Technische Universität Braunschweig

IBR

Software Acknowledgements for TPC

Piggy-Backing Link Quality Measurements to IEEE 802.15.4 Acknowledgements

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GINSENG Project

- Developing a WSN for industrial applications
- Petrogal oil refinery as testbed
- Deterministic performance and topology
- Transmission Power Control to prolong sensor life

TPC is necessary for reliability and energy effciency

Transmission Power Control for WSNs Primer

Saving some energy by reducing the transmission power

1. Sender sends a frame
2. Receiver can determine Link Quality Indicators for the received signal (i.e. RSSI)
3. Some form of feedback (RSSI value) is sent back to the sender
4. The original sender - depending on the feedback - may decide to increase to decrease its TX power next time

Sending feedback in (3) also incurs some cost, so in a worst case scenario the application of TPC may use more energy than not using it.

IEEE 802.15.4 ACK frame format

Bits	Field
15 14	Source Addressing Mode
13 12	Frame Version
11 10	Dest. Addressing Mode
9 8 7	**Reserved**
6	PAN ID Compression
5	Ack Request
4	Frame Pending
3	Security Enabled
2 1 0	Frame Type

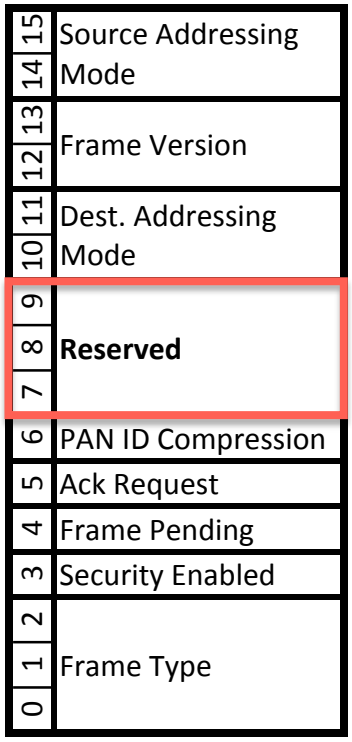
IEEE 802.15.4 Frame Control Field

Octets: 2	**1**	**2**
Frame Control	Sequence Number	FCS
MHR		MFR

IEEE 802.15.4 ACK frame

- There are 3 currently unused bits in the Frame Control Field

IEEE 802.15.4 ACK frame format



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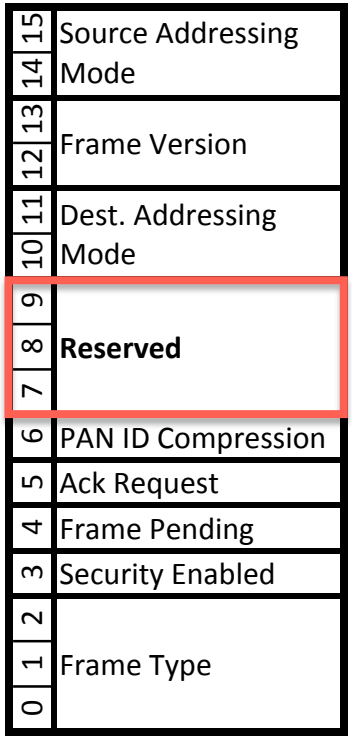

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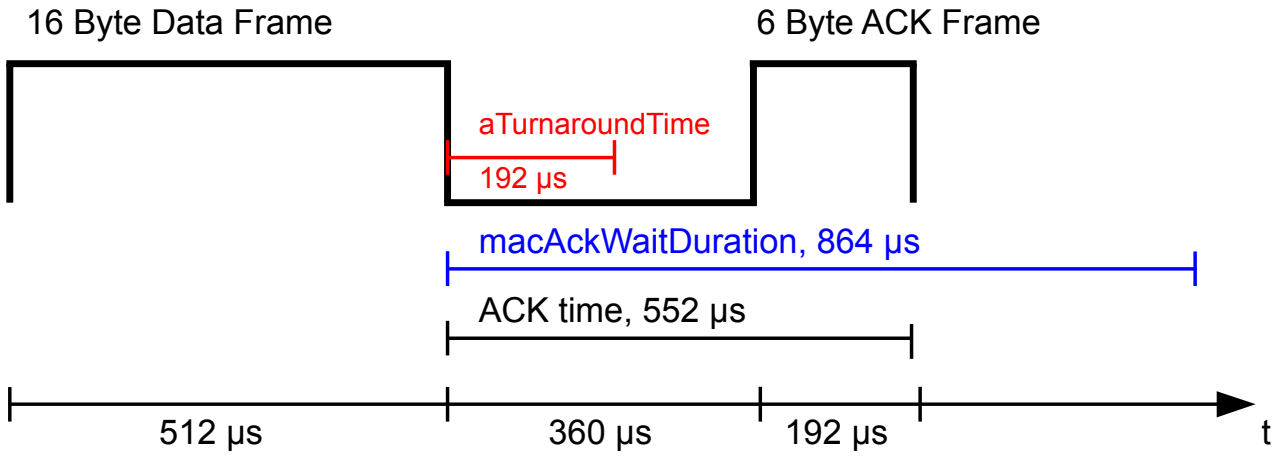
- There are 3 currently unused bits in the Frame Control Field
- $\rightarrow$ Plenty of room to put reception quality information
- Unfortunately most IEEE 802.15.4 transceivers send ACK frames in hardware, and thus their content cannot be modified

Timing Constraints

Measured Timing using CC2420 Hardware Acknowledgements

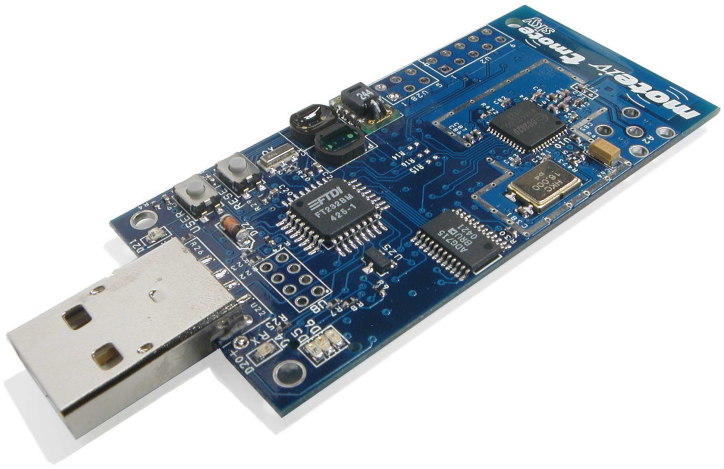


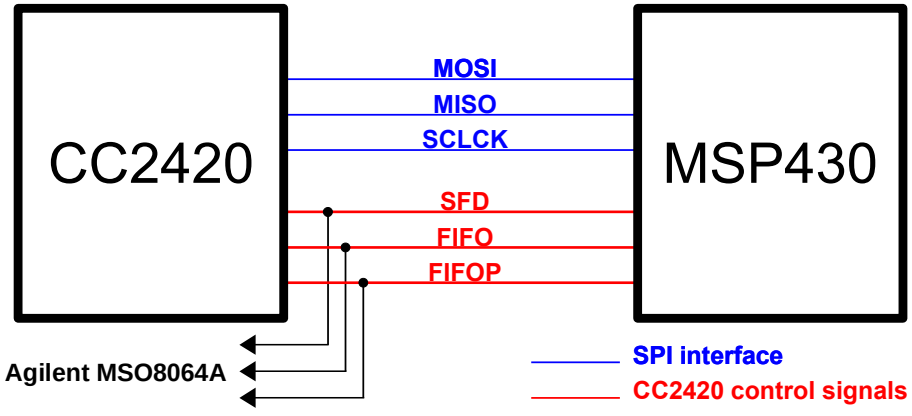
aTurnAroundTime: Earliest time after which it is allowed to commence sending an ACK frame (maximum allowed time to switch RF frontend from TX to RX mode)

mackAckWaitDuration: ACK must be completely received before this time

Plattform

- TMote Sky sensor nodes
- TI CC2420 IEEE 802.15.4 compliant transceiver
- Contiki Operating System





Contiki Standard CC2420 Driver

Using Hardware Acknowledgements

1. CC2420 receives complete frame
2. CC2420 checks CRC. If ok, automatically transmit ACK and raise interrupt
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Suppressing the ACK in (2) and constructing and sending it after (3) is not possible due to timing constraints!

Optimized CC2420 driver

Software Acknowledgements

1. CC2420 receives SFD. After `blocksize` bytes have been received it raises an interrupt
2. We read `blocksize` bytes
3. After reading the first 4 bytes, an ACK frame with LQI information is prepared and stored in CC2420's TXFIFO
4. Continue blockwise reading until frame is finished
5. If CRC check fails, the TXFIFO gets flushed. if CRC check is ok, the ACK frame will be send

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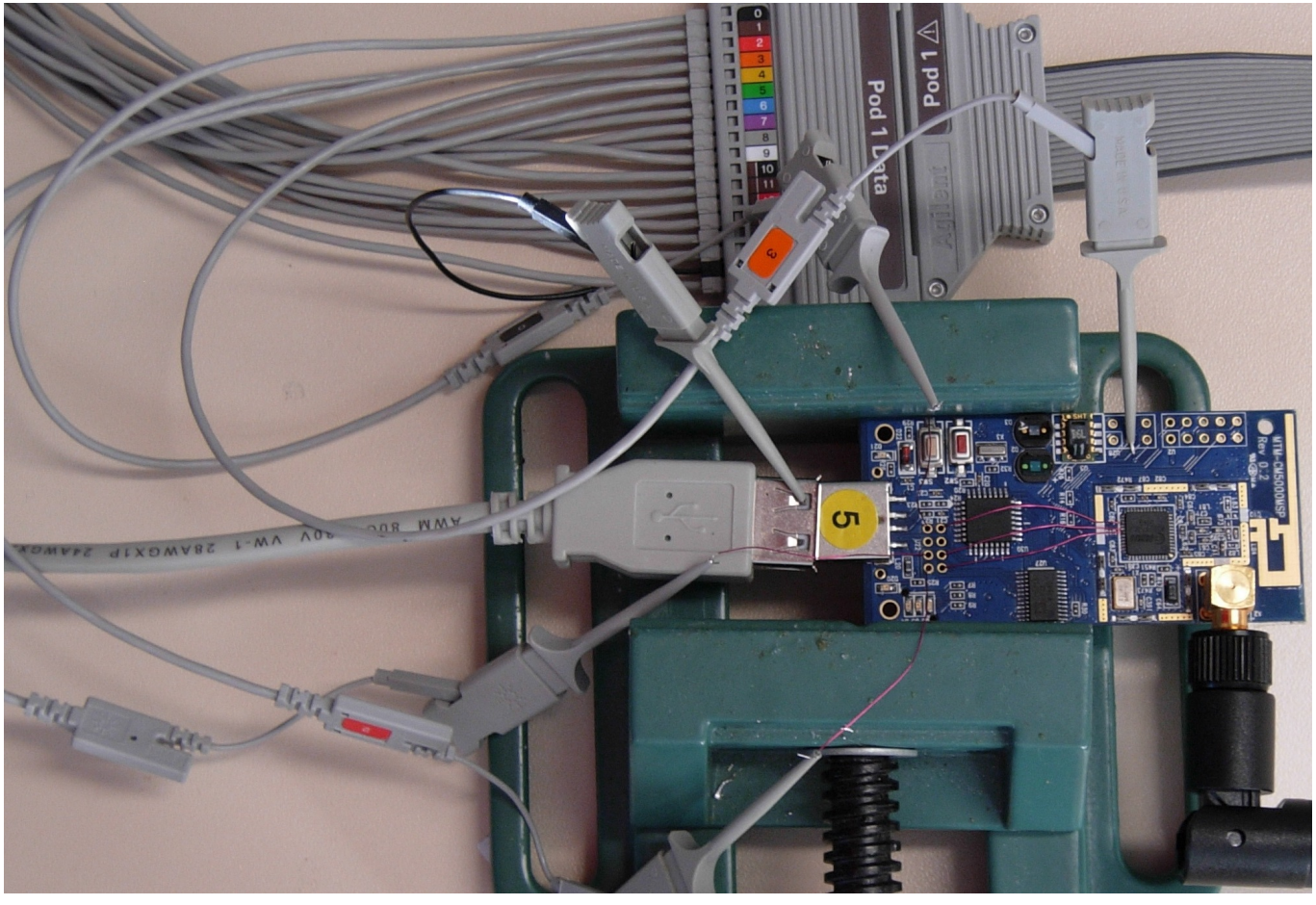
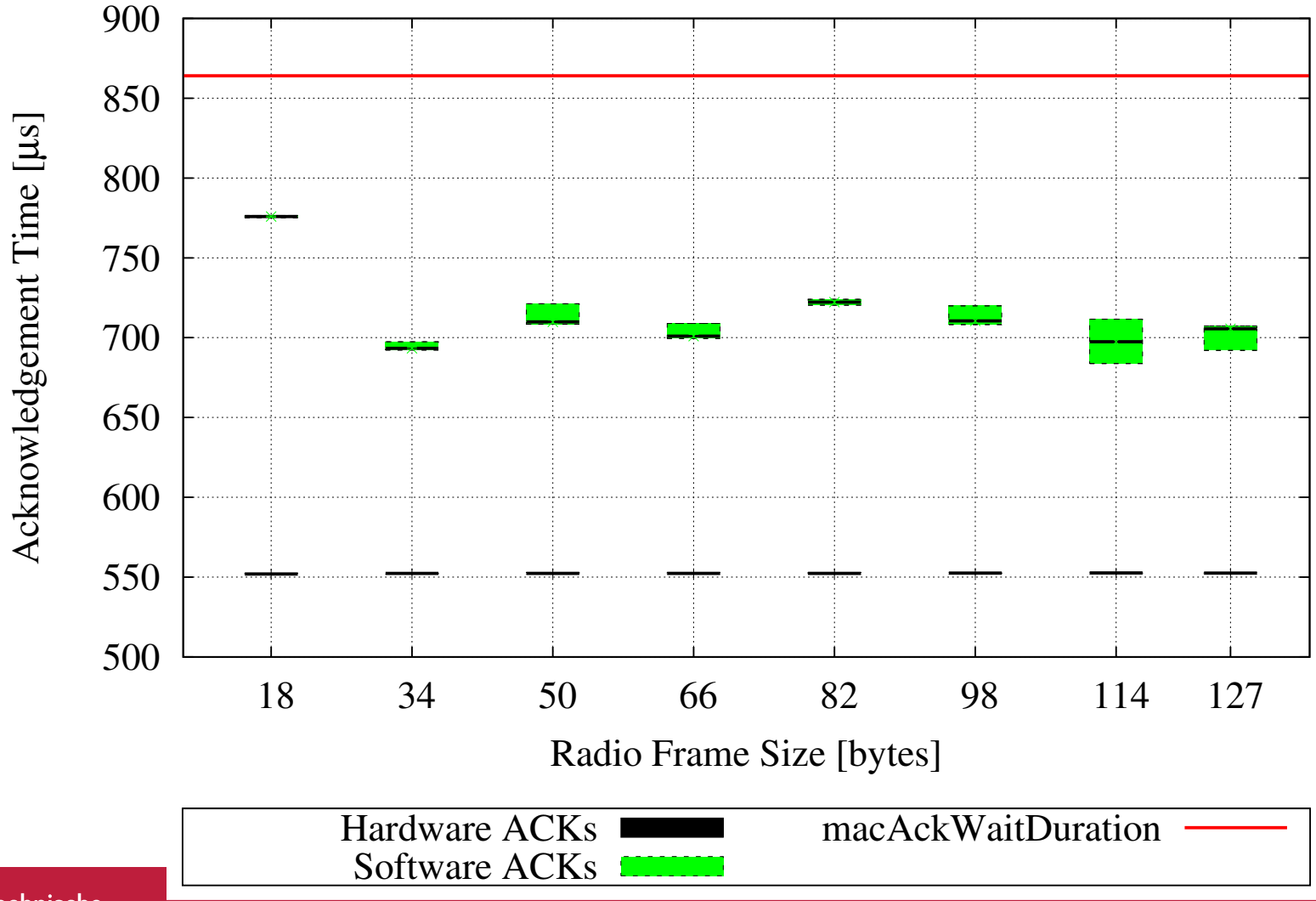
Because SPI is faster than 802.15.4 transmission speed, we can always make up for any computation delays in (3).

Measurement Setup



Measured timing using Agilent MSO8064A configurable triggers

Results: Software Acknowledgement Performance



Results: Packet Loss

	Avg.	Min.	Max.
Hardware ACKs	0.027 %	0.022 %	0.032 %
Software ACKs	0.060 %	0.052 %	0.063 %

- Using GINSENG TDMA MAC
- 5 runs of 1 hour, 15 data sources, one sink node
- On average transmitted 132506 data frames in one run
- Packet Loss = No Ack received = Either ACK frame or corresponding DATA frame lost

Results: Power Consumption

Power Cons.	Avg.	Run 1	Run 2
HW ACKs	0.74 mWh	0.73 mWh	0.76 mWh
SW ACKs	0.72 mWh	0.69 mWh	0.76 mWh

- 2 runs with 1000 packets
- 34 byte packet size
- Simple contention-based MAC
- Measured the power consumption of the receiver by monitoring the step-up converter supplying the node[1]

[1]: P. Dutta, M. Feldmeier, J. Paradiso, and D. Culler, "Energy Metering for Free: Augmenting Switching Regulators for Real-Time Monitoring"

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