Poster: LoSee: Long-Range Shared Bike Communication System Based on LoRaWAN Protocol

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Abstract

The employment of LPWAN technology is gradually becoming an evolution of IoT (Internet of Things) applications, for its significant improvements of signal sensitivity and noise tolerance. At present, however, many IoT applications, such as Chinese shared-bike systems, are still using the communication technology of traditional mobile network, which consumes considerable power and suffers from high communication cost. In this paper, we present LoSee, a long-range shared-bike communication system, based on the LoRaWAN protocol. We clarify the system parameters of LoSee and determine its communication range. LoSee prototype is implemented to track the bike route in real time. With this prototype, the relationship between the Packet Delivery Rate(PDR) and Signal to Noise Ratio(SNR) is built. Considering the impact of signal contention, a model is mathematically verified to decide the PDR with the node count and the duty cycle. Finally, LoSee communication range is concluded and a solution is proposed for setting up a shared-bike system in the campus by LoRaWAN, which reduces power consumption and eases gateway deployment.

1 Introduction

IoT is another great innovation after Internet and Mobile Network in the information era. There will be approximately 24 billion IoT devices around the world till 2020. IoT extends the network node count drastically by connecting usual things in daily life by wireless networking and sensing technology. In a specific deployment of IoT devices, a naive solution is utilizing traditional mobile network like 2G. This method is used by many present IoT devices but under costly consumption and deployment. To help communication technology fit IoT applications better, LPWAN(Low Power Wide Area Network) protocols have come out.

LoRaWAN, as one of the latest open source LPWAN protocols, creatively introduces LoRa in its Physical Layer. LoRa[1] is based on CSS (Chirp Spread Spectrum)[2] modulation, efficiently avoiding multipath transmissions and Doppler effect. As a result, the decode efficiency of signals is guaranteed. Take LoRa SX1276 transceiver as an example: its tolerance of LoRa signal RSSI and SNR are as low as -148dBm and -20dB respectively. Semtech, the patent holder of the LoRa chip, has been applying this technology to various IoT applications.

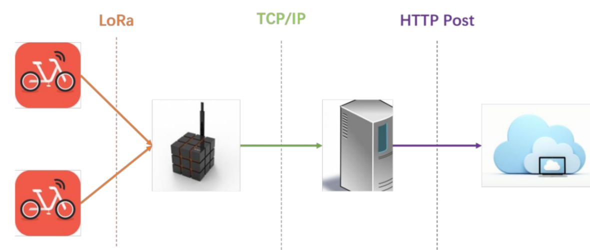

Figure 1. LoSee Prototype Architecture

In this paper, we explore the feasibility of LoRaWAN to improve the shared-bike system. We aim to answer three questions: First, how large can be the communication range of LoRaWAN to satisfy all the shared bikes in the campus? Second, how are gateways deployed to receive packets from bikes in the campus? Third, will the LoRaWAN system be better than the present mobile network?

In this paper, we present LoSee, a novel shared-bike communication system in the campus based on LoRaWAN. We estimate the shared-bike demand in Tsinghua University. Based on the application of tracking bike routes, we design the duty cycle of LoRa nodes and choose communication channels with viable transmission parameters. Meanwhile, by mathematical analysis and numerical simulation, we estimate PDR in the signal contention. As a result, the communication range of LoSee is concluded. We prove the LoRaWAN's advantages of low power and low deployment budget over traditional mobile networks. LoSee utilizes free ISM bands and efficiently distributes gateways to cover the whole campus, supporting all potential bikes.

2 Prototype Implementation

We build the prototype of LoSee, whose architecture is represented as Figure 1. Bike locations collected by nodes

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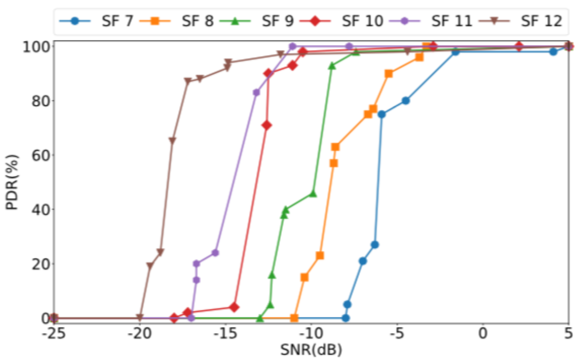

Figure 2. PDR-SNR relationships on different SFs

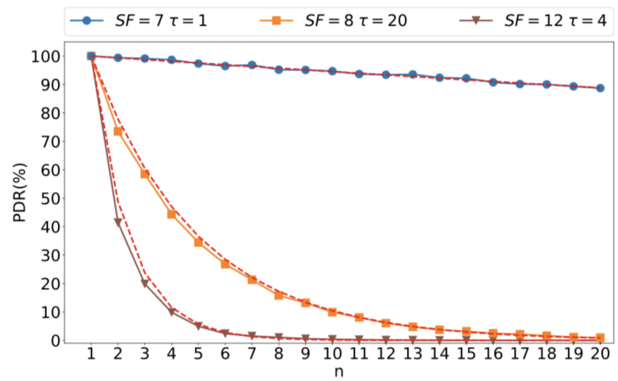

Figure 3. Signal conflict simulation vs. theoretical results of relationship between node counts and PDR(%)

are transmitted to the gateway and passed to the LoRa server through IP link. The LoRa server integrate packets' data into JSON files and HTTP post to the application in the cloud for visualization. Following are implementations of three main components in the architecture.

NodesIn the implementation of nodes, we use STM32L0 as MCU, single SX1278 as antenna and NEO-7N as GPS.

Gateways In the implementation of nodes, we use STM32L0 as MCU, single SX1276 as antenna and Raspberry Pi 3 for programming remotely.

Network and Application The LoRa Network and the monitor application are deployed on the Digital Ocean Cloud. Nodes, gateways and applications are registered on the LoRa Network. When the system is running, the network captures all packets transmitted by the registered nodes from known gateways. Each packet's LoRaWAN physical-layer payload is HTTP posted with link quality to the monitor application.

3 System Measurement and Implication

Based on LoSee, implemented as Section 2, LoRaWAN gateway communication range can be concluded using experimental results. Following are the definition and the estimate of the gateway communication range.

3.1 Communication Range

We assume the range is a circle area with the radius r and the total number of bikes are statically nearly the demand. The communication radius r is strictly defined as: any bike nearer than r from the gateway can have at least one packet accepted along any road segment.

3.2 PDR and SNR

In the experiment, we move one bike node with a fixed SF to different places with different SNRs. One bike node sends continuously 50-100 packets in one place and then PDR is calculated as the ratio of the accepted number to the total sum. We change SF from 7 to 12 and repeat the experiment. The result is shown as Figure 2.

3.3 PDR and Signal Contention

LoRaWAN does not specifies the signal avoidance mechanism in the protocol. Nodes can deliver their packets at any time. We simulate n nodes sending packets independently and randomly. The comparison between theoretical results and simulation results is shown as Figure 3.

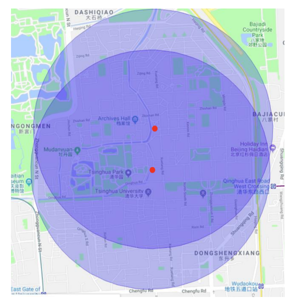

Figure 4. LoRa Gateway Locations in Tsinghua University

3.4 LoSee Range and Capacity

LoSee communication radius is about 1031 meters and its capacity is 423 bike nodes. To cover the whole area of Tsinghua University, only two gateways are needed, as locations in the Figure 4 show. Compared with numerous expensive 2G/3G/4G stations and devices deployed, LoRa is a efficient solution for offhand communication systems. In this application, LoRaWAN utilizes free ISM bands and LoRa Nodes are as low-power as 60mW in active mode. It is one sixth of 2G power consumption, which is up to about 400mW.

4 Conclusion

In this paper, we present a LoRaWAN based system LoSee, implemented as a network for communicating and localizing shared bikes in the campus. We evaluate its communication range with experimental results and simulation analysis. In the future, a more accurate estimate toward signal strength instead of LDPL needs to be studied. What's more, a LoRa-chip related interference measurement can improve the contention estimate of LoSee.

5 References

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