Poster Abstract: Traffic Aware Medium Access Control Protocol for Wireless Sensor Networks

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I. Introduction

Wireless Sensor Networks (WSNs) are characterized by varying loads of different traffic types including broadcast, multicast and unicast. Although, wireless medium is inherently broadcast in nature, the energy consumption behaviour relies heavily both on the load and type of the generated traffic. This is mainly because of the different amounts of control overhead transmitted and received for various types and loads of traffic. In this poster, we present a Traffic Aware Medium Access Control (TrawMAC) protocol for WSNs, which is tailored to the type and load of the generated traffic in order to give an energy efficient operation. We would like to present the operational cycle details of the MAC protocol, the rationale behind the various design aspects and the energy consumption performance gains as compared to the other widely used MAC protocols in sensor networks. Our poster will be supported by a 'table-top' demonstration of the protocol on Moteiv Inc.'s Tmote Sky sensor node platform.

In WSNs, preamble-sampling (PS) or channel polling MAC protocols are a very natural choice from the view point of energy efficient operation. The nodes randomly wake-up for a short period of time, poll the channel for a possible wireless activity and go to sleep if there is no packet in the air. A transmitting node needs to transmit a long preamble equal to the channel polling interval of the receiving nodes so that the periodically waking-up nodes may listen to it. Many protocols, for instance [1], [2], [3], propose different types of possible optimizations on the long preamble sequence. However, all of these protocols have shortcomings when it comes to various traffic patterns of broadcasts, multicasts and unicasts. Furthermore, these protocols are not specifically designed to cope with different amount of traffic loads efficiently. In this poster abstract, we present the protocol details of TrawMAC, which is specifically designed for energy efficient operation based on the traffic load and pattern. Depending upon the traffic characteristics, TrawMAC combines the advantages of [1], [2], [3] and offsets their disadvantages.

II. Traffic Aware MAC Protocol

TrawMAC is a PS-MAC protocol, which divides the monolithic preamble into small micro-frames each containing the information of the destination node and the time of the data transmission. This reduces overhearing undesired data and preamble like in [1]. TrawMAC exercises this micro-frame PS scheme in broadcast transmission. TrawMAC nodes also maintain a sleep schedule of the neighbours, which is announced in the micro-frames of preamble. After exchanging enough packets in a network, each node is able to know the sleep schedule of all of its neighbours. Optimization on the preamble length based on the gathered sleep schedule information of the neighbouring nodes (similar to [2]) is applied in the case of unicast traffic. Furthermore, TrawMAC uses strobed preamble technique [3] for unicast transmission, where after transmitting a micro-frame preamble, the transmitting node waits for its acknowledgement from the potential receiver. In the best case, only one micro-frame of the preamble needs to be transmitted. However, due to the possible mobility in the network, clock drifts and scarce traffic, the estimation of the neighbour's scheduled wake-up time can be unreliable and more than one micro-frame is needed to be transmitted. If the transmitter receives an acknowledgement of a microframe preamble, it immediately sends the data. Otherwise, it keeps on sending the subsequent micro-frames and waiting for their acknowledgements. In the worst case, the duration of micro-frame preamble transmission becomes equal to the check interval. This scheme is not only robust but also results in high energy conservation.

In broadcast traffic, the transmitter usually consumes a lot more energy since its long preamble cannot be shortened like in the case of unicast traffic. Therefore, frequent broadcasts can deplete the energy on the transmitters. In certain applications where broadcasts are carried out very frequently, it is sometimes more energy efficient to do multiple unicasts instead of a single broadcast. TrawMAC protocol has the intelligence to decide in different circumstances whether or not to replace a broadcast with multiple unicasts based on the node density, knowledge of the wake-up schedule, mobility in the network, etc.

In order to support high traffic loads and bursty traffic, TrawMAC transmits multiple back-to-back data frames with a single reservation. The number of data frames is indicated in each of the micro preamble frames. Support for back-to-back data frames transmission leads to less energy consumption for all nodes due to the elimination of multiple preamble transmission. On the other hand, for small data sizes, the data is piggybacked in the micro-frames, which are called data-frame preambles. It is also possible to use data-frame preamble with large data packets. However, using micro-frames is more energy efficient than repeating large data packets back-to-back.

In conclusion, TrawMAC adapts to both the load and type of the traffic to result in lower energy consumption as compared to the other widely used PS-MAC protocols. It is easily realizable on modern radios like Texas Instrument's CC2420 providing very fast Tx/Rx and Rx/Tx switching time and ultra-low power consumption in sleep mode.

Acknowledgment

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References

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[2] Amre El-Hoiydi and Jean-Dominique Decotignie, WiseMAC: An Ultra Low Power MAC Protocol for Multi-hop Wireless Sensor Networks, In Proc. of ALGOSENSORS 2004.
[3] M. Buettner, G. V. Yee, E. Anderson and R. Han, X-MAC: a short preamble MAC protocol for duty-cycled wireless sensor networks, In Proc. of SenSys 2006.

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Wireless Sensor Networks (WSNs) are characterized by different types of traffic loads and traffic types. The traffic type is categorized into unicast, multicast and broadcast, which leads to significantly different control overhead and therefore the resulting energy consumption. In this poster, we present a Traffic Aware Medium Access Control (TrawMAC) protocol for WSNs, which is tailored to the type and load of the generated traffic in order to achieve energy efficient operation. TrawMAC is a preamble sampling MAC protocol. Under various traffic types, it combines the advantages of WiseMAC, MFP-MAC and X-MAC and offsets their disadvantages. Additionally, it contains features like data frame preambles (DFP) and multiple back-to-back data packet transmission with single preamble reservation to efficiently handle variable traffic loads.

Design Philosophy and Operational Cycle

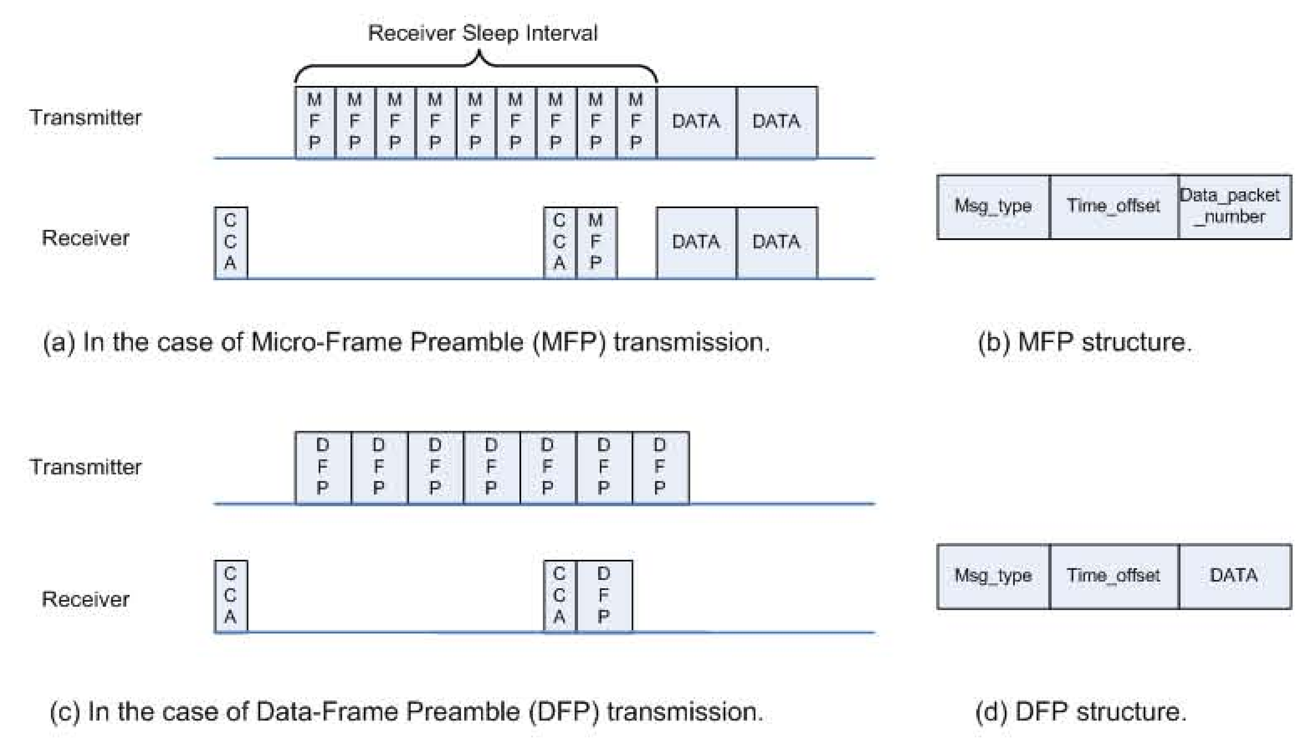


Figure 1. Operational cycle in the case of broadcast transmission.

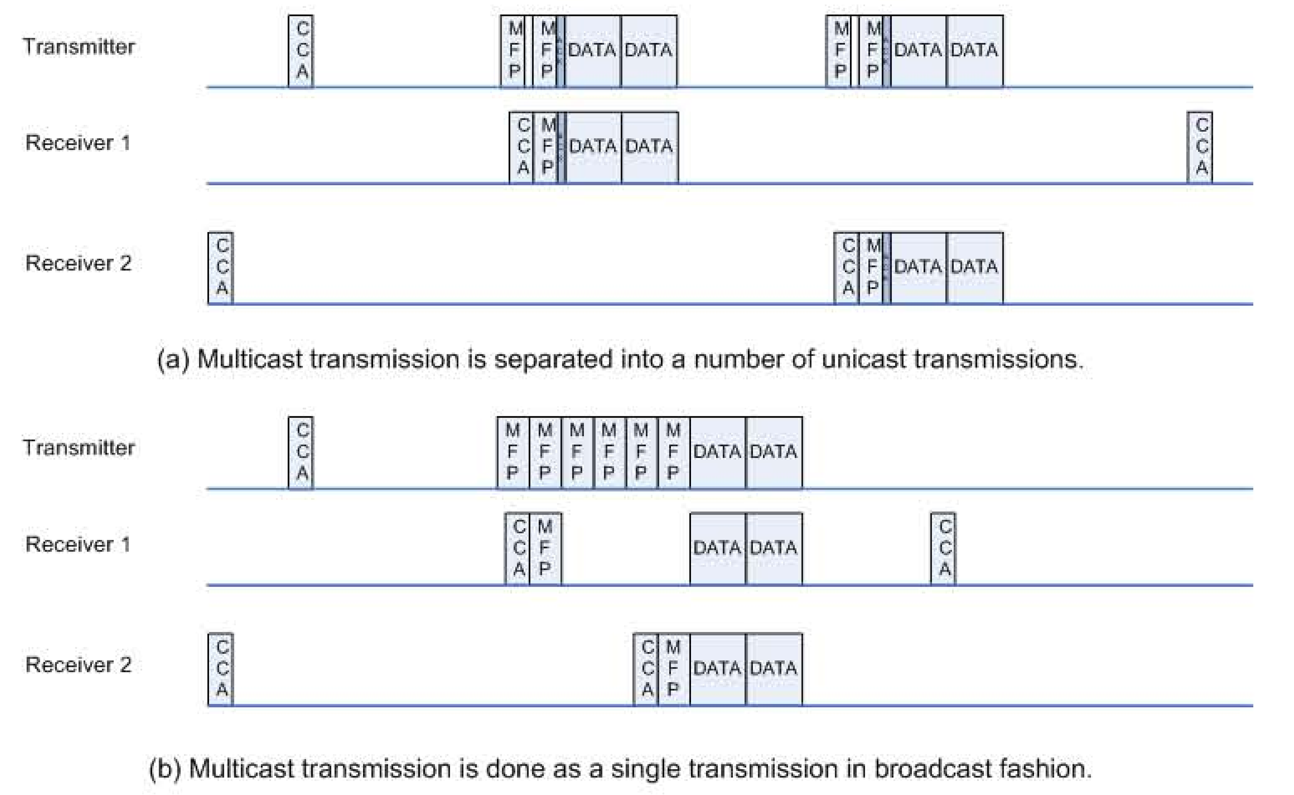


Figure 3. Operational cycle in the case of multicast transmission.

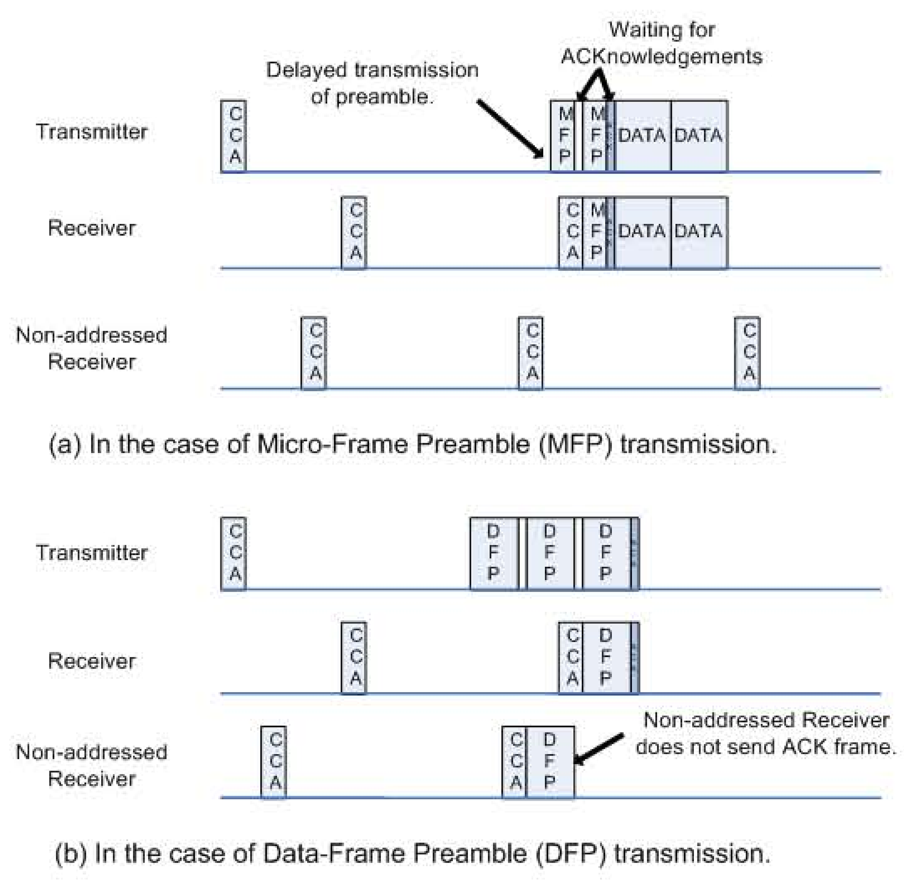
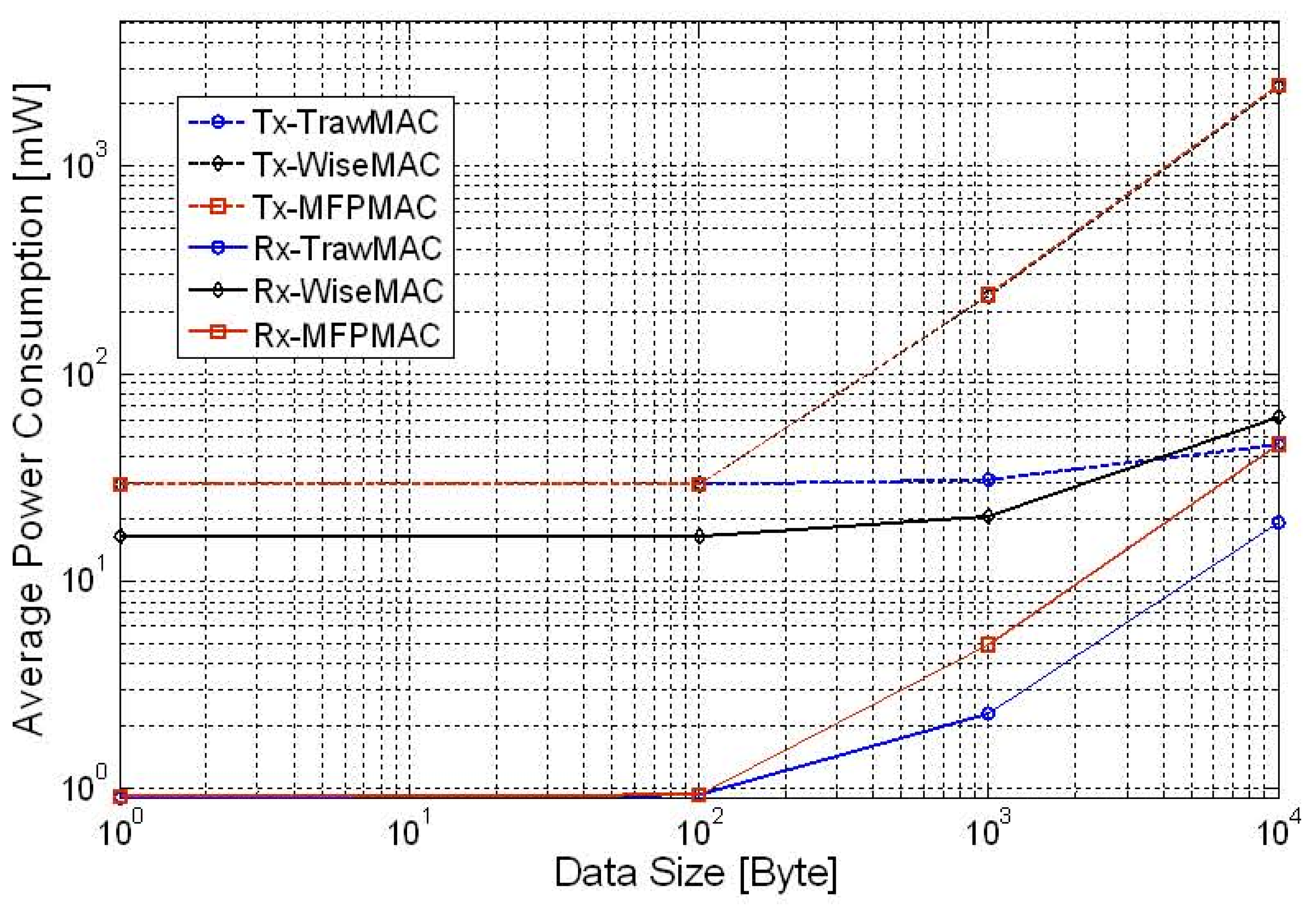


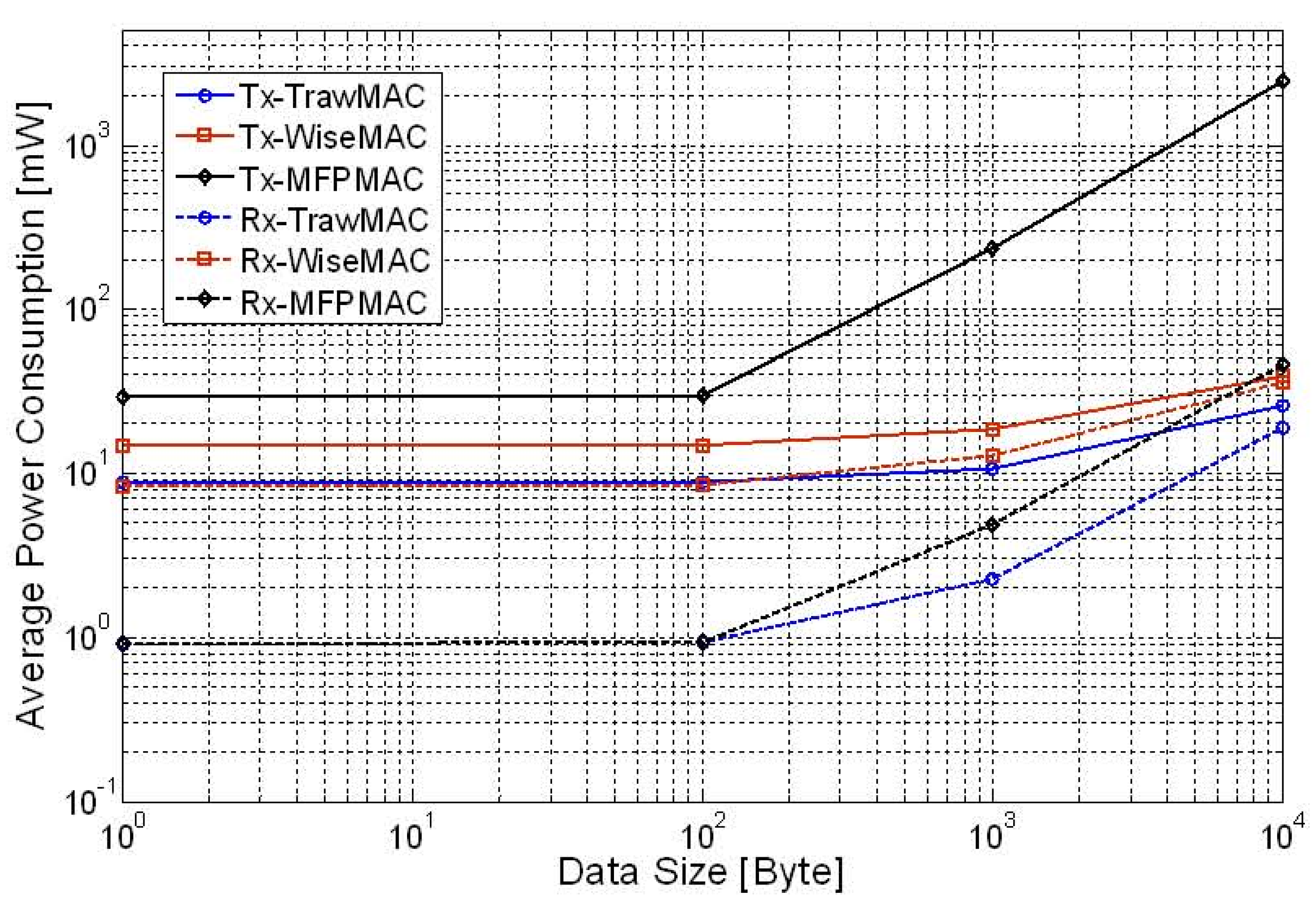
Figure 2. Operational cycle in the case of unicast transmission.

TrawMAC divides the monolithic preamble sequence into small preamble frames or micro-frames. In broadcast transmission, the complete preamble length, equal to the receiver's sleep cycle interval is transmitted before the data. The micro-frame contains the information of the number of data packets and the sleep schedule of the transmitter which relates to the time of the data transmission. A receiver upon receiving a micro-frame can go to sleep and wakes-up to receive the data, thereby avoiding receiving useless micro-frames. For bursty data transmission, multiple back-back data packets are supported. If the data size is smaller than a certain empirical threshold, DFP is transmitted instead of the micro-frames followed by the data. This behaviour is shown in Figure 1. TrawMAC nodes also maintain sleep schedule of the neighbours, which is announced in the preamble. Optimization on the preamble length based on sleep schedule information of the neighbouring nodes is applied in unicast and multicast traffic. TrawMAC uses strobed preamble technique for unicast transmission, where the transmitter waits for the acknowledgment of a micro-frame and upon receiving the acknowledgement, directly transmits the data as shown in Figure 2. In the case of multicast transmission, the transmitter decides the transmission behaviour based on the time schedule information of the receivers. In Figure 3, multicast transmission is broken down to a number of unicast transmissions when the wake up schedules of the receivers are very different while a single broadcast transmission is carried out with shorter preamble when the wake-up time of the receivers are close to each other.

Performance Comparison



Average power consumption of TelosB running TrawMAC, WiseMAC and MFP-MAC in *broadcast* transmission. TrawMAC shows minor energy efficiency improvement over small data sizes which becomes significantly large in case of bursty traffic.



Average power consumption of TelosB running TrawMAC, WiseMAC and MFP-MAC for *unicast* transmission. TrawMAC reduces the energy consumption on data transmission significantly regardless of the transmitted data size while providing improvement on the reception side at burst data reception.

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