NS3 Propagation Loss Models and their differences in a Wi-Fi-Simulation

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***Abstract*—Different path loss models in NS-3 are developed to capture the unique characteristics of different propagation scenarios and environments. Knowing the differences between said models and how they influence a NS-3 Simulation is crucial for researchers, since these Simulations should approximate the reality as best as possible. Another major part of these simulations is their running time. Acquiring information on how long a simulation should run to gather reliable results is important as well.**

I. Introduction and Motivation

There are many different propagation models in NS-3. Choosing the best one for a simulation is not evident immediately since they influence the results of a simulation differently. In addition, these models can be chained together to adjust the simulation to the targeted scenario. This work compares 5 models to point out differences between them. This overview will be useful for researchers, looking to find the right propagation model for their simulation and how long they should run them to get reliable results.

II. Methodology

The steady state scenario used for this study is a simple adhoc 5GHz Wi-Fi network containing 2 nodes with increasing distance by 1 m until the connection is lost. UDP-traffic with 1450 Bytes packet size is generated with a data-rate of 75Mbit/s. The output power is 10 dBm, with omnidirectional antennas and 1 dBi gain. 'The ConstantPositionMobilityModel' is used during the execution time. This simulation scenario was executed with NS-3 3.37 on an Ubuntu System with 128 GB DDR4 RAM and 2x AMD EPYC 7501 (32x 2.0 GHz) CPU's. The following models were tested and initialized with these specified attributes:
1) FriisPropagationLossModel: Frequency=5GHz. (implements the Friis free Space Propagation [1]; received-signal-strength (rss) and data-rate should decrease over distance); 2) FixedRssLossModel: rss=-80. (sets the signal loss to a specific, distance independent value); 3) ThreeLogDistancePropagationLossModel: Distance0=1.0, Distance1=200.0, Distance2=500.0, ReferenceLoss=46.77. (implements a variant of the log distance model [2] with 3 distance fields each with different exponents); TwoRayGroundPropagationLossModel: Freq=5GHz, HeightAboveZ=1, MinDistance=0.5, SystemLoss=1,(developed by Rappaport [3] includes reflected signals); NakagamiPropagationLossModel: Distance1=80, Distance2=200, m0=1.5, m1=0.75, m2=0.75, additionally the nodes got a height of 1 m and 5 m to create a suitable scenario for this model (implements Nakagami distribution [4] for different distances).

To determine an optimal simulation time, this scenario was executed first with the 'FriisPropagationLossModel', increasing simulation time and a fixed distance of 5 m between the nodes.

III. Results

The measured data-throughput over increasing simulation time is displayed in Fig.1. After 50 seconds, the data-rate reached ≈56 Mbit/s and did not significantly change after. The authors of [5] stated in chapter III.B.2., a simulation time long enough to reach the steady state of the experiment is crucial in order to produce reliable results as the simulation starts with empty caches, queues and tables. Therefore, the simulations were executed with a duration of 50 seconds for every model and distance variation.

The throughput and rss over distance for each model are displayed in Fig.2 and 3.

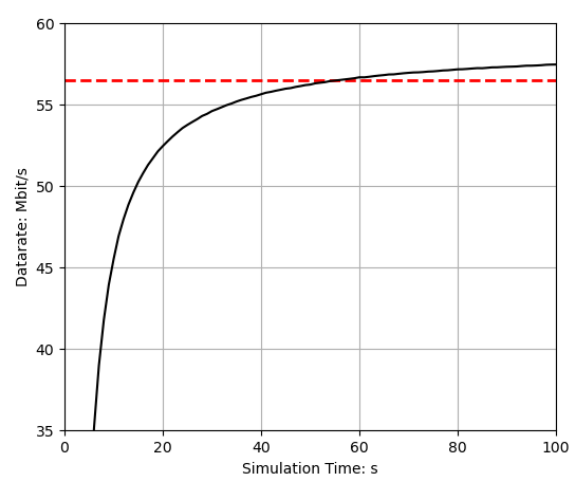

Fig. 1. Varying throughput over simulation time, 5m

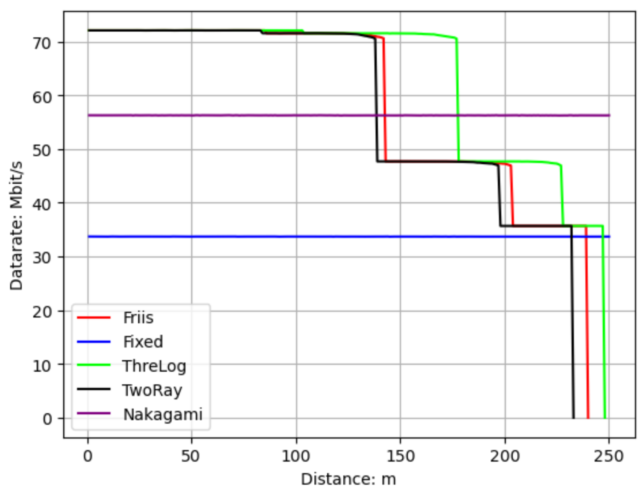

Fig. 2. Throughput over distance

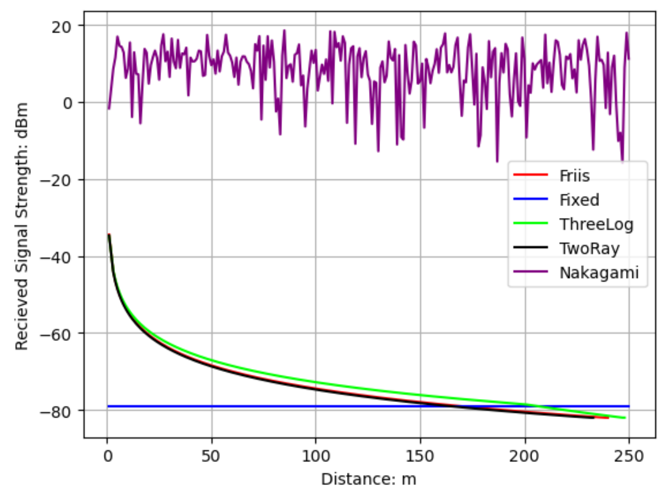

Fig. 3. Received Signal Strength over distance

The Friis-Model simulated the rss decreasing over distance like the free space path loss model defined by [1]. Accordingly the data-rate declined with increasing distance and the connection was lost at 240 m.

The 'FixedRssLossModel' set the signal loss independent from the transmitting power. Since the gain of the receiving antenna is 1 dBi we have a constant signal strength of -79,33 dBm. due to a lack of Signal loss, the receiving data-rate was constant throughout the simulation and the connection consisted.

With the 'ThreeLogDistancePropagationLossModel' the rss was constantly slightly higher. With a sudden change in the curve at 200 m where the middle distance field of the model begins and the calculation is adjusted ccording to the initial variables. The connection was lost at a distance of 248 m. The data-rate maintained a higher level due to the higher signal strength.

The TwoRayGroundPropagationLossModel is nearly identical to the Friis model. The overall signal strength is constantly lower but at higher distances the reflected rays from the ground affected the lower signal more significantly, therefore the connection is lost earlier at 233 m. The data throughput is, according to the signal strength, slightly lower compared to the Friis model

The Nakagami-Model produced jitter between 20.97 dBm and -15.8 dBm while the data-rate remains at ≈56Mbit/s since the signal loss was not high enough to cause a major data-rate decrease.

Multiple iterations of this simulation confirmed the meassured results.

IV. Conclusion

The five different propagation loss models compared can be classified in three categories. The realistic models like the Friis-, ThreeLog- and TwoRaypropagation-Model all calculate the path for ideal conditions. They can be adjusted with different initial variables to adjust them to a more specific scenario like a suburban scenario without ideal conditions.

The Nakagami-Model is a statistical model and implements a fading concept due to interference, multipath propagation, and other environmental factors.

The FixedRssModel is an entirely abstract model which is detached from reality. It ignores the transmission power and path losses, with no regard for the distance between nodes. It is beneficial for testing networks and protocols for specified signal strength or for a combination with other models.

Although some models may not be useful individually, they can be chained together, e.g. when the targeted scenario should include the fading from the Nakagami-Model with the empirical path loss from the Friis model. There are many possible initializations and combinations of said models which influence a NS-3 simulation as desired. To test these combinations may be a topic of future work.

In addition, it is shown that the simulation time of the scenario does have influence on the results. It requires indiviudal configuration for every simulation individually yet leads to more reliable results. The NS-3 Code is publicly available [6] for reproducing the results and further research.

References

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