Copula-Based Interference Models for IoT Wireless Networks

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Introduction

With the increasing scale of wireless networks deployments for the Internet of Things (IoT), a key issue is that the interference statistics are difficult to characterize. In this paper, we study the statistics of interference due to IoT networks that transmit small amounts of data.
A key observation is that sets of active devices change rapidly, which leads to **impulsive noise (interference) channels**. Moreover, these devices operate on multiple partially overlapping resource blocks. As such, we characterize the joint distribution and propose a tractable model based on **copulas**. Using our copula model, we derive closed-form achievable rates. This provides a basis for resource allocation and network design for coexisting IoT networks.

Problem of Interference

The IoT is expected to operate in the ISM bands:
- Low power wide area networks (e.g., SigFox and LoRa) on 863-870 MHz bands.
- ZigBee
- Radio frequency identification (RFID)
- Various devices (e.g., alarms, car keys, etc)

Most devices are uncoordinated!

ETSI and ERC recommendations for ISM bands require that transmitting devices either:
- Listen before talk (listen > 5 s)
- Restrict duty cycles (maximum percentage of on time per hour)

LoRa and SigFox rely on duty cycle access

$\Rightarrow$

Increasing interference with an increasing number of devices.

The Standard Interference Modeling Approach

The interference is given by

$$Z = \sum_{i \in \Phi} r_i^{-\eta/2} h_i X_i.$$

Conditioned on Φ and (h_i), Z is then assumed to be Gaussian.

For example, the expected rate is given by

$$\overline{R} = \mathbb{E}_{\Phi, h_j}[\log(1 + \mathrm{SINR})].$$

I.e., the devices transmit long packets.
This only makes sense when the set of interfering devices does not change.

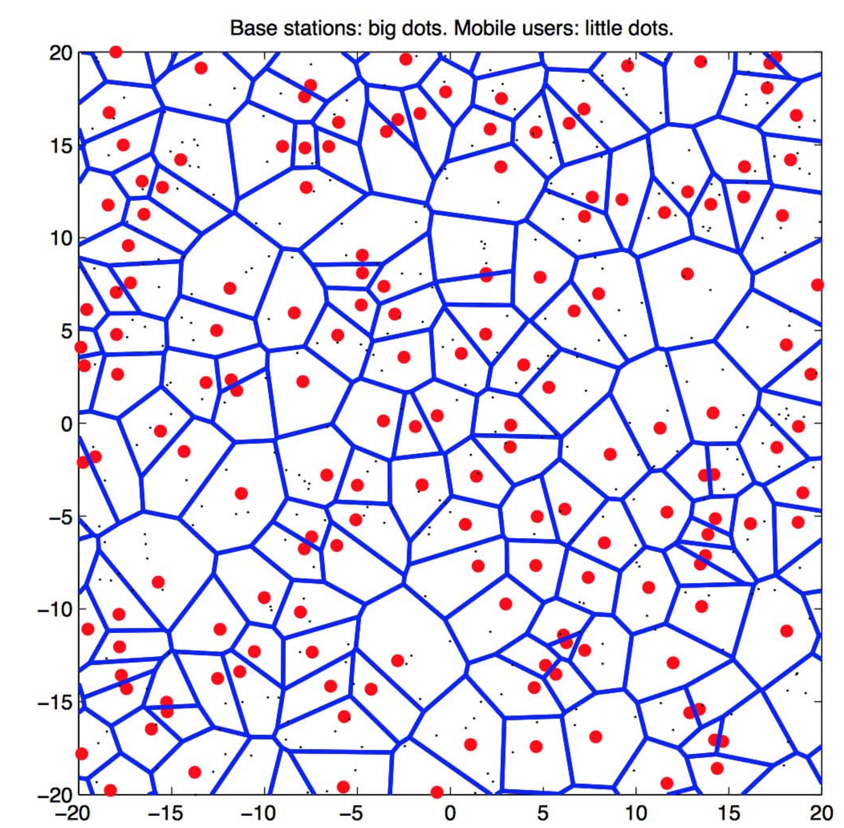

Fig. 1: Poisson Point Process.

New Chanllenges in IoT

In IoT communication networks, devices send small amounts of data.

That is, they send short packets.

$\Rightarrow$ **Interferers can change during a transmission.**

$\Rightarrow$ We cannot condition on the locations Φ to obtain a Gaussian model.

This scenario is called **dynamic interference**.

Access Scheme

- Uncoordinated: interfering devices independently transmit on band $k \in \mathcal{B}$ with probability p where