CARA: Collision-Aware Rate Adaptation for IEEE 802.11 WLANs

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Outline

- Introduction
- Automatic Rate Fallback
- Collision-Aware Rate Adaptation
- Performance Evaluation
- Conclusion

Introduction

- IEEE 802.11 provide multiple transmission rates to maximize the system performance.
  - e.g. 802.11b: 1, 2, 5.5, 11 Mbps
- Rate adaptation schemes
  - Closed-loop approaches
    - The receiver specifies its desired transmission rate and feeds back to the transmitter.
  - Open-loop approaches
    - A transmitter makes the rate adaptation decision solely based on its local Acknowledgement information.

Introduction (cont.)

- Automatic Rate Fallback (ARF)
  - A simple open-loop rate adaptation scheme, is implemented on most of the commercial device.
  - A key problem:
    - They do not consider malfunction severely when many transmission failures are due to collisions.

ARF in IEEE 802.11

- Operations:
  - When missing Ack frames:
    - it alternates the transmission rates by keeping track of a timing function.
  - If two consecutive Acks are not received correctly:
    - The second retry and the subsequent transmissions are done at a lower transmission rate.
    - And a timer is started.

ARF in IEEE 802.11 (cont.)

- When either the timer expires or the number of successfully-received Acks reaches 10:
  - The transmission rate is raised to the next higher transmission rate.
  - And the timer is cancelled.
- If an Ack is not received for the very next data frame:
  - The transmission rate is lowered again.
  - And the timer is restarted.

Collision-Aware Rate Adaptation (CARA)

- One salient feature of CARA:
  - It is able to differentiate collisions from channel errors at the transmitter side without any help/feedback from the receiver station.
- CARA specifies two methods:
  - RTS Probing
  - CCA Detection (Optional)

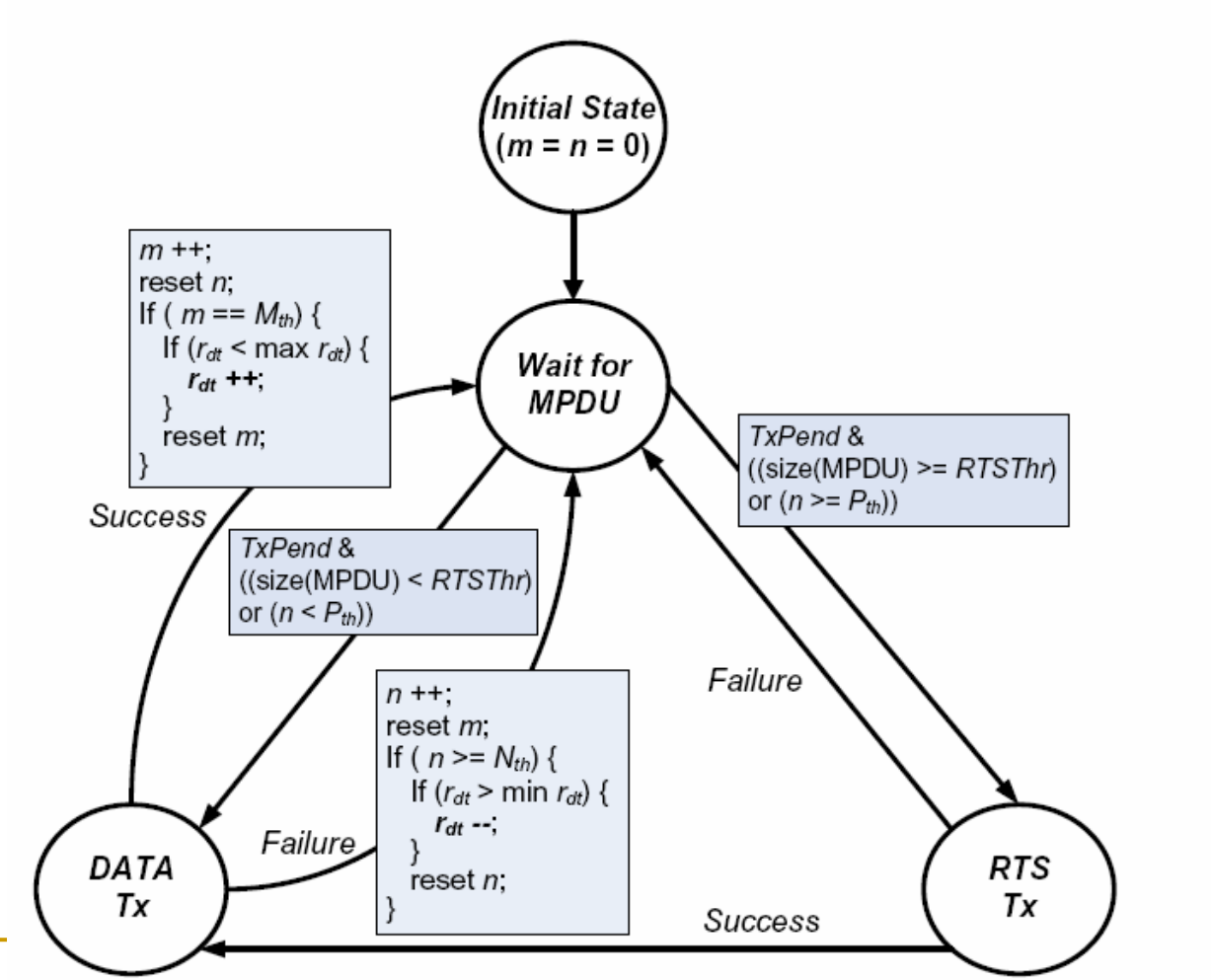
RTS Probing

- RTS/CTS:
  - Assumptions:
    - Transmission error probability of an RTS frame is negligible.
    - All the RTS transmission failures are due to collisions.
  - Collision or channel error detection:
    - A data transmission failure following a successful RTS/CTS exchange must be due to channel errors.
    - Unnecessary rate decrements are completely avoided.

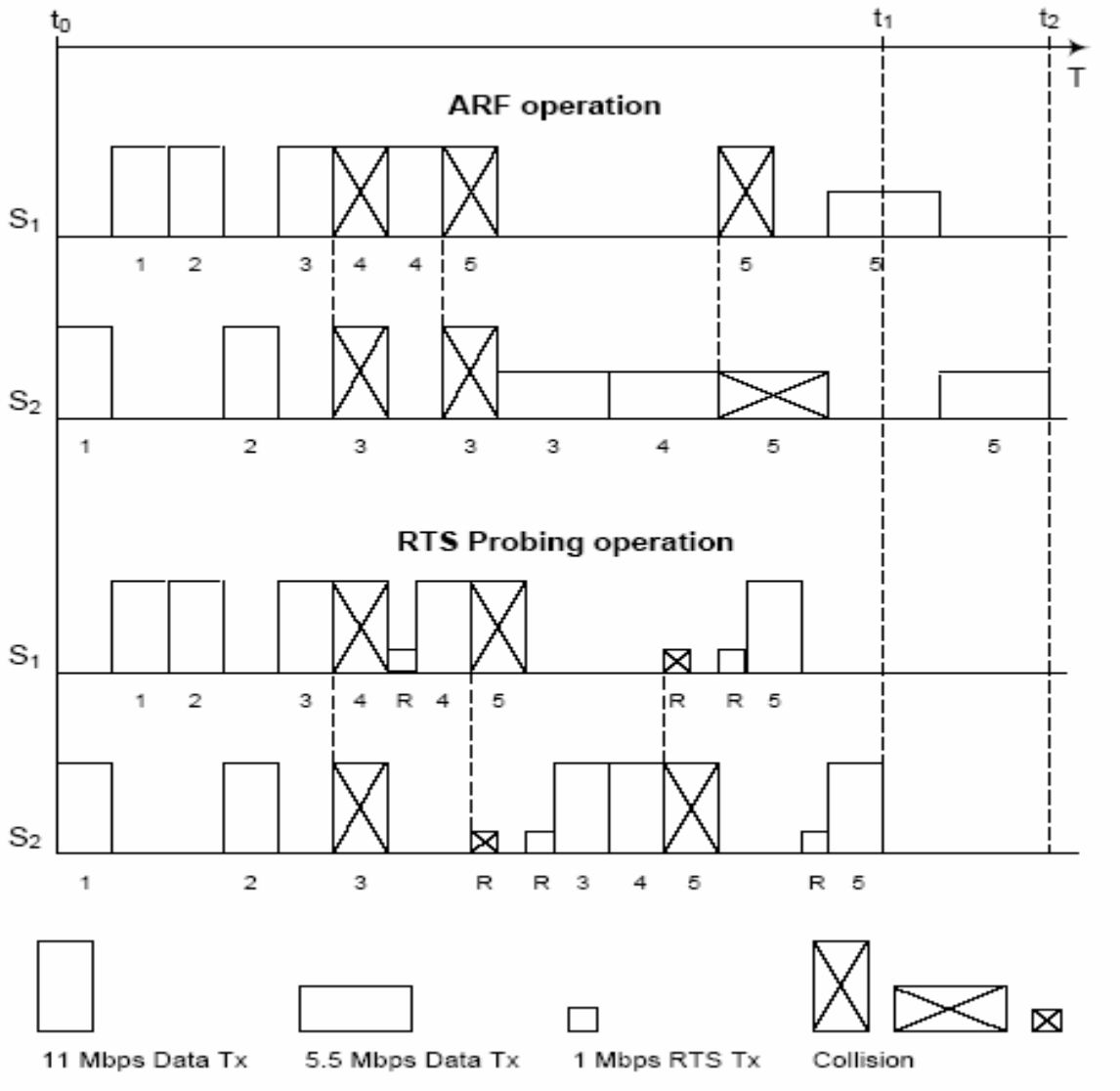
RTS Probing (cont.)

- Effect:
  - The added RTS/CTS overhead.
  - In fact, the RTS/CTS option is disabled in most 802.11 products.
- RTS Probing:
  - Enables RTS/CTS exchange only when a data frame transmission fails.

State Transition Diagram of RTS Probing



Example of RTS Probing



CCA Detection

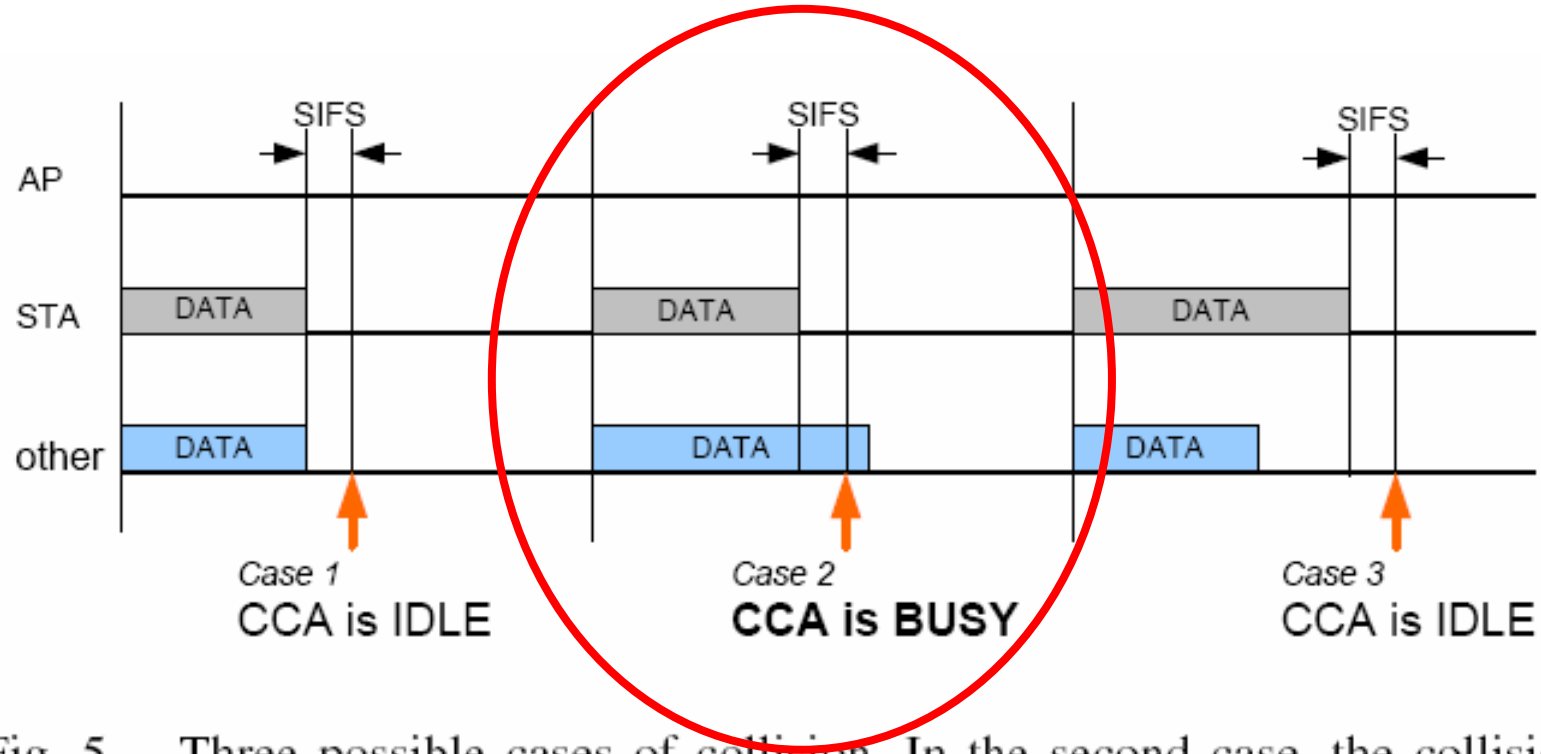
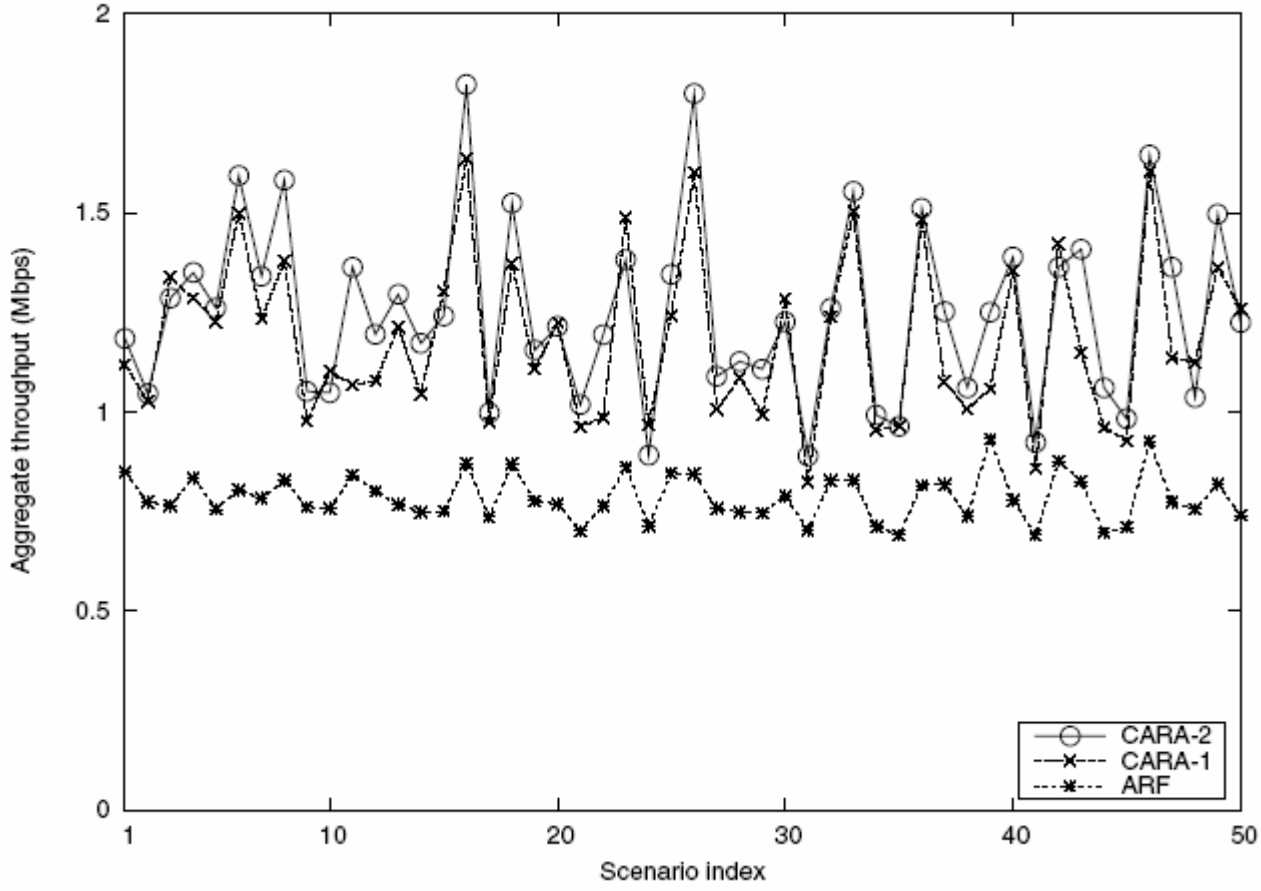


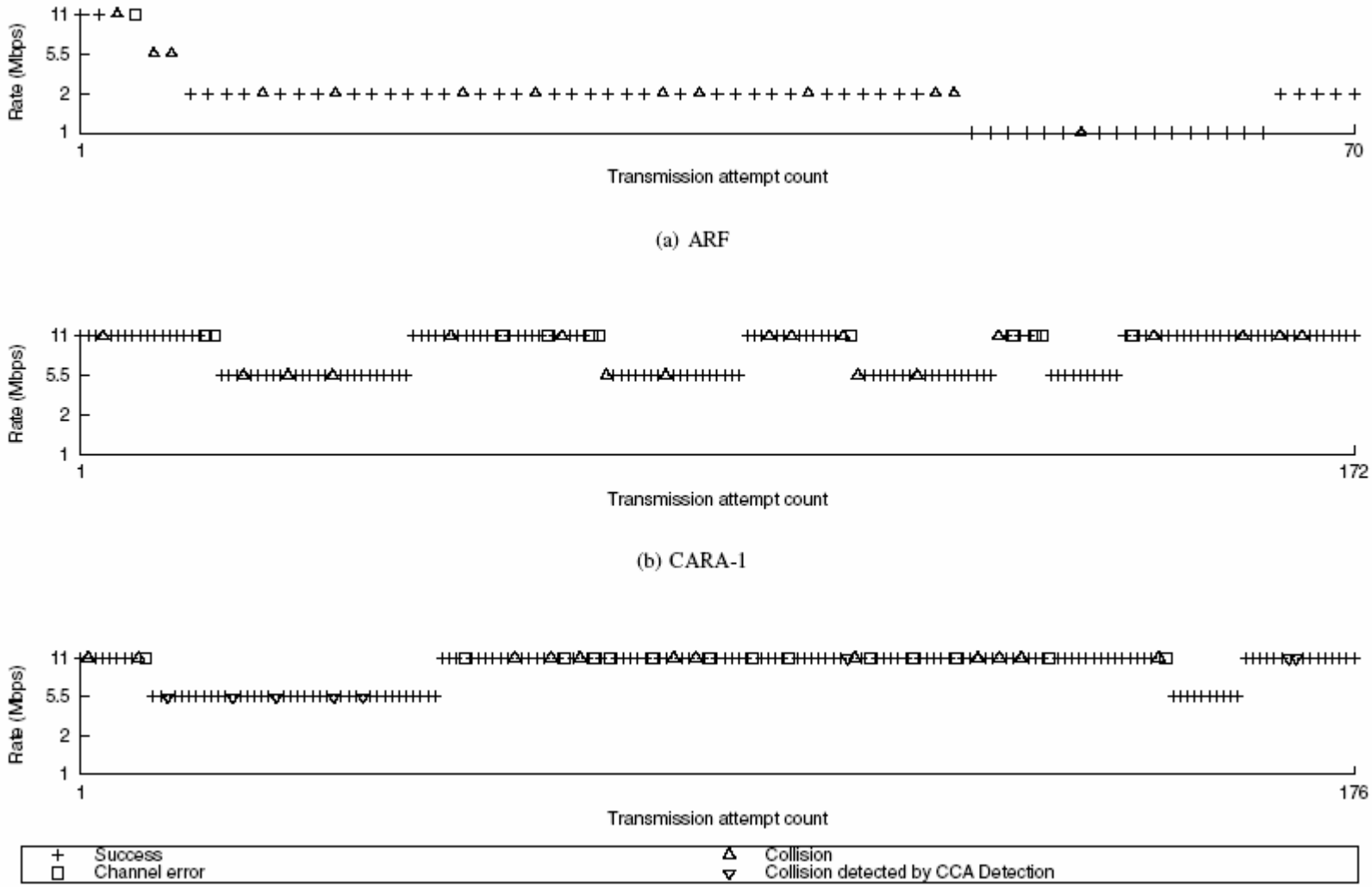
Fig. 5. Three possible cases of collision. In the second case, the collision can be detected via CCA detection.

CCA: Clear Channel Assessment

Performance



Comparison


Rate (Mbps)
11
5.5
2
1
1
70
Transmission attempt count
(a) ARF
Rate (Mbps)
11
5.5
2
1
1
172
Transmission attempt count
(b) CARA-1
Rate (Mbps)
11
5.5
2
1
1
176
Transmission attempt count
Success
Channel error
Collision
Collision detected by CCA Detection

Conclusions

- The key idea of CARA is that the transmitter station combines adaptively the RTS/CTS exchange with the CCA functionality to differentiate frame collisions from frame transmission failures caused by channel errors.
- Therefore, compared with ARF, CARA is more likely to make the correct rate adaptation decisions.

Conclusions (cont.)

- Moreover, CARA does not require any change to the current 802.11 standard, thus facilitating its deployment with existing 802.11 devices.