Collision Avoidance through Multiple RTS/CTS Dialogue in RFID System

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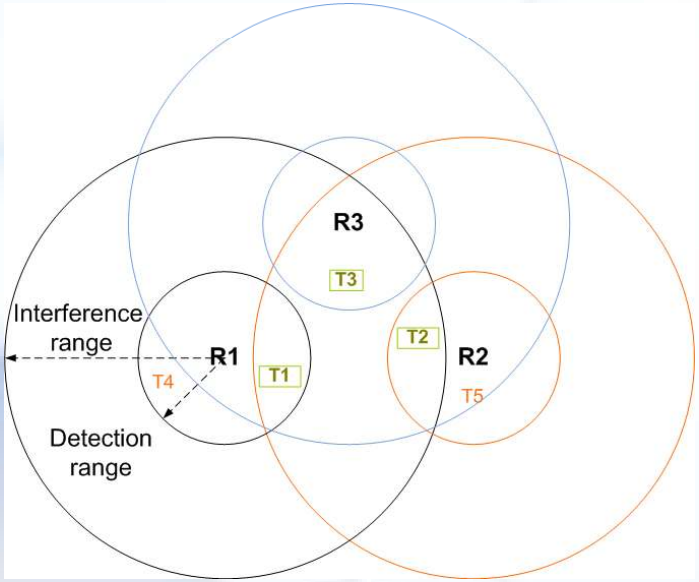
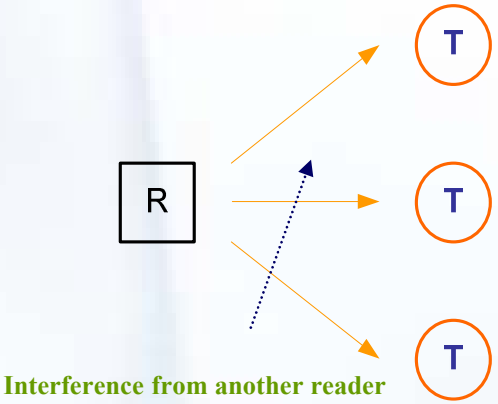
Problem Statements

- **Two kinds of interference in RFID system** [1]
  - **Reader-to-tag interference**
    - When a reader sends commands to the tags
  - **Reader-to-reader interference**
    - When a tag responds to the reader's command
- **Hidden node and collision problem**



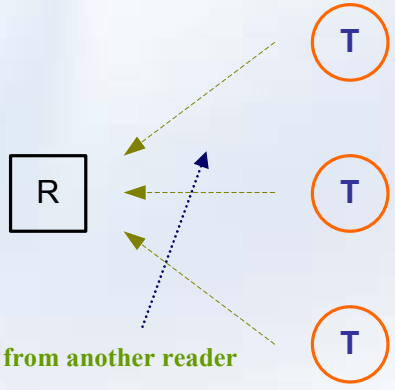
Hidden node and collision problem in RFID system

Two kinds of interference



Interference from another reader

Reader-to-tag interference

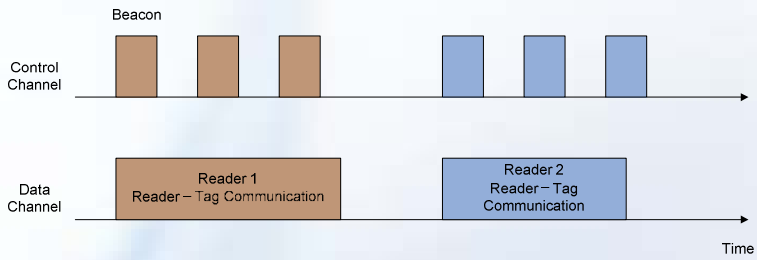


Interference from another reader

Reader-to-reader interference

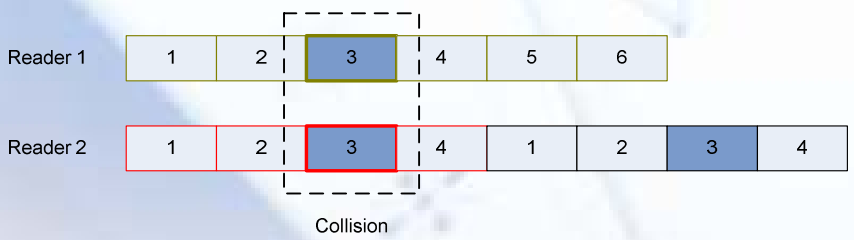
Related Works (1/2)

- **LBT(Listen Before Talk)** [2],[3]
  - **CSMA-based**
    - Sense the channel before communicating with tags
      - If not busy, then
        - Try to communicate with tags
      - If busy, then
        - Either sense another channel or re-sense the current channel after back off
    - Cons.
      - The reader may not be able to detect collision by carrier sensing alone
- **PULSE protocol** [1]
  - **CSMA-based**
    - Two separate channels used
      - One for broadcasting beacon signal
        - For informing other readers of own channel usage
      - The other for communicating with tags
    - Cons.
      - Two radios needed
      - Decrease of channel efficiency because of the collision in the control channel

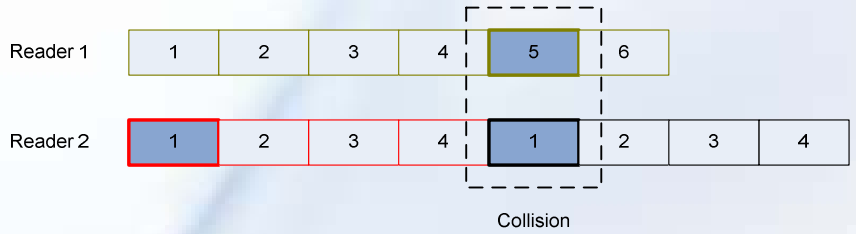


Related Works (2/2)

- **Colorwave** [4]
  - **TDMA-based**
    - Distributed protocol
    - Each reader has the different value of *max_color*
      - Before communicating with tags, select its own color (slot)
    - Cons.
      - Additional synchronization and collision detection mechanism needed
      - Potential collision may be occurred



Example of normal collision

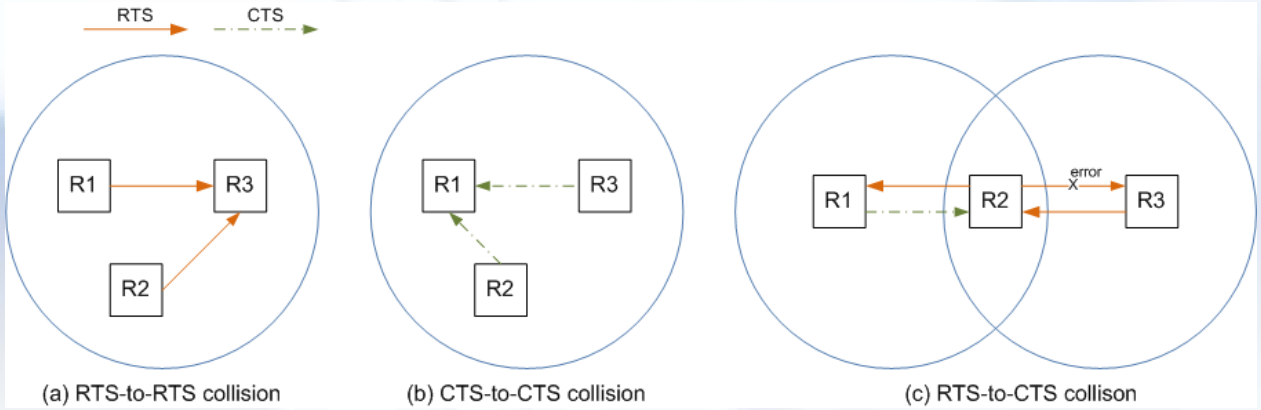


Example of potential collision

Proposed Scheme

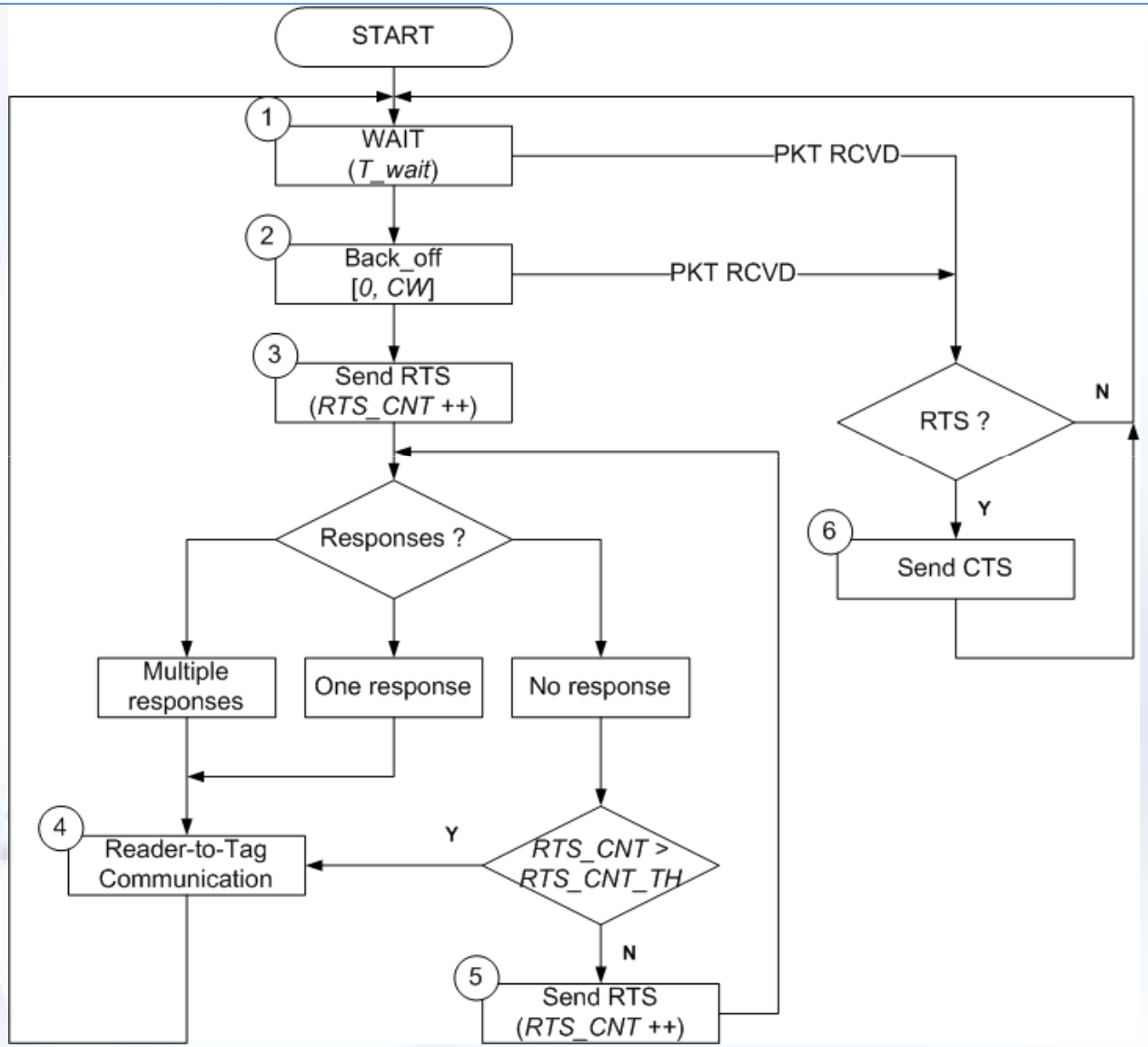
Main ideas

- **Channel reservation**
  - Use RTS/CTS dialogue
    - But not same with the method used in the literature
      - RTS/CTS packet informs other readers of only its identity information
      - RTS/CTS packets not including NAV information
      - Only 1 byte size of RTS/CTS packed employed
- **Collision Avoidance**
  - Use multiple RTS/CTS dialogue
    - After sending a RTS packet, if there is no response (either idle or collision)
      - Send a RTS packet after the random delay based on the *RTS_CNT_TH*



Proposed Scheme

- **Flow chart**



Simulation Environments

- **Simulator**
  - **OPNET 10.0**
- **Performance metric**

$$\text{Aggregated throughput} = \frac{\text{Total successful reading time}}{\text{Total simulation time}}$$

- **Simulation parameters**

SIMULATION PARAMETERS	VALUES USED
Network size	1 *km* x 1*km* square grid
Simulation run time	Each 10 minutes
Minimum Fixed listen time (*T_wait*)	5 *ms* [5]
Maximum back-off window size	256, 512, 1024
Back-off mini-slot duration	1 *ms*
Maximum random delay size	8
Random delay mini-slot duration	10 *us*
Maximum reading time	1*s*
Number of readers	16, 32, 48, 64, 96
Value *p* in *p*-persistent CSMA	0.01

Simulation Results(1/2)

- **Aggregated Throughput vs. number of readers**

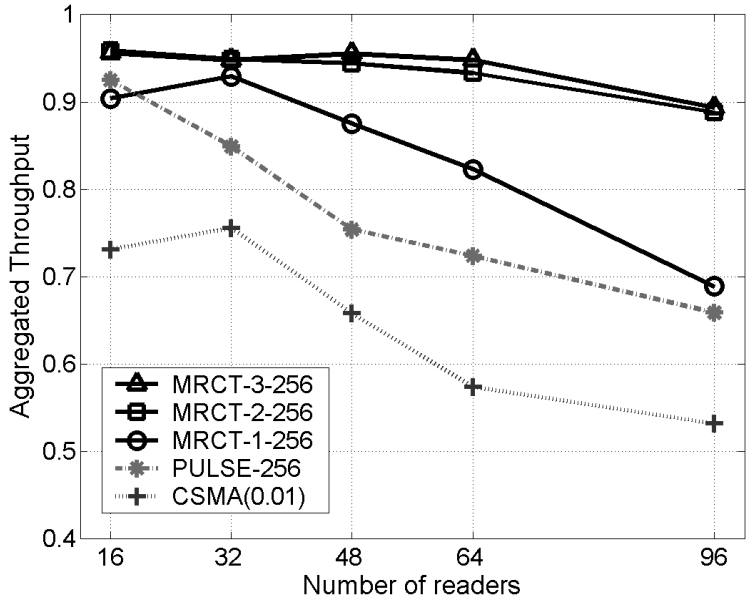


Fig. 1

For 96 tags,
MRCT-3 = 0.893 and PULSE = 0.659
23.4% higher

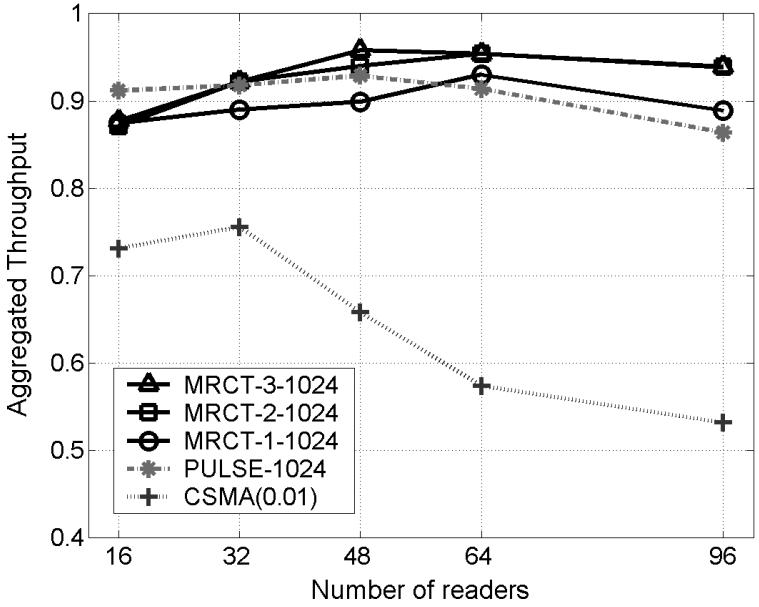


Fig. 2

For 96 tags,
MRCT-3 = 0.939 and PULSE = 0.864
7.5% higher

Simulation Results(2/2)

Aggregated Throughput vs. window size

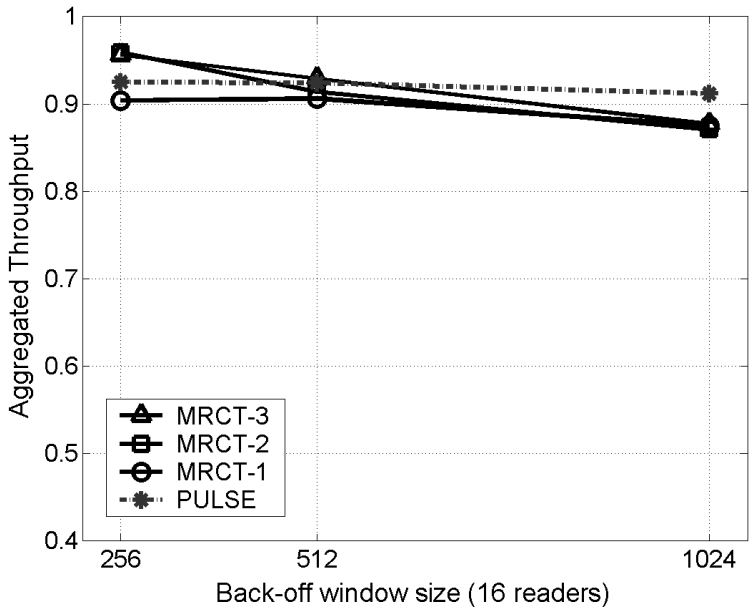


Fig. 3

For 256 window size,
MRCT-3 = 0.956 and PULSE = 0.925 => 3.1% higher.
For 1024 window size,
MRCT-3 = 0.877 and PULSE = 0.912 => 3.5% lower.

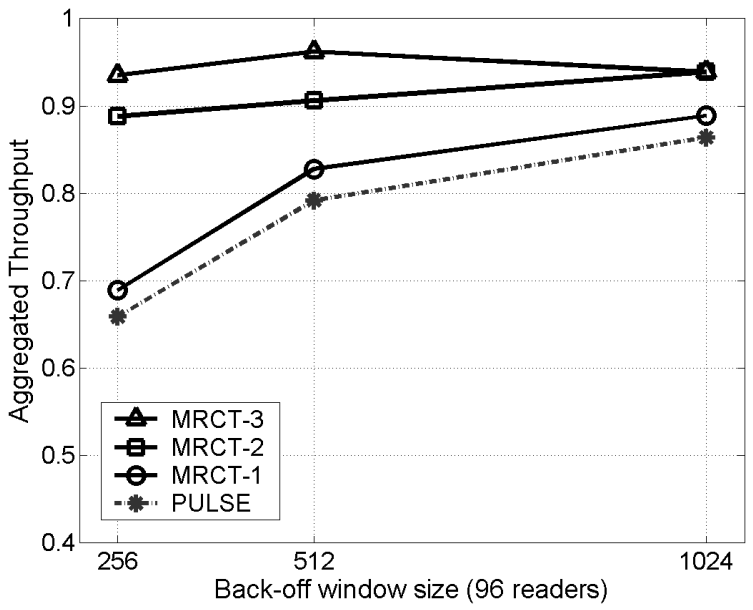


Fig. 4

For 256 window size,
MRCT-3 = 0.893 and PULSE = 0.659 => 23.4% higher.
For 1024 window size,
MRCT-3 = 0.939 and PULSE = 0.864 => 7.5% higher.

Conclusion

- **Interference in RFID system**
  - **Reader-to-tag interference**
  - **Reader-to-reader interference**
- **Proposed collision avoidance scheme**
  - **Multiple RTS/CTS exchange**
    - To reserve the channel
    - To reduce or eliminate the collision
- **Simulation results**
  - **Proposed scheme outperforms the conventional protocols**
    - *p*-persistent CSMA and the PULSE protocol
      - Because of the lower collision probability through the multiple RTS/CTS dialogue.

Reference

[1] S. M. Birari and S. Iyer , "PULSE: A MAC Protocol for RFID Networks ," in Proc. USN'2005, Nagasaki, Japan, Dec., 2005.

[2] ETSI EN 302 208-1 v1.1.1, September 2004. CTAN: http://www.etsi.org.

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[4] J. Waldrop, D. W. Engels, and S. E. Sarma., "Colorwave: An Anti-collision Algorithm for the Reader Collision Problem," in *Proc*. WCNC'03, New Orleans, Louisiana, USA, Mar., 2003.

[5] ETSI TS 102 562 v1.1.1, March 2007. CTAN: http://www.etsi.org.

[6] J. R. Cha and J. H. Kim, "Dynamic Framed Slotted ALOHA Algorithm using Fast Tag Estimation method for RFID System," in *Proc*. CCNC2006, Las Vegas, USA, Jan., 2006.

Thank you!!

Any Questions ??

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