Weird & Wireless: Why don't wireless transmissions go on forever?

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

If there's nothing in the way, why don't wireless transmissions appear to go on forever?

For those of you that are already experts in physics and engineering, you will most likely find this blog a bit elementary for you.

Nonetheless, I'm writing it because I routinely get asked questions similar to this one on a daily basis. Many see a bit of contradiction. For example, the stars in the sky are clearly very far away and millions of light-years and the visible and non-visible radiation still seems to make it all the way to us on earth, yet it seems that some radios die out quickly even when there aren't any obstacles in the path.

So the short answer is that all of these waves, unless they run into something and get absorbed or scattered will theoretically go on forever at the speed of light.

However, it is important to look at the relative energy of these waves. One of the key laws to the world of physics is the conservation of energy. There is a fixed amount of energy in the universe - you can't make more, you can't get rid of it, but you can change it from one form to another.

Of course for most of you, this will cement the fact that these electromagnetic waves, unless they run into something will go on forever. And while we know that there is lots of stuff out there in the universe, it sure appears that there is a whole lot of empty space. Obviously that doesn't tell the whole story.

Drop a pebble into a pool of water, the wave will extend away from the point of impact in a nice circle. As the wave gets farther from the centre, the circle obviously gets bigger.

In getting bigger, the energy in the wave is spread out over an ever expanding area. For the sake of the discussion, we will assume there is no impact to due to external forces so the energy of the whole wave remains the same. If we had an infinitely large pond of perfectly still water with a constant depth, the wave resulting from the pebble would technically go on forever in all directions. However, in doing so the magnitude (e.g. size) of the wave would get smaller.

Unfortunately, the stone in water example is only two-dimensional. Electro-magnetic waves operate in three dimensions so we need to extend the metaphor a bit.

When we look at an ideal radiator of electromagnetic waves, we need to think isotropically. This means waves extending out equally in all directions from a point (a.k.a. a sphere).

A good example might be a star like our very own sun. Just like the circle in the water, the electromagnetic energy spreads as the wave gets farther away, just like the surface area of a sphere.

From our basic geometry we know that the surface area of a sphere of radius r is $4\pi r^2$; hence as we get farther from the transmitter, the power in the waves get "stretched" accordingly meaning that the resulting strength of the signal at any point is INVERSELY proportional to the square of the distance (r) from the transmitter ($1 / 4\pi r^2$).

It gets very small, very quickly, but never really gets to zero. This is often referred to as an inverse square law - as you know, gravity also works this way.

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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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