Packetloss at different bitrates at different distances from the sender

Purpose

The purpose of this worksheet is to:

1. Determine the packet loss as a function of distance between the sender and receiver.
2. Determine when ground reflection becomes critical for the signal, and how to avoid this.
3. Determine if the data rate, should be change as a function of distance and height (max distance 100 m)

Theory

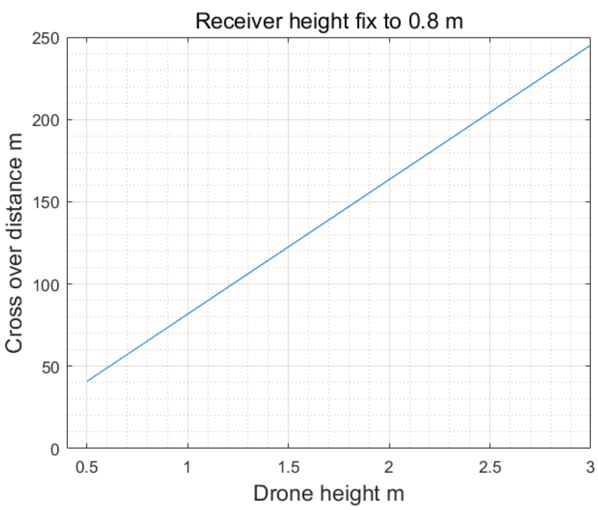
In an open field scenario (like on a football field) refraction can only be caused by the ground. These refractions can have negative impact on the transmitted signal, and to avoid this the following should be fulfilled [1], [2]:

$$d_c = (4\pi h_t h_r)/\lambda$$

- d_c : The cross over distance.
- h_t : The height of the transmitter.
- h_r : The height of the receiver.
- λ : The wavelength of the signal.

The above equation estimates the cross over distance, which is the distance at which the travel time of the transmitted signal becomes the same as its refraction. At this distance the refracted signal interferes destructively. If the d_c is smaller than the distance between the transmitter and receiver, the signal decreased approximated -20 dB/decade due to propagation loss in free space.

	d_c	h_t	h_r
1	25.54m	0.5m	0.8m
2	51m	1m	0.8m
3	76,6m	1,5m	0.8m
4	102,16m	2 m	0.8m
5	127,7m	2,5m	0.8m

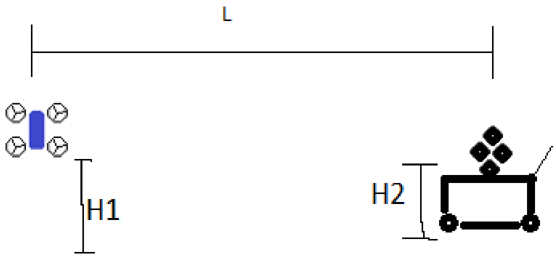


Method

Test parameters

To fulfill the purpose, we set up a 4 raspberry's (to get diversity in hardware) as receivers and a raspberry as sender as seen in the figure. We conduct several tests, varying one parameter at a time.

- L: the distance between the receivers and the sender.
- R: the data rate used.
- H1: the height of the drone.
- H2: the height of the receiver.



Test software

The software used is the simple sender and receiver used for the grid tests. The sender multicasts full network interface (1500 MTU) UDP packets at full speed for one minute. The receiver does nothing more than receive the packets and note the sequence number of the received packets.

Equipment

	Equipment
1.	3 x Raspberry Pi 1 model B incl. power supply and SD-card
2.	2 x Raspberry Pi 3 model b
34	5 x TP-link TL-WN722N USB Wi-Fi module 1 x RT5370

The sender is running on a Raspberry 3 with a Wi-Fi module (4).

Three receiver are using Raspberry Pi 1 with a Wi-Fi module (3) and one receiver is running on a Raspberry 3 with a Wi-Fi module (3).

Test description

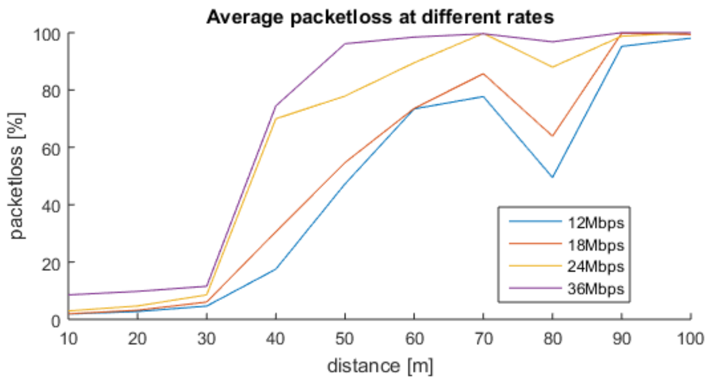
We conduct the first test with every combination of L and R, with the following values L = [10 20 30 40 50 60 70 80 90 100] meters and R = [12 18 24 36] Mbps. The H1 and H2 are fix to 0,5 m and 0,7 m. This test is performed on asphalt besides a build.

The second test is conducted with every combination of L and R, with the following values L = [10 20 30 40 50 60 70 80 90 100] meters and R = [36] Mbps. The H2 is fix to 0,8 m and H1 = [0,5 2] m. This test is performed on a football field.

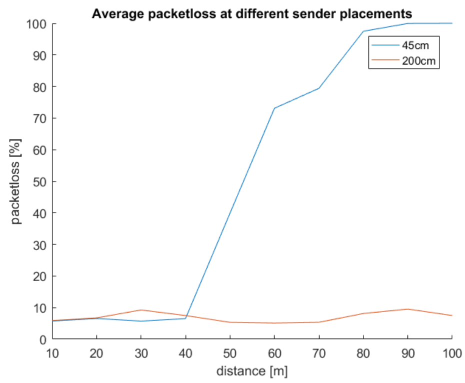
Results

The first test can be seen in the figure below. The figure shows the data rate performance measured over distance, with fix sender and receiver height. We see a clear trend that the higher rates have higher packet loss. A slightly higher packet loss is not necessarily a problem. If the difference in transmission rate is large enough, choosing a higher data rate with higher packet loss can mean, that we can transmit more data.

The difference in packet loss is only significant when the receivers are 40-50 meters away from the sender. When the receiver is further than 50 meters away the packet loss is too high to maintain a useful connection. At 80 meters, we see a revitalization of the throughput. The reason for this behavior is not immediately clear and even seem unintuitive. The best reasoning for this result is that the performance gain is due to the test set-up and its surroundings. More specifically, we expect signal reflection to be the main cause. For some reason when the sender is 80 meters from the receiver, reflection from the asphalt road is not interfering with the received signal. It is clearly seen that ground reflection have a negative impact on the transmitted signal, as the second test shows.



The second test, seen below, varies the height of the sender to see how this impacts the signal. When the transmitter is 2 meter above the ground, the packet loss is not affected by the signal refractions (at least not in a negative way) within the test range, 100 meter.



The data stream packet loos do not exceed the general packet loss, and it can be concluded, that if the drone stays within 100 meter and above 2 meter, is would not gain anything from changing the date rate as a function of the distance.

ReferenceS

Reference 1: Using the Right Two-Ray Model? A Measurement-based Evaluation of PHY Models in VANETs .

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https://pdfs.semanticscholar.org/a86f/90f1238ccb90181c26335684fd762247408e.pdf

Reference 2: Tom Henderson 2011-11-05

http://www.isi.edu/nsnam/ns/doc/node218.html