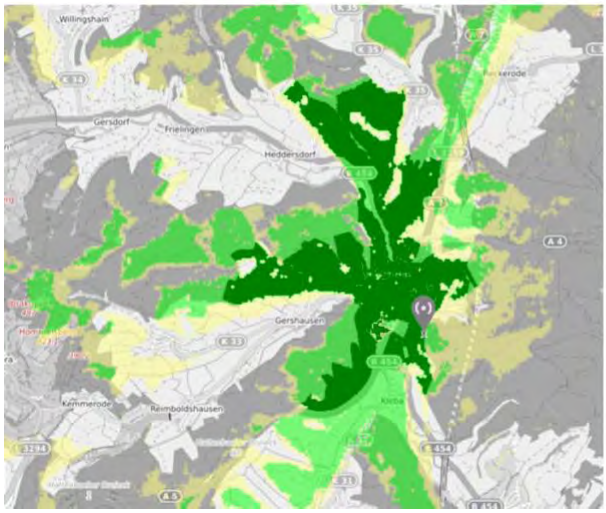

LPWAN COOKBOOK

How to develop LPWAN technology – real products, real networks

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First edition:
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The book has been finalised and will be further updated as necessary. All purchasers and sponsors will receive free PDF updates regularly. Any comments, requests, tips and suggestions related to the book or download zone are welcome.

New chapters are **marked with an update date** and major changes are formatted with green text. This approach is meant to help owners of previous editions to identify the changes and additions more quickly.

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1. Why Did I Write the LPWAN Cookbook?

I have been working in the wireless industry for more than 30 years. 30 years ago we had no word for "IoT" or "LPWAN". So when we developed radios with UART for data communication we had no way of knowing that these things would be called "IoT devices" decades later. 30 years ago there was no GSM network and the words NB-IoT, LoRaWAN, Sigfox or Weightless did not yet exist. I took my first steps in wireless data communication with Frequency Shift Keying (FSK) on private mobile phones (PMR). With PMRs we achieved communication speeds of 3600 bits per second. A short time later we started using public analogue trunked radios. These trunked radio systems provided local terrestrial wireless networks. We planned the trunked radio and the common wave radio networks with paper and pencil and then checked the real network coverage with test transmitters because there were no PCs with enough memory to run the simulation software. The last public analogue trunked radio network in Germany was taken out of service some years ago.

LPWAN is divided into public and private radio networks. Nowadays, anyone can set up their own private LPWAN on, for example, LoRaWAN or Weightless. In Germany, NB-IoT and LTE-M can be received nationwide via three network operators. In addition, there are various local city-wide LPWANs on LoRaWAN. The number of possible radio networks has multiplied.

NB-IoT and LTE-M are the new stars in the IoT firmament and combine classic cellular networks with LPWAN. The base station antennas for LTE are also used for NB-IoT and LTE-M. Both LPWA technologies feature new variable timers that enable wireless power management and extend the potential life of devices up to 10 years with the original battery. If the network coverage of the public LPWAN is not good enough for you, you have the option to set up your own radio network.

The LPWAN cookbook describes how to plan, simulate and test your own private LPWAN. On the cover of the book you can see the simulation of an LPWAN gateway for my birthplace of Kirchheim. The region of the community of Kirchheim, which is in Hesse/Germany, with its 12 villages and 8 valleys is simulated and tested in this book. The complete location data, with the height of the antenna and the digital files with the directional diagrams of almost 15 antennas can be downloaded free of charge with the LPWAN Cookbook. Everybody can follow the simulation with free software on their PC and plan their own LPWAN with the manual in the book.

A wireless network without sensors, telemetry and devices for locating objects is without value. A detailed explanation of how to develop and test your own LPWA device is given. An antenna is the most important component in an LPWA device. +/- 3 dB antenna gain mean the difference between 2.5, 5 or even 10 years of service from the battery. An antenna for NB-IoT/LTE-M and another for LoRaWAN/Sigfox are shown and explained in the simulation and in measurements. Everybody can copy these LPWAN PCB-antennas into their board. After the assembly of the PCB emissions testing is to be done according to RED (EU) or FCC (USA). The radio certification is another important chapter in the LPWAN Cookbook.

Once the hardware concept has been clarified, the software concept must follow. In the embedded domain, hardware and software can often not be separated from each

other. The Proof of Concept (PoC) is simple, the prototype is too, but a device with 10 years of battery life does not have a reset button. You can't pull a plug. The software must be bug-free and restart itself if necessary.

Another big chapter is the comparison of NB-IoT, LTE-M, LoRaWAN, and Sigfox. Since the updates of the LPWAN Cookbook are free as with the IoT / M2M Cookbook, this chapter will change at regular intervals. NB-IoT started life with many more features than other LPWANs in its first version and new features are added every few months. The LPWAN technology comparison should help to lighten the darkness of the LPWA jungle.

The LPWAN cookbook is intended to help wireless application developers to save some time and perhaps provide inspiring ideas. It's a book for developers and summaries the common experiences that I have gathered over several years in my various professions. Through leading a development team, I learned to think like a developer of an LPWAN device. In over 30 years of working with manufacturing and distribution, I've given wireless application developers the same advice and recommendations over and over again. With LPWAN, things do not get any easier.

In 2017 I launched reference designs for LPWAN called akorIoT with business partners. In addition, there is the collected experience from the development of almost 100 antennas, antenna matching or the development of entire LPWAN devices. The aim of this book is to guide the developers from the concept phase of an LPWAN device to the finished series product.

I hope you will enjoy reading the book and I hope it will save you some time as well.

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