

LLN PLUGFEST IETF 90

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Vicent Ladeveze

Jürgen Schönwälder
Pascal Thubert
Nestor Tiglao
Pere Tuset Peiró
Xavier Vilajosana
Qin Wang
Thomas Watteyne

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Source: <https://www.ietf.org/about/note-well.html>

Meeting Materials

- Remote Participation
 - Webex: <http://www.ietf.org/mail-archive/web/6tisch/current/msg02460.html>
 - Meetecho: <http://www.meetecho.com/ietf90/Inplugfest>
- Wiki page
 - https://bitbucket.org/6tisch/meetings/wiki/140720a_ietf90_toronto_plugfest
- Slides
 - *will be made available*

Agenda

- [09.00] Welcome and Initial Instructions
- [09.05] Participants Pitch (5 min per Participant)
- [09.45] Participants Pitch Tools (5 min per Participant)
- [10.15] Implementation/demonstration (Islands)
- [11.50] Feedback and open discussion.
- [12.40] Acknowledgements and Plugfest End
- [13.00] End of the plugfest

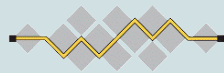
Presentations

1. Efficient ND based registration to Ethernet Backbone Router End-to-end (SmartMesh) IP (Pascal Thubert, Thomas Watteyne)
2. UC Berkeley's OpenWSN
 - a. Introduction and Overview (Nicola Accettura)
 - b. OpenWSN Web Interface (Vitor Garbellini, Marcelo Barros)
 - c. 6TiSCH Operation Sublayer (6top) (Qin Wang, Tengfei Chang)
 - d. On-The-Fly Scheduling (Thomas Watteyne)
 - e. The IP Flow Label within a RPL Domain (Xavier Vilajosana)
3. Analysis of TSCH networks using open source tools: OpenMote + Wireshark (Pere Tuset-Peiró)
4. FIT IoT-lab: a very large-scale open testbed for the IoT (Cédric Adjih)
5. RIOT, The friendly Operating System for the Internet of Things (Oliver Hahm, Thomas Eichinger)
6. Counters for Troubleshooting and Monitoring the 6LoWPAN Layer (Anuj Sehgal, Jürgen Schönwälder)
7. Wireshark integration (Vincent Ladeveze)
8. Live demonstration of Sewio's open sniffer solution (Nestor Tiglao)

Efficient ND based registration to Ethernet Backbone Router End-to-end (SmartMesh) IP

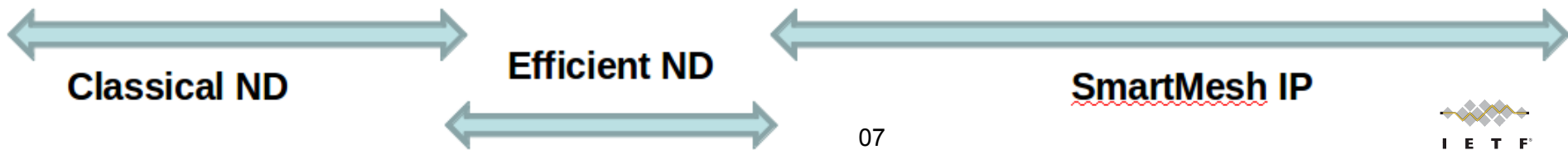
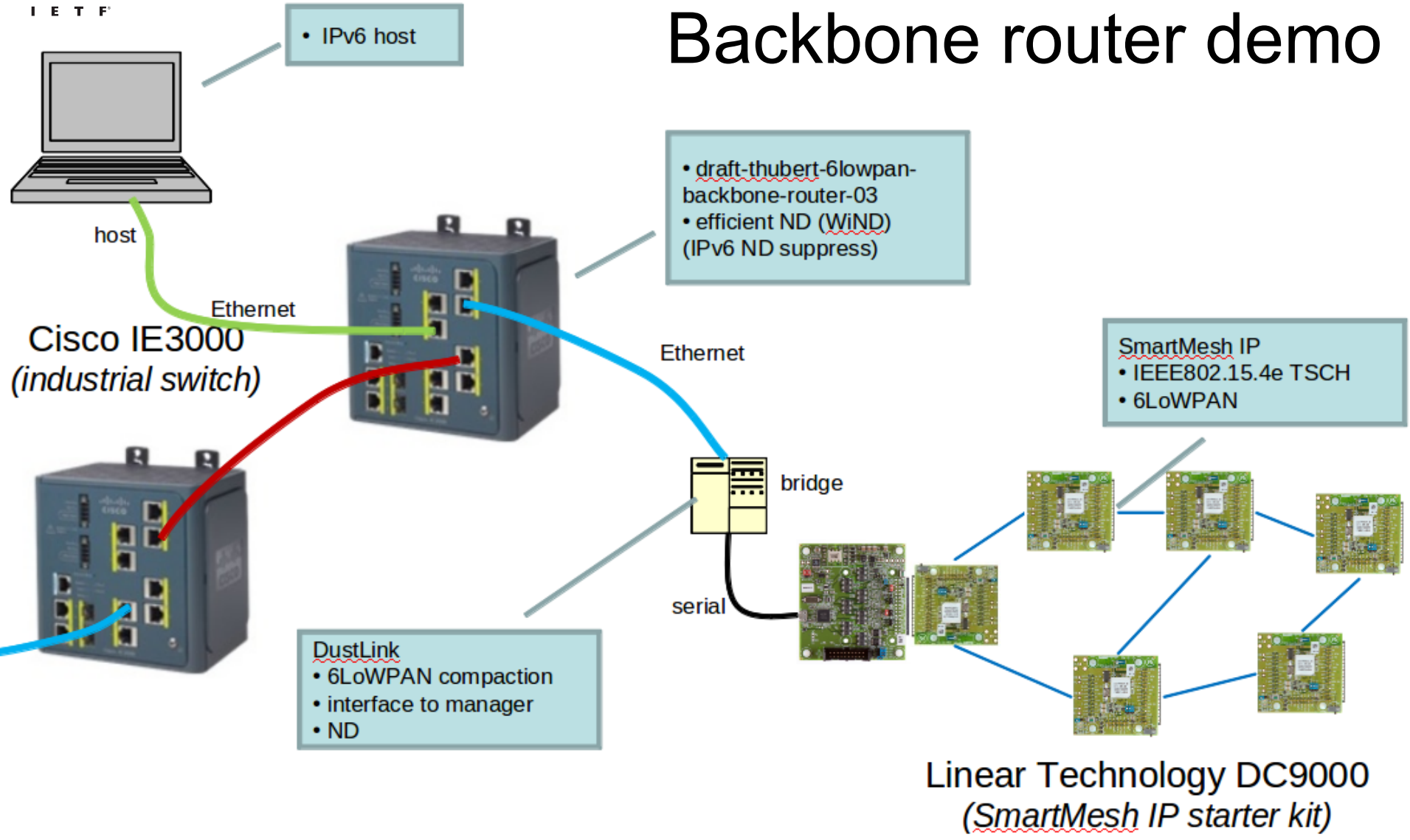
Pascal Thubert
Thomas Watteyne

Joined plugfest
90th IETF Meeting
Toronto



I E T F[®]

Backbone router demo



6LoWPAN ND vs. Efficient ND vs. RPL

Work needed for 6TiSCH architecture

Positioning and overlaps

Need for (6LoWPAN) ND between RPL Nodes?

Redistributing ND in RPL at the RPL edge

Non-RPL leaf using 6LoWPAN ND to attach

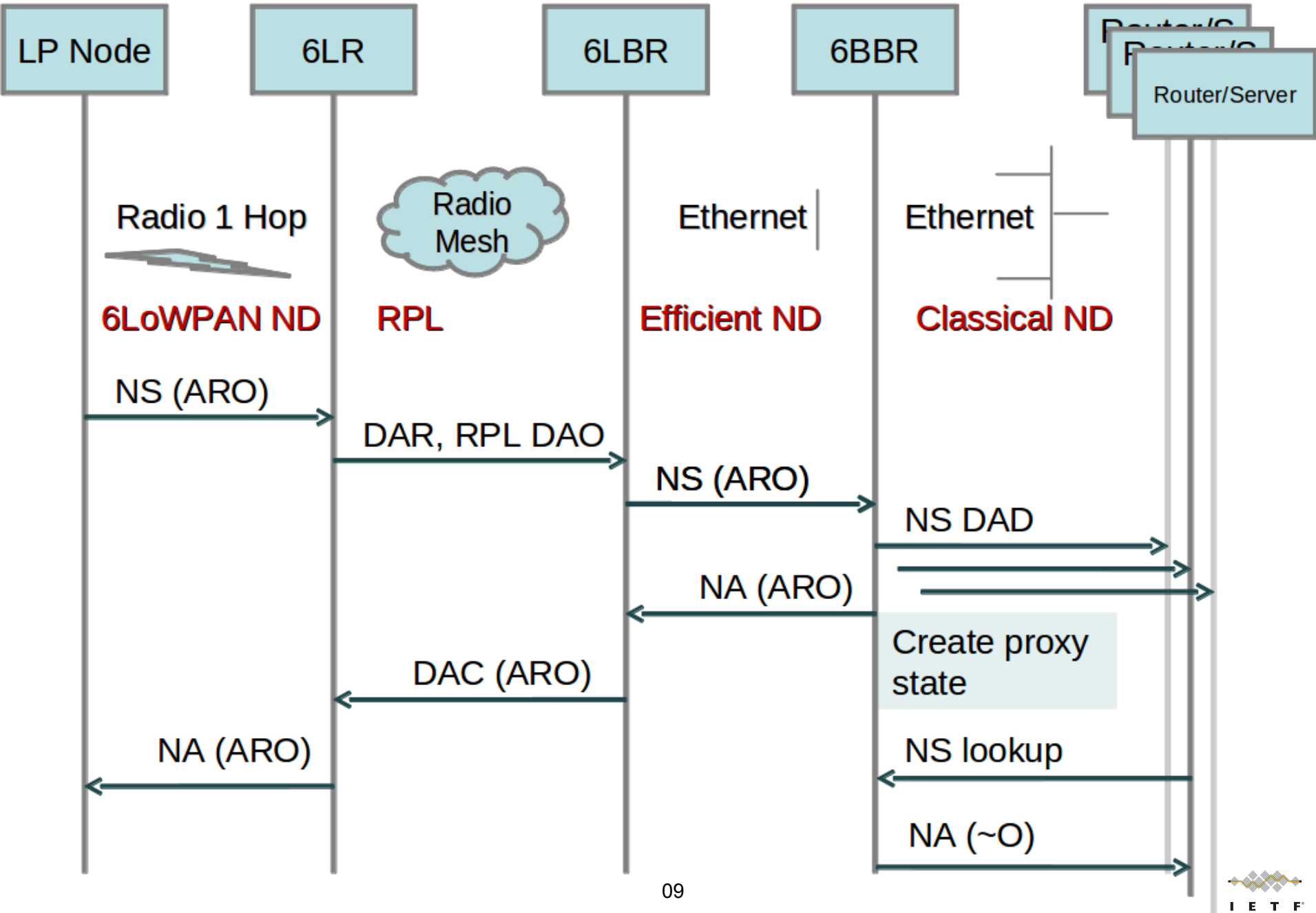
Requires TID in ARO as added in Efficient ND

draft-thubert-6lo-rfc6775-update-reqs-01

Redistributing routing protocol into ND

e.g. RPL root advertising DAO state as ARO

Demonstrated here with Smartmesh IP



New: Duplication

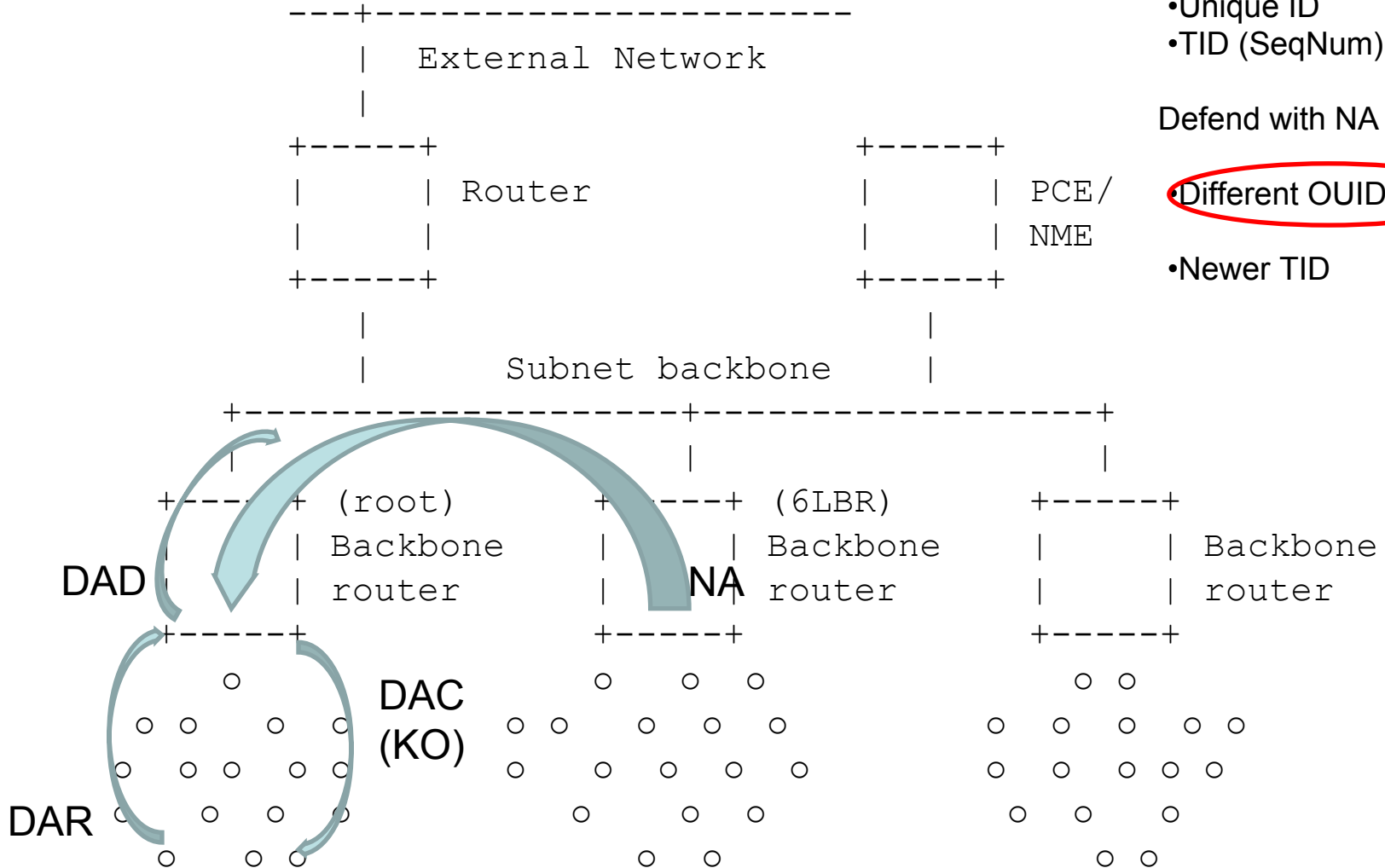
DAD option has:

- Unique ID
- TID (SeqNum)

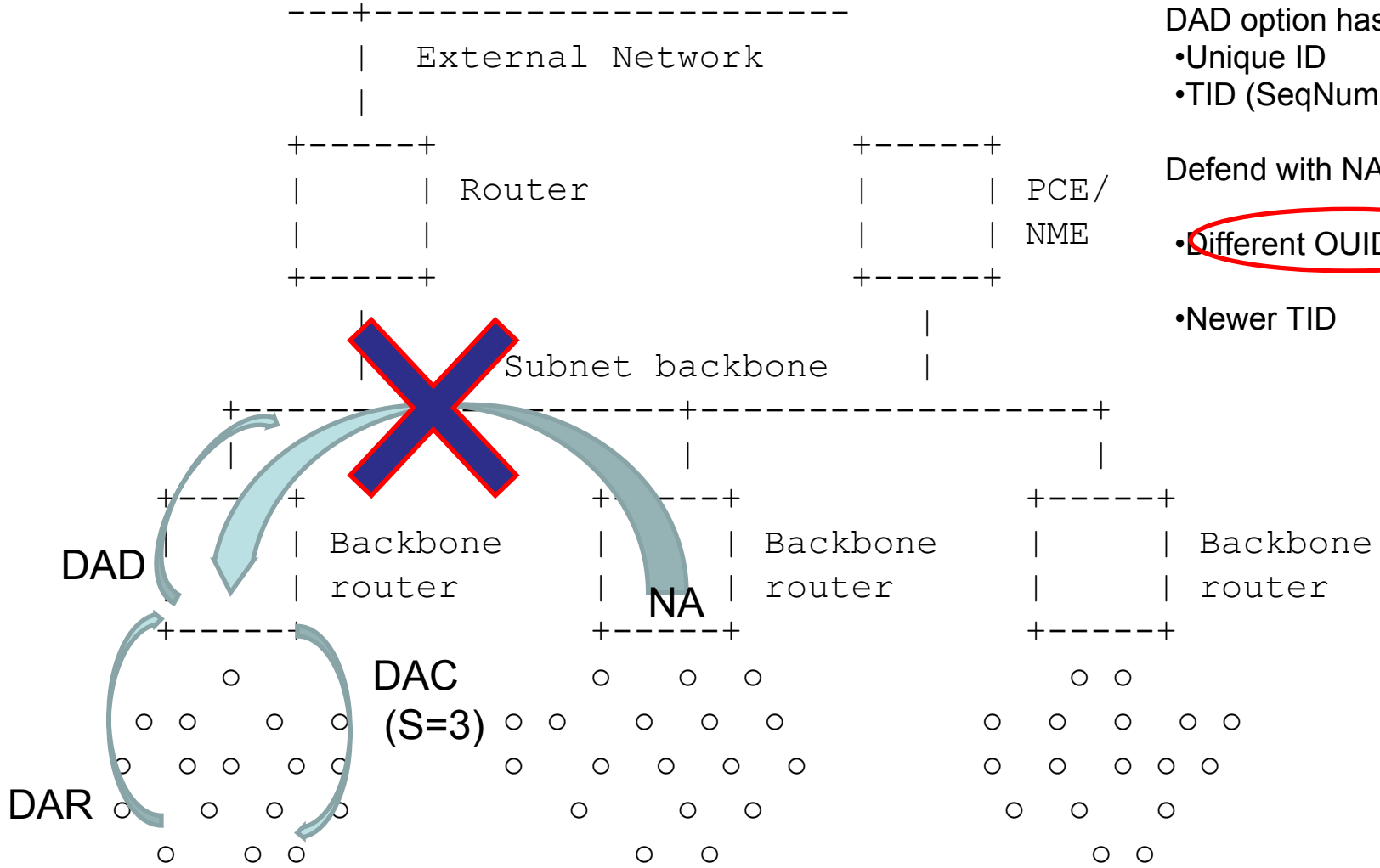
Defend with NA if:

Different OUID

- Newer TID



New: Mobility



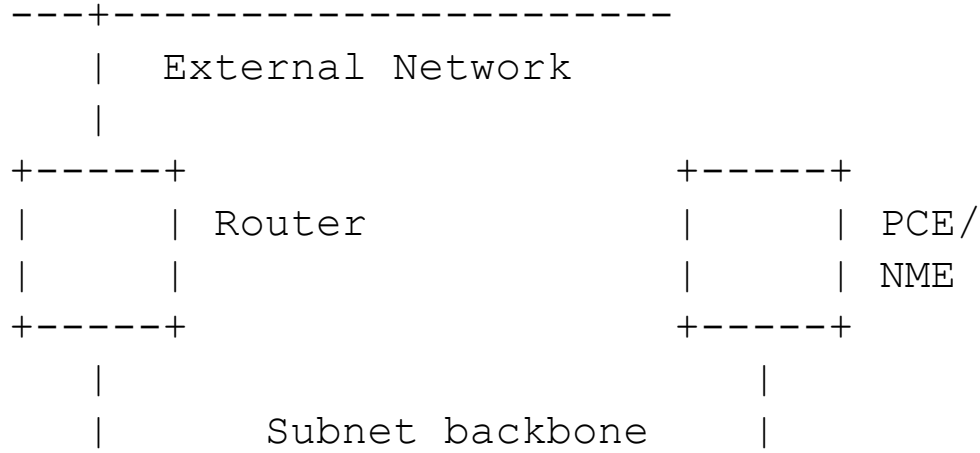
DAD option has:

- Unique ID
- TID (SeqNum)

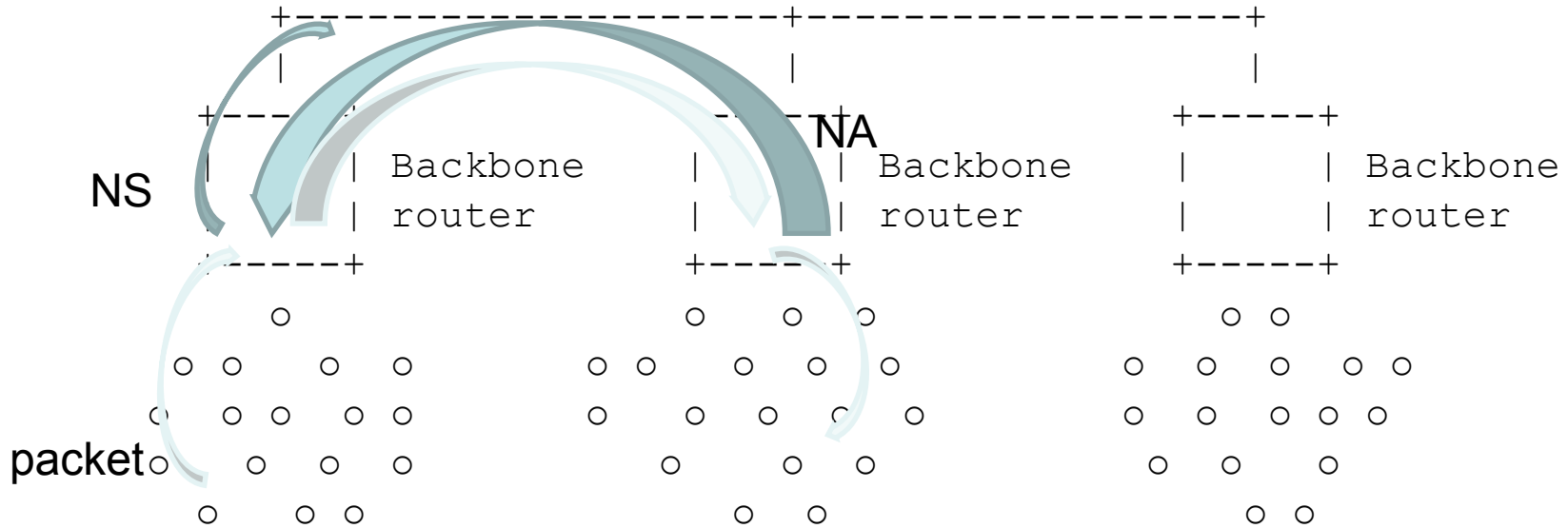
Defend with NA if:

- Different OUID
- Newer TID

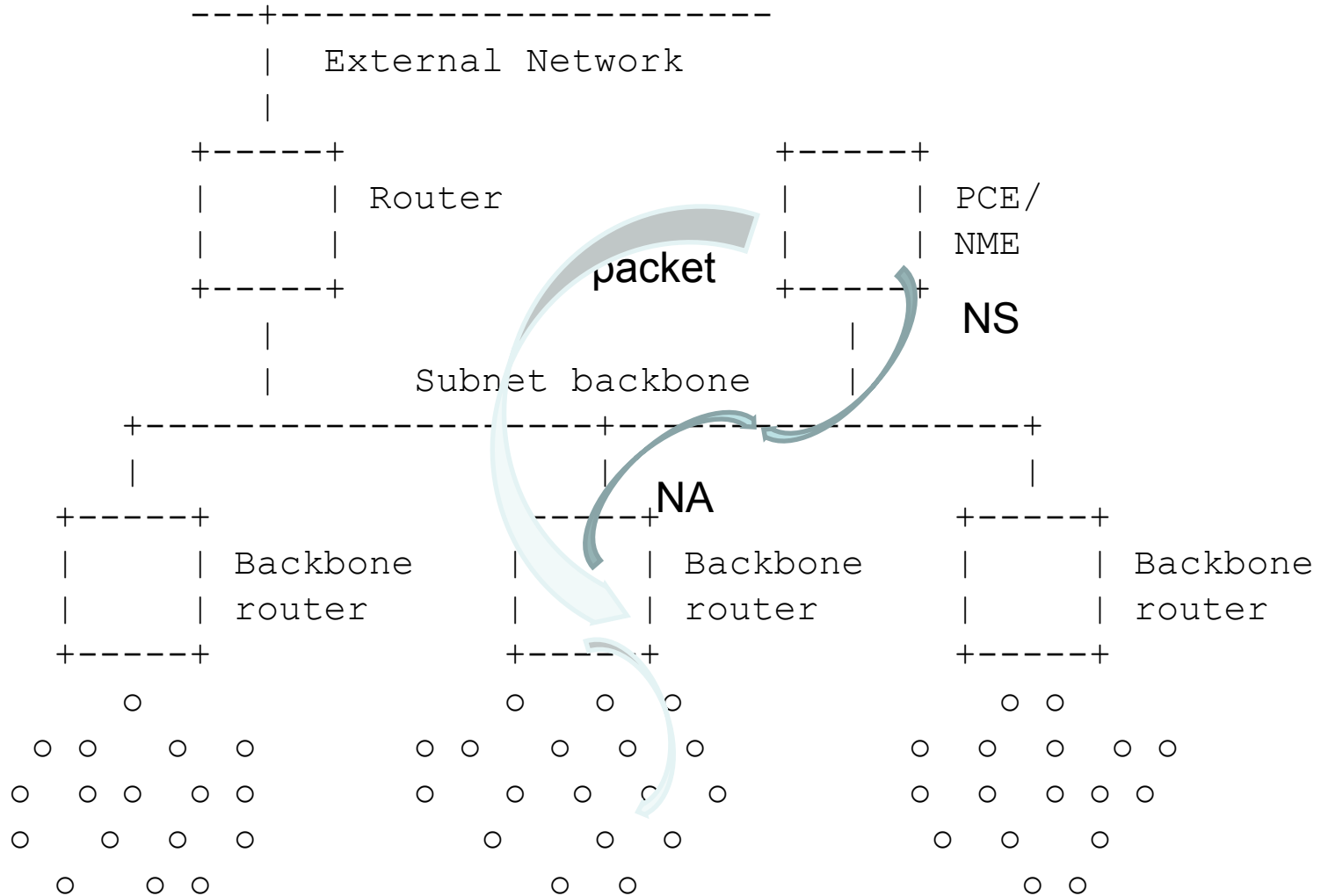
Resolution



- NA option has:
- Unique ID
 - TID (SeqNum)



Resolution (2)





Marcelo Barros, Nicola Accettura, Pere Tuset, Qin Wang, Tengfei Chang, Thomas Watteyne, Vitor Garbellini, Xavi Vilajosana
<http://www.openwsn.org/>

Overview

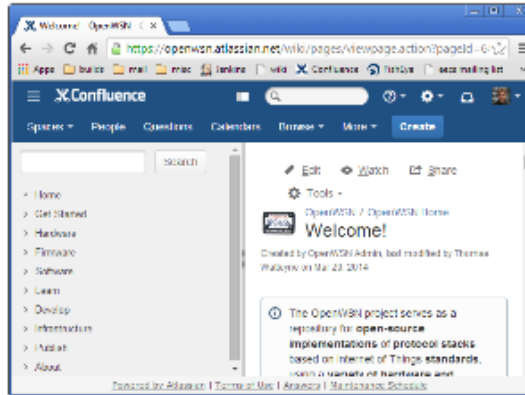
- <http://www.openwsn.org/>
- Goal: **open-source** implementations of a protocol stack based on **Internet of Things** standards, using a **variety** of hardware and software platforms
- Supported standards: **IEEE802.15.4e TSCH**, 6TiSCH, 6LoWPAN, RPL, CoAP



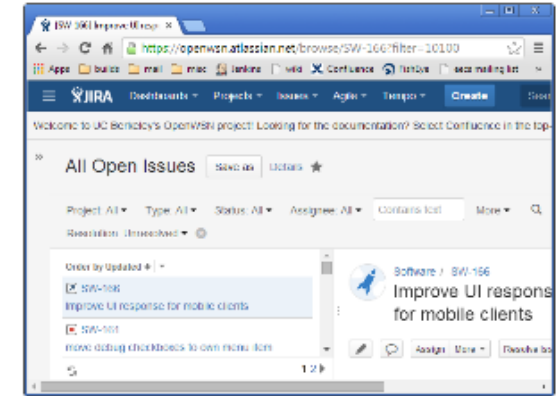
Open Source



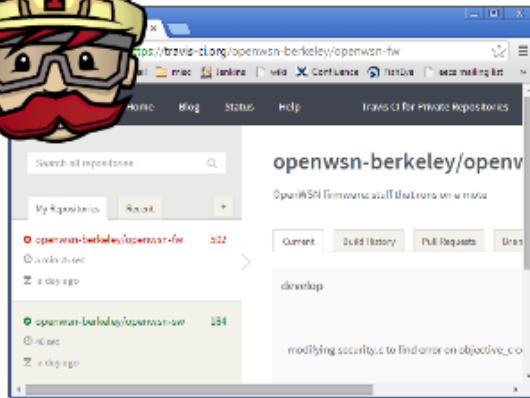
source code hosting



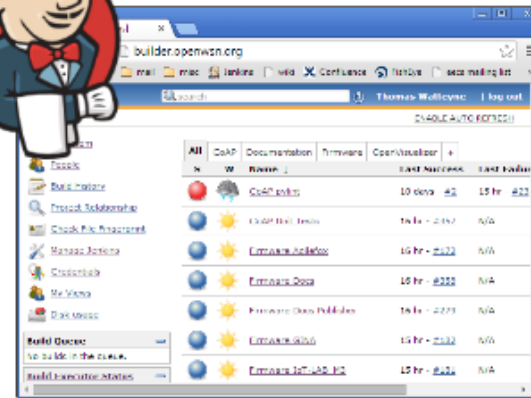
documentation



issue tracker and collaboration

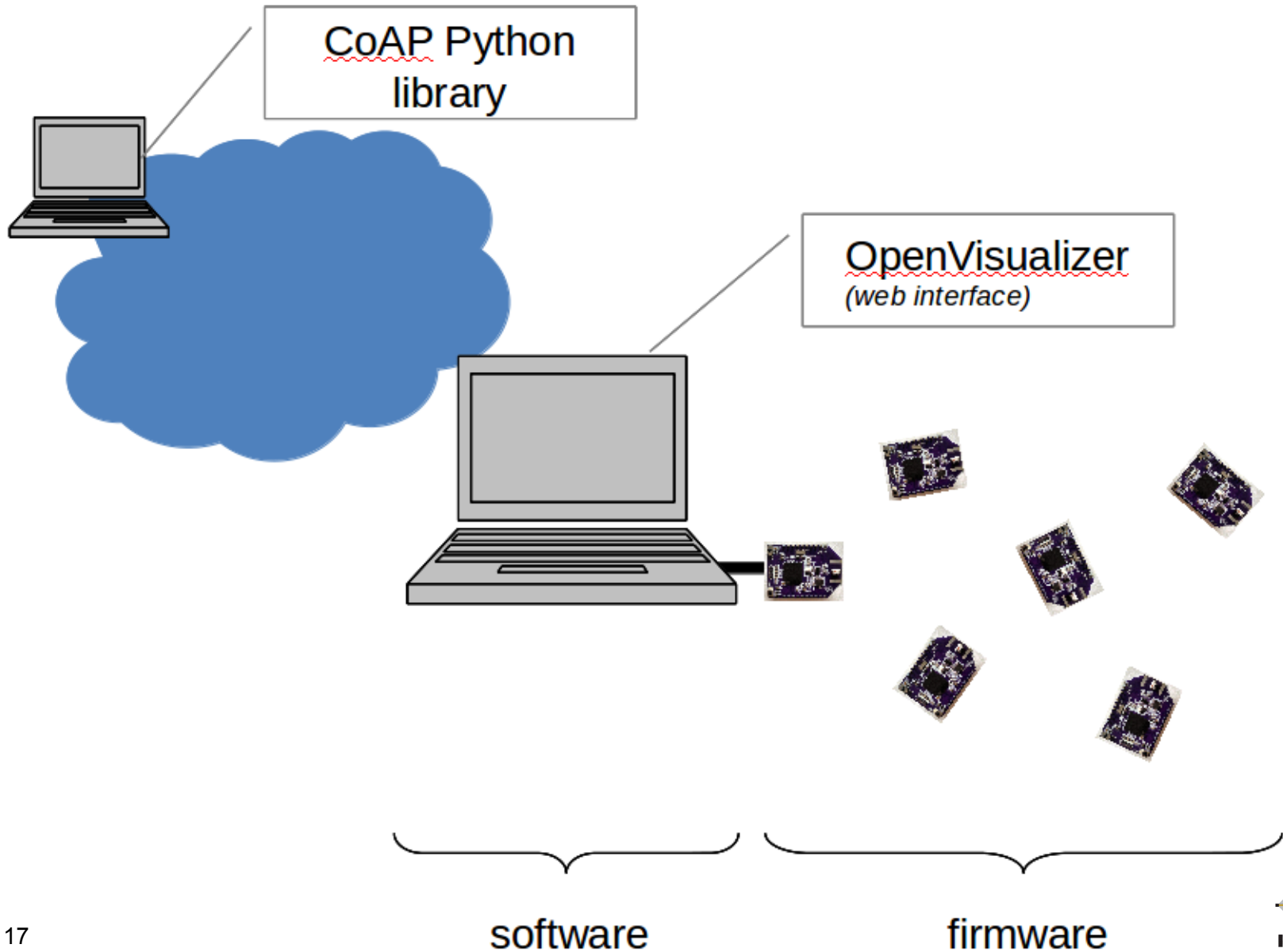


continuous integration



continuous integration

Architecture



Hardware Platforms



OpenMote
(CC2538)



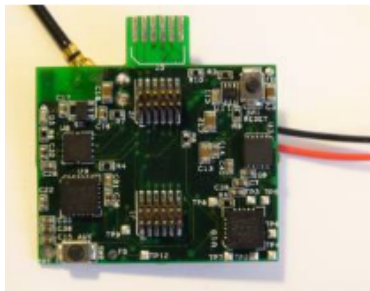
OpenMoteSTM



TelosB



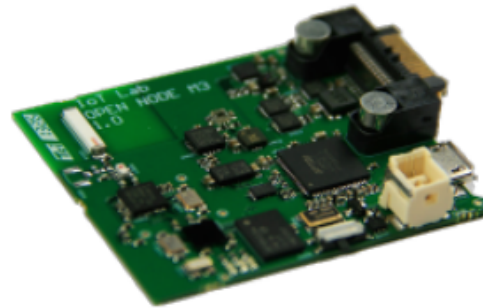
WSN430v13b
WSN430v14



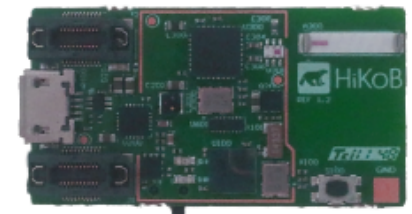
GINA



Zolertia Z1



IoT-LAB_M3



HiKoB Agilefox

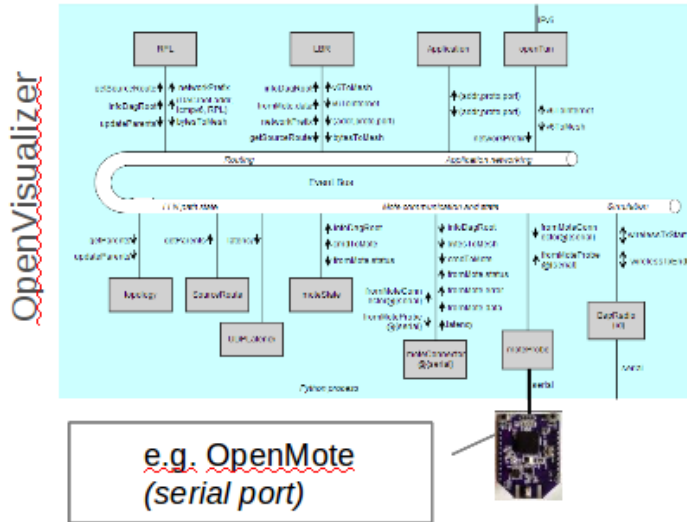
Several other
ports in
preparation...



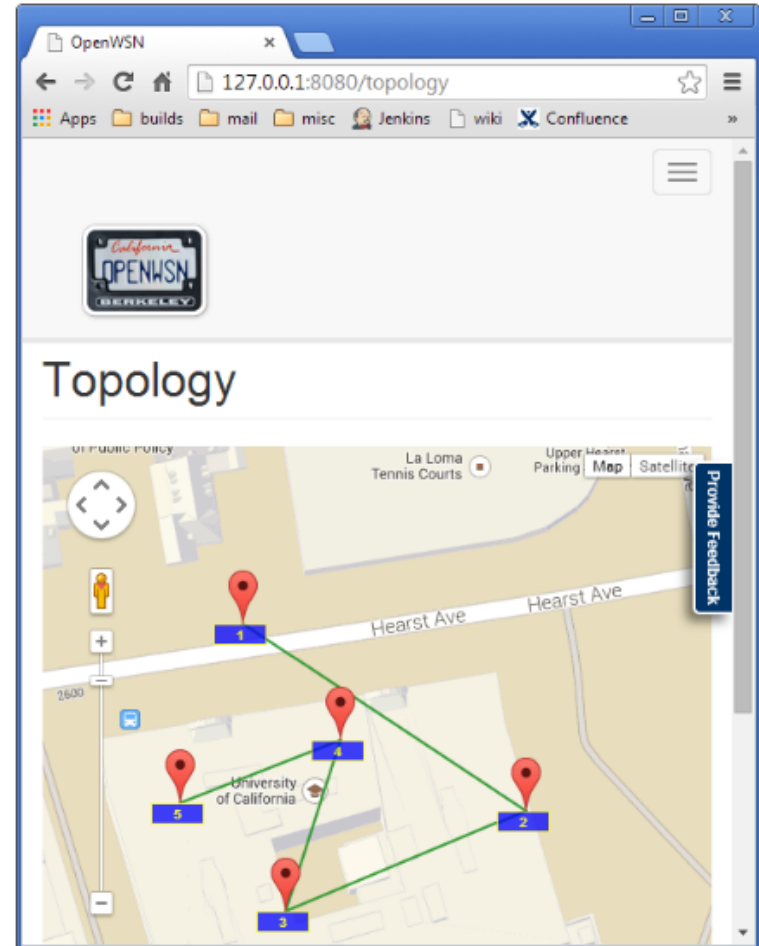
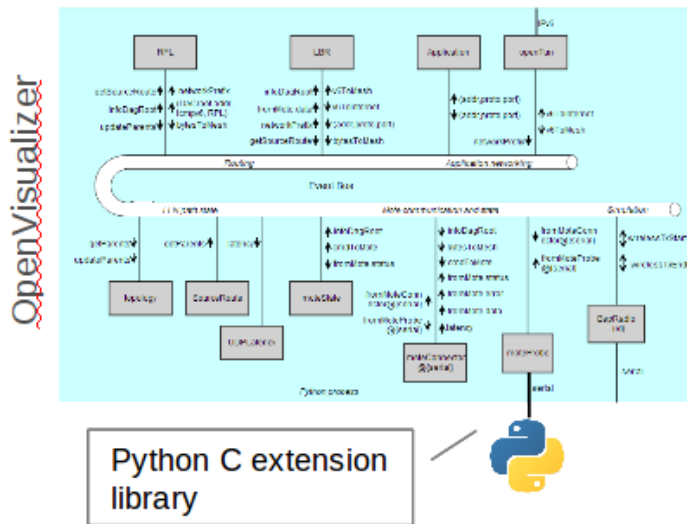
Python
(OpenSim
simulator)

OpenSIM

real hardware

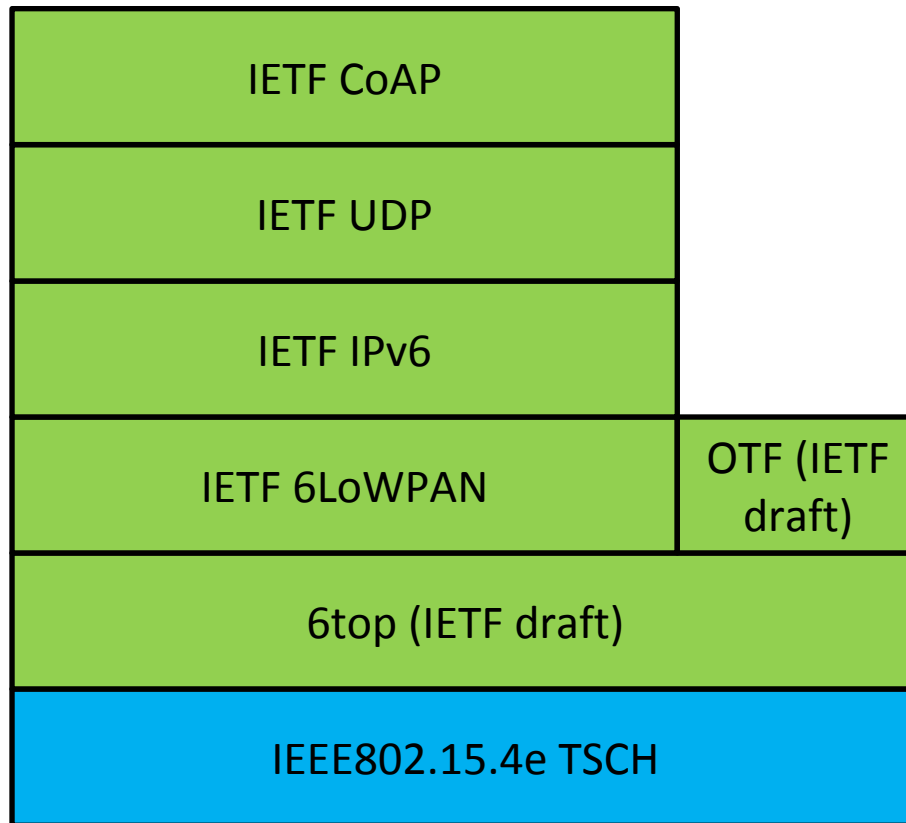


simulation

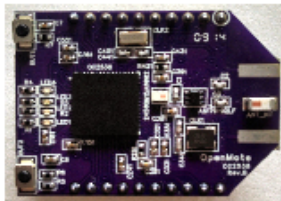
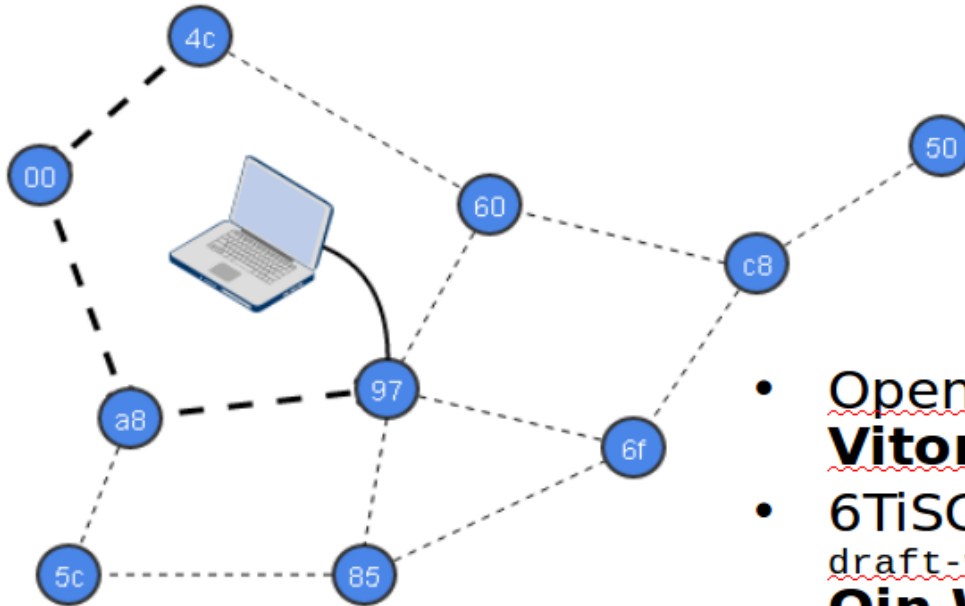


same (web) interface

Protocol Stack



What we are going to show



OpenMote
(CC2538)

- OpenWSN Web Interface
Vitor Garbellini, Marcelo Barros
- 6TiSCH Operation Sublayer (6top)
draft-wang-6tisch-6top-sublayer-01
Qin Wang, Tengfei Chang
- On-The-Fly Scheduling
draft-dujovne-6tisch-on-the-fly-03
Thomas Watteyne
- The IP Flow Label within a RPL Domain
draft-thubert-6man-flow-label-for-rpl-03
Xavier Vilajosana



OpenWSN Web Interface

Vitor Garbellini - Brazil

<garbellinivitor@gmail.com>

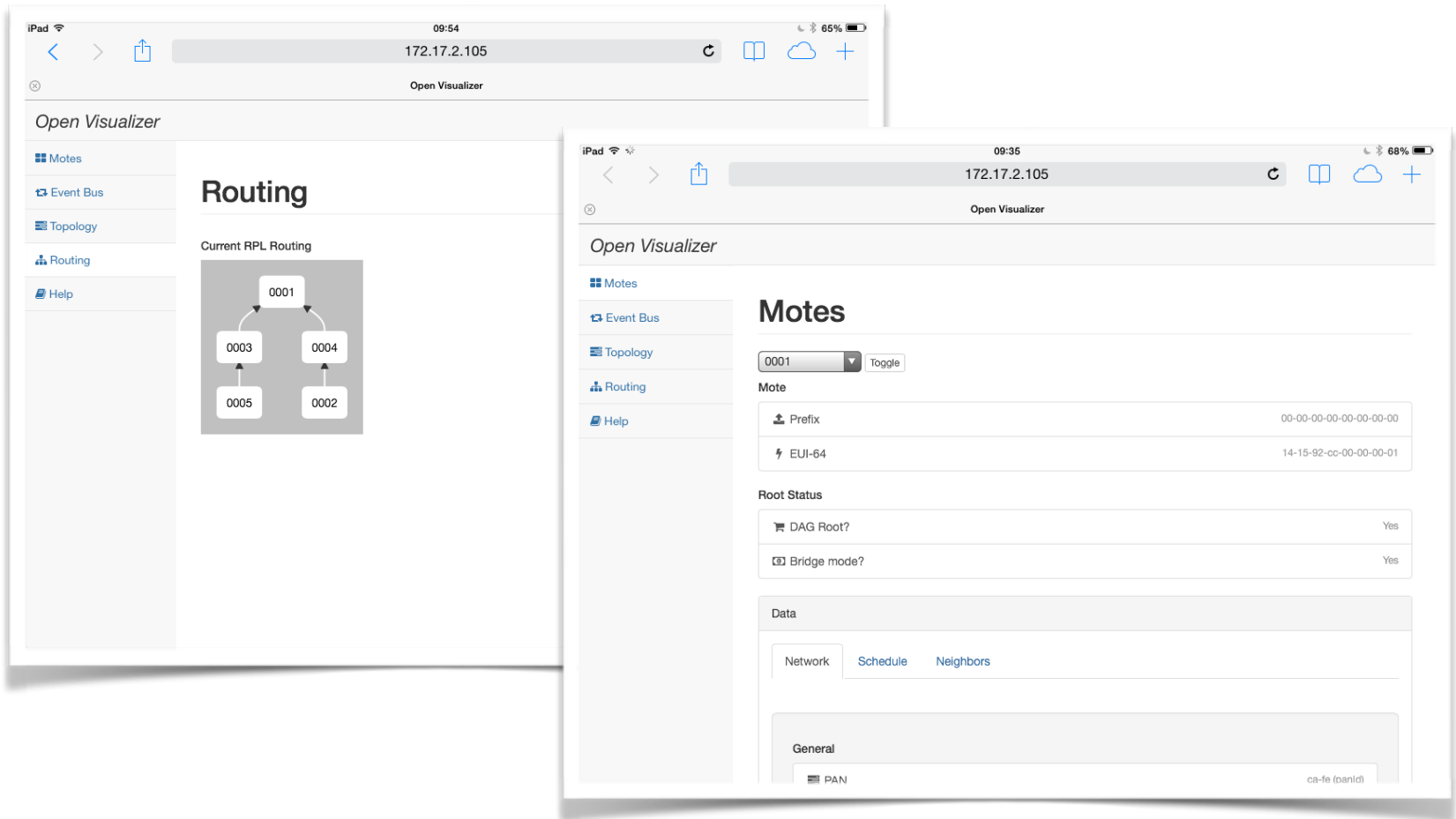
Marcelo Barros - Federal University of Uberlândia / Brazil

<marcelobarrosalmeida@gmail.com>

Goals

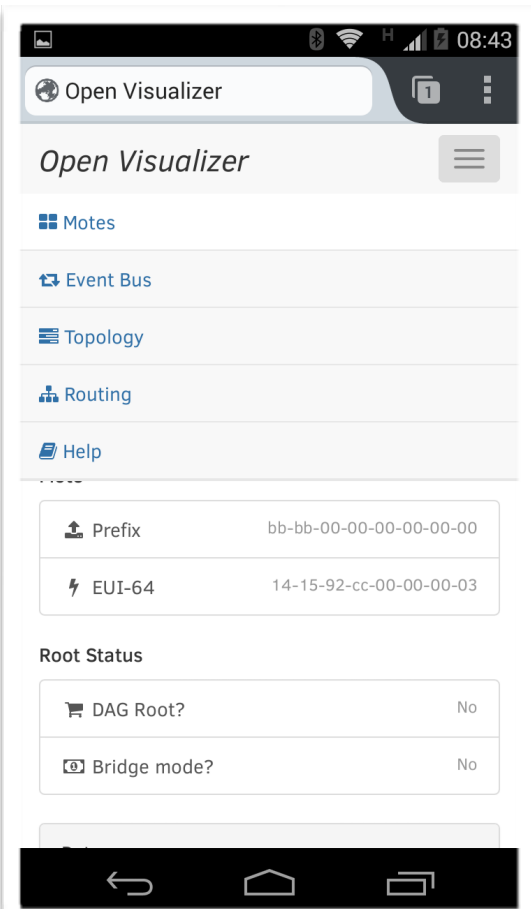
- Dynamic layout adjusted automatically for any screen size (divisions, tables, maps, menus)
- Better look and feel
- Mobile devices support
- Routing visualization
- Minimal modifications on current source code
- Based on Bootstrap, for a rich component library (<http://getbootstrap.com/>)

Desktop screenshots

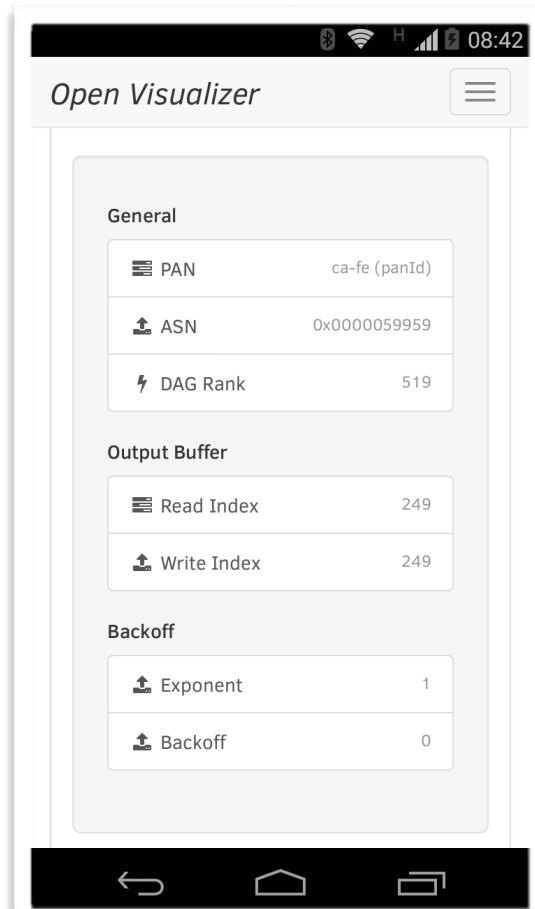


Similar layout, with menus at left, and new look and feel based on bootstrap

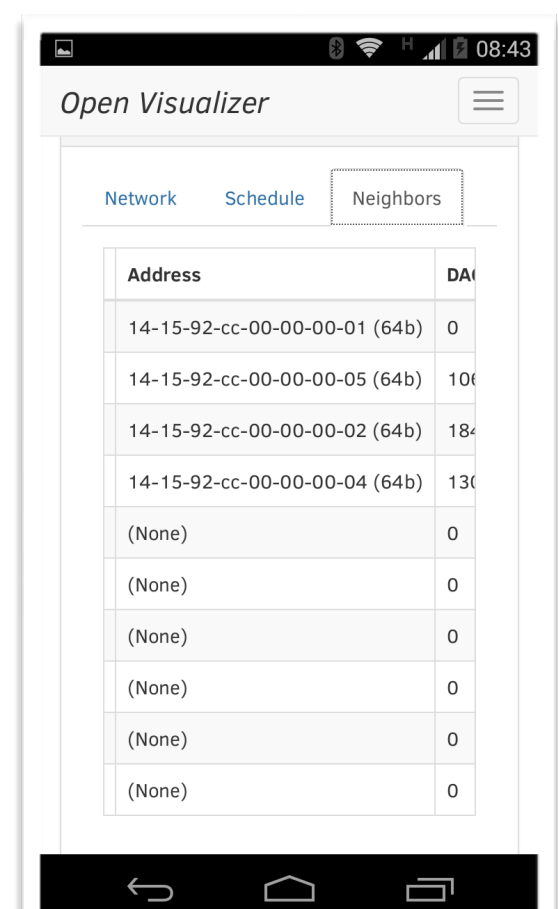
Mobile screenshots



Dropdown menu at top right

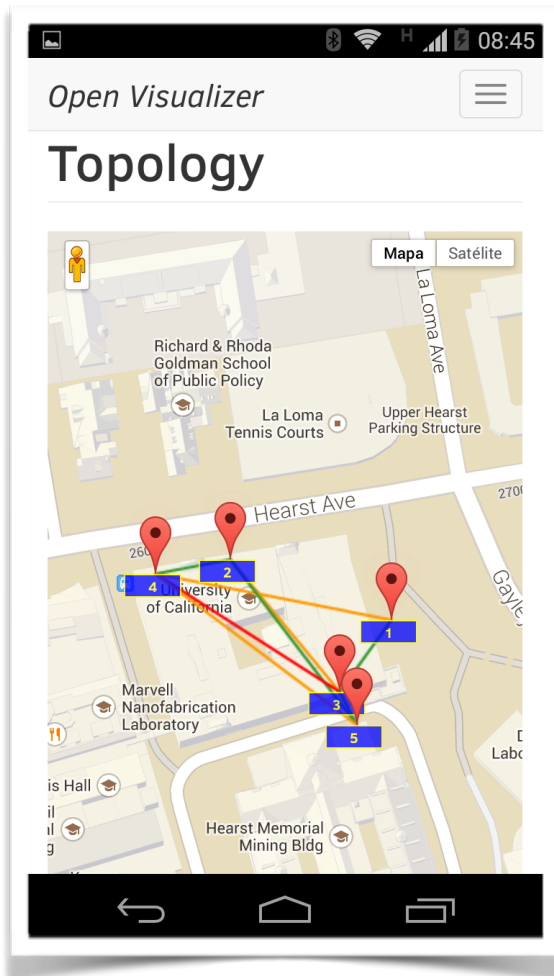


Screen divisions are adjusted to screen



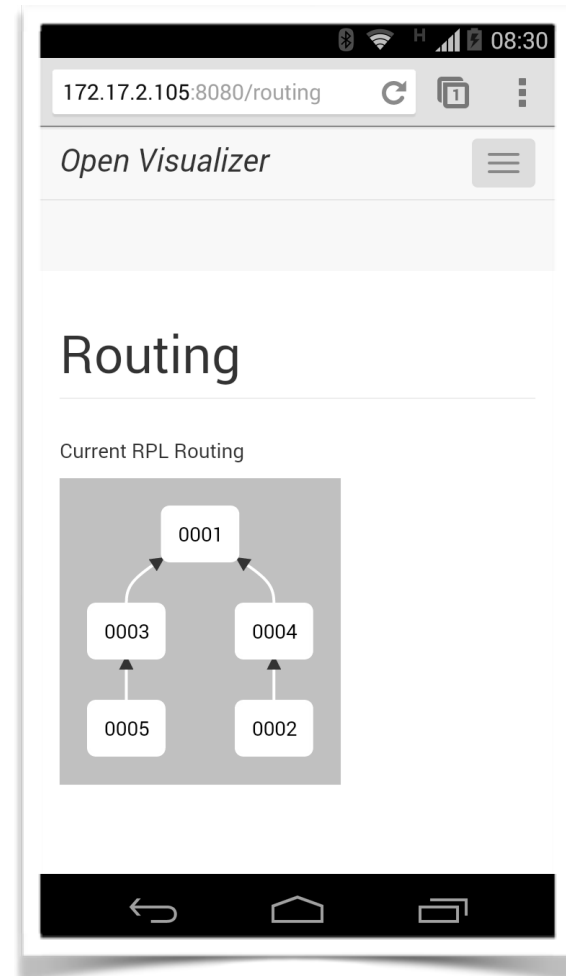
Tables can scroll horizontally

Mobile screenshots



Maps adjusted to the screen size

26



New routing diagram

Thanks !



“6TiSCH Operation Sublayer (6top)”

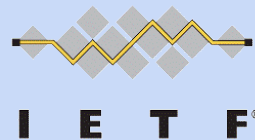
draft-wang-6tisch-6top-sublayer-01

Qin Wang, Tengfei Chang

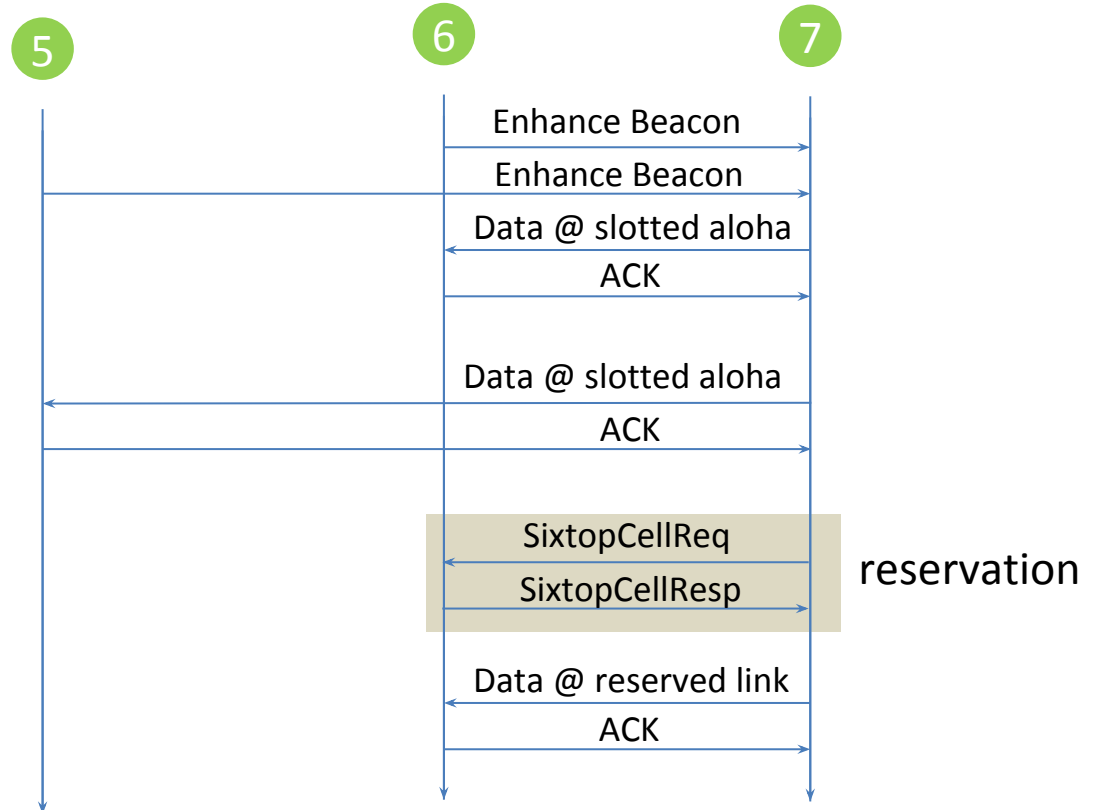
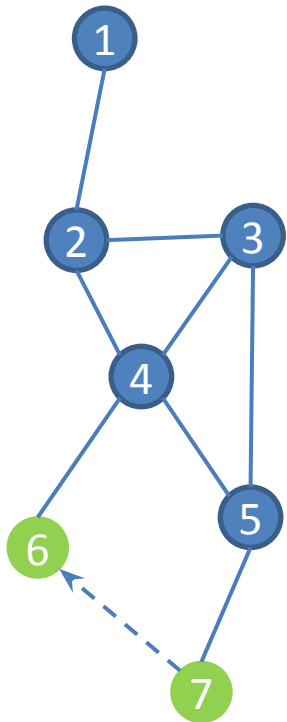
University of Science & Technology Beijing

wangqin@ies.ustb.edu.cn

tengfei.chang@gmail.com



6top Cell reservation



Element Information

6top Opcode IE

Format of a 6top Opcode IE (OpcodeIE).

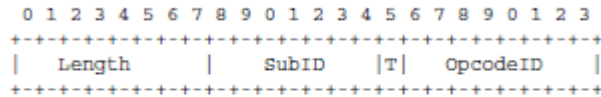


Figure 9

Length-1

SubID-0x41

6top Bandwidth IE

Format of a 6top Bandwidth IE (BwIE).

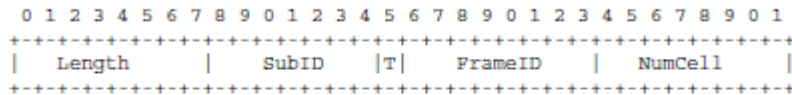


Figure 10

Length-2

SubID-0x42

6top Generic Schedule IE

Format of a 6top Generic Schedule IE (ScheduleIE).

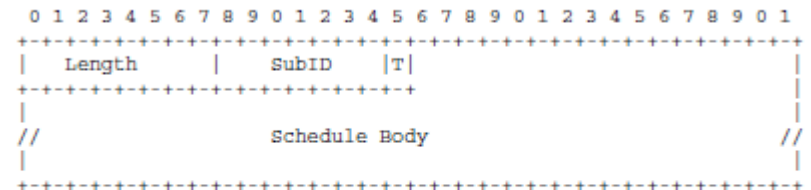


Figure 12

Length-variable

SubID-0x44

Packet format

Payload IE of Soft Cell Reservation Response

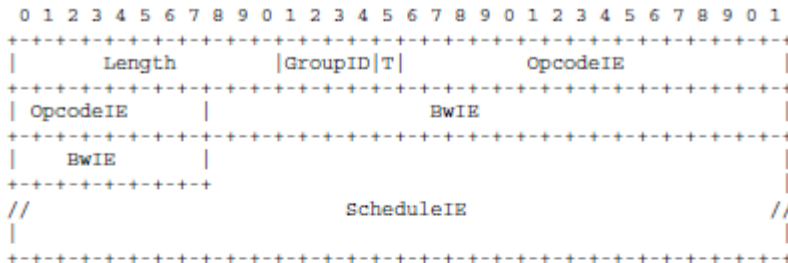


Figure 17

Length-variable

GroupID=0x1, i.e., MLME IE

T=1, i.e., payload IE

The OpcodeID field in the 3-octet OpcodeIE SHOULD be set to 0x01, indicates Reserve Soft Cell Response operation.

The NumCell field in 4-octet BwIE SHOULD be set to the number of cells which have been reserved successfully.

The ScheduleIE SHOULD specify all of the cells which have been reserved successfully.

In addition, TrackIDIE can be added in the packet to associate the reserved soft cells to a specific TrackID.

Cell reservation response
Cell reservation request

Cell remove request

Payload IE of Soft Cell Remove Request

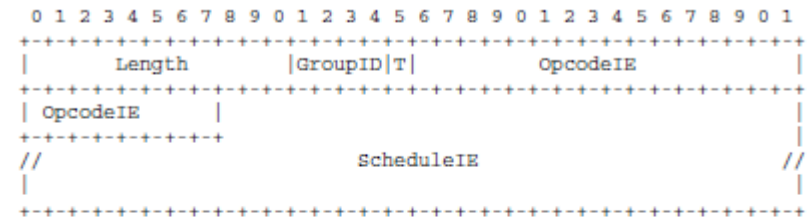


Figure 18

Length-variable

GroupID=0x1, i.e., MLME IE

T=1, i.e., payload IE

The OpcodeID field in the 3-octet OpcodeIE SHOULD be set to 0x02, indicates Remove Soft Cell Request operation.

The ScheduleIE SHOULD specify all the cells that need to be removed.

What will be shown

- Implementation of 6top sublayer
- Reserve and remove one cell at one time
- Reserve and remove cell along the routing path by calling 6top cell reservation command (OTF implemented by Thomas)
- On openmotestm platform

Thanks!

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tengfei.chang@gmail.com



Demonstrating “On-The-Fly Scheduling”

draft-dujovne-6tisch-on-the-fly-03

Thomas Watteyne



On-The-Fly Scheduling

- Context: a 6TiSCH network with distributed scheduling, and the 6top sublayer implemented
- Goal: a node decides locally when to add/remove cells to its TSCH communication schedule
 - If too many: wasted energy and bandwidth
 - If not enough: lost packets
- Exact algorithm is not specified. Multiple options:
 - Monitoring the state of the queues
 - [implemented] having the same number of TX than RX slots

OpenWSN x

127.0.0.1:8080/topology

California
OPENWSN
BERKELEY

Motes

Event Bus

Topology

Routing

Documentation

Topology

Map Satellite

Gayley Rd

University of California

Marvell Nanofabrication Laboratory

Hearst M

Kresge Engineering

Provide Feedback

Map data ©2014 Google Terms of Use Report a map error


DAGroot

- Requirements
 - IEEE802.15.4e TSCH network
 - 6top sublayer
 - CoAP
- Implementation done in OpenWSN

Goal: when mote 5 adds a cell to mote 4 through 6top negotiation, all nodes in the 4-3-2-1 multi-hop route do the same

OpenWSN x

127.0.0.1:8080/moteview/0001



Network Schedule Neighbors

Slot Schedule

- Current schedule of mote 5

| | Type | Shared? | Channel | Nbr Type | RX | TX | TX ACK | Last ASN |
|---|--------------|---------|---------|-----------|----|----|--------|--------------|
| 0 | 1 (ADV) | 0 | 0 | (None) | 7 | 6 | 6 | 0x000002d382 |
| 1 | 4 (TXRX) | 1 | 0 | (anycast) | 12 | 15 | 15 | 0x000002d3ba |
| 2 | 4 (TXRX) | 1 | 0 | (anycast) | 0 | 2 | 2 | 0x000002b468 |
| 3 | 4 (TXRX) | 1 | 0 | (anycast) | 3 | 4 | 4 | 0x000002d0af |
| 4 | 4 (TXRX) | 1 | 0 | (anycast) | 2 | 2 | 2 | 0x000002d13f |
| 5 | 4 (TXRX) | 1 | 0 | (anycast) | 1 | 1 | 1 | 0x000002c77f |
| 6 | 5 (SERIALRX) | 0 | 0 | (None) | 0 | 0 | 0 | 0x0000000000 |
| 0 | 0 (OFF) | 0 | 0 | (None) | 0 | 0 | 0 | 0x0000000000 |
| 0 | 0 (OFF) | 0 | 0 | (None) | 0 | 0 | 0 | 0x0000000000 |

Packet Queue

| Creator | Owner |
|----------|----------|
| 0 (NULL) | 0 (NULL) |
| 0 (NULL) | 0 (NULL) |

Provide Feedback

OpenWSN

127.0.0.1:8080/topology

IETF90 CoAP client - OpenWSN

coap://[bbbb::1415:92cc:0:5] /

/storm period= 135 GET PUT

/6t PUT DELETE

Topology

Routing

Documentation

University of California

Marvell Nanofabrication Laboratory

Donner Laboratory

Hearst Memorial Mining Bldg

Dept of Materials Science and Engineering

Kresge Engineering

Gayley Rd

Map Satellite


Provide Feedback

Map data ©2014 Google Terms of Use Report a map error

- Issue a command, over CoAP, for mote 5 to add a cell to mote 4 (CoAP PUT)
- Triggers a 6top neighbor-to-neighbor negotiation

OpenWSN x

127.0.0.1:8080/moteview/0001



Slot Schedule

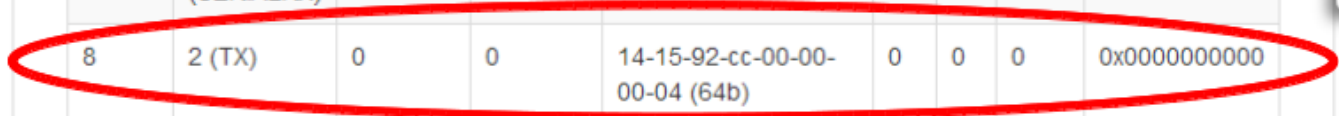
| Offset | Type | Shared? | Channel | Nbr Type | RX | TX | TX ACK | Last ASN |
|--------|--------------|---------|---------|-------------------------------|----|----|--------|--------------|
| | (ADV) | 0 | 0 | (None) | 25 | 25 | 25 | 0x0000036327 |
| | (TXRX) | 1 | 0 | (anycast) | 51 | 67 | 65 | 0x000003662a |
| | (TXRX) | 1 | 0 | (anycast) | 5 | 9 | 9 | 0x0000036145 |
| 3 | 4 (TXRX) | 1 | 0 | (anycast) | 7 | 11 | 11 | 0x0000035c60 |
| 4 | 4 (TXRX) | 1 | 0 | (anycast) | 8 | 6 | 6 | 0x0000035a0f |
| 5 | 4 (TXRX) | 1 | 0 | (anycast) | 7 | 9 | 9 | 0x00000363c6 |
| 6 | 5 (SERIALRX) | 0 | 0 | (None) | 0 | 0 | 0 | 0x0000000000 |
| 8 | 2 (TX) | 0 | 0 | 14-15-92-cc-00-00-00-04 (64b) | 0 | 0 | 0 | 0x0000000000 |
| 0 | 0 (OFF) | 0 | 0 | (None) | 0 | 0 | 0 | 0x0000000000 |

Packet Queue

| Creator | Owner |
|----------|----------|
| 0 (NULL) | 0 (NULL) |
| 0 (NULL) | 0 (NULL) |


Provide Feedback

- Mote 5 has added a cell to mote 4 (6top)



OpenWSN x

127.0.0.1:8080/moteview/0001



Slot Schedule

| Offset | Type | Shared? | Channel | Nbr Type | RX | TX | TX ACK | Last ASN |
|--------|--------------|---------|---------|-------------------------------|-----|----|--------|--------------|
| | (ADV) | 0 | 0 | (None) | 60 | 29 | 29 | 0x0000038a2b |
| | (TXRX) | 1 | 0 | (anycast) | 134 | 85 | 85 | 0x0000038a42 |
| | (TXRX) | 1 | 0 | (anycast) | 15 | 13 | 13 | 0x00000388b7 |
| 3 | 4 (TXRX) | 1 | 0 | (anycast) | 25 | 12 | 12 | 0x00000387f2 |
| 4 | 4 (TXRX) | 1 | 0 | (anycast) | 15 | 14 | 14 | 0x0000038575 |
| 5 | 4 (TXRX) | 1 | 0 | (anycast) | 18 | 13 | 13 | 0x0000037942 |
| 6 | 5 (SERIALRX) | 0 | 0 | (None) | 0 | 0 | 0 | 0x0000000000 |
| 8 | 3 (RX) | 0 | 0 | 14-15-92-cc-00-00-00-05 (64b) | 2 | 0 | 0 | 0x0000037b76 |
| 7 | 2 (TX) | 0 | 0 | 14-15-92-cc-00-00-00-03 (64b) | 0 | 4 | 4 | 0x000003891f |

Packet Queue

| Creator | Owner |
|----------|----------|
| 0 (NULL) | 0 (NULL) |
| 0 (NULL) | 0 (NULL) |

Provide Feedback

- Mote 4 has also added a cell to mote 3 (otf)

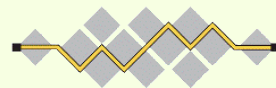
Similar behavior thing when removing a cell

Demonstrating “The IP Flow Label within a RPL Domain”

draft-thubert-6man-flow-label-for-rpl

Xavier Vilajosana
Universitat Oberta de Catalunya

xvilajosana@uoc.edu
xvilajosana@eecs.berkeley.edu



I E T F[®]

Hop by hop option in RPL

- The Hop-by-Hop Options header is used to carry optional information that must be examined by every node along a packet's delivery path. The Hop-by-Hop Options header is identified by a Next Header value of 0 in the IPv6 header.
- Per <http://tools.ietf.org/html/rfc6282#section-4.2>, the first 7 bits serve as an identifier for the IPv6 Extension Header immediately following the LOWPAN_NHC octet. The remaining bit indicates whether or not the following header utilizes LOWPAN_NHC encoding.
- The Length field contained in a compressed IPv6 Extension Header indicates the number of octets that pertain to the (compressed) extension header following the Length field. Note that this changes the Length field definition in [RFC2460] from indicating the header size in 8-octet units, not including the first 8 octets. Changing the Length field to be in units of octets removes wasteful internal fragmentation.

Hop by hop Option Header

4.3 Hop-by-Hop Options Header

The Hop-by-Hop Options header is used to carry optional information that must be examined by every node along a packet's delivery path. The Hop-by-Hop Options header is identified by a Next Header value of 0 in the IPv6 header, and has the following format:

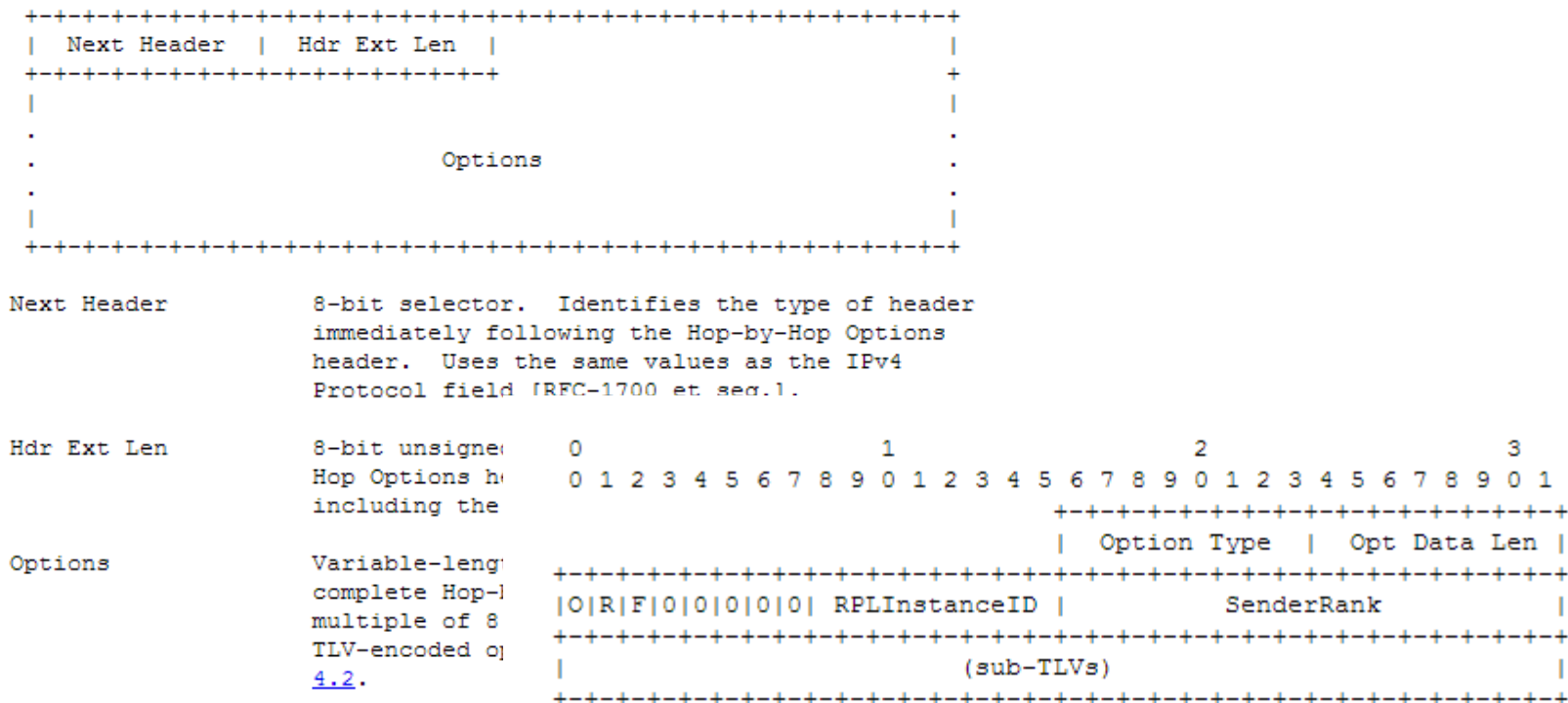


Figure 1: RPL Option

RPL Flow Label

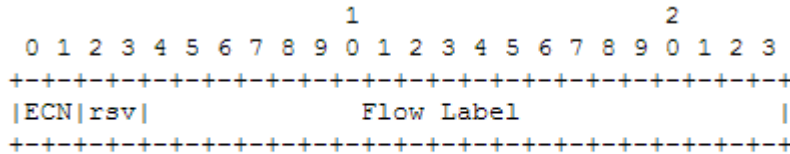


Figure 5: TF = 01: Flow Label carried in-line

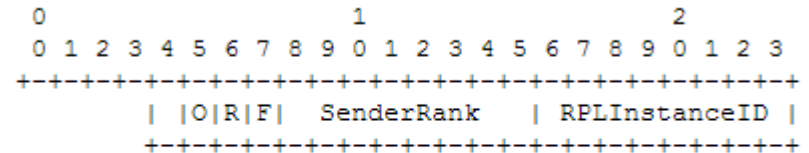


Figure 1: The RPL Flow Label

- Saved Bytes (5B)
 - 1 Byte for NHC field in LowPAN Header
 - 2 Bytes for Next Header and Hdr Ext. Len
 - 2 Bytes for Option Type and Opt Data Len

What will be shown

- Impl. draft-thubert-6man-flow-label-for-rpl-03
- RPL Non-Storing Mode (rfc6550-53,54)
- draft-ietf-6tisch-minimal-02
- On IEEE802.15.4e TSCH
- 4 hop network, demonstrating the use of flow label as a replacement to the IPv6 Extension Header (rfc6282#section-4.2)
- On OpenWSN. (www.openwsn.org)
- OpenMote platform (www.openmote.com)

Thanks!

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xvilajosana@eecs.berkeley.edu





“Analysis of TSCH networks using open source tools: OpenMote + Wireshark”

Pere Tuset-Peiró
OpenMote Technologies
peretuset@openmote.com

July 20, 2014
Toronto, Canada



OpenMote Technologies

OpenMote Family

OpenMote

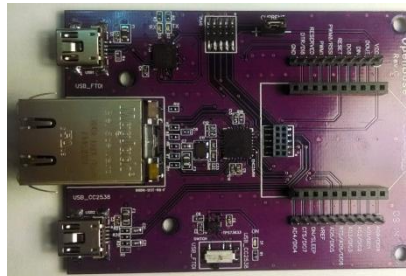
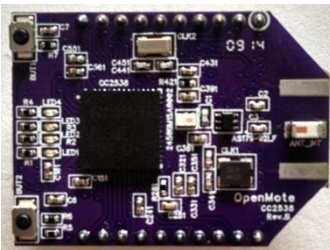
TI CC2538 SoC
(Cortex M3 + radio)
4 LEDs, 2 Buttons
2 antennas

OpenBase

Ethernet PHY+MAC
USB-to-UART port
USB-to-PHY port
10-pin ARM JTAG

OpenBattery

Temp./Humd.
Acceleration
Luminance
2xAAA batteries



OpenMote Technologies

Open source projects

Contiki

Started at SICS '02

BSD License

IEEE 802.15.4e CSL,
6LoWPAN, RPL, TCP/UDP

OpenMote-ready

OpenWSN

Started at UCB '09

BSD License

IEEE 802.15.4e TSCH,
6LoWPAN, RPL, TCP/UDP

OpenMote-ready

RiOT

Started at FUB '08

GNU LGPLv2.1 License

IEEE 802.15.4-2006,
6LoWPAN, RPL, TCP/UDP

OpenMote-pending*



Contiki

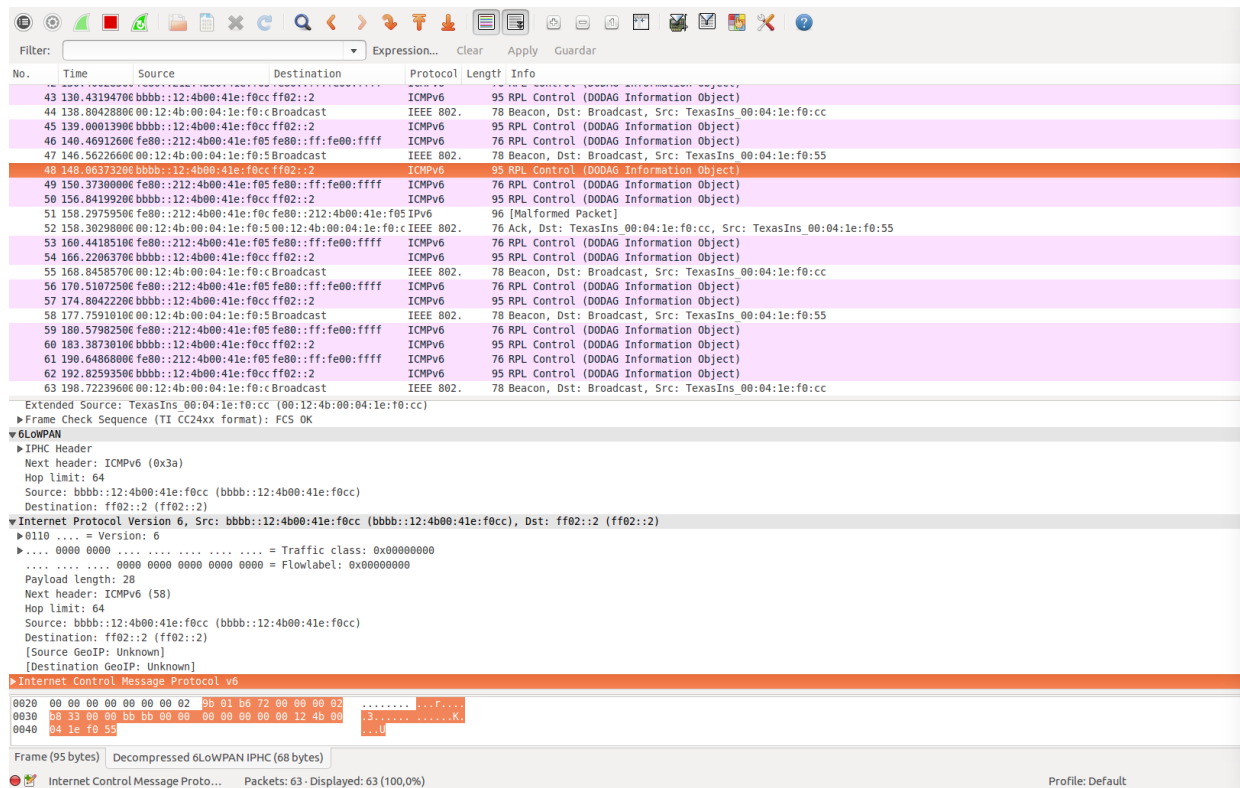
The Open Source OS for the Internet of Things



RiOT

What will be shown

- An IEEE 802.15.4e sniffer build using the OpenMote platform and Wireshark
 - Currently only supports one channel but support for a specific product for IEEE 802.15.4e multi-channel sniffing is planned



Future work

- A C++ API to use OpenMote features (Leds, Buttons, Sensors, etc.) easily
- Support for FreeRTOS in tickless mode with standby current consumption of only 1.6 μA
- A shield for the Raspberry Pi to be able to easily build a border router with Linux



Thanks!

Pere Tuset-Peiró
OpenMote Technologies
peretuset@openmote.com

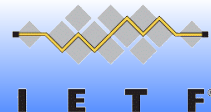


FIT IOT-lab

www.iot-lab.info

A very large
scale open testbed
for the Internet
of things

Presented by: Cédric Adjih (Inria)



FIT IoT-LAB



- **Who are we ?**

- Partners of a funded project: Equipex FIT

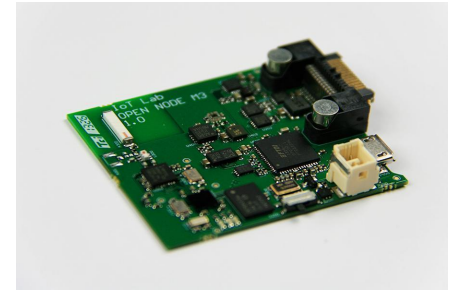


- **What is FIT IoT-LAB ?**

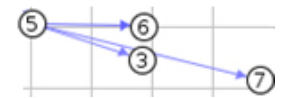
- 2700+ wireless nodes on 6 sites (IEEE 802.15.4 or sub-1 GHz)
- Remote access
- Open access



FIT IoT-LAB: related IETF WGs

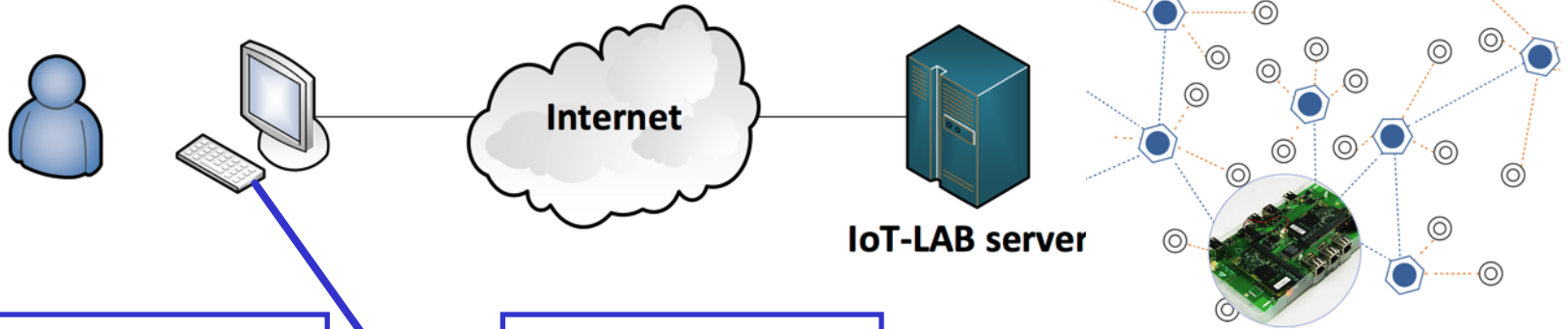


- **IoT-LAB nodes = LLN nodes:**
 - TI MSP430 + CC2420 or CC1101
 - Cortex-M3 (64 kB RAM, 512 kB Flash) + 802.15.4
 - [soon] Cortex-A8 linked with Cortex-M3 (Linux+)
- **Related to: ROLL, 6LoWPAN, 6TiSCH, ...**
- **through Open Software and Open Tools:**
 - Ports of:



FIT IoT-LAB

● Demo



1) Experiment configuration

2) Experiment results

The screenshot shows the FIT IoT-LAB web interface. The main content area displays "Experiment Details" for an experiment named "Tuto". The state is "Running", and the duration is 20 minutes. The number of nodes is 0. Below this, there is a table with columns for "Node", "Profile", "Firmware", and "Deployment". The table shows five rows, all with a "Success" status in the "Deployment" column.

| Node | Profile | Firmware | Deployment |
|-----------------------------|---------|----------|------------|
| m3-4.grenoble.iot-lab.info | | | Success |
| m3-5.grenoble.iot-lab.info | | | Success |
| m3-11.grenoble.iot-lab.info | | | Success |
| m3-13.grenoble.iot-lab.info | | | Success |
| m3-14.grenoble.iot-lab.info | | | Success |

The screenshot shows the FIT IoT-LAB web interface displaying experiment results. The main content area displays a network diagram with nodes and connections. The diagram shows a central node connected to several other nodes, which are further connected to each other, forming a network topology. The interface also shows a list of nodes and their status, with a "Success" status for all nodes.

Open systems
with IETF protocols
(RPL/COAP/6TiSCH/...)

FIT IoT-LAB

- **Future:**
 - FIT: more testbeds (Wifi, SDR,...)
 - Integration with **OneLab.eu**
- **Contact details:**
 - admin@iot-lab.info
 - www.iot-lab.info
- **See you also at the Bits-N-Bites on Thursday !**
 - (Cedric.Adjih@inria.fr)





The friendly Operating System for the
Internet of Things



Why RIOT?

Leveraging the reasons for the success of the Internet:

- Interconnectivity through open standards (6LoWPAN, RPL, CoAP...)
- Open Source implementation
- Simple, but powerful API (like POSIX)

One crucial thing to make the IoT happen:

- reliable and robust networking over (multi-hop) wireless links
- 6TiSCH is a promising approach
- Work towards 6TiSCH support in RIOT's network stack



I E T F

RIOT in the IETF

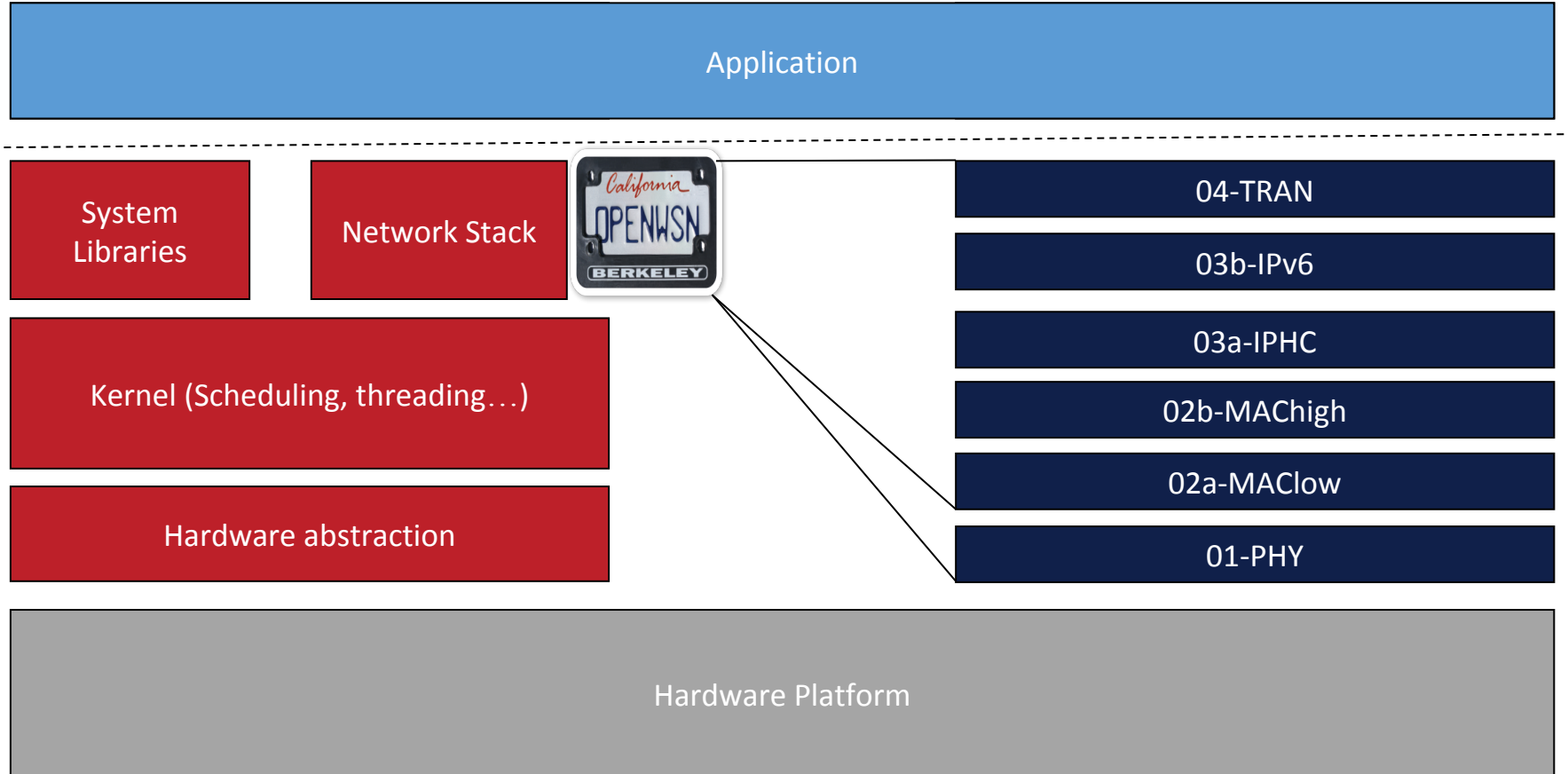
- 6lo(wpan):
 - Implementation of RFC 6282 from scratch
- roll:
 - Implementation of RFCs 6206, 6550, 6552 and 6719
 - RFC 6997 under development
- manet:
 - Porting of RFC 7181 from *olsr.org*
 - Implementation of ID draft-ietf-manet-aodvv2 from scratch on-going
- core:
 - Ported libcoap for RFC 7252

Of course, we're also participating in the other WGs in the IoT scope (lwig, dice, ace, icnrg, homenet...)



I E T F

Approach: OpenWSN stack integration in RIOT



Current State and Outlook

- Run OpenWSN in RIOT as a separate thread
- Replace board specific parts from OpenWSN with RIOT's drivers
- Adapt RIOT's radio driver and create a clean common interface
- Replace opentimers with RIOT's vtimers
- Run RIOT and OpenWSN applications on top

Join the RIOT!

- Fork us on Github:
 - <https://github.com/RIOT-OS/RIOT>
- Discuss on the mailing lists
 - devel@riot-os.org
 - users@riot-os.org
- Or live in IRC
 - #riot-os at irc.freenode.net
- Follow us on Twitter: @RIOT_OS

Counters for Troubleshooting and Monitoring the 6LoWPAN Layer

Anuj Sehgal, Jürgen Schönwälder
Jacobs University Bremen,
Germany draJ-ieL-6lo-lowpan-mib-01



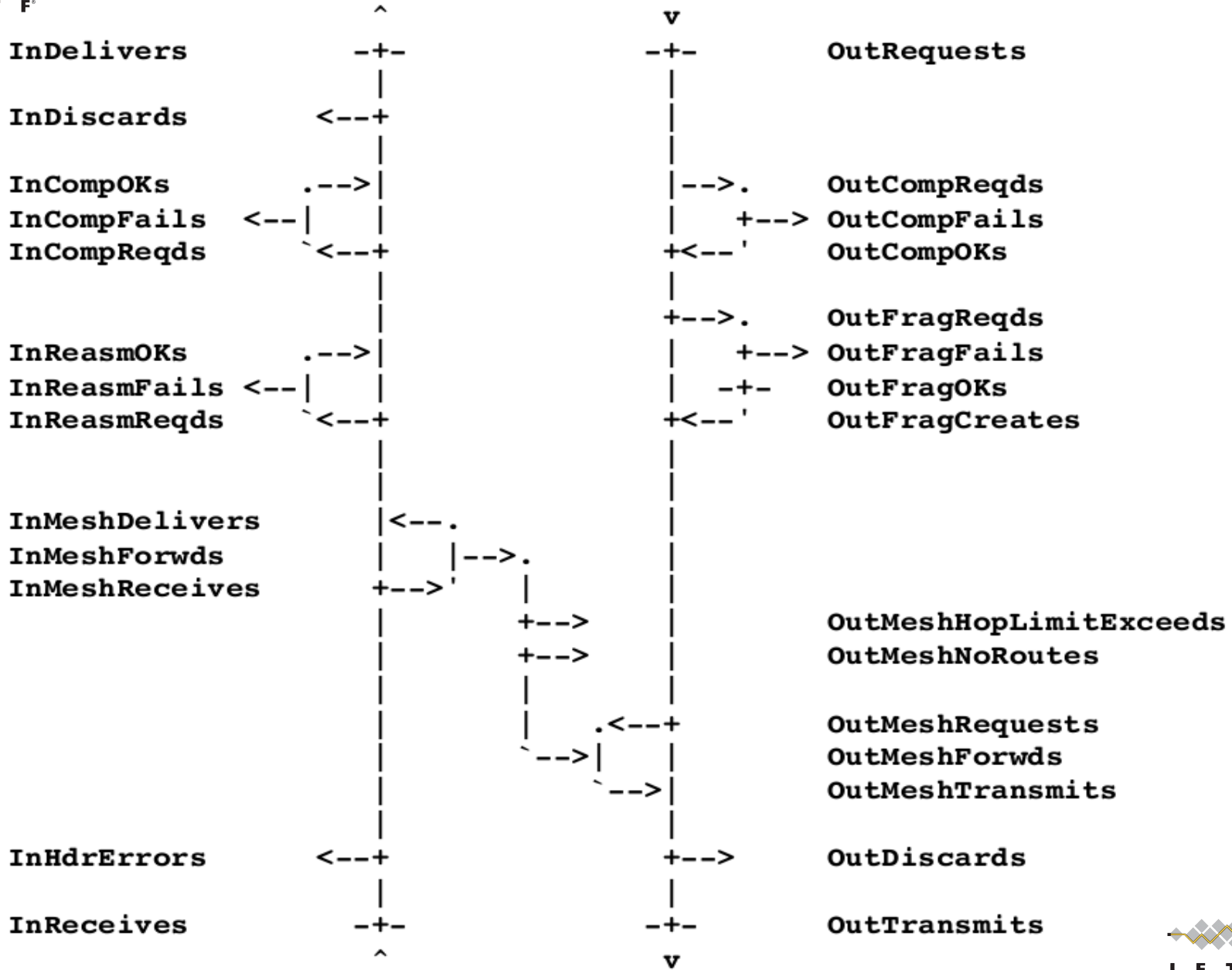
LOWPAN-MIB Module

- The counters defined in the LOWPAN-MIB module provide:
 - Statistics about the 6LoWPAN datagrams received and transmitted
 - Statistics about processing failures in the 6LoWPAN layer
- Counters can be used to troubleshoot problems related to fragmentation, compression or mesh forwarding



I E T F

IPv6 layer



interface layer



I E T F

SNMP Access to the Counters

```
bash 361
$ snmpwalk -v 1 -c public -Os -Op -v Mesh
lowpanReasmTimeout.0 = 3 seconds
lowpanInReceives.0 = 877
lowpanInHdrErrors.0 = 0
lowpanInReasmReqds.0 = 406
lowpanInReasmFails.0 = 4
lowpanInReasmOKs.0 = 30
lowpanInCompReqds.0 = 505
lowpanInCompFails.0 = 0
lowpanInCompOKs.0 = 507
lowpanInDiscards.0 = 88
lowpanInDelivers.0 = 508
lowpanOutRequests.0 = 508
lowpanOutCompReqds.0 = 509
lowpanOutCompFails.0 = 0
lowpanOutCompOKs.0 = 511
lowpanOutFragReqds.0 = 31
lowpanOutFragFails.0 = 0
lowpanOutFragOKs.0 = 31
lowpanOutFragCreates.0 = 291
lowpanOutDiscards.0 = 0
lowpanOutTransmits.0 = 782
End of MIB
$
```

```
3. scli
$ ~/src/scli/scli/scli
100 scli version 0.4.0 (c) 2001-2010 Juergen Schoenwaelder
scli > set scli protocol SNMPv1
scli > open snmp://[aaaa::11:22ff:fe33:4455]:1610//
(aaaa::11:22ff:fe33:4455) scli > show system info
Name: AVR Raven
Agent: snmp://public@[aaaa::11:22ff:fe33:4455]:1610//
Description: 6LoWPAN MIB Test Node
Contact: Anuj Sehgal <s.anuj@jacobs-university.de>
Location: Jacobs University Bremen
Vendor: Jacobs University <http://www.jacobs-university.de/>
Services: datalink network transport application
Agent-Boot-Time: 2014-07-18 11:26:47 +02:00
(aaaa::11:22ff:fe33:4455) scli >
```

```
1. scli
Agent: snmp://public@[aaaa::11:22ff:fe33:4455]:1610// up 0 days 00:04:25 09:38:33
Descr: 6LoWPAN MIB Test Node
Command: monitor 6lowpan stats

```

| | | | |
|--------------|----------|----------------|----------|
| inDelivers | 3 (887) | outRequests | 3 (855) |
| inDiscards | 0 (79) | outCompReqds | 3 (855) |
| inCompOKs | 3 (889) | outCompFails | 0 (0) |
| inCompFails | 0 (0) | outCompOKs | 3 (855) |
| inCompReqds | 3 (889) | outFragReqds | 2 (340) |
| inReasmOKs | 2 (357) | outFragFails | 0 (0) |
| inReasmFails | 0 (6) | outFragOKs | 2 (339) |
| inReasmReqds | 6 (1346) | outFragCreates | 6 (1178) |
| inHdrErrors | 0 (0) | outDiscards | 0 (0) |
| inReceives | 7 (1884) | outTransmits | 7 (1692) |



CoAP Access to the Counters

[aaaa::11:22ff:fe33:4455]:5683
2.05 Content (Blockwise) (Download finished)

| Header | Value | Option | Value | Info |
|------------|----------------|----------------|----------------|--------|
| Type | Acknowledgment | ETag | 0x01 | 1 byte |
| Code | 2.05 Content | Content-Format | text/plain | 0 |
| Message ID | 26085 | Block2 | 0 (64 B/block) | 1 byte |
| Token | empty | | | |

Payload (1)

4

Debug Control **Reset**

Token: use hex (0x..) or string x

Request Options

Accept: [dropdown]

Content-Format: [dropdown]

Block1 (Req.) Block2 (Res.) Auto: [input] [input]

Size1 Size2: [input] [input]

Observe: use integer x

ETag: use hex (0x..) or string x

If-Match: use an ETag x

If-None-Match

Uri-Host: not set x Uri-Port: n/s x

Proxy-Uri: use absolute URI x

Use Proxy-Scheme option

Response Options

Max-Age: use integer x

Location-Path: not set x Location-Query: not set x

Custom Options

Number Value

Implementation Details

| | Program [bytes] | Data [bytes] |
|---------------------------|-----------------|----------------|
| Contiki 2.6 | 34040 | 9599 |
| Contiki 2.6 + SNMP | 45764 (+ 11724) | 9799 (+ 200) |
| Contiki 2.6 + SNMP + CoAP | 64962 (+ 19198) | 13413 (+ 3614) |

- Implemented using Contiki 2.6
- Running on AVR Raven (128k Flash, 16k RAM)
- Jacobs Contiki SNMP stack (open source)
- Erbium Contiki CoAP stack (open source)

IEEE802.15.4e Wireshark dissector

Vincent Ladeveze



Capturing from OpenWSN [Wireshark 1.10.8 (v1.10.8-2-g52a5244 from master-1.10)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: zep Expression... Clear Apply Save

| No. | Time | Source | Destination | Protocol | Length | Info |
|-----|--------------|-------------------------|-------------------------|---------------|--------|-----------------------------------|
| 109 | 34.212813000 | Te80::1415:92cc:0:3 | Te80::1b15:92cc:0:1 | ICMPv6 | 198 | RPL Control (I |
| 110 | 34.219362000 | 14:15:92:cc:00:00:00:01 | 14:15:92:cc:00:00:00:02 | IEEE 802.15.4 | 121 | Ack, Dst: 14:15:92:cc:00:00:00:02 |
| 111 | 34.292680000 | bbbb::1415:92cc:0:5 | ff02::2 | ICMPv6 | 175 | RPL Control (I |
| 112 | 34.443601000 | bbbb::1415:92cc:0:2 | ff02::2 | ICMPv6 | 175 | RPL Control (I |
| 113 | 34.499709000 | bbbb::1415:92cc:0:4 | ff02::2 | ICMPv6 | 175 | RPL Control (I |

Frame 93: 175 bytes on wire (1400 bits), 175 bytes captured (1400 bits) on interface 0

- Ethernet II, Src: 00:ff:11:35:f1:f0 (00:ff:11:35:f1:f0), Dst: 00:ff:10:35:f1:f0 (00:ff:10:35:f1:f0)
- Internet Protocol Version 6, Src: bbbb::1 (bbbb::1), Dst: bbbb::1 (bbbb::1)
- User Datagram Protocol, Src Port: 0 (0), Dst Port: zep (17754)
- ZigBee Encapsulation Protocol, Channel: 20, Length: 81
- IEEE 802.15.4 Data, Dst: Broadcast, Src: 14:15:92cc:00:0000:04
- 6LoWPAN
 - Internet Protocol Version 6, Src: bbbb::1415:92cc:0:4 (bbbb::1415:92cc:0:4), Dst: ff02::2 (ff02::2)
 - Internet Control Message Protocol v6
 - Type: RPL Control (155)
 - Code: 1 (DODAG Information Object)
 - Checksum: 0xe829 [correct]
 - RPLInstanceID: 0
 - Version: 0
 - Rank: 6
 - Flags: 0xb8
 - Destination Advertisement Trigger Sequence Number (DTSN): 51
 - Flags: 0x00
 - Reserved: 00
 - DODAGID: bbbb::1415:92cc:0:1 (bbbb::1415:92cc:0:1)

0000 00 ff 10 35 f1 f0 00 ff 11 35 f1 f0 86 dd 60 00 ...5... .5

0010 00 00 00 79 11 08 bb bb 00 00 00 00 00 00 00 ...y... ..

0020 00 00 00 00 00 01 bb bb 00 00 00 00 00 00 00

Frame (175 bytes) Decompressed 6LoWPAN IPHC (68 bytes)

Frame (frame), 175 bytes Packets: 201 · Displayed: 165 (82... Profile: Def

- de-facto network packet analyzer
- collection of protocol dissectors
 - IEEE802.15.4-2006
 - 6LoWPAN
 - RPL
 - CoAP
 - etc.
- open-source and extensible

Capturing from OpenWSN [Wireshark 1.10.8 (v1.10.8-2-g52a5244 from master-1.10)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: zep Expression... Clear Apply Save

| No. | Time | Source | Destination | Protocol | Length | Info |
|-----|--------------|-------------------------|-------------|---------------|--------|----------------|
| 137 | 41.594445000 | bbbb::1415:92cc:0:2 | ff02::2 | ICMPv6 | 175 | RPL Control (I |
| 138 | 41.644462000 | bbbb::1415:92cc:0:5 | ff02::2 | ICMPv6 | 175 | RPL Control (I |
| 140 | 41.934265000 | bbbb::1415:92cc:0:4 | ff02::2 | ICMPv6 | 175 | RPL Control (I |
| 142 | 42.340521000 | 14:15:92:cc:00:00:00:02 | Broadcast | IEEE 802.15.4 | 158 | Beacon, Dst: I |
| 144 | 43.932231000 | 14:15:92:cc:00:00:00:05 | Broadcast | IEEE 802.15.4 | 158 | Beacon, Dst: I |
| 145 | 44.561063000 | bbbb::1415:92cc:0:3 | ff02::2 | ICMPv6 | 175 | RPL Control (I |
| 146 | 44.810393000 | bbbb::1415:92cc:0:2 | ff02::2 | ICMPv6 | 175 | RPL Control (I |
| 147 | 44.863906000 | bbbb::1415:92cc:0:5 | ff02::2 | ICMPv6 | 175 | RPL Control (I |

Frame 142: 158 bytes on wire (1264 bits), 158 bytes captured (1264 bits) on interface 0

- Ethernet II, Src: 00:ff:11:35:f1:f0 (00:ff:11:35:f1:f0), Dst: 00:ff:10:35:f1:f0 (00:ff:10:35:f1:f0)
- Internet Protocol Version 6, Src: bbbb::1 (bbbb::1), Dst: bbbb::1 (bbbb::1)
- User Datagram Protocol, Src Port: 0 (0), Dst Port: zep (17754)
- ZigBee Encapsulation Protocol, Channel: 20, Length: 64
- IEEE 802.15.4 Beacon, Dst: Broadcast, Src: 14:15:92:cc:00:0000:02
 - Frame Control Field: Beacon (0xea40)
 - = Frame Type: Beacon (0x0000)
 - = Security Enabled: False
 - = Frame Pending: False
 - = Acknowledge Request: False
 - = Intra-PAN: True
 - = Destination Addressing Mode: Short/16-bit (0x0003)
 - ..10 = Frame Version: 2
 - 11.. = Source Addressing Mode: Long/64-bit (0x0003)
 - Sequence Number: 37
 - Destination PAN: 0xcaff
 - Destination: 0xffff
 - Extended Source: 14:15:92:cc:00:0000:02 (14:15:92:cc:00:00:00:02)
 - Superframe Specification
 - Pending Addresses: 6 Short and 0 Long
 - FCS: 0x14a0 (Correct)
 - Data (18 bytes)
 - Data: 0000e004000000e005000000e006000000e0
 - Length: 18]

0000 00 ff 10 35 f1 f0 00 ff 11 35 f1 f0 86 dd 60 00 ...5.... .5....`

0010 00 00 00 68 11 08 bb bb 00 00 00 00 00 00 00 ...h....

0020 00 00 00 00 00 01 bb bb 00 00 00 00 00 00 00

0030 00 00 00 00 00 01 00 00 45 5a 00 68 84 e5 45 58EZ.h..EX

0040 02 01 14 00 01 01 ff 01 01 01 01 01 01 01 02

0050 02 02 02 00 00 00 00 00 00 00 00 00 00 00 00

OpenWSN: <live capture in progress> File: C:... Packets: 709 · Displayed: 603 (85... Profile: Default

Missing:

- IEEE802.15.4e-2012, in particular Information Elements

Capturing from OpenWSN [Wireshark 1.10.8 (v1.10.8-2-g52a5244 from master-1.10)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: zep Expression... Clear Apply Save

| No. | Time | Source | Destination | Protocol | Length | Info |
|------|---------------|-------------------------|-------------------------|---------------|--------|------------------------------------|
| 2199 | 678.753390000 | 14:15:92:cc:00:00:00:02 | 14:15:92:cc:00:00:00:03 | IEEE 802.15.4 | 121 | Ack, Dst: 14:15:92:cc:00:00:00:03 |
| 2200 | 678.802544000 | fe80::1415:92cc:0:4 | fe80::1 | UDP | 153 | Source port: 17754 |
| 2201 | 678.809213000 | 14:15:92:cc:00:00:00:01 | 14:15:92:cc:00:00:00:02 | IEEE 802.15.4 | 121 | Ack, Dst: 14:15:92:cc:00:00:00:02 |
| 2202 | 678.818048000 | 14:15:92:cc:00:00:00:04 | 14:15:92:cc:00:00:00:03 | 6LoWPAN | 142 | Data, Dst: 14:15:92:cc:00:00:00:03 |
| 2203 | 678.824516000 | 14:15:92:cc:00:00:00:03 | 14:15:92:cc:00:00:00:04 | IEEE 802.15.4 | 121 | Ack, Dst: 14:15:92:cc:00:00:00:04 |
| 2204 | 678.833466000 | 14:15:92:cc:00:00:00:03 | 14:15:92:cc:00:00:00:04 | IEEE 802.15.4 | 137 | Data, Dst: 14:15:92:cc:00:00:00:04 |
| 2205 | 678.839892000 | 14:15:92:cc:00:00:00:04 | 14:15:92:cc:00:00:00:03 | IEEE 802.15.4 | 121 | Ack, Dst: 14:15:92:cc:00:00:00:03 |
| 2206 | 678.848925000 | 14:15:92:cc:00:00:00:03 | 14:15:92:cc:00:00:00:02 | IEEE 802.15.4 | 137 | Data, Dst: 14:15:92:cc:00:00:00:02 |
| 2207 | 678.855219000 | 14:15:92:cc:00:00:00:02 | 14:15:92:cc:00:00:00:03 | IEEE 802.15.4 | 121 | Ack, Dst: 14:15:92:cc:00:00:00:03 |

Frame 2204: 137 bytes on wire (1096 bits), 137 bytes captured (1096 bits) on interface 0

- Ethernet II, src: 00:ff:11:35:f1:f0 (00:ff:11:35:f1:f0), dst: 00:ff:10:35:f1:f0 (00:ff:10:35:f1:f0)
- Internet Protocol version 6, Src: bbbb::1 (bbbb::1), Dst: bbbb::1 (bbbb::1)
- User Datagram Protocol, Src Port: 0 (0), Dst Port: zep (17754)
- ZigBee Encapsulation Protocol, Channel: 20, Length: 43
- IEEE 802.15.4 Data, Dst: 14:15:92cc:00:0000:04, Src: 14:15:92cc:00:0000:03
 - Frame Control Field: Data (0xee61)
 -001 = Frame Type: Data (0x0001)
 -0... = Security Enabled: False
 -0.... = Frame Pending: False
 -1.... = Acknowledge Request: True
 -1... = Intra-PAN: True
 - 11... = Destination Addressing Mode: Long/64-bit (0x0003)
 - 110... = Frame Version: 2
 - 11... = Source Addressing Mode: Long/64-bit (0x0003)
 - Sequence Number: 116
 - Destination PAN: 0xcafe
 - Destination: 14:15:92cc:00:0000:04 (14:15:92:cc:00:00:00:04)
 - Extended Source: 14:15:92cc:00:0000:03 (14:15:92:cc:00:00:00:03)
 - FCS: 0x9002 (Correct)
 - Data (20 bytes)
 - Data: 4302820101840201018809010701030008000002 [Length: 20]

0000 00 ff 10 35 f1 f0 00 ff 11 35 f1 f0 86 dd 60 00 ...5.... .5....`

0010 00 00 00 53 11 08 bb bb 00 00 00 00 00 00 00 ...S....

0020 00 00 00 00 00 01 bb bb 00 00 00 00 00 00 00

0030 00 00 00 00 00 01 00 00 45 5a 00 53 90 f4 45 58

0040 02 01 14 00 01 01 ff 01 01 01 01 01 01 01 02

0050 02 02 02 00 00 00 00 00 00 00 00 00 00 00

OpenWSN: <live capture in progress> File: C:... Packets: 4195 · Displayed: 3524 (8... Profile: Default

Missing:

- 6TiSCH-specific packet formats

Goals

- Develop extra dissectors for:
 - IEEE802.15.4e-2012
 - 6TiSCH I-Ds
- Develop multi-channel sniffer
 - TSCH networks channel-hop on up to 16 frequencies
 - You need to listen to 16 frequencies at the same time

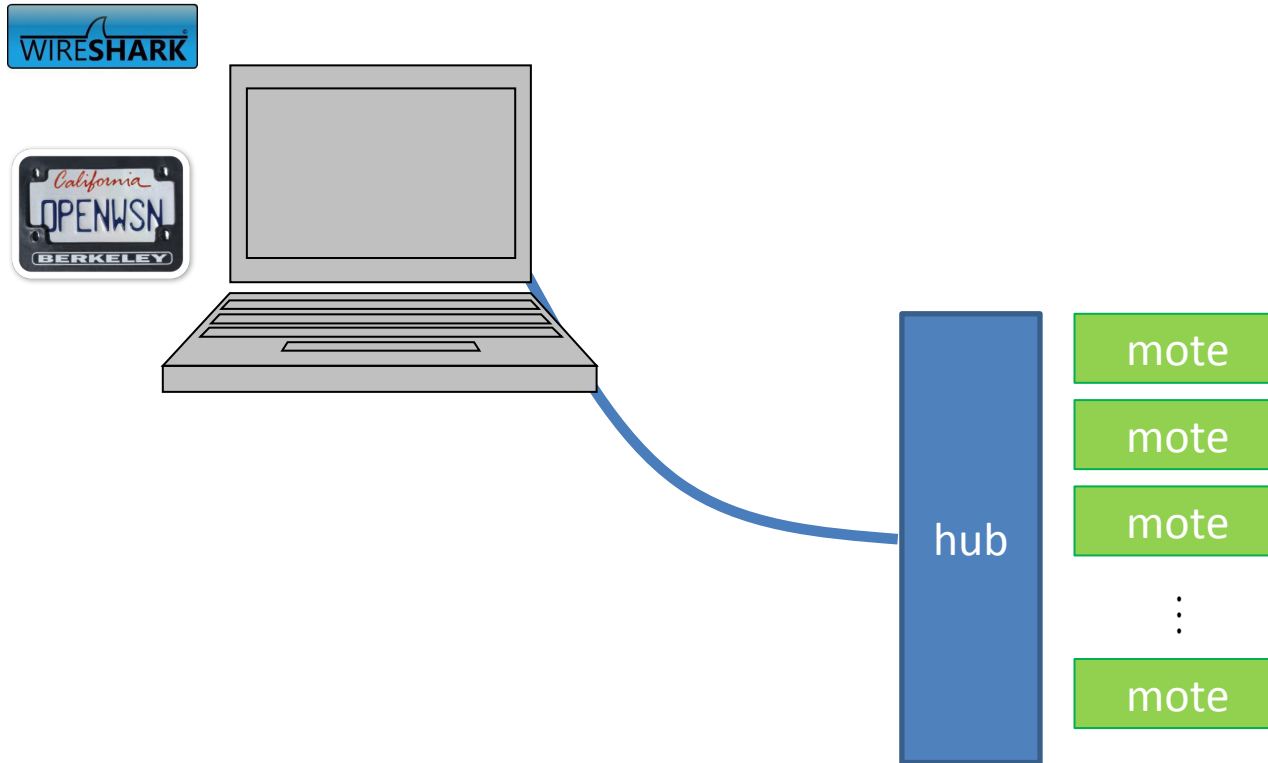
Status Dissector

- Work-in-Progress, help welcome!
- Based on previous work by Pieter de Mil
 - <https://github.com/pdemil/802154e-wireshark/>
- New development:
 - <https://github.com/VincentLadeveze/802154e-wireshark>
- Documentation:
 - <https://openwsn.atlassian.net/wiki/display/OW/Wireshark+dissector+development>

16-channel sniffer

- Idea! Help welcome
- Based on OpenWSN architecture:
 - Sniffer firmware
 - runs on all 12 platforms supported by OpenWSN
 - Connect 16 sniffer boards to OpenWSN
 - Typically over USB, or
 - Using OpenBase (Ethernet)
 - Start OpenVisualizer
 - configures the frequency of each board
 - Forwards the received packet to Wireshark

(Future) Final Solution



Volunteers?

Live demonstration of Sewio's open sniffer solution

Nestor Tiglao
nmctiglao@yahoo.com



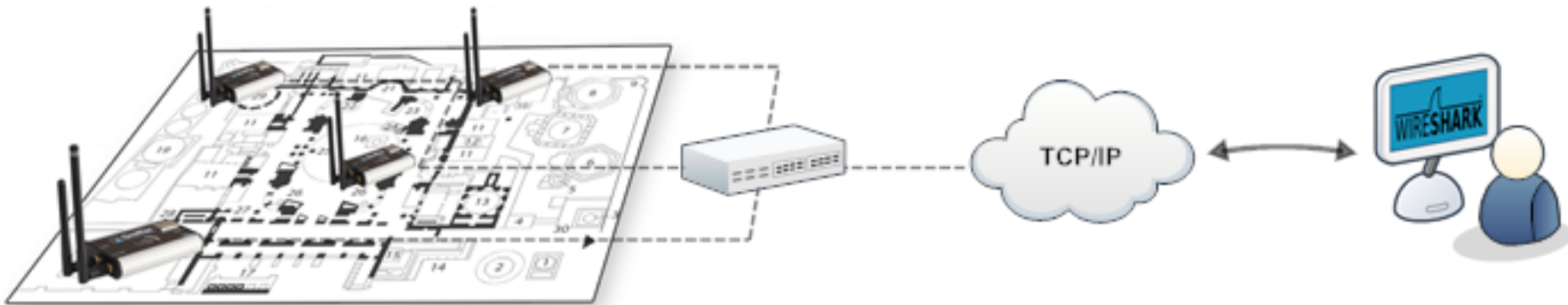
About Me

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- Current Project: WSN for Smart Grids
- 6lo and 6tisch WGs

Sewio Open Sniffer

- Fully open, Low-cost
- 802.15.4, Zigbee, 6LowPAN
- Multiplatform, multiband, time-precise (usec)
- Sniffing, Scanning, and Continuous Transmission capability
- <http://www.sewio.net/>



Work

- Transport Layer Optimization for Wireless Sensor Networks
 - Intermediate caching
 - Cross-layer Optimization
- Extension to Wireless Mesh Networks and Information-Centric Networking

Feedback and open discussion



Acknowledgements

We would like to thank authors of the ETSI CTI Plugtest draft 2012-02 that served as a guideline for this document. Thanks to Jari Arkko, Samita Chakrabarti, Oliver Hahm, Ulrich Herberg, Ted Lemon, Michael Richardson, Pascal Thubert and Thomas Watteyne, for their suggestions and helpful advice.

Thanks to Stephanie McCammon for her help in the organization of this event.

