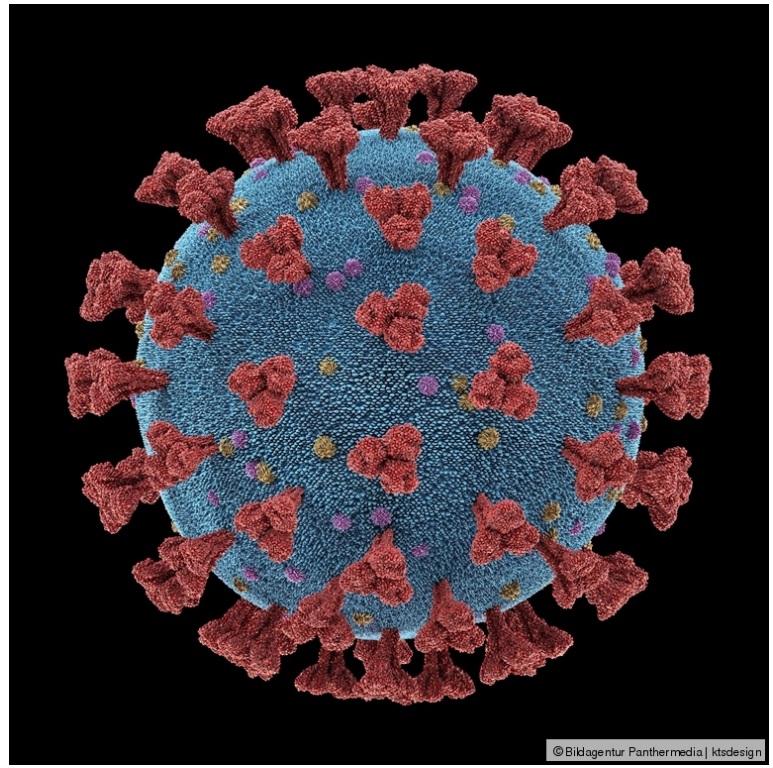
COVID-19 Measures

- Wear a mask (medical or FFP2) until you have taken a seat
- When seated you **may** take off the mask if you can maintain an interpersonal distance of 1,5 m
- Open the windows periodically whenever possible
- Behave reasonable and use common sense



FRANKFURT UNIVERSITY OF APPLIED SCIENCES

Internet of Things Seminar
Introduction

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Agenda

1 About me

2 Seminar Organization

3 Internet of Things

4 Topics

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Prof. Dr. Oliver Hahm

- Study of Computer Science at Freie Universität Berlin
- Software Developer for ScatterWeb and Zühlke Engineering
- Research on IoT and Operating Systems

Contact

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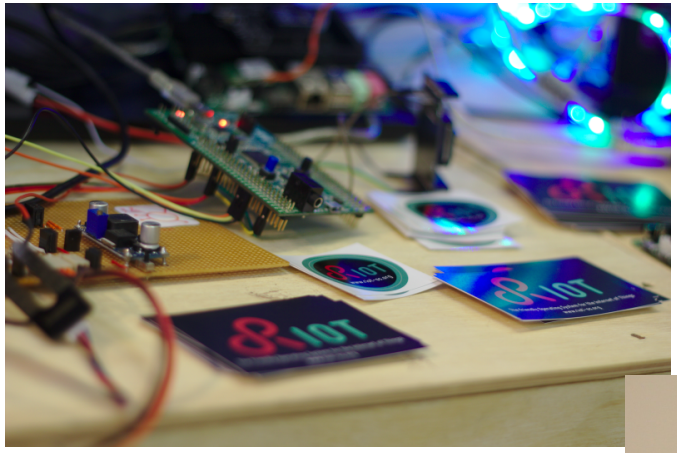
Office hours: Tuesdays 16:00 – 17:00, room 1-212

Join the RIOT!



You're interested in ...

- ... programming the IoT?
- ... collaborate with hundreds of people from all over the world?
- ... contribute to a big FLOSS project?

RIOT is the friendly operating system for the IoT!

Get in touch

Meet the community at a local Hack'n'ACK event at the university!
Every last Tuesday of a month at 5pm in room 1-234.

Or look at https://riot-os.org/community.html

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Learning objectives

- understand the basic technologies for the Internet of Things,
- asses emerging technologies concerning their suitability,
- get acquainted quickly with new technologies, and
- develop new application fields.
- to search for, read, summarize and cite scientific literature on a large scale;
- to read and interpret national and international standards;
- to write a report as a scientific paper;
- to give a scientific talk.

Organizational

- Group work (two students per group)
- Each group selects a topic from a given list
- Submit a paper at mid-term
- Review a paper
- Receive and address reviews
- Prepare final version
- Present your work

Moodle

Enrolment Key:
`IoTHahm`

RA-IoT Workshop

The final goal of this course is to successfully submit a paper to a local workshop:
The first International Workshop on Recent Advances in Internet of Things!

Dates

- April 13, 2022: Introduction and topic presentations
- April 20, 2022: Topic selection and introduction into scientific work
- May 23, 2022: Submission deadline
- June 17, 2022: Authors notification
- July 04, 2022: Camera ready paper submission
- tbd: Workshop (presentations)

Further Information

Course page

All material regarding this course can be found at
https://teaching.dahahm.de

This includes

- Announcements
- Slides
- Dates

Workshop page

The official page of the workshop is https://www.ra-iot.de

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The Internet of Things

What is the Internet of Things?

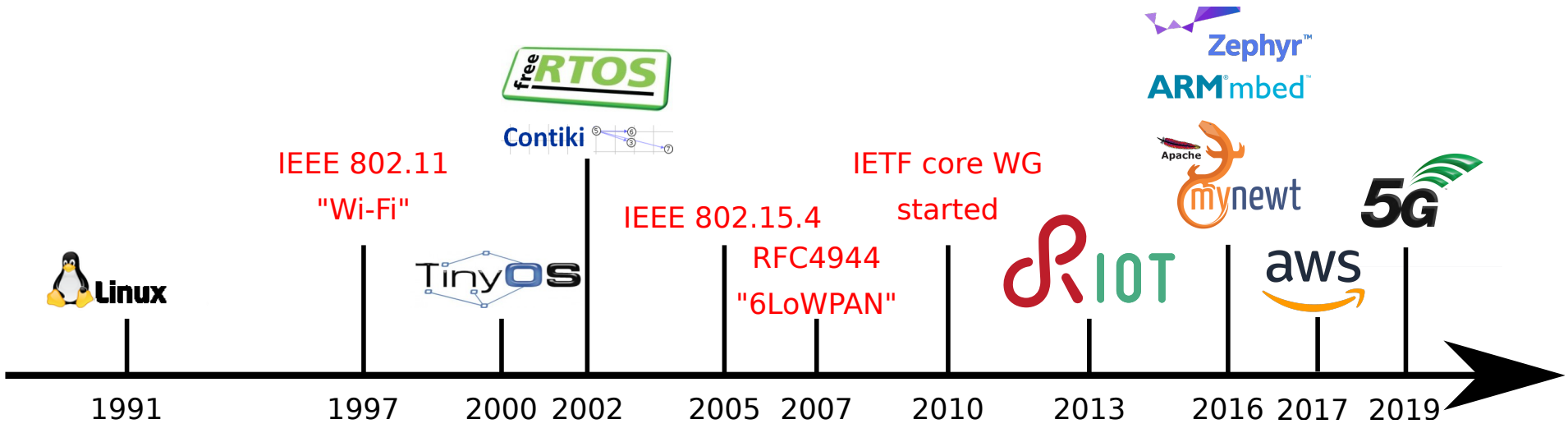
A Brief History of the Internet of Things

1982 A Coca-Cola vending machine was connected to the Internet at Carnegie Mellon University

1997 The **Smart Dust** research proposal at Berkeley kick-started research on **Wireless Sensor Networks (WSNs)**

1999 Kevin Ashton (P&G) coined the term **Internet of Things**

2008 Cisco identified the *birth* of IoT by the tipping point "when more 'things or objects' were connected to the Internet than people".

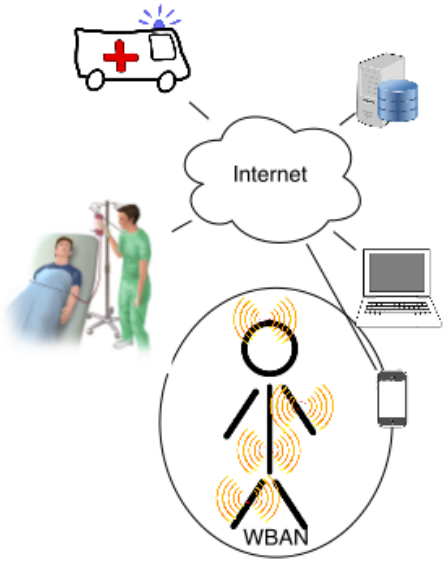


Connecting Smart Objects at Internet Scale

- From 3.5 billion Users to 50 billion Devices on the Internet
- Transforming Things into Smart Objects
- Enabling Interconnected Smart Services

Use Cases

Mobile Health



Micro & Nano Satellites

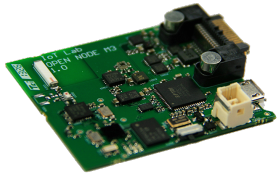
Industrial Automation

Building & Home Automation

Challenges

Low-end IoT Devices: Limited Resources (RFC7228)

iotlab-m3



Senslab WSN430

Arduino Due

- Memory < 1 Mb
- CPU < 100 MHz
- Energy < 10 Wh

Requirements

- Interoperability
- Energy Efficiency
- Reliability
- Latency
- Low Cost Factor
- Autonomy
- Security
- Scalability

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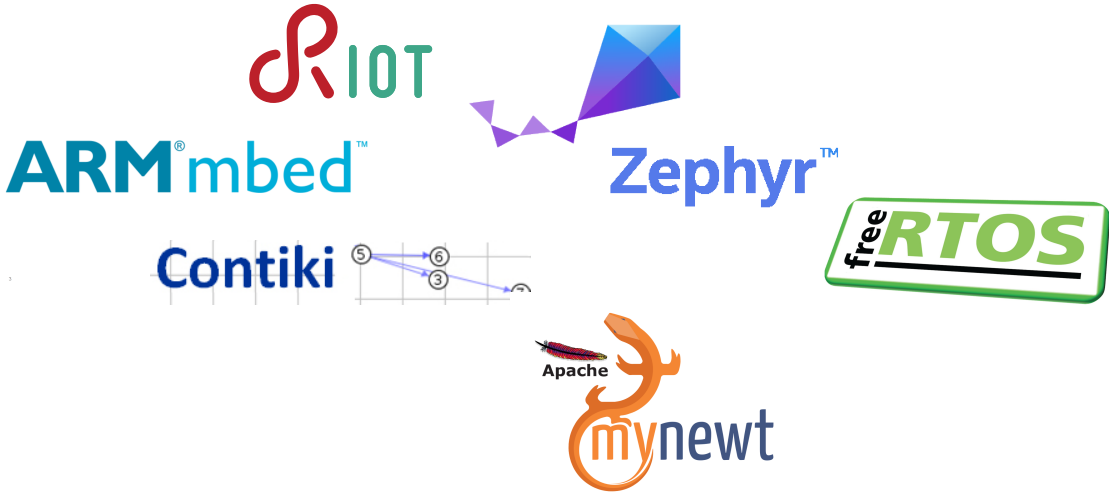
Operating systems for low-end IoT devices

- The particular challenges of IoT applications mandate for new operating systems
- Typical candidates are:
  - RIOT
  - Zephyr
  - mbedOS
  - FreeRTOS
  - mynewt
  - Contiki
  - Linux



- What about standards like POSIX for these OS?

Cloud solutions for IoT applications

- The backend of an IoT application is typically hosted in the cloud
- IoT cloud providers offer various services like providing endpoints, data processing, device management, or software update services
- Multiple commercial cloud providers exist
  - Azure IoT Hub
  - Google Cloud
  - AWS IoT

Key management and secure bootstrapping for large scale constrained-node networks

- IoT applications often comprise a large number of devices
- Security is important, but requires to provision the devices with keys and/or certificates
- How to generate and deploy keys and/or certificates for a large number of devices?
- How to do life-cycle management of keys and certificates?

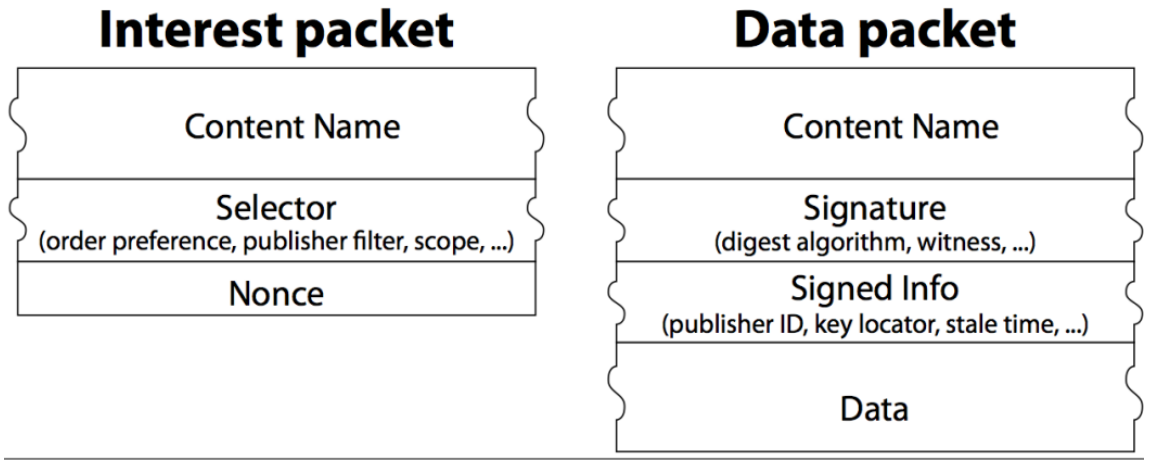
Clock synchronization protocols for low-end IoT devices

- Clock synchronization has been traditionally a topic in WSN research
- Research the evolution of protocols
- How can they be categorized?
- Which of them are appealing for IoT scenarios?
- What about approaches from more tradition IP networks?

IoT privacy concerns

- IoT is by nature ubiquitous and pervasive
- Which threats to the users' privacy exist in modern IoT applications?
- What are the technological and social challenges to face here?
- What is the current situation?

Information-centric smart object networking

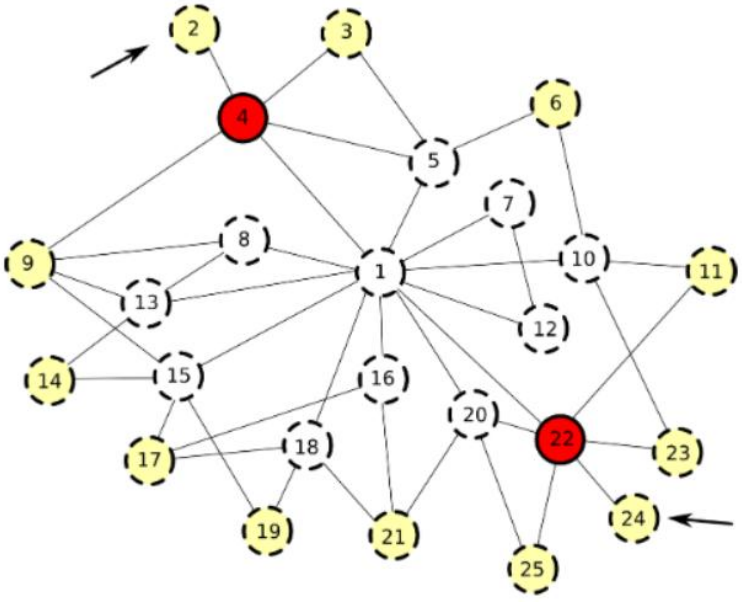


- Network users are typically interested in (named) content rather than locations
- Which approaches which deviate from traditional host-based networking exist?
- What are the advantages and challenges for ICN IoT?
- Where are we at with standardization?

Thread and Matter

- Protocol specifications are only building bricks and often leave important details to the user
- The Thread group created the Thread standard based on IPv6/6LoWPAN and various other existing specifications, mainly for home automation purposes.
- Matter is a recent effort by some bigger players on the market to build upon Thread.

Routing protocols for constrained networks



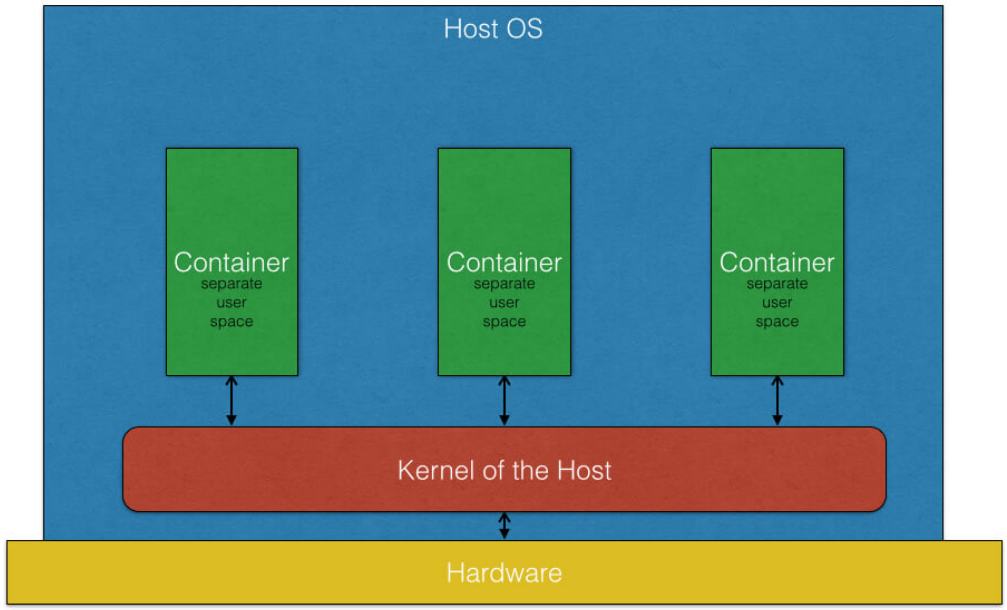
- The constraints and requirements of (low-power) IoT networks pose new challenges on the routing protocols to be used inside and between local IoT networks.
- Survey the evolution of WSN routing protocols.
- RPL, its flavors, and what else?
- MANET protocols?

Lightweight integrity and confidentiality

- How to encrypt and sign data in IoT networks?
- Channel security vs. object security
- Cryptography for constrained devices

Virtualization for low-power IoT devices

- Virtualisation allows for resource sharing among different applications while preserving proper separation.
- Typical low-power IoT devices have little resources, still in some cases virtualisation may make sense.
- Which approaches exist?



Operating System/Container Virtualization

Software updates for IoT systems

- Software updates for IoT systems is a crucial cornerstone of security.
- SUIT and what else?
- Problems, challenges, approaches

Survey on IoT applications

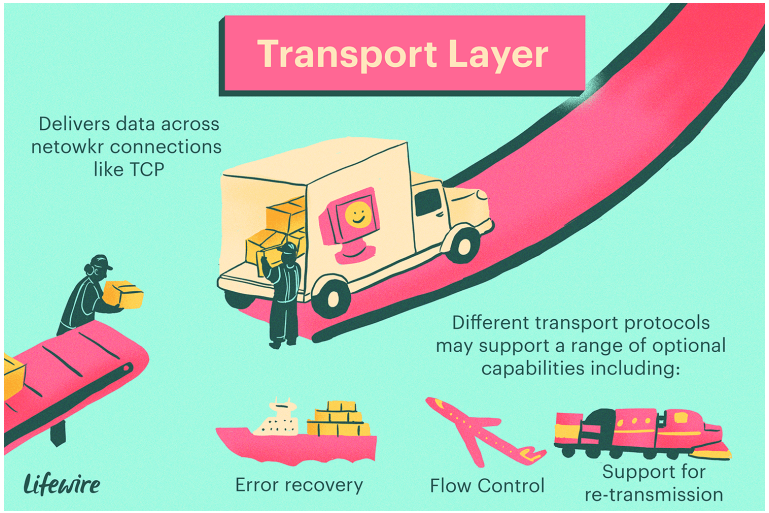
- Is IoT still missing a killer app?
- Many application scenarios: Home automation, building automation, industry automation, mobile health, connected cars
- What are the (economical, egological . . .) benefits from connected devices?

Low-power WPANs

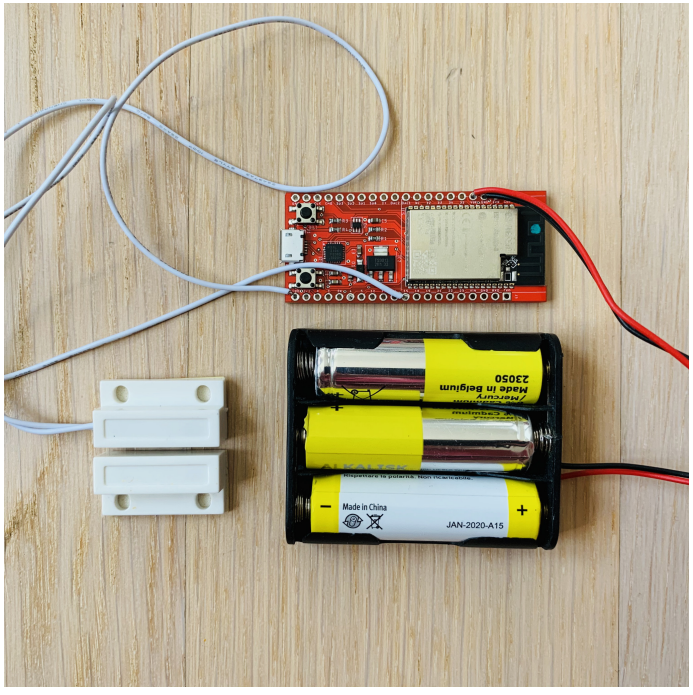
- Various technologies allow for long-range low-power wireless communication
  - Lora
  - Sigfox
  - NB-IoT
  - LTE-M
- What are the difference?
- What are the tradeoffs?

Transport layer issues for constrained-node networks

- Many (low-end) IoT solutions are in favor of UDP on the transport layer because of its low complexity and lightweight
- However, many traditional backend solutions (like MQTT or HTTP) are based on TCP
- Most recently a new Internet transport layer has evolved: QUIC
- What is the current state and what are the perspectives?
- What are challenges and what are the opportunities?



Evolution of low-power hardware



- Small microcontrollers are getting more and more powerful, energy-efficient, secure, and/or cheaper
- What are the latest developments?
- Which impact does this have on software design?

Device and fleet management

- In many IoT scenarios the amount of devices is huge
- How can these big networks be managed in a reasonable manner?
- What are the required services?
- Which providers do exist?

Programming low-end IoT devices

- Requirements and constraints of low-end IoT devices influences the choice of the programming language
  - Available compiler (+ toolchain)
  - Tooling (IDE, debugger etc.)
  - Size of resulting binaries
  - Access to hardware
  - Safety and security concerns
  - Learning curve
  - Feature set

Low-code for IoT applications

Low-Code Development Platform

A low-code development platform (LCDP) provides a development environment used to create application software through a graphical user interface. A LCDP may produce entirely operational applications, or require additional coding for specific situations. LDDP can reduce the amount of traditional time spent, enabling accelerated delivery of business applications. A common benefit is that a wider range of people can contribute to the application's development—not only those with coding skills but require a good governance to be able adhere to common rules and regulations. LCDPs can also lower the initial cost of setup, training, deployment and maintenance.

Energy-harvesting

- How far are we with the vision of smart dust?
- Which ways to harvest energy from the environment do exist?
- What are the challenges for the software?

Energy-efficient wireless protocols

- Examples
  - IEEE 802.15.4
  - BLE
  - IEEE 802.11ah

- (Wireless) Communication is typically one of the biggest energy consumer for low-end IoT devices
- Hence, efficient technologies are required

Industrial IoT

- Real-time systems
- Deterministic networking
- Certification
- Resilience