A Parallel Identification Protocol for RFID Systems

Linghe Kong, Liang He , Yu Gu , Min-You Wu , Tian He

Existing approach

- Sequential identification
  - Not suitable for large-scale RFID systems
- Parallel identification
  - CDMA
  - SDMA
  - FDMA
  - Buzz

CDMA

- Tags need to multiply their IDs with a pseudo-random noise before transmission
- Additional identification delay

Buzz

- Tags' responses are formatted into customized patterns
- Resolve collisions with compressive sensing
- Reader must accurately differentiate the signal strength
- Beyond the hardware requirement of current off-the-shelf RFID readers

Parallel Identification Protocol(PIP)

- Less identification delay
- Compatible with current off-the-shelf RFID devices
- Orthogonal to SDMA and FDMA

Scenario

- Single reader
  - Relatively powerful computation capability
  - Relatively powerful storage capability
- A number of tags
  - Each one has a bit string(64-512bits)
  - Partial bits construct the unique tag ID
  - m denotes #tags
  - n denotes #interrogated tags

An example

- m = 10 IDs which are {1, 2, 3, 4, ……., 10}
- n = 3 interrogated tags {7, 8, 10}

Flow chart of PIP

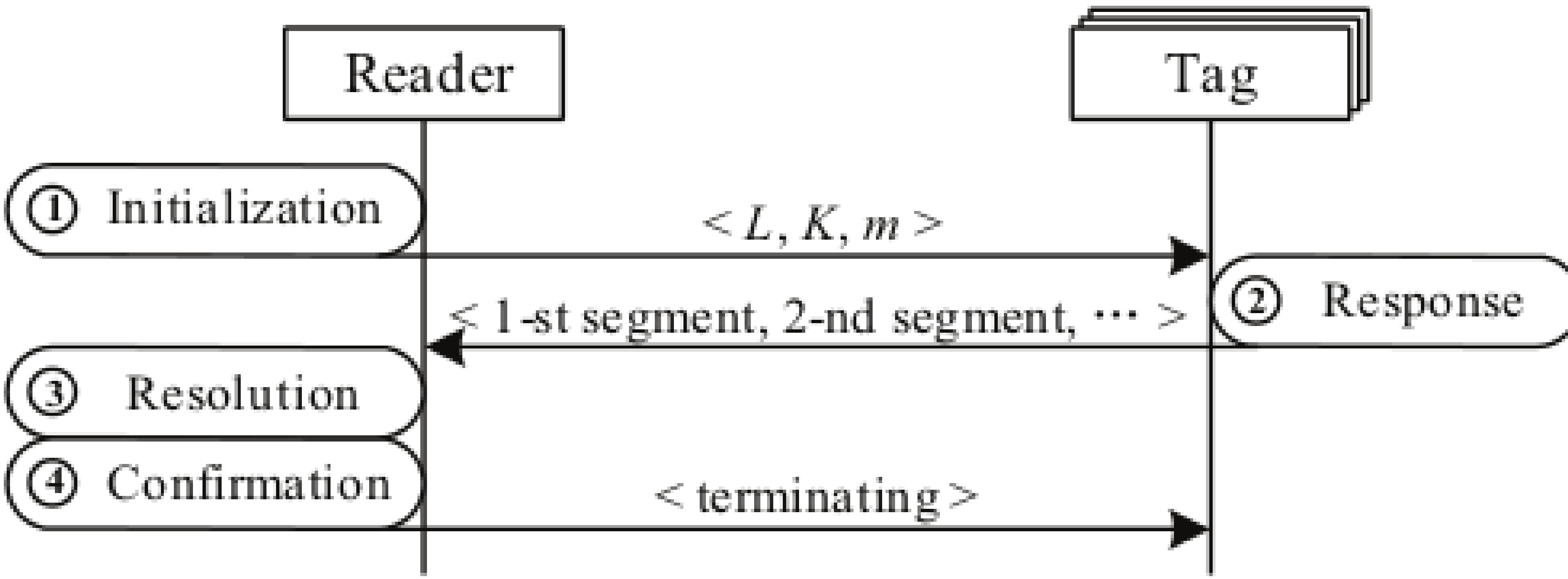

Fig. 4. Flow chart of parallel identification protocol.

Initialization

TABLE I
LIST OF THE MAPPING AND ENCODING RESULTS OF $m = 10$ TAGS BY RANDOMIZED MAPPING SCHEME AND L-K CODE WHEN SETTING $L = 5$, $K = 2$, NUM OF SEGMENTS $= 2$

1-st segment		**2-nd segment**	
ID mapping	ID encoding	ID mapping	ID encoding
$1 \to 1$	$\to 11000$	$1 \to 5$	$\to 01100$
$2 \to 2$	$\to 10100$	$2 \to 8$	$\to 00110$
$3 \to 3$	$\to 10010$	$3 \to 1$	$\to 11000$
$4 \to 4$	$\to 10001$	$4 \to 4$	$\to 10001$
$5 \to 5$	$\to 01100$	$5 \to 7$	$\to 01001$
$6 \to 6$	$\to 01010$	$6 \to 10$	$\to 00011$
$7 \to 7$	$\to 01001$	$7 \to 3$	$\to 10010$
$8 \to 8$	$\to 00110$	$8 \to 6$	$\to 01010$
$9 \to 9$	$\to 00101$	$9 \to 9$	$\to 00101$
$10 \to 10$	$\to 00011$	$10 \to 2$	$\to 10100$

Response

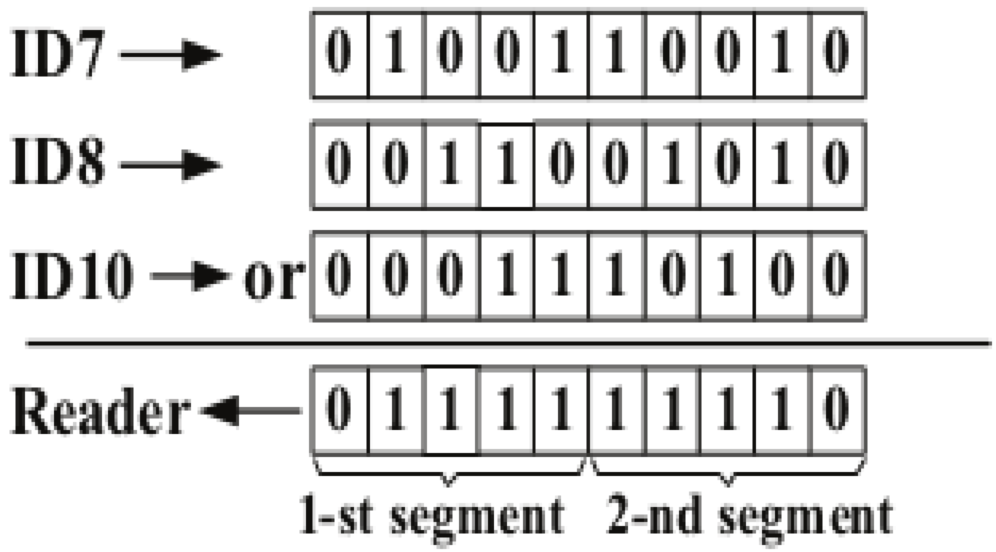

Fig. 2. The received bits are collided by concurrent responses of three tags.

Resolution

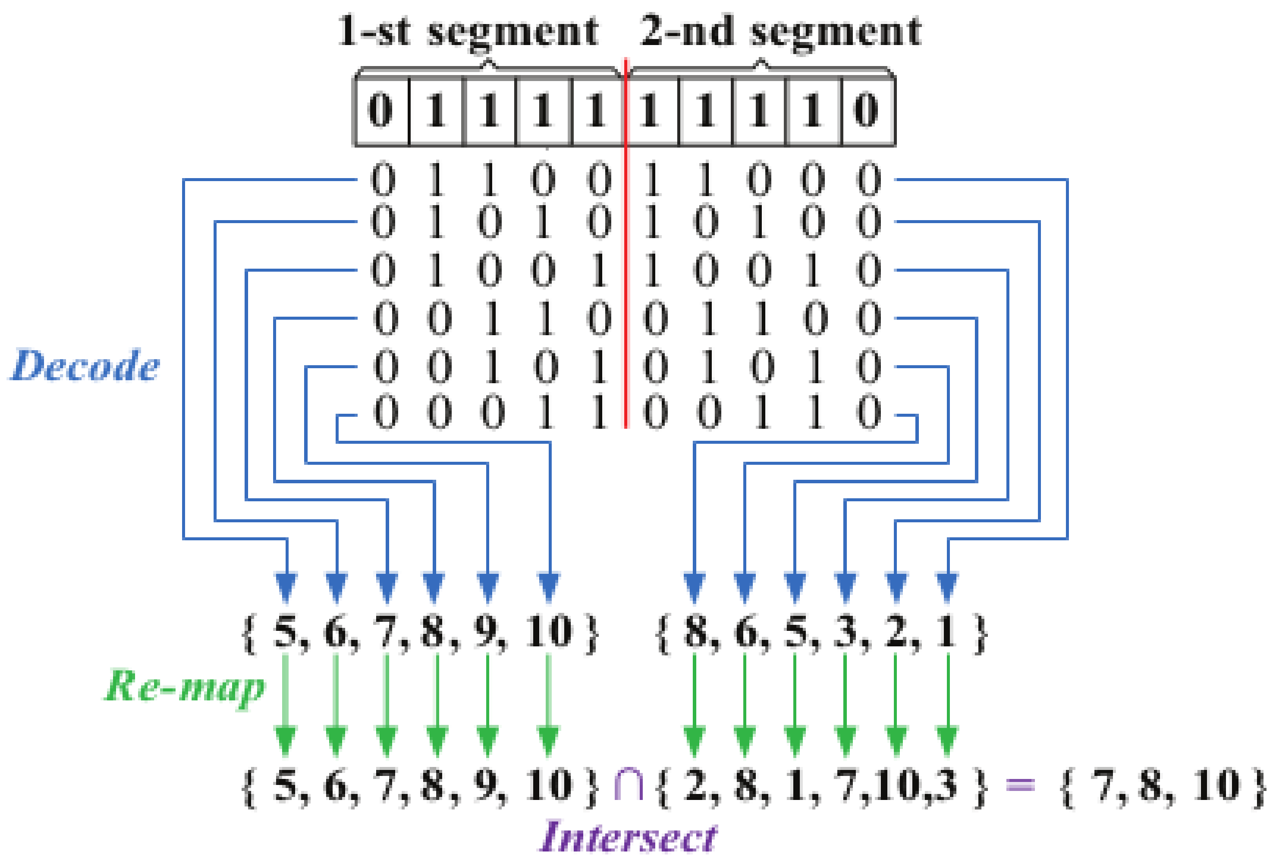

Fig. 3. Three tags {7,8,10} are resolved from the received bits.

Resolution

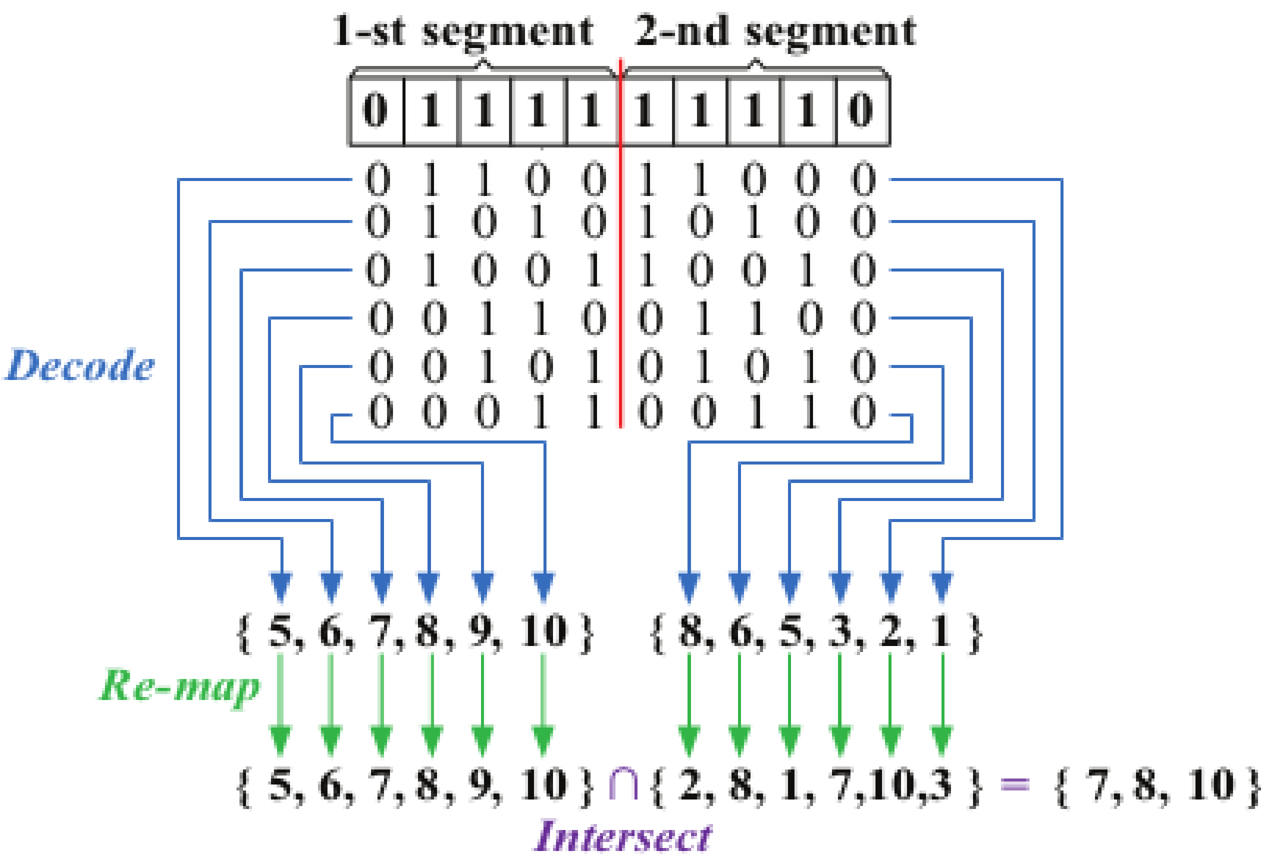

Fig. 3. Three tags {7,8,10} are resolved from the received bits.

Confirmation

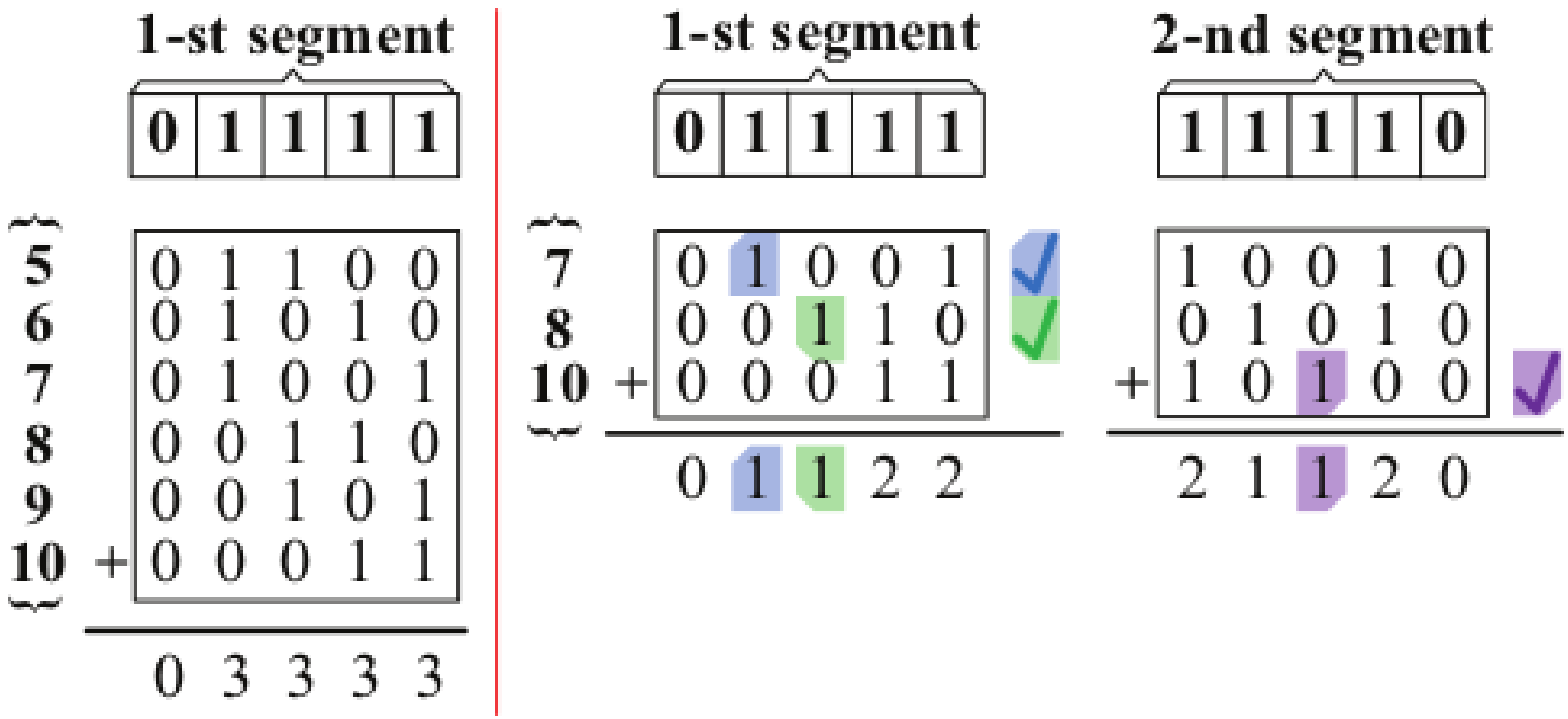

Fig. 5. Three tags {7,8,10} are confirmed.

- How to compute L, K and r ?

- How dose the table be worked out?

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Optimal <L, K, r>

- Objective
  - Shortest identification time
  - min(L * r)

- L : length of bit string
- K : #'1's in bit string
- r: # segments of bit strings

Range of feasible L

$$L \in \left[\min\{L \mid \binom{L}{\lfloor L/2 \rfloor} \geqslant m\}, \quad m\right].$$

K should be as small as possible

$$\min\{K \mid \binom{L}{K} \geqslant m\}.$$

The number of segments

$$F(r) = (m-n)\left(\frac{C-n}{m-n}\right)^r.$$

$$\min\{r \mid F(r) < \epsilon\},$$

- F(r) : #false IDs
- ε : a small constant

- How to compute L, K and r ?
- How dose the table be worked out?

Randomized mapping scheme

$$I(i) = \begin{cases} I & i = 1, \\ (I \times S_{i-1} + i - 1)\%m + 1 & i \geqslant 2, \end{cases}$$

- I : the tag ID
- I(i) : the mapping result of I for the ith segment
- S : set of mapping seed. Sequence of sorted integers which are relatively prime to m.

Evaluation

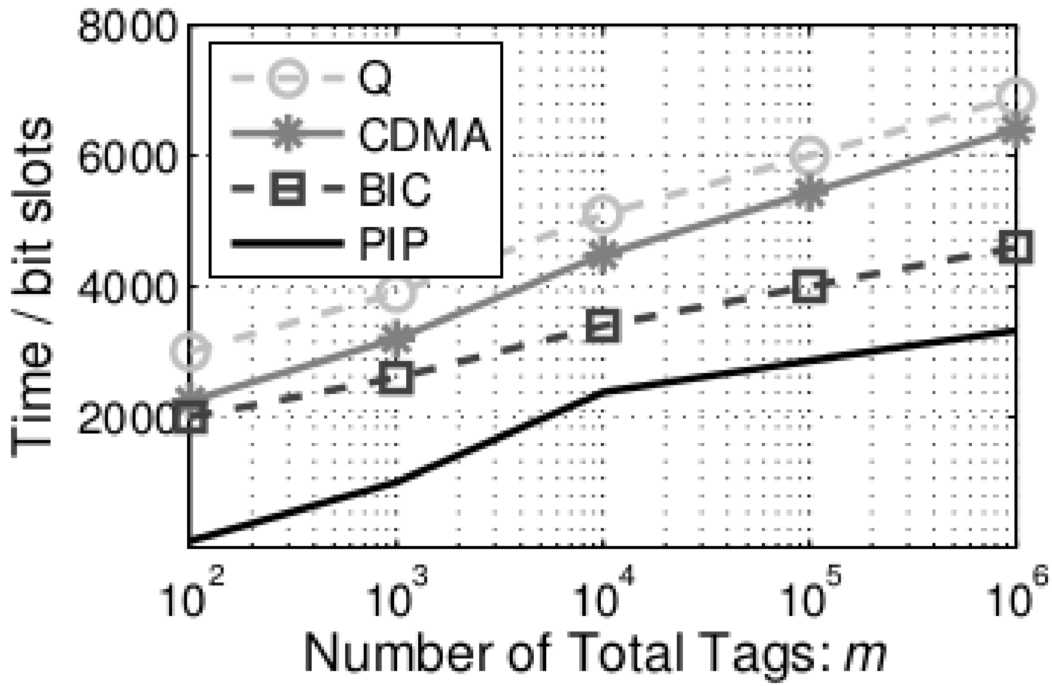

Fig. 6. Comparison on four protocols when m varying and $n = 100$.

Evaluation

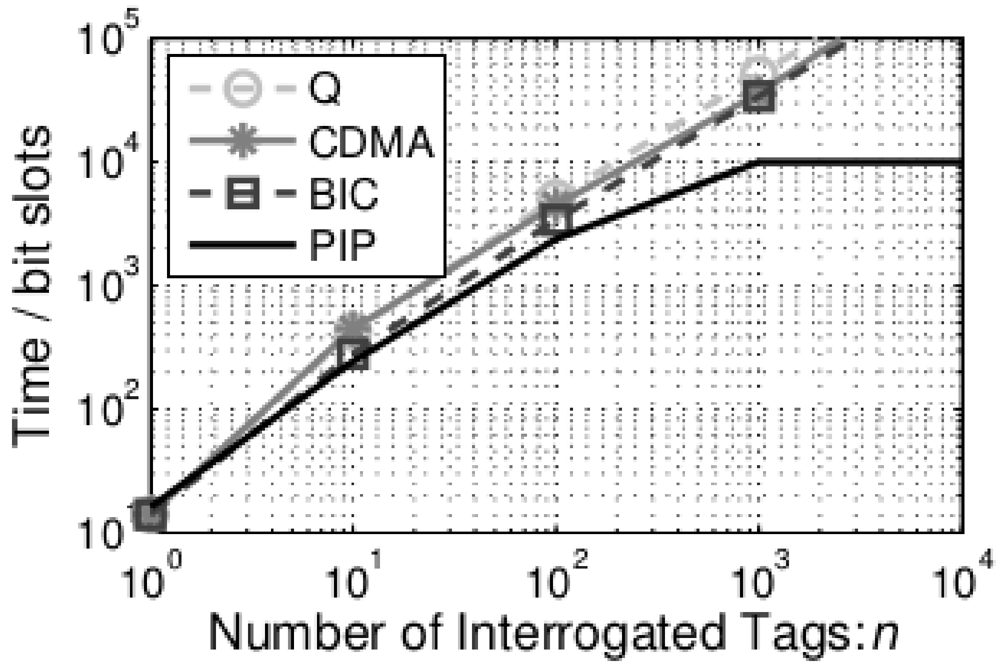

Fig. 7. Comparison on four protocols when n varying and $m = 10000$.