Radio protocols in theory and practice

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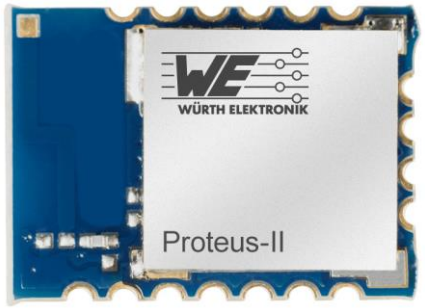
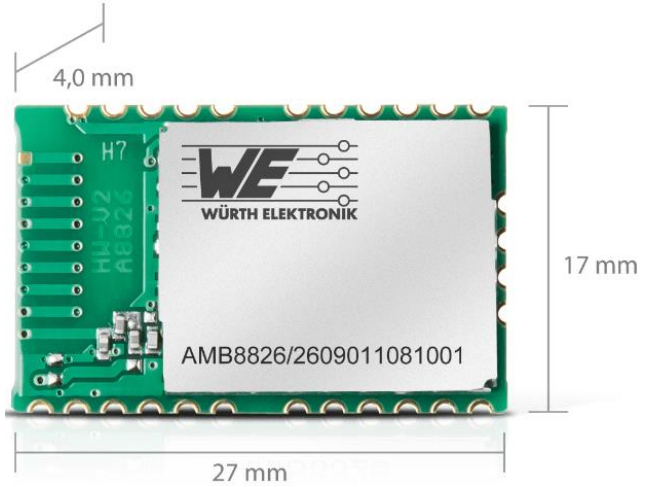
23. May 2019

Overview

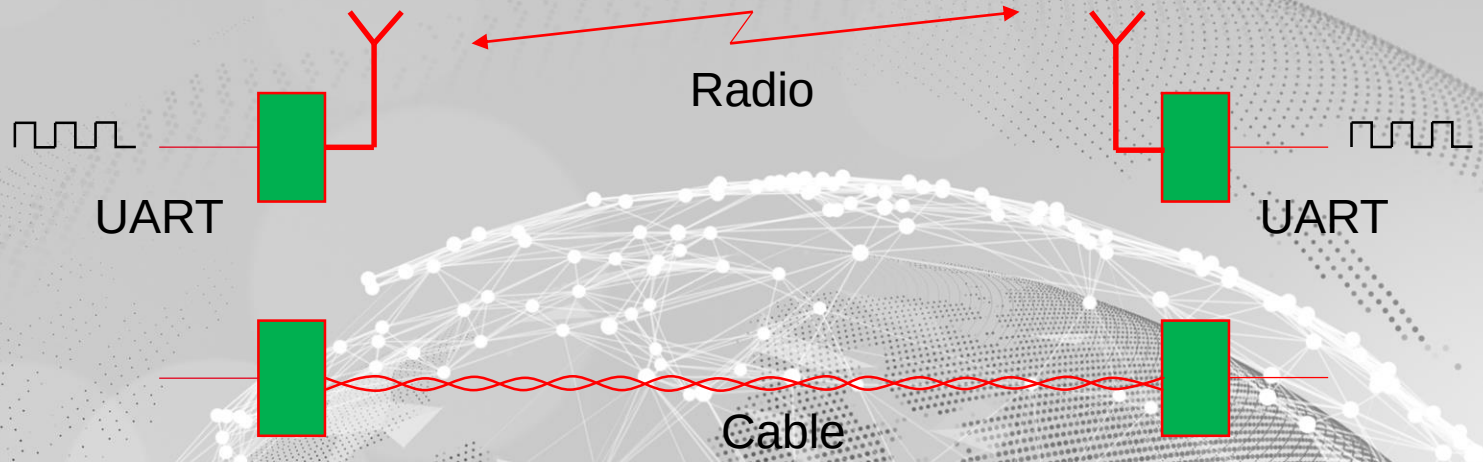
- Introduction: Protocols
- Software
- Hardware
- Physical layer
- Antenna types
- Range and attenuation
- Radio modules
- Engineering tools
- Summary





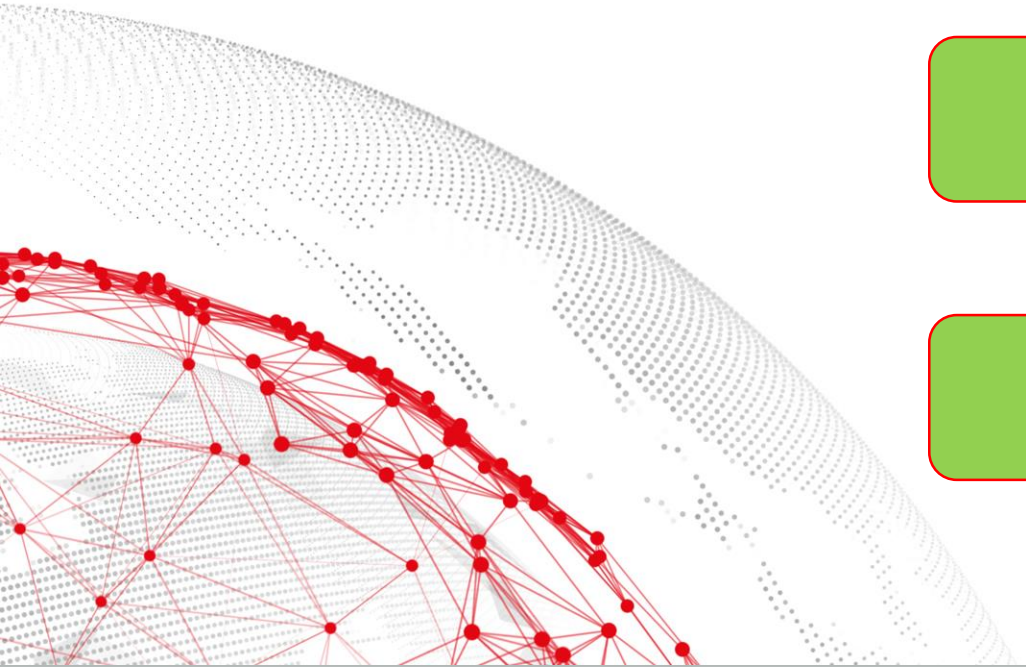
Introduction: Communications Protocol

A **communication protocol** consists of a set of rules that allow two or more entities to communicate information via a **physical quantity**.
The protocol defines the rules, syntax, semantics and synchronization of communication as well as possible error recovery methods.
Protocols may be implemented by **hardware** and/or **software**.



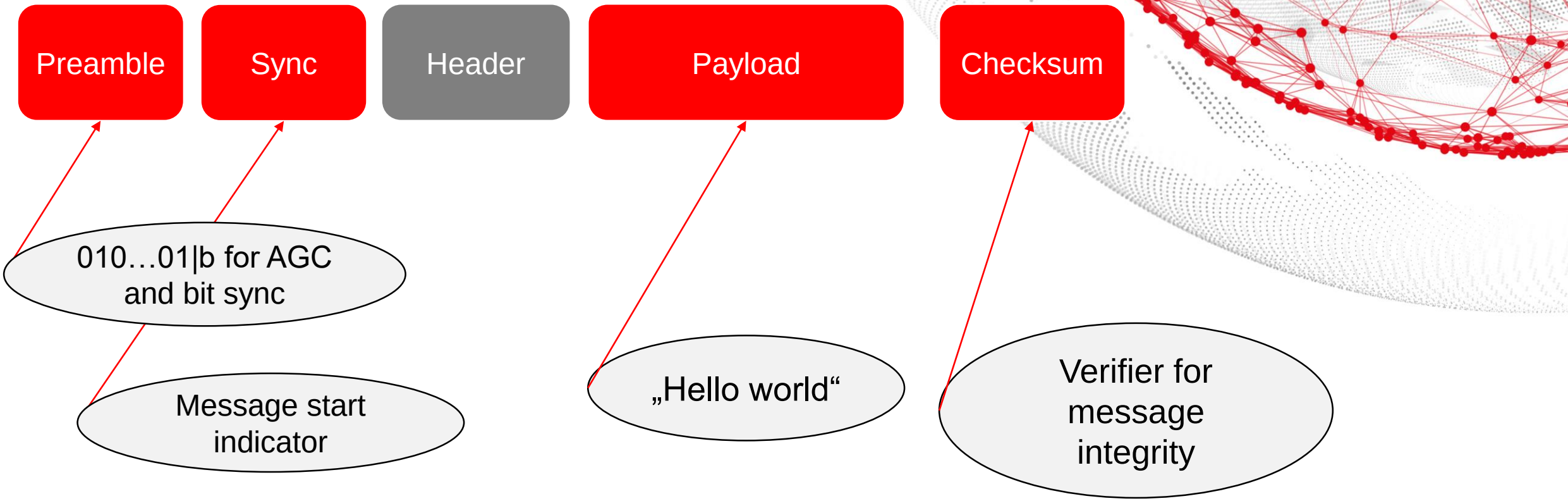
Introduction: Software

The protocol stack is an implementation of a computer networking protocol suite

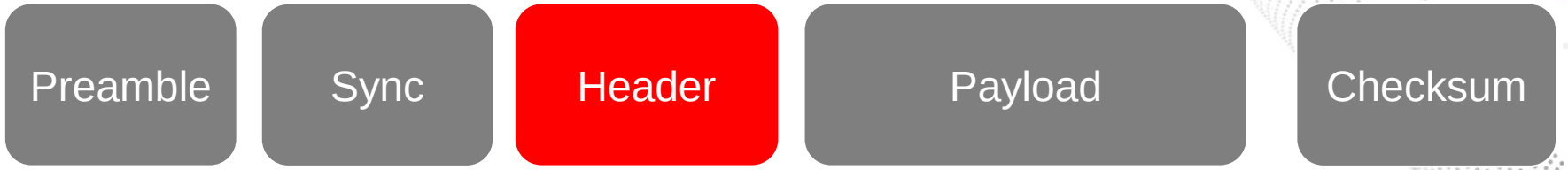


	PDU	Layer
Host Layers	Data	7 Application
	Data	6 Presentation
	Data	5 Session
	Segments	4 Transport
Media Layers	Packets	3 Network
	Frames	2 Data Link
	Symbol	1 Physical

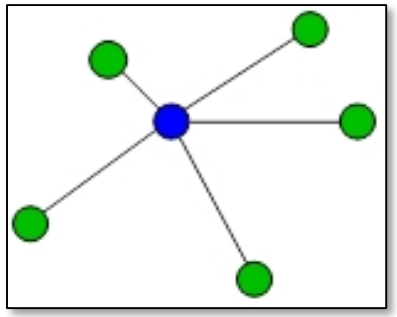
Radio protocol in practice



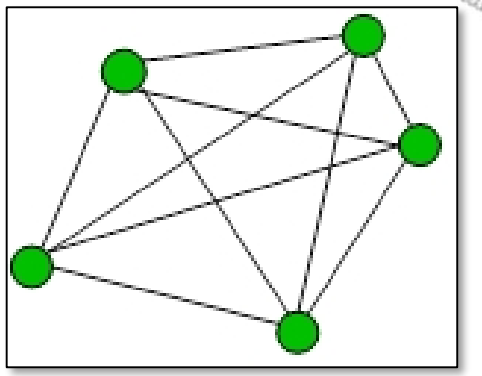
Radio protocol in practice



Header content	Network feature
Addressing	Allowing directed addressing and network topologies



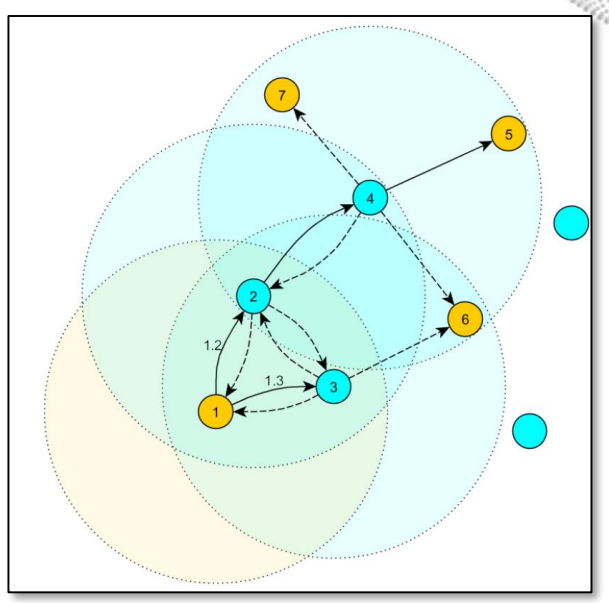
Star



Peer to Peer

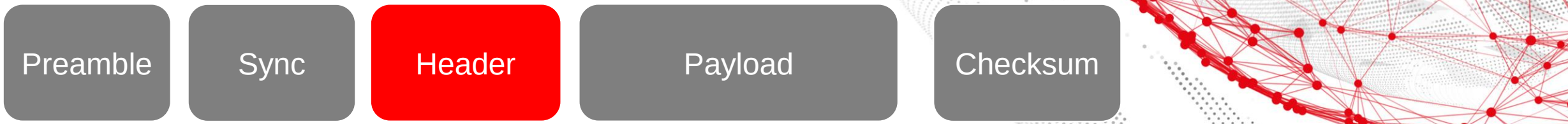
Radio protocol in practice

Header content	Network feature
Routing information	Allowing routing mesh networks
Time to live/hop counter	Used for flooding and routing mesh topologies



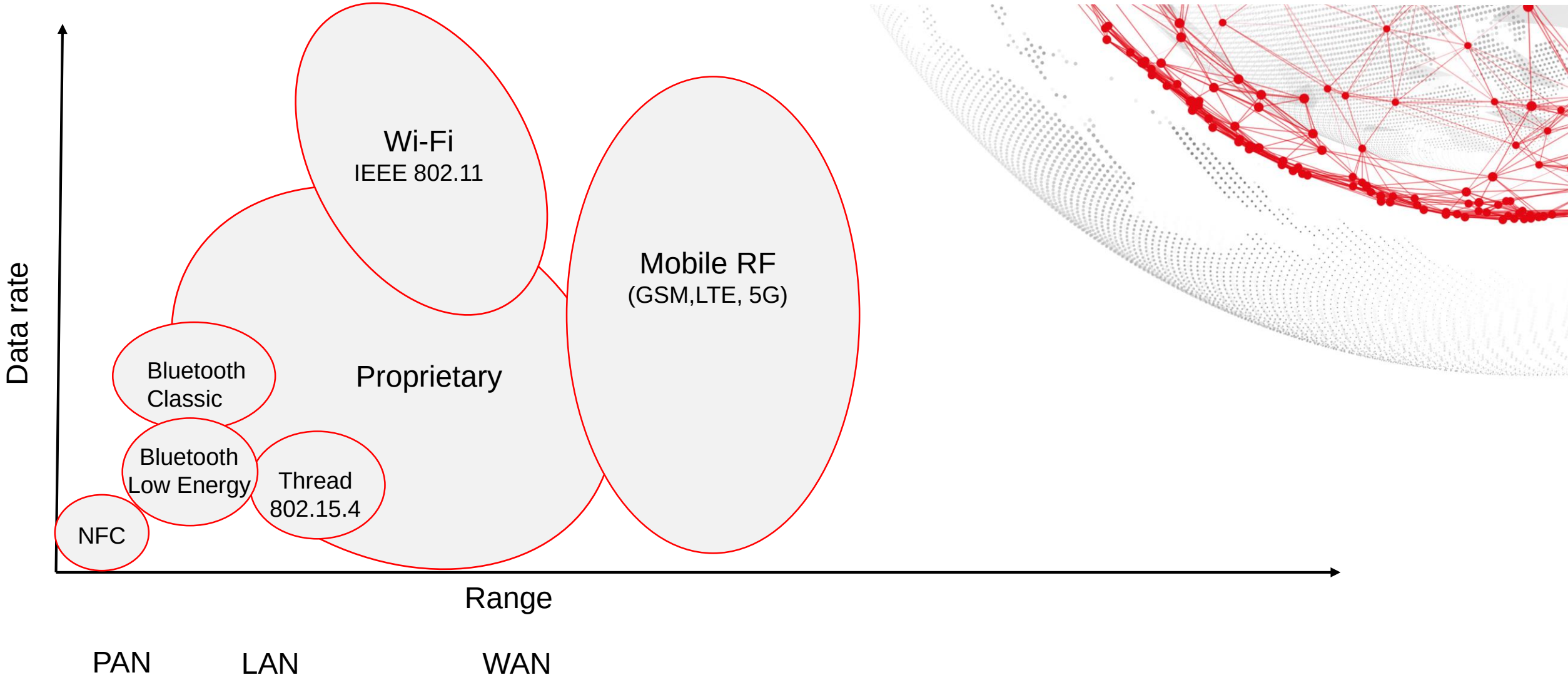
Flooding Mesh

Radio protocol in practice

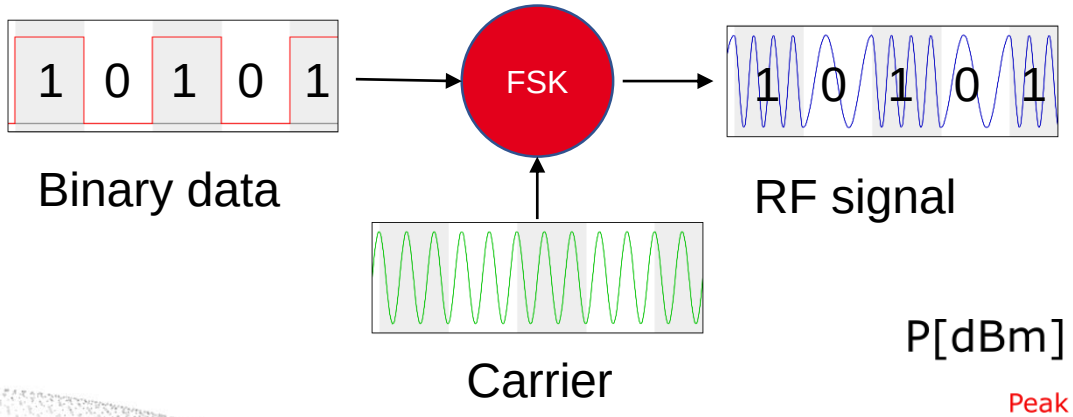


Header content	Network feature
Fragmentation information	Packet fragmentation for higher payloads
Acknowledgement	Allows retries for assured data transmission
Encryption information	Allows encrypted data transmission for secure systems

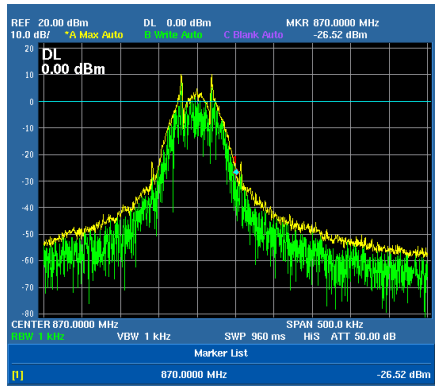
Radio standards

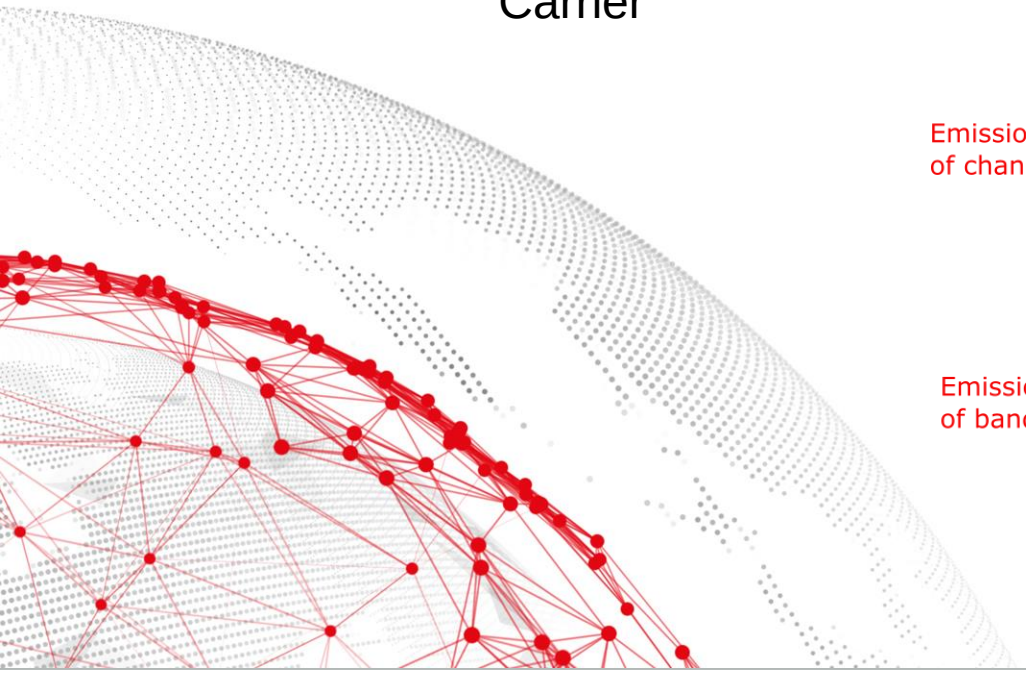


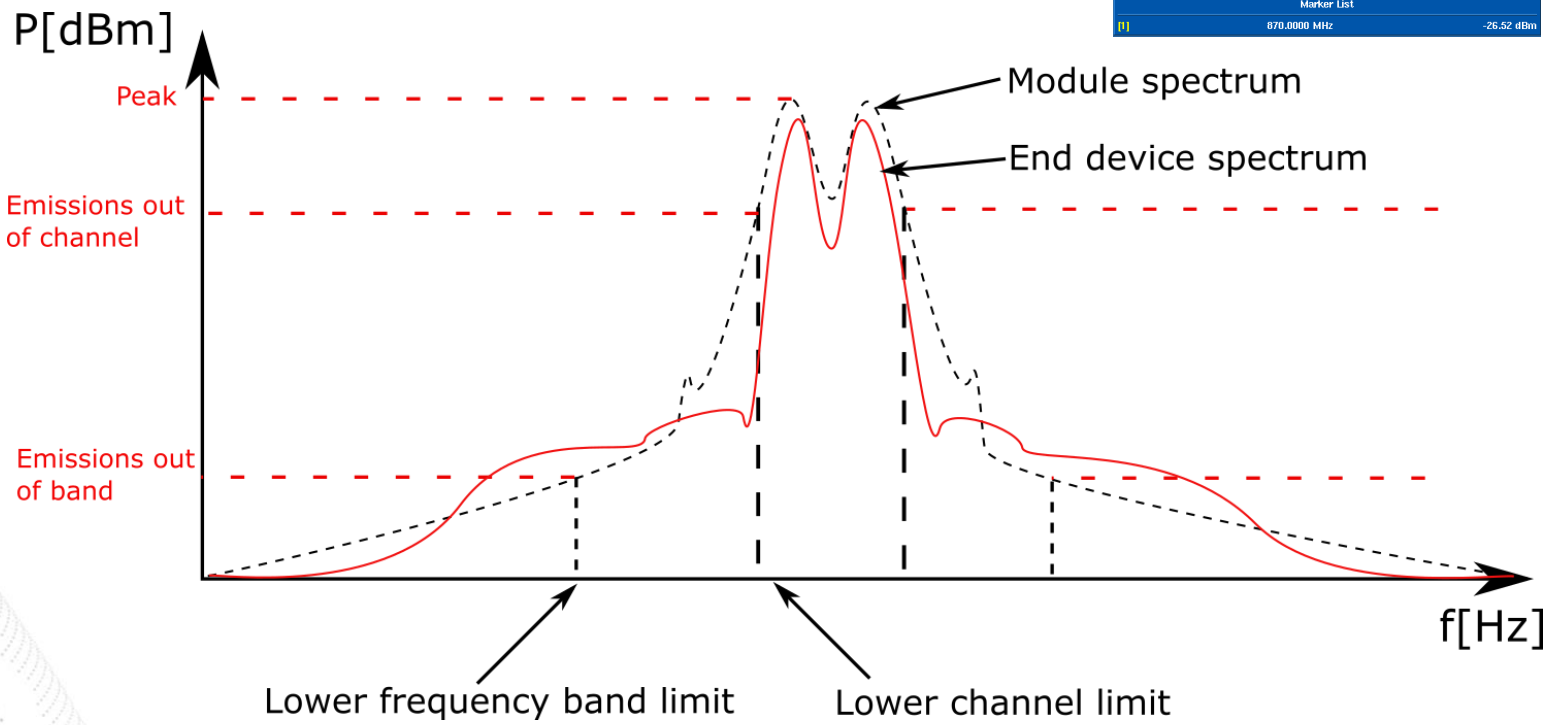
Physical layer: Basics 2-FSK



Spectrum







Physical layer: DSSS and FEC

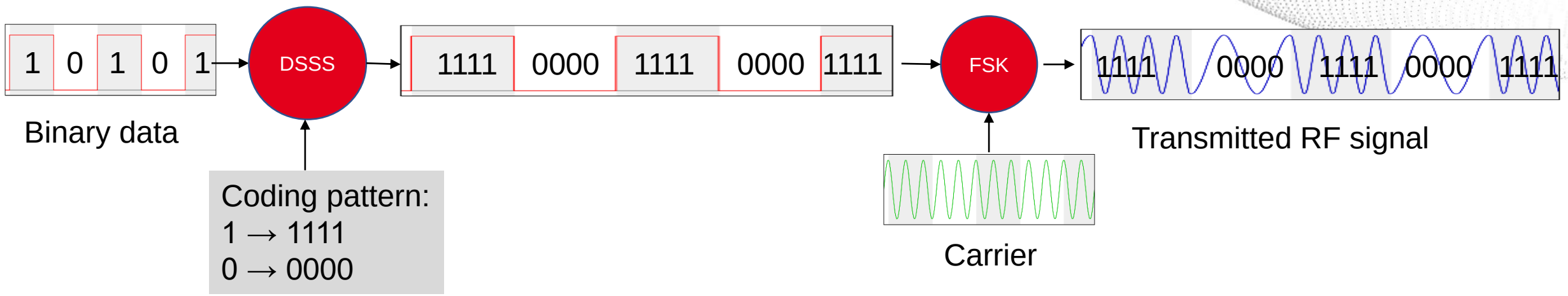
Digital modulation schemes allow to achieve higher ranges

- DSSS (Direct Sequence Spread Spectrum):

  Data to send is digitally spread before sending

- FEC (Forward Error Correction):

  Erroneous bits of the received data are corrected



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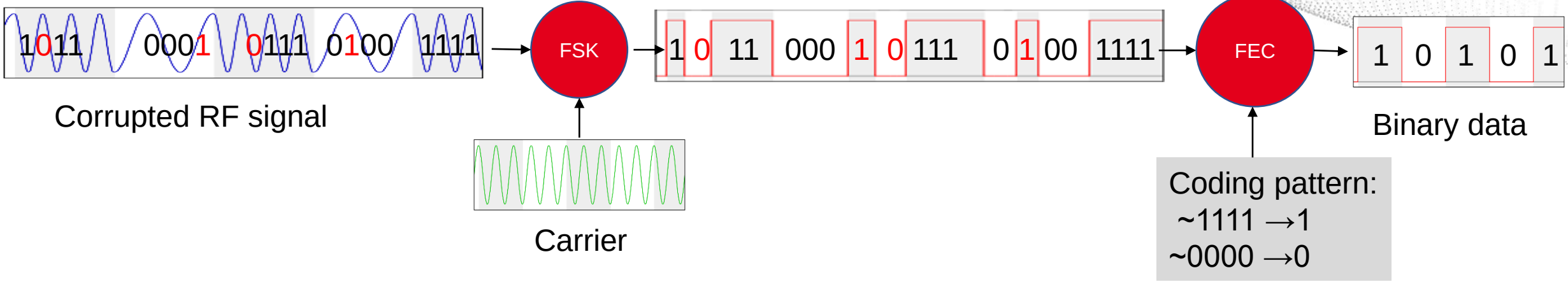
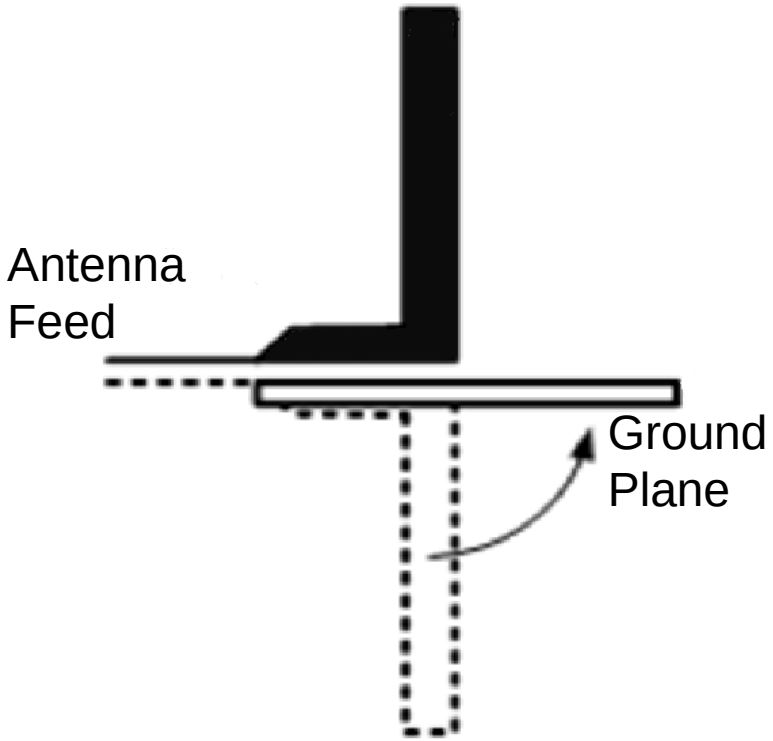
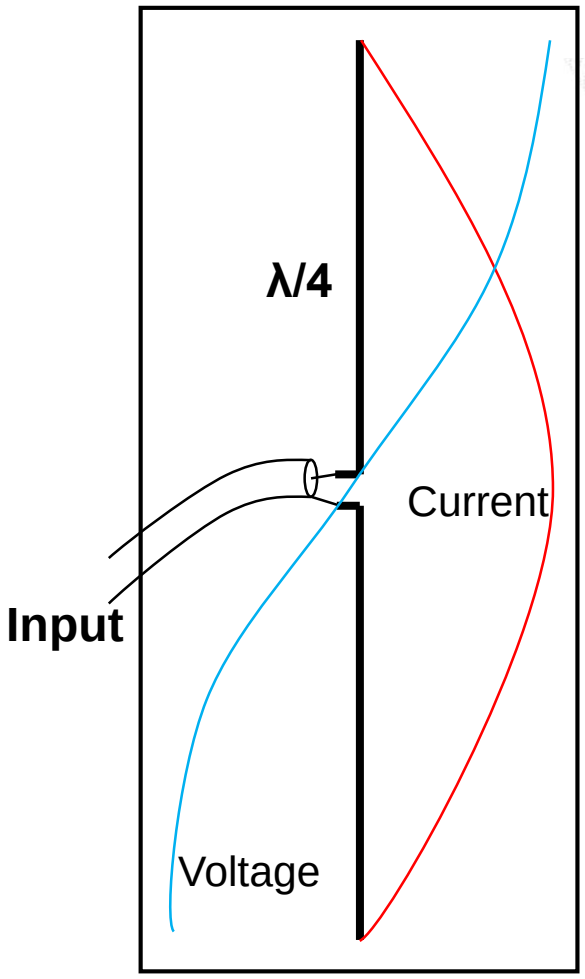


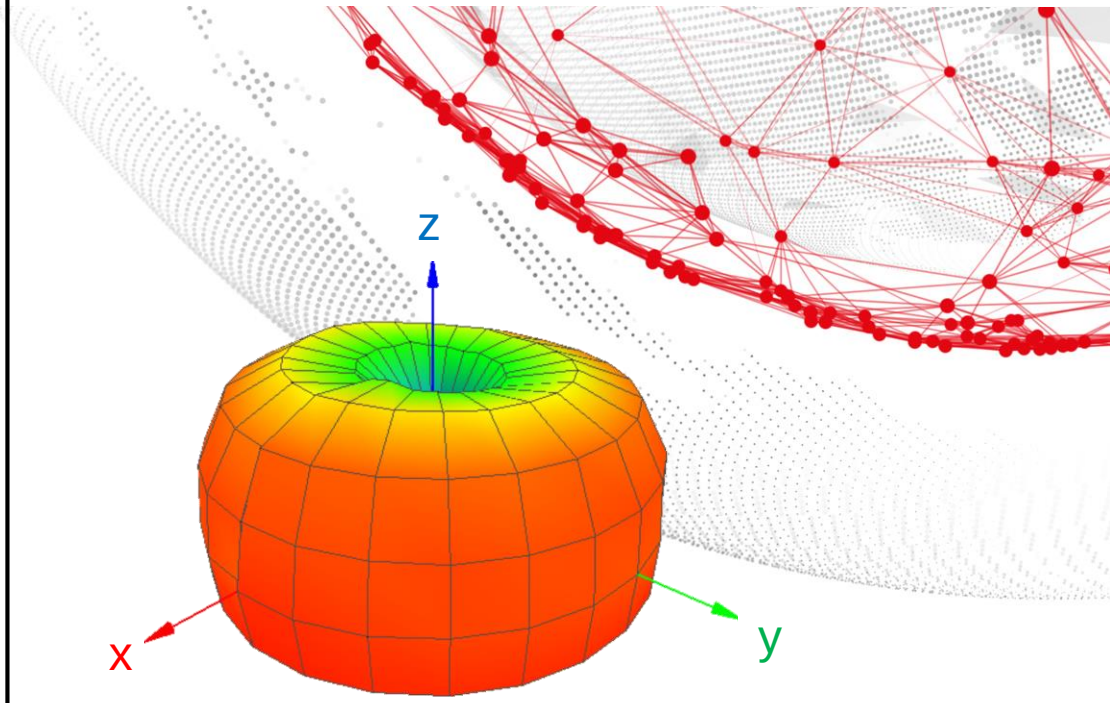
Antenna basics



Monopole Antenna Utilizing GND Plane as an Effective λ/4 Antenna Element



Maximum Power delivered at Quarter Wavelength

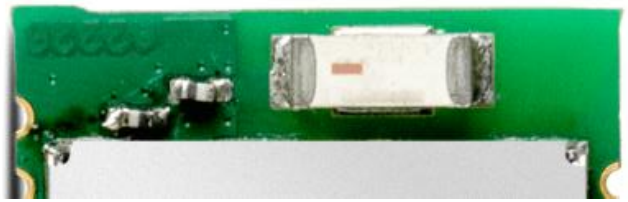


Emission Pattern of a Dipole Antenna

Quelle: TI

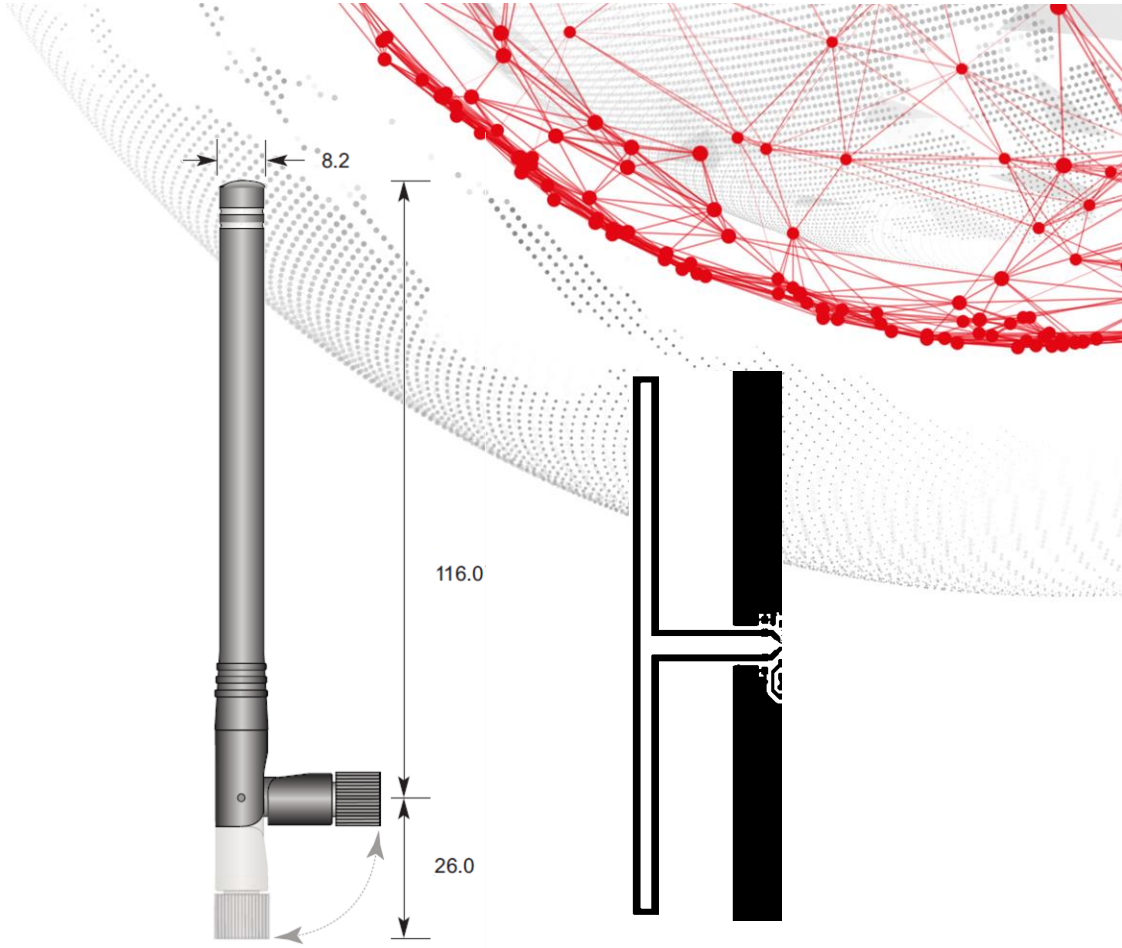
Antenna types

- Chip antenna
- PCB antenna
- Wire antenna
- Dipole antenna



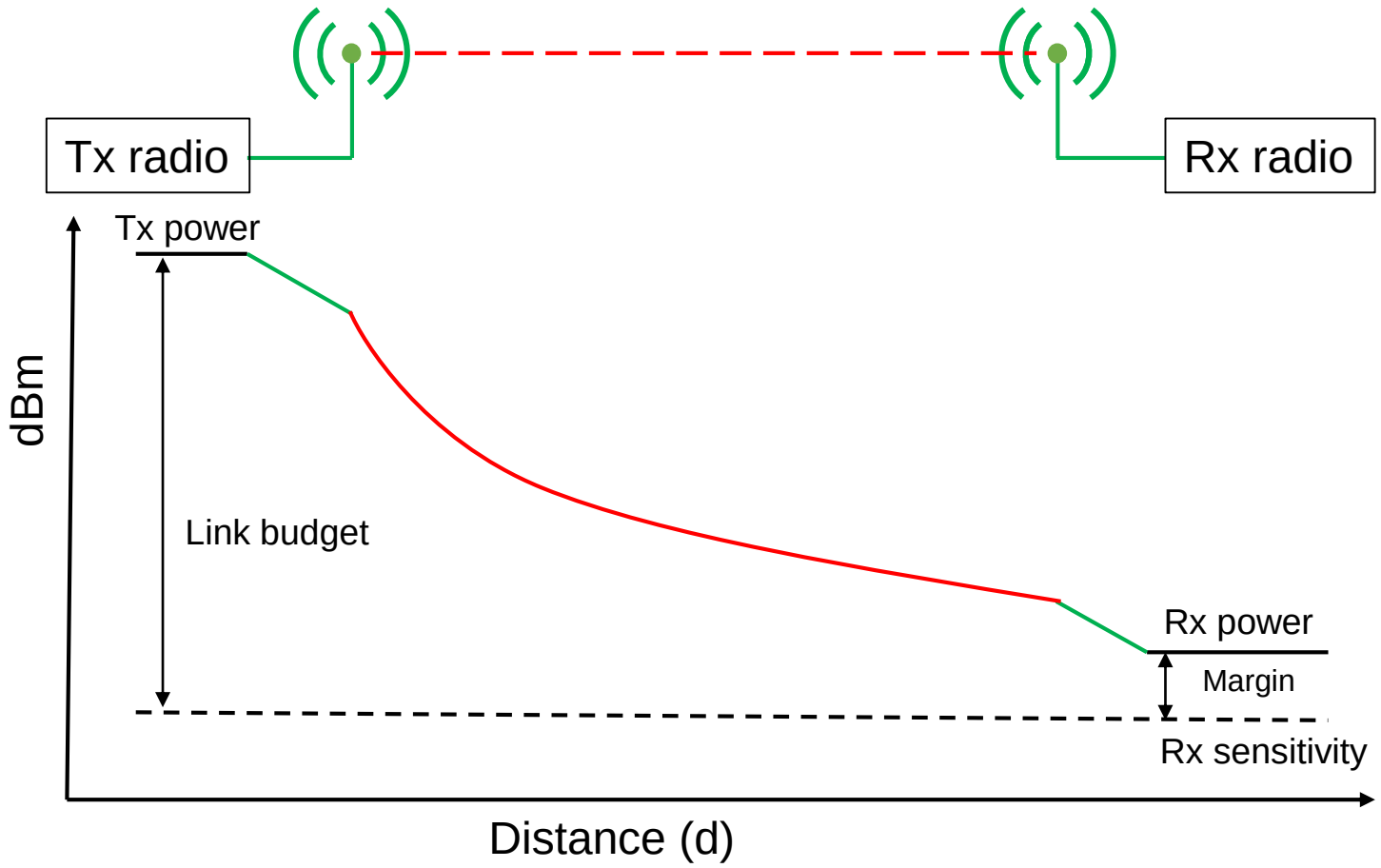
Chip Antenna

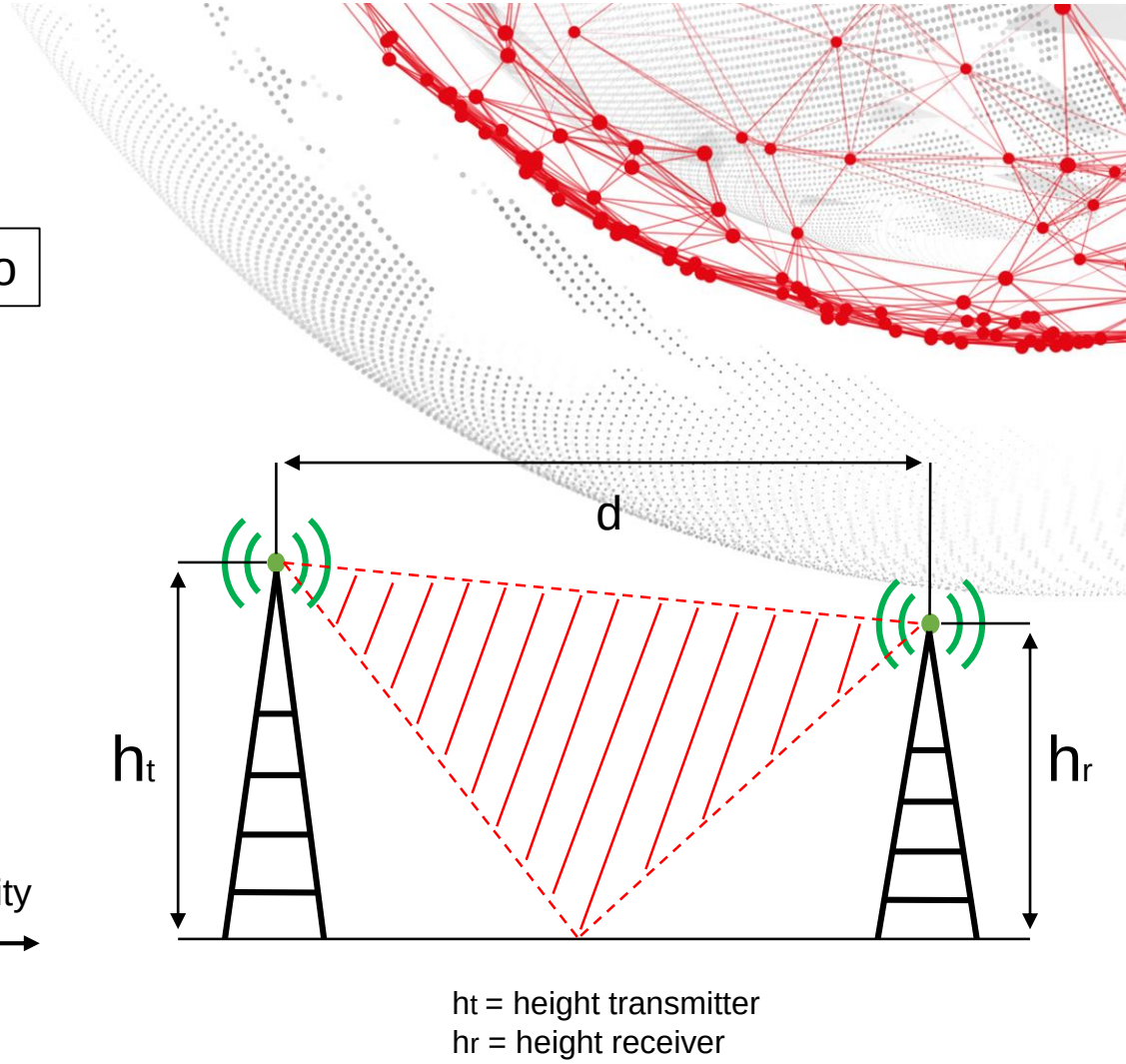
PCB Antenna



Dipole Antenna

Signal strength





ht = height transmitter
hr = height receiver

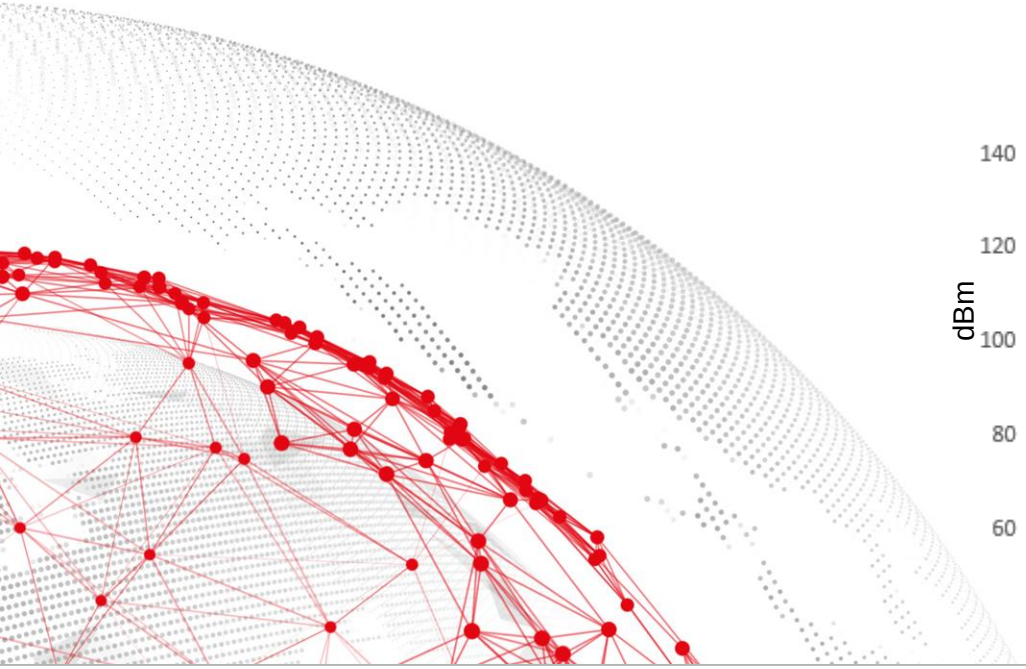
Attenuation

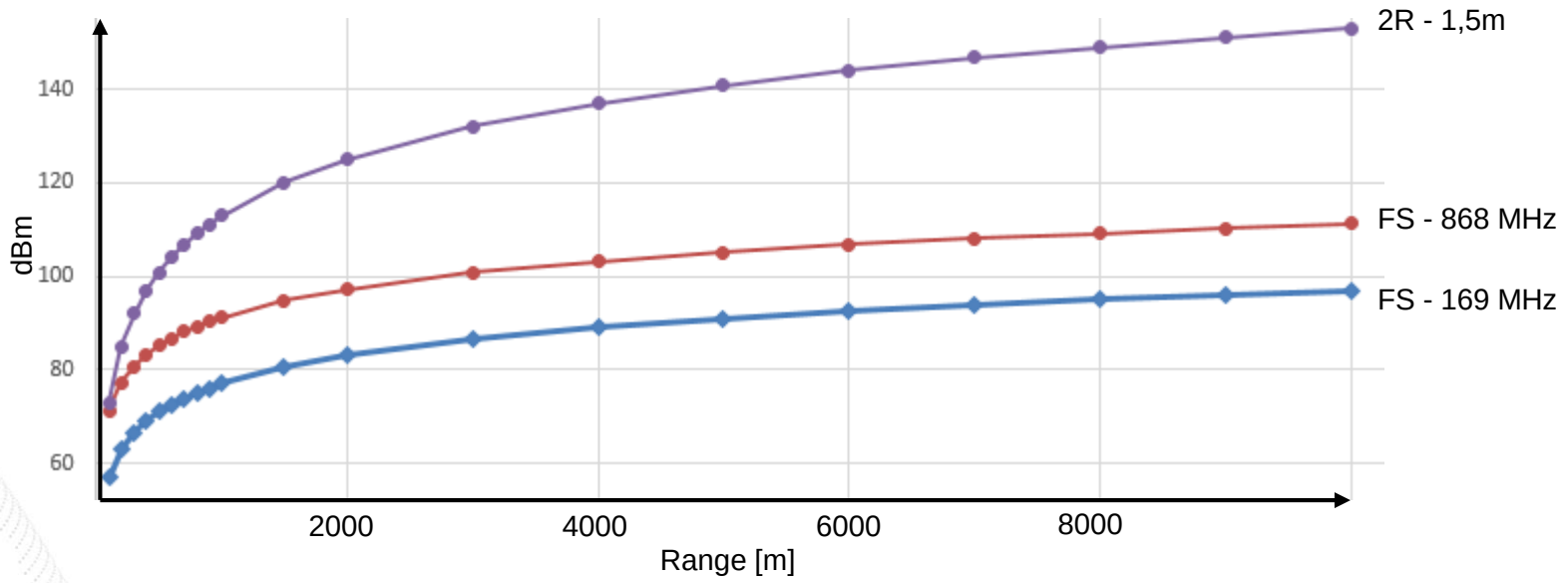
2-ray ground reflection (2R)

$$PL = 40\log_{10}(d) - 10\log_{10}(Gh_t^2 h_r^2)$$

Free-space path loss (FS)

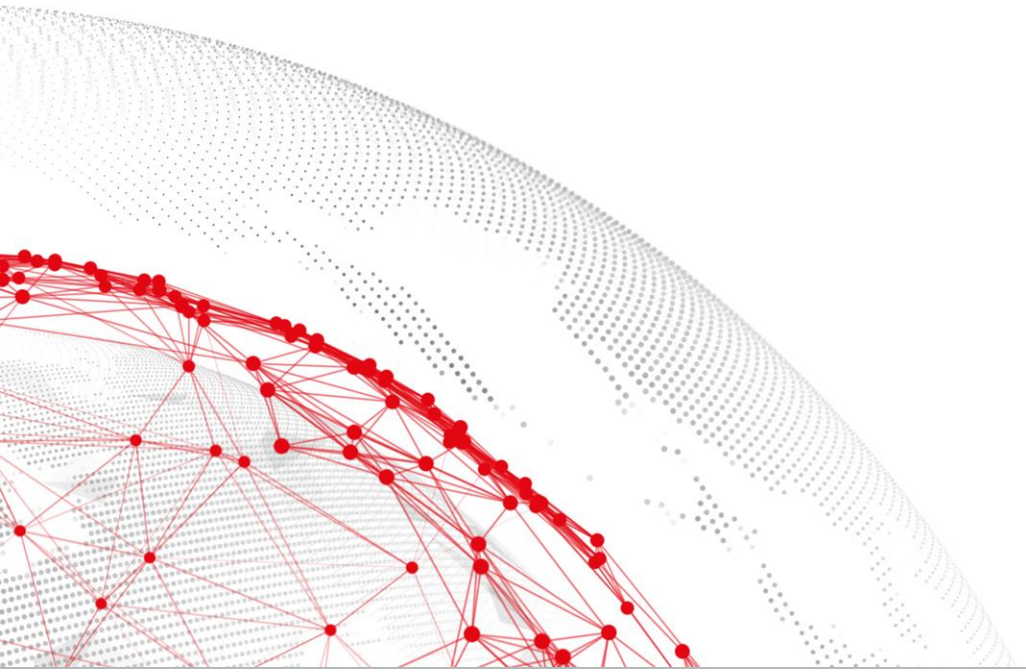
$$PL = 20 \cdot \log_{10}(r) + 20 \cdot \log_{10}(f) + 20 \cdot \log_{10}\left(\frac{4\pi}{c}\right)$$

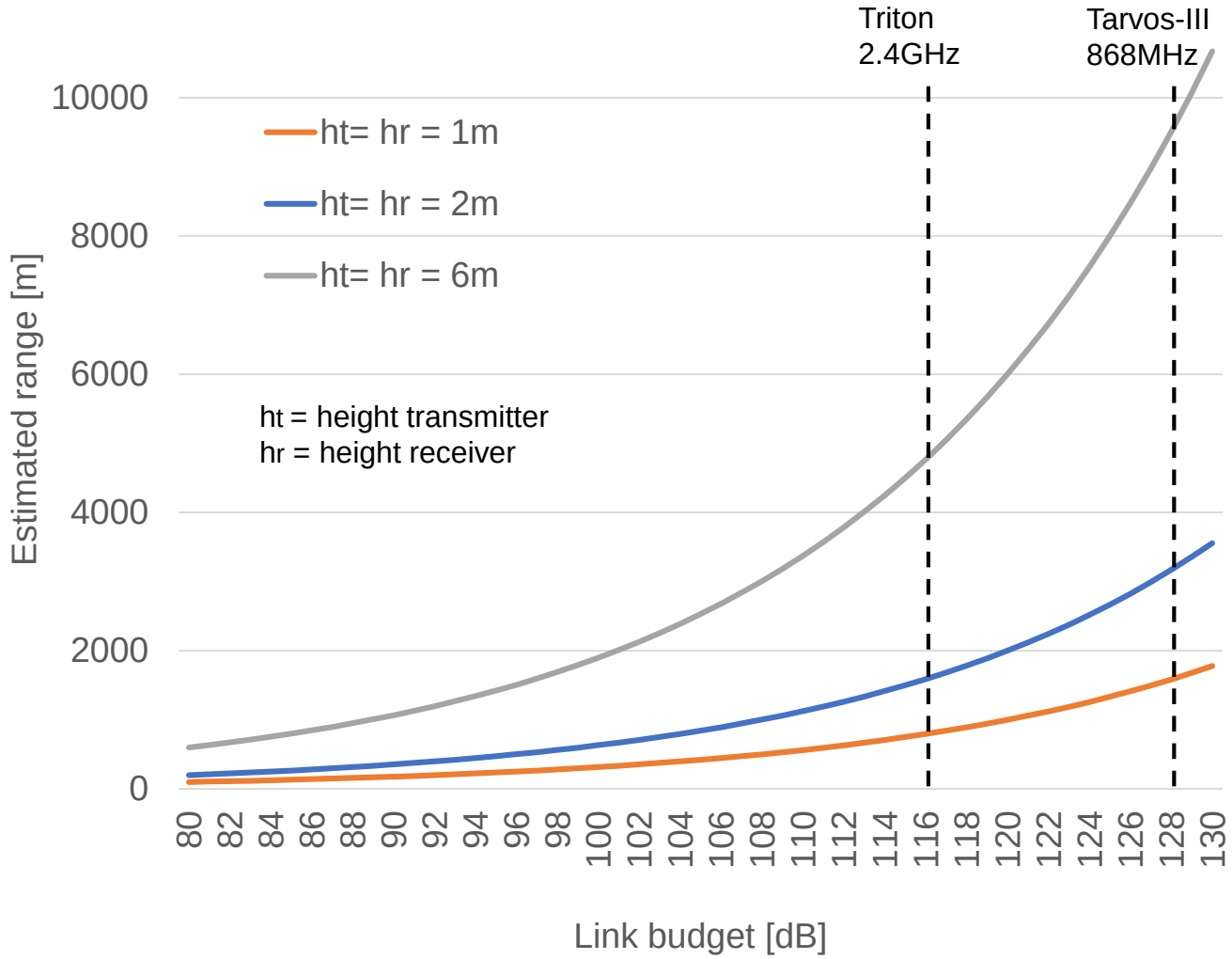




Range

$$Link\ budget_{dB} \approx P_{TX,dB} - Sens_{RX,dB}$$





Range

dBm and Watt

dBm	Power
0	1mW
10	10mW
14	25mW
27	500mW

Factors:

- Antenna (gain, sensitivity to body effects etc.)
- Sensitivity
- Output power
- Radio pollution (selectivity, blocking)
- Environment (Line of sight, obstructions, reflections, multipath fading)
- Coding methods (Manchester, FEC, DSSS,…..)

Rule of thumb:

- +6 dB ~ twice the distance
- Double the frequency ~ half the range
- +3dB ~ double the power
- +10dB ~ ten times the power

What does it mean in practice?

The antenna type determines factors such as gain, range, radiation characteristics, …

Test procedures – Antenna selection for typical environments by trial and error

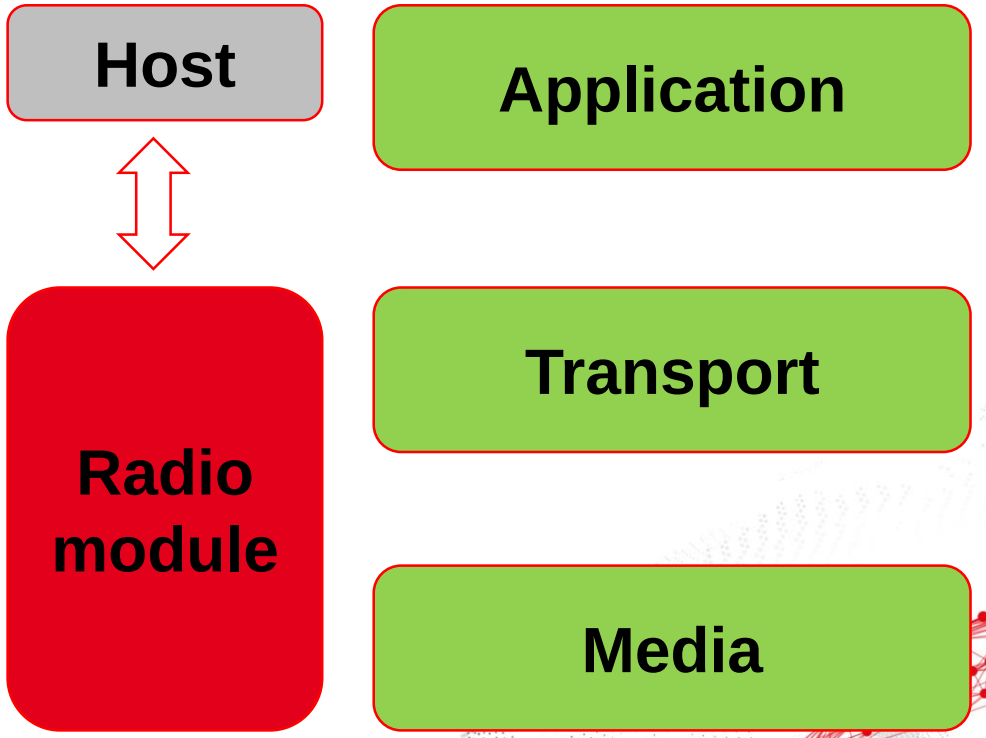
Radio module

Würth Elektronik radio modules contain

-Physical layer

-Radio stack including radio protocol

-Certifications required to use the frequency spectrum



Radio module

Further advantages:

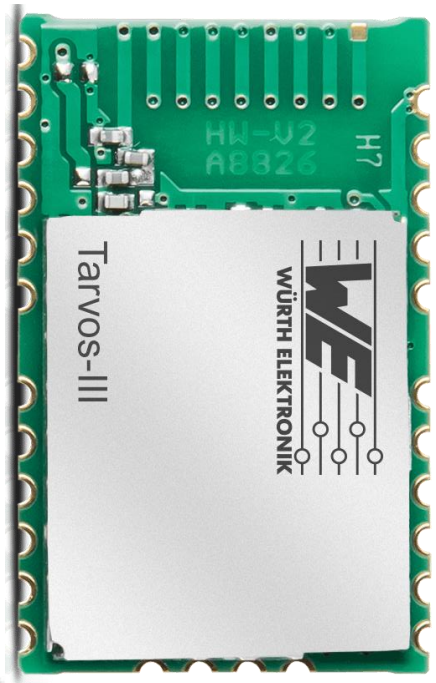
- 20 Years of experience in radio hardware and radio stack design
- Simple UART protocol to control the radio module (data transmission, control and configuration)

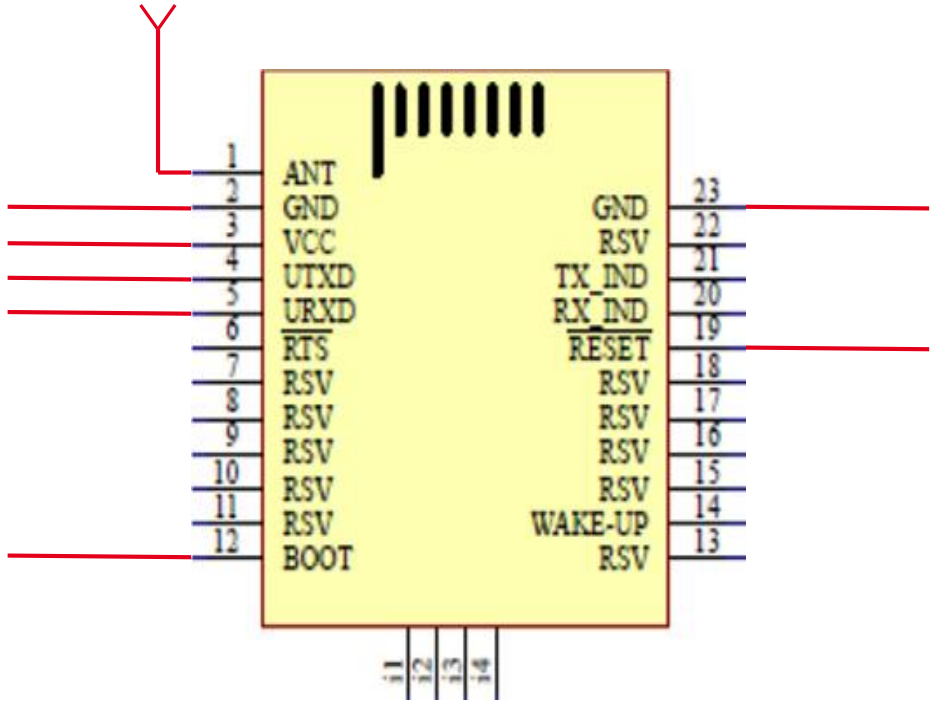
Radio module: Design-in

How to connect a radio module to a host controller?

Example Tarvos-III:

- **UART**
- **Antenna**
- **VCC and GND**
- **Reset and Boot**

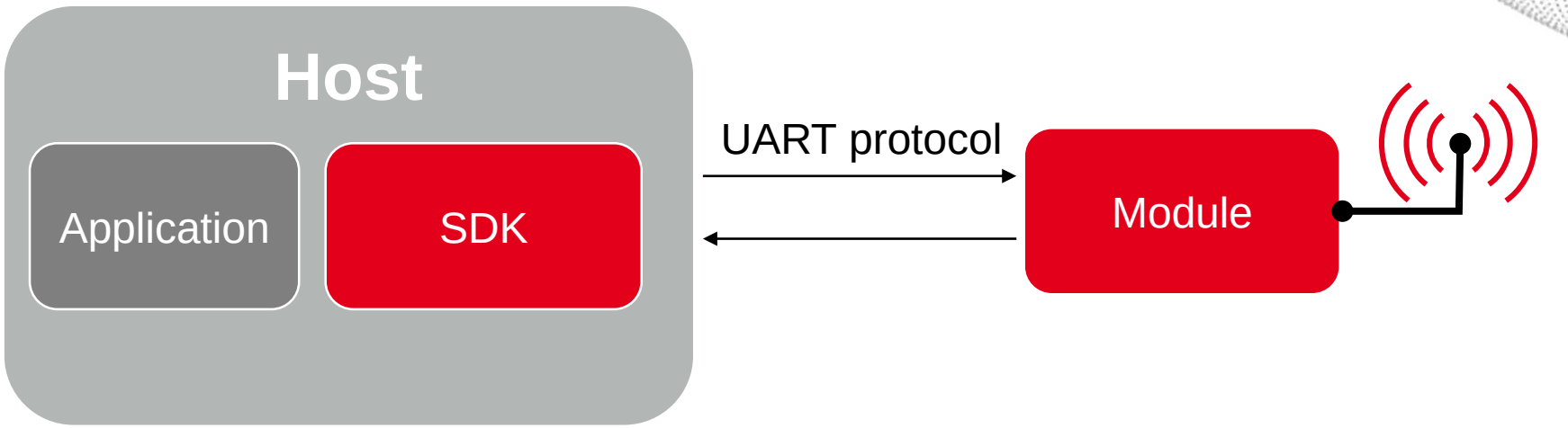




Wireless Connectivity SDK

Drivers in C source code for all SRD modules as well as USB sticks of Würth Elektronik eiSos

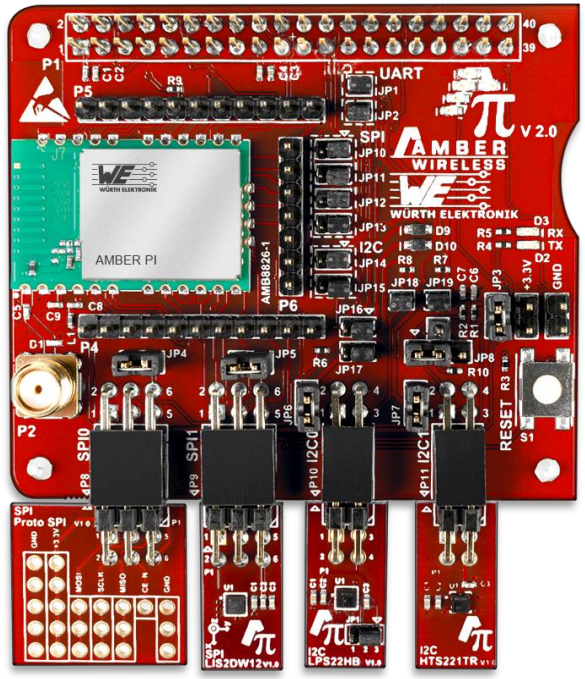
Implemented command Interface for the modules

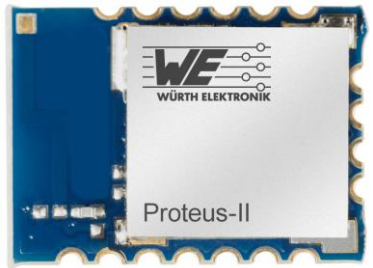


Evaluation Kits

Advantages?

- FTDI
- Antenna
- Pin Header
- Current measurement
- SDK





Thank you for your attention

WÜRTH ELEKTRONIK

And now we will stand by to answer your questions via the webinar tool.