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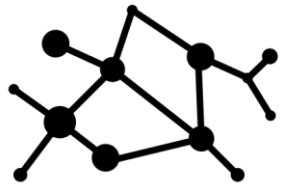
Electrical and Computer Engineering



WCSNG
Wireless Communications
Sensing and Networking

SyncScatter: Enabling Wi-Fi like Synchronization and range for Wi-Fi backscatter communication

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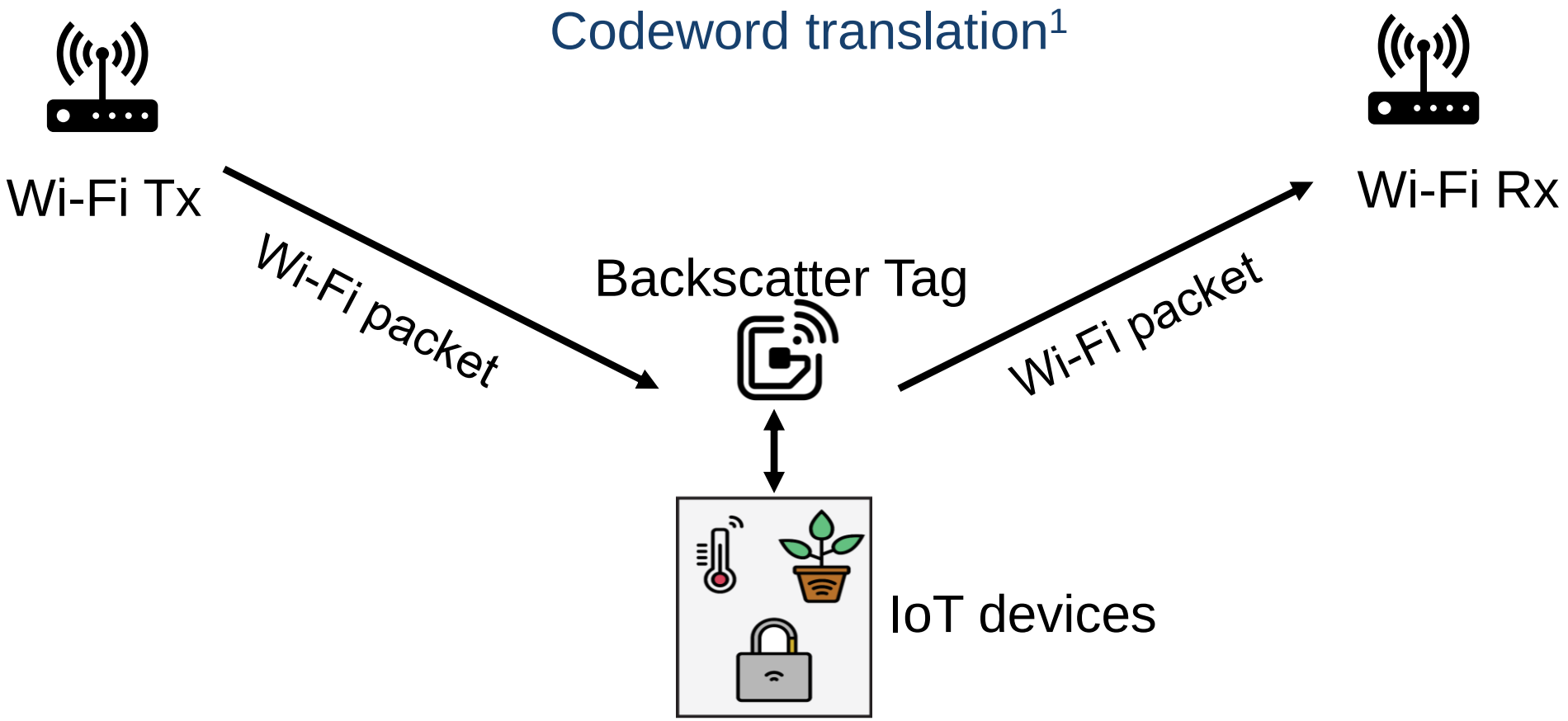
NSDI 2021

Miniature and Ubiquitous IoT devices

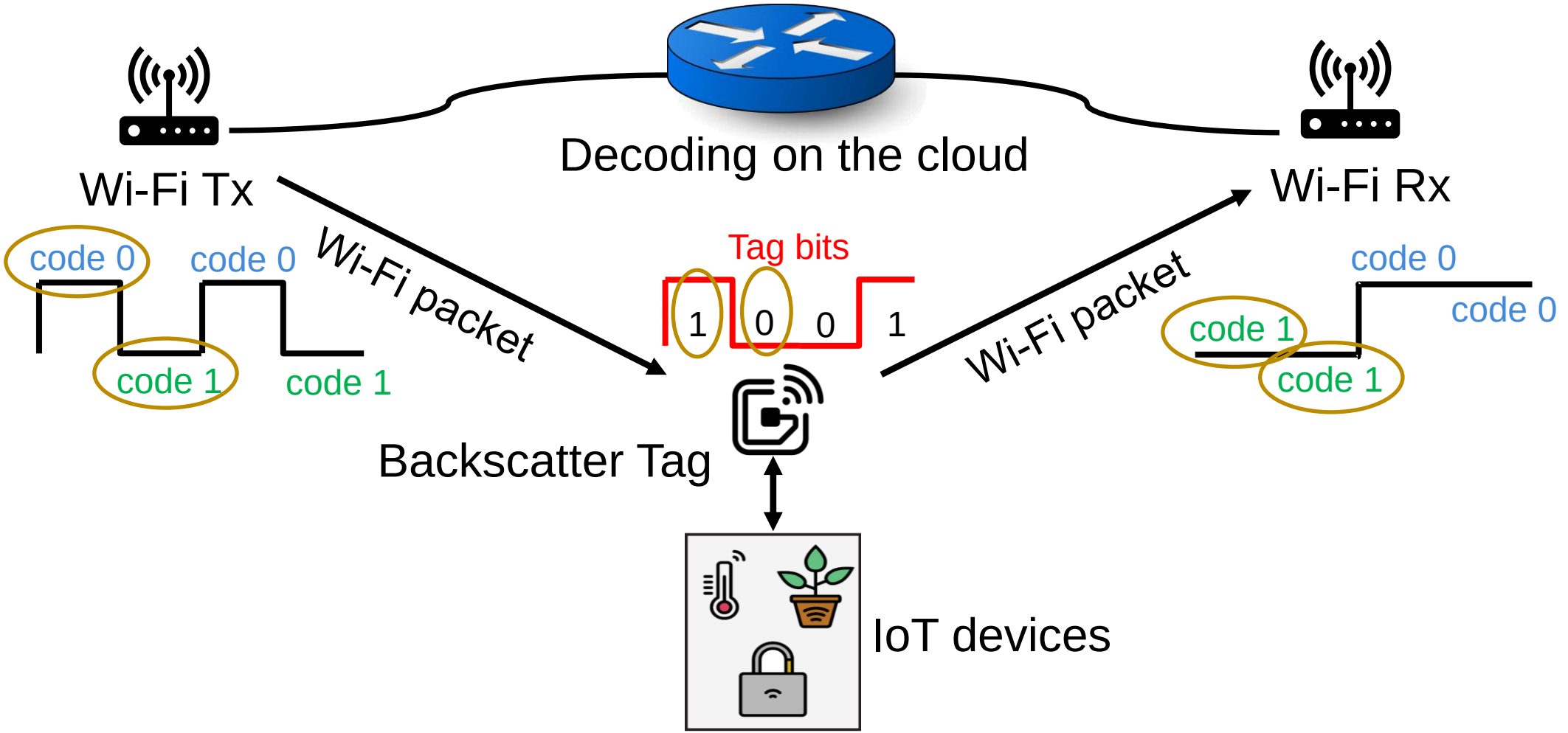
- Requires long battery life
- Wireless connectivity to existing infrastructure like Wi-Fi

Low power Wi-Fi connectivity

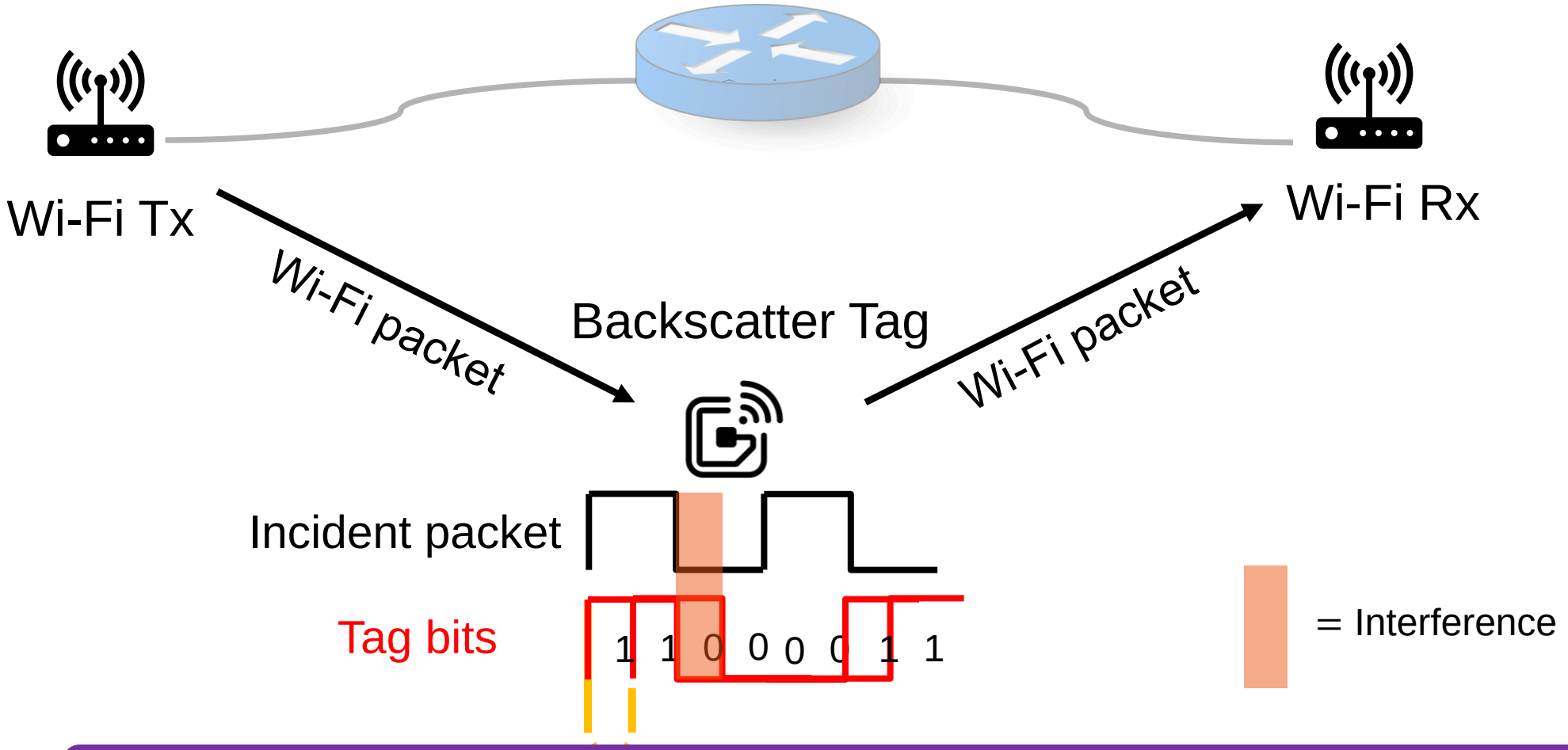


1) HitchHike: Practical Backscatter Using Commodity Wi-Fi (Sensys 2016)

Code-Word Translation



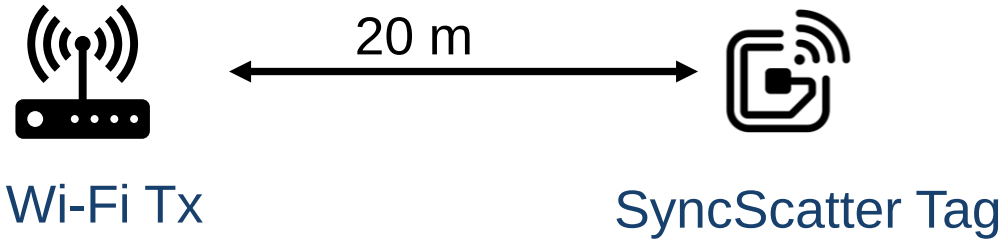
Code-word translation: Closer look



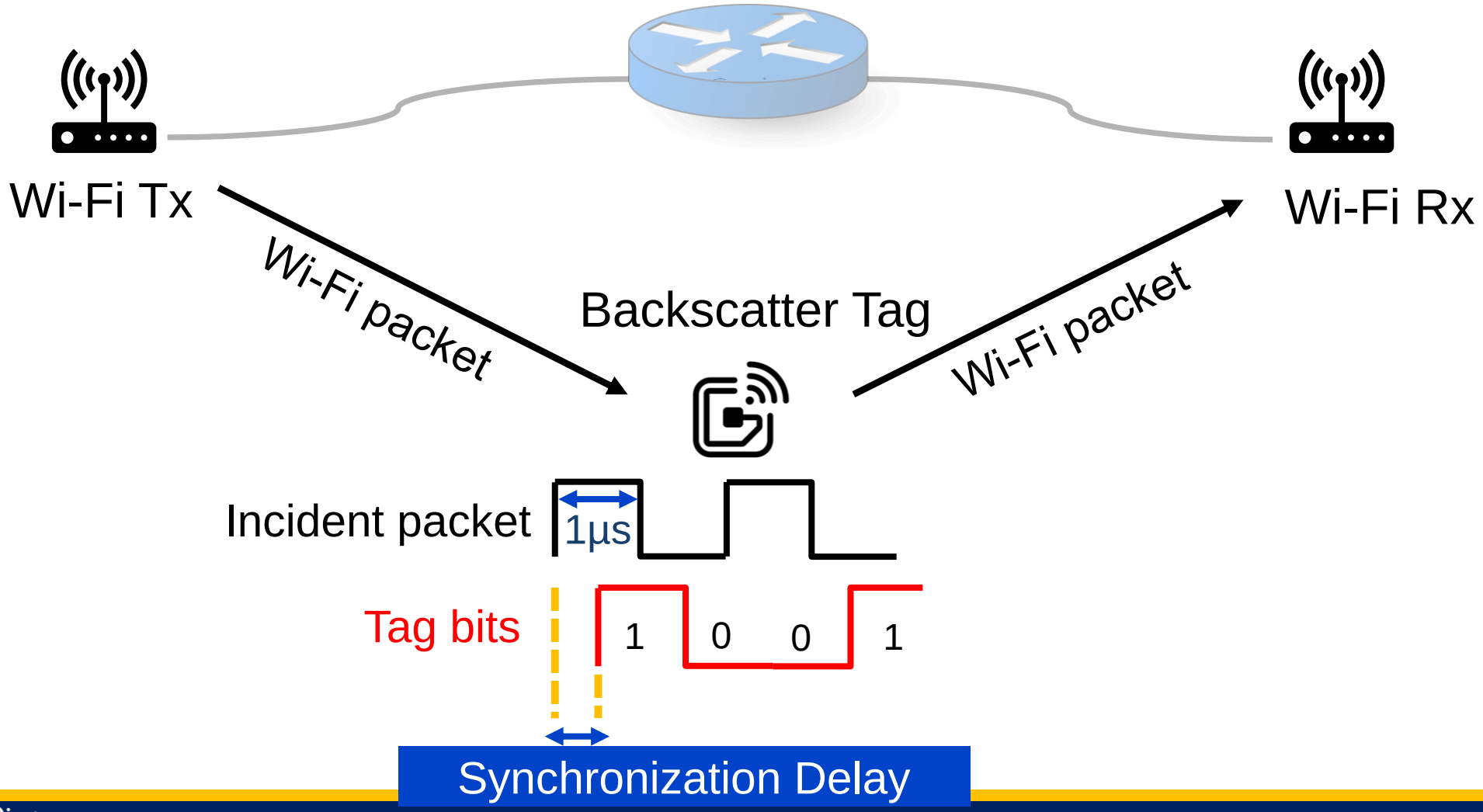
Can we synchronize to the incident Wi-Fi packets?

SyncScatter: Contributions

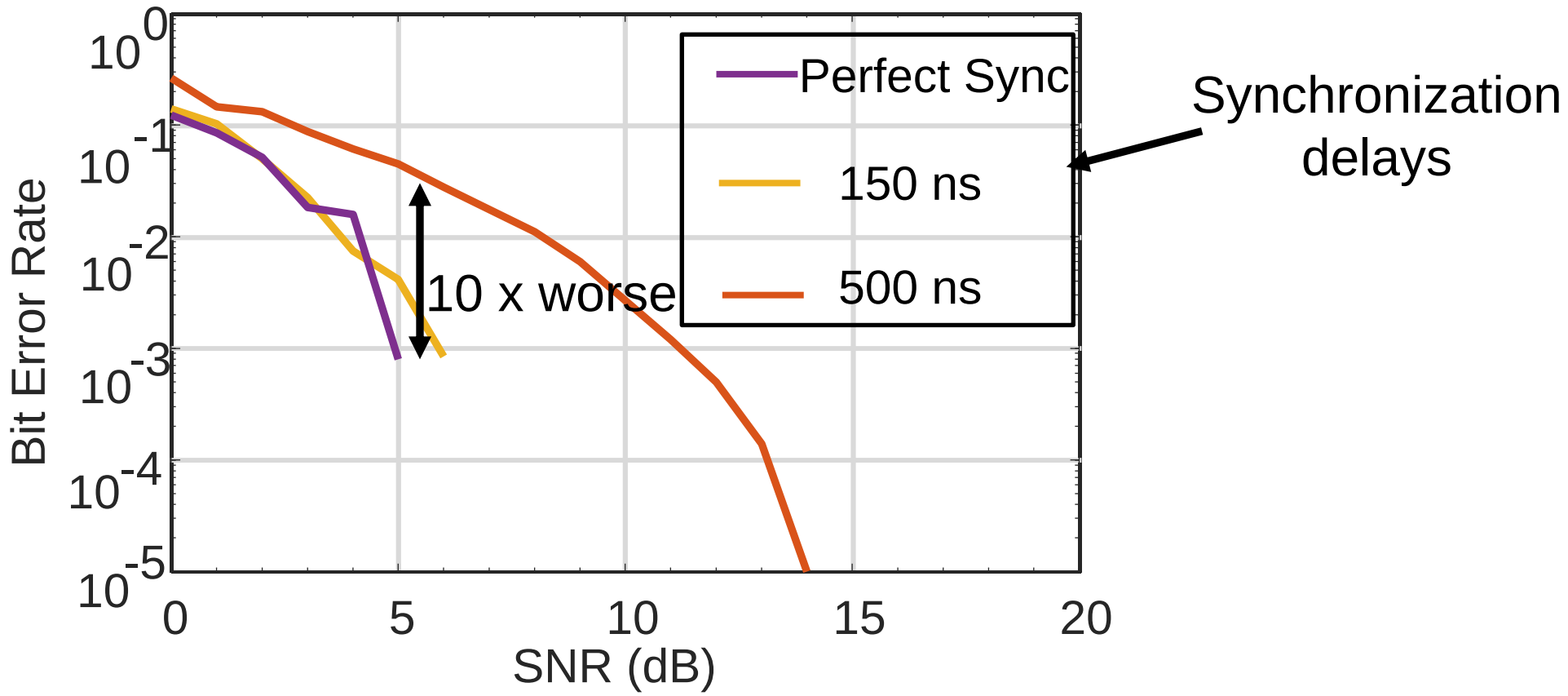
- Stringent synchronization requirements
- Hierarchical wake-up architecture
- 7.6 μW low power Integrated circuit for Synchronized backscatter
- 100x lower Bit error rate
- 4x Range improvement



Synchronization Requirements

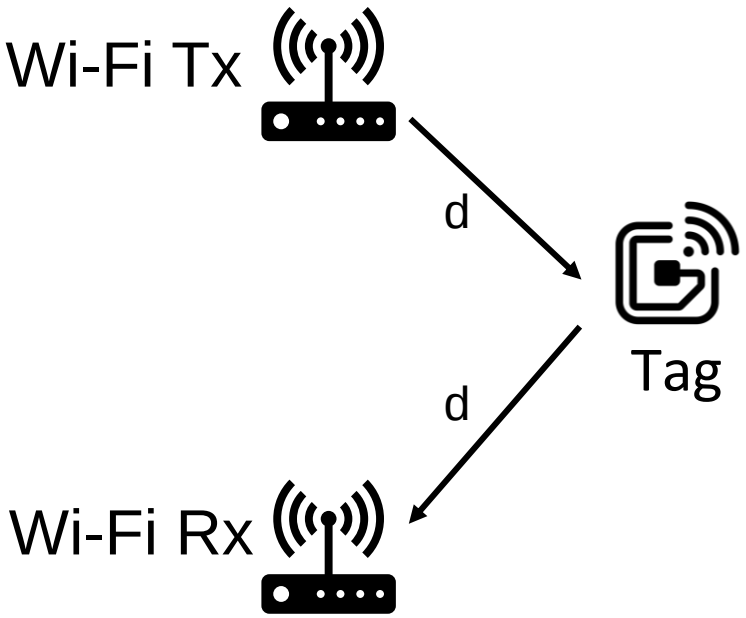


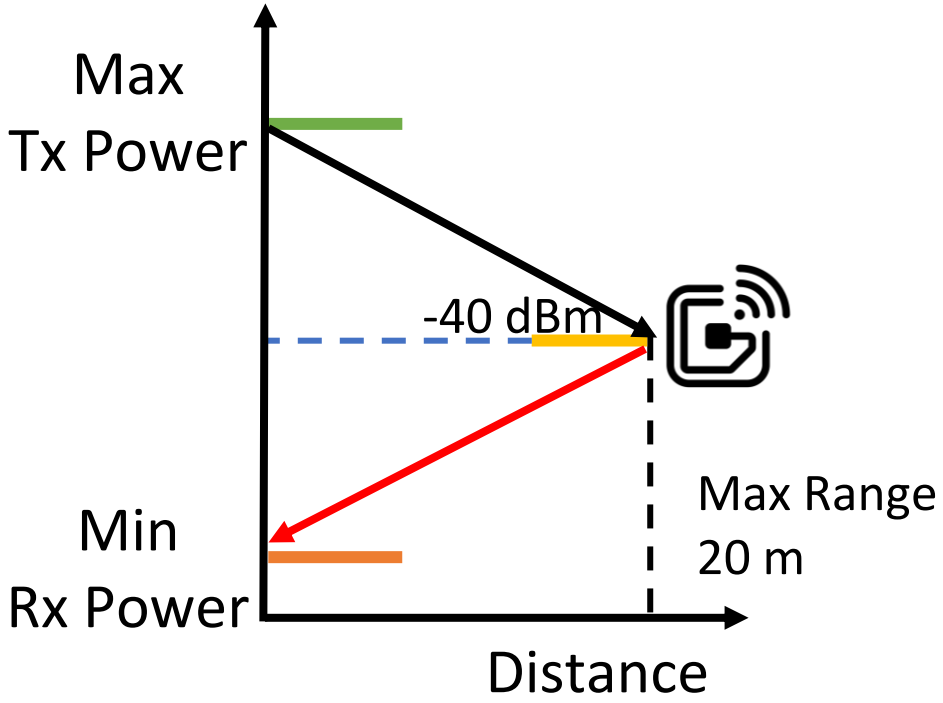
Lack of synchronization increases Bit Error Rate



150 ns synchronization accuracy is necessary

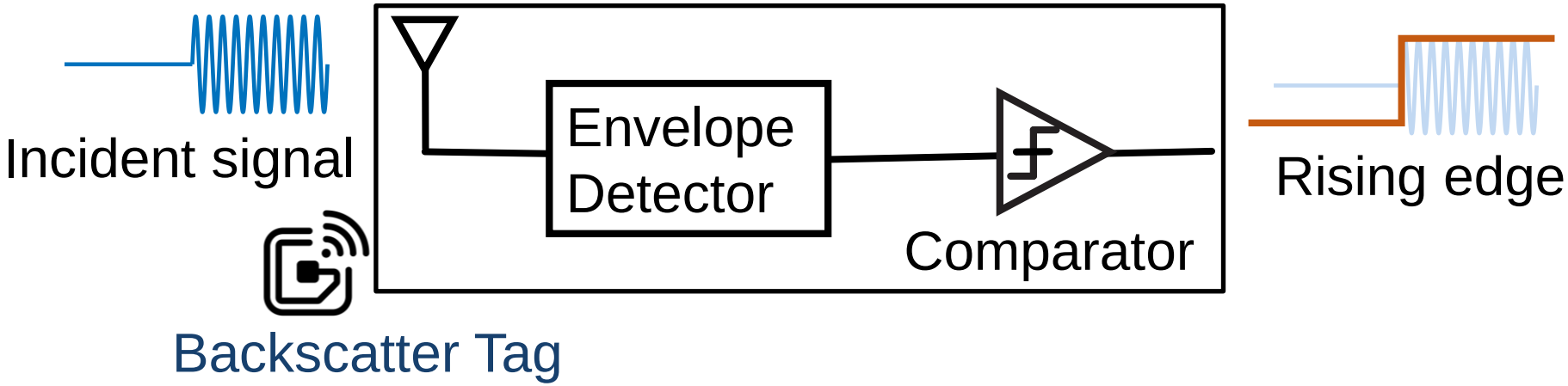
Requirement for long backscatter range





Need -40 dBm sensitivity and 150ns synchronization accuracy

How to Synchronize Incident signal with backscatter tag?



<150 ns

Synchronization accuracy

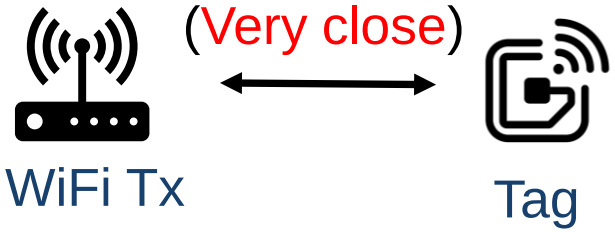
>6.67 MHz

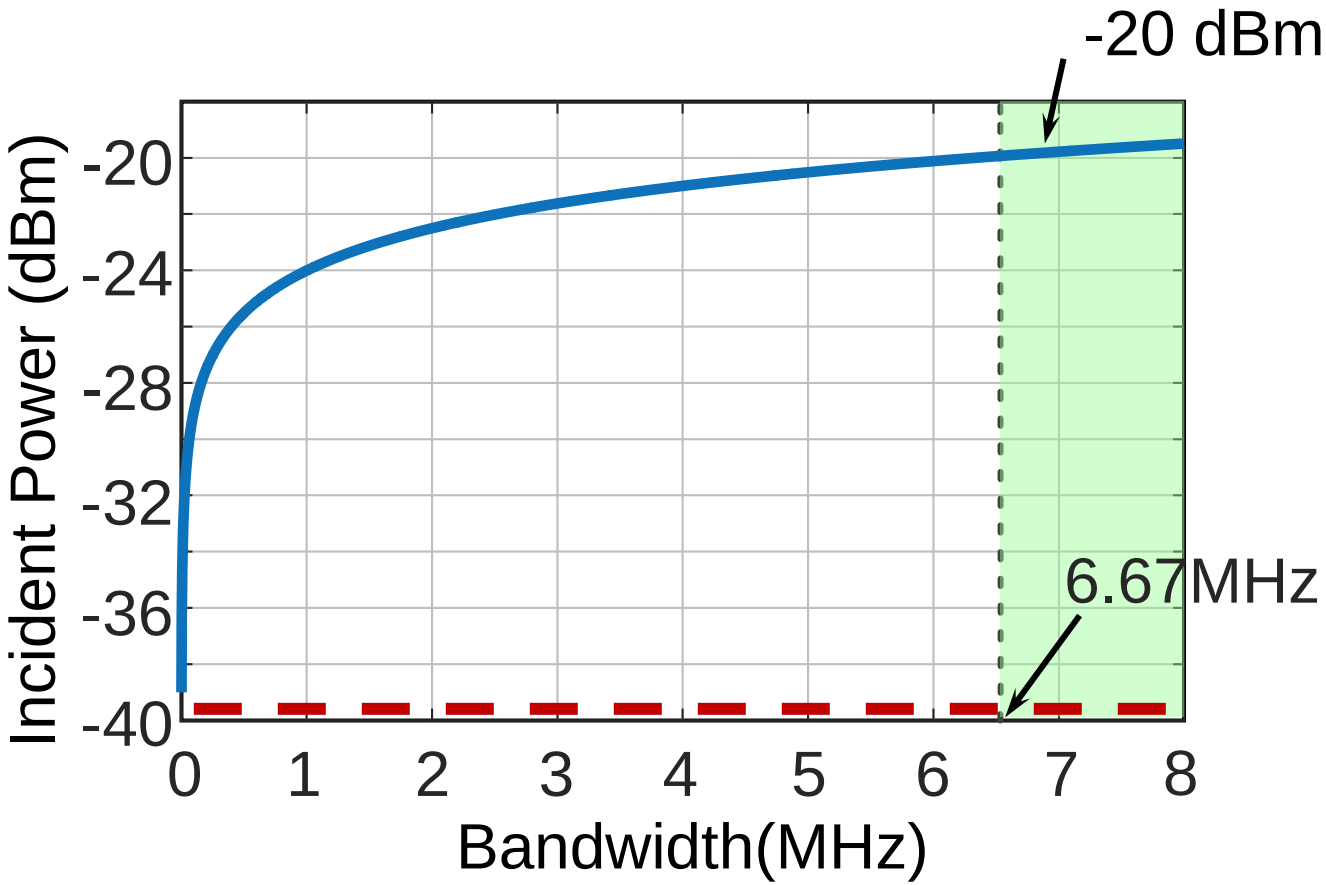
Envelope Detector (ED) Bandwidth

$$\text{ED Bandwidth} \propto \frac{1}{\text{Synchronization accuracy}}$$

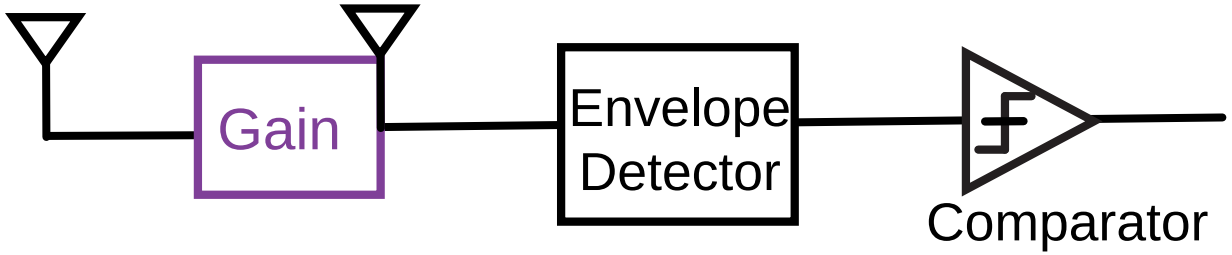
Challenge: How to enable long backscatter range?

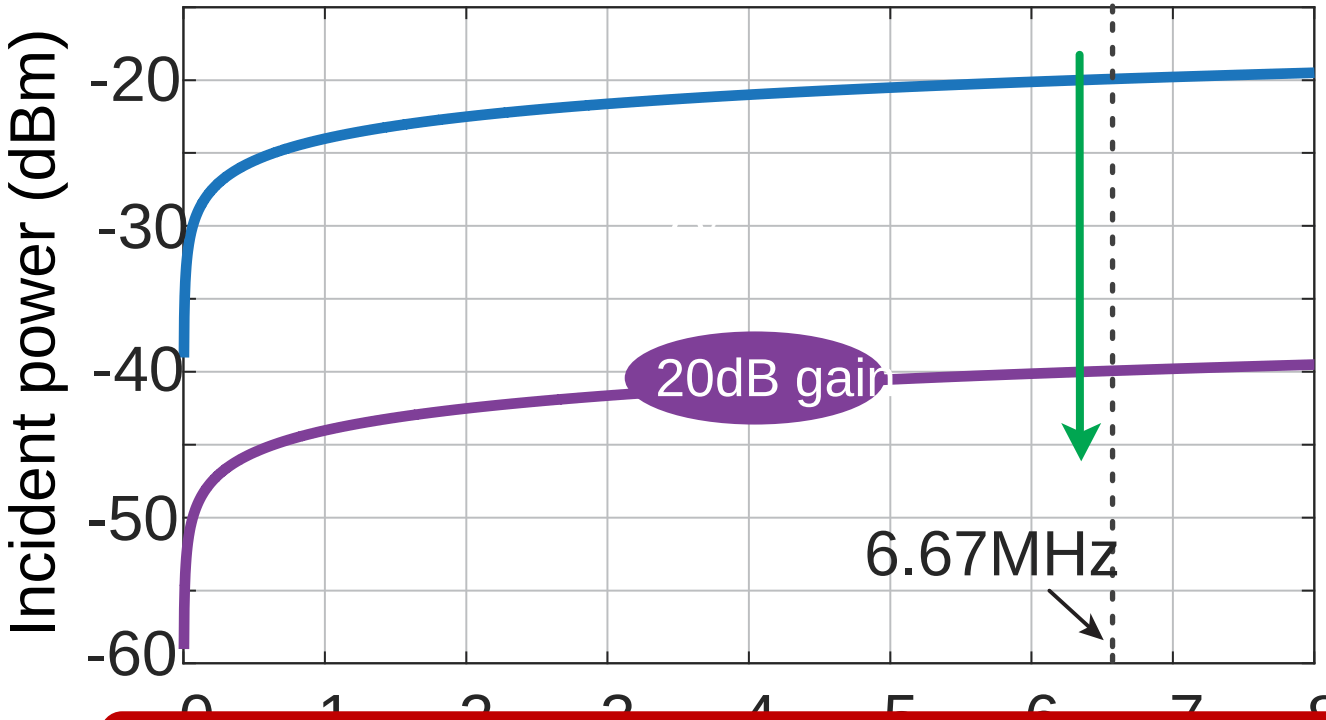
Incident signal power > Noise power ∝ ED Bandwidth





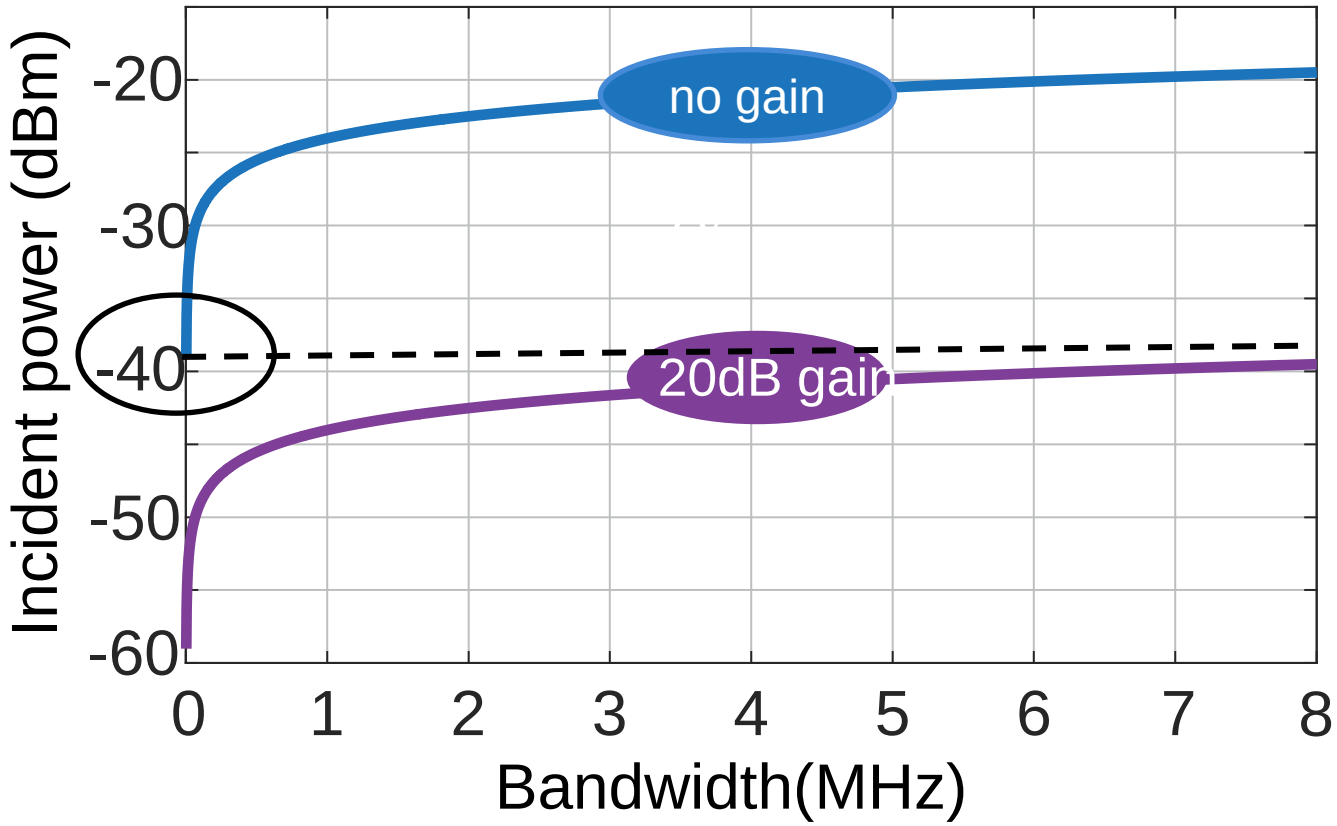
Improving the Tag sensitivity





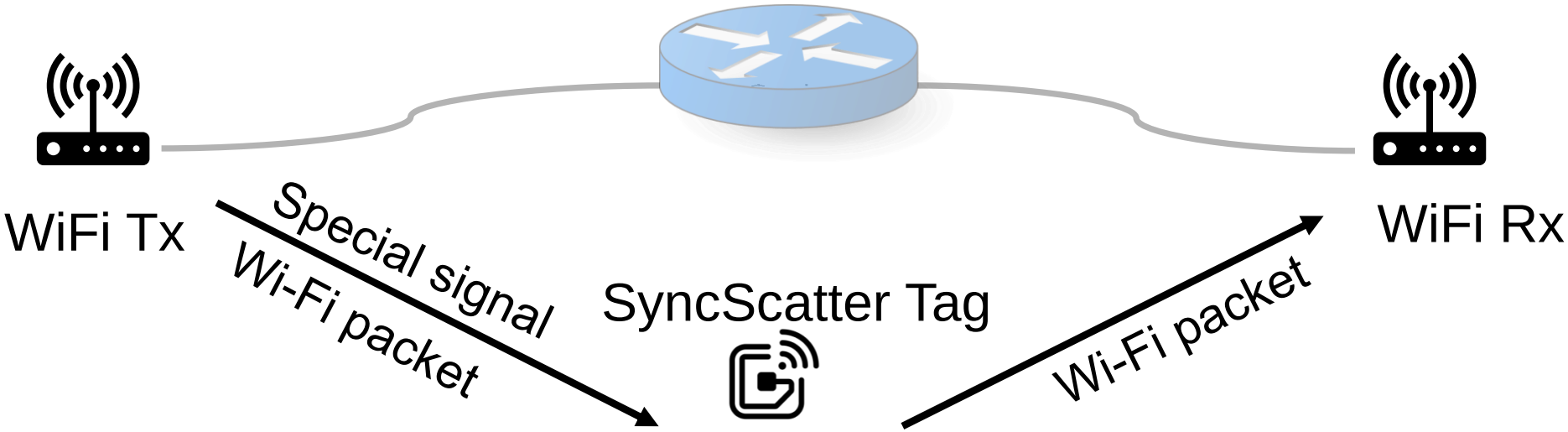
100 x increase in tag's power consumption

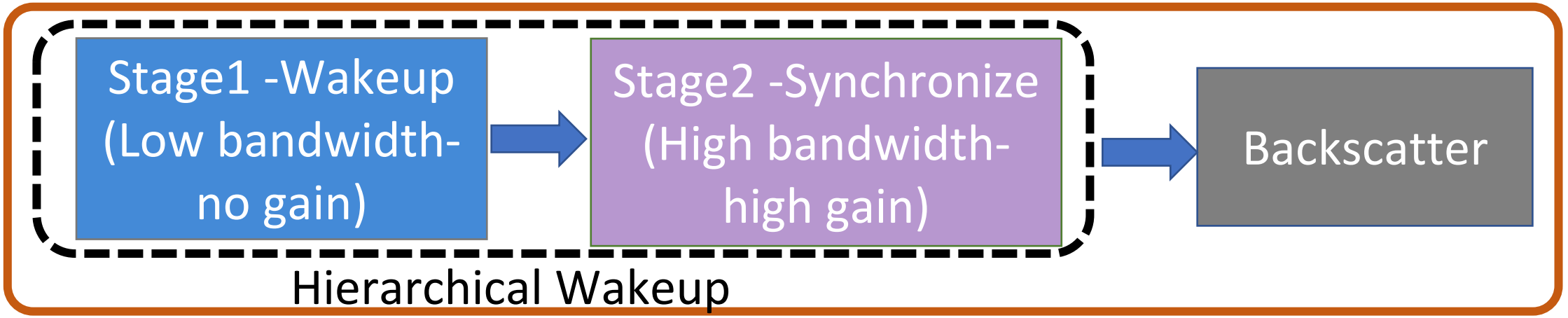
Achieving low power operation



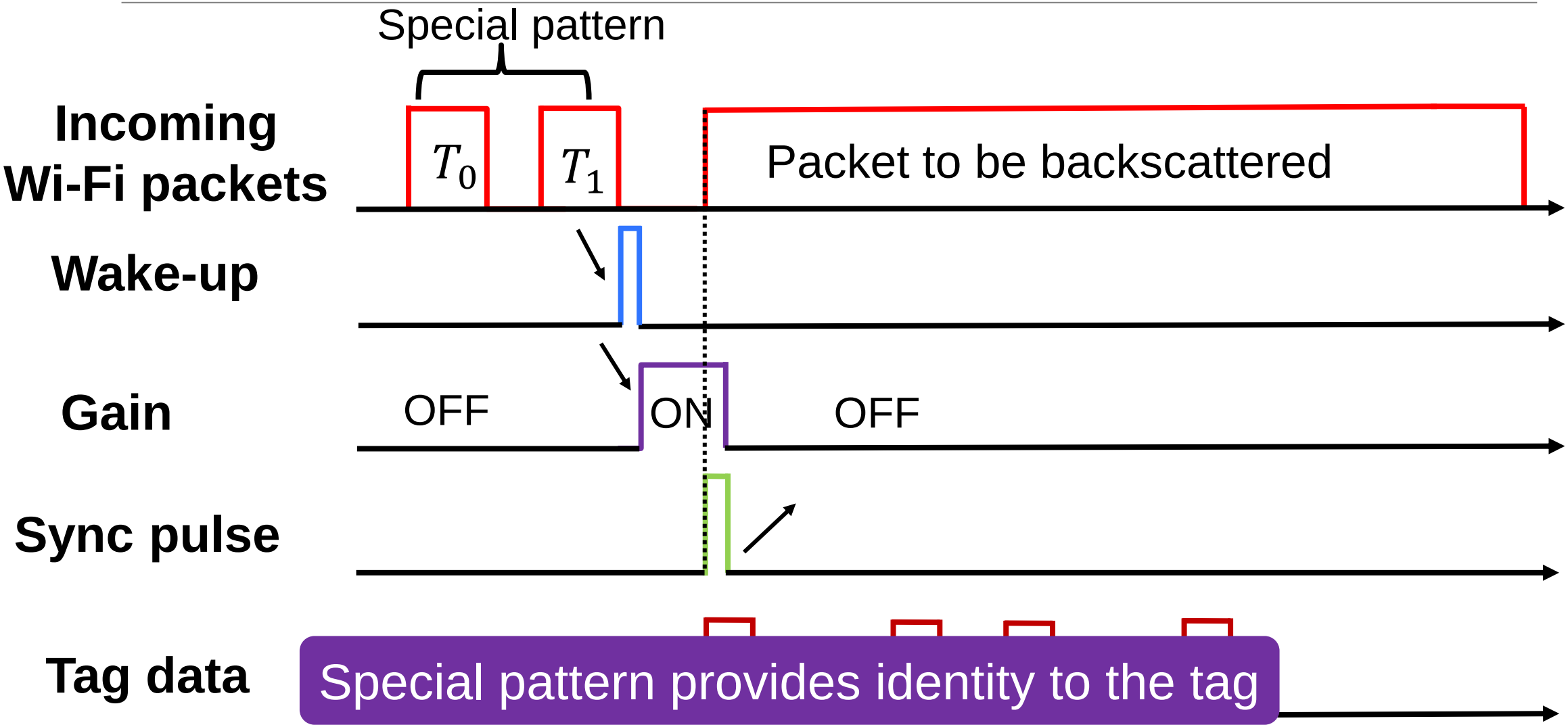
-40dBm incident power is sufficient for low bandwidth

Hierarchical wake-up receiver

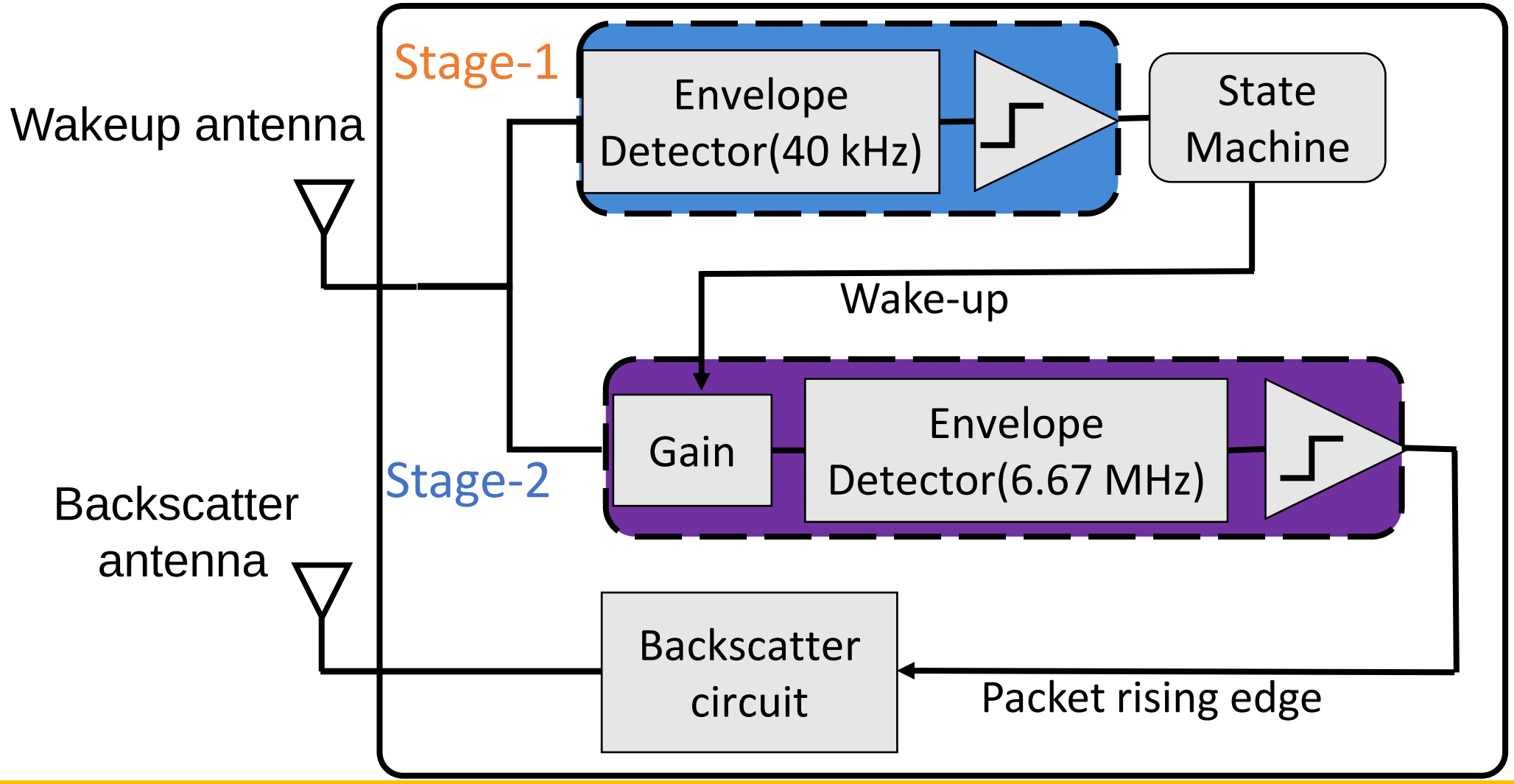




Hierarchical Wake-up receiver: Timing

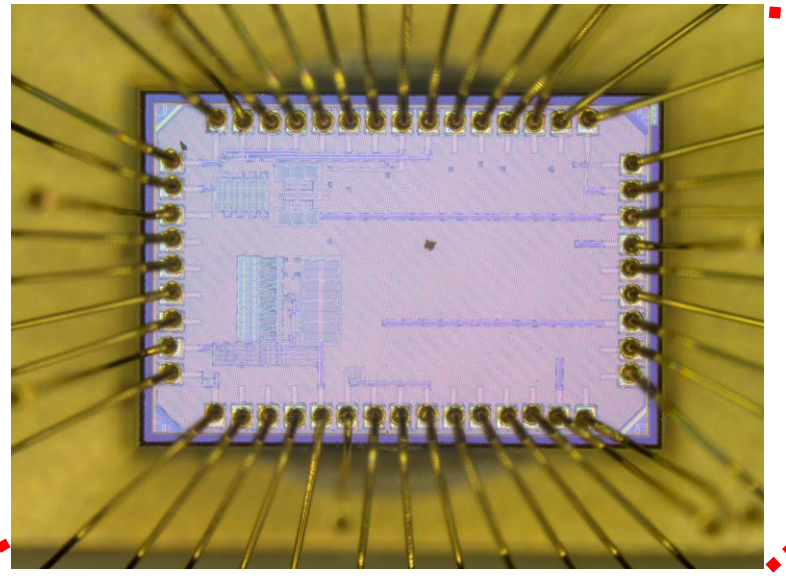


Overall tag Design

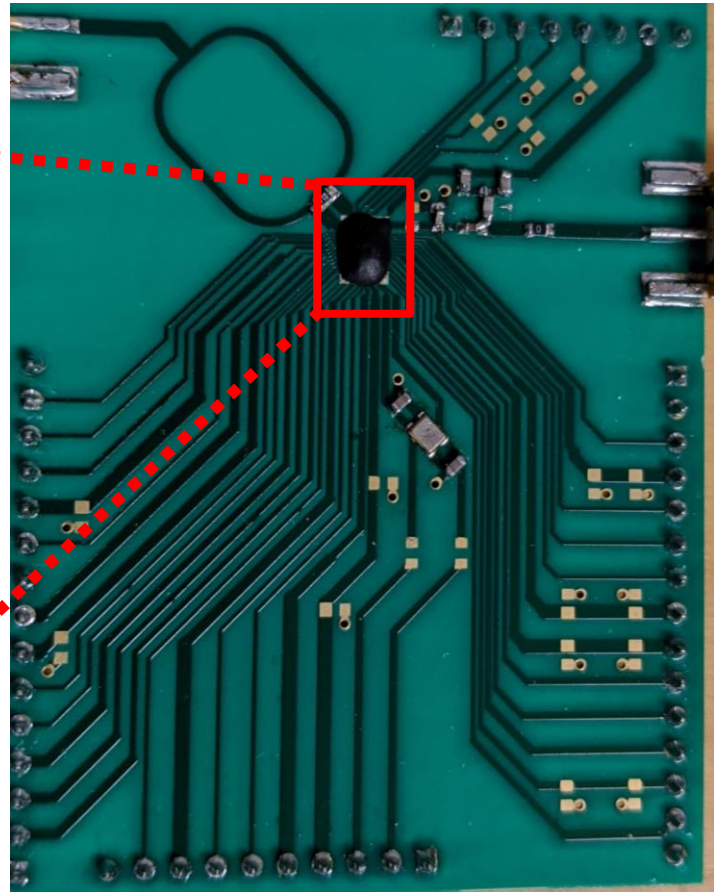


Integrated Circuit development

Tiny Chip – 1.5 mm²

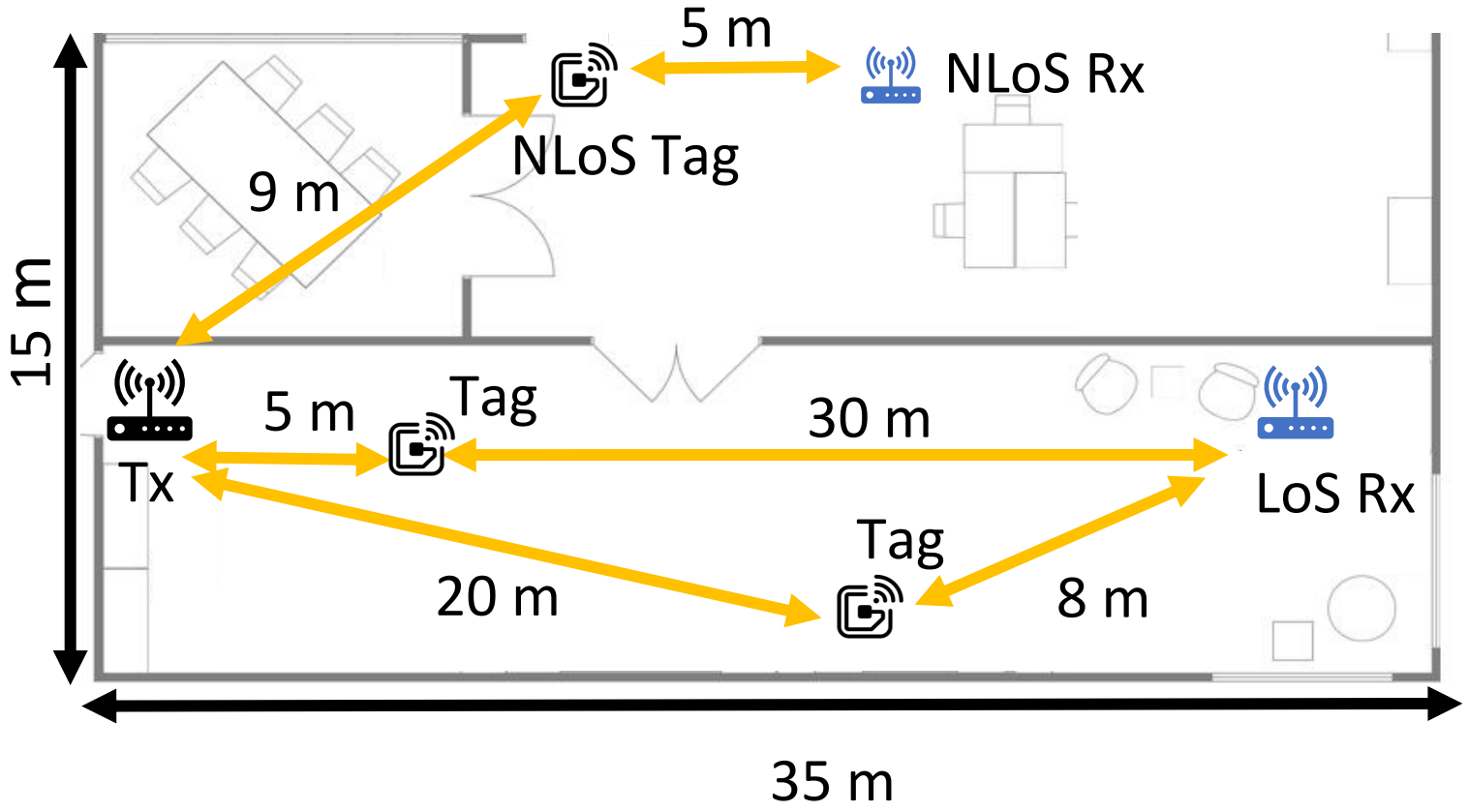


Integrated Circuit (IC)

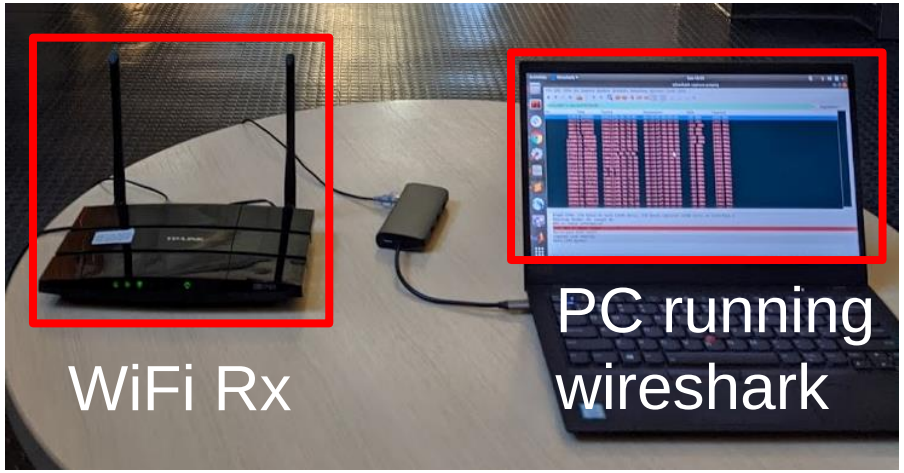


PCB

Evaluation setup



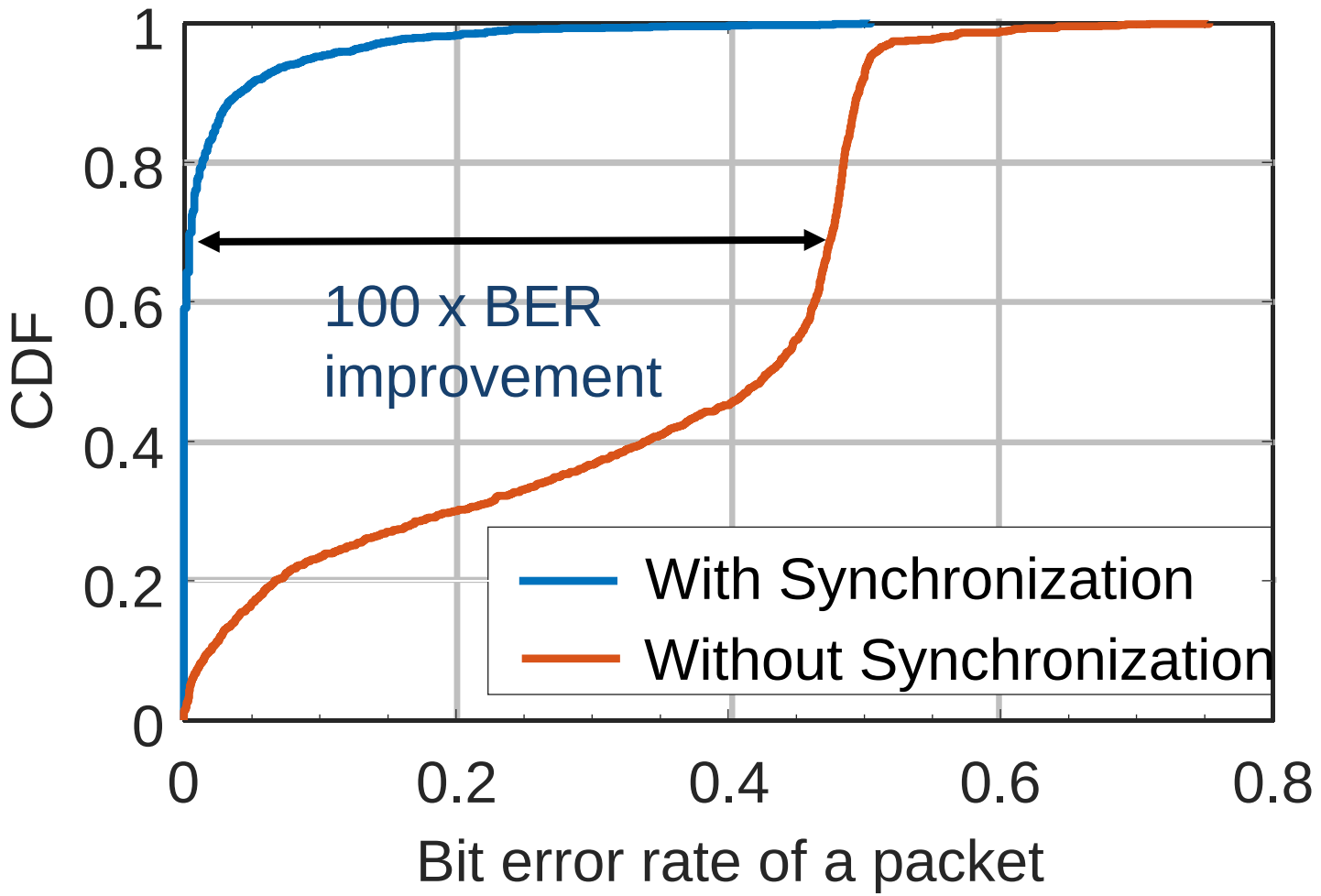
- TP-link WiFi access points
- 24dBm transmit power



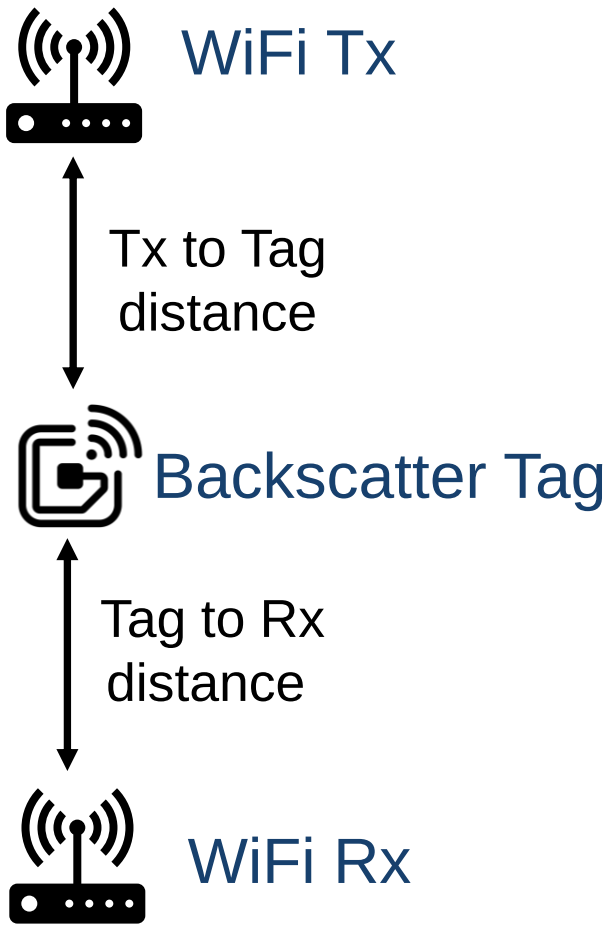
BER improvement

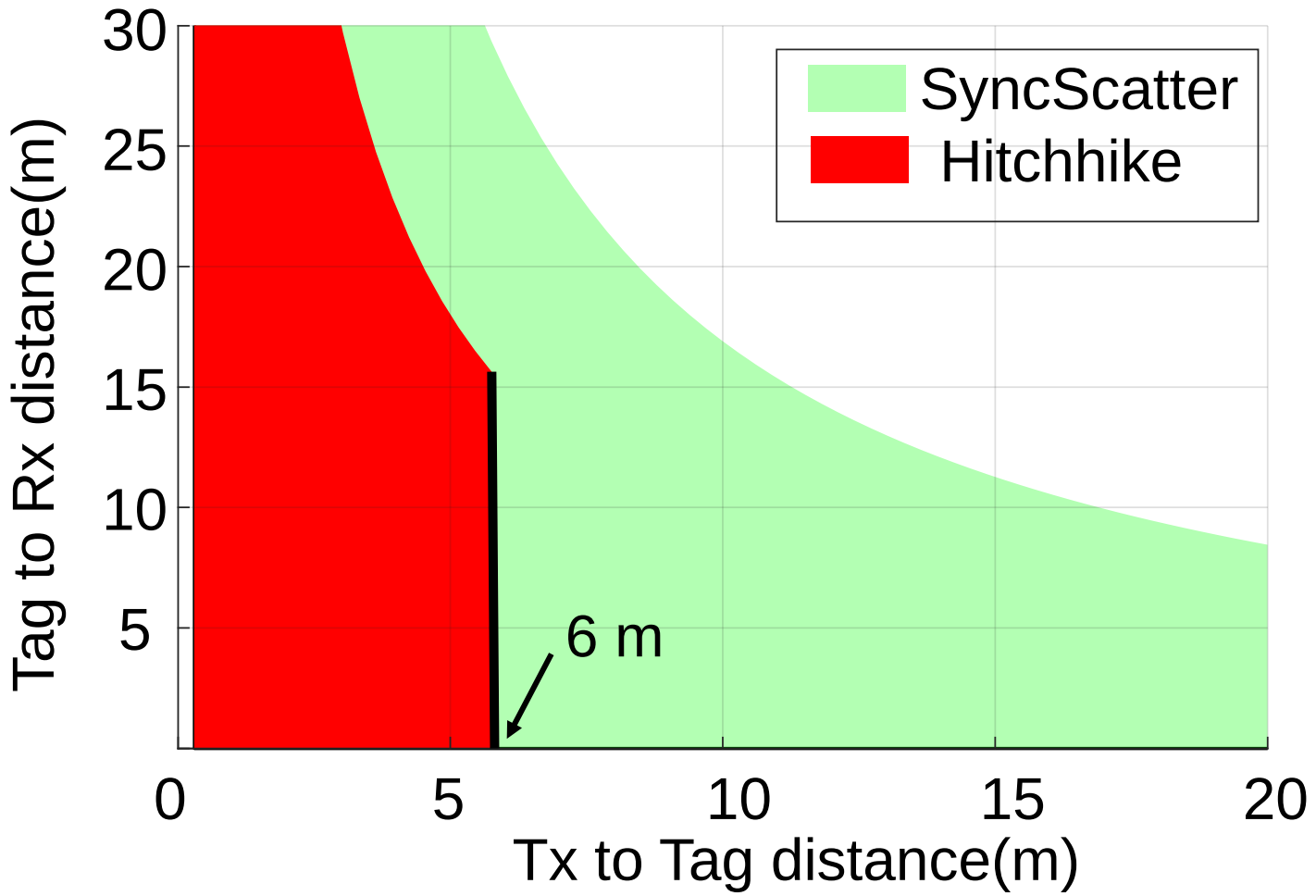
Without Synchronization:
BER > 0.2 for 70 % of packets

With Synchronization:
BER < 10^{-3} for 70 % of packets



Range improvement





Conclusion

- Hierarchical wake-up receiver design to achieve synchronization for Wi-Fi backscatter tags
- Extends the backscatter tag range for wide-area deployment
- Supports multi-tag operation

https://wcsng.ucsd.edu/syncscatter/

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