Wireless Networks

Lecture 8:
Fresnel zone of Wireless Communication.

Visual LOS

If you stand on top of some tall building, you can see for a very great distance. You may even be able to see for many miles on a very clear day. If you can physically see something, it is said to be in your visual line of sight (visual LOS). This LOS is actually the transmission path of the light waves from the object you are viewing (transmitter) to your eyes (receiver).
RF LOS

RF LOS is more sensitive than visible LOS to interference near the path between the transmitter and the receiver. You might say that more space is needed for the RF waves to be seen by each end of the connection. This extra space can actually be calculated and has a name: the **Fresnel zone**.

The Fresnel Zone

The Fresnel zones (pronounced frah-nell), named after the French physicist Augustin-Jean Fresnel, are a theoretically infinite number of ellipsoidal areas around the LOS in an RF link. Many WLAN administrators refer to the Fresnel zone when it is more proper to refer to the first Fresnel zone, according to the science of physics. While it may be the intention of most WLAN administrators to reference the first Fresnel zone when they speak of only the Fresnel zone, it is important that you understand the difference. The first Fresnel zone is the zone with the greatest impact on a WLAN link in most scenarios. The Fresnel zones have been referenced as an ellipsoid-shaped area, an American football-shaped area. The following figure shows the intention of this analogy.
The Fresnel Zone

Fresnel zone: \( d \) is the distance between the transmitter and the receiver; \( b \) is the radius of the Fresnel zone.
The Fresnel Zone

If we call the Fresnel zone 1 “1FZ” from. Since 1FZ is an area surrounding the LOS and this area cannot be largely blocked and still provide a functional link, it is important that you know how to calculate the size of 1FZ for your links. You'll also need to consider the impact of Earth bulge on the link and 1FZ.
Fresnel Calculations

To calculate the radius of the 1FZ, use the following formula:

\[ \text{Radius} = \sqrt{72.2 \times \left( \frac{D}{4 \times F} \right)} \]

\[ \cdot = 72.05 \times \sqrt{\frac{d}{4f}} (\text{Miles}) \quad \cdot = 17.32 \times \sqrt{\frac{d}{4f}} (\text{GHz}) \]

Where \( D \) is the distance of the link in miles and \( F \) is the frequency used for transmission in GHz and radius is reported in feet.

Fresnel Calculations

For example, if you are creating a link that will span 1.5 miles and you are using 2.4 GHz radios, the formula would be used as follows:

\[ 72.2 \times \sqrt{\frac{1.5}{4 \times 2.4}} = 28.54 \text{ feet} \]
Fresnel Calculations

it is important to realize that a blockage of the 1FZ of more than 40 percent can cause the link to become nonfunctional.

To calculate the 60 percent radius, so that you can ensure it remains clear, use the following formula:

$\text{Clearance radius} = 43.3 \times \sqrt{\frac{D}{4 \times F}}$

Fresnel Calculations

where D is the distance of the link in miles and F is the frequency used for transmission in GHz and radius is reported in feet. Using the same example we used to calculate the radius of the entire 1FZ, you will now see that the 60 percent clearance radius is only 17.12 feet.
Fresnel Calculations

However, this leaves no room for error or change. For example, trees often grow into the 1FZ and cause greater blockage than they did at the time of link creation.

For this reason, some WLAN engineers choose to use a 20 percent blockage or 80 percent clearance guideline, and this is the recommended minimum clearance.

Earth Bulge and the Fresnel Zone

Another factor that should be considered in 1FZ blockage is the Earth itself. As you know, the Earth—it turns out—is round.

This means that the farther apart you and I are (or any two objects for that matter), the greater will be the likelihood that the Earth is between us. This is demonstrated in the following figure.
Earth Bulge and the Fresnel Zone

If you are creating wireless links over distances greater than 7 miles using WLAN technologies, you will need to account for Earth bulge in your antenna positioning formulas.

Earth bulge is a potential problem in outdoor wireless links over greater distances. The formula to calculate the extra height your antennas will need to compensate for Earth bulge is:

\[
\text{Height} = \frac{D^2}{8}
\]
Earth Bulge and the Fresnel Zone

where height is the height of Earth bulge in feet and D is the distance between antennas in miles. Therefore, if you are creating an 8-mile link, you would process the following formula:

\[ \frac{11^2}{8} = 15.12 \text{ feet} \]

Using our guideline of rounding up, I would raise the antenna height by 15.5-16 feet to accommodate Earth bulge.

Earth Bulge and the Fresnel Zone

where height is the height of Earth bulge in feet and D is the distance between antennas in miles. Therefore, if you are creating an 8-mile link, you would process the following formula:

Minimum antenna height = \((57.8 \times \sqrt{(11/(4 \times 2.4))}) + (11^2/8)\)
Earth Bulge and the Fresnel Zone

where height is the height of Earth bulge in feet and D is the distance between antennas in miles. Therefore, if you are creating an 8-mile link, you would process the following formula:

\[
\text{Minimum antenna height} = (57.8 \times \sqrt{11/(4 \times 2.4)}) + (11^{2}/8)
\]

Incorrect installation, the trees obstruct the line of sight. The received signal will be severely attenuated.
Fresnel Zone

Incorrect Installation, the first Fresnel zone is partially obscured. The received signal will suffer attenuation path from node A to node D.

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Correct installation. The first Fresnel zone clears the trees.
Fresnel Zone

\[
r = 72.6 \times \sqrt{\frac{d}{4f}}
\]
Thank You