StripComm

Interference-resilient Cross-technology Communication in Coexisting Environments

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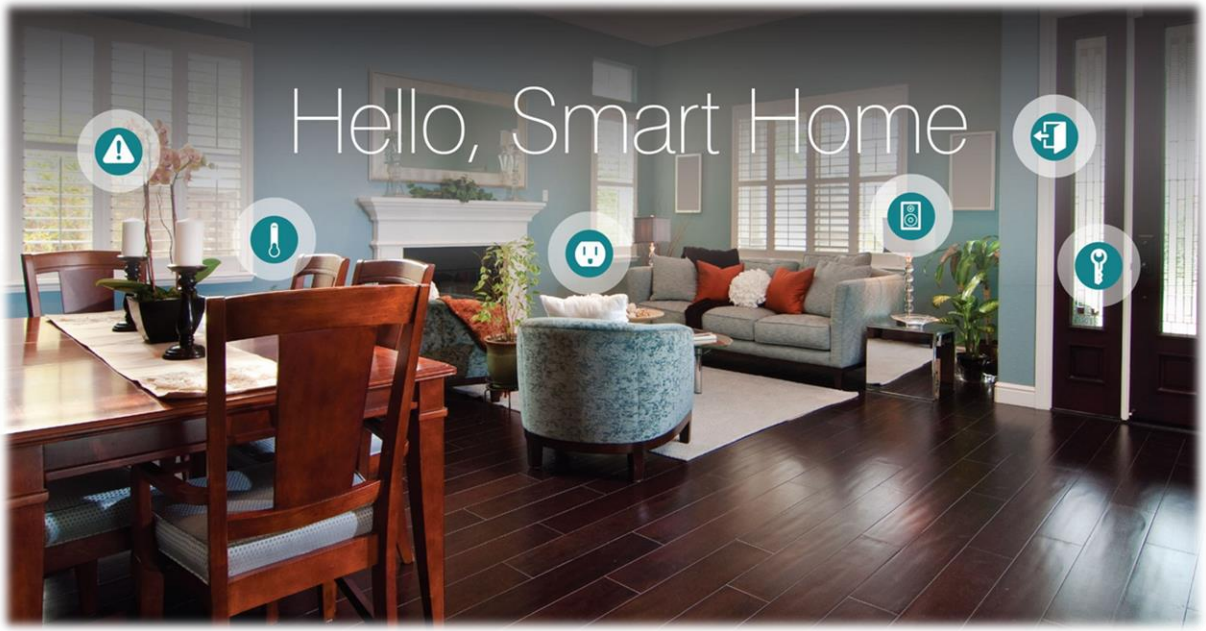
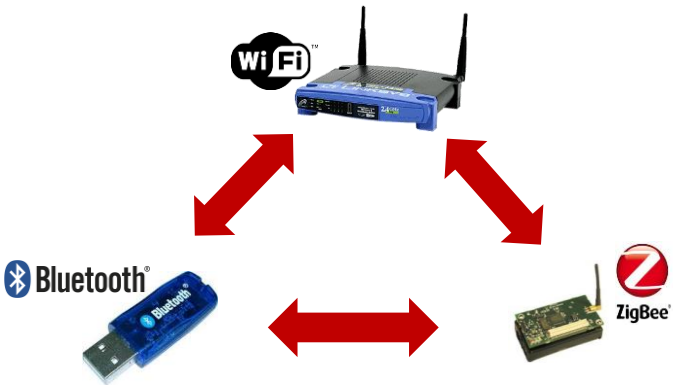
Wireless Coexistence

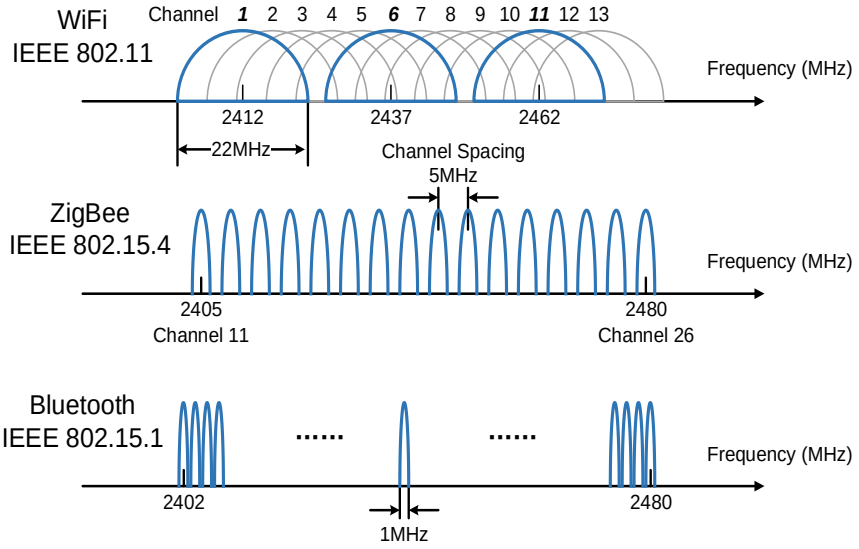
- Heterogeneous devices coexist
- Contention for the shared frequency resource
- Cooperation for smarter service



Interconnect Various Technologies

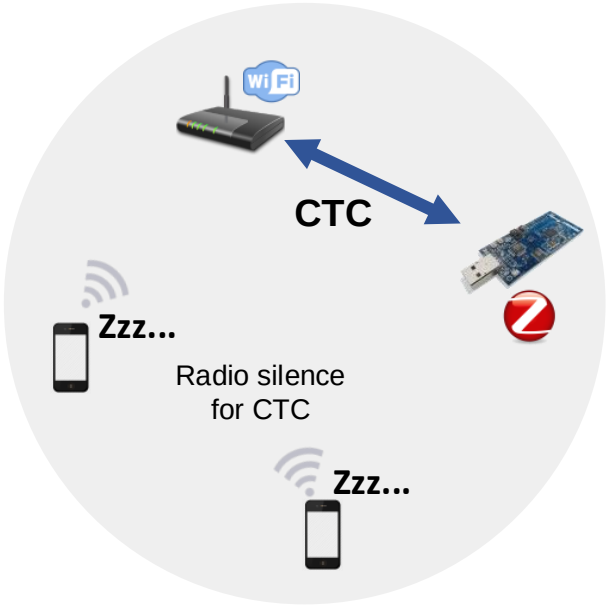
- Cross-technology Communication (CTC)
  - Emerging technique
  - Enable direct communication between heterogeneous wireless technologies

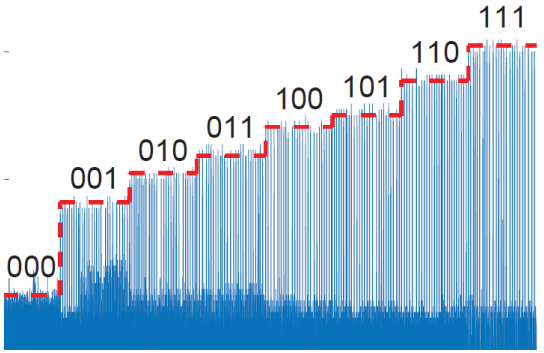




Existing CTC

- Packet-level CTC
  - Manipulating the packet amplitude, packet timing to build the side channel.
  - Require radio silence





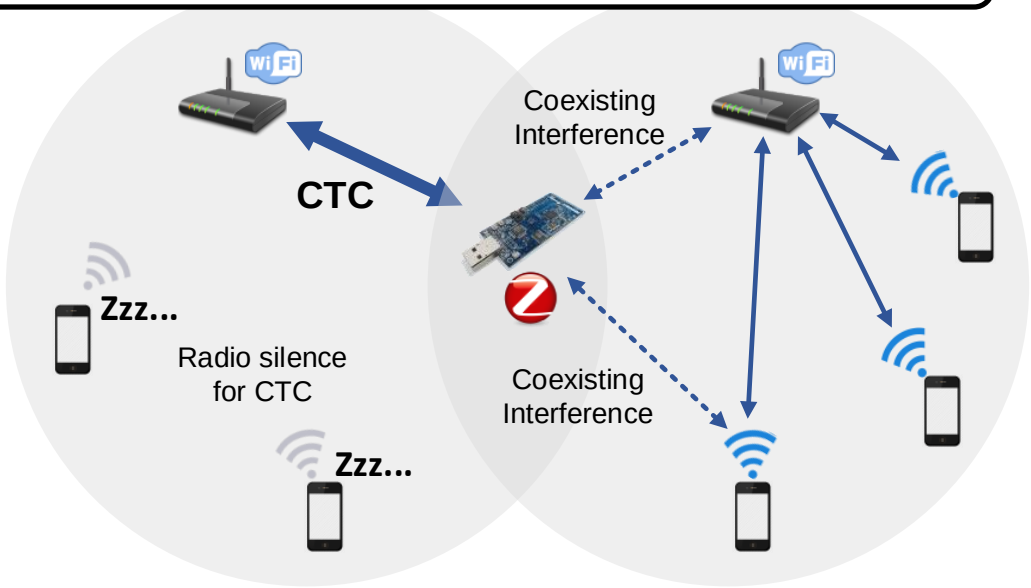
WiZig
Multiple energy levels

Energy modulation:
Packet presence → 1
Packet absence → 0

Motivation

- However…
  - Wireless coexistence
  - Hard to keep radio silence for all devices

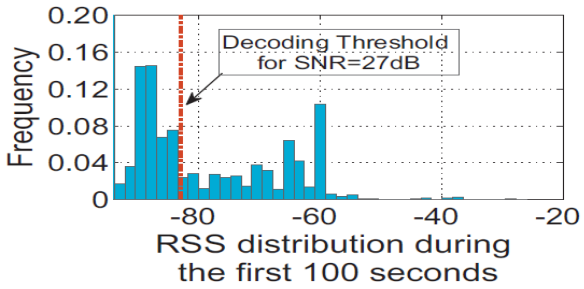
Coexisting interference will …?

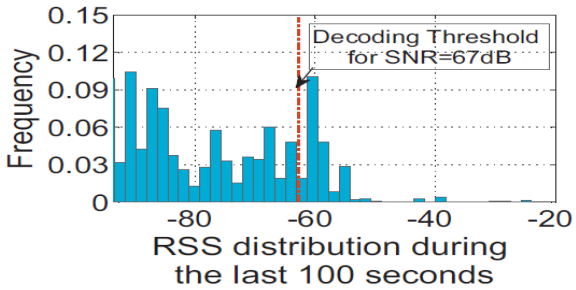


Energy modulation:
Packet presence → 1
Packet absence → 0

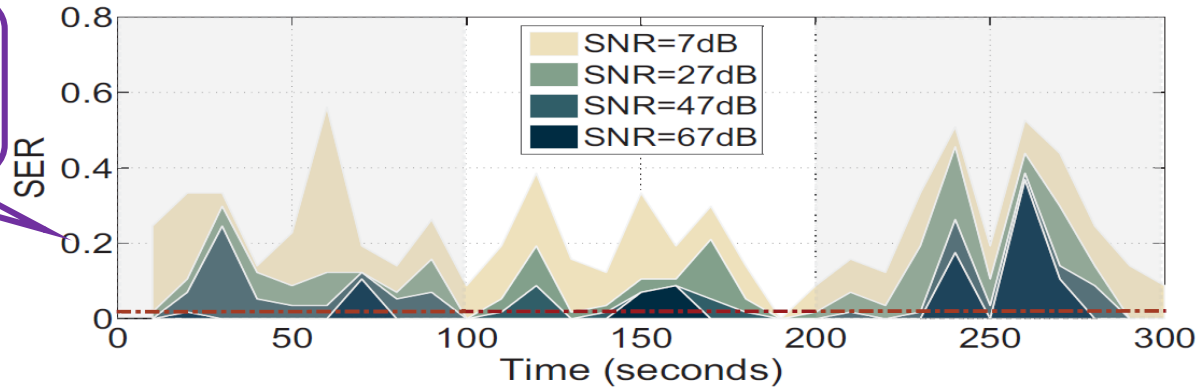
Motivation

- We study the performance of WiZig in an apartment
  - A CTC WiFi sender, a CTC ZigBee receiver
  - Uncontrolled ambient WiFi devices





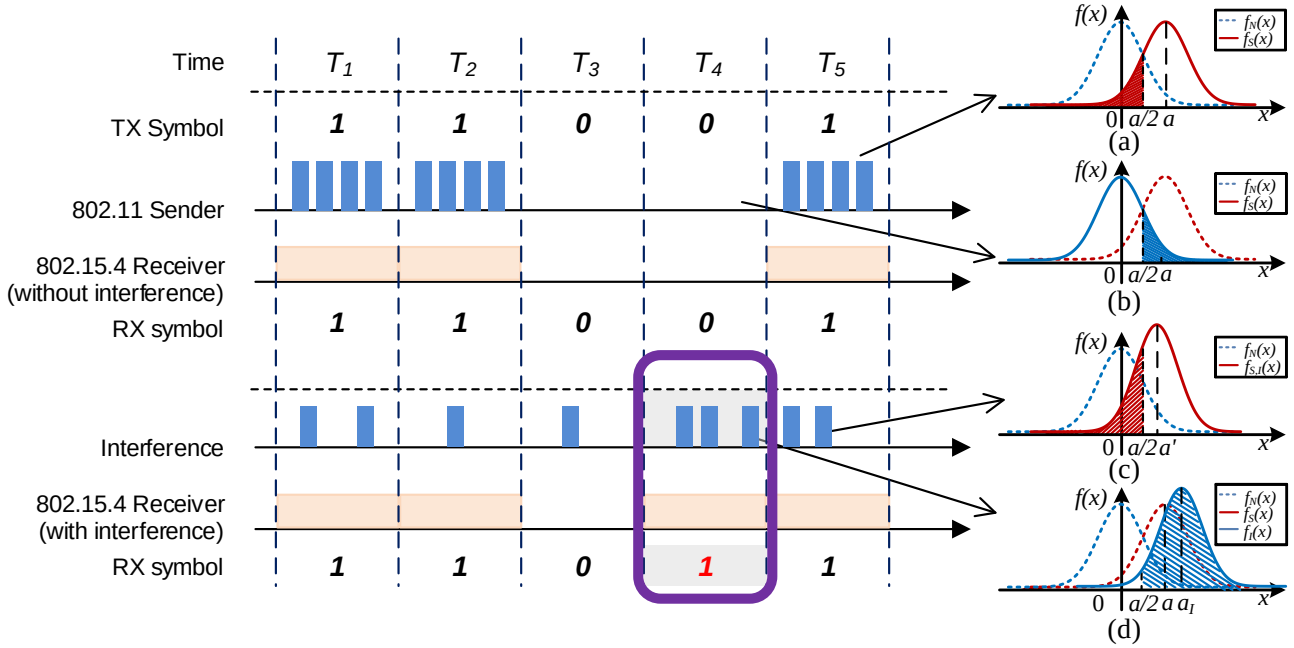
High SER
Low Throughput



SNR=CTC signal strength / channel noise + coexisting interference

Motivation

- Insight:
  - CTC rely on packet presence/absence, which is easily corrupted by the interference.



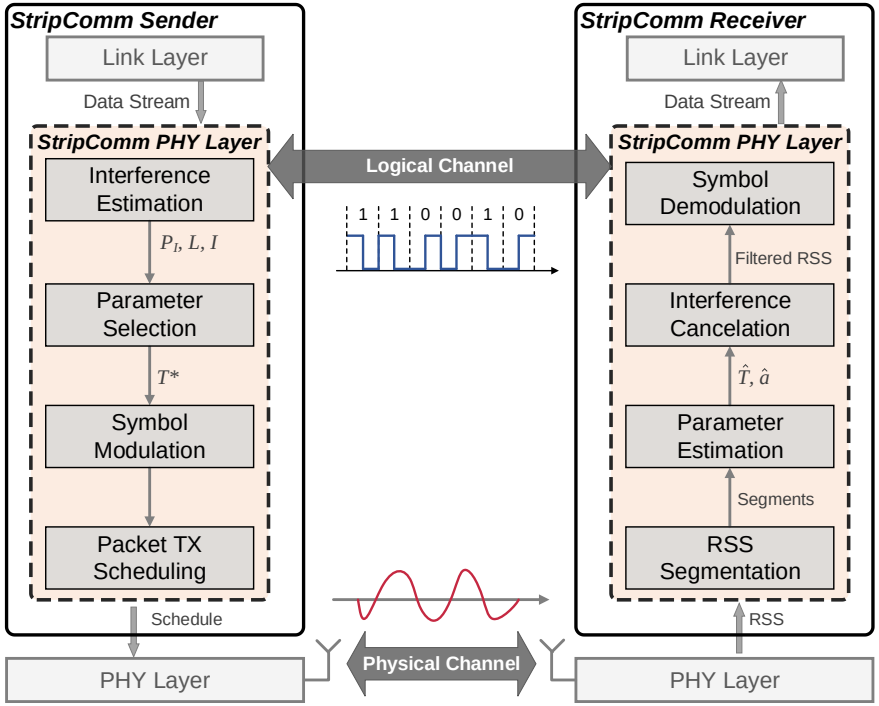
Interference leads to the false appearance of CTC packet presence

Outline

- Background & Motivation
- Design of StripComm
  - Interference-resilient coding
  - Interference-aware decoding
- Evaluation
- Conclusion

Design

- Goal: Interference-resilient CTC that achieves high throughput with low error rate even under coexisting interference.

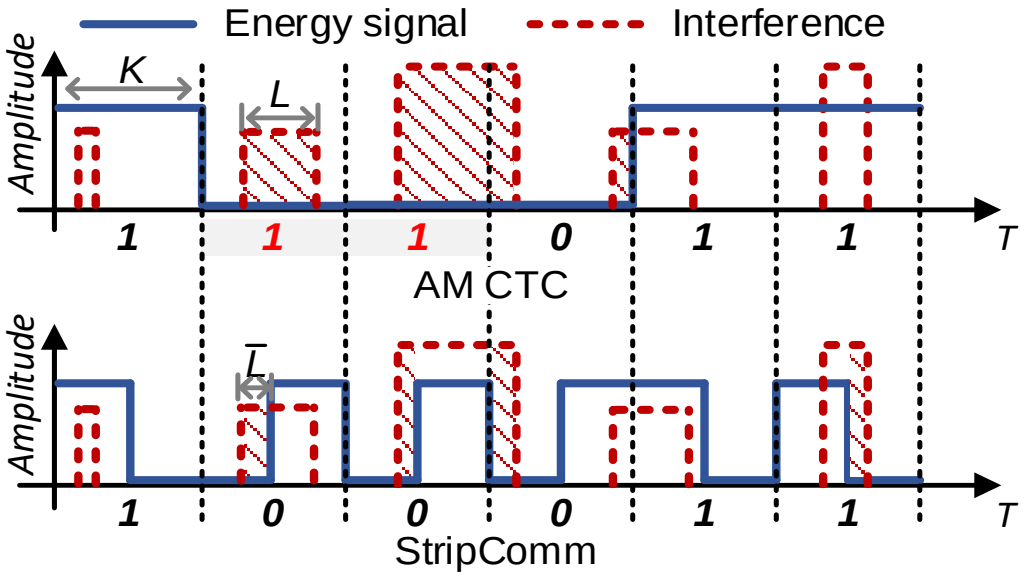


Interference-resilient coding

Interference-aware decoding

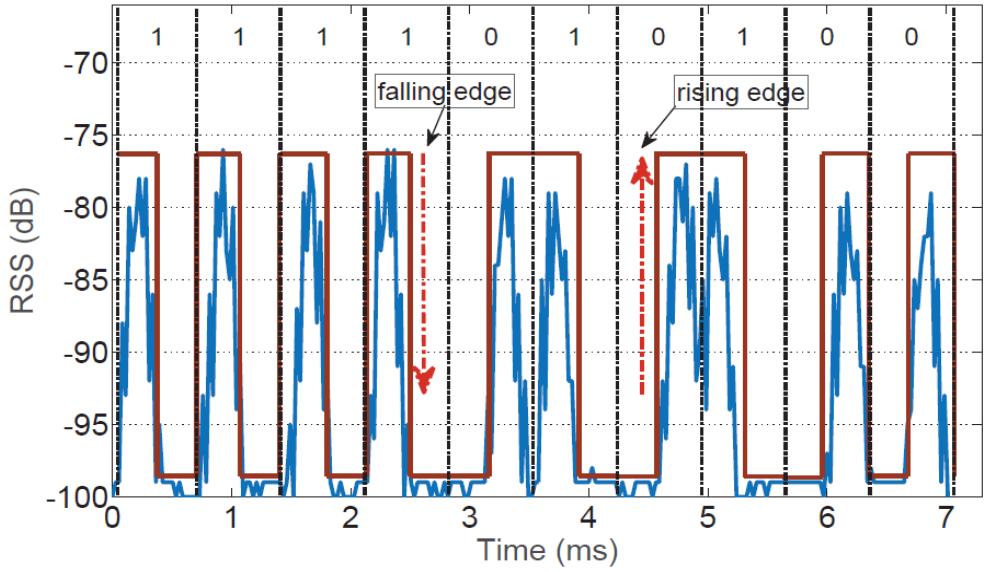
Interference-resilient coding

- Manchester Coding
  - Use *both packet presence (high) and absence (low)* to encode a symbol
  - Symbol 1: high then low
  - Symbol 0: low then high



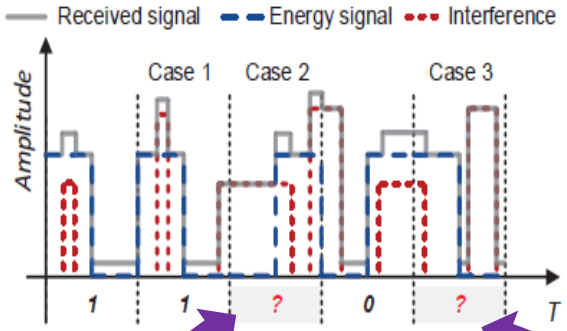
Interference-resilient coding

- StripComm defines a packet preamble to specify the start of a CTC packet
- StripComm sender controls the packet length and transmission timing, based on the encoded CTC symbols.

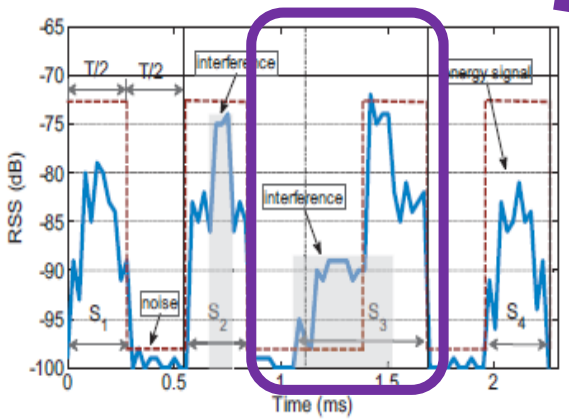


Interference-aware decoding

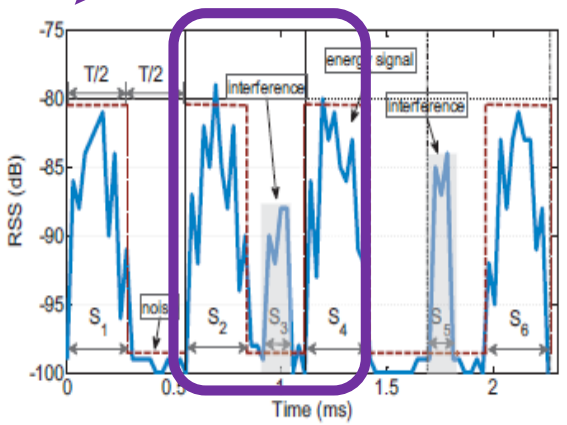
- Find falling and rising edges, and decode symbols by the "high then low" and "low then high" patterns of the RSS sequence.
- However, the segments' amplitude, length, interval can be corrupted.



Overlapped



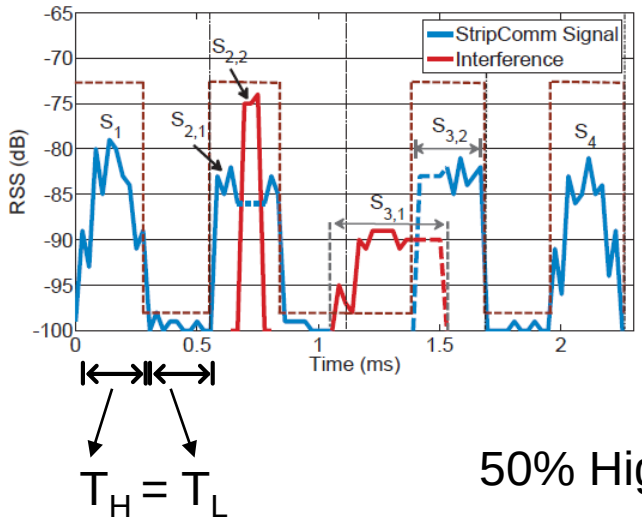
Inserted

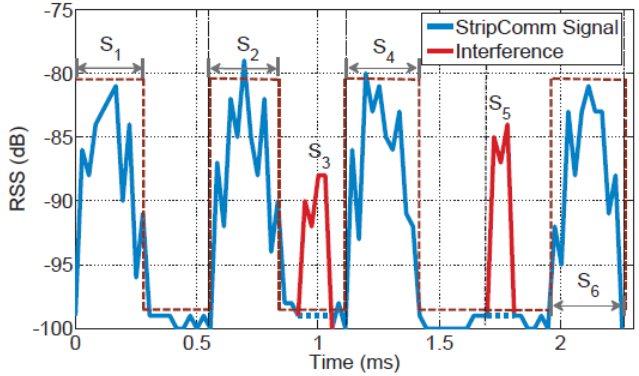


Interference-aware decoding

- Use *self similarity* to *strip interference* from the interested signal

Feature	Description	Self-similarity
DC_i	Duty cycle of the window containing S_i	Ratio similarity
T_i	Segment length of S_i	Time similarity
ISI_i	Inter-segment interval between S_i and the last segment marked as signal	
a_i	Average amplitude of segment S_i	Amplitude similarity
δ_i^a	Variance of the amplitudes ofS_i	





50% High, 50% Low

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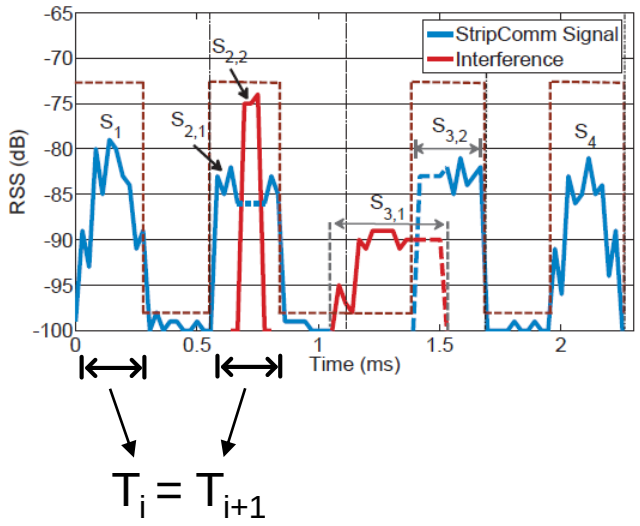

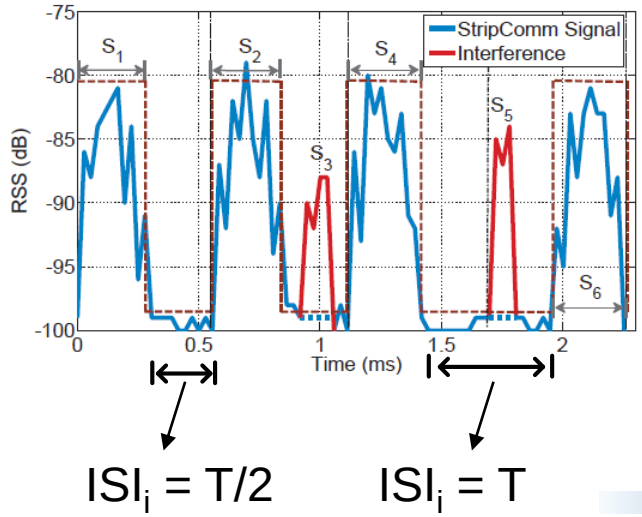

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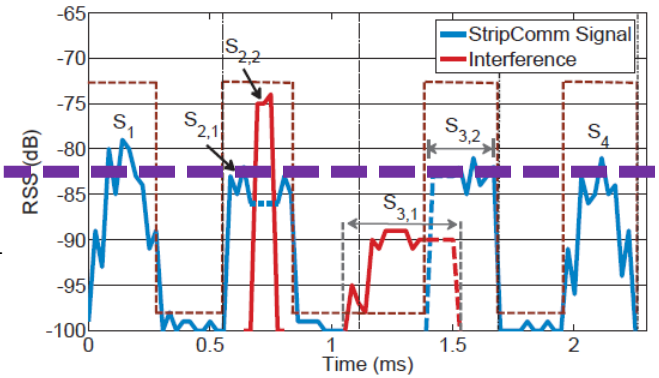
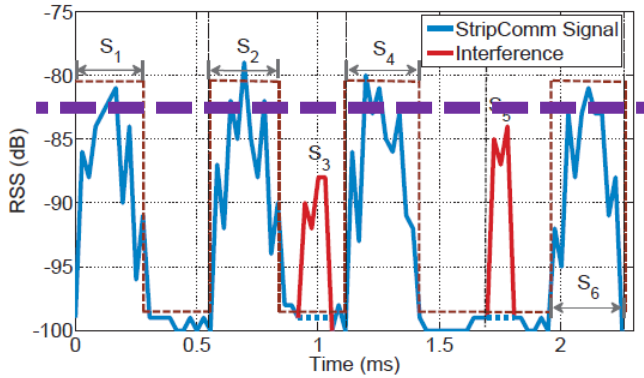
$a_i \approx a_{i+1}$
$\delta_i^a \approx \delta_{i+1}^a$





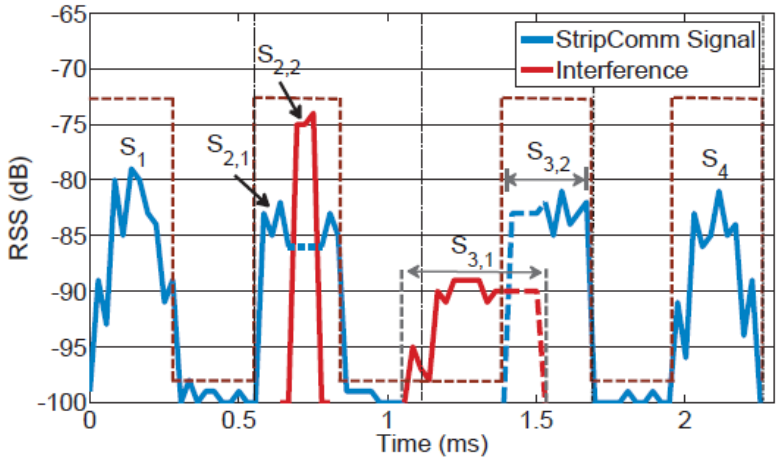
$a_i \approx a_{i+1}$
$\delta_i^a \approx \delta_{i+1}^a$

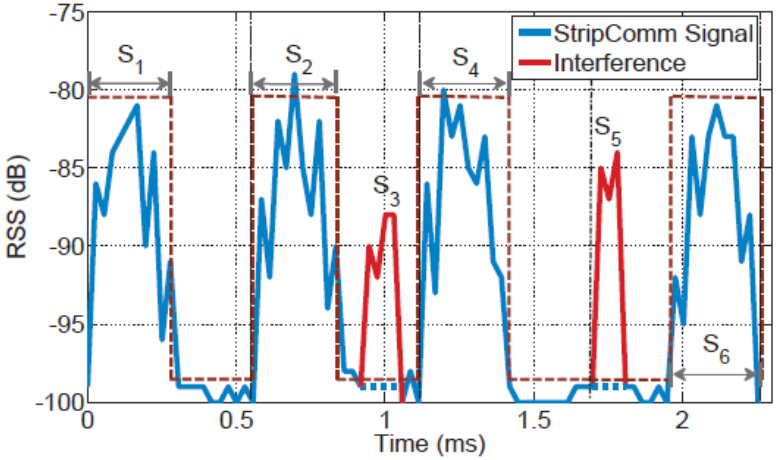
Packets experience similar channel conditions in a short time,

$$a_i \approx a_{i+1} \qquad \delta_i^a \approx \delta_{i+1}^a$$

Interference-aware decoding

- Use *self similarity* to *strip interference* from the interested signal





- Decode the symbols from the processed RSS sequence (blue sequences)

Outline

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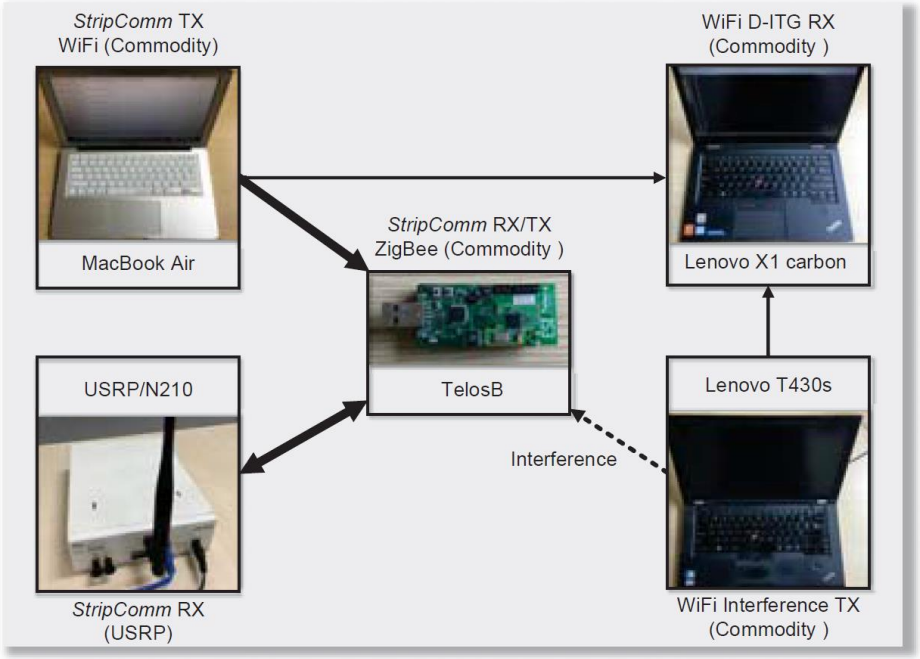
Evaluation

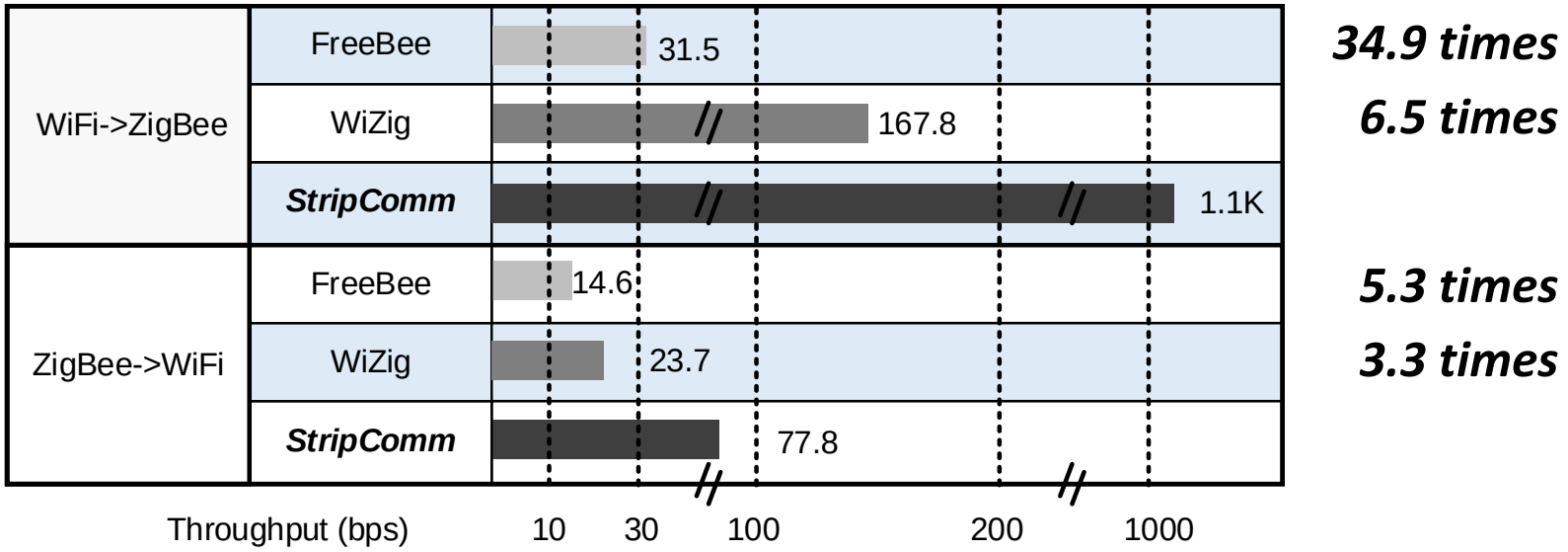
- Setup
  - ZigBee: TelosB (raido: cc2420)
  - WiFi: commercial laptops, D-ITG traffic generator

    USRP/N210
- Environments:
  - Office and lab



Overall Performance

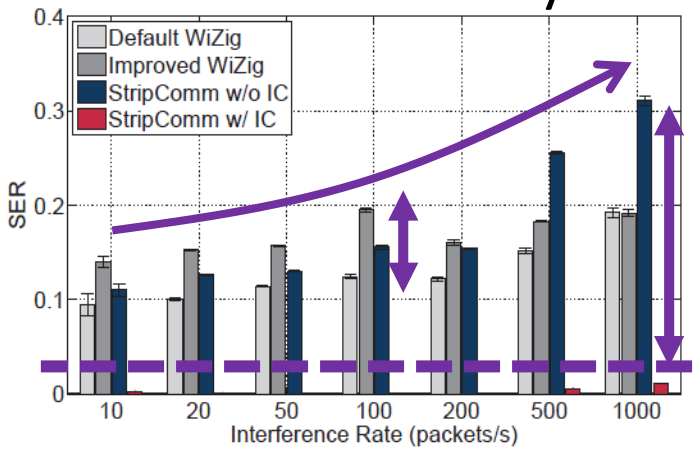
- Throughput
  - When Symbol Error Rate (SER) < 0.01
- WiFi -> ZigBee: 1.1Kbps, *6.5X* higher than the state-of-the-art
- ZigBee - > WiFi: 77,8bps, *3.3X* higher than the state-of-the-art



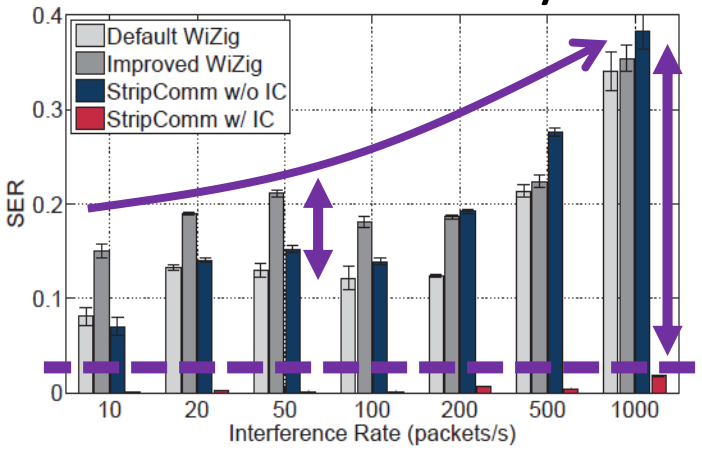
Performance under Interference

➢SER vs. Interference rate (packets/second)

Packet size = 50bytes



Packet size = 1000bytes



(1) With interference rate increases, SER increases;

(2) Stripcomm has a low SER;

(3) Interference-resilient coding can conquer partial interference;

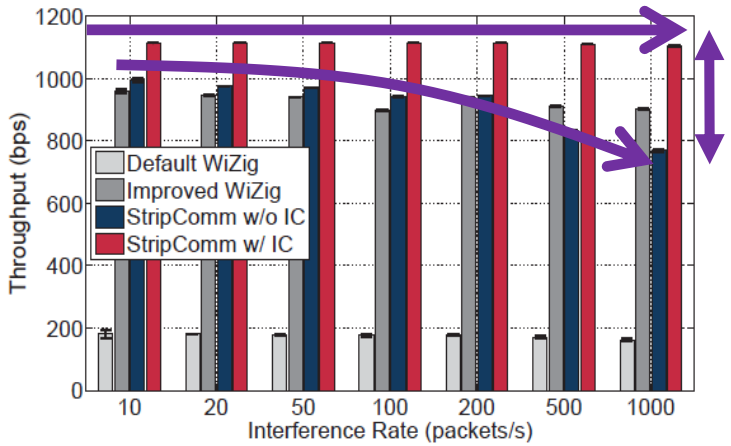
(4) Interference-aware decoding can solve most of the interference.

Performance under Interference

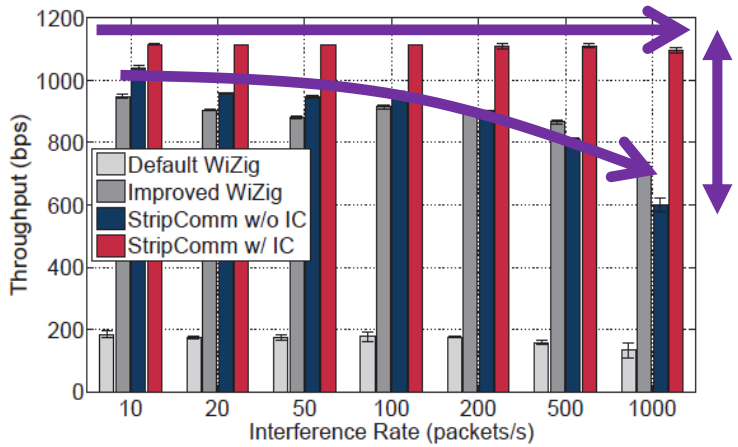
- Throughput vs. Interference rate (packets/second)

(1) With interference rate increases, throughput decreases;
(2) Stripcomm has relative stable throughput due to the low SER;
(3) Interference-aware decoding significantly improves the throughput.

Throughput



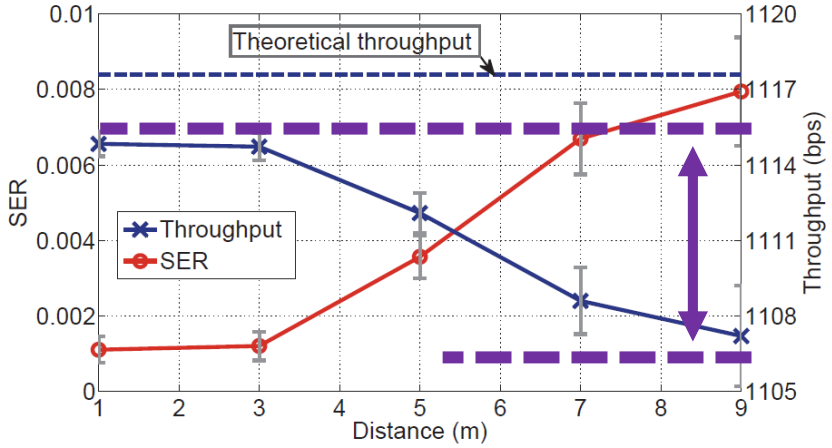
Packet size = 50bytes



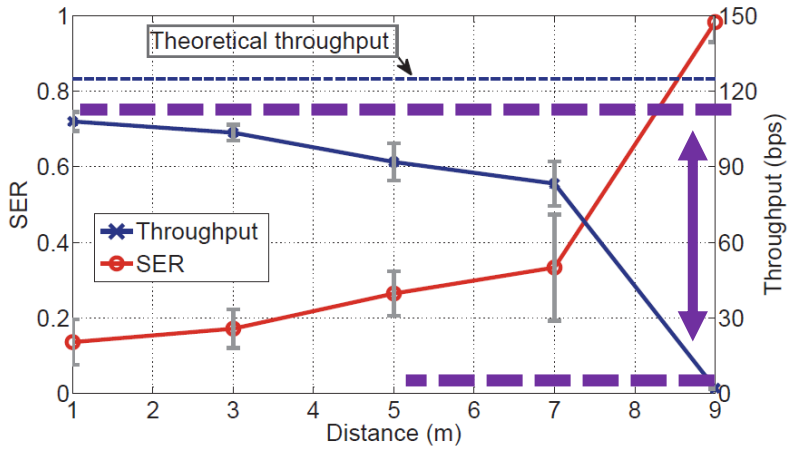
Packet size = 1000bytes

Performance vs. Distance

- Distance between the sender and receiver



StripComm from WiFi to ZigBee



StripComm from ZigBee to WiFi

(1) From WiFi to ZigBee, throughput decreases slightly;

(2) From ZigBee to WiFi, throughput decreases significantly;

(3) StripComm from ZigBee to WiFi is more sensitive to distance than from WiFi to ZigBee due to the high TX power of WiFi.

Conclusion

- We present StripComm, an ***interference-resilient*** CTC.
- We design the ***interference-resilient coding*** method and the ***interference-aware decoding*** method.
- We evaluate StripComm under various experimental settings.
  - Results demonstrate StripComm can achieve the throughput up to ***1.1Kbps***, ***6.5X*** higher than the state-of-the-art.

StripComm

Interference-resilient Cross-technology Communication in Coexisting Environments

Thank you!

Q & A