technische universität dortmund

Project A4

### Resource efficient and distributed platforms for integrative data analysis

Prof. Dr. Olaf Spinczyk, Prof. Dr. Michael ten Hompel, Prof. Dr. Christian Wietfeld

Problem

Providing Methods for Development of Resource-aware Applications in Distributed Cyber-physical Systems

Development & Simulation of Resource Models
- Energy harvesting, consumption & radio resources
- Provide resource information for offline simulations and online applications
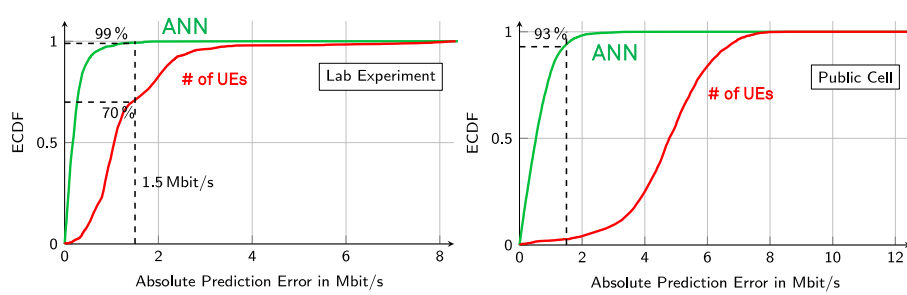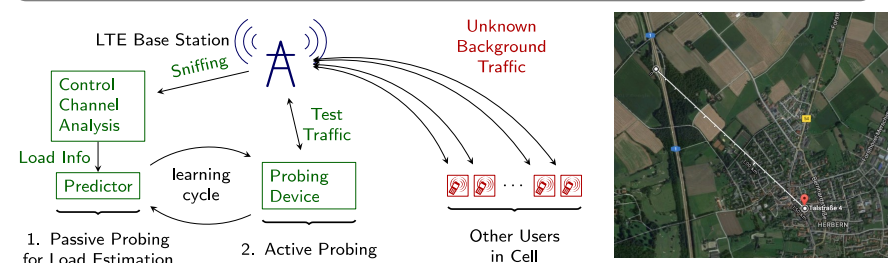
LTE — Edge Node — Edge Node — Edge Node — LTE
PhyNodes
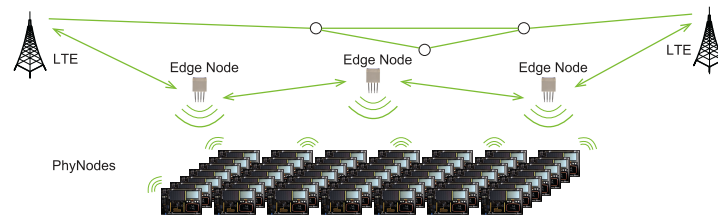
Creation of PhyNetLab Platform
- Energy-neutral PhyNode
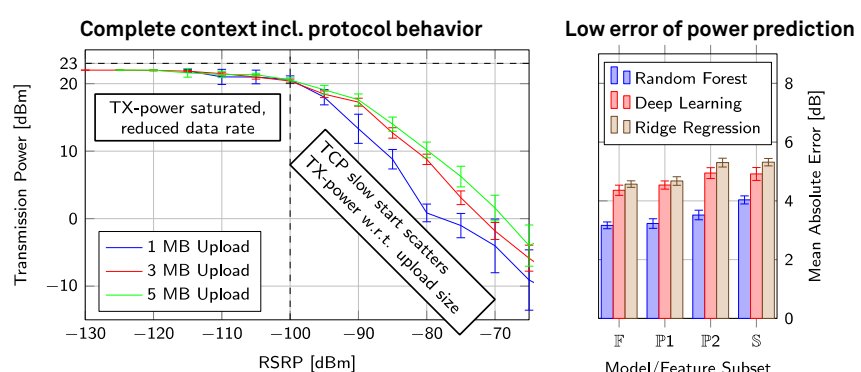- Extensible hierarchical communication system validation in environment

Methodology & Results

Resource-efficient Wireless Networking
by learning from the real network behavior

Passive Data Rate Prediction

LTE Base Station — Sniffing — Unknown Background Traffic
Control Channel Analysis
Load Info
Predictor — learning cycle — Probing Device — Test Traffic
1. Passive Probing for Load Estimation
2. Active Probing for Validation
Other Users in Cell

ANN — 99% — # of UEs — Lab Experiment
1.5 Mbit/s
ECDF vs Absolute Prediction Error in Mbit/s
70%

ANN — 93% — # of UEs — Public Cell
ECDF vs Absolute Prediction Error in Mbit/s

[Falkenberg, Heimann, Wietfeld, GLOBECOM, 2017]

Offline and Online Transmission Power Prediction   (A1) (B4)

Complete context incl. protocol behavior
Transmission Power [dBm] vs RSRP [dBm]
23 dBm
TX-power saturated, reduced data rate
TCP slow start scatters
TX-power w.r.t. upload size
1 MB Upload / 3 MB Upload / 5 MB Upload

Low error of power prediction
Random Forest / Deep Learning / Ridge Regression
Mean Absolute Error [dB]
Model/Feature Subset: F, P1, P2, S

[Falkenberg, Sliwa, Piatkowski, Wietfeld, VTC-Fall, 2018]

Extensions of CoPoMo   (B4)

Impact of carrier aggregation (CA)
Power Consumption [W] vs a_{CA}
CA Wastes Power
Environment: Urban / Suburban / Rural
Reference Without CA
2600 MHz
1.25 1.29
CA Saves Power
800 MHz
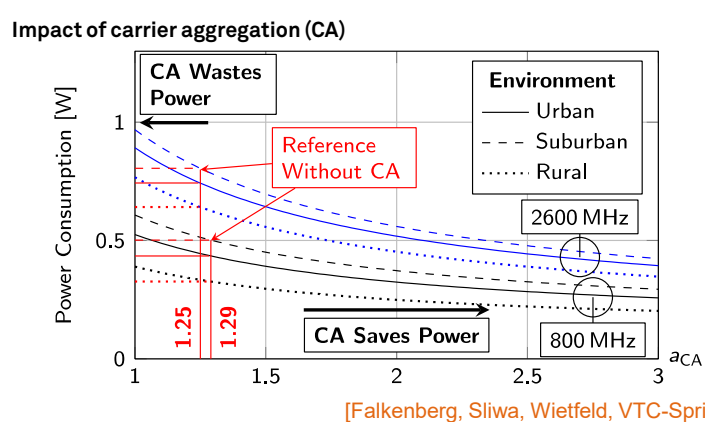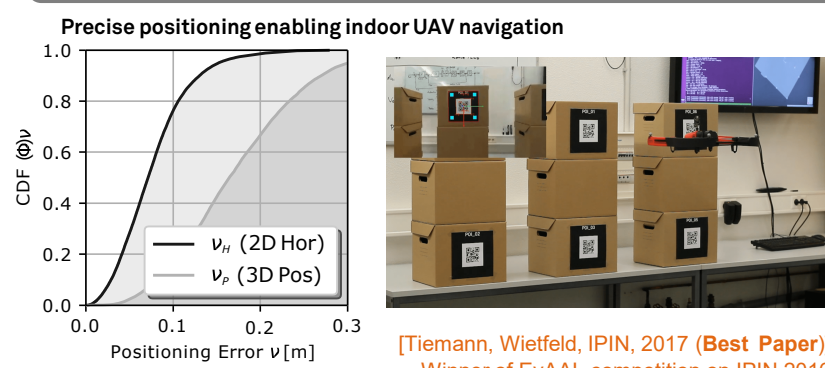
[Falkenberg, Sliwa, Wietfeld, VTC-Spring, 2017]

Support Offloading Decisions   (B2)

[Libuschewski/2017a]

ATLAS – TDOA-based UWB Localization

Precise positioning enabling indoor UAV navigation
CDF $(\phi)\nu$ vs Positioning Error ν [m]
ν_H (2D Hor)
ν_H (3D Pos)

[Tiemann, Wietfeld, IPIN, 2017 (**Best Paper**)]
Winner of EvAAL competition on IPIN 2016

Automated Hardware Energy Models
for offline and online usage

Embedded Device Driver Models

App. App. | App. App.
OS Funct. | OS Funct.
$E(t)?$ Driver | Driver $E(t) \cong x$ sync.
$E(t) = x$ Hardware | Hardware $E(t) = x$
Classic driver | Automaton

Based on priced-timed automata
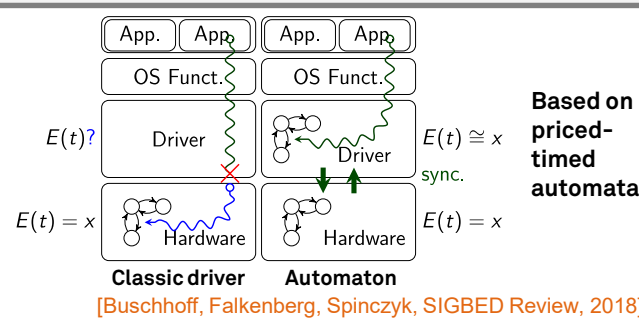
[Buschhoff, Falkenberg, Spinczyk, SIGBED Review, 2018]

Energy-aware Device Driver Synthesis

Offline Measurements — Online Accounting — Analysis, Refinement
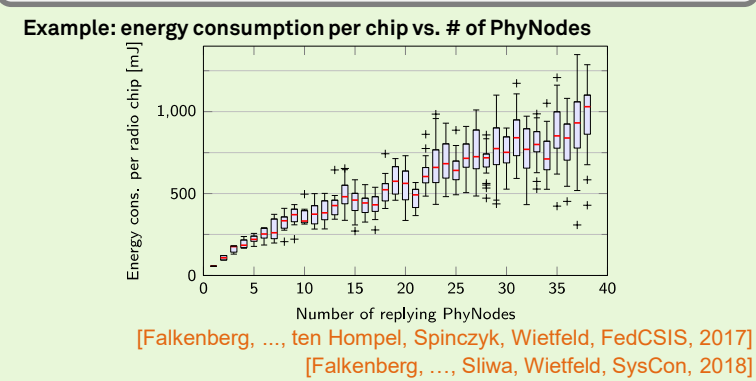Measurement Application
Hardware — Instrumented Driver — Model
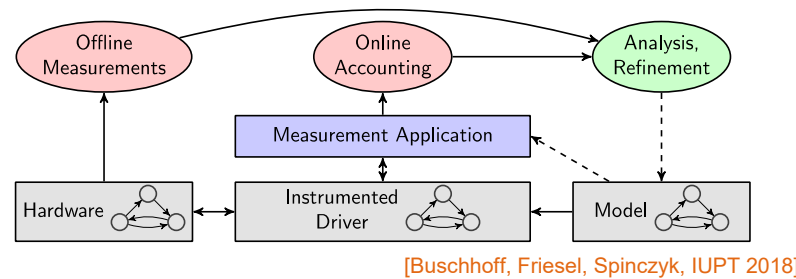
[Buschhoff, Friesel, Spinczyk, IUPT 2018]

PhyNetLab Testbed
for validation

Scalability Evaluations and Simulations

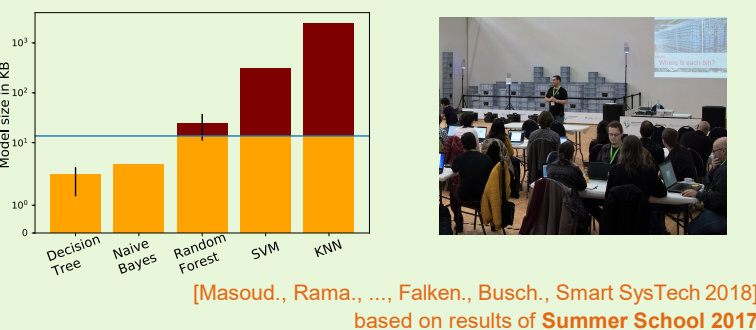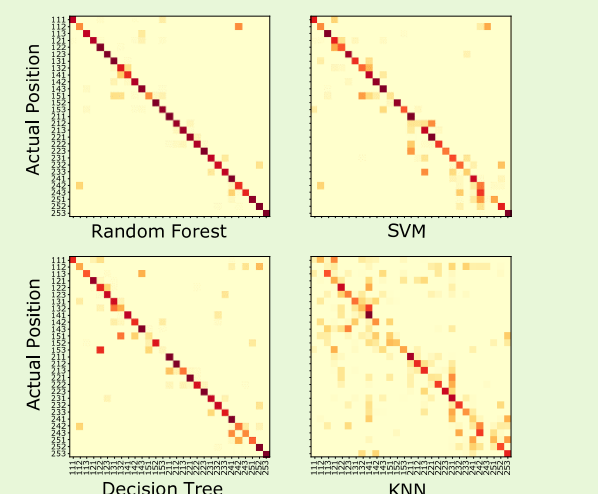Example: energy consumption per chip vs. # of PhyNodes
Energy cons. per radio chip [mJ] vs Number of replying PhyNodes

[Falkenberg, ..., ten Hompel, Spinczyk, Wietfeld, FedCSIS, 2017]
[Falkenberg, ..., Sliwa, Wietfeld, SysCon, 2018]

Resource-constrained Data Analysis in Real-life Environment

Machine learning based indoor localization using environmental data

Random Forest | SVM
Decision Tree | KNN
Actual Position

Model size in KB:
Decision Tree, Naïve Bayes, Random Forest, SVM, KNN

[Masoud., Rama., ..., Falken., Busch., Smart SysTech 2018]
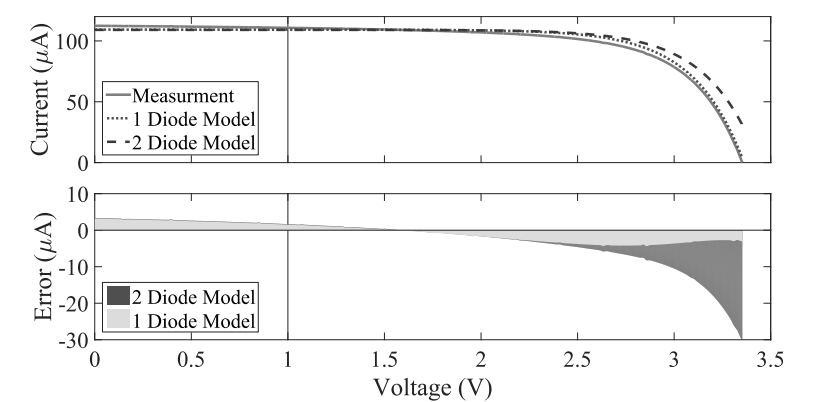based on results of **Summer School 2017**

Indoor PV Harvesting Income Prediction
based on in-depth modelling of PV HW

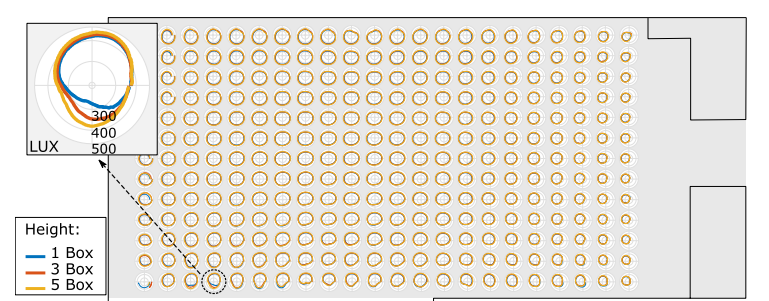#### Automated Data Collection in Dedicated Lab Environment

[Masoudinejad, ...,Roidl, ten Hompel, IREC2015 (**Best Paper**)]
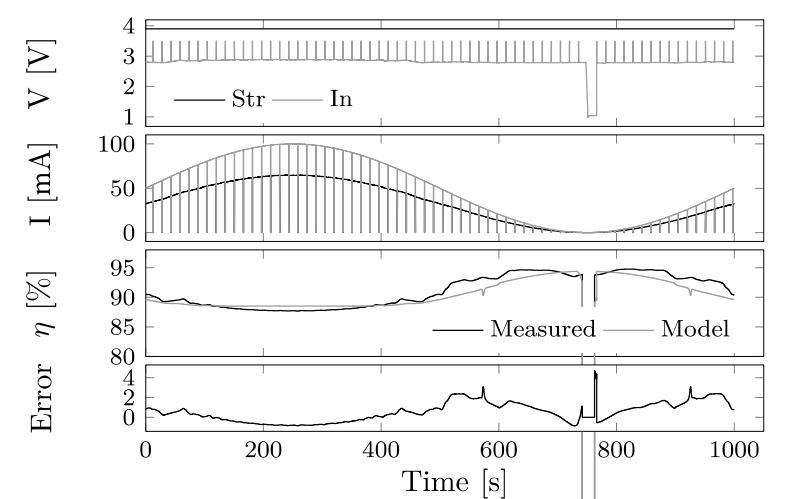
Detailed Models for Single and Double Diode

Current (µA) vs Voltage (V)
Measurment / 1 Diode Model / 2 Diode Model
Error (µA): 2 Diode Model / 1 Diode Model

[Masoudinejad, ..., ten Hompel, IRSEC, 2015]

Automatic Space Scanning

LUX 400 500
Height: 1 Box / 3 Box / 5 Box

ANN-based Converter Modelling

V [V] — Str — In
I [mA]
η [%] — Measured — Model
Error
Time [s]

[Masoudinejad, ..., Benini, ten Hompel, SPEEDAM, 2018]

flw Lehrstuhl für Förder- und Lagerwesen

CS 12 computer science 12

CNI Communication Networks Institute