been done and are still missing relative to the modules of the project.

Then an overview of the work that has to be done in the following weeks leading to the final project delivery.

It is also important to note that the micro site of the project contains information of the work done in each week until this delivery and also the project plan.

Network Sensor:

Module objective:

The network sensor is the module that evaluates the overall connection quality between two nodes in the ad-hoc network, which can be used by other modules of the project such as the camera or the relay module to adapt the sending quality and adjust the relay drones position respectively.

The quality is measured by some parameters such as the latency, the received signal strength indicator, the transmission and reception bit rate and others.

Already implemented:

1. Retrieving network quality parameters (Latency, Received Signal Strength Indicator, Transmission Bit Rate, Receiving Bit Rate, Number of packets Received, The overall connection quality which can be low medium or high) for every node in the ad-hoc connected to the drone where the sensor is running.

2. Providing a way for the ground station to ask for all the connections or a specific one.

3. A simulated version of the network sensor in order for the other modules to perform tests without having to physically have the drones running with the sensor.

Next steps:

Although a functional version of this module is available and was developed according to the project schedule there are some improvements that can be made that we only became aware of during the development phase of this module.

We now explain some of the improvements that can be done in the following weeks in parallel with other tasks.

One improvement is in the way this module calculates the latency between two nodes, as it makes use of pings which inject traffic in the network. Although generating a relatively small amount of traffic compared to the amount already passing through the ad-hoc, there are certainly other ways to do it such as having synchronized clocks between the nodes and measuring the already available traffic or even checking the time between a tcp SYN and SYN ACK packet.

In the simulated version it might be needed to include more scenarios, what we mean by that is that the way it is now doesn't take into account factors like buildings or other objects that obstruct the signal between the nodes.

Adaptive Camera Module:

Module objective:

This module is responsible for the capture and transmission from the camera that is connected to the drone controller (Nvidia Jetson Nano), to a local grounstation that runs the dashboard software. It is also responsible for dynamically changing the video quality feed, according to the network state.

When the network sensor is active, the quality will be selected from 3 presets (High, Medium, Low), changing automatically the adequaat preset in order to maintain the best quality/reliability ratio.

Already implemented:

1. Transmission from drone's camera via the ad-hoc network to a server.

2. Displaying the live video feed on the dashboard, from multiple drones and simultaneous streams.

3. Manually change camera quality on the fly via the dashboard

Next steps:

The main next step for this module is the implementation of the dynamic change in video quality, using the network sensor of the drone for measuring the state of the network. This is done by changing the 3 network quality presets according to multiple factors of the drone's network, using the most adequate. As the manual change is already being done correctly only the integration and adjustment of parameters for the best moment to transition between the video qualities is needed.

Relay Algorithm:

Module objective:

This module has the aim to create an algorithm to find the optimal position for drones relay using the quality of the network. Relay drones are used to give drone missions (specific drones that are performing a programmed mission) access to the network. With the objective to optimize the resources available, relay drones have to be in an optimal position so it will give access to the network to most drones missions as possible. To achieve that goal, drones will use a network sensor, also developed, to analyze the quality, an artificial intelligence algorithm to find the perfect position and many modules to structure everything.

Already implemented:

1. Structure for the relay algorithm (Entities, RelayLinks, RelayBridges, NetworkState...).

2. Definition of the position for the drone relay in optimal network.

3. Conversion the drone relay already developed, in python, to the final language, groovy.

4. Development of an optimized search (Search Tree), for the relay of drones.

Next steps:

One improvement that can be done is to refine the artificial intelligence of the algorithm. If we can accomplish that, the response time between the environment changes and the corresponding decisions based on that will be decreased.

Develop an exploration mode for drone relay. The aim is to move a drone relay depending on the new drone's mission. If one drone relay is relaying network to one drone mission and another drone mission comes on, that drone relay must adapt his position so only one drone relay is needed.

Lastly, we can improve drone movements by developing another search tree to that objective.

Dashboard:

Module objective:

The dashboard is the module that has the objective to create an abstraction layer between the code behind the functionalities and the final user. So it gives a lot of information to the user, such as. values of the sensor, localization, commands to control the drone, battery information, live video, some information in the form of a chart for an easy analise and much more.

For its development it is mainly used nuxt, html and css for the frontend and for the backend was mainly used mongoDB and Django.

Already implemented:

1. It is possible to visualize real time video sent from the drones.

Next steps:

Display sensor information. With the values obtained from drones, show that information on the dashboard.

Display telemetry information from the drones.

Discussion:

In this phase of the project we have a preliminary version of all components that we are integrating and testing with each other.
For example the first version of the relay algorithm is integrated with the simulated version of the network sensor so that the relay drone positioning takes into account the network quality.
As for the camera and its integration in the dashboard we can already see and change the quality of the video in it.
That being said the next step overall is to polish the modules, dynamically change the camera quality so that if the drone starts to lose connectivity it sends the video in a lower quality as to not overload the network, adjusting at the same time the telemetry information transmission ratio. We also have to add information to the dashboard and transition all the integrated modules from a simulated environment to a real scenario. It may seem like a lot however the foundation, which is the hardest part, is coming along nicely.

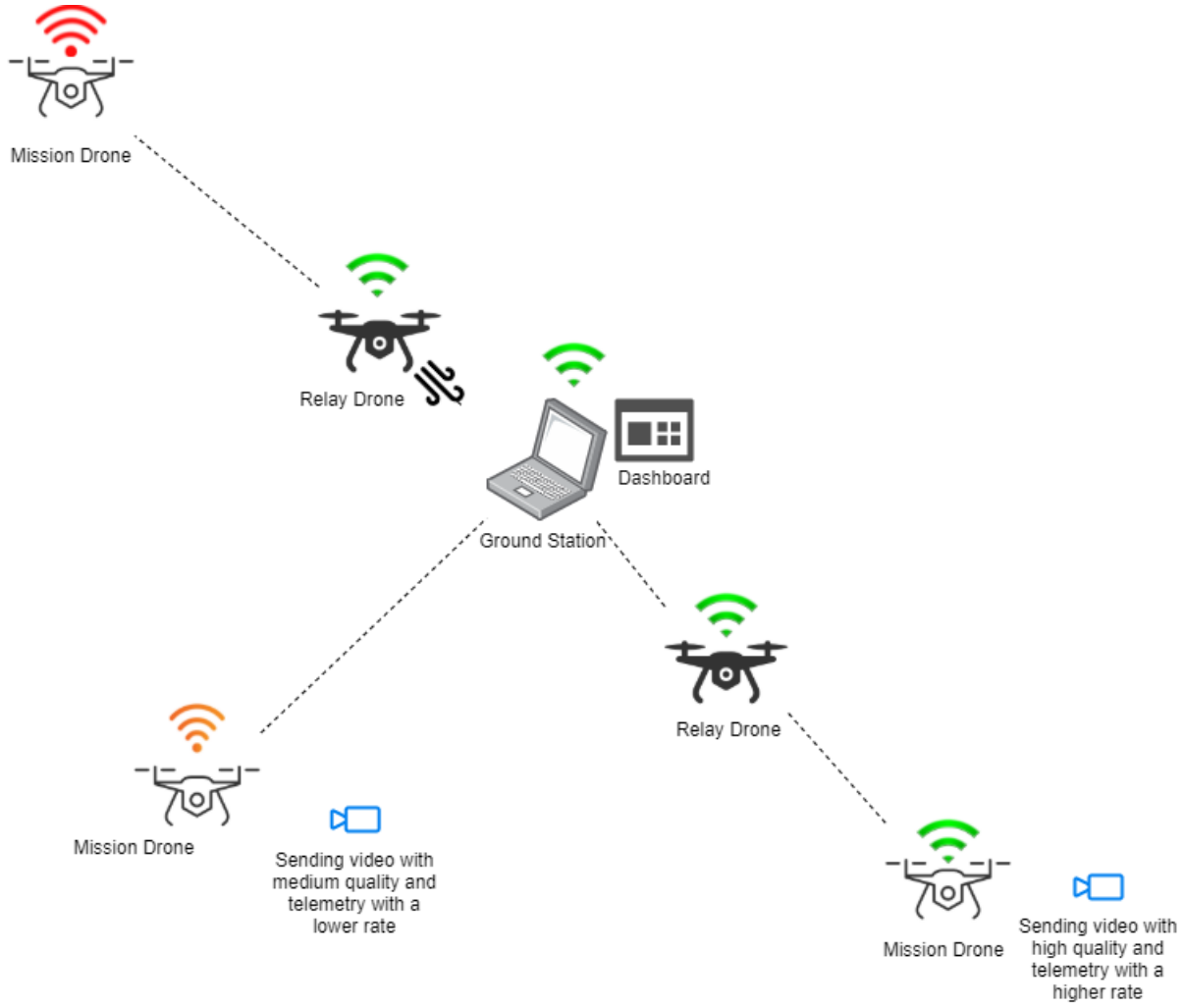

Figure 5: Project overview