06/06/2019

LoRa Network Planning and Simulation Optimization

1 Introduction

The LoRa network is generally built according to the needs of business development and driven by use cases, mainly in smart cities, smart buildings, smart agriculture, etc., both outdoor and indoor application scenarios, such as asset or cargo tracking, meter reading applications, and manhole covers, parking spaces, smoke detection, meeting rooms, etc.

Wireless network planning and optimization is an important part of network construction to effectively anticipate or solve problems such as capacity, coverage, and interference, improve network utilization efficiency, and improve investment yield. Nowadays, before the construction of LoRa network, network planning tools are used for planning and there are very few projects for optimization. Only once the first business cases are effective with first sensors deployed, some unexpected problems of coverage or capacity might appear, and would require optimization tool.

2 LoRa Network Planning

Before the LoRa network coverage planning and optimization, it needs to determine the regional scope of the service deployment, performance requirements such as the rate and power consumption of the service, and the requirements of the service deployment scenario, and then determine the outdoor and indoor network planning indicators.

2.1 LoRa Network Planning Indicators Considerations

For LoRa, the spreading factor reflects the level of coverage of the network and the achievable traffic rate (i.e. service level). The rate and power consumption supported by different spreading factors are different, and the demodulation thresholds required by different spreading factors are also different. Therefore, it needs to understand the performance requirements to manage use cases related to the developed business.

SpreadingFactor (RegModulationCfg)	Spreading Factor (Chips / symbol)	LoRa Demodulator SNR
6	64	-5 dB
7	128	-7.5 dB
8	256	-10 dB
9	512	-12.5 dB
10	1024	-15 dB
11	2048	-17.5 dB
12	4096	-20 dB

In network planning, it also needs to consider different requirements according to the use cases and scenarios to be managed, and the coverage required by the network is also different. The outdoor gateway can cover the outdoor and a certain degree of indoors, but it does not necessarily cover all the scenes. For example, the basement and deeper indoor coverage are difficult to cover by the outdoor gateway, and need to be supplemented by an indoor gateway. For example, outdoor street lighting, environmental monitoring, asset/cargo tracking, generally do not need to consider the penetration loss of buildings, but for indoor meter reading, smart home, smoke and other terminals, it is necessary to consider different levels of indoor penetration loss. For example, penetration loss in dB depends on the location of the indoor device, 10-18dB for light indoor and 24-30dB for deep indoor are standard values but can be customized according to the operational context.

2.2 LoRa Network Planning Indicators

LoRa coverage planning indicators can be characterized by two dimensions: business performance and signal strength or quality, while also considering coverage satisfaction probability, generally considering 95% coverage.

Since different spreading factors correspond to different service levels such as different rates, transmission durations, and power consumption, an uplink spreading factor or a downlink spreading factor may be considered as a service performance target. LoRa is mainly based on the above services, and needs to meet the uplink service performance requirements, while ensuring that the downlink can be correctly demodulated and received. After the service performance requirements are clarified, combined with the antenna gain, transmit power, demodulation threshold, and interference level of the actual LoRa equipment, the requirements for signal strength or quality can be known. If multiple services are deployed in the same area, The business with high performance requirements determines the planning indicators.

For example, considering the coverage priority, the spreading factor 12 (also known as SF12) is used as the service planning target. If the terminal power saving, rate, and capacity performance are comprehensively considered, the spreading factor 10 (a.k.a. SF10) is considered as the planning index, and of course, the spreading factor can be determined according to the actual service demand.

3 LoRa Network Simulation Evaluation and Optimization

The simulation evaluation is a scheme that can combine the 3D map and the site information to evaluate the network coverage effect in the area, and continuously iteratively simulates the site information that satisfies the coverage planning indicator. In addition to clearly covering the planning indicators, two important conditions for simulation evaluation are LoRa network planning simulation tools and maps.

The specific steps of the simulation evaluation are:
1. Clear coverage and coverage planning indicators and coverage scenarios.
2. Determine simulation parameters, including LoRa device antenna radiation type, antenna gain, transmit power, operating frequency, demodulation threshold, and parameters such as interference and loss, and prepare 3D maps and existing site information (station height, latitude and longitude, etc.).
3. Simulate iteration and optimization, output the site information that meets the requirements of the planning indicators, and then estimate the coverage radius.

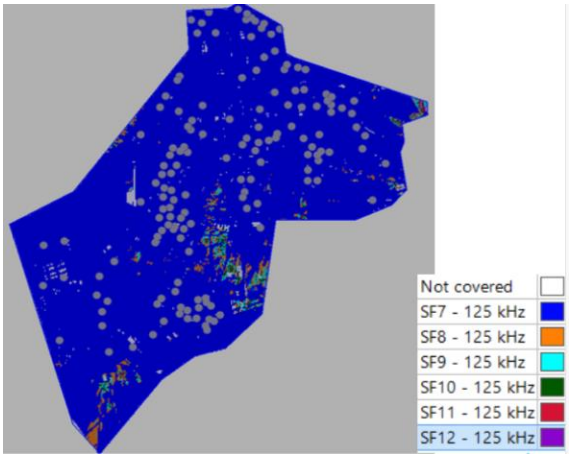
4 LoRa network simulation evaluation and optimization case based on S_IoT tool

The S_IoT tool is an IoT planning and optimization tool developed by SIRADEL. It relies on a leading 3D ray tracing propagation model Volcano and provides advanced 3D visualization. It can be used to simulate and evaluate the outdoor and indoor coverage of the current network, as well as network coverage after adding or adjusting the gateway. At the same time, the S_IoT tool evaluates a large number of IoT-specific indicators, such as the impact of the geographical distribution of the gateway. In the application scenario with mobile devices, S_IoT also considers the evaluation index of the positioning accuracy.

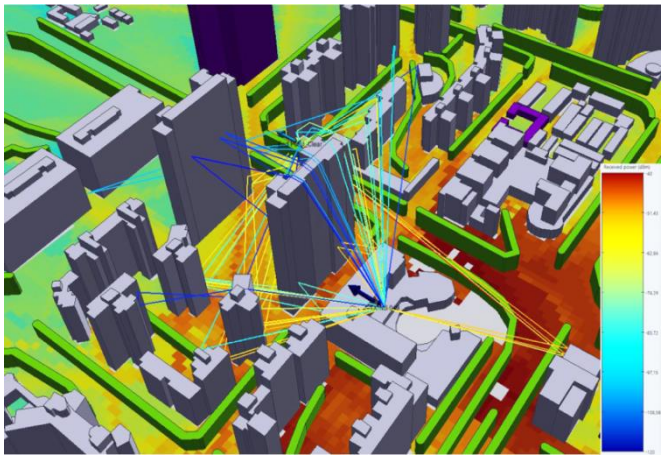
Tencent deployed the first LoRa IoT network in Shenzhen. In the process of network construction and optimization, Tencent cooperated with SIRADEL, French provider, to simulate and evaluate the LoRa network in key areas of Shenzhen based on SIRADEL's S_IoT tool. Thanks to S_IoT, the deployment is easier and faster, but especially more reliable, leading therefore to fewer optimization steps before achieving high service level and great user experience.

This simulation evaluation used Shenzhen map with three-dimensional and 5-meter resolution for simulation. Volcano propagation model in S_IoT enables to predict with a high level of accuracy and reliability the real network coverage, especially in dense, therefore challenging, areas. On the one hand, the indicators such as the uplink receiving power, uplink receiving quality, spreading factor, and number of receiving gateways of the user arriving at the gateway in different outdoor and indoor locations that can be achieved by the initial network are used to evaluate the network coverage effect. On the other hand, according to the coverage planning indicators and the candidate sites, the simulation evaluation obtains the site adjustment and optimization suggestions that meet different coverage levels.

The evaluation results show that the Shenzhen LoRa network has achieved continuous coverage in the core urban area, and some areas have achieved indoor deep coverage. It is currently the largest LoRa network in China. Taking Nanshan District of Shenzhen as an example, the proportion of the outdoor uplink spreading factor less than or equal to 10 is over 99%, which means that the coverage terminal can achieve a higher rate with lower transmission power. At present, based on the recommendations of the simulation evaluation results, the site optimization of a smart community in Nanshan District has been completed, and the deep indoor coverage has been further supplemented to meet the deployment requirements of indoor LoRa service nodes.



Lora outdoor uplink Spread Factor distribution NanShan District, ShenZhen



Received Power Coverage simulation in a smart community of NanShan District with S_IoT planning tool

5 Conclusion

LoRa wide coverage is one of its important features. Its continuous network construction and deployment is worth exploring and researching. In actual project deployment and application, LoRa network can also be deployed in different scenarios and on-demand.

This paper introduces the LoRa network coverage planning and simulation evaluation optimization scheme, and based on SIRADEL S_IoT tool to simulate the Tencent Shenzhen LoRa network, to quickly obtain the network coverage performance evaluation results and the optimization scheme to meet different coverage levels. In the case of meeting the coverage performance requirements, the LoRa network planning indicators are clarified, and the network construction in the actual environment is performed according to the simulation evaluation results, which can save construction time and cost.