PRESS RELEASE

Fraunhofer solves networked sensors' energy problems

In Fraunhofer's lighthouse project, the development of a extremely energy-efficient and modular hardware creates the basis for a comprehensive Internet of Things.

The Internet of Things (IoT) is growing steadily. An enormous number of networked nodes collecting, evaluating and converging data in a network is therfore already necessary today. The problem: The energy consumption of the nodes is enormous. According to a study by the International Energy Agency in 2013, the energy requirements of all networked devices worldwide corresponded to the total demand for electrical energy in Germany. Within the next few years, this need will almost double to 1140 terawatts per year, with networked IoT accounting for a significant share of this growth. For this reason, it is important that the sensors become more energy efficient.

So far, industry and research have not come up with a comprehensive solution: for each application, a single IoT hardware is developed that is more or less energy efficient. The Fraunhofer-Gesellschaft wants to change that: In its "Towards Zero Power Electronics" (ZEPOWEL) lighthouse project, a hardware solution is to be developed that is both holistic and extremely energy-efficient. In a following step, networked sensors could even work with complete self-sufficiency.

Fraunhofer uses two levers: Firstly, the nodes themselves are to consume significantly less energy, and secondly, energy savings are to be achieved at the systemic level. This means that communication with other systems will also save energy. "We want to create the technological platform for a comprehensive IoT application," explains Erik Jung, project team member at the Fraunhofer Institute for Reliability and Microintegration IZM.

The Fraunhofer Institutes want to solve the following challenges:

1. Highly efficient components for robust and secure communication

New technologies are being developed in the lighthouse project, such as an ultra-low-power wake-up receiver, which ensures that a sensor node does not have to transmit data continually, but rather "awakens" at a certain threshold or through an authenticated request from outside.

The module developed in the project is expected to be 1000 times more efficient than

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existing standard radio solutions. The receiver responds only to authorized and cryptographically secured signals that are actually relevant for it. In this way, the sensor node can remain in standby mode with minimal power consumption and be activated immediately by the WakeUp receiver as necessary.

2. More accurate measurement with less energy

In addition, the project is aiming at a unique sensor innovation: an air quality sensor is intended to be coupled with a micro-pump. The pump will then serve as a measuring amplifier by greatly increasing the amount of supplied air. If this attempt is successful, the result will be a sensor that can be built with much less intrinsic sensitivity, while at the same time providing data that is far more accurate. Whereas today's sensors can deliver 5000 measurements at a power of 1250 microwatts per second, the developed sensor is expected to deliver twice as many readings per second with a power of less than 10 microwatts.

The sample sensor is intended to measure the particulate matter in cities. While measurements of particulate matter used to be extremely time-consuming and could therefore only be performed at a few nodes at the same time, the new technology is intended to enable a denser and more accurate measurement. The intelligent networking of the nodes and the connection to common cloud platforms can be used to create a detailed model of fine particulate emissions in cities. The applications are numerous: for example, traffic flow control could be based on it, and navigation systems could adapt their routes to it independently.

3. Sensors supply themselves with electricity even more easily

Not only is the collection and transmitting of data to be optimized, but also the energy balance of the nodes themselves.

Therefore, a broadband harvester is to be developed, a kind of harvester for ambient energy. Its efficiency is quadrupled in comparison to the current state of the art: to harvest 100 microwatts of power from its environment, it only needs a quarter of the area, namely 5-by-5 square millimeters. The energy harvested in this way is stored in a newly developed thin-film battery, which is integrated directly on the hardware chip. This fully integrated approach of battery, harvester and energy converter is unique in the world.

An example makes clear how this can work: if you throw something on the ground, energy is generated with a bandwidth of a few hertz up to a few kilohertz. An absorber that only resonates at one hundred hertz can therefore only absorb little energy from the throwing. However, if a resonator is developed that can absorb energy over a wide frequency range, significantly more energy is harvested from the throwing.

4. Modular construction kit for every application

The ZEPOWEL lighthouse project has also set itself the goal of not developing any purely application-specific nodes, but instead a modular approach based on the plug and play principle. "We offer a module for many applications: it's a plug-in system, like with Lego blocks. Click – and it works," explains Erik Jung. The resulting platform consists of individual innovations created by the institutes which can be combined as desired. While a specific hardware solution has been created for each IoT application, a universal IoT hardware is being developed in this project. Depending on the application, the customer can then "cherry pick" as he prefers.

The partners in the Fraunhofer lighthouse project and their tasks

Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT

The Fraunhofer EMFT contributes its expertise in production-oriented microtechnology, innovative sensor solutions and microdosage to the project. In the project, the institute will develop a highly integrated gravimetric CMOS particle sensor consisting of low-noise analog signal processing, a multi-channel, high-performance analog-to-digital converter and subsequent digital signal processing. The system is complemented by a microactuator that allows on-demand media delivery. The actuators, driver electronics and sensors are used modularly as a system-in-package (SIP) in the IoT node.
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Fraunhofer Institute for Embedded Systems and Communication Technologies ESK

The Fraunhofer ESK is principally involved with applied research in the field of information and communication technology (ICT) with a focus on reliable communication systems. The institute works in the fields of communication technologies and architectures as well as design and security for the sectors of networked mobility, industrial communication as well as smart grid and telecommunication.
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Fraunhofer Institute for Applied Solid State Physics IAF

The Fraunhofer IAF develops cost-effective and highly efficient power amplifiers and transceiver ICs for the mm-wave frequency range at 60 GHz on the basis of gallium nitride (GaN) on silicon. This approach translates high-performance GaN technology to

low-cost silicon substrates for mass application.
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Fraunhofer Institute for Integrated Circuits IIS

In the ZEPOWEL Lighthouse Project, the Fraunhofer Institute for Integrated Circuits IIS is working on the development of integrated ultra-low-power radio receivers for ISM bands with standard CMOS technology. In addition to the integration of the radio receiver, encryption procedures are also to be investigated which enable secure wake-up processes with minimal power consumption.
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Fraunhofer Institute for Integrated Systems and Device Technology IISB

The Fraunhofer IISB performs applied research and development in the business areas of power, energy electronics and semiconductors. In the ZEPOWEL lighthouse project, the Fraunhofer IISB is conducting research on extremely compact power converters of the next generation, while at the same time reducing power loss to a minimum. In close cooperation with its partner institutes, novel technologies for predictive maintenance of cognitive systems are being developed.
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Division Engineering of Adaptive Systems EAS

The Fraunhofer IIS/EAS is developing an ultra-low-power circuit for self-sufficient sensor applications. Included are components for universal conditioning and analog-to-digital conversion of various sensor signals that can be automatically migrated between different semiconductor technologies.
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Fraunhofer Institute for Photonic Microsystems IPMS

The Fraunhofer IPMS is developing an ASIC that converts the energy which is absorbed by the broadband harvester into a charging voltage for the battery. Instead of the battery, the energy can also be stored on a capacitor. In addition, thin-film processes for the production of functional layers that contain lithium are being developed and evaluated in terms of the extent to which they can be used as nanometer-thin electrode and electrolyte materials for miniaturized lithium-ion accumulators in microelectronics.
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Fraunhofer Institute for Silicon Technology ISIT

In the project, the Fraunhofer ISIT is developing a broadband energy harvester for mechanical and magnetic environment energy. The efficiency of the silicon component is quadrupled compared to currently available harvesters.
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Fraunhofer Institute for Reliability and Microintegration IZM

As a systems integrator, the Fraunhofer IZM merges individual components into miniaturized modules which can then be assembled as a module kit depending on the intended purpose. In accordance with the demands for computing power, communication requirements and energy availability, the appropriate CPU modules are selected and then programmed with firmware which is optimized for energy minimization.
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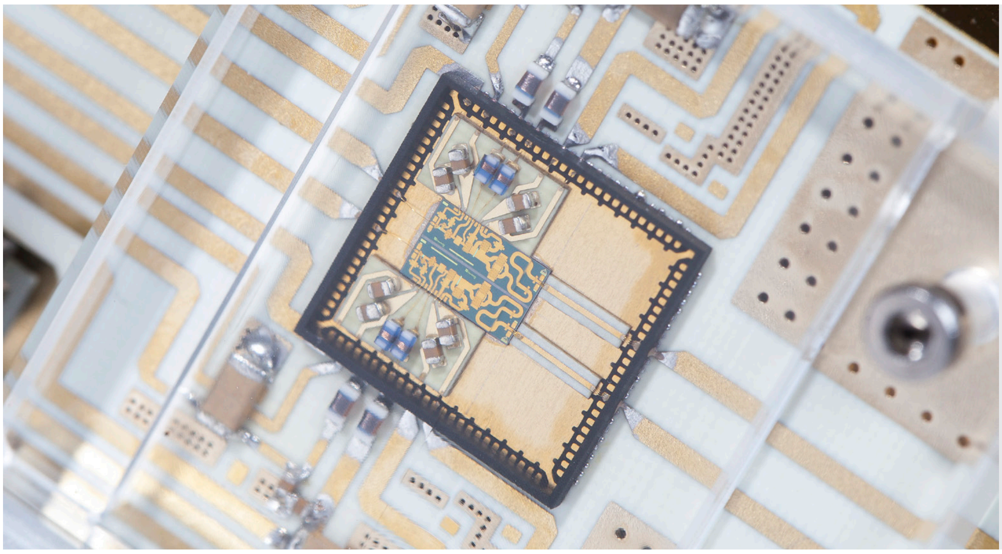

Power amplifiers in radio nodes for targeted data transmission for 5G. © Copyright: Fraunhofer IAF | Picture in color and printing quality: www.fraunhofer.de/en/press