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6TiSCH On-the-Fly Scheduling
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Abstract

This document describes the environment, problem statement, and goals of 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 Softcells between neighbor nodes to satisfy different types of constraints, based on the specific application. The Softcell 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 Softcells 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 Softcell between a couple of nodes, or a Bundle in the TSCH schedule. Also, OTF allows to negotiate the aggregate bandwidth without explicitly dealing with a reservation of a specific subset of Softcells.

Status of This Memo

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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 extensible, and thus, applicable in different scenarios, this draft is a general

framework. The exact scheduling algorithm and set of statistics is out of scope of this document. This document follows the terminology defined in [I-D.ietf-6tisch-terminology] and the mechanisms described on [I-D.ietf-6tisch-tsch]

2. Allocation policy

OTF Softcell scheduling is distributed. OTF sends scheduling requests to the 6top module, which allocates the requested Softcells. Softcell scheduling requests to the 6top layer are negotiated on a peer to peer basis without the participation of a PCE. While a distributed mechanism reduces the latency compared to a centralized one, this may generate Softcell allocation collisions between different pairs of neighbor nodes. OTF keeps track of the Softcell and Bundle scheduling.

An allocation policy describes which are the rules to follow in order to comply with the requirements of different types of traffic, according to its variability, throughput and latency restrictions.

OTF supports 3 types of allocation policies, namely Single, Group and Hybrid allocation policies.

Single allocation policy: OTF schedules individual Softcells in response to the current algorithm requests. OTF schedules single Softcells from the scheduling requests to 6top. 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 is used for communication. The remaining cells inside the Bundle remains 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 keeps track of the individual softcells, the

allocated Bundles and the number of allocated cells inside the Bundle.

3. Allocation methods

Unlike the Allocation Policies, an allocation method deals with the specific mechanisms to schedule cells from 6top. Given an Allocation Policy, the algorithm uses one or two methods altogether. 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: Since Bundles represent a group of pre-scheduled Softcells, they become immediately available. Unlike SoftCell scheduling, which requires a negotiation period between the node's 6top layers, the delay is reduced when a Softcell from a Bundle is used. Nevertheless, the use of Bundles forces the receiver module from the node to be in the Active state during the length of the Bundle, thus increasing power consumption.

Once the Bundle is allocated, OTF may ask for sizing/re-sizing BW of a bundle, which implies softcells are reserved. For this purpose, OTF only calculates the required Bandwidth, and 6top maps the BW to the number of soft cells according to some QoS setting, e.g. over-provision ratio, and finally 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: When there is a scheduling request to 6top for a new Softcell, the 6top layer negotiates this request with the 6top layer of the neighbor. This negotiation may take one or more Softcells to complete, thus increasing the overhead. On the other side, when Softcell scheduling is used, the receiver module from the node only stays in the Active node for the scheduled Softcells, thus saving energy. This mechanism assumes that the OTF algorithm schedules Softcells only when they are required.

4. Input parameters: statistics and instant values

Short summary of a potential set of statistics and instant values that could be used as input parameters. Direct interaction with 6top.

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

5. Bundle usage management in OTF: TODO

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

5.1. Cell Reservation/Deletion

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

5.2. Bundle Size Increase/Decrease

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

6. Schedule storage on OTF: TODO

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?)

7. Scheduling Algorithm container and selection

There can be several scheduling algorithms for OTF. The current algorithm can be selected with an external command. The commands allowed are: SET and GET. Scheduling algorithms are numbered from 1 to 255. OTF algorithm 0 is reserved for the default scheduling algorithm, defined as follows:

Step 1: Obtain the Bandwidth requests from child nodes (incoming traffic)

Step 2: Obtain the node Bandwidth requirement from the application (self traffic)

Step 3: Obtain the current outgoing scheduled Bandwidth (outgoing traffic)

Step 4: If (outgoing < incoming + self) then schedule a number of Soft Cells to satisfy requirements

Step 5: If (outgoing > incoming + self) then unschedule the unused Soft Cells

Step 6: Loop to Step 1

8. Acknowledgements

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9. References

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