Toward Fast and Deterministic
Clone Detection
for Large Anonymous RFID Systems

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Anonymous RFID

unknown tag identifiers (IDs)
Anonymous RFID Clone Tag Detection

unknown tag identifiers (IDs)
any clone tags?
Cloning Attack
Cloning Attack
Compromise tags & Produce Replicas/Clones;
Clone tags = Genuine tags.
Any Clones?
Solution Goals

- Anonymity Preservation
- Deterministic Detection
- Fast Detection
Design Choices

- Anonymity Preservation
  isolate ID from protocol design
- Deterministic Detection
  verify the existence of clones
- Fast Detection
  minimize time and comm. cost
Fast & Deterministic Protocols

**BASE**

Tags with ID Indices $h(f, r, ID)$

Time Slots
S: Singleton
C: Collision

Count Tags by Slot State

Cardinality Contradiction: $N_{tag} \geq 1 + 2 + 1 + 2 = 6 > 5 = N_{id}$

**DeClone**

Anonymous RFID Clone Detection

DeClone
Fast & Deterministic Protocols

BASE
using cardinality contradiction

Tags with ID Indices
h(f, r, ID)
Time Slots
S: Singleton
C: Collision

Count Tags by Slot State

Cardinality Contradiction: \( N_{\text{tag}} \geq 1 + 2 + 1 + 2 = 6 > 5 = N_{\text{id}} \)

DeClone
using unreconciled collision
Fast & Deterministic Protocols

BASE

using cardinality contradiction

DeClone

using unreconciled collision
• Motivation
clone tags make
tag cardinality > ID cardinality
• Motivation
  clone tags make
  tag cardinality > ID cardinality

\[ N_{id} = 5 \]
• Motivation
clone tags make
tag cardinality > ID cardinality

$N_{id}=5 \rightarrow N_{tag}=6$
cardinality contradiction
Tags with ID Indices

BASE
Tags with ID Indices

$h(f, r, ID)$

Time Slots
$S$: Singleton
$C$: Collision

 Cardinality Contradiction: $N_{tag} + 1 + 2 + 1 + 2 = 6 > 5$
BASE

Tags with ID Indices

\( h(f, r, \text{ID}) \)

Time Slots
\( S: \) Singleton
\( C: \) Collision

Count Tags by Slot State

<table>
<thead>
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<th></th>
<th>≥2</th>
<th></th>
<th></th>
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<td></td>
<td></td>
<td>1</td>
<td>≥2</td>
</tr>
</tbody>
</table>
BASE

Tags with ID Indices

\[ h(f, r, ID) \]

Time Slots
\( S \): Singleton
\( C \): Collision

Count Tags by Slot State

Cardinality Contradiction: \( N_{tag} \geq 1 + 1 + 2 + 1 + 2 = 6 > 5 = N_{id} \)

clone detected
BASE

- Limitation not that fast for large systems

Cardinality Contradiction: $N_{\text{tag}} \geq 1 + 2 + 1 + 2 = 6 > 5 = N_{\text{id}}$

detect clones when almost all tags are counted; but clone tags may respond earlier.
Fast & Deterministic Protocols

BASE
using cardinality contradiction

Tags with ID Indices
$h(f, r, ID)$

Time Slots
S: Singleton
C: Collision

Count Tags by Slot State

Cardinality Contradiction: $N_{tag} \geq 1 + 2 + 1 + 2 = 6 > 5 = N_{id}$

DeClone
using unreconciled collision
DeClone

• Motivation
clone tags induce collisions that cannot be reconciled via re-arbitration
DeClone

• Challenge
verify unreconciled collision without tag IDs known a priori?

unreconciled collision due to two same-ID tags?
DeClone

- Design

marry up slotted Aloha and tree traversal
Fast & Deterministic Protocols

**BASE**

using cardinality contradiction

Tags with ID Indices

\( h(f, r, ID) \)

Time Slots

S: Singleton
C: Collision

Count Tags by Slot State

1  \( \geq 2 \) 1  \( \geq 2 \)

Cardinality Contradiction: \( N_{tag} \geq 1 + 1 + 1 = 3 > 5 = N_{id} \)

DeClone

using unreconciled collision

Anonymous RFID Clone Detection
Evaluation

BASE is faster for small systems
DeClone is faster for large ones
Evaluation

DeClone is faster as clone ratio increases
BASE is nearly constant
CONCLUSION

Two Fast & Deterministic Protocols

BASE

using cardinality contradiction
faster for small systems

DeClone

using unreconciled collision
faster for large systems
esp when clone ratio↑

Anonymous RFID Clone Detection
Thank You

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