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RADIO ASTRONOMY WINTER SCHOOL 2020

EFFECTS OF VARYING DISTANCE ON WIFI SIGNAL

Submitted by

<u>Group 10</u>

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ABSTRACT

This experiment was conducted as a part of Radio Astronomy Winter School (RAWS) 2020 to verify inverse-square law relation(1/R2) between Wi-Fi signal strength and distance. RSSI, or "Received Signal Strength Indicator," is a calculation of how well an access point or router can hear a signal from your computer. If you have enough signal to get a decent wireless link, it's a quality that is useful to assess. A simple setup consisting of laptop running the signal strength measurement software as a receiver and mobile phone as a transmitter was used.

APPARATUS REQUIRED

- Hardware

  Mobile phones with hotspot, laptop running the signal strength measurement software, measuring tape.
- Software

  Vistumbler, LINUX python script.

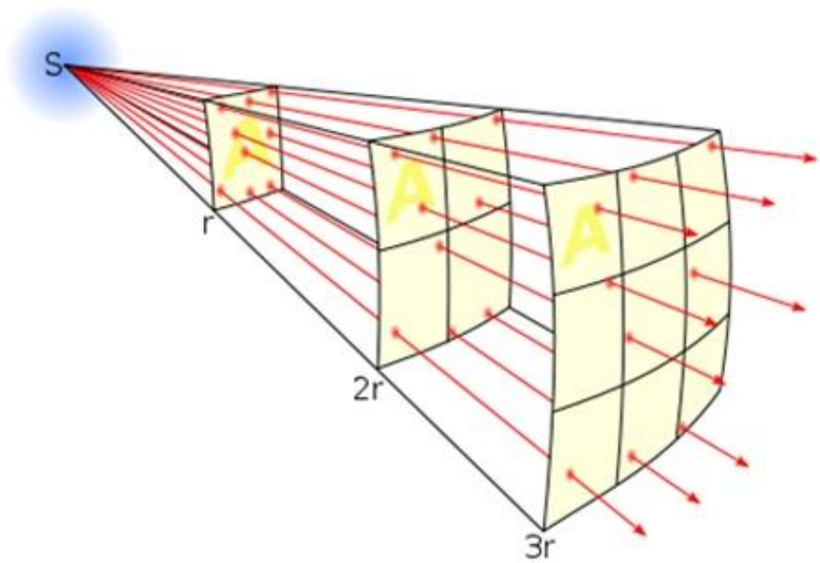
PRINCIPLES INVOLVED

The intensity (or illuminance or irradiance) of light or other linear waves radiating from a point source (energy per unit of area perpendicular to the source) is inversely proportional to the square of the source distance, so that the target (of the same size) absorbs only one-quarter of the energy twice as far away (in the same time period).

More generally, the radiance of a spherical wavefront varies inversely, i.e., the intensity (or power per unit area in the direction of propagation) of a spherical wavefront.

Let P be the total power of a point source radiated from (for example, an omnidirectional isotropic radiator). This power is spread over larger and larger spherical surfaces at great distances from the source (compared to the source's size) as the distance from the source increases. Since the surface area of a radius r sphere is $A = 4\pi r^2$, the intensity I (power per unit area) of radiation at distance r is

$$I = \frac{P}{A} = \frac{P}{4\pi r^2}$$



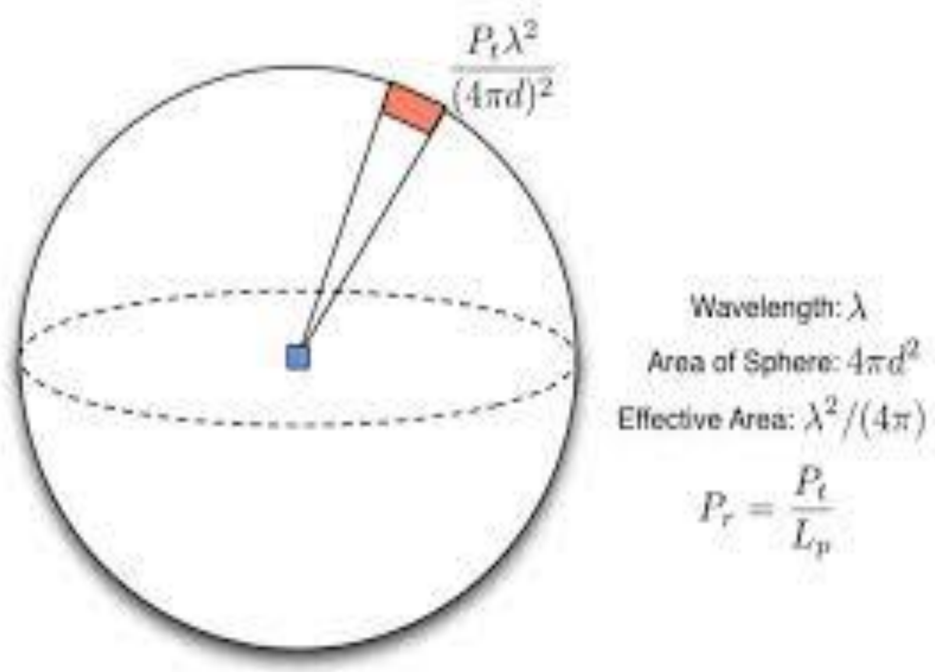
EM waves' intensities fall as 1/r2 assuming nothing gets in the way, but the geometry of the place one does the experiment gives a more complicated dependence that's unlikely to be a function of r alone. If an exponential decay occurred, it would look linear when we plot decibels against distance, because the decibel scale is logarithmic.

We plotted decibels against log-distance (or e^{Power} against distance, but that would lead to too many orders of magnitude on the axes), which on an inverse-square model should become a straight line of gradient −2 assuming one takes logarithms "the same way" for distance as for decibels. So, multiplication by 10 should add 10 points and then the base of the logarithm would be $10^{0.1}$. Working instead with base-e ("natural") logarithms, we expect a straight line of gradient −20/ln10 since multiplication by 10 would only add ln10 points.

$$\text{The recieved power is } P_r = \frac{P_t \lambda^2}{16\pi^2 R^2} \text{ or } P_r = \frac{\kappa}{R^2} \text{ where } \kappa = \frac{P_t \lambda^2}{16\pi^2}$$

$$\log(P_r) = -2\log(R) + \log(\kappa)$$

Here κ will be constant for a specific medium if transmitted power P_r doesn't change. We know that c=λυ, where c is speed of EM wave, λ is the wavelength of wave, υ is the frequency of the wave.



- Isotropic transmit antenna: Radiates signal equally in all the directions
- Assume a point source,
  - At a distance d from the transmitter, the area of the sphere enclosing the Tx is: $A=4\pi d^2$
  - The "power density" on the sphere is $P_t/4\pi d^2$
- Isotropic receiver antenna: Captures power equal to the density times the area of the antenna. Ideal area of the antenna is

$$A_{ant}=\lambda^2/4\pi$$

- The received Power is

$$P_r= P_t/4\pi d^2 \times \lambda^2/4\pi = P_t\, \lambda^2/(4\pi d^2)$$

PROCEDURE

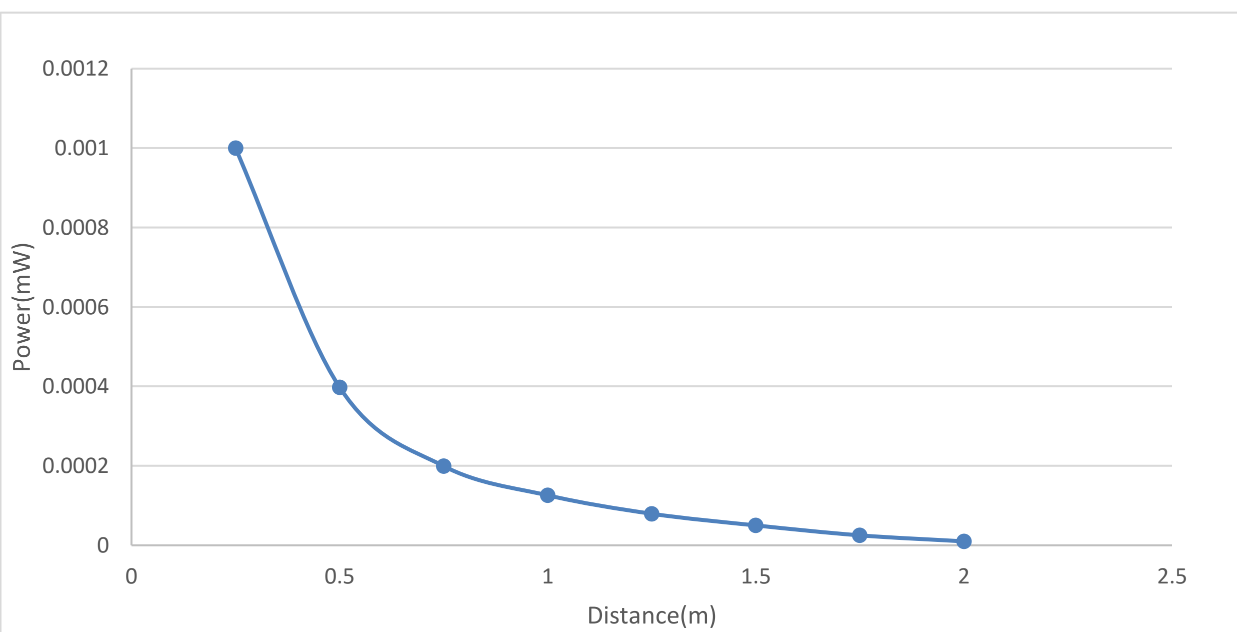
- Create a Wi-Fi hotspot on the mobile phone and connect the laptop to the hotspot.
- Disconnect the mobile phone from internet. Put the mobile phone in Flight Mode.
- Start varying the distance between the devices.
- Measure and note down the distance and the corresponding power.
- Plot the signal strength vs distance on a log-log plot and fit the appropriate curve to the data. Check the residuals.

NOTES:

- Find the exact location of Wi-Fi antennas in the devices for best results.
- Keep your mobile phone and laptop charged.
- The detecting might take a few seconds to settle down on a reading. Make sure not to move around the setup during this time.
- A lower limit to the signal strength could be between -80 dBm to -95 dBm. Avoid measurements below -80 dBm.

RESULTS AND DISCUSSION

It can be seen that when the distance increases, power is getting reduced and the graph shows $1/r^2$ relation.



When we plot a log-log plot we get a linear graph as expected.