Fraunhofer

RESEARCH NEWS

02 | 2012

1 Robot reconnoiters uncharted terrain

Mobile robots have many uses. They serve as cleaners, carry out inspections and search for survivors of disasters. But often, there is no map to guide them through unknown territory. Researchers have now developed a mobile robot that can roam uncharted terrain and simultaneously map it – all thanks to an algorithm toolbox.

2 Broadband internet for everyone

In the developing world, 96 percent of all households have no internet access. Even in Germany, many regions are still without broadband connectivity. But in future, a revolutionary new technology for wireless networks will allow the gaps in rural internet provision to be closed at significantly less cost.

3 Fuel from market waste

Mushy tomatoes, brown bananas and overripe cherries – to date, waste from wholesale markets has ended up on the compost heap at best. In future it will be put to better use: Researchers have developed a new facility that ferments this waste to make methane, which can be used to power vehicles.

4 Tailor-made search tools for the web

For companies, customer feedback is a matter of strategic importance. Smart apps for the semantic analysis of user opinions from the web help businesses keep an eye on feedback. Users benefit as well: With the „Eat and Drink" app, the user can quickly learn all about the special features of restaurants, cafes and bars.

5 Fresh city tomatoes, any time

Why not produce lettuce, beans and tomatoes where most of the consumers are to be found: in the city? The flat roofs of many buildings are well-suited for growing vegetables. Rooftop greenhouses can also make use of a building's waste heat and cleaned waste water.

6 Jointly utilizing LTE networks

Data-intensive Internet applications on smartphones, tablets and laptops are more popular than ever before. The result: Traffic on the mobile network is increasing at a blinding speed. Intelligent technologies are intended to increase the data rates on the new LTE network. The solution is to use the mobile networks jointly.

Fraunhofer Press
Franz Miller
Britta Widmann
Phone: 089 1205-1302
presse@zv.fraunhofer.de
www.fraunhofer.de/presse

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 60 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 18,000, who work with an annual research budget totaling 1,66 billion euros. Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the USA and Asia serve to promote international cooperation.

Editorial notes:
Research News l Frequency: monthly l ISSN 09 48 - 83 83
Published by Fraunhofer-Gesellschaft l Press Office l Hansastraße 27 l 80686 München l
Telefon +49 89 1205-1333 l presse@zv.fraunhofer.de
Editorial Staff: Franz Miller, Janine van Ackeren, Marion Horn, Britta Widmann l Reprints free of charge.
We encourage you to favor the online version and newsletter via www.fraunhofer.de/fhg/EN/press
This bulletin is also available in German as "Mediendienst".

Fraunhofer

Robot reconnoiters uncharted terrain

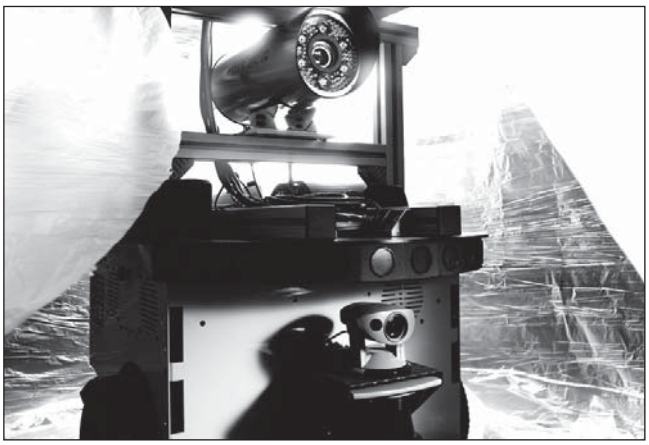
Industrial robots have been a familiar sight in the workplace for many years. In automotive and household appliance manufacture, for example, they have proved highly reliable on production and assembly lines. But now a new generation of high-tech helpers is at hand: Mobile robots are being used in place of humans to explore hazardous and difficult-to-access environments such as buildings in danger of collapsing, caves, or ground that has been polluted by an industrial accident. Equipped with sensors and optical cameras, these robots can help rescue services search for victims in the wake of natural disasters, explosions or fires, and can measure concentrations of hazardous substances. There's just one problem: Often there is no map to show them the location of obstacles and steer them along navigable routes. Yet such maps are critical to ensuring that the high-tech machines are able to make progress, either independently or guided by remote control. Researchers at the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe have now developed a roaming land robot that autonomously reconnoiters and maps uncharted terrain. The robot uses special algorithms and multi-sensor data to carve a path through unknown territory.

"To be able to navigate independently, our mobile robot has to fulfill a number of requirements. It must be able to localize itself within its immediate surroundings, continuously recalculate its position as it makes its way through the danger area, and simultaneously refine the map it is generating," says graduate engineer Christian Frey of the IOSB. To make this possible, he and his team have developed an algorithm toolbox for the robot that runs on a built-in computer. The robot is additionally equipped with a variety of sensors. Odometry sensors measure wheel revolutions, inertial sensors compute accelerations, and distance-measuring sensors register clearance from walls, steps, trees and bushes, to name but a few potential obstacles. Cameras and laser scanners record the environment and assist in the mapping process. The algorithms read the various data supplied by the sensors and use them to determine the robot's precise location. The interplay of all these different elements concurrently produces a map, which is updated continuously. Experts call the process Simultaneous Localization and Mapping, or SLAM.

Mobile robots face an additional challenge: to find the optimal path that will enable them to complete each individual task. Depending on the situation, this may be the shortest and quickest route, or perhaps the most energy-efficient, i.e. the one that uses the least amount of gasoline. When planning a course, the high-tech helpers

must take into account restrictions on mobility such as a limited turning circle, and must navigate around obstacles. And should the environment change, for example as a result of falling objects or earthquake aftershocks, a robot must register this and use its toolbox to recalculate its route.

"We made our toolbox modular, so it's not difficult to adapt the algorithms to suit different types of mobile robot or specific in- or outdoor application scenarios. For example, it doesn't matter what sensor set-up is used, or whether the robot has two- or four-wheel drive," says Frey. The software can be customized to meet the needs of individual users, with development work taking just a few months. Frey adds: "The toolbox is suitable for all sorts of situations, not only accident response scenarios. It can be installed in cleaning robots or lawnmowers, for example, and a further possible application would be in roaming robots used to patrol buildings or inspect gas pipelines for weak points." From March 6-10, the IOSB researchers will be demonstrating their mobile robot technology at the CeBIT trade fair – visit them at the joint Fraunhofer booth in Hall 9 (Booth E08).



Equipped with multiple sensors and optical cameras, the mobile robot roams over dangerous ground. (© Fraunhofer IOSB)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB
Fraunhoferstr. 1 l 76131 Karlsruhe, Germany l www.iosb.fraunhofer.de
Contact: Dipl.-Ing. Christian Frey l Phone +49 721 6091-332 l christian.frey@iosb.fraunhofer.de
Press: Sibylle Wirth l Phone +49 721 6091-300 l sibylle.wirth@iosb.fraunhofer.de

Fraunhofer

Broadband internet for everyone

John just loves playing soccer, and he's really looking forward to the weekend game, which he's agreed to organize. First, he needs to tell his teammates and friends about it, then he must rustle up an opposing team and find a referee – all of which will take him a considerable amount of time. In order to contact everyone, he'll have to send countless SMS messages; he'll have to make all the arrangements on his cell phone because he lives in a rural area in Zambia, and has no internet access. But that's about to change, for John's village is set to acquire an eKiosk with a number of PCs, and its inhabitants will then have access to services such as email, chat, web browsing and internet telephony. This new internet connectivity is being made possible by WiBACK Wireless Backhaul Technology, which has been developed by the Fraunhofer Institute for Open Communication Systems FOKUS in Berlin. Researchers at the institute have succeeded in significantly reducing both the capital expenditure and the operating costs involved, meaning it is now possible to set up tailor-made IT infrastructures and communications networks away from the major towns and cities of developing and emerging countries and to connect even those in rural areas to the World Wide Web. WiBACK is a wireless network that uses existing technologies to build a far-reaching network of radio links using inexpensive WiBACK routers. Naturally, the system is designed to support all existing wireless technologies.

The demands that will be made on the WiBACK network in the developing world are huge. "Our technology has to be reasonably priced, low maintenance, auto-configuring and robust. It also has to bridge massive distances of several hundred kilometers. Should a router fail, data must divert automatically. And should an operating error occur, the system must be able to restore itself to normal operation. WiBACK fulfills all these requirements," says Prof. Karl Jonas, project leader at FOKUS. Routers are installed on water towers, purpose-built masts or other similar high-lying points. Since the equipment has GSM and UMTS interfaces, the network is also suitable for mobile communications. And this extremely energy-efficient technology is powered by solar cells. WiBACK wireless networks are due to be rolled out to several countries in sub-Saharan Africa in summer 2012. Jonas is happy to report that "even schools and hospitals in sparsely populated areas will then be able to access the internet." He and his team are assisted by ICT management consulting company Detecon, which is responsible for drawing up the business plan.

In the meantime, FOKUS researchers have already embarked upon their next project, to ensure that infrastructure-poor regions within Germany will also benefit from these

inexpensive developments for wireless broadband internet. The first pilot network is currently being built on the fringes of the Westerwald and will be used to test just how reliable the network will be when it is in continuous operation. For example, what will happen when a network hub fails, perhaps because of a power cut? As Jonas points out, "We won't be installing solar cells in Germany, since the electricity network covers almost the entire country." Initially, he and his team are providing a remote farm in Hennef-Theishohn with mobile communications and broadband internet. To do this, they have set up a 21-kilometer radio link between the Fraunhofer-Gesellschaft's existing fiber optic connection in Birlinghoven and the farm, using a local substation operated by energy supplier RWE as a relay point. WiBACK technology can also be employed during major events such as soccer games to increase the overall capacity of the mobile communications network for a set period of time.

In this connection, the researchers are keen to draw attention to the system's energy consumption: "WiBACK will automatically register if a soccer stadium is full to bursting and increase the number of available network hubs accordingly," says Jonas. He and his team will be demonstrating precisely how this works at CeBIT in Hannover from March 6-10, where they will be installing a WiBACK network incorporating several activate-on-demand routers on a simulated soccer pitch (Hall 9, Booth E08).

A researcher positions a WiBACK network antenna. (© Fraunhofer FOKUS)

Picture in color and printing quality: www.fraunhofer.de/press

---

Fraunhofer Institute for Open Communication Systems FOKUS
Kaiserin-Augusta-Allee 31 I 10589 Berlin, Germany I www.fokus.fraunhofer.de
Contact: Prof. Karl Jonas I Phone +49 2241 14-1599 I karl.jonas@fokus.fraunhofer.de
Press: Marina Grigorian I Phone +49 30 3463-7388 I marina.grigorian@fokus.fraunhofer.de

Fraunhofer

Fuel from market waste

Drivers who fill up with natural gas instead of gasoline or diesel spend less on fuel and are more environmentally friendly. Natural gas is kinder on the wallet, and the exhaust emissions it produces contain less carbon dioxide and almost no soot particles. As a result, more and more motorists are converting their gasoline engines to run on natural gas. But just like oil, natural gas is also a fossil fuel, and reserves are limited. Researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart have now developed an alternative: They have found a way to obtain this fuel not from the Earth's precious reserves of raw materials, but from fruit and vegetable waste generated by wholesale markets, university cafeterias and canteens. Fermenting this food waste produces methane, also known as biogas, which can be compressed into high-pressure cylinders and used as fuel.

In early 2012, the researchers will begin operating a pilot plant adjacent to Stuttgart's wholesale market. The facility uses various microorganisms to generate sought-after methane from the food waste in a two-stage digestion process that lasts just a few days. "The waste contains a lot of water and has a very low lignocellulose content, so it's highly suitable for rapid fermentation," says Dr.-Ing. Ursula Schließmann, head of department at the IGB. But it still presents a challenge, because its precise composition varies every day. Sometimes it has a high proportion of citrus fruits, while other times there are more cherries, plums and lettuce. On days with a higher citrus fruit content, the researchers have to adjust the pH value through substrate management, because these fruits are very acidic. "We hold the waste in several storage tanks, where a number of parameters are automatically calculated – including the pH value. The specially designed management system determines exactly how many liters of waste from which containers should be mixed together and fed to the microorganisms," explains Schließmann. It is vital that a correct balance be maintained in the plant at all times, because the various microorganisms require constant environmental conditions to do their job.

Another advantage of the new plant lies in the fact that absolutely everything it generates can be utilized; the biogas, the liquid filtrate, and even the sludgy residue that cannot be broken down any further. A second sub-project in Reutlingen comes into its own here, involving the cultivation of algae. When the algae in question are provided with an adequate culture medium, as well as carbon dioxide and sunlight, they produce oil in their cells that can be used to power diesel engines. The filtrate water from the biogas plant in Stuttgart contains sufficient nitrogen and phosphorus

to be used as a culture medium for these algae, and the reactor facility also provides the researchers with the carbon dioxide that the algae need in order to grow; while the desired methane makes up around two thirds of the biogas produced there, some 30 percent of it is carbon dioxide. With these products put to good use, all that is left of the original market waste is the sludgy fermentation residue, which is itself converted into methane by colleagues at the Paul Scherrer Institute in Switzerland and at the Karlsruhe Institute of Technology.

Others involved in this network project, which goes by the name of ETAMAX, include energy company EnBW Energie Baden-Württemberg and Daimler AG. The former uses membranes to process the biogas generated in the market-place plant, while the latter supplies a number of experimental vehicles designed to run on natural gas. The five-year project is funded to the tune of six million euros by the German Federal Ministry of Education and Research (BMBF). If all the different components mesh together as intended, it is possible that similar plants could in future spring up wherever large quantities of organic waste are to be found. Other project partners are the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising, FairEnergie GmbH, Netzsch Mohnopumpen GmbH, Stulz Wasser- und Prozesstechnik GmbH, Subitec GmbH und the town Stuttgart.

This plant in Stuttgart makes biogas out of waste from wholesale markets. (© Fraunhofer IGB)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
Nobelstr. 12 l 70569 Stuttgart, Germany l www.igb.fraunhofer.de
Contact: Dr.-Ing. Ursula Schließmann l Phone +49 711 970-4222 l ursula.schliessmann@igb.fraunhofer.de
Press: Dr. rer. nat. Claudia Vorbeck l Phone +49 711 970-4031 l claudia.vorbeck@igb.fraunhofer.de

Fraunhofer

Tailor-made search tools for the web

Does my city have a nice, quiet beer garden with a grill? Which restaurant has spicy Asian cuisine on its menu, and which cafe dreamily delicious cakes? Who offers the quickest service for a tasty lunch? Nowadays, anyone turning to the Internet in search of the special features of the local restaurant scene can choose between a host of online reviews or starred listings in portals for general categories such as value for the money, food and service. What is often lacking, though, is the reasoning behind the good or bad review. A new, intelligent smartphone app now provides details about restaurants, bars and cafes: "Eat and Drink" analyzes more than 200,000 reviews from throughout the Internet, condensing opinions, bundling information, gleaning specific features from the sources and providing restaurant recommendations. At a glance, the user can see whether or not the atmosphere is welcoming, the clientele is young, or the background music is a source of annoyance. "Our intelligent app makes the user's job easier. There's no need to read through lengthy restaurant reviews, instead the app provides a summary of the special features and main aspects of a particular establishment. 'Eat and Drink' provides information as to why a particular rating is positive or negative," Dr. Melanie Knapp of the Fraunhofer Institute Intelligent Analysis and Information Systems IAIS notes. "The user simply launches an area or keyword search. The result is displayed in the form of tags."

With "Eat and Drink," Knapp and her team have created an app that semantically analyzes and processes unstructured text. In contrast to keyword or rule-based processes like those used by well-known online search engines, this solution uses learning and pattern-recognizing methods to deliver results that are much more refined and far less cut-out in nature. The researchers call their intelligent search methods "Smart Semantics". This approach enables machine-driven classification of complex websites and detailed analysis of text, even at the sentence level. The method studies syntax, individual words, verbs, pronouns and nouns. The underlying technologies on which the app is based were developed by IAIS scientists in the THESEUS research program (www.theseus-programm.de/en/index.php). "Customer opinions can be optimally evaluated using our search technology. It can be flexibly adapted for use with all kinds of topics and text. Apps and programs could also be developed for entirely different sectors, such as consumer goods or the automobile industry. ‚Eat and Drink' is just one example of how technologies generated under the THESEUS program can be practically applied in the B2C and B2B areas," Knapp explains.

Just what such a B2B application might look like is demonstrated by the experts in the form of "Quote" – a semantic search engine for quotations. This application has been trained to hunt down quotations by public figures found in online premium news providers. Angela Merkel, Magdalena Neuner or Till Schweiger are just some of the VIPs whose statements can be called up using the app. Users can also search for quotes on specific topics, such as Greece or the euro – "Quote" returns current quotations found on the content of interest. The app also generates a fact file on each person. The file provides a list of the topics on which the person in question has been quoted in recent months. "Press offices are not the only ones interested in 'Quote'. Politicians and managers in the public eye can also use the search engine as a research tool, or to analyze the competition," Knapp is convinced. Researchers will be demonstrating their Smart Semantic Apps in action from March 6 through 10 at the CeBIT trade fair, at the joint Fraunhofer stand located in Hall 9, Stand E08.

Customers' and users' online opinions can be optimally evaluated using search technologies developed by Fraunhofer IAIS. (© Fraunhofer IAIS)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS
Schloss Birlinghoven | 53754 Sankt Augustin, Germany | www.iais.fraunhofer.de
Contact: Dr. Melanie Knapp | Phone +49 351 83391-3253 | melanie.knapp@iais.fraunhofer.de
Press: Katrin Berkler | Phone +49 2241 14 2252 | katrin.berkler@iais.fraunhofer.de

Fraunhofer

Fresh city tomatoes, any time

What could be fresher? On his way home from the office, the computer scientist harvests tomatoes from his company's rooftop greenhouse. The plants growing there thrive on the building's purified waste water and waste heat. Plantation systems such as this are still unheard-of in Germany. But they may make their debut soon: "In our inFarming project – which is short for 'integrated farming' – we are developing solutions that can be speedily implemented for the urban landscape. Our goal is to grow vegetables atop existing buildings," certified engineer Volkmar Keuter, project manager at the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT in Oberhausen, explains. Actually, there are many varieties of plants suitable for growing on city farms. "Along with vegetables and fruit, we also want to look into growing plants that produce active ingredients for medications."

The benefits: reducing the area required for agriculture, almost no transportation costs and, as a result, lower emissions - not to mention the boost in freshness when the tomatoes grow right on the consumer's roof. Waste heat from buildings and additional solar modules would be enough to supply the greenhouses with the energy they need. Semi-transparent solar cells are ideally suited for the purpose because they do not rob the plants of the light they need to grow. Water consumption is minimal, too: in a self-contained system, water used for the plants is circulated back, cleaned and reused. Multifunctional microsieves and photocatalytic and thus self-cleaning coatings keep the water quality high. Nutrients for the plants can even be filtered out of rainwater and waste water. "Our concept relies on hydroponic systems or hydrocultures. A thin, controlled film of water is all it takes for plants to absorb needed nutrients. The advantage: the yield is ten times higher, and soil is too heavy for many building roofs. That is why we are working on systems to supply plants with nutrients," the researcher reports.

In Germany there are around 1,200 million square meters' worth of flat-roofed, non-residential buildings. Roughly a quarter of this area could provide herbs and vegetables with a place to thrive. The plants would then absorb some 28 million metric tons of 28 CO_2 in Germany's cities each year. This is the equivalent of 80 percent of CO_2emissions produced by industrial operations in Germany. "Our cooperation partner – BrightFarm, a US firm - has already completed several projects in New York. The company started out in 2005 with a small research institution on a raft before going on to build greenhouses atop a school for teaching purposes. This year, 1500 square meters' worth of roof space were developed in both the South Bronx and

Brooklyn. Here in Germany, we are building an applications lab at the Fraunhofer-inHaus-Center in Duisburg. This is the Fraunhofer innovation workshop for intelligent room and building systems," certified geographer Simone Krause, Volkmar Keuter's colleague, points out.

The idea for urban agriculture is not new and is a hot topic of discussion at international level. Urban, vertical, sky or rooftop farming are the names by which the various approaches are known. Worldwide, futuristic, garden-bearing structures are the brainchildren of designers and architects in particular. Keuter and Krause, on the other hand, intend to make use of existing buildings. The researchers have their work cut out for them. "For instance, we have to set up logistics chains for regionally produced lettuce and herbs. Other questions include: Which products are best-suited? How widely accepted are nutrient solutions as an alternative to soil? We are relying on very high-quality vegetables, not on mass production," Simone Krause quickly adds. As of yet, there are only a handful of tomatoes growing on rooftops or in high-rises, but the idea is bearing fruit worldwide - after all, the freshness is hard to beat. For further information, visit www.infarming.de.

Formation and training site at the Manhattan School for Children (NY, USA).
(© Fraunhofer UMSICHT)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT
Osterfelder Str. 3 l 46047 Oberhausen, Germany l www.umsicht.fraunhofer.de
Contact: Dipl.-Ing Volkmar Keuter l Phone +49 208 8598-1113 l volkmar.keuter@umsicht.fraunhofer.de
Press: Iris Kumpmann l Phone +49 208 8598-1200 l iris.kumpmann@umsicht.fraunhofer.de

Fraunhofer

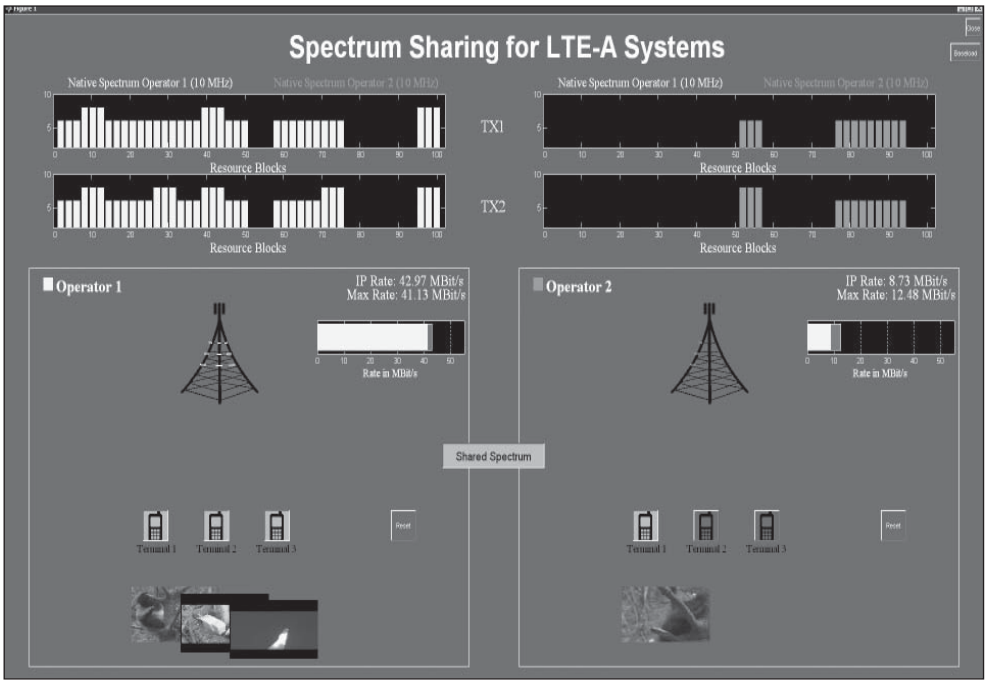
Jointly utilizing LTE networks

Smartphones and tablets are some of the big sellers of the past year. Mobile Internet usage has increased rapidly with the sales success: according to a study of the industry association VATM, in 2011 the average data volume per mobile Internet user increased by 82 percent in Germany. In contrast to its predecessor UMTS, with the new LTE mobile radio standard, the clearly higher data rates and the shorter signal transmission times, providers want to cover the expected traffic. That is why the expansion of the LTE network is being pursued aggressively. Providers are setting up ever more base stations to prevent data bottlenecks, because with each new sending and receiving station increases network capacity. Basically, a network can be densified as much as desired. Neighboring base stations often use the same frequencies, and networks can cope with the resulting interference between the cell towers. However, this also means setting up ever more mobile radio antennas, which drives up costs and takes a great deal of time.

Researchers at the Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute HHI in Berlin have developed new solutions to meet the growing requirements. The idea: two or more providers use the network jointly, meaning they are sharing the frequencies and the infrastructure. "This way, for example, customers of network provider A in Bavaria could use the base stations of network provider B in Brandenburg and vice versa," says Dr. Volker Jungnickel of HHI. LTE Spectrum Sharing, as the experts call their technology, offers providers many advantages beyond cost savings. They can close coverage gaps and make LTE available more quickly in rural areas. "In the city, by combining the functions, they can double the density of the base stations and thus the capacity of both networks. The data rate per surface area increases, and more users are provided with service at the same time without having to erect new antennas. The end user profits from shorter downloading and uploading times," the researcher explains. On top of that, short-term peak loads can be absorbed reciprocally: if one network is under particular stress, one network partner can increase its bandwidth by borrowing frequency shares from another network partner. Because frequencies can be divided up dependent not only of load but also of channel, if the reception is bad in one's own network, one can simply use the spectrum of the partner network.

LTE spectrum sharing is made possible by intelligent algorithms that control the allocation of the radio frequencies in a decentralized way. For this to happen, certain information, such as the traffic load, the quality of the channel, and which services

are being used at the moment is exchanged between providers. "With our technology, networks can coordinate to provide access to additional radio resources in the network of the partner. With the aid of fixed rules, we can distribute signal processing across networks, so no central control is required," Jungnickel points out. The researchers will be on hand to demonstrate how this works, live and in real-time, at the Mobile World Congress in Barcelona from February 27 - March 1, 2012 in Hall 2, Booth E41.



Intelligent algorithms permit decentralized control of the distribution of radio frequencies in LTE networks. (© Fraunhofer HHI)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute HHI
Einsteinufer 37 l 10587 Berlin, Germany l www.hhi.fraunhofer.de
Contact: Dr. Volker Jungnickel l Phone +49 30 31002-768 l volker.jungnickel@hhi.fraunhofer.de
Press: Dr. phil. Gudrun Quandel l Phone +49 30 31002-400 l gudrun.quandel@hhi.fraunhofer.de