It seems, that LoRa and IoT are somehow connected and both are currently hyped very much. Today, I try to put things a little in order, show you the basic principles of LoRa, its plusses and minuses,and also show you my own LoRa gateway and a LoRa client, and send a first message to the things network. A lot of stuff. So, buckle up. The journey starts.

LoRa is a Low Power Wide Area Network standard, also called LPWAN. This term consists of three parts:

1. Low Power
2. Wide Area
3. Network

Let’s start with “network”. The difference between a normal small device and an IOT device is its capability to connect to the internet. And because we expect millions of them, we need a network to connect all of them. This network has to be based on standards, because the network itself and the IOT devices will not be built by the same company. Best is always an international standard accepted by “everybody”.

The next is “Wide Area”. Our ESP8266 devices can connect to our Wi-Fi network, which is part of a LAN, or local area network. We all know, that its reach is limited to a few meters around our access points. Wide area networks need to bridge much bigger distances. This is necessary for IOT devices because we want to use them everywhere.

The real old guys might remember AM radio stations. You were able to receive AM even in the middle of nowhere, far away from the station. This was really “wide area”. But these transmitters were huge, usually they are able to emit kilowatts of energy. So, it is quite easy to bridge big distances using high power. But now, we come to the third word: “Low power”. If we want to work on batteries, we do not have a lot of power for transmission. And we see the dilemma: We want kilometers of reach, but have no power to spend. Fortunately, physics gives us a third parameter to ease this dilemma a bit: It is called bandwidth. The physical laws say, that, if we want to create a radio connection for a certain distance, we can either increase transmission power or decrease the bandwidth of the channel. But why should we bother about bandwidth? Because bandwidth and maximum capacity of a channel are directly related: The smaller the bandwidth, the lower the capacity of your channel. I still remember the old days of Morse where a good operator was able to transmit 2 characters per second, which is a little less than 20 bits/second. Today, our wireless LANs are capable of transferring millions of characters per second. And they are still always too slow…

To visualize the relation between bandwidth and range, we can use this chart: On the x-axis, we have the range, and on the y-axis, the bandwidth. Let’s now look at some of the well-known technologies and where they fit: Wi-Fi has a high bandwidth, but only a low reach. And we know from our ESP8266, it is quite power hungry. Not in the kW as the old radio stations, but it easily needs a quarter of a watt during transmission. And if we go up into the new, faster standards, the power hunger increases. And you know, that the reach of 5 GHz links is shorter than the ones of 2.4 GHz links.

The next is mobile internet on our smartphones. The reach here is a few 100 meters up to a few kilometers in rural areas. But also here, you do not get fast 4G coverage if you are in the middle of nowhere, because the next antenna tower is probably a few kilometers away. And we all know, that the battery live of our smartphones is not great at all, because this technology needs quite some power.

The next technology is Bluetooth. This technology runs well on small batteries as we know from many gadgets. But, unfortunately its reach is only a few meters. So, all of these technologies do not fulfill the needs of our IOT devices, which was Low power and wide area.

I think, you know now, what will come: LoRa. It has its own space: Long range, but, because of power limitations, also low, in reality extremely low bandwidth. And this bandwidth is not only limited by the law of physics, no, it is even more limited by human law, as we will see later on.

So, we know now, where LoRa fits. To make it very clear: It is absolutely not comparable with Wi-Fi and not at all a replacement of this technology. It is much closer to the mobile internet standards, where also low power variants are in development. But it has its space with sensor networks, if these sensors do not transmit a lot of data. For telemetry in formula one, for example, this technology would not be suitable, because of the number of readings required. For humidity of your plants, it is perfect, because soil humidity usually does not change in seconds. Or if you monitor the occupation of a parking lot, you also might not detect too many changes a day.

In order to understand the “range” better, we have to deal with a quit complex topic: The Link budget. What is “link budget”, and why is it so important?

The link budget is, as every other budget, something you have at the beginning and which you spend over time. If your budget is used, you cannot spend more (at least, this is, what we learned, when we were young).

The link budget has to do with the link, or the connection between the sender and the receiver. It is filled up by the transmission power of the sender and the sensitivity of the receiver and it is calculated in decibel, or dB. It is also frequency dependent: The link budget of exactly the same transmitter and receiver on 2.4 GHz would be 9 db less compared with the budget of Lora on 868MHz. The link budget is deducted by all sorts of obstacles between the sender and the receiver like distance, cables, walls, trees, and so on. If the link budget is used up, the receiver will only create some noise and we do not get any usable signal.

So, what is the link budget for LoRa compared with other technologies like LTE or 4G? LoRa has, according its inventor Semtech, a link budget of 154 dB, which is much higher than the mobile internet with only 130 db, even if the radiated power is much higher than with LoRa. But what does this mean? Is this an important difference?

Fortunately, we find so called “radio link budget calculators” on the internet. Let’s do some calculations to understand the topic better: First, let’s assume we have a line of sight connection between the sender and the receiver and everything is perfect. As we know, our LTE budget is 130 dB. So, let’s check the biggest distance we can communicate. We set everything to zero and the distance to 100 km: And we get -131.5dB, which is already more than the 130. So, LTE, even in ideal conditions, does not bridge 100 km. 80 km would be ok.

Now we check Lora with a budget of 154 dB: At 1000km it is still below the 154 dB and at 1300 km it is close to the 154 db. I think, you get the point?

As I said, this is all theoretical. If we connect our antennas to the sender and receiver, and we assume we have 10 meters of cable in total, we lose about 8 db. If we check, the maximum distance is now reduced to 500 km. So, 10 meters of cable is equivalent to 800 km in free air. And we did not use thin cable, we used RG58 cable.

Next, we have to spend parts of our budget for all obstacles between the sender and the receiver the signal hits like walls, or trees. The thicker and the more conductive the obstacle, the more budget it requests. And sometimes, we even do not have a line of sight and we have to work with reflected signals, which reduces the link budget extremely.

Luckily, we can also increase the budget. We can add an amplifier between the sender and the antenna. Or we use a different kind of antenna with some “gain”. I will not cover this topic here. But at the end, “human” law allows us only a certain power emitted by the antenna, because we use a “free band”. I shortly mentioned 868 MHz before. This is the frequency used by LoRa in Europe. If we ask Google, we see, that each region uses different frequencies. This is, why you have to pay attention when you buy a LoRa device. They all have their band marked on the back. And because my Chinese supplier sent me a wrong device, I even have one for 915 MHz to show to you.

All these frequencies have something in common: They are “free bands” and we do not need to apply for a license or pay a monthly fee to use it. Which, I think, is very good. But it comes with a handicap: The allowed power is only 25mW in Europe and a little more in the US. Which is really not a lot. Even my small amateur radio rig has 5 watt output power…

We learned, that the budget of LoRa is much bigger than of LTE. Why is this? Is LoRa really the better technology? Or did its inventors even create a “miracle”? No, LoRa is not at all a miracle, and it complies with all physical laws. Its high budget is mainly achieved by a very narrow bandwidth. So, how big or small is the throughput of such a Lora connection? The rated capacity ranges from 250 bit per second to 250 kbs. Which is rather low compared with the Megabits of LTE. But, unfortunately, this is not the whole truth, as we will see later on.

One important thing at the end: The LoRa standard is supported by a big alliance of companies, called the LoRa alliance. Which is important for the future.

Up till now, we just covered the transmission technology between the IOT device and “something”. The next question is: How can we connect our other devices or applications to these devices? Here comes the network into play. It is called LoRaWAN. The LoRaWAN consist of distributed Gateways or concentrators, which are connected to the internet. And it consists of an infrastructure, which is capable to transmit the IOT messages to our applications.

Here we have an overview over the whole infrastructure: Many devices connect to one gateway, many gateways are connected to the “broker infrastructure”, and many applications are also connected to the same brokers.

And here, we see two different approaches: The commercial and the community approach. In many places, telecom companies started to deploy networks. As with cellular phones, you can buy a contract and use this infrastructure. You just have to connect your devices to the available networks. Here, you see a press release from the Netherlands and a price plan from Swisscom. Sigfox is only providing IOT communication. But they do not use a slightly different protocol between the IOT devices and the network.

The community approach is led by the things network, abbreviated, TTN. You find a link in the description. These guys built a infrastructure to transfer the messages between the gateways and your application. But they need, of course, many gateways all over the world. And because of that, they are glad if people like me build such a gateway and deploy it. They provide a map of all available gateways, and you can check here, if one is close to you. If so, you can connect your devices through this gateway and the TTN network to your application, free of charge, of course. Great!

Unfortunately, there was no gateway where I live. So, I had to build my own. Here it is: It consists of a concentrator PCB, in my case a IC880A from IMST, and a Raspberry 2. The concentrator has 8 RF channels, so it can support up to 8 IOT devices in parallel. Which is not a lot if we read the projected numbers of IOT devices… So, what to do?

If we would agree, that each device would only use one channel, let’s say for 50% of the time, we could already support 16 devices. And if each device only would use the channel by only 1%, we could already support 800 devices just with my gateway. And that is exactly the concept. This is, why I told you before, that the bandwidth will be reduced even more. And this concept is also in line with the law, which allows only a 1% maximum usage of these frequencies by one device. So, you can divide the 250 bps by 100, which is 2.5 bps in the worst case. And now, we are slower than Morse. And we are not finished with reducing capacity: You remember your walkie talkies? What was the rule there? Yes, only one should speak at one time. Otherwise, nobody got anything. And because we use the same channel for both communication directions, this applies here as well.

To preserve the valuable capacity and because we want to use this network mainly for sensors, LoRa favors the direction from the sensor to the Gateway, and limit the traffic in the other direction. Also that will be a topic of a future video. So, I have now a Gateway in my area and I only need one additional part: A sensor node.

All sensor nodes consist of at least two components: A microprocessor, and a communication module. You can use your microprocessor of choice and connect it with a communication module which complies with the LoRa standard. There are a few out there, mainly the RFM95 and the SX1276. As already mentioned, these modules usually exist in three different versions, for 433, 868, and 915 MHz. BTW: They are not as cheap as other RF modules. This is probably, because the Lora technology belongs to only one company, Semtech…

For my first tests, I use a Dragino shield and an Arduino Uno. Also this device will be covered in one of the next episodes.

But now, let’s check, if the whole thing works: The Arduino should be able to transfer a message. So, first, let’s check in the air: Yes, the Spectrum Analyzer sees some traffic on frequencies between 868 and 869 MHz. So, the sensor device works and the concentrator should get it, because we still have lots of link budget left: The distance is only a few centimeters and there are no major obstacles between the two devices. So, let’s check on the console of TTN: Yes, we see the messages coming. And the message is “hi”.

So, summarized:

LoRa is a new transmission standard between distributed devices and distributed gateways

It has an extremely low channel capacity, a very low power consumption, and therefore a very high link budget

Which makes it ideal for low power sensors distributed everywhere, also far from the next gateway

There are two different approaches for the network: A commercial and a community approach

The community approach is based on privately built and operated gateways and an infrastructure which transfers the messages from the gateway to your application

This was a first introduction. The next episodes will cover the build and connection of a gateway, as well as the build of a client, some range tests and so on. Stay tuned!

I hope, this video was useful, or at least interesting for you. If true, then like. Bye