

Mobile Tagging (2)

CSE 162 – Mobile Computing

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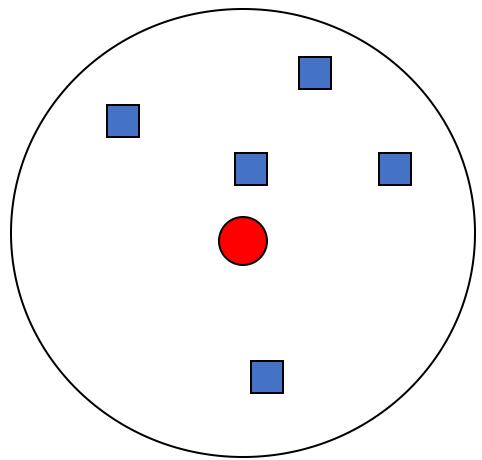
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Collision Avoidance in RFID

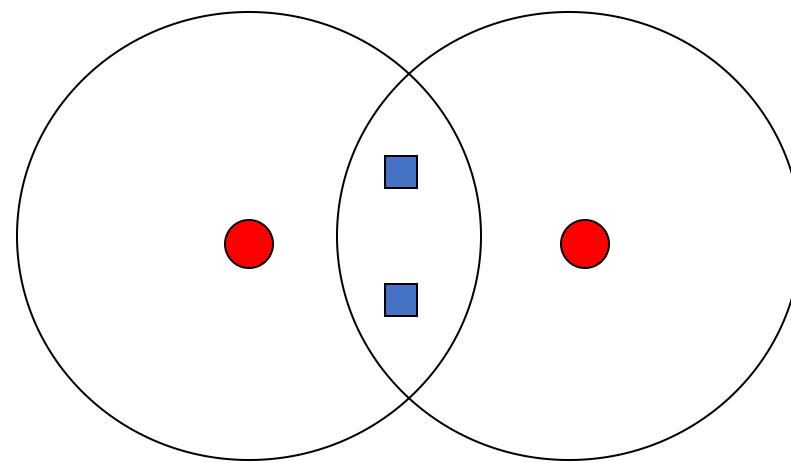
- Tag collision
- Reader collision

Tag collision



Probability-based
Deterministic-based (Prefix-based)

Reader collision



Centralized
Distributed

Tag-to-Tag Collision Avoidance

Tag Collision Problem

When multiple tags are in range of the reader:

- All the tags will be excited at the same time.
- Makes it very difficult to distinguish between the tags.

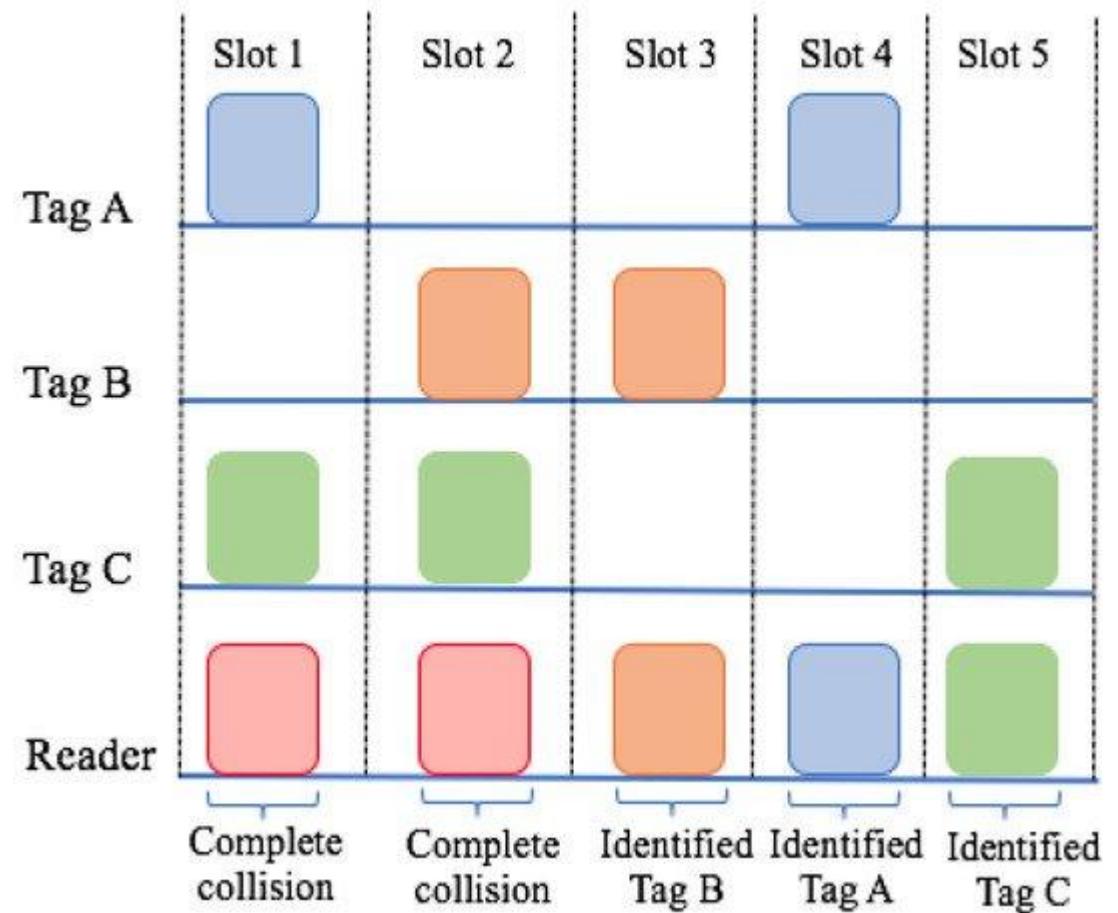
Tag Collision Problem

- Collision avoidance mechanisms:
 - Probabilistic: Tags return at random times.
 - Deterministic: Reader searches for specific tags.

Aloha Algorithm

Tag Collision avoidance: ALOHA

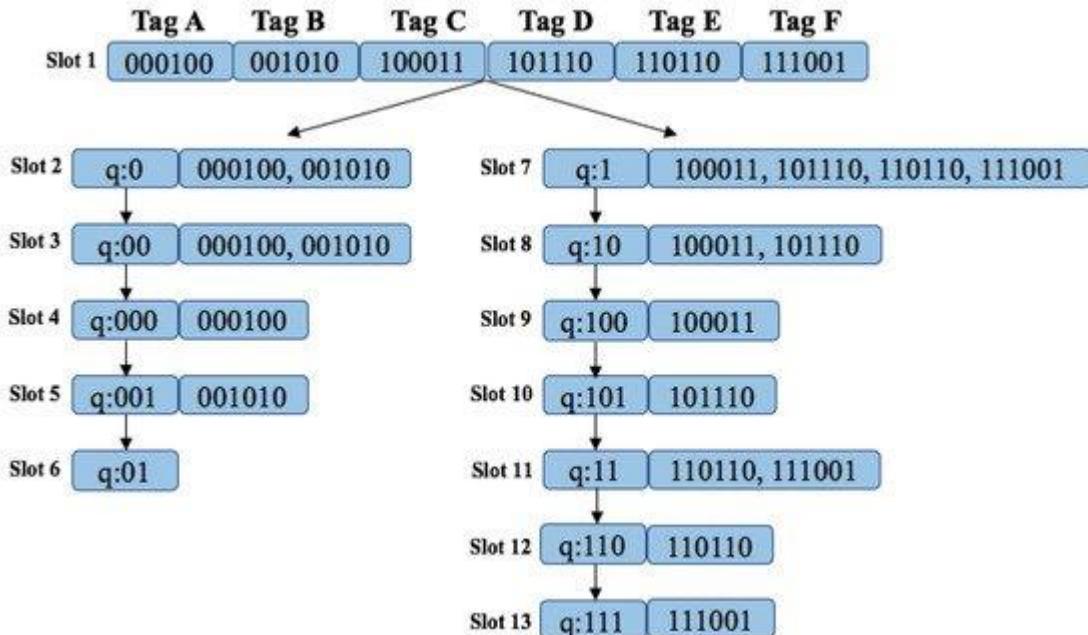
- Tags detect when a collision has occurred, and attempt to resend after waiting a random interval.
- Pros: simple
- Cons: when tags are dense, the network can reach congestion collapse.



Query Tree

Query Tree

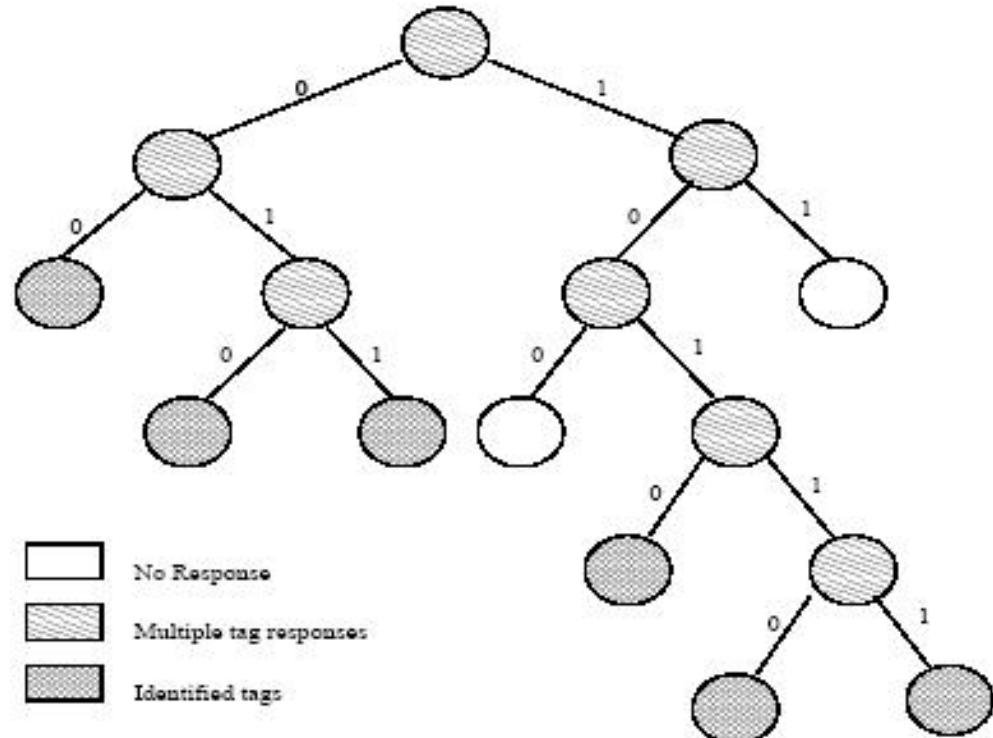
- Assumption: tagID stored in k bit binary string
- Algorithm
 - Reader queries for prefix of length p
 - In case of collision queries prefix of length $p+1$



Query Tree– Example

- Reader queries for prefix of length p
- In case of collision, reader queries for prefix of length $p+1$
- Example: consider tags with prefixes: 00111, 01010, 01100, 10101, 10110 and 10111

Step	Query Prefix	Response
1	0	Collision
2	1	Collision
3	00	00111 (Identified)
4	01	Collision
5	10	Collision
6	11	No Response
7	010	01010 (Identified)
8	011	01100 (Identified)
9	100	No Response
10	101	Collision
11	1010	10101 (Identified)
12	1011	Collision
13	10110	10110 (Identified)
14	10111	10111 (Identified)



Query Tree - Pros and Cons

- Pros
 - Simple
 - Bounded Query time
- Cons
 - Require prior knowledge about the tags
 - It can be unavailable

Binary Search Protocol

Binary Search Protocol

- Reader transmitting a serial number from the reader to all the tags in the interrogation area.
- Only tags which have an equal or lower ID value than the received serial number will respond to the request
- The reader checks the tags' responses bit by bit using Manchester coding and if a collision is detected, the reader divides the tags into subsets based on the collided bits.
 - Requirement: the reader can detect which bit has collisions
- Benefit: no prior knowledge about the Tag IDs is required

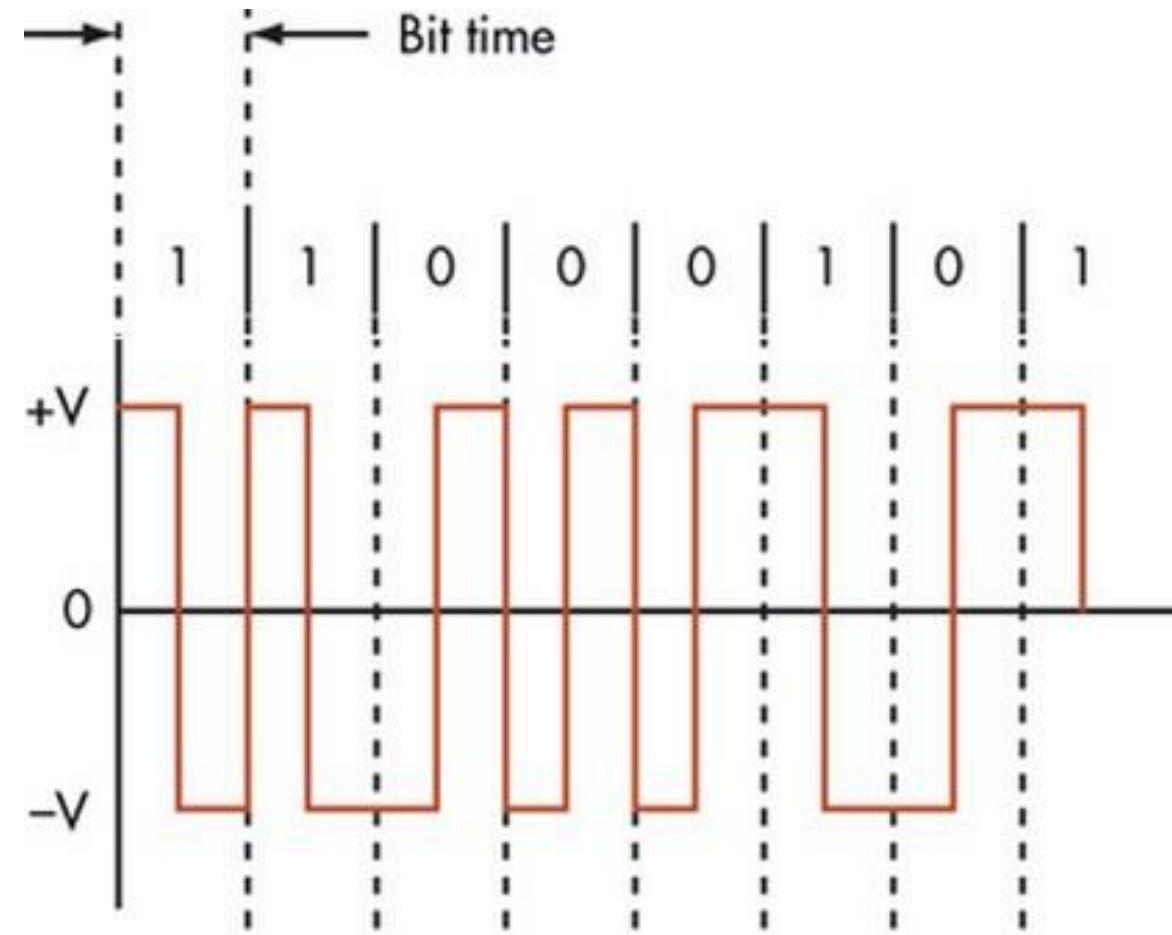
Binary Search Protocol

Slot Number	Reader Command	Tag A (010)	Tag B (011)	Tag C (100)	Tag D (110)	Result	Type of Slot
Slot 1	111	010	011	100	110	XXX	Collision
Slot 2	011	010	011			01X	Collision
Slot 3	010	010				010	Success
Slot 4	111		011	100	110	XXX	Collision
Slot 5	011		011			011	Success
Slot 6	111			100	110	1X0	Collision
Slot 7	101			100		100	Success
Slot 8	111				110	110	Success

- The reader begins by interrogating tags with the maximum ID value 111. Tags with a value of less than 111 will respond to the query. Their answer results in collision XXX
- In the next slot, the reader transmits a new query by replacing the most significant collided bit (MSB) with a 0. The reader transmits a new query, 011, and all tags compare their ID with the received value. Communication in this slot again results in a collision (01X).
- In the third slot, the reader replaces the third bit of the command with a 0 and transmits the next query, 010. In the new interrogation round (slot 3) only Tag A has a value equal to or lower than 010, and therefore it is successfully identified.
- After this slot, the reader restarts the query value with the initial value 111 and transmits it. This procedure is repeated until all of the tags are identified.

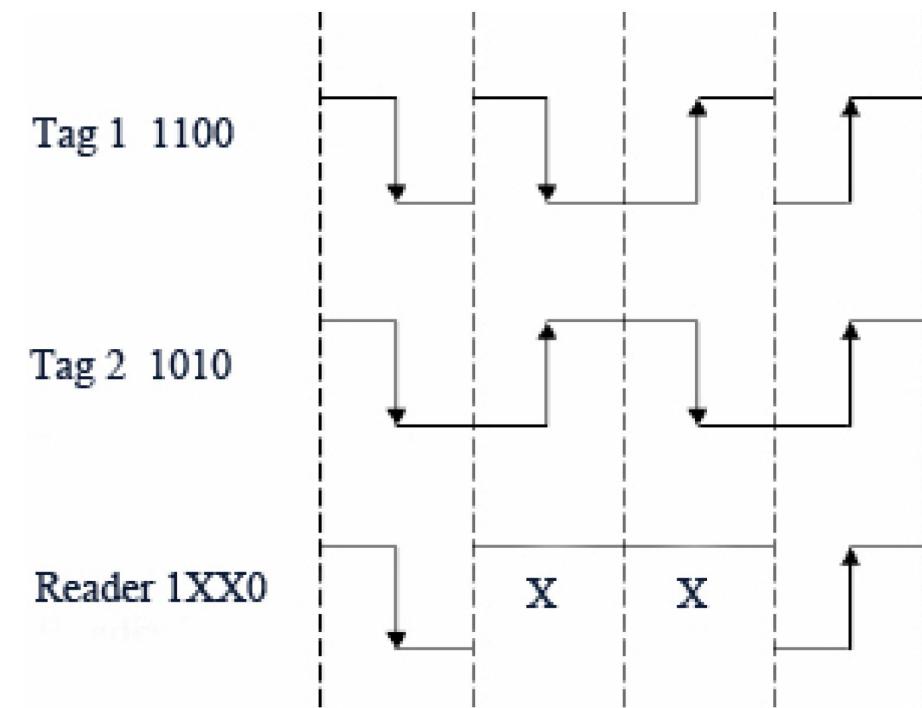
Manchester Coding

- High to Low transition is mapped as binary logic-1
- Low to High transition is mapped as binary logic-0
- Transition occurs exactly in the middle of bit period.



Collision Detection in Manchester Coding

- When two tags respond with different data, abnormal signals can be detected



Memoryless Algorithm

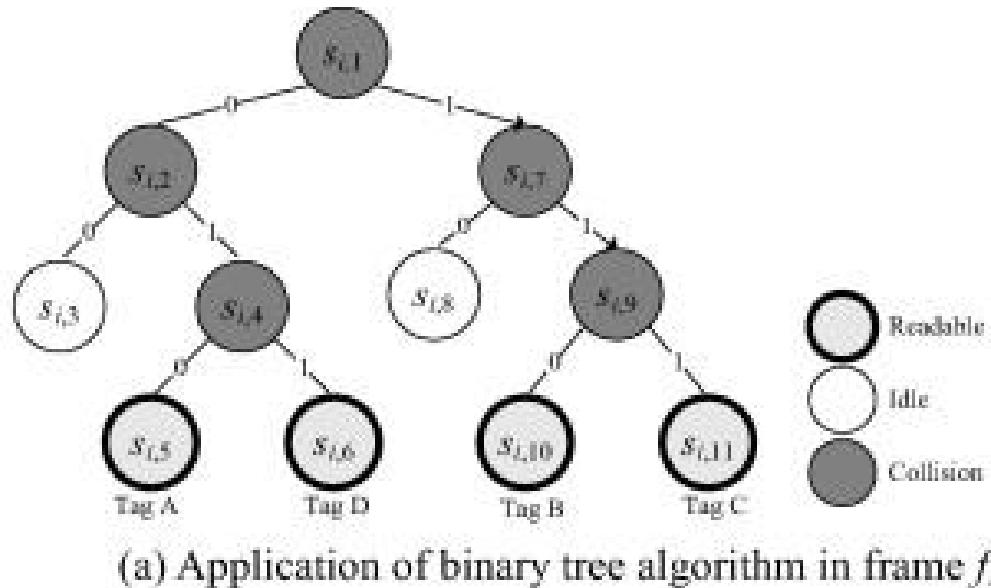
Memoryless Algorithm

Can be applied when the reader does not know all the IDs

- Reader queries for tags
- Reader informs in case of collision and tags generates 0 or 1 randomly
- If 0 then tag retransmits on next query
- If 1 then tag becomes silent and starts incrementing its counter (which is initially zero)
- Counter incremented every time collision reported and decremented every time identification reported
- Tag remains silent till its counter becomes zero

Example

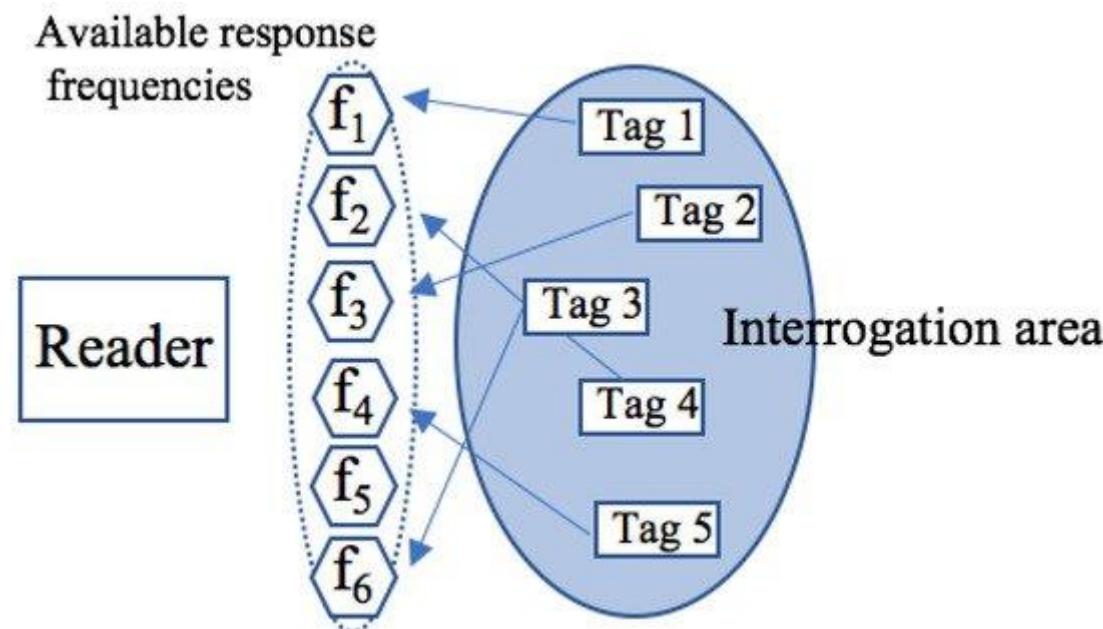
- Reader informs tags in case of collision and tags generate 0 or 1 randomly
- If 0 then tag retransmits on next query, else tag becomes silent and starts a counter.
- Counter incremented every time collision reported and decremented otherwise.



Slot	Counter value					Responding tag	Feedback message
	Reader	Tag A	Tag B	Tag C	Tag D		
1	0	0	0	0	0	A,B,C,D	Collision
2	1	0	1	1	0	A,D	Collision
3	2	1	2	2	1		Idle
4	1	0	1	1	0	A,D	Collision
5	2	0	2	2	1	A	Readable
6	1		1	1	0	D	Readable
7	0		0	0		B,C	Collision
8	1		1	1			Idle
9	0		0	0		B,C	Collision
10	1		0	1		B	Readable
11	0			0		C	Readable
12	-1						Terminate

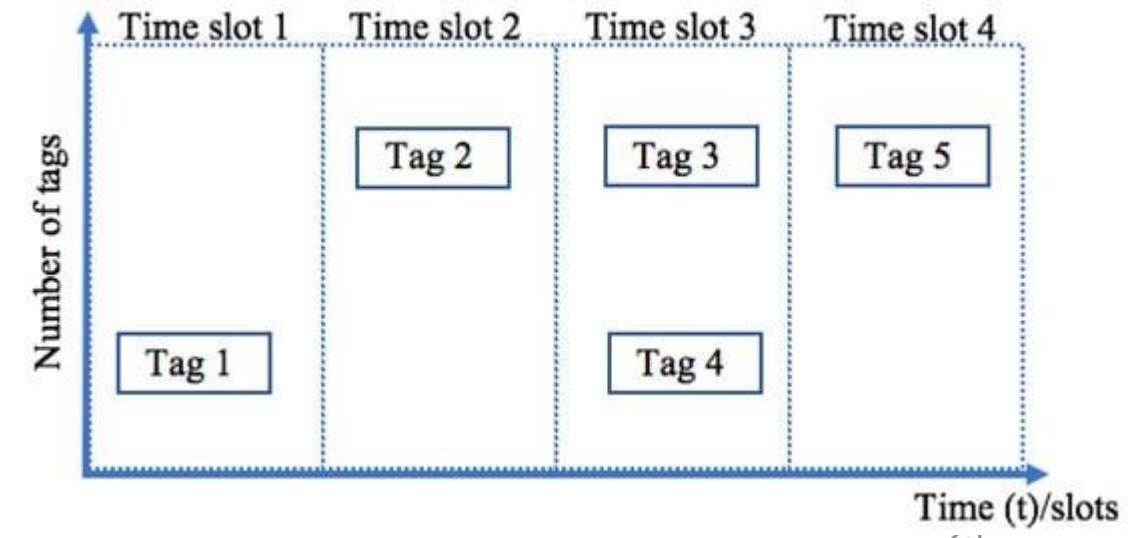
FDMA

- **FDMA** : Interfering readers transmit at different frequency
Adding tuning circuitry to the tags will increase the cost



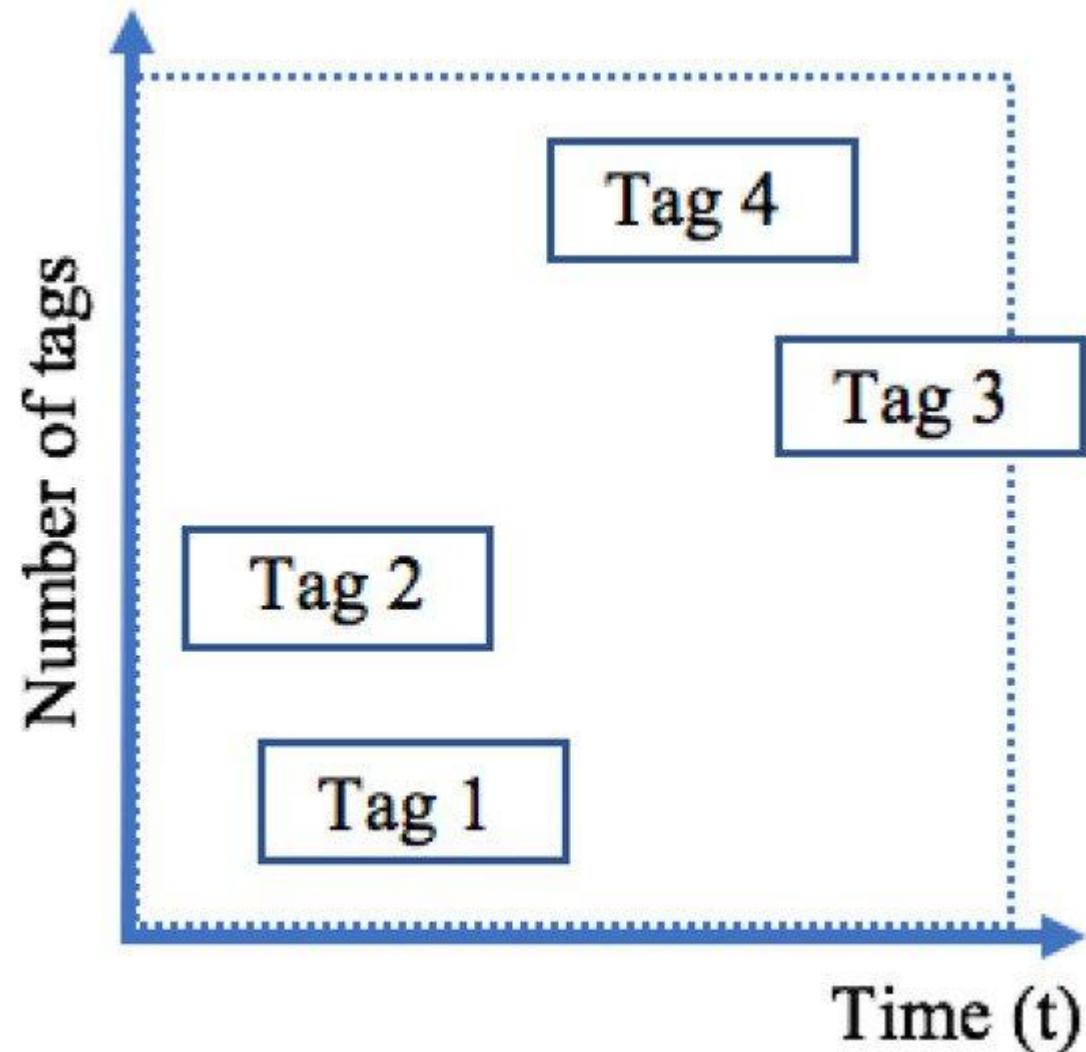
TDMA

- TDMA (Time Division Multiple Access)
 - The largest group of RFID anti-collision protocols
 - Tag driven (tag talk first, TTF)
 - Tag transmits as it is ready
 - Aloha
 - SuperTag
 - Tags keep quiet and retransmit until reader acknowledges
 - Reader driven (reader talk first, RTF)
 - Polling, splitting, I-code, contactless



CDMA

- **CDMA** : Interfering readers modulate signals with orthogonal codes
 - Requires complex circuitry at tags which will increase the cost of passive tags
 - Too complicate and too computationally intense for RFID tags as well

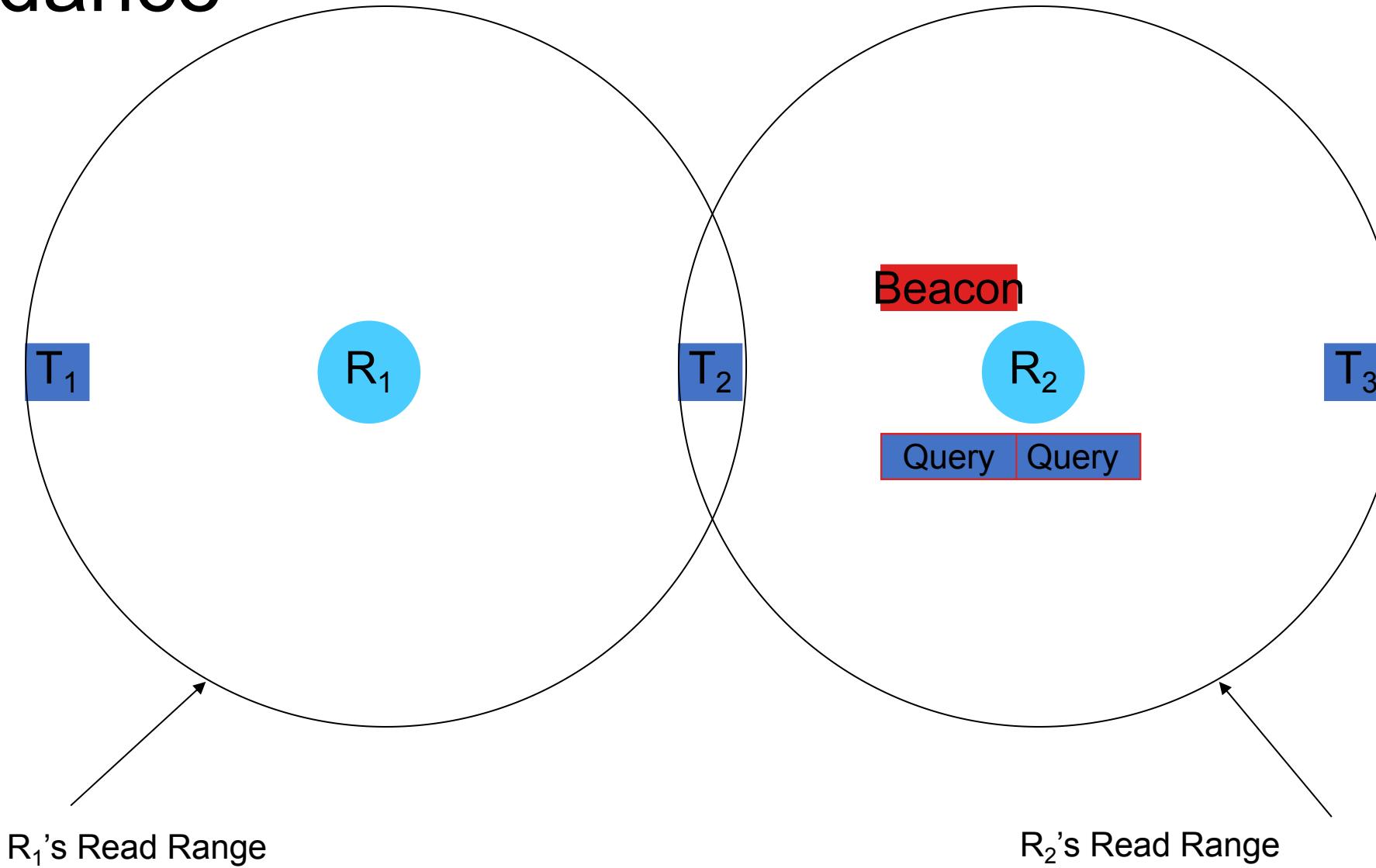


Reader-to-Reader Collision Avoidance

Reader-reader collision avoidance: beacon based solution

- A reader while reading tag, periodically sends a beacon on the control channel
- Assumptions
 - The range in the control channel is sufficient for a reader to communicate with all the possible readers that might interfere in the data channel

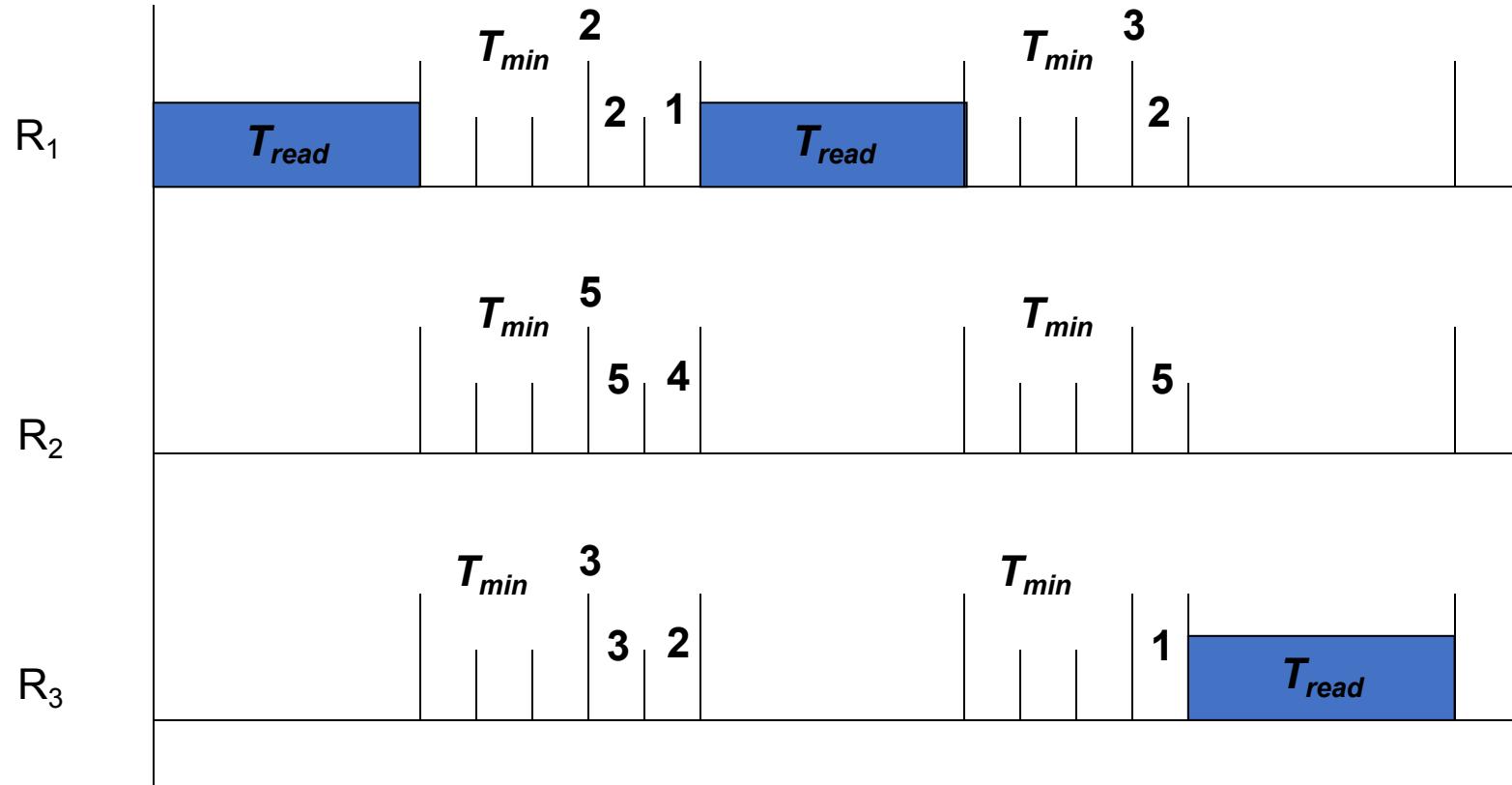
PULSE Protocol for RFID Reader Collision Avoidance



PULSE Protocol Overview

- Before communicating, a reader listens on the control channel for any beacon for T_{min} time
- If no beacon on the control channel for T_{min} , start communication on the data channel
- Reader periodically transmits a beacon on the control channel while communicating with the tags

Contend backoff



R₁ chooses 2 BI, R₂ chooses 5BI, R₃ chooses 3BI