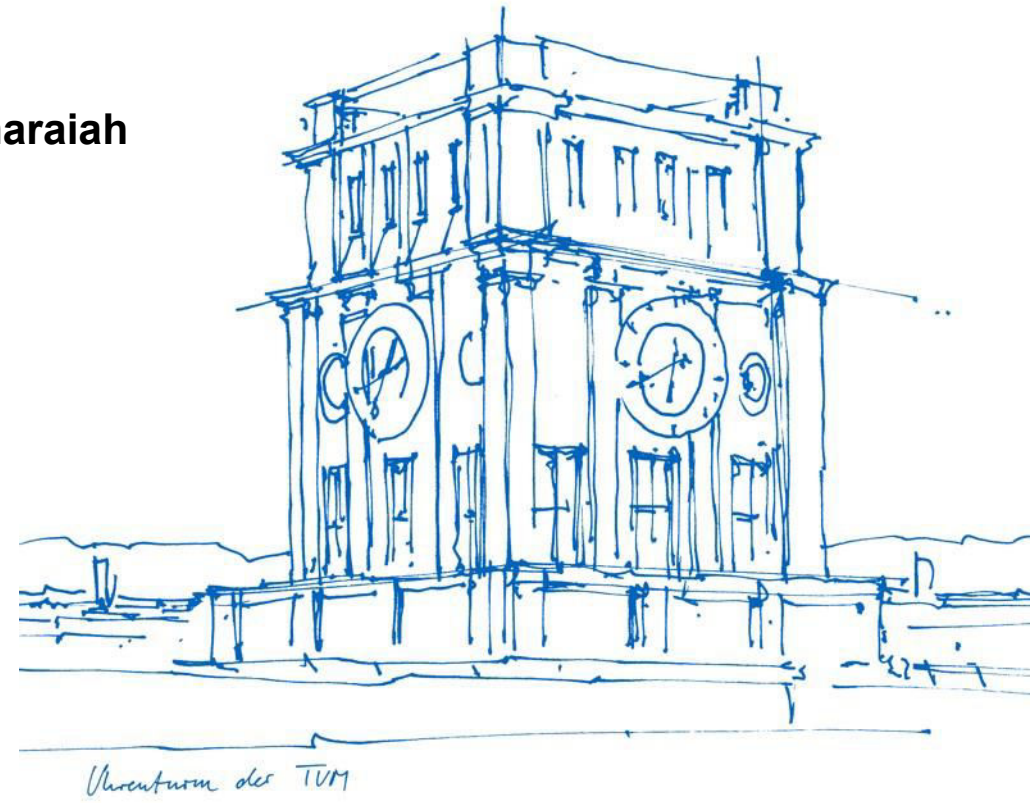
Chair of Communication Networks
Department of Electrical and Computer Engineering
Technical University of Munich

Development and delay characterization of east bound interface for IWSN.

Research Internship

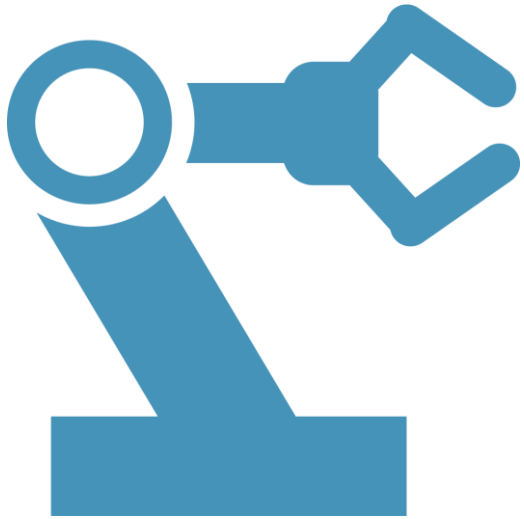
Yadhunandana Rajathadripura Kumaraiah
ga83jeb@mytum.de

Supervisor(s):
Murat Gürsu[1] and Samuele Zoppi[2]
murat.guersu@tum.de[1]
samuele.zoppi@tum.de[2]



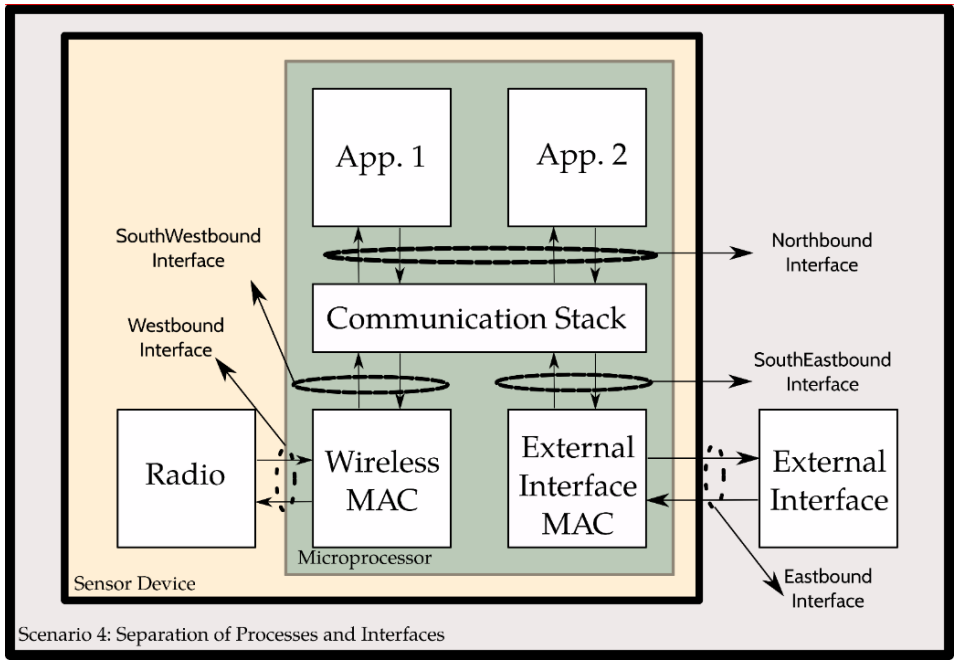
Motivation

- Stringent latency requirement in Industrial communication.
  - Latency requirement in milliseconds.
  - WSNs are attactive due flexibility and ease of deployment.
  - Problem: Providing low latency over wireless channel.
  - State-of-the-art literature concentrates on designing deterministic TSCH schedule.



Overview

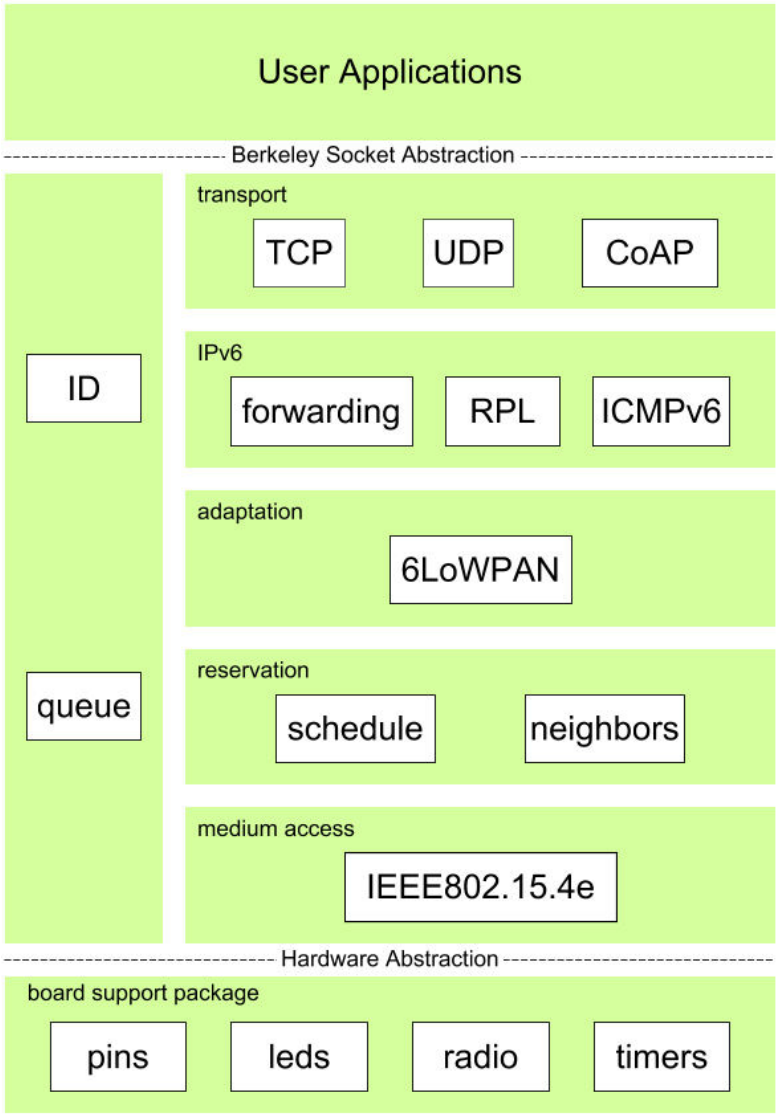
- OpenVisualizer makes measurements hard and introduces huge latency.
- Identifying components required for network functionality.
- Development of east bound interface.
- External MAC modified to improve latency.
- Latency characterization and bottleneck analysis.



Source: Murat Gürsu

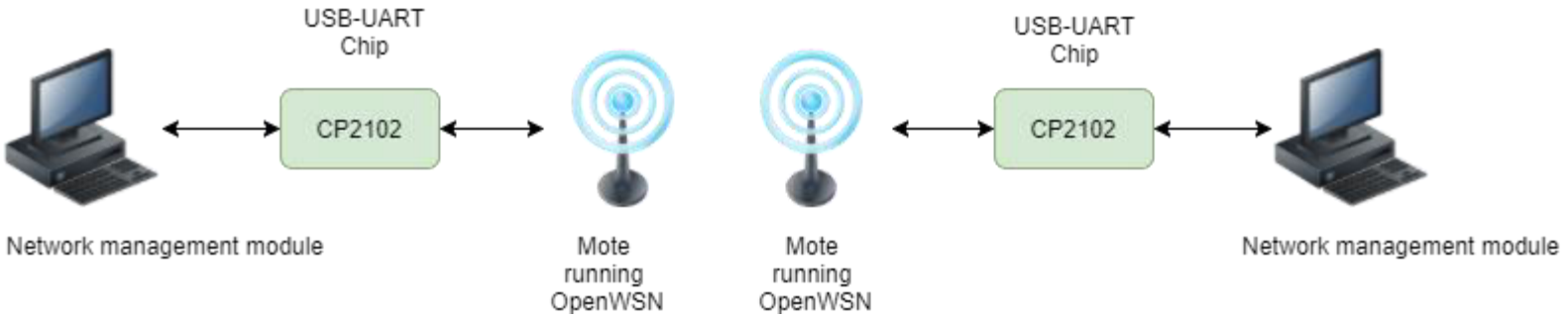
East bound interface components

- OpenWSN is an open source implementation of internet of things standard protocol stack.
- Implements IEEE802.15.4e TSCH MAC layer.
- East bound components:
  1. Open serial driver
  2. Network management module.



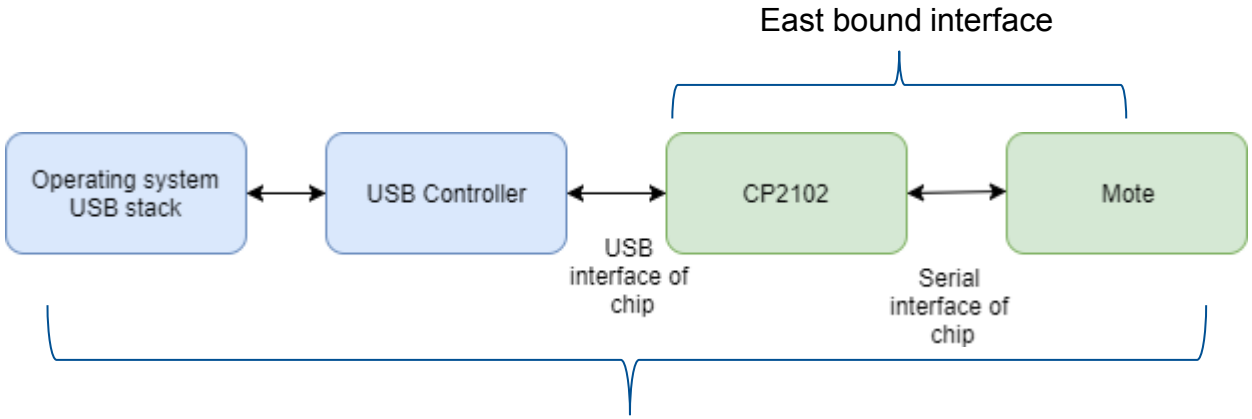
Experimental setup

- Following figure represents experimental setup.
- Host computers run python network management modules.
- Openserial driver interfaces with host computer via east bound interface.



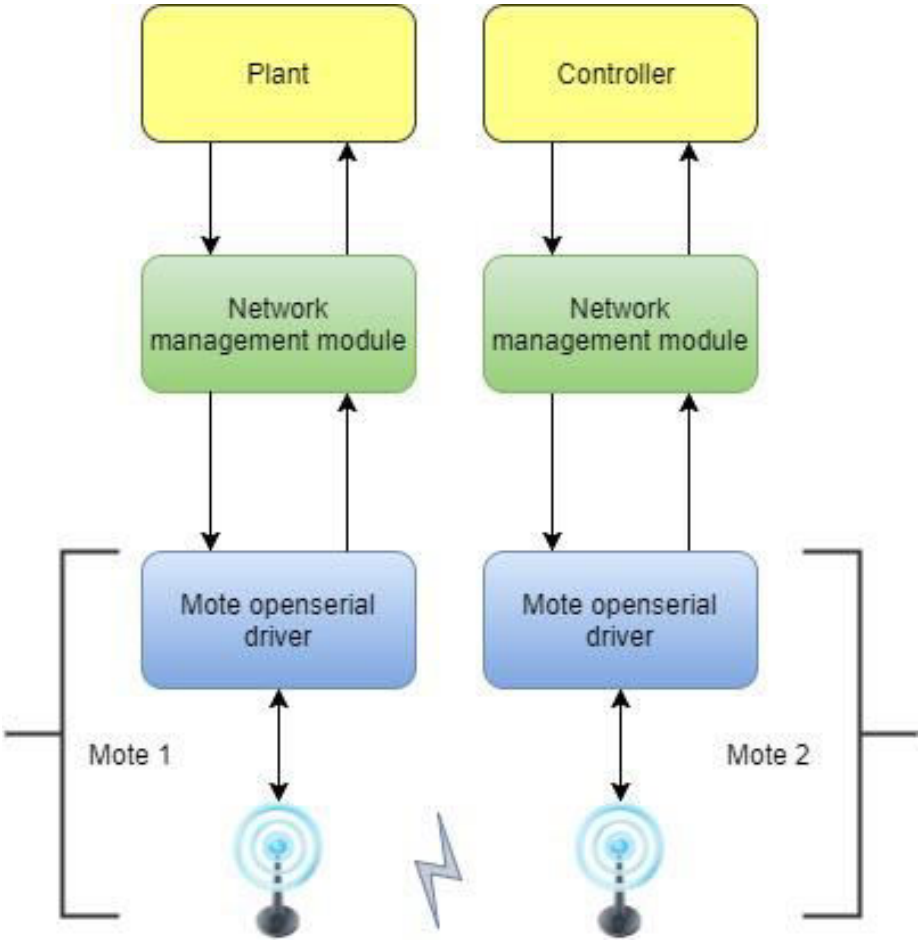
East bound interface hardware view

- Complete picture of east bound interface.
- Interface between CP2102 and mote is considered as east bound.



Implementation

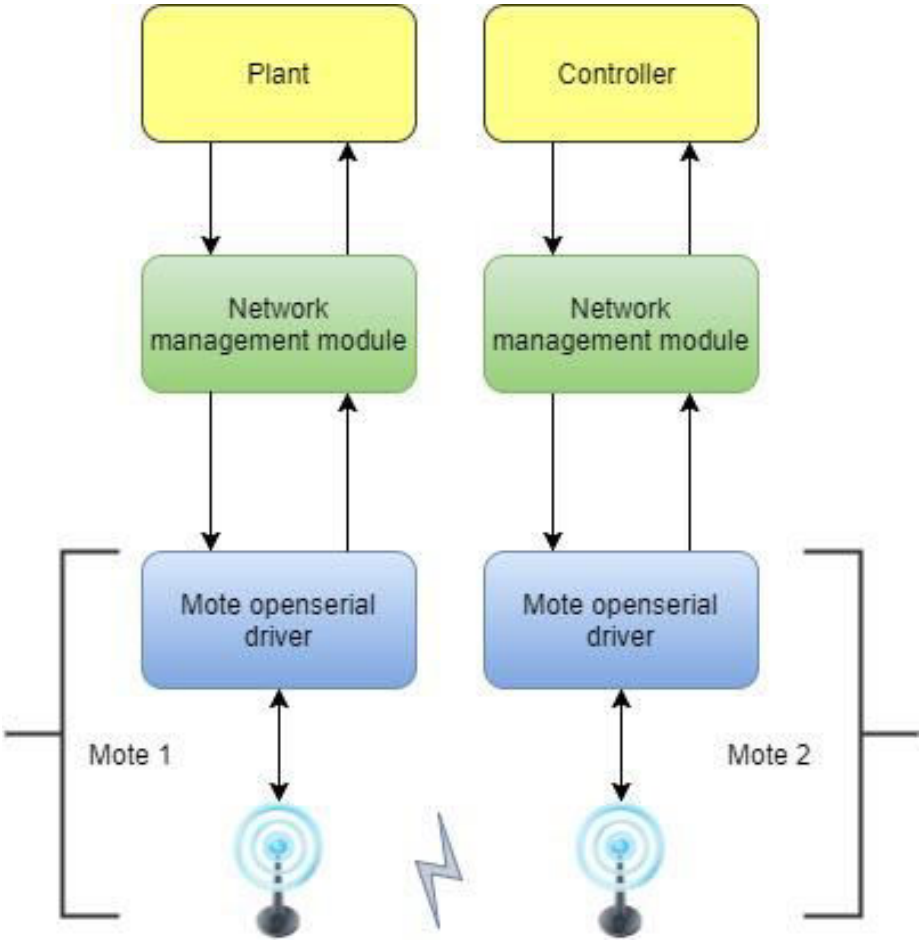
- Openserial driver design.
  - Implements communication protocol over serial.
  - TX and RX circular buffers.
  - Implements commands to allow network management from the host.
  - Scheduled in serial TX/RX slots from MAC layer.
  - Facilitates to inject packets to WSN.



Setup from software perspective

Implementation

- Minimal network management module.
  - Eases network latency measurement.
  - Implements a protocol as defined by openserial driver.
  - Injects compressed UDP packet.
  - Control data collection.
  - Routing table maintenance.



Setup from software perspective

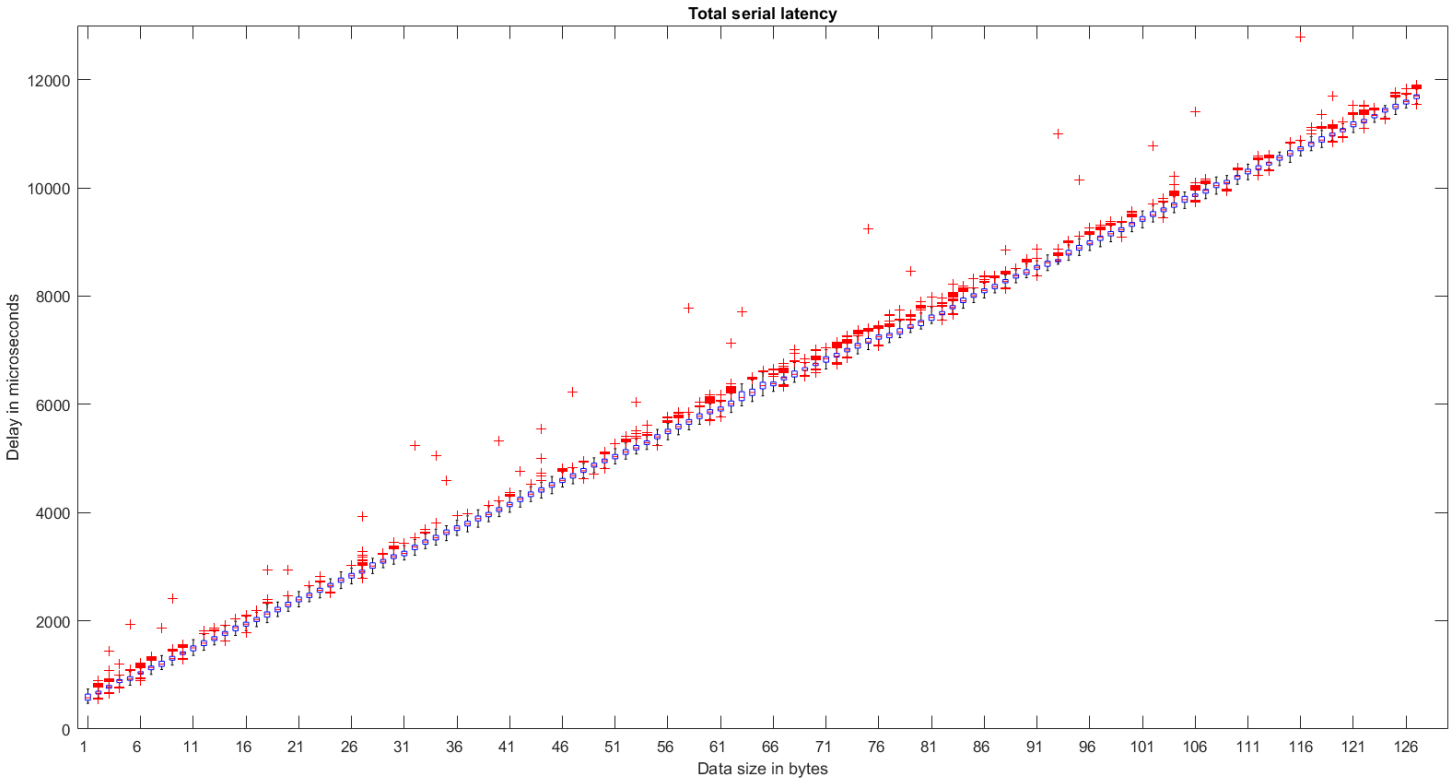
Latency components and analysis

- Latency in the external interface consists of four components
- Host controller delay, USB protocol delay, chip delay and significant serial interface delay.
- Out of all these delays, serial delay dominates.
- Delays can written in the equation form as shown below.
- T_{usb} value is negligible.

$$T_{total} = T_{host} + T_{usb} + T_{chip} + T_{serial}$$

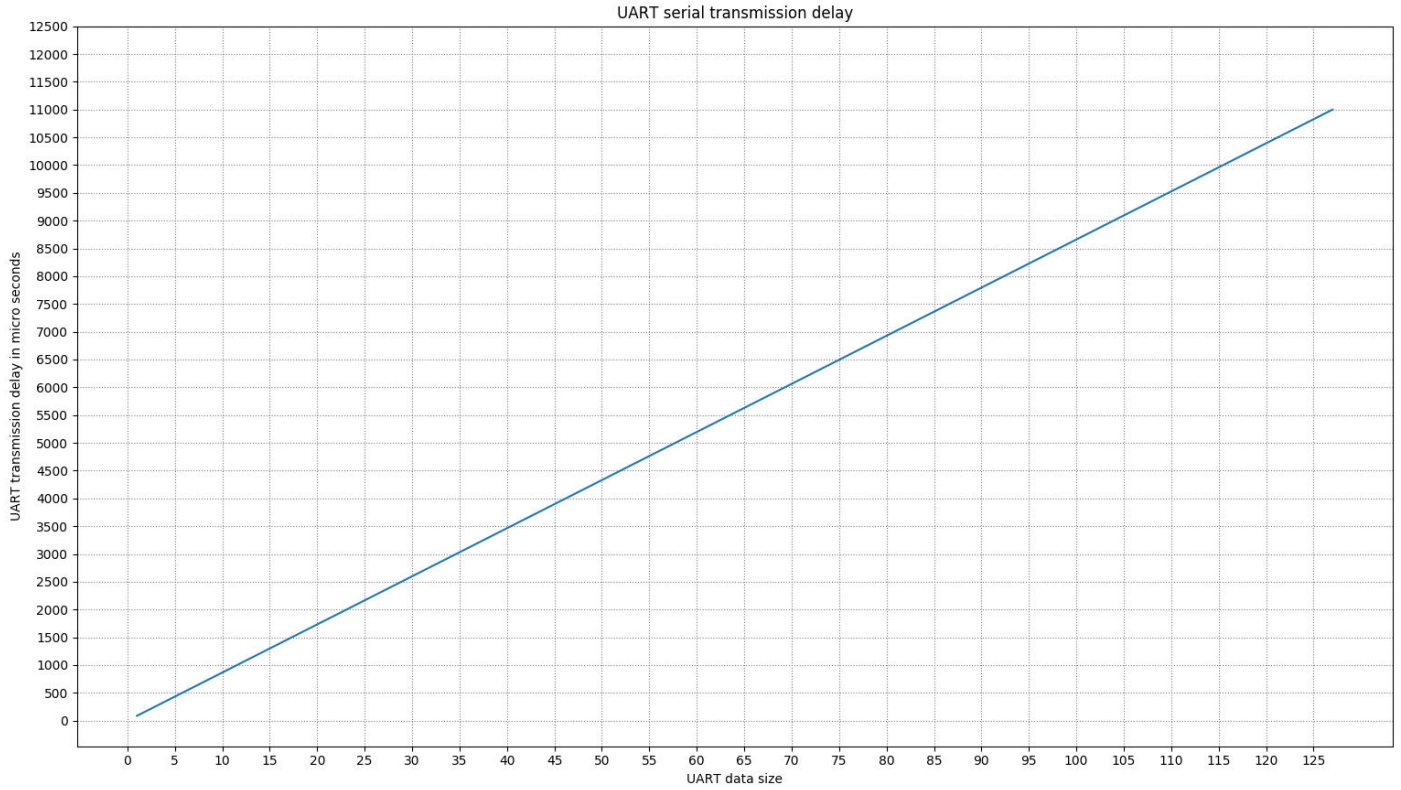
Total latency (T_{total}) due to external interface.

- Overall latency of east bound interface and Hardware plus processing delay of host.
- USB 2.0 full speed, Bulk end point, End point max packet size 64 bytes.



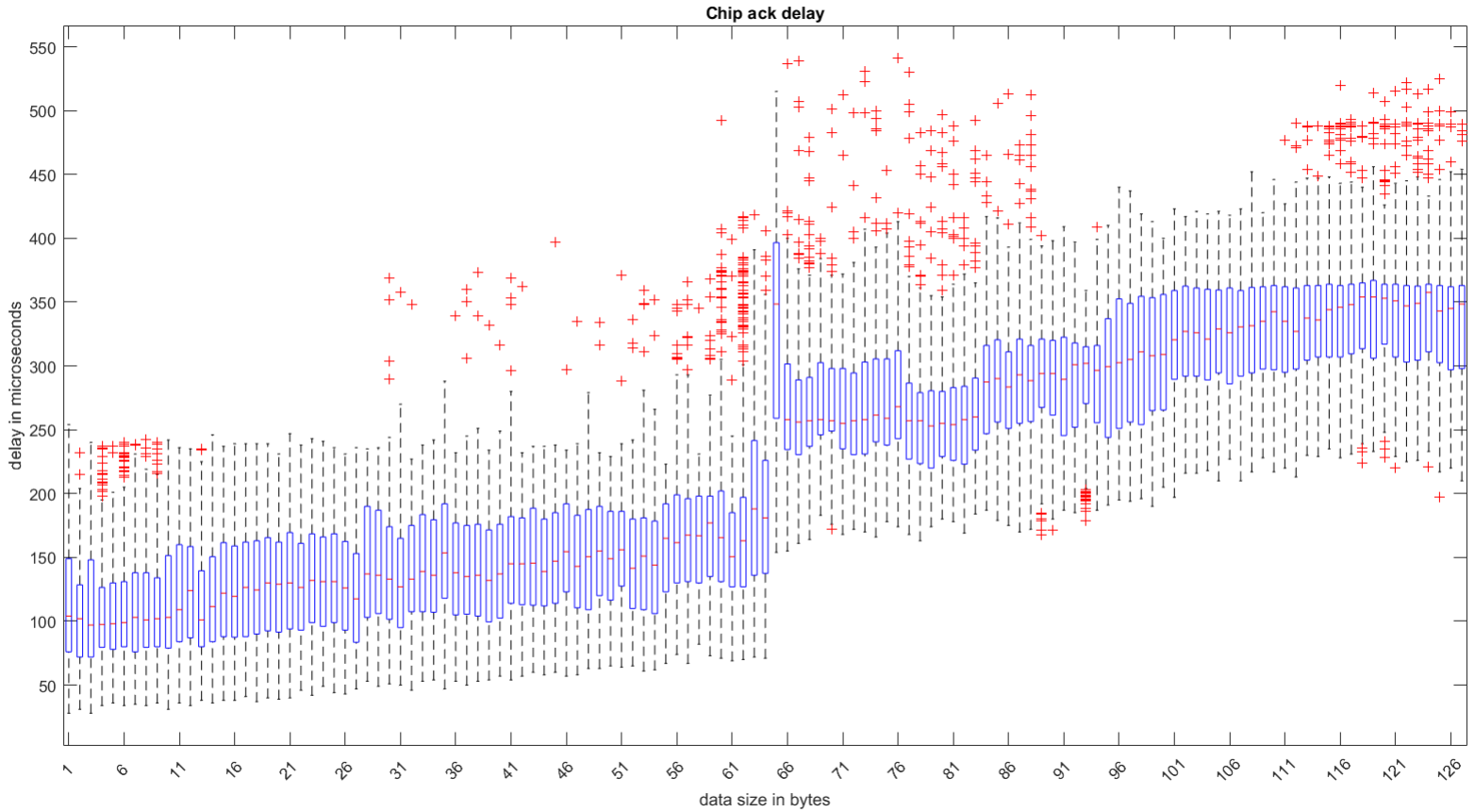
East bound interface latency (T_{serial})

- Depends on serial interface latency.
- Serial latency is linearly dependent on data size.
- Baud rate 115200 bps(86.5 micro seconds per byte)



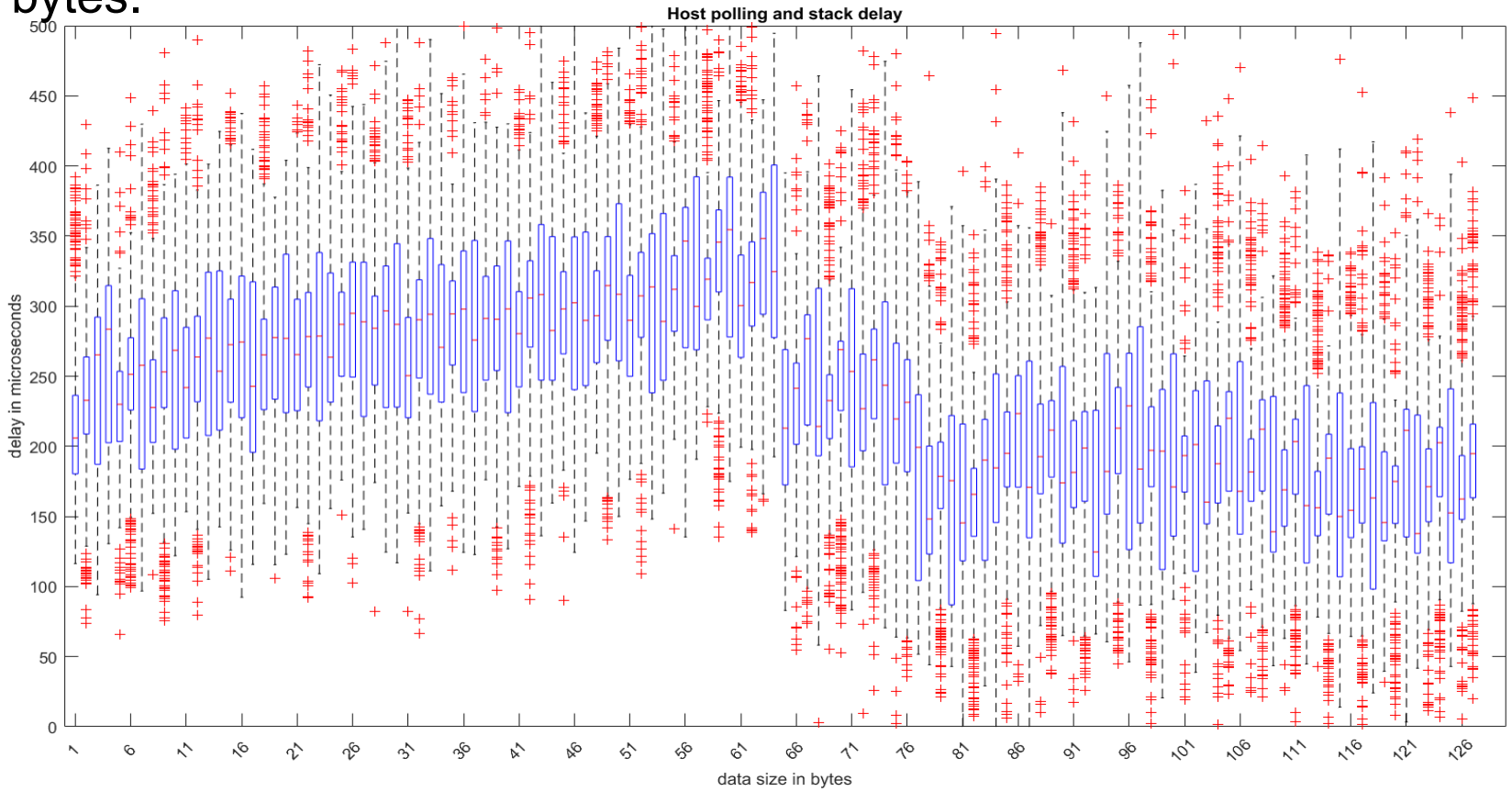
Processing delay at USB-UART chip (T_{chip})

- Delay is weakly dependent on data size until 64 bytes after that increases approximately by 80 micro seconds(on average).



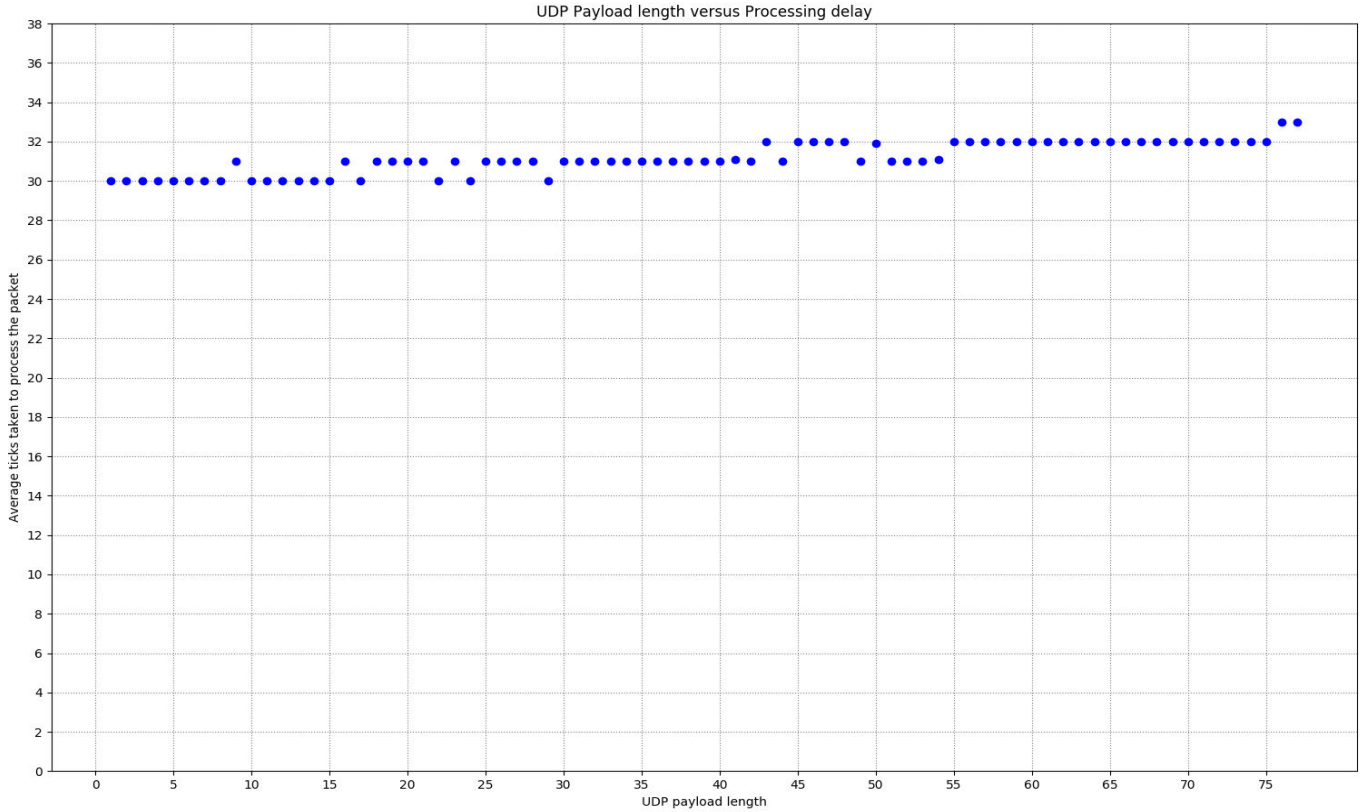
USB controller and Polling delay (T_{host})

- Again USB controller delay increases weakly with data size, Reduces as data size reaches 64 bytes, since end point max data size is 64 bytes.



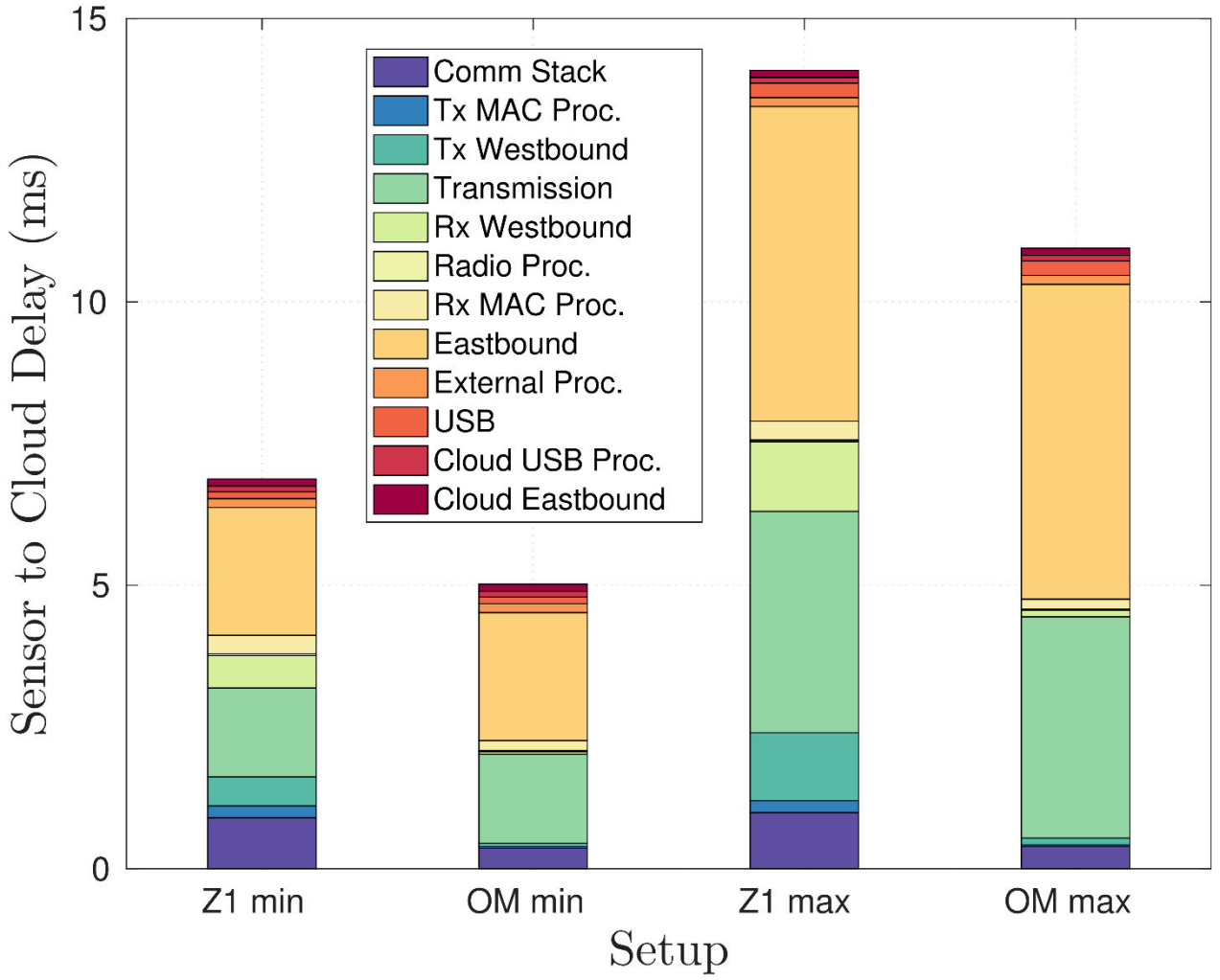
Communication stack processing latency

- Delay measured in ticks. 1 tick = 30 microsec
- Processing time before packet is injected in queue (around 0.9ms)
- Header appending, compression and checksum calculation etc.



Latency contribution comparison

- End to end latency for wireless sensor node.



Source: Murat Gürsu

Latency and slot width design

- Eastbound interface puts a constraint on slot width.
- Width of the slot should be designed based on serial data traffic.
- Slot width should be sufficient enough to accommodate serial data.
- Slot size reduction restricted by serial latency.
- Equation relating slot width serial data size.

$$\max\_bytes\_per\_slot = (baud\_rate/10) * slot\_size$$

At baudrate of 115200, we can send only 69 bytes via eastbound interface.

Future work

- Characterizing queuing delay in chip
- Separating USB overhead, USB controller delay and USB stack delay.

References

[1] Özkan, Hasan Yagiz, Bachelor thesis Minimalistic Frame Structure building and Bottleneck Analysis for LLDN with OpenWSN.

[2] H. Murat Gürsu, Samuele Zoppi, Hasan Yagız Ozkan, Yadhunandana R. K., Wolfgang Kellerer, Tactile Sensor to Cloud Delay: A Hardware and Processing Perspective.

[3] OpenWSN wiki. https://openwsn.atlassian.net/

[4] Usb in nutshell. http://www.beyondlogic.org/usbnutshell/usb4.shtml# Bulk. Accessed: 2017-10-12.

[5] Olfa Gaddour and Anis Koubˆaa. Rpl in a nutshell: A survey. Computer Networks, 56(14):3163 – 3178, 2012.

Thank you!

Questions?