Internet of Things

Introduction

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Agenda

- About
- Organizational
- Introduction
- Research Fields

Agenda

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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Learning objectives

- Comprehension of IoT systems
  - understand the basic technologies for the Internet of Things,
  - assess emerging technologies concerning their suitability,
  - get acquainted quickly with new technologies, and
  - develop new application fields.
- Scientific skills
  - 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

- Individual work
- Each student selects a research field from a given list
- Get an overview about the selected field
- Identify a relevant research question in this field
- Give a presentation about this area
- Submit a report in the end

campUAS

Enrolment Key: `HahmIoT`

Hands-on Experience

In order to gain a solid understanding of IoT technologies, it is inevitable to gather practical experience: Four times this semester we will conduct some hands-on sessions.

Format and Scope

- Presentations:
  - General introduction
  - Spotlight on research question
  - Should not exceed 25 minutes
  - Presentation tool of your choice
- Report:
  - Four pages (including references)
  - IEEE double column format[1]
  - LaTeX or Microsoft Word

[1] https://www.ieee.org/conferences/publishing/templates.html

Dates

- April 16, 2024: Introduction
- April 23, 2024: Research field selection and introduction into scientific work
- April 30, 2024: No session
- May 07, 2024: First Hands-on Session (Getting to know RIOT)
- May 28, 2024: Second Hands-on Session (Connecting *things* to the Internet)
- June 11, 2024: Third Hands-on Session (Setting up the cloud services)
- July 02, 2024: Last Hands-on Session (Connecting the dots)

In between:
your presentations

Assessment

- 40% for the report
  - Research question
  - Content
  - Structure
  - Presentation and format
  - Literature
- 20% practical work
- 40% for the presentation

Further Information

Course page

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

This includes

- Announcements
- Slides
- Dates

Agenda

The Internet of Things

What is the Internet of Things?

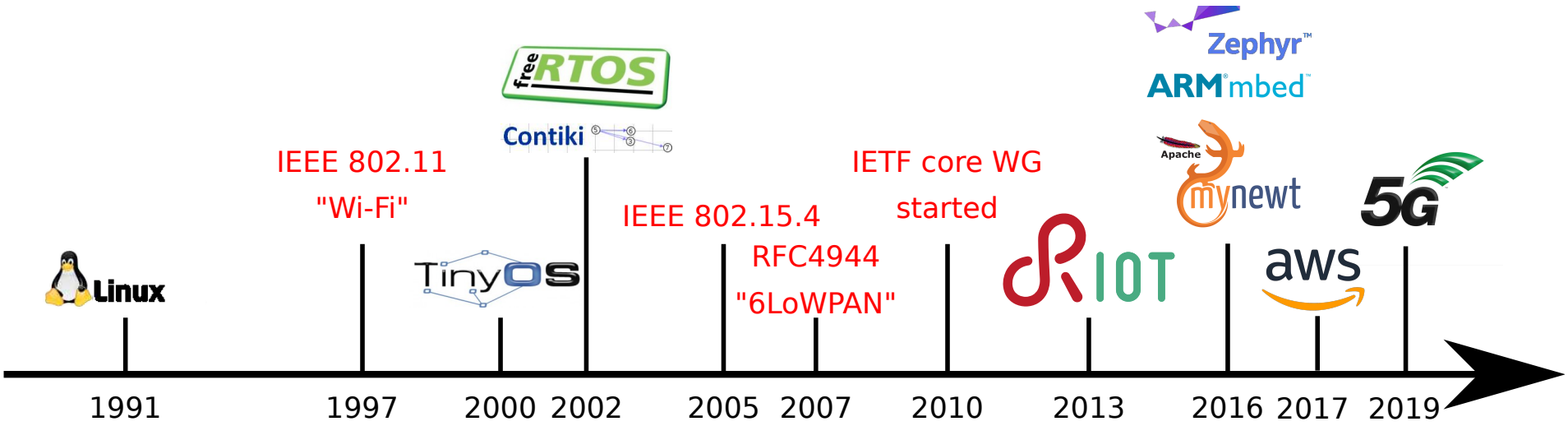
A Brief History of the Internet of Things

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".

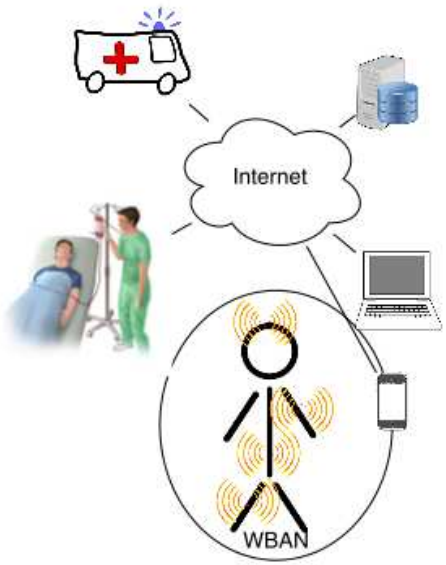


Connecting Smart Objects at Internet Scale

- 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



Building & Home Automation

Micro & Nano Satellites

Industrial Automation

Challenges

What are the main challenges and research areas for the Internet of Things?

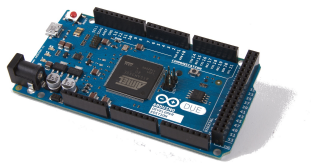
Challenges

Low-end IoT Devices: Limited Resources (RFC7228)

iotlab-m3

Senslab WSN430

Arduino Due



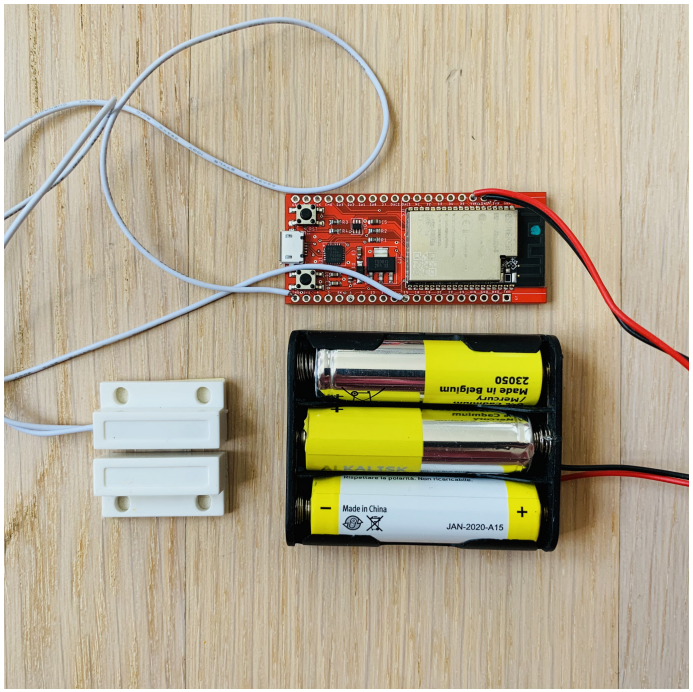
- Memory < 1 Mb
- CPU < 100 MHz
- Energy < 10 Wh

Requirements

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

Agenda

Evolution of low-power hardware



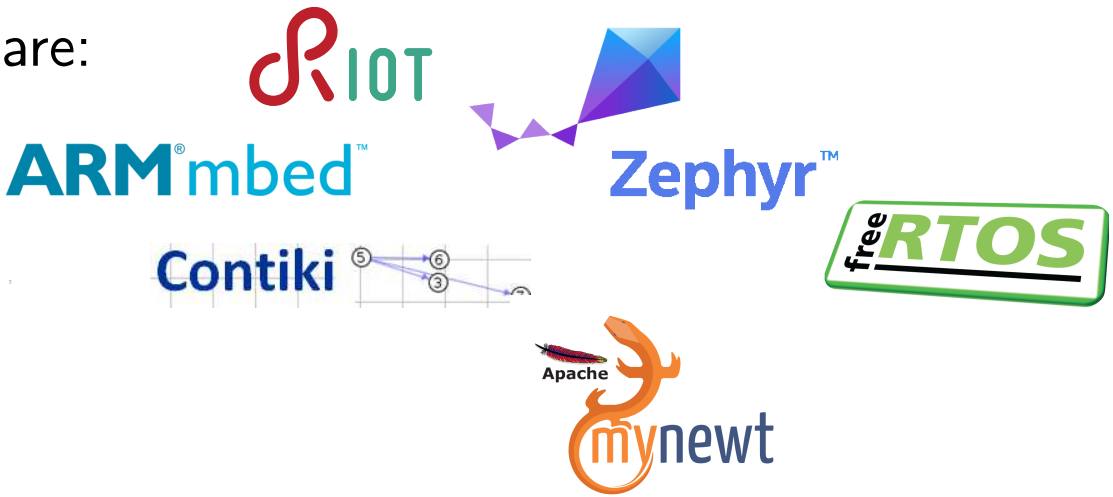
- Small microcontrollers are getting more and more powerful, energy-efficient, secure, and/or cheaper
- What are the latest developments?
- Which impact does this have on software design?

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

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?

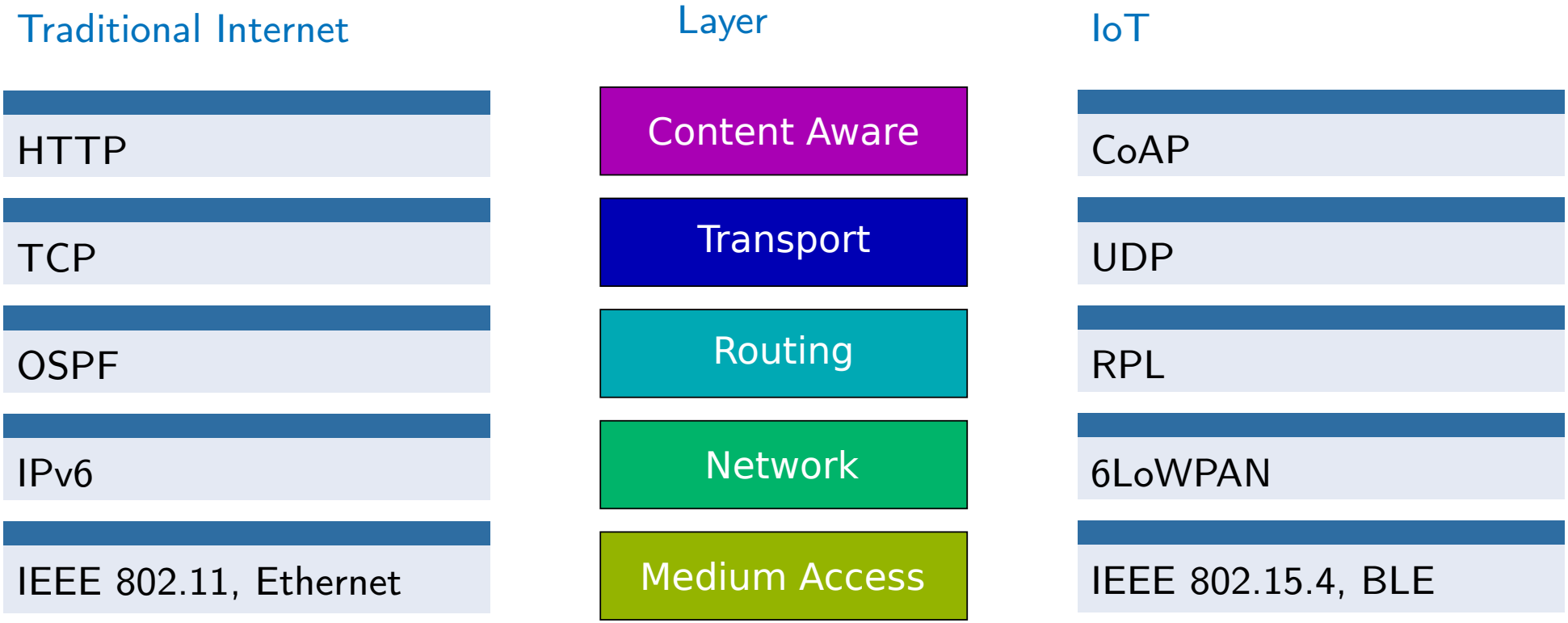
Energy-efficient wireless protocols

- Examples
  - IEEE 802.15.4
  - BLE
  - IEEE 802.11ah

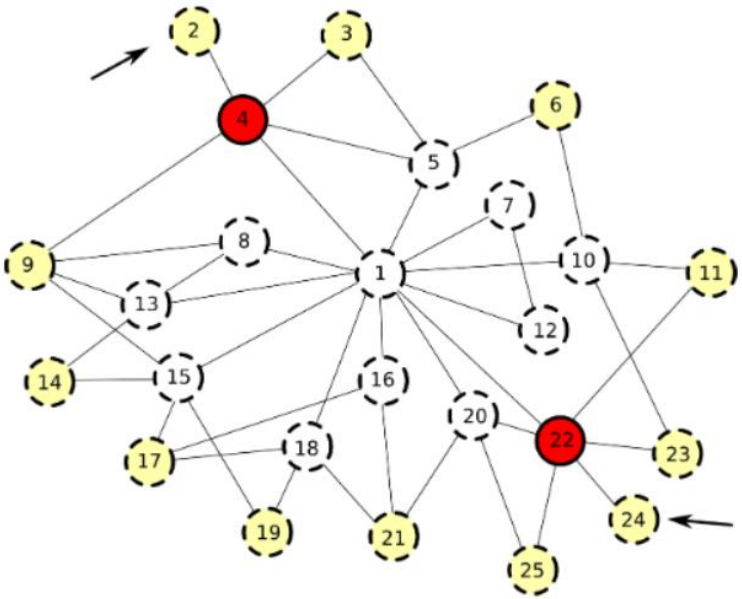
- (Wireless) Communication is typically one of the biggest energy consumer for low-end IoT devices
- Hence, efficient technologies are required

The IoT Network Stack

- Integration of constrained-node networks into the Internet
- Adaptation of traditional Internet Protocols
- Standardization and interoperability efforts



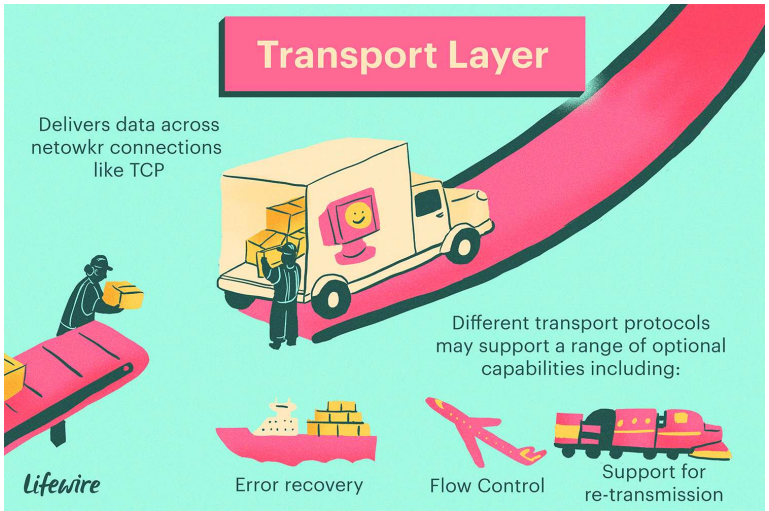
Routing protocols for constrained networks



- 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?

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?



Lightweight integrity and confidentiality

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

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

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?

Any Questions?