WTE-MAC: Wakeup Time Estimation MAC for Improving End-To-End Delay Performance in WSN

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Summary

- Motivation
- Previous Schemes: B-MAC, X-MAC
- Proposed Enhancement: Synchronization at the Neighbor's Duty Cycle (SND)
- Proposed Enhancement: Virtual Tunnels (VT)
- Simulations
- Conclusions

Motivation

- Applications
  - Event monitoring
  - Military intrusion detection
- Very light traffic scenario
- Bursty traffic when it occurs
- Requirements
  - Very low power consumption (long operation time)
  - Low end-to-end delay on event

Source: http://www.agentvi.com/21-Solutions-74-Critical_Infrastructure_Govt

Motivation

- Energy efficiency important
- Contention-based protocols
- Duty cycling

Synchronous CB protocols	Asynchronous CB protocols
S-MAC, T-MAC	B-MAC, X-MAC
• Duty cycle's phase synchronized • Control packets for synchronization (SYNC) • Less energy efficient • Low end-to-end delay	• Nodes not aware of duty cycle's phase of other nodes • No synchronization overhead • Best energy efficiency • But: high end-to-end delay

- Lee et al.: can we join the best of both worlds?

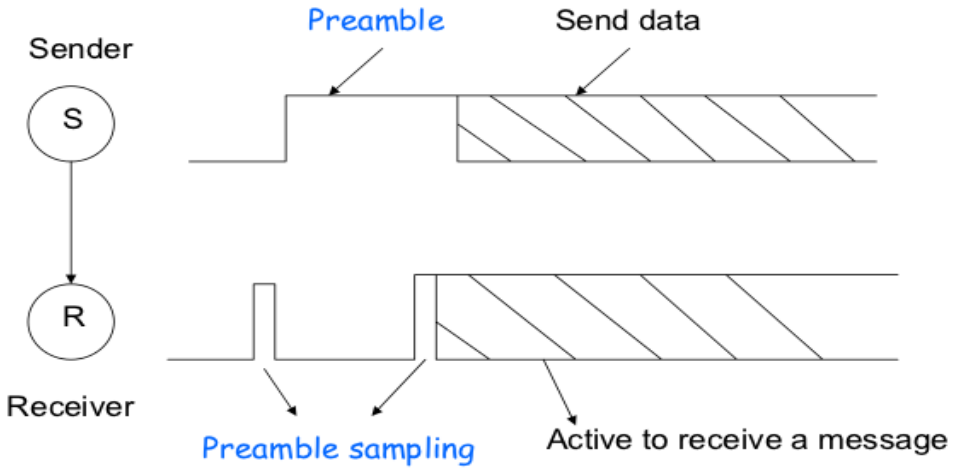
Problem Statement and Approach

- Develop contention-based MAC algorithm having
  - Low power consumption
  - Low end-to-end delay
- Low power consumption achieved by basing proposed algorithm on an asynchronous algorithm (X-MAC)
  - No SYNC packets overhead
- Low end-to-end delay achieved by
  - Using the asynchronous algorithm's packets themselves (preambles) for synchronization – SND
  - Creating virtual connections for transmitting date bursts – VT

Previous Schemes: B-MAC, X-MAC

B-MAC

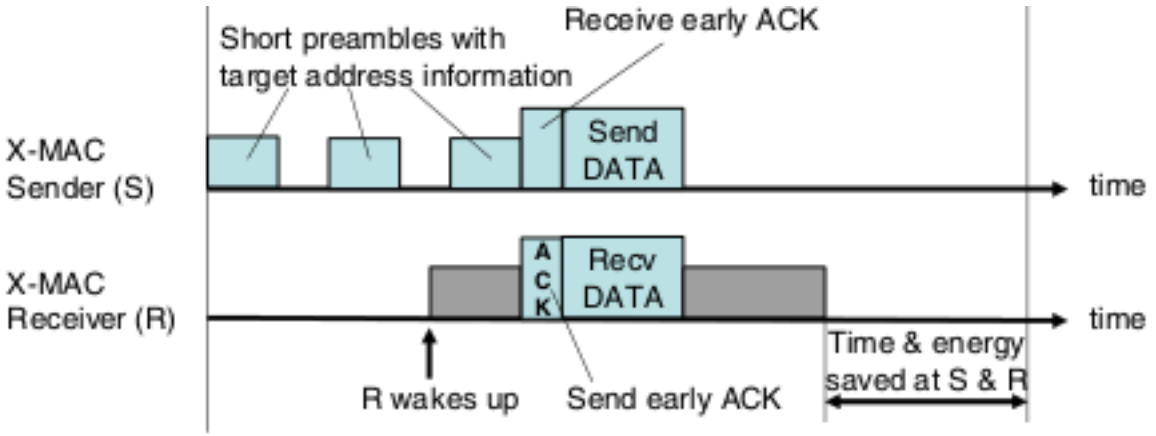
- Preamble sampling



Source: http://www.engr.uconn.edu/~bing/cse5300/slides/sensor-network-mac.pdf

X-MAC

- Short Preamble sampling
- Early ACK

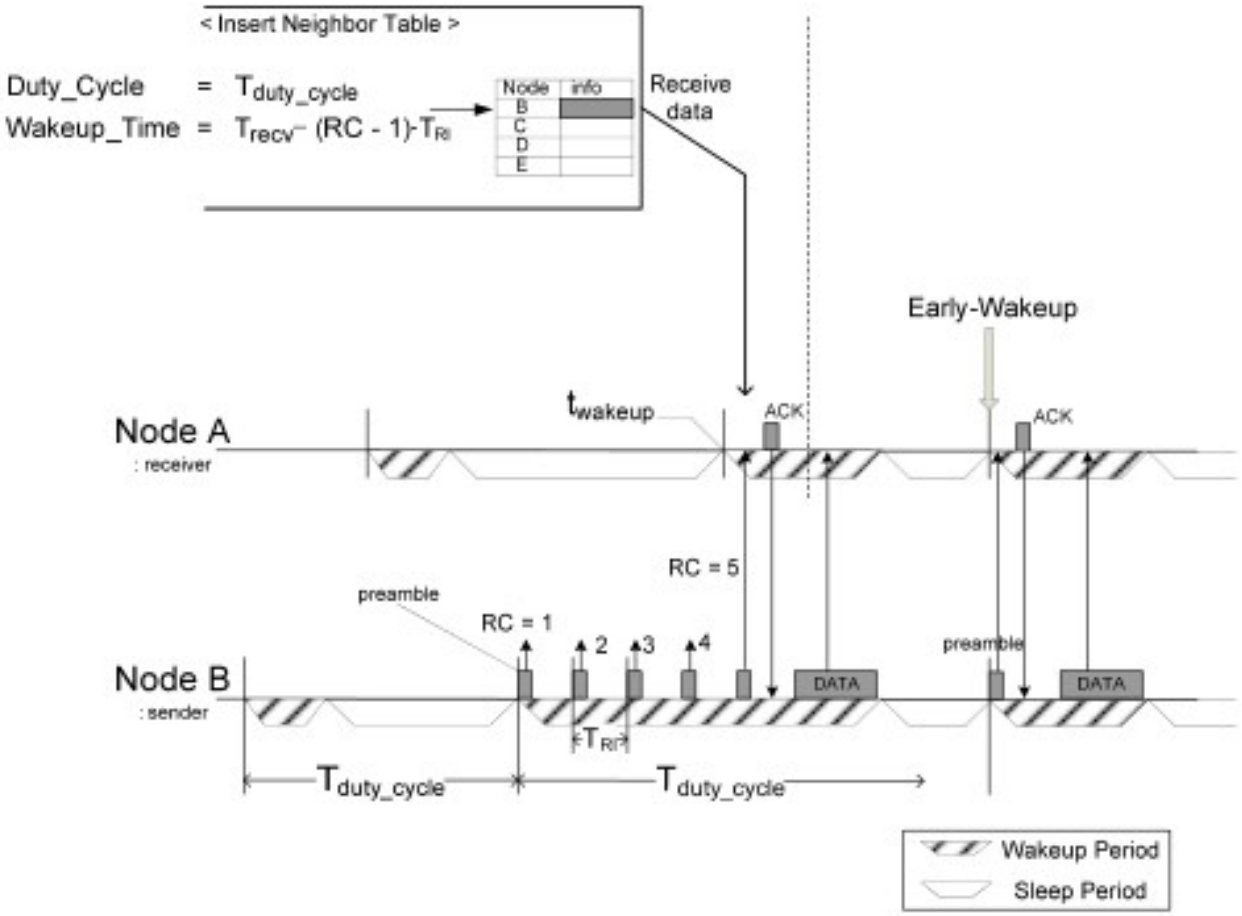


Source: Buettner et al., X-MAC: "A Short Preamble MAC Protocol for Duty-Cycled Wireles Sensor Networks"

Synchronization at the Neighbor's Duty Cycle (SND)

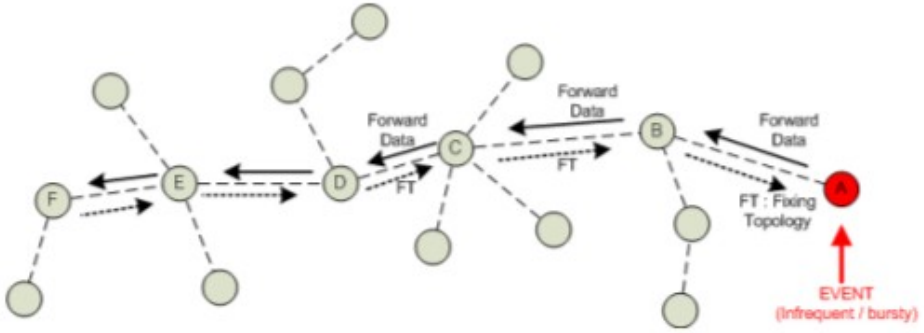
- Basic scheme works just like X-MAC
  - Short preamble sampling
  - Early ACK
- Short preambles contain synchronization information
  - Retransmission Interval (RI)
  - Retransmission Count (RC)
  - Duty Cycle Duration (DD)
- Receiver estimates duty cycle phase from this information and thereby synchronizes to sender
  - Neighbors get synchronized after data transmission

Synchronization at the Neighbor's Duty Cycle (SND)



Virtual Tunnel (VT)

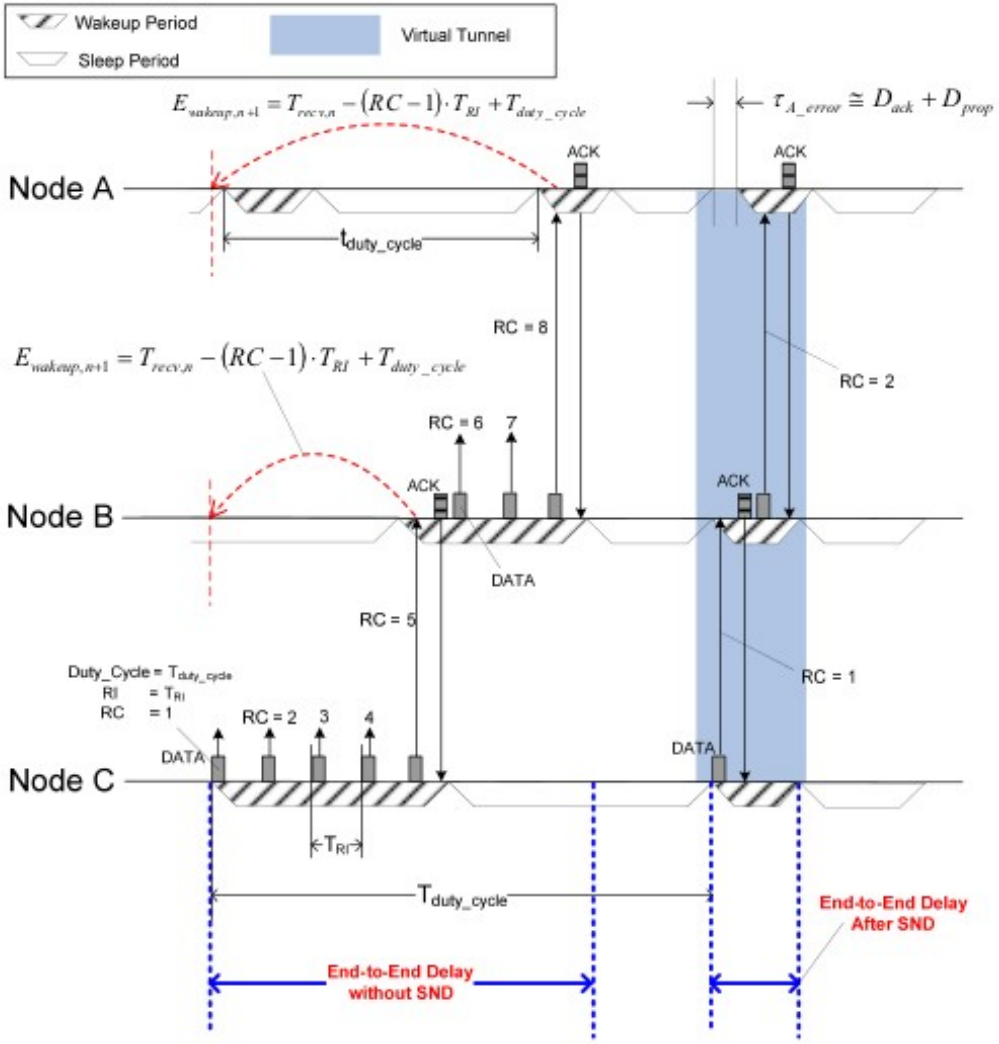
- Designed for efficient transmission while
  - Data is sporadic and in bursts
  - Transfers are multi-hop
- Circuit established from source to destination
  - Uses ACK packets for establishing circuit without overhead
  - Forwarding is not changed while circuit is present
  - Circuit released after burst



- Scheme reduces end-to-end delay

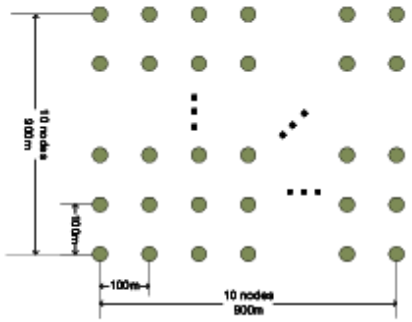
Virtual Tunnel (VT)

- All nodes synchronize to the same original transmitter (node C)
- RC count keeps increasing through hops
- Every node compensates for synchronization mismatches caused by ACK packets

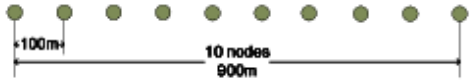


Simulations

- Networks



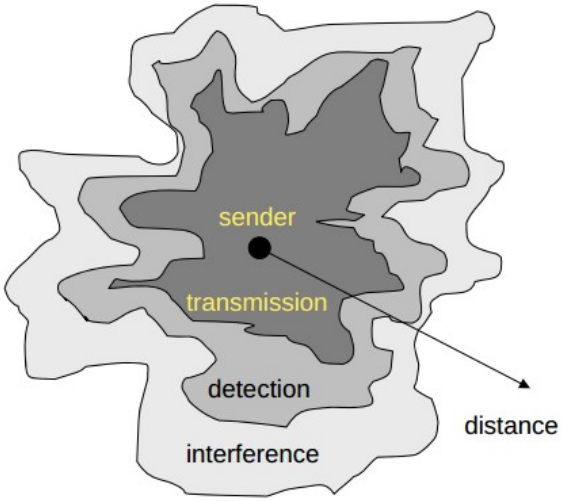
GRID



LINEAR

- Routing: AODV (grid), flooding (linear)

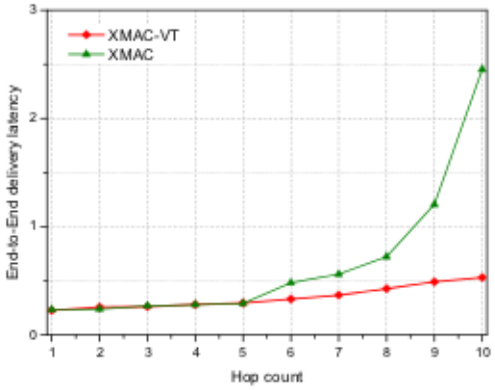
- Interference, CCA, communication range
  680 meters, 280 meters, 200 meters



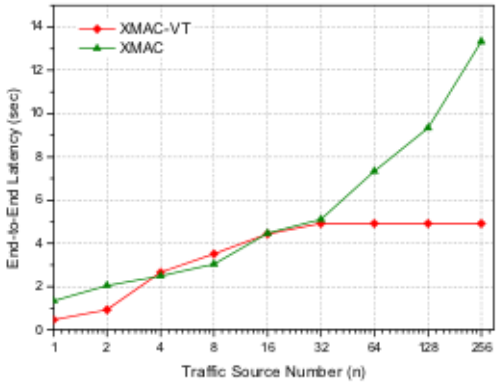
Source: http://www.st.ewi.tudelft.nl/~koen/wsn/2012/lecture2.pdf

Simulations

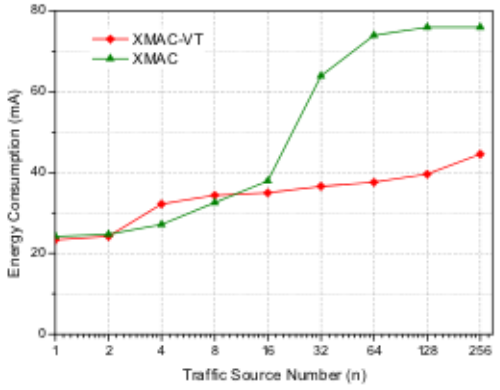
- Grid network
- End-to-end delay reduced w.r.t X-MAC
  - Due to synchronization with the VT mechanism
  - More significant on longer distance (multi-hop) and higher bitrate communication
- Energy consumption reduced w.r.t. X-MAC
  - Less short preamble transmissions and idle listening



(a) End-to-end latency as hop (Grid)



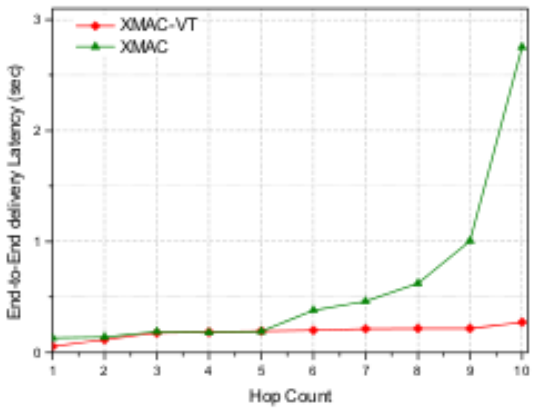
(b) End-to-end latency as traffic (Grid)



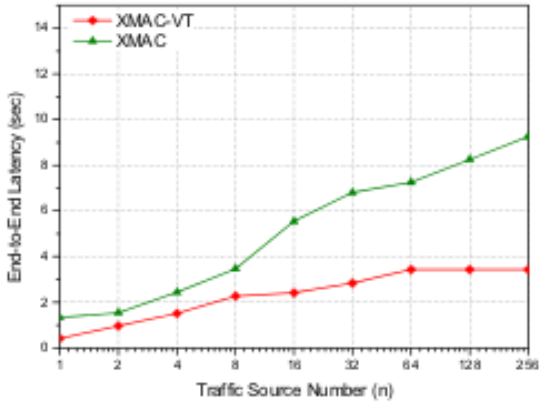
(c) Energy consumption as traffic (Grid)

Simulations

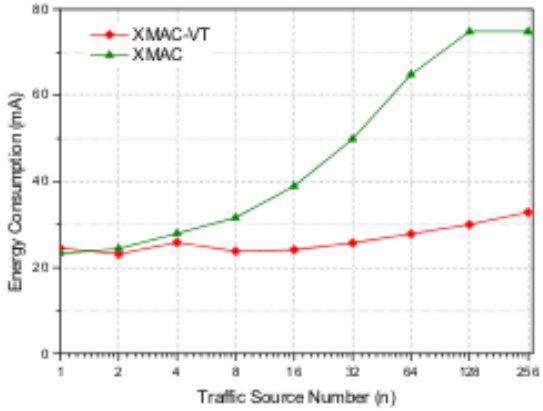
- Linear network
- Similar picture
- Slightly better performance due to lower neighboring interference



(d) End-to-end latency as hop (Linear)



(e) End-to-end latency as traffic (Linear)



(f) Energy consumption as traffic (Linear)

Conclusions

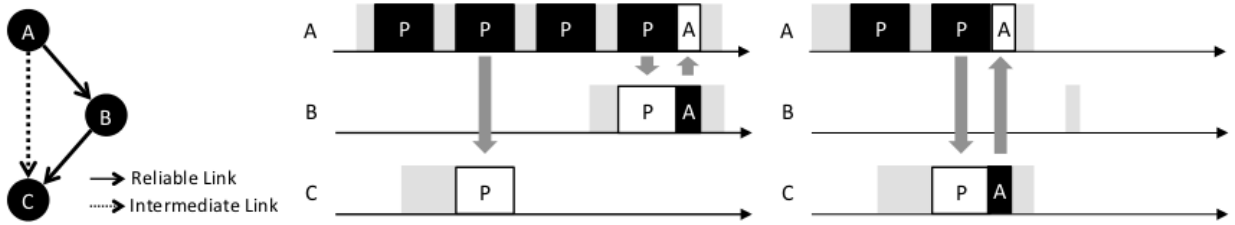
- Proposed enhancements for an asynchronous contention-based MAC protocol for Wireless Sensor Networks (X-MAC)
- Low end-to-end delay without SYNC overhead (synchronous protocols)
- Keeps (even improves) low power consumption of asynchronous protocols
- Virtual Tunnels for bursty traffic
- Applications: event monitoring, military intrusion

Conclusions

- Other approaches achieving low power, low delay

- Wireless Sensor MAC (WiseMAC) (El-Hoiydi et. al)
  - Preamble sampling, no early ACKs (listening feedback)
  - Sender learns timing from *receiver* through (data) ACKs
  - SND: receiver learns timing from *sender* through preambles
  - Bursts through 'frame pending bit'

- Opportunistic Routing in WSN (Landsiedel et al.)
  - Anycast routing (many potential receivers)
  - Consensus protocol for choosing forwarder



Questions