# X-MAC: A Short Preamble MAC Protocol for Duty-Cycled Wireless Sensor Networks

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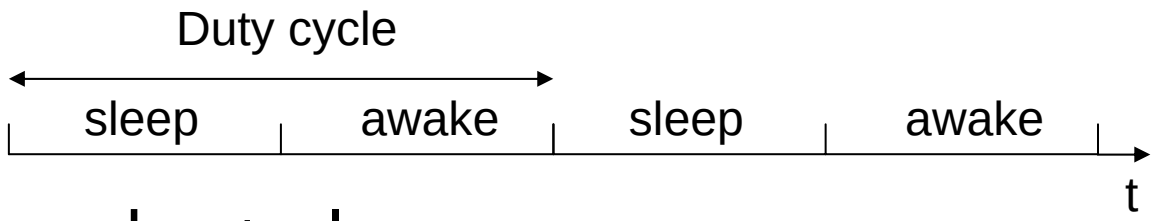
# Outline

- Introduction
- Asynchronous Protocol
- X-MAC Protocol
- Evaluation and Comparison
- Conclusions
- Discussions

# Introduction

- Duty cycle
  - Awake state
  - Sleep state
  - 1 duty cycle = awake + sleep




- Design challenges
  - To achieve high throughput
  - Low latency
  - Energy efficiency

# Introduction

- Two categories
  - Synchronized approaches
    - Pre-scheduled wake-up pattern
    - Ex: S-MAC (2002), T-MAC (2003)
  - Asynchronous approaches
    - Independent wake-up pattern
    - Ex: B-MAC (2004), Wise-MAC (2005)

# Asynchronous Protocol

- No idle listening
- Low power listening (LPL)
  - Preamble sampling
- A sender transmits a ***preamble*** before sending data.
- When the receiver will wake up and detect the preamble, it **stay awake** to receive this data.

# Asynchronous Protocol

- Advantages
  - The duty cycles of sender and receiver are completely decoupled
  - No synchronized overhead
  - Low power listening saves energy

# Asynchronous Protocol

Disadvantages:

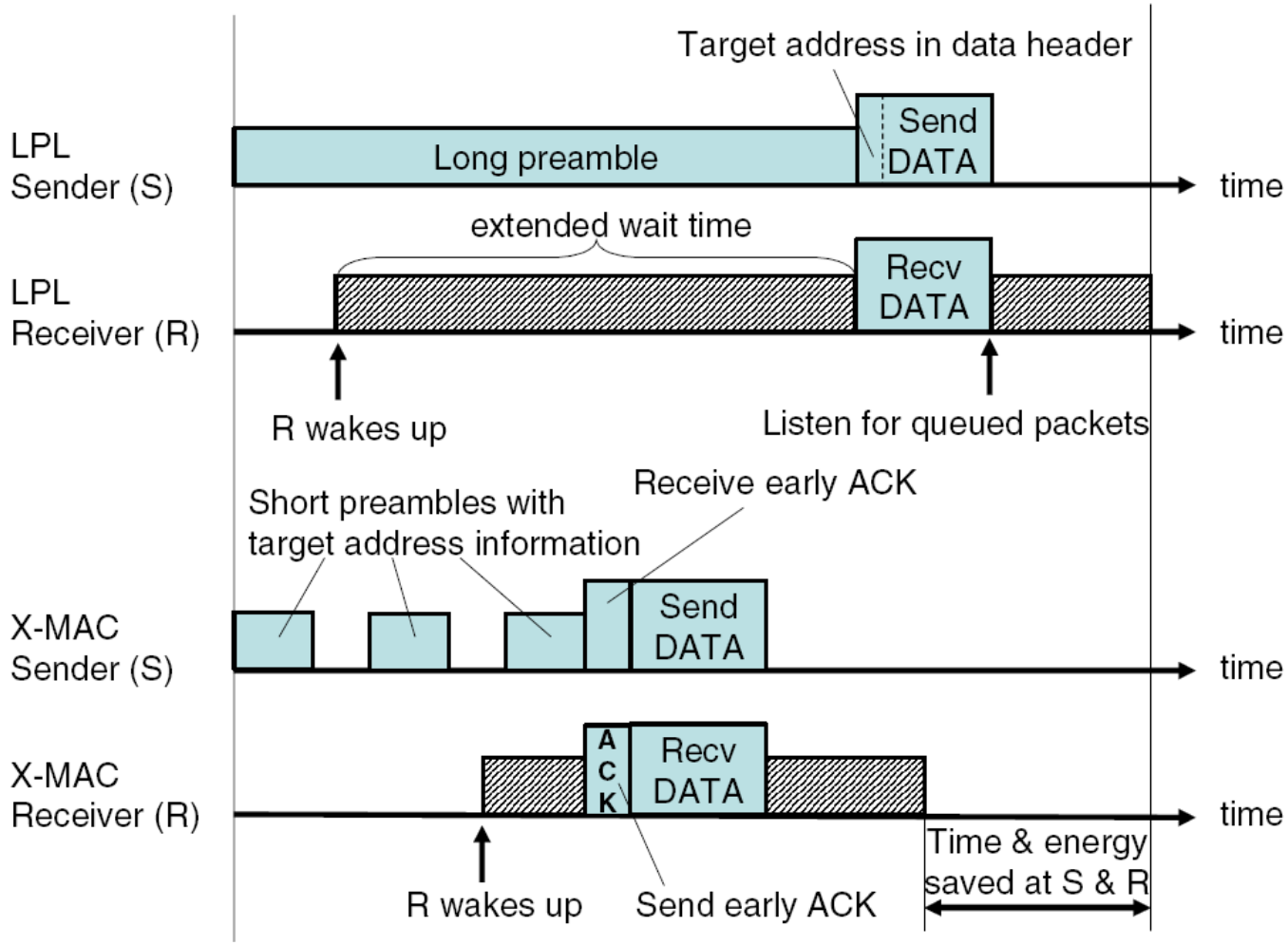
1. Long waiting time
2. Overhearing problem
3. Per-hop latency

# X-MAC Protocol

- The X-MAC is designed to address the following problems
  - Overhearing problem
  - Excessive preamble
  - Incompatibility with packetizing radio

# Avoid Overhearing

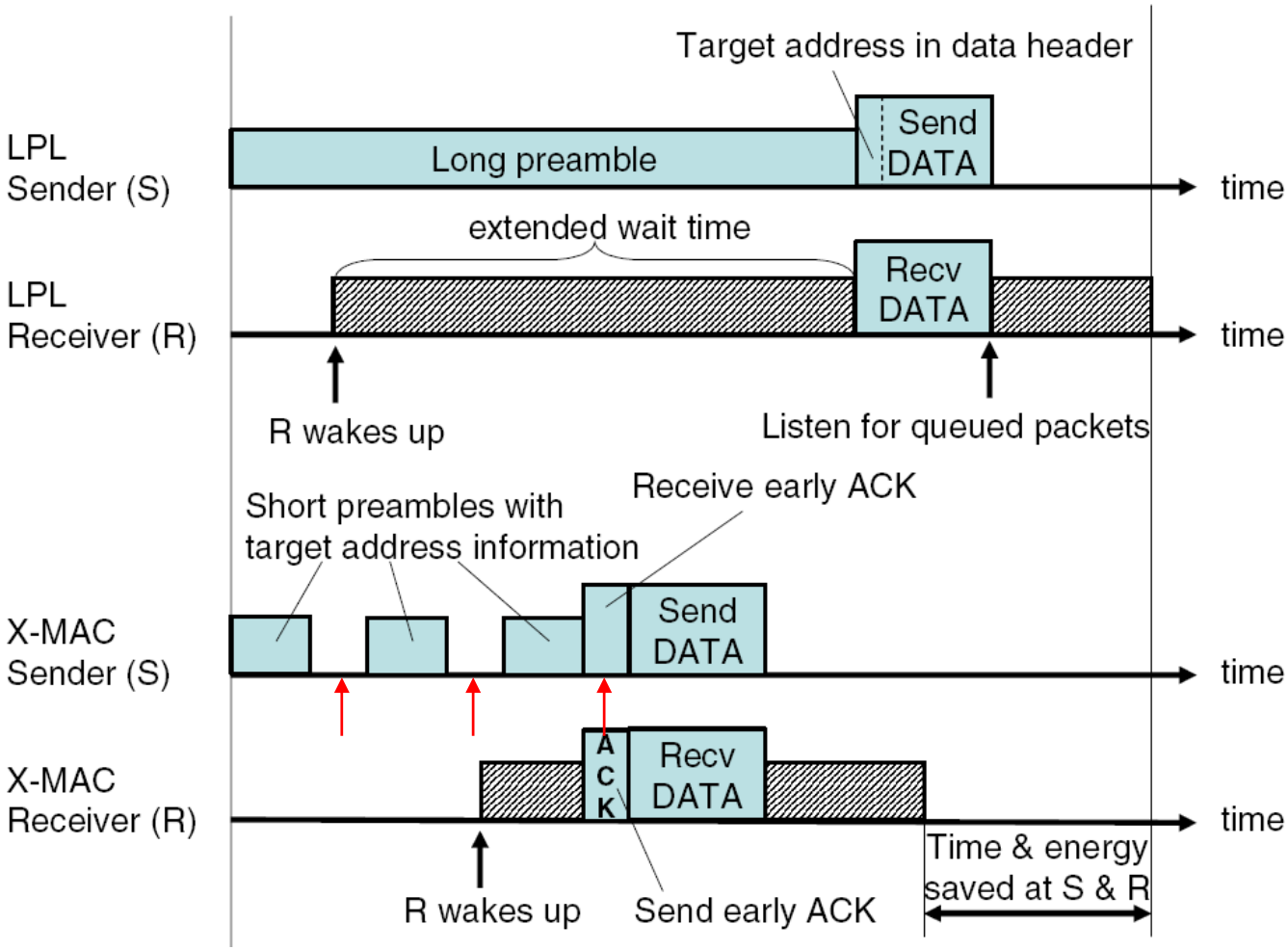
- Short preamble packet
  - Containing the ID of target node



# Reducing Excessive Preamble

- Excessive preamble due to
  - No way to know that the receiver has woken up
  - A number of transmitters wait to send to a particular receiver
- Solution
  - Strobed preamble
  - Early ACK

# Reducing Excessive Preamble



# Packetizing Radios

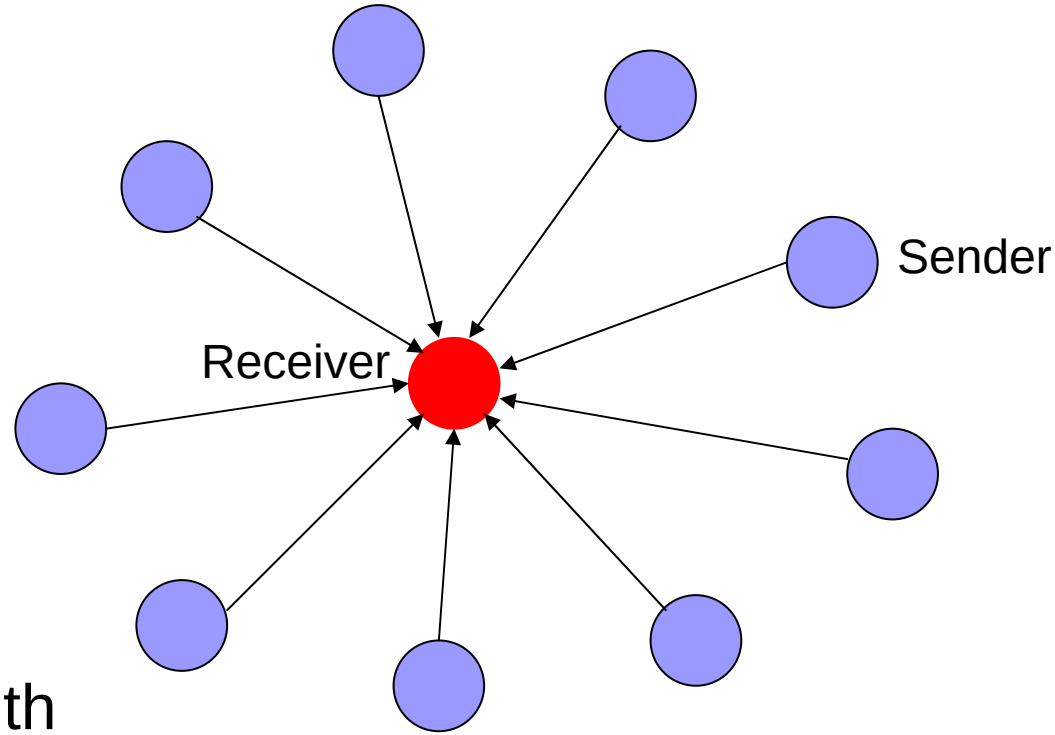
- LPL methods are designed for bit stream radios
  - Individual bits are received by radios
  - Chipcon CC1000
- New radio hardware
  - A raw bit stream
    - Fixed preamble, header, CRC…etc
  - Chip CC2420 (802.15.4)
  - Long preamble is not suitable for it

# Evaluation and Comparison

- Simulation platform
  - Mantis Operating System (MOS)
    - Developed at the University of Colorado at Boulder
- Hardware platform
  - TelosB mote
    - An 802.15.4 compliant device
    - It is compatible with MICAz
- Comparison protocol
  - A basic LPL MAC protocol

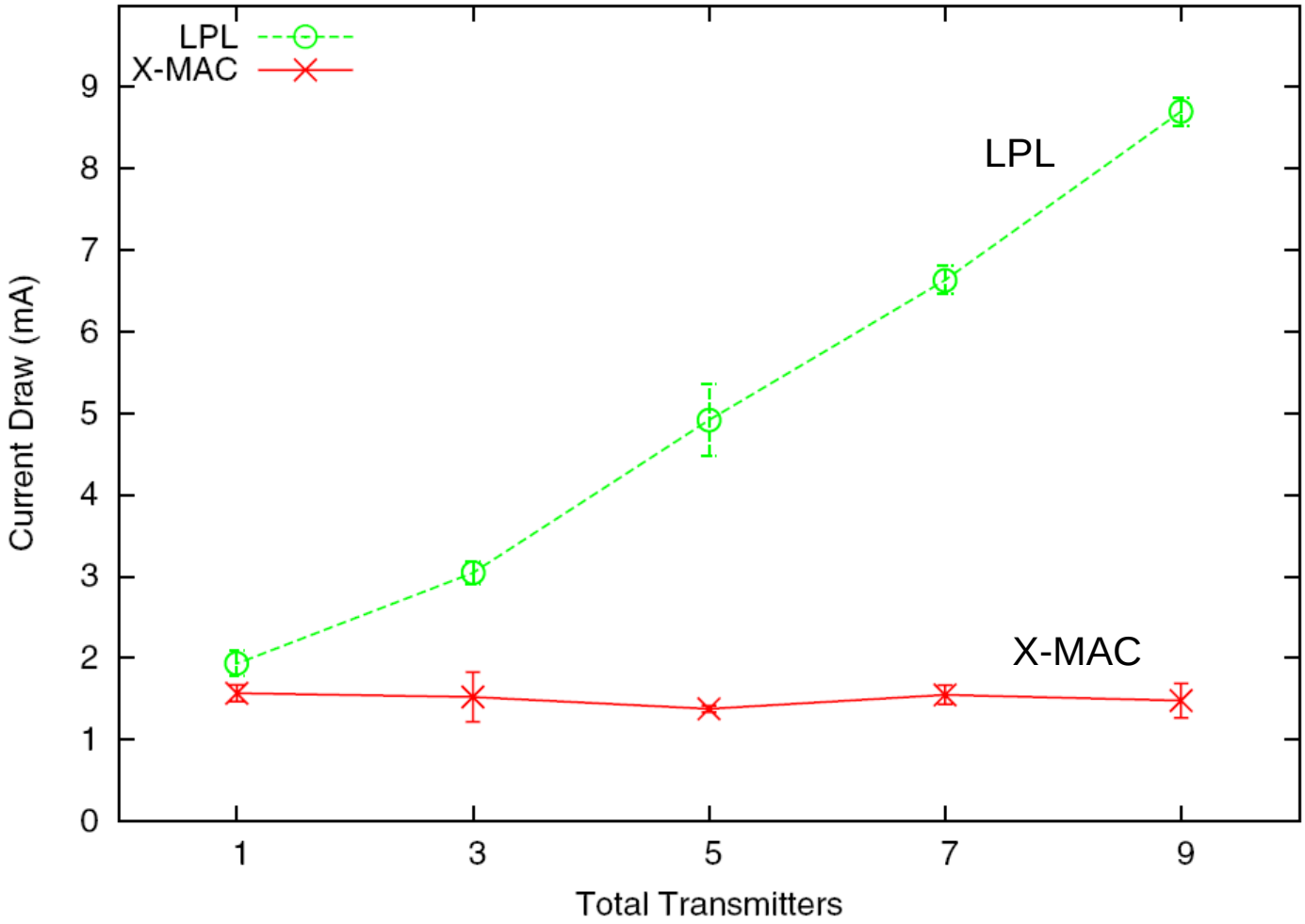
# X-MAC Performance

Star topology
- 1 receiver
- 9 senders

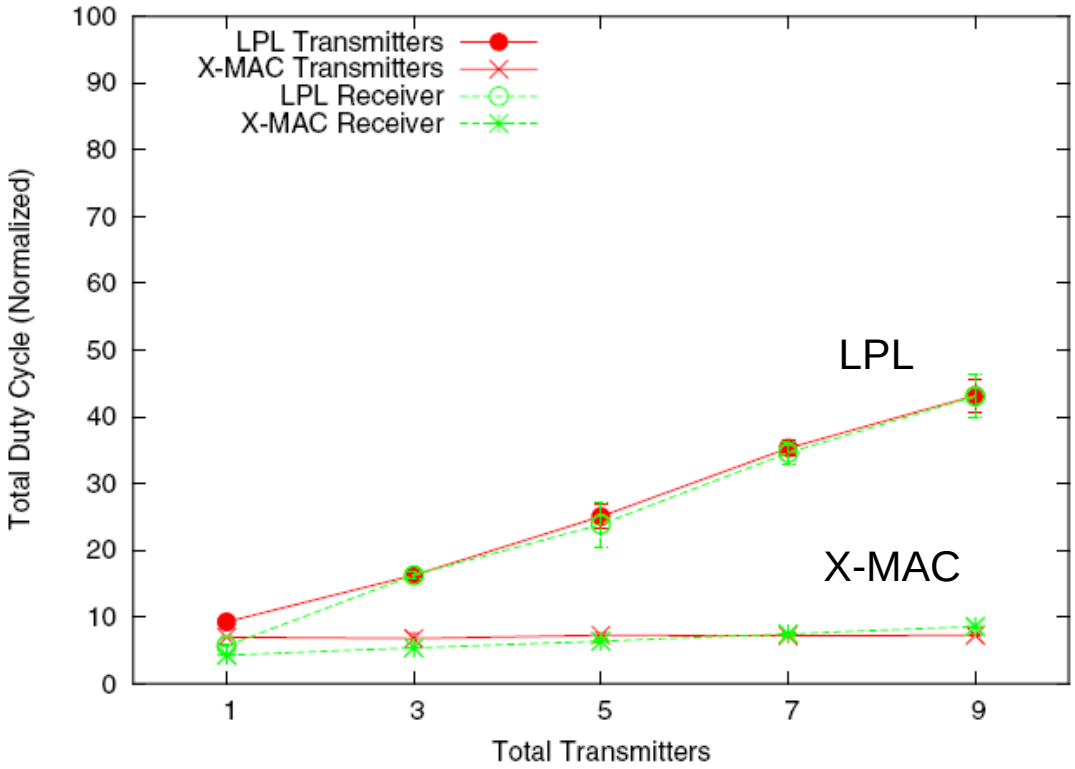



Sleep period
= 500 ms
=preamble length

# Power Consumption vs. Density (Traffic Load)

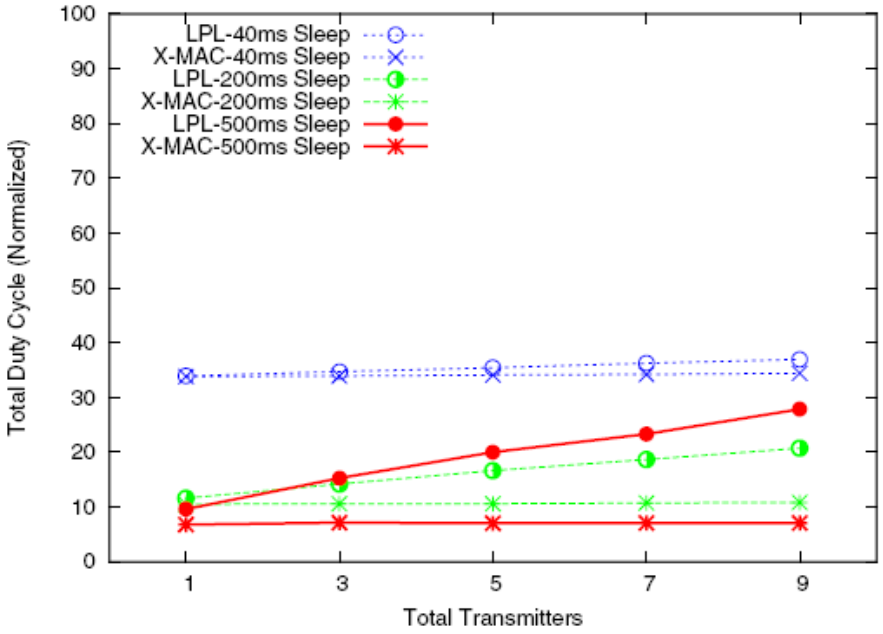


# Duty Cycle under No Contention

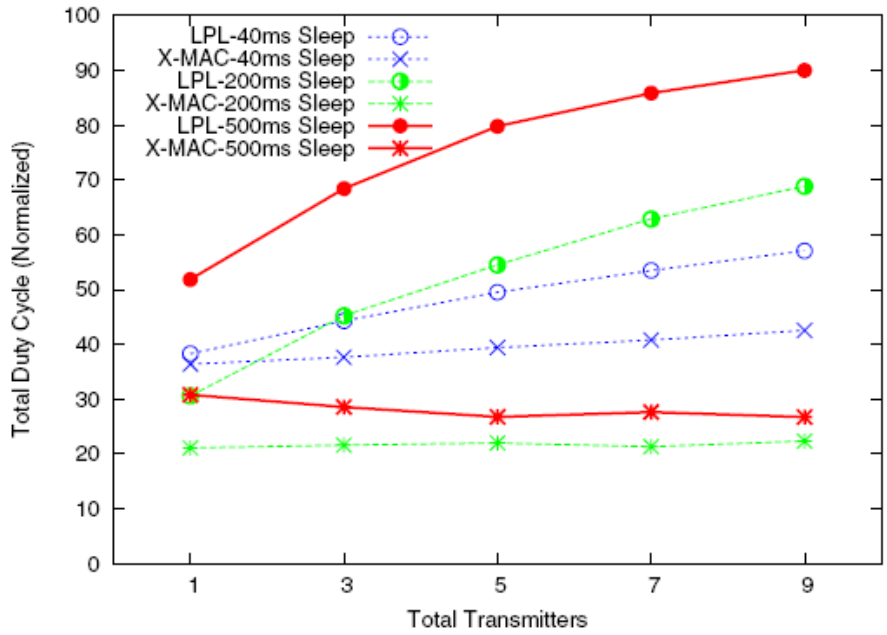



Packet sending rate = 1 packet / 9 secs

# Duty Cycle under Contention

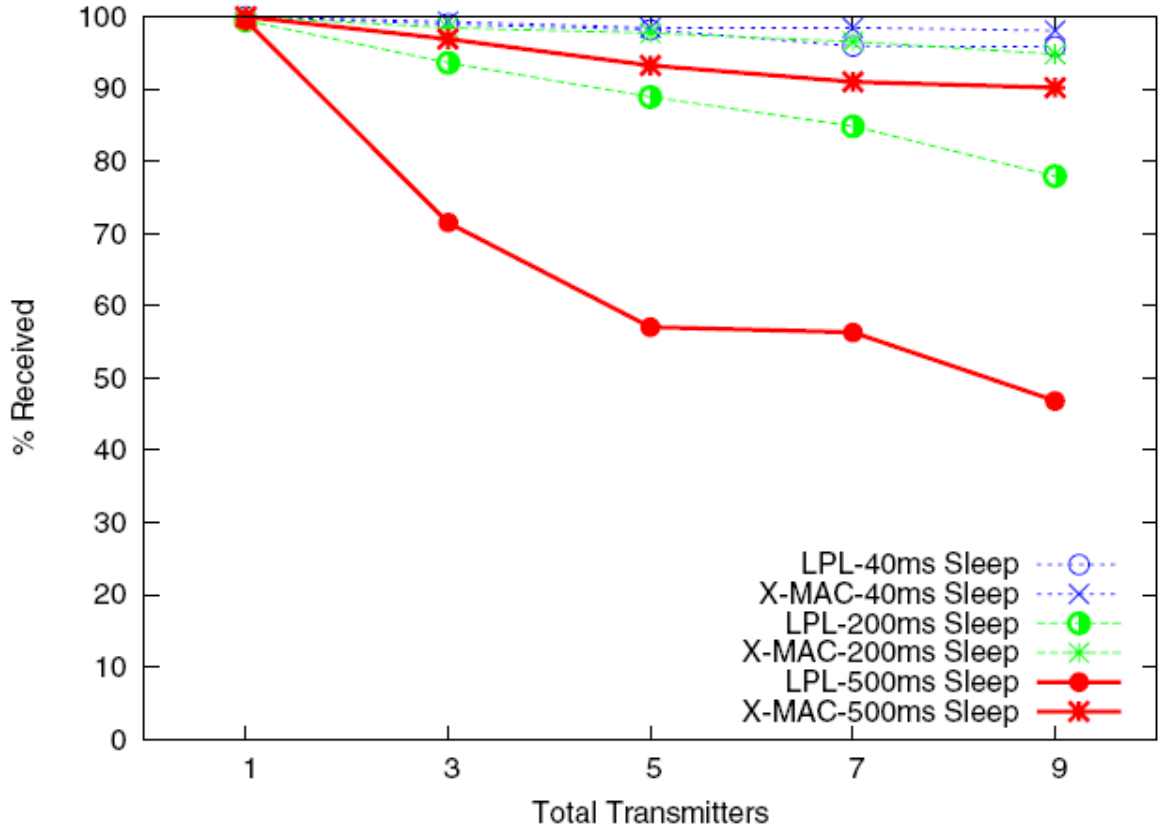



Packet sending rate = 1 packet / 10 secs



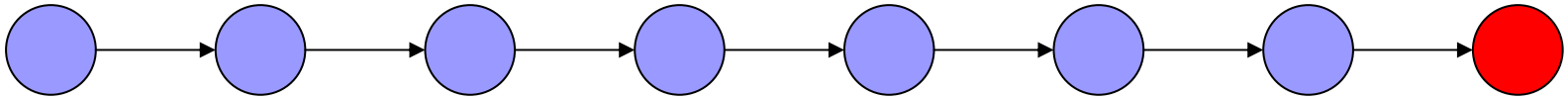

Packet sending rate = 1 packet / 1 sec

# Transmission Success Rate



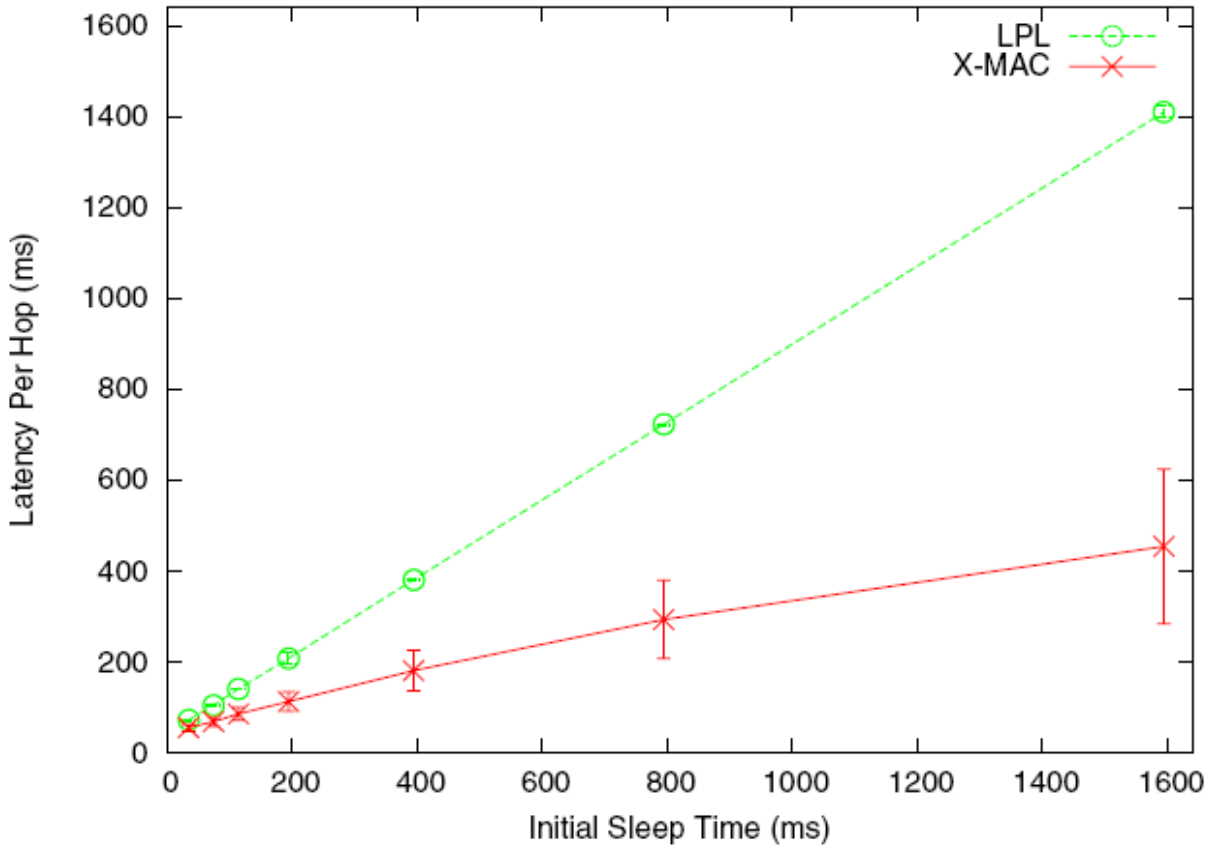

Packet sending rate = 1 packet / 1 sec

# Latency



Sender

Receiver



# Conclusions

- This paper proposes a new approach to low power communication in WSN
- X-MAC employs a **strobed** method by transmitting a series of short preambles, each containing the **address** of target node
- X-MAC solves **overhearing** problem and reduces **excessive preamble**

# References


[1] W. Ye, J. Heidemann, and D. Estrin. An energy efficient mac protocol for wireless sensor networks. In *21st International Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM'02)*, New York, NY, USA 2002. **(S-MAC)**

[2] T. van Dam and K. Langendoen. An adaptive energy efficient mac protocol for wireless sensor networks. In *1st ACM Conference on Embedded Networked Sensor Systems (SenSys)*, pages 171–180, 2003. **(T-MAC)**

[3] J. Polastre, J. Hill, and D. Culler. Versatile low power media access for wireless sensor networks. In *The Second ACM Conference on Embedded Networked Sensor Systems (SenSys)*, pages 95–107, November 2004. **(B-MAC)**

[4] A. El-Hoiydi and J. Decotignie. Low power downlink mac protocols for infrastructure wireless sensor networks. *ACM Mobile Networks and Applications*,10(5):675–690, 2005. **(Wise-MAC)**