Poster Abstract: Emergency Response MAC Protocol (ER-MAC) for Wireless Sensor Networks

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ABSTRACT

We introduce ER-MAC, a hybrid MAC protocol for emergency response wireless sensor networks. ER-MAC is designed as a hybrid of the TDMA and CSMA approaches, giving it the flexibility to adapt to traffic and topology changes. It adopts a TDMA approach to schedule collision-free slots. Nodes wake up for their scheduled slots, but otherwise sleep to conserve energy. When an emergency occurs, nodes that participate in the emergency monitoring change their MAC behaviour by allowing contention in TDMA slots. Simulations in ns-2 show that ER-MAC outperforms Z-MAC with higher delivery ratio, lower latency, and lower energy consumption.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design,Wireless communication

General Terms

Algorithms, Design, Performance

Keywords

MAC Protocol, Wireless Sensor Networks, Fire Emergency

1. INTRODUCTION

Wireless sensor networks (WSNs) have been proposed for emergency applications, such as building fire monitoring and response. WSNs that deal with this type of application must be both traffic and topology adaptive. The communication protocol should be delay tolerant during normal periodic monitoring, and energy efficient. But when an emergency event occurs, energy efficiency should be traded for a higher delivery ratio and lower latency. Most existing medium access control (MAC) protocols are not designed to cope with this high level of adaptivity. Protocols such as Z-MAC [3], PMAC [5], and Crankshaft [1] are designed to adapt to traffic changes. However, unlike our proposed protocol ER-MAC (emergency response-MAC), none of them are both traffic and topology adaptive. This requirement creates several new research challenges that we have addressed in our protocol design and implementation.

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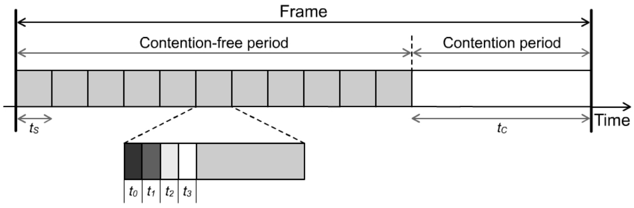

Figure 1: ER-MAC's frame structure

2. ER-MAC PROTOCOL DESIGN

We propose ER-MAC, a hybrid MAC protocol for emergency response WSNs. The key principle of ER-MAC design is a TDMA schedule which access to it is managed adaptively by emergency messages. ER-MAC initially communicates using CSMA/CA. In the startup phase, the data gathering tree and TDMA schedules are created. A non-leaf node assigns one unicast slot to send its own data, several unicast slots to forward its descendants' data and a broadcast slot to synchronise its children.

3. MAC PRIORITISATION

The ER-MAC frame consists of contention-free slots and a contention period as depicted in Fig. 1. We include a contention period at the end of a frame to support new node addition. In normal monitoring, communication between sensor nodes follows the nodes' schedules. To further conserve energy, a sender turns off its radio if it has no data to send and a timeout forces a receiver back to sleep if it does not receive any packets. When fire is detected, only nodes which are affected by the fire change their MAC to emergency mode, while other nodes remain in the normal mode. A node changes the MAC by allowing contention in TDMA slots with the following rules:

t_0: owner with high priority packets transmits.
t_1: non-owner with high priority packets contends.
t_2: owner with low priority packets transmits.
t_3: non-owner with low priority packets contends.

4. SIMULATION AND RESULTS

We implemented ER-MAC in ns-2 [4]. The results are based on the mean value of five different network deployments that are simulated five times each using random seeds, enough to achieve a 95% confidence interval. The network consists of 100 nodes deployed within randomly perturbed

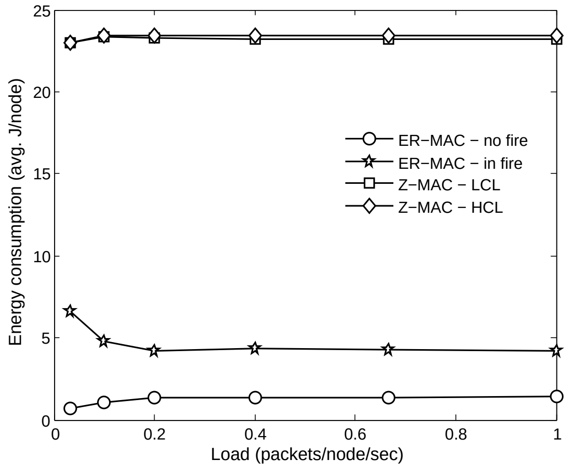

Figure 2: Energy consumption

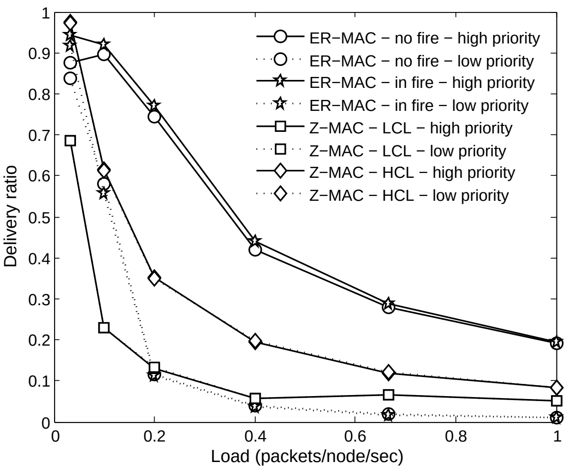

Figure 3: Delivery ratio

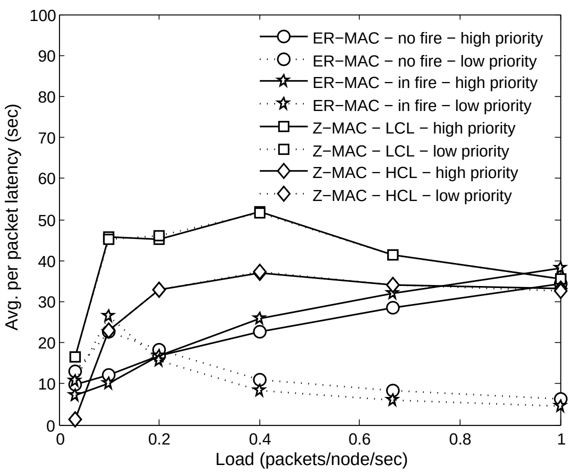

Figure 4: Latency

Table 1: ER-MAC Simulation Parameters in ns-2.

Simulation parameters	Default value
Transmission range	10 m
Transmit power	52.2 mW
Receive/idle listening/transition power	59.1 mW
Sleep power	0.003 mW
Transition time	580 μs
ER-MAC TDMA slot size	50 ms
ER-MAC TDMA sub-slot size	5 ms

grids, where a node is placed in unit grid (8 m x 8 m) and the coordinates are slightly perturbed. We use a simple wireless channel using the two-ray ground radio propagation model. We also randomly select up to n links and for each drop up to m packets, where m is large enough to model unreliable links. Our simulation parameters presented in Table 1 were based on Tmote sky hardware [2]. In each experiment, we simulated a data gathering for 300 seconds. In all simulations, every sensor node except the base station generates packets with fixed intervals.

We compared the performance of ER-MAC against Z-MAC [3] in terms of average energy consumption per node, packet delivery ratio, and average per packet latency. We considered no-fire and in-fire situations for ER-MAC, and forced Z-MAC to operate in either *low contention level* (LCL) or *high contention level* (HCL) to model these situations. For the in-fire situation, we assume all nodes are in fire from the beginning of the simulation. The results depicted in Figure 2, 3, and 4 show that ER-MAC achieves higher delivery ratio, lower latency, and lower energy consumption compared to Z-MAC.

Our current work includes the implementation of ER-MAC in Contiki running on a Tmote sky testbed and a design of routing protocols for building fire monitoring.

5. ACKNOWLEDGMENTS

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