Radio Propagation Models Implemented in Ns2

The radio propagation models implemented in *ns* are used to predict the received signal power of each packet. At the physical layer of each wireless node, there is a receiving threshold. When a packet is received, if its signal power is below the receiving threshold, it is marked as error and dropped by the MAC layer. Up to now there are three propagation models in *ns*, which are the free space model[1], two-ray ground reflection model and the shadowing model

1 Free space model

The free space propagation model assumes the ideal propagation condition that there is only one clear line-of-sight path between the transmitter and receiver. H. T. Friis presented the following equation to calculate the received signal power in free space at distance from the transmitter.

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

Where Pt is the transmitted signal power, Gt and Gr are the antenna gains of the transmitter and the receiver respectively. L is the system loss, and lambda the wavelength The free space model basically represents the communication range as a circle around the transmitter. If a receiver is within the circle, it receives all packets. Otherwise, it loses all packets

2 Two-ray ground reflection model

A single line-of-sight path between two mobile nodes is seldom the only means of propagation. The two-ray ground reflection model considers both the direct path and a ground reflection path. It is shown that this model gives more accurate prediction at a long distance than the free space model. The received power at distance is predicted by

$$P_r(d) = \frac{P_t G_t G_r {h_t}^2 {h_r}^2}{d^4 L}$$

where Pt is the transmitted signal power, Gt and Gr are the antenna gains of the transmitter and the receiver respectively. L is the system loss and ht and hr are the heights of the transmitter and receiver antennas respectively.

The equation shows a faster power decrease with an increases in distance. However, the two-ray model does not give a good result for a short distance due to the oscillation caused by the constructive and destructive combination of the two rays. Instead, the free space model is still used.

3 Shadowing model

3.1 Background.

The free space model and the two-ray model predict the received power as a deterministic function of distance. They both represent the communication range as an ideal circle. In reality, the received power at certain distance is a random variable due to multi path propagation effects, which is also known as fading effects. In fact, the above two models predicts the mean received power at distance . A more general and widely-used model is called the shadowing model.

Environment		β
Outdoor	Free space	2
	Shadowed urban area	2.7 to 5
In building	Line-of-sight	1.6 to 1.8
	Obstructed	4 to 6

Some typical values of Path loss beta

Environment	σ_{dB} (dB)
Outdoor	4 to 12
Office, hard partition	7
Office, soft partition	9.6
Factory, line-of-sight	3 to 6
Factory, obstructed	6.8

Some typical value of shadowing deviation in dB

The shadowing model consists of two parts. The first one is known as path loss model, which also predicts the mean received power at distance *d* denoted by Pr(do).

$$\left[\frac{\overline{P_r(d)}}{P_r(d_0)}\right]_{dB} = -10\beta\log\left(\frac{d}{d_0}\right)$$

Where Beta is called the path loss exponent, and is usually empirically determined by field measurement.

The second part of the shadowing model reflects the variation of the received power at certain distance. It is a log-normal random variable, that is, it is of Gaussian distribution if measured in dB. The overall shadowing model is represented by

$$\left[\frac{P_r(d)}{P_r(d_0)}\right]_{dB} = -10\beta \log\left(\frac{d}{d_0}\right) + X_{dB}$$

Where XdB is a Gaussian random variable with zero mean and standard deviation (sigma). The shadowing model extends the ideal circle model to a richer statistic model: nodes can only probabilistically communicate when near the edge of the communication range.