Weird & Wireless: What happens when an RF hits an obstacle?

Welcome again to the wonderful but sometimes weird world of wireless comms, written by Joel Young, CTO of Digi International.

Let's get beyond line of sight. What's the definition of an obstacle and what happens when an RF hits one?

In previous blogs we discussed the concept of **free space loss** as it relates to spherical expansion from an isotropic transmitter, a.k.a. an inverse square law. We also covered the **frequency dependency of propagation in free space** as defined by the aperture of an isotropic receiver.

Most recently, we introduced a piece of wisdom from **Augustin Fresnel** which provides the basis for what is commonly referred to as "line of sight." Unfortunately all of these concepts present us with a set of rather big problems, because they are all based on "IDEAL" situations.

There is of course no such thing as a truly isotropic transmitter or receiver - this is probably good news as we'll find out a little later.

In addition, true line of sight is a rare occurrence indeed - again something I personally am thankful for as I genuinely appreciate the blue sky during the day as well as a reddish-orange sunset.

In the world of visible light, we know the Fresnel radius is very small so we generally know an obstacle and its effects when we see one. We know that visible light, when it hits an obstacle is either absorbed or scattered. Of course, when it is absorbed we generally think of it has having a very dark colour and it usually gets hot. When it is scattered, we generally see the result by the appearance of various colours. Remember, the notion of colour isn't anything real - it's just our eyes' way of tuning into the different light frequencies that they detect.

The same principles apply in the lower frequency, longer wavelength RF world; it's just that the rules of absorption and scattering change a bit - and thank fully so, otherwise our radios would never be able to get through any walls. Okay, this is easy enough at a macro level, but what are the rules? This is where it gets a little bit sticky.

The rules of absorption seem clear enough, but I admit, the rules around scattering are a bit more challenging to conceptualise.

In the world of waves, at a fundamental level, there can be one of only three potential outcomes when encountering an obstacle: (1) the wave pass through it-albeit maybe after getting bumped around a bit, (2) the bounces off it kind of like a pool ball hitting a bumper - it might come straight back (like a reflection) or it might head off in some angular direction, or (3) the energy of the wave gets absorbed - which generally causes an increase in temperature.

Let's take a closer look at absorption. We know that the energy of the wave is converted to heat and we generally know this is because all the atoms start moving faster and running into each other - but why do higher frequencies appear to get absorbed easier than low frequencies?

The answer relates back to our antenna aperture discussion a few weeks back. It takes a big opening to capture a long wavelength. I like to think of it this way.

When an electro-magnetic wave hits an obstacle, it tries to get everything vibrating inside at the same frequency and in the same direction as propagation. If successful, the wave appears to pass on through. With a long wavelength, low frequency, there really isn't all that much opportunity for the wave to get off track.

However, high frequencies, with short wavelengths have trouble staying the course because of the potential for all the other little movements. I like to think that they appear to be very easily distracted. This effect shows up with all waves, not just the electromagnetic ones - have you ever heard of a high frequency fog horn? I think not.

We know that microwave ovens appear to cook because the microwaves don't pass through water very well. It then stands to reason that microwaves probably won't pass through foliage very well either. Leaves tend to contain a lot of water.

Thinking of it this way, scattering really isn't all that different. It means that the wave "rattles around" in the obstacle (or on the surface of the obstacle) and gets spit back out in some other direction. Depending on how it emerges, we may call it a reflection or a refraction. The nice thing about scattering is that, if we are skilled, we can use the properties of an obstacle to help guide the wave.

Have you ever noticed that those same microwaves that have trouble getting through water appear to find their way around concrete parking garage? It's amazing that enough rattling around can actually give the appearance of progress or in this case, enough wrongs tend to make a right.

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Prior to joining Digi, Joel was VP of Sales & Marketing at Transcrypt International where he was responsible for sales, marketing, and product development for all information security products. During his tenure at Transcrypt, he also served as VP of Product Development and VP of Engineering where he was responsible for engineering, research and product development for wireless communications products, cellular telephony, wireline telephony and land mobile radio, data security and specialized digital radio products.

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