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6TiSCH On-the-Fly Scheduling
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Abstract

This document describes the environment, problem statement, and goals of the On-The-Fly (OTF) scheduling for the IEEE802.15.4e TSCH MAC protocol in the context of LLNs. The purpose of OTF is to dynamically adapt the number of reserved cells between neighbor nodes to satisfy different type of constraints, based on the specific application. The cell reservation with OTF is distributed: neighbor nodes negotiate the cell(s) to be (re)allocated/deleted among them, without the intervention of a centralized entity. This document aims to define a module which uses the functionalities provided by the 6top sublayer to extract statistics and to reserve/delete cells in the schedule, leaving the reservation/deletion algorithm, and the number and type of statistics to be used in the algorithm itself, open. OTF allows to reserve/delete either a single cell between a couple of nodes, or a set of them (i.e., a bundle) in the TSCH schedule. Also, OTF allows to negotiate the aggregate bandwidth of a link without explicitly dealing with a reservation of a specific subset of cells.

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1. Introduction

The IEEE802.15.4e standard [IEEE802154e] was published in 2012 as an amendment to the Medium Access Control (MAC) protocol defined by the IEEE802.15.4-2011 [IEEE802154] standard. The Timeslotted Channel Hopping (TSCH) mode of IEEE802.15.4e is the object of this document.

On-The-Fly (OTF) scheduling is a distributed protocol intended to enable a node to define a common schedule with its neighbors without the intervention of a centralized entity. In particular, this document describes the methods, flows and packets involved in this process by using the functionalities offered by the 6top sublayer, as defined in [I-D.wang-6tisch-6top]. In order to be extendible, and thus, applicable in different scenario, OTF has not been designed for

working with a specific scheduling algorithm nor with a well-defined set of statistics. It provides a general framework and a set of methods that can be used by different algorithms. This document follows the terminology defined in [I-D.palattella-6tisch-terminology] and the mechanisms described on [I-D.watteyne-6tisch-tsch]

2. Allocation policy

OTF Cell allocation is distributed. All the allocation requests are sent to 6top, which will be in charge of granting the requested Softcells or Bundles. Since the requests are satisfied on a peer to peer basis, without the participation of a PCE, this may generate Softcell reservation collisions between different pairs of nodes. Although distributed reservation reduces the latency, this can be done at the cost of increasing the Softcell allocation collision probability There are 3 types of allocation policies supported by OTF, namely Post-allocation, Pre-allocation and Hybrid allocation.

On the Post-allocation policy, according to the current algorithm decision, OTF sends allocation requests to 6top for individual softcells. After the softcells are granted, OTF keeps track of the number of cells allocated for each of the neighbours. If the algorithm decides to free cells to any neighbour, a deallocation request is issued to 6top. When the deallocation is confirmed, OTF updates the internal cell allocation tables.

On the Pre-allocation policy, given a decision from the algorithm, OTF requests to 6top the allocation of a block of Softcells, called a Bundle. When the allocation is granted, the algorithm decides which of the allocated cells inside the Bundle will be used for communication. The remaining cells inside the Bundle will remain allocated but not used. OTF keeps track of the allocated Bundles, and the number of used cells inside the Bundle. Used cells inside a Bundle are consecutive starting from the first cell in the Bundle. When the algorihtm decides to enlarge or reduce the Bundle size, OTF forwards this request to 6top.

On the Hybrid allocation policy, when the algorithm issues an allocation request for new cells, OTF must decide between allocating individual softcells, incrementing the number of used cells within a Bundle, or request to 6top to enlarge the Bundle if there were no free cells inside. OTF keps track of the individual softcells, the allocated Bundles and the number of allocated cells inside the Bundle.

2.1. Allocation methods

OTF uses two allocation methods: Bundle and Softcell.

The Bundle allocation method requests to 6top a group of cells called a Bundle. OTF manages internally the allocation of individual cells within the Bundle. The goal of this allocation method is to provide a low-delay response after a surge in bandwidth usage, at the expense of energy consumption. Once the Bundle is allocated, OTF may ask for sizing/re-sizing BW of a bundle, which implies softcells will be reserved. For this purpose, OTF only calculates required Bandwidth, and 6top maps the BW to the number of soft cells according to some QoS setting, e.g. over-provision ratio, and then allocates and maintains them.

The Softcell allocation method calculates the required Bandwidth and requests individual softcells to 6top. The 6top layer allocates and maintains the individual softcells. This method reduces energy consumption by allocating only the required bandwidth, to the expense of increasing cell allocation latency.

3. Input parameters: statistics and instant values

Short summary of a potential set of statistics and instant values that could be used as input parameters.

List of parameters available from 6top: mainly statistics related to queues

Method to configure 6top to provide historical values for each requested parameter

Method to ask 6top for instant values for each requested parameter

Method for asking list of parameters from 6top and thus, for checking if a parameter is avaialble or not

4. Bundle usage management in OTF

Methods that trigger the request of increasing/decreasing the bundle, and thus, adding/deleting cells

4.1. Cell Reservation/Deletion

The commands to reserve/delete Softcells. interaction with 6top

4.2. Bundle Size Increase/Decrease

The commands to increase/decrease the Bundle size. interaction with 6top

5. Schedule storage on OTF

The description and access to the schedule storage on OTF

The commands to retrieve bundle usage values and statistics from OTF (based on previous values obtained by 6top?)

The commands to retrieve cell usage values and statistics from OTF (based on previous values obtained by 6top?)

6. Algorithm selection

There may be multiple algorithms stored within OTF. Here we describe how to select one of the stored algorithms.

7. Acknowledgements

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8.1. Informative References

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