Computer Networks

Transmission Media (Unguided) and Antennas

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Antennas

- Electrical conductors used to radiate or collect electromagnetic energy

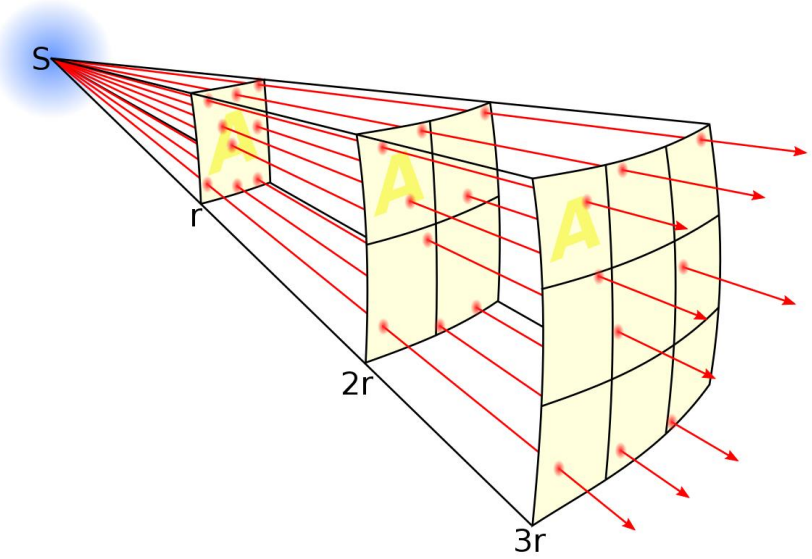
- Transmission antenna: Electrical energy → converted to electromagnetic energy → radiated into the surrounding

- Reception antenna: Electromagnetic energy → converted to electrical energy → fed to the receiver

Isotropic Antennas

- Isotropic antenna:
  - A point in space that radiates power in all directions equally with a spherical radiation pattern

$$\frac{P_t}{P_r} = \left(\frac{4\pi d}{\lambda}\right)^2 = \left(\frac{4\pi f d}{c}\right)^2$$

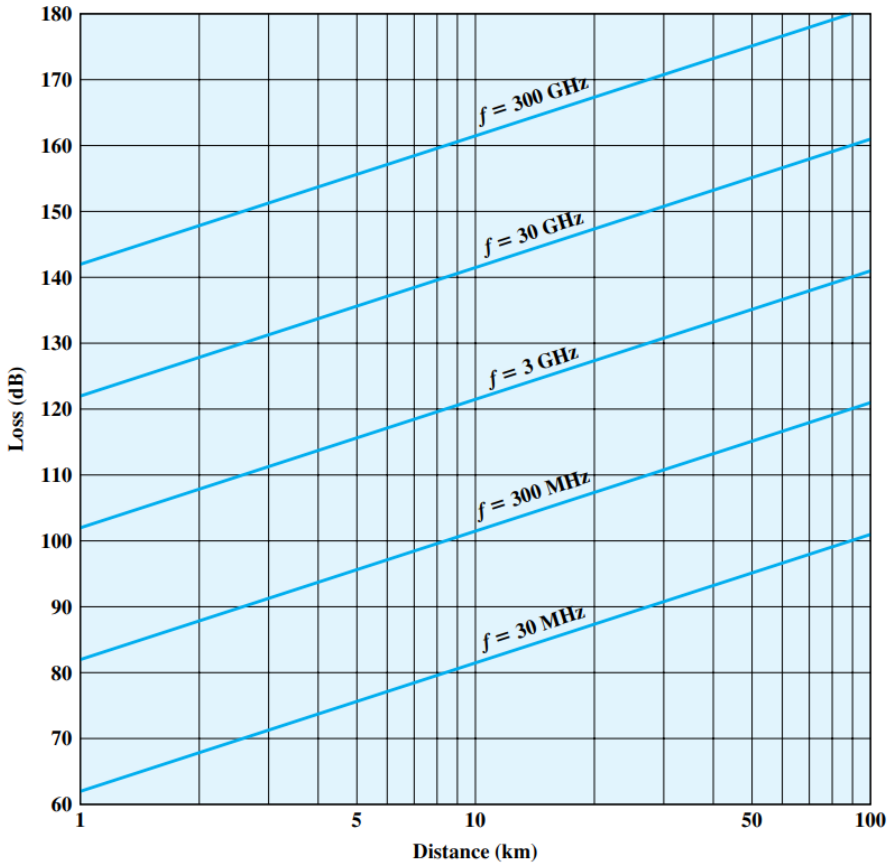


Src: https://en.wikipedia.org/wiki/Free-space_path_loss

Isotropic Antennas

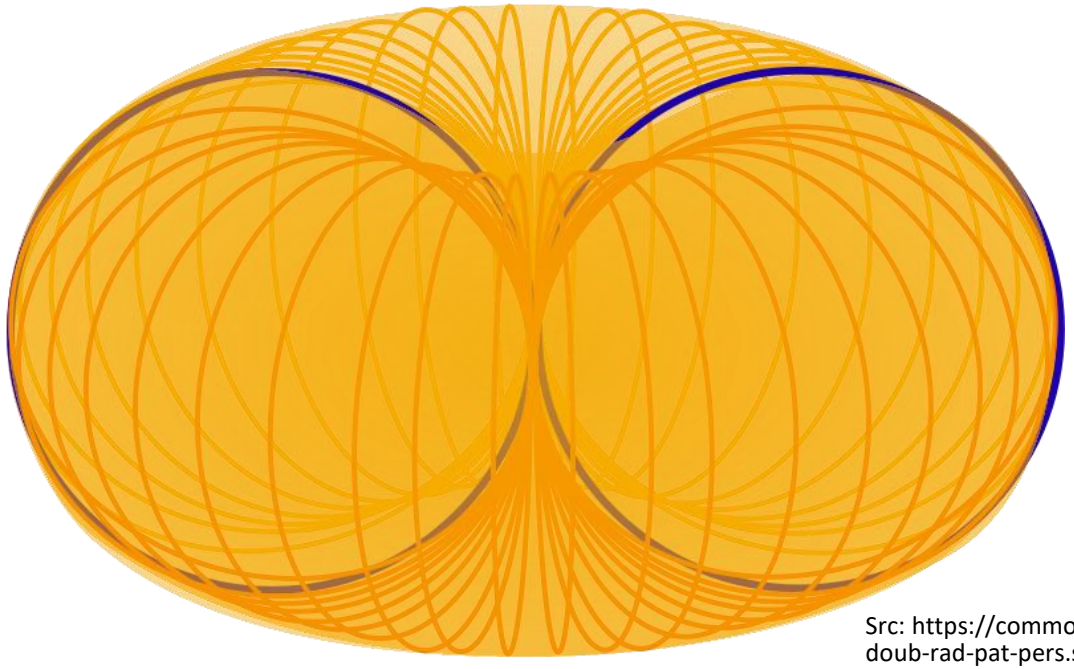
Lose $\propto f$

$$\frac{P_t}{P_r} = \left(\frac{4\pi d}{\lambda}\right)^2 = \left(\frac{4\pi f d}{c}\right)^2$$



Omni-directional Antennas

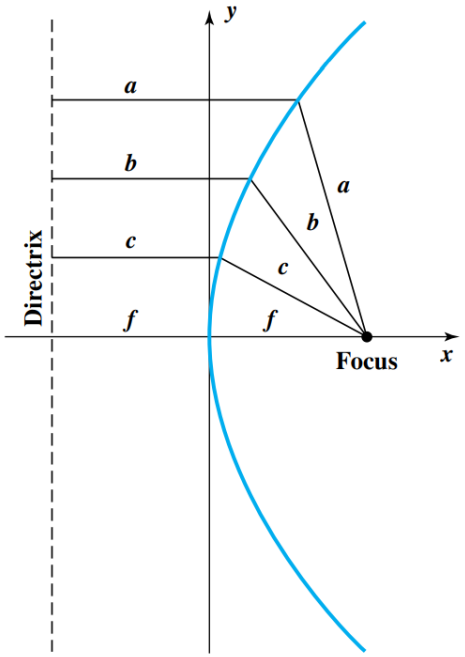
- Omni-directional antenna: power propagates uniformly in all directions in a plane
  - Cell phones, FM radios, walkie-talkies etc.



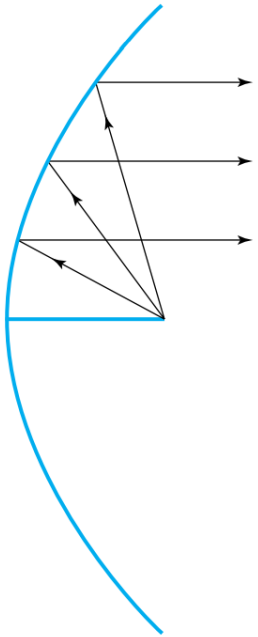
Src: https://commons.wikimedia.org/wiki/File:Elem-doub-rad-pat-pers.svg

Directional Antennas

- Directional antenna: Parabolic reflective antenna



(a) Parabola



(b) Cross section of parabolic antenna showing reflective property

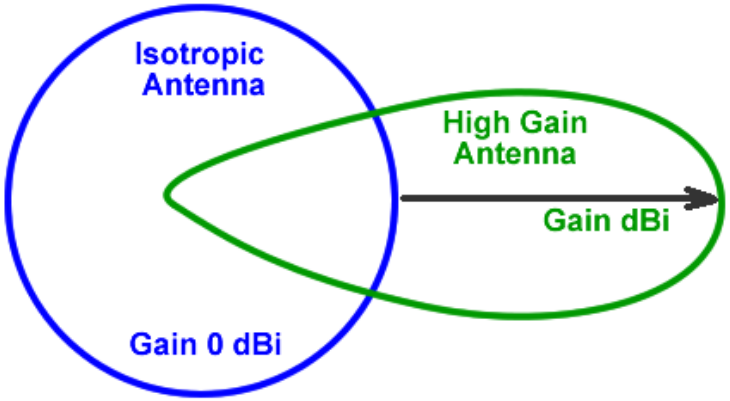
Antennas

- Directional antenna: Parabolic reflective antenna
  - Satellite communications, radio telescopes etc.

Src:https://commons.wikimedia.org/wiki/File:Antenna_03.JPG

Antenna Gain

- Antenna gain:
  - Measure of directionality
  - Defined as the power output in a particular direction, compared to that produced in any direction by a perfect isotropic antenna (dBi)
  - http://www.cisco.com/en/US/prod/collateral/wireless/ps7183/ps469/product_data_sheet09186a008008883b.html



Src: https://www.ahsystems.com/articles/Understanding-antenna-gain-beamwidth-directivity.php

Radiated power of isotropic antenna

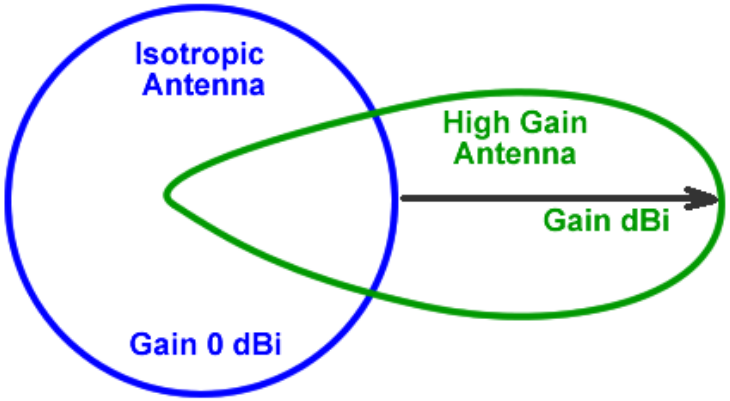
$$G_{dB} = 10\log_{10}\frac{P_i}{P_d}$$

Radiated power of directional antenna

Antenna Gain

- Consider a directional antenna with a gain of 6 dB over a reference antenna and that radiates 700 W. How much power must the reference antenna radiates to provide the same signal power in the preferred direction?

$$G_{dB} = 10\log_{10}\frac{P_i}{P_d}$$



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Free Space Path Loss

❑Free space path loss:

$$\frac{P_t}{P_r} = \frac{1}{G_t G_r}\left(\frac{4\pi d}{\lambda}\right)^2 = \frac{1}{G_t G_r}\left(\frac{4\pi f d}{c}\right)^2$$

- G_t: Transmit antenna gain
- G_r: Receiver antenna gain
  - Receiver antenna provides an aperture with an effective area for receiving a fraction of the transmitted power

Free Space Path Loss

- Assume that a ground station is transmitting a signal of 250 W to a satellite at 4 GHz (earth to satellite distance is 35863 km). The antenna gains are 44 dB and 48 dB. What is the received power?

$$\frac{P_t}{P_r} = \frac{1}{G_t G_r}\left(\frac{4\pi d}{\lambda}\right)^2 = \frac{1}{G_t G_r}\left(\frac{4\pi f d}{c}\right)^2$$

Summary

- Wireless transmission medium:
  - Isotropic, omnidirectional and directional antenna
  - Free space path loss
  - Antenna gain