

Distributed Energy Measurements in WSN Testbeds with a Sensor Node Management Device (SNMD)

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Motivation

- Energy efficiency is essential for autonomy in WSNs

 **Development of energy efficient protocols and mechanisms**


- Requires reliable detailed information on energy consumption
- Evaluating energy efficiency is anything but simple
 - A lot of nodes in WSNs
 - Wireless communication makes debug comm. not side effect free
 - Complex communication protocols
 - Energy consumption depends on real WSN environment

- Approaches

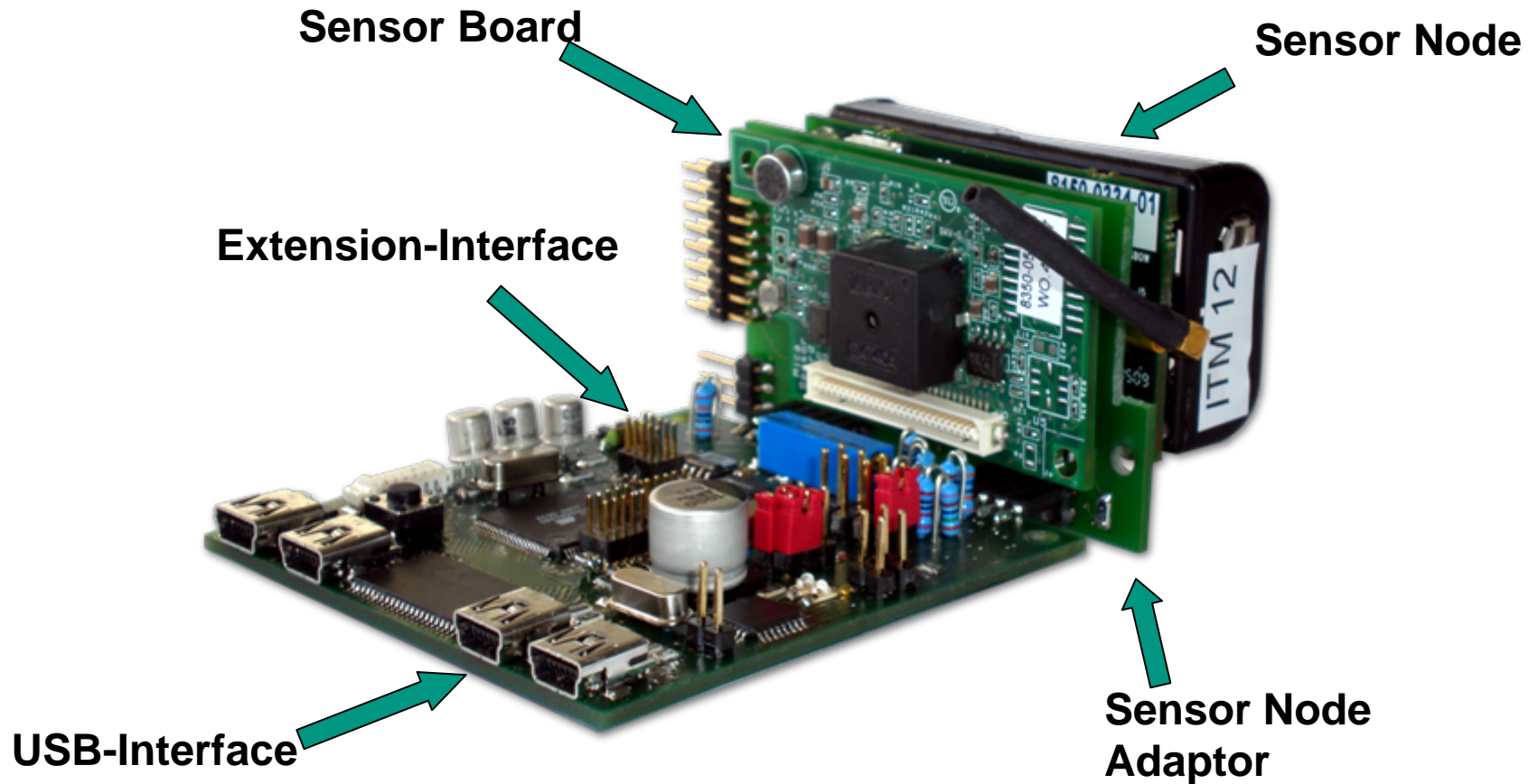
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|---------------------------|---|---|
| ■ Theoretical estimation? |  | Complex and idealized! |
| ■ Simulations? |  | Simplified and untrustworthy! |
| ■ Testbeds? |  | Bingo! But... challenging |

- Nevertheless: **Measure energy efficiency in testbeds to (dis)prove!**

Challenges and Goals of evaluating energy efficiency in testbeds

- Energy measurements
 - Side-effect free monitoring
 - Precise measurement
- Distributed energy measurements
 - Still a lot of nodes
 - Correlation of results
- Management support for automated experiments
 - Application deployment and results inquiry
 - Reproducibility of results
- Our approach:
Dedicated Monitoring and Management HW for every single node
 **Sensor Node Management Device (SNMD)**

Sensor Node Management Device (SNMD)



SNMD: Measurement Capabilities

- Battery emulation enables experiments with
 - Extreme battery states
 - Various battery types
 - Simulate environmental factors like temperature
- Sampling rate:
 - up to 20kHz unbuffered stream
 - up to 500kHz buffered
- Sample buffer: 448.000 samples
- Sampling resolution: 16bit
- Measurement ranges:
 - Current: Selectable 0-150 / 200 / 500mA
 - Voltage: 0-10V

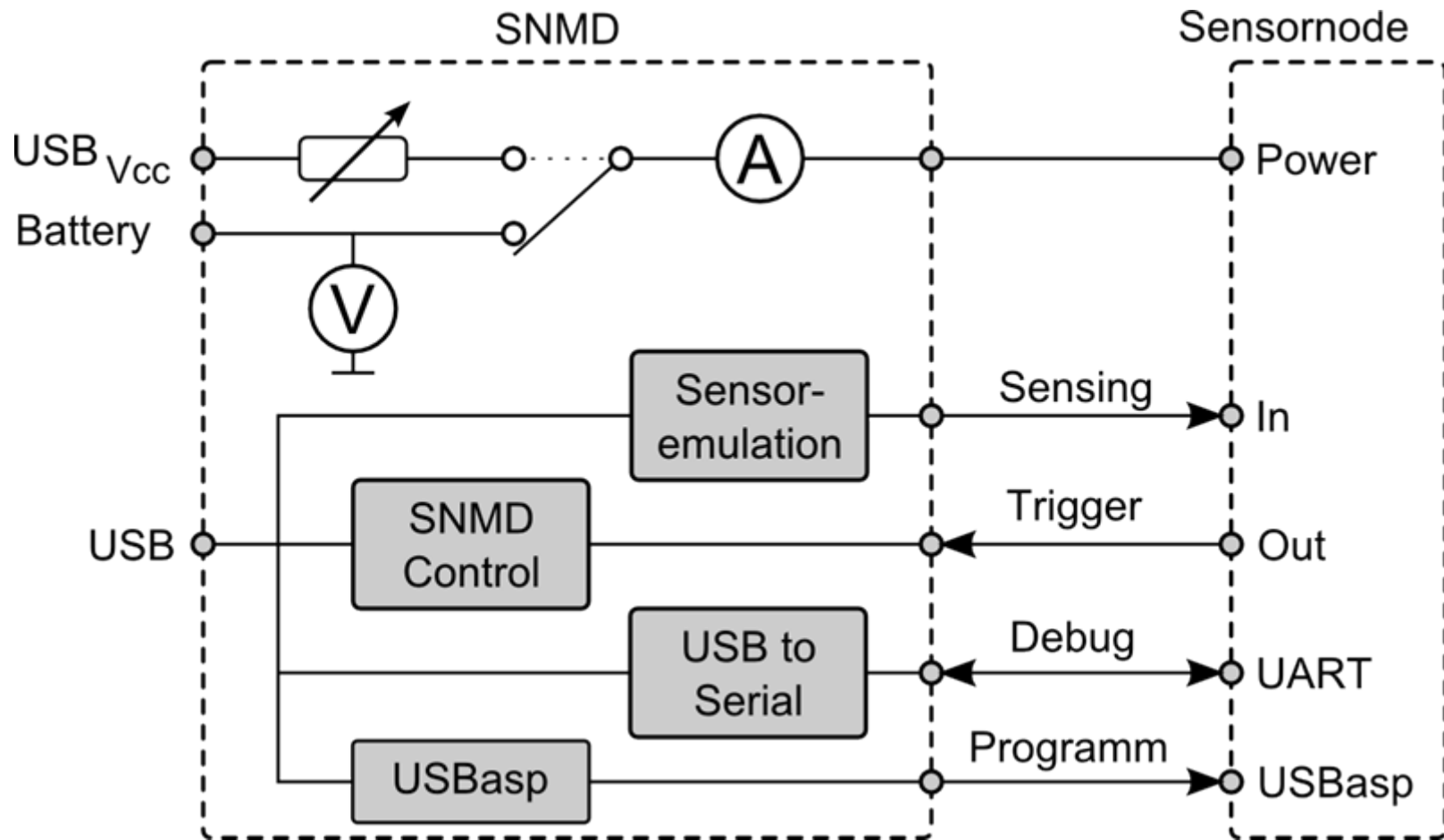


SNMD: Management Capabilities

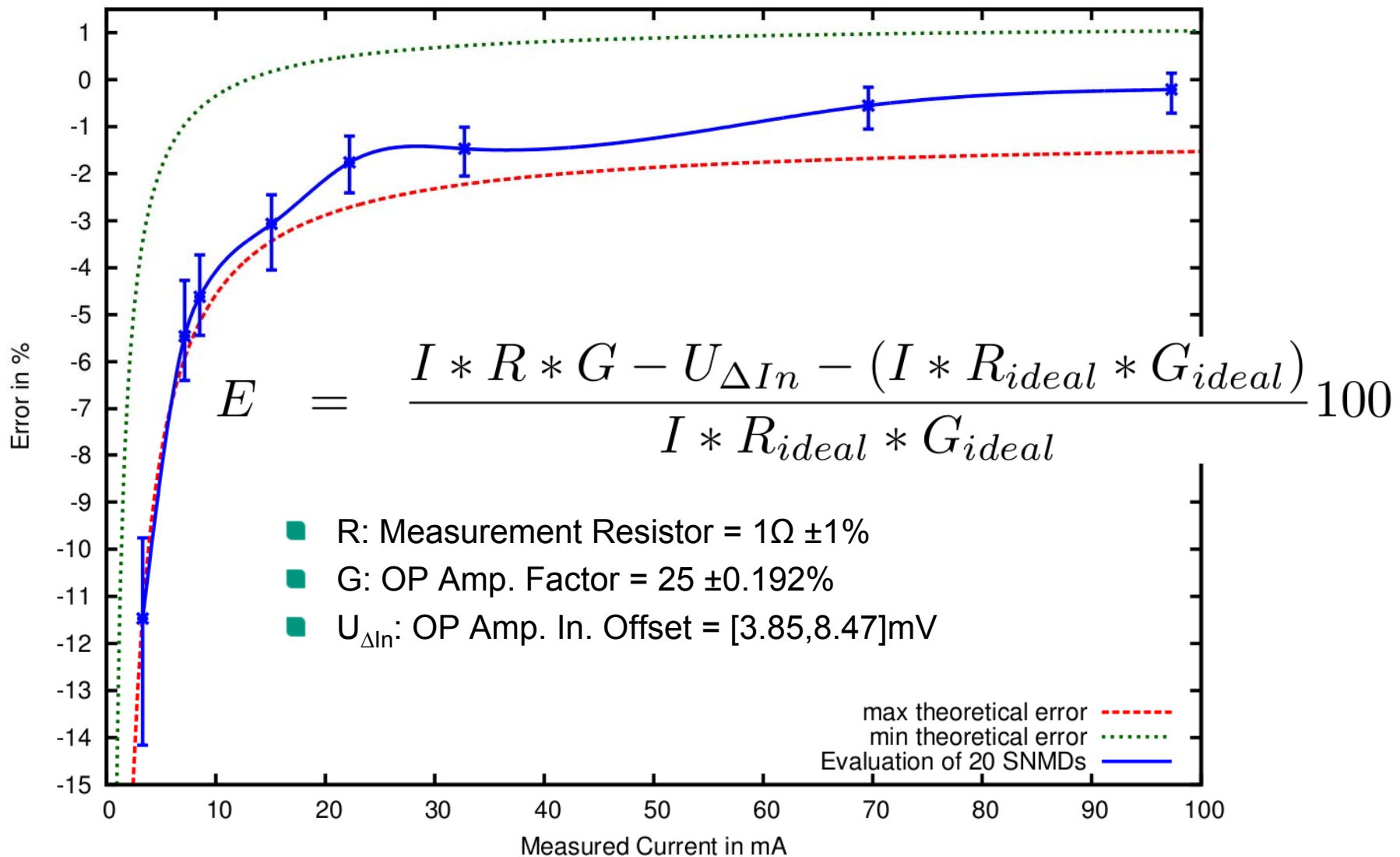
- Universal interface to arbitrary sensor node platform
 - Simple adapters for each platform needed
- Serial console user interface over USB
- Triggering measurements by sensor node or user
- USB to serial converter for sensor node debug output support
- Node programming
 - Built-in programmer for Atmel chips
 - Programming over USB for other platforms
- Comprehensive extension interface:
 - I²C, SPI, 16bit I/O subsystem
 - Additional storage: SD-Cards, ...
 - Sensor node environment simulation
- Battery charging capabilities



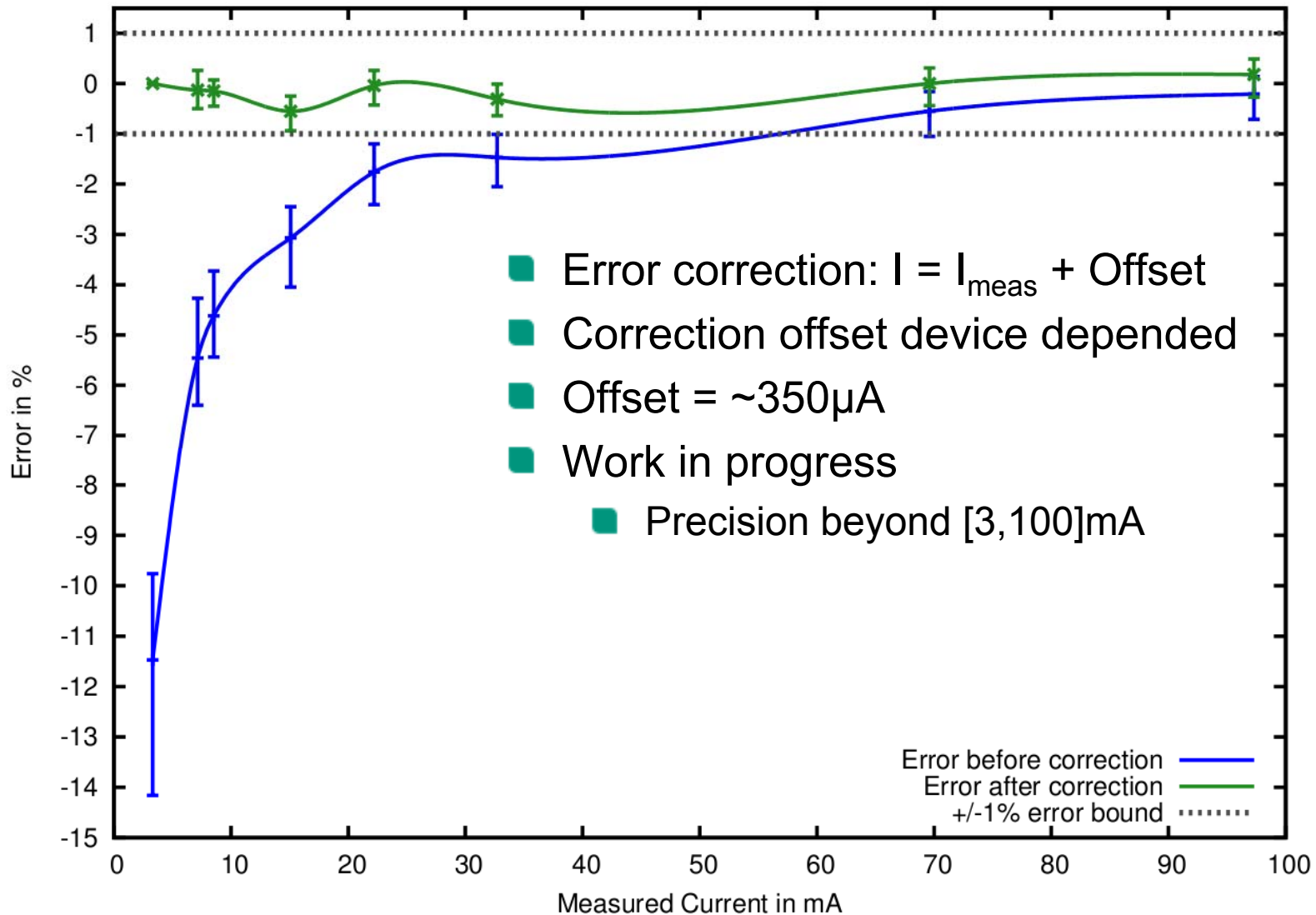
SNMD: Block Diagram



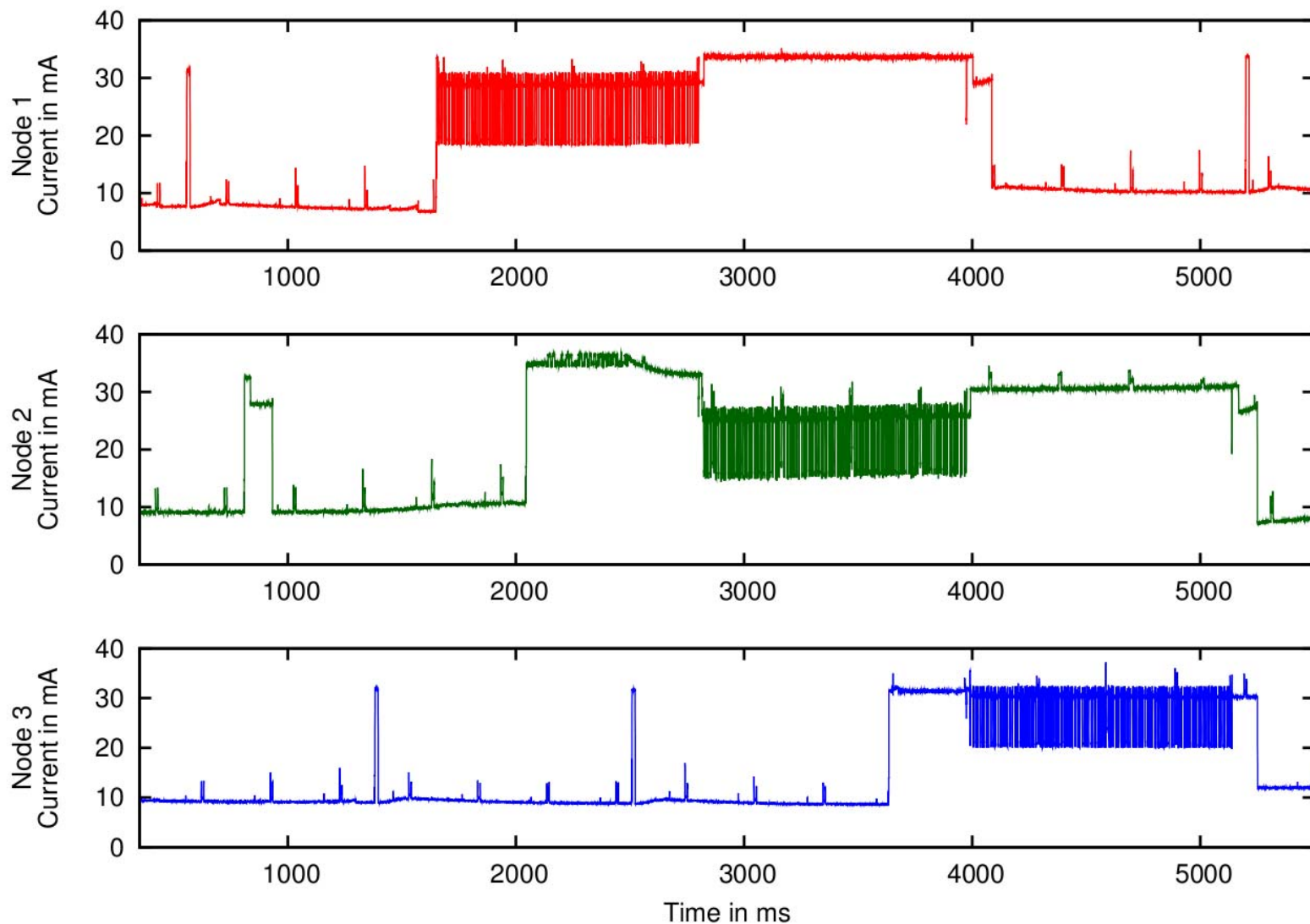
SNMD: Measurement Precision – The Theory



SNMD: Measurement Precision – Correction



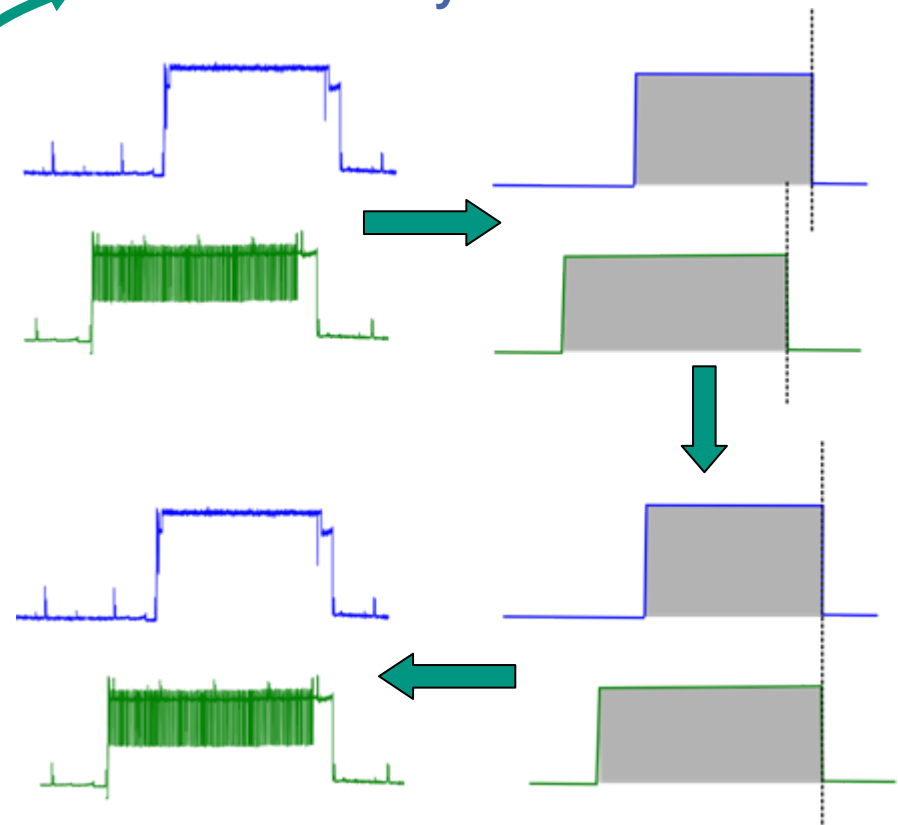
Measurement Examples and Expertise




Future Work

- High Dynamic Measurements
 - Stand-By current $< 1\text{mA}$
 - Radio activity current $> 50\text{mA}$
- HW-Compensation of measurement errors
- Cool extension boards
 - Sensor emulations
 - Displays
- Node mobility support
- Correlation of distributed measurements

Offline Time Synchronisation



Conclusion

- SNMD is a dedicated tool for WSN testbeds, providing
 - Experiment and sensor node management support
 - Detailed insights into energy consumption behaviour of WSN protocols
 - Flexibility by optional extensions
- First Experiments highly promising
 - Successful energy efficiency comparison of two protocols in live demo at SenSys 2009 in Berkeley
 - Measurements precise as expected, but...
 - Potential for boosting the precision
- Still affordable solution
- Used in  Sensor Actuator Networks Development Testbed



Thank you for your attention!



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