Poster: Time Encoding for Energy Efficiency and Scalability in Wireless Networks

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ABSTRACT

Low Power Wide Area Networks (LPWAN) desire 1) energy efficiency, 2)long communication range, and 3) scalability for ubiquitous connectivity. Existing technologies any two and trade off the third. We propose a differential time modulation that is energy efficient in a large-scale, long-range network.

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1 INTRODUCTION

State-of-the-art energy efficient protocols and recent research on battery-less communication [1] have a range of less than 100m. LPWAN [2] strategies promise longer battery life by limiting the number of messages per day restricting scalability due to increased collisions with increasing number of nodes/messages. The focus of this work is to develop communication algorithms that satisfy all three characteristics by leveraging their relaxed data-rate and latency requirements. We propose a time based encoding technique that reduces energy consumption by reducing channel time, in turn accommodating a large number of nodes over a long-range.

2 TIME ENCODING

The inspiration for this technique comes from pulse-position modulation(PPM) [3]. PPM encodes information in the position of a pulse within a time frame. A single pulse to conveys a symbol of *n* bits, irrespective of the value of *n*, making the energy per symbol to be the energy per bit for an n-bit symbol. Despite the energy efficiency, its adoption in a wireless system is non-trivial. Transmitting and receiving a single symbol with a tight time synchronization is challenging. We propose a differential modulation technique, where the time period between two unique symbols viz., the anchor symbols, conveys the information to be transmitted. The total power consumption for any length of data is constant, equal to the energy consumed for transmitting the anchor symbols. The anchor symbols are fixed length, irrespective of the data encoded in the time between them. Hence, the larger the data, lower is the energy per bit. During the time between the anchor symbols, the system is in deep sleep mode and draws μA current. Thus, an efficient design of the anchor symbol is crucial for energy efficiency of the system.

3 ANCHOR SYMBOL DESIGN

The anchor symbol indicates the start/stop of a message and uniquely identifies the sender. The smallest number of bits that reliably achieve these goals is the minimum anchor symbol length. The longer the anchor symbol, higher is the probability of bit error, but lower is the probability of false positives. The probability of bit error for a given energy per bit, E_b, and noise spectral density, N_O is given by,$P_e = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_O}}\right)$. Probability of false positive for an n bit anchor symbol with ϵ erroneous bits is given by [4]: $P_f = (0.5)^n \sum_{i=0}^{\epsilon} \binom{n}{i}$. For various modulation techniques, we identify the optimum length that reduces P_f and P_e.

4 CONCLUSIONS AND FUTURE WORK

We are building a prototype with off-the-shelf components to study anchor length, patterns to identify senders reliably and analyze the data-rate for timing based modulation.

REFERENCES

[1] Yacine Challal Tifenn Rault, Abdelmadjid Bouabdallah. Energy efficiency in wireless sensor networks: A top-down survey. *Computer Networks*, 2014.
[2] Marco Di Felice Luciano Bononi Federico Montori, Luca Bedogni. Machine-to-machine wireless communication technologies for the internet of things: Taxonomy, comparison and open issues. *Pervasive and Mobile Computing*, 2018.
[3] Zabih Ghassemlooy, AR Hayes, NL Seed, and ED Kaluarachchi. Digital pulse interval modulation for optical communications. *IEEE Communications Magazine*, 1998.
[4] Lawrence J. Mueller. Synchronization of pulse code modulation telemetry. Master's thesis, University of Missouri at Rolla, 1968.

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