University of Duisburg-Essen
Networked Embedded Systems Group

Batteryless Internet of Things Seminar

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Overview

- Background
- Goals
- Topics
- Participation
  - Work
  - Requirements
  - Organization

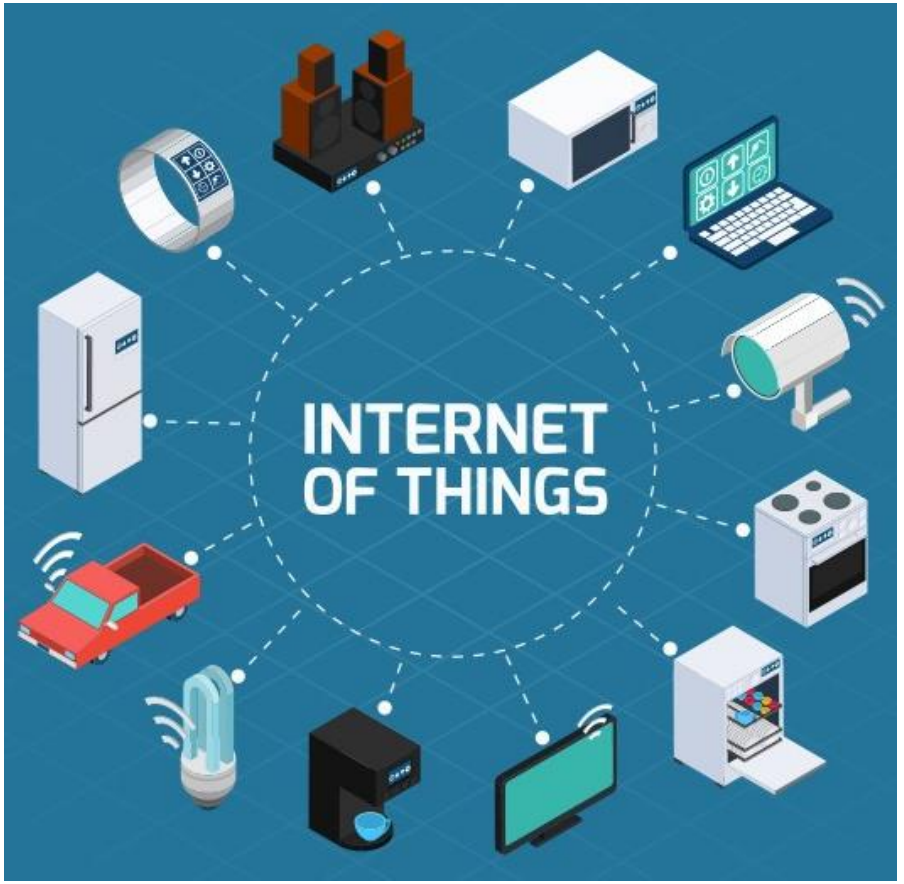
Background – Internet of Things (IoT)

- Collections of small, cooperating, low-complexity computing devices
- IoT devices perform sensing, actuating, data processing and communication tasks
- Possible applications:
  - Building Automation: “Smart Buildings”
  - Health Monitoring
  - Environment monitoring
  - And countless others!



Background – Internet of Things (IoT)

- IoT devices can communicate with humans and also other devices over the Internet
- IoT devices will be soon ubiquitous in everyday-life
- This ubiquity, however, comes with a number of challenges such as security, energy consumption, etc.



Background – Internet of Things (IoT)

- IoT devices are mostly assumed to be battery-operated
- Problems with such an assumption:
  - Large scale deployment of IoT devices → Many, many batteries!
  - Batteries must be eventually replaced at some point, which leads to:
    - Tremendous workload
    - Environmental concerns



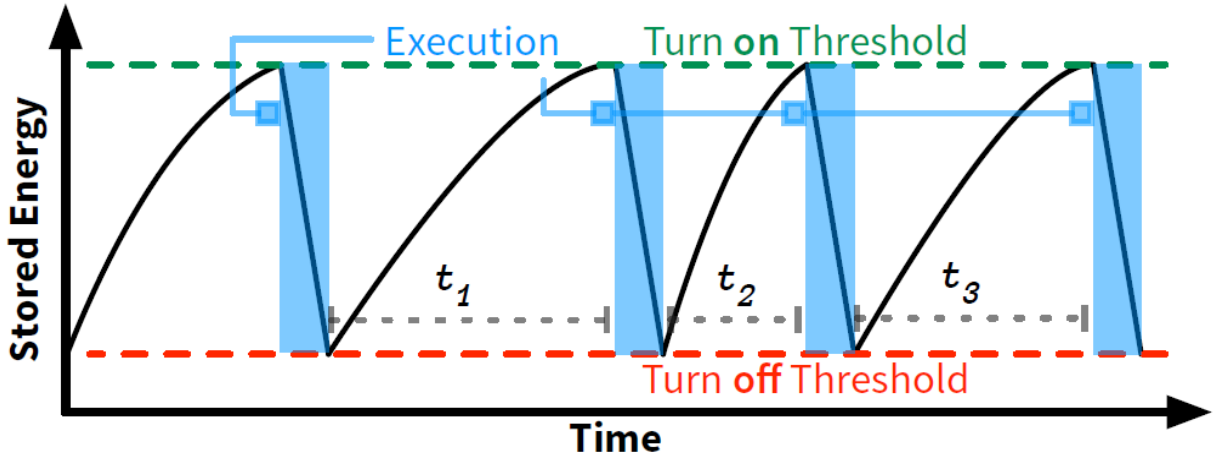
Image source: https://erprecycling.b-cdn.net/en-at/wp-content/uploads/sites/9/2017/07/img-erp-org-old-batteries-to-recycling-578663071.jpg

Background – Towards Batteryless IoT

- Batteryless operation of nodes: A Possible Alternative?
- Batteryless sensor nodes…
  - Harvest Energy from their operation environment
  - Store harvested energy in (super)capacitors
  - Operate Opportunistically whenever enough energy is available

Background – Intermittent Computing

- A node might run out of power several times per second!
- Opportunistic approach to task execution → “Intermittent Computing”



Intermittent execution pattern for an energy harvesting batteryless device

Image source: Hester, Josiah, and Jacob Sorber. "Batteries not included." XRDS: Crossroads, The ACM Magazine for Students 26.1 (2019): 23-27

Batteryless IoT Seminar

- Addresses aspects such as…
  - Challenges caused by ultra-low power operation of devices
  - Approaches for adapting well-established solutions of the IoT field also for batteryless devices
  - Novel solutions that could be exploited by utilizing cutting-edge technology to solve challenges of batteryless devices

Goals

- Learn about Batteryless IoT and the challenges that such a paradigm poses to the system designers and developers
- Learn how to acquire and present scientific knowledge
  - Acquire expert knowledge on a certain topic autonomously
  - Describe your findings in a report in a comprehensible way
  - Present your findings to other people in a comprehensible way

Suggested Topics

1. Energy Management in Batteryless IoT
2. Checkpoint-based Application Execution in Batteryless IoT
3. Task-based Application Execution in Batteryless IoT
4. Time Keeping and Time Synchronization in IoT Networks
5. Wake-Up Radios and their Applications in IoT Networks
6. Firmware Updates in IoT Networks
7. Platforms and Testbeds
8. Backscatter Communication

Suggested Topics

- The list of topics will also be available on the Moodle page of the course, together with suggested related papers
- It is also possible to add new, relevant topics if you are interested in a topic not included here. Please let us know if this is the case!
- Each topic will be assigned to one person only

Work (less than 10 students)

- Acquire expert knowledge on your topic
  - Do a literature research, read scientific papers and book chapters
  - Understand your topic and put it into the seminar's overall topic
- Prepare a ***written report*** on your topic
  - 7-10 pages (3 Cr.) or 12-15 pages (6 Cr.)
- Give a ***scientific talk*** about your topic
  - Talk of 30 minutes
  - Answer questions in subsequent discussion
- Engage in the ***discussion***
  - Ask questions

Work (at least 10 students)

- Acquire expert knowledge on your topic
  - Do a literature research, read scientific papers and book chapters
  - Understand your topic and put it into the seminar's overall topic
- Prepare a ***written report*** on your topic
  - 5-7 pages (3 Cr.) or 8-10 pages (6 Cr.)
- ***Review*** 2 other written reports
- Give a ***scientific talk*** about your topic
  - Talk of 20 minutes
  - Answer questions in subsequent discussion
- Engage in the ***discussion***
  - Ask questions

Participation – Written Report (References)

- Any material you use for your report must be listed in the bibliography and cited at the appropriate place in the text
- Verbatim quotes of source material are discouraged
  - If you absolutely need to quote something, you must properly identify the passage as a quotation and cite the source.
  - Quotes should be a maximum of 2–3 sentences.
  - Again: Avoid quotations, use your own words.

Warning:

Copying material under any other circumstances is plagiarism and will immediately result in failing the seminar!

Example: How Not to Cite Other People's Work

Original paper:

Wireless sensor networks (WSN) were invented to study, control, and monitor events and phenomena. […] The information collected by the sensor nodes is delivered, by following the multihop paradigm, to a sink node and through this to nodes connected to the Internet. […] These nodes are active devices with computing and communication capabilities that not only sample real world phenomena but also can filter, share, combine, and operate on the data they sense.

From: M. Conti and S. Giordano. Multihop Ad Hoc Networking: The Reality, *IEEE Communications Magazine*, 45(4):88-95, 2007.

Summary:

Wireless sensor networks (WSN) [1] were invented to study, control, and monitor events and phenomena. The information collected by the sensor nodes is delivered, by following the multihop paradigm, to a sink node and through this to nodes connected to the Internet. …

[1] M. Conti and S. Giordano. Multihop Ad Hoc Networking: The Reality, *IEEE Communications Magazine*, 45(4):88-95, 2007.

- Verbatim copy of original text
- Example is plagiarism independent of citation

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Summary:

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- No copy of complete sentences, but not own words
- Again plagiarism despite citation

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From: M. Conti and S. Giordano. Multihop Ad Hoc Networking: The Reality, *IEEE Communications Magazine*, 45(4):88-95, 2007.

Summary:

Wireless sensor networks consist of small computers that are used to monitor physical phenomena. They use wireless multi-hop communication to deliver their data to a sink node. Instead of just forwarding data, they have the capability to actively filter and aggregate sensor readings.

- Own words
- But no reference to source
- Just summary of a single paper

Example: How to Cite Other People's Work

Original paper:

Wireless sensor networks (WSN) were invented to study, control, and monitor events and phenomena. […] The information collected by the sensor nodes is delivered, by following the multihop paradigm, to a sink node and through this to nodes connected to the Internet. […] These nodes are active devices with computing and communication capabilities that not only sample real world phenomena but also can filter, share, combine, and operate on the data they sense.

- Own words
- Summarizes information from several papers
- References original sources
- ***Hint***: Do not look at original papers when writing, use your notes

Summary:

Wireless sensor networks [1] consist of small computers that are used to monitor physical phenomena. A promising application is structural health monitoring where sensor networks are used to detect damage of buildings [2].

Sensor networks use wireless multi-hop communication to deliver their data to a sink node [1]. Instead of just forwarding data, they have the capability to actively filter and aggregate sensor readings.

[1] M. Conti and S. Giordano. Multihop Ad Hoc Networking: The Reality, *IEEE Communications Magazine*, 45(4):88-95, 2007.

[2] N. Xu *et al*. A Wireless Sensor Network for Structural Monitoring, *Proceedings of SenSys'04*, 2004.

Organisation: Calendar (less than 10 students)

# Week	Date	Topic
0	21.04	Kickoff
1	27.04	Topic Selection
2	04.05	Topic Selection
3	11.05	
4	18.05	References & Structure
5	25.05	
6	01.06	
7	08.06	
8	15.06	
9	22.06	
10	29.06	Report
11	06.07	
12	14.07	Presentation

Organisation: Calendar (at least 10 students)

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7	08.06	
8	15.06	Report
9	22.06	
10	29.06	Reviews
11	06.07	
12	14.07	Presentation

Organisation: Grading

Less than 10 students

- 30% - Knowledge
- 30% - Report
- 30% - Presentation
- 10% - Participation

- Performance must be satisfactory in all categories

At least 10 students

- 30% - Knowledge
- 20% - Report
- 20% - Presentation
- 20% - Review
- 10% - Participation

- Performance must be satisfactory in all categories

Organisation: Meetings

- Due to the current situation regarding COVID-19 and the resulting contact restrictions, there will be no personal meetings and presentations held
- The kickoff meeting will be held online, using virtual meeting rooms
  - This will also be the case for the final presentations, unless the situation changes in the future
- During the semester, it is also possible to have online meetings to answer questions about the seminar
- Links for accessing the virtual meeting rooms will be shared on the Moodle page of the course
- Please check the Moodle page regularly for updates and possible changes!

Next Steps

- During the next week
  - Join the kickoff meeting on 21st of April, at 10:00!
  - You get access to the seminar topics to choose from
- Before the topic selection deadline (see calendar)
  - Use the forum on Moodle to select your topic and confirm the participation
  - ATTENTION: First come first served!
- Afterwards
  - Further material and deadlines notified via Moodle
- If you have questions at any point, please feel free to contact us!