The friendly operating system for the IoT!

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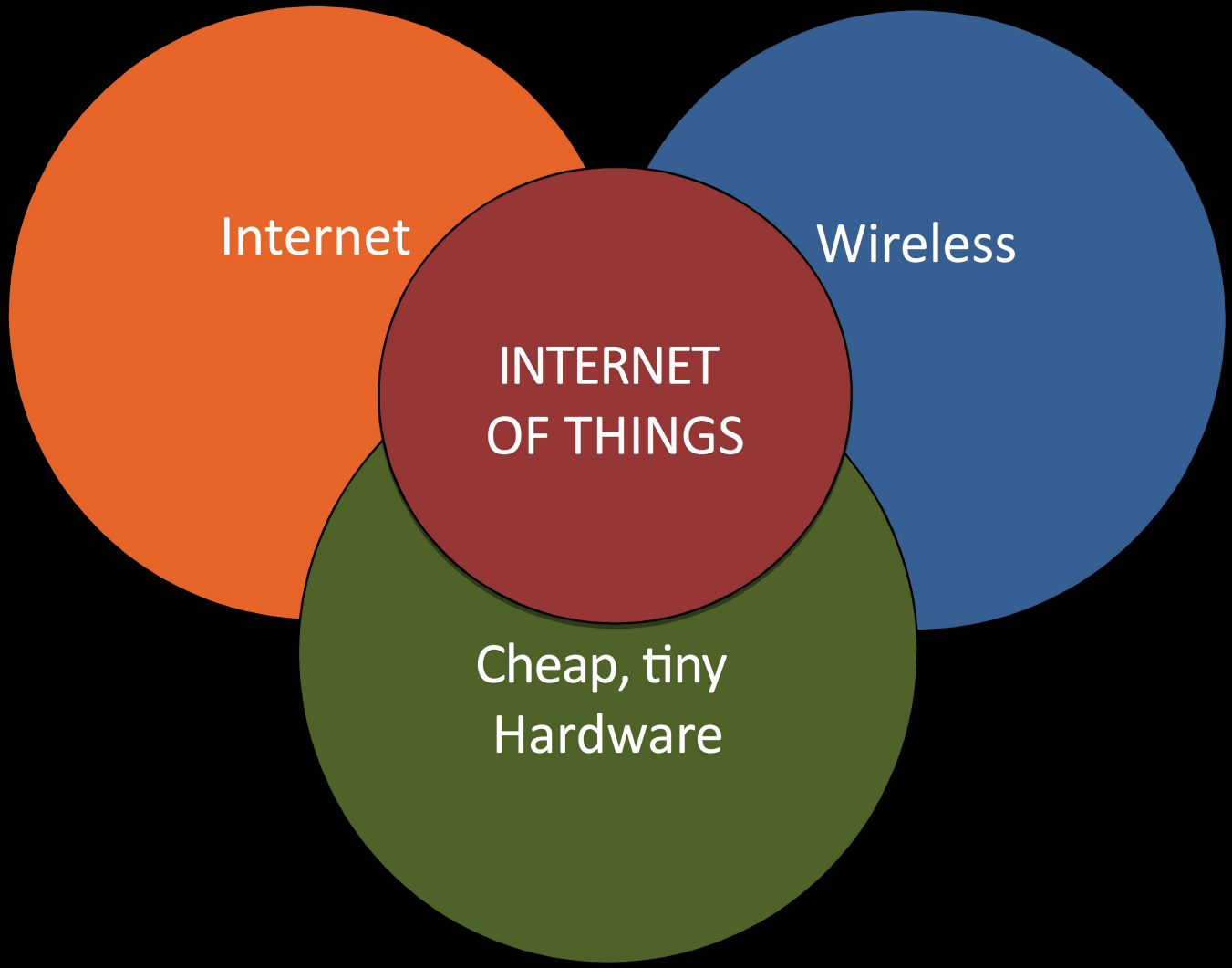
AGENDA

- Our vision of the IoT
- Wishlist for an IoT operating system
- RIOT specs
- Zoom on connectivity
- Zoom on portability
- RIOT as a platform for experiments
- Join the RIOT

RIOT

The Big Picture: a Giant Collision



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Our Vision of the IoT

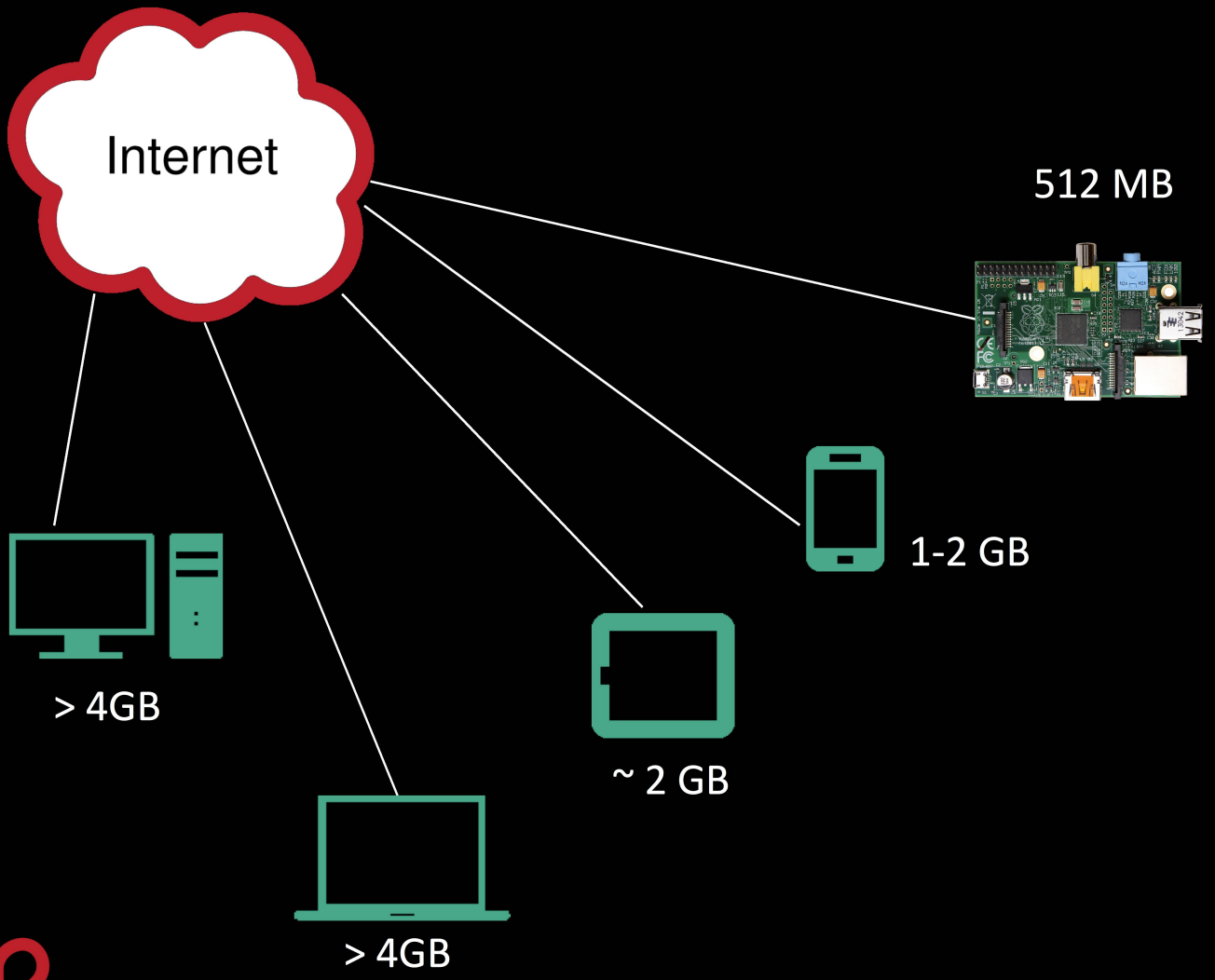
- A new world of interconnected hardware
- A new world at the application layer
- A new world in terms of user experience

➔ Physical Computing

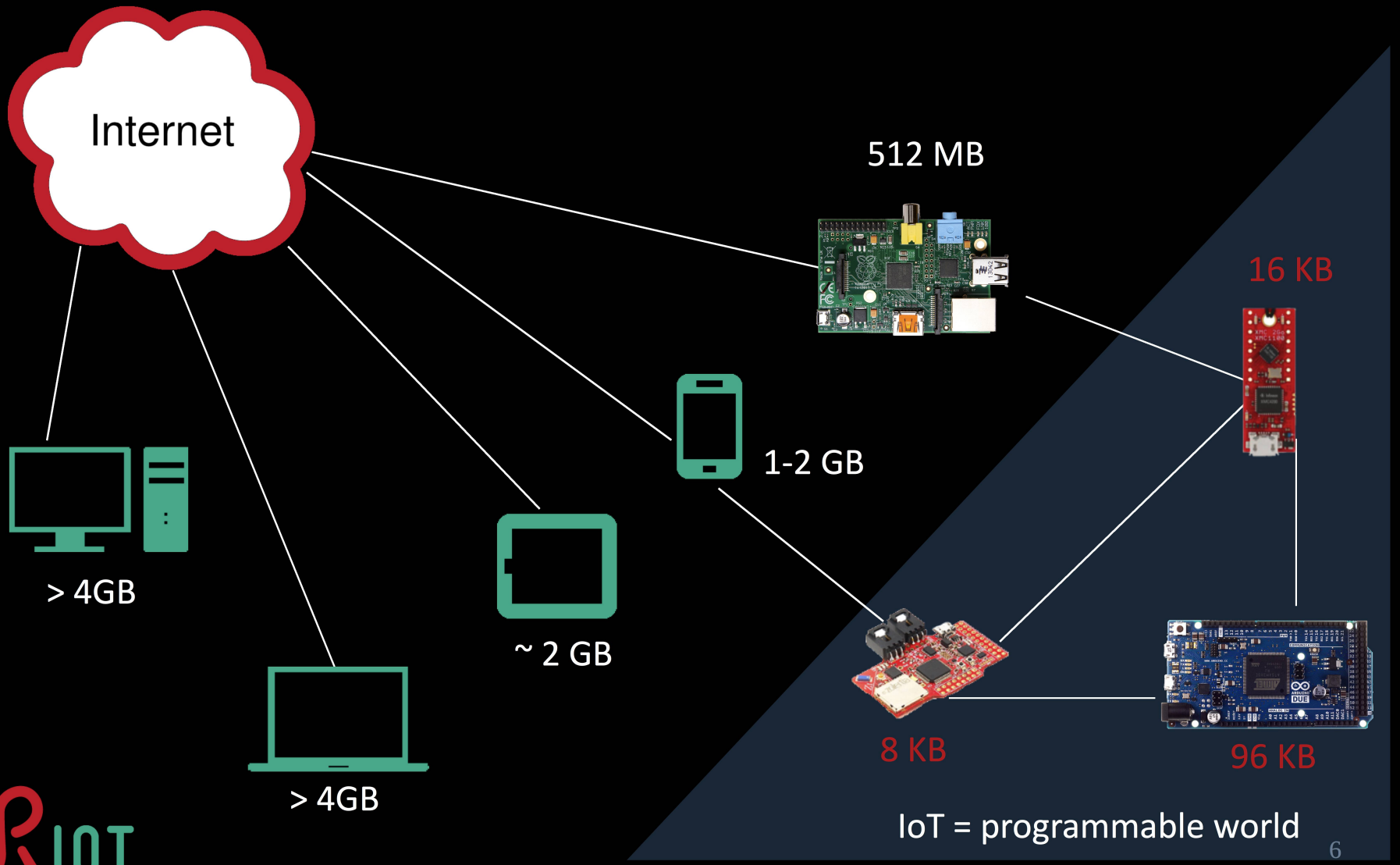
i.e. our interface to the Internet will no longer be predominantly a screen, a keyboard and/or a mouse

RIOT

The Internet



The Internet of Things

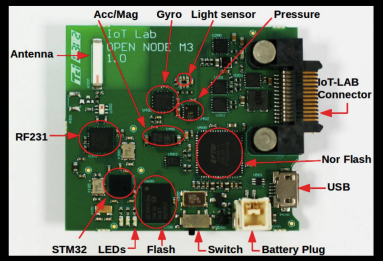


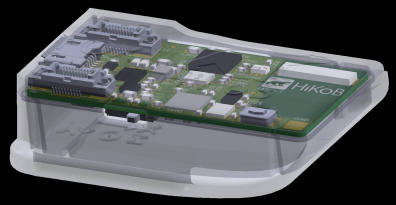
IoT: From the Hardware Perspective

- The IoT is already here
  - Tiny, cheap & exciting new devices pop up daily
  - Mostly equipped with Atmel AVR, TI MSP430, or increasing numbers of ARM Cortex-M MCUs
  - Typically running with a CPU frequency < 100MHz and less than 100 kB RAM

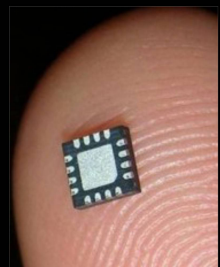
Arduino Uno board
8-bit Atmel AVR

TI eZ430 Chronos watch 16bit
MSP 430
sub-GHz radio





HiKoB boards
32bit ARM Cortex-M3
2.4 GHz radio



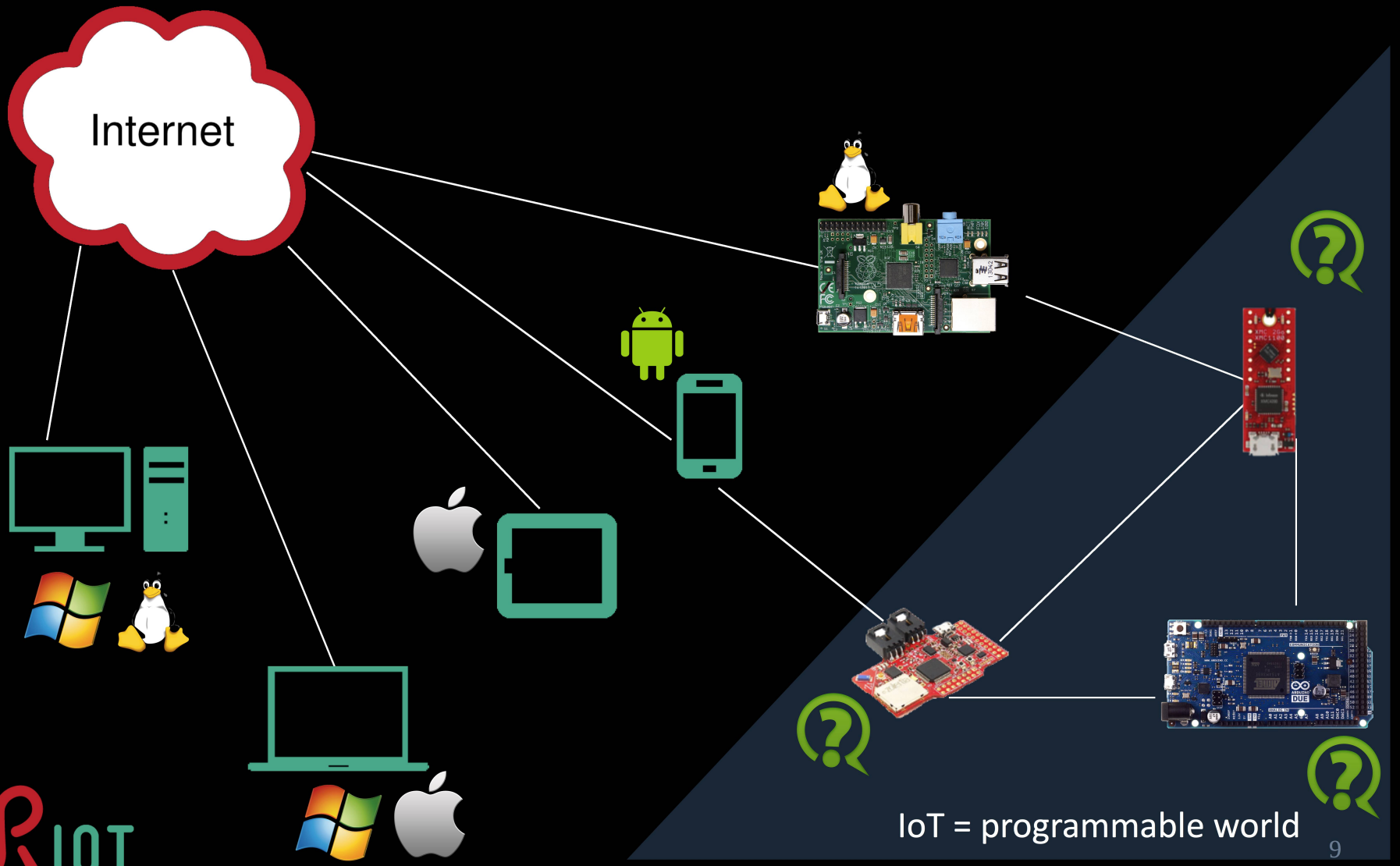
Smart Dust

But : No IoT Until…

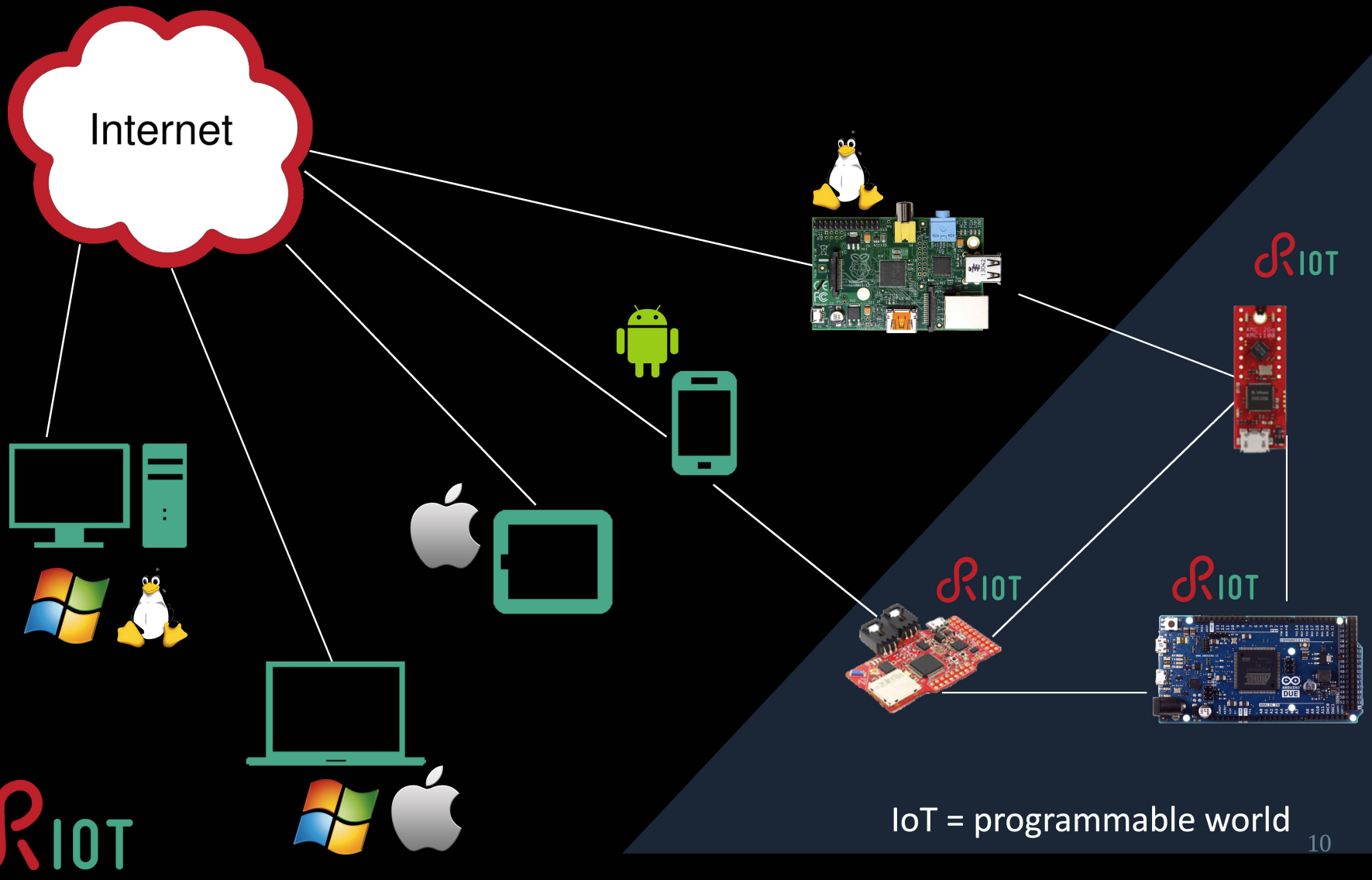
- … a software big-bang happens
  - Similar to mobile phone industry since 2007 with iOS and Android dominance
  - Must have : de facto standard OS, providing consistent API & SDK across-hardware platforms

RIOT

IoT: The Operating System Question



RIOT : The Friendly OS for the IoT



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Wishlist for an IoT Operating System

An operating system for the IoT should:

- Support heterogeneous hardware
- Have a low memory footprint
- Provide interoperability with the Internet
- Make applications portable

RIOT

Developing for the IoT

It should be easy to program, with support for:

- ✓ standard programming languages & techniques
- ✓ well known APIs (e.g. POSIX sockets)
- ✓ familiar debugging tools
- ✓ on-chip debugging capabilities
- ✓ comprehensive documentation

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Developing for the IoT

It should be secure & independent :

- open source
- vendor-independent
- cloud-independent
- architecture-independent (8-bit, 16-bit, 32-bit)

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Meet RIOT

- Free, open source (LGPLv2.1) operating system for IoT
  - Write your code in ANSI-C or C++
  - Compliant with the most widely used POSIX features like pthreads and sockets
  - No IoT hardware needed for development
    - Run & debug RIOT as native process in Linux

Valgrind

GDB
The GNU Project Debugger

RIOT

RIOT Specs

- Microkernel architecture (for robustness)
  - The kernel itself uses ~1.5K RAM @ 32-bit
- Tickless scheduler (for energy efficiency)
- Deterministic O(1) scheduling (for real-time)
- Low latency interrupt handling (for reactivity)
- Modular structure (for adaptivity)
- Preemptive multi-threading & powerful IPC

-- E. Baccelli, O. Hahm, M. Günes, M. Wählisch, T. Schmidt. RIOT OS: Towards an OS for the Internet of Things. In *The 32nd IEEE International Conference on Computer Communications (INFOCOM 2013)*.

-- H. Will, K. Schleiser, J. Schiller. A Real-Time Kernel for Wireless Sensor Networks Employed in Rescue Scenarios. In *The 34th IEEE Conference on Local Computer Networks (LCN 2009).*

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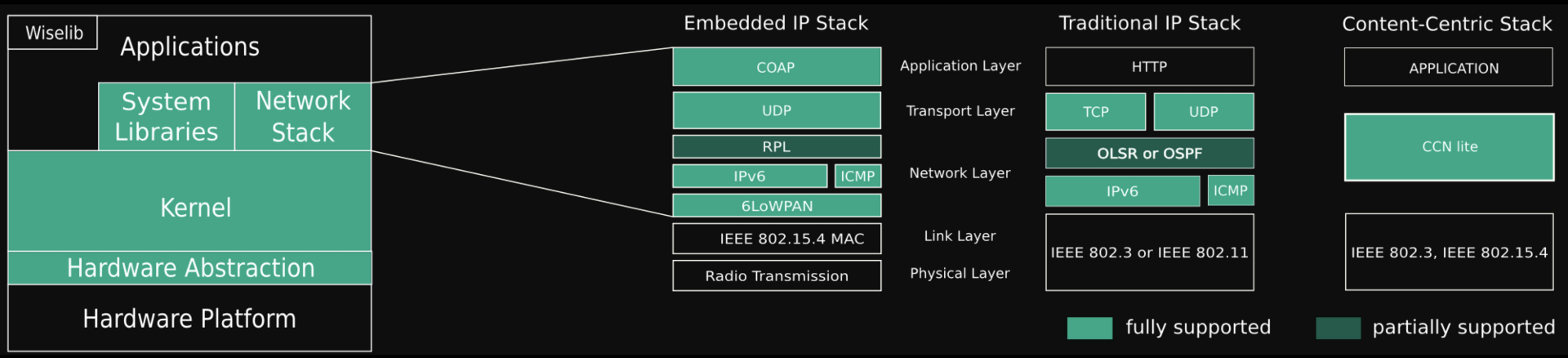
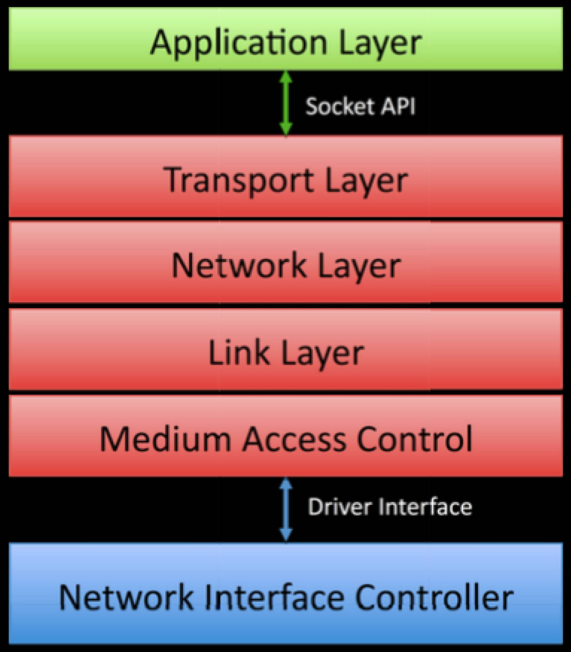
RIOT Supports Several Network Stacks

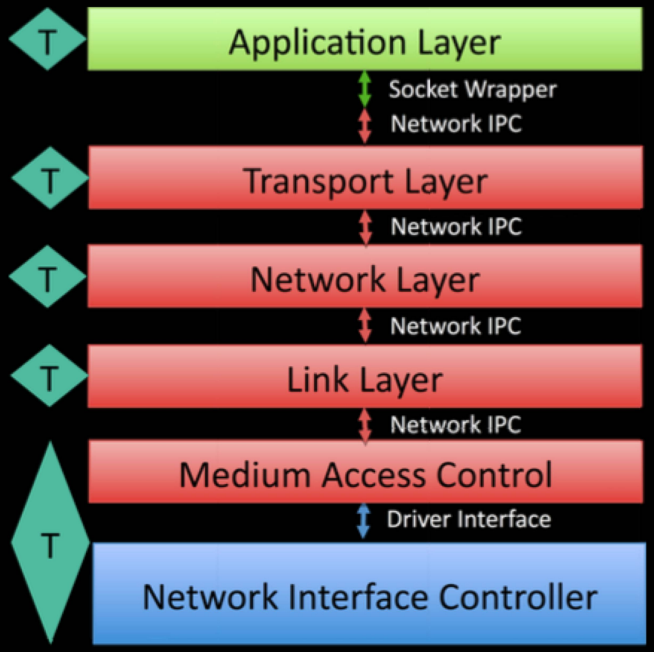


- BSD-like ports for: OpenWSN, LibCoAP
- What's already there:
  - Application layer (CoAP, CBOR), Transport layer (UDP, TCP), Network layer (IPv6, 6LoWPAN, RPL, CCN-lite), Link layer (IEEE 802.15.4 and 802.15.4e support)
  - Nativenet: network emulation & debugging
- On-going:
  - Bluetooth LE link layer support, Cooja and ns-3 simulator support, AODVv2, OLSRv2, & more...

Towards a Flexible Embedded Stack Design



Traditional Network Stack Architecture



RIOT Network Stack Redesign

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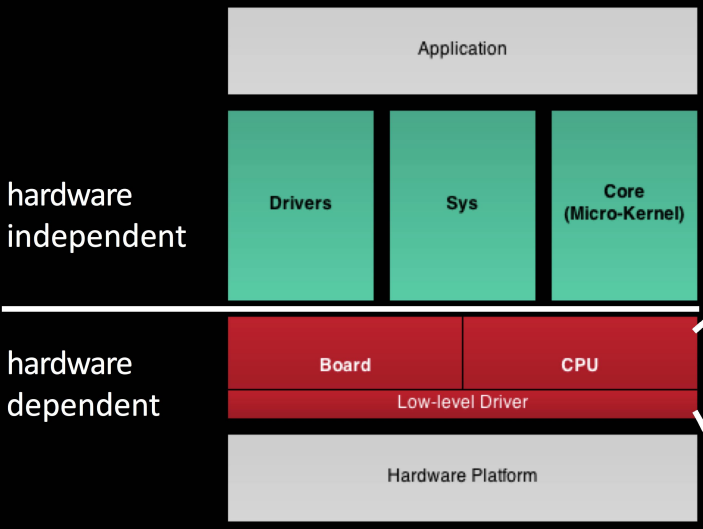
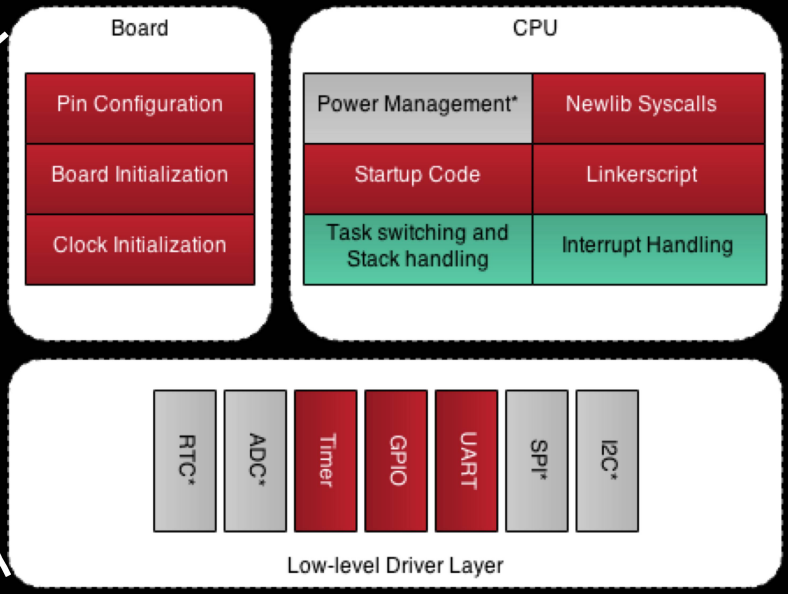
Code for RIOT is Portable

- Code your application once & run it everywhere
  - Mostly 32-bit platforms, but 8-bit and 16-bit platforms are supported, too
  - Independent from vendor-specific solutions
- Easy porting of RIOT to new hardware
  - Porting is a matter of hours, or days
  - e.g. support for new ARM Cortex-M boards is ‘trivial ’

Portable Architecture



Zoom on Board & CPU



Red: must have

Green: must have but shared by all ports with same architecture

Grey: optional for initial porting

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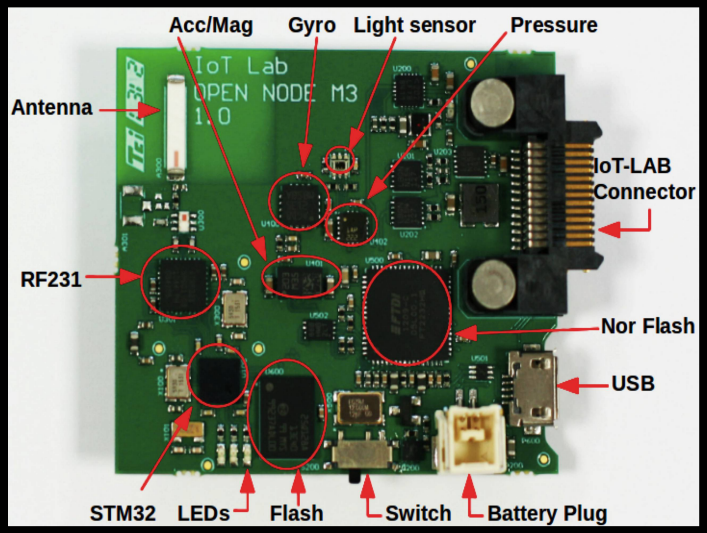
RIOT Runs on Open Testbed Hardware

- Comprehensive support for IoT-LAB M3 open node, including :
  - Full support of AT86RF231 radio chip
  - Support for all sensors (light, temperature, pressure, gyro, accelero-/magnetometer)
  - Support for the micro-controller (STM32f1 ARM Cortex M3)



RIOT as a Platform for Experiments

- Upcoming tutorial : RIOT use on IoT-LAB
  - Testing a distributed IoT application
  - Sensor monitoring & IPv6/6LoWPAN

IoT-LAB open testbed : http://www.iot-lab.info

- Other uses:
  - Emulation of virtual networks without changes to RIOT code
  - Connect real nodes to virtual topologies of RIOT instances
  - Experiments with new protocols & concepts for the IoT
    (e.g. content-centric networking)

– E. Baccelli, C. Mehlis, O. Hahm, T. Schmidt, M. Wählisch). Information-Centric Networking in the IoT: Experiments with NDN in the Wild. In *1st ACM International Conference on Information Centric Networks (ICN 2014)*.

  - Low learning curve => RIOT as a teaching platform

– O. Hahm, E. Baccelli, H. Petersen, M. Wählisch, T. Schmidt. Simply RIOT: Teaching and Experimental Research in the Internet of Things. In *13th ACM/IEEE International Conference on Information Processing in Sensor Networks (IPSN 2014)*.

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In a Nutshell : RIOT is Accessible

- The goal is to be the fastest coding platform:
  - code your IoT app or your IoT protocol in one afternoon
- Designed to be interoperable:
  - standard APIs & standard network protocols
  - Contiki could run as a RIOT thread (but not the reverse ;)
  - RIOT can run as a Linux process
- Designed to be a modular solution:
  - from kernel-only to full stack including hardware support, network stacks, schedulers & your favorite API (POSIX, Arduino coming soon ?)

RIOT

Join the RIOT

- Open source community
- ~ 150 forks on GitHub
  https://github.com/RIOT-OS/RIOT
- ~ 150 people on the developer mailing list: devel@riot-os.org
- Developers from all around the world
- Support & discussions on IRC:
  irc.freenode.org #riot-os
- ~ 500 followers on Twitter


IOT