Wireless Sensor Networks

4. Medium Access

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Efficiency of Preamble Sampling

- Few messages
  - Better: long sleep phases
  - Receiver consume most of the total energy
- Many messages
  - Short sleep phases
  - Sender consume most of the total energy
  - We observe for preamble time T and some positive constants c, c ', c":

$$\text{Energy} = cT + \frac{c'}{T} + c''$$

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Sensor-Mac (S-MAC)

- Ye, Heidemann, Estrin
  - An Energy-Efficient MAC Protocol for Wireless Sensor Networks, INFOCOM 2002
- Synchronized sleep and wake cycles
- MACA (RTS / CTS)
  - for collision avoidance
  - and detection of possible sleep cycles

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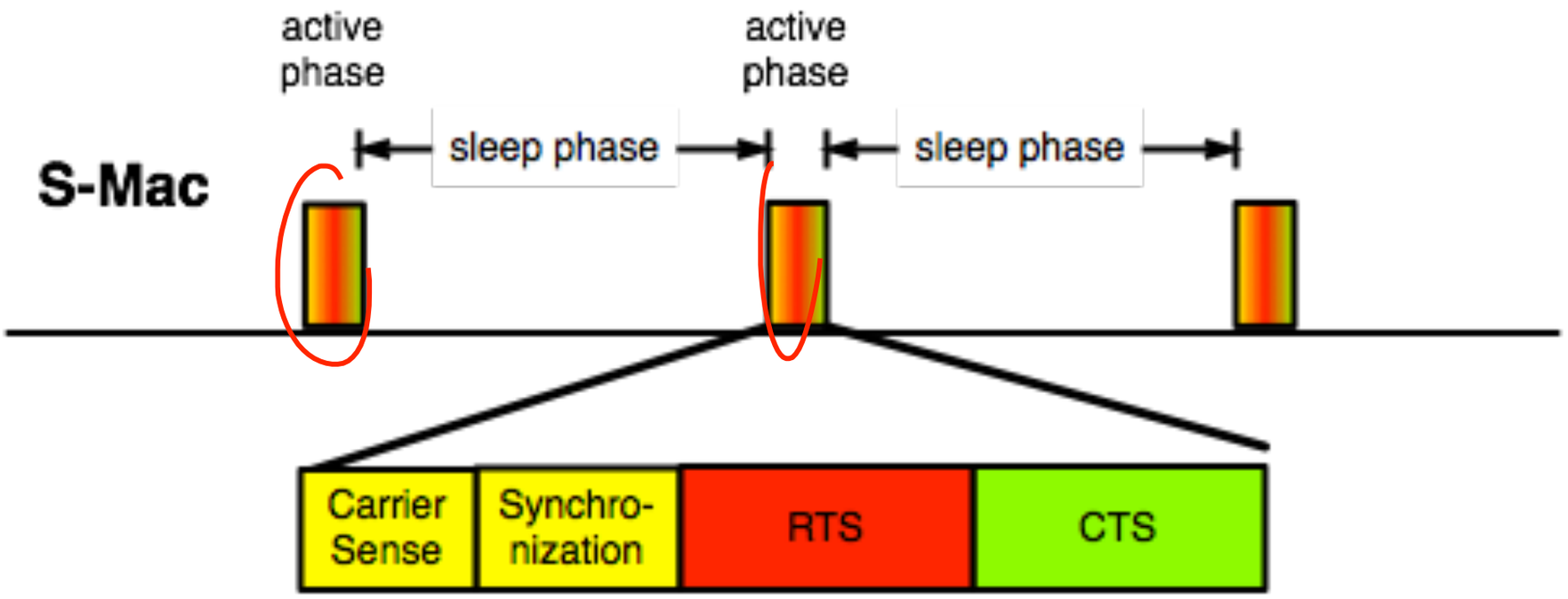
S-MAC Protocol

- Active phase
  - Carrier Sensing
  - Send Sync packet synchronizer short sleep duration with ID and
  - Interval for Request to Send (RTS)
  - Interval for Clear-to-Send (CTS)



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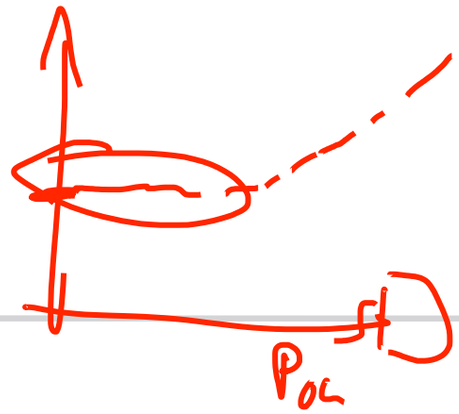
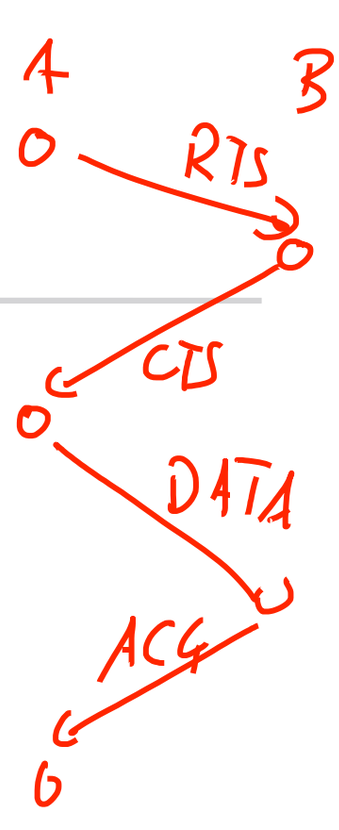
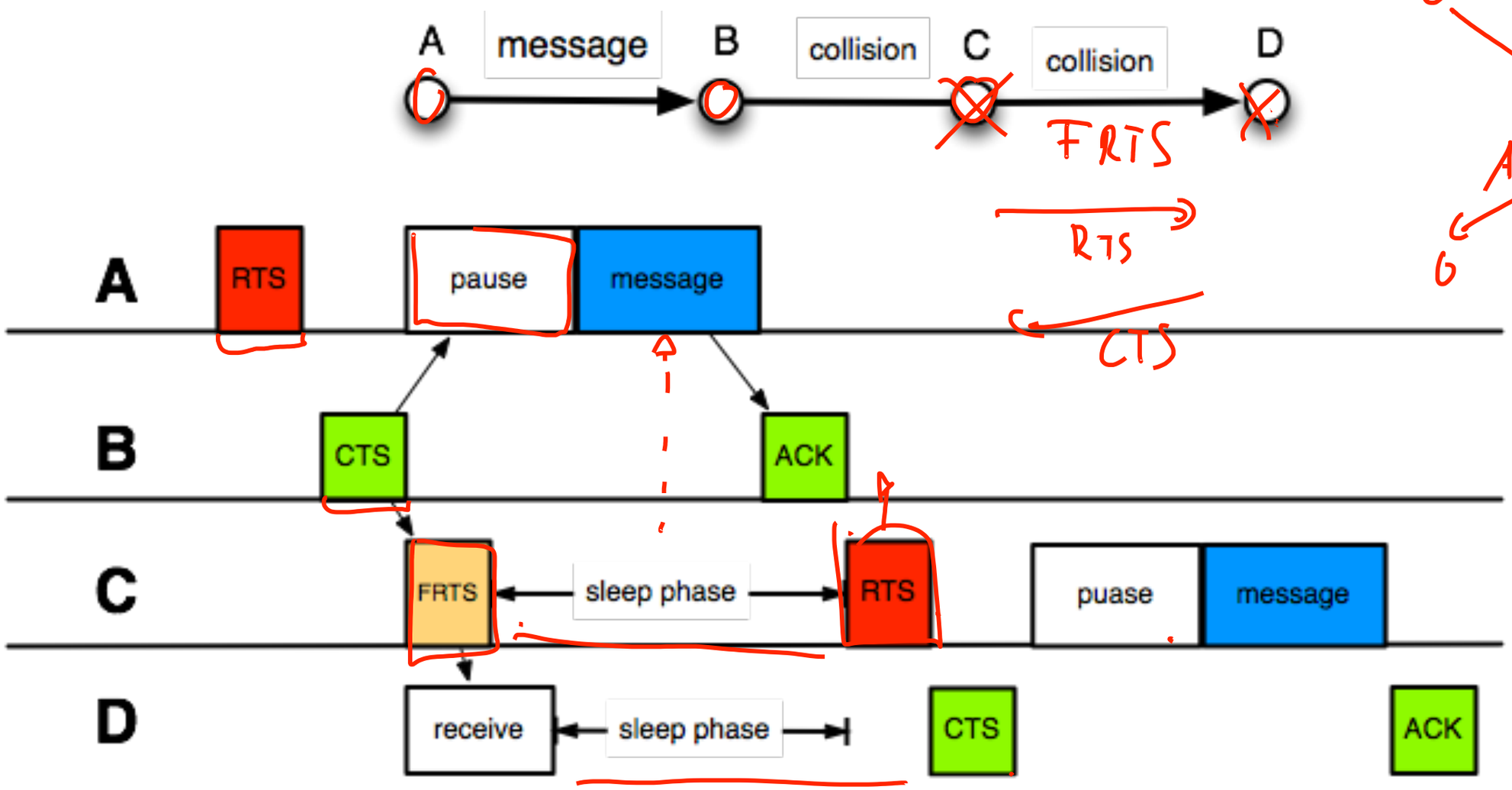
Timeout-MAC (T-MAC)

- T. van Dam, K. Langendoen
  - An Adaptive Energy-Efficient MAC Protocol for Wireless Sensor Networks, SenSys 2003
- Main goal
  - extension of the MACA-protocol to save energy
- Method
  - Traffic dependent sleep cycles
  - New: FRTS-Signal (Future Request to Send)
    - informs about future message
    - Allows adapted sleep phases of the receiver

T-MAC

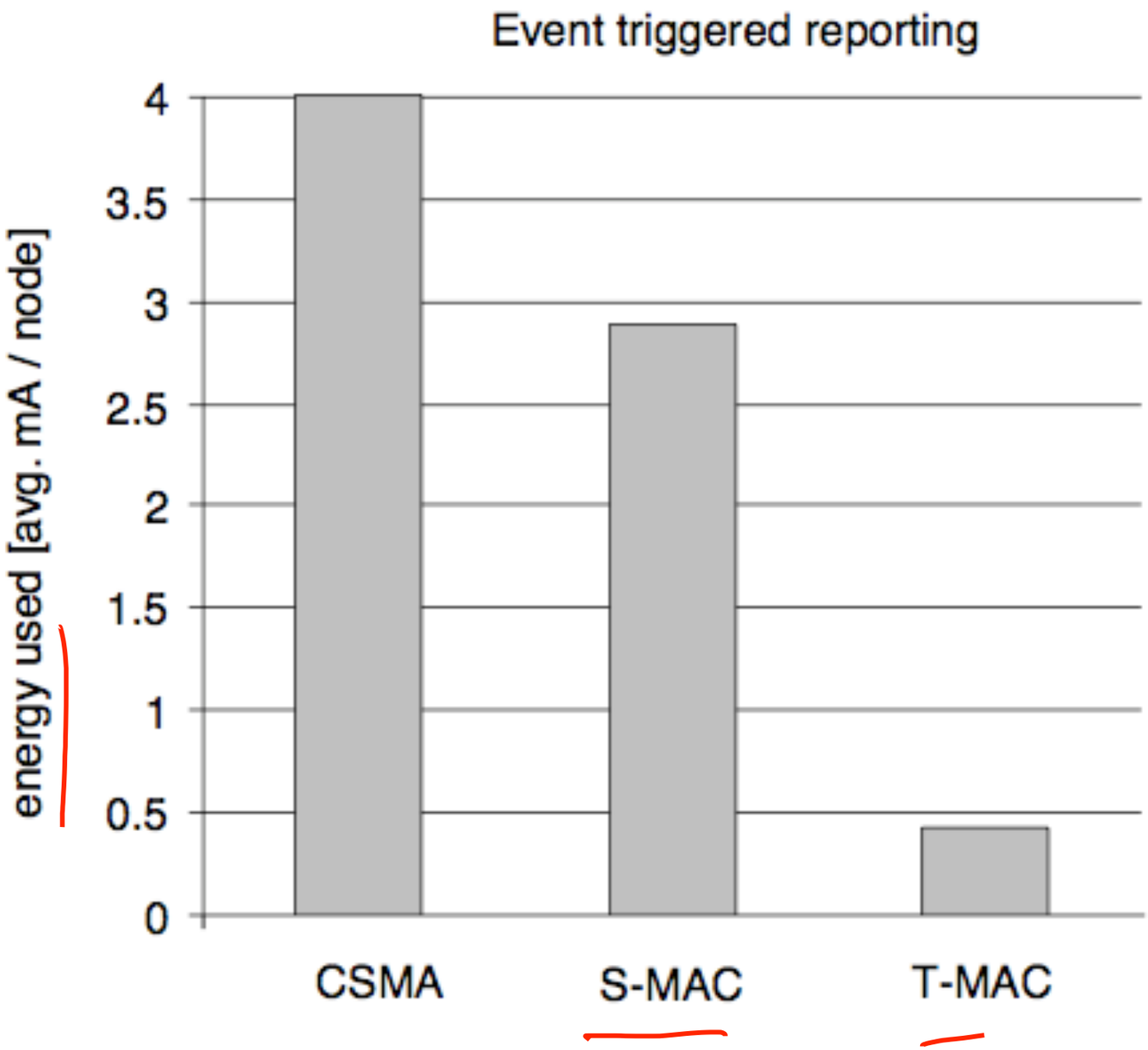



A
B
RTS
CTS
DATA
ACK


A
message
B
collision
C
collision
D
FRTS
RTS
CTS
A
RTS
pause
message
B
CTS
ACK
C
FRTS
sleep phase
RTS
puase
message
D
receive
sleep phase
CTS
ACK

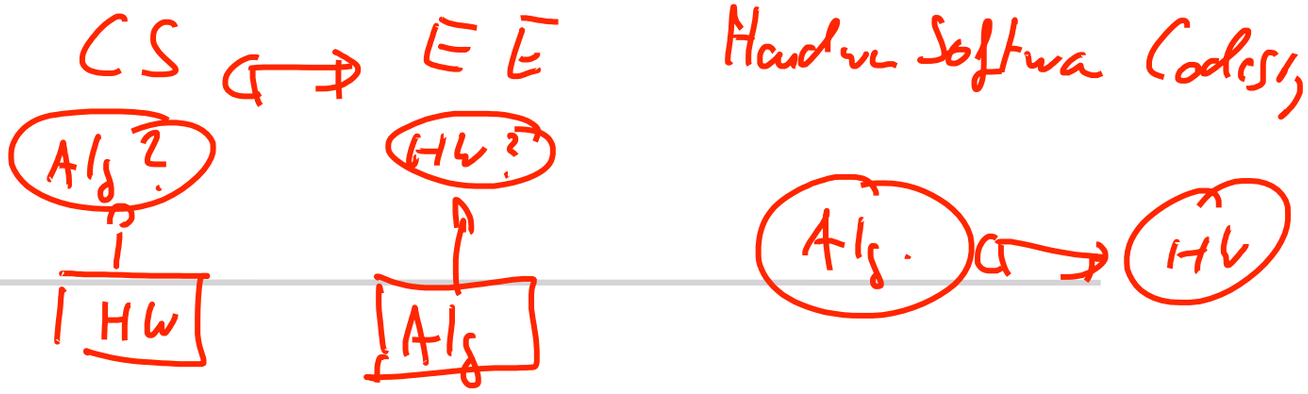
Comparison of S-MAC and T-MAC

- FRTS solves problems that are increased by adapted sleep cycles
  - e.g. Early Sleeping i.e., Falling asleep because sender is blocked by foreign CTS
- Simulation indicates significant energy reduction
  - also improve the throughput

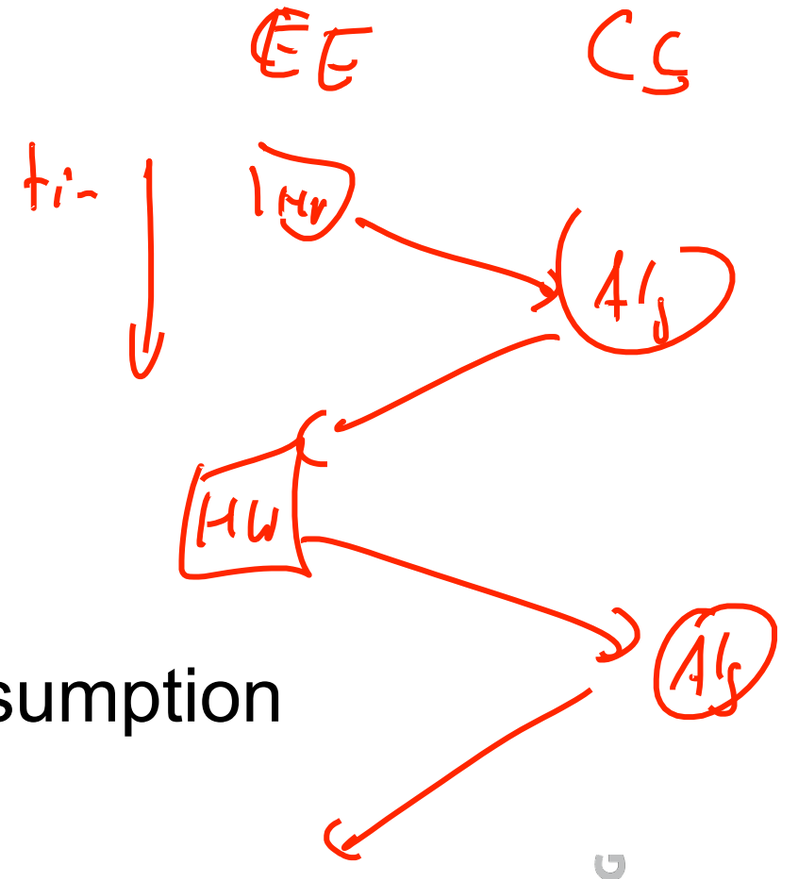


T. van Dam, K. Langendoen, An Adaptive Energy-Efficient MAC Protocol for Wireless Sensor Networks, SenSys 2003

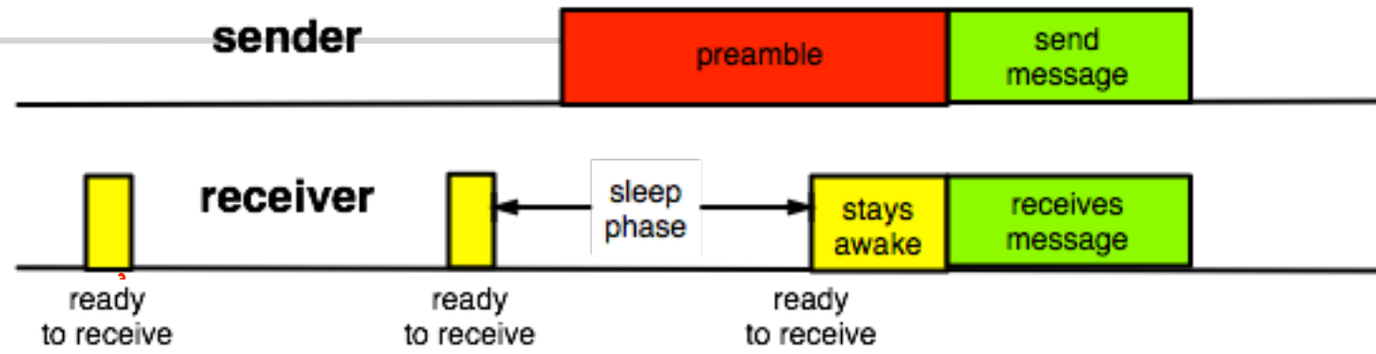
B-MAC



- Polastre, Hill, Culler
  - Versatile Low Power Media Access for Wireless Sensor Networks, SenSys'04, November 3–5, 2004, Baltimore, Maryland, USA.
- B-MAC (Berkeley-MAC)
  - no synchronization
  - Clear Channel Assessment
  - Evaluation of RSSI compared to noise
  - Hardware-oriented implementation
  - Very simple, low memory and power consumption

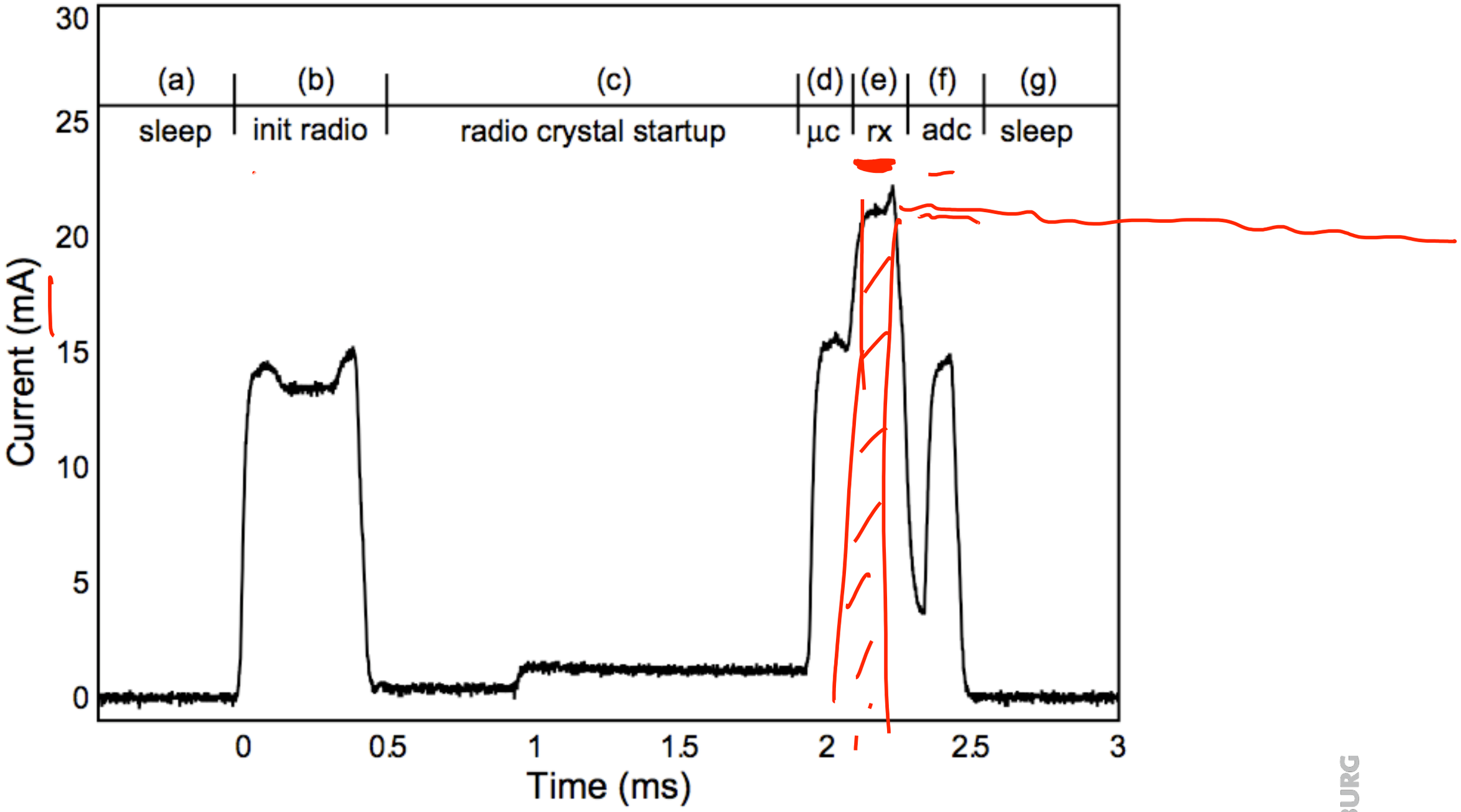


B-MAC



- Low Power Listening
  - Preamble Sampling
  - Special wake-up protocol
  - adapted to hardware with low power consumption
  - Node goes into sleep mode after test
- optional
  - RTS / CTS
  - Acknowledgments
- De-facto standard for WSN MAC Protocols

Low Power Listening



Polastre, Hill, Culler, Versatile Low Power Media Access for Wireless Sensor Networks, SenSys'04

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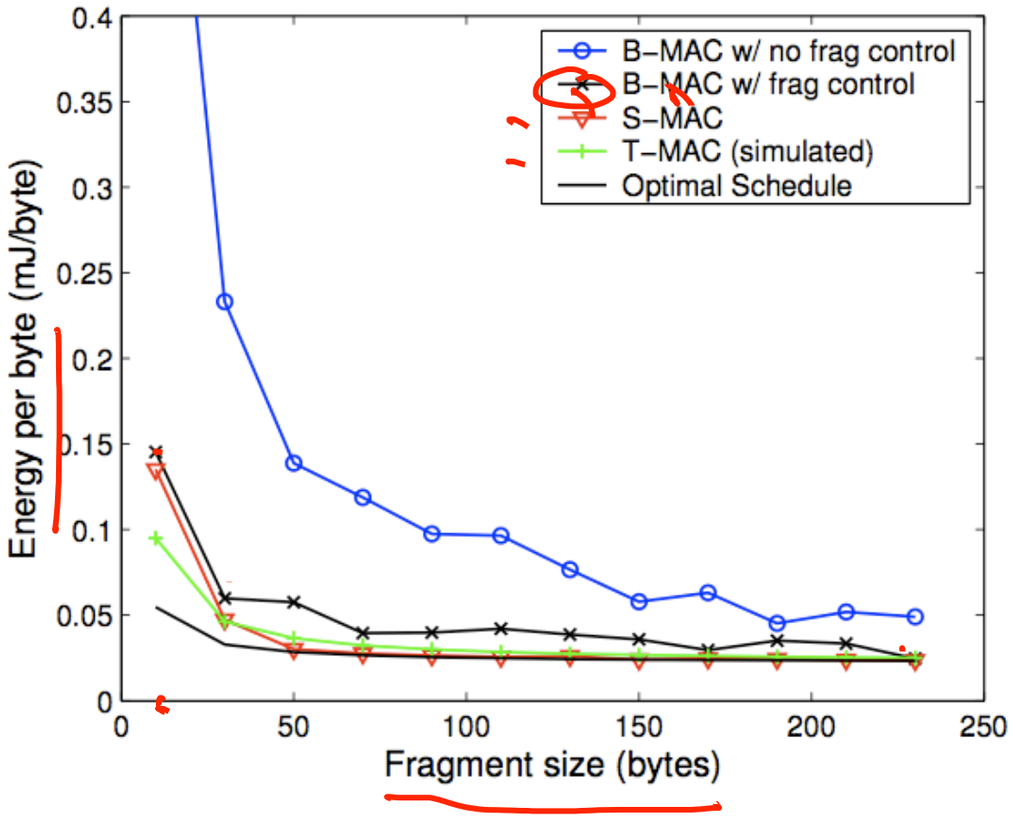
Memory Consumption B-MAC and S-MAC

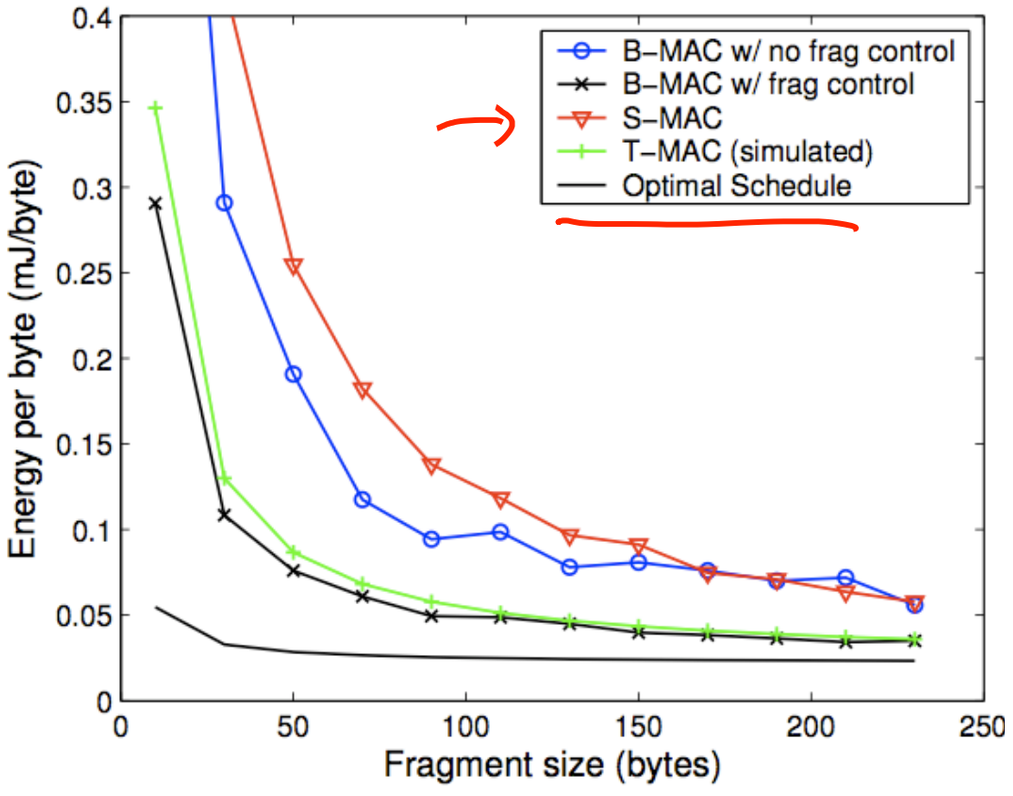
Protocol	ROM	RAM
B-MAC	3046	166
B-MAC w/ ACK	3340	168
B-MAC w/ LPL	4092	170
B-MAC w/ LPL & ACK	4386	172
B-MAC w/ LPL & ACK + RTS-CTS	4616	277
S-MAC	6274	516

Polastre, Hill, Culler, Versatile Low Power Media Access for Wireless Sensor Networks, SenSys'04

Comparison of Energy Consumption



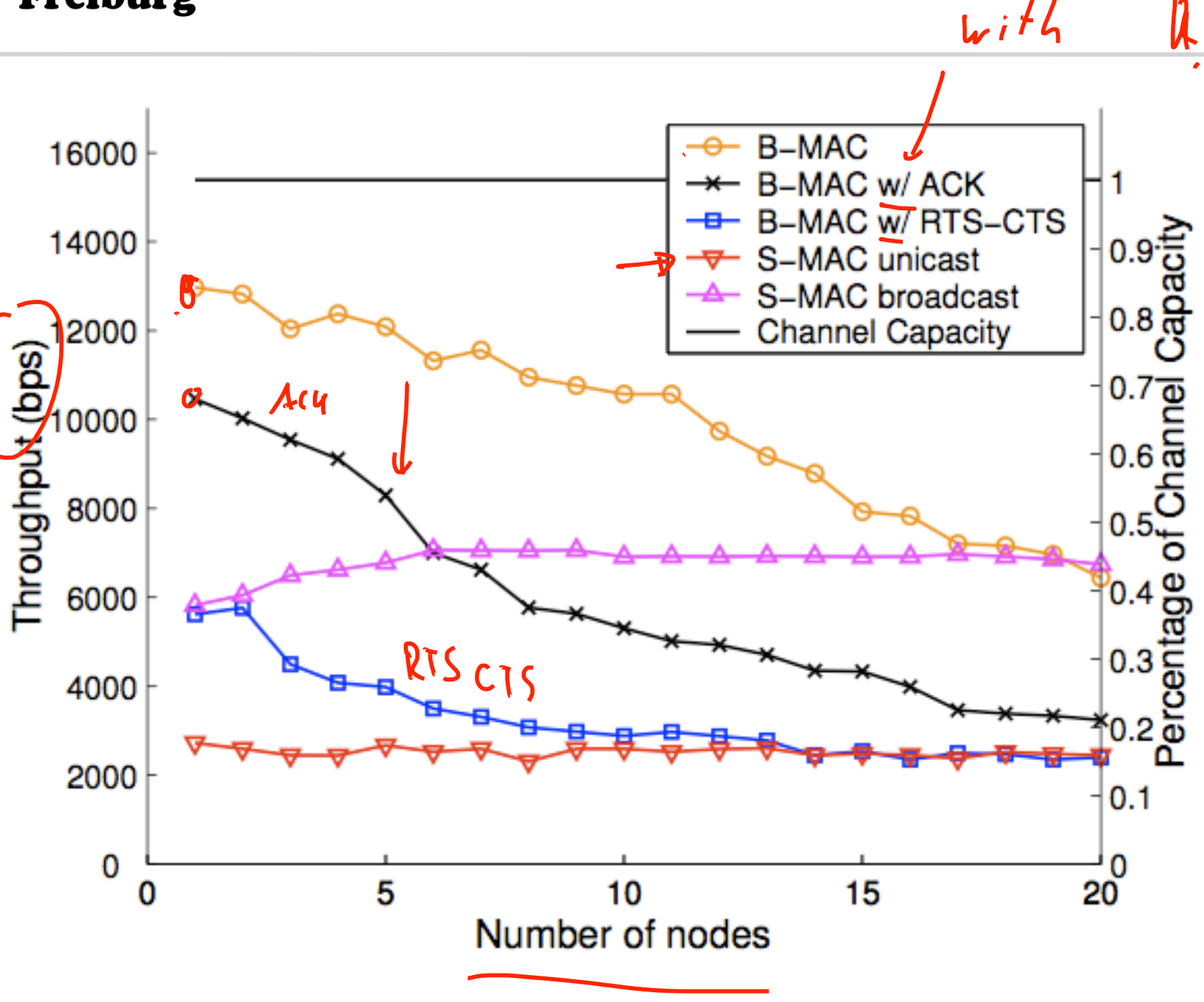
(a) 10 second message generation rate

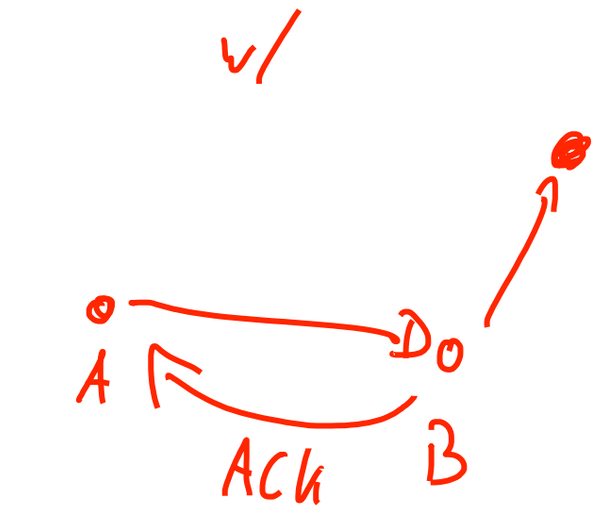


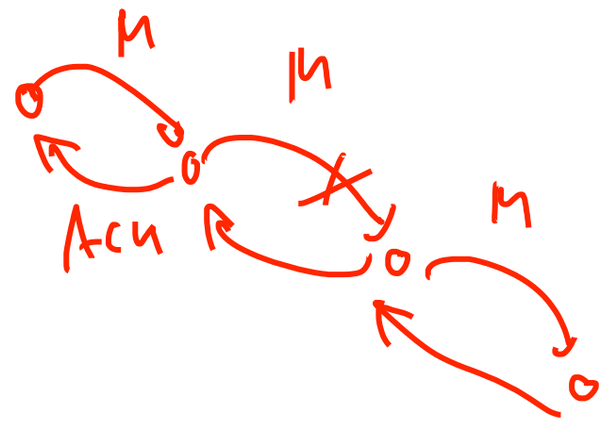
(b) 100 second message generation rate

Polastre, Hill, Culler, Versatile Low Power Media Access for Wireless Sensor Networks, SenSys'04

Throughput







Polastre, Hill, Culler, Versatile Low Power Media Access for Wireless Sensor Networks, SenSys'04

Outlook MAC in WSN

- Many other protocols in WSN
  - LEACH, TRAMA, PAMAS, SMACS, ...
- Very large diversity of protocols
  - very simple and very complex protocols
  - very specialized for certain hardware or not at all
  - TDMA, CDMA, clustering, multi-hop, single-hop, ...
- Further reading
  - Karl, Willig: Protocols and Architectures for Wireless Sensor Networks, Wiley, 2005

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