

# Vodafone Innovation Park

Yearbook 2016



**Vodafone**  
Power to you





“**Innovation is the basis for advancing the development of new technologies.**”

Sonja Graf  
Innovation Park Director

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# Introduction

## Innovations for the gigabit society

In recent years, our networks have become ever faster and ever more efficient. From 2G/GSM in the early stages of telecommunications, with data rates in the kilobit range, through to 3G/UMTS with data rates of several megabits, we now offer speeds of around 400 megabits per second – in mobile communications as well as in our high-performance fibre optic cable network. And we're still not satisfied. We are bringing our customers into the gigabit society. These developments are possible because we are pushing ahead with innovations such as "Carrier Aggregation" which combines different spectrum bands.

Such technological advances require considerable effort in development and creative innovation processes. With the Innovation Park, we at Vodafone have our very own recognised establishment where such processes are initiated, modified and expertly accompanied all the way through to their technical implementation. Our expertise and facilities have proved so convincing that our business partners and third parties regularly test their innovations and concepts in our Innovation Park Labs and have them undergo control and certification using a live network.

A selection of these projects is presented in this Yearbook. I hope it makes for an exciting read – and would be delighted if it inspires you to push ahead innovations, both great or small, in your own areas.

With warmest regards,

Dr. Hannes Ametsreiter,  
CEO Vodafone Germany

# Open Innovation

## in the VIP Labs

## Ideas engine

### Vodafone Open Innovation Programme

In its Open Innovation Programme, Vodafone develops new products and services together with its partners – from the initial concept right through to market launch. In 2015-16 the programme got off to a perfect start with a think tank in which over 20 companies from a variety of sectors participated. The programme continued in July and October with two “InnoCamps” around the theme “Digital Economy”. The highlight of the programme was the Open Innovation Summit, which took place in November in the course of Vodafone Innovation Days.

On the Hirschburg in Königswinter, creative ideas were developed together and transformed into concrete innovative concepts. In addition to prototype development, a central activity of the summit was creating business models. Project teams applied various techniques which could be flexibly geared to the specific requirements of individual projects. The days were characterised by the enthusiasm of the participants, innovative ideas and absorbing, meaningful discussions.

Prototypes, mock-ups and lectures at the Open Innovation Summit in November presented results and shared impressions from the current programme: the platform Sharerado has since become a successful start-up, helping clients to implement uncomplicated sharing schemes. Mr. Eden is an innovative smart home solution, specifically focused on garden maintenance. Crowd TV provides a platform for mobile video journalists, enabling them to easily market and distribute up-to-the-minute local reporting.



Open Innovation at work: in think tanks (above) and at the Open Innovation Summit (below), participants work on innovative concepts, through to the development of prototypes and business models.

**BACK2Speech is a health app which provides digital support for the follow-up care of patients with speech impediments. “Smart Home for Silent Products” delivers a solution for manufacturers of non-networkable products enabling them to still interact with their customers innovatively and digitally. A key priority for 2016/17 is to pursue the most promising ideas in the form of development clusters. We are focused on organising and preparing for the next InnoCamps and for the very first Open Innovation Contest. The activities will concentrate strongly on the following fields: Automotive, Mixed Reality and the Internet of Things.**



From concept to business model and demonstrator; participants in Vodafone's Open Innovation Programme benefit in all aspects.

## The sharing economy made easy

Sharerado is a white label platform designed for any sharing scheme imaginable – be it for workspaces, cars, small appliances, construction machines or parking spaces. Vodafone's Open Innovation Programme played a crucial role in its development.

The sharing platform is itself a start-up, which provides other start-ups as well as established companies with a fast and uncomplicated route to participate securely and without problems in the expanding sharing economy.

The Vodafone Innovation Park, with its Open Innovation Programme and coordinated development clusters, played a decisive role in the technical implementation of this innovative concept. The cross-industry “Innovation Camps” provided the initial spark for the business model whilst the participating partners delivered the necessary technology development. Finally, coaches with extensive professional experience helped to draw up business plans and prepare prototypes.

The success of the sharing platform is further proof of the strength of Vodafone's Open Innovation Programme. With its help, Sharerado were able to sharpen up their innovative concept and associated business model and transfer them into the initial prototypes. These could then be presented to potential customers and stakeholders. Moreover, the Open Innovation Programme helped to build up a network of partners who further supported the implementation of the developed product and business idea until it was ready for market launch.

# Innovation Garage Workshop for innovation

Innovation needs the space as well as the courage to depart from the beaten track and break new ground. With the Innovation Garage, Vodafone's Innovation Park has created an experimental space for new ideas, concepts and products based on the very latest technologies.

Together with students of different universities and colleges, staff at the Vodafone Innovation Park work in the Innovation Garage on the development and implementation of use cases. Customers can thereby see concrete examples of possible applications of the latest technologies.

Besides bridging the gap between abstract technology and real, tangible applications, assessing commercial value is paramount in every project – the possibility of product development and workable business models are always taken into consideration.

With the Innovation Garage, Vodafone has a flexible platform at its disposal to develop and validate innovative ideas for new products and services – for its own projects as well as for collaborating with customers in the implementation of prototypes.

## Assisting in the development of a VPN Security Solution

A good example of the innovation being driven forward by the Innovation Garage is the VPN Security Solution patented by the European Patent Office (see p.25). The Innovation Garage was responsible for the selection, development and implementation of both hardware and software. Students working in the Innovation Garage bring with them a broad range of expertise, which is especially beneficial when it comes to translating an idea into an actual prototype.

First of all, a suitable platform had to be found. The in-house EasyBox was perfect for this task. To extend its range of capabilities, the team combined it with a single-board development computer. Once the newly developed software was operable, the students developed a counterpart prototype app with which a router's VPN-Gateway can be opened and shut via SMS. The app makes the practical use of the VPN Security Solution more attractive and comfortable.

To have an attractive look as well as functionality, prototype packaging was designed with the use of free 3D-software. This prototype was then printed out with the aid of a 3D printer in around 50 hours. The end result was a functional prototype, including packaging.



“Many of the Innovation Garage's items may look like ‘toys’ but they allow us to discover the opportunities offered by new technologies, as well as potential restrictions. For example, the legal framework proved the undoing of the drone. This insight, however, was of considerable value for future work of this kind. Such lessons are especially important for projects operating within short timescales. Were such problems not known in advance, time scheduling would get out of control.”

Thomas Ackermann



## CeBIT 2016

### A gigabit router combines the benefits of cable and LTE networks



Speed record at CeBIT: the combination of broadband and LTE connections, each with the latest transmission technology, delivered genuine gigabit data rates.

Vodafone Innovation Park exhibited a gigabit router at the CeBIT 2016 in Hannover. It revealed the possibilities offered by combining two different access technologies such as cable and LTE.

Visitors at CeBIT were able to experience maximum download speeds of 1.1 Gbit/s and upload speeds of 100 Mbit/s. This solution was achieved together with our network partner Ericsson.

On a 50-inch screen, visitors were able to view either two simultaneously running 4K videos or the results of a velocity measurement.

For the gigabit router, a cable modem was connected to a broadband cable connection with a maximal speed of 550 Mbit/s. One of the latest generations of LTE modems provided the aggregated bandwidth (Carrier Aggregation) of three LTE frequencies with higher modulation (256 QAM). The LTE connection could thereby be raised to a maximum of 587 Mbit/s.

The combination of both data streams and the dynamic routing of data was realised using the "Multipath TCP Protocol". At the convention, this took place in a mini PC and, for the network, with the help of Ericsson's "Multi Service Proxy".

The gigabit router highlights the potential offered by the combination of broadband cable and LTE and marks the first step towards a convergent commercial product. Vodafone customers will therefore profit from the best of both worlds of speed and stability. Whenever one of the data paths is interrupted, the complete data transfer is immediately taken up by the other.

The exhibited technical solution is, moreover, technology-neutral, so that it will be able to allow any desired combinations of available access technologies in the future, such as DSL, cable, WiFi and LTE.

# Innovation Days 2015

## Focus on 4.5G|LTE



The Innovation Days 2015, which took place from 9–12 November, bore the motto: “Connected. Together. Smart.” The demonstration of various new 4.5G functions offered a preview of technological developments over the next two to four years. Vodafone could therefore offer a foretaste of 5G technology.

During the Vodafone Innovation Days 2015, visitors had the opportunity to become familiar with a total of 34 showcases all around the theme of 4.5G.

**LTE Broadcast** – also called “evolved Multimedia Broadcast Multicast Service (eMBMS)” – distributes video data and radio programmes, for example, in a radio cell or to the entire network of smartphones or tablets for any number of receiving devices. Users require only a compatible LTE device with a LTE Broadcast app. At events, LTE Broadcast conveys exclusive perspectives to audiences. Whether at music festivals, sailing regattas, military events, mountain bike races, ski runs or motorsports – spectators can get an overview of the event while still having the sense of being part of it.

**Carrier Aggregation** – through the bundling of several carrier frequencies, the very highest data rates could be demonstrated. Top speeds of up to 1.2 Gbit/s with five aggregated frequencies have been experienced in the VIP Labs.

This will enable gigabit speeds in the Vodafone mobile network from 2018. Already in July 2016, Vodafone introduced transmission rates of up to 375 Mbit/s through 3-Carrier-Aggregation – i.e. combining three frequency ranges – in its live network. It was the first network provider in Germany to do so. The upgrade process will proceed step by step through the coming years.

**LTE on public domain frequencies** – this refers to the deployment of LTE in the 5GHz WiFi spectrum. Better network coverage and a higher network capacity are available as a result. Anchoring communications in the LTE network guarantees robust mobility, simple authentication, as well as a very high level of security.

Two different technical implementations were exhibited: first, a “LTE WLAN Aggregation” (LWA), which provides users with the sum bandwidth of both technologies; second, “License Assisted Access”, whereby LTE uses unused capacities in the 5GHz frequency band.



Innovators in discussion: (left image) visitors at Innovation Days 2015 enjoy the view from the “Enterprise ViEW” room on the 18th floor of Vodafone Towers. (Right image, from left to right) Dr.-Ing. Axel Schulz, former director of the Vodafone Innovation Park, Harmut Kremling, Vodafone Ambassador, Dr. Hannes Ametsreiter, CEO of Vodafone Germany, Dr. Eric Kuisch, Technology Managing Director of Vodafone Germany, and Ralf Irmer, Senior Manager Corporate Strategy at Vodafone Germany.

**Proximity Services** – also called LTE Direct or Device-to-Device Communication – is a new, innovative short range communication technology, which permits the exchange of information between two devices, also when not part of a network. This means that smartphones will be able to search for persons or places of interest within a radius of 200-500 metres. In the event of a “hit”, the user is informed instantly. An app for “social discovery” was presented at the Innovation Days. It shows the preferences of other participants, for example, at events.

**Critical Communications** – solutions from Motorola, Huawei and Tassta were presented for security-related communications as in public sector applications. They showed how the digital trunked radio TETRA can be augmented through LTE so as to improve the organisation of security forces. Sample applications such as Push-to-Video, Bodycams, real-time positioning and Smart Dispatch were demonstrated with custom devices.

The Buggy, developed at RWTH Aachen University, serves as a mobile test platform for “Galileo Online!” and was exhibited at the Innovation Days 2015



### Overview of other exhibits:

**Movis (Mobile Video Inspection System)**

Video documentation for system acceptance testing, servicing and technical consulting

**NVIDIA GRID** Virtual desktops and workstations use the highest graphics computing power via a cloud infrastructure

**Galileo Online!** High-precision positioning via satellite and mobile communications

**CONVERGE** Vehicle-2-X communication on the basis of LTE-Broadcast (eMBMS)

**Internet of Things and Cloud & Hosting** Connecting M2M communications with the Vodafone data centre

**Innovative backup concepts for site connectivity** Combined landline and mobile networks for reliable broadband access infrastructures

**Secure Phone** Reliable and secure communication using Secure Login, Secure Net, Secure E-mail and Secure Call

**One Net Business** hosted solution for unified communications

**Next Generation Social Networking** “StreamR over LTE Broadcast” enables sharing of video streams over social media

**Hybrid Access** A combination of LTE and DRL for increased bandwidth

**Cloud-based Virtual Enterprise Gateway (vEGW)** Corporate access on the basis of software-designed networking

**Pico-RBS** Indoor-access to LTE with up to 150Mbit/s

**Virtualized Mobile Network Gateway** Operation of a mobile radio cell with software-defined networking

**Video HD Glasses for Internal Services** Video glasses for outdoor use by technicians or for education and training purposes

**Digital Bike Lock** A bicycle lock controlled over the mobile network

**Cellular Internet of Things (CIoT)** Innovation Garage studies for realising connected home solutions

### 9<sup>th</sup> German Innovation Summit



The German Innovation Summit took place in Munich on February 24, 2016. Its motto: “Digitalisation – Innovations – Sustainability – Strategies.”

The Vodafone Innovation Park is among the participants at the renowned summit for innovators. In its presentation, “LTE Advanced – Providing the data highway for a new mobility world”, Vodafone informed the other participants about the next steps to be taken in developing mobile technology.

The Innovation Summit once more proved itself to be an excellent platform for networking and making valuable contacts. Both the exclusive launch event and opportunities for intensive discussions in an informal atmosphere proved highly popular among all participants.

# Projects, products and developments

## Vodafone Innovation Park Labs support the development and testing of the new fixed-line all-in-one solution for business customers

As part of the modernisation of Vodafone fixed-line network, the business customer division is developing "System Access Plus". The Vodafone Innovation Park Labs were closely involved in its development and in operational checks

Traditional ISDN connections are being gradually replaced by modern all IP connections. To enable business customers who still utilise ISDN-based telephone systems and other ISDN devices to take part in this modernisation, Vodafone is developing the "System Access Plus".

At the heart of this future product is the new Enterprise PlusBox 340. It possesses an integrated xDSL modem which supports all ADSL connections offered by Vodafone from 6 to 100 Mbit/s bandwidth (for technicians: Annex J based) as well as VDSL connections. Four ISDN connections ("S0 connections") are available to the customer which they can continue to use for their existing ISDN devices for both voice and data services. An automatic configuration system (ACS) and a modem installation code (MIC) ensure problem-free set-up of the PlusBox 340.

Vodafone Innovation Park Labs supported their colleagues from the business customer division in the development and quality acceptance of the PlusBox 340. They provided the voice and data infrastructure of the Vodafone live network and tested the functionality and product quality of the PlusBox 340 with voice and data load generators.



## Vodafone Germany launches the first commercial product using eSim

When Vodafone Germany launched the Samsung Gear S2 Classic 3G in March 2016, it was the first network provider in Europe to bring a product equipped with an embedded SIM (eSIM) to the market.

The Vodafone Innovation Park supported the launching of this product with key roles being played by the Centralised Test Centre Terminals (CTC) and the SIM Technology Centre (STC).



# eSIM



PIN and PUK remain – but the SIM card is developing from the physical chip card to a profile on an eSIM built into the device.

Unlike traditional SIM cards, an eSIM is fixed into the device and physically inaccessible to the user. The concept has many advantages: the eSIM chip, tiny even in comparison to a nanoSIM, saves considerable space. And the login data and configuration profile saved on the SIM can be easily downloaded onto the chip via an internet connection. The download procedure for specific network login data (“customer credentials”) for customer authentication, as well as the necessary security, has been specified by the global association of network providers, the GSM Association (GSMA).

For the commercial launch of the first eSIM product, the Centralised Test Centre Terminals (CTC) and the SIM Technology Centre (STC) at the Vodafone Innovation Park were responsible for assessing and validating the technical aspects. In addition to developing test cases and validation concepts for the eSIM device, the new profile download procedure was also reviewed. Particular focus was given to protecting customer authentication data as well as on compliance with GSMA standards.

In testing the devices, user experience was a priority but problem cases were also extensively investigated. The user experience when activating and using the eSIM has to be as positive and consumer-friendly as possible.

The problem cases cover situations concerning the activation process in which specific interference, such as entering a dead zone, may impact eSIM activation.

With their tests, CTC and STC ensure that customers enjoy a positive experience with eSIM and that the risk of customer complaints is kept to the minimum.

The eSIM introduced to the German market is based on the GSMA specification “Remote SIM Provisioning Architecture Phase 1”. A further development of this specification is currently being worked on at the GSMA where manufacturers of SIM cards, devices and Chipsets, as well as network providers, are all closely involved. On behalf of Vodafone, the STC is taking part in this initiative. With its help, Vodafone is actively collaborating on the GSMA specification “Remote SIM Provision Phase 2”. It permits new functions and adapts further processes and systems in the mobile network so as to be compatible with eSIM profiles. The next major advance should allow Vodafone customers to load profiles onto all eSIM devices available on the market.

## Re-launching the Vodafone Innovation Park website



In autumn 2016, the Vodafone Innovation Park website launched its new look.

The new design is not only technically and optically at the cutting edge but also significantly increases the site’s user-friendliness.

The focus was on bringing the site’s content up to date and gearing it to customer needs. Simplified navigation now ensures customers can find the required information even more quickly.

The new site gives a clear overview of how the Innovation Park is structured and provides visitors with information about individual lab locations as well as about the technologies and services available at the Park.

Private and business customers alike can now rediscover the Innovation Park for themselves at [www.vodafone-innovation-park.de](http://www.vodafone-innovation-park.de).

# Networks, research and partners

## The Galileo Satellite System and the **Galileo Online: GO!** sponsoring project

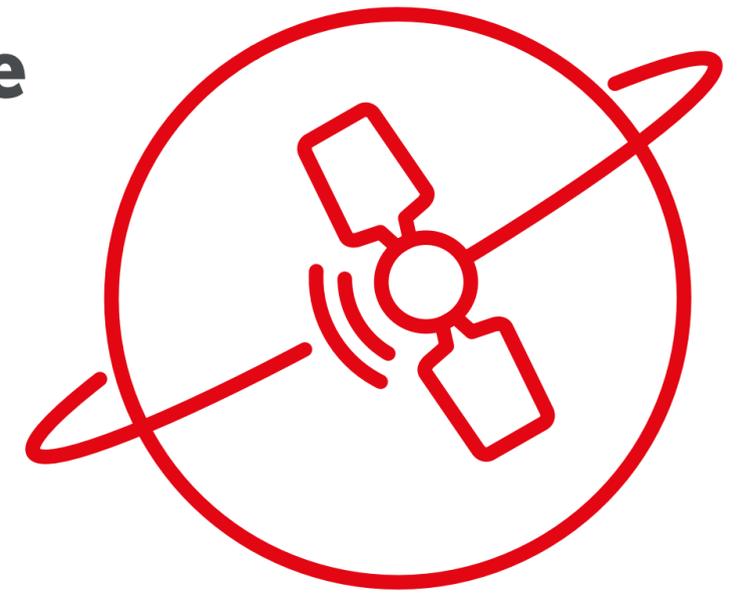
The European global satellite navigation and timing system Galileo will deliver data for precise position determination across the globe. It operates under civil control and its technical construction is similar to that of the American GPS. Vodafone is actively involved in the project, helping in particular to enable localisation via mobile communications.

Galileo is based on 30 satellites that orbit the earth from a height of 23,260 kilometres and at a speed of 3.6 kilometres per second. A network of tracking stations controls the satellites. 24 satellites are needed for the smooth running of the system whilst the remaining 6 serve as reserves. At present, eight of the 30 satellites are already in space. Galileo is the first collaborative project conducted by the EU and ESA and is set to secure independence from the American GPS, the Russian Glonass and the Chinese BeiDou.

Receivers the size of handheld mobile devices such as smartphones or navigation systems are able to determine their own positions via radio signals from the satellites with a precision of approximately four metres. The project "Galileo Online: GO!" is charged with the developing such receivers. It has been running since April 2015 and is sponsored by Germany's Federal Ministry of Economic Affairs. An important peculiarity of the GO! Receiver is its integrated communication interface, which connects the receiver via mobile communications with a central services infrastructure.

Vodafone is actively involved in the project and provides the necessary communications infrastructure in the lab as well as in the field. The Vodafone Innovation Park serves as the perfect testing environment.

A working model of a Galileo Receiver Platform (GO! Receiver), which combines mobile communications and navigation, is currently being developed together with RWTH Aachen and other partners. The architecture of the GO! Receiver is to then be made available to industry to enable the manufacture of finished products based upon the technology.



Vodafone can see great potential for enterprise solutions here. An example is the GO! Receiver's use by the Deutsche Bahn, where it will lead to more precise traffic control systems. The goal is to reduce the number of delays and to provide more specific information to rail customers.

Machine-to-machine (M2M) modules are used for communication between the GO! Receiver and a central services platform. These modules are usually freely programmable, have various sensors and can therefore be specifically adapted for the required application. When further processing units are integrated, functions such as localisation or even components of applications can be transferred to the module. The M2M module thereby becomes a "Smart Featured Cellular Device" (SFCD), on which solutions can be implemented in a manner familiar from modern smartphones.

With the GO! solution, additional location data can be identified and/or adjusted via mobile communication using the SFCD. Access to mobile parameters facilitates fast, alternative positioning and therefore supports Galileo localisation through procedures such as fingerprinting (matching of mobile field strengths) or trilateration (measuring the distance to base stations by means of signal strengths).

This redundant design raises the level of operational security because positioning is also possible when satellite data is unavailable. In addition, satellite-based localisation can be accelerated on the GO! Receiver when signal reception from the satellite is temporarily interrupted.

The image shows the prototype of a "Smart Featured Cellular Device" (SFCD), realised by the Vodafone Innovation Park within the framework of the GO! project.



## Vodafone Innovation Park staff trained for deployment in crisis areas

At the beginning of April 2016, 20 members of staff from different Vodafone international subsidiaries met up in a provisional camp in Wales. The volunteers were being prepared for deployment in disaster zones. One of the participants was the project engineer Mamoon Rassa from the Vodafone Innovation Park Labs and who had been selected from over 200 applicants worldwide.

The Vodafone Instant Network Programme has the aim of supplying mobile communications assistance and phone charging equipment in disaster zones within the shortest possible time. Within the framework of the so-called HEAT Training (Hostile Environment Awareness Training), the volunteers were being prepared for such deployments.



As well as technical knowledge, the volunteers were provided with detailed information relevant to survival in crisis areas – including how to behave in a kidnapping situation, awareness of mine threats, leadership, team- and conflict-management, and much more. As an officially certified volunteer, Mamoon Rassa is now equipped, together with around 70 other Vodafone employees, to install an instant network or instant classroom in crisis areas, refugee camps, as well as in developing countries.



## Bachelor's and master's theses at the Vodafone Innovation Park

Through cooperation with universities and participation in sponsorship projects, students and interns can contribute across a range of technical areas in the Vodafone Innovation Park.

The Vodafone Innovation Park continues to support bachelor's and master's thesis projects in cooperation with supervising universities.

The bachelor's thesis "High-precision Localisation via Mobile Communications Systems – a Potential Analysis", a collaboration with the University of Duisburg, investigated the potential of so-called "fingerprinting" for a localisation via the LTE mobile network. Just as a finger print can identify a human being, so too can a location be identified through the specific characteristics of the signal field of a mobile network. In a first step (offline phase) signal field measurements are taken at known positions over a defined distance. "Fingerprints" of the mobile network are recorded and stored in a databank. In a second phase, the "fingerprints" are measured at random points along the defined distance to determine the most likely position by means of a comparison with the databank and the application of mathematical procedures. This localisation can take place autonomously on a smartphone or on a M2M module and requires no further components in the network. The positive results of the thesis have encouraged the Vodafone Innovation Park to pursue the fingerprinting method as a potential alternative to conventional localisation procedures in mobile communications technology.

Another bachelor's thesis was carried out in collaboration with the Hochschule für Technik und Wirtschaft (University of Applied Sciences for Engineering and Economics) in Berlin. Its topic was "The Deployment of LTE Proximity Services in the Context of Car2Car and Car2X". It investigated the potential for using "LTE Direct" (also called D2D – "Device to Device") for communications between two vehicles (Car2Car). Implementation via LTE was therefore compared to other proximity technologies such as WLAN or Bluetooth and evaluated with respect to Car2Car and Car2X communication. The thesis also demonstrated the first D2D applications in "Discovery Mode".

In follow-up theses, the investigation is being extended to the LTE-V standard. LTE-V (LTE Vehicle) is an extension of the LTE device-to-device communication standard for applications in the automotive market. Vodafone intensively supports the ongoing standardisation work that is involved. The Vodafone Innovation Park plans to develop prototypes with early network and chipset implementations and to trial them on a test track in a real environment.

# Technology, patents and methods

## Using LEGO® SERIOUS PLAY® to improve collaboration

When developing new products, teams are often faced with the challenge of forming a clear picture of the common goal. This is especially so when different disciplines are involved in delivering a solution. The LEGO® SERIOUS PLAY® provides a creative approach to meeting this challenge.

Interdisciplinary teams often use the same terms in their daily work so in talks they may get the false impression that everybody has the same understanding of a project's mission and goals. On this basis, individual team members invest time and work in their own specialist areas to make their contribution to the end result. But the first tangible results can soon reveal that different individuals may have had different interpretations of the supposedly clear project requirements. The laborious process then begins of trying to harmonise everybody's work.

The LEGO® SERIOUS PLAY® method is a moderated process for use within organisations, teams and projects to support ideas or innovations, promote communication, to generate a shared focus and solutions, and to improve collaboration within a project or team.

The method is based on a concept known as "hand knowledge". It promotes creativity through activating the hand/brain connection which generates new ideas and solutions. Using Lego® bricks, models are built so that particular problems and tasks can be made concrete and understandable for all participants. On this basis, solutions can be developed via communication, assembly and disassembly, or through optimising the model.

Since 2015, the Vodafone Innovation Park has had two moderators trained in these innovation methods. The methods were presented to participants and selected employees in several workshops within the framework of Innovation Days 2015. Given sample questions, the participants could develop corresponding models and convince themselves of the genuine practical utility of these innovation methods.



LEGO® SERIOUS PLAY® offers interdisciplinary teams a great opportunity to improve their cooperation with the help of games. The moderators Robin Friedrich and Michael Suellwold are trained in applying these innovation methods.



## Standardised tests for devices using new antennae technology

The use of multiple antennae in devices (MIMO – Multiple Input, Multiple Output) has been standard since the launch of LTE. Nevertheless, the unified testing of devices with MIMO over an air interface is highly complex. It is therefore vital to standardise methods of measurement in such a way that the results of measuring devices of different categories, conducted at various locations, can still be compared with one another. The Vodafone Innovation Park Labs support a newly adopted procedure.

At the end of March 2016, the most important organisation for standardisation in the area of mobile technology, the 3GPP RAN4, established the standard method for the measurement of MIMO devices over the air interface (“over the air” or OTA for short). The “MPAC” procedure is now to be adopted. The abbreviation stands for “Multi-Probe Anechoic Chamber” and refers to a shielded measuring cabin in which several receiving antennae (“probes”) are installed.

Vodafone’s Centralised Test Centre Terminals (CTC) took an active part in the standardisation and was able to push through the MPAC procedure favoured by many experts against alternative systems. The application of this procedure for MIMO OTA antennae testing best replicates real world conditions because it takes special account of the spatial radiation patterns of antennae in environments with multipath effects (e.g. through reflection off buildings).

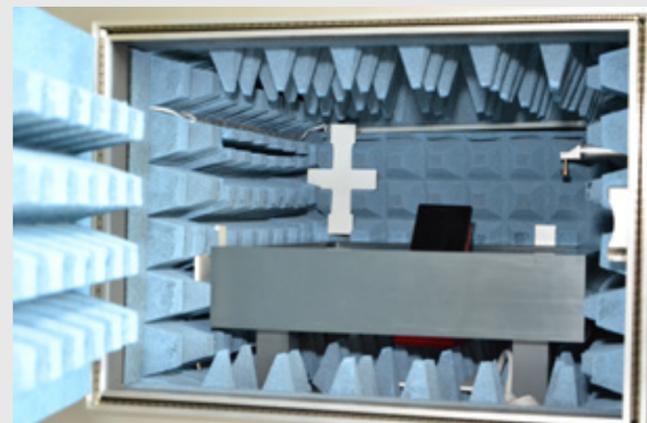
In a next major step, the 3GPP plans to establish a minimum requirement for MIMO OTA. Vodafone is also intensively involved in this standardisation – adoption of the standard is planned for the end of March 2017. Conformity with minimum MIMO OTA performance will then be mandatory for all LTE devices which are certified according to the GCF (Global Certification Forum) – and thus for all devices distributed by Vodafone.

The GSM Association, with its team “Antenna Performance” (TSG-AP), will soon begin a test campaign under the direction of Vodafone which will survey various device models of different LTE categories in LTE relevant frequency bands. The results of this campaign will be published across the industry and thus serve as an important basis for 3GPP in establishing the minimal requirements for MIMO OTA performance.



Above: MIMO OTA tests according to MPAC methods are based on a configuration of dual-polarised test antennae across a single plane. The device under test is placed in the middle.

Below: The antennae tests of MIMO devices are also conducted in special high frequency chambers which are similarly constructed to those shown here.



## A Vodafone employee’s patented invention: VPN Security Solution



The European Patent Office granted Vodafone a patent for an invention by the Vodafone employee Thomas Ackermann. A prototype was then built in cooperation with the Vodafone Innovation Park’s Innovation Garage and presented at Innovation Days 2015.

The catalyst for the invention is the very low uptake of home automation systems. According to surveys, 40 percent of internet users have security concerns about such applications. This massively restricts usage of all possible forms of smart meters – a market that is also of great interest to Vodafone and for which considerable growth potential is forecast.

The patented process is an upgrade to the current security procedures in routers and services such as VPN connections. It increases security still further by not granting VPN access unless activated through a second pathway, such as SMS or voice activation. In the meantime, VPN access remains disabled and therefore protected against attacks over the internet.

The major benefit for customers is that this security measure needs no specialist knowledge and its activation requires only a few seconds. Moreover, the patented security solution also removes the need for so-called DynDNS services, which are often subject to a fee.

## WiFi Calling / Voice over WiFi (VoWiFi)

With “WiFi Calling”, Vodafone customers can make phone calls over WiFi. Colleagues can therefore be reached in offices and halls with poor network coverage – in buildings with thick concrete walls for example. WiFi Calling offers excellent call quality in such situations.

If a smartphone is registered in a WiFi network, it establishes a secured connection to the Vodafone mobile network via a VPN tunnel. The user can then be reached at his or her mobile number and can even make outbound calls over the network. This also allows for uninterrupted conversations during the transition between leaving the WiFi network and registering in the mobile network – and vice versa.

“WiFi Calling” is based on the service “Voice over LTE” (VoLTE). A precondition, therefore, is that the SIM card is unlocked for this service. Smartphones require special software from the smartphone manufacturer to enable this function. VoWiFi calls then function via the normal user interface and no app is required. Following a launch with a small number of smartphone models, the supported portfolio is now being continually expanded.

The new systems and interfaces necessary for “WiFi Calling” were constructed in the Vodafone Innovation Park Labs on the basis of the already available VoLTE implementation. Further systems were modified and the entire service has been implemented and integrated. Vodafone was able to launch the “WiFi Calling” service at the end of May 2016. It was the first network provider in Germany to do so thanks to the timely and successful validation and approval of individual systems as well as of the entire service in accordance with end-to-end tests and the certification of devices.



## Security audits of SIM card production facilities



To guarantee the security of SIM cards, the complete supply chain has to be considered from end to end. For this reason, experts from Vodafone's SIM Technology Centre (STC) regularly conduct security and quality audits in SIM manufacturing sites.

The SIM card is the customer's key to the network and to Vodafone services. It guarantees the integrity of billing, provides for encrypted connections and now facilitates payment services, train ticket purchases and car key functions. It therefore stands to reason that SIM card security is of paramount importance to Vodafone.

Yet the security of SIMs is not only down to chip cards: it has to be guaranteed along the entire supply chain. Alongside many other measures, experts from Vodafone's SIM Technology Centre (STC) also conduct regular security and quality audits at SIM manufacturing sites.

The scope of these audits is broad and encompasses, in addition to the structural security of the manufacturing site, the complete IT architecture, production processes, as well as the generation and handling of any data relevant to security. The introduction of new SIM products and production technologies is also tested, evaluated and approved by the Vodafone experts. Only once a production site is classified as suitable and in conformity with Vodafone's standards is it permitted to manufacture SIM cards for the Vodafone Group.

Seven SIM production sites are currently in operation worldwide. Together they produce 300 million SIM cards per year.

## Quality assurance tools meet the latest demands of business

Testing procedures have to be introduced early in the development process and continue even once the product has been launched. To ensure a comprehensive approach to security, the Vodafone Innovation Park Labs have built a platform which enables automated testing.

Leaving the testing of mobile services to their final acceptance has long been regarded as insufficient. Tests are now part of product development and ongoing quality control procedures, continuing after the launch of a product or service where necessary. Testing procedures must therefore be implemented with a high degree of flexibility and integration in the development process. To this end, short test cycles and a high degree of automation are decisive because time plays an increasingly important role in ensuring that a product can be brought quickly to market. Moreover, our customers do not only use Vodafone services domestically, but expect the same standards of use and performance in other Vodafone countries. Taking all this into account means that the testing environment also has to incorporate roaming and SIM card switches.

In order to satisfy these requirements, Vodafone's quality assurance division (QA) built a test platform offering an integrated system to automate development and acceptance testing.

End-to-end tests are performed on actual smartphones and tablets which are controlled via USB by "device agents". Persons conducting the tests then have access to all the actions of a device through a PC – as though the device were in their own hands.

This enables text to be input via the display keypad, mouse-controlled clicks and movements on the touchscreen, as well as access to log files and traces. The combination of device agents and physical devices forms the "Vodafone Device Cloud". With Android, iOS, Windows Phone and BlackBerry OS, this platform supports all relevant operating systems. In addition, it offers full integration within the Continuous Integration commonly used by development departments.

The Device Cloud currently provides around 200 devices with SIM cards from more than 21 different Vodafone countries. Under the name "Global App Viewer", the service has been available to all Vodafone international subsidiaries since March 2016.

The platform is currently being enlarged in order to support Vodafone employees in their active monitoring of end to end scenarios for mobile services. Call Centre employees too have access to the available devices, including SIM cards, in order to have a full grasp of specific problems to aid customer communications.

All network scenarios supported by the platform can be automated. The Java-based code of the test script allows for quick and flexible adjustment and enables end to end scenarios to be prepared within a short time period.

But not only Vodafone employees and external development divisions use this platform. In future, joint test sessions will be conducted with device manufacturers in the context of device acceptance in Vodafone's Centralised Test Centre Terminals (CTC). The Device Cloud is used in a reference system so that tests are performed directly and log files can be analysed collectively. This saves considerable time compared with piecemeal analyses which can take weeks at a time.

Due to the expected increase in roaming, a so-called "SIM Switcher" is being developed with which SIM cards can be switched automatically. Moreover, the solution's flexibly scalable architecture enables usage in the satellite module. Remote access to devices available in the local radio network via "Satellite Device Agents" is then possible. This permits end to end testing under real mobile network conditions. Portugal and the Czech Republic are already covered by such "Satellite Device Agents", whilst Spain is currently installing the technology.

### Vodafone's collaboration in the standardisation of Narrowband-IoT

The Internet of Things (IoT for short) places its own demands on mobile networks. The standard Narrowband-IoT fulfils these specifications – and Vodafone was actively involved in its standardisation.

In July 2016, a working group of the 3GPP (3rd Generation Partnership Project) approved the specifications for the new technology: Narrowband Internet of Things (NB-IoT for short).

Compared to the mobile communications standards existing today, NB-IoT is distinguished by its essentially greater scope and ability to support a higher number of devices per radio cell. At the same time, NB-IoT devices should achieve a battery life of up to 15 years. In addition, NB-IoT allows cost-efficient implementation on both network and device sides.

Employees of the Vodafone Innovation Park contributed their suggestions relating to radio and core networks, as well as to monitoring and configuration, to the relevant working groups. They thereby made successful contributions to the standardisation of this important technology.



## 5G test and development system

Thanks to collaboration with Ericsson, since April 2016 a test system for the next generation of mobile communications has been available at the Vodafone Innovation Park Labs in Düsseldorf.

In November 2015 Vodafone and Ericsson signed a MoU (Memorandum of Understanding) on the theme of 5G. On the basis of this partnership, an Ericsson 5G test and development system was installed in the VIP Labs in Düsseldorf. This test system was put into operation as planned in April 2016 and is linked to the Ericsson Eurolab in Aachen.

In the lab, the test system operates at a frequency band of 700 MHz and already facilitates the demonstration of 5G type applications such as quick and effective facial recognition via webcams. The system allows testing of applications with the help of 5G-type modules such as “network slicing” and a “local cloud” which enables shorter reaction times and higher data rates in comparison with the remoter central cloud which has long been the standard.

Further 5G-type consumer and enterprise applications are being tested in the development environment, such as holoportation, robotics, vehicle communication and Narrowband-IoT.

## From an idea to a solution for the entire company: the SIM Multiplexer in the Innovation Park Lab

Testing services and devices increasingly requires different SIM cards to be used – for example, to simulate roaming situations. The Vodafone SIM Technology Centre (STC) therefore developed a SIM card multiplexing system.

The SIM Multiplexer is intended to help automate tests using multiple SIM cards. A specific challenge was to construct the Multiplexer in such a way that it meets electromagnetic compatibility (EMC) requirements. This meant ensuring, for example, that SIM cards and signals along the extended cable route between SIM and phone were not disrupted by radio waves from terminals or by other interference.

In a first step, the topic was examined in a bachelor's thesis prepared in collaboration with the University of Applied Sciences, Düsseldorf. Using a prototype, this work tested the technical feasibility and implementation potential of EMC requirements.

The Test Automation Team at the Vodafone Innovation Park brought this prototype to the production phase with the support of the Network Optimisation division and the Innovation Park Lab. They also upgraded it with features for a mobile and global application. Since the SIM Multiplexing System is mobile and capable of being controlled from a distance, it enables applications such as roaming and billing tests. The Vodafone Innovation Park is making this solution available to the entire company.

The team are now at work installing this Multiplex System for roaming tests in different countries. An upgrade for eSIM technology and the use of a SIM card reader/writer are also on their roadmap.



Vodafone employees Harald Trapp (above left) and Tim Lien (right) worked closely together to design the first prototypes of a SIM Multiplexer (below) for in-house automated testing



Software-Defined Networking, or SDN for short, is a new approach to managing IP networks. The aim is faster, more flexible and more efficient network configuration. In cooperation with Cisco and Arista, Vodafone Innovation Park Labs in Düsseldorf have built a test environment for SDN.

In comparison with previous network architectures, Software Defined Networking is based upon separating the control plane from the forwarding plane. The logic of the network elements is controlled by software via a high-performance server. This allows for significantly enhanced performance data-packet forwarding; the connections are faster and more efficient. In addition, network behaviour can be controlled over defined interfaces.

Since network connections today are frequently established between virtual machines that all run on the same "administration platform", it makes sense to also virtualise the applied network devices. SDN simplifies the combination of physical and virtual devices. This creates a virtual "overlay network" which can in turn contain both physical and virtualised network devices.

In order to gain experience with this technology, to test and evaluate solutions, and prepare for its later launch onto the Vodafone network, the Vodafone Innovation Park Labs in Düsseldorf have built their own SDN test environment in collaboration with its partners Cisco and Arista.

Both physical networks are organised in a modern research centre architecture which guarantees decreased lag times, higher bandwidths and redundant connections. Virtual firewalls and monitoring tools for targeted analytics and troubleshooting are also components of this architecture. With these test environments, Vodafone and customers of the Innovation Park Labs can stay one step ahead of the game in preparing for the technologies of the future.

## Test environments for Software-Defined Networking

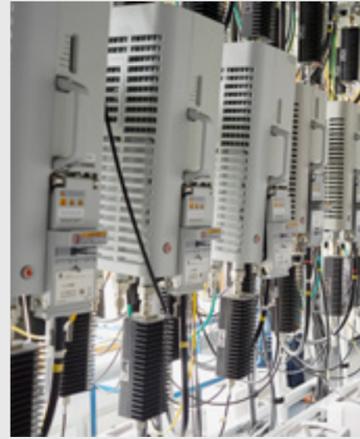
### Internet of Things (IoT) in the Vodafone Innovation Park Lab's Radio Reference Room

Vodafone Innovation Park Labs are equipped for the future: their Radio Reference Room in Düsseldorf provides all access technologies and analysers necessary for certifying IoT solutions.

The number of devices connected to the internet has rapidly increased over the past few years. From circa 12.5 billion devices worldwide in 2010, estimates for 2020 place the figure closer to 50 billion (sources: Cisco Systems, Statistica 2016). Meanwhile, the connected world continues to incorporate more and more fields of application.

The basis of communication in the "Internet of Things" (IoT) is always a chipset or module. These are tested and certified in the Vodafone Innovation Park Labs in conjunction with current mobile communications technology. In addition, the Vodafone Innovation Park also provides certification of complete IoT solutions.

The Radio Reference Room in Düsseldorf therefore contains a specialised IoT test environment. Tests are based upon globally applicable Vodafone requirements and implemented by experts. Customers of the Vodafone Innovation Park can therefore be confident that their products work flawlessly in later stages of their life cycle.



### Automating the testing of IP phones

To test IP fixed-line phones for use with the Vodafone product "One Net Business", Vodafone Innovation Park Labs developed an automated test solution.

Thorough testing ensures that IP phones with the tested firmware function faultlessly with "One Net Business". Essential telephone functions are tested as well as practical features such as call forwarding. To carry out these tests both quickly and efficiently, Vodafone Innovation Park Labs have upgraded their test automation capacity ("Access Device AutoMation" or ADAM for short) to support IP phones. This development has been in operation since May 2016 and can be used for other enterprise solutions that function on the basis of IP phones but don't use the reference platform of One Net Business.

# Thank you

“ Dear readers,

I'm Sonja Graf and have been director at the Vodafone Innovation Park since the beginning of 2016. I am therefore especially delighted to be able to give you an exciting insight into our multifaceted work in this Yearbook.

The Yearbook can show only a small number of our projects. I therefore hope that you have enjoyed the articles we selected.

At this point I would like to thank my team for their fantastic performance and wide-ranging support. Without it, this Yearbook would not have been possible.

I am already excited about the coming year. Development doesn't stand still and many interesting new products are already beginning to take shape. We'll look forward to presenting them to you in the next Yearbook.

With best wishes,

Yours  
Sonja Graf

”



# Meet our experts

## How to contact the Vodafone Innovation Park

Are you planning an innovative project? Do you manufacture devices or modules? Be sure to contact us and we'll find the best solution for a collaboration to suit your company and its requirements. Contact our experts and discover more about the Vodafone Innovation Park.

Become a Ready Business. With Vodafone.

# Contact

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