

GLOBECOM 2022

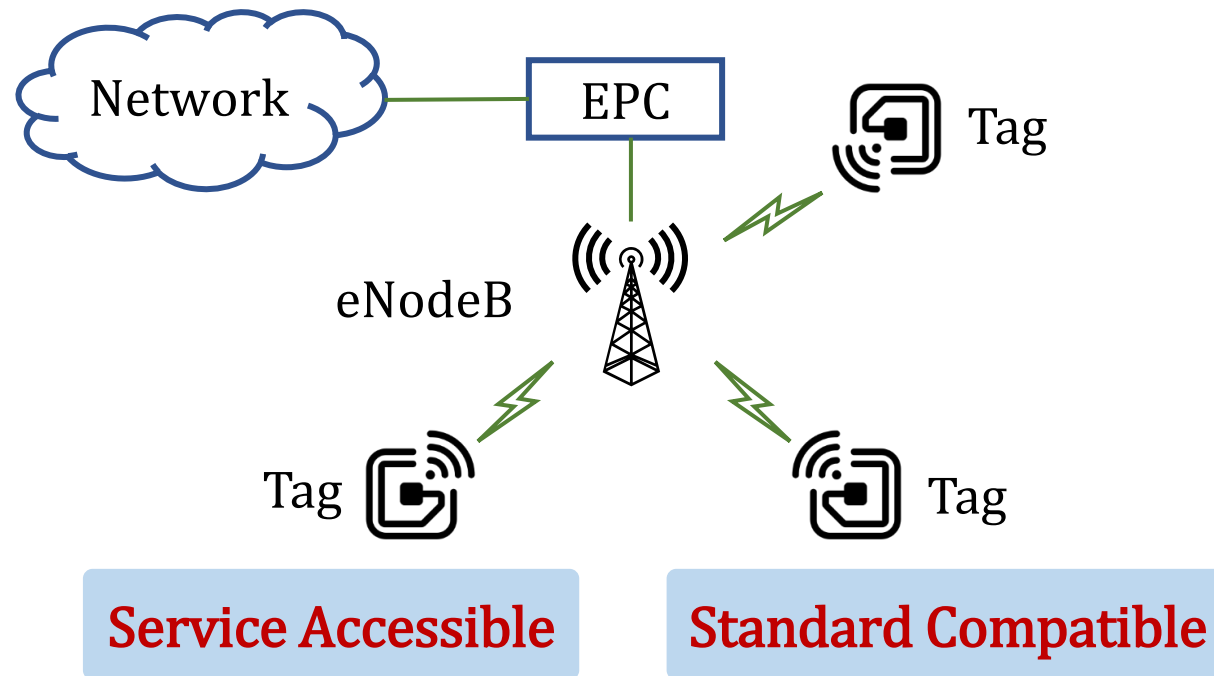
LTE-like Paging and Synchronization for Ambient Backscatter

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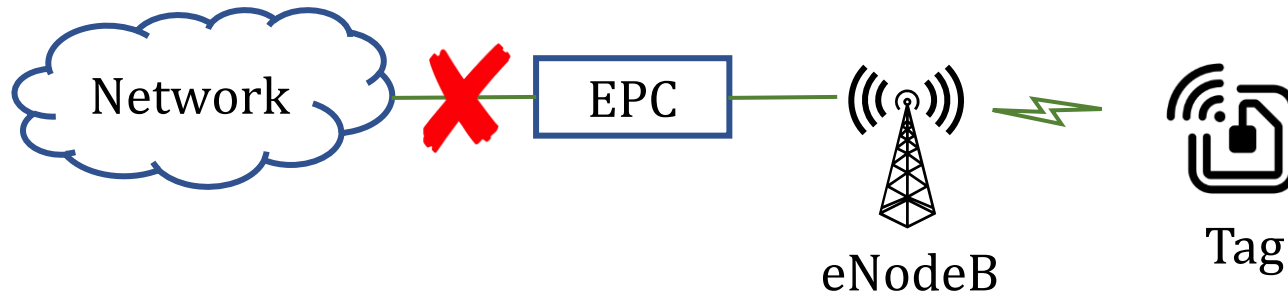
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LTE-like Backscatter

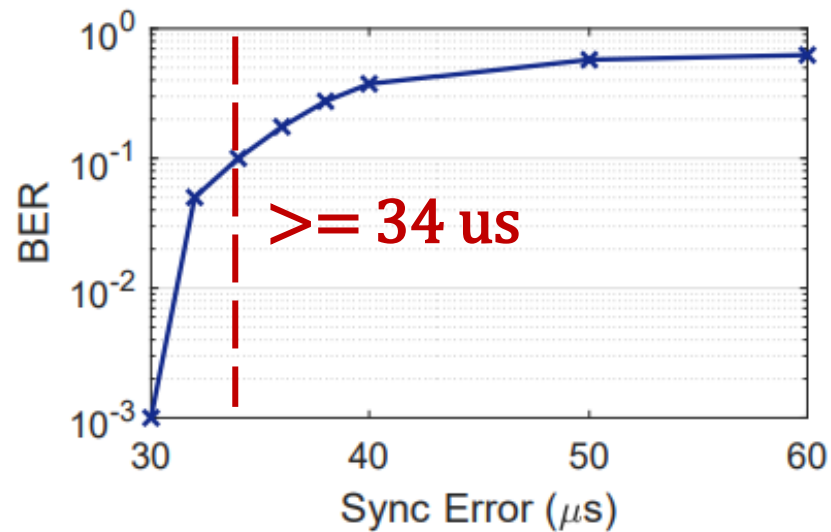


Problem 1: Lack of paging



Problem 2: Inaccurate synchronization

- Necessity of synchronization



The effect of synchronization error on LTE backscatter modulation

- LScatter's synchronization

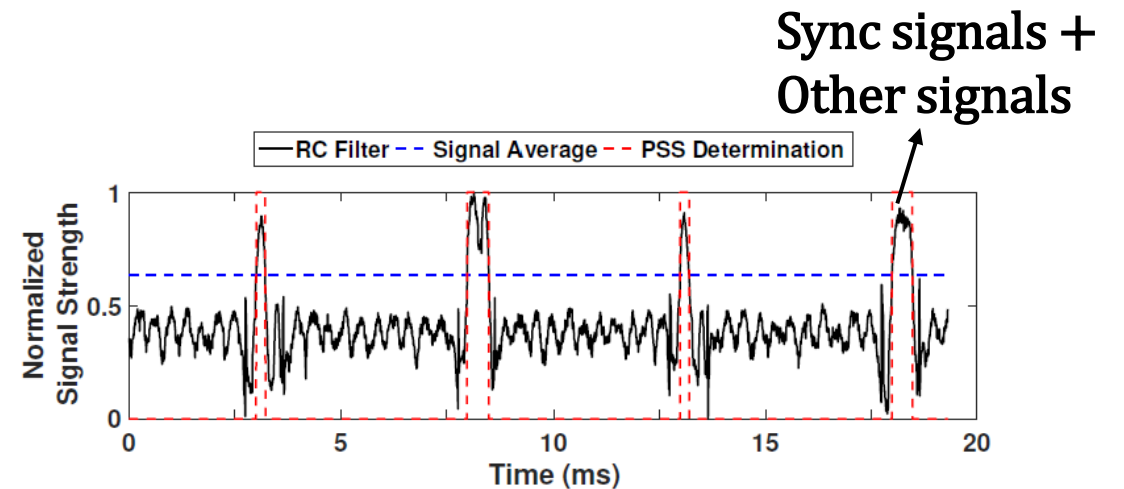


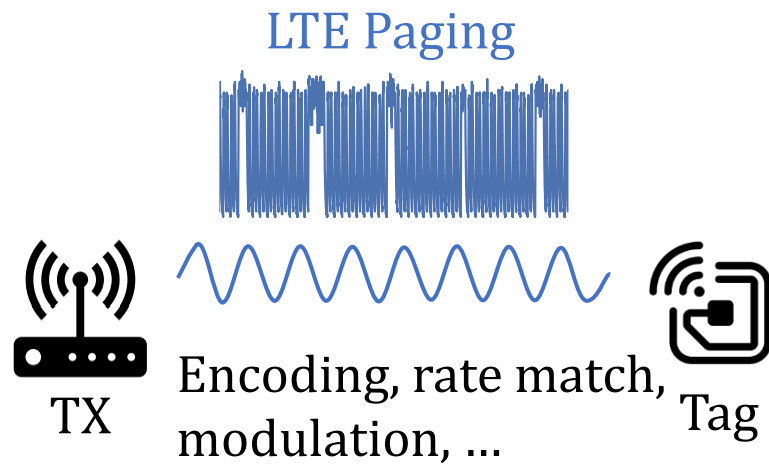
Figure 8: Outputs of Each Stage for the Sync Circuit

PSS misjudgment

Challenges

- How to page tags in an ultra-low-power way?
- How to accurately synchronize LTE downlink signals?

Standard paging

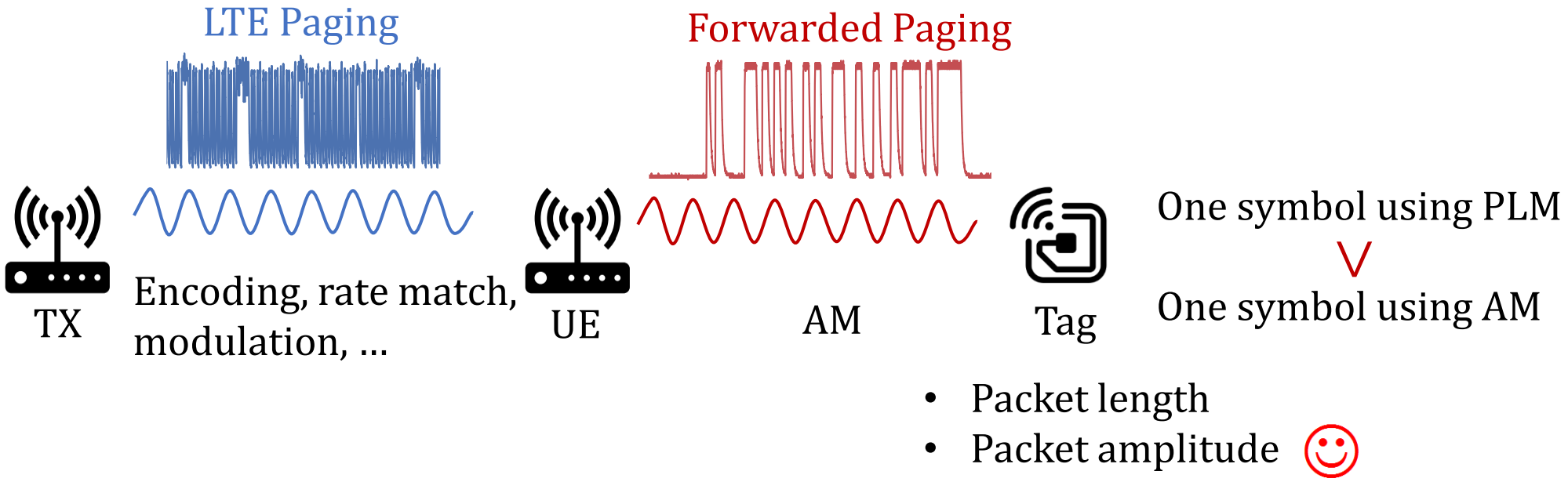


- No power-hungry components
- limited resources

Demodulation, rate recovery, decoding, ...

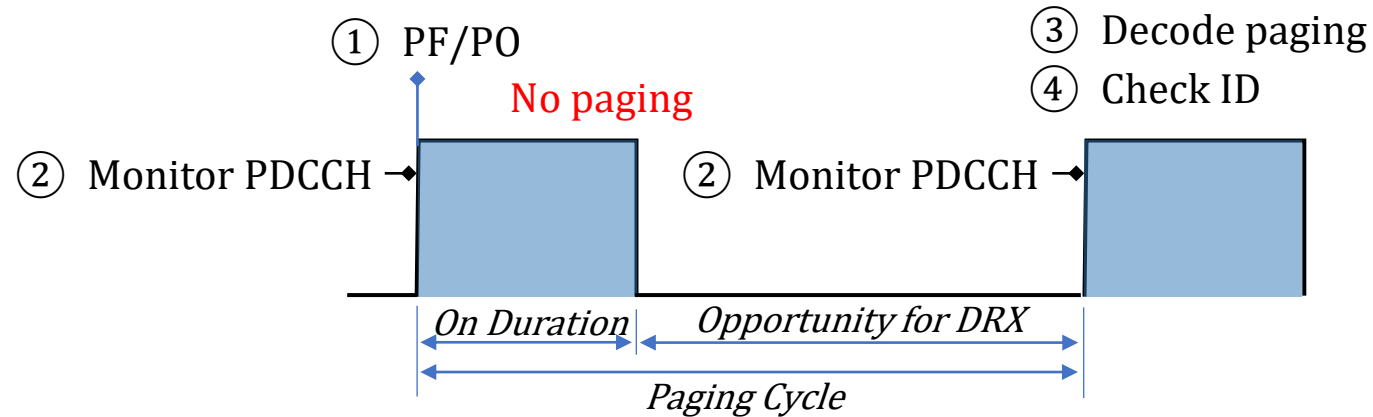
Energy-constrained tags cannot afford standard paging reception.

Paging forwarding



LTElike uses the UE to forward the paging message from the base station in the form of AM.

Paging reception



1. How to determine PF and PO? \Rightarrow Start of the identified paging packet



2. How to get paging message? \Rightarrow Decode AM signal

Challenges

- How to page tags in an ultra-low-power way?

- How to accurately synchronize LTE downlink signals?

Standard synchronization (cross-correlation)

Resource consumption

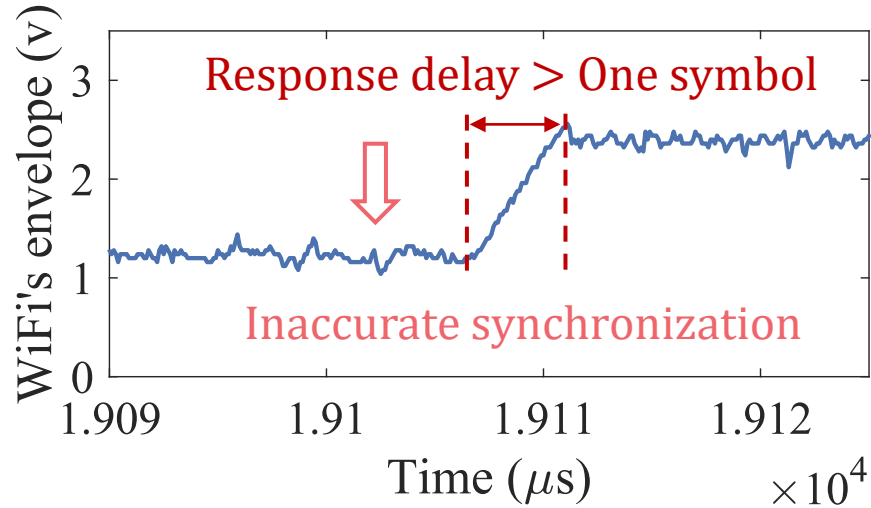
- The template size is 1010.
- a 10*10 multiplier consumes 116 Look-Up-Tables (LUTs).
- a 10*10 adder consumes 10 LUTs.

	Multipliers	Adders	LUTs
Total	1010	1009	127250

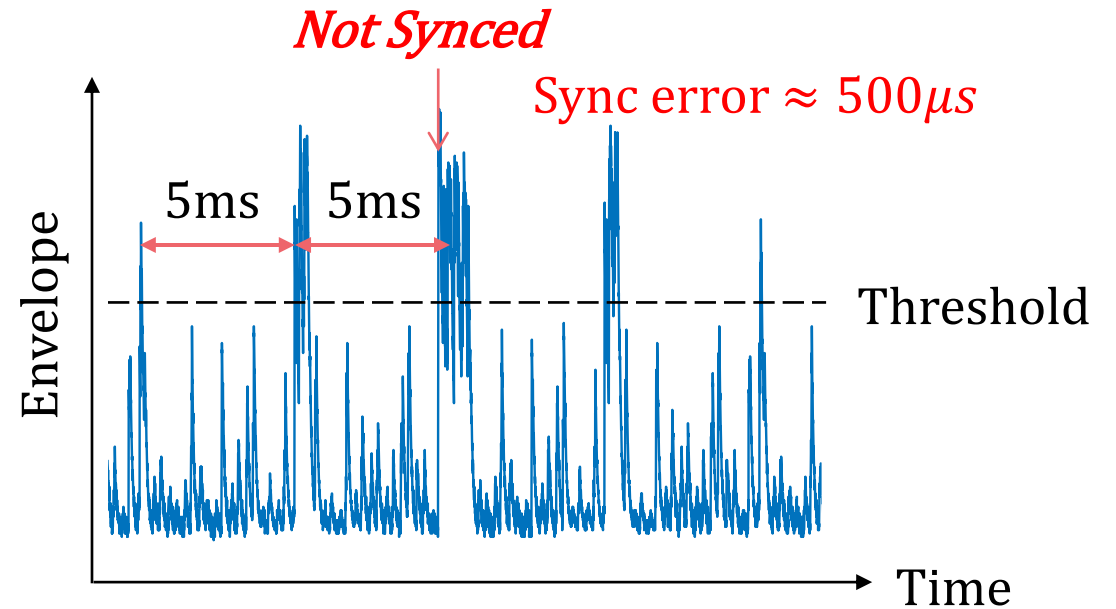
>> 17600 LUTs
(storage capacity)

Our tag with limited storage resources can't handle the correlation operation based on multiplication.

Rising edge detection



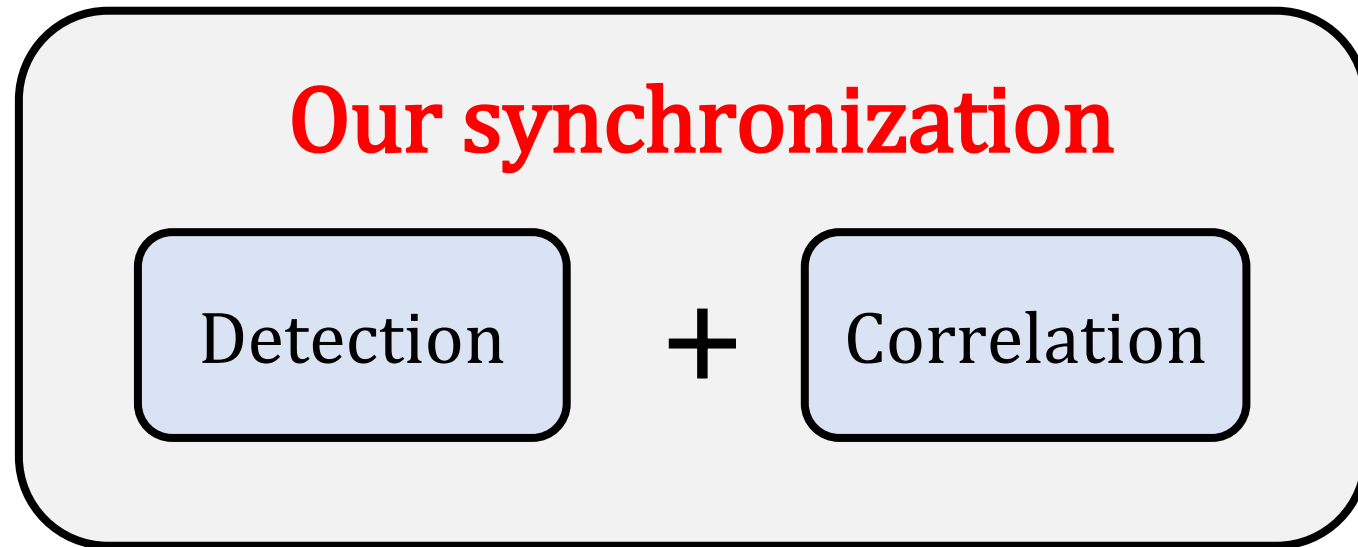
Response delay



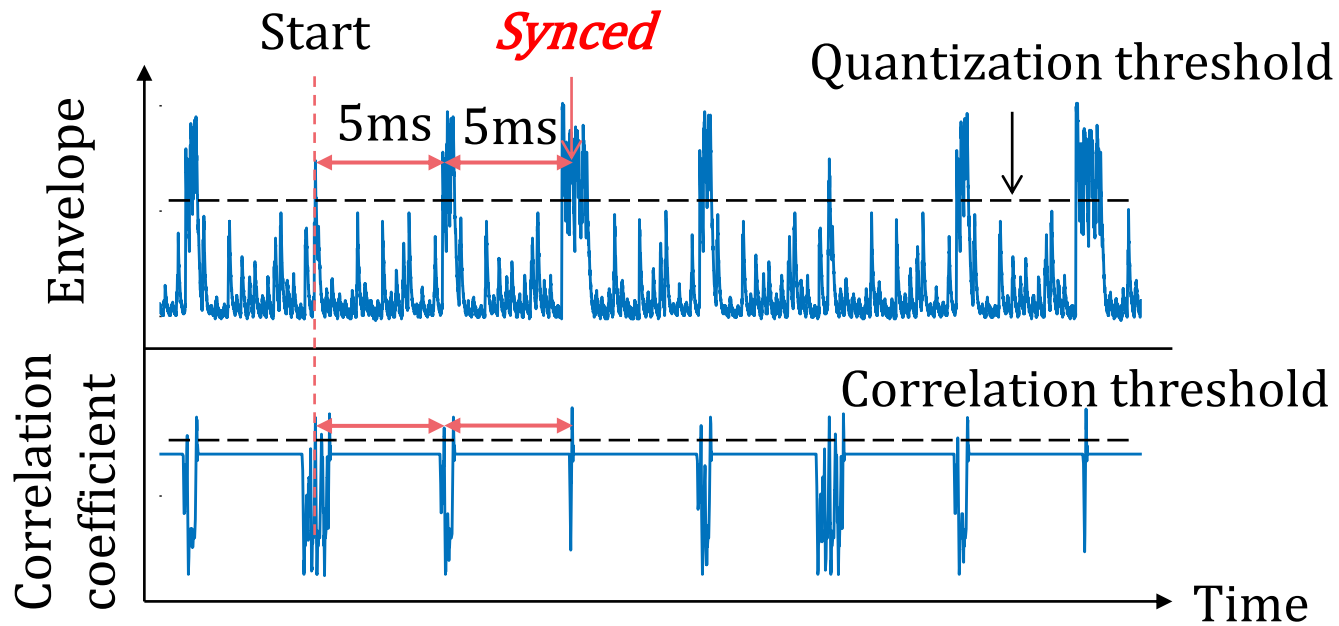
LScatter's synchronization

LScatter has poor synchronization performance due to response delay and inability to distinguish between sync and other signals.

Our synchronization

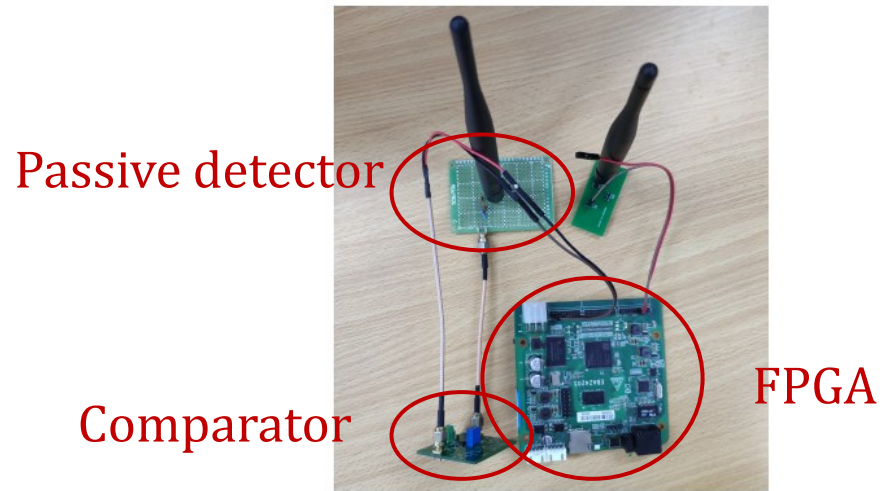


Our synchronization

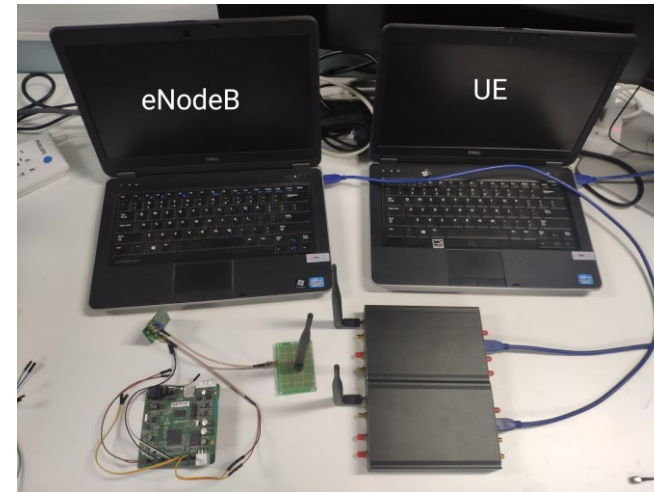


LTElike's synchronization improves the synchronization accuracy based on the periodicity of the LTE signal.

Implementation



Our tag prototype

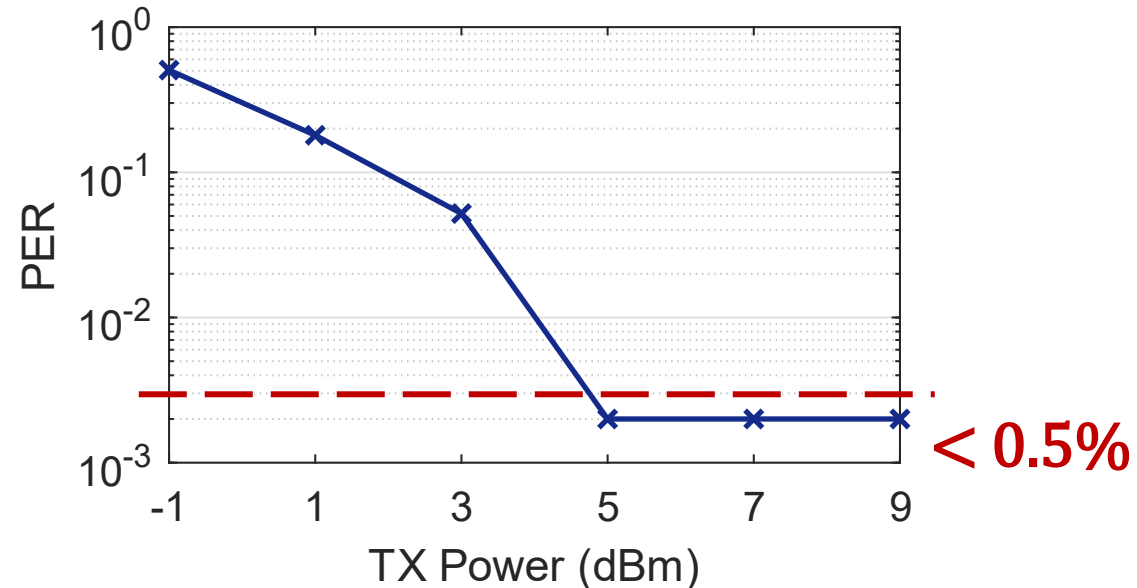
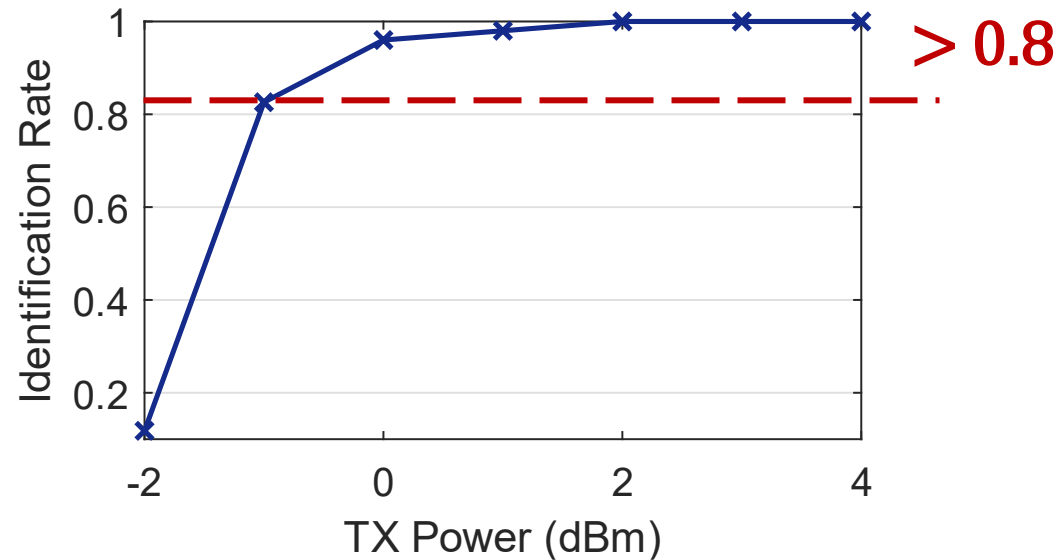


Experiment deployment

Evaluation

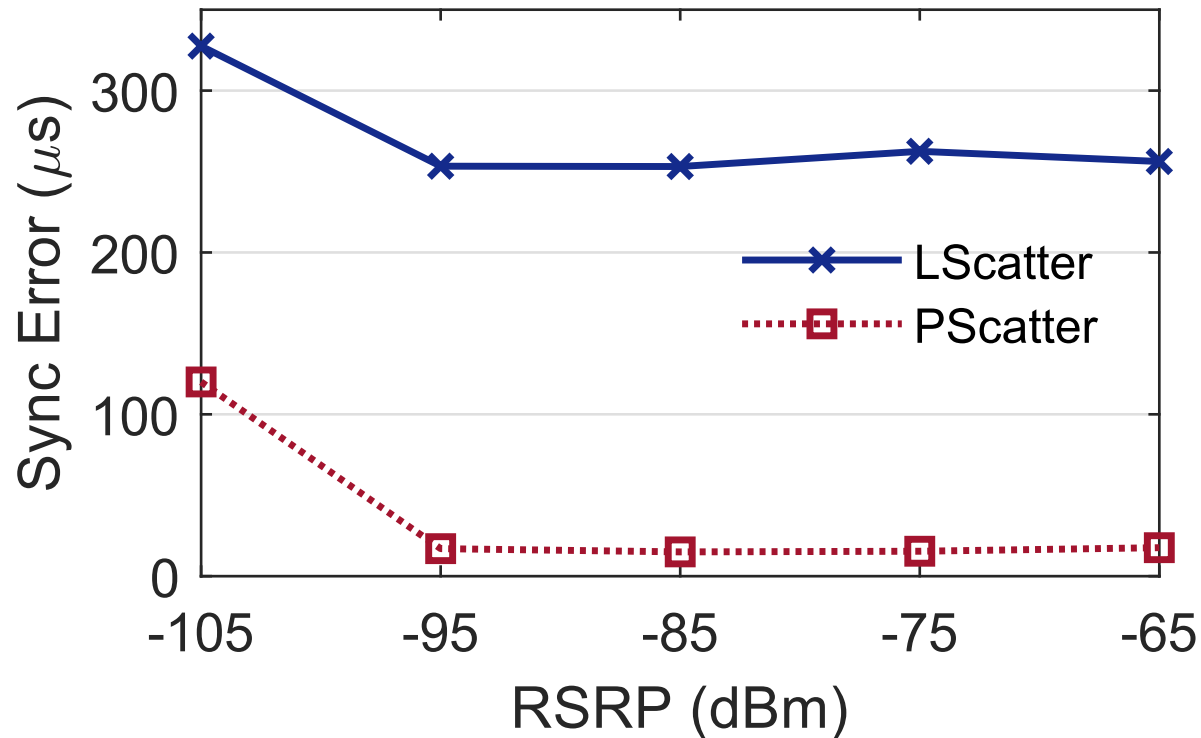
- Paging Reception
- Signal Synchronization
- Wakeup Reception

Impact of TX power



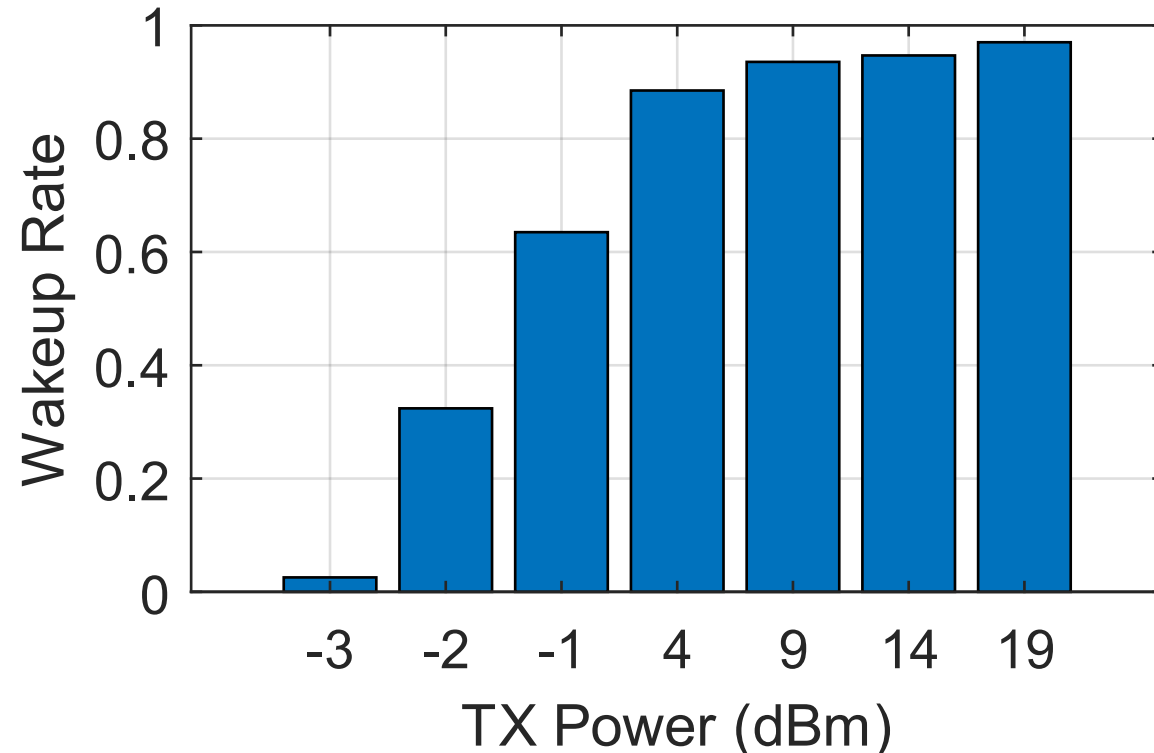
The maximum paging identification rate is 100% and the PER is 0.2% when the transmit power reaches 5 dBm.

Synchronization accuracy



The mean synchronization error of LTElike is 17x better than that of LScatter.

Wakeup rate



Wakeup rate increases with transmit power and the maximum wake-up rate is 0.97.

Conclusion

- We propose a novel LTE backscatter design.
 - page tags in an ultra-low-power way
 - high-accuracy synchronization
- LTElike provides opportunities for backscatter sensors to access LTE services and wireless connectivity.

Thanks!