

Dependable Interference-Aware Time-Slotted Channel Hopping for Wireless Sensor Networks

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November 28, 2018

Introduction

- ▶ Time-Slotted Channel Hopping (TSCH)
 - ▶ channel access method for shared medium networks
- ▶ Medium Access Contention (MAC)
- ▶ Enhanced Time-Slotted Channel Hopping + Distributed Channel Sensing (ETSCH+DCS)
 - ▶ aims to detect good quality channels to be utilized for communication
- ▶ Non-Intrusive Channel-quality Estimation (NICE)
 - ▶ technique that detects energy interference in each timeslot's idle portions at the network coordinator location

TSCH Timeslot

- ▶ TSCH divides time into fixed time periods called *timeslots*

$$Channel = HSL[(ASN + Channel\ Offset)\%|HSL|] \quad (1)$$

- ▶ Different Channel Offsets assigned to different links in the network to enable parallel communications [1]
- ▶ HSL may include all or a subset of channels determined by the upper layers in the protocol stack

Protocol Stack

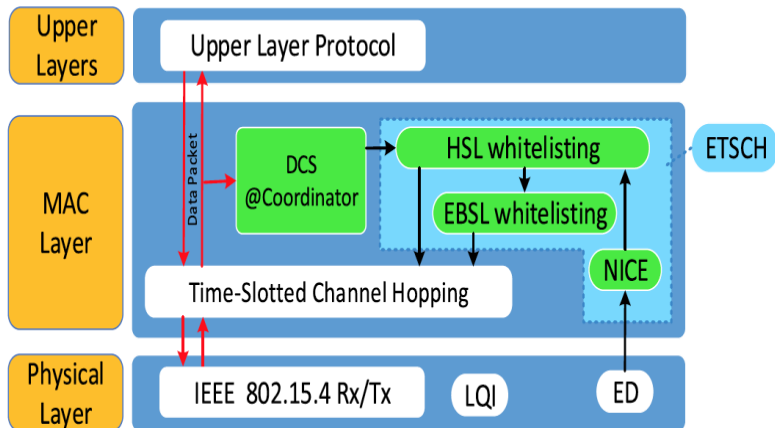


Figure: Coordinator Node Components

Non-Intrusive Channel Quality Estimation (NICE)

- ▶ NICE provides centralized interference detection for ETSCH
- ▶ Problem: coordinator may cause interference for nodes
- ▶ Distributed channel quality sensing together with NICE
- ▶ NICE cannot be used in other nodes to perform (Energy Detections) EDs and extract the quality of channels [2]

Algorithm

ALGORITHM 1: ETSCH+DCS Components

Data:

CQE []: an array to store Channel Quality Estimation results of all channels

HSL []: an array to store the main Hopping Sequence List, to be used by TSCH

EBSL []: an array to store Enhanced Beacon hopping Sequence List, to be used by TSCH

```
1 NICE (CQE [])
2   every timeslot do
3     while it is the silent period do
4        $ch \leftarrow (ch + 1) \% 16;$ 
5        $energy\_level \leftarrow ED(ch);$ 
6        $CQE[ch] \leftarrow EWMAFilter(energy\_level);$  /* see EWMA Filter in Equation (6) */
7     end
8   end
9 end
```

Experiment

- Noise Generators (NGs) detect noise interference on channels

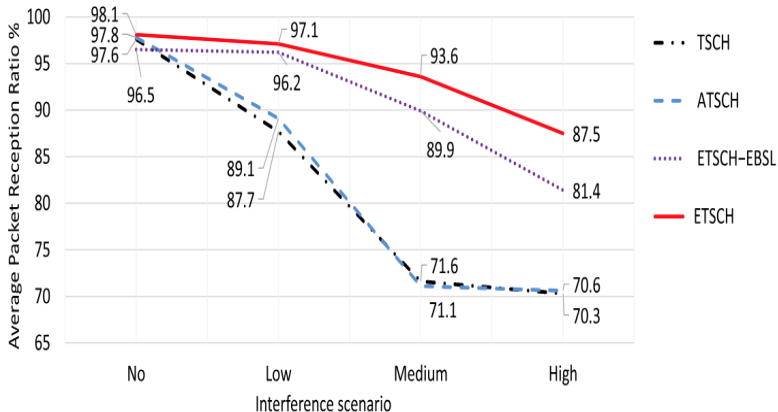


Figure: Avg. PRR of Different Interference Scenarios

Conclusions

- ▶ ETSCH and EBSL have higher PRR than plain TSCH and ATSCH.
 - ▶ less packet bursts/packet losses
- ▶ NICE technique on its own isn't as effective
 - ▶ DCS technique can detect and decrease existing interference
- ▶ Researching on, layering, and combining different protocols help improve the existing ones, thus mitigating interference, improving PRR, and improving the quality of the channels.

References



Kannan Srinivasan, Maria A. Kazandjieva, Saatvik Agarwal, and Philip Levis.

The beta-factor-factor: Measuring wireless link burstiness.

In Proceedings of the 6th ACM Conference on Embedded Network Sensor Systems (SenSys08). ACM, New York, NY, 2942.



X. Vilajosana, Q. Wang, F. Chraim, T. Watteyne, T. Chang, and K. S. J. Pister.

A realistic energy consumption model for TSCH networks.
IEEE Sens. J. 14, 2 (Feb. 2014), 482489.