An Energy-efficient MAC layer Scheme for 802.11-based WLANs

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outline

- Energy efficient issues for WLANs
- Related low power solutions
- 802.11 standard access method
- The Energy-efficient Distributed Access (EDA) scheme
- Simulation results
- Conclusions

Energy efficient issues for WLANs

- Four states and each power consumption of WLAN interface [4][5]
  - Transmitting state : 1.65W
  - Receiving state : 1.4W
  - Idle state: 1.15W
  - Doze state: 0.045W (radio transceiver is turned off)
- High energy expenditure even if WLAN does not transmit or receive
  - CSMA/CA mechanism forces the WSTA to continuously sense the channel
- It is mandatory to reduce the time spent in Tx/Rx/Idle state, and increase the time in doze mode

Related low power solutions

- IEEE 802.11 power saving mode
  - Not a efficient solution under low traffic load
- Adaptive ATIM window size according to the network load
  - Some critical packets might be lost
- Two channel scheme: one for control and the other for data transmission
  - WLAN interface can be turn off when no data for Tx or Rx

Related low power solutions

- Each WSTA estimates the channel utilization and transmission probability during backoff period
- Estimate the appropriate contention window
- Adaptive the transmission rate

802.11 standard access method

1. Carrier sense mechanism check the medium before transmitting a frame
2. WSTA select a backoff counter from the range of CW
3. If the carrier sense mechanism detects the channel is idle for the DIFS, the backoff counter is decremented during idle channel periods
4. WSTA can transmit the frame if the backoff counter is decremented to 0
5. When frame is transmitted successfully, WSTA would receive a ACK after a SIFS

The Energy-efficient Distributed Access (EDA) scheme

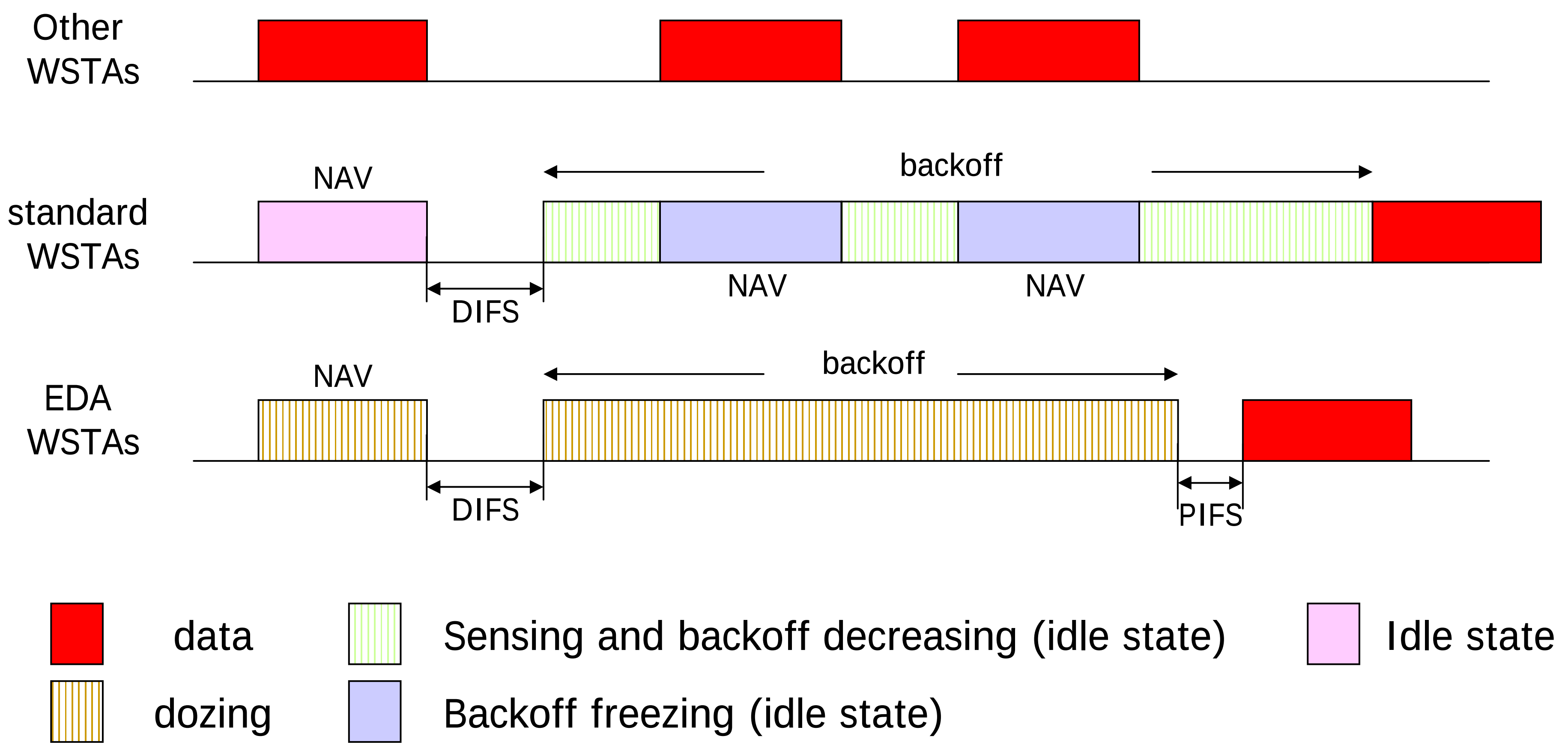
- Objectives
  - Convert the time in idle state into doze state
  - Limit as much as possible the degradation of system performance in terms of traffic delay

- Slight modifications of standard
  - Virtual sensing mechanism
  - Backoff procedure

The Energy-efficient Distributed Access (EDA) scheme

1. Carrier sense mechanism check the medium before transmitting a frame
2. WSTA select a backoff counter from the range of CW
3. If the carrier sense mechanism detects the channel is idle for the DIFS, WSTA enters the doze state and decreases the counter while being in the doze state
4. WSTA can transmit the frame if the backoff counter is decremented to 0 while channel is idle for PIFS
5. When frame is transmitted successfully, WSTA would receive a ACK after a SIFS

The Energy-efficient Distributed Access (EDA) scheme



The Energy-efficient Distributed Access (EDA) scheme

- The WSTA decrements the backoff continuously being in the doze state
  - Saving the energy wasted in idle state

- Waiting PIFS before transmitting
  - Reduce the probability of colliding with ACK frame

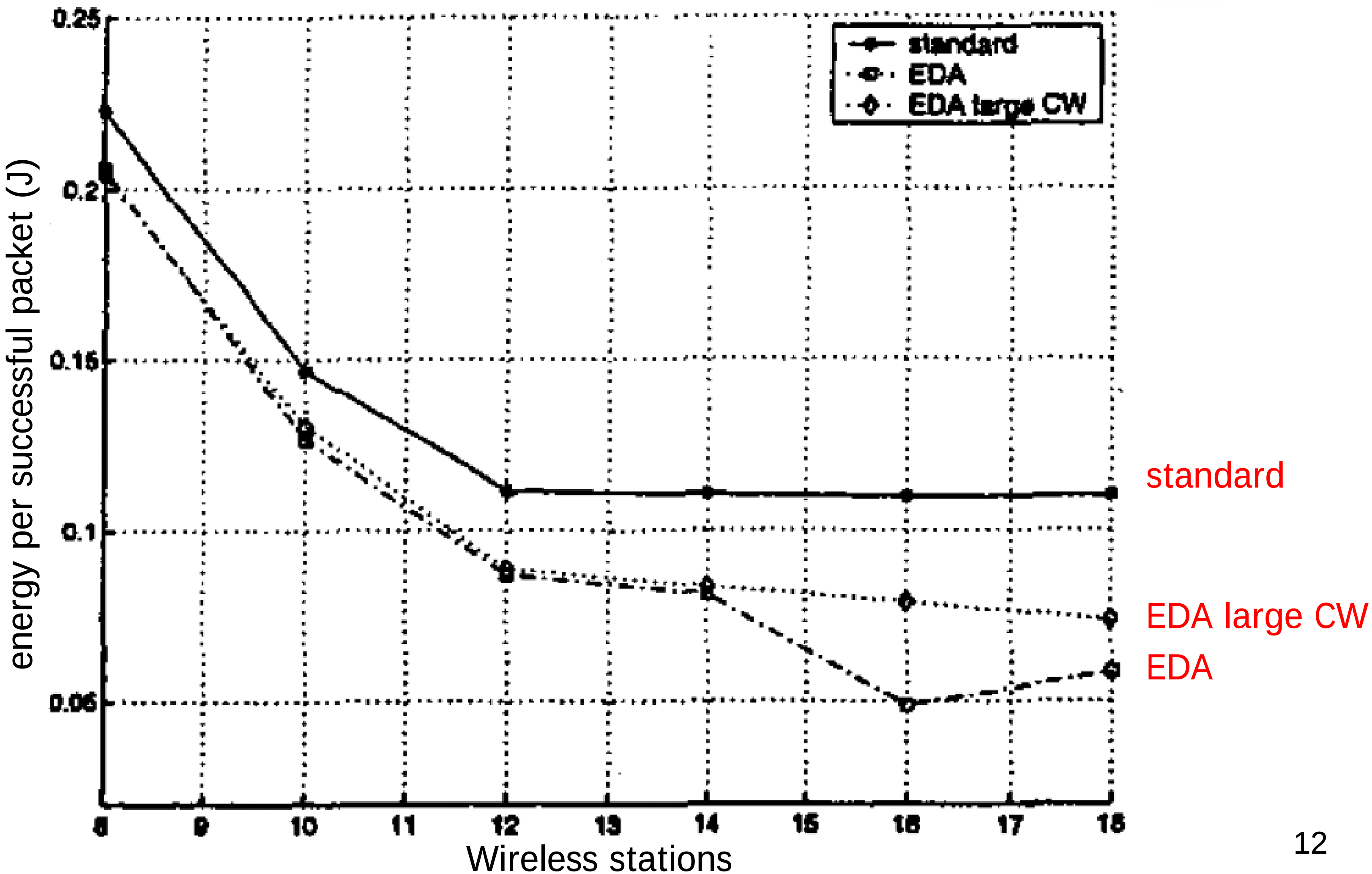
Simulation results

- Parameter setting

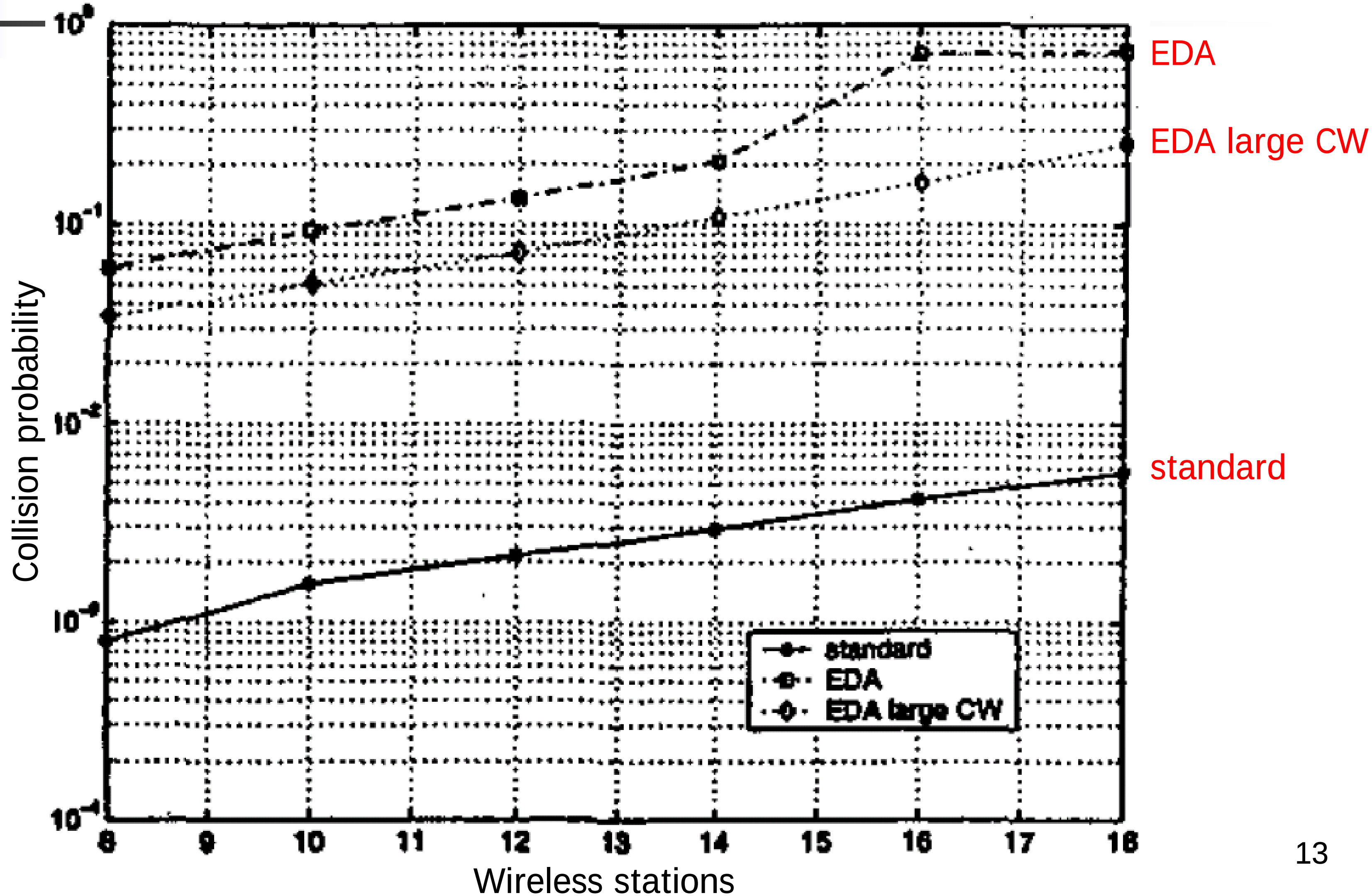
CW_{min} (std., EDA)	31
CW_{max} (std., EDA)	1023
CW_{min} (large EDA)	63
CW_{max} (large EDA)	2047
RTS Threshold	400 bytes
Slot time	20μs
SIFS time	10μs
DIFS time	50μs
EIFS	60μs
Short Retry Limit	20
Long Retry Limit	10
Preamble Length	144 bits
PCLP length	48 bits
ACK Frame Length	112 bits
UDP payload	8000 bits

- 3 simulation scenario
  - 802.11 standard
  - EDA
  - EDA large CW

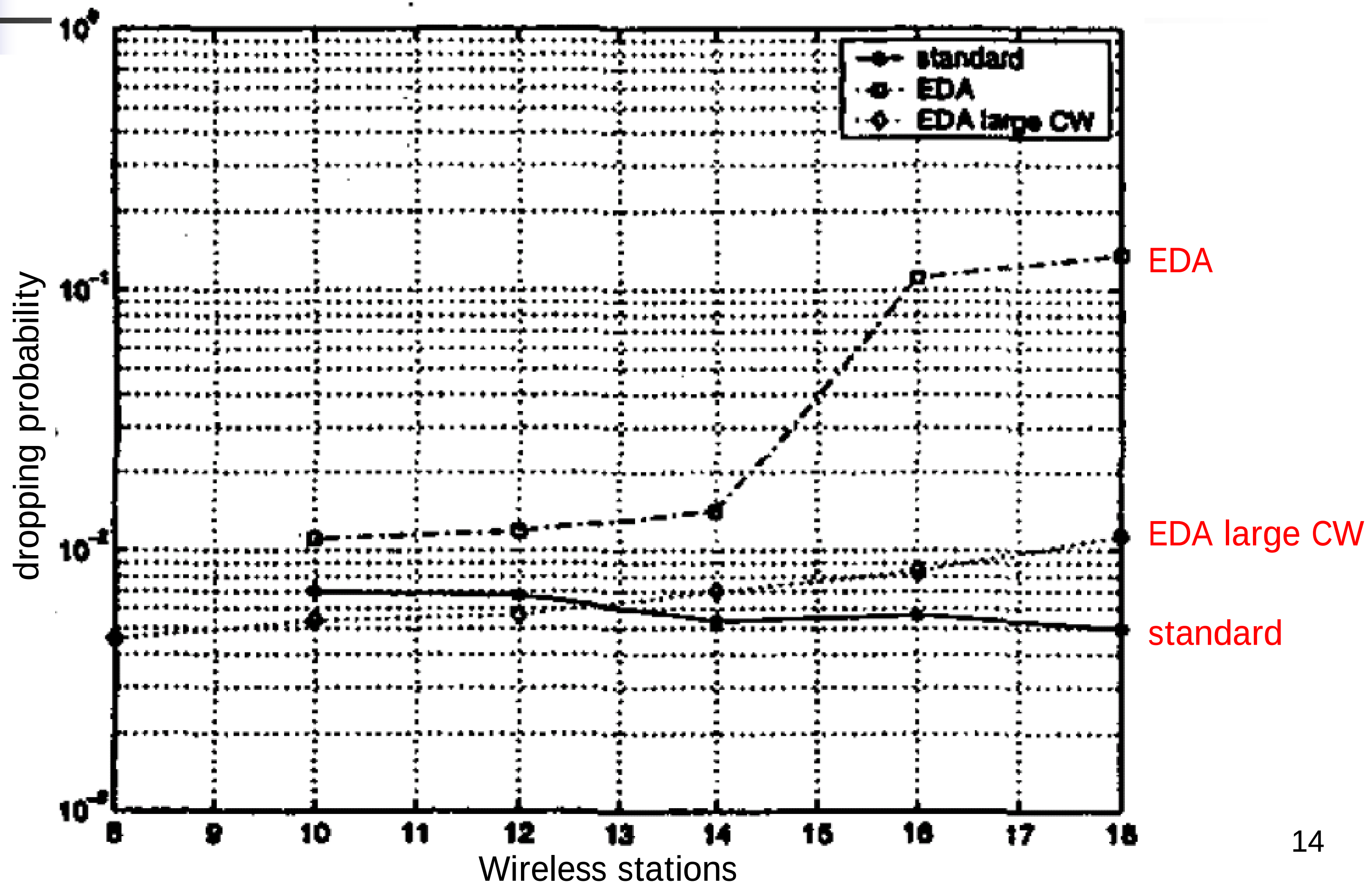
Average consumption per successful packet vs. the number of wireless stations



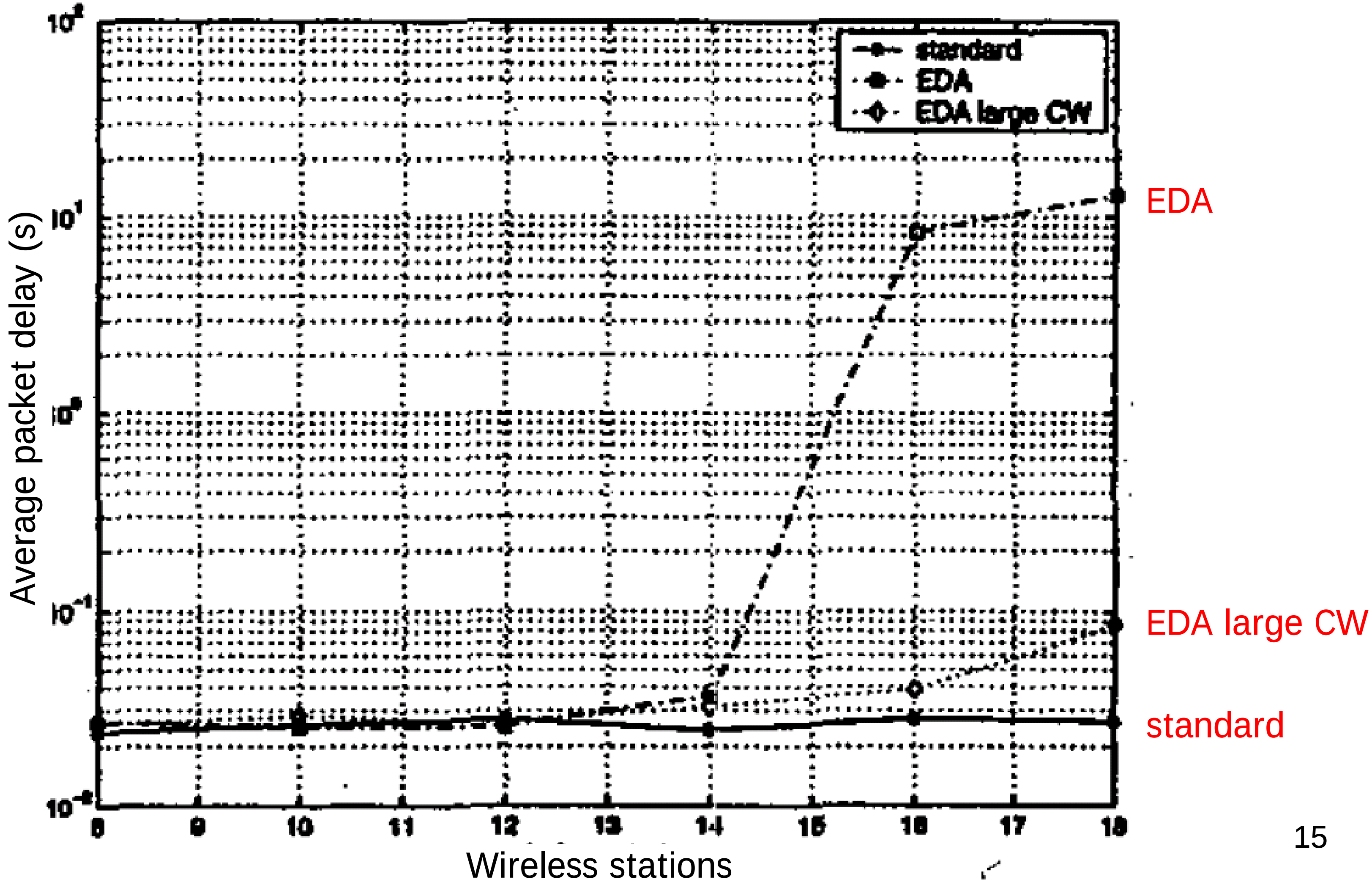
Collision probability vs. the number of wireless stations



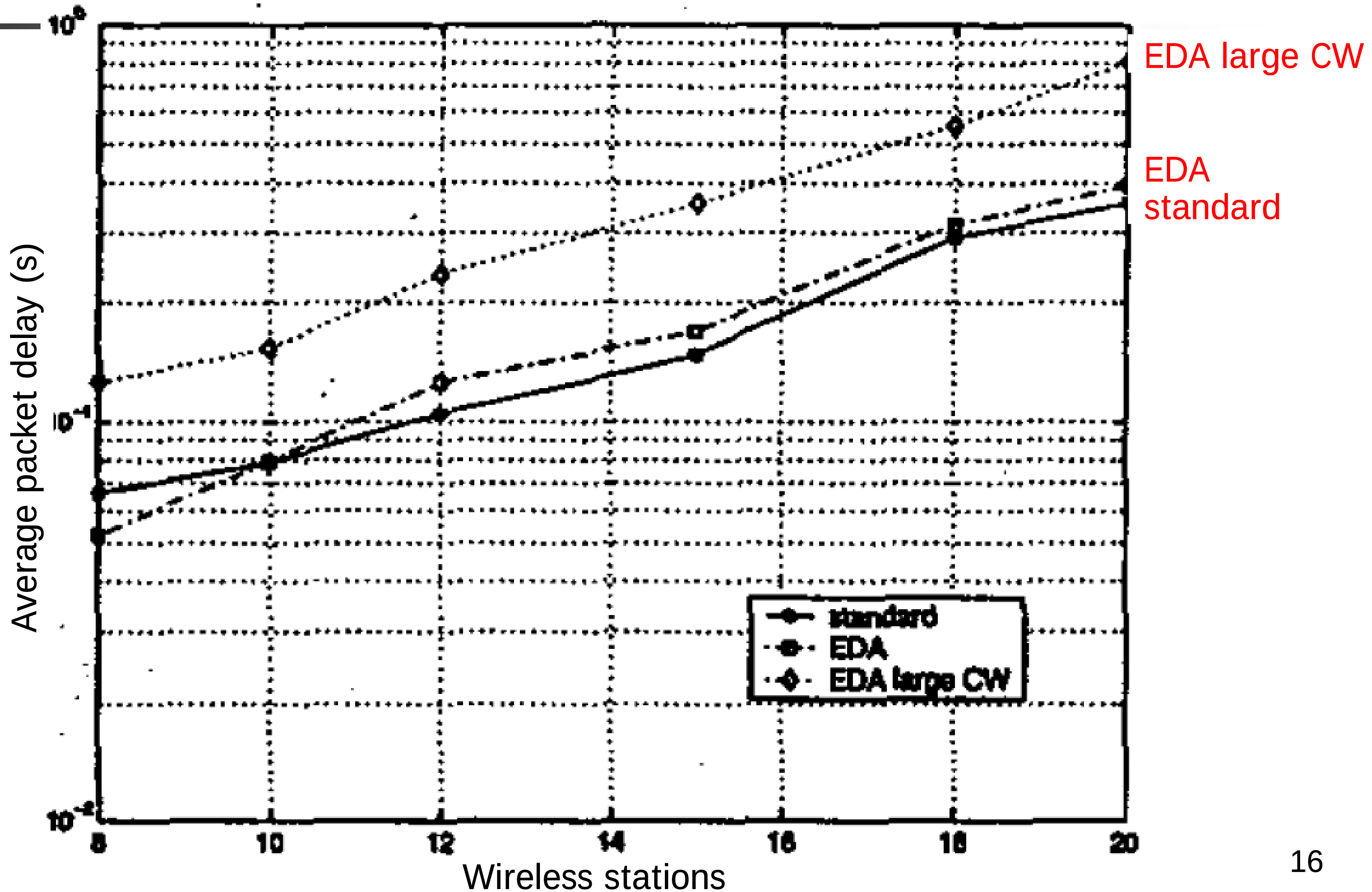
Dropping probability vs. the number of wireless stations



Average packet delay vs. the number of wireless stations – Uplink



Average packet delay vs. the number of wireless stations - Downlink



Conclusions

- EDA scheme is proposed to reduce the energy consumed in sensing medium
  - EDA WSTAs enter the doze state and count down the backoff timer when sensing the medium is busy
- There exists trade-off between energy saving, traffic delay and collision probability
- The results show that EDA scheme reduces energy consumption while traffic delay is slightly increased