Yann DOUZE
Twitter : @yann_douze
Linkedin :
https://www.linkedin.com/in/yanndouze/

The Internet Of Things
C6 : Radio Transmission and propagation

Radio Transmission and propagation

- ✓ Units and definitions: Decibel, dBm, RSSI, Sensitivity and SNR
- ✓ Examples and studies of technical documentation

Units and definitions : Decibel - 1

dB: **Ratio between two powers**

An attenuation → represented by a negative number (**-**).

A gain → represented by a positive number (**+**).

dB ?

$$G_{dB} = 10\log\left(\frac{P_R}{P_T}\right)$$

Power ratio in dB	Power ratio	
10 dB	Multiplication by 10	$P_R = 10\ P_T$
3 dB	Multiplication by 2	$P_R = 2\ P_T$
0 dB	Equality	$P_R = P_T$
-3 dB	Division by 2	$P_R = P_T/2$
-10 dB	Division by 10	$P_R = P_T/10$

Interest ?

Units and definitions : Decibel - 2

Air

P_T : 90 dB attenuation

P_T : Transmit power

P_R : Received power

P_R is 1 billion times smaller than P_T

Power ratio in dB	Power ratio
+ 10 dB	Multiplication by 10
+3 dB	Multiplication by 2
0 dB	Equality
-3 dB	Division by 2
-10 dB	Division by 10

$$P_T = 10^9 \times P_R \qquad = \underbrace{10 \times 10 \times 10 \ldots \times P_R}_{9\ times}$$

$$G_{dB} = \underbrace{10 + 10 + 10 \ldots}_{9\ times} = 90\ dB$$

The decibel for power : dBm

dBm : Ratio (in decibel) between a power and the power of 1mW

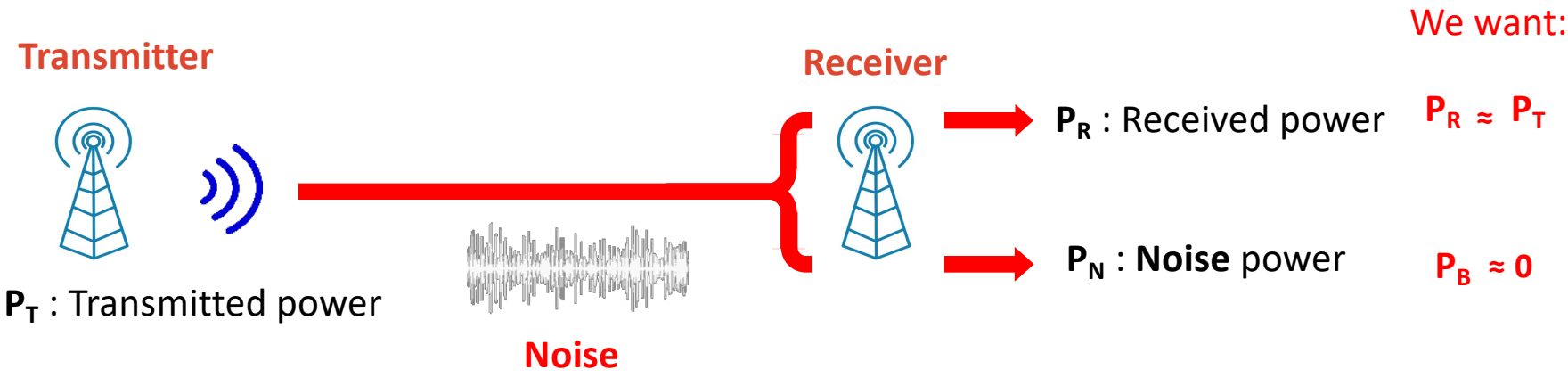
Power in dBm	Power ratio	
10 dBm	Multiplication by 10	**x10 → 10 mW**
3 dBm	Multiplication by 2	**x2 → 2 mW**
0 dBm	Equality	**1 mW**
-3 dBm	Division by 2	**0,5 mW**
-10 dBm	Division by 10	**0,1 mW**

The walkie-talkie has a transmission power of 2W. What is the transmission power in dBm?

$$P_T = 1ml$$

$$P_{T(dBm)} =$$

Definitions: RSSI, Sensitivity, SNR



dBm
- ❑ **RSSI** (Received Signal Strength Indication): power $\mathbf{P_R}$ of the received signal

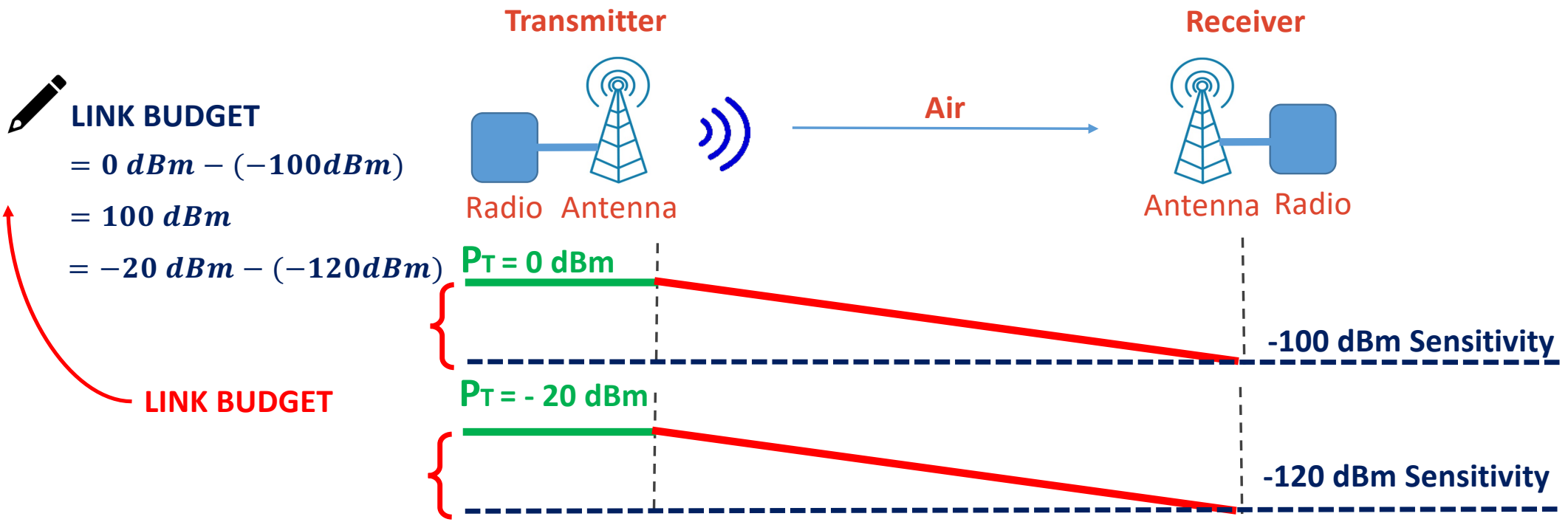
dBm
- ❑ **Sensitivity**: minimum RSSI to receive a signal

RSSI > Sensitivity
RSSI < Sensitivity

dB
- ❑ **SNR** (Signal over Noise Ratio): Ratio of P_R and P_N

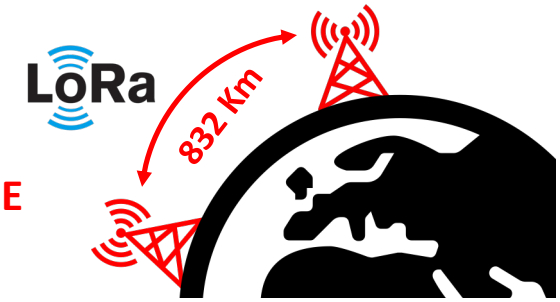
$\mathbf{P_R/P_N}$

Definitions: Link Budget



- **Link Budget**: P_T - Sensitivity
  - ✓ **In LTE (4G):** 130 dB
  - ✓ **In LoRa:** 157 dB

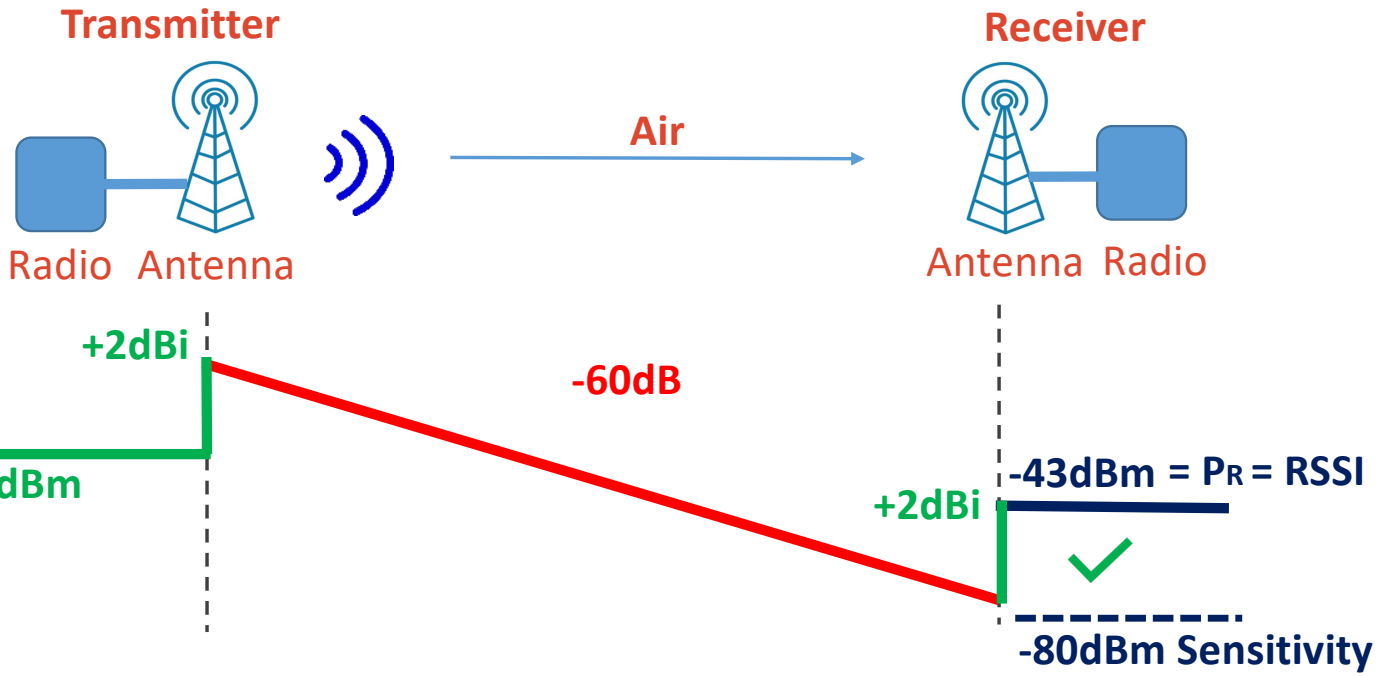
BIG LINK BUDGET ➡ **LONG** DISTANCE



Example - 1

A transmitter uses 13dBm with a 2dBi gain antenna. The air loss is 60dB. Then a 2dBi gain antenna is connected to a receiver with a -80dBm sensitivity.

1) Will the signal be received? ✓ YES
2) The noise on the receiver is measured at -50dBm. What is the SNR? ✓ SNR = 7 dB



2) $SNR_{dB} = P_R - P_N$

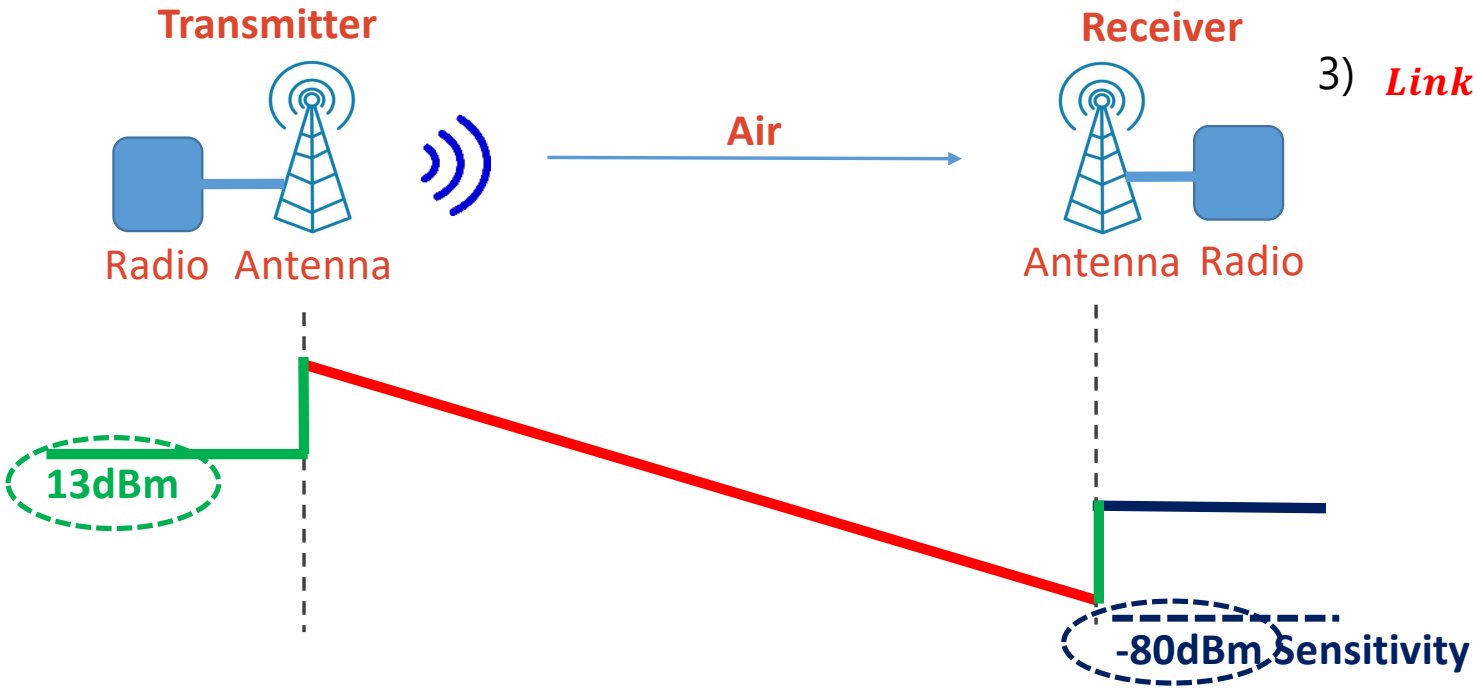
$= RSSI - (-50)$

$= 7dB$

Example - 2

A transmitter uses 13dBm with a 2dBi gain antenna. The air loss is 60 dB. Then a 2dBi gain antenna is connected to a receiver with a -80dBm sensitivity.

3) What is the link budget ?



3) $\boldsymbol{Link\ Budget = 13\ dBm\ -(-80\ dBm)}$

$\boldsymbol{= 93\ dBm}$

LET'S RECAP 

- ❑ The decibel helps to represent ratio (dB) or power (dBm).
- ❑ RSSI is the power received.
- ❑ If the RSSI is above the receiver sensitivity, the transmission is successful.
- ❑ The Link budget evaluate the potential of the transmission.
- ❑ The SNR is the ratio between the signal and the noise.
- ❑ With a high SF, the reception capabilities are improved (sensitivity and SNR)