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UNIVERSITÄT FREIBURG

Algorithms for Radio Networks

MACAW

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MACAW

- **Bharghavan, Demers, Shenker, Zhang**
  - MACAW: A Media Access Protocol for Wireless LAN‘s, SIGCOMM 1994
  - Palo Alto Research Center, Xerox
- **Aim**
  - Redesign of MACA
  - Improved backoff
  - Fairer bandwidth sharing using *Streams*
  - Higher efficiency
    - by 4- and 5-Handshake

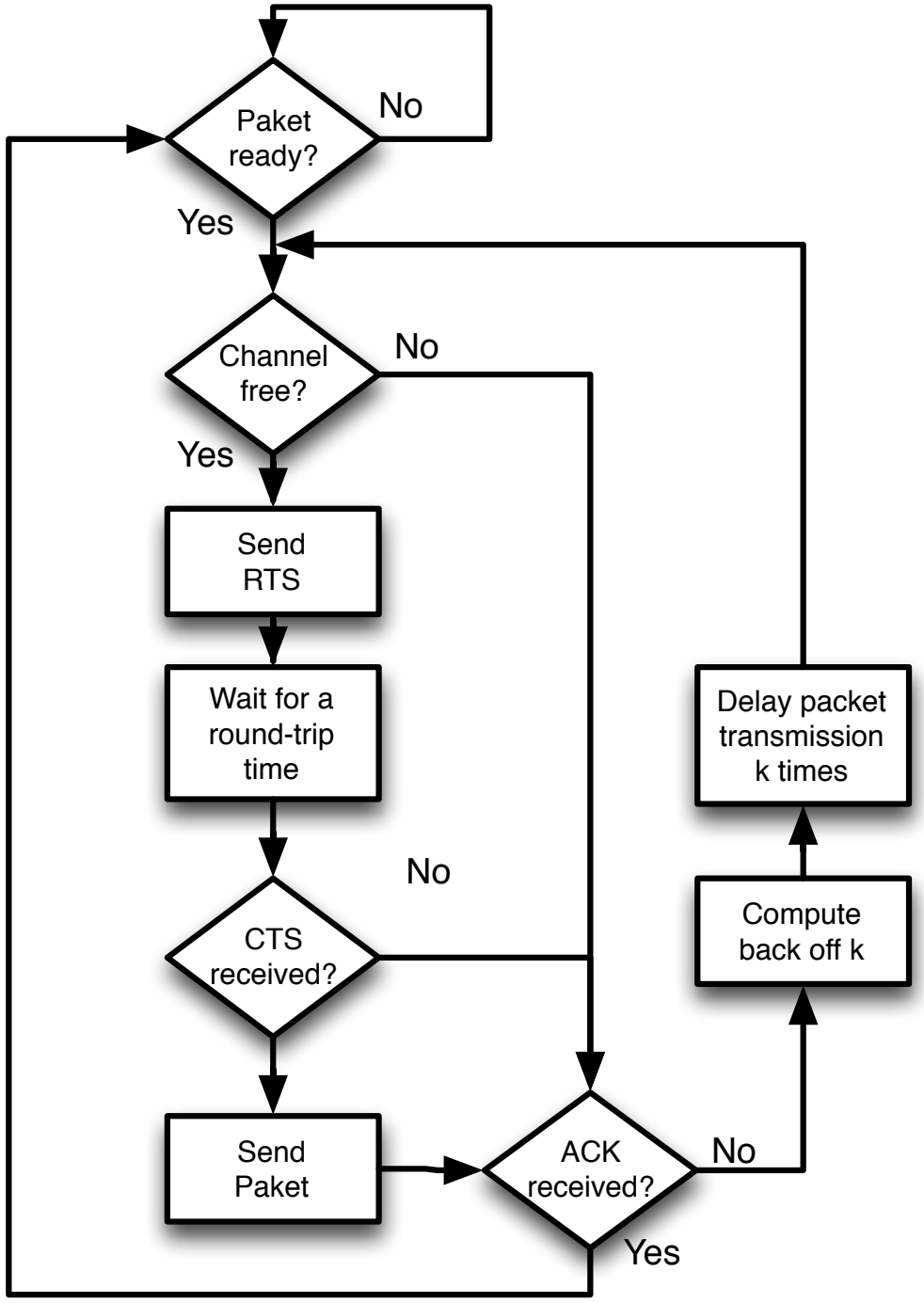
Acknowledgment in the Data Link Layer

- **MACA**
  - does not use Acks
  - initiated by Transport Layer
  - very inefficient
- **How can MACA use Acks?**

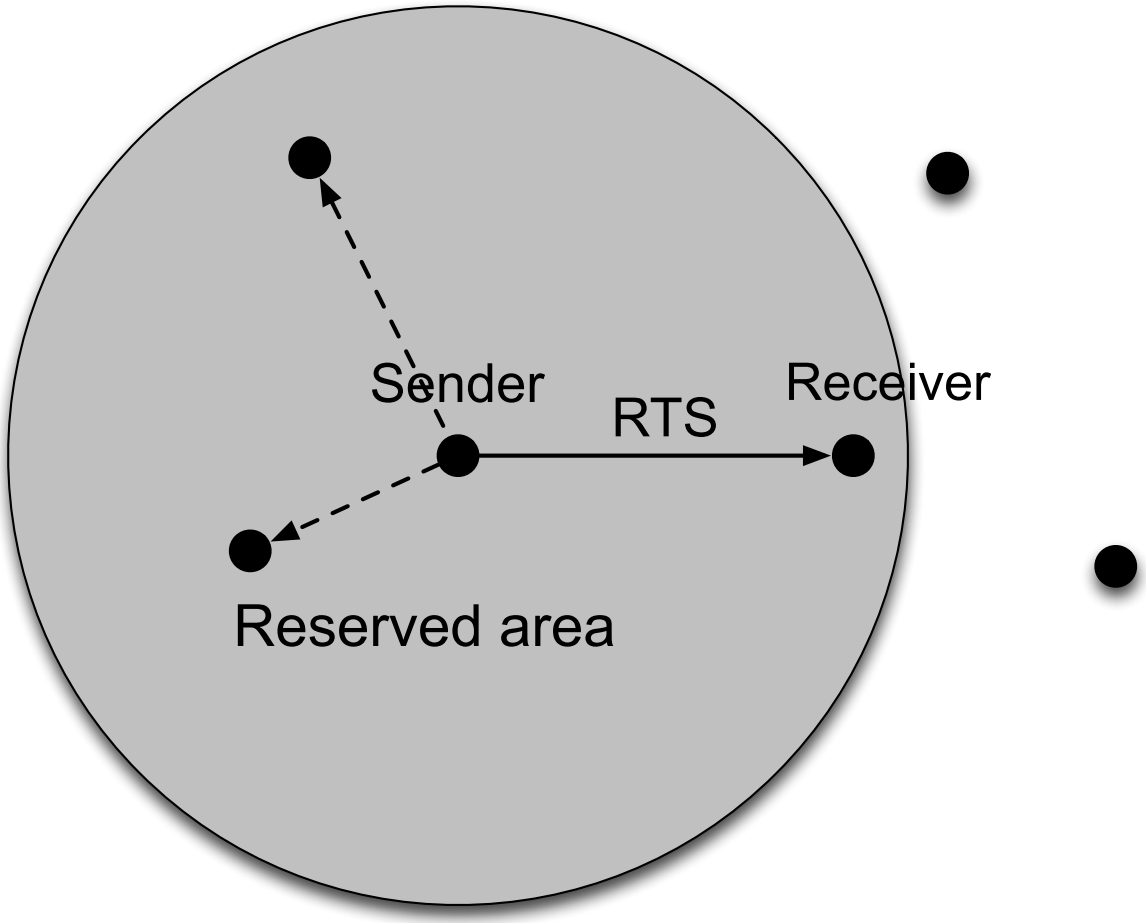
MACAW
4 Handshake

- **Participants**
  - Sender sends RTS
  - Receiver answers with CTS
  - Sender sends data packet
  - Receiver acknowledges (ACK)
- **Third parties**
  - Nodes receiving RTS or CTS are blocked for some time
  - RTS and CTS describe the transmission duration
- **Sender repeats RTS, if no ACK has been received**
  - If receiver has sent ACK
  - then the receiver sends (instead of CTS) another ACK

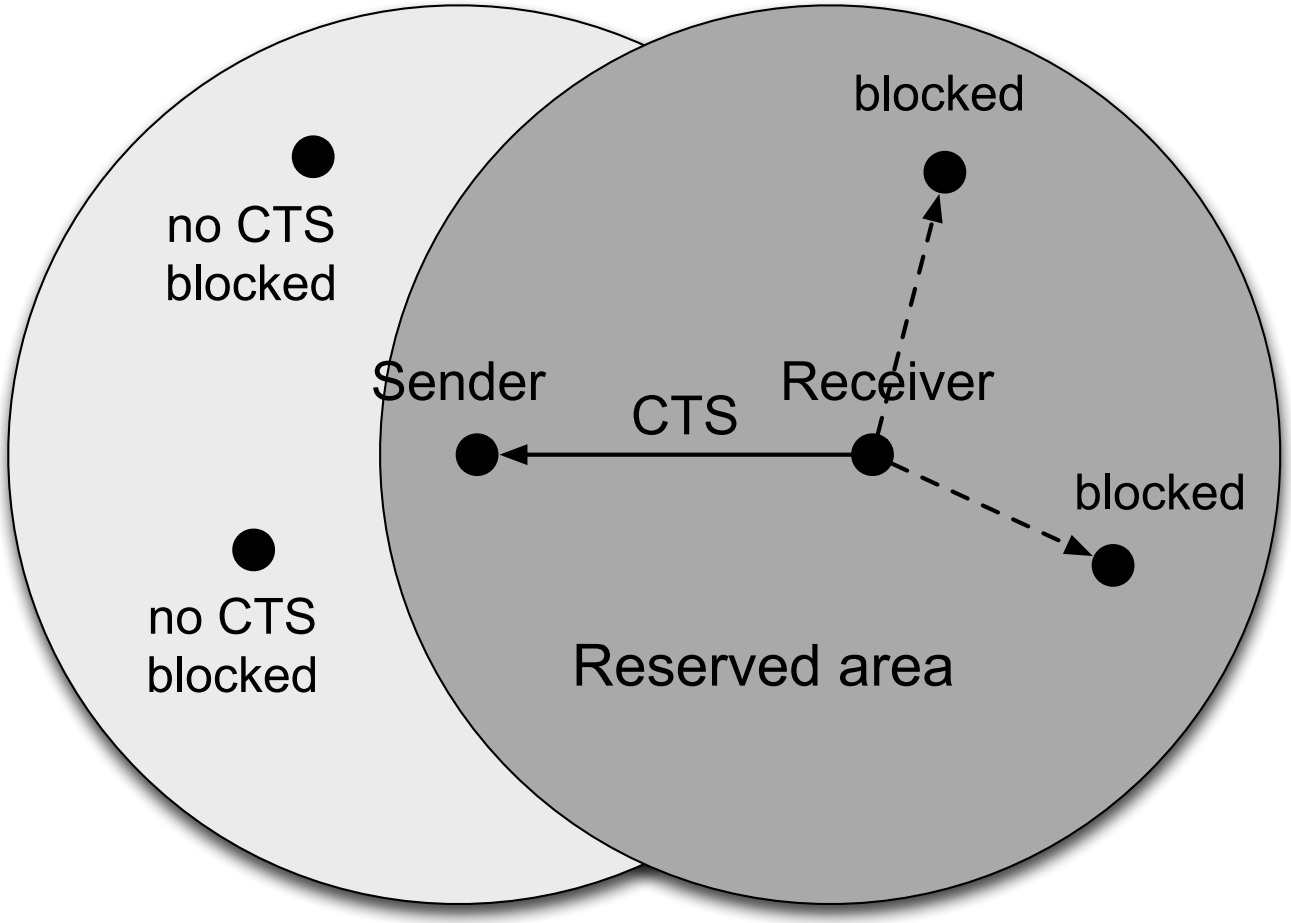
MACAW


Paket ready?
No
Yes
Channel free?
No
Yes
Send RTS
Wait for a round-trip time
No
CTS received?
Send Paket
ACK received?
No
Yes
Compute back off k
Delay packet transmission k times

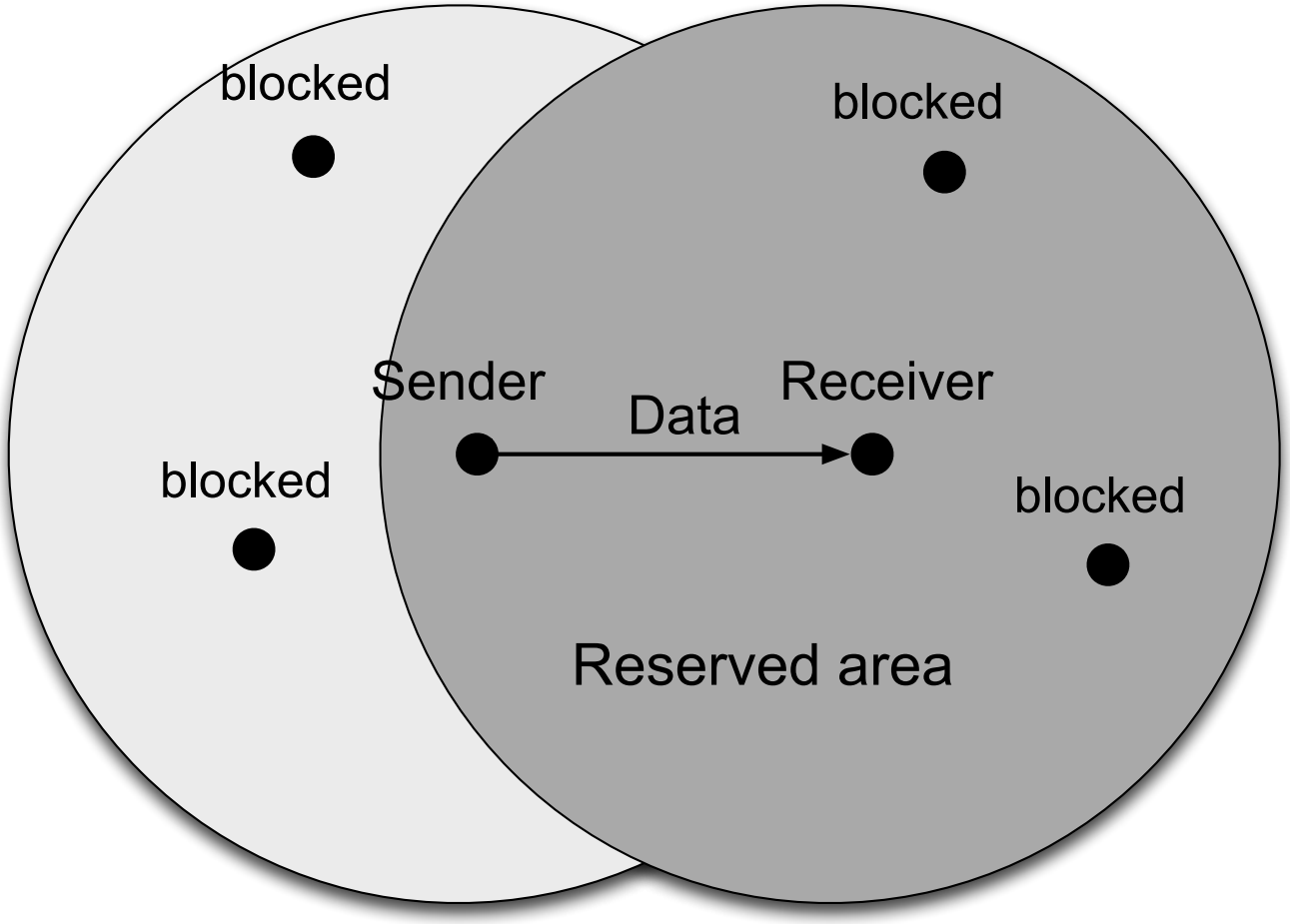
MACA 4-Handshake
RTS



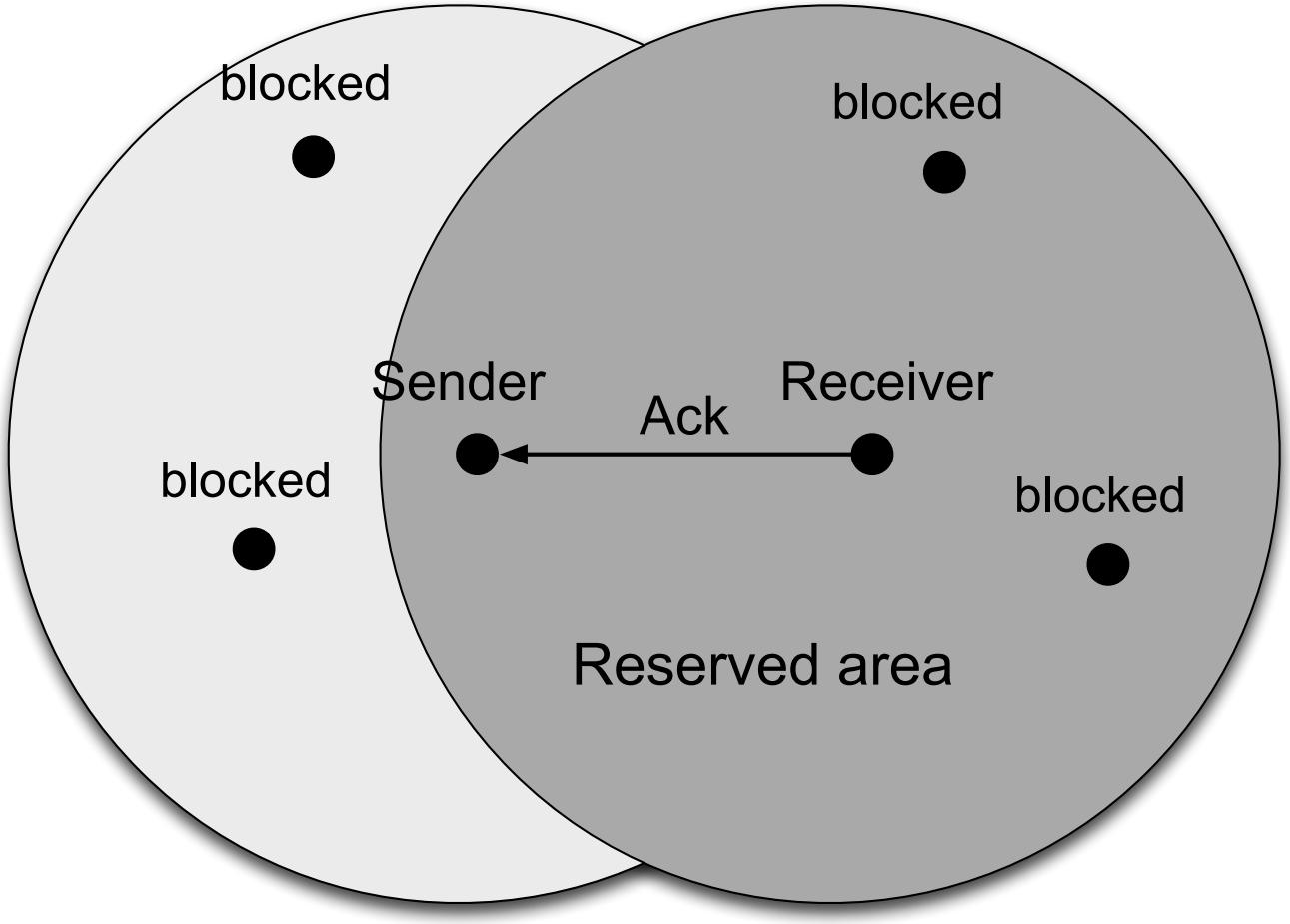
MACAW 4-Handshake
CTS



MACAW 4-Handshake Data



MACAW 4-Handshake Ack



Acknowledgments

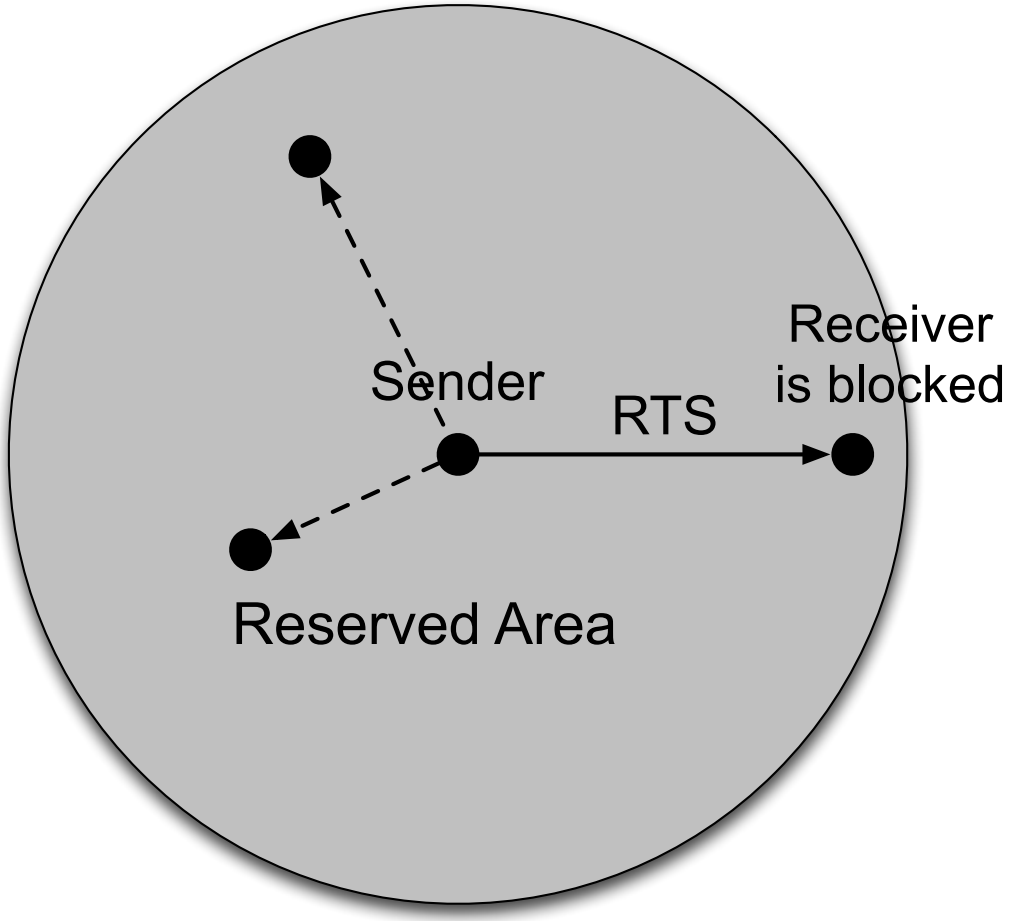
- **Adding ACKs to MACA**
  - In MACA done by transport layer
- **leads to drastical improvements of throughput even for moderate error rates**

error rate	throughput	
	RTS-CTS-DATA	RTS-CTS-DATA-ACK
0	40	37
0,001	37	37
0,01	17	36
0,1	2	10

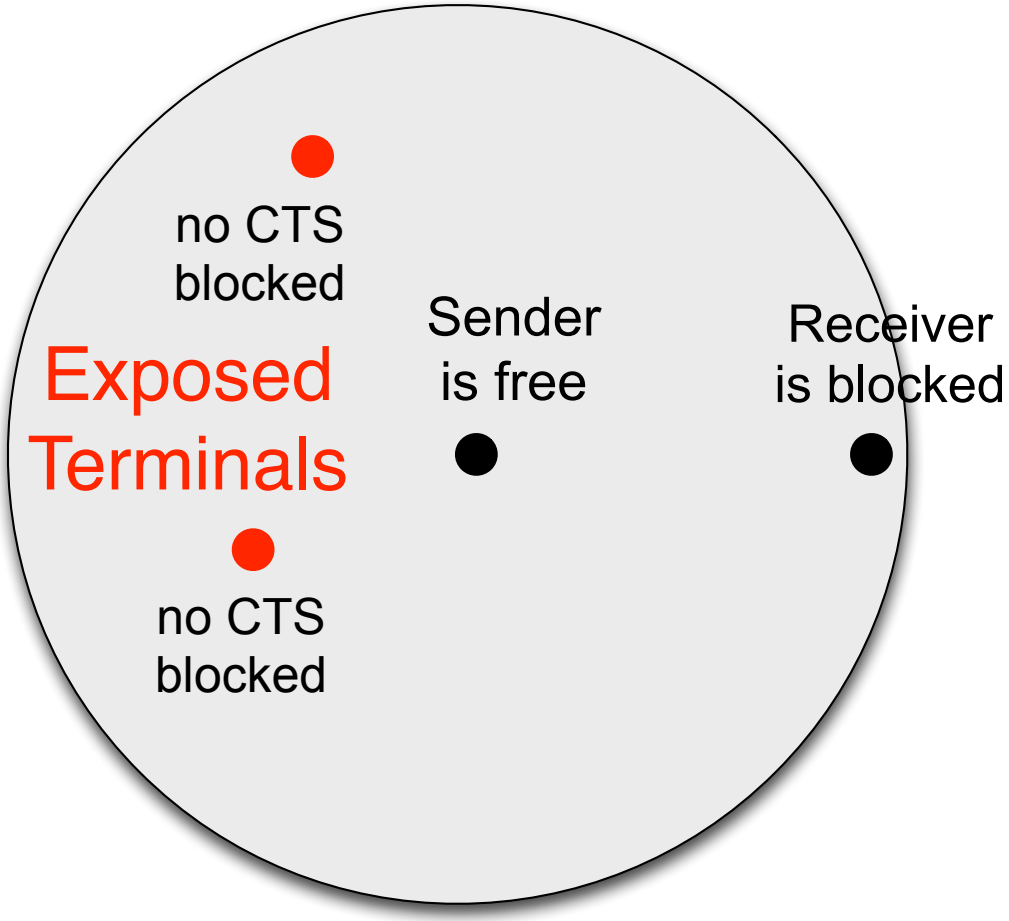
MACAW
4 Handshake

- **Worst-Case blockade**
  - Sender sends RTS
  - Receiver is blocked
  - Sender is free
  - But the environment of the sender is blocked

MACAW 4-Handshake
RTS



MACAW 4-Handshake
CTS is missing



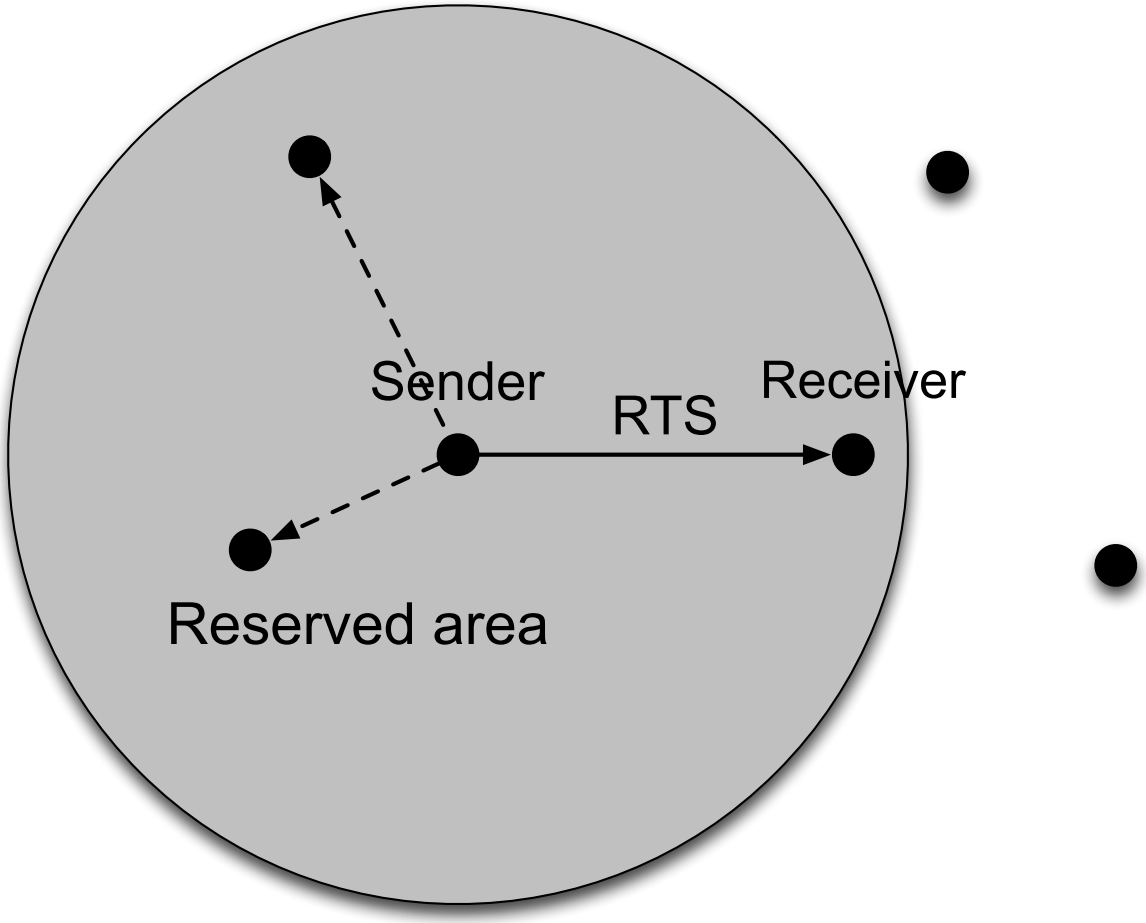
MACAW
5 Handshake

- **4-Handshake increases Exposed Terminal Problem**
  - Overheard RTS blocks nodes
  - even if there is no data transfer
- **Solution**
  - Exposed Terminals are informed whether data transmission occurs
  - Short message DS (data send)
- **5 Handshake reduces waiting time for exposed terminals**

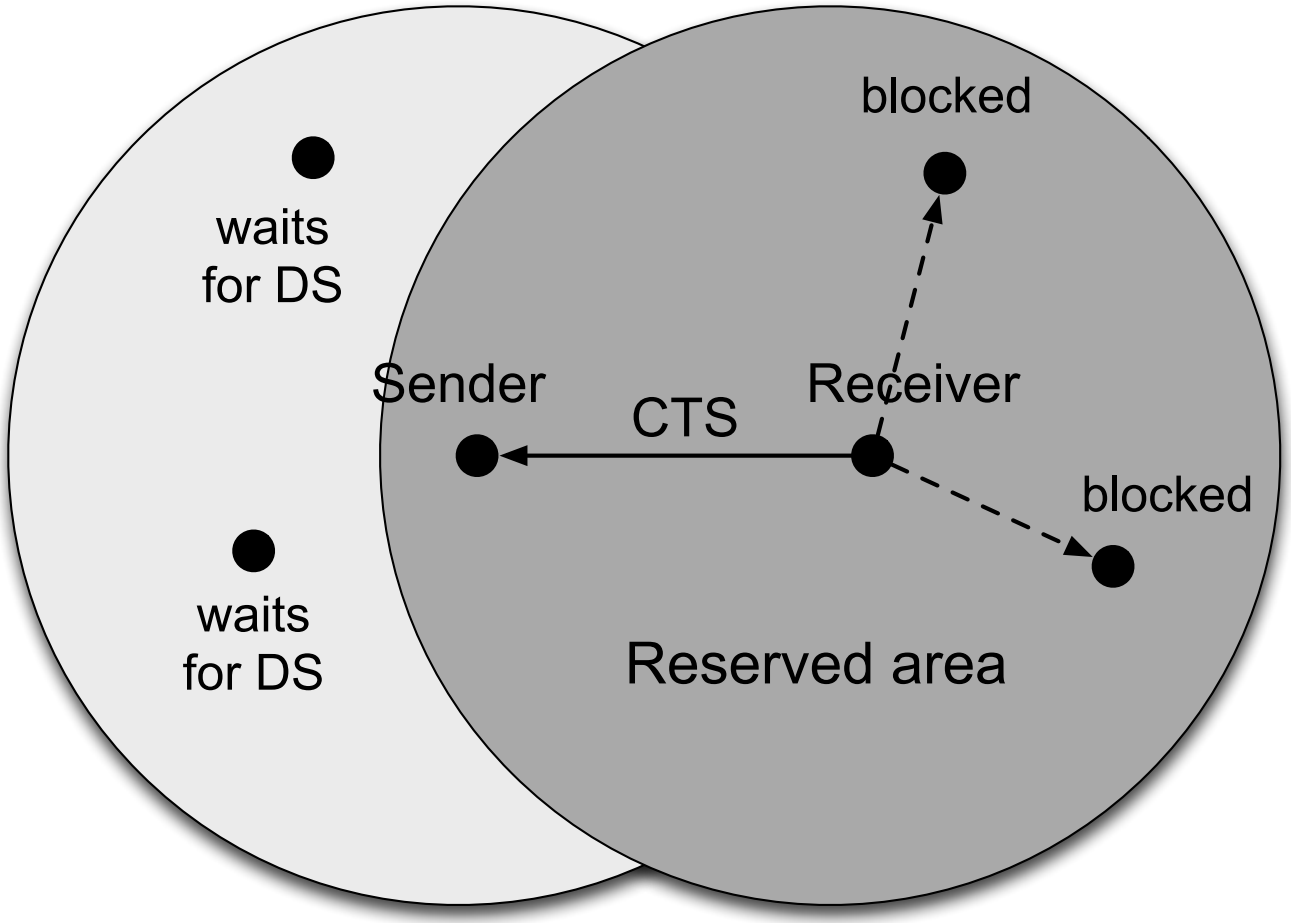
MACAW
5 Handshake

- **Participants**
  - Sender sends RTS
  - Receivers answers with CTS
  - Sender sends DS (Data Send)
  - Sender sends DATA PACKET
  - Receiver acknowledges (ACK)
- **RTS and CTS announce the transmission duration**
- **Blocked nodes**
  - have received RTS and DS
  - have received CTS
- **Small effort decreases the number of exposed terminals**

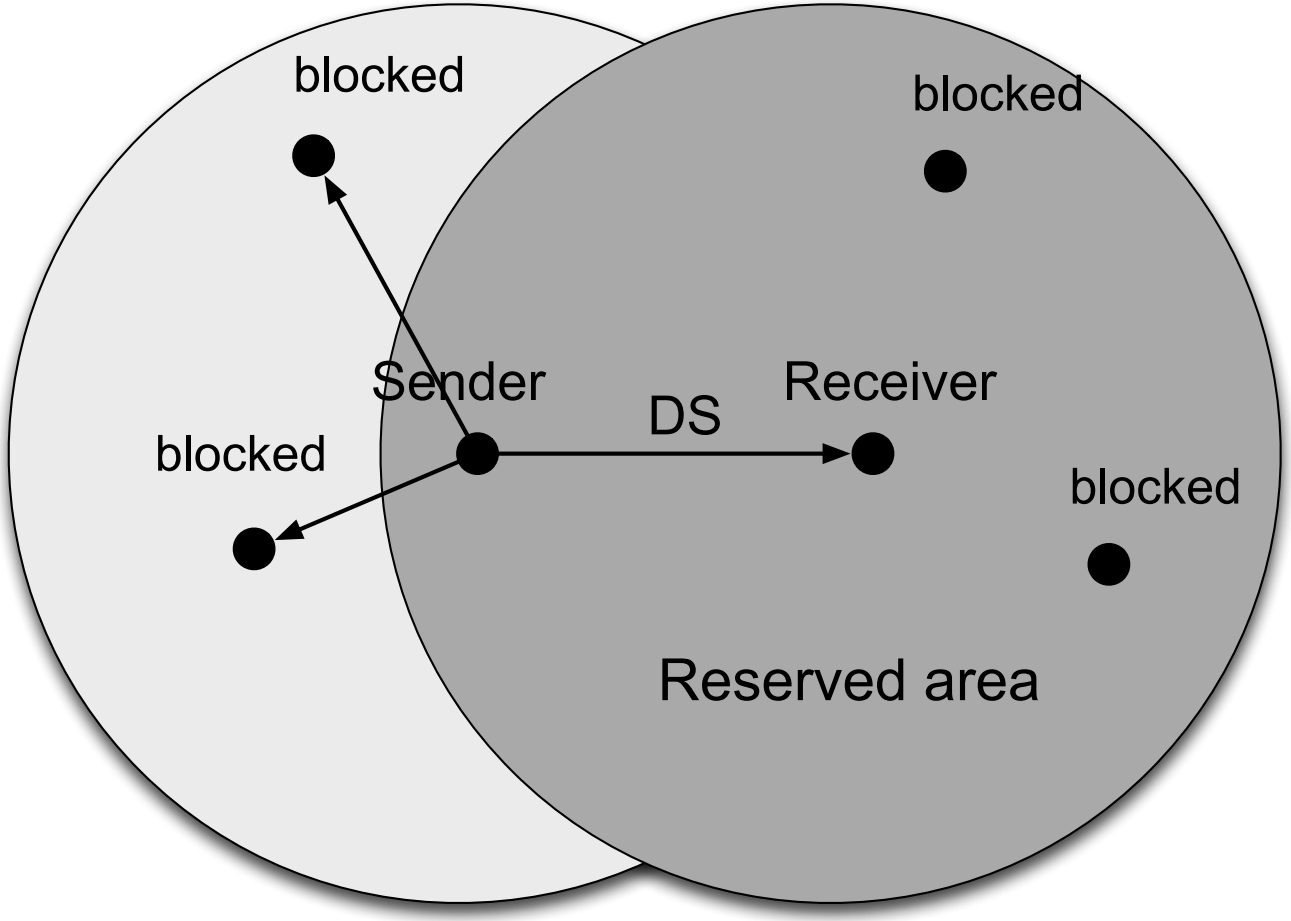
MACAW 5-Handshake
RTS



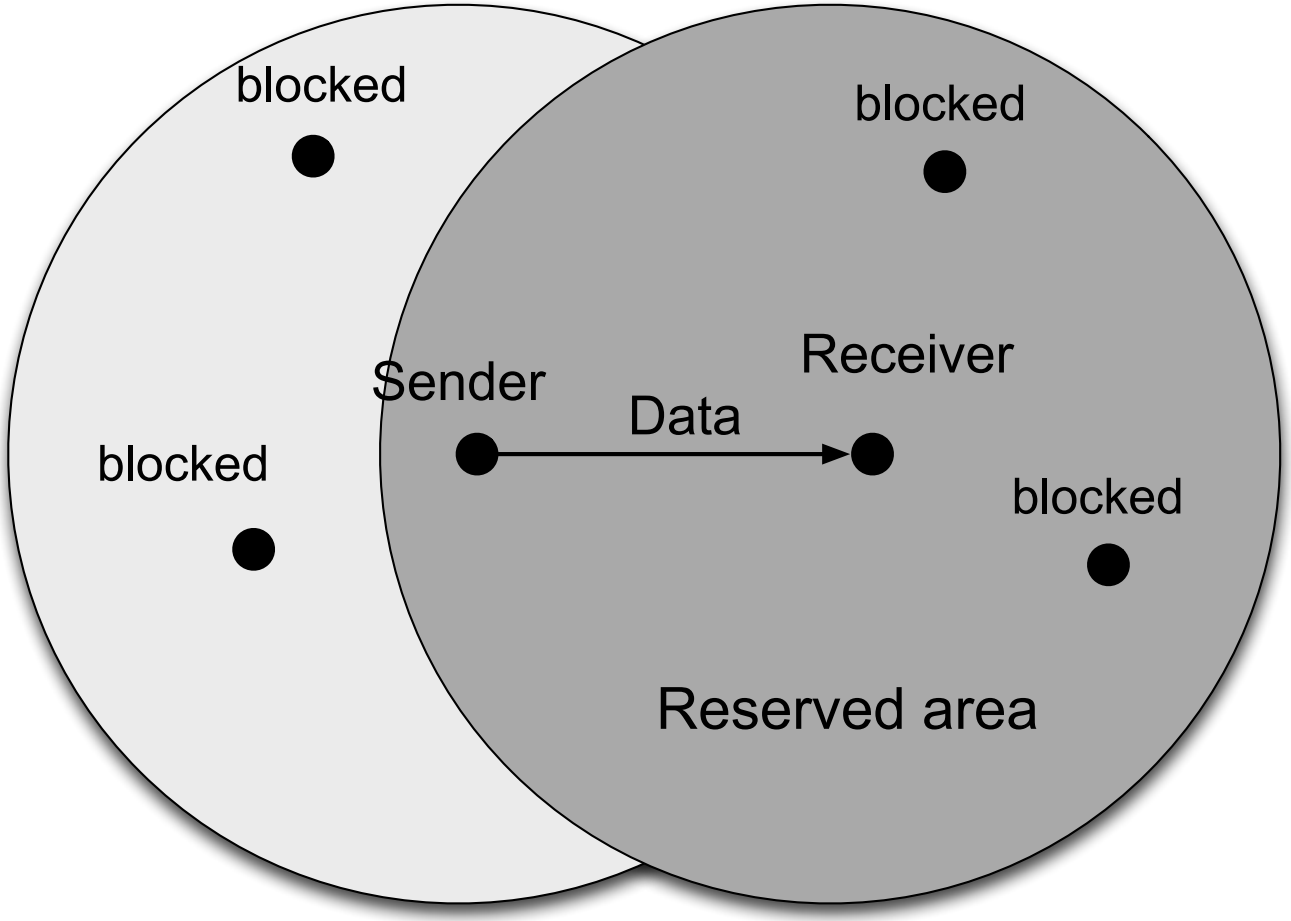
MACAW 5-Handshake
CTS



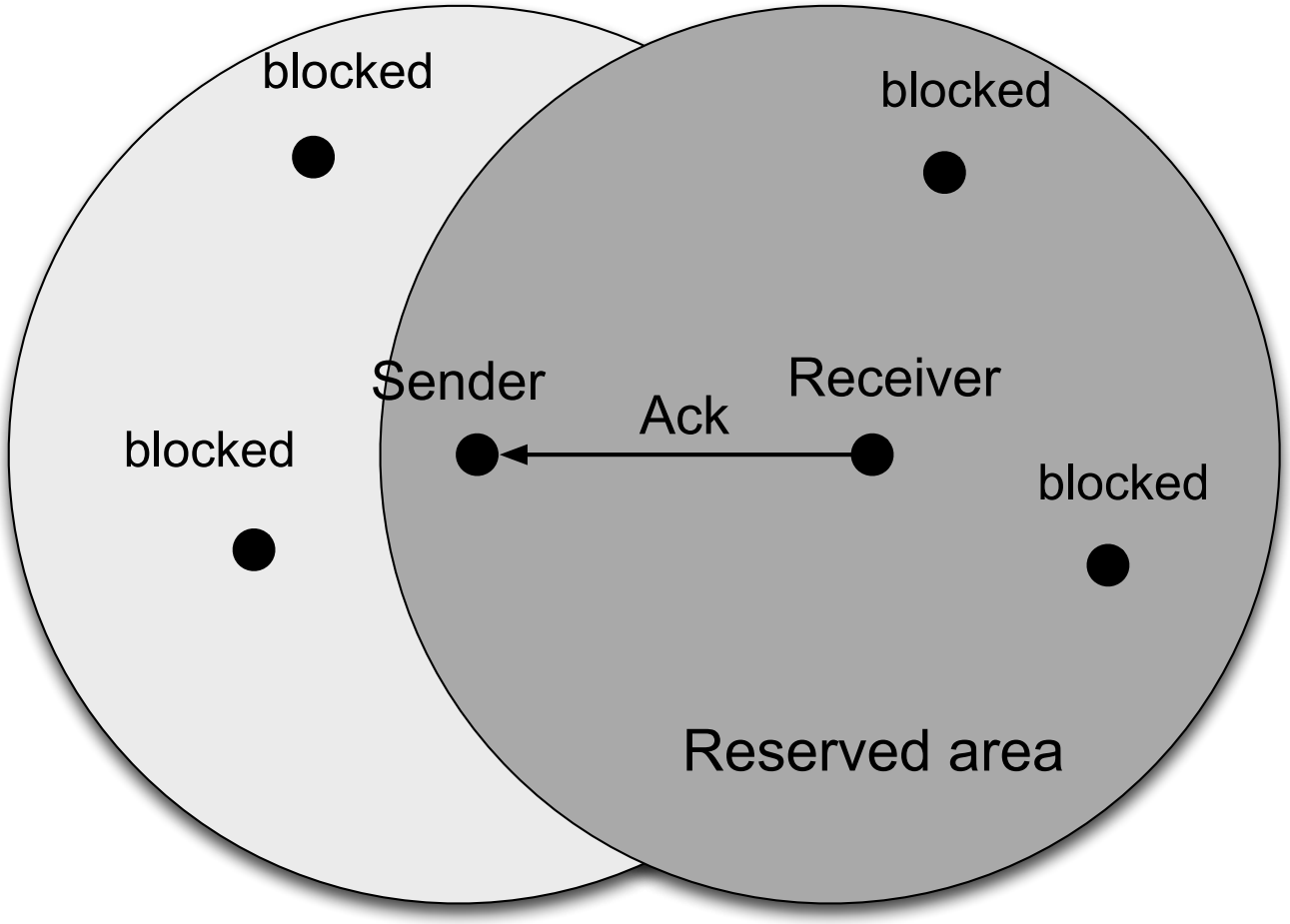
MACAW 5-Handshake DS



MACAW 5-Handshake Data



MACAW 5-Handshake
ACK



Unfair Distribution

- **4 and 5-Handshake create unfair distribution**
  - A has a lot of data for B
  - D has a lot of data for C
  - C receives B and D, but does not receive A
  - B can receive A and C, but does not hears D
- **A is the first to get the channel**
- **D sends RTS and is blocked**
  - Backoff of D is doubling
- **At the next transmission**
  - A has smaller backoff
  - A has higher chance for next channel access

RRTS

- **Solution**
  - C sends RRTS (Request for Request to Send)
    - if ACK has been received
  - D sends RTS, etc.
- **Why RRTS instead of CTS?**
  - If neighbors receive CTS, then they are blocked for a long time
  - Possibly, D is not available at the moment

Backoff Algorithms

- **After collision wait random time from {1,.. Backoff}**
- **Binary Exponential Backoff (BEB) algorithm**
  - Increase after collision
    - backoff = min{2 backoff, maximal backoff}
  - Else:
    - backoff = Minimal Backoff
- **Multiplicative increase, linear decrease (MILD)**
  - Increase:
    - backoff = min{1.5 backoff, maximal backoff}
  - Else:
    - backoff = max{backoff - 1, minimal-backoff}

Information Dissemination for Backoff-Algorithm

- **Backoff parameter are overheard**
  - participants adapt the parameters to the overheard backoff values
  - using MILD
- **Motivation**
  - if a participant has the same backoff value, then the fairness has been reached

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