Enabling High-Rate Backscatter Sensing at Scale

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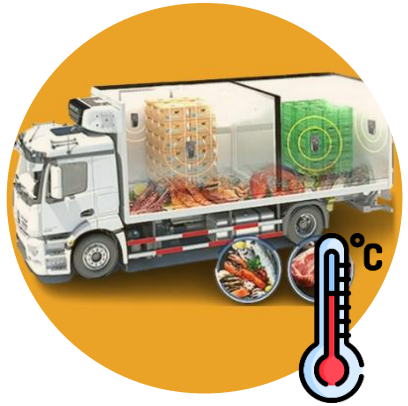
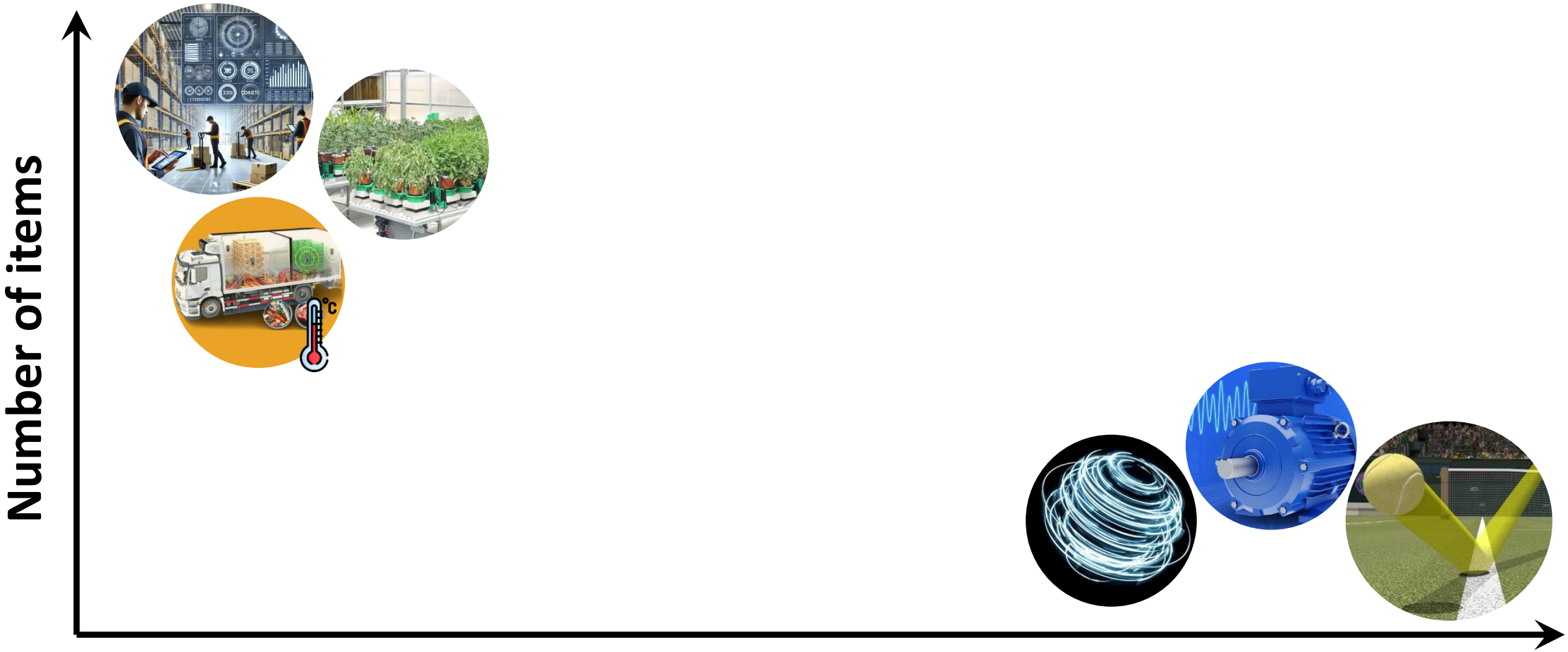
Today's wireless sensing…



Challenge: Performing *high-rate* sampling of the targets *at scale*

However…



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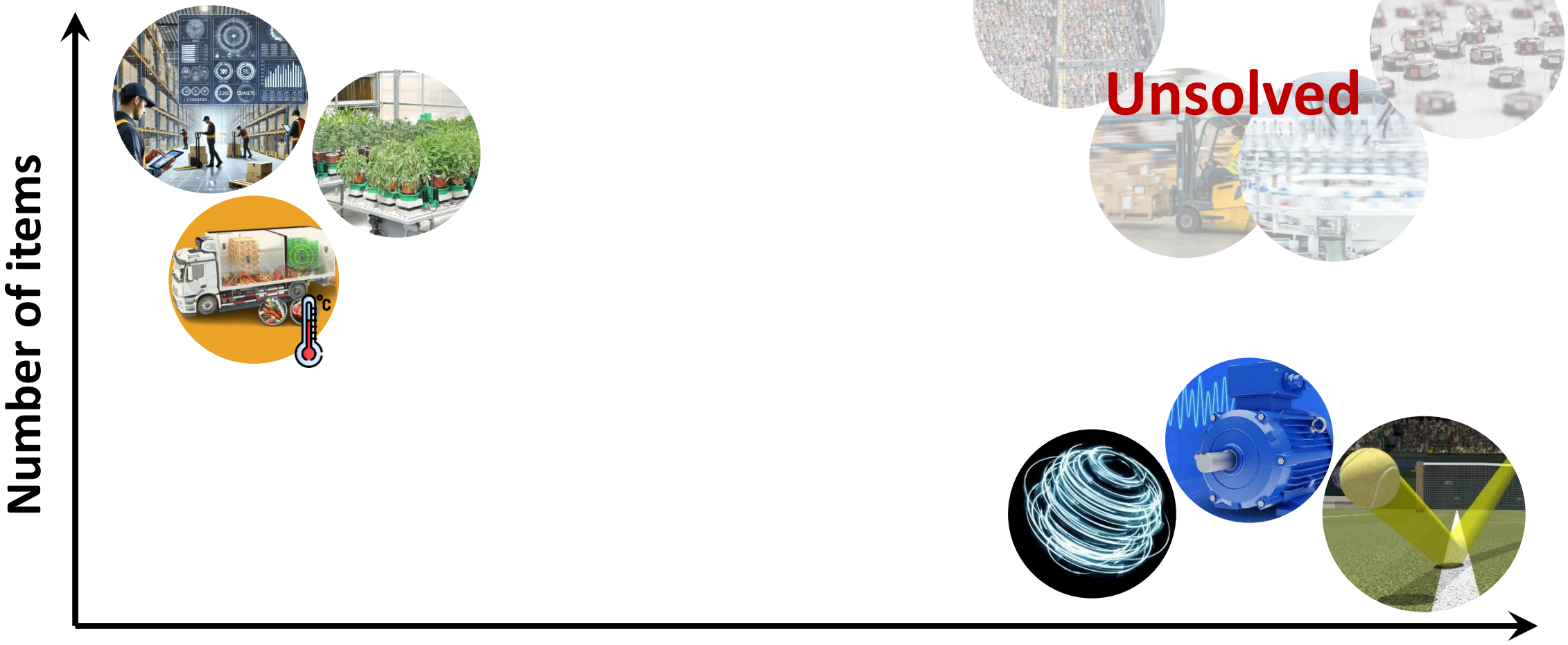

Can we build a sensor that can be tracked seamlessly at scale?

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µTag

Concurrency: 150

Sampling Rate: 12KHz

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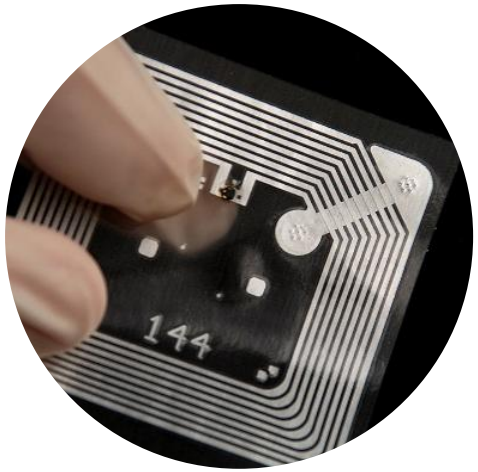
V.S.

150X↑
240X↑



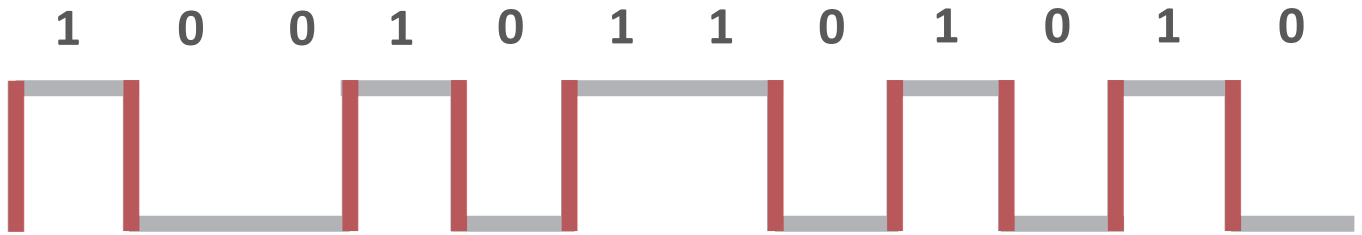
RFID

Concurrency: 1
Sampling Rate: 50 Hz

Core of µTag:
RF “gene editing” technology

OOK backscatter V.S. RF "gene editing"

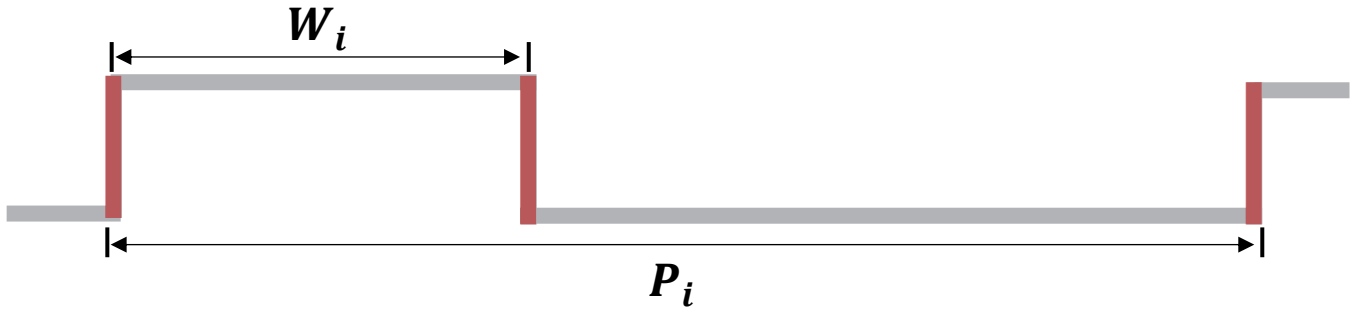
OOK backscatter:



1001 0110 1010 -> **Miller decoder** -> ID: 101

Flip the state for more than **N times** to transmit a N-bit ID

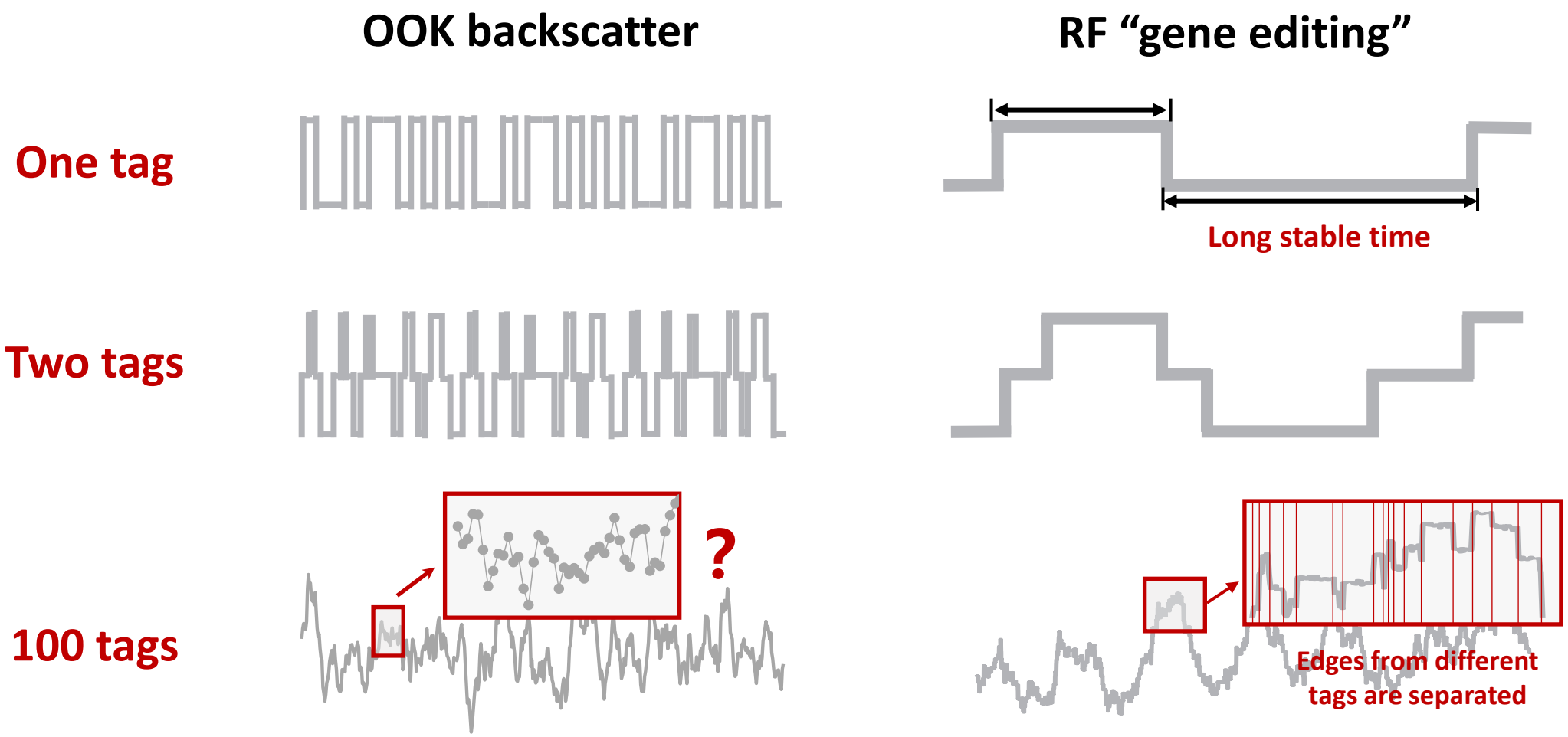
RF "gene editing" :



$\{P_i, W_i\}$ -> ID: 1010011…

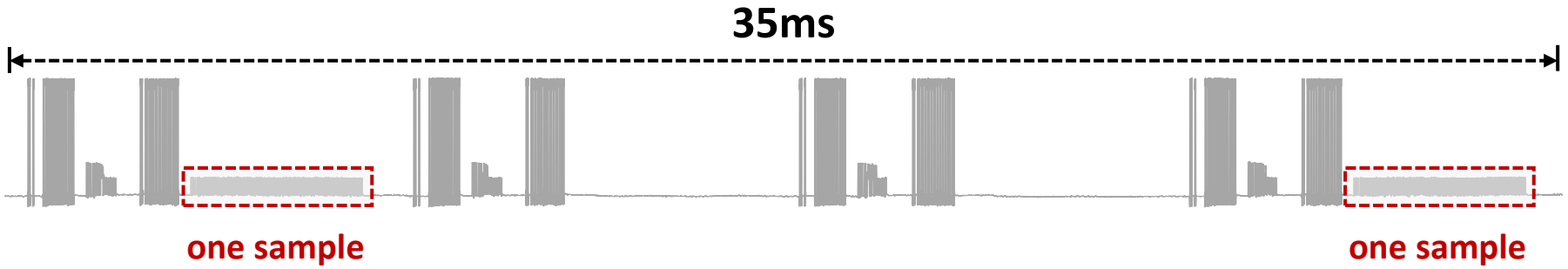
Flip the state for **three times** to transmit its ID, no matter how long the ID is

Gain in concurrency



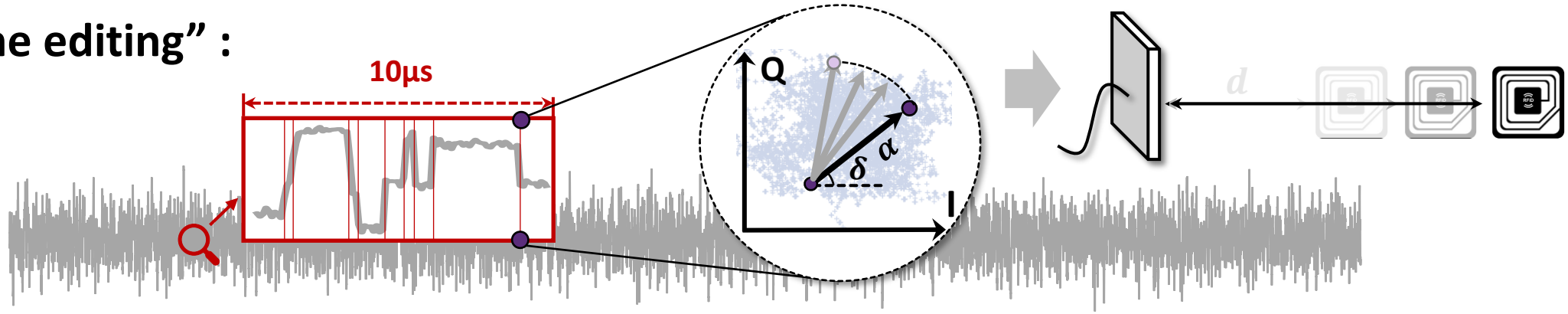
Gain in per-tag sampling rate

OOK backscatter:



Treat one **RFID packet** as one sample of the tag's **motion state**

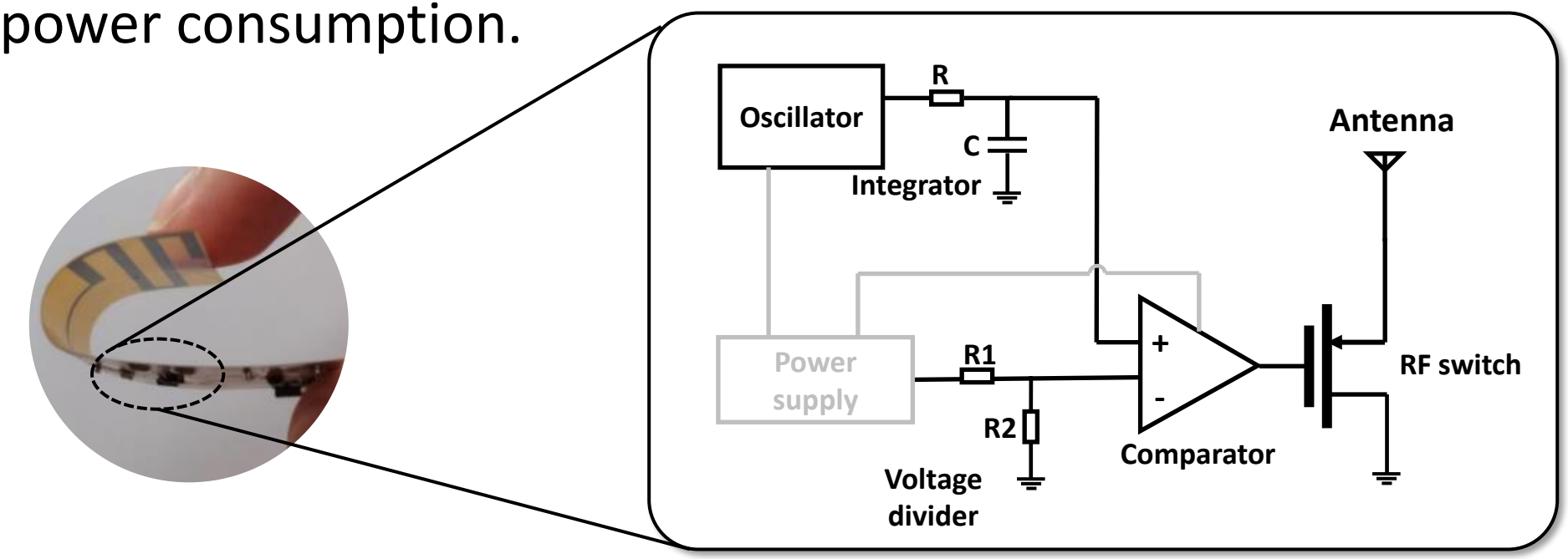
RF "gene editing" :



Treat one **edge vector** as one sample of the target's **motion state**

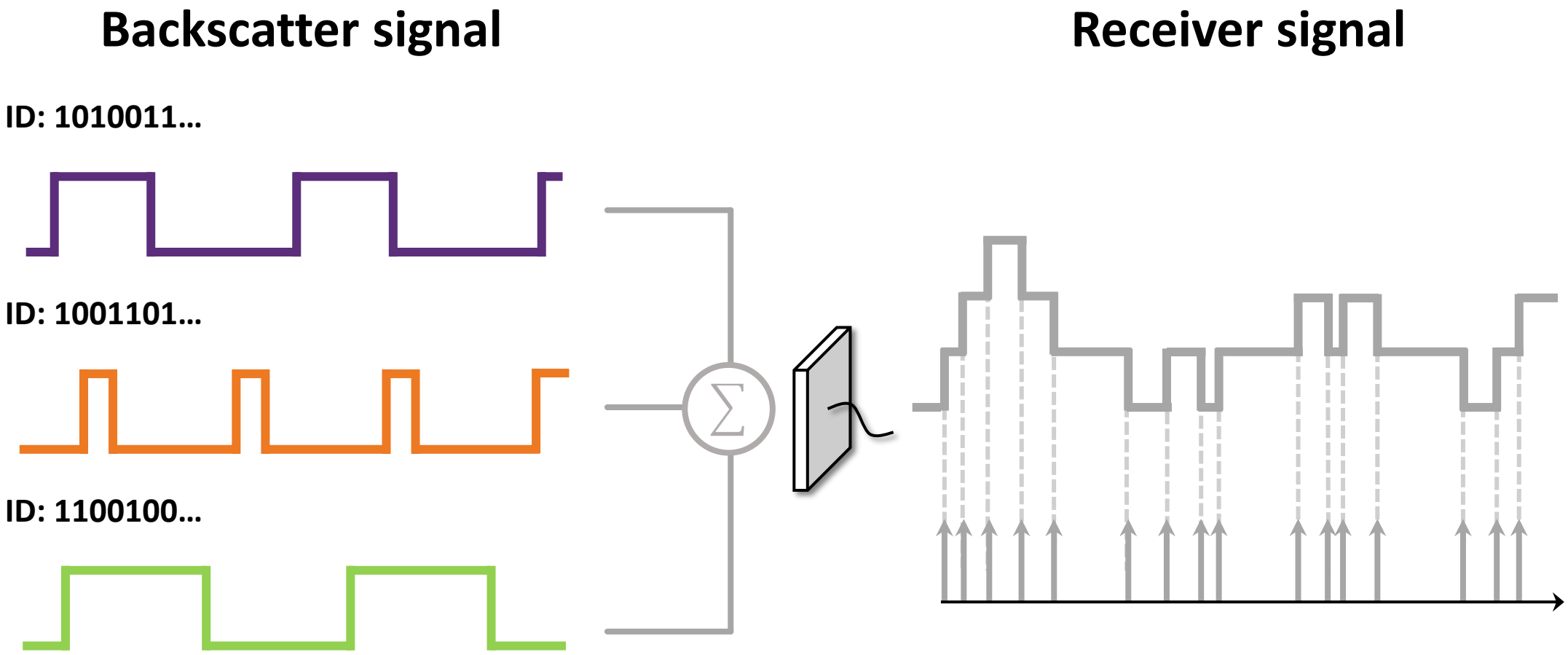
Gain in power and cost

Sub-μW-level power consumption.

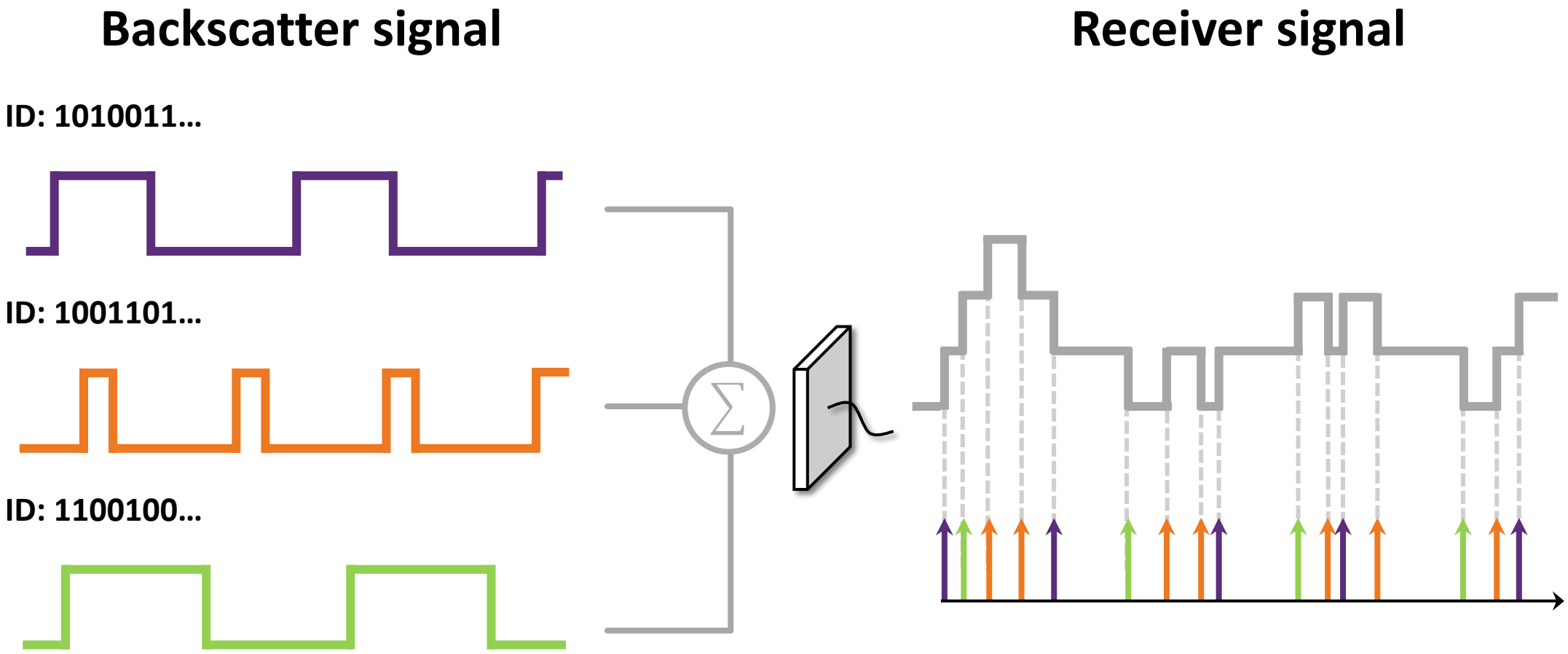


- The pattern of a square signal that characterize a tag can be controlled using ultra-low power **(sub-μW-level)** low cost analog circuits
- The high concurrency property allows **no-protocol design**, with no decoding, no MAC, no packet buffers, and no high-speed RF oscillators

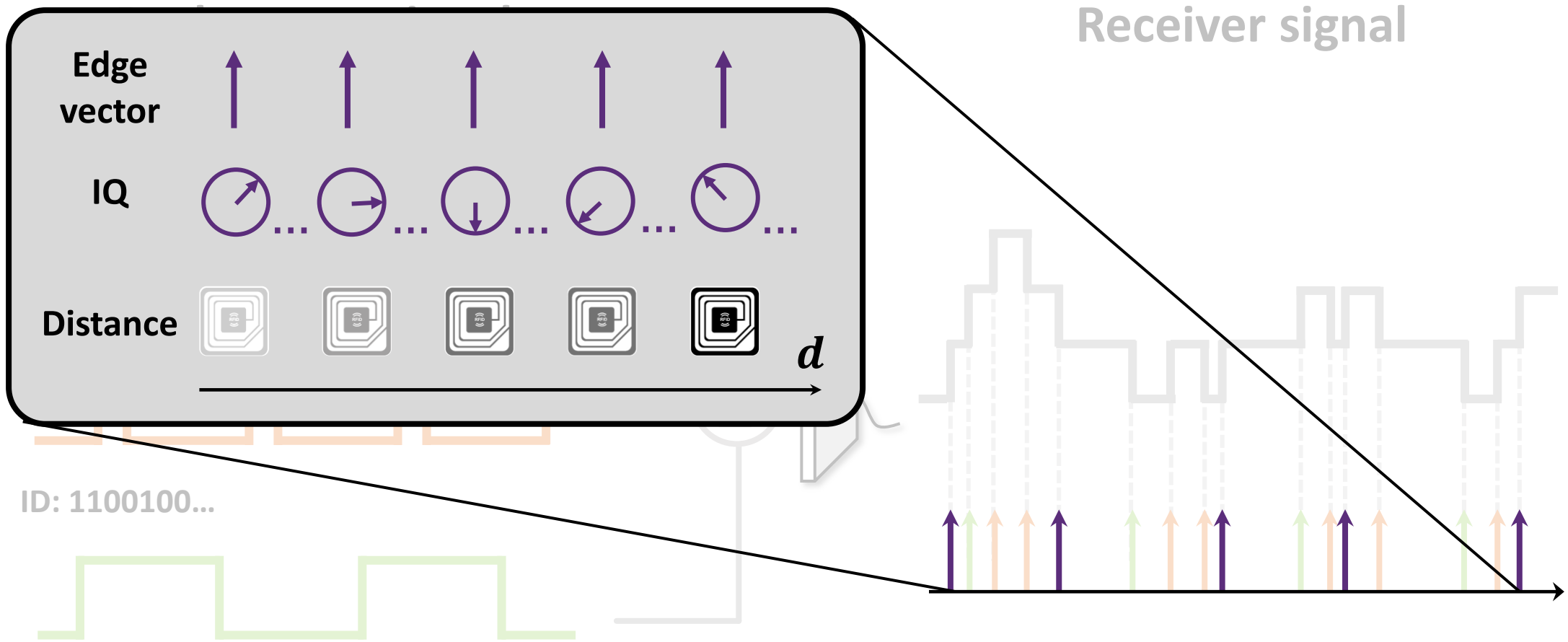
Identification and sensing



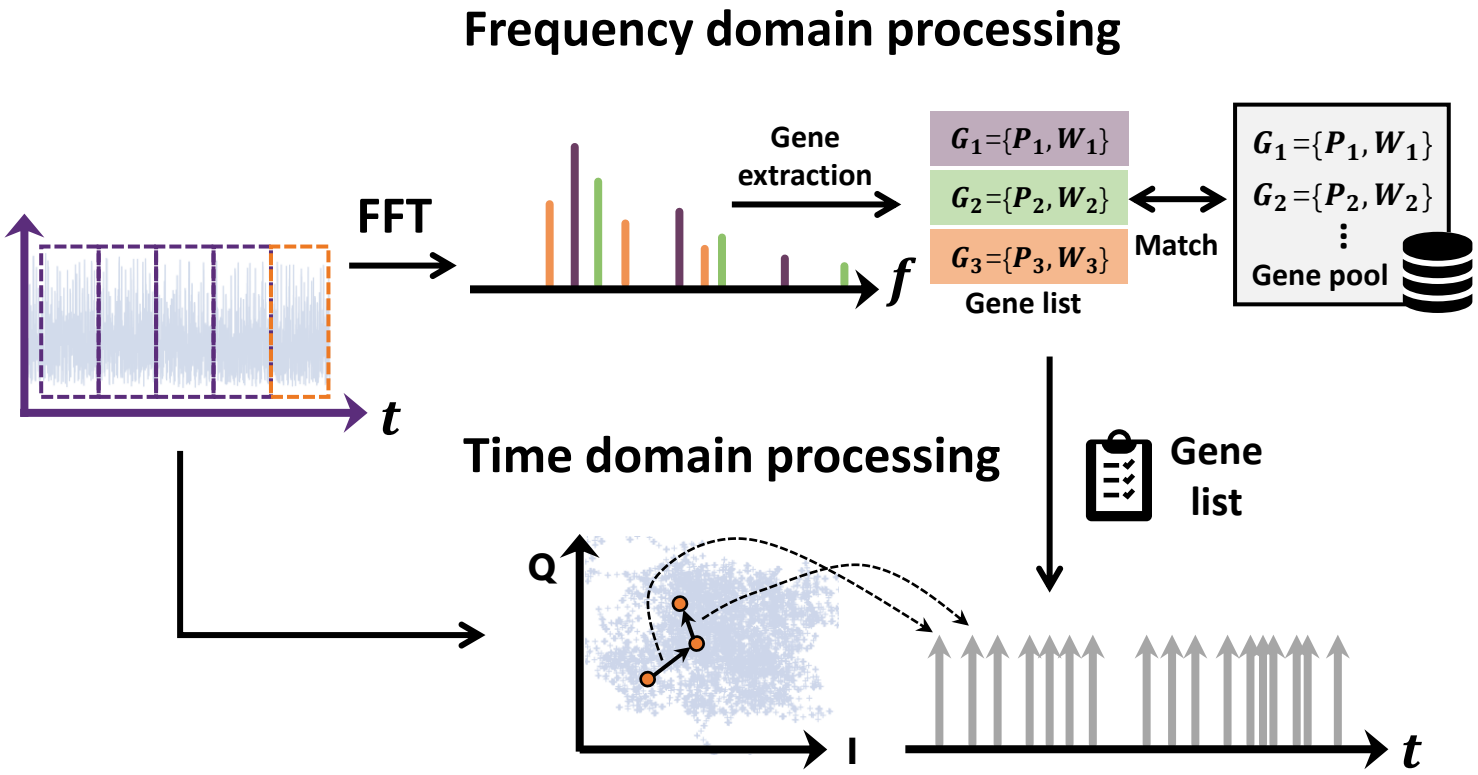
Identification and sensing



Identification and sensing



Multi-dimension analysis



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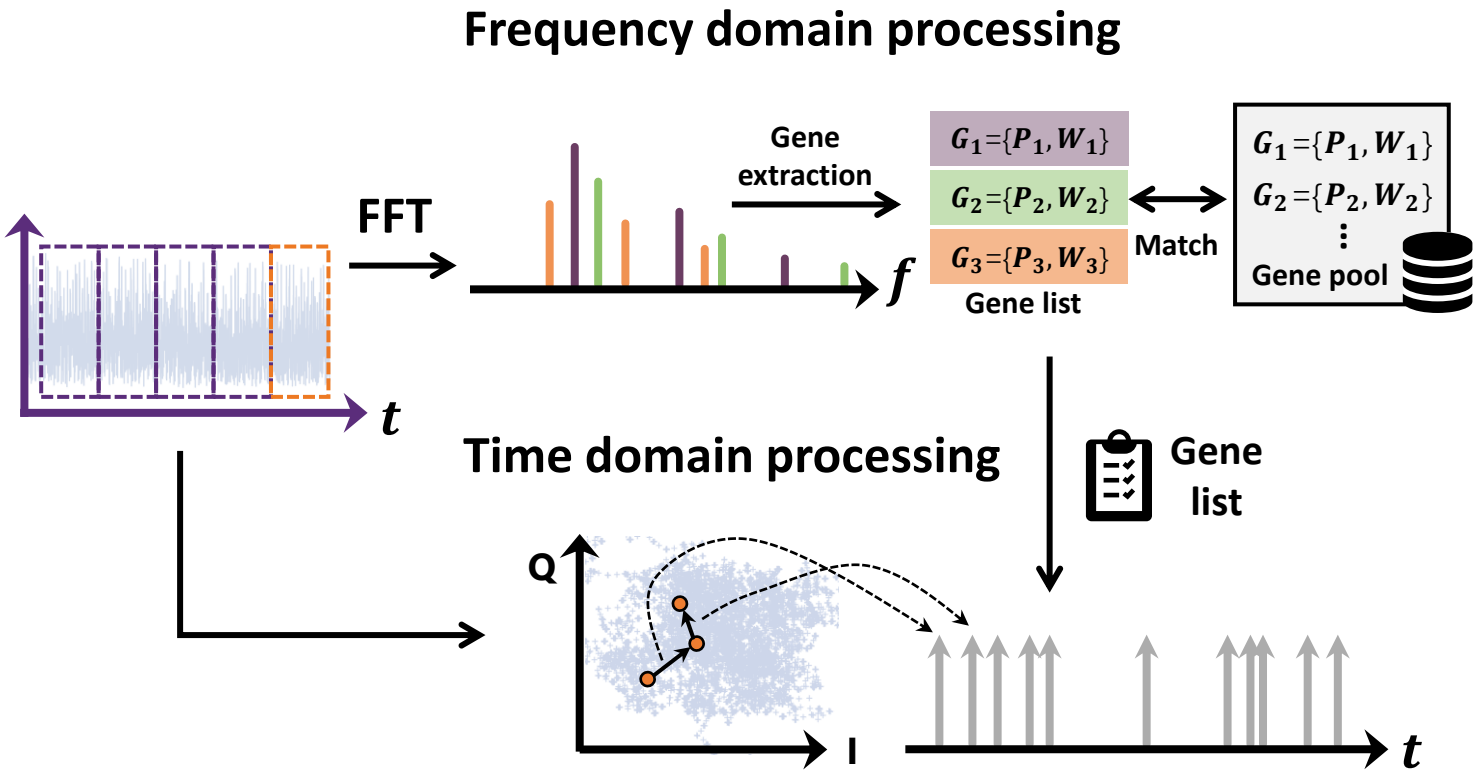

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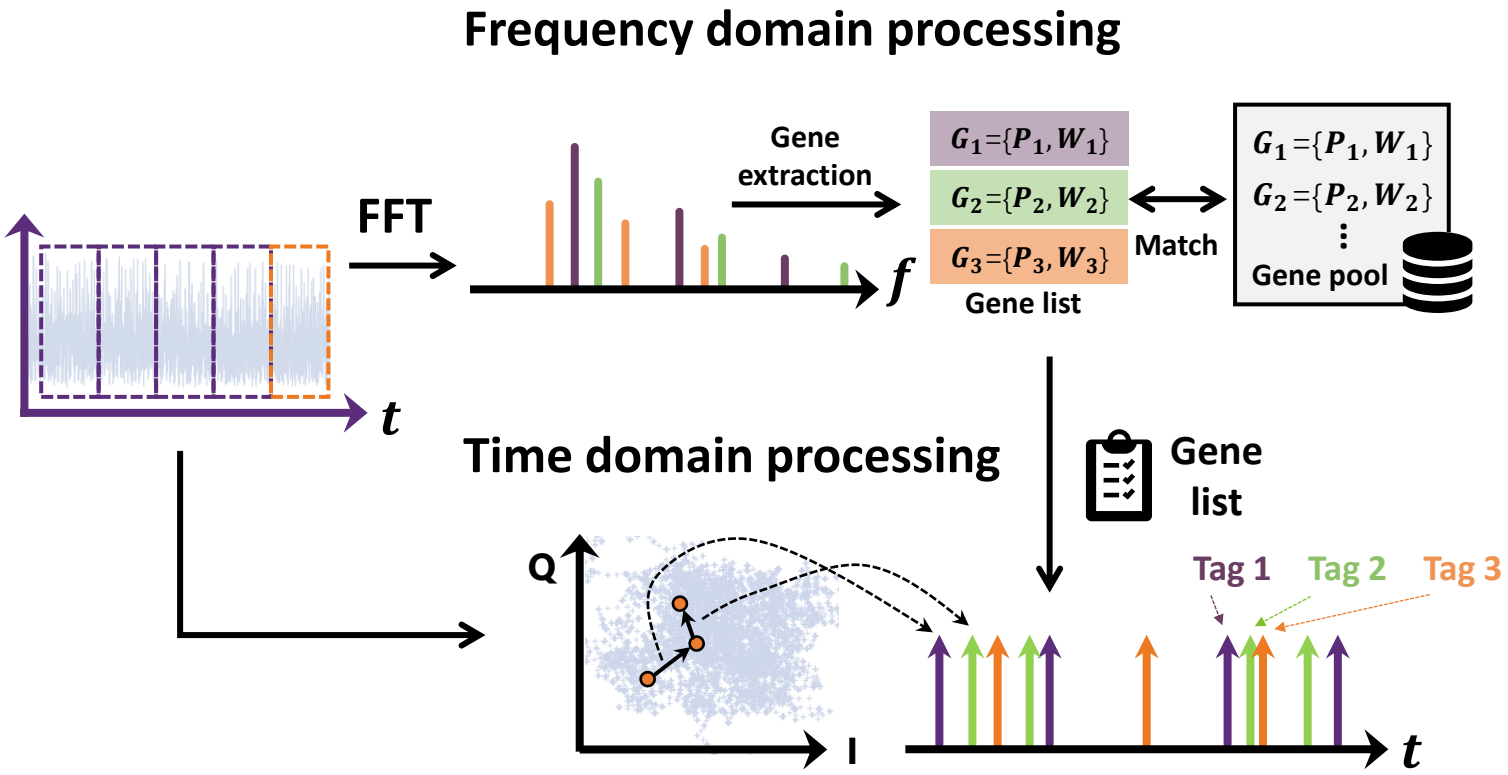

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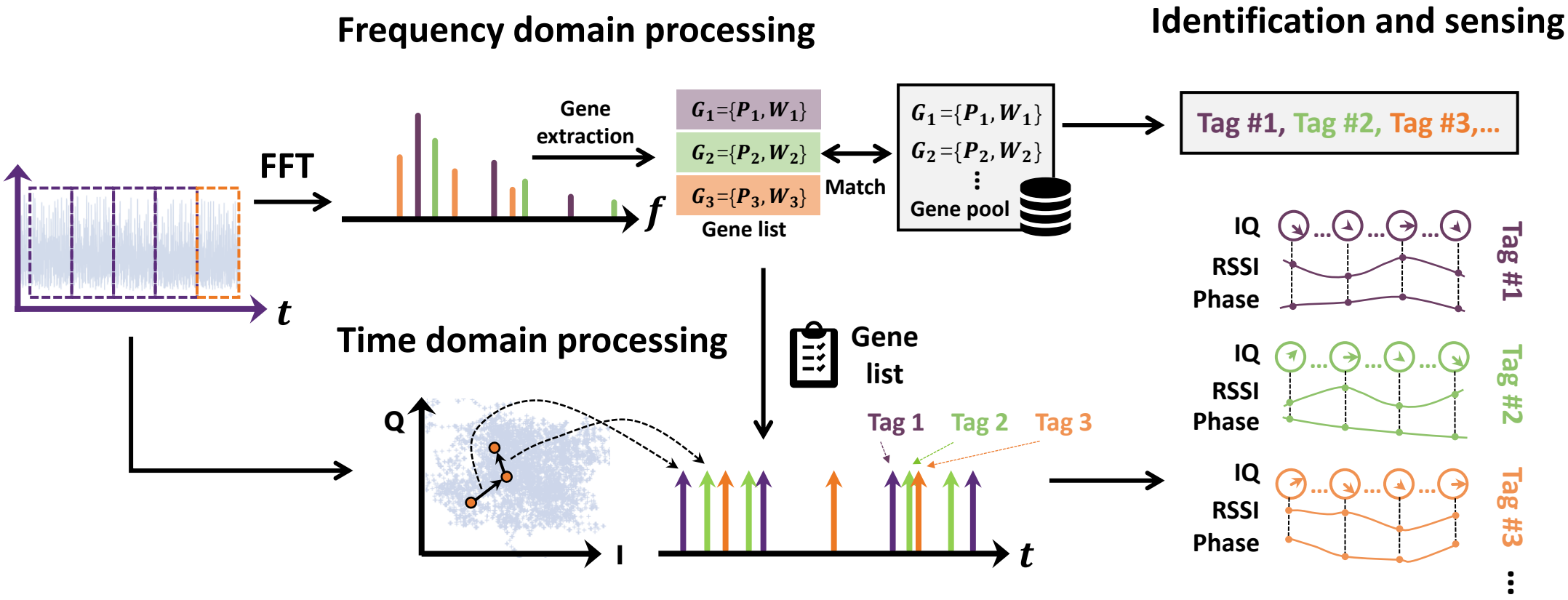


More details can be found in our paper

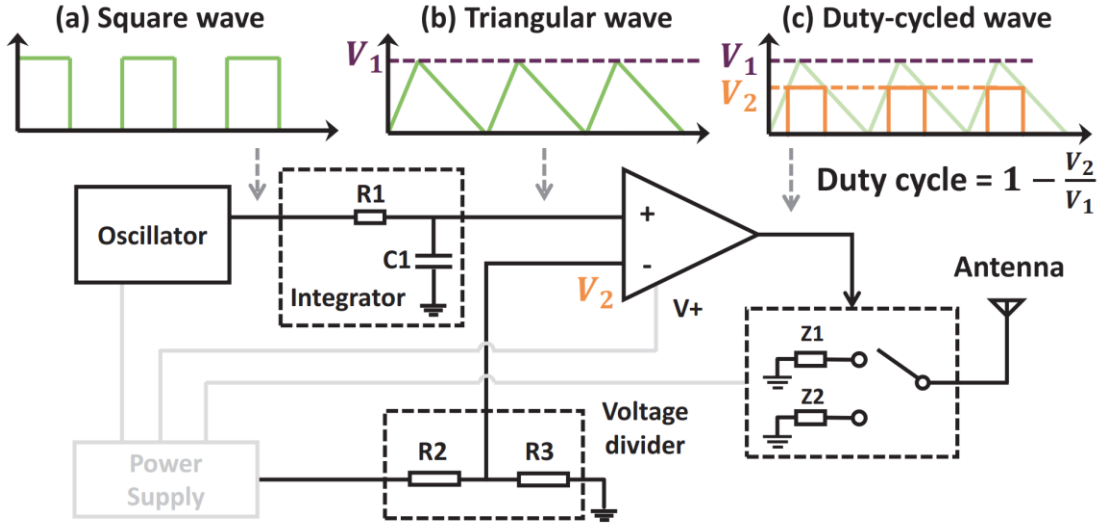
Evaluation

Implementation

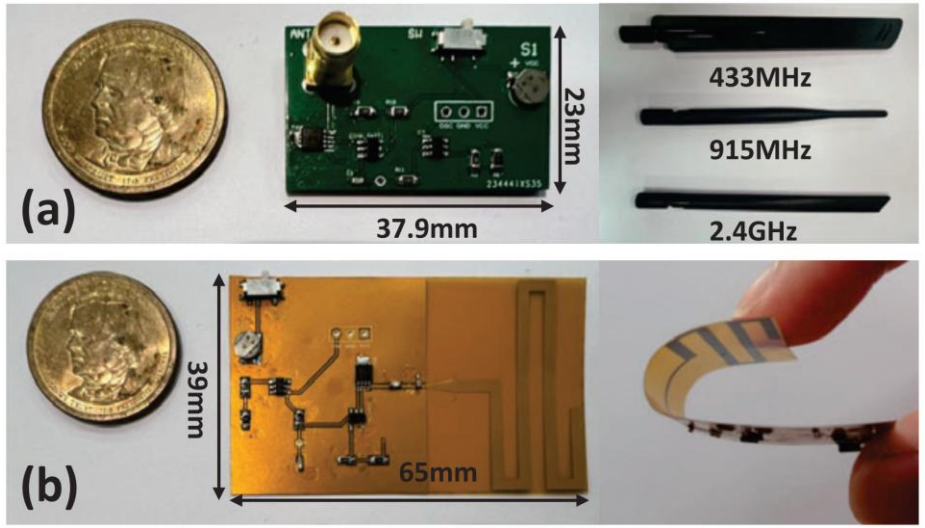
Reader: USRP N210 SDR with commercial antennas (433MHz/915MHz/2.4GHz)

Tag side: Including rigid tag and flexible tag.

Power Consumption: 38-107µW (PCB measured); 0.13-0.52µW (IC simulation)

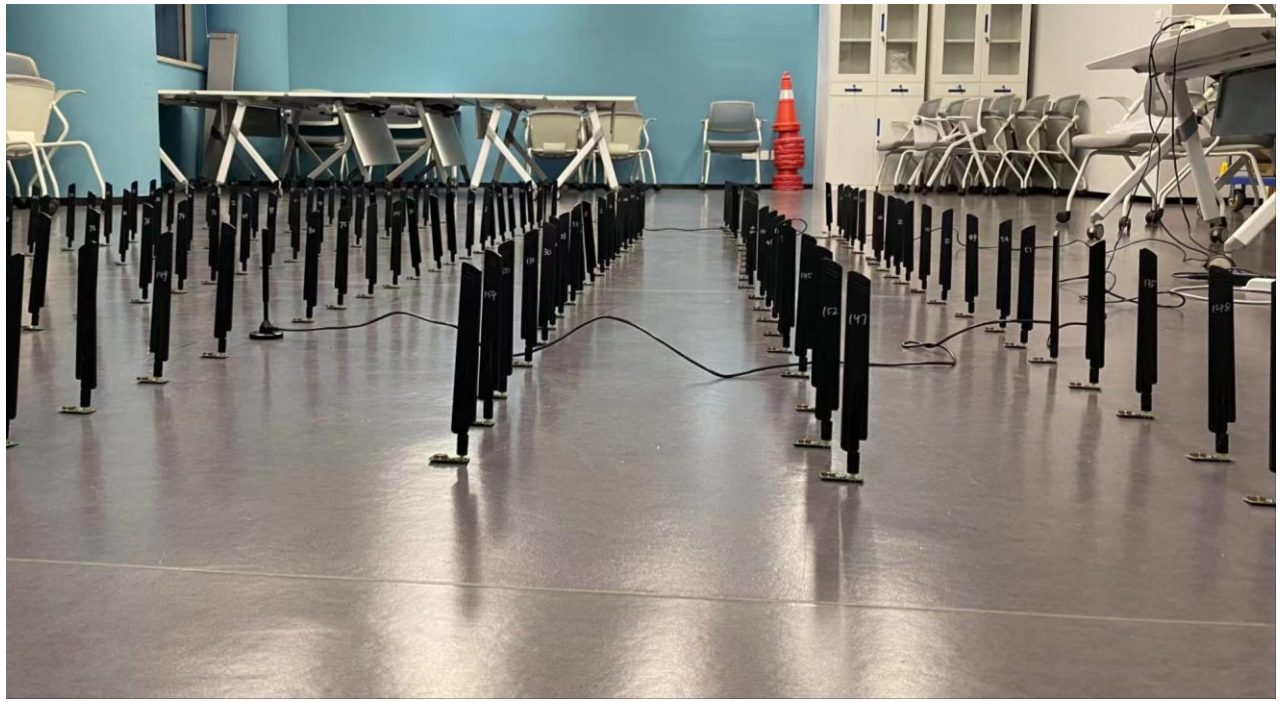


µTag hardware design



µTag PCB prototype

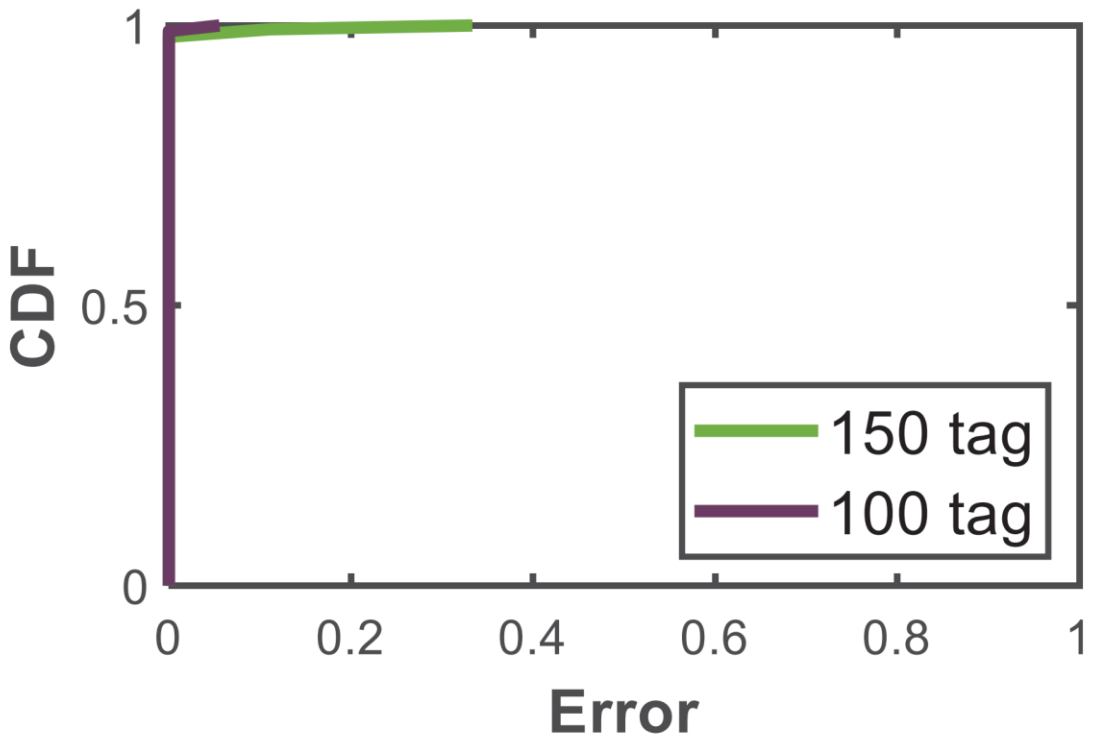
Experimental setup



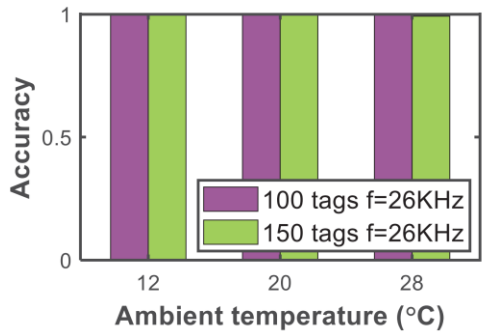
Open Space

Multipath Rich

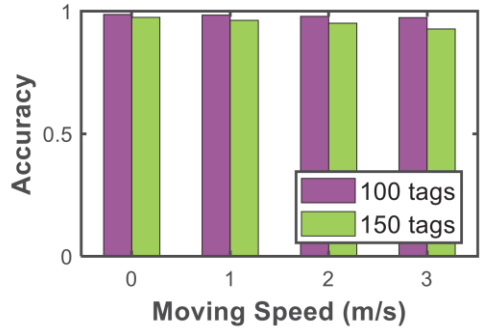
Identification accuracy



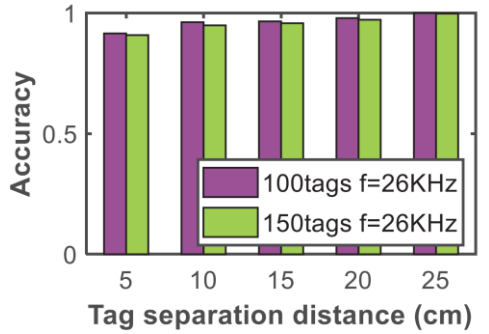
Achieving 99th percentile error of 0



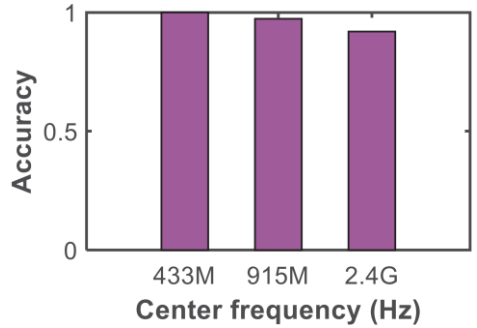
Temperature



Moving speed

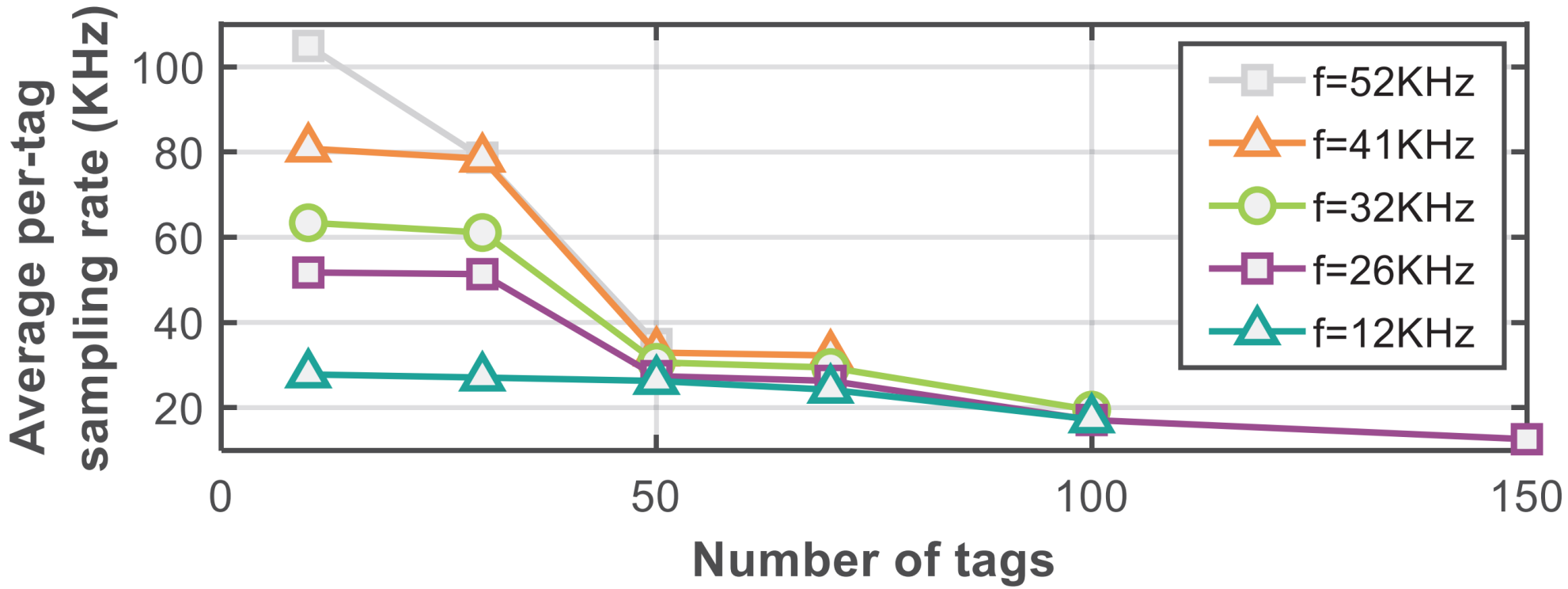


Tag spacing



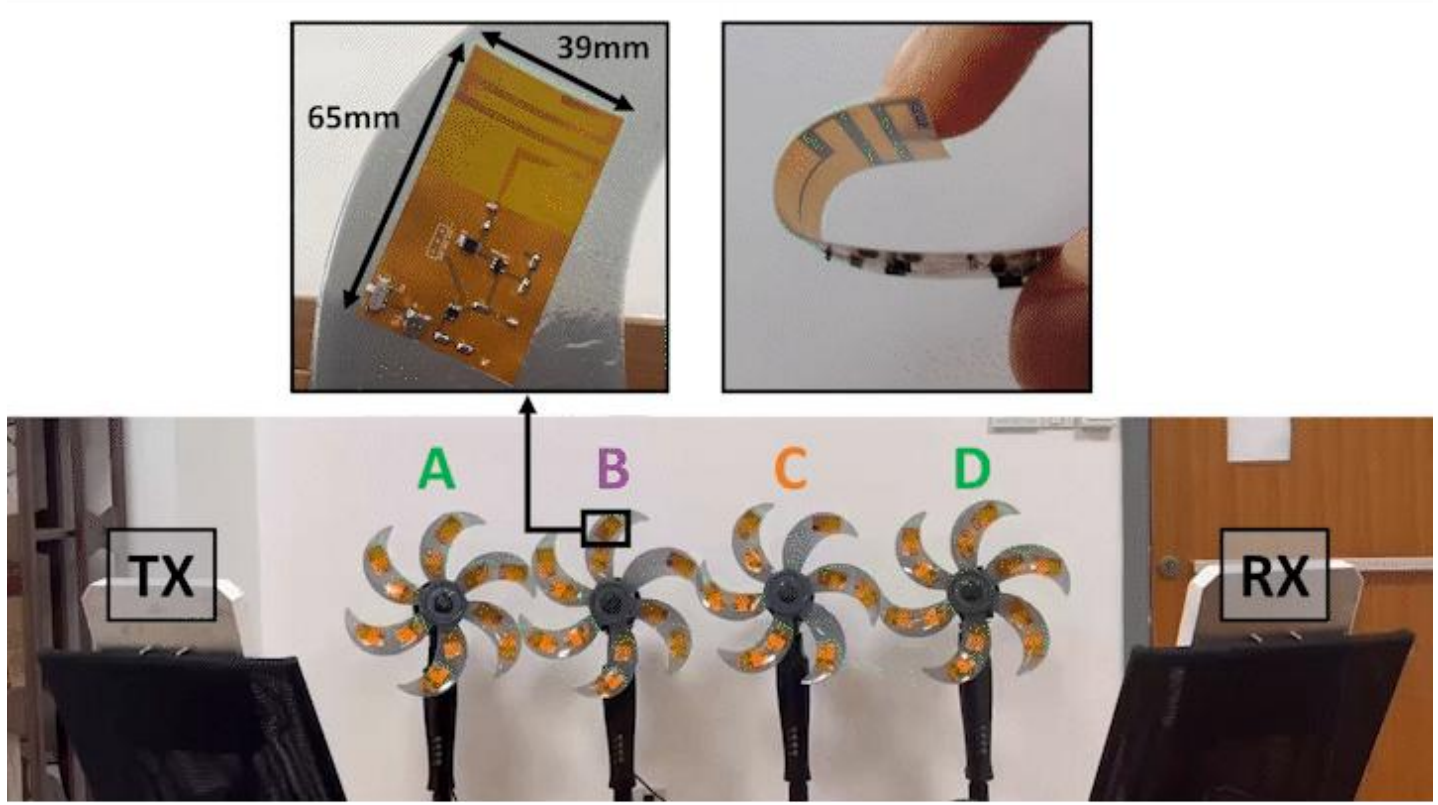
Center frequency

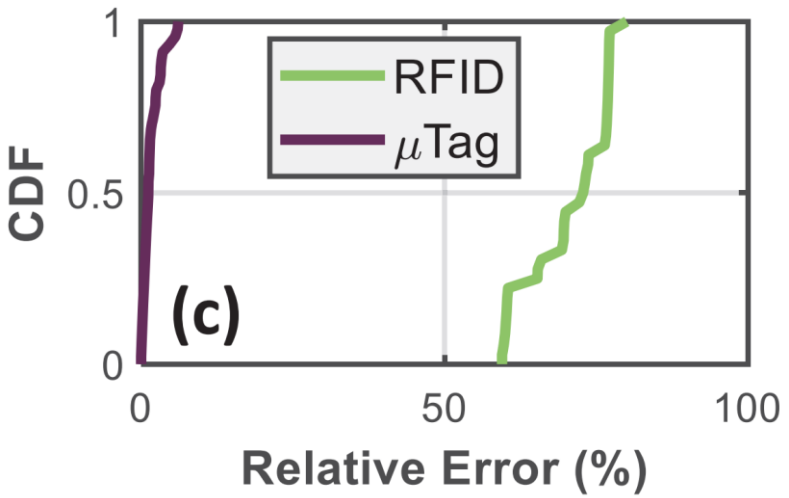
Large-scale and high-speed sampling



µTag can support concurrent tracking of *150 targets* with a *12kHz per-tag sampling rate*

Sensing performance





µTag can accurately sense large-scale moving targets

Conclusion

- A novel RF gene editing technique that enables KHz-level sampling of hundreds of tags in parallel.
- A full system μTag, which involves a set of well-rounded techniques, from hardware design, modulation method, to decoding algorithm
- We present a prototype of μTag, which shows that all of the above can be achieved on ultra-low-power devices.

Thanks
Q&A