IETF 89 - London

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IPv6 over the TSCH mode of IEEE 802.15.4e

Etherpad for minutes:
http://etherpad.tools.ietf.org:9000/p/notes-ietf-89-6tisch

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Minutes are taken *
This meeting is recorded **
Presence is logged ***

* Scribe; please contribute online to the minutes at http://etherpad.tools.ietf.org:9000/p/6tisch?useMonospaceFont=true
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*** Please make sure you sign the blue sheets

Administrivia

- Blue Sheets
- Scribes (Thanks!)
  - Xavi Vilajosana
  - Dominique Barthel
- Jabber (Thanks!)
  - Guillaume Gaillard

Objectives

- Second WG meeting
- Report on progress on WG docs, especially around information and data models
- Acknowledge work around security
- Report on 6TiSCH plugfest
- Explore unchartered draft and on-going work

Agenda

Intro and Status [10min]
- Note-Well, Blue Sheets, Scribes, Agenda Bashing
- Quick Reminders:
  - 6TiSCH charter recap
  - 6TiSCH milestones recap

Overall Architecture and Context [15min]
- <draft-ietf-6tisch-terminology-01> (Maria-Rita Palattella)
- <draft-ietf-6tisch-architecture-01> (Pascal Thubert)

Information and Data Models [20min]
- <draft-wang-6tisch-6top-interface-02> (Xavi Vilajosana)
- <draft-wang-6tisch-6top-sublayer-00> (Qin Wang)

Security [20min]
- Security discussions: summary and outlook (Michael Richardson, Michael Behringer)

Report on plugfest [30min]
- Overview and goals (Xavi Vilajosana)
- Presentation of outcome <plugfest participants>

Unchartered drafts if time permits [20min]
- <draft-dujovne-6tisch-on-the-fly-02> (Diego Dujovne)
- <draft-piro-6tisch-security-issues-01> (Giuseppe Piro)
- <draft-svshah-tsvwg-deterministic-forwarding-00> (Shitanshu Shah)

Any Other Business [5min]

Charter Recap

Description of Working Group

The Working Group will focus on enabling **IPv6** over the **TSCH mode of the IEEE802.15.4e standard**. The extent of the problem space for the WG is **one or more LLNs**, eventually federated through a common backbone link via one or more LLN Border Routers (**LBRs**).

The WG will rely on, and if necessary extend, existing mechanisms for authenticating LBRs. Initially, the WG will **limit its scope to distributed routing over a static schedule**. In that case, a node's schedule can be either preconfigured, or learnt by a node when joining the network, but it remains unchanged after the node has joined a network.

The Routing Protocol for LLNs (**RPL**) is used on the resulting network. The WG will interface with other appropriate groups in the IETF Internet, Operations and Management, Routing and Security areas.

Work Item 1

Produce "**6TiSCH architecture**" to describe the design of 6TiSCH networks. This document will highlight the different architectural blocks and signalling flows, including the operation of the network in the presence of **multiple LBRs**. Initially, the document will focus on **distributed routing operation over a static TSCH schedule**.

Work Item 2

Produce an **Information Model** containing the management requirements of a 6TiSCH node. This includes describing how an entity can manage the TSCH schedule on a 6TiSCH node, and query timeslot information from that node. A data model mapping for an existing protocol (such as Concise Binary Object Representation (**CBOR**) over the Constrained Application Protocol (**CoAP**)) will be provided.

Work Item 3

Produce "**Minimal 6TiSCH Configuration**" defining how to build a 6TiSCH network using the Routing Protocol for LLNs (**RPL**) and a **static TSCH schedule**. It is expected that RPL and the Objective Function 0 (**OF0**) will be reused as-is.

The work will include a **best practice** configuration for RPL and OF0 operation over the **static schedule**. Based on that experience the group may produce a requirements draft for OF0 extensions, to be studied in ROLL.

Milestones

12/2013 - WG to adopt 6TiSCH terminology
12/2013 - WG to adopt IEEE802.15.4e TSCH overview
12/2013 - WG to adopt 6TiSCH architecture
12/2013 - WG to adopt 6TiSCH minimal configuration
04/2014 - WG to adopt 6top draft(s)
04/2014 - WG to adopt 6TiSCH data model for CoAP
08/2014 - Submit YANG data model in 6top draft for preliminary OPSDIR review
08/2014 - Submit 6TiSCH architecture for preliminary SECDIR review
11/2014 - Initial submission of 6TiSCH minimal configuration to the IESG
11/2014 - Initial submission of 6top draft(s) to the IESG
11/2014 - Initial submission of 6TiSCH data model for CoAP to the IESG
12/2014 - Initial submission of 6TiSCH terminology to the IESG
12/2014 - Initial submission of 6TiSCH architecture to the IESG
12/2014 - Evaluate WG progress, propose new charter to the IESG
06/2015 - 6TiSCH Minimal and 6top draft(s) in RFC publication queue
12/2015 - 6TiSCH architecture and terminology in RFC publication queue

draft-ietf-6tisch-terminology-01

Maria Rita Palattella (Ed.)
Pascal Thubert
Thomas Watteyne
Qin Wang

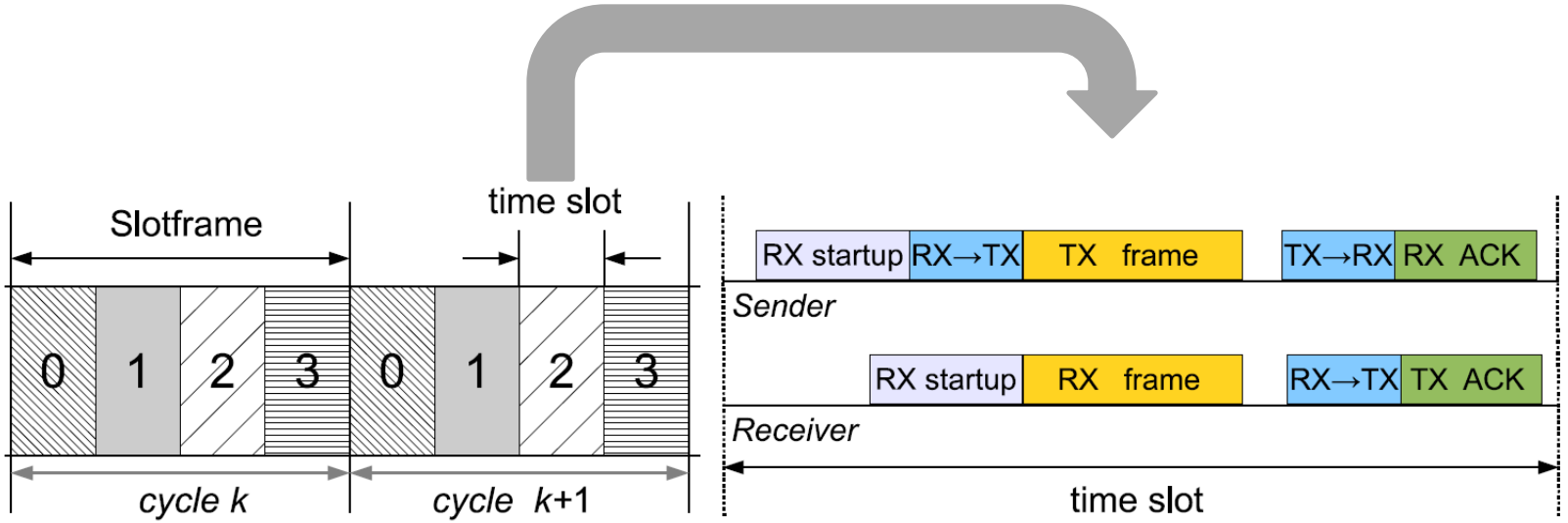
draft-ietf-6tisch-terminology-01

- Status:
  - Adopted at IETF88
  - Latest version published 02/13/2014 http://tools.ietf.org/html/draft-ietf-6tisch-terminology-01
- Changes since IETF88
  - Additional terms (see next slides)

Basic 6TiSCH terminology

(short recap 1/2)

- Slotframe
- TSCH schedule
- Cell (scheduled, unscheduled, soft, hard)
- Bundle
- Track



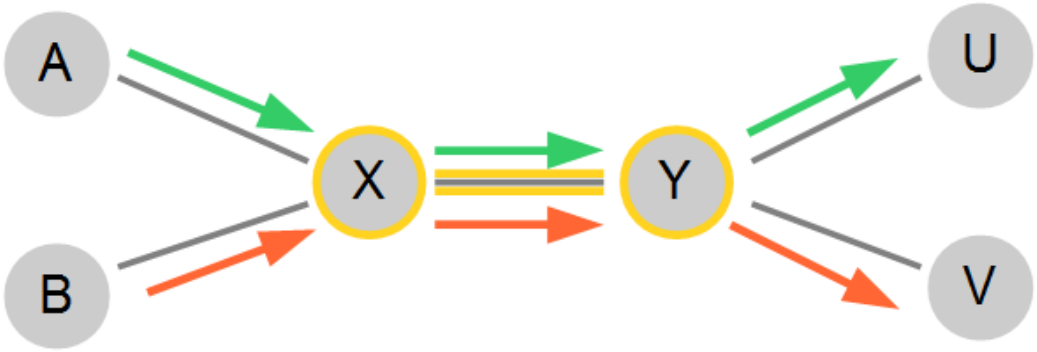
(a) slotframe

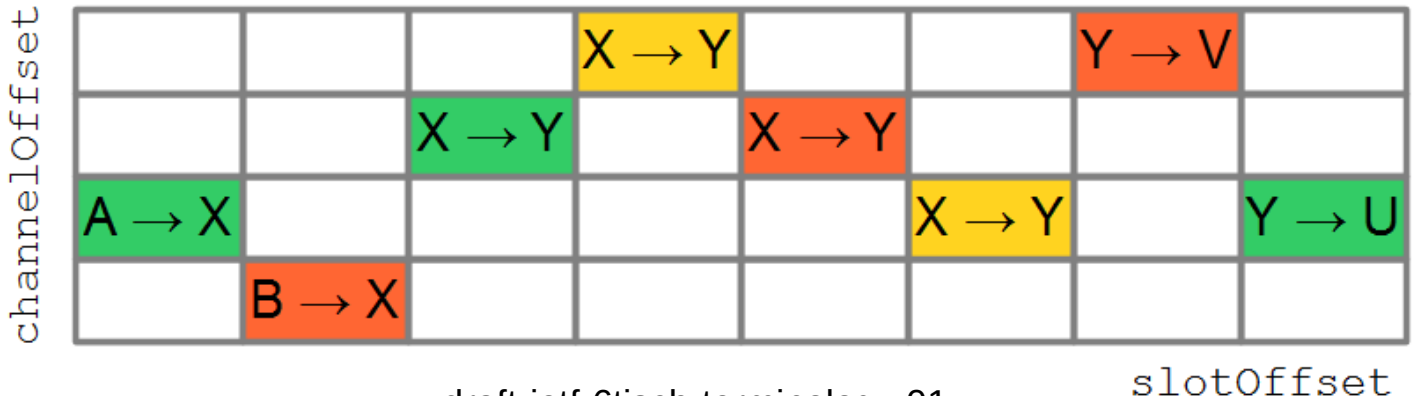
(b) data frame and ACK transmission within a timeslot

Basic 6TiSCH terminology

(short recap 2/2)

- Slotframe
- TSCH schedule
- Cell (scheduled, unscheduled, soft, hard)
- Bundle
- Track





Chunk

- **CHUNK:** A well-known list of cells, well-distributed in time and frequency, within a slotframe; a chunk represents a portion of a slotframe that is globally known by all the nodes in the network, but it can be managed separately by a single node. A node can have multiple chunks, overlap. They can be pre-programmed, or can be computed by an external entity at the network bootstrap.

Channel distribution/usage (CDU) matrix

- **CDU matrix:** Matrix of height equal to the number of available channels (i.e, ChannelOffsets),representing the **spectrum(channel) distribution among the different (RPL parent) nodes in the networks.** Every single element of the matrix belongs to a specific chunk. It has to be noticed that such matrix, even though it includes all the cells grouped in chunks, belonging to different slotframes, is different from the TSCH schedule.

draft-ietf-6tisch-architecture-01

Pascal Thubert (Ed.)
Thomas Watteyne
Robert Assimiti

draft-ietf-6tisch-architecture-01

- Status:
  - Adopted at IETF88
  - Latest version published 02/14/2014 http://tools.ietf.org/html/draft-ietf-6tisch-architecture
  - WIP version at https://bitbucket.org/6tisch/draft-ietf-6tisch-architecture
- Changes since IETF88
  - Incorporated text on 6top vs. RPL (section 7.2)
  - Added text on chunk management (section 7.6)
  - New terms e.g. Channel Distribution/Usage matrix

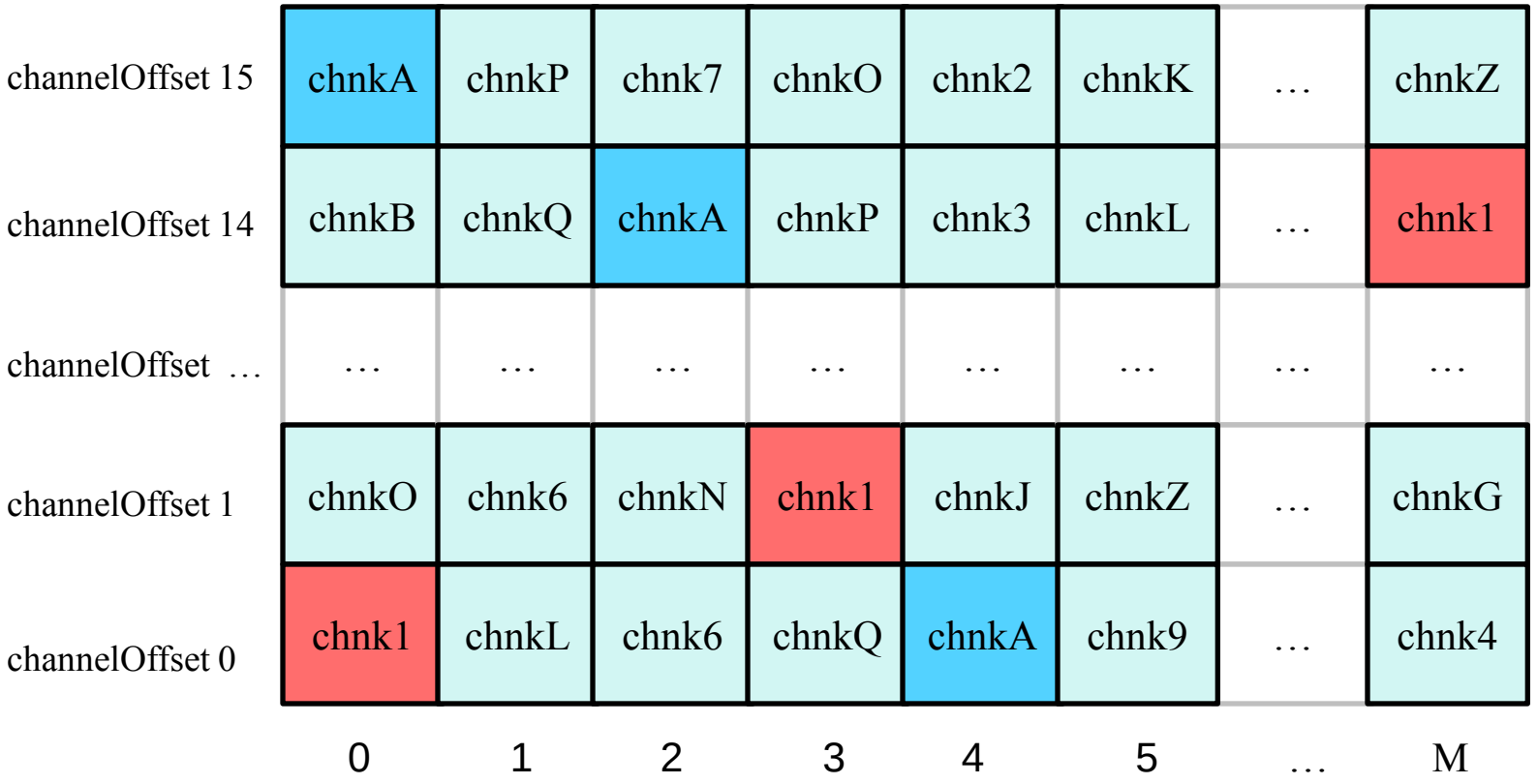
6top and RPL

- Objective Function can leverage 6top databases
  - abstract neighbor table with stats
  - cell quality metrics (RSSI, LQI)
  - ASN of last received packet
- RPL can also influence MAC behavior
  - Extended Beacons period
- 6top provides a broadcast channel for DIO

Chunks

- To support the distribution of timeslot allocation.
  - Optional. E.g. not used in minimal
  - Operates for a whole group of cells at a time
  - Well-known partition on the CUD matrix
  - Used to obtain exclusive authority within interference domain
  - Different from Bundle that is a dynamic collection used for xmit
- Mechanism for appropriation still TBD
  - Done by RPL parents only
  - Expectation: similar to DAD

Channel distribution/usage (CDU) matrix



Related Work at IETF

- 6MAN
  - Status on Backbone router / Efficient ND
  - Flow Label:
    - Saves HbH with RPL option and eventually IP in IP encapsulation
    - Should we push work to 6MAN?
- 6lo
  - Status on Fragments forwarding and recovery
- Transport area
  - Deterministic DSCP (pres by Shitanshu next)

Related Work at IEEE

IEEE802.15.4 6TiSCH Interest Group,

- Formed November 2013
- Potential collaboration on MAC related issues,
- promote 6TiSCH related work to IEEE
- e.g. New IEs for 6top to 6top.

Related Work at ISA

ISA100 WG1 Roadmap Study Group

- formed February 2014
- Report out: Oct 28, 2014, during meeting at ISA in North Carolina.
- Proposed Charter:

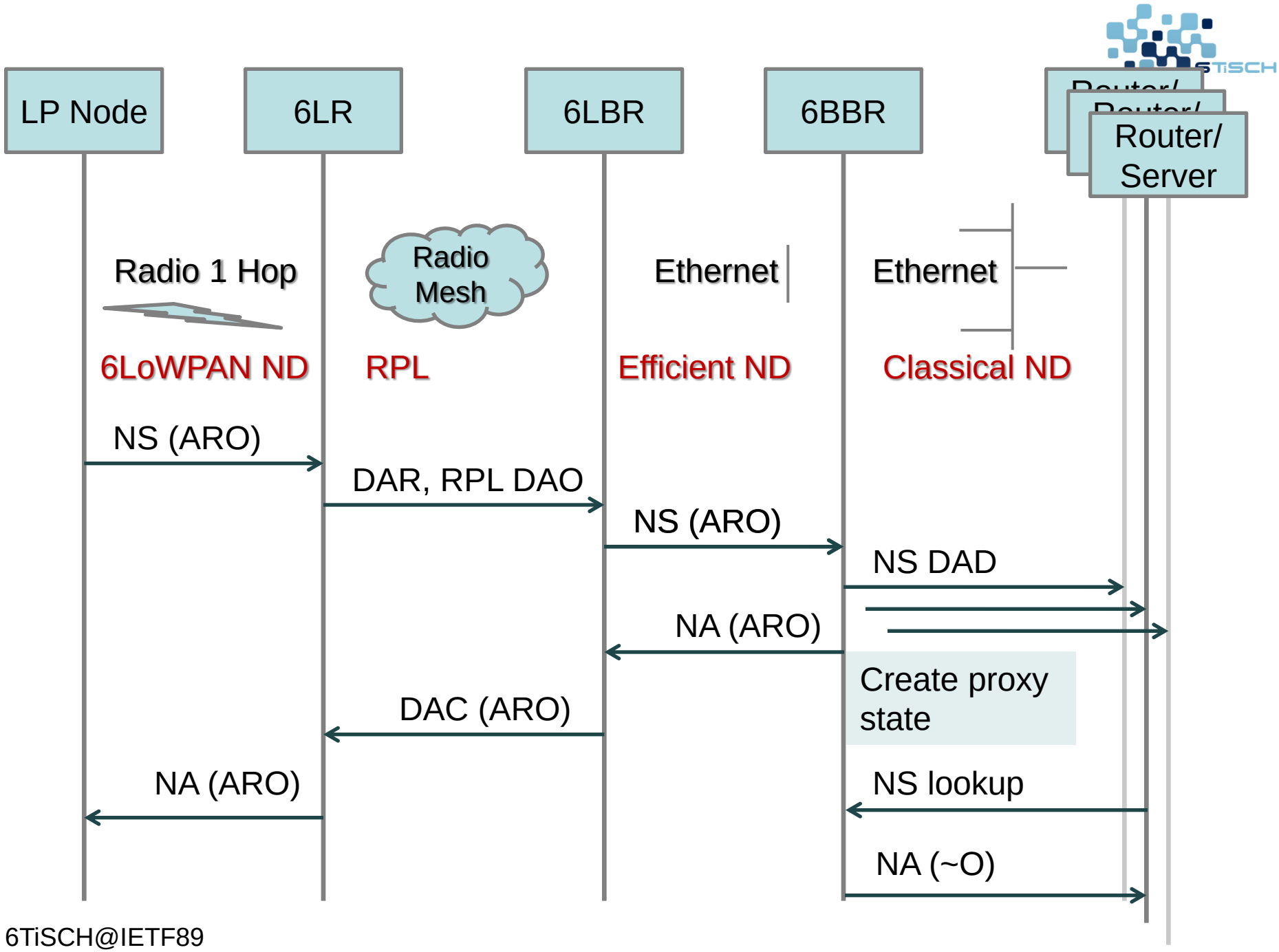
  Investigate emerging technologies to identify opportunities for next generation wireless systems for automation. Opportunities will be used to draft a roadmap for future committee working group charters.

Related Work at ISA (cnt'd)

- Candidate technologies and areas of interest include but are not limited to:
  - IETF: 6TiSCH/6top, RPL, CoAP/MQTT/XMPP, Rest, PANA, HTTP/VPN
  - IEEE: 802.1 TSN, 802.15.4-2014 (TSCH)
  - Management: centralized, distributed, LWM2M
  - Alternate PHYs (15.4g, …)
  - …

Next items to cover

- 6LoWPAN vs. RPL
  - Positioning and overlaps
    - Need for ND between RPL Nodes?
    - DAD operation without ND?
  - Redistributing ND in RPL
    - Non-RPL leaf using 6LoWPAN ND to attach
    - Requires TID in ARO as added in Efficient ND
  - Redistributing RPL (or other route-over) in ND
    - RPL root advertising DAO state as ARO
    - Demonstrated at PlugFest with Smartmesh IP


LP Node
6LR
6LBR
6BBR
Router/
Server
Radio 1 Hop
Radio
Mesh
Ethernet
Ethernet
6LoWPAN ND
RPL
Efficient ND
Classical ND
NS (ARO)
DAR, RPL DAO
NS (ARO)
NS DAD
NA (ARO)
Create proxy
state
DAC (ARO)
NA (ARO)
NS lookup
NA (~O)

Next items to cover (Cnt'd)

- Security Architecture
  - Started work (pres. by Michael next)
  - Document Art (ISA100, Wireless HART, Wi-SUN)
  - Should we merge ultimately?

- Related work and discussions
  - PANA vs. 1x
  - ACE
  - SACM
  - EU Cybersecurity candidate project

draft-wang-6tisch-6top-interface-02
draft-wang-6tisch-6top-sublayer-00

Qin Wang (Ed.)
Xavier Vilajosana
Thomas Watteyne

Status

Split dratf-wang-6tisch-6top into:

1. dratf-wang-6tisch-6top-interface (-02)

   New

2. dratf-wang-6tisch-6top-sublayer (-00)

   mainly from dratf-wang-6tisch-6top

draft-wang-6tisch-6top-interface-02

draft-wang-6tisch-6top-interface-02

- Status:
  - Individual submission
  - Latest version published 02/14/2014 http://tools.ietf.org/html/draft-wang-6tisch-6top-interface-02.txt
  - WIP version at https://bitbucket.org/6tisch/draft-wang-6tisch-6top-interface
- Changes since IETF88
  - New submission.

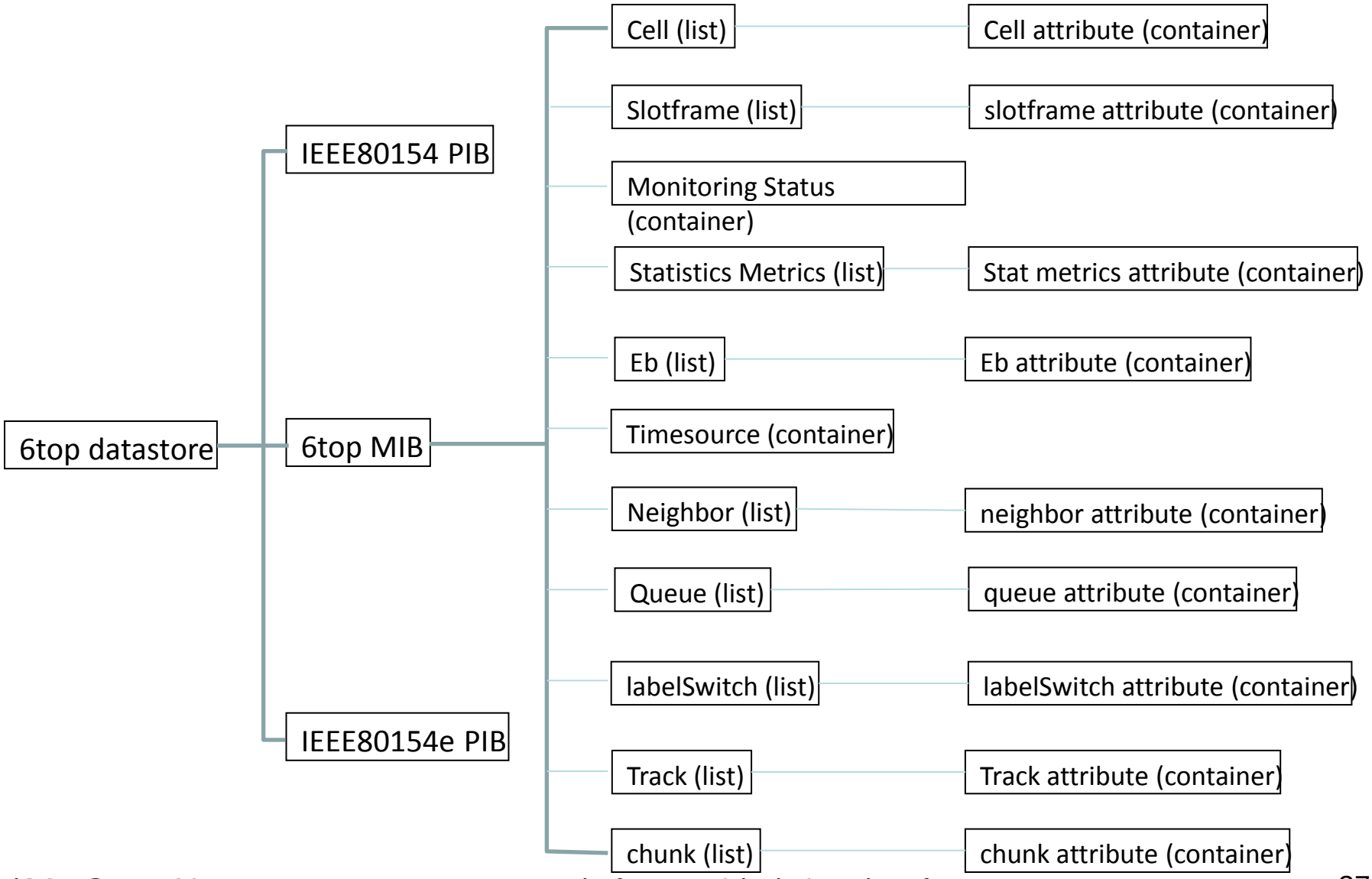
http://www.ietf.org/internet-drafts/draft-wang-6tisch-6top-interface-02.txt

Table of Content

Introduction

- Defines a generic data model for the 6TiSCH Operation Sublayer (6top), using the YANG data modeling language.
- This data model gives access to metrics (e.g. cell state), TSCH configuration and control procedures, and support for the different scheduling mechanisms
- This data model can be used for future network management solutions defined by the 6TiSCH working group.

6top datastore



CellList

```
list CellList {
   key "CellID";
   description
   "List of scheduled cells of a node with all of its neighbors,
   in all of its slotframes.";
   leaf CellID {
      type uint16;
      description
      "Equal to Linkhandle in the linkTable of TSCH";
      reference
      "IEEE802154e";
   }
   leaf SlotframeID {
      type uint8;
      description
      "Equal to SlotframeHandle defined in TSCH";
      reference
      "IEEE802154e";
   }
   leaf SlotOffset {
      type uint16;
      description
      "Defined in IEEE802154e.";
      reference
      "IEEE802154e";
   }
   leaf ChannelOffset {
      type uint8;
      description
      "Defined in IEEE802154e. Value range is 0..15";
      reference
      "IEEE802154e";
   }
```

CellList

```
leaf LinkOption {
   type bits {
      bit Transmit {
         position 0;
      }
      bit Receive {
         position 1;
      }
      bit Share {
         position 2;
      }
      bit Timekeeping {
         position 3;
      }
      bit Reserved1 {
         position 4;
      }
      bit Reserved2 {
         position 5;
      }
      bit Reserved3 {
         position 6;
      }
      bit Reserved4 {
         position 7;
      }
   }
   description
   "Defined in IEEE802154e.";
   reference
   "IEEE802154e";
}
leaf LinkType {
   type enumeration {
      enum NORMAL;
      enum ADVERTISING;
   }
```

CellList

```
leaf CellType {
   type enumeration {
      enum SOFT;
      enum HARD;
   }
   description
   "Defined in 6top";
}
leaf TargetNodeAddress {
   type uint64;
   description
   "Defined by 6top, but being constrained by TSCH
   macNodeAddress size, 2-octets. If using TSCH as MAC,
   higher 6-octets should be filled with 0, and lowest
   2-octets is neighbor address";
}
leaf TrackIDIndex {
   type uint16;
   description
   "A TrackID is a tuple (TrackOwnerAddr,InstanceID), where
   TrackOwnerAddr is the address of the node which initializes
   the process of creating the track, i.e., the owner of the
   track; and InstanceID is an instance identifier given by
   the owner of the track.";
}
```

CellList

```
container Statistic {
   leaf NumOfStatistic {
      type uint8;
      description
      "Number of statistics collected on the cell";
   }
   list MeasureList {
      key "StatisticsMetricsID";
      leaf StatisticsMetricsID{
         type uint16;
      }
      leaf StatisticsValue{
         type uint16;
         config false;
      }
   }
}
```

ChunkList
Used to add/
Remove chunk

```
list ChunkList {
   key "ChunkId";
   leaf ChunkId{
      type uint16;
      description
      "The id of a chunk";
   }
   leaf SlotframeId{
      type uint8;
      description
      "The id of the slotframe that is mapped to this chunk";
   }
   leaf SlotBase {
      type uint16;
      description
      "the base slotOffset of the chunk";
   }
   leaf SlotStep {
      type uint8;
      description
      "the slot incremental of the chunk";
   }
   leaf ChannelBase {
      type uint8;
      description
      "the base channelOffset of the chunk";
   }
   leaf ChannelStep {
      type uint8;
      description
      "the channel incremental of the chunk";
   }
   leaf ChunkSize {
      type uint8;
      description
      "the number of cells in the chunk. The chunk is the set
      of (slotOffset(i), channelOffset(i)),
      i=0..Chunksize-1,
      slotOffset(i)= (slotBase + i * slotStep) % slotframeLen,
      channelOffset(i) = (channelBase + i * channelStep) % 16";
   }
}
```

ChunkCellList
Used to retrieve the status of a cell in current chunk

```
list ChunkCellList {
   key "SlotOffset ChannelOffset";
   leaf SlotOffset{
      type uint16;
      description
      "The slotoffset.";
   }
   leaf ChannelOffset{
      type uint16;
      description
      "The channeloffset.";
   }
   leaf ChunkId {
      type uint16;
      description
      "Identifier of the chunk the cell belongs to";
   }
   leaf CellID{
      type uint16;
      description
      "Initial value of CellID is 0xFFFF. When the cell is
      scheduled, the value of CellID is same as that in
      CellList";
   }
   leaf ChunkCellStatus {
      type enumeration {
         enum UNUSED;
         enum USED;
      }
   }
}
```

Management Command list

- **Cell** Commands
  - Add/remove hard/soft Cells
- **Slotframe** Commands
  - Add/remove slotframe
- **Monitoring** Commands
  - Configure monitoring process
- **Statistics** Commands
  - Configure statistics to collect
  - Retrieve statistics
- **Network Formation** Commands
  - Configure Enhanced Beacons contents
  - Configure when to send EBs
- **Time Source Neighbor** Commands
  - Set a node's time source neighbor(s)
- **Neighbor** Commands
  - Manage the neighbor table
- **Queuing** Commands
  - Create a queue
  - Read queue statistics
- **Security** Commands
  - Manage the node's keying material
- **Chunk (Chunk cell)** Commands
  - Add/remove/ chunk (cell from chunk)
- **Label Switching** Commands
  - Label Switching mapping/unmapping

Next Step

- 3.2. YANG model of the IEEE802.15.4 PIB
  - Security PIB
  - Others?
- 3.3. YANG model of the IEEE802.15.4e PIB
  - Table 52b—TSCH-specific MAC PIB attributes
  - Table 52c—*macSlotframeTable* (covered by slotframeList)
  - Table 52d— *macLinkTable* (covered by CellList)
  - Table 52e—TSCH-MAC PIB attributes for *macTimeslotTemplate*
  - Table 52f—TSCH-MAC PIB attributes for Hopping Sequence

draft-wang-6tisch-6top-sublayer-00

draft-wang-6tisch-6top-sublayer-00

- Status:
  - Individual submission
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Table of Content

Changes from dratf-wang-6tisch-6top

- Flags for Cells
- Remove section 3 “Using 6top” and re-organize the contents
- Modify commands’ parameters for consistent with data model.
- Add “Chunk commands” and “Chunk-cell commands”.
- Remove security related commands.
- Detail the interaction with IEEE802.15.4e TSCH

Flags in Cell Model

- LinkOptions. (defined in IEEE802.15.4e)
  - b0: Transmit,
  - b1: Receive,
  - b2: Shared,
  - b3: Timekeeping
  - b4-b7: reserved
- LinkType. (defined in IEEE802.15.4e)
  - NORMAL = 0. ADVERTISING = 1
- CellType. (defined in 6top)
  - SOFT =0, HARD=1

Next Step

- Flags setting of broadcast cell in receiver side
- IE, packet, and message sequence for supporting chunk
- MIB attributes for supporting On-The-Fly
- Solve remained issues for dratf-wang-6tisch-6top*.(next page)*

Issues need to be addressed

Regarding to 6top ⇔ 6top, and more

■**Add 6top-level ACK in response to a Delete soft cell and Delete hard cell ?** Maybe the requesting node could indicate it expects an ACK as part of the Opcode IE.

■**Should Deleting hard cells command trigger a Hard Cell Remove Request?** For example when we delete hard cells because the neighbor has disappeared.

■**How to make 6top extendible with profiles?** In the 6top draft, we leave some attributes/functions open to upper layer or application, e.g. “The exact metrics for statistics are out of the scope of this document”, “The policy to select cells corresponding to a Delete soft cell command is out of scope of this document.”. Profile is a way to implement the flexibility and extendibility. We need to define how to make a profile in the next step.

Security discussions: summary and outlook

Michael Richardson

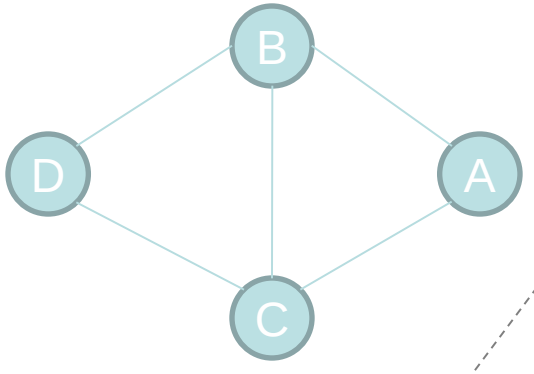
Michael Behringer

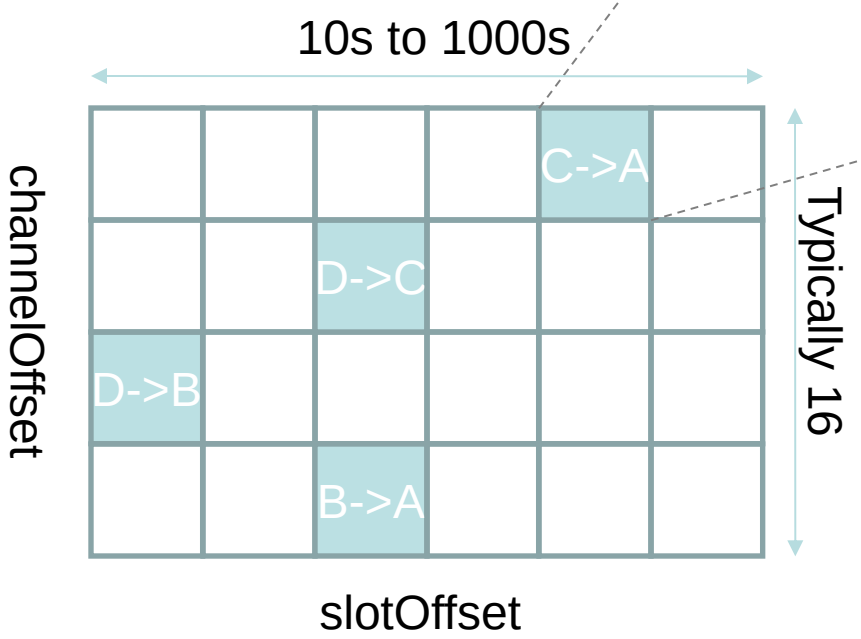
6tisch authorization requirements

Need two things:

1. Authorization for a mote/node to join a network (layer-2/3 keys)
2. Authorization for a PCE to write a schedule into the mote/node (layer-5/6/7 YANG/CoAP) (in centralized mode)

Timeslotted Channel Hopping





- This schedule described by YANG data model, communicated by CoAP

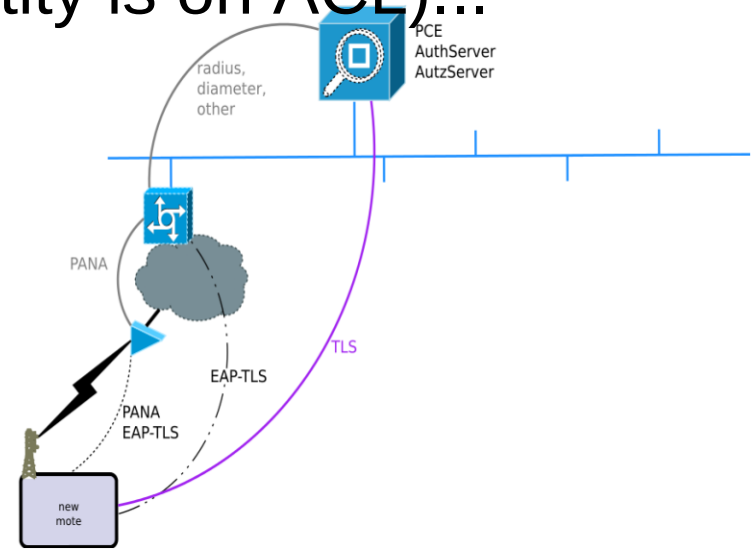
Node join: PANA/ZigBeeIP option

1. ZigBeeIP-style PANA. Creates EAP-TLS connection from mote to Authenticator.

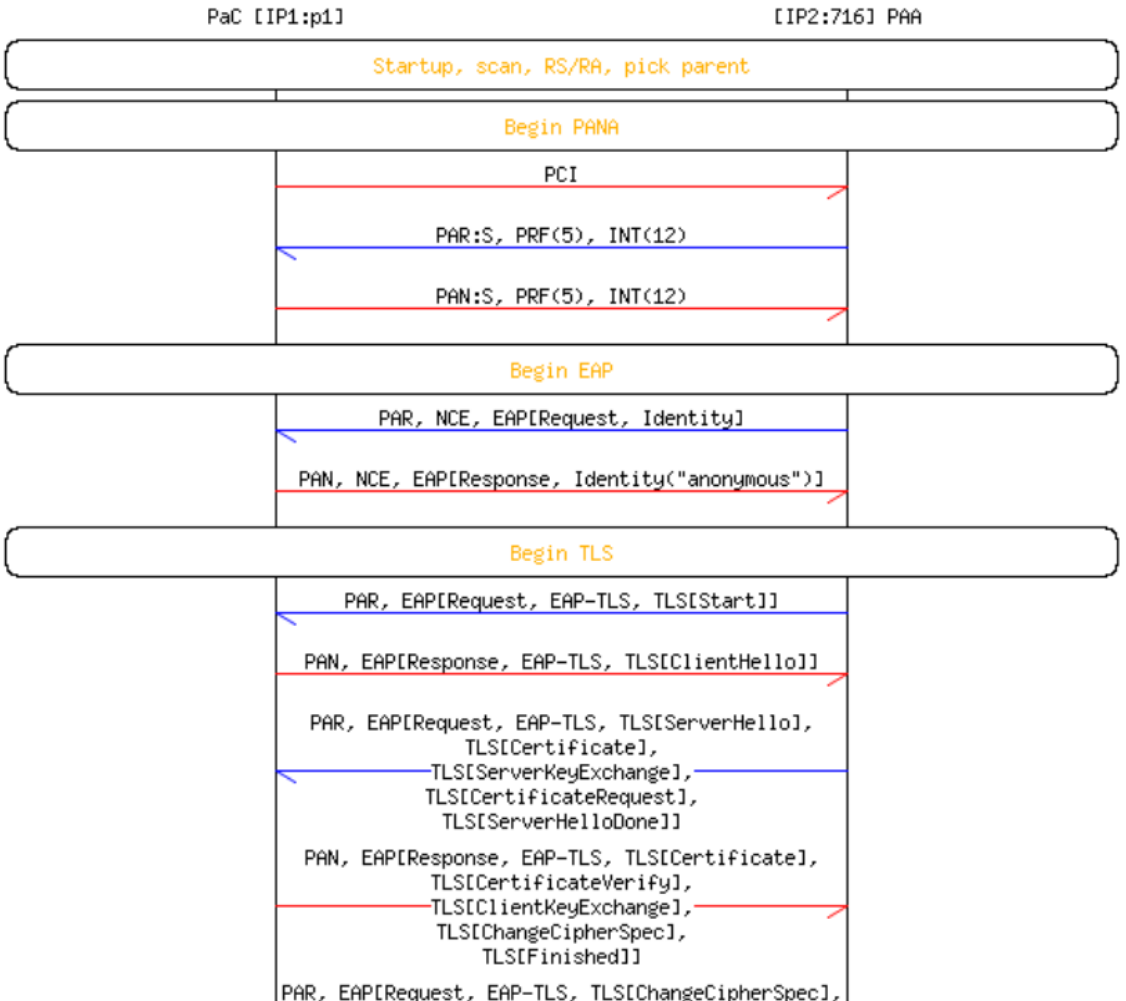
2. Authenticator (likely co-located with PCE and AS) needs to use vendor certificate chain

See draft-pritikin-bootstrapping-keyinfrastructures-00

1. In this case, authorization may be explicit (Domain Certificate) or implicit (identity is on ACL)...

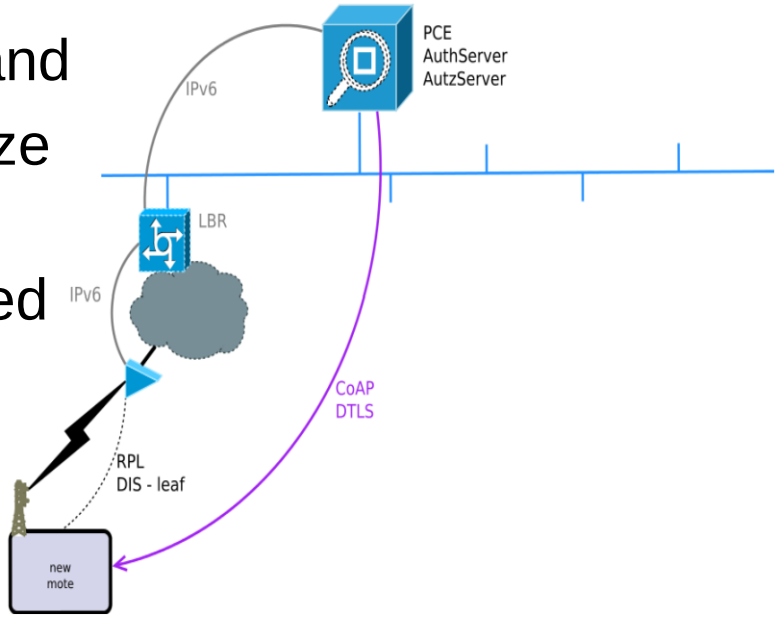


ZigBee IP enrollment (8.3.4) part 1

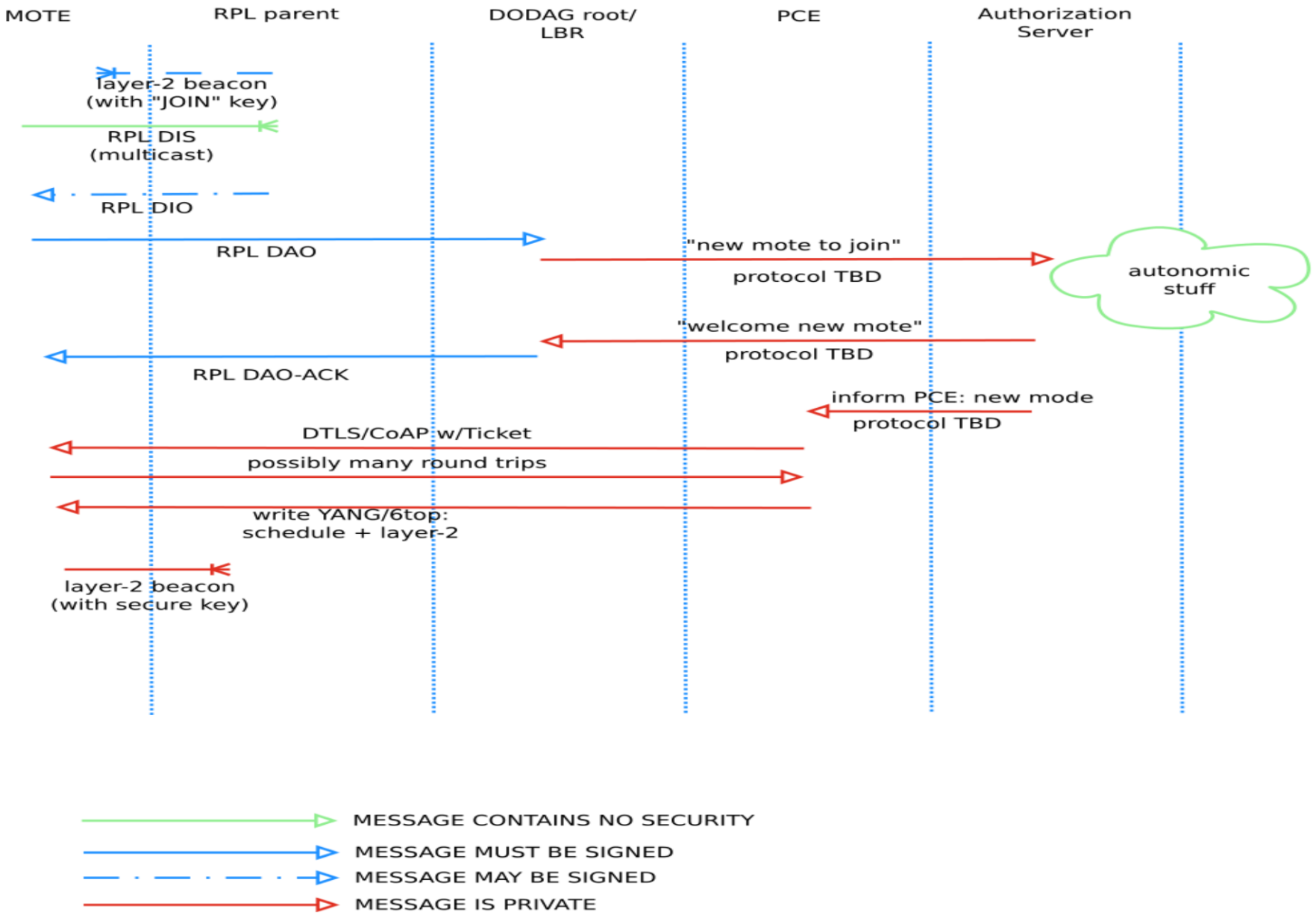


Node join: WirelessHART-like

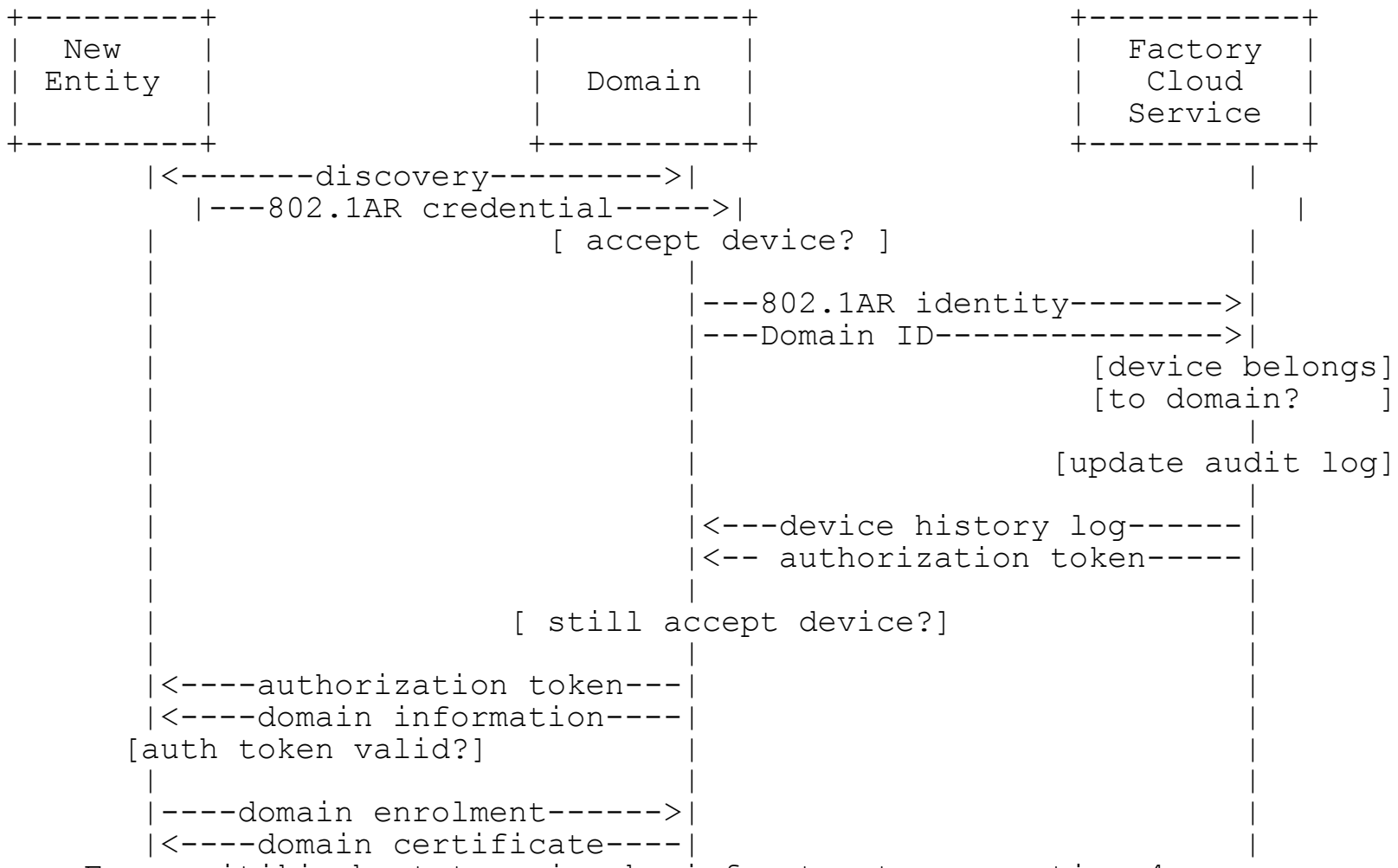
1. First join insecure (well-known-key) mesh (assumed: non-storing).
2. LBR notifies PCE/authorization server,
3. uses draft-pritikin-bootstrapping-keyinfrastructures-00 to get authorizations a) mote to join network, b) PCE to write net network parameters to mote.
4. Mote has to authenticate network, and
5. network has to authenticate/authorize mote, and
6. Mote has to **authorize** being updated with secure parameters



Time Sequence for RPL/CoAP

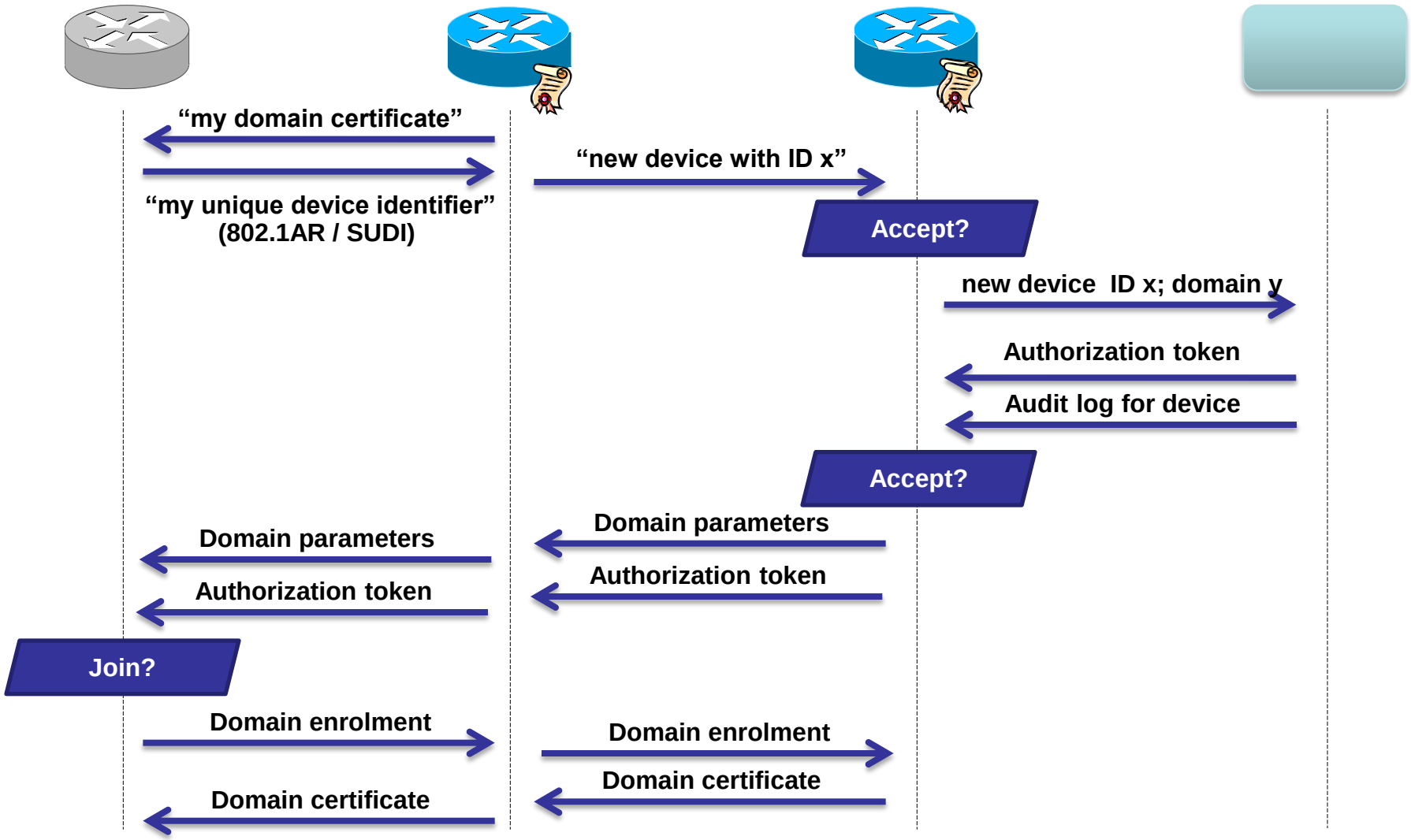


Autonomic Flow



Secure Domain Certificate Enrolment

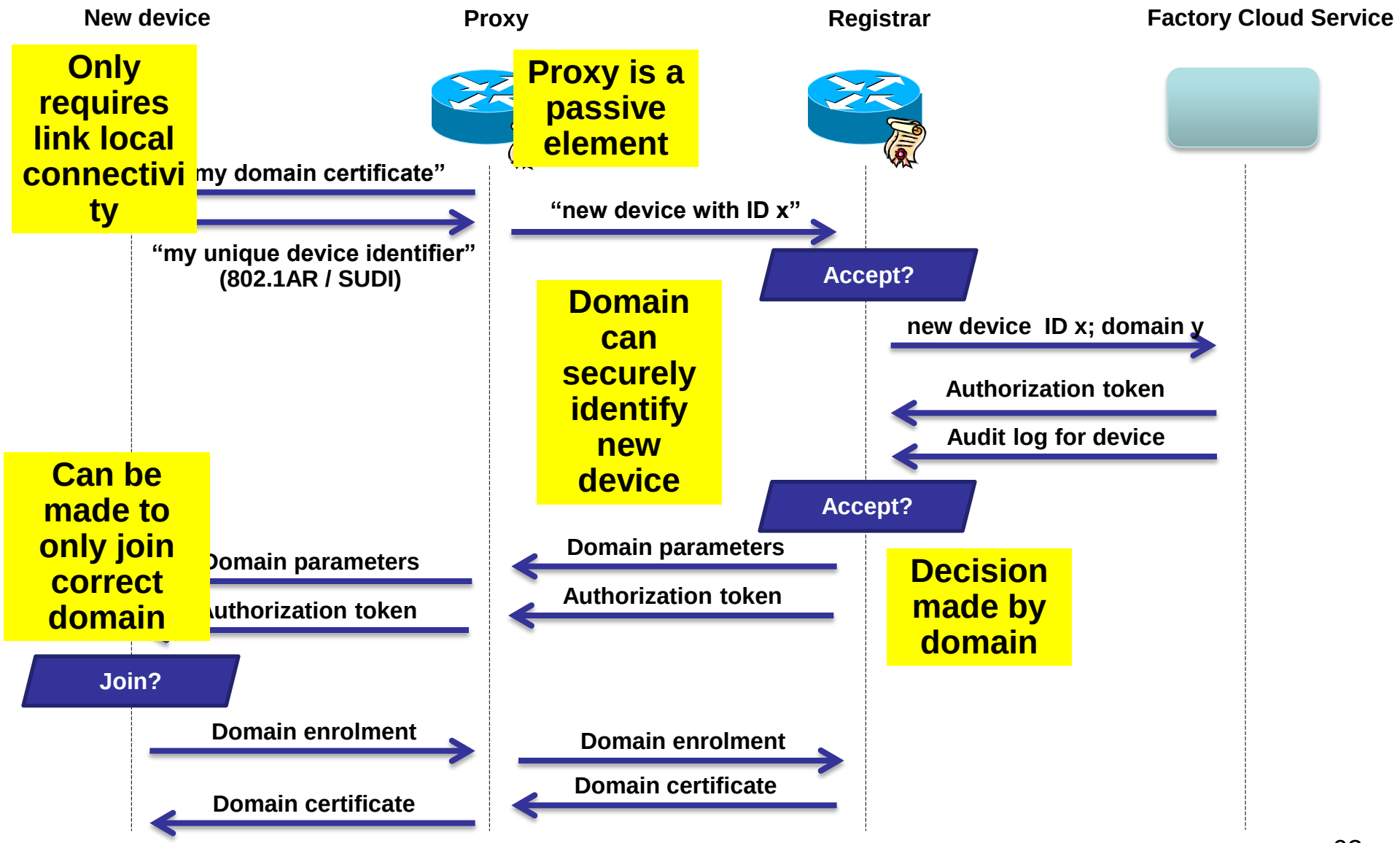
draft-pritikin-bootstrapping-keyinfrastructures



See: http://tools.ietf.org/html/draft-pritikin-bootstrapping-keyinfrastructures/

Secure Domain Certificate Enrolment

draft-pritikin-bootstrapping-keyinfrastructures



See: http://tools.ietf.org/html/draft-pritikin-bootstrapping-keyinfrastructures/

Requirements for RPL/CoAP security

- Define new layer-2/layer-3 YANG objects for 15.4e security and RPL security.
- Use draft-sudhaakar-6tisch-coap-00 to write them.
- Inspire from WirelessHART/ISA100 documents

PCE schedule write

- Authorization required for PCE to write schedule to mote.
- Operations occur over CoAP, see:
- draft-wang-6tisch-6top-interface and
- draft-sudhaakar-6tisch-coap-00 drafts.

Report on plugfest

Xavi Vilajosana (Chair)

<plugfest participants>

Agenda

- [09.00] Welcome and Initial Instructions
- [09.05] Minimal 6TiSCH draft overview
- [09.15] Participants Pitch (5min per Participant)
- [09.45] Participants Pitch Tools (5min per Participant)
- [10.15] Interoperation (Islands)
- [11.30] Brainstorm, ideas, discussion and wrap up slides for WG meeting
- [12.00] Acknowledgements and Plugfest End


6TiSCH
IETF 89 – Plugfest – London

Pictures

Focus 1: Interoperation

- The goal is to achieve interoperation between different hardware and software implementations of 6TiSCH technology.
  - The focus during this event is on: http://tools.ietf.org/html/draft-ietf-6tisch-minimal-00.
- Participants bring devices which implement parts or all of the draft. Three levels of interoperation are proposed, in increasing completeness:
  - Level 1, star topology. A single BBR devices acts as the time source neighbor for all other nodes. Nodes need to demonstrate frame-based and acknowledgement-based synchronization. The static TSCH schedule, as well as all slot timings are taken from draft-ietf-6tisch-minimal-00.
  - Level 2, multi-hop topology. This level builds upon level 1. The goal of this level is full compliance to draft-ietf-6tisch-minimal-00, including multi-hop routing (RPL).
  - Level 3, on-the-fly scheduling. TODO

Focus 2: Demonstration

- Participants are encouraged to bring devices and technology based on 6TiSCH, which they believe can be of interest for the other participants.
- These devices may or may not participate in the interoperation event.
- Demonstration of more complete systems are encouraged, for example systems which show the interconnection of a 6TiSCH based mesh to traditional networks.

Focus 3:Tools

- Participants are encouraged to bring and present different tools developed around 6TiSCH networks.
- Possible tools included:
  - acquisition devices (i.e. "sniffers")
  - packet analysis tools (e.g. Wireshark)
  - simulation/emulation platforms

Plugfest Summary

OpenMote.com

Pere Tuset
Universitat Oberta de Catalunya

OpenMote Demo

Present OpenMote platform:

Based on SoC TI cc2538

OpenBase

OpenBattery

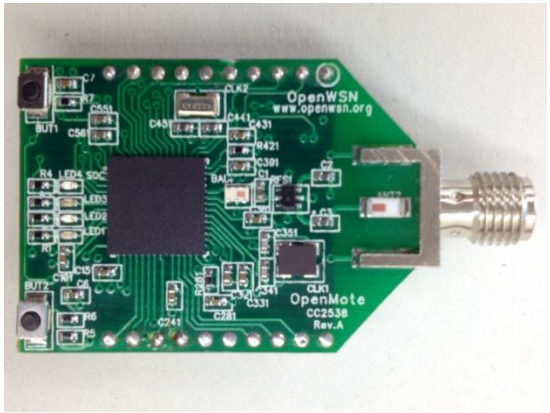
Running OpenWSN

Minimal draft implementation

RPL 0OF

Presenter: Pere Tuset (UOC)

See: http://www.openmote.com/



*Conexión de área local [Wireshark 1.10.5 (SVN Rev 54262 from /trunk-1.10)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
900	427.040059000	00:12:4b:00:04:0f:61:e3	Broadcast	IEEE 802.15.	78	Beacon, Dst: Broadcast, Src: TexasIns_00:04:0f:61:e3
901	428.209289000	00:12:4b:00:04:0f:61:81	00:12:4b:00:04:0f:61:e3	IEEE 802.15.	76	Data, Dst: TexasIns_00:04:0f:61:e3, Src: TexasIns_00:04:0f:61:81
902	428.215016000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:81	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:81, Src: TexasIns_00:04:0f:61:e3
903	428.704624000	00:12:4b:00:04:0f:61:c8	00:12:4b:00:04:0f:61:e3	IEEE 802.15.	76	Data, Dst: TexasIns_00:04:0f:61:e3, Src: TexasIns_00:04:0f:61:c8
904	428.710253000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:c8	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:c8, Src: TexasIns_00:04:0f:61:e3
905	429.364537000	00:12:4b:00:04:0f:61:81	00:12:4b:00:04:0f:61:e3	IEEE 802.15.	76	Data, Dst: TexasIns_00:04:0f:61:e3, Src: TexasIns_00:04:0f:61:81
906	429.370210000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:81	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:81, Src: TexasIns_00:04:0f:61:e3
907	429.381913000	fe80::212:4b00:40f:61c8	fe80::212:4b00:40f:61e3	IPv6	96	[Malformed Packet]
908	429.387085000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:c8	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:c8, Src: TexasIns_00:04:0f:61:e3
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910	430.856160000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:c8	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:c8, Src: TexasIns_00:04:0f:61:e3
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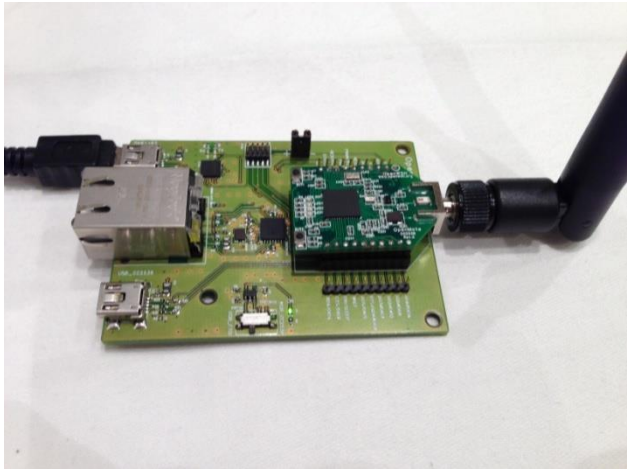
912	431.351088000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:81	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:81, Src: TexasIns_00:04:0f:61:e3
913	431.707759000	bbbb::12:4b00:40f:6181	ff02::2	ICMPv6	95	RPL Control (DODAG Information Object)
914	432.203944000	fe80::212:4b00:40f:6181	fe80::212:4b00:40f:61e3	IPv6	116	[Malformed Packet]
915	432.209107000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:81	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:81, Src: TexasIns_00:04:0f:61:e3
916	432.817367000	00:12:4b:00:04:0f:61:c8	Broadcast	IEEE 802.15.	78	Beacon, Dst: Broadcast, Src: TexasIns_00:04:0f:61:c8
917	433.491242000	00:12:4b:00:04:0f:61:81	00:12:4b:00:04:0f:61:e3	IEEE 802.15.	76	Data, Dst: TexasIns_00:04:0f:61:e3, Src: TexasIns_00:04:0f:61:81
918	433.496937000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:81	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:81, Src: TexasIns_00:04:0f:61:e3
919	433.821459000	00:12:4b:00:04:0f:61:c8	00:12:4b:00:04:0f:61:e3	IEEE 802.15.	76	Data, Dst: TexasIns_00:04:0f:61:e3, Src: TexasIns_00:04:0f:61:c8
920	433.827050000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:c8	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:c8, Src: TexasIns_00:04:0f:61:e3
921	434.646769000	00:12:4b:00:04:0f:61:81	00:12:4b:00:04:0f:61:e3	IEEE 802.15.	76	Data, Dst: TexasIns_00:04:0f:61:e3, Src: TexasIns_00:04:0f:61:81
922	434.652501000	00:12:4b:00:04:0f:61:e3	00:12:4b:00:04:0f:61:81	IEEE 802.15.	76	Ack, Dst: TexasIns_00:04:0f:61:81, Src: TexasIns_00:04:0f:61:e3

```
Frame 628: 76 bytes on wire (608 bits), 76 bytes captured (608 bits) on interface 0
Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
IEEE 802.15.4 Data, Dst: TexasIns_00:04:0f:61:e3, Src: TexasIns_00:04:0f:61:81
Data (39 bytes)
```

```
0000  00 00 00 00 00 00 00 00  00 00 00 00 80 9a 61 dc   ........ ......a.
0010  af fe ca e3 61 0f 04 00  4b 12 00 81 61 0f 04 00   ....a... K...a...
0020  4b 12 00 00 00 00 00 00  00 00 00 00 00 00 00 00   K....... ........
0030  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
0040  00 00 00 00 00 00 00 00  00 00 00 80               ........ ....
```

File: "C:\Users\PERETU~1\AppData\Local\Ter | Packets: 922 · Displayed: 922 (100.0%) · Dropped: 0 (0.0%) | Profile: Default

ES 9:39 06/03/2014



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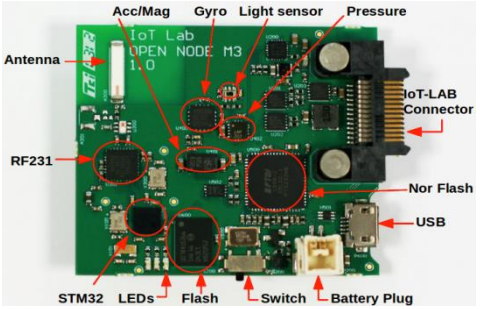
Oliver Hahm – Thomas Eichinger

RIOT - an OS for the IoT

- Free, open source platform (LGPLv2 license):
  - https://github.com/RIOT-OS/RIOT
- RIOT principles: IoT application development with zero learning curve
  - standard languages (C or C++)
  - full multithreading
  - basic POSIX (sockets…)
  - well-known tools such as gdb, Valgrind, profiler…
- RIOT characteristics: small but powerful
  - micro-kernel, modular architecture
  - real-time capabilities & energy efficiency
  - low memory footprint (min. 1.5k of RAM)
  - support for 16bit architectures (e.g. MSP430) to 32bit architectures (e.g. ARM Cortex, x86)
  - up-to-date network stacks (6LoWPAN stack, IPv6 stack, CCN stack, **OpenWSN stack**)

OpenWSN port on RIOT

- Current state of the port
  - OpenWSN powered by RIOT scheduler + timers
- What we are testing at 6TiSCH plugtest
  - OpenWSN ported on RIOT running on IoT-Lab hardware (STM32 Cortex-M3 w/ AT86RF231 transceiver at 2.4GHz)



- Next steps for OpenWSN + RIOT
  - Strategy to maximize synergy?
  - Merge 6LoWPAN stack from RIOT and 6LoWPAN stack OpenWSN?
  - Use RIOT platform to port OpenWSN to other hardware platforms?

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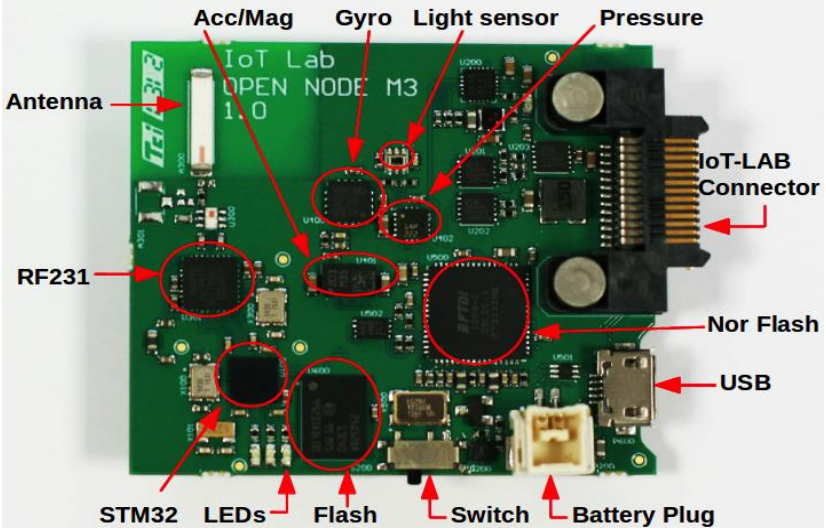
IoT Lab

“IoT-Lab” nodes

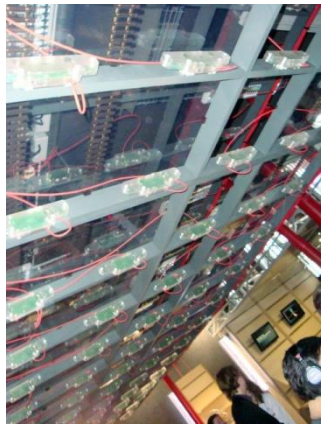
- Hardware:
  - IoT-Lab Cortex-M3 Open Node
  - **MCU:** ARM Cortex M3, 32-bits, 72 Mhz, 64kB RAM (STM32F103)
  - **Radio:** Atmel AT86RF231 (802.15.4 2.4GHz)
- Software: OpenWSN direct port

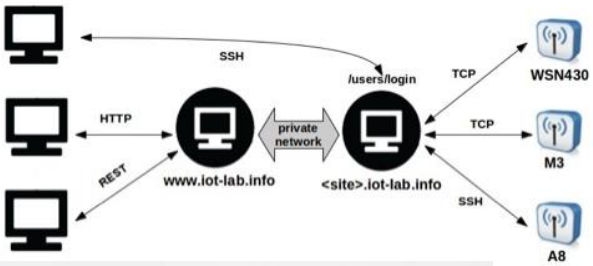


https://openwsn.atlassian.net/wiki/display/OW/IoT-LAB_M3

IoT-Lab Platform(s)

- Part of a very large scale open wireless sensor network:
  - IoT-Lab (Senslab), included in a federation (FIT/OneLab)
  - Upcoming: https://github.com/iot-lab/iot-lab/wiki
  - (current: http://senslab.info/ WSN430)





Set of Tools

- Web Portal
- REST API
- CLI

- In site Paris/Rocquencourt

In-door GPS signal replication

Clock synchronization

User and sniffer packets timestamping

DeTAS demo

Nicola Accettura, Gennaro Boggia,
Luigi Alfredo Grieco and Elvis Vogli

Politecnico di Bari

Decentralized Traffic Aware Scheduling (DeTAS)

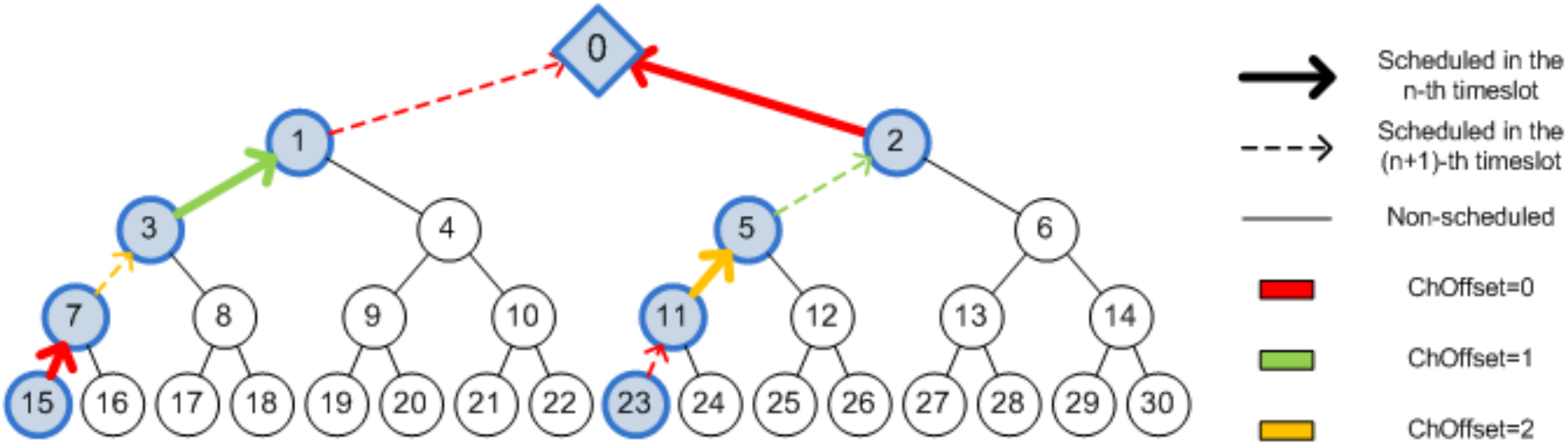
- Two signalling phases:
  - Each node communicates its bandwidth requirements to its own parent; bandwidth requirements account for locally generated traffic and traffic to be delivered.
  - A network manager starts the schedule computation, which is then performed hop by hop towards the leaf nodes.
- ***Collision-free*** schedule for MP2P traffic
  - ***3 channels*** are sufficient for scheduling the entire network

Bounded schedule allowing coexistence with other schedules

- The ***minimum*** schedule length depends on the traffic load and on the topology

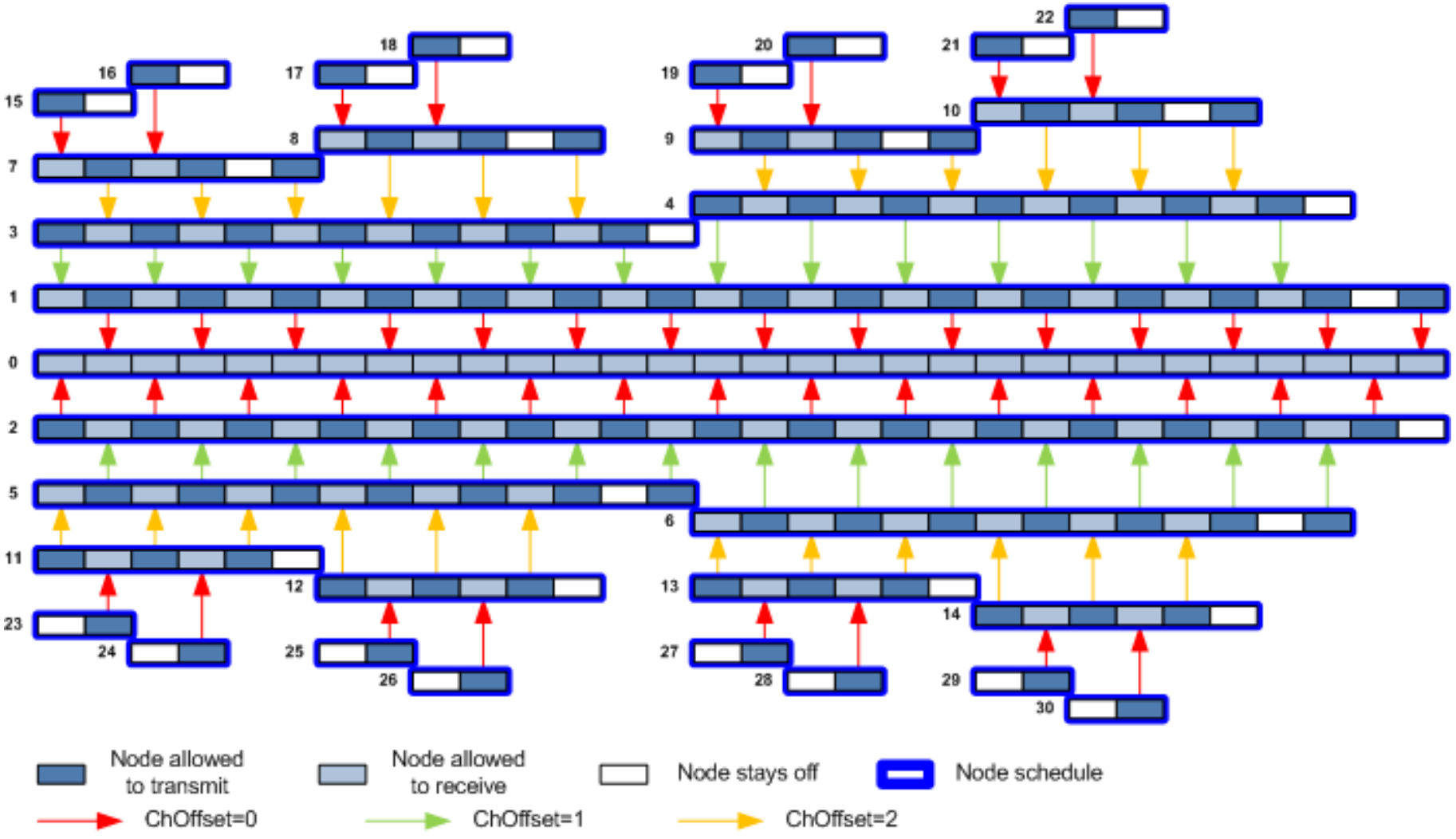
- Cells allocated on each node reflect ***bandwidth requirements*** (N rx-cells for incoming traffic, n tx-cells for node traffic, and N tx-cells for traffic to be delivered)

A simple example



The nodes allowed to exchange traffic during each timeslot are those contained in a ***double-chain***

A packet available on a node before the schedule beginning is transmitted to the PAN coordinator within a slotframe



How signaling has been implemented

REQ_cmd :

•It is a MAC command frame containing the node bandwidth request information.

•It is sent to the prefered parent as unicast message.

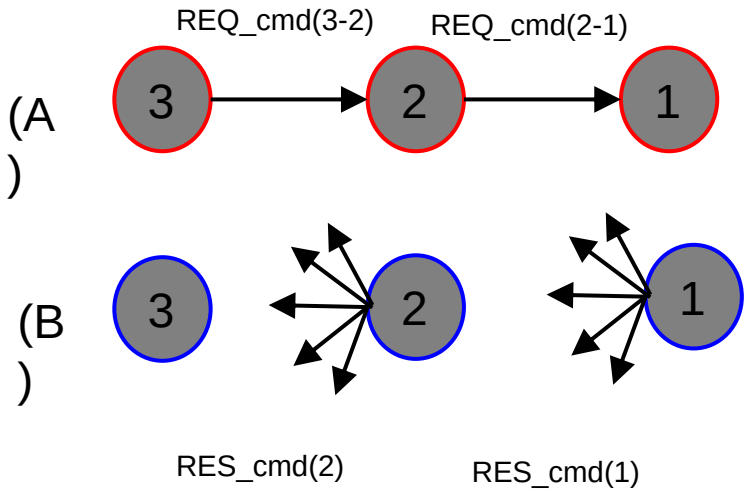
•Each node receiving a REQ command extracts the information and sends a request to its prefered parent with the bandwidth data updated accordingly

RES_cmd:

•It is a MAC command frame broadcasted from the coordinator after receiving a REQ.

•It contains the scheduling information related to each child of the PAN coordinator.

•A node receiving a RES extracts the information needed to build the schedule and then broadcasts a RES command in order to update its own children with the new schedule.



What will be shown

- Some real topologies highlighting the performance of DeTAS:
  - Binary tree
  - Double-chain
- Node statistics in the OpenWSN environment:
  - Duty-cycle
  - Packet loss ratio
  - Delay

Backbone Router PlugFest demo

draft-thubert-6lowpan-backbone-router
draft-chakrabarti-nordmark-6man-efficient-nd

Pascal Thubert & Thomas Watteyne

6TiSCH WG Meeting
89th IETF Meeting
London

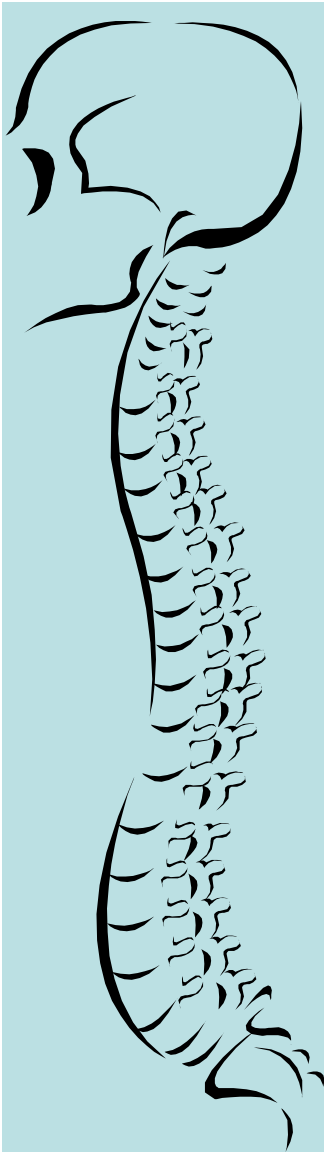
What's a Backbone Router?

Common ND based abstraction over a backbone

Scales DAD operations (distributes 6LoWPAN ND LBR)

Scales the subnetwork (high speed backbone)

Allows interaction with nodes on the backbone or in other subnets running different operations



http://tools.ietf.org/html/draft-thubert-6lowpan-backbone-router

Backbone router demo

- IPv6 host

host

Ethernet

- draft-thubert-6lowpan-backbone-router-03
- efficient ND (WiND) (IPv6 ND suppress)

Cisco IE3000
(industrial switch)

Ethernet

bridge

serial

SmartMesh IP
- IEEE802.15.4e TSCH
- 6LoWPAN

DustLink
- 6LoWPAN compaction
- interface to manager
- ND

Linear Technology DC9000
(SmartMesh IP starter kit)

Classical ND

Efficient ND

SmartMesh IP

Binding Table entries from Efficient ND

COM6:9600baud - Tera Term VT

Fichier Edition Configuration Contrôle Fenêtre(W) Aide

```
ND  2002:DB9::10                          ECC8.828D.9540  Fa1/3          1  0005  138mn STALE      80451 s          0    0000.0000.0000.0000

Switch#sh ipv nei bin
Binding Table has 23 entries, 20 dynamic
Codes: L - Local, S - Static, ND - Neighbor Discovery, DH - DHCP, PKT - Other Packet, API - API created
Preflevel flags (prlvl):
0001:MAC and LLA match     0002:Orig trunk           0004:Orig access
0008:Orig trusted trunk    0010:Orig trusted access  0020:DHCP assigned
0040:Cga authenticated     0080:Cert authenticated   0100:Statically assigned


    Network Layer Address               Link Layer Address Interface       vlan prlvl  age   state     Time left         TID  Device unique ID
L   10.10.10.1                              64A0.E719.EF40  Vl1              1  0100  158mn REACHABLE                    0    0000.0000.0000.0000
ND  FE80::EEC8:82FF:FE8D:9540               ECC8.828D.9540  Fa1/3            1  0005   96s  REACHABLE  213 s             0    0000.0000.0000.0000
L   FE80::66A0:E7FF:FE19:EF40               64A0.E719.EF40  Vl1              1  0100  158mn REACHABLE                    0    0000.0000.0000.0000
ND  FE80::5E26:AFF:FE03:1A6D                5C26.0A03.1A6D  Fa1/4            1  0005  104s  REACHABLE  207 s             0    0000.0000.0000.0000
ND  FE80::3481:4081:FED0:A642               001D.7296.0EA0  Gi1/1            1  0005  142mn DOWN       81108 s          0    0000.0000.0000.0000
ND  FE80::4DE:6C35:739D:504                 3C97.0ECB.7CC2  Fa1/3            1  0005  103s  REACHABLE  199 s             0    0000.0000.0000.0000
ND  AAAA::E5AB:32C2:5B9B:6B72               3C97.0ECB.7CC2  Fa1/3            1  0005    6mn STALE      89958 s          0    0000.0000.0000.0000
ND  AAAA::4DE:6C35:739D:504                 3C97.0ECB.7CC2  Fa1/3            1  0005  131mn STALE      79878 s          0    0000.0000.0000.0000
ND  AAAA::17:D00:3F:FEA3                    5C26.0A03.1A6D  Fa1/4            1  0005   25s  REACHABLE  289 s(33 s)       0    0017.0D00.003F.FEA3
ND  AAAA::17:D00:3F:F824                    5C26.0A03.1A6D  Fa1/4            1  0005   25s  REACHABLE  282 s(33 s)       0    0017.0D00.003F.F824
ND  AAAA::17:D00:3F:F820                    5C26.0A03.1A6D  Fa1/4            1  0005   25s  REACHABLE  289 s(33 s)       0    0017.0D00.003F.F820
ND  AAAA::17:D00:3F:F81E                    5C26.0A03.1A6D  Fa1/4            1  0005   25s  REACHABLE  280 s(32 s)       0    0017.0D00.003F.F81E
ND  AAAA::17:D00:3F:F598                    5C26.0A03.1A6D  Fa1/4            1  0005   25s  REACHABLE  281 s(33 s)       0    0017.0D00.003F.F598
ND  AAAA::17:D00:38:70C                     5C26.0A03.1A6D  Fa1/4            1  0005   25s  REACHABLE  283 s(32 s)       0    0017.0D00.0038.070C
ND  AAAA::17:D00:38:3D9                     5C26.0A03.1A6D  Fa1/4            1  0005   25s  REACHABLE  284 s(32 s)       0    0017.0D00.0038.03D9
ND  AAAA::17:D00:38:3CA                     5C26.0A03.1A6D  Fa1/4            1  0005   25s  REACHABLE  276 s(33 s)       0    0017.0D00.0038.03CA
ND  AAAA::CAF1                              3C97.0ECB.7CC2  Fa1/3            1  0005  130mn STALE      81714 s          0    0000.0000.0000.0000
ND  AAAA::CAB0                              ECC8.828D.9540  Fa1/3            1  0005  124mn STALE      80444 s          0    0000.0000.0000.0000
ND  AAAA::3                                 001D.7296.0EA0  Gi1/1            1  0005  118mn DOWN       80260 s          0    0000.0000.0000.0000
ND  AAAA::2                                 5C26.0A03.1A6D  Fa1/4            1  0005   98s  REACHABLE  203 s             0    0000.0000.0000.0000
L   AAAA::1                                 64A0.E719.EF40  Vl1              1  0100  158mn REACHABLE                    0    0000.0000.0000.0000
ND  2002:DB9::198                           3C97.0ECB.7CC2  Fa1/3            1  0005  135mn STALE      79019 s          0    0000.0000.0000.0000
ND  2002:DB9::10                            ECC8.828D.9540  Fa1/3            1  0005  139mn STALE      80407 s          0    0000.0000.0000.0000

Switch#sh ipv nei bin
Binding Table has 23 entries, 20 dynamic
Codes: L - Local, S - Static, ND - Neighbor Discovery, DH - DHCP, PKT - Other Packet, API - API created
Preflevel flags (prlvl):
0001:MAC and LLA match     0002:Orig trunk           0004:Orig access
0008:Orig trusted trunk    0010:Orig trusted access  0020:DHCP assigned
0040:Cga authenticated     0080:Cert authenticated   0100:Statically assigned
```

6LoWPAN ND vs. Efficient ND vs. RPL

- Work needed for 6TiSCH architecture
- Positioning and overlaps
  - Need for (6LoWPAN) ND between RPL Nodes?
  - If not, how do we do DAD without ND?
- Redistributing ND in RPL at the RPL edge
  - Non-RPL leaf using 6LoWPAN ND to attach
  - Requires TID in ARO as added in Efficient ND
- Redistributing RPL (or other route-over) in ND
  - RPL root advertising DAO state as ARO
  - Demonstrated at PlugFest with Smartmesh IP

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Minimal 6TiSCH Demo

6TiSCH
Internet-Draft
Intended status: Informational
Expires: May 23, 2014

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November 19, 2013

Minimal 6TiSCH Configuration
draft-ietf-6tisch-minimal-00

Abstract

This document describes the minimal set of rules to operate a IEEE802154e Timeslotted Channel Hopping (TSCH) network. This minimal mode of operation can be used during network bootstrap, as a fallback mode of operation when no dynamic scheduling solution is available or functioning, or during early interoperability testing and development.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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Vilajosana & Pister Expires May 23, 2014 [Page 1]

Conclusions

- Wireshark dissectors are needed
- Minimal draft congestion
  - Make slotframe length configurable
  - Make number of active slots configurable
    - Position??
- **Action Item**: determine recommended slotframe length&number active slots according to network size/degree/drift rate

Thanks

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draft-dujovne-6tisch-on-the-fly-02

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Maria Rita Palattella
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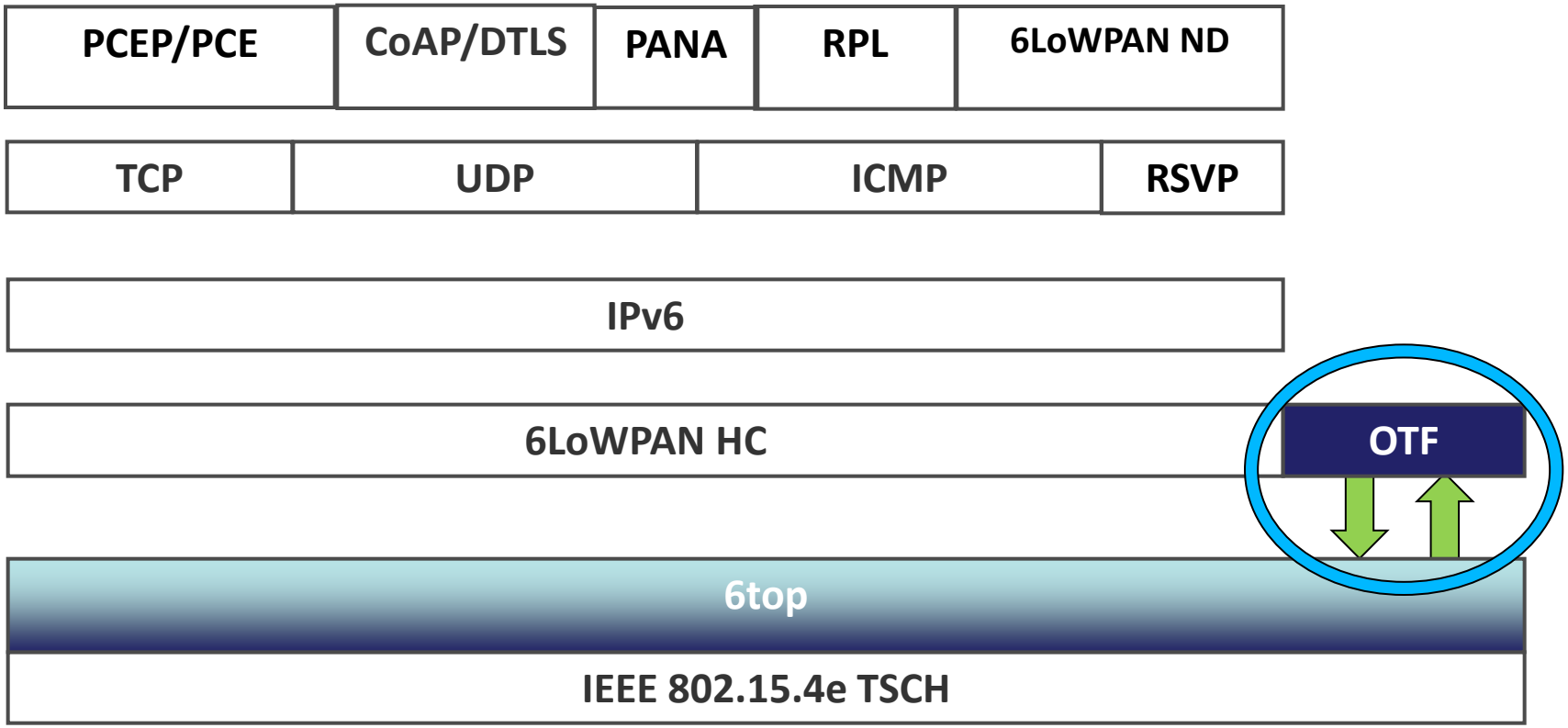
draft-dujovne-6tisch-on-the-fly-02

- Status:
  - Individual submission
  - Latest version published 02/14/2014
    http://tools.ietf.org/html/draft-dujovne-6tisch-on-the-fly-02.txt
  - WIP version at
    https://bitbucket.org/6tisch/draft-dujovne-6tisch-on-the-fly
- Changes since IETF88
  - Precised allocation policies / methods
  - Included default BW estimation algorithm and scheme for selecting a given algorithm among a set.

OTF:Plugin Module



Allocation Policies

- Approach used by OTF for increasing/decreasing BW
- Post-Allocation Policy:
  - Recovery (reactive) approach: BW is allocated as needed.
- Pre-Allocation Policy:
  - Provision (predictive) approach: BW is allocated in advance, using bundles.
  - The bundle size is defined by the estimation of the future BW requirements for each neighbor.
- Hybrid Allocation Policy
  - Combination of Post- and Pre-allocation

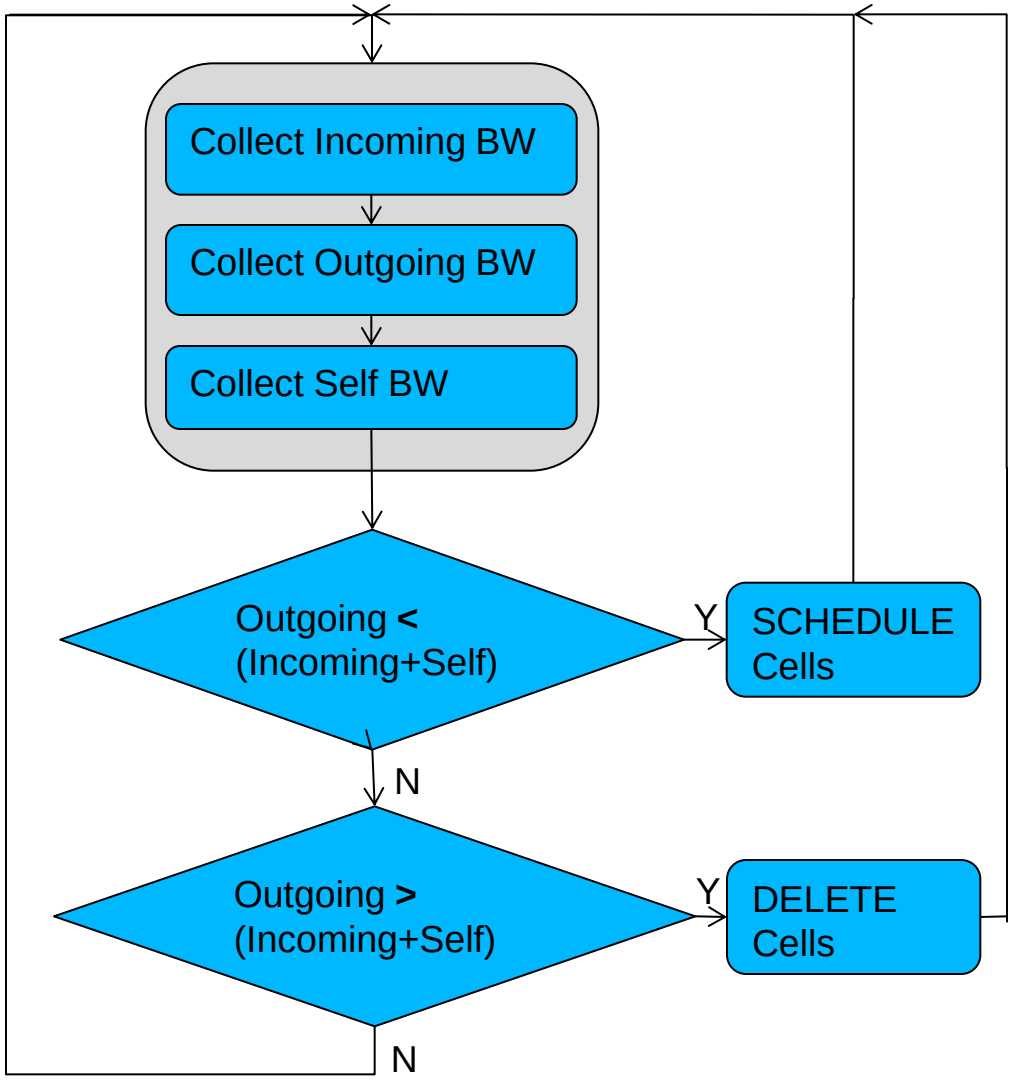
Pre- vs. Post-

- Pre-allocation **reduces allocation latency**: cells are overprovisioned and a-priori scheduled.
  - Provides a low-delay response in case of a bandwidth surge,
  - But keeps the receiver active during the whole length of the bundle, **increasing power consumption**.
- Post-allocation **consumes less energy**: allocates the exact number of cells;
  - **But increases latency**: 6top negotiates the request with the neighbors.

Policy	Latency	Energy
Pre-allocation	Low	High
Post-allocation	High	Low

Algorithm selection / Default BW estimation

- OTF supports different BW estimation algorithms
- It is possible to select a given algorithm (by setting an index)
- A default algorithm is suggested in the draft (contributed by Prof. K. Pister):



TODOs

- Specify commands to get/set algorithm
- Explore chunk allocation
- Internal bundle accounting
- Define interface btw OTF and 6top (how to get statistics, how to ask for cells/bundles allocation/deallocation)

draft-piro-6tisch-security-issues-01

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draft-piro-6tisch-security-issues-01

- Status:
  - Individual submission
  - Latest version published 12/14/2013 http://tools.ietf.org/html/draft-piro-6tisch-security-issues-01.txt
  - WIP version at https://bitbucket.org/6tisch/draft-piro-6tisch-security-issues
- Changes since IETF88
  - Added references and justification of assumptions
  - Interaction between 6top and MAC (new command to setup the security)
  - Key negotiation procedure based on DH and STS-protocol

(Initial) goals

- support security features (encryption and authentication) at the MAC layer of IEEE 802.15.4e networks
- identify possible security configurations
- design an efficient mechanism to configure maintain a secured IoT domain
- develop a lightweight Key Negotiation Protocol (KMP)

what in the draft

- Security features at the MAC layer
- 5 Security configurations
- Interaction between 6top and MAC through specific commands for the management of the initialization of the security domain and the key negotiation protocol (KMP)
- 3 phases: setting-up, bootstrap, key negotiation phase
- KMP based on both DH and Station-to-station protocol (with certificates)
- Focus on one-hop neighbors

Work in progress…

- Consider only the Fully Secured Network Configuration (more suitable for 6TiSCH targets)
- Substitute MAC and 6top command with specific Information Elements
  - It is supposed the presence of an entity that handled the security
  - IEs are used to exchange data among devices
  - 6top commands are used to configure MAC PIB security parameters
- Extension of the KMP scheme to multi-hop scenarios and e2e-security
- New draft in the next two weeks

…and future steps

- Feedbacks from 6TiSCH mailing list
- Identify what aspects are in line with 6tisch Security Task Force ideas
- Update the draft accordingly
- Explain how managing the join of a device with no security information (or with just initial secrets)
    - Already done in our draft
    - Useful (maybe) for the security task force team

draft-svshah-tsvwg-deterministic-forwarding-00

Shitanshu Shah

Pascal Thubert

draft-svshah-tsvwg-deterministic-forwarding-00

- Status:
  - Individual submission
  - Latest version published 01/08/2014
    http://tools.ietf.org/id/draft-svshah-tsvwg-deterministic-forwarding-00.txt
- Changes since IETF88
  - New submission

Topics

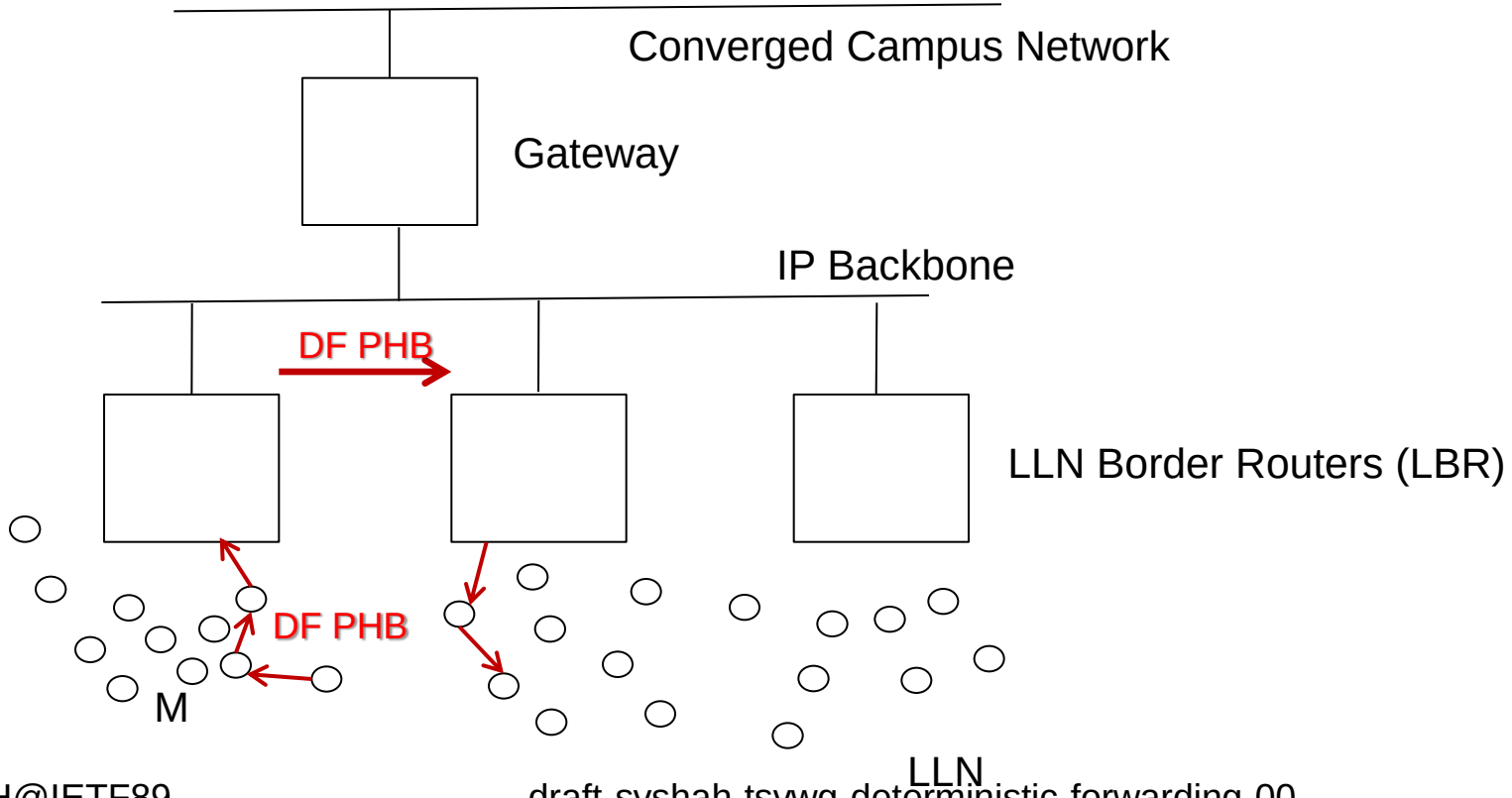
- Motivation for new DSCP
- Scope
- DF Per Hop Behavior
- Next Steps

Motivation

- Time scheduled forwarding treatment requirement for time sensitive traffic (eg. closed loop control signals)
  - From emerging applications of machine to machine networks
- Various initiatives on standardizing various L2 to prepare for this capability (6TiSCH and Deterministic Ethernet) already underway
- L3 has no existing DSCP to classify such PHB
  - And thus need for a new DSCP
- Need for a standard behavior across vendors and across multiple networks
  - Proprietary code-point or proprietary solution does not work

Scope

- Time sensitive traffic forwarding through LLN nodes
- Time sensitive traffic forwarding from one LL Network to another connected through IP Backbone



DF PHB

- Provisioning
  - Provisioning of fixed/relative time for scheduling
  - Provisioning of max data to be transmitted during scheduled time

- Note that provisioning may be done via any of possible methods (like command interface, off-box provisioning agents, signaling protocol)

- Conditioning at En-queue
  - Discard non-compliant packets (compliance of scheduled time and max-data)
  - Any other specific compliance metric in 6TiSCH?
- Forwarding of packets at determined/scheduled time
- Scheduling MUST pre-empt service to any other class of traffic

DF PHB

- Optional inspection of other packet fields (or deep-packet inspection)
  - If more than one stream with different deterministic parameters
  - Packet subject to further classification within DF Diffserv class

Next Steps

- Incorporate review comments from the 6TiSCH WG
- Socialize Proposal with the TSVWG

Any Other Business?

Thank you!