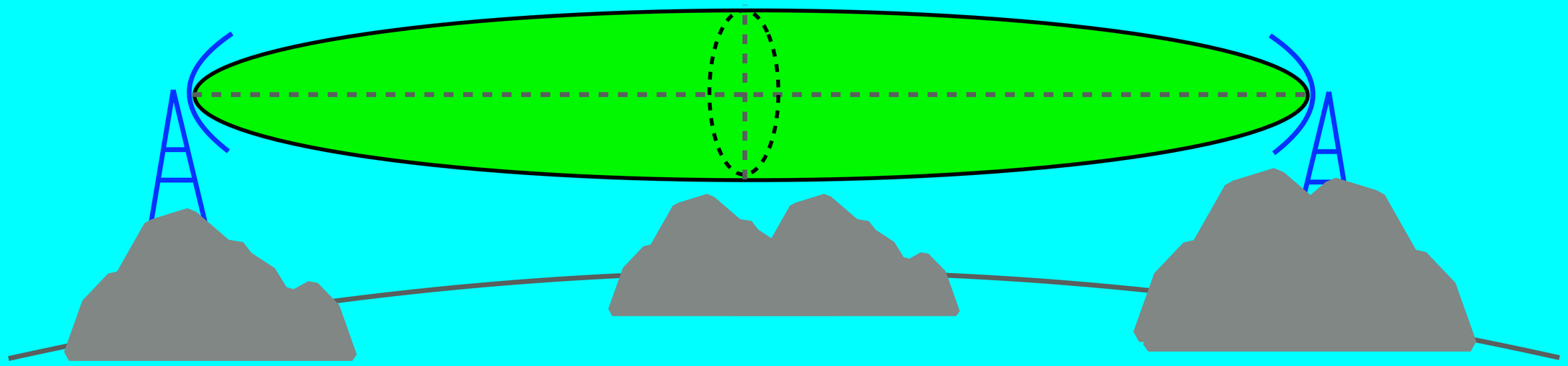
LORA / LORAWAN TUTORIAL 7

Fresnel Zone



INTRO

- In this tutorial I will explain what the Fresnel zone is.

FRESNEL ZONE

- The Fresnel zone is an elliptical shaped body around the direct line of sight path between the end node and the gateway.

- Any obstacle within this volume, for example buildings, trees, hilltops or ground can weaken the transmitted signal even if there is a direct line of sight between the end node and the gateway.

- The maximum radius of the Fresnel zone, located half the distance between end node and gateway is calculated as follow:

```
r = 8.657 x sqrt(D / f)
r = Fresnel zone radius in m
D = distance in km
f = frequency in GHz
```

FRESNEL ZONE

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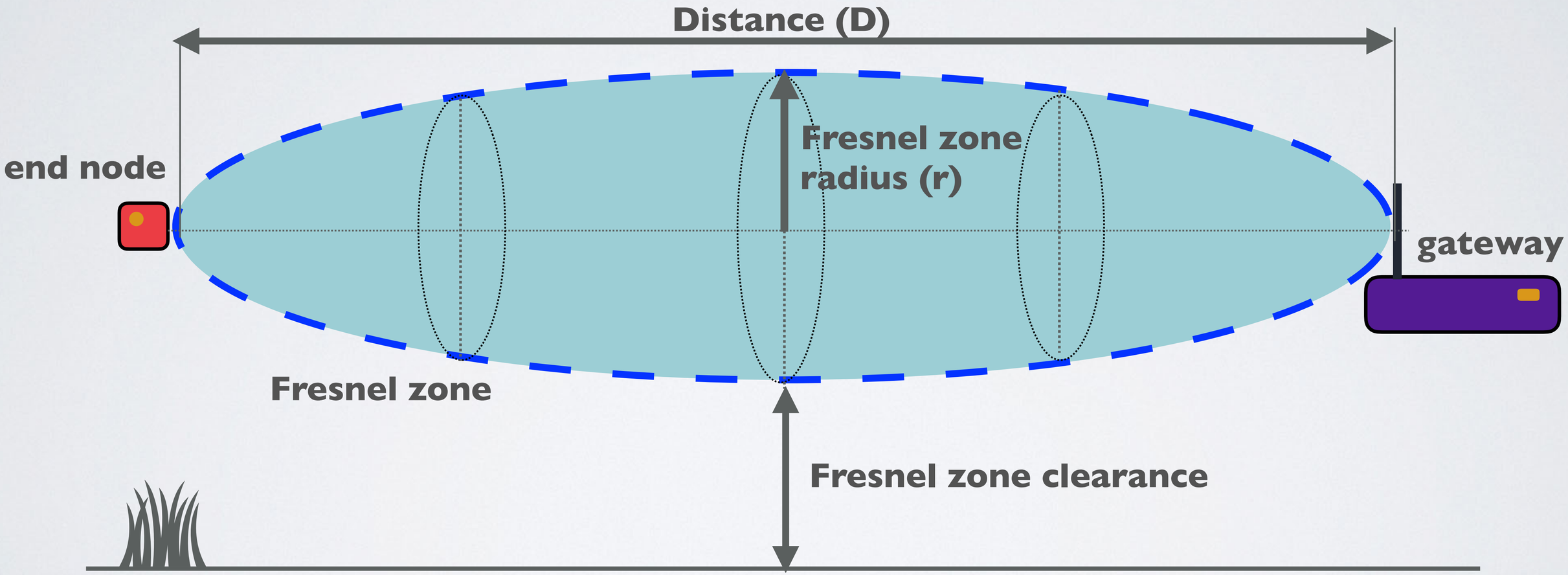
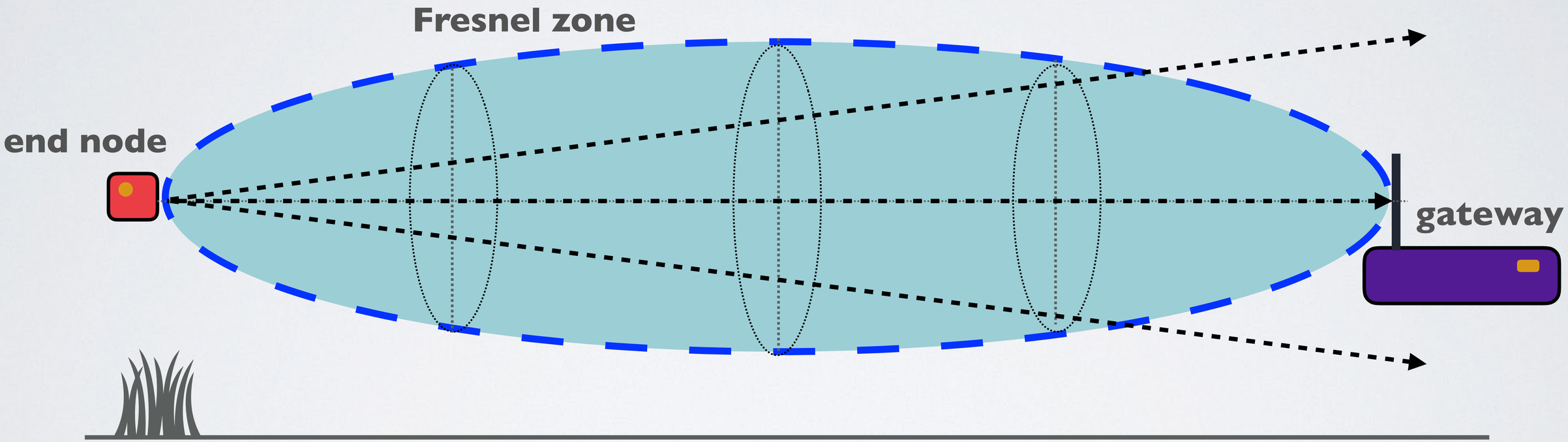


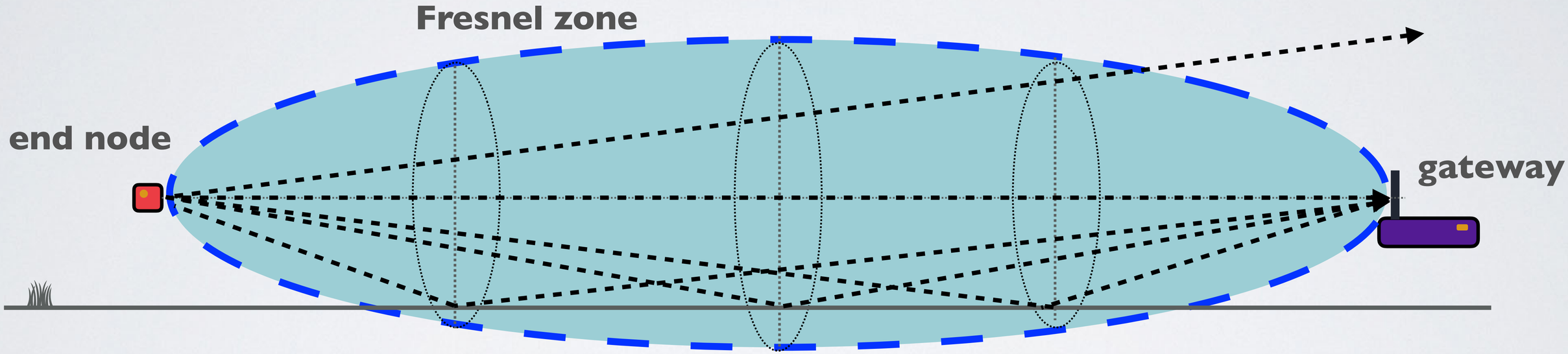
FRESNEL ZONE



End node sends signal to gateway without any interference
No obstacles in the Fresnel zone

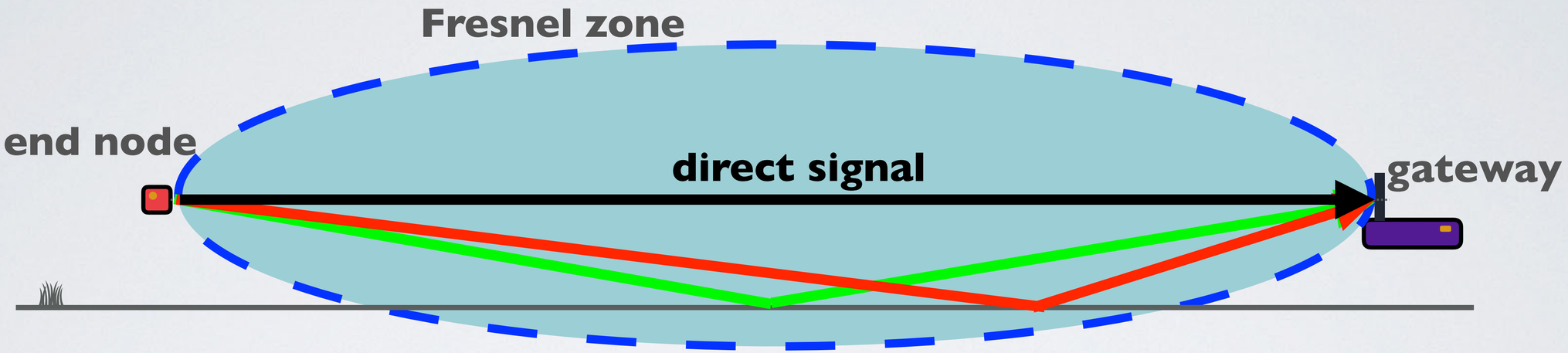
FRESNEL ZONE

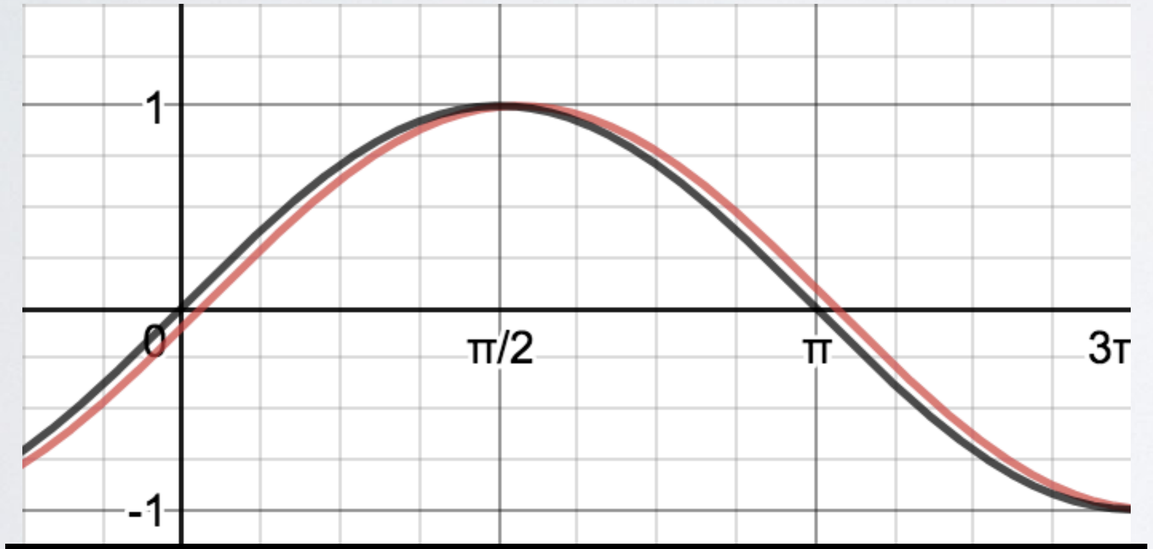
Change the distance between end node and gateway or change the end node and/or gateway vertical position



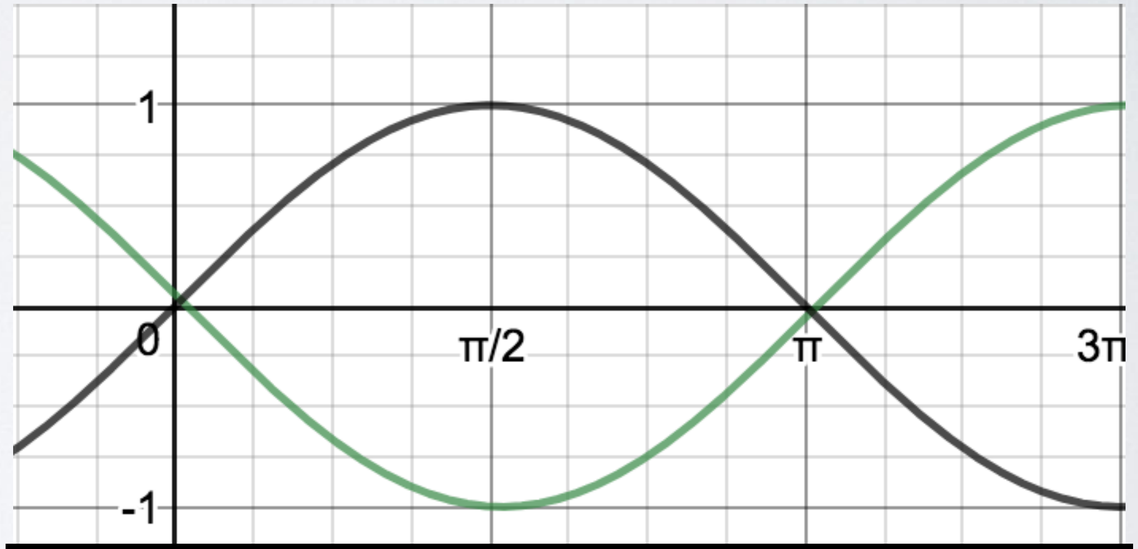
Ground is inside the Fresnel zone
Reflected signals interfere with the direct signal

FRESNEL ZONE





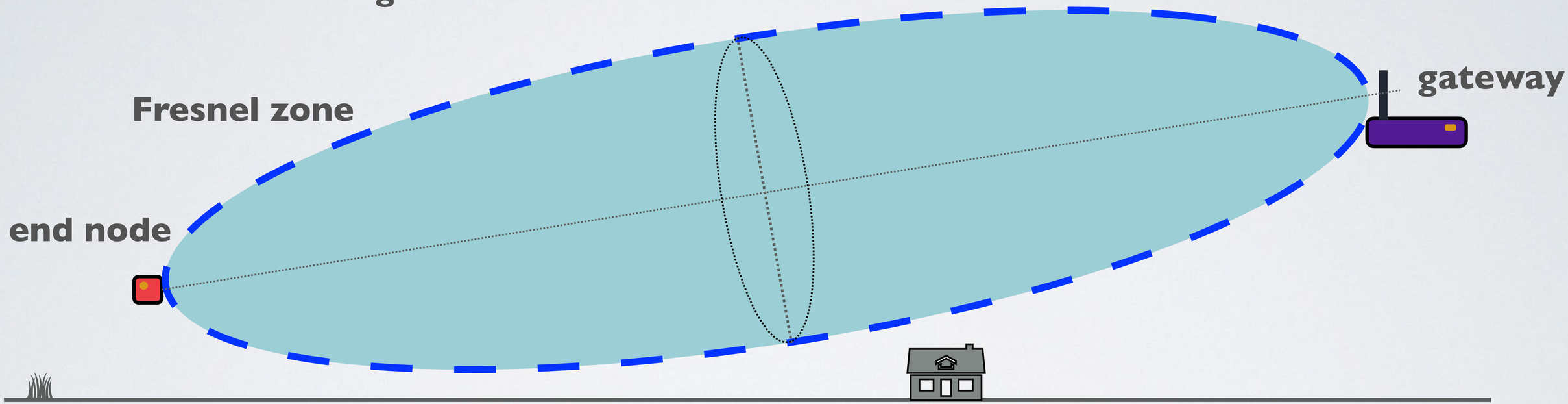
Direct and reflected signals are in phase. Direct signal will be enhanced.



Direct and reflected signal out of phase. Direct signal will be cancelled out.

FRESNEL ZONE

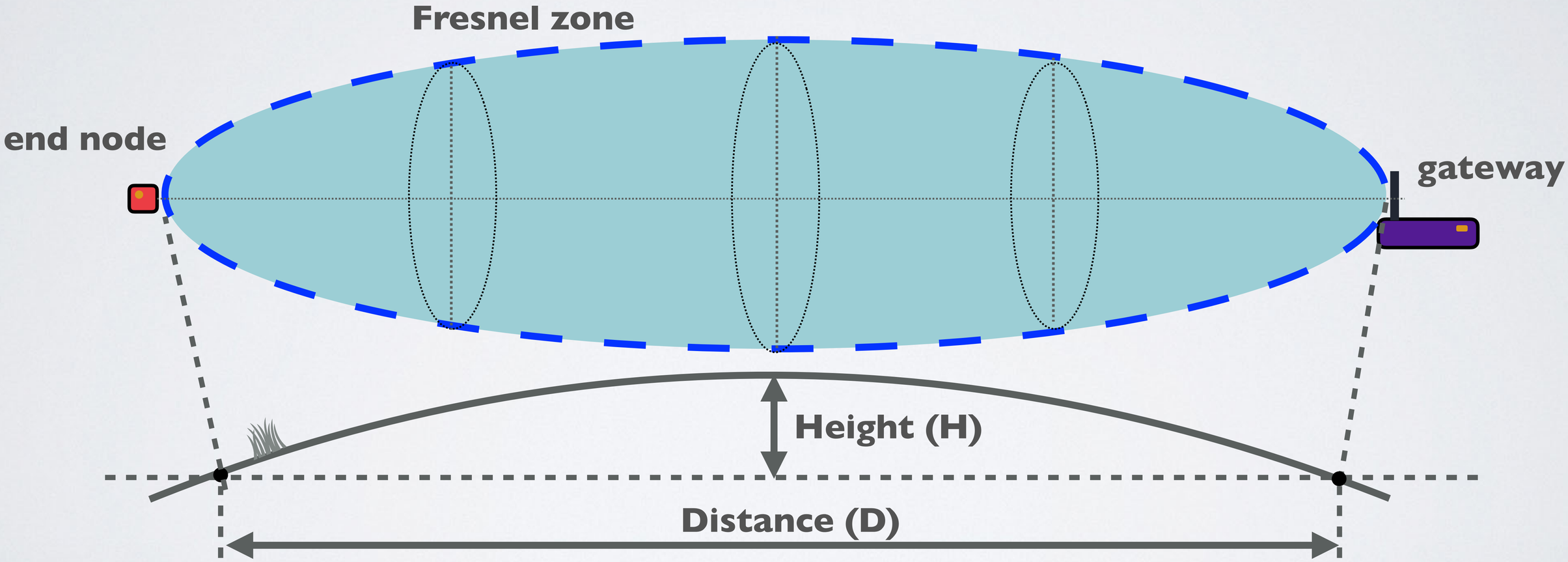
Place antenna at a higher location



End node sends signal to gateway without any interference
No obstacles in the Fresnel zone

FRESNEL ZONE

- The Fresnel zone equation **r = 8.657 x sqrt(D / f)** is based on a flat earth. It does not take the curvature of the earth into consideration.

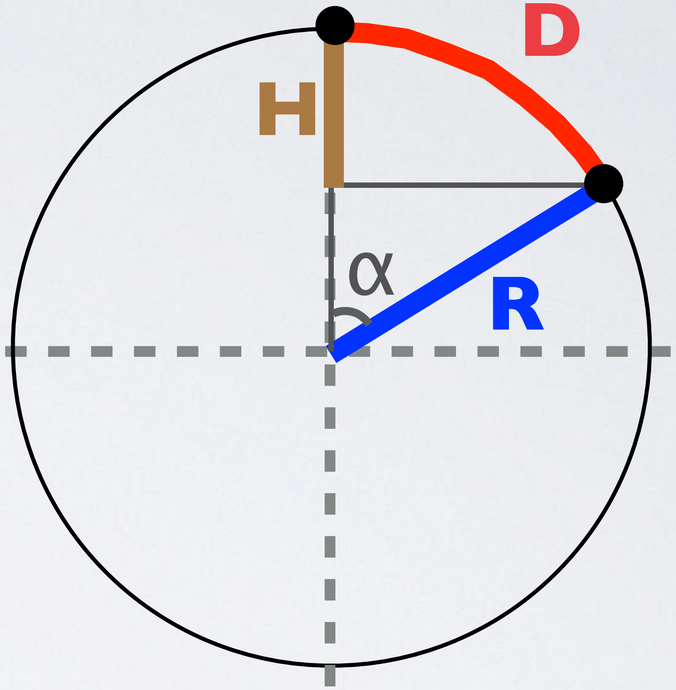


FRESNEL ZONE

- To calculate height H:

$$\alpha = D \times \frac{360}{2 \times \pi \times R}$$

$$H = R - (R \times \cos\alpha)$$



- H = Height (or earth curvature allowance) in km
  D = Distance between end node and gateway in km
  R = Earth radius in km = 6371 km
  α = Angle between end node and gateway in degrees

FRESNEL ZONE

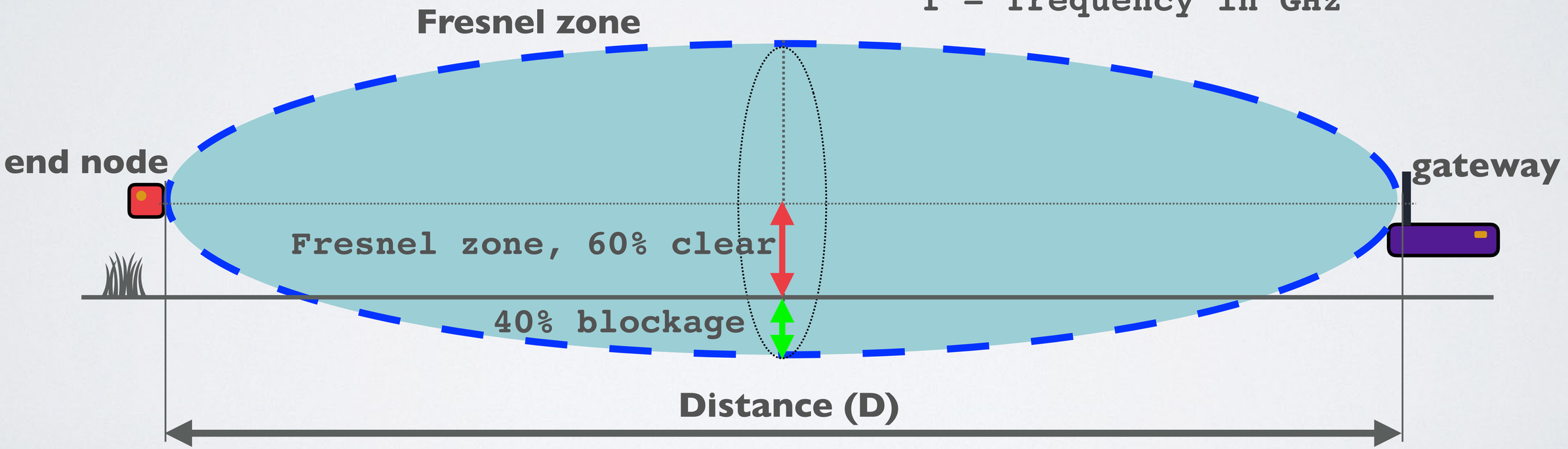
Distance (km)	Height (m)
0.1	Negligible
0.5	Negligible
1	Negligible
2	Negligible
5	1.96

Distance (km)	Height (m)
10	7.85
15	17.66
20	31.39
25	49.05
30	70.63

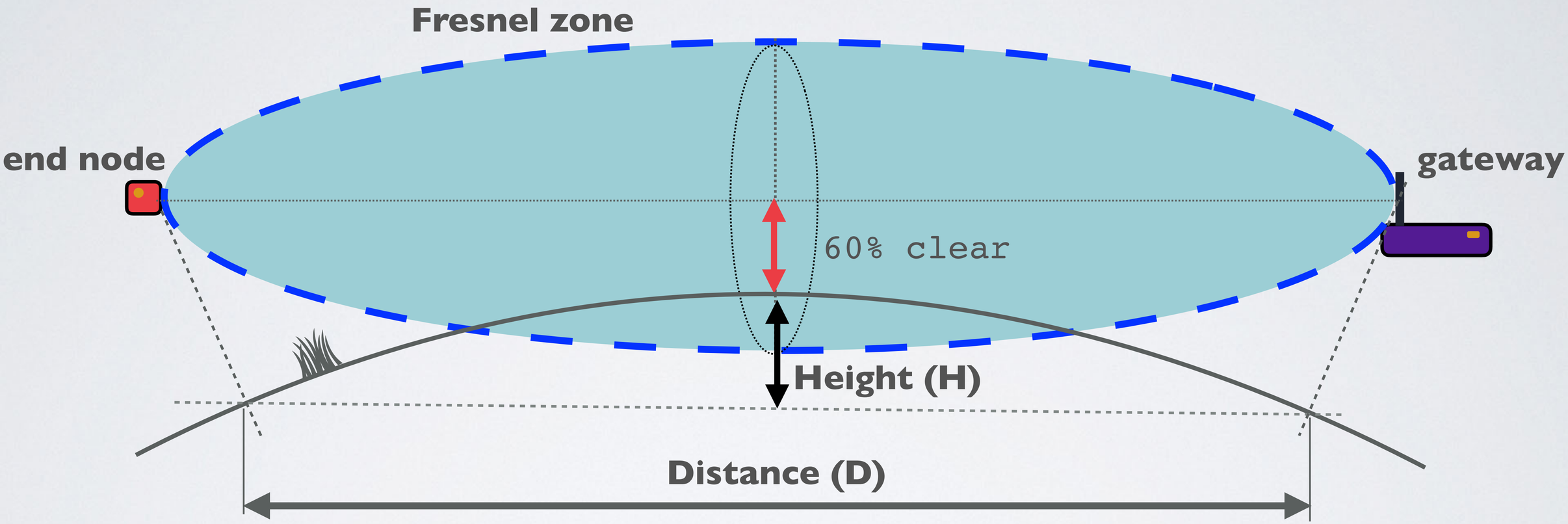
FRESNEL ZONE

- As a rule of thumb Fresnel zone should always be clear of obstruction but this can be impractical so it is said that beyond 40% blockage, signal loss will become significant.

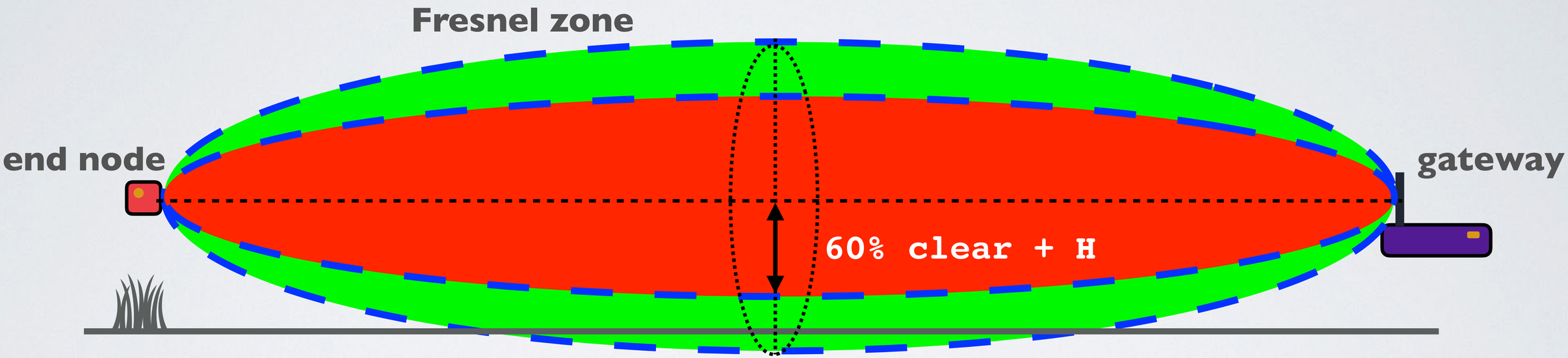
```
r = 8.657 x sqrt((0.6 x D) / f)
r = Fresnel zone radius in m
D = distance in km
f = frequency in GHz
```



FRESNEL ZONE



FRESNEL ZONE



FRESNEL ZONE

Example: f = 868 MHz = 0.868GHz H is the earth curvature allowance.
100% clear: **r = 8.657 x sqrt(D / f)**, 60% clear: **r = 8.657 x sqrt((0.6xD) / f)**

100 % clear

D (m)	D (km)	r (m)	r + H (m)
100	0.1	2.94	2.94
500	0.5	6.57	6.57
1000	1.0	9.29	9.29
2000	2.0	13.14	13.14
5000	5.0	20.78	22.74
10000	10.0	29.38	37.23

60 % clear

D (m)	0.6 x D (km)	r (m)	r + H (m)
100	0.06	2.28	2.28
500	0.3	5.09	5.09
1000	0.6	7.20	7.20
2000	1.2	10.18	10.18
5000	3.0	16.09	18.05
10000	6.0	22.76	30.61

IMPROVE RADIO SIGNAL PERFORMANCE

- For the best radio signal performance:
  - The gateway antenna must be placed outdoors at a high location (avoiding obstacles in the Fresnel zone).
  - The antenna design for both gateway and end nodes must be optimised for its regional frequency.
  - Keep the antenna polarisation vertical for both gateway and end nodes and use omnidirectional antenna to cover a large area.