



UC San Diego

JACOBS SCHOOL OF ENGINEERING  
Electrical and Computer Engineering



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

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# Miniature and Ubiquitous IoT devices

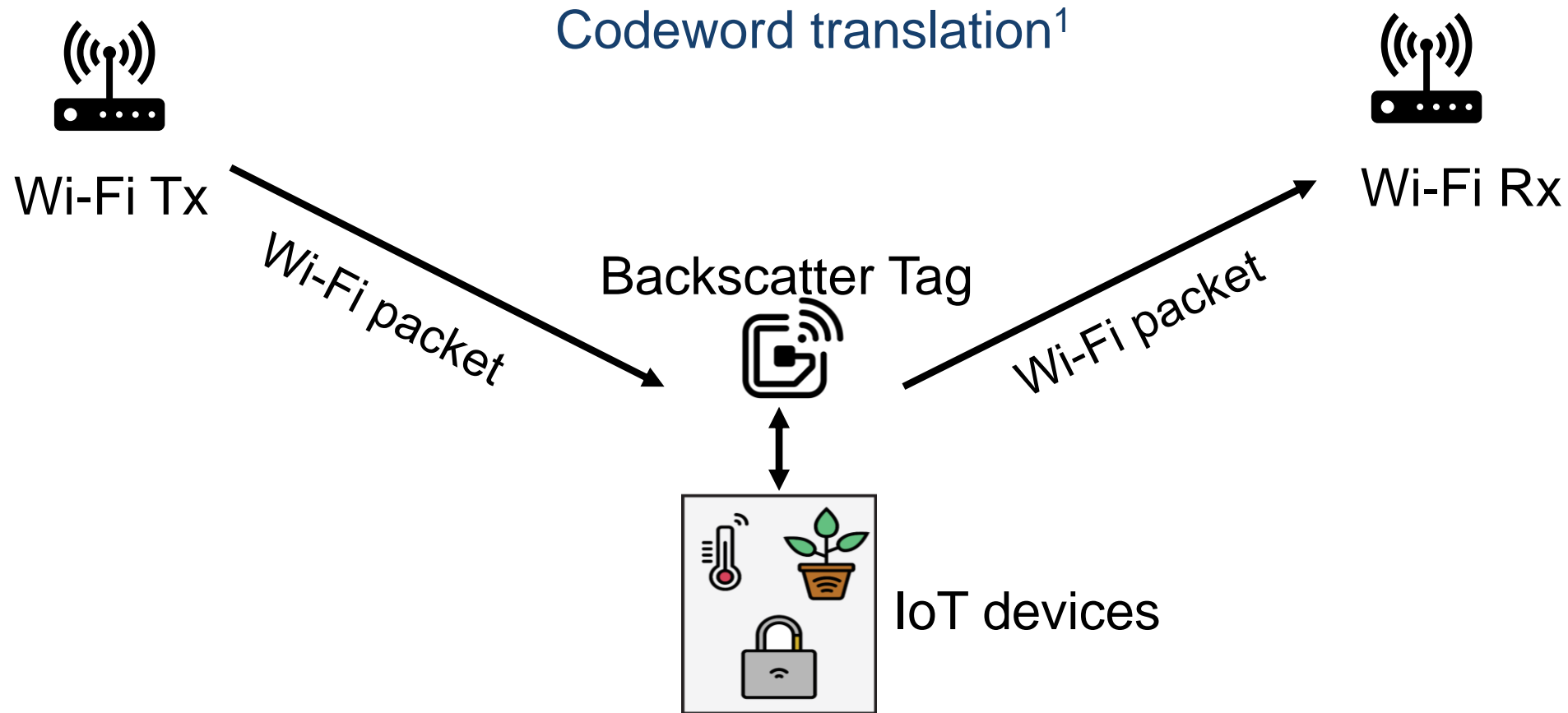
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- Requires long battery life
- Wireless connectivity to existing infrastructure like Wi-Fi

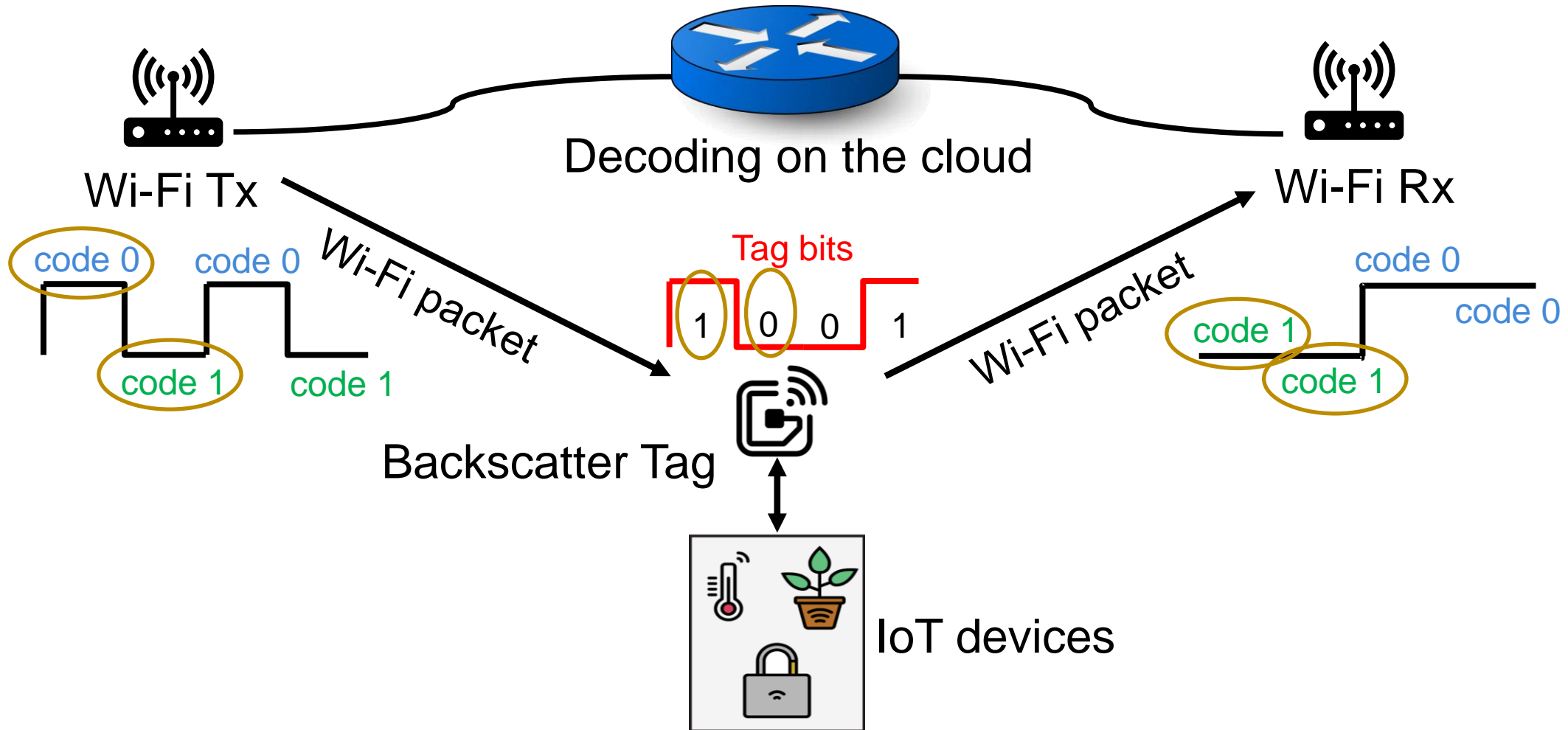


# Low power Wi-Fi connectivity

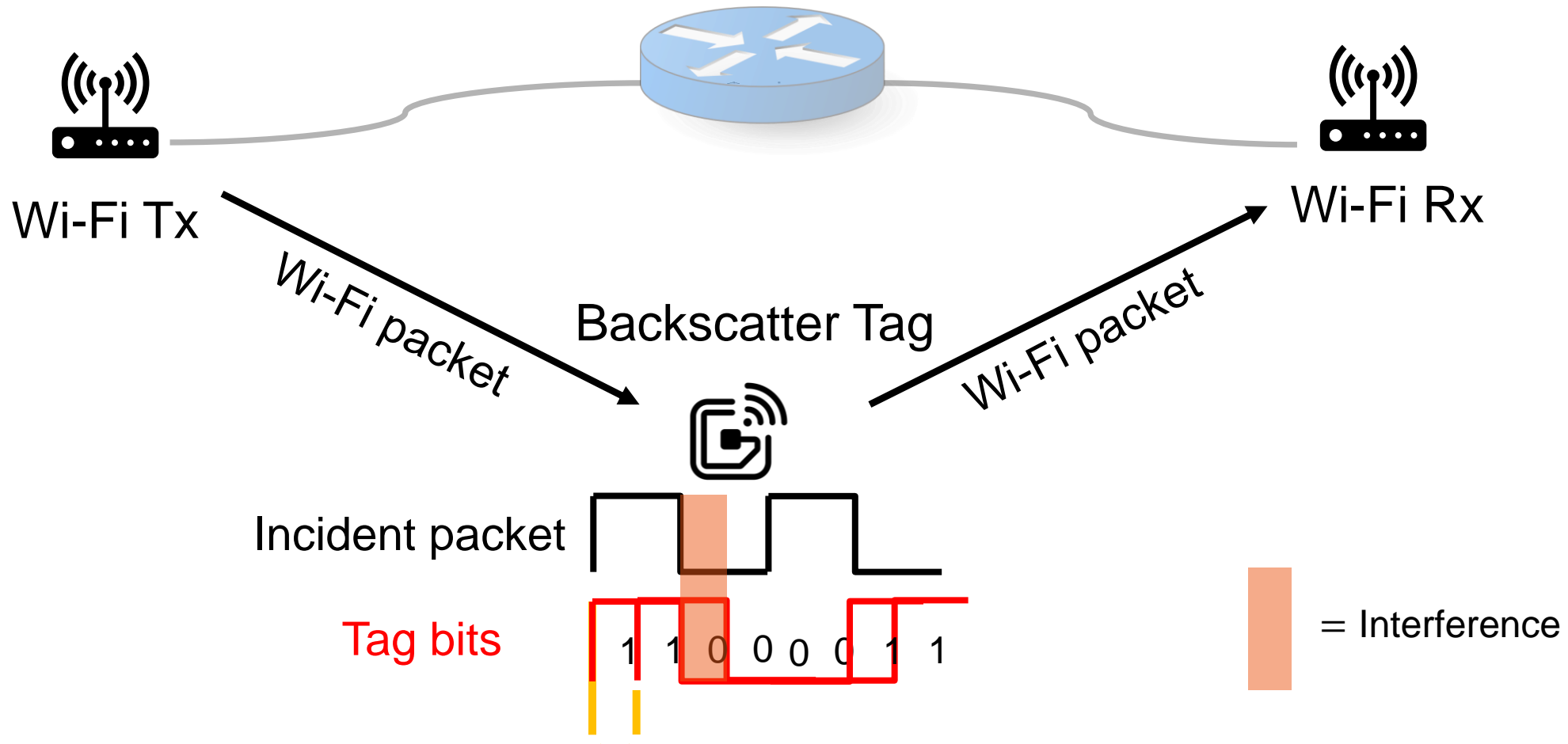


1) HitchHike: Practical Backscatter Using Commodity Wi-Fi (Sensys 2016 )

# Code-Word Translation



# Code-word translation: Closer look

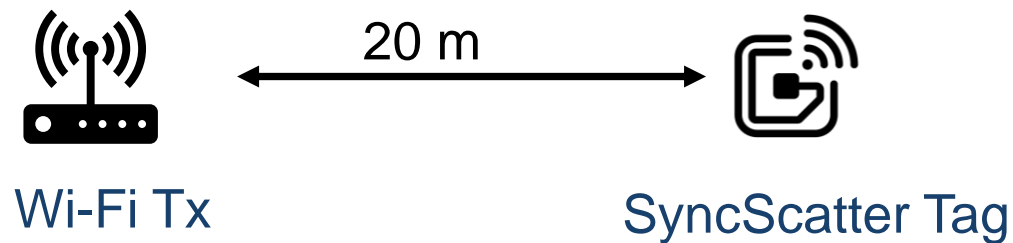


Can we synchronize to the incident Wi-Fi packets?

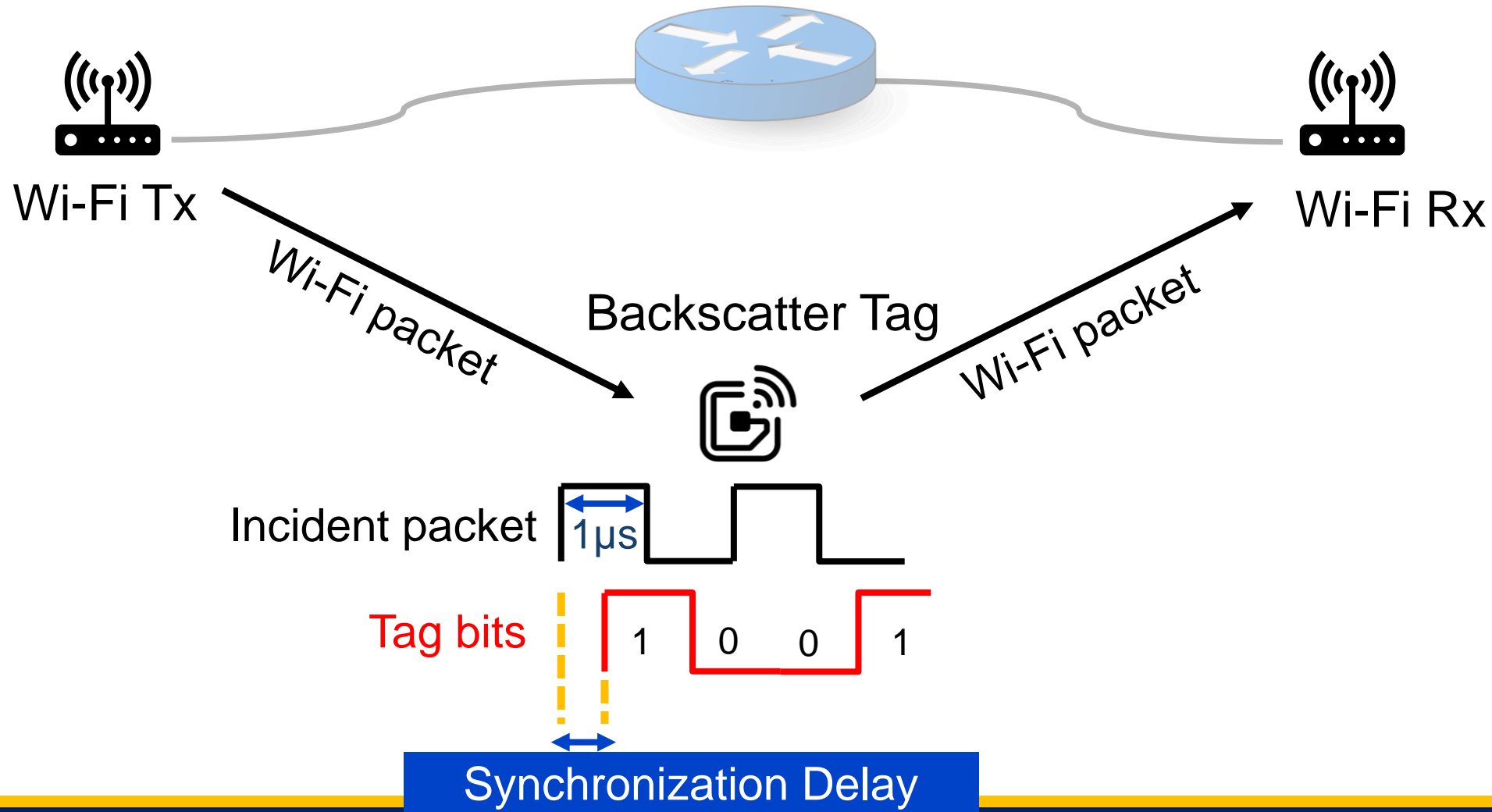
# SyncScatter: Contributions

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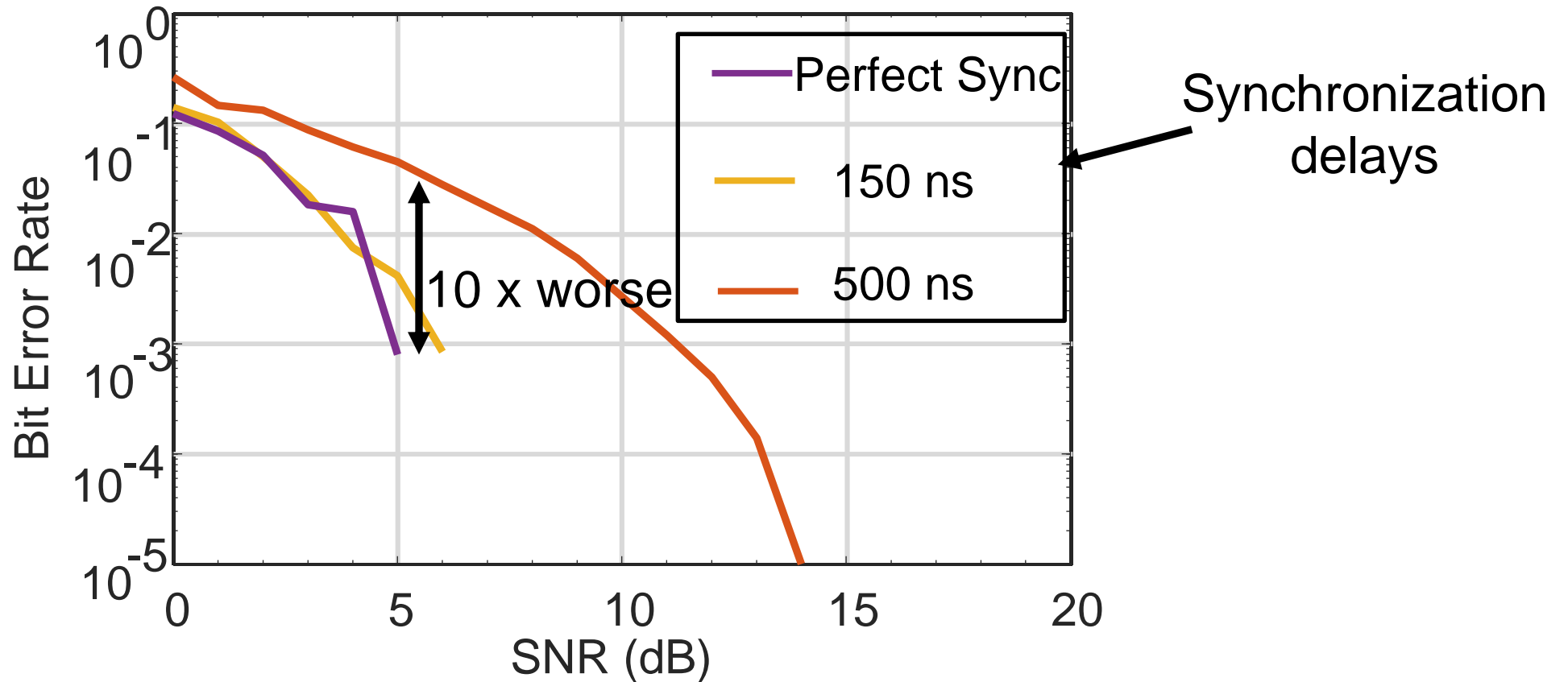
- ❖ Stringent synchronization requirements
- ❖ Hierarchical wake-up architecture
- ❖ **7.6  $\mu W$**  low power Integrated circuit for Synchronized backscatter
- ❖ **100x** lower Bit error rate
- ❖ **4x** Range improvement



# Synchronization Requirements



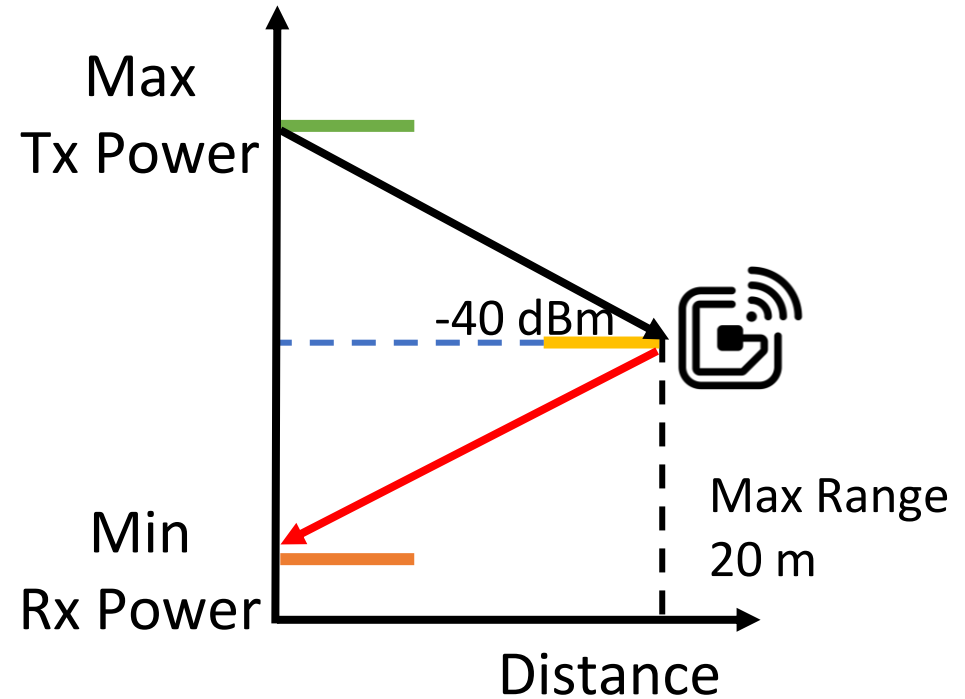
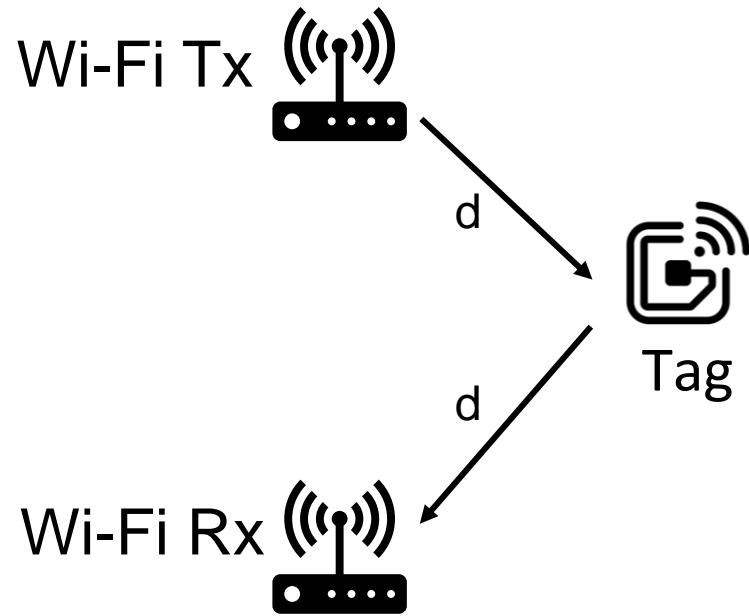
# Lack of synchronization increases Bit Error Rate



150 ns synchronization accuracy is necessary

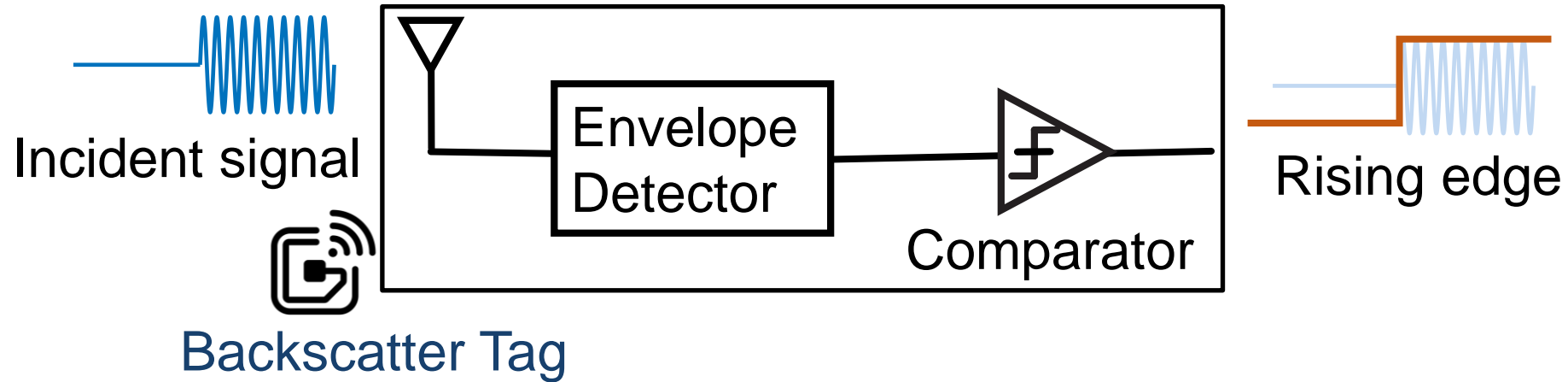


# Requirement for long backscatter range



Need -40 dBm sensitivity and 150ns synchronization accuracy

# How to Synchronize Incident signal with backscatter tag?



<150 ns

Synchronization accuracy



>6.67 MHz

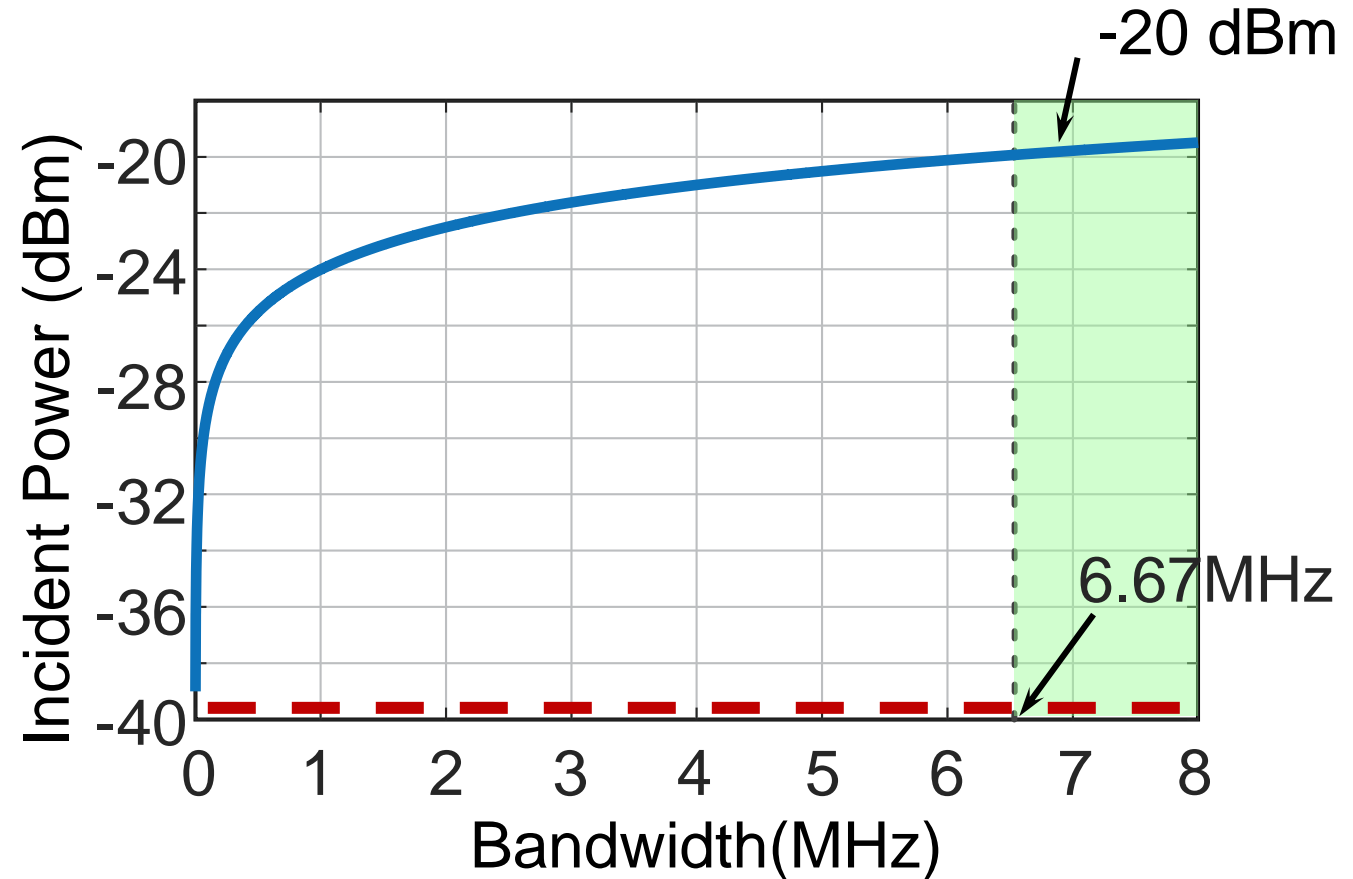
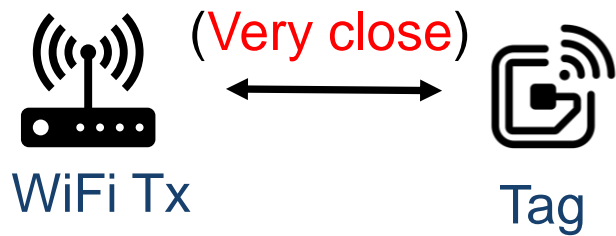
Envelope Detector (ED) Bandwidth

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

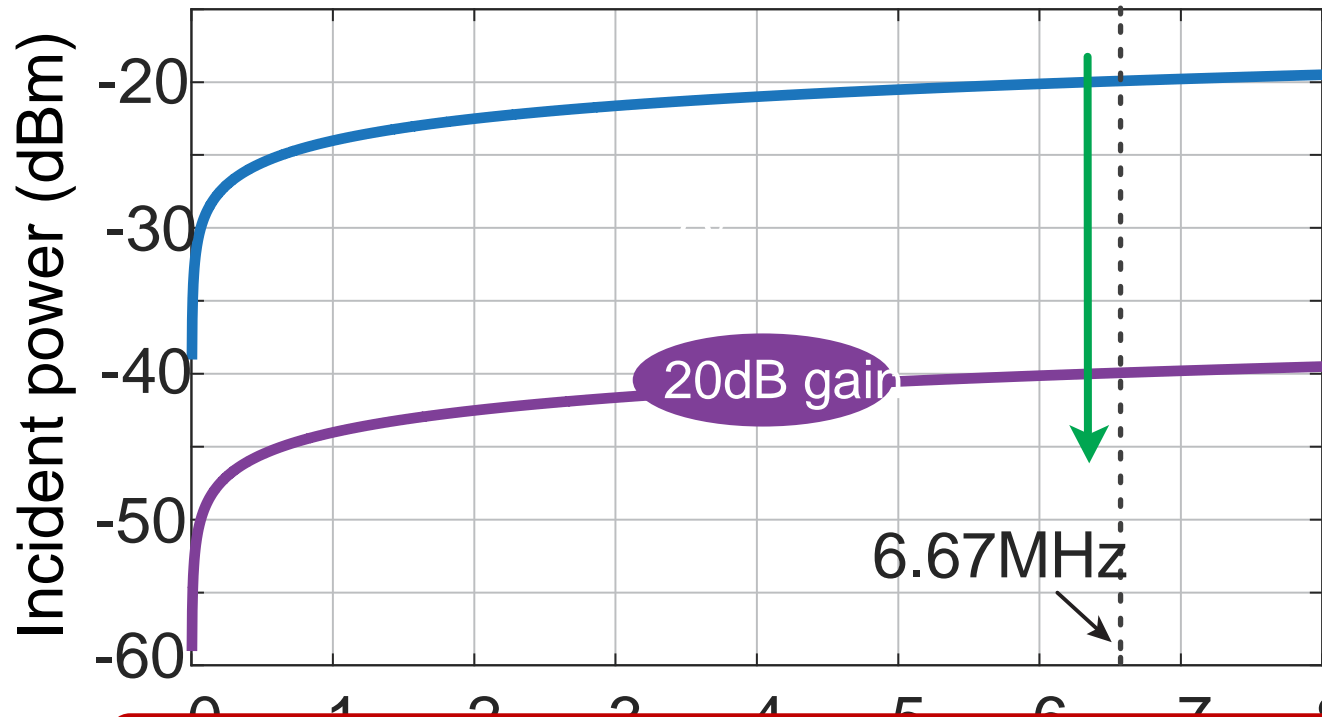
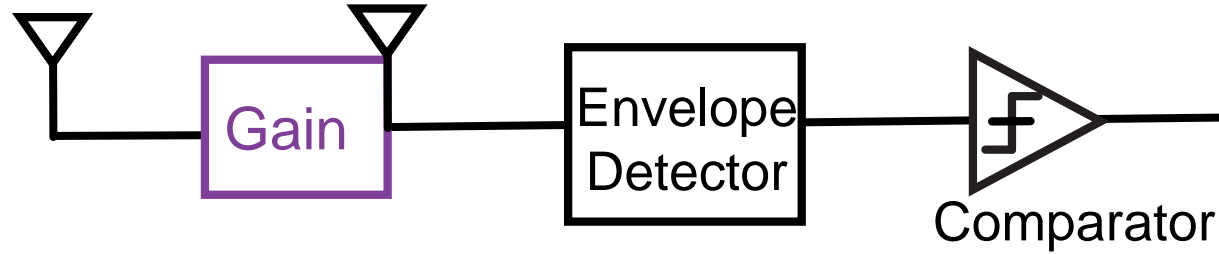
# Challenge: How to enable long backscatter range?

Incident signal power >

Noise power  
 $\propto$  ED Bandwidth

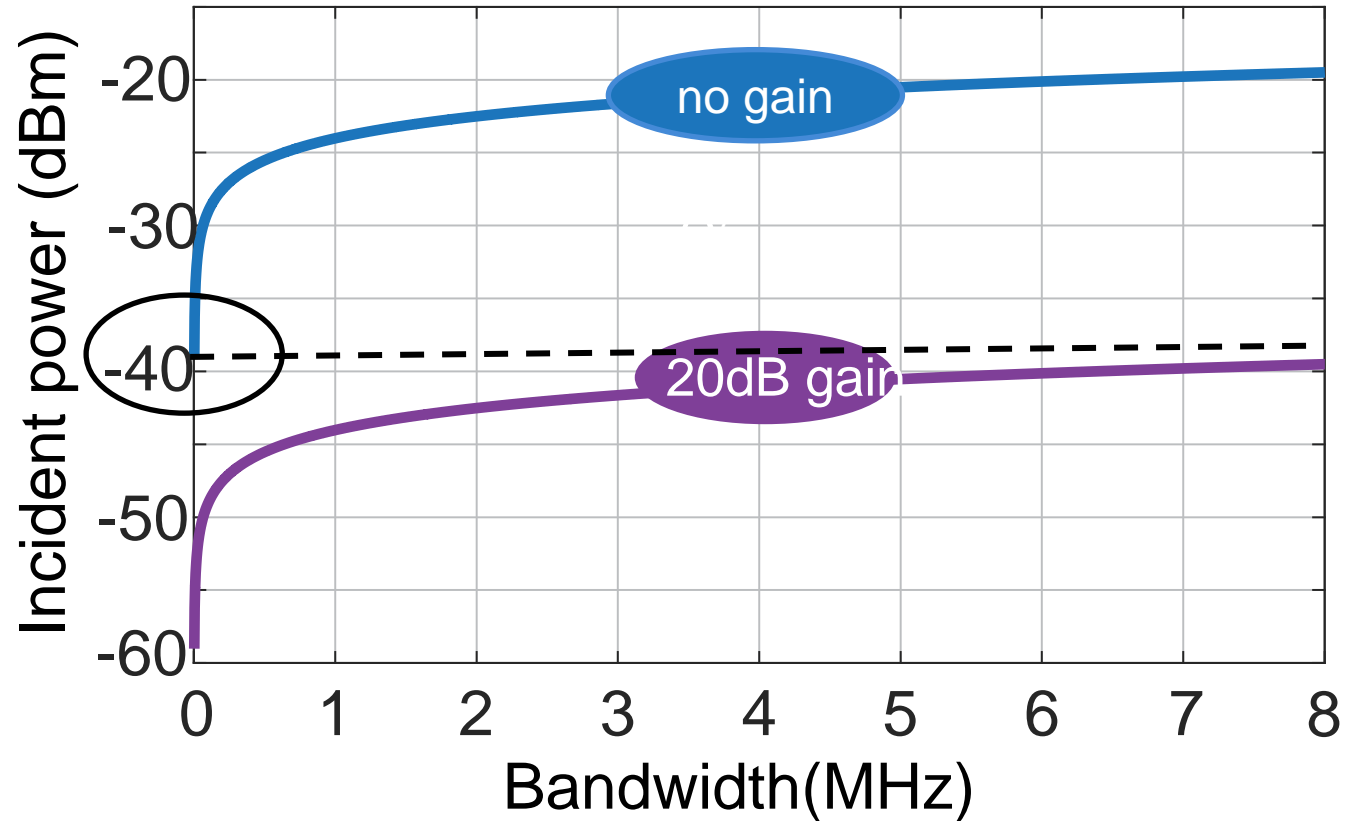


# Improving the Tag sensitivity



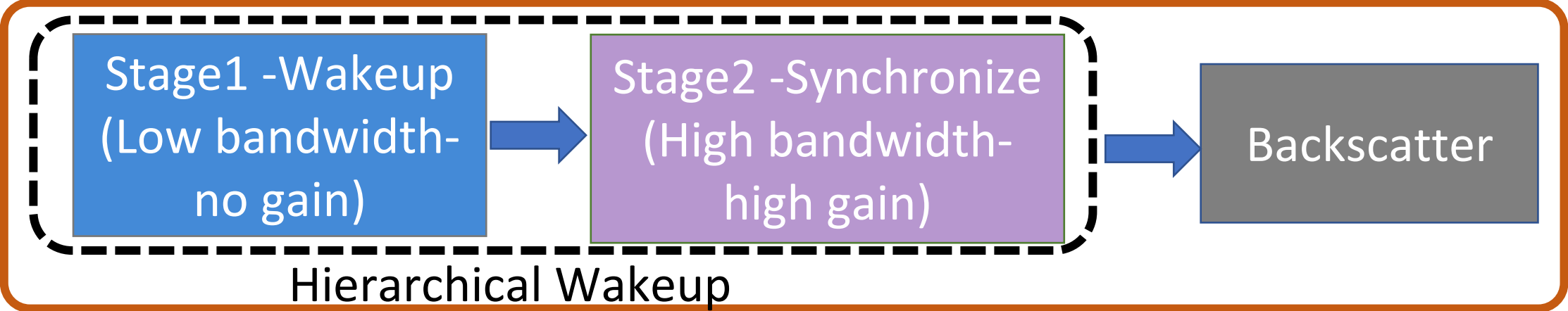
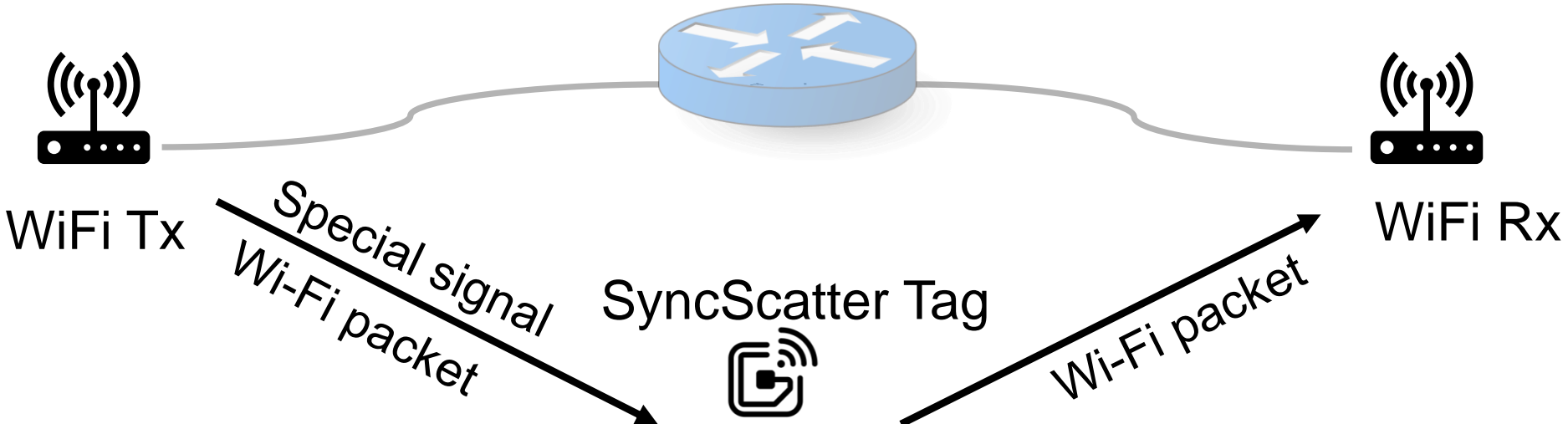
100 x increase in tag's power consumption

# Achieving low power operation

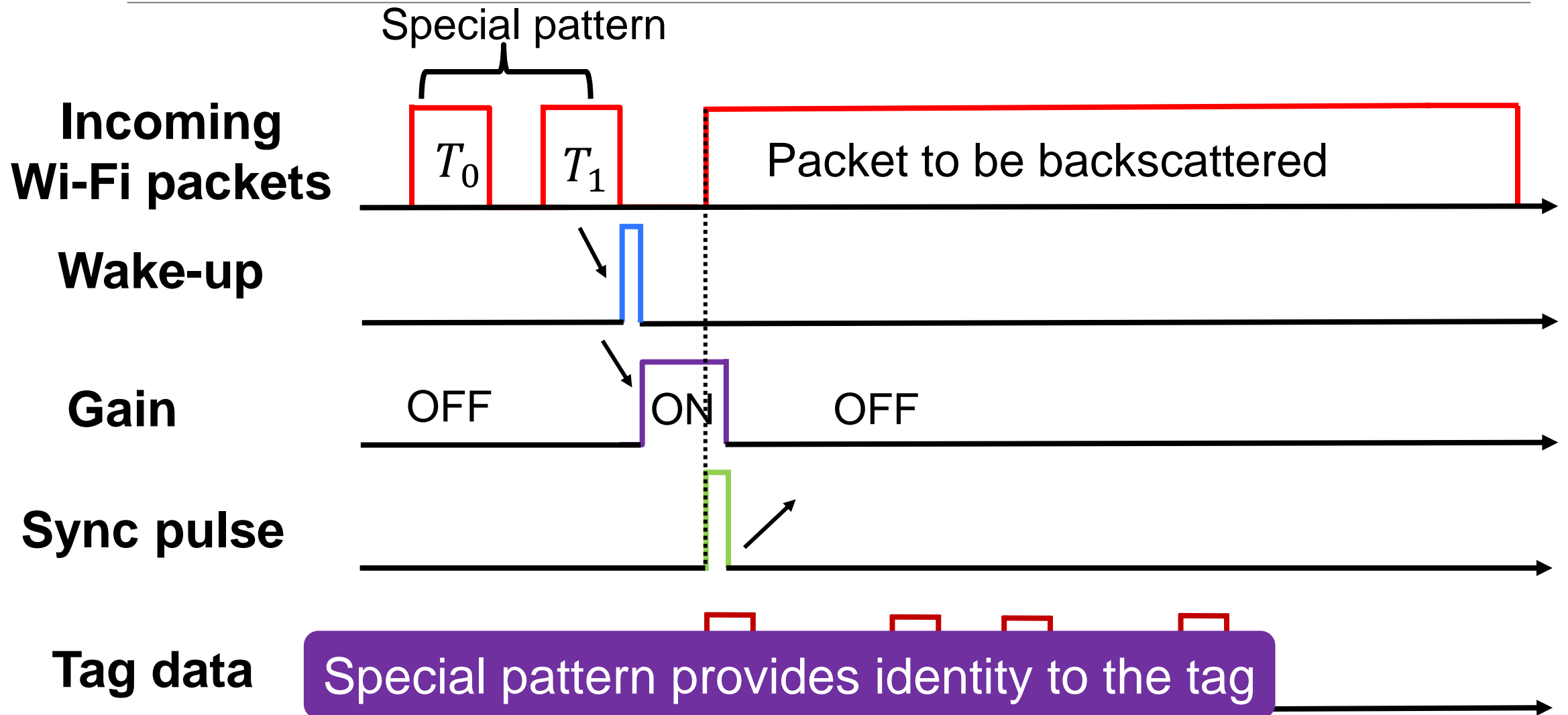


-40dBm incident power is sufficient for low bandwidth

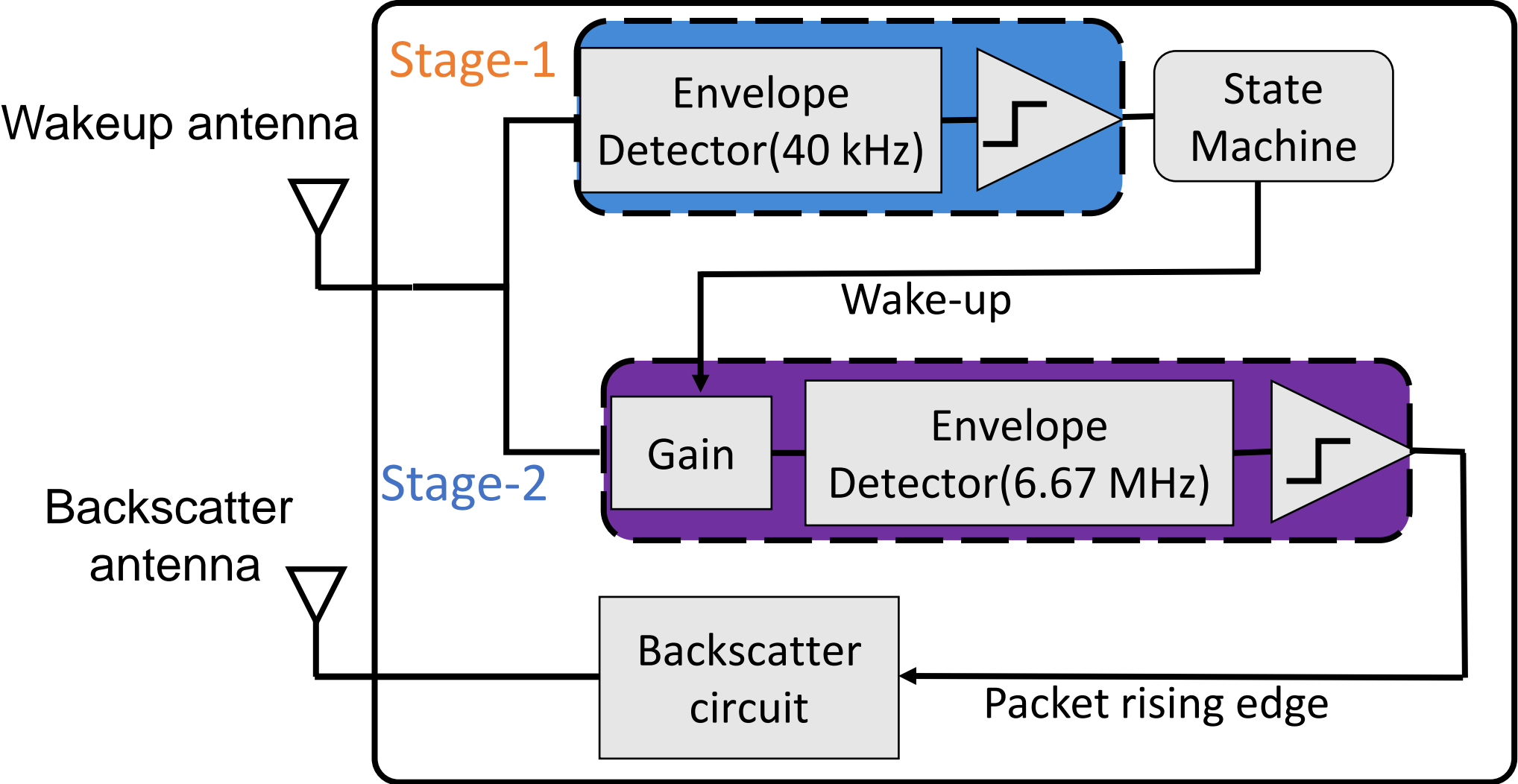
# Hierarchical wake-up receiver



# Hierarchical Wake-up receiver: Timing



# Overall tag Design

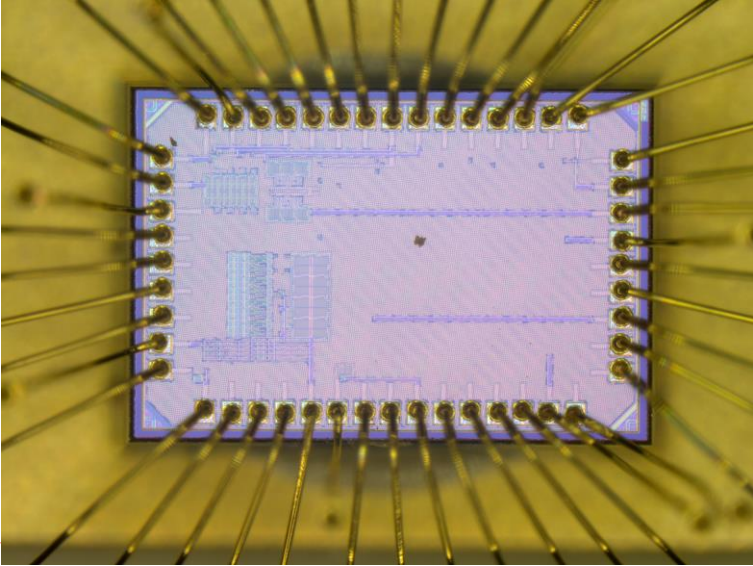




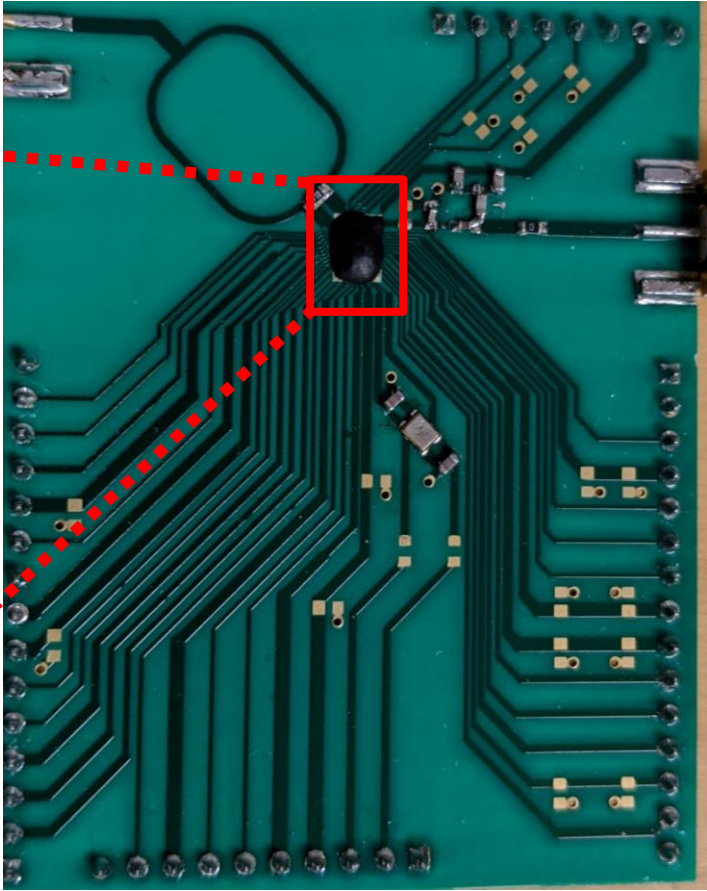
# Integrated Circuit development



Tiny Chip – 1.5 mm<sup>2</sup>

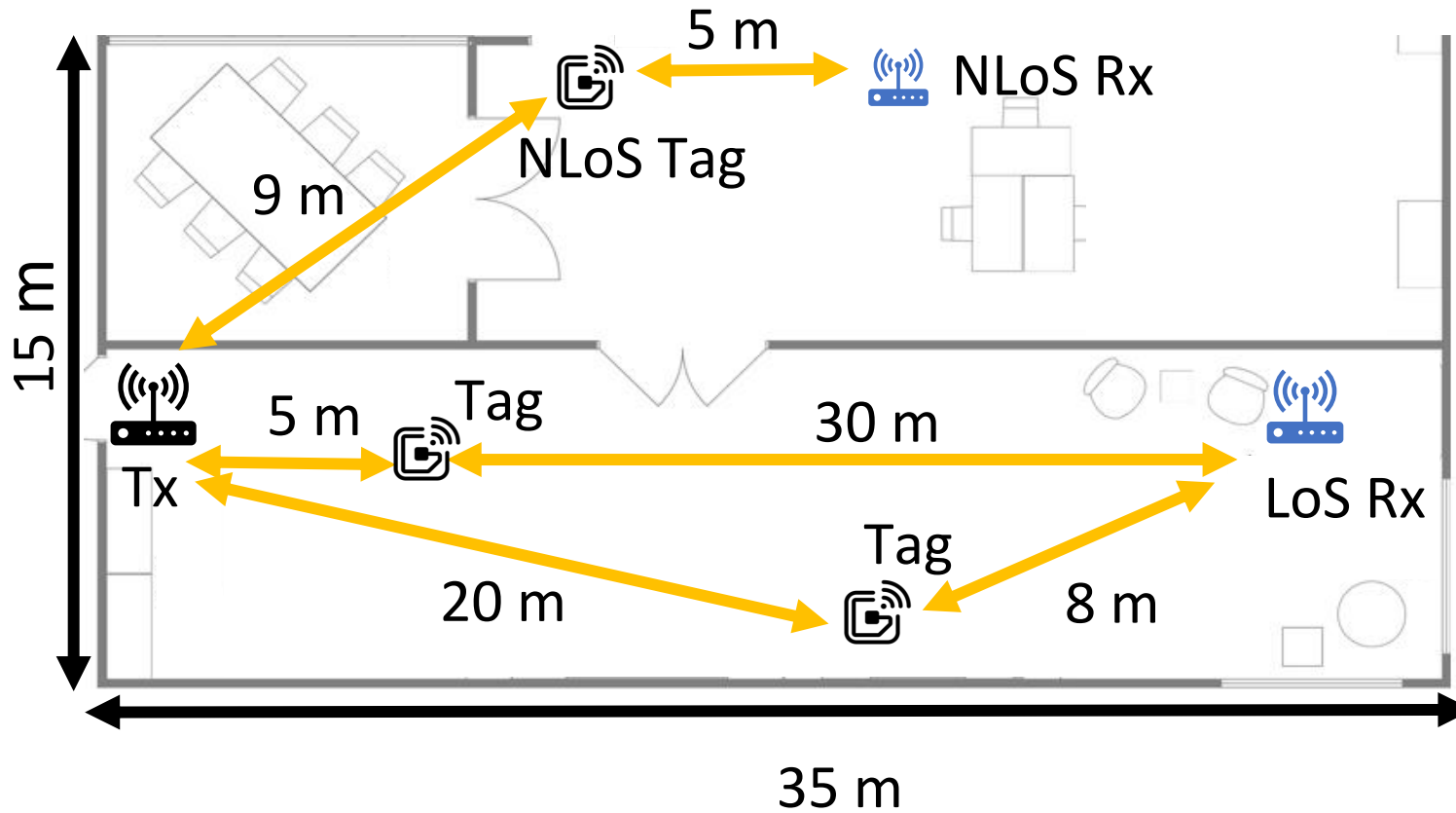


Integrated Circuit (IC)

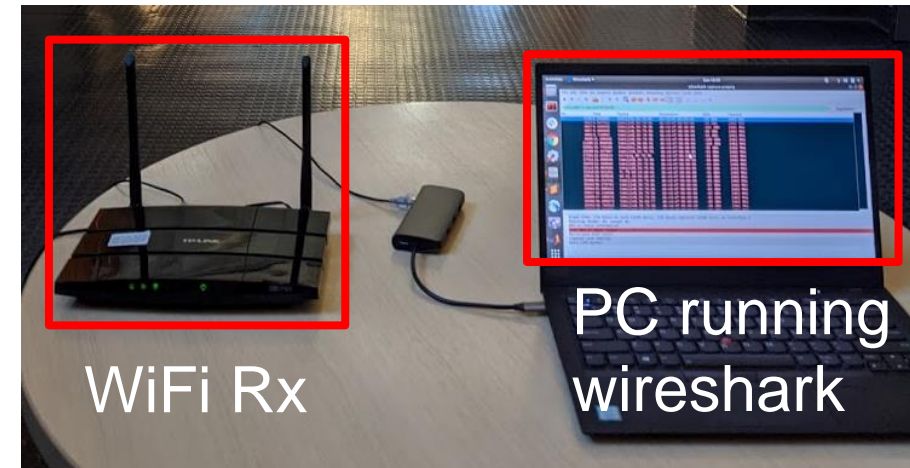


PCB

# Evaluation setup



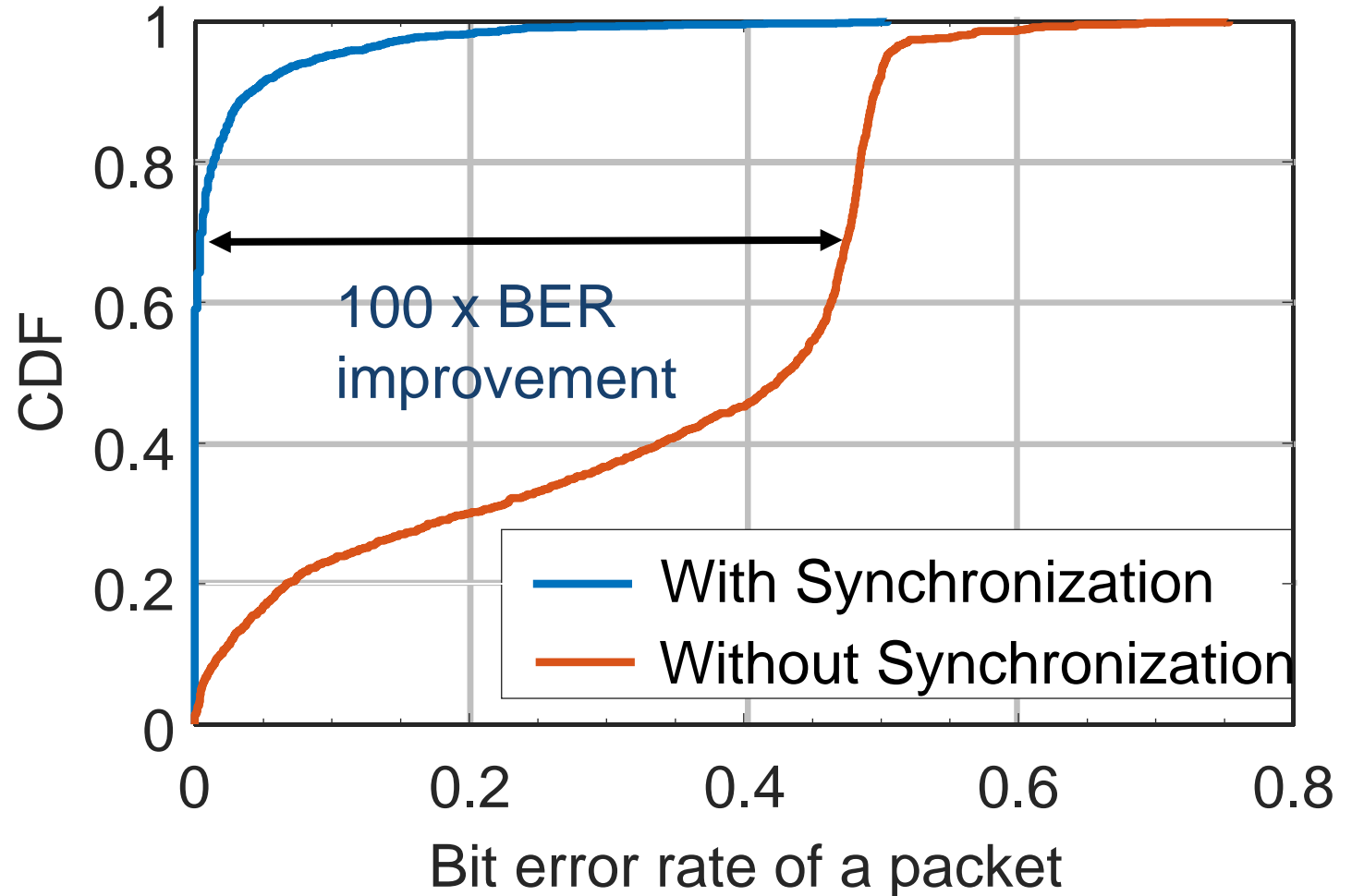
- TP-link WiFi access points
- 24dBm transmit power



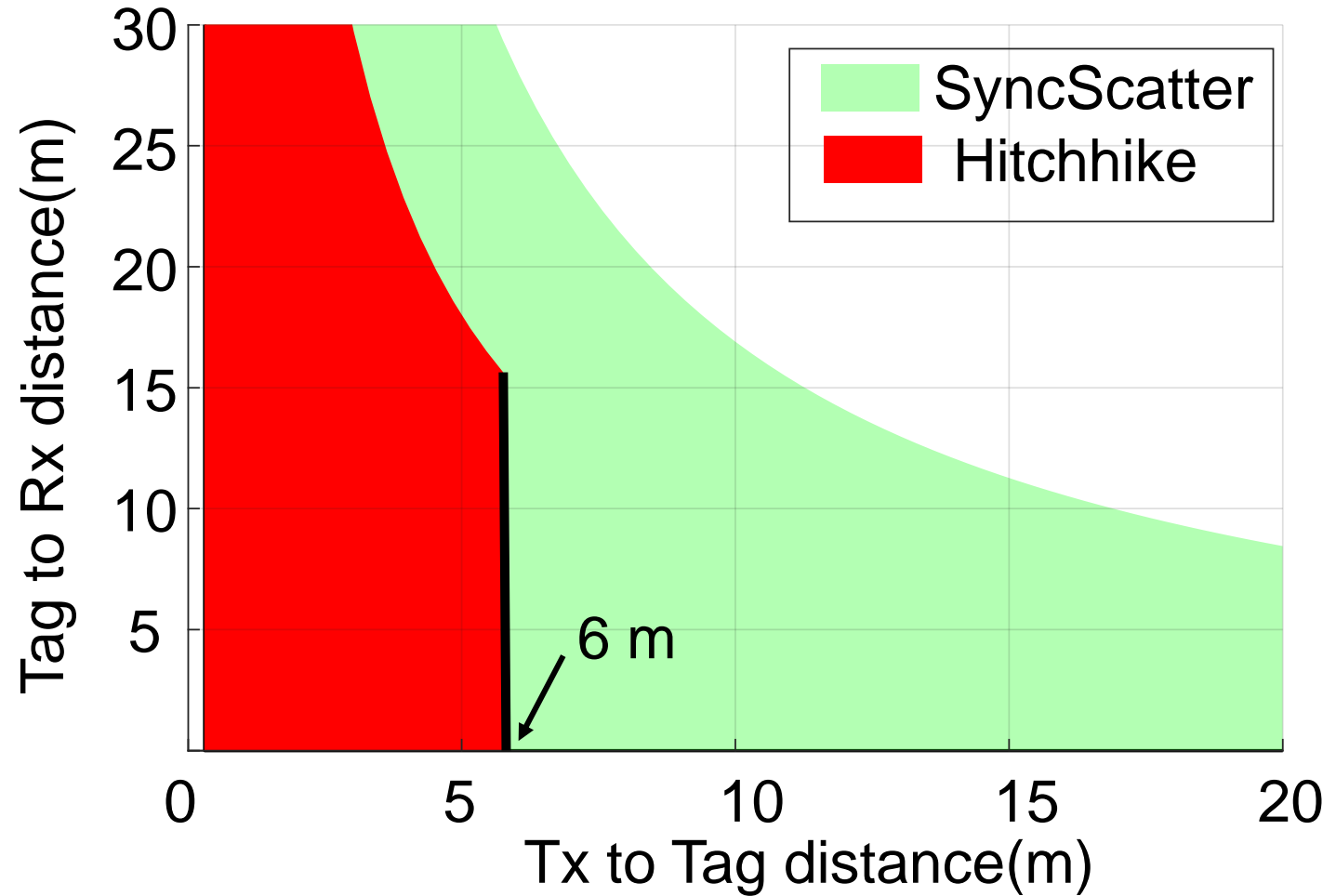
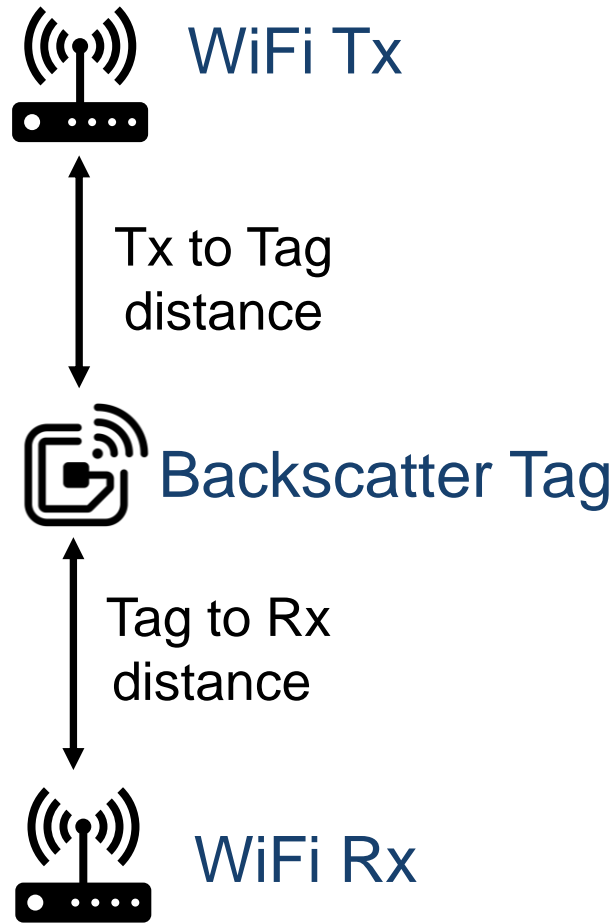
# BER improvement

**Without Synchronization:**  
BER > 0.2 for 70 % of packets

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



# Range improvement



# Conclusion

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- 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/>

