

Introduction to the IETF 6TiSCH Stack with OpenWSN & OpenMote

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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

- <1ppm packet loss
- <10ppm latency miss ratio
- <100uA average current

Manageability

- Flow isolation
- Scheduling
- Resource management

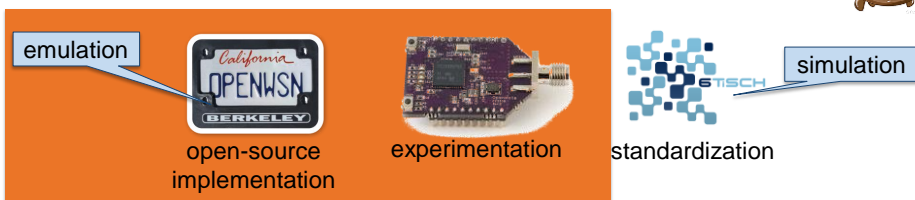
Ease of use

- 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...



Outline

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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

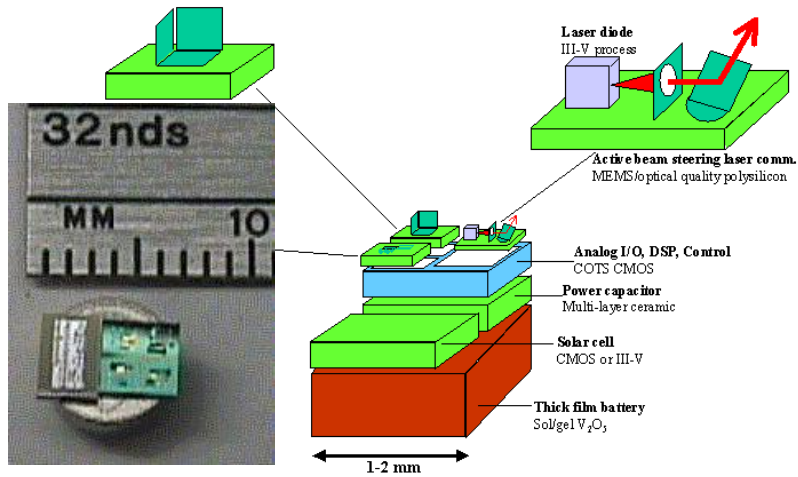


Important!

The Internet of Things

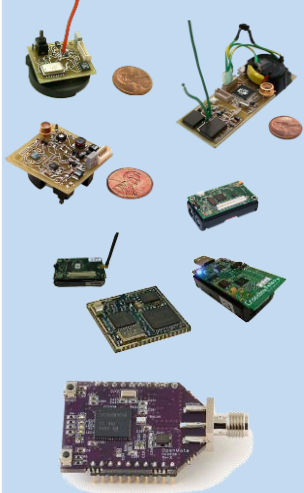


1997, the Smart Dust vision



Smart Dust

Macro motes



Easy to use efficient protocol stacks



Contiki
uIPv6



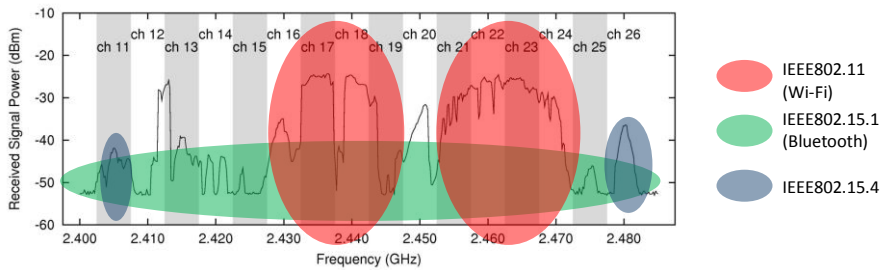
Performance?

Reliability

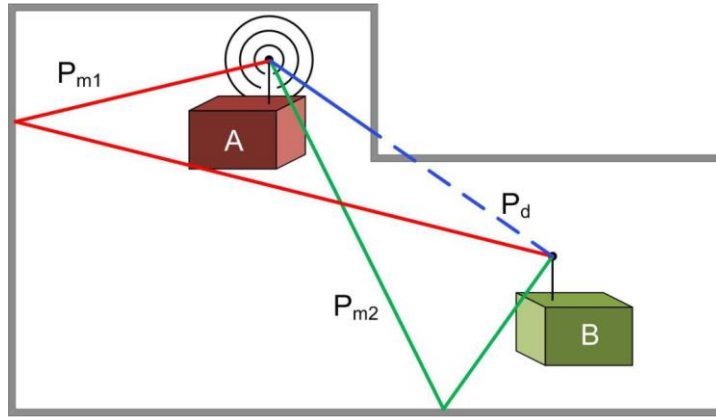
Lifetime



First Challenge: External Interference



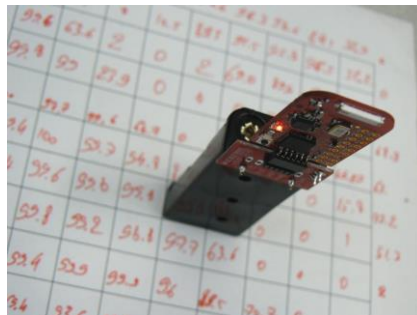
Second Challenge: Multipath Fading



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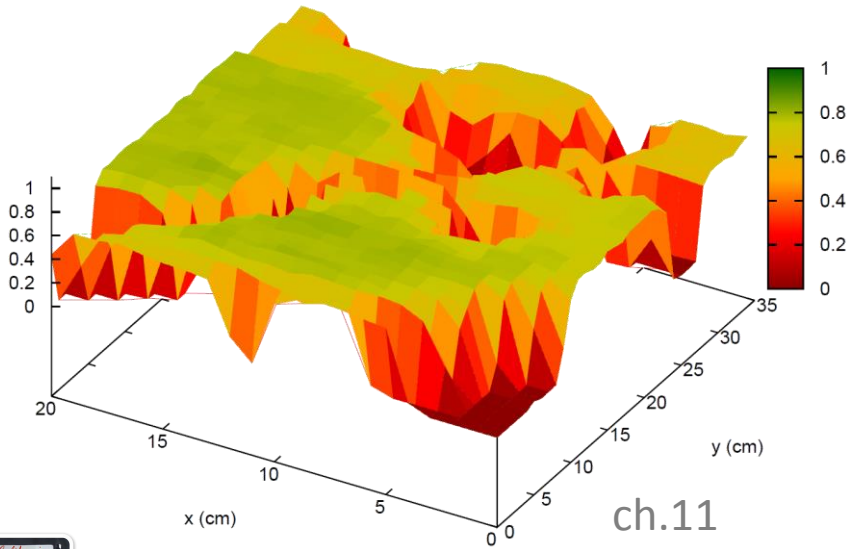
Second Challenge: Multipath Fading

- 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



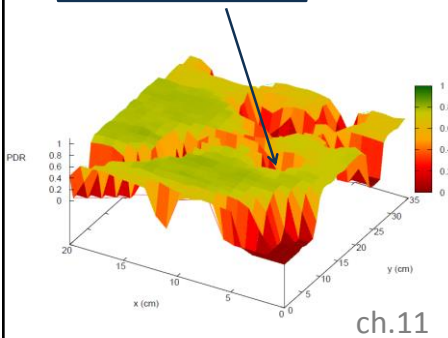
12

Second Challenge: Multipath Fading

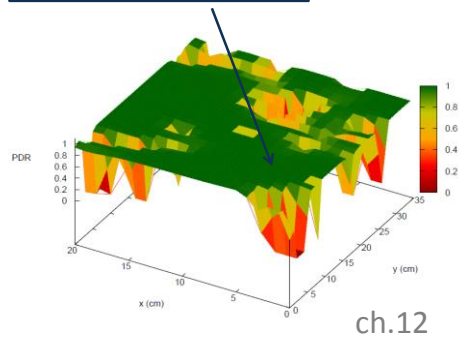


Second Challenge: Multipath Fading

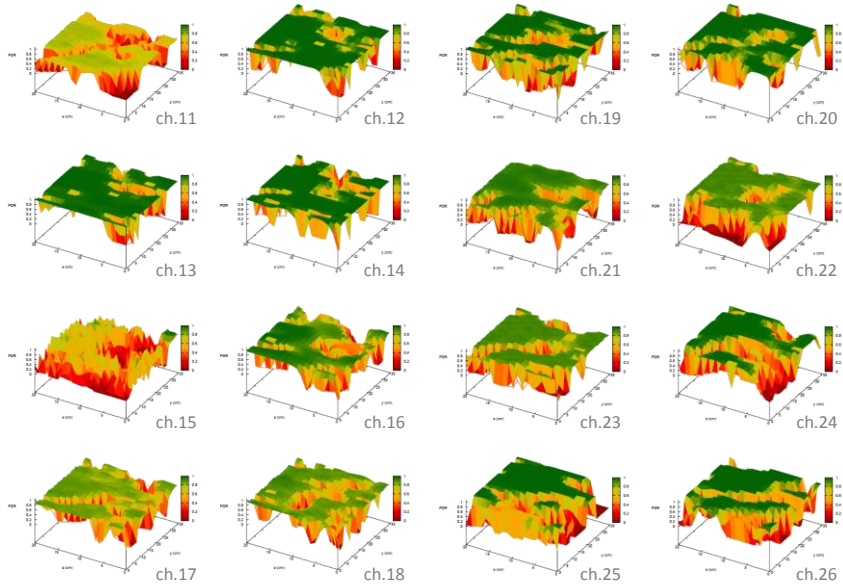
0% reliability



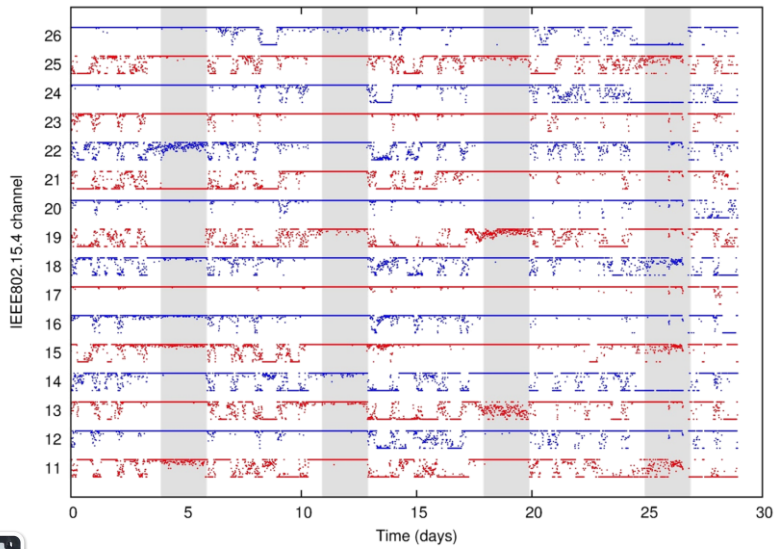
100% reliability



Second Challenge: Multipath Fading



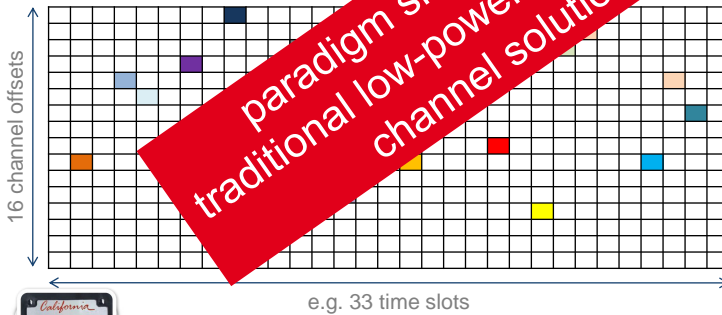
Second Challenge: Multipath Fading



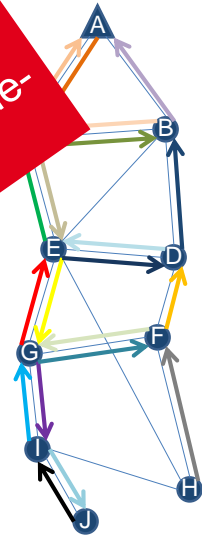
Time Synchronized Channel Hopping

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

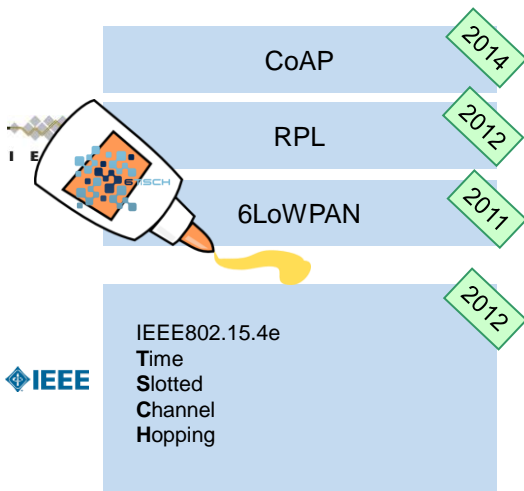
...and energy



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



We Want The Best of Both Worlds!



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

- 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**



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ETSI 6TiSCH #2 interop event

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

organizer: sponsors:



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



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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



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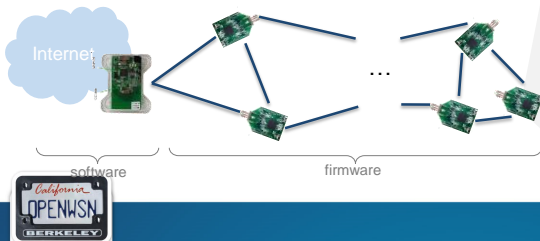
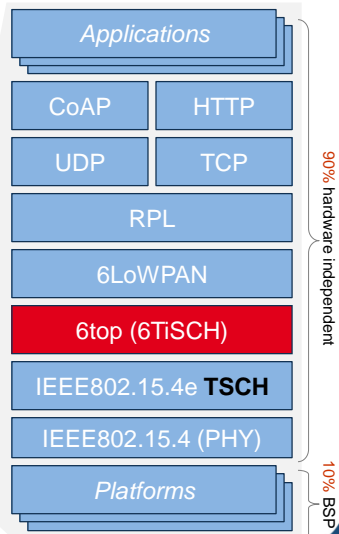
Overview of OpenWSN



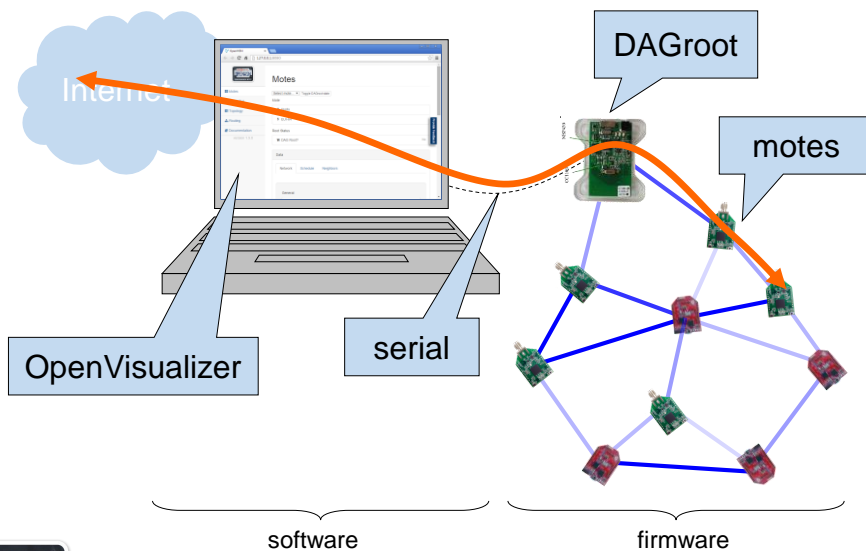
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www.OpenWSN.org

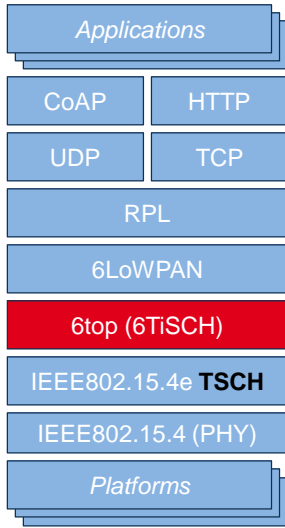
- Open-source implementation of the state-of-the-art standardized protocol stack for the IoT
 - Running on 11 popular platforms
- Over 60 direct contributors, catalyst for research around TSCH networks
- State-of-the-art software project management tools: Atlassian, Jenkins, Travis-CI, GitHub, Doxygen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



Architecture

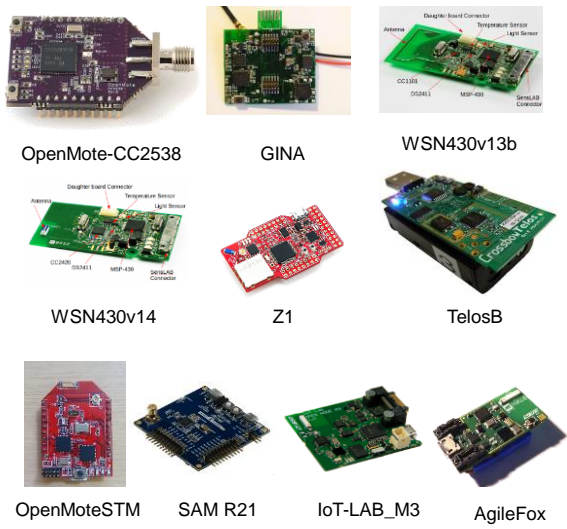


www.OpenWSN.org

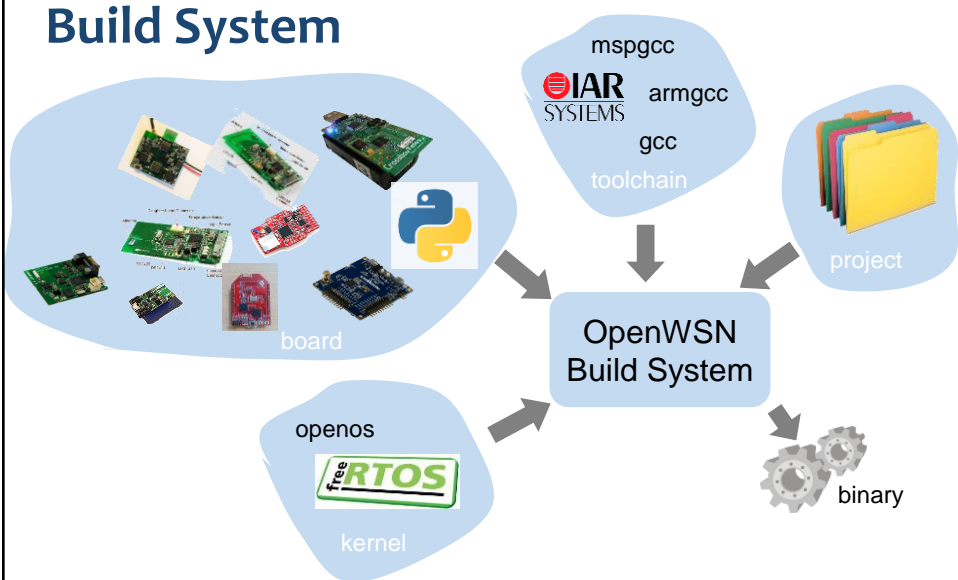


90% hardware independent

10% BSP



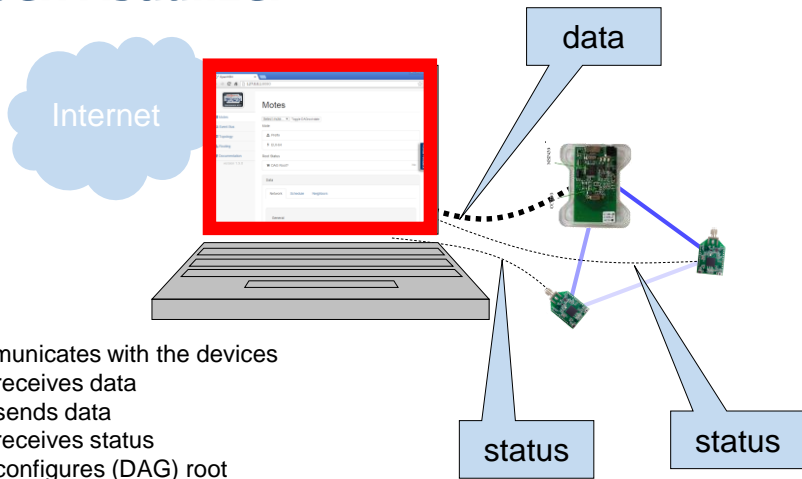
Build System



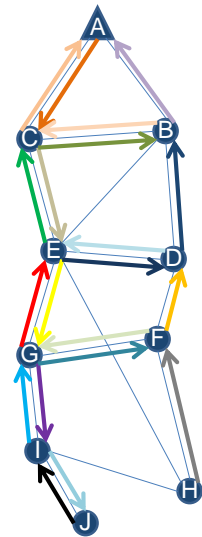
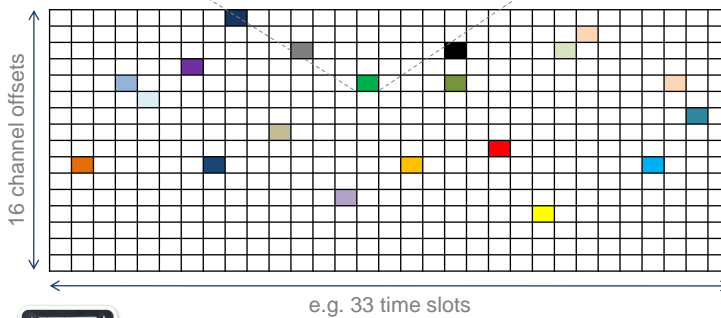
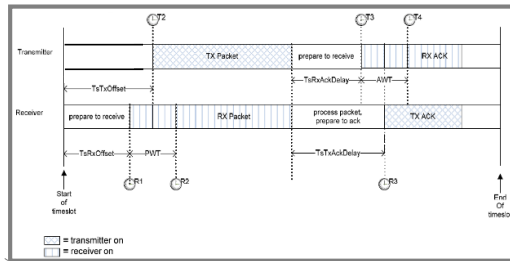
```
scons board=<board> toolchain=<toolchain> kernel=<kernel> <project>
```



OpenVisualizer

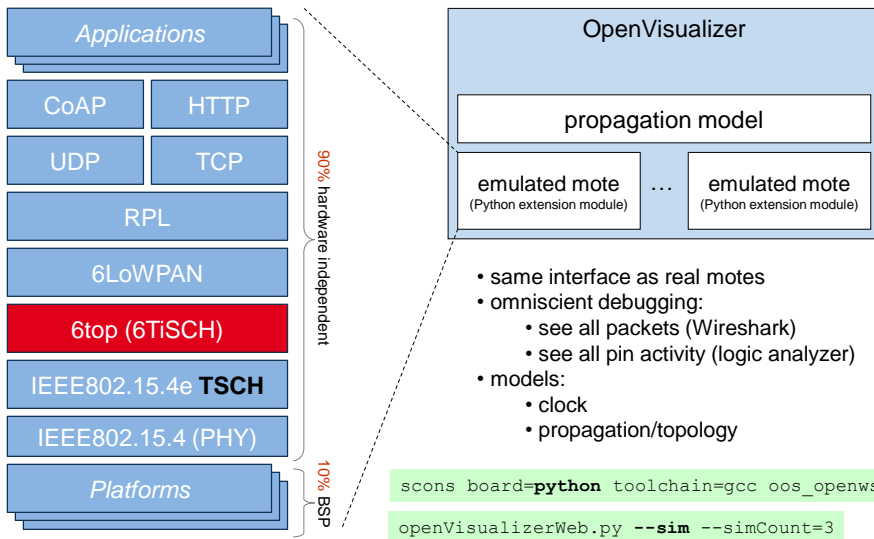


- communicates with the devices
 - receives data
 - sends data
 - receives status
 - configures (DAG) root
- 6LoWPAN/IPv6 compression
- RPL source route calculation
- written in Python

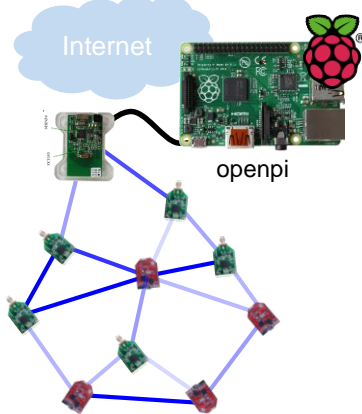




OpenSim Emulator



OpenPi



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

openpi.openwsn.org



OpenVM

vmware®

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

openvm.openwsn.org

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Collaboration Tools



source code
(GitHub)

Atlassian
Confluence
documentation

Atlassian
JIRA
ticketing

www.openwsn.org



continuous integration
(Travis-CI and Jenkins-CI)



Doxygen

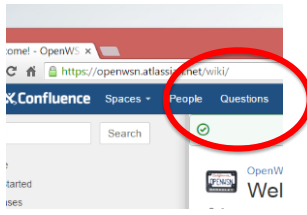
source code documentation



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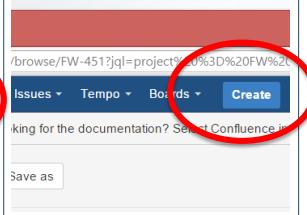
In Practice

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



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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



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Idea...

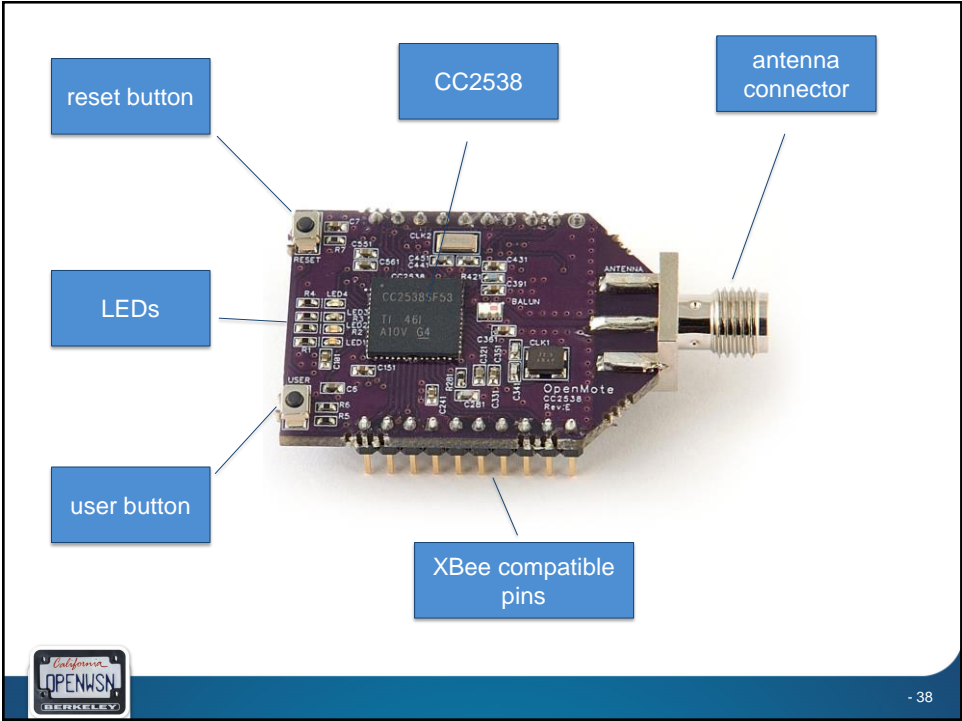
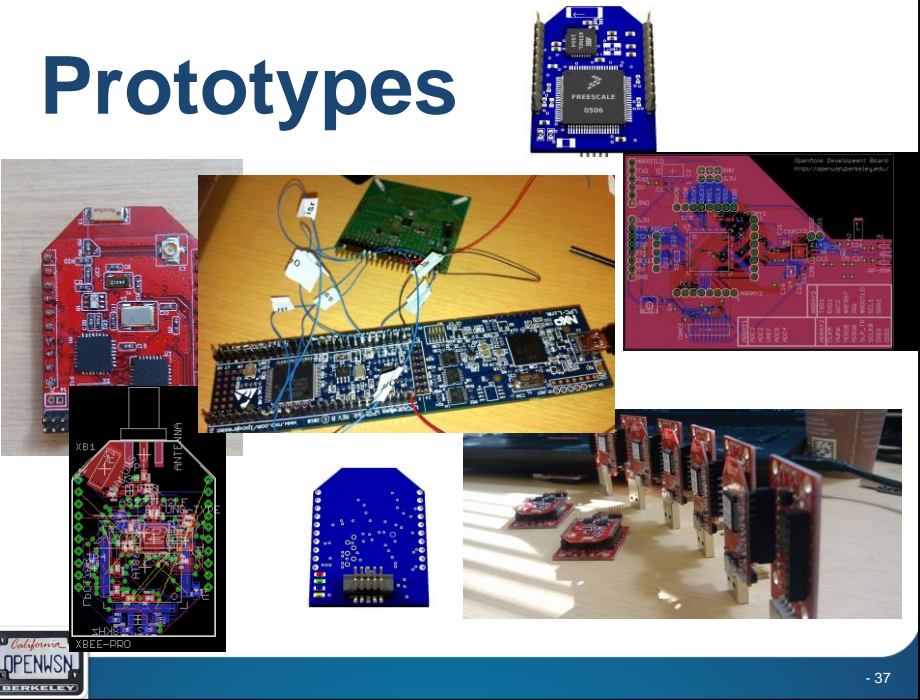
Develop a modular platform which is as user friendly as the TelosB with updated hardware and software...

... and call it OpenMote.



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Prototypes



CC2538



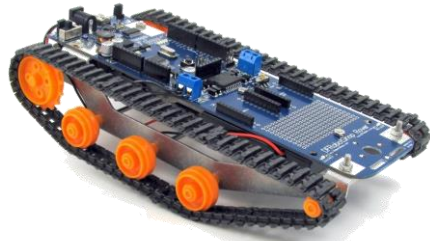
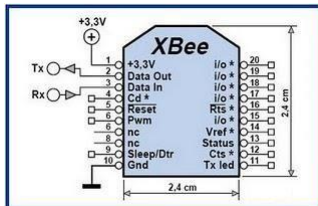
- Texas Instruments, 2014
- True System-on-Chip
 - ARM Cortex M3 micro-controller
 - IEEE802.15.4 radio
 - Shared memory
- Up to date specs
 - 32 MHz max. CPU speed
 - 32 kB RAM
 - 512 kB flash
- Extensive peripherals
 - GPIO
 - ADC
 - SPI
 - I2C
 - UART
 - Timers



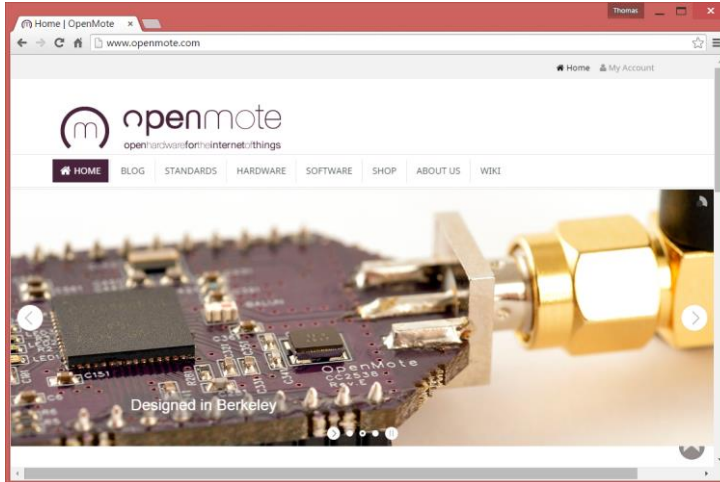
XBee form factor



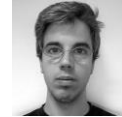
- Well-established form factor
- “automatic” set of accessories



The OpenMote Company!



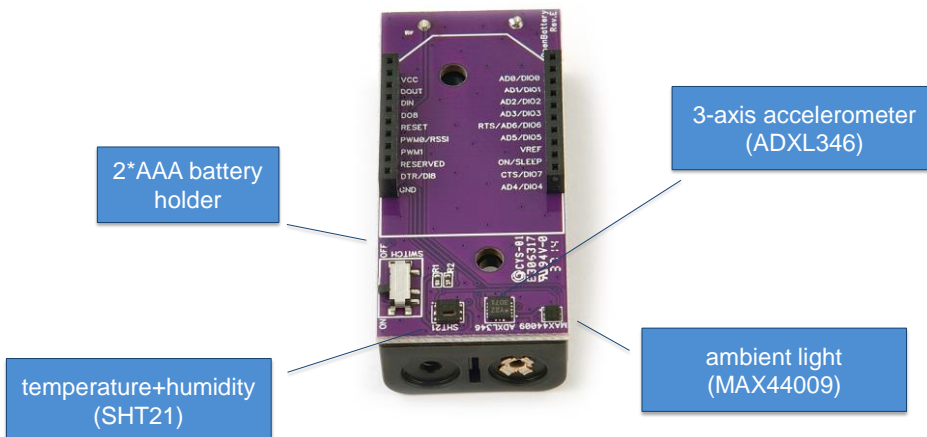
Xavi Vilajosana



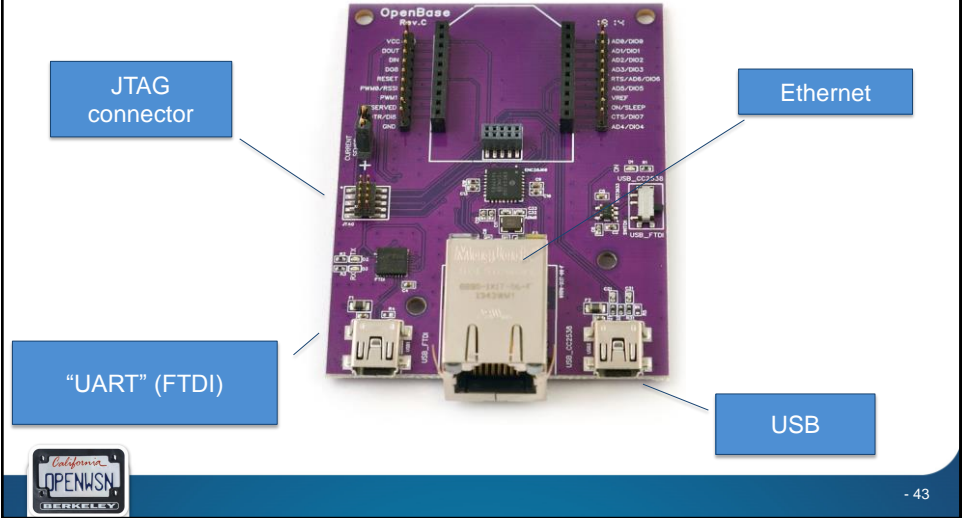
Pere Tuset



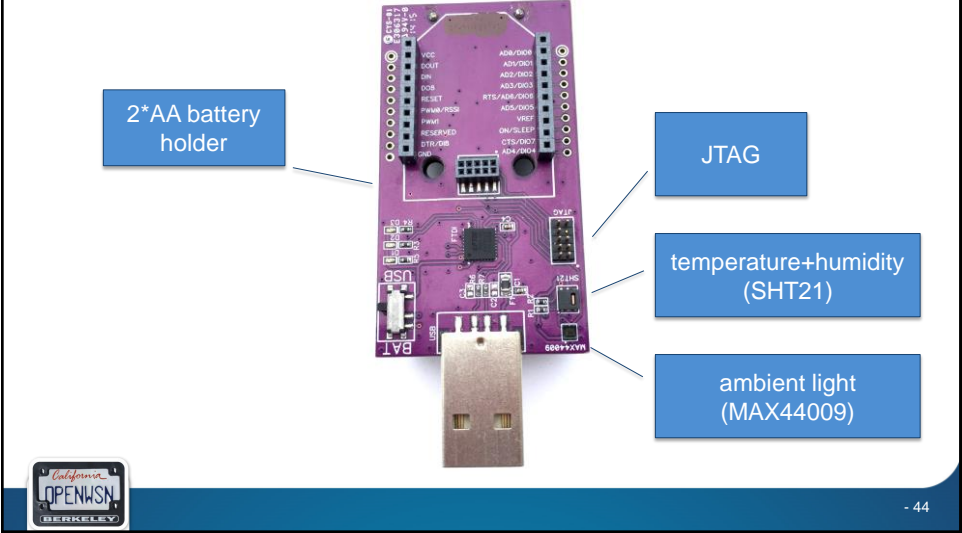
OpenBattery



OpenBase



OpenUsb



OpenMote Ecosystem



OpenMote

OpenBattery

OpenBase

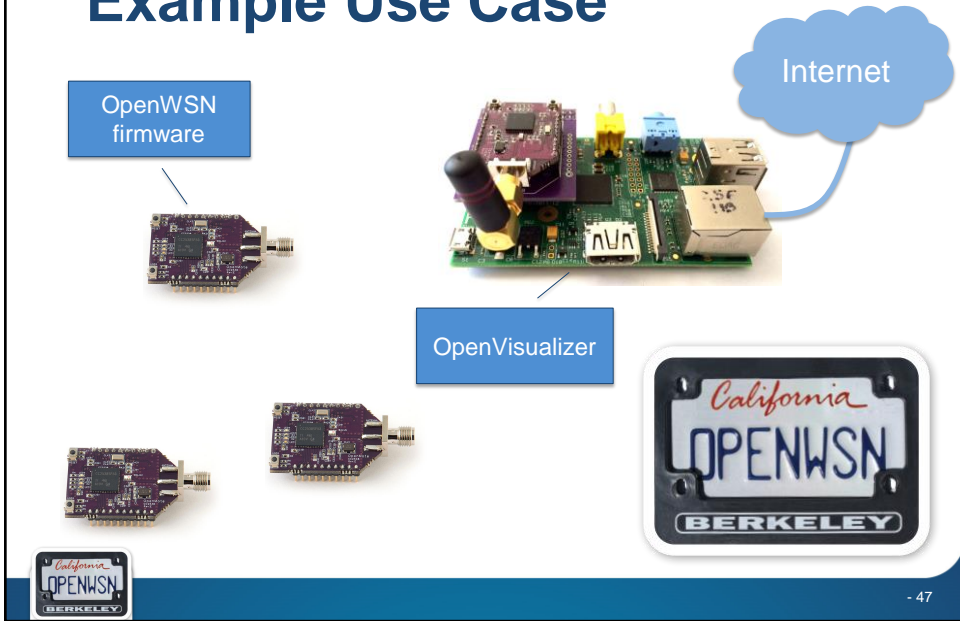
OpenUsb



Mission Accomplished 😊



Example Use Case



Thank you!



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www.openwsn.org



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