6TiSCH
Internet-Draft
Intended status: Informational
Expires: June 19, 2017

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December 16, 2016

Terminology in IPv6 over the TSCH mode of IEEE 802.15.4e
draft-ietf-6tisch-terminology-08

Abstract

This document provides a glossary of terminology used in IPv6 over the TSCH mode of IEEE 802.15.4e (6TiSCH). This document extends existing terminology documents for Low-power and Lossy Networks.

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1. Introduction

The IEEE802.15.4 Medium Access Control (MAC) has evolved with the Time Slotted Channel Hopping (TSCH) mode for industrial-type applications. It provides deterministic capabilities to the point that a packet that pertains to a certain flow crosses the network from node to node following a very precise schedule, like a train leaves intermediate stations at precise times along its path.

This document provides additional terminology elements to cover terms that are new to the context of TSCH wireless networks and other deterministic networks.

2. Terminology

The draft extends [RFC7102] and use terms from [RFC6550] and [RFC6552], which are all included here by reference.

The draft does not reuse terms from IEEE802.15.4e such as "path" or "link" which bear a meaning that is quite different from classical IETF parlance.

This document adds the following terms:

6TiSCH: IPv6 over the Timeslotted Channel Hopping (TSCH) mode of IEEE802.15.4e. It defines (i) the 6top sublayer; (ii) a set of protocols for setting up a TSCH schedule in distributed approach, for managing the allocation of

resources; and (iii) the architecture to bind them together, for use in IPv6 TSCH based networks.

6top: The "6TiSCH Operation Sublayer" (6top) is the next highest layer of the IEEE802.15.4e TSCH medium access

control layer. It implements and terminates the "6top Protocol" (6P), and contains a "6top Scheduling Function" (SF).

SF: The "6top Scheduling Function" (SF) "is the cell management entity that add or delete cells dynamically based on its allocation policy in order to fulfill cell requirements. The cell negotiation with a neighbor is done using 6P. General guidelines for designing a SF are provided in [I-D.ietf-6tisch-6top-protocol].

SFID: The "6top Scheduling Function Identifier" (SFID) is a 4-bit field identifying a SF. Defined in [I-D.ietf-6tisch-6top-protocol].

6P: The "6top Protocol" (6P) allows neighbor nodes to communicate to add/delete cells to one another in their TSCH schedule. Defined in [I-D.ietf-6tisch-6top-protocol].

6P Transaction: Part of the "6top Protocol" (6P), the action of two neighbors exchanging a 6P request message and the corresponding 6P response message. Defined in [I-D.ietf-6tisch-6top-protocol].

ASN: Absolute Slot Number, the total number of timeslots that have elapsed since the PAN coordinator has started the TSCH network. Incremented by one at each timeslot. It is wide enough to not roll over in practice. See [IEEE802154-2015] and [RFC7554].

Blacklist of Frequencies: A set of frequencies which should not be used for communication. See [IEEE802154-2015] and [RFC7554].

BBR: Backbone Router. In the 6TiSCH architecture, an LBR and

also a IPv6 ND-efficiency-aware Router (NEAR) [I-D.chakrabarti-nordmark-6man-efficient-nd]. Performs ND proxy operations between registered devices and classical ND devices that are located over the backbone.

Broadcast Cell: A scheduled cell used for broadcast transmission.

Bundle: A group of equivalent scheduled cells, i.e. cells identified by different [slotOffset, channelOffset], which are scheduled for a same purpose, with the same neighbor, with the same flags, and the same slotframe. The size of the bundle refers to the number of cells it

contains. For a given slotframe length, the size of the bundle translates directly into bandwidth. A bundle is a local abstraction thar represents a half-duplex link for either sending or receiving, with bandwidth that amounts to the sum of the cells in the bundle. A bundle is globally identified by (source MAC, destination MAC, TrackID). At Layer 3, a pair of bundles forms a link. By using a well-known constant, NULLT, as TrackId for a L3 link, the IP link between adjacent nodes A and B comprises 2 bundles: (macA, macB, NULLT) and (macB, macA, NULLT). At Layer 2, a pair of bundles forms a switching state. Considered a segment A-B-C along a track, there are two bundles in node B, one incoming = (macA, macB, trackId) and one outgoing = (macB, macC, trackId).

CCA: Clear Channel Assessment. Mechanism defined in [IEEE802154-2015], section 6.2.5.2. In a TSCH network, CCA can be used to detect other radio networks in vicinity. Nodes listen the channel before sending, to detect other ongoing transmissions. Because the network is synchronized, CCA cannot be used to detect colliding transmission within the same network. CCA is necessary for the 6TiSCH minimal configuration [I-D.ietf-6tisch-minimal] in shared slots, and in presence of multiple instances of 6TiSCH networks.

Cell: A single element in the TSCH schedule, identified by a slotOffset, a channelOffset, a slotframeHandle. A cell can be scheduled or unscheduled.

Centralized Cell Reservation: A reservation of a cell done by a centralized entity (e.g., a PCE) in the network.

Centralized Track Reservation: A reservation of a track done by a centralized entity (e.g., a PCE) in the network.

ChannelOffset: Identifies a row in the TSCH schedule. The number of available channelOffset values is equal to the number of available frequencies. The channelOffset translates into a frequency when the communication takes place, resulting in channel hopping. See [RFC7554].

Channel Distribution/Usage (CDU) matrix: : Matrix of cells (i,j) representing the spectrum (channel) distribution among the different nodes in the 6TiSCH network. The CDU matrix has width in timeslots, equal to the period of the network scheduling operation, and height equal to the number of available channels. Every cell (i,j) in the

CDU, identified by (slotOffset, channelOffset), belongs to a specific chunk. It has to be noticed that such a matrix which includes all the cells grouped in chunks, belonging to different slotframes, is different from the TSCH schedule.

Chunk: A well-known list of cells, distributed in time and frequency, within a CDU matrix; a chunk represents a portion of a CDU matrix. The partition of the CDU in chunks is globally known by all the nodes in the network to support the appropriation process, which is a negotiation between nodes within an interference domain. A node that manages to appropriate a chunk gets to decide which transmissions will occur over the cells in the chunk within its interference domain (i.e., a parent node will decide when the cells within the appropriated chunk are used and by which node, among its children.

Dedicated Cell: A cell that is reserved for a given node to transmit to a specific neighbor.

Deterministic Network: The generic concept of deterministic network

is defined in [I-D.ietf-detnet-architecture]. When applied to 6TiSCH it refers to the reservation of tracks which guarantee an end to end latency and optimize the PDR for well-characterized flows.

Distributed Cell Reservation: A reservation of a cell done by one or more in-network entities (typically a connection endpoint).

Distributed Track Reservation: A reservation of a track done by one or more in-network entities (typically a connection endpoint).

EB: Enhanced Beacon frame used by a node to announce the presence of the network. It contains enough information for a joining node to synchronize to the network. See [IEEE802154-2015] and [RFC7554].

Hard Cell: A scheduled cell which the 6top sublayer cannot relocate.

Hopping Sequence: Ordered sequence of frequencies, identified by a Hopping_Sequence_ID, used for channel hopping, when translating the channel offset value into a frequency (i.e., PHY channel). See [IEEE802154-2015] and [RFC7554].

IE: Information Element, a Type-Length-Value containers placed at the end of the MAC header, used to pass data between layers or devices. Some IE identifiers are managed by the IEEE [IEEE802154-2015]. Some IE identifiers are managed by the IETF [I-D.kivinen-802-15-ie].

JCE: The Join Coordination Entity (JCE) is a central entity that coordinates the joining of new nodes in the network. See [I-D.ietf-6tisch-minimal-security] and [I-D.ietf-6tisch-dtsecurity-secure-join].

JA: The Join Assistant (JA) is a one-hop neighbor of a joining node that may facilitate it to become meaningful part of the network (e.g., by serving as a local

connectivity point to the remainder of the network). JA emits EBs, used by JNs to synchronize to the network. See [I-D.ietf-6tisch-minimal-security] and [I-D.ietf-6tisch-dtsecurity-secure-join].

JN: The Joining Node (JN) is a device attempting to join a particular 6TiSCH network. See [I-D.ietf-6tisch-minimal-security].

Join Protocol: The protocol which secures initial communication between a joining node and the JCE.

LBR: Low-power Lossy Network (LLN) Border Router. It is an LLN device, usually powered, that acts as a Border Router to the outside within the 6TiSCH architecture.

Link: A communication facility or medium over which nodes can communicate at the link layer, i.e., the layer immediately below IP. Thus, the IETF parlance for the term "Link" is adopted, as opposed to the IEEE802.15.4e terminology.

Operational Network: A IEEE802.15.4e network whose encryption/ authentication keys are determined by some algorithms/ protocols. There may be network-wide group keys, or per-link keys.

(to) Relocate a Cell: The action operated by the 6top sublayer of changing the slotOffset and/or channelOffset of a soft cell.

(to) Schedule a Cell: The action of turning an unscheduled cell into a scheduled cell.

Scheduled cell: A cell which is assigned a neighbor MAC address (broadcast address is also possible), and one or more of the following flags: TX, RX, shared, timeskeeping. A scheduled cell can be used by the IEEE802.15.4e TSCH implementation to communicate. A scheduled cell can be either a hard or a soft cell.

Shared Cell: A cell marked with both the "TX" and "shared" flags.

This cell can be used by more than one transmitter node. A back-off algorithm is used to resolve contention. See [IEEE802154-2015] and [RFC7554].

SlotOffset: Identifies a column in the TSCH schedule, i.e., the number of timeslots since the beginning of the current iteration of the slotframe. See [IEEE802154-2015] and [RFC7554].

Slotframe: A collection of timeslots repeating in time, analogous to a superframe in that it defines periods of communication opportunities. It is characterized by a slotframe_ID, and a slotframe_size. Multiple slotframes can coexist in a node's schedule, i.e., a node can have multiple activities scheduled in different slotframes, based on the priority of its packets/traffic flows. The timeslots in the Slotframe are indexed by the SlotOffset; the first timeslot is at SlotOffset 0. See [IEEE802154-2015] and [RFC7554].

Soft Cell: A scheduled cell which the 6top sublayer can relocate.

Timeslot: A basic communication unit in TSCH which allows a transmitter node to send a frame to a receiver neighbor, and that receiver neighbor to optionally send back an acknowledgment. See [IEEE802154-2015] and [RFC7554].

Time Source Neighbor: A neighbor that a node uses as its time reference, and to which it needs to keep its clock synchronized. See [IEEE802154-2015] and [RFC7554].

Track: A determined sequence of cells along a multi-hop path. It is typically the result of a track reservation. The node that initializes the process of establishing a track is the owner of the track. The latter assigns a unique identifier to the track, called TrackID.

TrackID: Unique identifier of a track, assigned by the owner of the track.

TSCH: Time Slotted Channel Hopping, a medium access mode of the

[IEEE802154-2015] standard which uses time synchronization to achieve ultra low-power operation and channel hopping to enable high reliability. See [IEEE802154-2015] and [RFC7554].

TSCH Schedule: A matrix of cells, each cell indexed by a slotOffset and a channelOffset. The TSCH schedule contains all the scheduled cells from all slotframes and is sufficient to qualify the communication in the TSCH network. The number of channelOffset values (the "height" of the matrix) is equal to the number of available frequencies. See [IEEE802154-2015] and [RFC7554].

Unscheduled Cell: A cell which is not used by the IEEE802.15.4e TSCH implementation. See [IEEE802154-2015] and [RFC7554].

3. Security Considerations

Since this document specifies terminology and does not specify new procedures or protocols, it raises no new security issues.

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