Fraunhofer
ESK

FRAUNHOFER INSTITUTE FOR EMBEDDED SYSTEMS
AND COMMUNICATION TECHNOLOGIES ESK

ANNUAL REPORT 2015

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Dear Customers, Partners and Employees,

Human communication serves as a means of exchanging information. Most of the time it works well, especially if the communication partners know each other. But misunderstandings and interruptions can still occur.

When applied to technical communication between vehicles, machines and devices, it means more information is being exchanged thanks to a growing degree of connectivity. But even in these situations, failed transmissions and data loss are commonplace.

In 2015, Fraunhofer ESK made several contributions to ensuring more reliable and efficient technical communication:

Launch of the digital test track on the A9 highway near Nuremberg
On the digital test track, vehicles share information regarding danger situations. Communication is carried out in real-time using the LTE mobile network, without the typical latency. This fast and reliable flow of information will one day help to relieve traffic congestion and prevent accidents. We implemented this project (page 12) together with Continental, Deutsche Telekom AG and Nokia Networks. I'm especially proud that the project was recognized in March 2016 with a best practice award by the Intelligent Connectivity Initiative.

E-mobility – efficiency and safety is a must
Within the SafeAdapt project (page 14), our researchers collaborated with partners from industry and science to develop an adaptive electric/electronics software architecture (E/E system) for electric vehicles. The system is designed to detect and rectify problems during operation on its own, thus leading to improved safety, reliability and cost efficiency.

From Mobility 4.0 to Industry 4.0
Manufacturing and production systems are also becoming increasingly connected. The growing numbers of networked machines, plus large volumes of data, demands a reliable communication architecture. Together with our partner Huawei, we have illustrated how this architecture could be created. The white paper „Industrial Internet of Things" - a reference architecture for the communication (page 15) - provides an important building block for the future of industrial communication.

Broadband data transmission
VDSL and G.fast coexist, provide interference-free data transmission and even make it possible to expand broadband communication using the existing copper wire infrastructure. We demonstrated how this works in the joint project FlexDP (page 17).

You will find other interesting projects in this year's annual report.

All of the project activities depend on human communication between the employees and with our customers, partners and financial sponsors. With this in mind, I'd like to express my sincere thanks to all of you for another year of excellent cooperation. I'm looking forward to our continued work on the communication capabilities of the future, in whatever form they might take.

Sincerely,

Rudi Knorr

ABOUT FRAUNHOFER ESK

Fraunhofer ESK develops distributed, heterogeneous networked systems in the business units automotive, telecommunication, energy and industrial communication.

Core expertise
The institute's broad positioning is based on extensive expertise in the areas of communication technology, application protocol and network architecture and distributed systems analysis and validation.

Business Units
In the business unit automotive, Fraunhofer ESK conducts research into communication technologies and software architectures for reliable connected driving (car-to-car, car-to-x). The institute also works on methods for the development of flexible and reliable software, particularly for net-worked embedded automotive systems.
In the area of energy supply, Fraunhofer ESK conducts research into future smart grid communication requirements, including analyzing which technologies are suitable for various application scenarios.
Fraunhofer ESK supports Industry 4.0-capable automation system platforms by developing robust wireless systems and application protocols that are designed for integrating cloud services.
To address the growing demand for bandwidth and improved security for telecommunications systems and architectures, Fraunhofer ESK optimizes existing technologies such as VDSL vectoring and develops new access, in-house solutions and automated test and analysis processes.

Advisory Board
The Advisory Board, which comprises experts from industry, science and the public sector, provides guidance and advice regarding the institute's strategic alignment and helps to forge contacts with industry and other related organizations.

Members

Dr. Michael Frehse (Chairman)
Head of Section and Sub-Division Head for Information and Communications within the German Federal Ministry of the Interior

Lars Weber (Vice Chairman)
GWAdriga GmbH

Prof. Dr. Bernhard Bauer
Dean of the School of Computer Sciences at the University of Augsburg
Professor for distributed system software methodologies

Dr. Christoph Grote
Managing Director, BMW Research and Technology GmbH
BMW Group

Dr. Reiner Hoeger
Continental Automotive GmbH
Director Engineering Governance
Automotive Systems and Technology

Kai Horten
Chairman of the Management Board at ESG Elektroniksystem- und Logistik-GmbH

MR Dr. Ulrich Steger
Bavarian Ministry for Economic Affairs, Infrastructure, Transport and Technology
Section VIII/6

CORE EXPERTISE – BUSINESS UNITS – SERVICES

CORE EXPERTISE

COMMUNICATION TECHNOLOGIES

Wired Transmission Technologies	Wireless Networks	Reliable Ethernet/ IP Communication
Telecommunications modeling	Robust, energy-efficient data transmission and localization	Embedded, mission-critical real-time systems
Performance and conformity testing for DSL and PLC systems	QoS guarantees in dynamic environments for WLAN, Car-to-x	QoS management, planning and validation

SOFTWARE

Adaptive Systems	Dependable Software
E/E system communication, from the network to the middleware level	Analysis and test
Car-to-X communication for road safety and infotainment	Design and tool platforms

BUSINESS UNITS

AUTOMOTIVE	ELECTRICITY GRIDS	TELE-COMMUNICATIONS	AUTOMATION TECHNOLOGIES
E/E system communication, from the network to the middleware level Car-to-X communication for road safety and infotainment	Smart metering and smart grid communication technologies	Multicore software for industrial applications Wireless communication in industrial environments	Real-time communications across efficient and reliable access networks Process optimization for the utilization of mobile devices in business applications

AUTOMOTIVE

One of the major goals of the automotive and R&D industries over the next ten years is to relieve the strain on the transportation infrastructure. The activities are focused on two key approaches: technology-independent connectivity between traffic participants and highly-automated driving.

Simple assistance systems, equipped with sensors such as distance monitors, have already become a standard feature in most modern vehicles. The next major technological step is fully autonomous driver assistance systems that assume control of the vehicle without driver intervention. For this to happen, the vehicle sensors must be capable of capturing data for not only the vehicle itself, but for the surrounding environment, both in a predictive manner and in real-time. The combination of internal sensors and communication between the vehicles and the road infrastructure will make it possible to develop automated cooperative assistance systems such as cooperative platooning one day.

Still, the high demands placed on such safety-critical systems bring to light basic questions related to reliability. Coping with the complexities of the internal and external communication architecture as early as the design phase requires abstracting model-driven descriptions of the functions and the non-functional features. Ensuring functional safety while the vehicle is being operated calls for fail operational communications architectures.

To enable autonomous driving functions for instance, in the future vehicles will feature high-grade, seamless and fail operational connectivity. To improve safety and increase efficiency, Fraunhofer ESK is conducting research into technologies and methods for connecting vehicles with their surroundings and developing design methods and software architectures for automotive applications in complex, adaptive and connected environments.

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INDUSTRIAL COMMUNICATION

The research activities of the Industrial Communication business unit are focused on the development of increasingly robust and real-time capable wireless technologies for industrial applications, as well as the development of protocol stacks for integrating sensors into the cloud.

Industrie 4.0

Industry 4.0 is creating strong demand for flexible networking technologies in manufacturing environments, particularly for wireless connectivity and the integration of sensors and actuators into cloud platforms.

To effectively manage the coexistence of industrial wireless systems, ESK researchers developed Awair, a software program that monitors the wireless environment and rapidly detects problems with signal quality and interference. Manufacturing companies can thus improve the coexistence of their own wireless systems and facilitate interference-free operation.

A further research focus of this business unit is the incorporation of local sensors and actuators into cloud platforms. Researchers developed and integrated protocol stacks that facilitate communication between conventional PLC technology and modern cloud/IoT platforms.
This business unit helps companies integrate their industrial components into IoT and cloud platforms. One example is the installation of predictive maintenance applications for the efficient maintenance and servicing of large distributed systems and equipment.

Smart Grid

Smart grids can become reality only when the network components, smart meters or electric vehicles communicate with one another using a common technology. Our researchers are working to connect smart meters and switching components to the grid provider's infrastructure in real-time. They are also testing new transmissions technologies and protocol stacks, such as the IEC 61850, in the laboratory and in the field.

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TELECOMMUNICATION

In the Telecommunication business unit, the Access & In-house Networks and Communication Solutions groups focus their research activities on reliable broadband (gigabit) transmission via fiberglass/copper wire networks, as well as the secure transmission of information through communication solutions. In addition, expertise in the field of IT forensics in real-time systems is being developed.

The groups are working on hybrid communication infrastructures, as well as on migration paths and technologies for expediting the transformation of existing solutions.

Access & In-house Networks specializes in the development of cable modems and simulation programs for the high bit-rate (> 1 GBit/s) transmission of data in existing infrastructures near and in buildings. This group also develops technology compatibility assessments on the basis of real measurements, such as analyzing vectored VDSL versus G.fast. New fields of application for this group include know-how transformation in areas such as high bit-rate vehicle bus systems.

Communication Solutions is active in the area of cyber security, which involves authentication and trust in industrial production. In the APOLI project, a consortium of machine engineering companies, software developers, IT security firms and Fraunhofer ESK are researching and developing a simple, yet secure method of user authentication for remote maintenance applications.

Apart from validating the communication, there is a need to identify network irregularities that could be caused by cyber attacks or espionage. The group is involved in several joint projects with government organizations, industry partners and universities to develop potential analysis methods.

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FRAUNHOFER ESK FACTS AND FIGURES

Finances

The Fraunhofer ESK budget totaled approximately 6.14 million in 2015 and comprised 4.5 million in personnel costs and 1.3 million in material expenses.
At 1.3 million, contract research earnings generally remained unchanged from 2014 and represent 21.2 percent of the total budget.

Personnel

At the end of 2015, the Fraunhofer Institute for Embedded Systems and Communication Technologies ESK had 59 employees, of which 80 percent were active in science and technology. The scientists were supported by 35 research assistants over the course of the year. In addition, 53 interns and graduate students worked at the institute, acquiring scientific know-how and experience or completing scientific papers.

The institute currently has employees from 11 countries. 29 percent of the workforce is female.

Laboratories

Fraunhofer ESK operates four stationary labs and one mobile lab:

- Access & Inhouse Test Lab – for testing telecommunication network components, services and solutions
- NGN Test Lab – for analyzing and testing local communication solutions and cloud services
- Automotive Lab – tool platform for automotive manufacturer and supplier development projects
- Automation Lab – for measuring, testing and developing wireless systems
- Victor – modified, street-legal BMW that functions as a demonstrator for connecting driving

Publications

Fraunhofer ESK researchers published a total of 72 scientific papers*, advised 13 graduate students while working on their bachelor's and master's theses, and filed three patents. One researcher completed his doctorate.

Patents

- Chen, Y.; Husmann, C.: Verfahren, Vorrichtung und Computerprogramm zum Bestimmen einer Information über eine Wahrscheinlichkeit, dass ein empfangenes Symbol mit einem getesteten Modulationsverfahren moduliert wurde. Patent, 2015
- Chen, Y.; Husmann, C.: Verfahren, Vorrichtung und Computerprogramm zum Bestimmen eines Modulationsverfahrens, mit dem eine Mehrzahl von empfangenen Symbolen moduliert wurde. Patent, 2015
- Golestani, A.; Wilfert, D.; Zimmer, C.: Verfahren zur Lokalisierung einer Mobilstation. Patent, 2015

*publication period: Jan. 2015 – Aug. 2016

FRAUNHOFER NETWORK AND ALLIANCES

As part of the Fraunhofer-Network, Fraunhofer ESK is deeply involved in the Information and Communication Technologies Alliance as well as the Microelectronics Alliance. Through collaboration between institutes with a similar technical focus, these alliances provide a platform for developing future projects and new technologies. This alliance bundles the mechanical engineering, electronics and IT expertise of its member institutes with the goal of developing solutions to address problems that affect individual as well as multiple disciplines. Fraunhofer ESK can thus rely on the other institutes to supplement its own expertise.

Fraunhofer ESK also actively participates in technology and industry committees outside of the Fraunhofer-Gesellschaft including standards groups like AUTOSAR and the Car2Car Communication Consortium and industry associations such as the German Association of Engineers and the BICCNET and Mechatronics clusters. Within the standards committees, the goal is to drive the development of standards forward and to ensure that the institute's development activities stay ahead of the technology curve. Participation in industry organizations helps Fraunhofer ESK pin-point the needs of the market and develop corresponding solutions.

www.fraunhofer.de
www.iuk.fraunhofer.de
www.mikroelektronik.fraunhofer.de
www.embedded.fraunhofer.de

Groups, Committees, Alliances

- Fraunhofer-Allianz Embedded Systems
- Fraunhofer-Verbund IuK
- Fraunhofer-Verbund Mikroelektronik
- AUTOSAR
- ARTEMIS-IA
- BICCNet
- Cluster Mechatronik
- Arbeitskreis Software-Qualität und -Fortbildung e.V. (ASQF)
- BITKOM
- Bluetooth Special Interest Group
- Broadband Forum
- CAR2CAR Communication Consortium
- Competence Center for Applied Security Technology, CAST e.V.
- CNA
- DKE/UK STD_1911.1 Netzintegration Lastmanagement und Dezentrale Energieerzeugung
- EAST-ADL Association
- Eclipse Foundation
- European Telecommunications Standards Institute (ETSI)
- Gesellschaft für Informatik e.V.
- Gesellschaft für Verkehrstelematik Bayern – ITS Bavaria
- Institute of Electrical and Electronics Engineers (IEEE)
- ITG Fachgruppe 5.2.5 Access- und Home
- ITU-T Zugang
- kit e.V.
- Münchner Kreis
- Runder Tisch: „Automatisiertes Fahren" des Bundesministeriums für Verkehr und digitale Infrastruktur (BMVI)
- SafeTRANS
- SDL Forum Society
- Universal Plug- and Play-Forum
- Verband der Elektrotechnik (VDE)
- Verbund 4-Labs
- Verein Deutscher Ingenieure e.V. (VDI)
- VDI - Gesellschaft Fahrzeug- und Verkehrstechnik
- ZD.B - Zentrum Digitalisierung Bayern

FRAUNHOFER ESK SERVICES

PRODUCT DEVELOPMENT, TESTING AND OPTIMIZATION SUPPORT

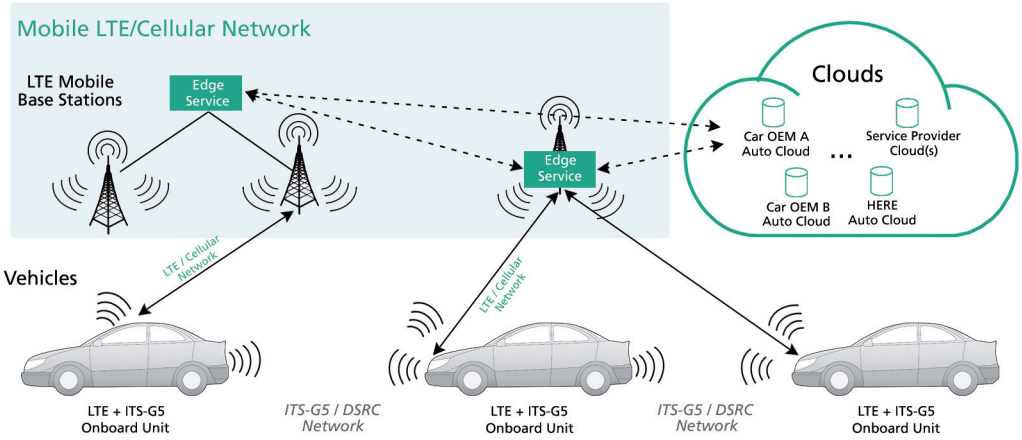
Contract-based R&D work covering specific development steps
Technical feasibility analyses
Prototype implementation
Development and test tools
License and patent exploitation

COLLABORATION

One-off R&D contracts
Framework agreements
Large-scale projects
Partnerships
Innovation clusters

RESEARCH INTO TECHNOLOGIES AND METHODS

Basic research within government-funded projects
Consortium project coordination
Innovation networks and alliances
Technology studies and expert analyses for general research purposes and company-specific applications



INCREASED TRAFFIC SAFETY WITH LTE AND MOBILE EDGE COMPUTING

As part of a joint project, Fraunhofer ESK, Continental, Deutsche Telekom and Nokia Networks are demonstrating how vehicles can share highway traffic information and warnings using the Deutsche Telekom LTW mobile network. To keep transmission times to a minimum, one segment of the Deutsche Telekom network was equipped with innovative mobile edge computing technology from Nokia Networks and enhanced with a service developed by Fraunhofer ESK that is designed for the positioning-based distribution of notifications with low latency. This combination enables car-to-car signal delay times of less than 20 milliseconds, a first in the industry. Together with a vehicle electronics interface developed by Continental, various applications for safer and more comfortable driving can be realized. A prime example is the implementation of warnings for sudden braking and unexpected lane changes when overtaking.

This involved supplementing the mobile network base stations with plug-in modules, or so-called cloudlets, which ensure that the communication traffic is routed locally within the respective mobile network cell instead of traversing the entire network. This drastically reduced signal delay times to around 20 milliseconds. Without the new technology, transmission over the LTE network can take up to 100 milliseconds.

Each test vehicle features an on-board unit that is connected to the vehicle system and which communicates with the LTE network via a wireless module. Continental provided the application software and the graphical interface for the application scenarios and is also responsible for integrating the LTE technology with the vehicle bus (CAN) signals. In conjunction with Fraunhofer ESK's GeoService software that runs on the LTE base station, the system captures status and warning notifications from the vehicles and processes them directly in the next LTE base station. Using calculations carried out locally in the base station, the system can send out nearly delay-free traffic warnings to all vehicles located in the relevant areas.

This joint project was awarded first place in the „Traffic" category in the 2016 best practice competition conducted by the Intelligent Connectivity (German: Intelligente Vernetzung) initiative organized by the German Federal Ministry for Economic Affairs and Energy. Together with the German consulting firm Management- und IT-Beratung MHP, a Porsche company and first-time participant in the project, the project partners are planning to continue the collaboration through a follow-up project in the area of vehicle connectivity.

Fraunhofer ESK Contribution

- Development of a service for the positioning-based propagation of traffic notifications (Geo-Service) with low latency for mobile edge computing
- Provisioning of the on-board unit (OBU) with the ezCar2X® software framework
- Integration of the tablet-based user interface via Bluetooth

This is a joint project involving:
Continental, Deutsche Telekom and Nokia Networks

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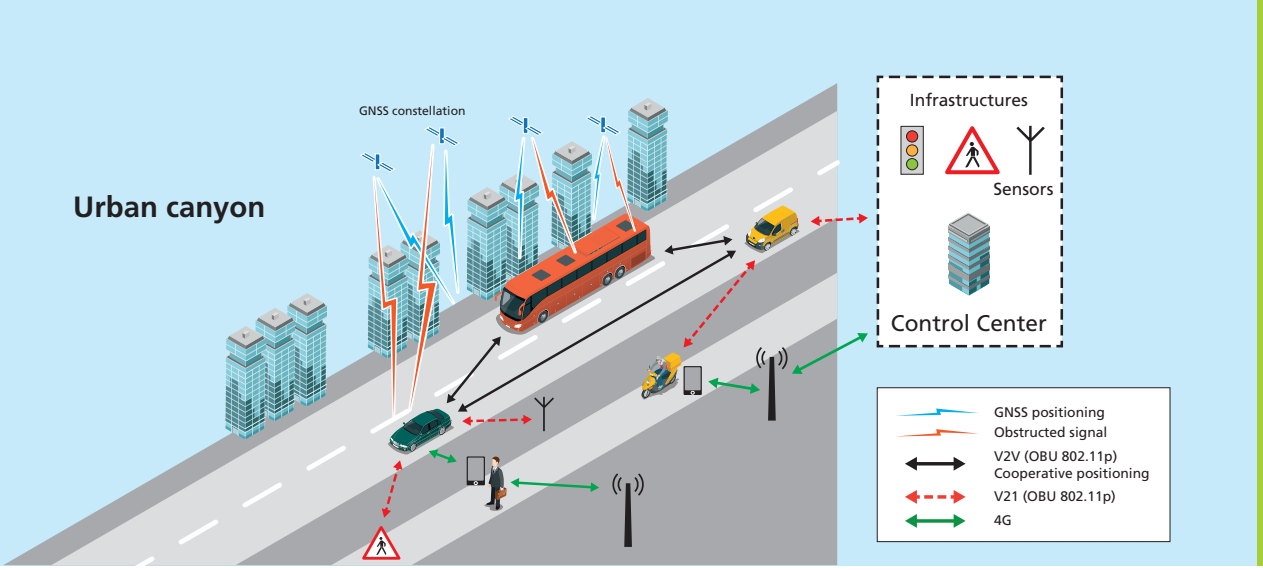

PEDESTRIANS, CYCLISTS, VEHICLE DRIVERS – TRAVELLING SAFELY WITH REAL-TIME MOBILE COMMUNICATION

By connecting all traffic participants, we can deal more effectively with traffic congestion, accidents and undue environmental pollution. The issue is that vehicles normally utilize the ITS-G5 wireless standard while pedestrians rely on their LTE-based smartphones. The aim is to enable traffic participants to communicate with one another in real-time, irrespective of the individual wireless technologies. In the TIMON project, Fraunhofer ESK and its partners are researching concepts that will allow this vision to become reality. The idea is to ensure that drivers, cyclists, pedestrians and the traffic infrastructure have continuous access to all relevant information from the immediate surroundings, thus allowing them to adapt to the current traffic situation. Especially pedestrians and cyclists can be for example protected from collisions by real-time warnings. The entire system will be evaluated in a simulated environment, as well as in two field tests in the Netherlands and Slovenia.

Fraunhofer ESK Contribution

- Hybrid communication system (ETSI ITS-G5 and LTE) with intelligent strategies for selecting the optimal technology
- Geomessaging service for utilizing the ETSI geonetworking protocol via mobile wireless and for vehicles, cyclists, pedestrians.

This is a joint project involving:

Universidad de Deusto (Spain), Iskra (Slovenia), CTTC (Spain), Intecs (Italy), ScraperWiki (UK), GeoX (Hungary), XLAB (Slovenia), JP LPT (Slovenia), Corte (Belgium), TASS International (Netherlands)

Funding:

The TIMON project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement number 636220.

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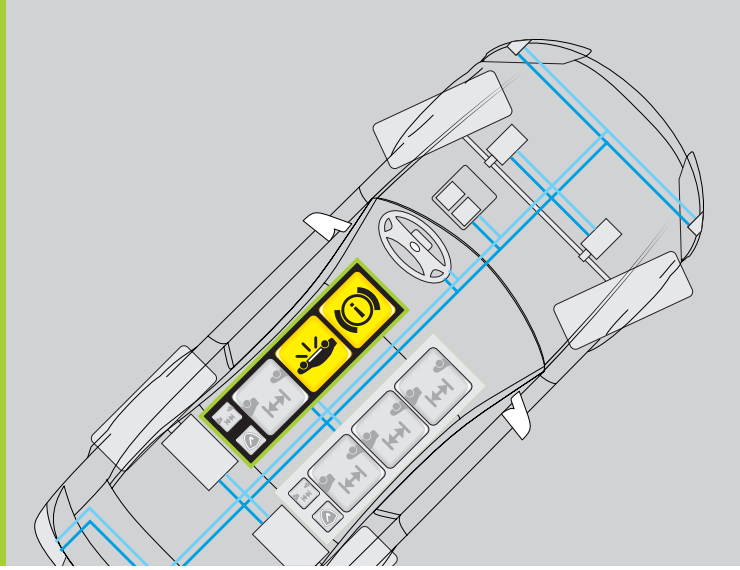

SAFER AND MORE ROBUST E-VEHICLES THROUGH ADAPTIVE E/E SYSTEMS

Software architectures in E-vehicles and automated vehicles must be able to independently correct errors and disruptions while the vehicle is operating to ensure better safety, reliability and cost efficiencies. In the EU-funded SafeAdapt project, researchers developed an adaptive electric/electronic (E/E) software architecture that addresses this requirement. The six-nation project team also conducted research into the design and validation methods for this architecture to ensure that development of the system was carried out in line with the functional safety standards specified in ISO 26262. At the conclusion of the project, the results were evaluated under real conditions utilizing test vehicles and a driving simulator.

Fraunhofer ESK customers can integrate this fail-operational behavior into their products. Our researchers are ready to support you through studies, software architecture designs, software tool implementations and even the development of complete prototypes.

Fraunhofer ESK Contribution

- Overall project coordination and management
- System concept and evaluation (with partners)
- Safe adaptation platform core (with partners)
- Automatic generation of the fail operational configurations
- Fail operational AUTOSAR and tool chains

This is a joint project involving:

CEA LIST (France), Delphi (Germany), DuraCar (Netherlands), Fico Mirrors (Spain), Tecnalia Research & Innovation (Spain), Pininfarina (Italy), Siemens (Germany) and TTTech Computertechnik (Austria).

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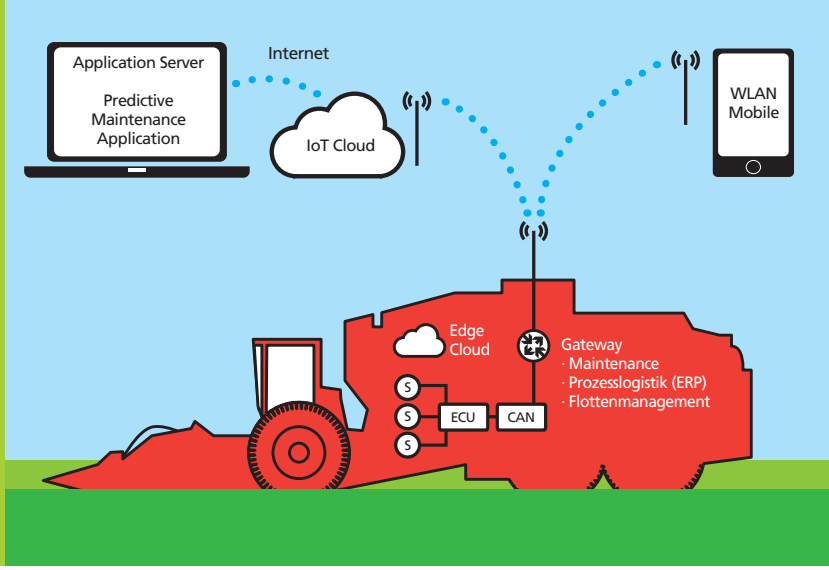

PREVENTION IS BETTER THAN CURE. PREDICTIVE MAINTENANCE FOR HARVESTING MACHINES

In the field, harvesting machines lack continuous, real-time access to the Internet. For this reason, reliable transmission of data to a central maintenance service is not always possible. Potential outages can nevertheless be detected before they happen by deploying a so-called edge cloud, which is an application gateway that analyzes sensor data originating from critical areas of the machine, such as the transmission. If abnormal conditions are detected, an alarm is generated. This so-called predictive maintenance approach saves time and minimizes costly machine down-time. An additional advantage is that rather than being restricted to one machine, the system can be used to monitor an entire fleet while it's operating in the field.

Current whitepaper on the subject of the Internet of Things:

A design for a reference communication architecture design in the industrial Internet of Things

The industrial Internet of Things (IIoT) brings with it a wide range of connected devices. The task of the IIoT communication reference architecture is to manage this complexity. Fraunhofer ESK and Huawei put together a white paper that outlines what this type of reference architecture looks like.

Download unter:
http://s.fhg.de/iiot

Fraunhofer ESK Contribution

- Selection, test and implementation of the machine-to-machine (M2M) protocols and interfaces
- Support during implementation of the edge-cloud-based predictive maintenance application

This is a joint project involving:
Holmer Maschinenbau GmbH
Huawei

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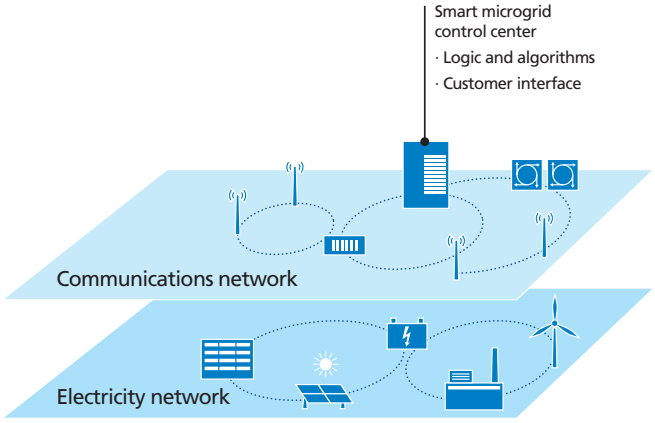

SMART MICROGRIDS REDUCE LOCAL ELECTRICITY NETWORK COSTS

Growing numbers of volatile energy sources, such as solar and wind power systems, are being connected to the conventional power grid. Communication between the components in the existing grid and the renewable energy networks transforms the conventional electricity networks into so-called smart grids. Smart microgrids help to balance the supply and demand in the local grid segments. As part of a field test carried out in an industrial park, Fraunhofer ESK researchers defined the communication architecture for such a smart microgrid. Among other things, this involved evaluating the requirements, analyzing the data that needs to be shared between the components, as well as the interaction between the electricity and communication networks, and selecting the communications technologies. LTE was deployed for quick integration of the network components.

The communications network and the electricity network form the two levels of the smart grid. A central server can be deployed to implement network support algorithms, to provide the grid operator's control center insights into the current network situation and to offer the customer information about their own electricity usage.

Fraunhofer ESK Contribution

- Planning the smart microgrid communication system
- Implementation support during development of the smart microgrid
- Analysis of special application scenarios
- Simulation of the interaction between the electricity and communication networks
- Smart microgrid testing

This is a joint project involving:

Axiros GmbH (Axiros)
Bittner + Krull Softwaresysteme GmbH (B+K)
Europäische Funk-Rundsteuerung GmbH (EFR)
Stadtwerke Augsburg Energie GmbH (swa)
Technical University Munich (TUM)

Funding:

This project was funded by the Bavarian Ministry for Economic Affairs, Infrastructure, Transport and Technology.

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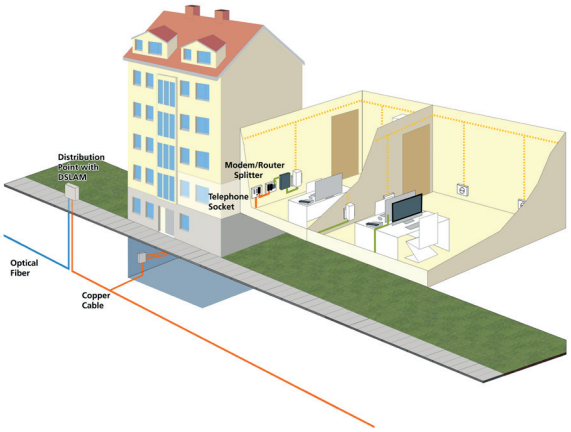

FLEXDP – FLEXIBLE BROADBAND DISTRIBUTION POINTS ENHANCE COPPER WIRE

With the build-out of the fiberglass network rapidly progressing in Germany, the next milestone is referred to as fiber-to-the-distribution-point (FTTdp). This approach involves running the fiber to a distribution point at a flexible location no more than 250 meters from the customer premise. The remaining path to and inside the building or home utilizes the existing copper wire telephone infrastructure. In the FlexDP project, Fraunhofer ESK researchers used the technical components of the distribution point to create a functional prototype that was tested in the ESK Access & In-house Test Lab. The test demonstrated that VDSL2- and G.fast-based distribution points can be successfully implemented under near-real conditions.

Fraunhofer ESK Contribution

- Testing that served as a basis for developing various cable and signal noise models for copper wire infrastructures
- Examination of transmission methods such as VDSL2 vectoring and G.fast in a simulated environment
- Development of new approaches for better coexistence between VDSL2 vectoring and G.fast in a simulated environment

This is a joint project involving:

Lantiq Beteiligungs- GmbH & Co KG, an Intel Company
InnoRoute GmbH

Funding

The project was funded by the Bavarian Research Foundation.

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VOIP SECURITY AWARENESS CAMPAIGN DEMONSTRATOR

Voice over IP (VoIP), which is rapidly replacing conventional telephone services, can be easily integrated into existing IT environments, although this is often done without examining the system for security vulnerabilities. With this in mind, the German Federal Ministry of Information Security (BSI) wants to increase the awareness of the security risks associated with VoIP.

Fraunhofer ESK researchers have developed a demonstrator for the BSI, which can be used to visually represent potential security vulnerabilities when using VoIP and thus identify necessary security measures. The demonstrator software, developed by project partner Alphasystems, provides a single user interface for managing the VoIP system and displaying the slides.

Security awareness – technology is only half the battle

Computers, mobile phone usage and the Internet are becoming more secure. That's what we hear at least. Because if users are not aware of the risks of utilizing technology, even the best security measures, whether encryption or access security, are superfluous. The result is harm to equipment and systems caused by malware, unauthorized access to sensitive data and other malicious activities. For this reason, awareness campaigns are meant to make users within an organization more cognizant of the various aspects of information technology and communication security.

Fraunhofer ESK Contribution

- Demonstration flow planning
- Installation of the VoIP system and general hacker tools
- Implementation of the hacker attacks

This is a joint project involving:

Alphasystems (subcontractor)

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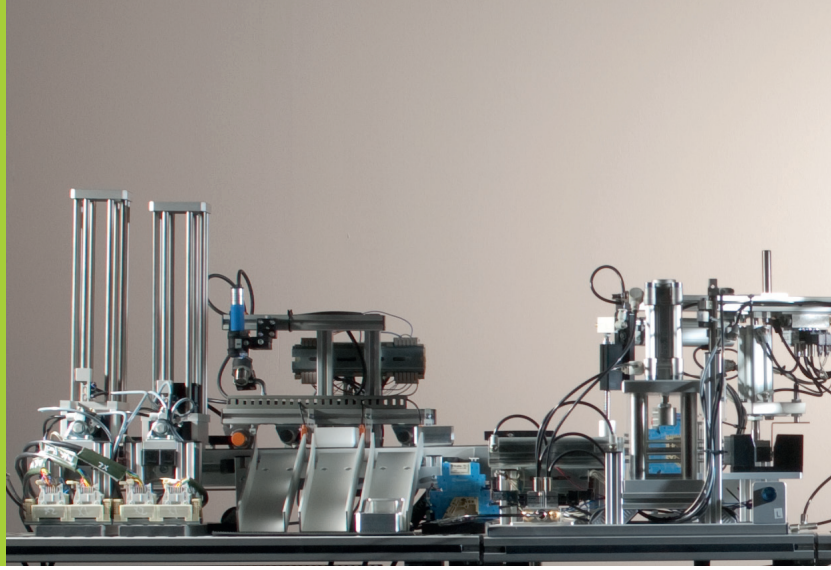
LABORATORIES



AUTOMATION LAB

The Automation Lab is equipped to develop, measure and test various communication systems and includes the ESK-developed Awair wireless system monitoring solution and a model factory.

Equipment

Measurement environment for analyzing the wireless spectrum, wireless propagation and protocols

- Broadband transmit and receive antenna system (up to 7 GHz)
- Spectrum analyzer
- Vector network analyzer
- Signal generator
- Logic analyzer
- Real-time wireless spectrum monitoring

Software defined radio

- Hardware: USRP2 with 2.4/5 GHz and 868 MHz board
- Development: Matlab and GNURadio

Sensor network development

- Transceiver modules: CC11xx, CC24xx and CC25xx
- IEEE 802.15.4, Zigbee, ISA100, Wireless HART
- Operating systems: TinyOS, FreeRTOS and others
- Microcontrollers: EFM32, STM32 and others
- Proprietary hardware/software platform

Industrial automation

- Model factory, including production automation with distributed controls
- Cloud-based control
- TSN test bed

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LABORATORIES

AUTOMOTIVE LAB

The Automotive Lab offers manufacturers and suppliers various platforms for testing development projects in the areas of automotive networks, real-time operating systems, infotainment and driver assistance.

Equipment

- DANA tool developed by ESK for the model-based development and validation of automobile software systems
- ERNEST framework developed by ESK for the design and simulation of networked E/E software
- ezCar2X® Framework developed by ESK for the rapid prototyping of connected vehicle and road infrastructure applications
- Vehicle and rest bus simulation, ECU prototyping, vehicle bus testing (CAN, MOST, FlexRay, Ethernet)
- Tools for TCP/IP conformity testing and for the simulation/design of Ethernet-based networks
- ARTiS family: prototyping for CAN, MOST, FlexRay, Ethernet and infotainment applications
- Car2X communication hardware from diverse manufacturers for carrying out interoperability tests and optimizing wireless transmissions

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VICTOR – CONNECTED DRIVING DEMONSTRATOR

The VICTOR demonstrator is a street-legal BMW 320i station wagon that was modified for test purposes.

VICTOR is the ideal platform for the rapid prototyping and testing of reliable Car-2-X communication concepts. VICTOR can be used together with the ezCar2X® software framework developed by Fraunhofer ESK to evaluate various cooperative driver assistance communication systems with one or more technologies or to test new communication technologies and architectures. Currently equipped with multiple ITS-G5 and LTE interfaces, VICTOR will eventually be enhanced with other technologies such as ITS-G63 and LTE V2X.

Apart from the communication interfaces, VICTOR can also be retrofitted with integrated sensors. Three radar sensors and one laser scanner sensor monitor the surrounding environment while an inertial measurement unit provides centimeter-precise positioning. In order to access and merge the sensor data and use it for creating cooperative environment models, the demonstrator features two patch panels.

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LABORATORIES

ACCESS & IN-HOUSE TEST LAB

The Access & In-house Test Lab is designed for analyzing communication systems in accordance with international standards and for evaluating and enhancing customer-specific solutions.

Equipment

- Measurement stations for VDSL2/ADSL2+ standards conformance tests
- Special test environment for broadband powerline communication (PLC) systems
  - Test network for broadband PLC testing in a real environment
  - Spectrum analyzer for PLC signal measurements
- Software defined radio platform for transmission experiments
- Twisted pair and power line test networks
  - Access network for vectoring tests
  - In-house network for vectoring tests and for evaluating special building scenarios
- Measurement equipment
  - Ethernet test system (Spirent test center, Spirent smartbits, IXIA Chariot)
  - PC-based data and load generators and analyzers
  - Vector signal/network/spectrum/impedance analyzers
  - Bit error rate tester
  - Diverse measurement instruments such as energy and power measurement devices and DSL/ISDN testers

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NGN TEST LAB

The NGN Test Lab is set up for analyzing communication systems - from local environments to cloud services - as well as for evaluating and enhancing customer-specific solutions.

Equipment

- Various Internet connectivity (ADSL, VDSL, Gbit connectivity to the German Research Network)
- Protocol analyzers, traffic generators
- Powerline adapter test environment
- Model institute for the central private cloud Fraunhofer voice service

Services

- Usability and interoperability tests:
  - Testing of communication solution prototype implementations
  - Independent transmission system tests
  - Communication systems and applications prototype design and implementation
- Measurements:
  - User equipment testing, such as powerline adapters
  - Transmission system characteristics and behavior
- Information security:
  - Analysis of communication protocols and Internet-based services
  - IP network security and routing concepts
  - Design and prototype implementation of customer-specific security architectures

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CHAIR FOR COMMUNICATION SYSTEMS

Fraunhofer ESK is headed by Prof. Dr. Rudi Knorr, who also holds the Chair for Communication Technology at the University Of Augsburg Department Of Computer Science. This chair is devoted to basic research in the cutting-edge field of self-organizing communication systems in conjunction with next generation networks such as cyber-physical systems or the Internet of Things.

The research activities and teaching curriculum are focused on the new demands being placed on information and communication technologies and embedded communication systems. In the future, a wide range of applications, systems, equipment, machines, vehicles and ICT networks will have to operate together in order to provide functions and services that are far beyond the capabilities of the individual components. The challenge here involves ensuring reliability, which means the ability to dynamically react in real-time to changes in the environment, the availability of the devices, services, resources and the degree of robustness in the communication system.

In this area, the research activities include not only basic technologies for reliable connectivity and data transmission, but also the interoperability and uniformity of various systems and components required for end-to-end communication, particularly with an eye on the future Internet, or the Internet of Things. In other words, a scenario in which Internet technologies pervade all technical systems, leading to the creation of a global and application-wide integration platform.

The research also focuses on adaptive methods for the dynamic and more efficient utilization of wireless and wired channels and the development of new algorithms and protocols for self-organizing networked systems

Current research projects include the design of reliable IP-based communication processes for internal vehicle systems and wireless Car-2-X communication, as well as transmission technologies, methods for integrating vehicles into mobility concepts, sensor networks and protocols for smart grids and intelligent production systems.

PUBLICATIONS

Bittl, S.: **Efficient distribution of static or slowly changing configuration parameters in VANETs.** Beitrag auf dem 7. International Workshop on Reliable Networks Design and Modeling (RNDM), München

Bittl, S.; Aydinli, B.; Roscher, K.: **Distribution of pseudonym certificates via bursts for VANETs with low and medium mobility.** Beitrag auf der 8. Wireless and Mobile Networking Conference (WMNC), München

Bittl, S.; Aydinli, B.; Roscher, K.: **Effective certificate distribution in ETSI ITS VANETs using implicit and explicit requests.** Beitrag auf dem 8. International Workshop Nets4Cars, Sousse

Bittl, S.; Aydinli, B.; Roscher, K.: **Efficient rate-adaptive certificate distribution in VANETs.** Beitrag auf dem 12. International Symposium on Wireless Communication Systems (ISWCS), Brüssel

Bittl, S.; Gonzalez, A. A.: **Privacy endangerment from protocol data sets in VANETs and countermeasures.** Beitrag auf der 4. International Conference on Smart Cities and Green ICT Systems (SMARTGREENS), Lissabon

Bittl, S.; Gonzalez, A. A.: **Privacy issues and pitfalls in VANET standards.** Beitrag auf der 1. International Conference on Vehicle Technology and Intelligent Transport Systems (VEHITS), Lissabon

Bittl, S.; Gonzalez, A. A.; Myrtus, M.; Beckmann, H.; Sailer, S.; Eissfeller, B.: **Emerging attacks on VANET security based on GPS time spoofing.** Beitrag auf der Conference on Communications and Network Security (CNS), Florenz

Bittl, S.; Gonzalez, A. A.; Spähn, M.; Heidrich, W. A.: **Performance comparison of data serialization schemes for ETSI ITS car-to-X communication systems.** In: International Journal on Advances in Telecommunications, Vol.8 (2015), Nr.1-2, S. 48-58

Bittl, S.; Roscher, K.: **Efficient authorization authority certificate distribution in VANETs.** Beitrag auf der 2. International Conference on Information Systems Security and Privacy (ICISSP), Rom

Bittl, S.; Roscher, K.: **Feasibility of Verify-on-Demand in VANETs.** Beitrag auf dem 4. Fachgespräch Inter-Vehicle Communication, Berlin

Bittl, S.; Roscher, K.; Gonzalez, A. A.: **Security overhead and its impact in VANETs.** Beitrag auf der 8. Wireless and Mobile Networking Conference (WMNC), München

Bittl, S.; Schlegel, M.; Roscher, K.: **Simulationsbasierte Evaluierung eines zeit- und ortsbasierten Pseudonym-Wechsel-Verfahrens für ETSI ITS: Dezentraler Ansatz zur Verbesserung der Privatsphäre von Fahrern.** Beitrag auf der 31. Gemeinschaftstagung Automotive Security, Wolfsburg

Chen, C: **Modeling a building energy management system scenario based on OGEMA framework for power flow optimization.** Master Thesis, 2015

Drabek, C.: **DANA - behavioral verification of automotive infotainment software-interfaces.** Vortrag auf der Automotive HMI Cosmos (IQPC), Mainz

Drabek, C.; Paulic, A.; Weiß, G.: **Reducing the verification effort for interfaces of automotive infotainment software.** Beitrag auf dem SAE World Congress, Detroit/Mich.

Fanucchi, D.; Knorr, R.; Staehle, B.: **Impact of network monitoring in IEEE 802.15.4e-based wireless sensor networks.** Beitrag auf dem 16. International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM), Boston/Mass.

Feiertag, K.: **Angriffserkennung in Software-Defined Networks: Implementierung und Evaluation eines Flow-basierten Erkennungssystems.** Master Thesis, 2016

Franze, J.; Marriott, K.; Wybrow, M.: **Does a split-view aid navigation within academic documents?** Beitrag auf dem 15. Symposium on Document Engineering (DocEng), Lausanne

Göckel, F.: **Correlations between network conditions and quality of CACC systems in terms of safety, efficiency and channel utilization.** Master Thesis, 2016

Heidrich, M.: **Anwendungsszenarien und Referenzarchitektur in der Industrie 4.0.** Vortrag auf der IT2Industry, München

Heidrich, M.: **Drahtloses Koexistenzmanagement in der Produktion.** Vortrag auf dem Innovation Forum Digitalisierung 2015, München

Heidrich, M.: **Fehlende Standards bremsen das Internet der Dinge noch.** In: Elektronikpraxis (2015), Kompendium Internet of Things, S. 16-18

Heidrich, M.: **Funk für Industrie 4.0 - Anwendungsszenarien, Cognitive Radio.** Vortrag auf dem Workshop Funkkommunikation für Industrie 4.0, Berlin

Heidrich, M.: **The concept of industry 4.0.** Vortrag auf der Industrie Paris, l'usine du futur, Paris

PUBLICATIONS

Heidrich, M.: **Wireless communication for industry 4.0.** Vortrag auf dem 3. M2M Alliance Academic Day 2015, Düsseldorf

Heidrich, M.; Luo, J. J.: **Industrial Internet of Things: Referenzarchitektur für die Kommunikation.** Whitepaper, 2016

Heinrich, P.; Bergler, H.; Oswald, E.: **Early energy estimation of networked embedded systems executing concurrent software components.** In: International Journal of Modeling and Optimization: IJMO, Vol.5 (2015), Nr. 2, S. 119-127

Heinrich, P.; Gossen, D.; Oswald, E.; Knorr, R.: **Early energy estimation of heterogeneous embedded networks within adaptive systems.** Beitrag auf der 4. International Conference on Energy Efficient Vehicles (ICEEV), Dresden

Heinrich, P.; Oswald, E.; Knorr, R.: **Energy saving potential of adaptive, networked, embedded systems: A case study.** Beitrag auf der 6. International Conference on Smart Grids, Green Communications and IT Energy-aware Technologies (ENERGY), Lissabon

Hellstern, M.: **Konzept und prototypische Umsetzung eines Meta-Objekt Modells für die Fusionierung von C2X- und Sensordaten.** Master Thesis, 2015

Hincapie Henao, D.; Leibiger, M.: **Advanced simulations for G.fast, Vectoring & Co.** In: EETimes.com, (2016), Nr. 7, S. 28-30

Hincapie Henao, D.; Maierbacher, G.; Achtzehn, A.; Petrova, M.: **Evaluation of binder management for partially controlled DSL vectoring systems.** Beitrag auf der International Conference on Communications (ICC), Smart City and Smart World, London

Hincapie Henao, D.; Maierbacher, G.: **Impact-analysis for coexisting G.fast and vectored VDSL2.** Beitrag auf der Conference on Standards for Communications and Networking (CSCN), Tokio

Hincapie Henao, D.; Maierbacher, G.; Leibiger, M.: **Rate and reach gains of vectored DSL in the current access network.** Beitrag auf der 9. ITG-Fachkonferenz Breitbandversorgung in Deutschland, Berlin

Hofbauer, Brigitte: **Quantitative IT-Sicherheitsbewertung von Authentifizierungs- und Autorisierungsverfahren.** Master Thesis, 2016

Jiru, J.; Mammu, A. S. K.; Roscher, K.: **Adaptive decision algorithms for data aggregation in VANETs with defined channel load limits.** Beitrag auf dem Intelligent Vehicles Symposium (IV), Seoul

Krojer, F.; Furjanic, I.: **NFV und SDN machen Produktionsnetze fit für Industrie 4.0.** In: Funkschau, (2015), Nr.5, S. 40-41

Langer, F.: **Bewertung des Kommunikationsverhaltens eingebetteter Systeme mit Hilfe selbstlernender Verfahren.** Dissertation, 2015

Langmann, R.; Stiller, M.: **Industrial Cloud - Status und Ausblick.** In: HMD Theorie und Praxis der Wirtschaftsinformatik, Vol. 52 (2015), Nr. 5, S. 647-664

Leibiger, M.: **Hybride Breitbandtechnologien aus Sicht der Forschung. Labortests, Simulationen und Praxisrelevanz.** Vortrag auf BUGLAS Infothek Super-Vectoring, G.fast & Co. - worauf sich TK-Unternehmen nun einstellen müssen, Frankfurt a.M.

Leibiger, M.; Furjanic, I.; Messerer, T.; Krojer, F.; Handel, P.: **Home Gateways in zukünftigen Netzen: Die Auswirkung von SDN und NFV auf die Sicherheit privater Daten.** Whitepaper, 2015

Mammu, A. S. K.; Jiru, J.; Hernandez-Jayo, U.: **Cluster based semantic data aggregation in VANETs.** Beitrag auf der 29. International Conference on Advanced Information Networking and Applications (AINA), Gwangju

Manderscheid, M.; Weiß, G.; Knorr, R.: **Verifying network performance of cyber-physical systems with multiple runtime configurations.** Beitrag auf der 15. International Conference on Embedded Software (EMSOFT), Amsterdam

Messerer, T.: **Einsatz von Skype im Unternehmen: Chancen und Risiken.** Studie, 2016

Namita, N: **A method for evaluating failover scenarios in distributed real-time systems: An AUTOSAR case study.** Master Thesis, 2016

Nauck, E.; Niestegge, G.; Spähn, M.: **Welche Kommunikation erfordern Smart Grid & Smart Market?**: Poster anlässlich der Fachtagung „Von Smart Grids zu Smart Markets", Kassel

Nauck, E.; Niestegge, G.; Spähn, M.: **Welche Kommunikation erfordern Smart Grid und Smart Market?** Beitrag auf der Fachtagung „Von Smart Grids zu Smart Markets", Kassel

PUBLICATIONS

Oliveira da Penha, D.; Weiß, G.: **Parameterization of fail-operational architectural patterns.** Beitrag auf dem 30. ACM/SIGAPP Symposium on Applied Computing (SAC), Salamanca

Oliveira da Penha, D.; Weiß, G.; Stante, A.: **Pattern-based approach for designing fail-operational safety-critical embedded systems.** Beitrag auf der 13. International Conference on Embedded and Ubiquitous Computing (EUC), Porto

Oswald, E.: **Mehrstufiger Rollout hat mehr Vor- als Nachteile.** In: BWK. Das Energie-Fachmagazin, (2015), Nr.4, S. 3

Pant, D.: **Design, implementation, and assessment of predictive cognitive channel access for industrial communication in the 2.4 GHz ISM band.** Master Thesis, 2015

Panthangi Manjunath, R.: **Congestion control by in-vehicle traffic shaping for vehicular safety applications.** Master Thesis, 2016

Petreska, N.; Al-Zubaidy, H.; Knorr, R.; Gross, J.: **On the recursive nature of end-to-end delay bound for heterogeneous wireless networks.** Beitrag auf der International Conference on Communications (ICC), Smart City and Smart World, London

Rafiq, S.: **A framework for systematic analysis of event traces for software debugging and optimization.** Vortrag auf der Solutions for MultiCore Debug Conference (SMD), München

Rosenthal, T.; Feismann, T.; Schleiß, P.; Weiß, G.; Klein, C.: **Adaptive Software für sicherheitskritische Funktionen in Batterieelektrischen Fahrzeugen.** Beitrag auf der 7. Fachtagung „Automotive meets Electronics" (AmE), Dortmund

Ruiz, A.; Juez, G.; Schleiß, P.; Weiß, G.: **A safe generic adaptation mechanism for smart cars.** Beitrag auf dem 26. International Symposium on Software Reliability Engineering (ISSRE), Gaithersburg/Md.

Saad, A.; Mansour, N.; Friedrich, A.; Youssef, Z.; Dahlhaus, D.; Sharma, M.; Al Halaseh, R.; Majeed, E.; Kohrt, K. D.; Bruck, G.; Knorr, R.; Jung, P.: **Cognitive radio prototype for industrial applications.** Beitrag auf der 22. European Wireless Conference (EW), Oulu

Saad, A.; Staehle, B.: **Towards a time-domain traffic model for adaptive industrial communication in ISM bands.** Beitrag auf den Wireless Days (WD), Toulouse

Saad, A.; Staehle, B.; Chen, Y.: **On interference detection using higher-order statistics. Beitrag auf der 13.** International Conference on Industrial Informatics (INDIN), Cambridge

Shah, J.: **Design and Evaluation of a distributed consensus Framework for safety related applications in Vehicular Ad-hoc NETworks (VANETs).** Master Thesis, 2016

Spähn, M.; Nauck, E.: **Nahtlose Integration von Elektrofahrzeugen ins Smart Grid: Kommunikationsschnittstellen für das Energiemanagement.** In: Bulletin. Electrosuisse, (2015), Nr. 3, S. 43-46

Staehle, B.: **Funk für industrielle Anwendungen – Probleme und Herausforderungen.** In: Mechatronik News, (2015), Nr. 3, S. 3-4

Staehle, B.: **Nutzung von Funk in deutschen Unternehmen.** Studie, 2015

Steiner, T.: **Evolving traffic scenarios to test driver assistance systems in simulations.** Beitrag auf dem 8. International Workshop Nets4Cars, Sousse

Stiller, M.: **Cloudbasierte Steuerungsdienste für die Produktion von morgen.** Vortrag auf dem Clusterworkshop „Cloud Computing für die Automation", Augsburg

Stiller, M.; Heidrich, M.; Langmann, R.: **Cloud basierte IEC 61131 Steuerungsdienste auf Basis von Webtechnologien.** Beitrag auf dem 1. Automobil Symposium, Wildau

Tomatis, A.; Menouar, H.; Roscher, K.: **Forwarding in VANETs: GeoNetworking. In: Campolo, Claudia (Ed.): Vehicular ad hoc networks: Standards, solutions, and research.** Cham: Springer, 2015, S. 221-251

Weber, C.: Staehle, B.: **Systeme im Funkspektrum verteilen.** In: IT & production, (2015), Nr.10, S. 58-59

Weber, L.; Heidrich, M.: **Smart Metering. Success depends on selecting the right information and communication technology.** Beitrag auf der SmartER Europe Conference, Essen

Weiß, G.; Eilers, D.: **SafeAdapt. Safe Adaptive Software for Fully Electric Vehicles:** Poster anlässlich des European Battery, Hybrid and Fuel Cell Electric Vehicle Congress (EEVC), Brussels

Zhang, Z.: **Determination of real-time network configuration for self-adaptive automotive systems.** Master Thesis, 2015

HOW TO FIND US

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By train
From Munich main station: Take the U4 or U5 subway (U-Bahn) in the direction of Laimer Platz or Westendstrasse as far as Heimeranplatz. Exit the most forward portion of the train and follow the signs to the Hansastrasse exit. Cross Hansastrasse using the pedestrian crosswalk, then immediately turn right and walk approximately 50 meters. We are located on the fourth floor of the next large building, Hansastrasse 32.

Please note, the journey from the Munich main station to Heimeranplatz requires two stripes with the MVV stripe card.

By air
From Munich airport, take the S8 or S1 suburban rail (S-Bahn) line as far as Karlsplatz Stachus station, and change to the U4 or U5 subway (U-Bahn). Travel in the direction of Laimer Platz as far as Heimeranplatz. Exit the most forward portion of the train and follow the signs to the Hansastrasse exit. Cross Hansastrasse using the pedestrian crosswalk, then immediately turn right and walk approximately 50 meters. We are located on the fourth floor of the next large building, Hansastrasse 32.

By car
If arriving in Munich on the A8 motorway, take it right through to the end and continue straight on Verdistrasse. Turn right on Meyerbeerstrasse, then left on Landsberger Strasse, and right on Elsenheimer Strasse, which eventually turns into Hansastrasse. Travel straight for approximately 500 meters. Our building is on the right hand side, Hansastrasse 32.
If arriving in Munich on any other motorway, follow the signs to the Mittlerer Ring (city circular) in the direction of the Stadtmitte (city center).

Traveling north to south: using the Mittlerer Ring, you will cross the railroad lines at Donnersbergerbrücke. Stay in the right hand lane as you enter the tunnel. At the end of the tunnel, take the first exit Westend/Heimeranplatz. Take the first right onto Tübinger Strasse, then the next right onto Dillwächterstrasse and finally the first right onto Hansastrasse. Travel straight for approximately 150 meters. Our building is on the right hand side, Hansastrasse 32.

Traveling south to north: using the Mittlerer Ring, take the Westend/Heimeranplatz exit, cross the intersection and turn left onto Hansastrasse. Travel straight for approximately 100 meters. Our building is on the left hand side, Hansastrasse 32.

Parking is available in the underground garage of our building by entering from Dillwächterstrasse. Parking spaces for visitors are on the basement level (Untergeschoss) and are numbered as follows: 101-109, 164, 165, 167, 168, 169, 170 and 177-181.

EDITORIAL NOTES

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