SANDbed: A Flexible Experiment Environment for WSNs
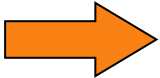
Anton Hergenröder, hergenroeder@kit.edu
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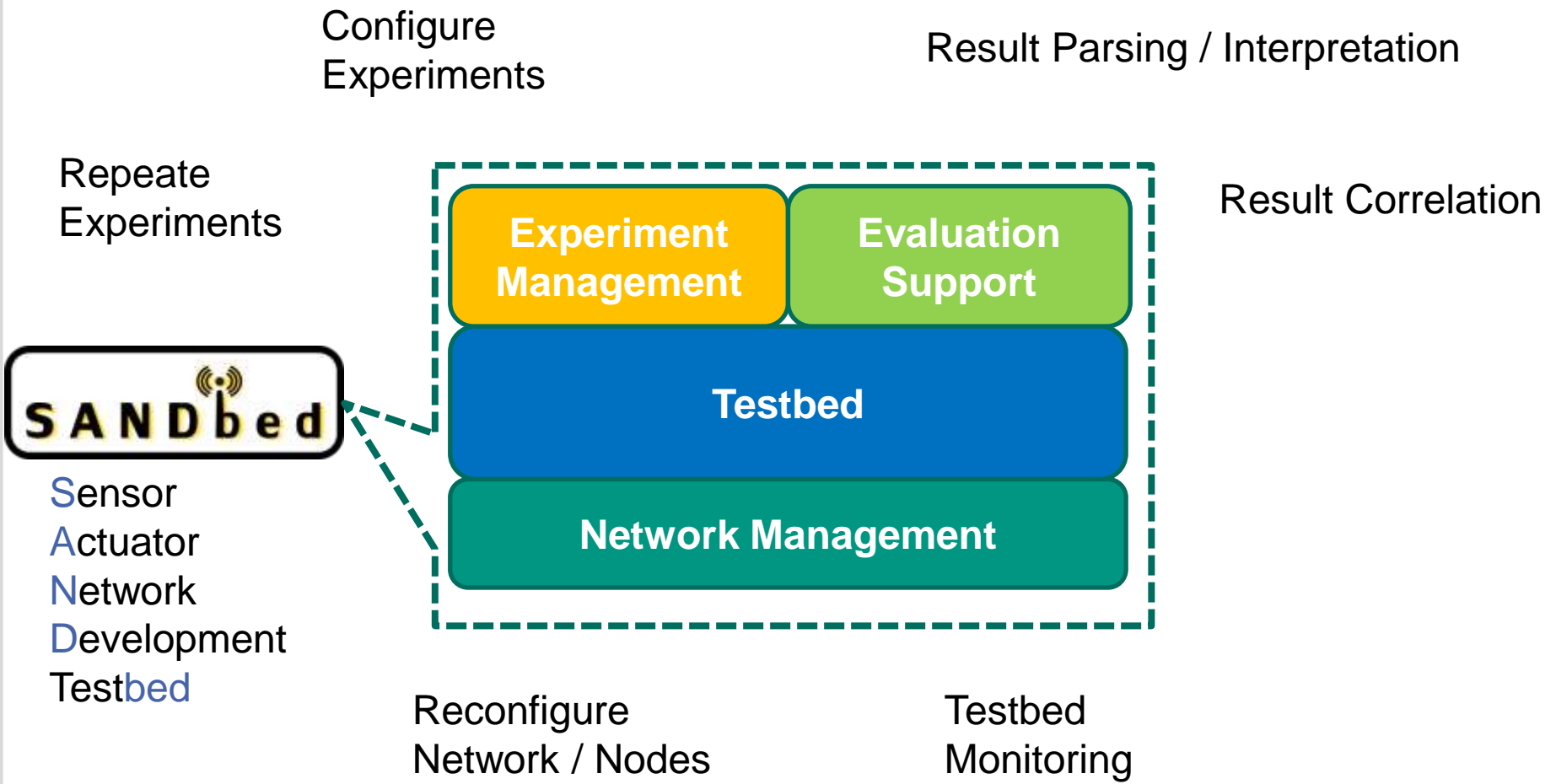Institute of Telematics, Prof. Martina Zitterbart

Motivation

- Plenty of WSN applications/protocols already exist
- Mostly verified with theoretical or simulative evaluations
    - Theoretical models   ➡   Complex and idealized!
    - Simulations   ➡   Simplified and untrustworthy!
- Both provide only approximative results
    ➡ Trend to experimentation in WSN Community
- Many WSN testbeds developed / work in progress
- But, real life experimentation is challenging
- So it is in WSN
    - A lot of nodes
    - Complex communication protocols
    - WSN affected by environment
    - Side effects
- Nevertheless: Experiment in testbeds to (dis)prove theory/simulations!

Goals and challenges in WSN testbeds

- Evaluation metrics in WSN: Performance, robustness, reliability, security, … and energy efficiency

  ➡ Support for energy efficiency evaluation in a distributed fashion

- Application deployment and results inquiry
- Reproducibility of results

  ➡ Management support for automated experiments

- Large amount of results

  ➡ Evaluation support

- Large amount of nodes

  ➡ Network management

  ➡ Cost efficiency

Experimenation Platform Components

Configure
Experiments

Result Parsing / Interpretation

Repeate
Experiments

Result Correlation

SANDbed

Experiment Management

Evaluation Support

Testbed

Network Management

Sensor
Actuator
Network
Development
Testbed

Reconfigure
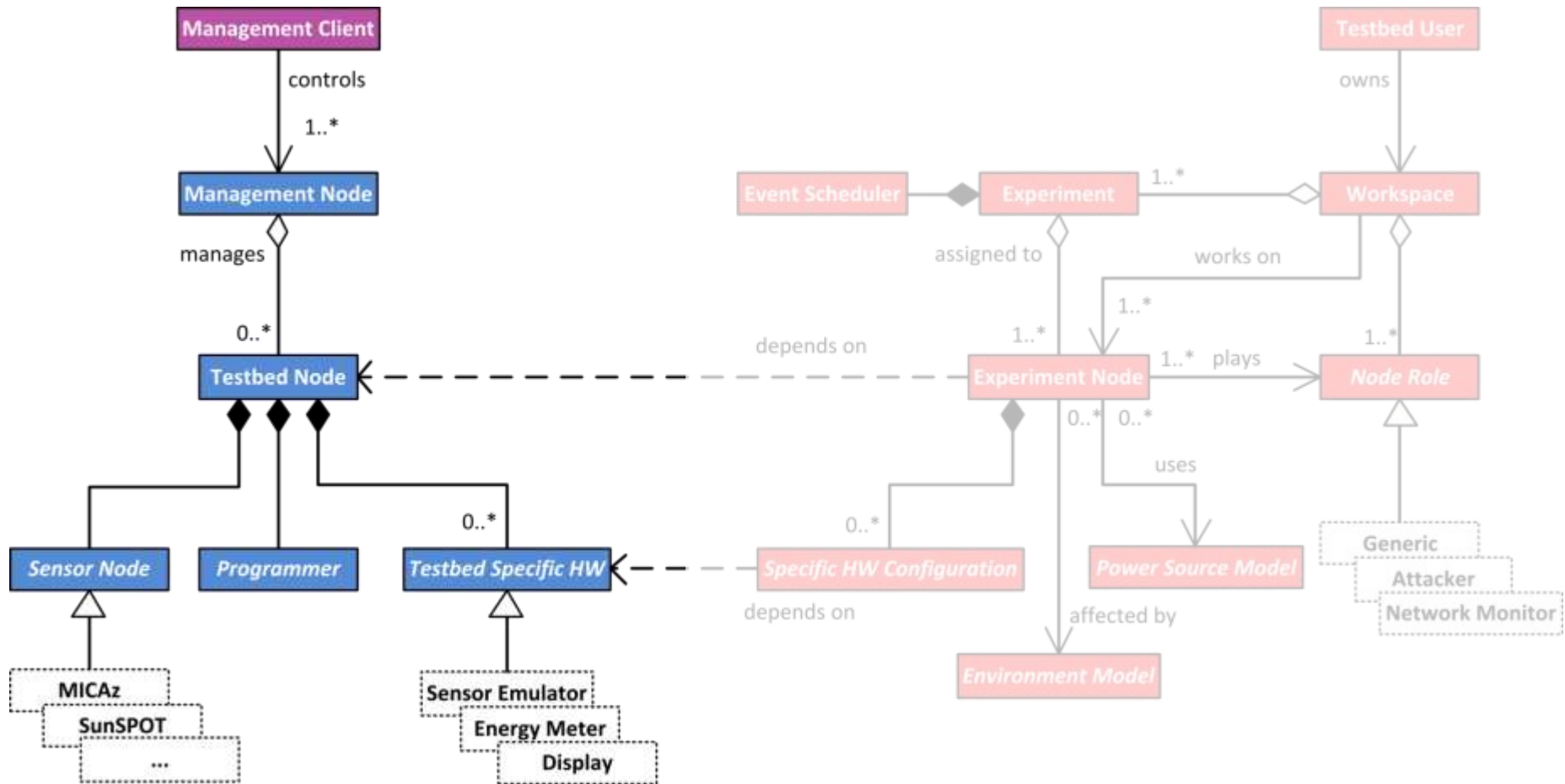Network / Nodes

Testbed
Monitoring

SANDbed Architecture

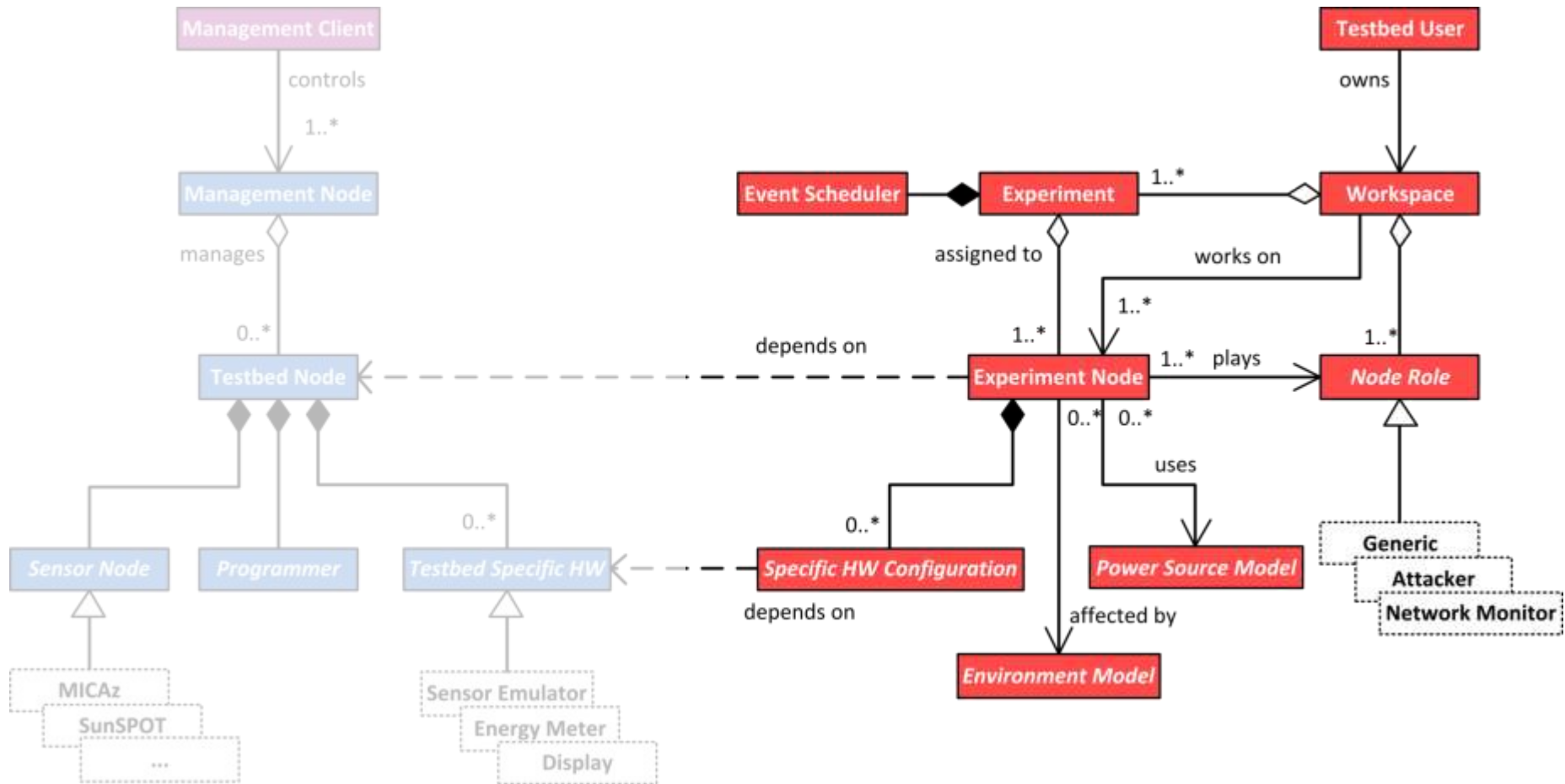Object oriented management information model, describing
- Managed objects
- Associations
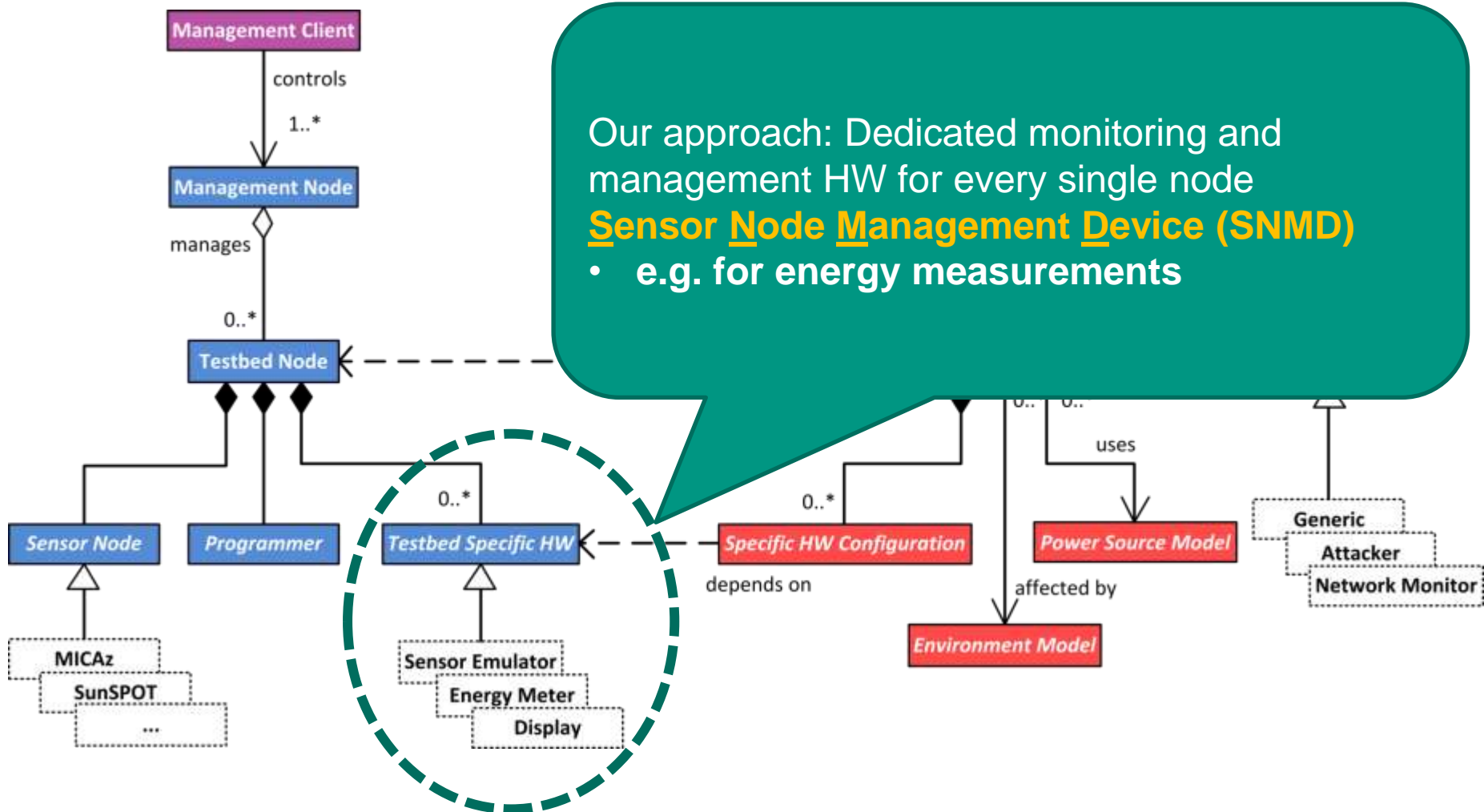- Management domains (different views on testbed)
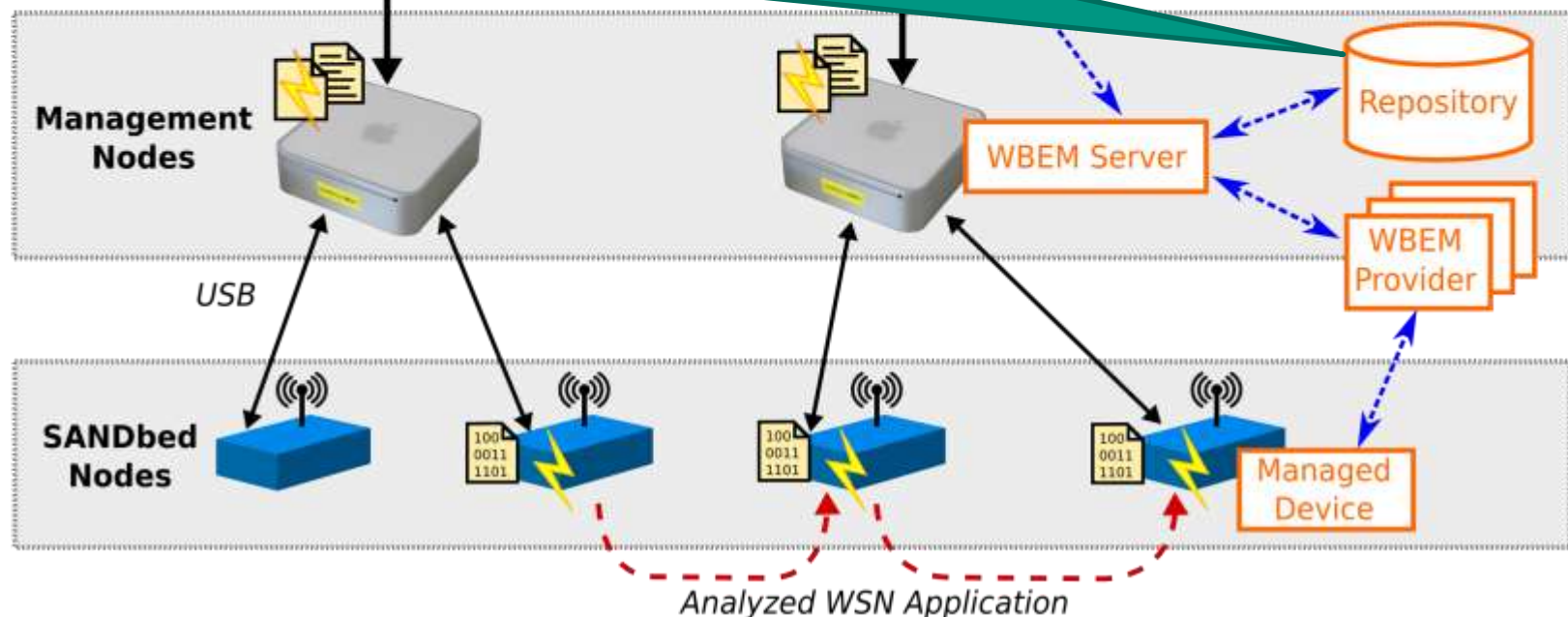
SANDbed Network View

SANDbed Experiment View

SANDbed Core Information Model

Our approach: Dedicated monitoring and management HW for every single node
Sensor Node Management Device (SNMD)
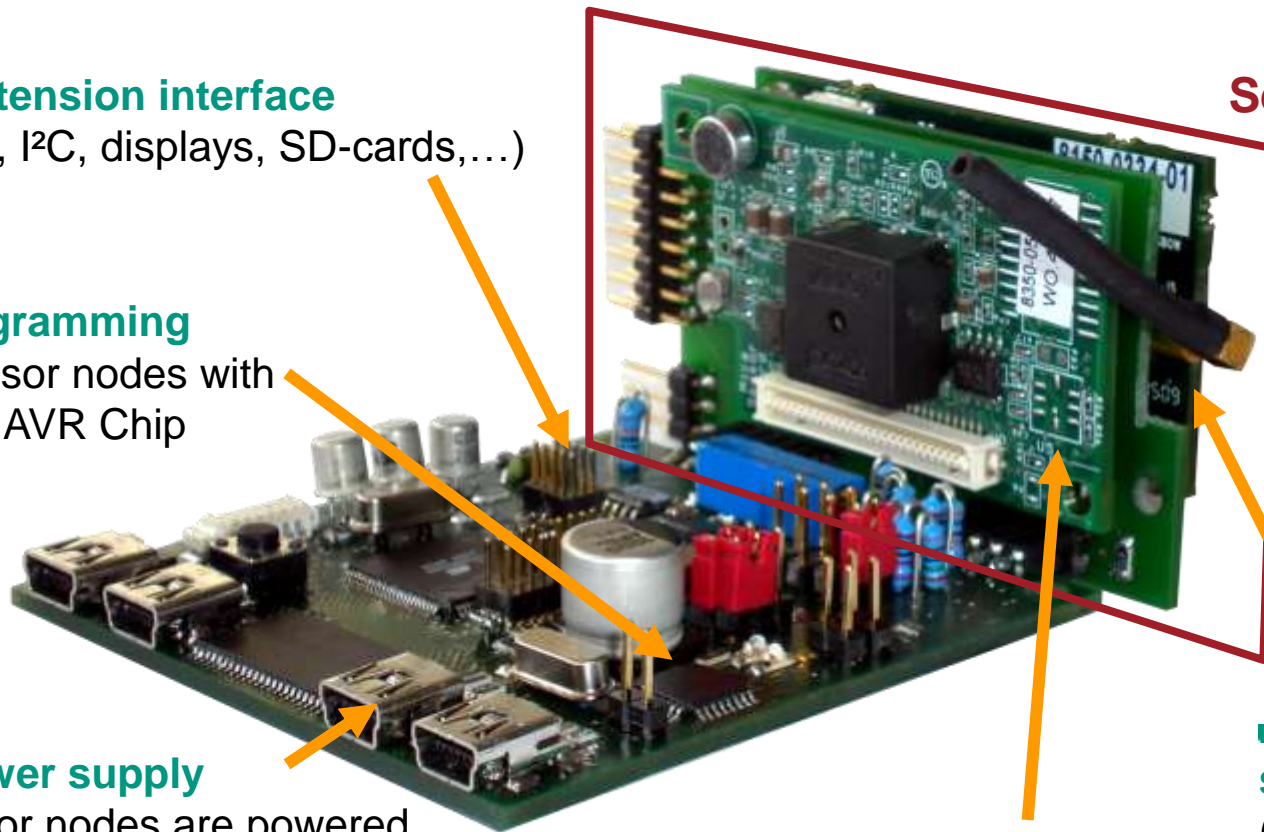- **e.g. for energy measurements**

Sensor Node Management Device (SNMD)

- Serves as management interface to sensor network
- Enables energy measurements on individual nodes

Extension interface
(SPI, I²C, displays, SD-cards,…)

Programming
of sensor nodes with
Atmel AVR Chip

Sensor network

Power supply
Sensor nodes are powered
via USB or batteries

Sensorboard

**Attached
sensor node**
(i.e. MicaZ, IRIS,
SunSPOT, …)

SNMD: Measurement Capabilities

- Simple shunt resistor based approach
- Sampling rate:
    - up to 20kHz unbuffered
    - up to 500kHz buffered
- Buffer: 448k samples
- Measurement ranges:
    - Current: Selectable 0-500mA (we use 110mA)
    - Voltage: 0-10V
- Sampling resolution: 16bit
- Precision: <1% rel. Error over 25dB
- Battery emulation enables experiments with
    - Extreme battery states
    - Various battery types
    - Different environmental factors like temperature
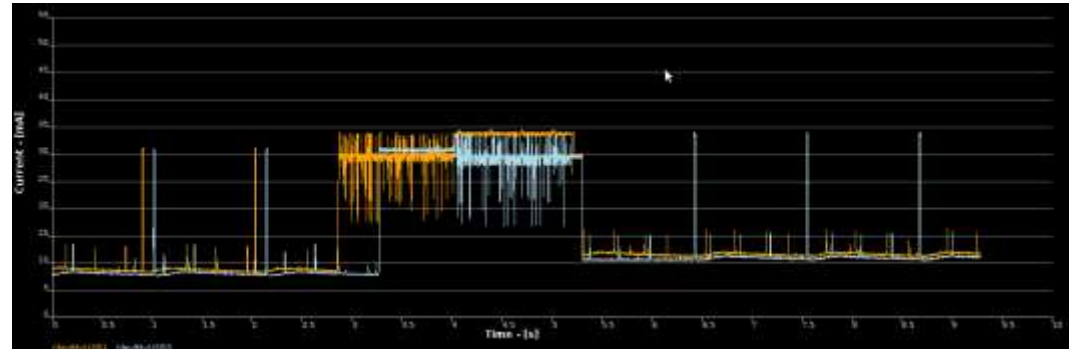
SNMD Accuracy
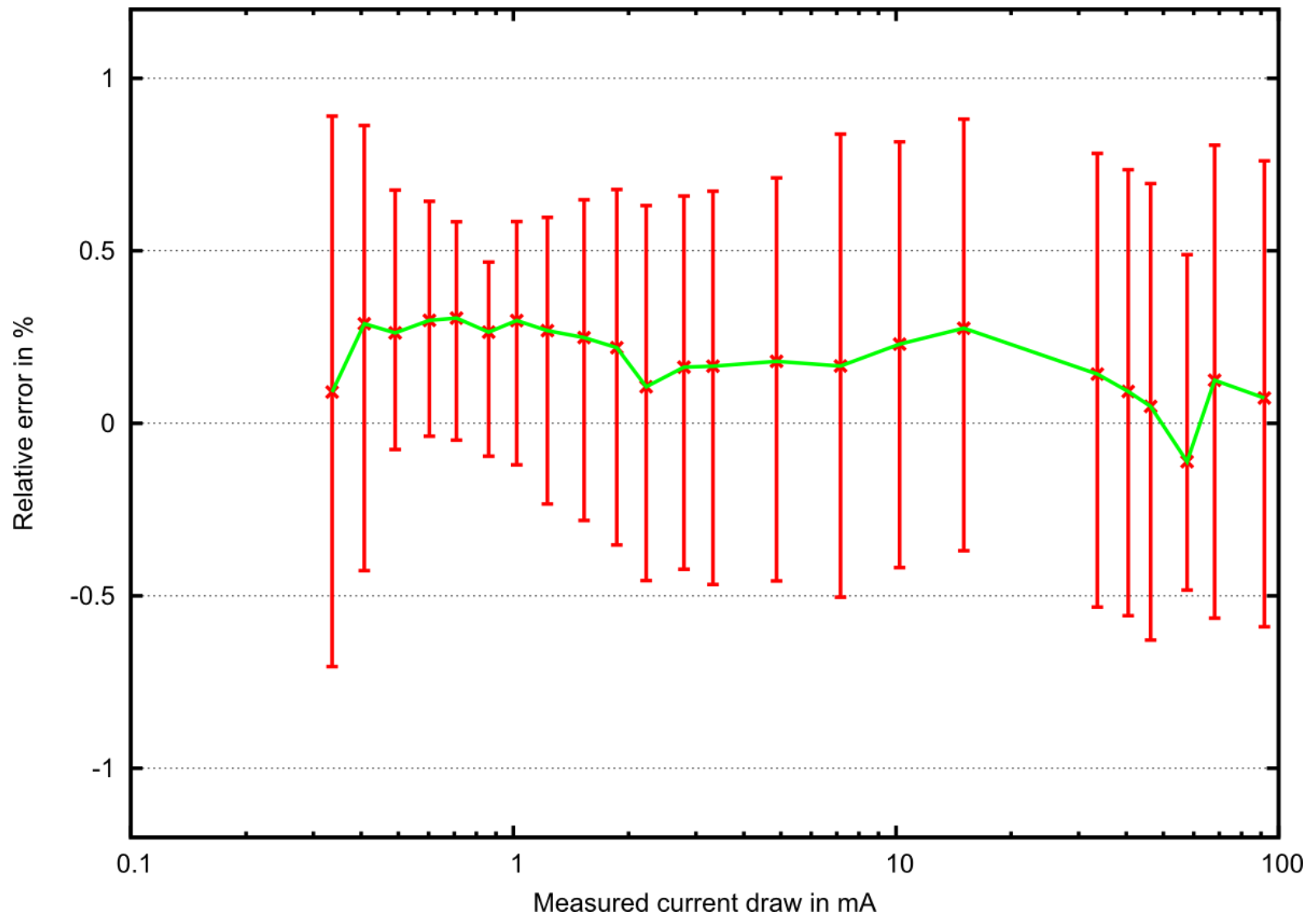
SNMD: Management Capabilities

- 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:
  I^2C, SPI, 16bit I/O subsystem
  - Additional storage: SD-Cards, …
  - Sensor node environment simulation
- Battery charging capabilities

SANDbed Deployment

- Currently
  - 22 nodes on a single floor
  - Homogeneous MICAz WSN
  - Nearly intermeshed
  - Topology can be influenced by systematic selection of nodes and transmission power adjustment
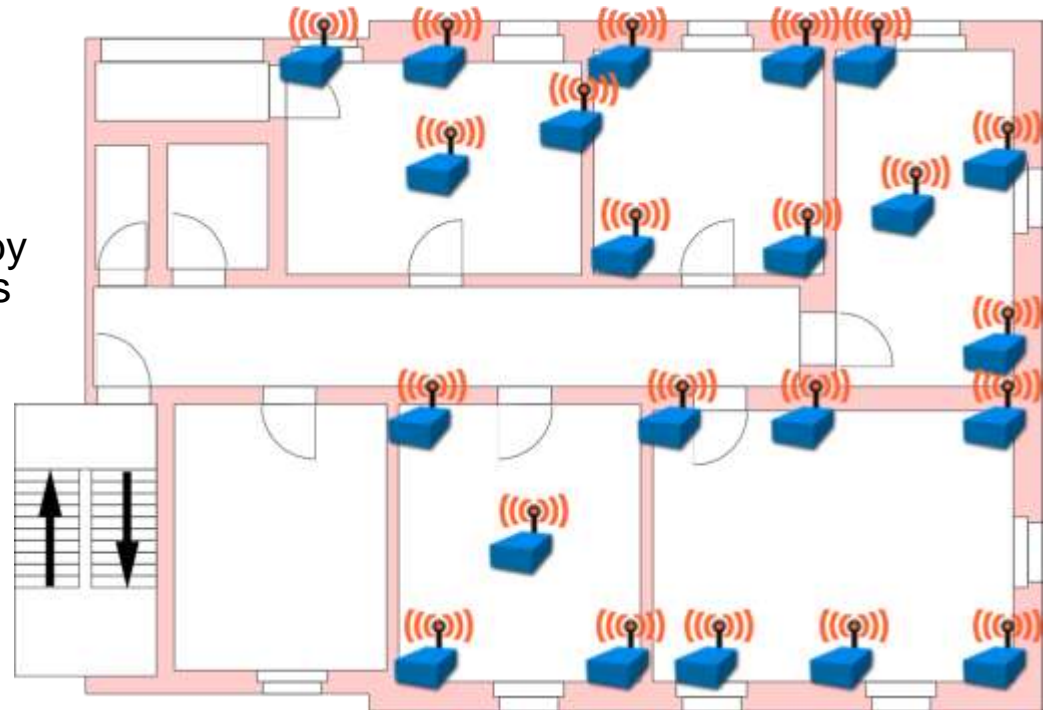
- Planed
  - 46 nodes, distributed in two buildings
  - Heterogeneous WSN is possible (especially MICAz, IRIS, SunSPOTs)
  - Mobile nodes in addition (i.e. robots or portable nodes)

Summary

- 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
- SANDbed: WSN experiment environment
    - Backed by flexible management platform
    - Extensible and adoptable for future requirements
- SANDbed is already in use
    - MAC protocol evaluation (B-MAC, X-MAC, TinyOS LPL, …)
    - Concast protocol evaluation (Collection Tree Protocol - CTP), …)
    - Gaining experience in automated reproducible experimentation in WSNs

SNMD	Distributed Energy Measurement	Management-Platform

Thank you for your attention!

Dipl.-Inform.
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Any Questions?

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