EXTENSION OF LEE'S PREDICTION MODEL

by

WILLIAM C. Y. LEE
PACTEL CELLULAR
IRVINE, CA

I. SCENARIO

In mobile radio environment, the base station antenna is set up high, usually 30 to 50 meters, and the mobile unit antenna is usually 2 to 3 meters above the ground. Also the communication-link distance is usually much larger than the base-station antenna height. In this scenario, the reflective point of the specular reflected wave is always close to the mobile. An illustration of the scenario is shown in Fig. 1. The philosophy behind Lee's model(1) is described as follows:

II. TWO FACTORS CONTRIBUTING TO PROPAGATION LOSS

First, the natural terrain contour contributes to the propagation loss i.e. the variation of terrain contour such as flat terrain, hilly terrain, rolling-hill terrain, mountain region, etc. cause different propagation losses.

Second, the man-made structures surrounding the mobile unit contributes to the propagation loss. It is because the mobile unit antenna-height is much lower than the surrounding structure of the mobile unit. Then the man-made structure based on the urban structures, suburban structures, rural structures and open areas will introduce different levels of reception at the mobile unit. Then forming up a prediction model for pathloss is to sum up the loss from both the natural terrain contribution and the man-made structure contribution.

III. OBTAINING A PATHLOSS CURVE ON VIRTUALLY FLAT GROUND

Before making a prediction of path loss in an area we have to know how to separate these two factors of contributions previously mentioned. First, we would like to find a pathloss curve in one area due to the man-made structure only. Although areas seldom are really flat we would like to achieve a pathloss data with no terrain contour variation involved. In order to do it, we have to run the signal strengths in different directions at different distances, then draw a conventional pathloss curve among the data plotted along the radio-path distance. The way of generating the pathloss curve in a particular area is averaging the high signal data points received from high elevation spots with the low signal data points received from low elevation spots. Therefore, as a result the pathloss curve is representing the man-made structure area on a virtually flat ground. This is a different concept, even though Lee's model also finds the pathloss curve from a different perspective.

IV. OBTAINING A PATHLOSS CURVE OVER AN ACTUAL TERRAIN

The actual non-flat terrain contour will introduce a gain or loss as compared with the effective antenna height h_e of the base station from the mobile location to the actual antenna height h_a; gain, if the effective antenna is greater than the actual antenna; loss, otherwise. The antenna-height gain is illustrated in Fig. 2. The antenna-height gain(2) is based on the specular reflected wave shown in Fig. 2. It is because the reflected wave whose reflected point close to the mobile unit would contribute the most reflected energy at the mobile unit. Other reflected waves called diffusely reflected waves (see Fig. 2) contributes neglegible energy. Therefore, Lee's model needs to use the information of terrain topology to calculate the effective antenna-heights with which the antenna-height gain G can be obtained as

$$G = 20 \log (h_e/h_a)$$

V. THE PROPAGATION PATHLOSS OVER WATER

Using Lee's model, we can obtain the propagation pathloss over water shown in Fig. 3. The derivation is as follows: In Fig. 3, one direct wave and two reflected waves. One reflected wave is mainly reflected from the wide open water surface and one is reflected close to the mobile unit. Both reflected waves can be considered as specular refected waves. We sum up three waves

$$P_r = \frac{P_t}{(4\pi d/\lambda)^2} \left| 1 - e^{+j\Delta\phi_1} - e^{+j\Delta\phi_2} \right|^2 \qquad (1)$$

where P_t is the transmitted power, d is the distance and λ is the wavelength. $\Delta\phi_1$ and $\Delta\phi_2$ are the phase differences which relates to the path-length difference between the direct wave and two reflected waves respectively. Since $\Delta\phi$ and are very small usually for the land-to-mobile path, then $\cos\Delta\phi \approx 1$ and $\sin\Delta\phi \approx \Delta\phi$, Eq. (1) becomes

$$P_r = \frac{P_t}{(4\pi d/\lambda)^2} \left| 1 - \cos\Delta\phi_1 - \cos\Delta\phi_2 - j\,(\sin\Delta\phi_1 + \sin\Delta\phi_2) \right|^2$$

$$\approx \frac{P_t}{(4\pi d/\lambda)^2} \left[1 + (\Delta\phi_1 + \Delta\phi_2)^2 \right] \qquad (2)$$

since $(\Delta\phi_1 + \Delta\phi_2)^2 << 1$, then Eq. (2) becomes

$$P_r = \frac{P_t}{(4\pi d/\lambda)^2} \qquad (3)$$

Eq. (3) is the same as the power received under the free-space condition. It is shown that the propagation pathloss over water is the same as a free space loss. Therefore, we may conclude that the pathloss for land-mobile propagation over land is 40 dB/dec and the pathloss for land-mobile propagation over water is 20 dB/dec.

VI. CONCLUSION

This paper has described the philosophy behind Lee's model. First, the pathloss in an area is obtained as if the area has virtually flat ground. Second, the effective antenna-height gain is introduced and is changing based on the actual terrain contour where the mobile unit is traveling in real time in that area.

Also, extend the Lee's model concept to obtain the land-to-mobile pathloss over water. It is found to be 20 dB/dec, the same as in a free-space loss condition.

REFERENCES

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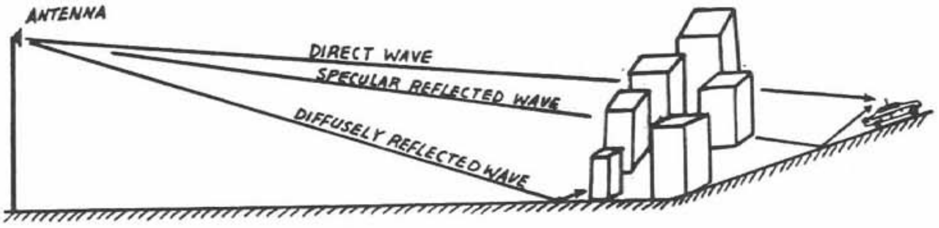

FIG. 1 Illustration of Direct Wave Specular Reflected Wave and Diffusely Reflected Wave in a Mobile Radio Environment

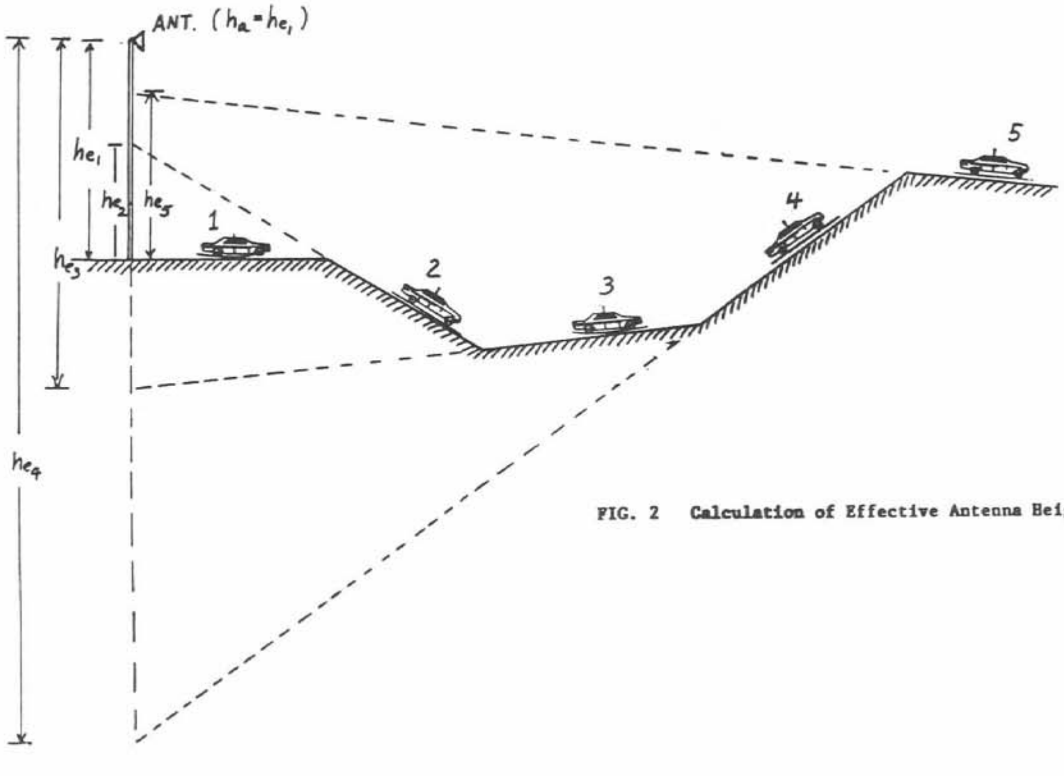

FIG. 2 Calculation of Effective Antenna Heights

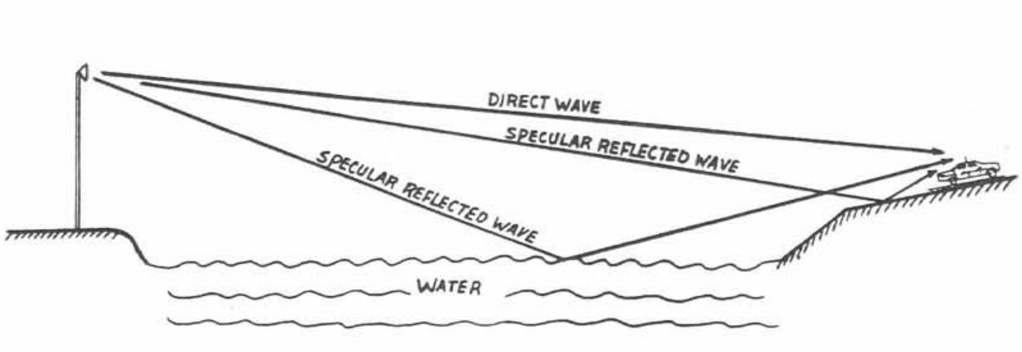

FIG. 3 An Additional Specular Reflected Wave Arrived from the Water Surface