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UNIVERSITÄT FREIBURG

Algorithms for Radio Networks

Wireless Sensor Networks: MAC
STEM, Preamble Sampling, S-MAC

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Media ACcess
MAC

- **Prevention of collisions on the medium**
  - Fair and efficient bandwidth allocation
- **MAC for WSN**
  - Regulates sleep cycles for participants
  - Reduces waiting time for active reception
- **Standard protocols are not applicable for WSN**
  - Energy efficiency and sleep times must be added

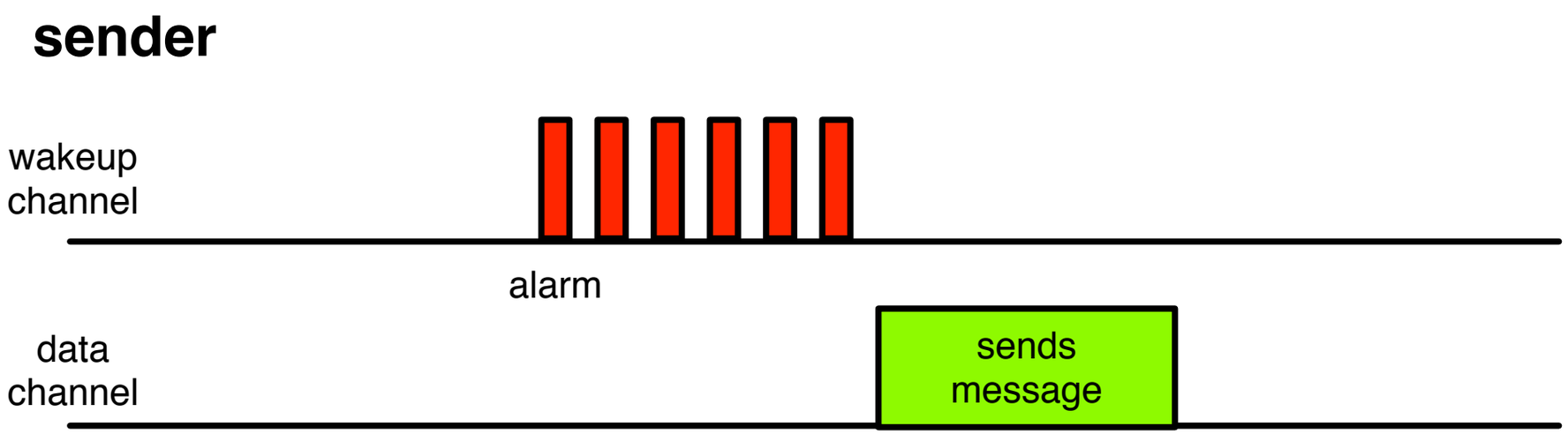
MACA and WSN

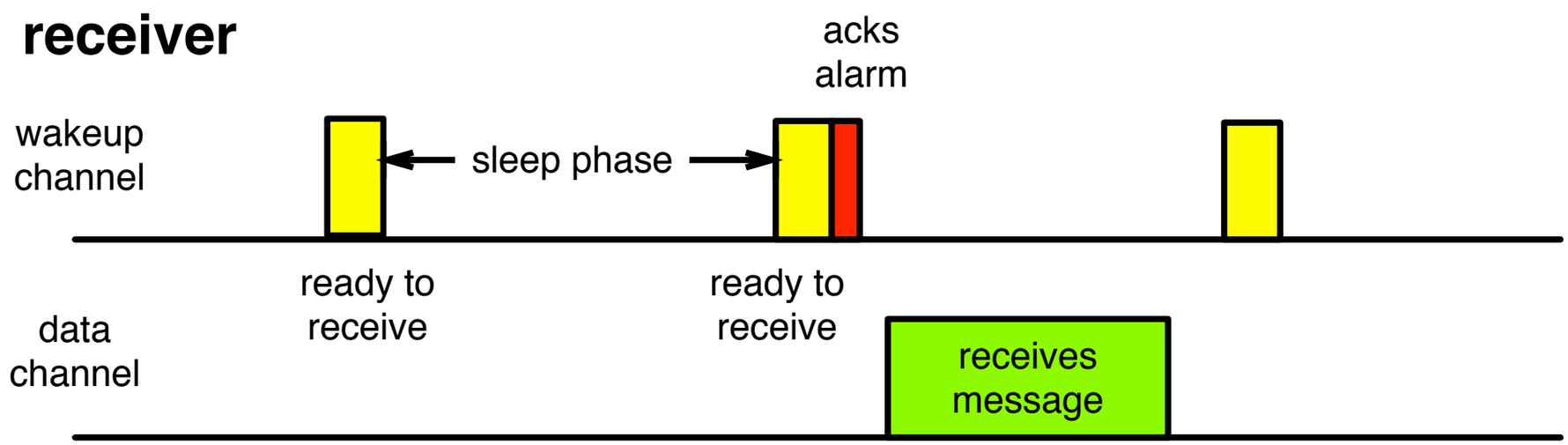
- **MACA:**
  - Channel must be monitored for RTS and CTS
  - Nodes waking up can disrupt existing communications
- **Solution in IEEE 802.11:**
  - Announcement Traffic Indication Message (ATIM)
    - prevents receiver from starting a sleep cycle
    - informs about upcoming packages
    - is sent within the beacon interval
  - When no message is pending, then the client can switch off its receiver (for a short time)

STEM

- **Schurgers, Tsiatsis, Srivastava**
  - STEM: Toplogy Management for Energy Efficient Sensor Networks, 2001 IEEEAC
- **Sparse Topology and Energy Management (STEM)**
- **Special hardware with two channels**
  - Wakeup channel
  - data channel
- **no synchronization**
- **No RTS / CTS**
- **Suitable for decentralized multi-hop routing**

STEM


sender
wakeup channel
alarm
data channel
sends message


receiver
acks alarm
wakeup channel
sleep phase
ready to receive
ready to receive
data channel
receives message

STEM

Sparse Topology and Energy Management Protocol

- **Wakeup channel**
  - sender announces message
  - announcement will be repeated until the receiver acknowledges
  - receiver sleeps in cycles
- **Data channel**
  - is used for undisturbed transmission
- **No RTS / CTS**
- **No carrier sensing**

Discussion STEM

- **Sleep cycles ensure efficiency in the data reception**
  - longer cycles improve energy efficiency
  - but increase the latency
- **Too long sleep cycles**
  - increase the energy consumption at the transmitter
  - lead to traffic congestion in the network
- **Lack of collision avoidance**
  - can result in increased traffic because of long waiting times
  - increase energy consumption

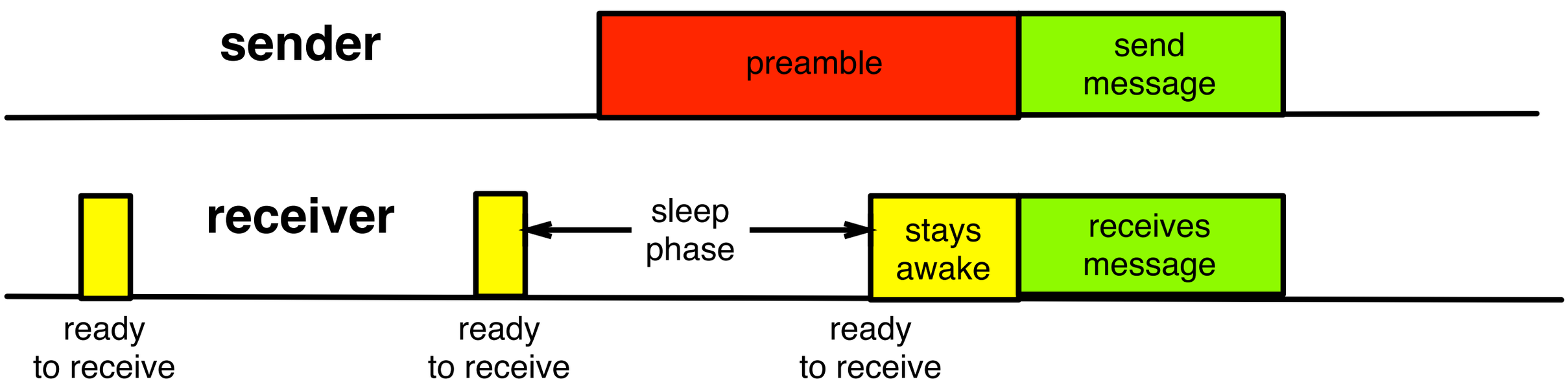
STEM

- **STEM**
  - can be combined with GAF (Geographic Adaptive Fidelity)
  - GAF reduces the sensor density, by allowing only the activation of one sensor in a small square
- **T-STEM**
  - STEM adds a busy-signal channel to wake up and to prevent communication from interruption

Preamble Sampling

- **Only one channel available and no synchronization**
- **Receiver**
  - wakes up after sleep period
  - listens for messages from channel
- **Sender**
  - sends a long preamble
  - and then the data packet

Preamble Sampling



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":

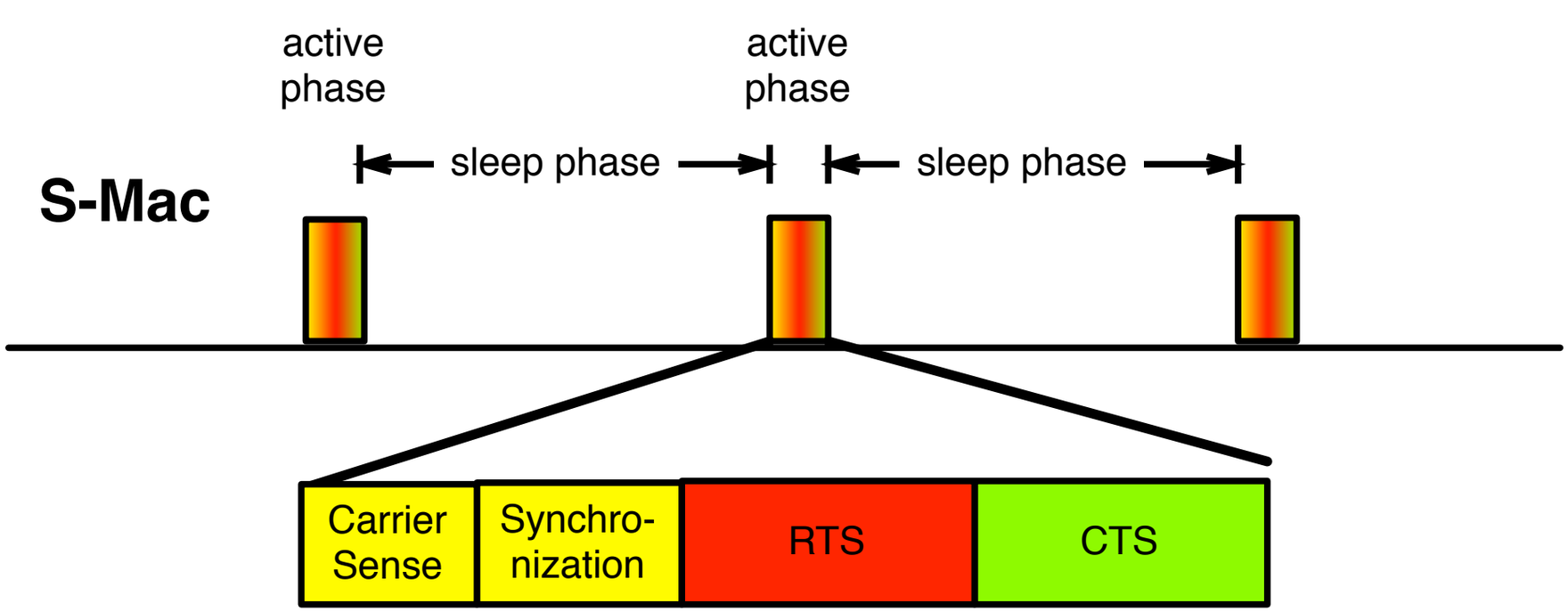
$$\text{Energy} = cT + \frac{c'}{T} + c''$$

Sensor-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

S-MAC Protocol

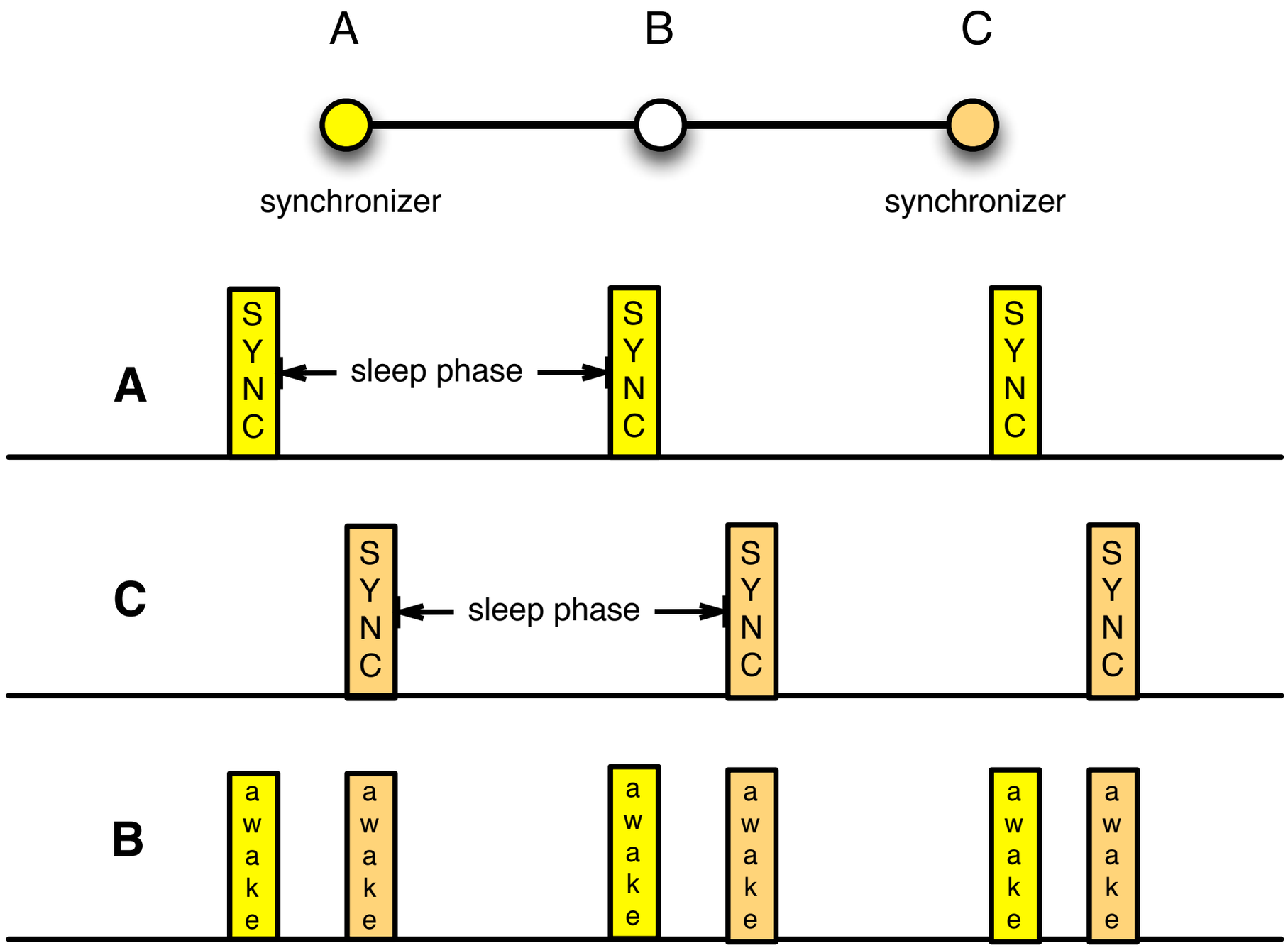
- **Active phase**
  - Carrier Sensing
  - Send Sync packet synchronizer short sleep duration with ID and
  - Interval for Request to Send (RTS)
  - Interval for Clear-to-Send (CTS)



Schedule

- **Each node maintains Schedule Table**
  - with the sleep cycles of known neighbors
- **At the beginning listen to the channel for potential neighbors**
  - the sender adapts to the sleep cycles of the neighbors
  - if several sleep cycles are notices, then the node wakes up several times
- **If after some time no neighbors have been detected (no sync)**
  - then the node turns into a synchronizer
  - and sends its own Sync packets

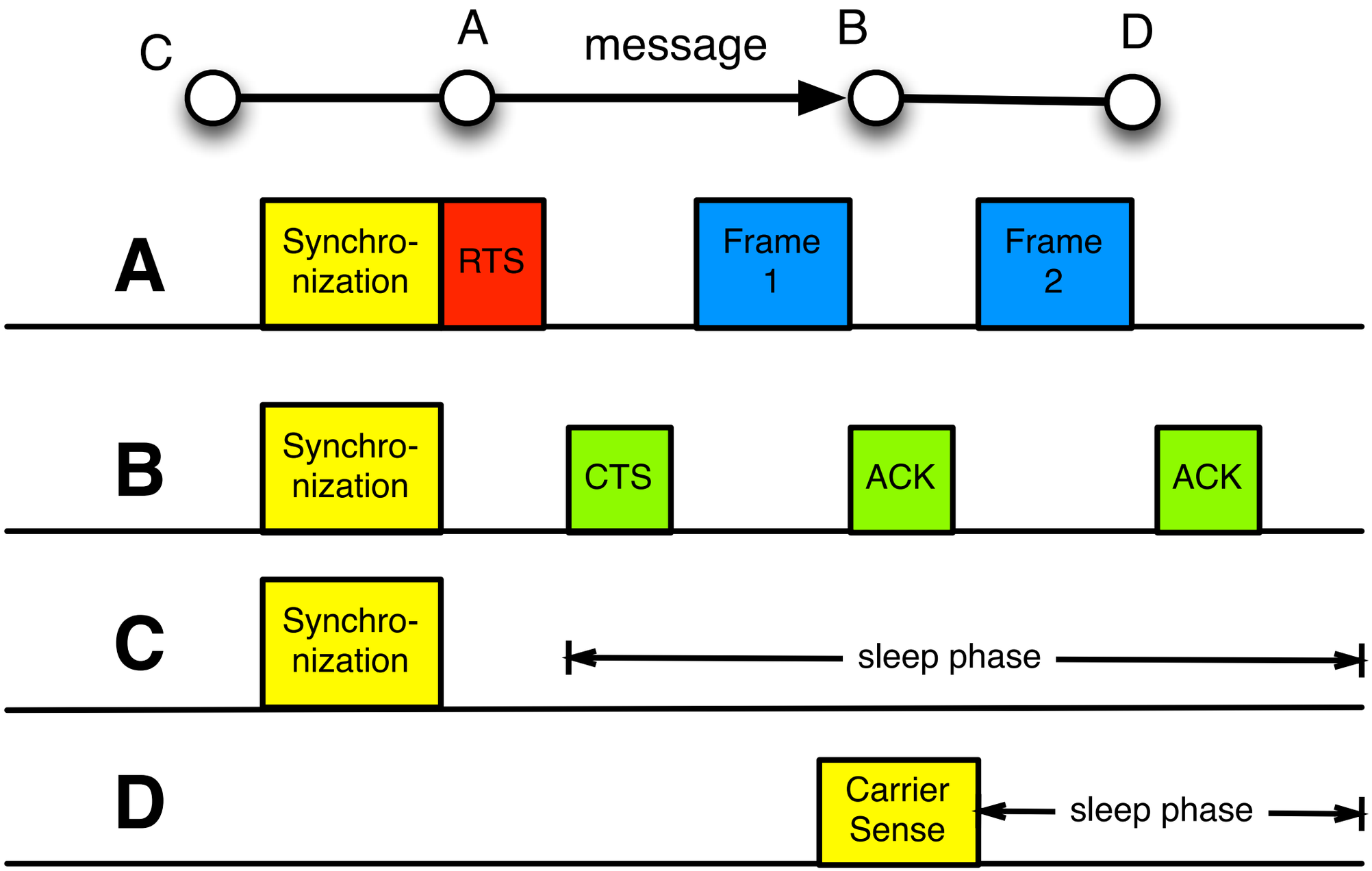
Synchronized Islands



Message Transmission

- **If a node receives RTS for a foreign a node is a,**
  - then he goes to sleep for the announced time
- **Packet is divided into small frames**
  - be individually acknowledged with (ACK)
  - all frames are announced with only one RTS / CTS interaction
  - If ACK fails, the packet is immediately resent
- **Small packets and ACK should avoid the hidden terminal problem**
- **All frames contain the planned packet duration in the header**

Message Transmission
S-MAC



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