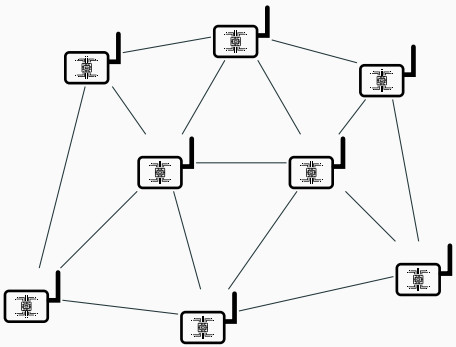
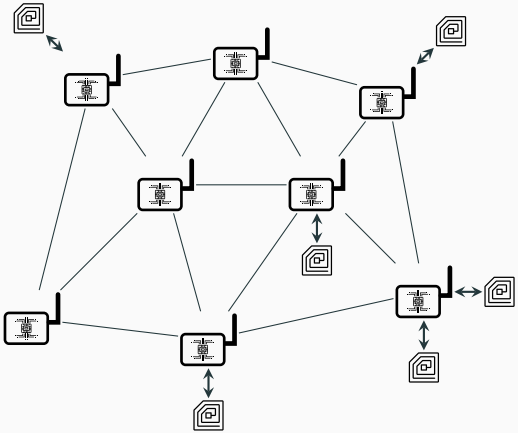
TagAlong: Efficient Integration of Battery-Free Sensor Tags in Standard Wireless Networks

Carlos Pérez-Penichet Diliushi Piumwardane Christian Rohner Thiemo Voigt

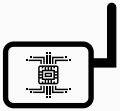
Attractive Applications



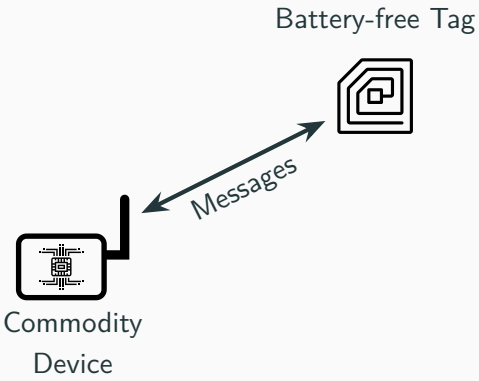
Attractive Applications

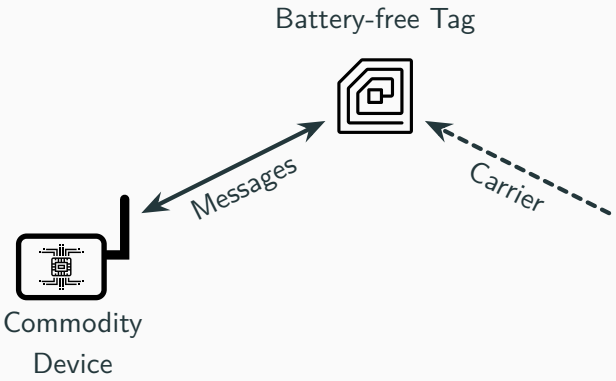


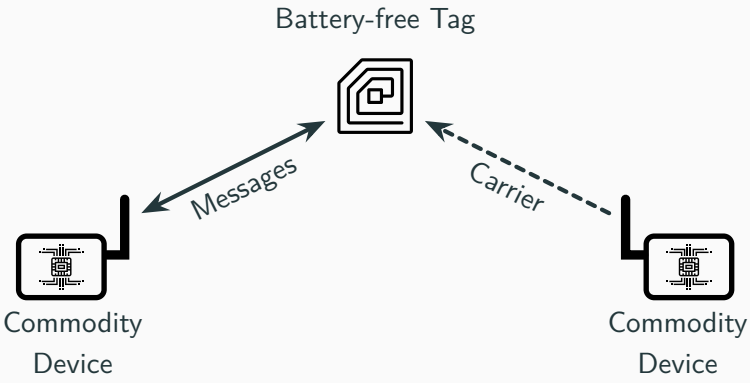
Battery-free Tag



Commodity
Device


Battery-free Tag
Messages
Commodity
Device


Battery-free Tag
Messages
Carrier
Commodity
Device


Battery-free Tag
Messages
Carrier
Commodity
Device
Commodity
Device

Challenges

Energy

Latency

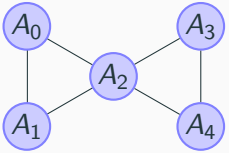
Interference

TagAlong

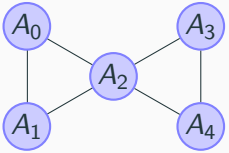
TagAlong

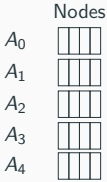
- Parallelize interrogations
- Share carrier generators when possible
- Synchronize tag interrogations

System Model

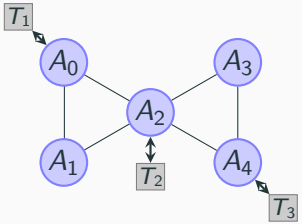


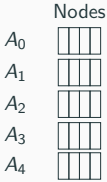
System Model





System Model





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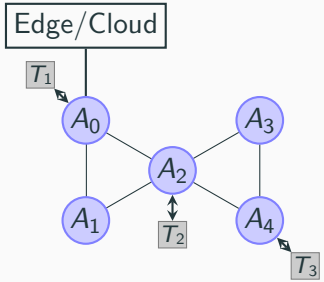

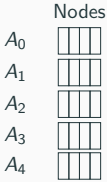

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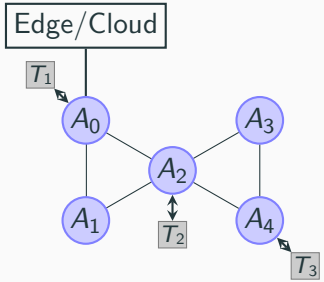
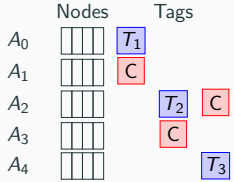
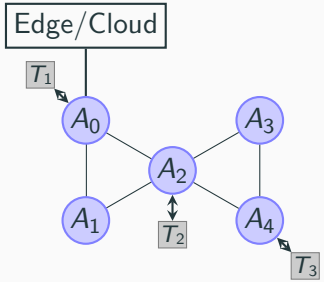
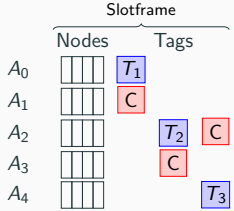


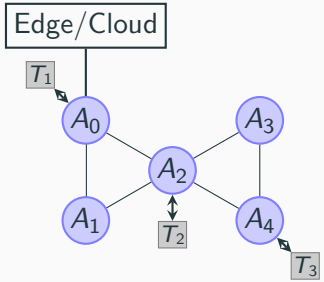


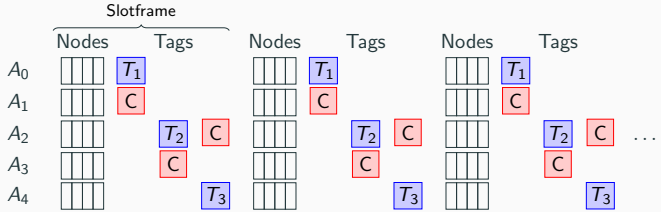
System Model



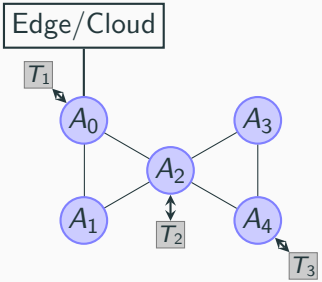


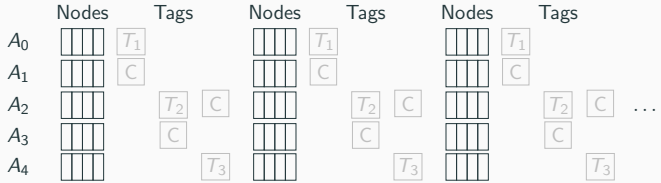
System Model



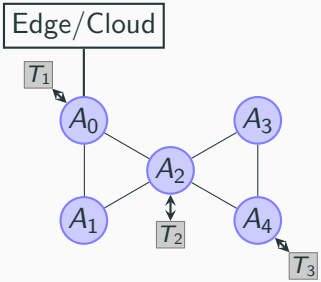


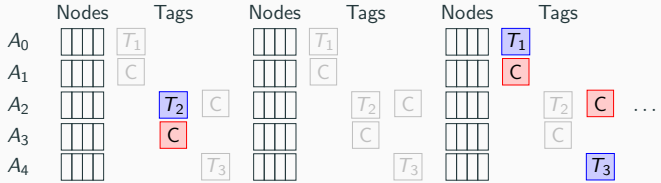
System Model



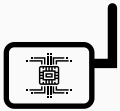


System Model

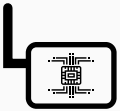




Tag Interrogation

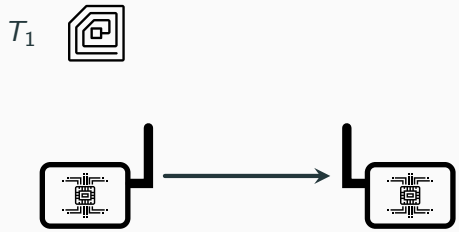


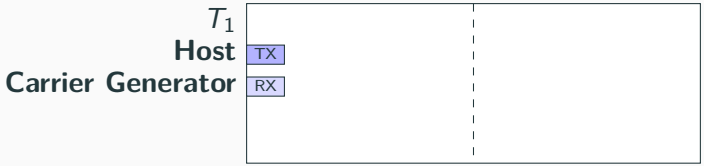
Host



Carrier Generator

Tag Interrogation





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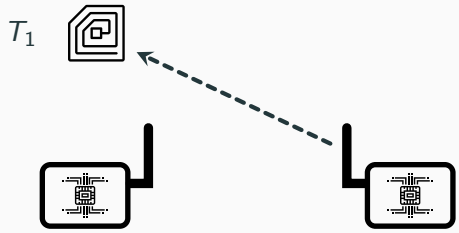

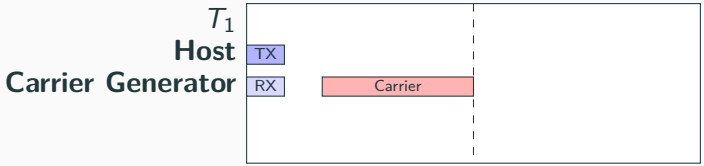

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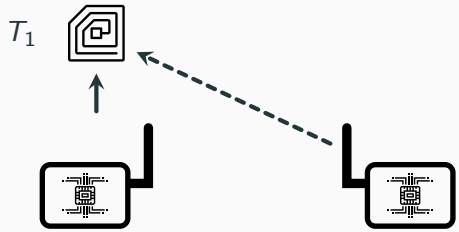

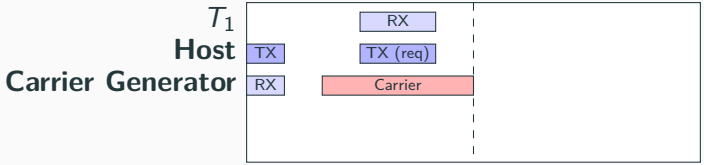

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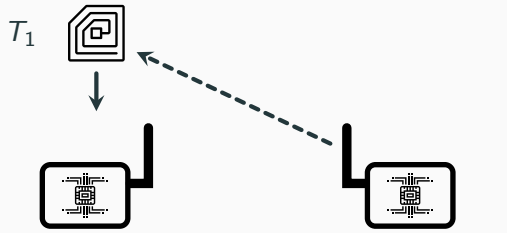
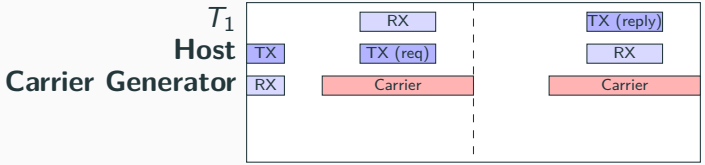
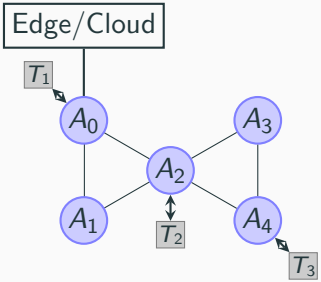
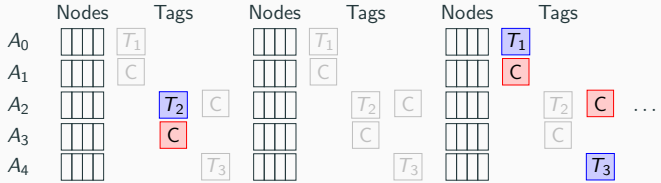


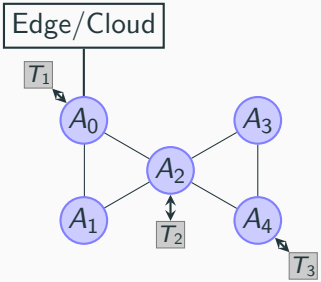


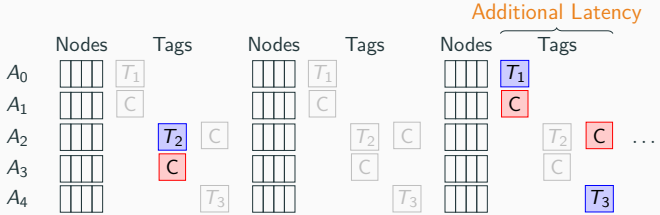
System Model





System Model





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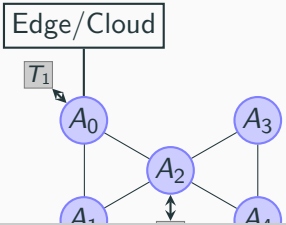
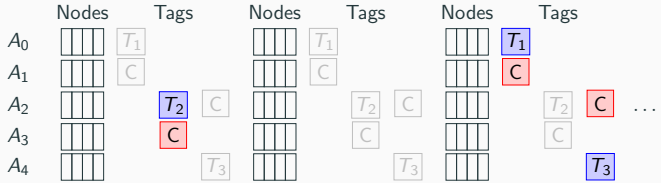
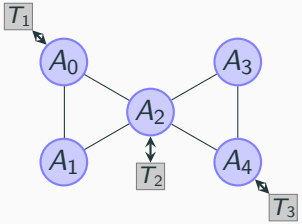


Must reduce length of tags' schedule

. . . to minimize energy, latency and spectum overhead



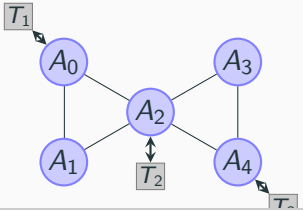
Example



Sequential Schedule

cycle	1	2	3
A_0	T_1		
A_1	C		
A_2		T_2	C
A_3		C	
A_4			T_3

Example



Share carrier generators

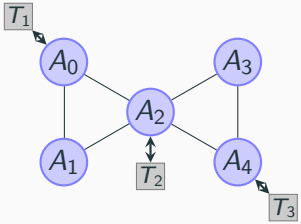
. . . to save energy, time and spectrum

Sec

cycle

A_0	T_1			
A_1	C			
A_2		T_2	C	
A_3		C		
A_4			T_3	

Example



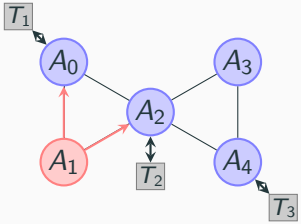
Sequential Schedule

cycle	1	2	3
A_0	T_1		
A_1	C		
A_2		T_2	C
A_3		C	
A_4			T_3

TagAlong's Schedule

cycle	1	2	3
A_0	T_1		
A_1	C		
A_2	T_2		
A_3		C	
A_4		T_3	

Example



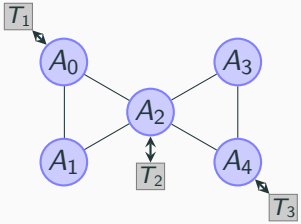
Sequential Schedule

cycle	1	2	3
A_0	T_1		
A_1	C		
A_2		T_2	C
A_3		C	
A_4			T_3

TagAlong's Schedule

cycle	1	2	3
A_0	T_1		
A_1	C		
A_2	T_2		
A_3		C	
A_4		T_3	

Example



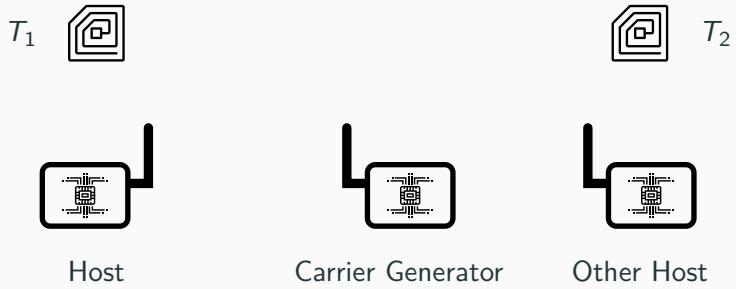
Sequential Schedule

cycle	1	2	3
A_0	T_1		
A_1	C		
A_2		T_2	C
A_3		C	
A_4			T_3

TagAlong's Schedule

cycle	1	2	3
A_0	T_1		
A_1	C		
A_2	T_2		
A_3		C	
A_4		T_3	

Tag Interrogation



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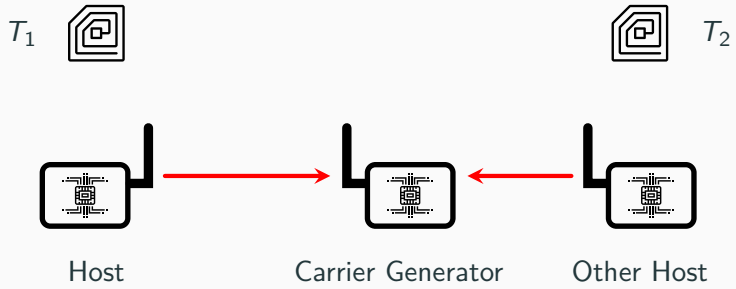

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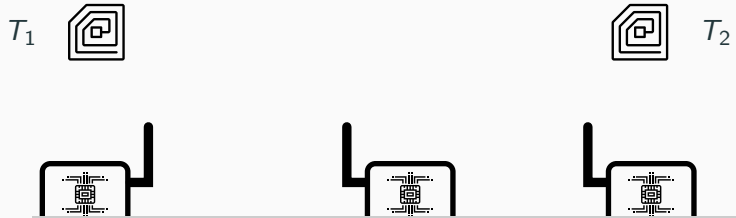
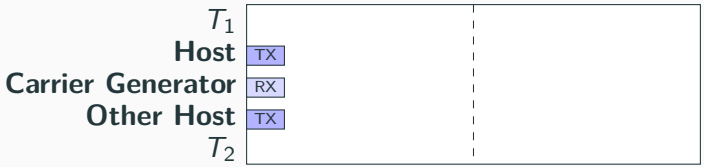


Unmodulated carrier as carrier request

avoids collissions in shared carrier generators



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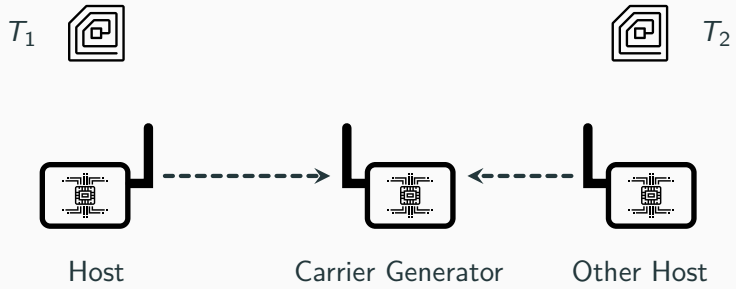

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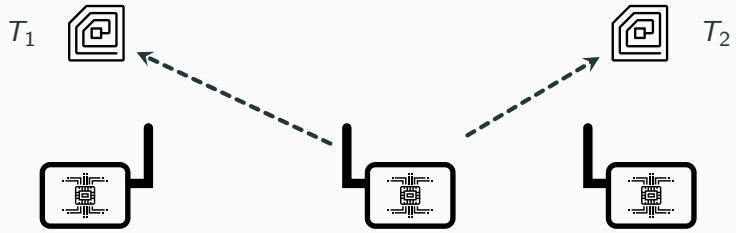

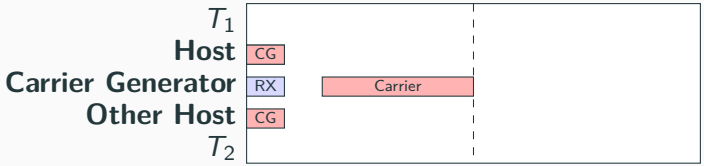

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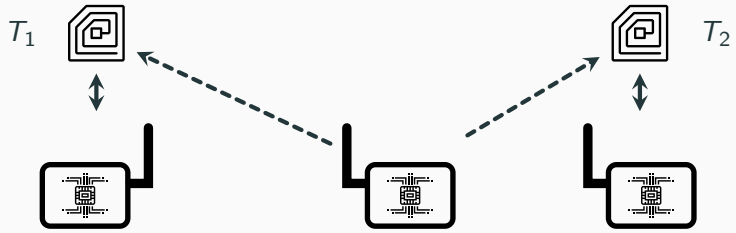
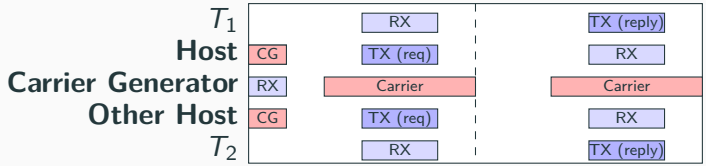
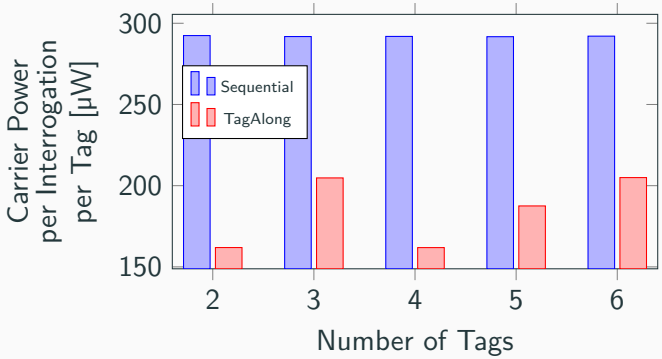




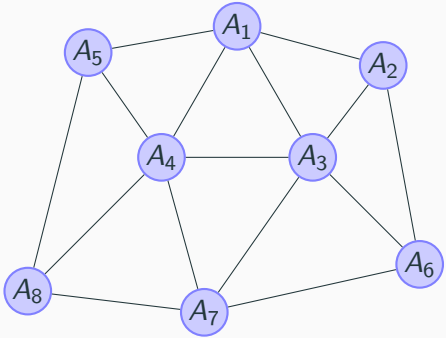
System Overview

1. Collect network topology in cloud/edge
2. Compute schedule with constraint solver
3. Disseminate new schedule

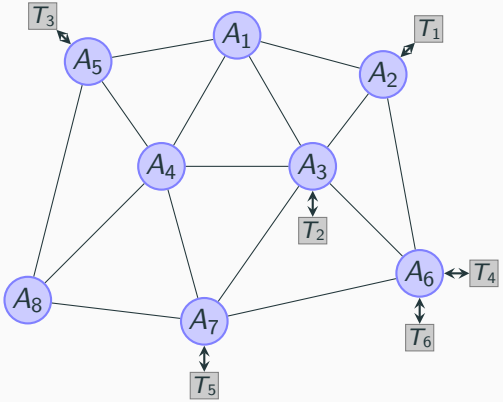
Power


Carrier Power per Interrogation per Tag [μW]
300
250
200
150
Sequential
TagAlong
2
3
4
5
6
Number of Tags

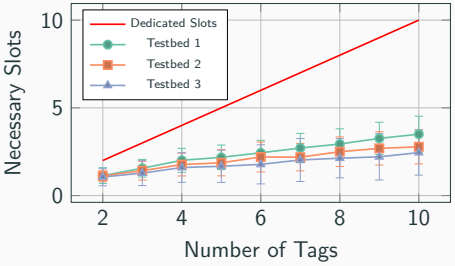
With Real Testbed Topologies

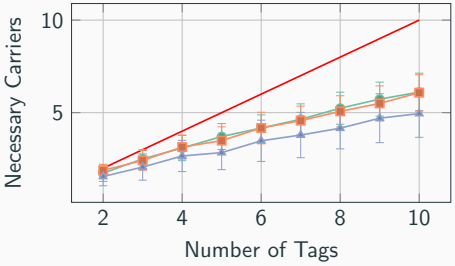


With Real Testbed Topologies



With Real Testbed Topologies





Conclusions

1. First system to coordinate carriers for battery-free devices
2. Implemented and tested in real testbed
3. Optimizes latency, energy consumption and spectrum usage

Thank You