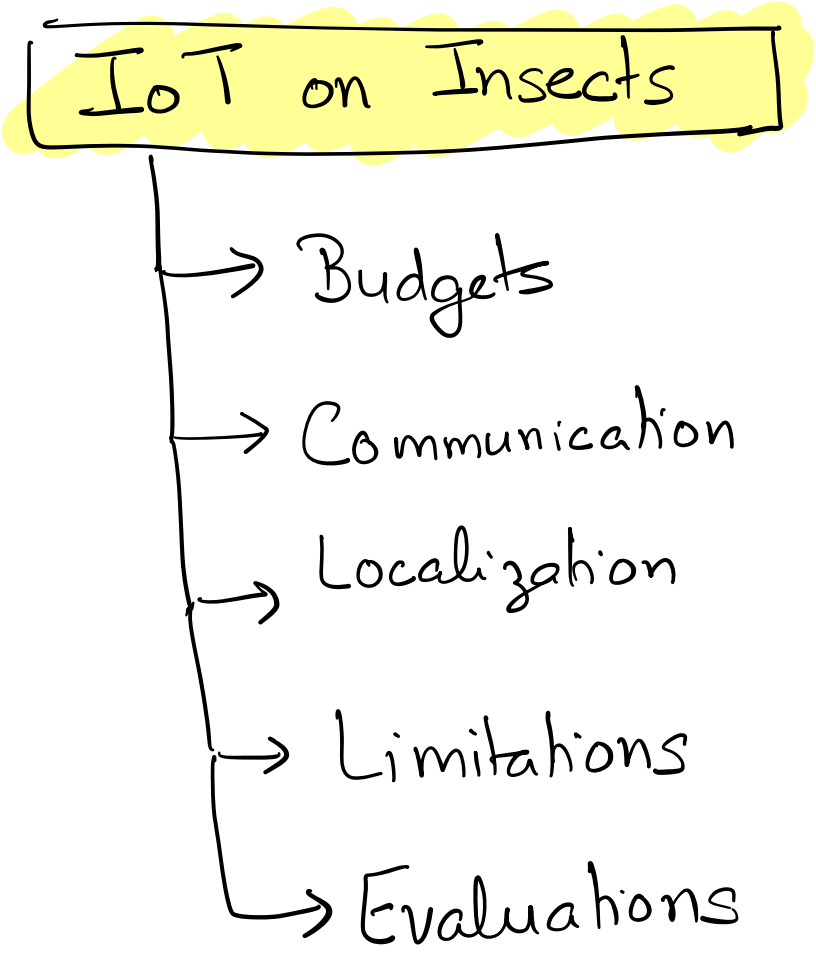

IoT on Insects
Budgets
Communication
Localization
Limitations
Evaluations

Project Discussion

Friday ⟸ Presentations.

Wednesday → Dec 6

12 to 2:30

15 minutes per project

- 10 minutes of speaking
- 5 minutes of Q&A.

Insect IoT: Motivation

insects fly free

⇑

no batteries

insects have unique sensory capabilities.

ubiquitous

Budgets

PCB
Antenna
Attaching stuff.

Weights: 105mg.

Battery: 70 mg.

micro-controller: 4.1 mg.

Sensors

Communication → antenna.

PCB design

Antenna

Attach to insects?

Communication.

Getting data from sensors

Wi-Fi/BLE ⟸ → high power
→ Limited range

Backscatter ← really low power.

AP, close to the hw.

→ transmits narrow band signal

→ insect device reflects this signal

ON-OFF Keying

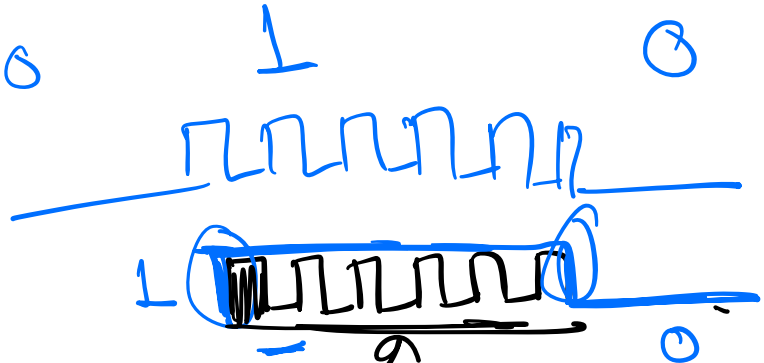
Problem

900 MHz

902MHz ←  reflecting + shift freq. by 2MHz

→ band pass filter.

cost
Some power



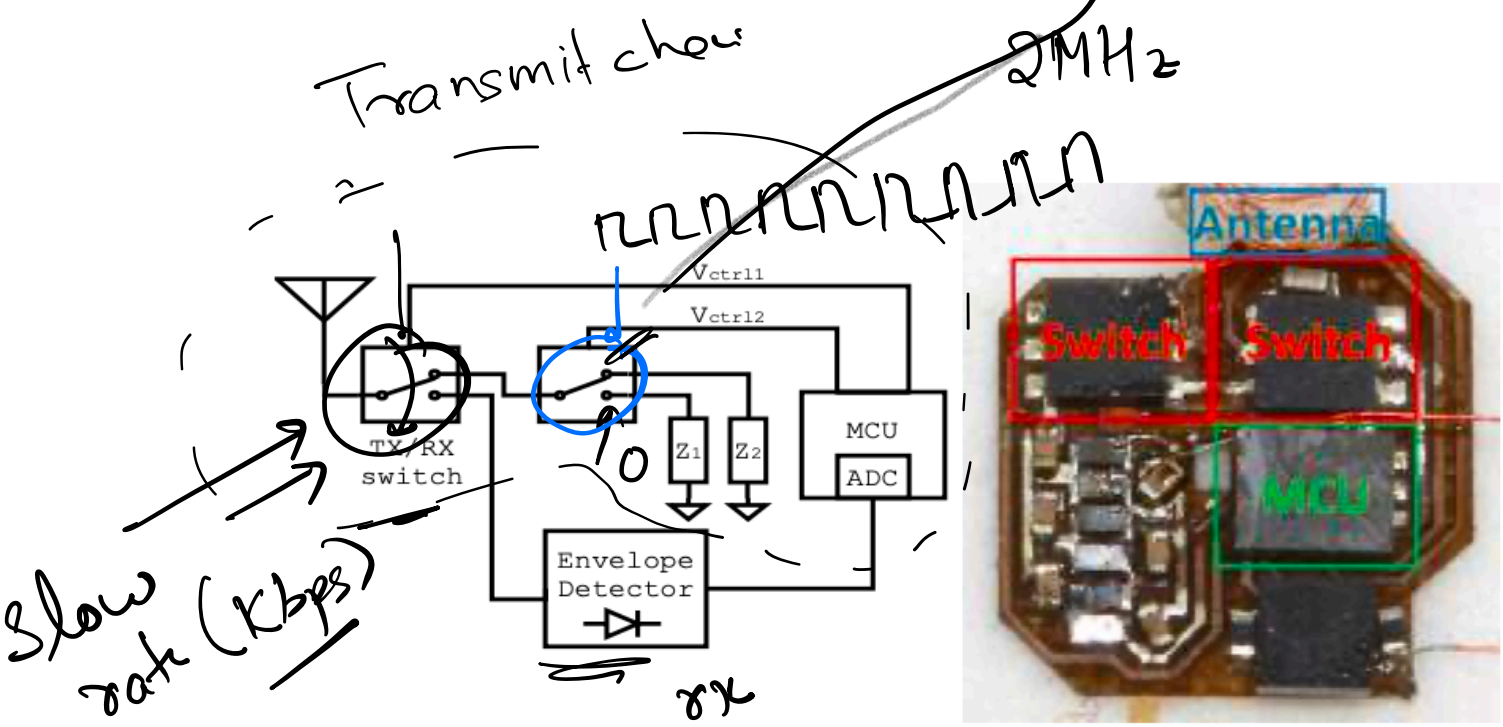
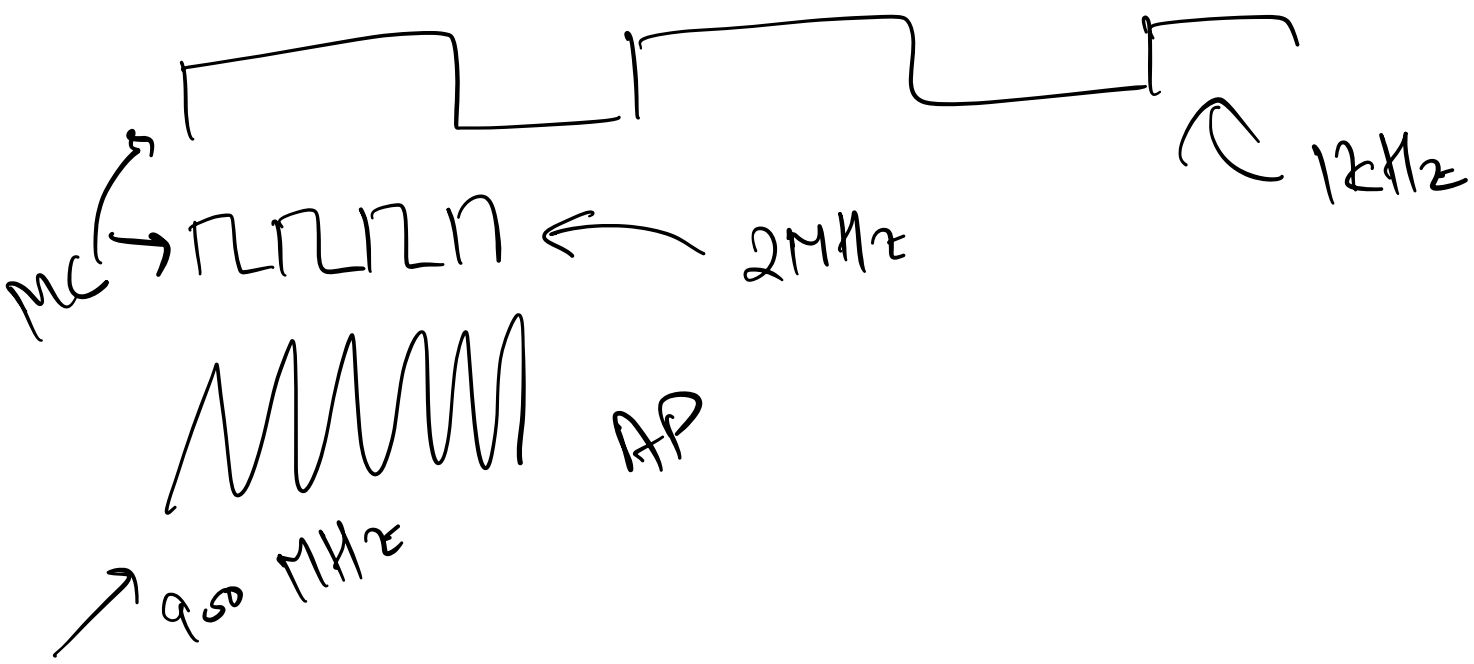


Figure 8: Backscatter hardware including a block diagram (left) and light-weight hardware implementation (right).

Rx → shift of 2MHz

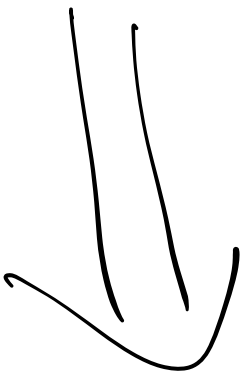
data symbol modulated at Kbps.



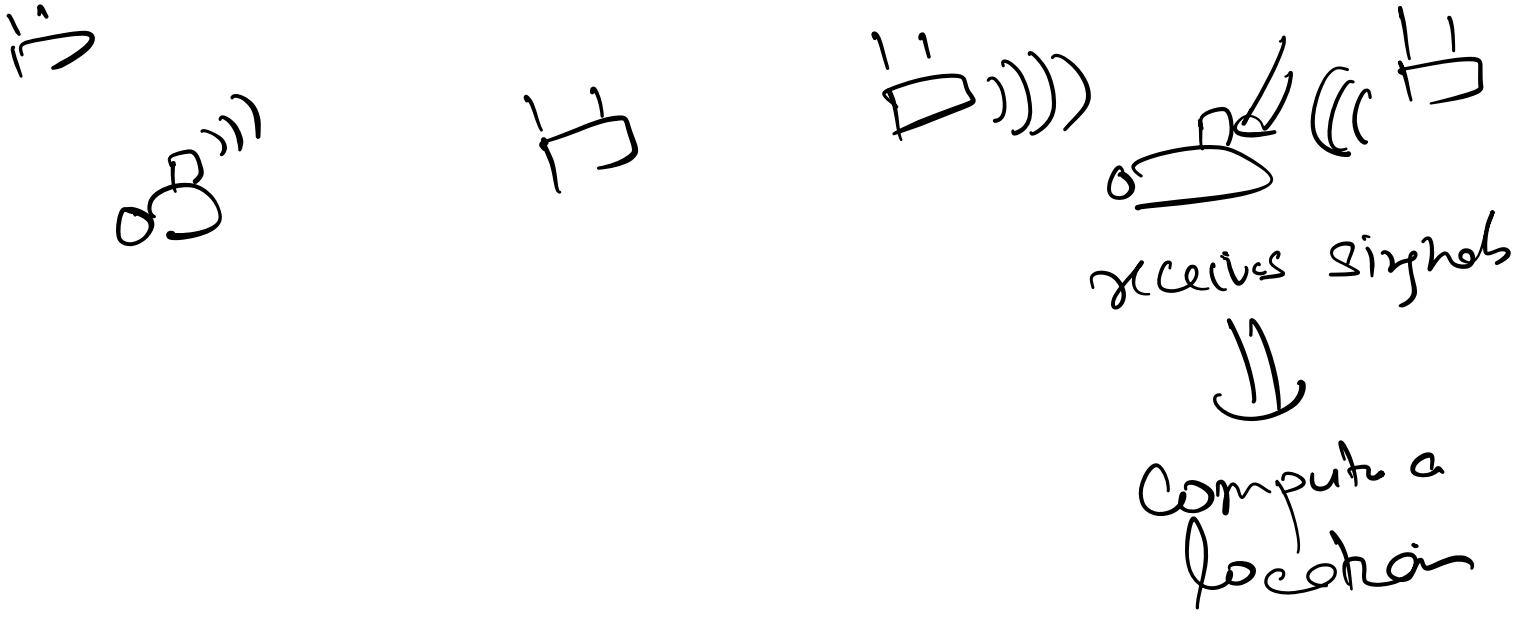
Localization

GPS → too power hungry.

Satellite signal is weak
↳ do a lot of processing to recover that signal.



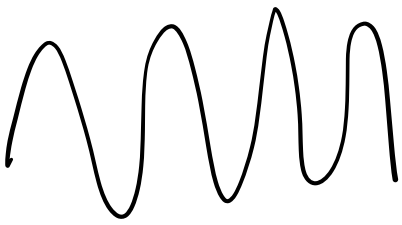
bring satellites down
↳ AP.



receives signals

Compute a location

900MHz



⇒ channel ⇒ amp

⇓ phase.

↳ multiple antennas

→ 900MHz clock

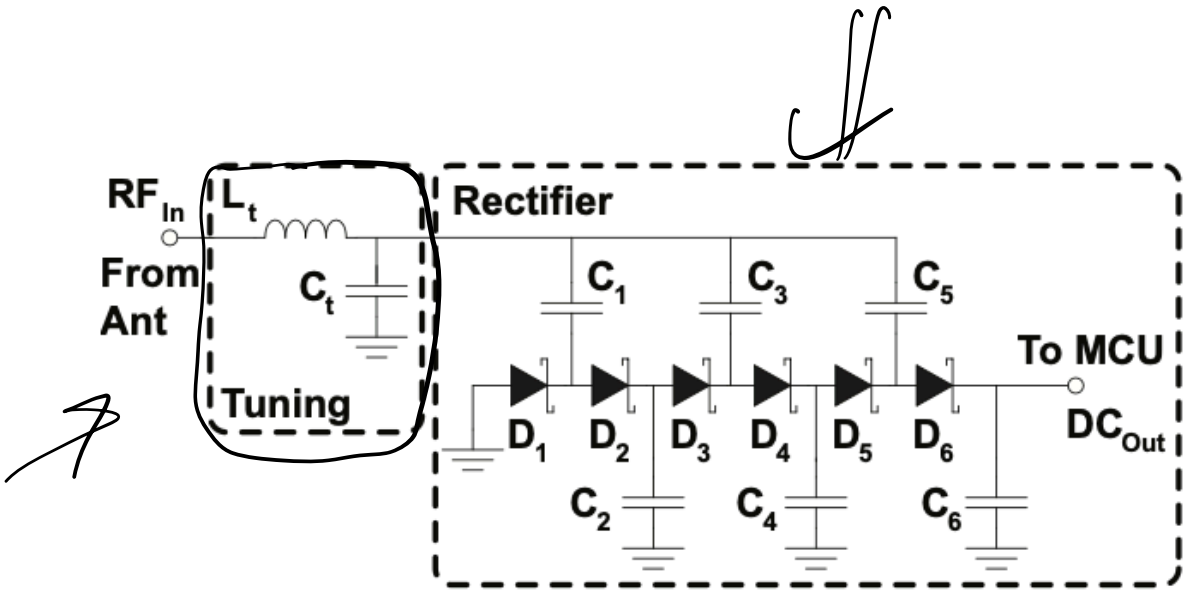
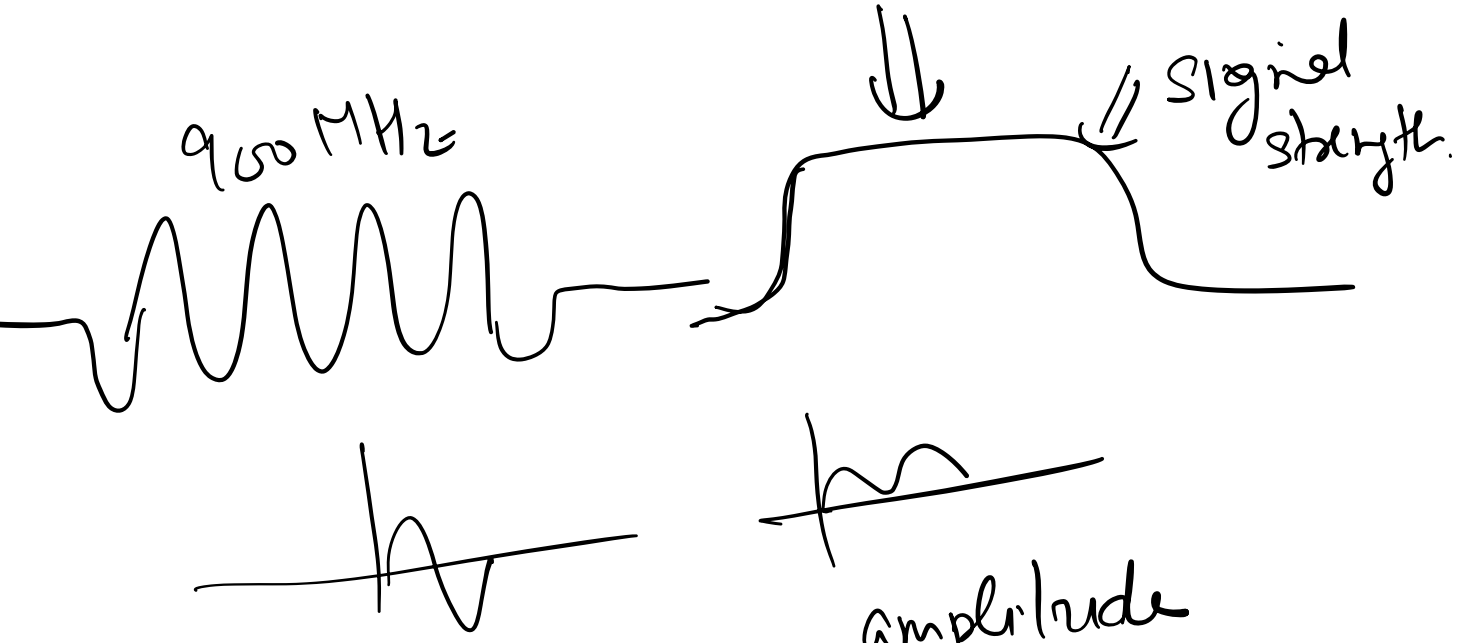


Figure 5: Envelope detector circuit diagram.

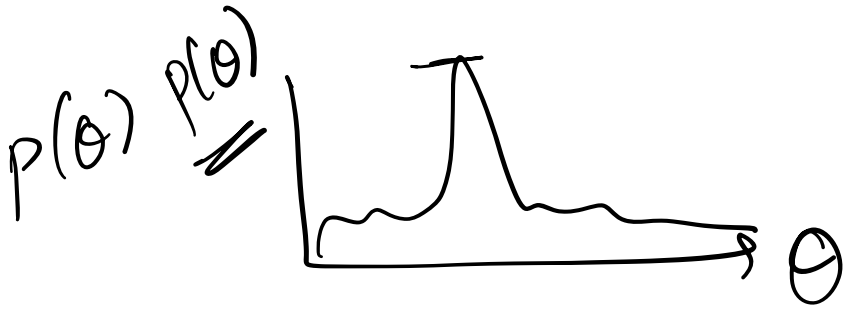


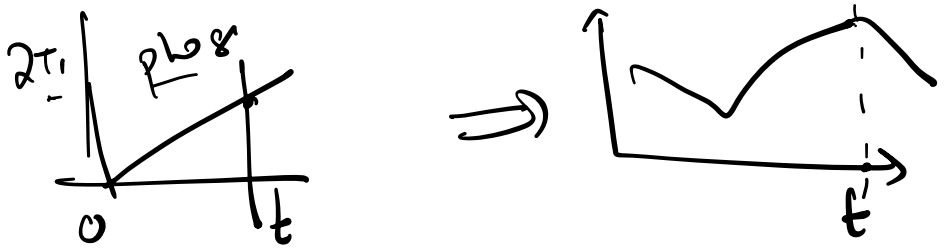
amplitude without having to sample at 900MHz

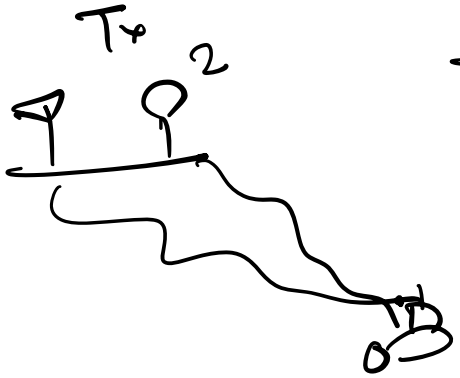
Amplitude ⟹ location?

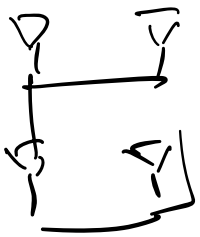
$$\Delta\phi = \frac{2\pi}{\lambda} x \cos\theta$$

$$P(\theta) = \left| \sum_i h e^{j \frac{2\pi}{\lambda} i x \cos\theta} \right|$$









Evaluation

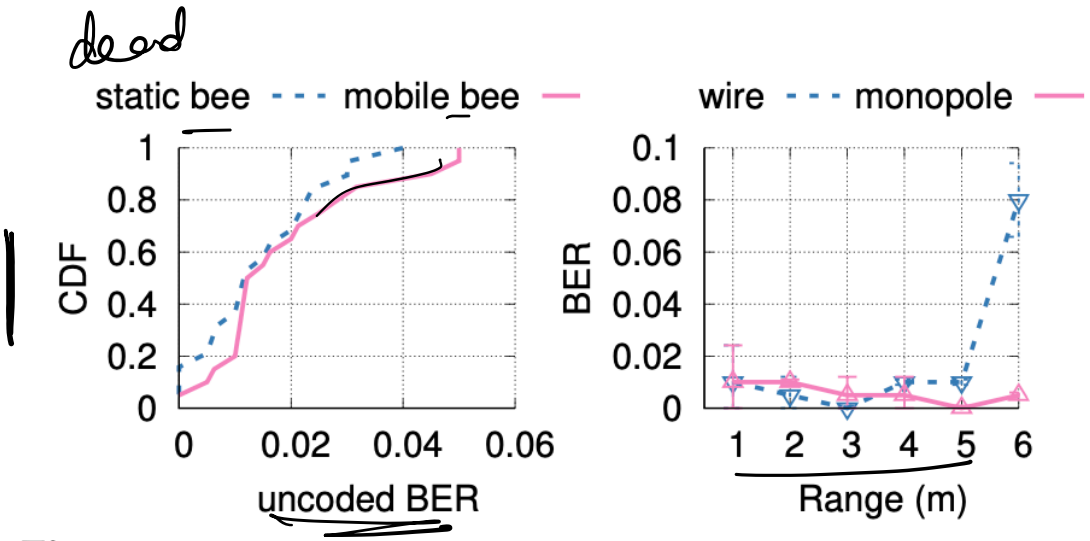


Figure 14: Backscatter performance. The uncoded BER is low and comparable to prior backscatter designs [77] and the bee can upload data when it is back at the hive.

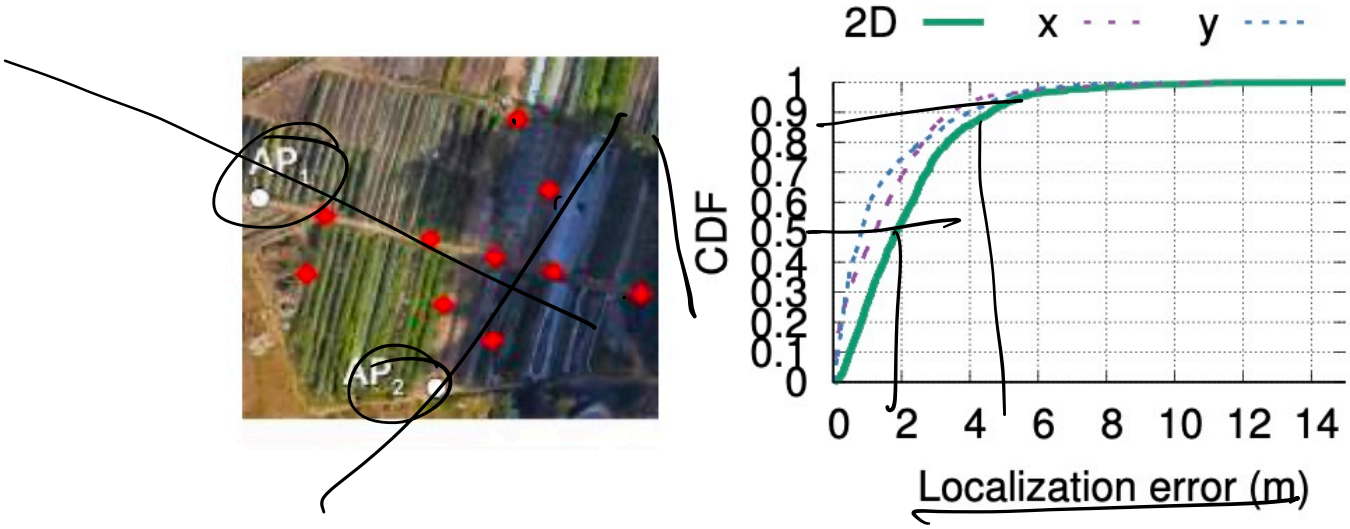


Figure 11: 2D accuracy with deployment in farm.

Limitations

- seasonal bees.
  (insects can die ⇒ e-waste)
- battery life.
- AP needs to be close.
- Interference management
- 900MHz
- Cameras on bees? ↔ size, power

Fabrication

flow