Curriculum Vitae

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Background & education

01/2019 – 07/2023 **ETH Zürich**, Department "Information Technology & Electrical Engineering"

Doctoral studies, advised by Prof. Dr. Lothar Thiele

Publications:
- 4 first-author publications
- 3 conference presentations
- 10 additional papers with collaborators

- Doctoral thesis: "*Seeking Autonomy for Low-Power Wireless Networks*"

02/2017 – 12/2018 **ETH Zürich**, Department "Information Technology & Electrical Engineering"

Master of Science (MSc) "Information Technology & Electrical Engineering"

Specializations:
- Wireless communication
- Computer networks
- Network security

- Semester thesis: *"Localizing mobile nodes in a relative coordinate system"*
- Semester thesis: *"Unleashing the power of real-time Internet of Things"*
- Master thesis: *"TotTernary: A wearable platform for social interaction tracking"* (conducted at the **University of California in Berkeley**, USA)

Average mark 5.90 / 6 (all theses graded with maximal grade 6)

10/2015 – 12/2016 **Swiss Armed Forces**, training to and serving as infantry platoon leader

09/2012 – 09/2015 **ETH Zürich**, Department "Information Technology & Electrical Engineering"

Bachelor of Science (BSc) "Information Technology & Electrical Engineering"

Average mark 5.41 / 6 (first year exams passed with mark 5.58 / 6)

07/2008 – 08/2012 **Kantonsschule Zug**, Zug

Swiss Federal Matura

Specialization:
- Physics & Applied Mathematics
- Immersion class with four subjects in English

Best male graduate in the Canton with mark 5.73 / 6

08/2006 – 07/2008 **Kantonsschule Hohe Promenade**, Zurich

For more details of papers and theses, please refer to the "Appendix" on page 5

Achievements

- "Best artifact" Award at IPSN '23 for the presented paper on Hydra

- 3rd place at the *Cyber 9/12 Student Challenge* 2018 as team lead out of 20 international teams

- One of the best 25 entries to the "Swiss Startup Awards" for startup "Banabird"

- Member of the "Swiss Study Foundation", which mentors distinguished Swiss students

- Award "Very good" of "Schweizer Jugend forscht" for the Matura project

- Röthlisberger-Prize 3rd place for the Matura project

Work experiences

08/2015 – 10/2015 **Leica Geosystems**, Heerbrugg, as a *Software Engineer*

Design, evaluation and implementation of a two-way communication link over Long Range Bluetooth in-between laser measurement stations
- Embedded systems programming on two proprietary platforms
- Programming in C

12/2013 – 07/2015 **Banabird (Startup)**, Zurich, as *Chief Operating Officer (COO)*

Development of an online tool for writing and reading interactive stories with individual paths for personalized experiences with fellow students from ETH Zurich and University of Zurich
- Operational planning and internal coordination & management
- Designing and implementing the website, especially the entire backend using REST and Hibernate for the database access
- Programming of an Android app for mobile interaction in Java

Attended the "Swiss Startup Awards" as one of the 25 best entries

08/2012 – 09/2012 **IBM Research Laboratory**, Rueschlikon, as a *Research Assistant*

High-frequency S-parameter measurements on a multi-channel printed circuit board designed by IBM and converting the measurements into time domain using *the Cadence/Spectre* circuit simulator

09/2010 – 10/2010 **Siemens Building Technologies**, Zug, as a *Software Engineer*

Integration of publicly available weather information and predictions over radio into a building information systems for further processing
- Embedded systems programming on the *DESIGO Tx-Open* Platform
- Programming in C++ and C# including designing the GUI

07/2010 – 08/2010 **Super Computing Systems (SCS)**, Zurich, as an *Intern*

Assistant of the company-wide IT Support
- Setup and installation of workstations and servers
- Maintenance on IT infrastructure and public website
- Working with Linux and Windows operating systems

Didactical experiences

01/2019 – 02/2022 **Research Assistant** for Prof. Thiele
- Lectures „Technische Informatik 1“ and „Embedded Systems“
- Supervised 5 master theses and 4 student theses
- Designed and conducted both written and oral exams
- Co-organized a hackathon and student visiting days

02/2015 – 08/2015 **Teaching Assistant** for Prof. Novotny
- Lecture „Elektromagnetische Felder und Wellen D-ITET“
- PVK (exam preparation course) assistant chosen by the students

09/2014 – 02/2015 **Teaching Assistant** for Prof. Steger
- Lecture „Diskrete Mathematik D-ITET“

09/2013 – 07/2014 **Teaching Assistant** for Prof. Tröster
- Lecture „Digitaltechnik D-ITET”
- PVK (exam preparation course) assistant chosen by the students

Skills

Programming languages

C / C++

- Doctoral studies involving a variety of MCU architectures (STM32L & STM32F, nRF52, MSP430) and radios (IEEE 802.15.4, LoRa, Bluetooth, LTE, UWB), both bare-metal and using FreeRTOS
- Master thesis writing bare-metal applications for two different MCUs to drive sensors and radios and interleave processing and communication
- Programming of an audio communication link at *Leica Geosystems*
- Semester thesis “*Localizing mobile nodes in a relative coordinate system*” on an embedded platform using PlatformIO and Arduino Due
- Semester thesis “*Unleashing the power of real-time IoT*” using the Contiki OS and custom-built hardware running TI microprocessors
- Practice oriented C++ & C# - programming during an internship at *Siemens*

Python

- Automated testing pipeline, protocol verification and data processing during the doctoral studies to run scalable experiments on our public testbed
- Visualization and monitoring of running deployments in Alpine environments
- Discrete event simulation of multiple protocols including energy and timing
- Machine learning using Scikit-learn and PyTorch on proprietary datasets
- Implementation of a network stack parser on an embedded Linux platform

Java

- Extensive experience in Java and JSF for web development
- Android app programming for a semester project
- Programming of a robot in Java for the Matura project

Various

- *JavaScript, HTML, CSS, XML & HQL* for a large web project with fellow students which was hosted on private servers
- *Matlab* through various projects at university, notably during a semester project in which we simulated the flow of pedestrians
- *Microsoft DirectShow* implementations for recording and playing audio and transmitting it over the network at *Leica Geosystems*
- Extensive practical experience with the agile project management SCRUM framework for project management of a group project
- Used to revision control systems for software such as Subversion and Git

Hardware related skills

- Integration of a variety of sensors (IMU, inclinometer, GNSS, vibration, environmental)
- Designed a highly complex 4-layer PCB including two radios in EAGLE
- Designed two extensive sensor PCBs including analogue frontends in ALTIUM
- Design review of schematics and layouts for multiple communication and processing boards, including performing initial operation and planning iterations of new designs
- Hand-soldering of SMD components down to 0201 size and ball grid arrays
- Extensive experience in HW testing and power measurements

Language skills

German: Native language (C2)

English: Proficient user (C2)

Certificate of Advanced English (CAE) Grade A (91/100 Points)

- 3 years immersion classes (Biology/History/Math in English)
- optional course *English Conversation* during 1 ½ years
- three-weekly language stay in Torquay, GB (Group Advanced), Summer 09

French: Intermediate (B1)

Hobbies

Mountaineering, climbing, handball, hiking, jogging, reading, ice hockey

References

Available on request

Appendix

Papers

"Demos: Robust Orchestration for Autonomous Networking"
at the International Conference on Embedded Wireless Systems and Networks (EWSN)

- Design of a communication protocol that automatically orchestrates clusters of nodes
- Implementation on the SX1262 RF transceiver, combining coordination and discovery
- Testing on an in-house testbed including a mobile node to split and recombine clusters

Abstract: Research in wireless sensor networks has resulted in a remarkable breadth of highly capable systems. However, while specialized protocols perform well in the setting they were designed for, they often lack the ability to quickly adapt once operating conditions change drastically. Of particular importance is resilience to node and link failures, as clusters of nodes that lost their leader or split apart need to re-organize and find each other again. With Demos, we present a low-power wireless protocol that ensures robust network orchestration despite such failures. Demos rapidly finds consensus on leadership with its cluster coordination mechanism even if the set of nodes fluctuates by introducing new election quorums. In addition, a novel discovery scheme enables autonomous clusters to merge on the fly and maximize network coverage. Experiments with controlled mobility on a multi-hop network of 24 nodes demonstrate that Demos maintains reliable data exchange despite severe disruptions and adapts to changes within seconds. We further find that Demos' ability to continuously coordinate and discover achieves highly robust orchestration of fully autonomous clusters.

"Hydra: Concurrent Coordination for Fault-tolerant Networking"
at the International Conference on Information Processing in Sensor Networks (IPSN)

- Design of a communication protocol for low-power WSNs that provides fault tolerance
- Implementation on the SX1262 RF transceiver using two complex communication primitives
- Testing on an in-house testbed with extensive instrumentation and automated validation

Abstract: Low-power wireless networks have the potential to enable applications that are of great importance to industry and society. However, existing network protocols do not meet the dependability requirements of many scenarios as the failure of a single node or link can completely disrupt communication and take significant time and energy to recover. This paper presents Hydra, a low-power wireless protocol that guarantees robust communication despite arbitrary node and link failures. Unlike most existing deterministic protocols, Hydra steers clear of centralized coordination to avoid a single point of failure. Instead, all nodes are equivalent in terms of protocol logic and configuration, performing coordination tasks such as synchronization and scheduling concurrently. This concept of concurrent coordination relies on a novel distributed consensus algorithm that yields provably unique decisions with low delay and energy overhead. In addition to a theoretical analysis, we evaluate Hydra in a multi-hop network of 23 nodes. Our experiments demonstrate that Hydra withstands random node failures without increasing coordination overhead and that it re-establishes efficient and reliable data exchange within seconds after a major disruption.

"STeC: Exploiting Spatial and Temporal Correlation for Event-based Communication in WSNs"
at the ACM Conference on Embedded Networked Sensor Systems (SenSys)

- Design of a communication protocol which leverages event-driven synchronization
- Implementation on a combination of long- and short-range communication links
- Testing on a testbed and a year-long deployment on a rock glacier in Alpine terrain

Abstract: Low-power wireless sensor networks have demonstrated their potential for the detection of rare events such as rockfalls and wildfires, where rapid reporting as well as long-term energy-efficient operation is vital. However, current systems require periodic synchronization to maintain network coordination, heavily rely on node placement or use costly long-range links to infrastructure. We present STeC, a novel wireless communication design that directly exploits the spatial and temporal correlation of signals from the sensed phenomenon to orchestrate event-based communication. We leverage the locality of a co-detection, where a physical event triggers multiple sensors quasi-simultaneously, to efficiently collect, characterize and report sensor data. This eliminates the overhead of periodic network activity and centralized control, resulting in more energy-efficient communication with a lower, more consistent detection latency. In doing so, we propose a fundamentally new approach to avoid the elementary conflict between duty cycle and latency requirements immanent to synchronous protocols by exploiting correlated sensor signals for networking. Experiments using real-world traces of a natural hazard detection application show that STeC reduces the detection latency by up to 87 % compared to standard single-hop communication and outperforms traditional schedule-based methods by up to 58.4 × in energy efficiency.

"SociTrack: infrastructure-free interaction tracking through mobile sensor networks"
at the International Conference on Mobile Computing and Networking (MobiCom)

- Design of a dual-radio architecture for high fidelity distance measurements
- Implementation on UWB and BLE radios as a symbiosis of ranging and discovering
- Testing together with social scientists in various case studies over 4 years

Abstract: Social scientists, psychologists, and epidemiologists use empirical human interaction data to research human behaviour, social bonding, and disease spread. Historically, systems measuring interactions have been forced to choose between deployability and measurement fidelity---they operate only in instrumented spaces, under line-of-sight conditions, or provide coarse-grained proximity data. We introduce SociTrack, a platform for autonomous social interaction tracking via wireless distance measurements. Deployments require no supporting infrastructure and provide sub-second, decimeter-accurate ranging information over multiple days. The key insight that enables both deployability and fidelity in one system is to decouple node mobility and network management from range measurement, which results in a novel dual-radio architecture. SociTrack leverages an energy-efficient and scalable ranging protocol that is accurate to 14.8 cm (99th percentile) in complex indoor environments and allows our prototype to operate for 12 days on a 2000 mAh battery. Finally, to validate its deployability and efficacy, SociTrack is used by early childhood development researchers to capture caregiver-infant interactions.

Theses

Semester theses

"Localizing mobile nodes in a relative coordinate system" with Prof. Dr. Srdjan Capkun

- Design, implementation and evaluation for GNSS-less positioning systems using two-way UWB communication for secure distance measurements without given infrastructure
- Embedded system based on *Arduino Duo* and custom-built hardware
- Programming with C++, Python, R and Matlab using PlatformIO

Abstract: This thesis presents an infrastructure-less, scalable, real-time positioning system for mobile entities. The system is designed based on multidimensional scaling (MDS) and multilateration. One of the key features is that there is no need for fixed anchor nodes. We achieve this by leveraging multidimensional scaling to generate a relative 3D coordinate system, after which all nodes can be mobile. The system can support real-time position estimation of multiple mobile nodes with high accuracy. We evaluated systems using both simulations and a prototype implementation. The implementation achieves an accuracy of 30 cm and supports up to 40 moving nodes updating their position every second. This thesis is a first step towards evaluating the feasibility of building an infrastructure-less secure positioning system.

"Unleashing the power of real-time Internet of Things" with Prof. Dr. Lothar Thiele

- Implementation, optimization and evaluation of a paper written by Romain Jacob et al. for enabling hard real-time constraints on wireless networks with distributed applications
- Embedded system based on a custom-built platform from ETH with multiple processors
- Programming with C and Matlab on a modified version of the Contiki OS

Abstract: With the recent surge in the interest for the Internet of Things (IoT) and an increased deployment of cyber-physical systems (CPS) in commercial and industrial applications, distributed systems have gained a significant influence on modern civilization and are performing increasingly complex tasks. Building such platforms in a reliable manner is challenging, as they include concurrent tasks on the application and the communication layers. As the majority of such devices features a single processor, tasked with both communicating over the network as well as sensing and computing, real-time scheduling conflicts arise as the resource separation of the applications in software is difficult to manage.
To achieve such independence, we propose a platform consisting of dedicated application (AP) and communication (CP) processors which are completely decoupled in terms of resource access, clock speeds and power management using BOLT. Leveraging this hardware separation, we then use the Distributed Real-time Protocol (DRP) to provably provide end-to-end real-time guarantees for the communication between distributed applications over a multi-hop wireless network. By establishing a set of contracts at run-time, DRP ensures that all messages reaching their destination meet their hard deadline. To demonstrate this, we implement the BLINK scheduler directly on the AP and adapt the LWB round structure to use DRP as a control layer protocol. We show that our system is capable of supporting several hundred simultaneous streams and can respond to requests in maximally 3 stream periods over up to 10 hops.

Master thesis

"TotTernary: A wearable platform for social interaction tracking"

with Prof. Dr. Prabal Dutta (UC Berkeley) and Prof. Dr. Lothar Thiele (ETH Zurich)

- Development of a prototype social interaction tracking platform at the University of California, Berkeley in collaboration with researchers at Vanderbilt University
- Hardware design and assembly of a custom PCB including narrowband and ultra wideband RF layout for a size and weight-constraint platform
- Programming with C, JavaScript and Matlab for bare metal embedded applications

Abstract: Commercial ultra-wideband radios leverage the availability of accurate timestamps to estimate distances based on two-way time of flight measurements with centimeter accuracy and hence enable high-precision localization. Their superior performance compared to previous technology encourages the use of such devices for social interaction tracking and the study of human behaviour in various environments with high fidelity. To enable the observation of cohorts under real-life circumstances, domain scientists require an infrastructure-free and configurable solution which satisfies both the severe space and energy constraints common for such applications. Currently, no system can satisfy lifetime requirements for deployments of more than a week and achieve the decimeter accuracy sought by sociologists and epidemiologists while respecting mobility and latency demands of diverse populations.

TotTernary provides a mobile, accurate, responsive, and reliable platform for ranging measurements which allows users to gather both distance and position information with decimeter accuracy. Measuring only 61mm x 35mm and weighing 7.7 g, it integrates two radios to achieve both low-power neighbour discovery and direct user interactions using Bluetooth Low Energy as well as precise ultrawideband ranging measurements. The system leverages a novel energy-efficient ranging protocol with linear message complexity to achieve lifetimes of up to 39 days. We show how the platform can be tailored to varying scenarios by adjusting the ranging fidelity and the update rate and demonstrate the use of dynamic adaptions to changing environments. Furthermore, leveraging both antenna as well as frequency diversity, we demonstrate that the median ranging error can be reduced by up to 86% and that our system is capable of highly reliable and consistent measurements with as little as 14.8 cm of ranging error in the 99th percentile and a 90% confidence interval of 11.3 cm. This work presents the first infrastructure-free, long-term research platform which enables domain scientists to measure human interactions with previously unprecedented accuracy and flexibility.