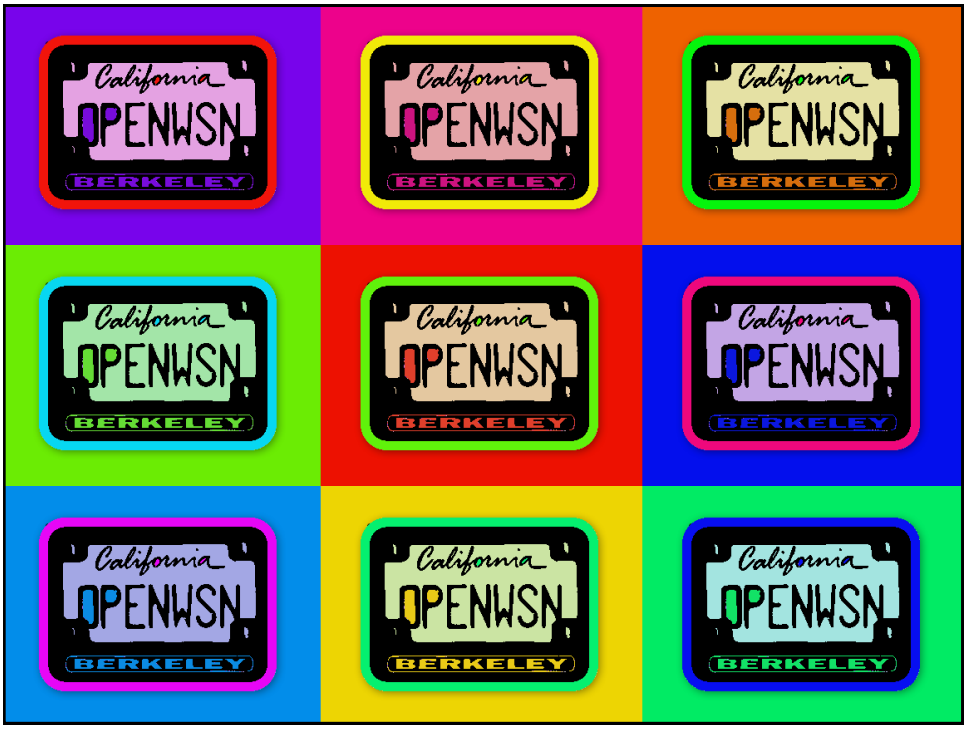


openmote
openhardwarefortheinternetofthings

Inria

UOC
Universitat Oberta de Catalunya

Introduction to the IETF 6TiSCH Stack with OpenWSN & OpenMote

Thomas Watteyne[1], **Xavier Vilajosana**[2], **Pere Tuset**[3], **Tengfei Chang**[1]

[1] Inria, France
[2] Universitat Oberta de Catalunya, Spain
[3] OpenMote Technologies, Spain

IEEE ICT, Thessaloniki, Greece, 16 May 2016

Goals

- Introduce you to the **context** of OpenWSN and OpenMote:
  the Internet of Important Things
- Why **OpenWSN** was born and what it is/does
- Why the **OpenMote** was created and what it is
- Give you a **hands-on tour** of OpenWSN running on the OpenMote
- Do a little **competition** to win an OpenMote kit

Grand Challenge

"A wireless network that performs like a wired network"

Determinism	**Manageability**	**Ease of use**
• <1ppm packet loss • <10ppm latency miss ratio • <100uA average current	• Flow isolation • Scheduling • Resource management	• Off-the-shelf hardware • No installation • No programming

Industry 4.0, "Factory of the Future", urban, building, environmental applications

Research Challenges
- What are the limits (throughput, latency, reliability, power consumption)?
- Which scheduling approach: Centralized? Distributed? Hybrid?
- etc, etc, etc…

emulation

open-source implementation

experimentation

simulation

standardization

Outline

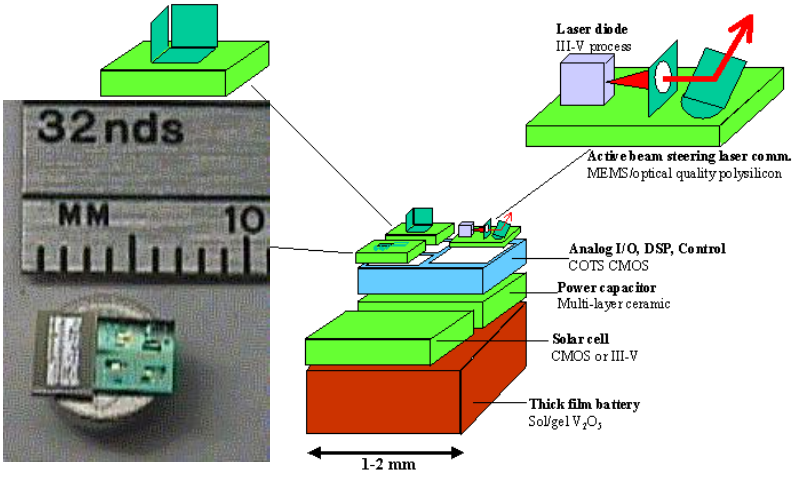
14.00
15.00
16.00
16.30
17.00
17.30
17.45

1. The Internet of (Important) Things
2. Overview of OpenWSN
3. Overview of the OpenMote
4. Hands-on tour
5. A little exercise
6. Q&A

Important!

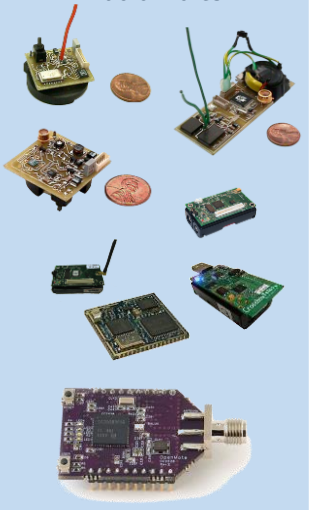
The Internet of Things

1997, the Smart Dust vision



Smart Dust

Macro motes



Easy to use efficient protocol stacks

TinyOS

blip

Contiki

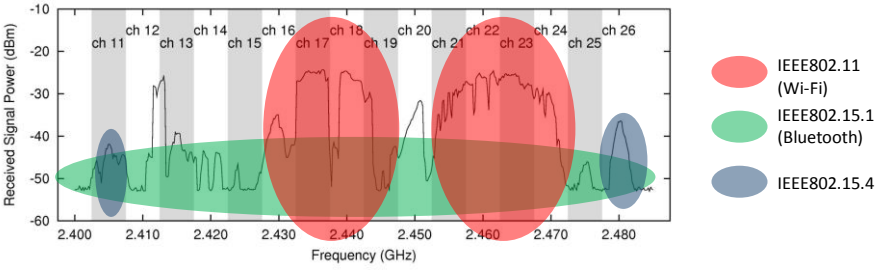
uIPv6

Performance?

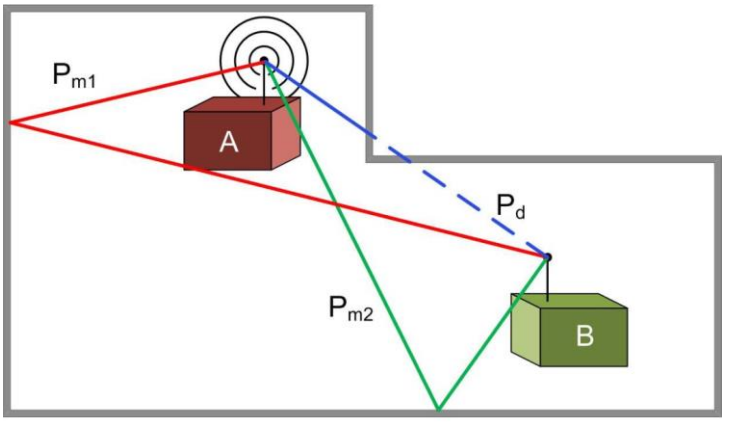
Reliability

Lifetime

First Challenge: External Interference

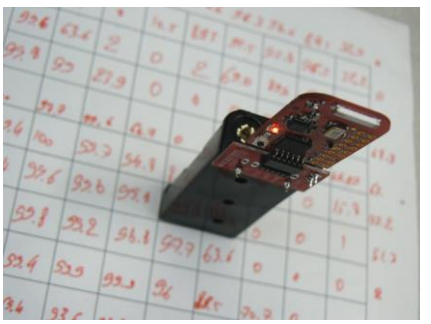


Second Challenge: Multipath Fading

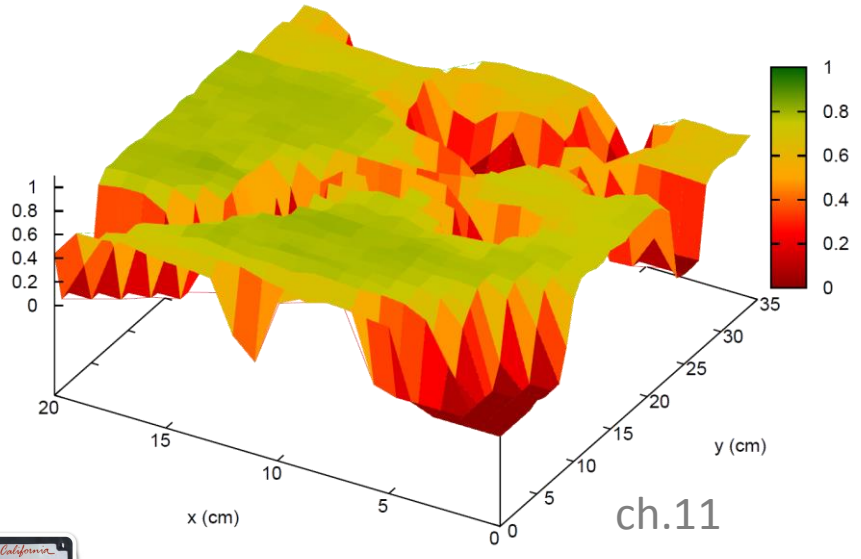


Second Challenge: Multipath Fading

- Separate sender and receiver by **100cm**
- Have sender send bursts of **1000 packets**
- Have receiver **count** the number of received packets
- **Move transmitter** around in a 20cmx35cm square and start over



Second Challenge: Multipath Fading

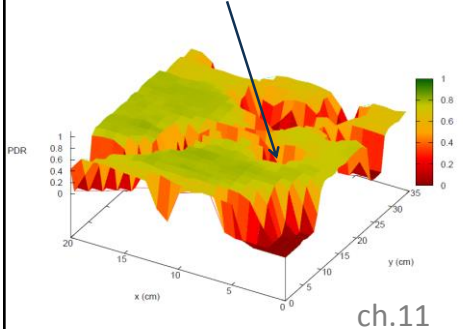


ch.11

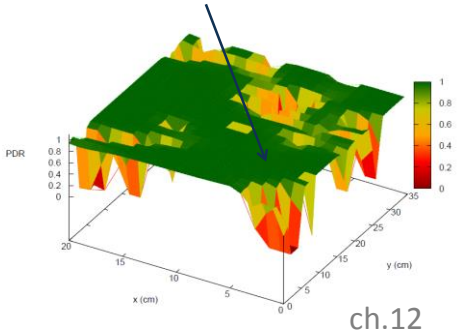
Second Challenge: Multipath Fading

0% reliability

100% reliability

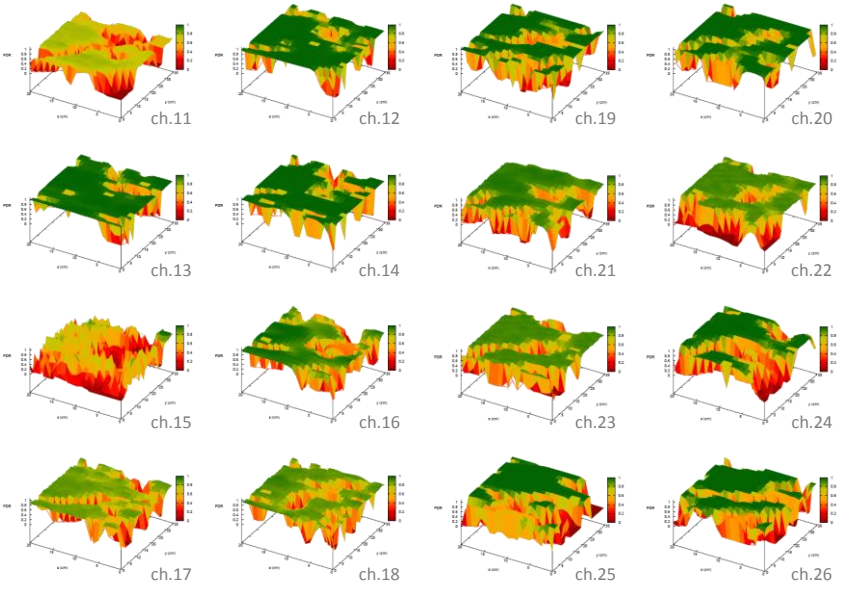


ch.11

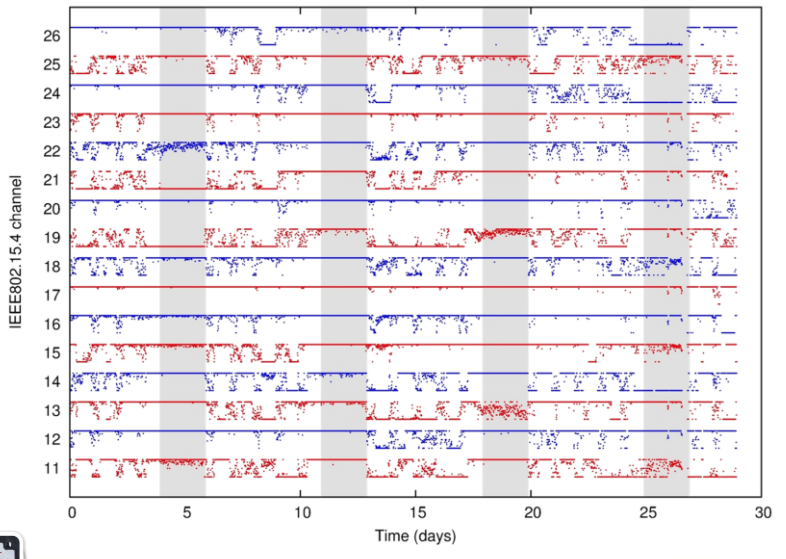


ch.12

Second Challenge: Multipath Fading



Second Challenge: Multipath Fading

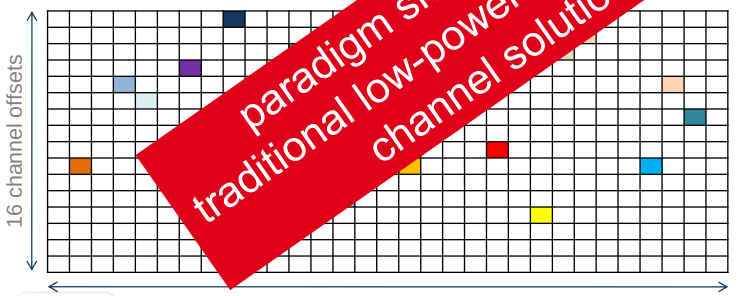


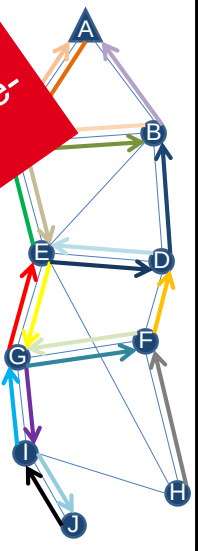
Time Synchronized Channel Hopping

- Motes are synchronized
- Communication follows a schedule
- Schedule gives tunable trade-off between
  - packets/second
  - latency
  - robustness

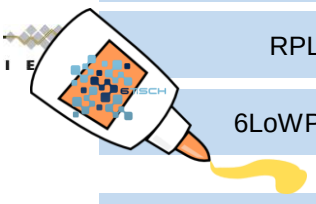
…and ener

paradigm shift compared to traditional low-power listening single-channel solutions!





We Want The Best of Both Worlds!



CoAP 2014

RPL 2012

6LoWPAN 2011

Ease-of-use of IPv6
- global addressing
- web-like interactions

IEEE

IEEE802.15.4e 2012
Time
Slotted
Channel
Hopping

Industrial Performance
- wire-like reliability
- "deploy and forget" lifetimes

IETF 6TiSCH

- created October 2013
- *IPv6 over the TSCH mode of IEEE 802.15.4e*
- 300+ members (mix between academic and non-academics)
- Face-to-face meetings at IETF86, IETF87, IETF88, IETF89, IETF90, IETF91, IETF92, IETF93, IETF94
- Over 100 meetings (incl. telcos)
- plugfests/interop:
  - IETF89, London, 2014
  - IETF90, Toronto, 2014
  - IETF93, Prague, 2015
  - **Paris, 2-4 Feb 2016**

ETSI 6TiSCH #2 interop event

17-18 July 2015, Prague
2-4 February 2016, Paris
July 2016, Berlin

organizer: ETSI

sponsors: openmote, Inria

Preparation
- **OpenWSN** selected as **reference implementation**
- "Golden Device"

Participation and Tests
- 14 participating companies*
- test pairings, each 1:30 hours in duration
- 16 tests

Outcome
- 48 test sessions performed (60% of all combinations)
- 100% overall compliance!

* list of participants under NDA

Application Domains

Smart Factory

Control loops in a wireless process control network, in which high reliability and a fully deterministic behavior are required.

- Bounded latency
- Ultra-high reliability

Smart Building

Service Provider networks transporting data from different independent clients, and for which an operator needs flow isolation and traffic shaping.

- Flow isolation
- Traffic Engineering

Environmental Monitoring

Networks comprising energy harvesting nodes, which require an extremely low and predictable power consumption.

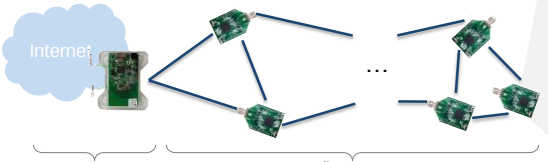
- Ultra low power operation
- Predictable battery lifetime

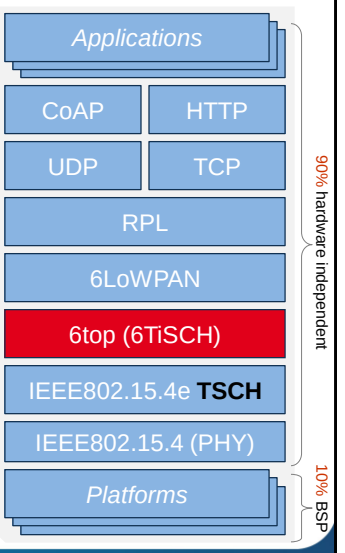
Flexibility & Customization

Overview of OpenWSN

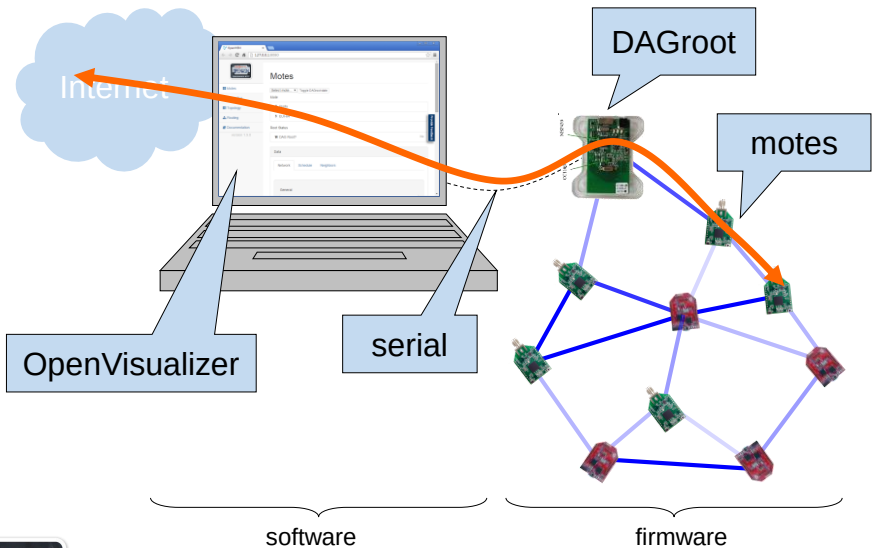
www.OpenWSN.org

- Open-source implementation of the state-of-the-art standardized protocol stack for the IoT
  - Running on 11 popular platforms
- Over 60 direct contributors, catalyst for research around TSCH networks
- State-of-the-art software project management tools: Atlassian, Jenkins, Travis-CI, GitHub, Doxygen
- Open-source (BSD license)

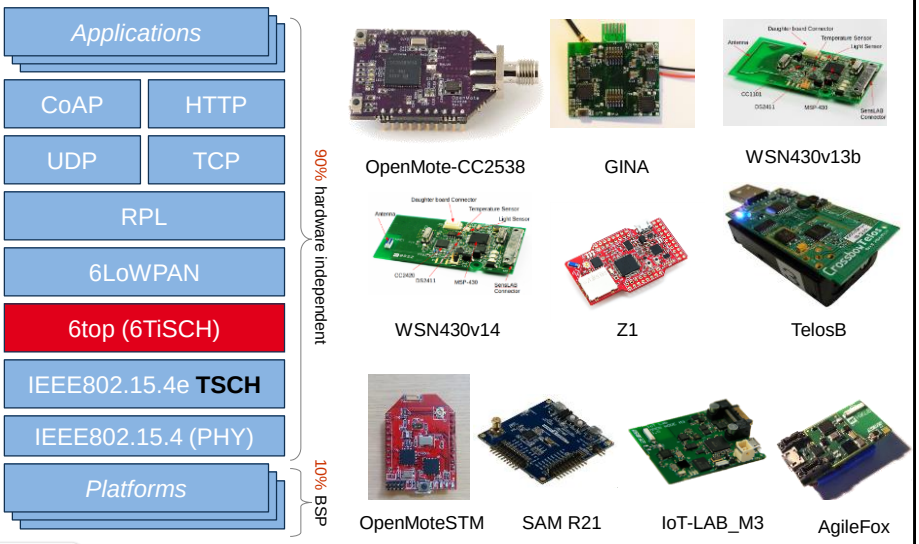




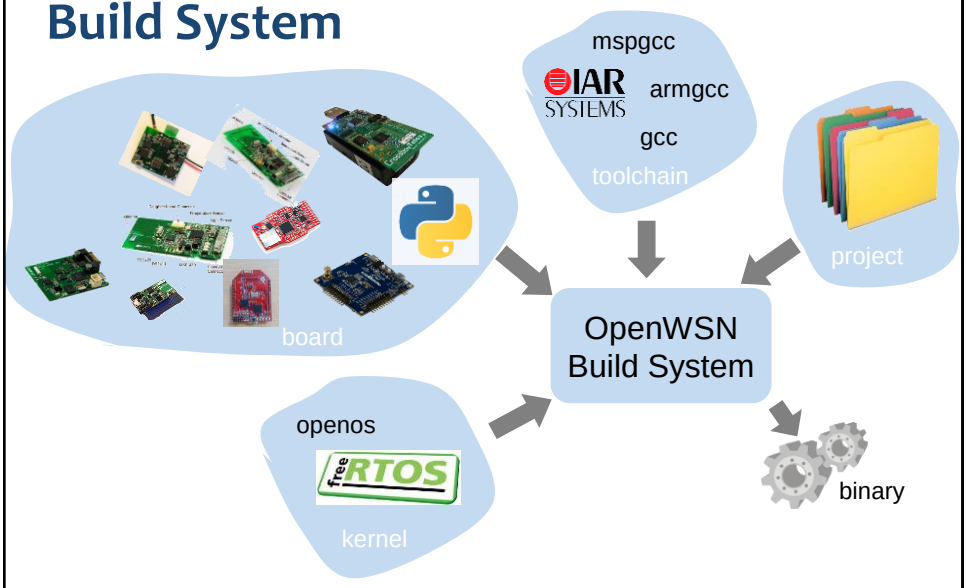
Architecture



www.OpenWSN.org

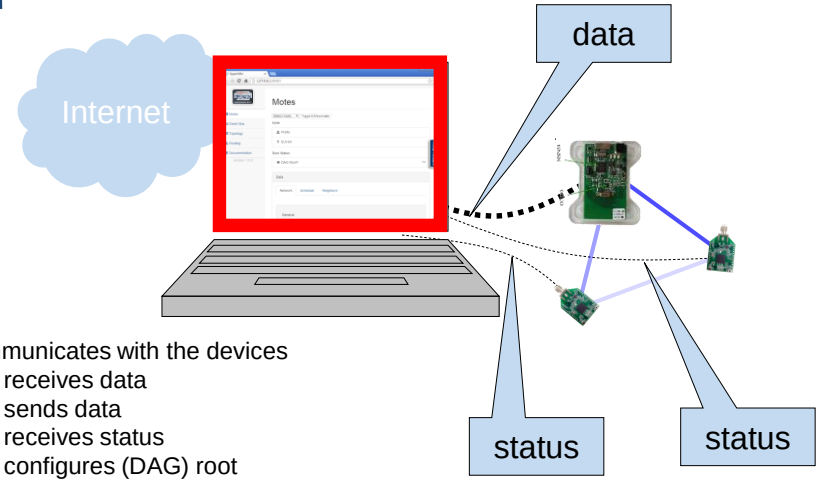


Build System

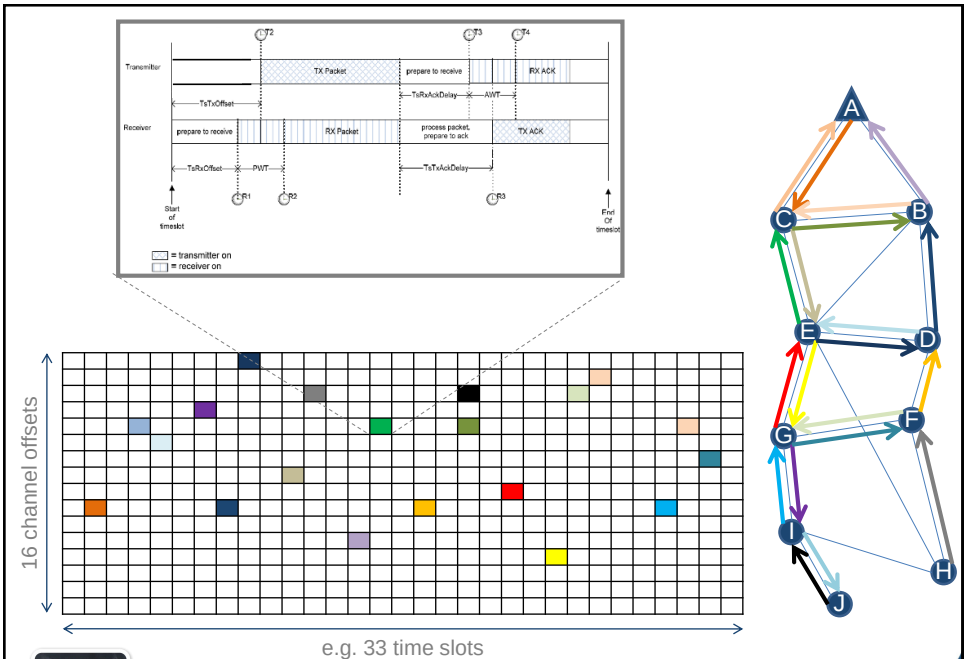



```
scons board=<board> toolchain=<toolchain> kernel=<kernel> <project>
```

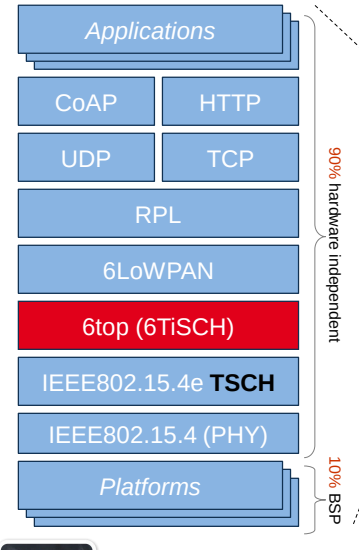
OpenVisualizer

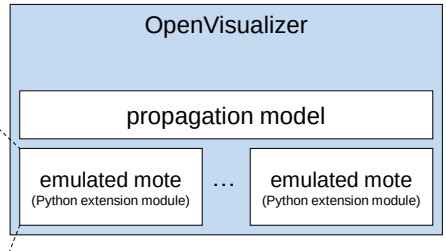


- communicates with the devices
  - receives data
  - sends data
  - receives status
  - configures (DAG) root
- 6LoWPAN/IPv6 compression
- RPL source route calculation
- written in Python



OpenSim Emulator



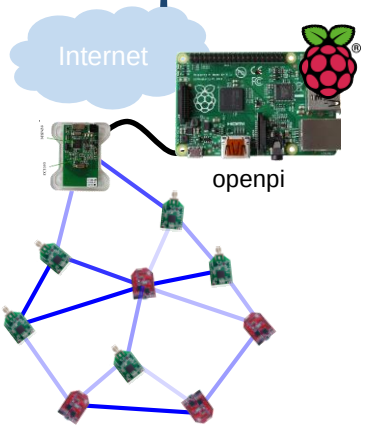


- same interface as real motes
- omniscient debugging:
  - see all packets (Wireshark)
  - see all pin activity (logic analyzer)
- models:
  - clock
  - propagation/topology

```
scons board=python toolchain=gcc oos_openwsn
```

```
openVisualizerWeb.py --sim --simCount=3
```

OpenPi



• OpenVisualizer pre-installed on Raspberry Pi image
• built nightly with latest OpenVisualizer

openpi.openwsn.org

OpenVM

• run with (free) VMware
• all toolchains pre-installed

openvm.openwsn.org

Collaboration Tools

source code
(GitHub)

Atlassian Confluence
documentation

Atlassian JIRA
ticketing

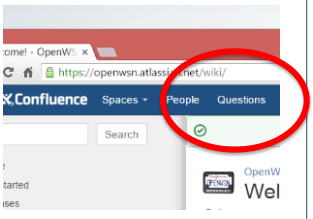
www.openwsn.org

continuous integration
(Travis-CI and Jenkins-CI)

Doxygen
source code documentation

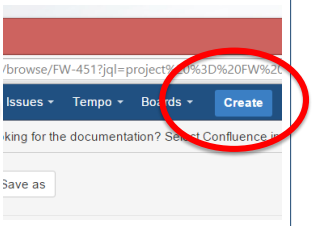
In Practice

Ask a Question



https://openwsn.atlassian.net/wiki/questions

Report a Bug



https://openwsn.atlassian.net

Contribute!

1. Clone
2. Create issue, assign to yourself
3. Fix, commit, push, create pull request
4. Mark issue as “resolved”
5. (We) merge and close issue

Atlassian Confluence

Atlassian JIRA

Overview of the OpenMote

TelosB, an old friend

MSP430f1611 (48 kB flash, 10 kB RAM)
CC2420 (IEEE 802.15.4 compliant)

Good

- Standalone
- Programmable
- Good operating system support
- Deployable
- Extension headers

Bad

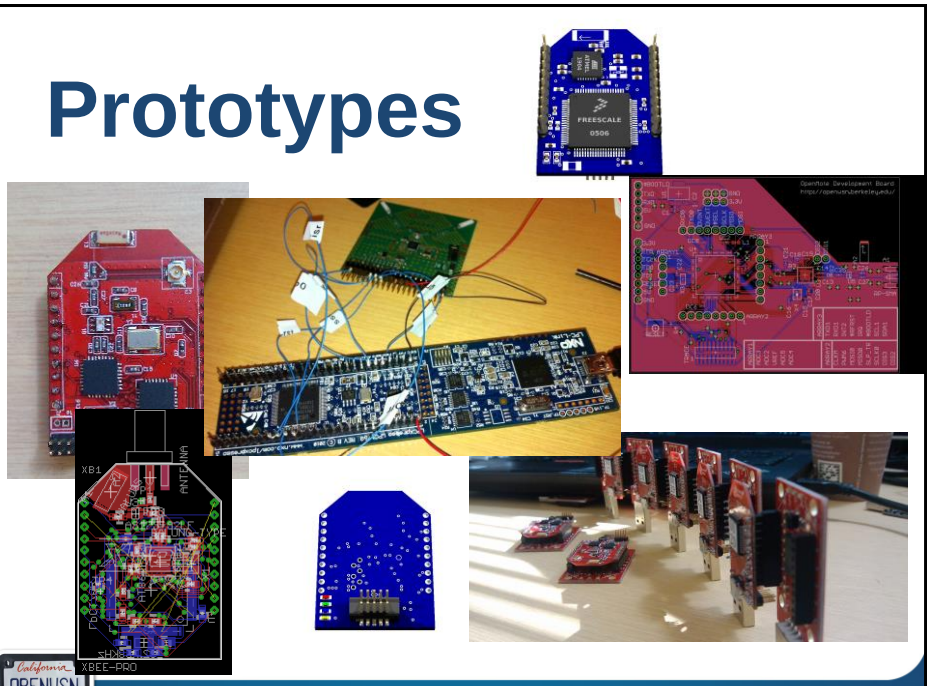
- Designed 09/24/2004…
- Outdated:
  - Little RAM
  - Little flash
  - Slow
  - Energy-Hungry
- Cannot be used as module

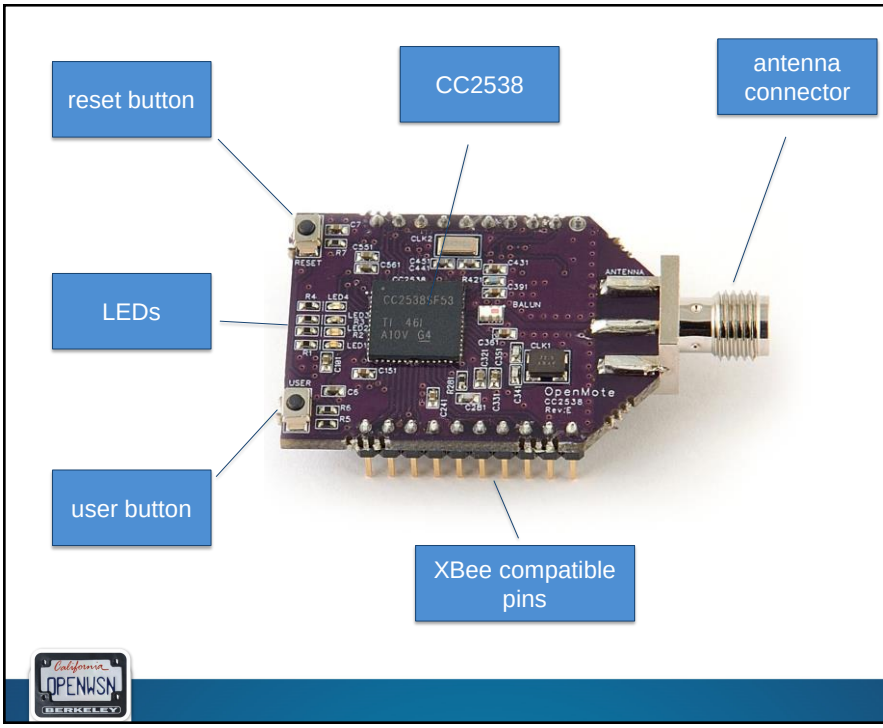
Idea…

Develop a modular platform which is as user friendly as the TelosB with updated hardware and software…

… and call it OpenMote.

Prototypes


FREESCALE
0506
ANTENNA
XB1
XBEE-PRO

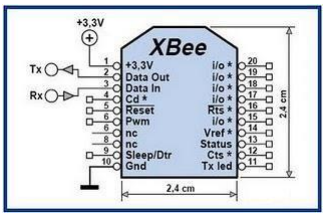

reset button
CC2538
antenna connector
LEDs
user button
XBee compatible pins
RESET
USER
ANTENNA
BALUN
OpenMote
CC2538
Rev:E

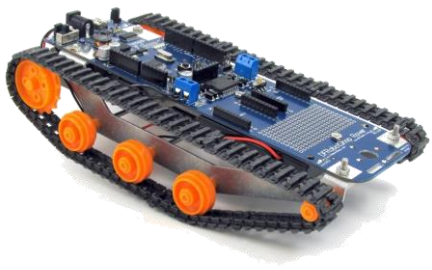
CC2538

- Texas Instruments, 2014
- True System-on-Chip
  - ARM Cortex M3 micro-controller
  - IEEE802.15.4 radio
  - Shared memory
- Up to date specs
  - 32 MHz max. CPU speed
  - 32 kB RAM
  - 512 kB flash
- Extensive peripherals
  - GPIO
  - ADC
  - SPI
  - I2C
  - UART
  - Timers

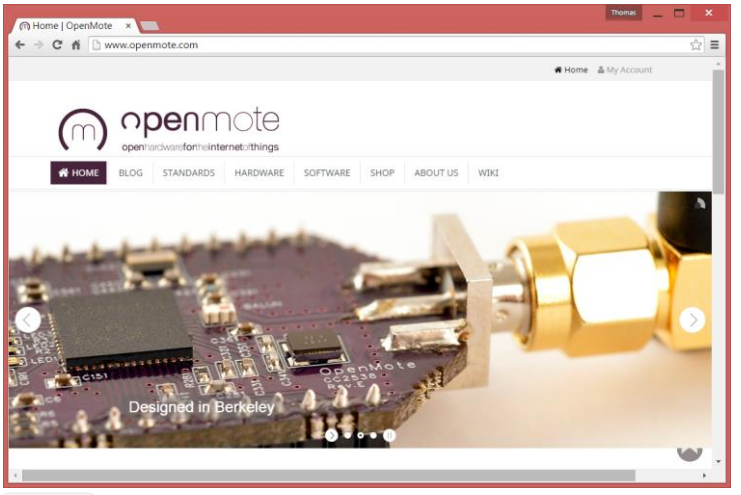
XBee form factor

- Well-established form factor
- “automatic” set of accessories





The OpenMote Company!



Xavi Vilajosana

Pere Tuset

OpenBattery

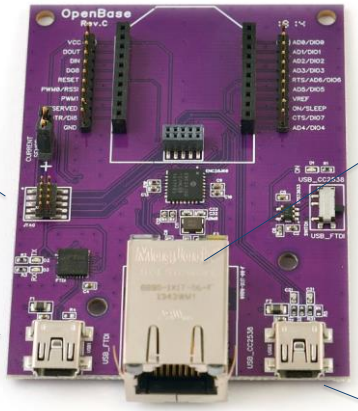
2*AAA battery holder

3-axis accelerometer (ADXL346)

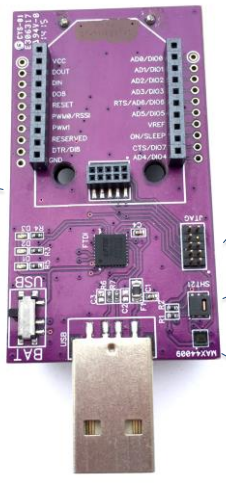
temperature+humidity (SHT21)

ambient light (MAX44009)

OpenBase



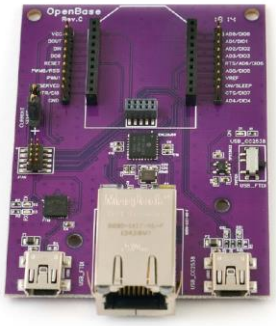
OpenUsb



OpenMote Ecosystem

OpenMote

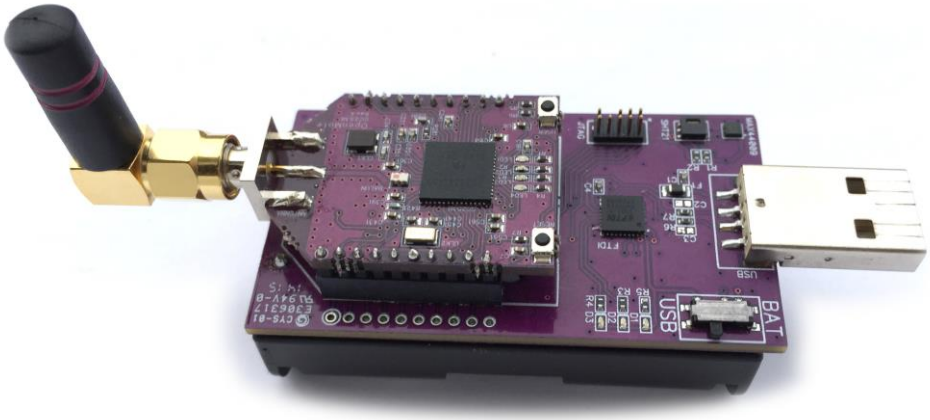
OpenBattery



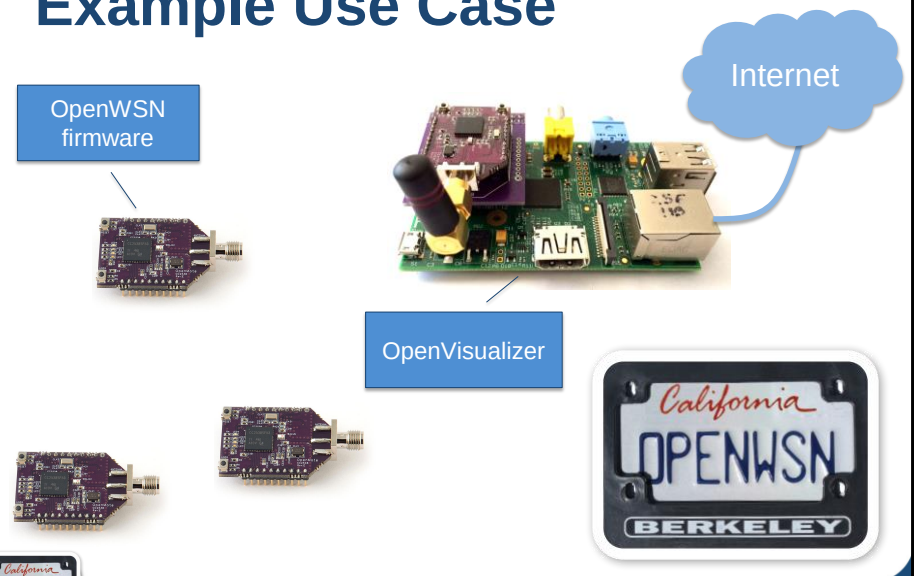
OpenBase

OpenUsb

Mission Accomplished ☺



Example Use Case



Thank you!

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openmote
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Inria

UOC
Universitat Oberta de Catalunya

Introduction to the IETF 6TiSCH Stack with
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[2] Universitat Oberta de Catalunya, Spain
[3] OpenMote Technologies, Spain

IEEE ICT, Thessaloniki, Greece, 16 May 2016