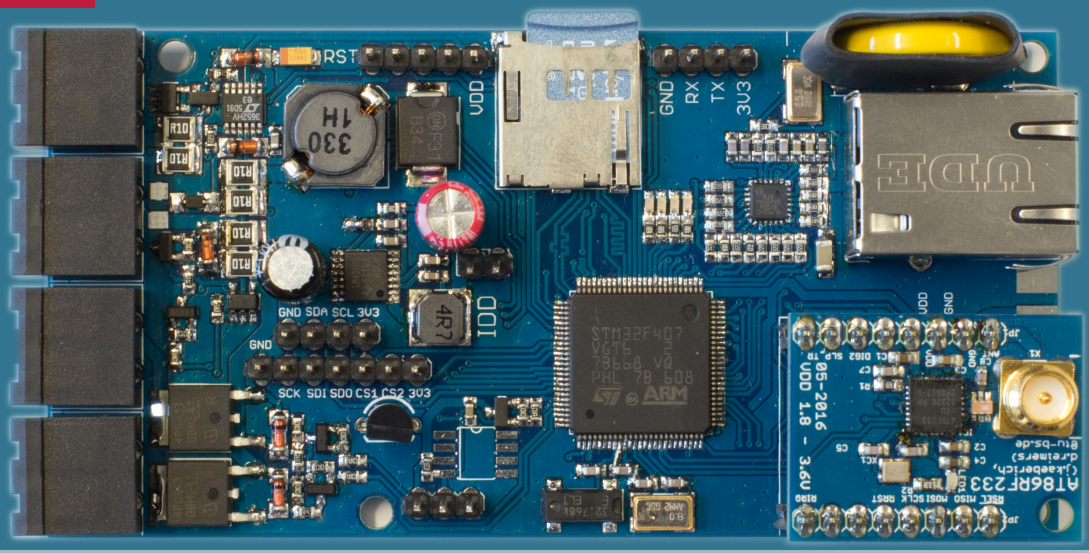
Technische Universität Braunschweig

Institute of Operating Systems and Computer Networks



Amphisbaena: A Two-Platform DTN Node

Stephan Rottmann, Robert Hartung, Jan Käberich, Lars Wolf, October 13, 2016

Institute of Operating Systems and Computer Networks

Use Case

Scenario

- Battery-powered node outdoors
- Several MB of data per day on SD card
- At unknown time, tractor arrives for short contact to collect data via DTN

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  - IEEE 802.15.4
- *Raspberry Pi* Single-Board Computer
  - Wireless LAN

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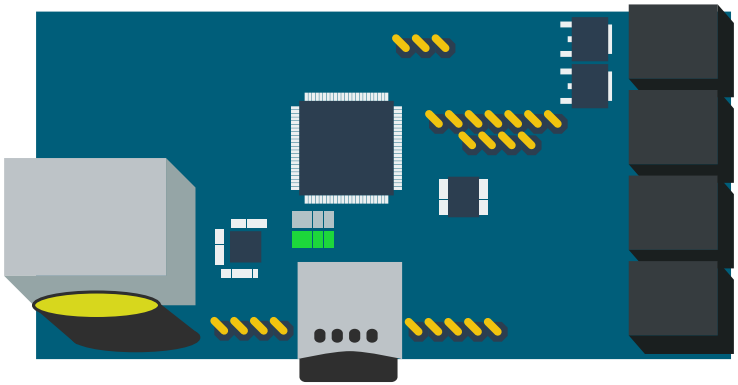
- *Raspberry Pi* Single-Board Computer
  - Wireless LAN
- **SBC only powered up when needed**

System Architecture



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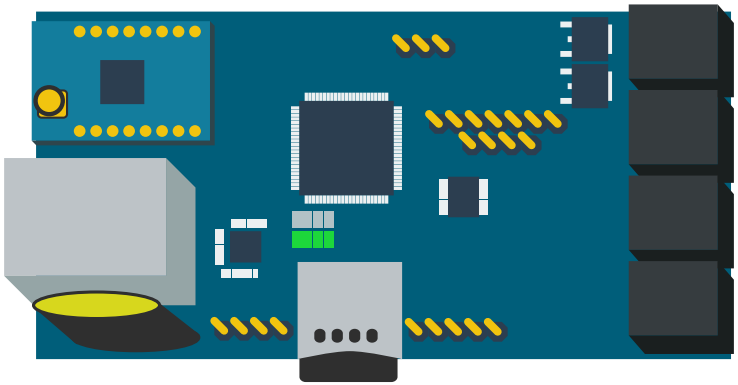

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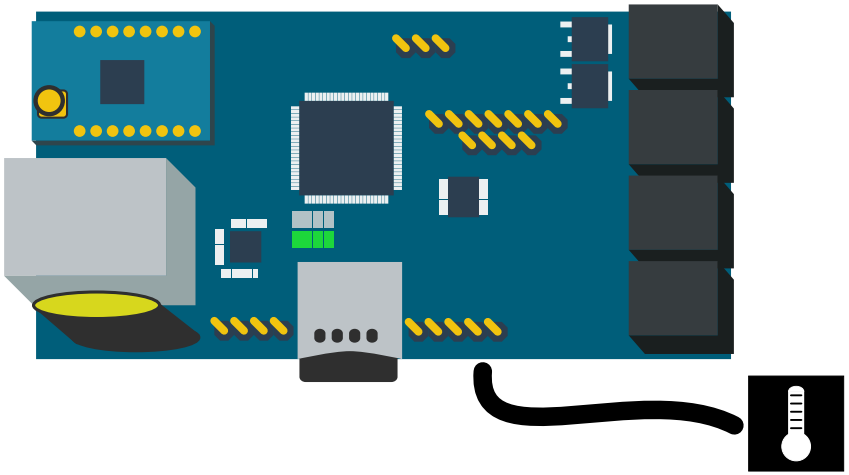

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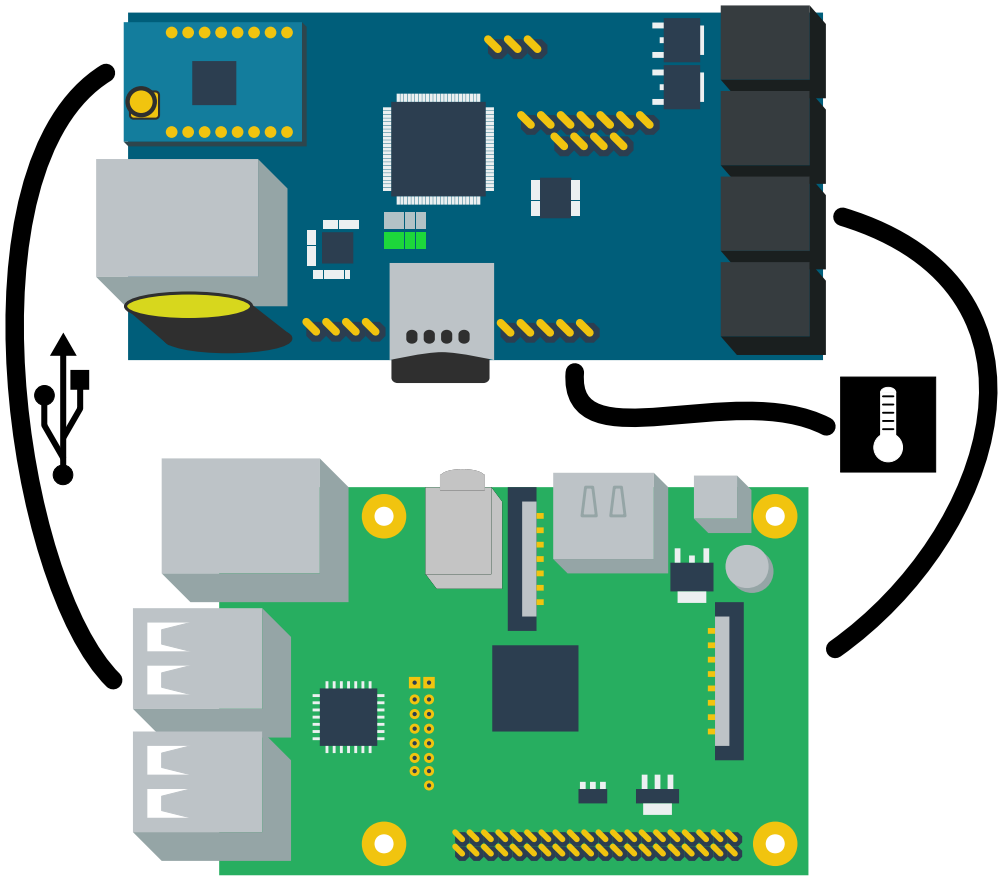

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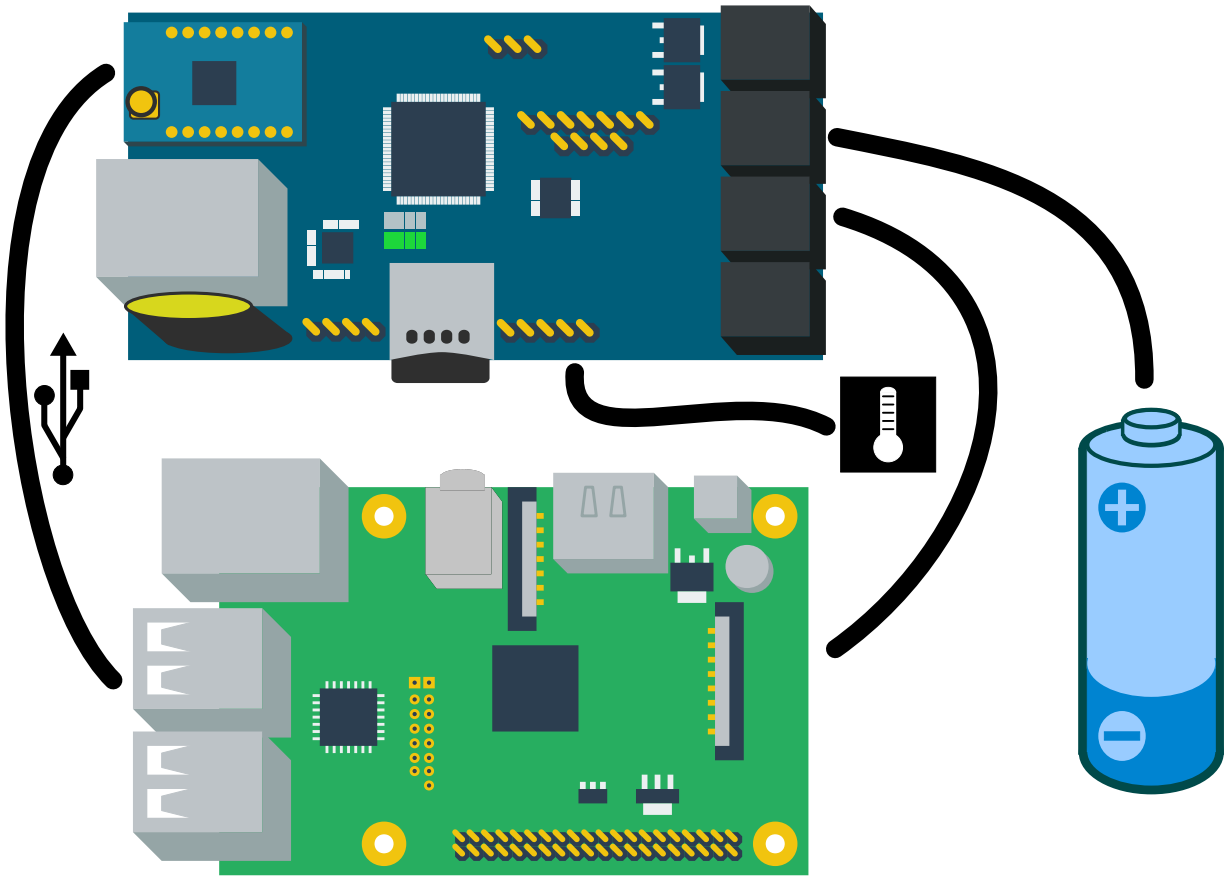

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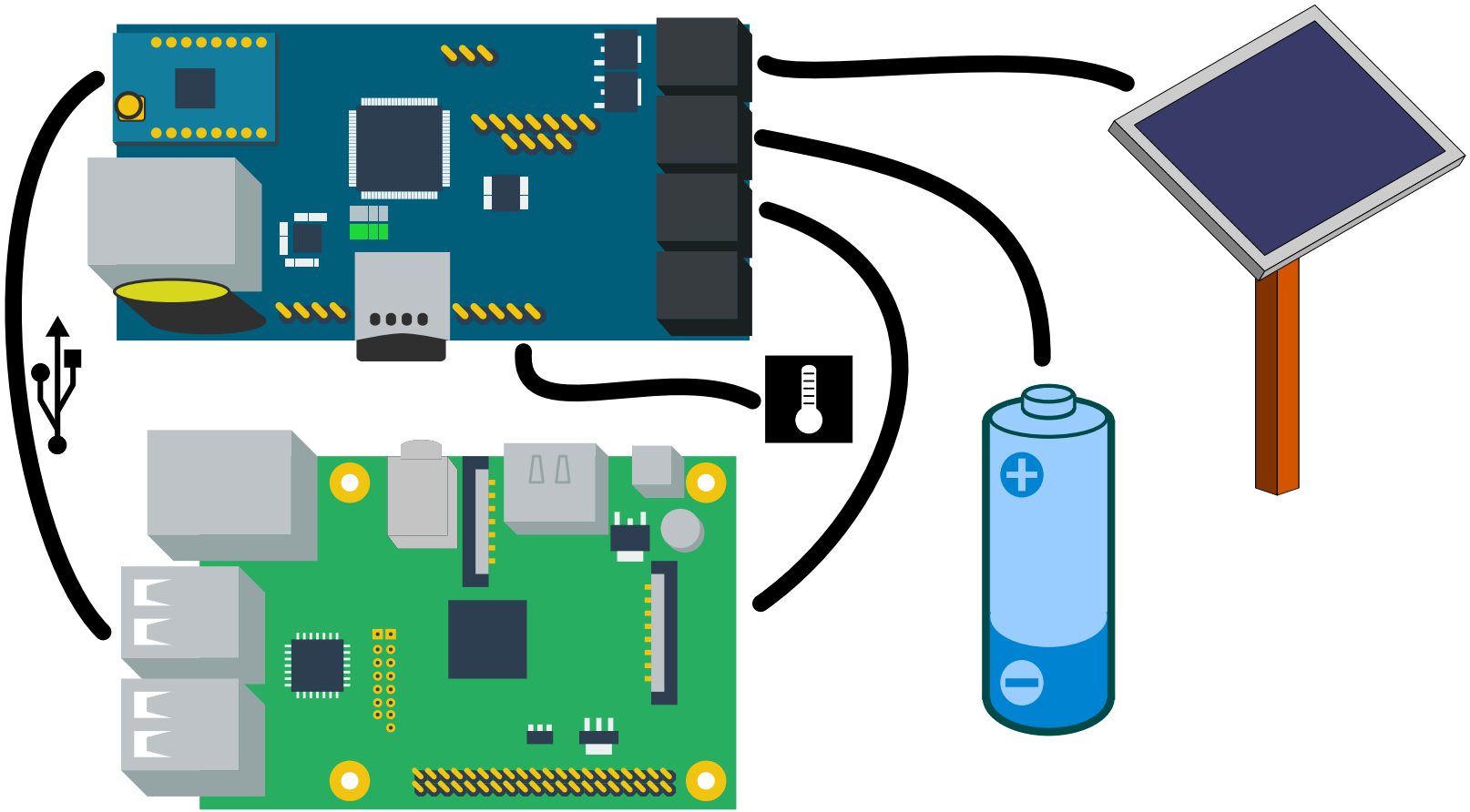
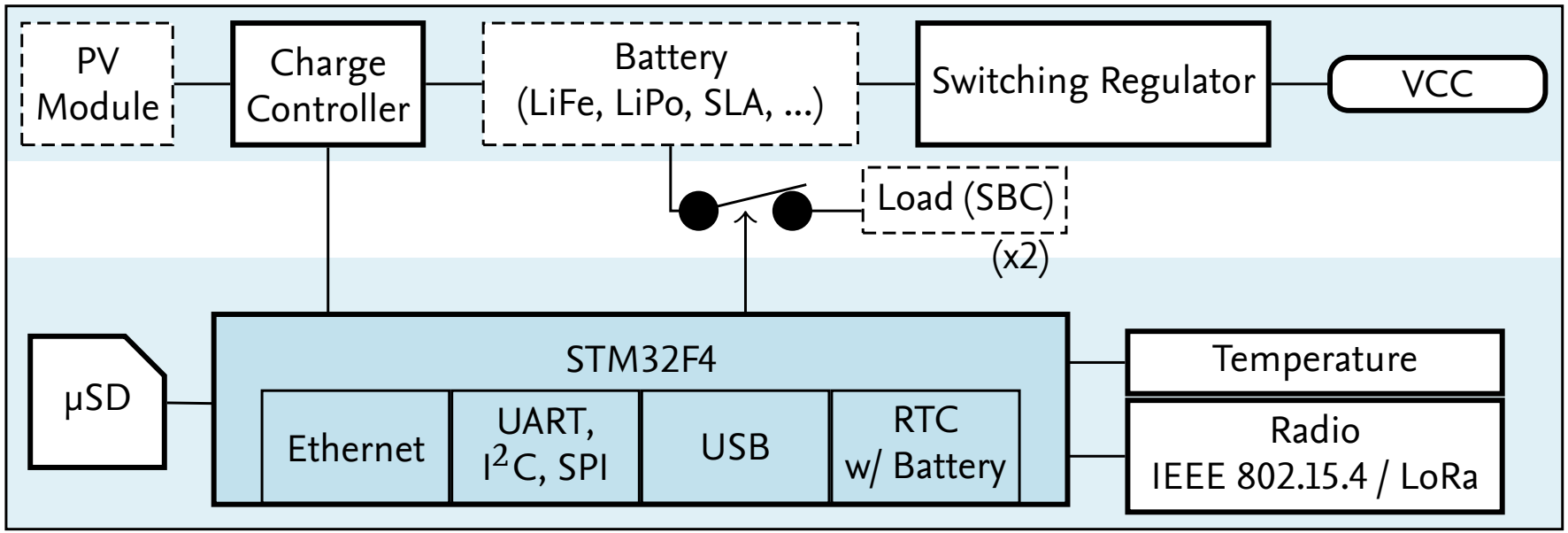
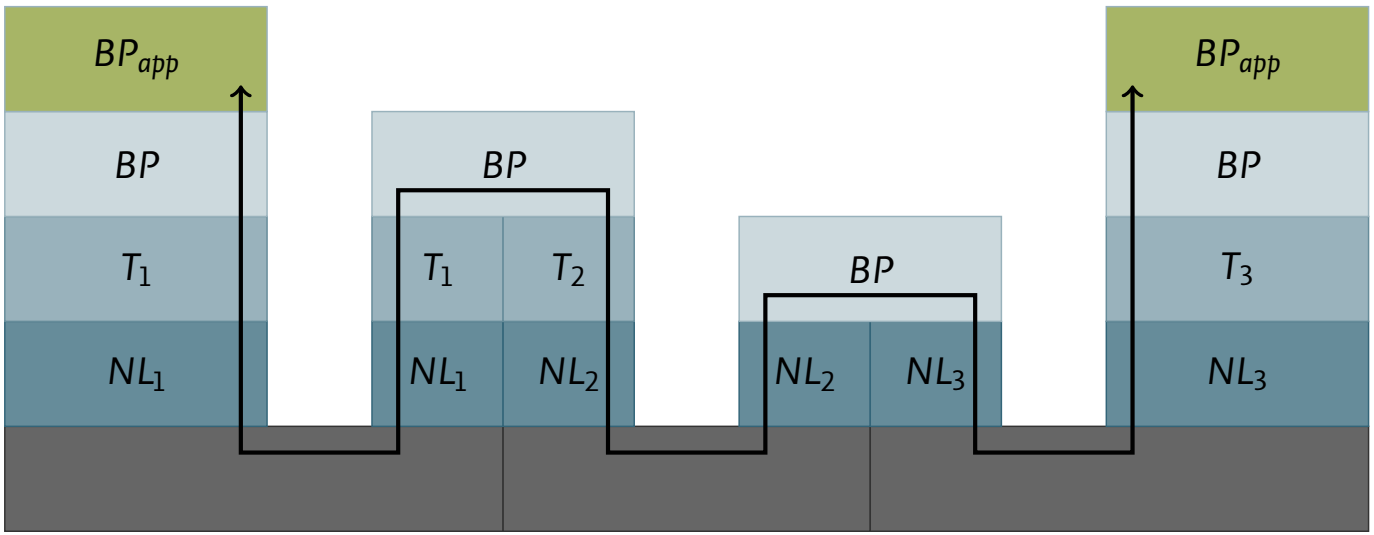


Hardware Details



Bundle Protocol

- Overlay network
- **D**elay/**D**isruption **T**olerant **N**etwork
- Multiple network/transport layers supported at single node
- RFC4838, RFC5050



Communication Aspects

Two Platforms

- Both platforms are running a DTN stack
  - *miniDTN* on MCU platform
  - *IBR-DTN* on Raspberry Pi
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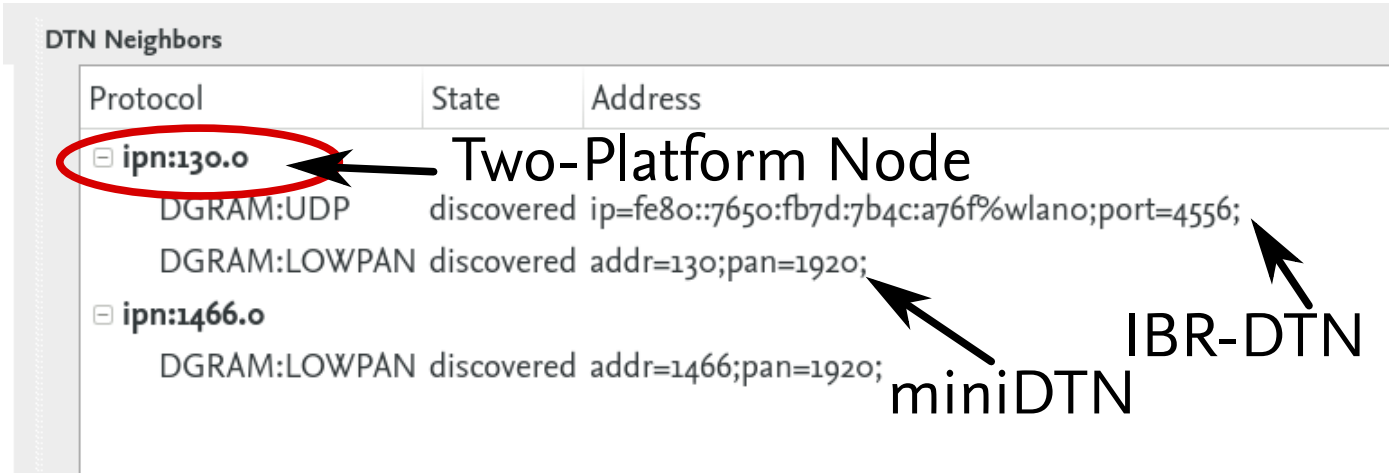
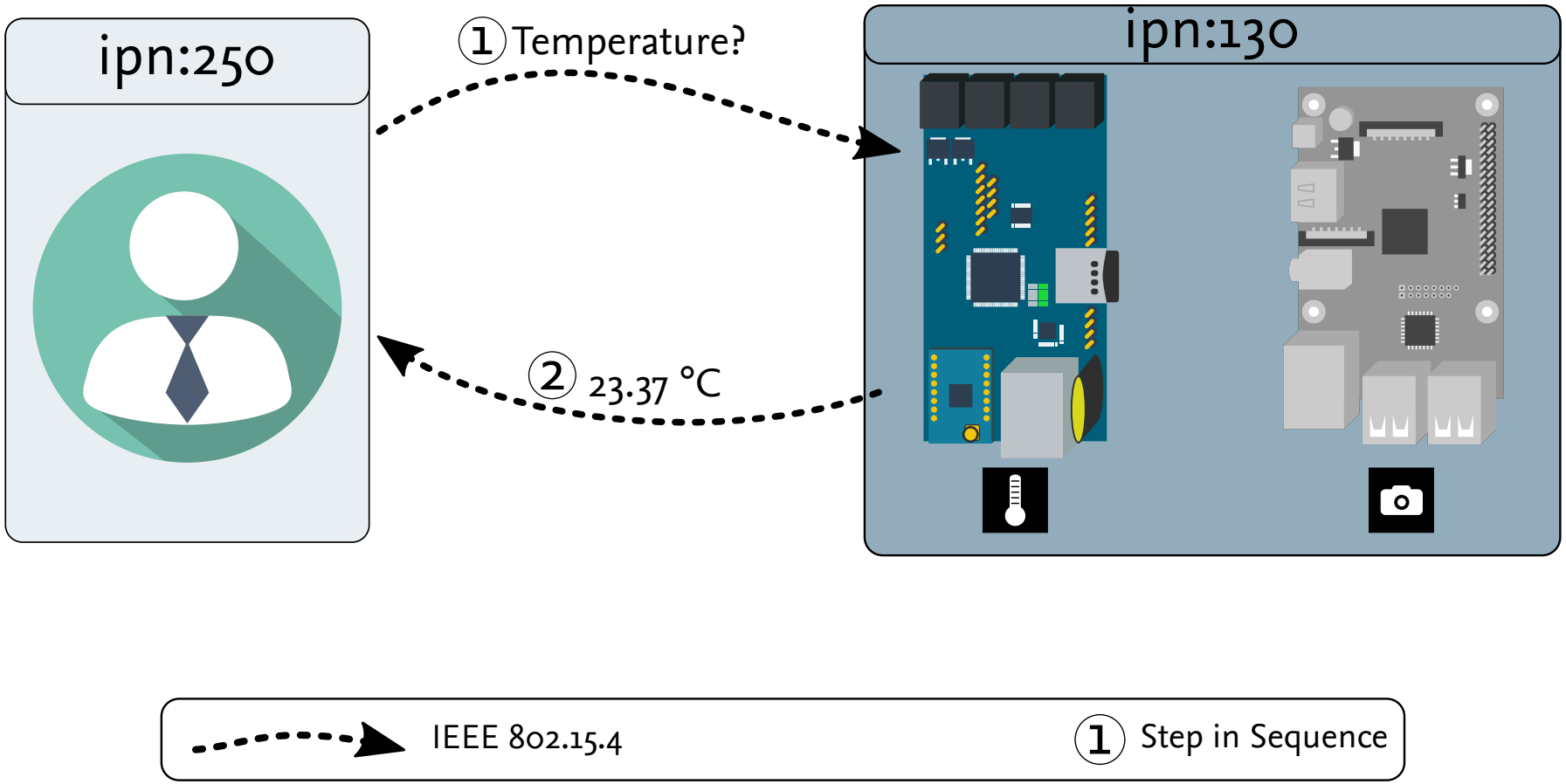
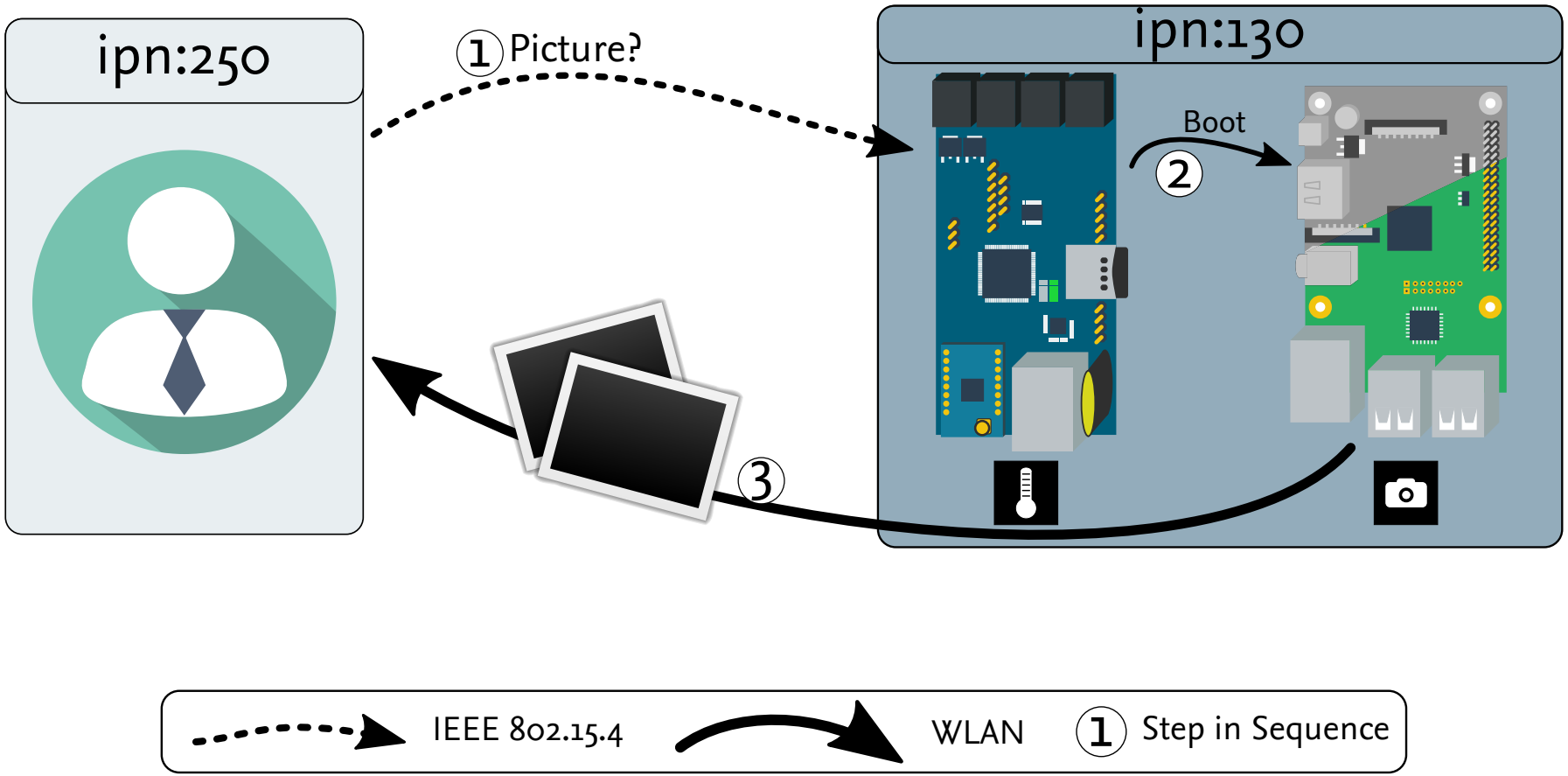


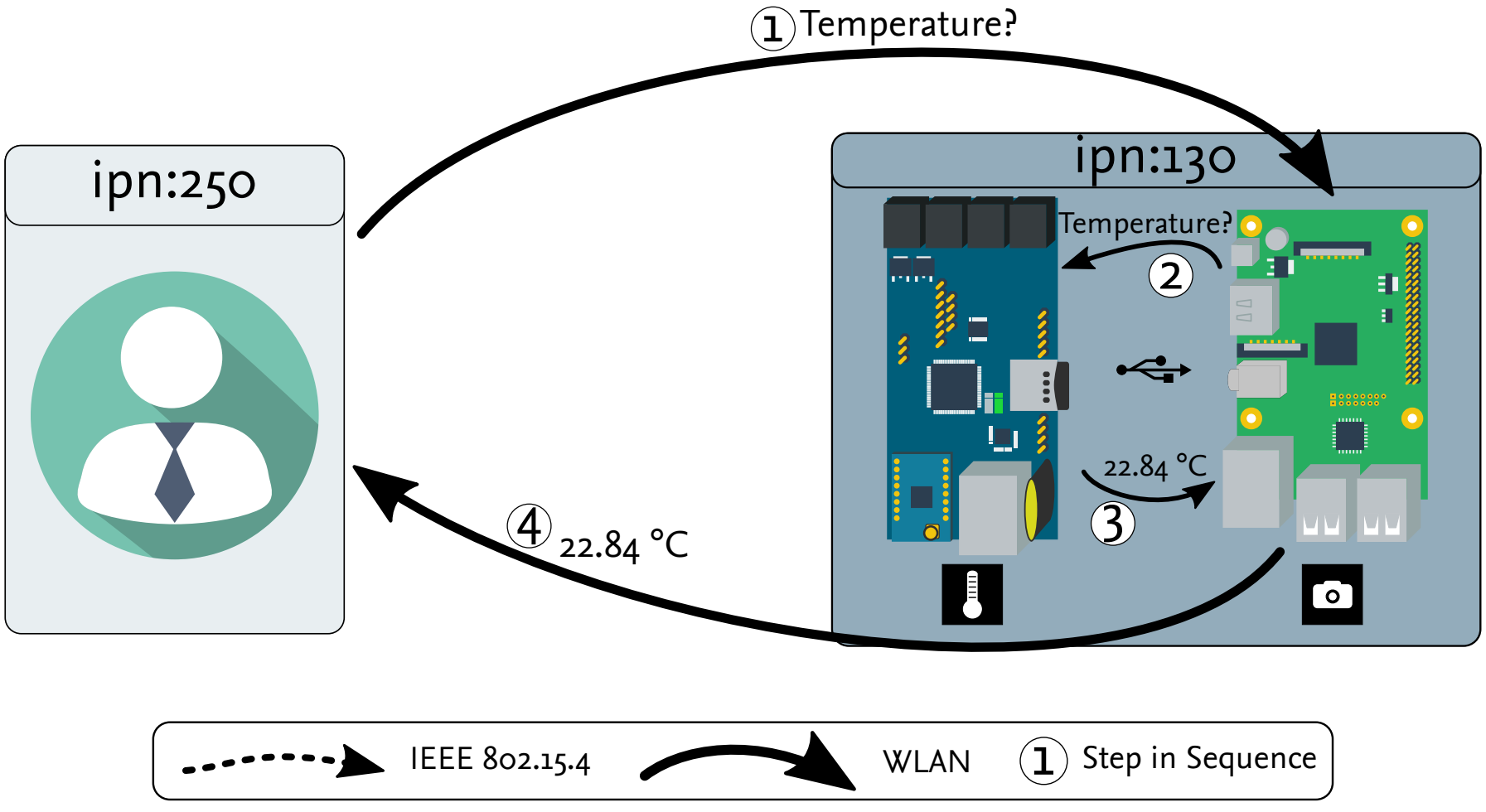
Use Case: Client sends all Bundles to ipn:130 (1)



Use Case: Client sends all Bundles to ipn:130 (2)



Use Case: Client sends all Bundles to ipn:130 (3)



Other Options

Applications Besides *(inter)active* Scenarios

- "Typical" DTN scenarios:
  - Disasters, after which infrastructure is broken
  - Battlefield communications
  - Simple relay node
    - Large data transfers via IEEE 802.15.4, interrupted and resumed via WiFi
- Bringing kind of Internet to rural areas
  - Ferry node (bus, boat, drone, ...)
    - Checks, if data is available and Raspberry Pi should be powered up
- For short-term operation, energy harvesting not necessary

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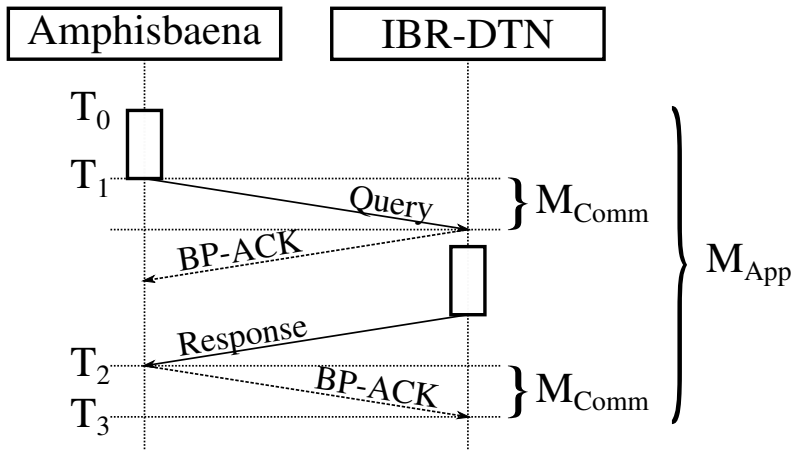
Beneficial in every scenario where whole processing or communication power is not needed continuously

Evaluation: Protocol

Query-Response Protocol

- Different sizes of data
- Small request, large response
  - Take a picture
- Large request, small response
  - E.g., transfer new software to station
  - Store-and-Forward approach:
    - Store data for other node temporarily



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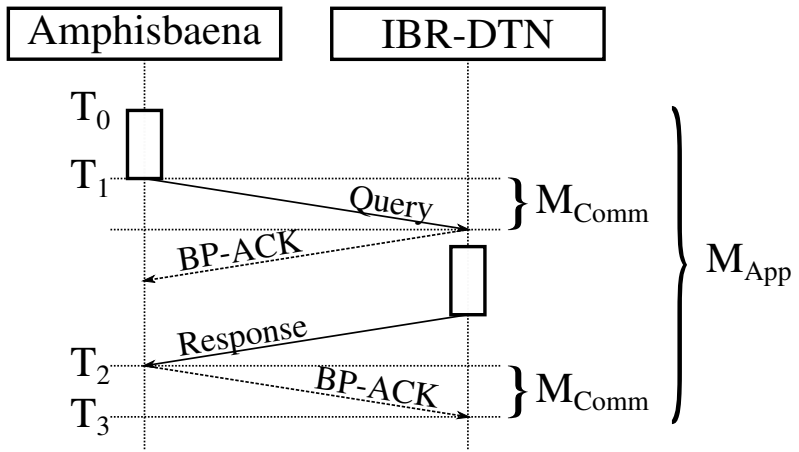


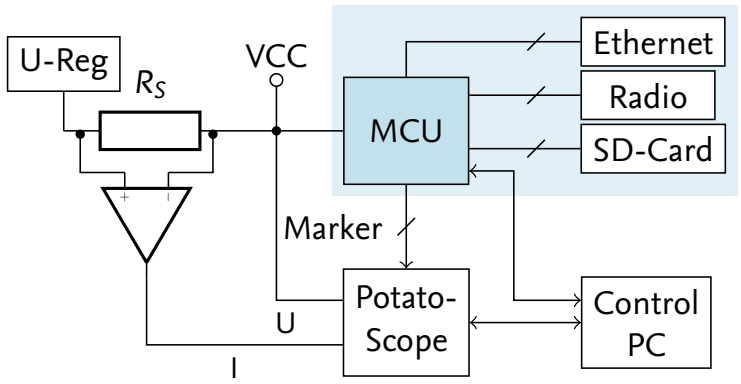
Large Data transfers

- Collect sensor data from the day

Evaluation: Setup

Measurement Setup

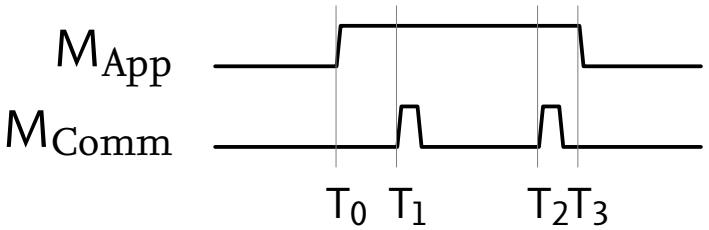
- Setup similar as in Demo yesterday
- Energy measurements
  - Current and voltage
  - 100 kHz sample rate
  - *Markers* for synchronization

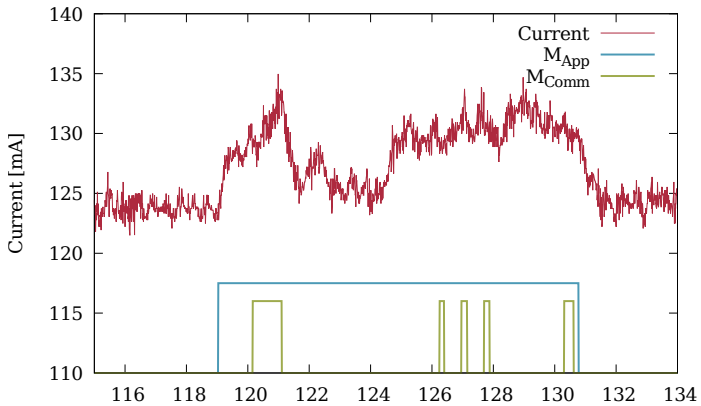


Evaluation: Protocol

Timing

- T_0: *Amphisbaena* prepares **Query**
- T_1: **Query** is being sent on wire
- T_2: **Response** from *IBR-DTN* ack'd
- T_3: Transfer finished





Evaluation

Optimization Goals

- Energy demand and time depend on...
  - Communication Interface
    - IEEE 802.15.4, Ethernet, WLAN
  - CPU clock
- **Both have influence on time needed for transmission**
- **Both have influence on energy needed for transmission**
- What should be optimized, energy **OR** time?

$$\mathbf{C}(s_{tx}, s_{rx}, M_i, f_{CPUj}) = (E, T)(s_{tx}, s_{rx}, M_i, f_{CPUj})$$

s_{tx}, s_{rx}: Size of data to be sent/received
M_i: Communication medium (Ethernet, IEEE 802.15.4)
f_{CPU_j}: Clock frequency of CPU

Parameters for Evaluation

Communication Interfaces

- IEEE 802.15.4
- WLAN (from Linux Board)
- (Ethernet)

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- 24 MHz
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- 64 Byte and 1024 Byte in any combination for s_{tx} and s_{rx}

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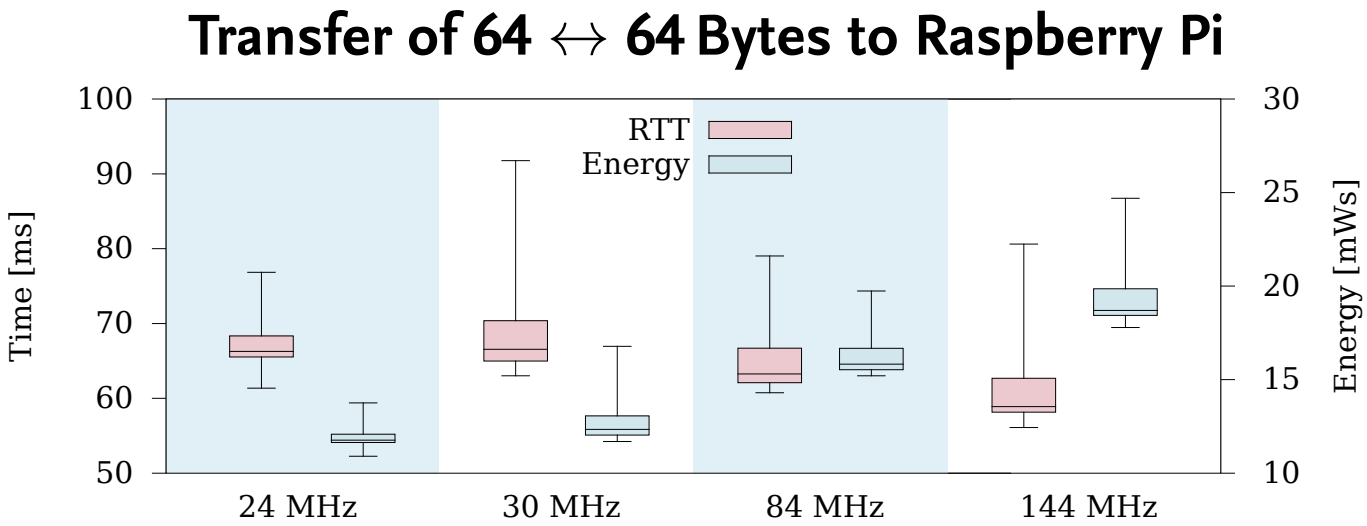
Communication Partner

- *Amphisbaena*
- *IBR-DTN* running on Raspberry Pi
- (*IBR-DTN* running on Intel Core i7-3770 based Computer)

Results: Small Bundles via IEEE 802.15.4



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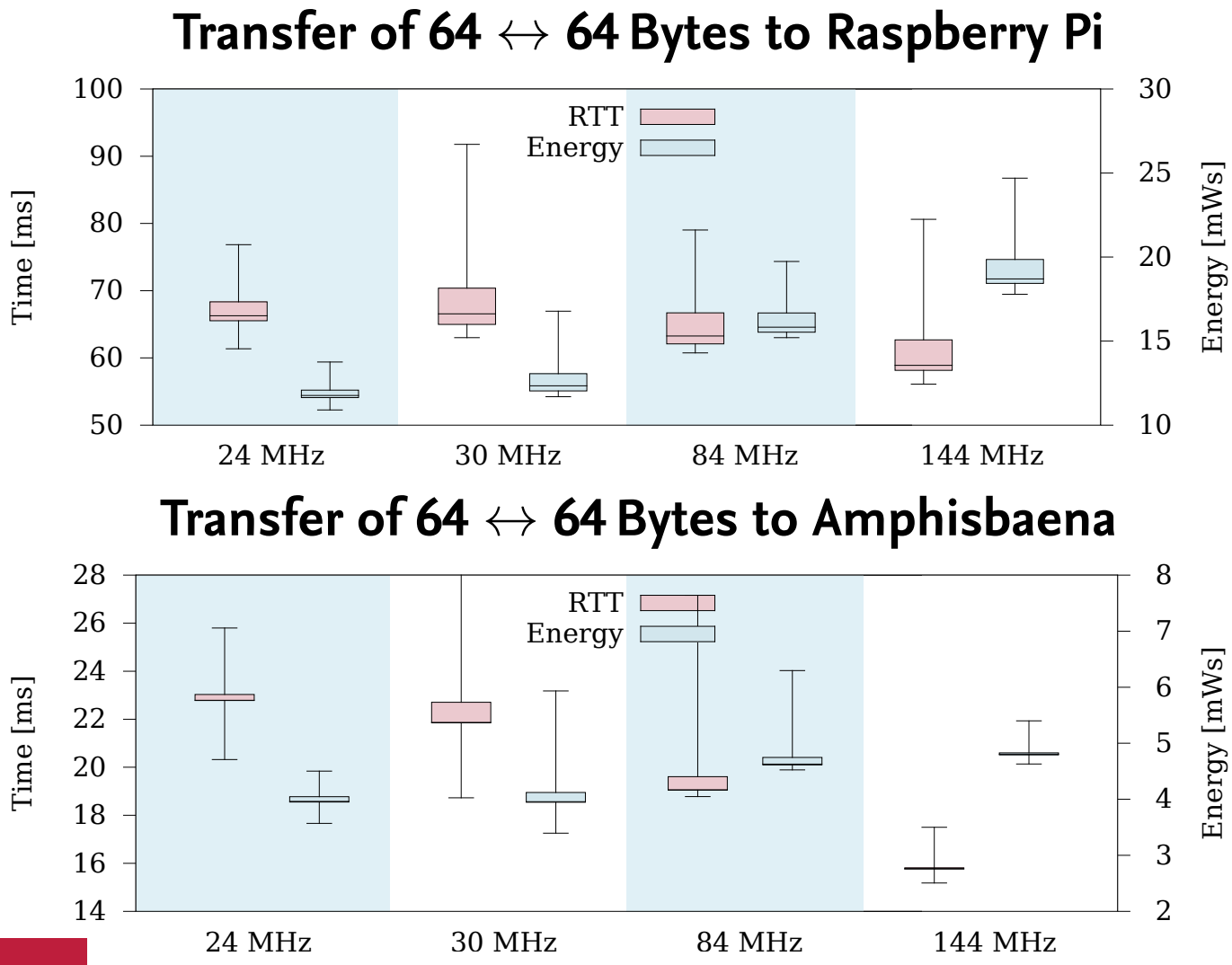

Findings

- **Small Bundles via IEEE 802.15.4**
  - **Increasing f_{CPU} not useful when communicating with RPi**

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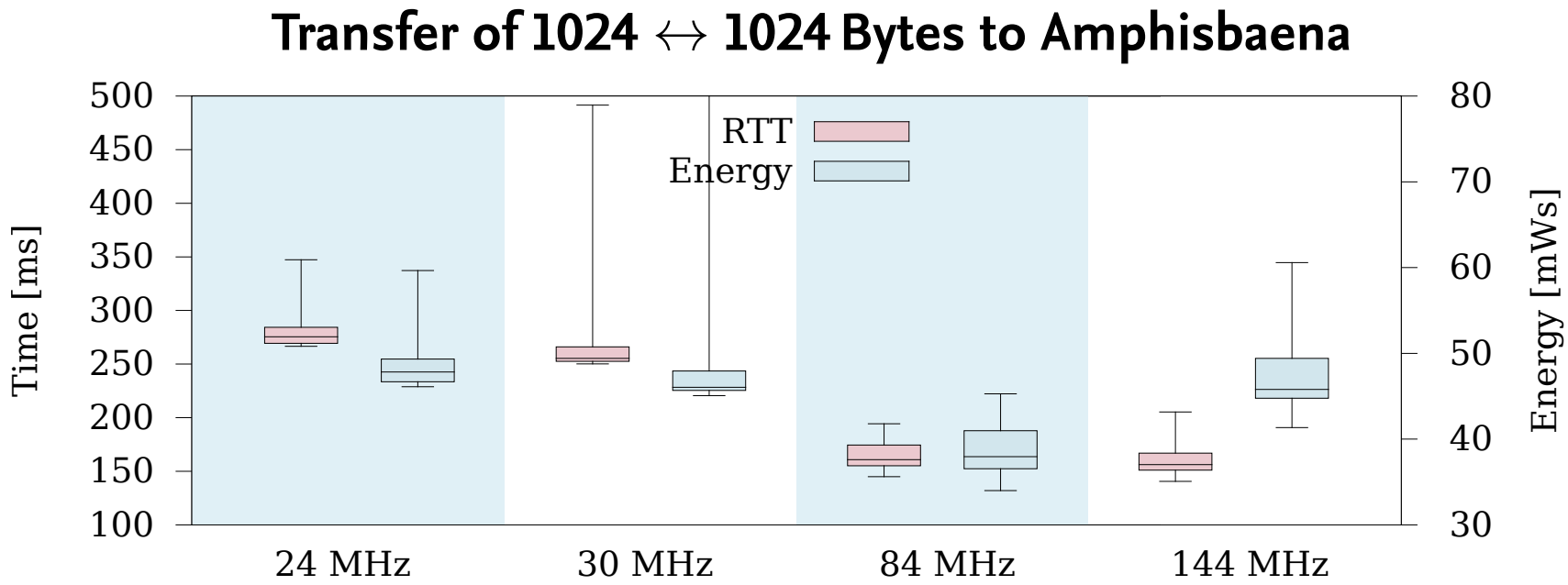

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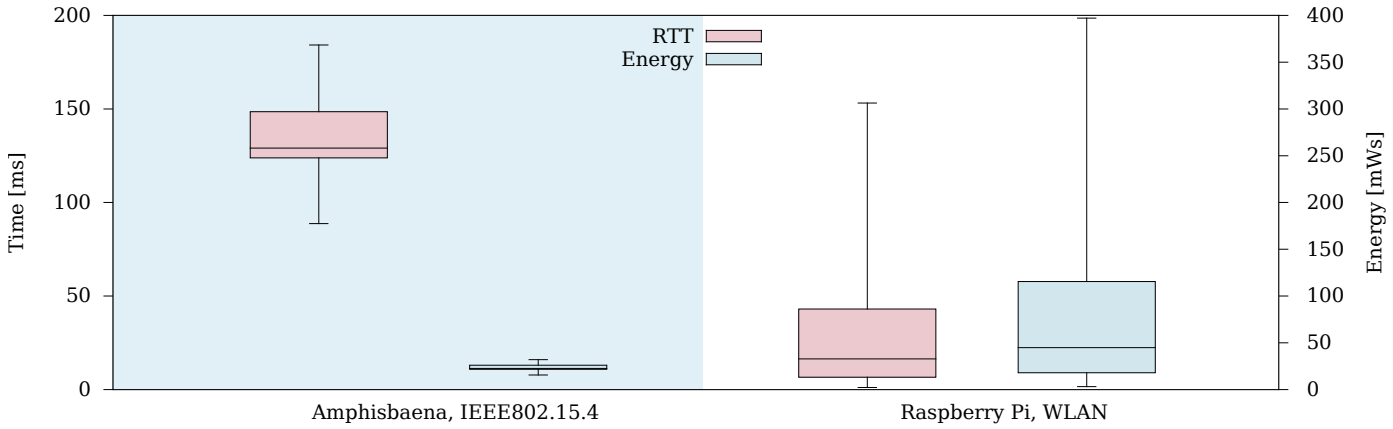
- **Optimum may not be at bounds of parameters**

Results: Many large Bundles in a Row

Transfer via IEEE 802.15.4 vs. WLAN (Data shown per Bundle)



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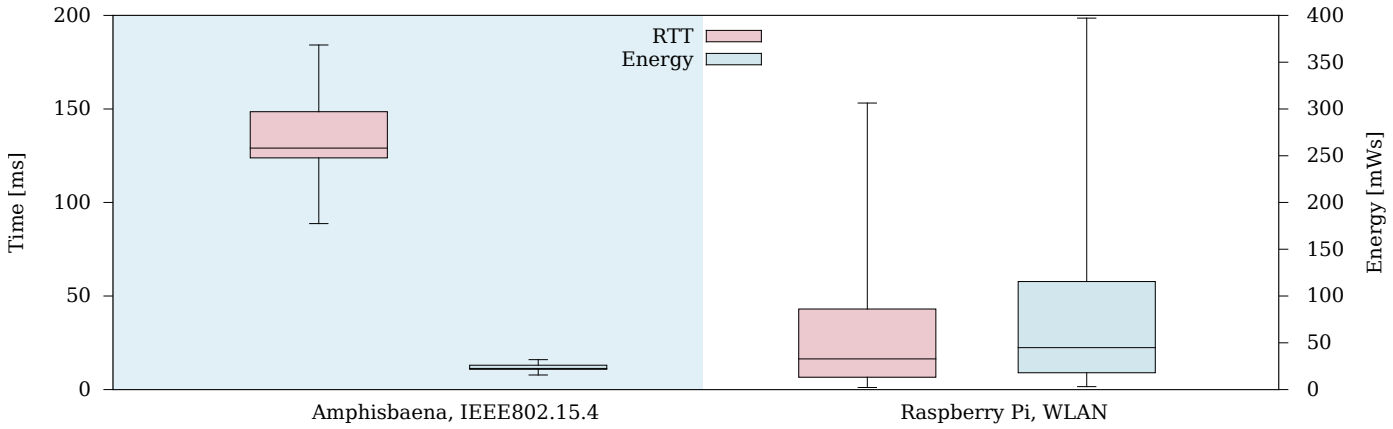

SBC Type	Medium	Boot-Time	Energy
Raspberry Pi Mod B[1]	WLAN	†103.23 s	203.963 Ws
Raspberry Pi2 Mod B[2]	WLAN	24.1 s	30.157 Ws

[1] Running Raspbian *wheezy* // [2] Running Raspbian *jessie* // † Association with WLAN AP may take very long

Findings

- Small Bundles via IEEE 802.15.4
  - Increasing f_{CPU} not useful when communicating with RPi
- Optimum may not be at bounds of parameters
- **Large differences in speed between WLAN and IEEE 802.15.4**
  - **But: Booting costs energy, too!**

Conclusions

- Two-Platform DTN node
  - MCU-based board, Raspberry Pi
- Both parts appear as a single node
- Energy demand depends on
  - Communication medium
  - Communication partner
  - Clock frequency
- Large delays for *IBR-DTN* on platforms like Raspberry Pi
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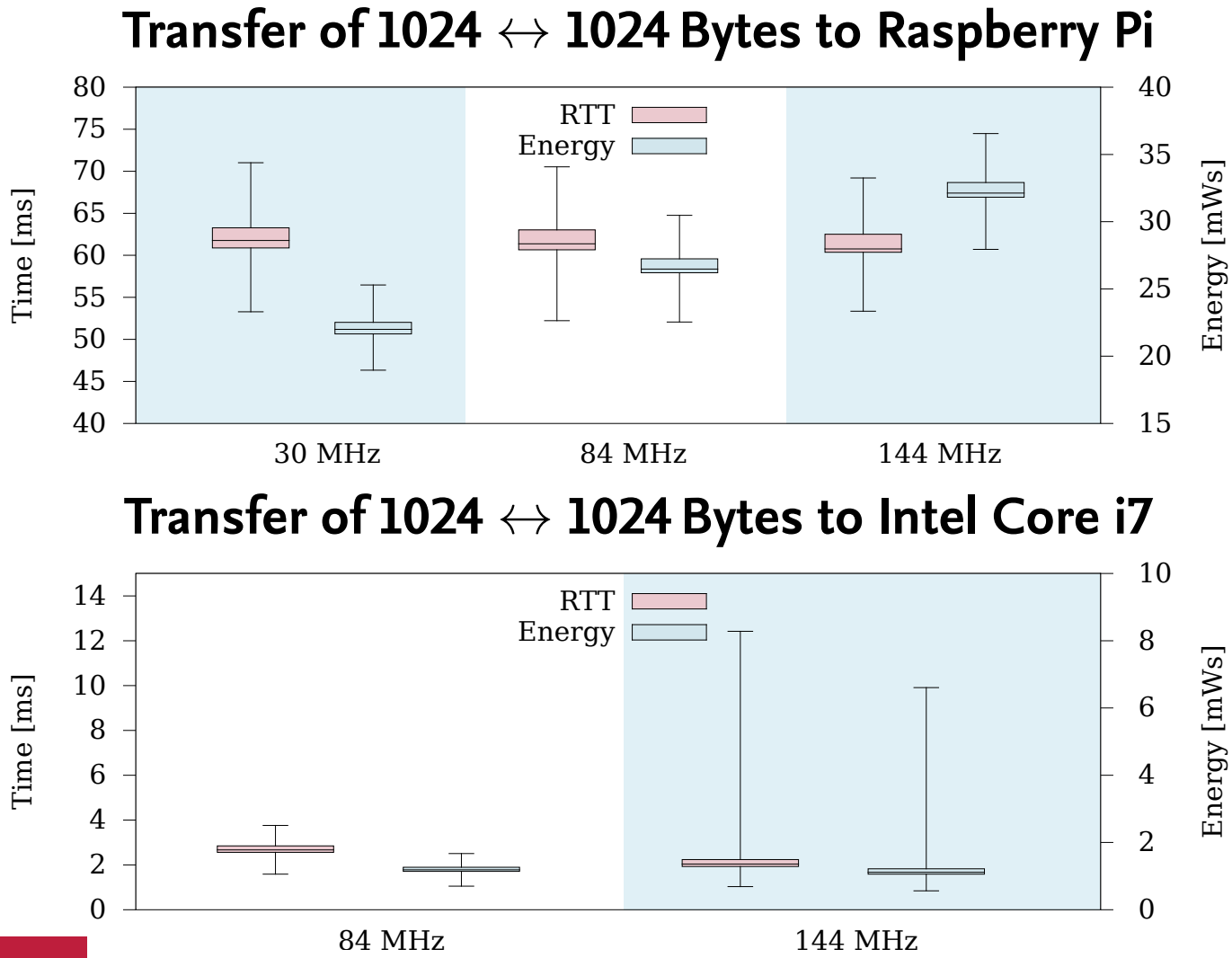
Thank you! Any Questions?

rottmann@ibr.cs.tu-bs.de

In Greek mythology, Amphisbaena is a serpent with two heads.

Results: Large Bundles via Ethernet



Findings

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  - Increasing f_{CPU} not useful when communicating with RPi
- Optimum may not be at extrema of parameters
- **Ethernet**
  - **Strongly dependent on Communication Partner**
  - **Large delays on Raspberry Pi $\rightarrow$ low f_{CPU}**

Cooperation

Cooperation of DTN implementations

- DTN stacks know of each others applications
- If a bundle for the other one is received, it will be forwarded
  - Linux platform may be powered up
- *Amphisbaena* may decide to boot Linux if bundle is too big
- Cooperation is transparent to neighbors
- Information is exchanged via USB between *miniDTN* and *IBR-DTN*

Power Supply

- Efficient Switching Regulator *LM43603*
  - Provides 3.3 V
- Charge Controller *LT3652HV*
  - Charges Li-Ion/LiPo/$LiFePO_4$ /Lead-Acid
- Photovoltaic Module

Processing Unit

- STM32F407VGT MCU
  - Ethernet, USB
  - SD Card
  - I^2C, SPI, UART, ...
  - RTC with Backup-Battery
- Two Outputs for Load
  - MOSFET High Side Switches
- Low Power Radio
  - IEEE 802.15.4
  - LoRa
- 1-wire Temperature Sensors *DS18B20*