TELCO SOLUTIONS COMPACT

MicroNova
Software and Systems

2023

SMO-Architecture & Network Slicing

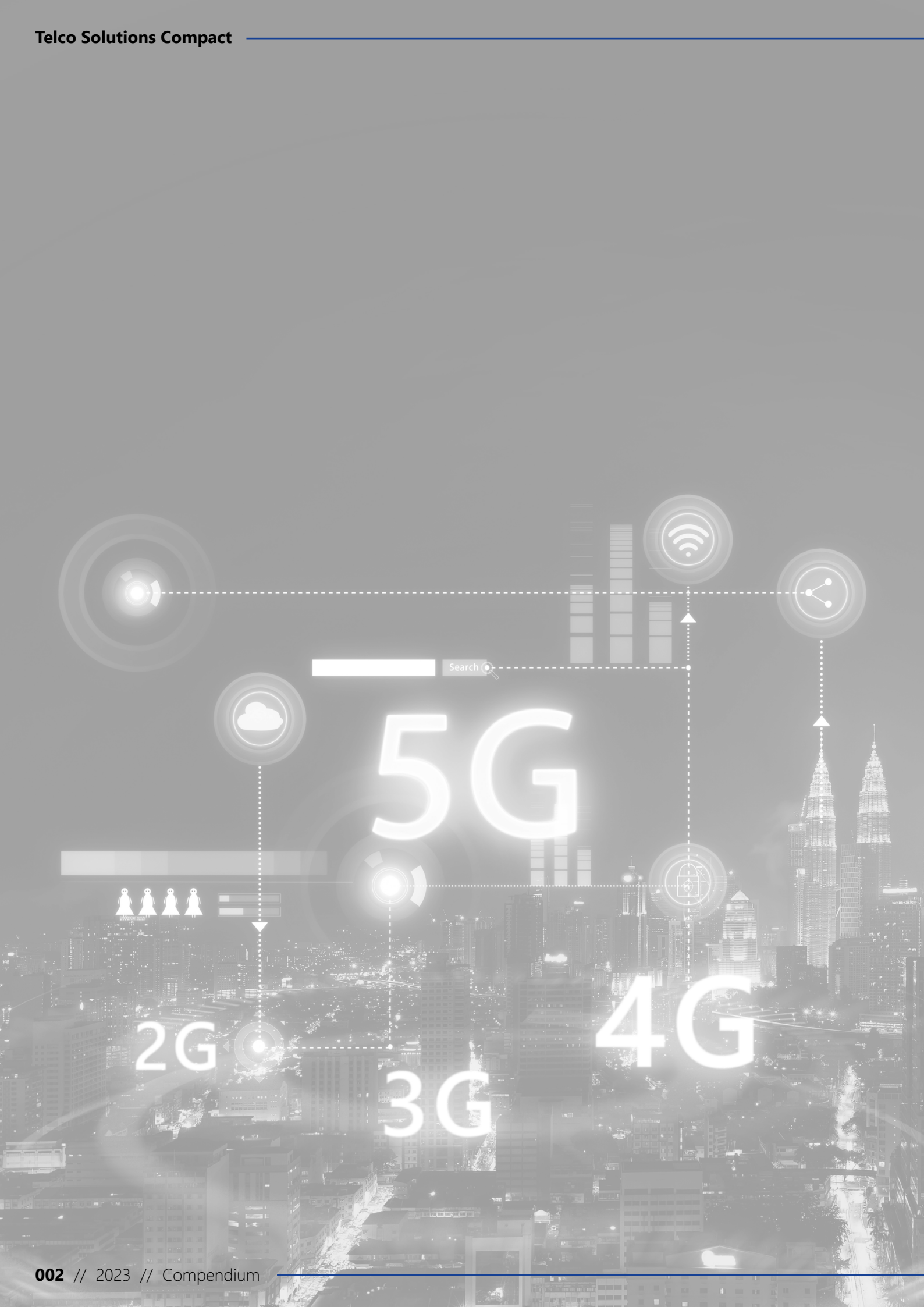
More flexible and dynamic networks through MicroNova's COM5 solutions

Proof of Concept: MicroNova and Iquall

Orchestrated and fully automated environments with existing equipment

Open-RAN, SDN and NFV

MicroNova offers an O-RAN-compliant solution for operating the Open Radio Access Network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5G
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Configuration of Mobile Networks

Dear Reader,

the introduction of 5G is possibly the biggest change the telecommunications industry has ever faced. And I don't mean the technology per se, rather the applications. Of course, there is still a long way to go in terms of developments. But the foundations are now in place to make these fields of application a reality through innovation and competition. 5G therefore has a key role to play in the transformation to a gigabit society.

With network slicing and private networks, specific industrial use cases are emerging with applications that rely on some key 5G functionalities. I can name Enhanced Mobile Broadband (eMBB) for handling large amounts of data, Massive Machine Type Communication (mMTC) for the Internet of Things (IoT), or Ultra Reliable Low Latency Communications (uRLLC) for autonomous driving as examples. Looking at this overall picture, we get a sense of the economic and even societal implications of 5G.

MicroNova can and will engage effectively wherever we can support innovation and mitigate complexity from a technological point of view. This is because both the industry itself and the technology used are becoming more complex, and as a result the required know-how is becoming more extensive and diversified. That is why knowledge and skills have to be developed and intelligently linked or interconnected. This in turn means that solutions are also becoming more complex and expansive.

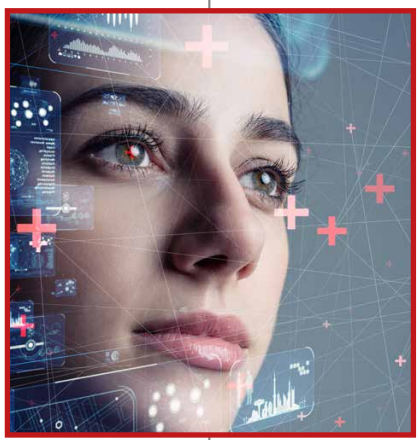
In concrete terms, for MicroNova this means that we will continue with our work in network management with passion and dedication. We will complement this by developing more solutions expertise in application areas that match our know-how – for both the long-standing and very trusting partnerships with our existing customers, and for new clients.

Let's move together towards a gigabit society. I'm very much looking forward to this journey.

Yours,

Hinrich Bey

Head of Telco Solutions, MicroNova



Market Commentary...

Ingo Bauer, Head of Product Management, MicroNova

The need for data volume and the demand for modern network management are growing steadily. Telecom companies have to develop new business models if they want to thrive on their own infrastructure.

Hunger for bandwidth is unlimited. Germany plans to invest EUR 100 billion in expanding the broadband internet by 2025. Cables are intended to allow speeds in the gigabit range – that's about 20 times faster than the current standard 50 megabit connections and ten times faster than LTE. This expansion will not be accomplished by better fiber-optic cables only; it will require a combination of the latest state-of-the-art technologies, such as fiber optics and the future 5G mobile standard, the frequencies for which the German government granted in 2019.

New applications, such as connecting machines via the Internet of Things (IoT), are also generating a massive growth in data. However, these requirements cannot be met by simply increasing bandwidths. The introduction of smart networks is an important step; they process data independently and prioritize it for the fastest possible transfer to the user. Another procedure is the combination of such networks with reliable real-time transfer. Together, these measures form the basis for tackling the rapidly growing flood of information on the network side.

MNOs must therefore constantly expand their networks by building additional base stations and creating higher bandwidths, and in ever shorter cycles. Another major strategic challenge operators have to respond to is the decline in core services such as telephony and SMS. While they "only" provide the cables, internet companies, such as Google and Facebook, earn the big money through data they acquire via social media networks and services. New business models are therefore in demand. Regardless of what these may ultimately look like, MNOs are dependent more than ever on the efficiency and reliability of their networks to implement them.

With pressure to compete in this increasingly complex and dynamic market, the need for solutions such as COM5.Mobile is growing. By automating their network management, mobile network operators reduce the number of people needed to configure, optimize, and rapidly adapt networks to new circumstances. Only with the aid of the appropriate tools, can MNOs guarantee their customers short time-to-market, the right quality and bandwidth, and high availability.

During its 25-year history, the digital mobile industry has learned to always react quickly and flexibly to changes in the market by facilitating evolution in technology and business. This applies to both innovations in networks and equipment as well as changes in consumer behavior. MicroNova helps telecommunications companies withstand the pressure to consolidate, and, with COM5.Mobile, provides the perfect tool for planning and configuring mobile networks. ■

Innovation Cluster 5G BERLIN e.V.

In 2018 the Innovation Cluster 5G BERLIN e.V. is aiming to promote innovations around 5G key technologies for urban applications.

TEXT: Editorial staff PICTURE: © sdecoret / Shutterstock.com

The 5G BERLIN initiative is driving digitalization in the German capital. For this purpose, a test environment has been set up for joint research projects, the testing of 5G technologies and the development of new applications. Furthermore, an information network has been created to provide the basis for new partnerships and to support knowledge transfer. The innovation cluster 5G BERLIN therefore constitutes a regional as well as national networking platform for start-ups, small and medium-sized businesses, research institutes, universities, large corporations and public agencies.

5G test environment for urban applications

The 5G test environment has been set up on the North Campus of the university "Technische Universität Berlin" and is used to test 5G key technologies for urban applications under real conditions. The infrastructure consists of 5G macro cells with smaller radio cells to provide local, broadband, and highly responsive communications. In order to achieve very high data transmission rates, streetlights are equipped and connected with 5G millimeter wave technology. The components for the 5G test environment are supplied and further developed in the overall system by the project partners, modeling all the relevant technology components of a 5G network.

Strong partnerships

The founding members include atesio, EANTC, the Fraunhofer-Gesellschaft, GasLINE, Highstreet Technologies, HyperMesh, Infotecs, and MicroNova. Since 5G Berlin has been established, other companies from the fields of passenger transportation, semiconductors, network equipment suppliers/operators as well as start-ups and trade associations have joined the 5G BERLIN innovation cluster.

"MicroNova's commitment as one of the founding partners of 5G BERLIN e.V. outlines the potential we see in the new mobile communications standard. Many of the future business models have not even been put on paper yet, let alone entered into development. However, there is a large number of applications in the pipeline," says Georg Kieferl, former Head of Telco Solutions at MicroNova. "Our participation enables us to play an active role in shaping the technology, and thereby strengthen our innovation leadership in configuring and planning mobile networks. This will benefit our customers and their users." ■

SMO Architecture & Network Slicing

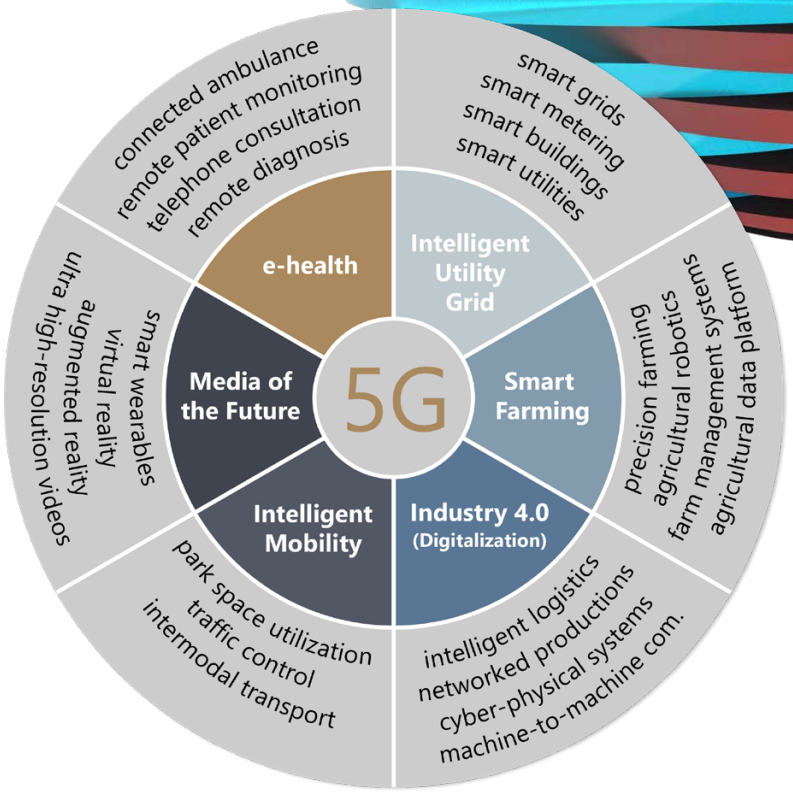
New application scenarios around 5G and Internet of Things (IoT) require flexible and dynamic mobile networks. MicroNova has the solutions for this, thanks in part to Services and Management Orchestration (SMO) architecture and network slicing.

TEXT: Ingo Bauer **PICTURES: © Photobank.kiev.ua, samoila ionut / Shutterstock.com; © kstudija / Fotolia.com**

The introduction of the 5G standard in telecommunications has ushered in a new era for network operators. New classes of service, including quality of service, make it possible to map an almost unmanageable variety of new, customer-specific use cases. For the network operators, this means that a change is taking place from a – in terms of services – previously by way of comparison rigid radio network to a fully dynamic, highly flexible, service-oriented one. The keyword is SMO – Service and Management Orchestration.

SMO – The service takes center stage

The structure of an SMO architecture can be subdivided both horizontally into abstraction layers and vertically into network domains.



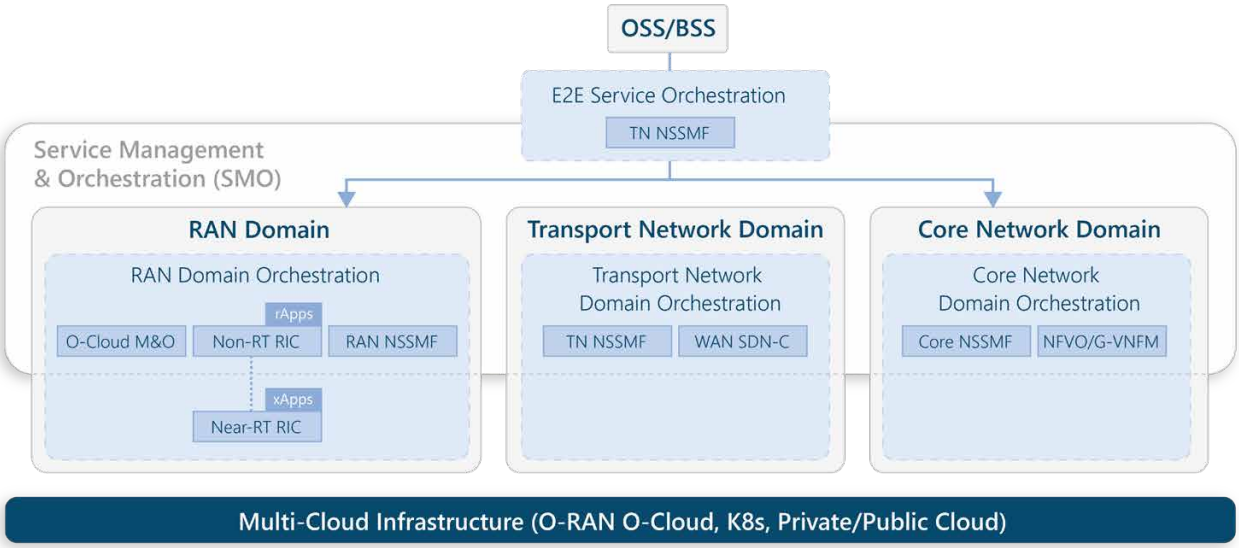
1 Application domains of 5G networks © Bundesregierung

The complexity of the use cases or parameters to be supported rises steadily as you move through the horizontal layers. At the service layer (Service or Multi-Domain Orchestrator), the service is still defined or described in a very abstract way on the basis of defined KPIs or service quality relevant for the end user (see diagram). The Multi-Domain Orchestrator or E2E Service Orchestrator interprets these requirements and automatically distributes associated jobs to the respective network domain with accordingly detailed requirements prepared for the particular network segment. The Domain Orchestrator receives these and uses them to initiate the prerequisite steps for service provisioning.

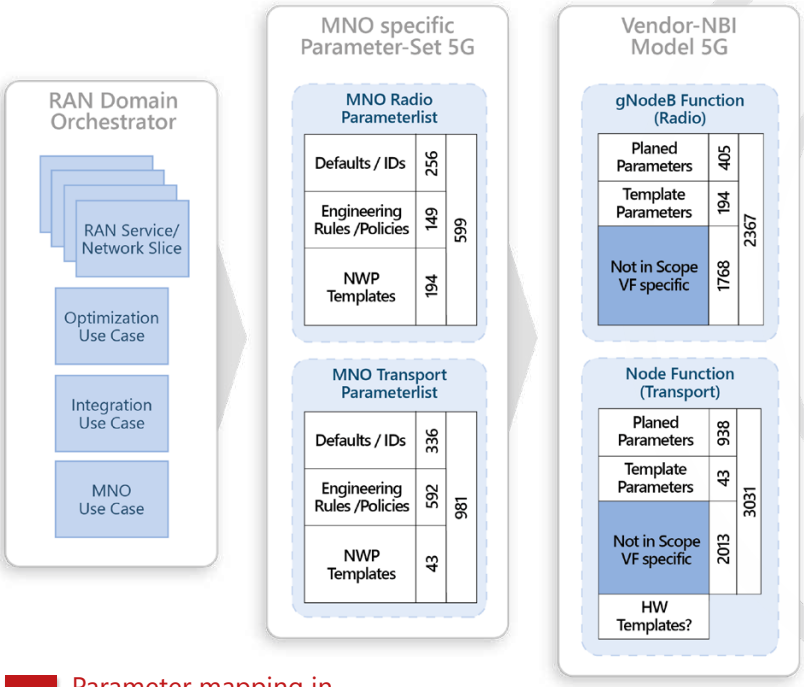
In addition to checking and reserving the required network resources, this also includes setting up the needed control loops for subsequent quality assurance and finally activating the service in the network. Communication with the network takes place via the domain-specific SDN Controller, which – since it is in close proximity to the network – has the highest level of detail and must know and operate the respective manufacturer- and technology-specific models including their properties. At this level, the very specific network design of the according operator also comes into play (see figure).

Network Slicing

Previous mobile radio technologies are based on a relatively rigid radio network that is impossible to expand for different applications without considerable effort. While the further development of LTE technology already enables conditional scaling, for example via narrowband IoT (NB IoT), a great deal of 'manual' effort is still generally required for network management – both for engineering and in operation. As an essential link between service and network, only network slicing offers the fundamental technological basis for making a service-oriented mobile network economically accessible to the customer and the network operator – because it enables network operators to divide their existing Radio Access Network (RAN) into 'network slices'.



2 The illustration shows a typical SMO architecture. It usually consists of one or more orchestration platforms with different abstraction levels or for different network domains.



3 Parameter mapping in COM5.SDN RAN Controller

These can be seen as virtual, independent networks that can be specifically adapted to the needs of the respective customer and made available to them. The basis for a service-oriented network can be created by also defining services and their quality. This includes, for example, solutions in the field of smart homes or autonomous driving. As the rollout of 5G technology progresses, slices can even be offered on a time and location basis, which saves costs.

This opens up a service- or application-oriented allocation of network resources for mobile network operators (MNOs), with a specific quality of service (QoS) for customers and end devices. With network slicing, Vodafone expects that "(...) in the future it should be possible for customers to pre-order 5G slices required for applications in a self-administration portal or 'shop system' for a specific location and a specific period of time. This means that on-demand network connectivity for the next industrial revolution can be ordered with just a few clicks of the mouse. And at a lower price – a far cry from the investment that companies would have to make to provide a defined, high-quality network connection at the required location by other means."

Network slicing enables MNOs to map their network as independent, logical, isolated end-to-end segments on a physical infrastructure. By prioritizing network traffic or flexibly allocating the associated resources, it is possible to grant customers different quality assurances (Service Level Agreements, or SLAs for short) and/or offer extensive customization. The basis for being able to offer such a range of services is the SDN/NFV architecture, which is what makes the concept of a highly flexible, dynamic, and scalable network slice possible in the first place (cf. InNOVAtion 2-2020). The figure on (1) shows a 5G structure with the different layers or network domains.

Network slicing and KPIs

The table on next page describes the 5G standard KPIs according to ITU-2020 of the International Telecommunication Union (ITU) including mapping to the 3GPP service classes. Derived from this is the definition of a 'virtual' network slice, which ultimately gives the provider or receiver of a service the same service or network slice from the classes of Enhanced Mobile Broadband (eMBB), Massive Machine Type Communications (mMTC), and Ultra Reliable Low Latency Communications (URLLC).

* https://www.vodafone.de/business/featured/technologie/wie-network-slicing-in-5g-netzen-nach-bedarf-bandbreite-latenz-und-dienstqualitaet-sicherstellt/

COM5.SDN RAN Controller

The COM5.SDN RAN Controller developed by MicroNova follows the O-RAN paradigm by providing a global network view by means of a logical centralized controller. The focus is on a vendor-independent, standardized southbound interface based on O1: A REST interface to a web-based user interface is complemented by other such connections to other (RAN) apps, for example to the COM5.SDN Radio Intelligence Controller. To give a high degree of automation, the controller provides an abstraction of the network keys, performance indicators (KPI) and configuration parameters; clarification is required in advance of integration on account of the respective customer-specific mapping.

Basically, the COM5.SDN Radio Controller provides the functions of a classic element management system (EMS) with regard to fault, configuration, accounting, performance, and security management (FCAPS). The following overview shows its main functionalities:

- Reads out the entire network configuration and topology
- Automatically adopts network planning data for the configuration of the static part of the network
- Supports integration use cases for an initial configuration of the O-RAN components (rollout) while supporting different split scenarios
- Provides RAN resource management
- Reconfigures and optimizes the network
- Performs RAN parameter changes
- Allows RAN feature activation/deactivation
- Reads out performance parameters cyclically from the network
- Reads the RAN component error memory
- Provides all parameters and functions via a REST interface for other RAN apps

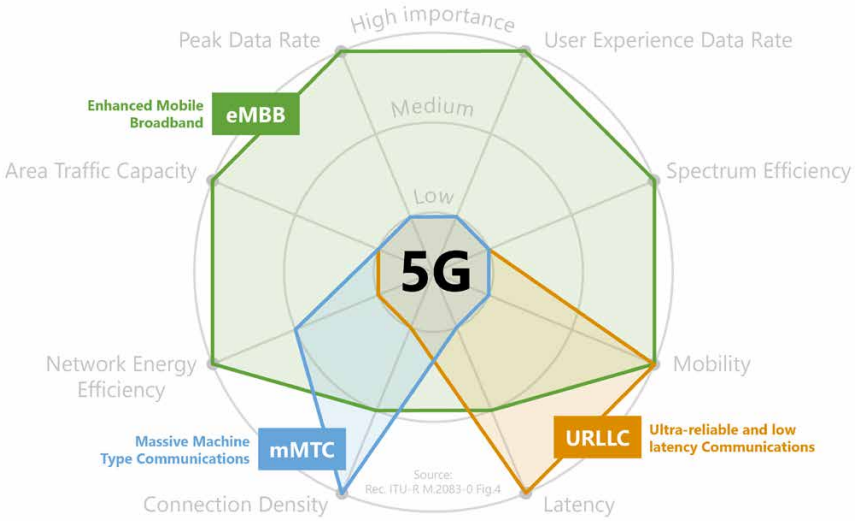
In its initial implementation, MicroNova integrated the COM5.SDN Radio Controller into an ONAP (Open Network Automation Platform) environment and implemented it on the basis of the OpenDaylight framework. The COM5.SDN Radio Controller essentially consists of the following components:

- RAN Configuration Manager
- RAN Statistic Manager
- RAN Topology and Inventory Manager

KPI / feature	Description	Requirement	5G use case
Peak data rate	Maximum data rate to be supported	20 Gbps	eMBB
User experienced data rate (perceived data rate)	Data rate that should be available for the user experience 95% of the time.	100 Mbps	eMBB
Latency	End-to-end packet delay	4 ms 1 ms	eMBB URLLC
Mobility	Maximum speed for hand-off and QoS	500 km/h	eMBB URLLC
Connection Density	Total number of devices per area unit	10-6 / km^2	mMTC
Energy Efficiency	Energy consumption of data transmitted / received per unit (device or network)		eMBB
Area Traffic Capacity	Total traffic in service area	10 $Mbps/m^2$	eMBB
Peak Downlink Spectrum Efficiency	Throughput per unit, radio bandwidth and network cell	30 bps/Hz	eMBB

4 KPI definition according to ITU-2020 with mapping to 3GPP service classes

The following diagram presents these variables in graphic form and enables appropriate monitoring.



5 Network Slicing KPIs at a glance

The standardization and further development of 5G and the next-generation networks are discussed and promoted in various bodies around the world, such as 3GPP, ITU, ETSI, O-RAN Alliance, and NGMN. Various use cases are implemented and tested, and existing ones are further developed and new ones specified, in connection with a large number of research projects.

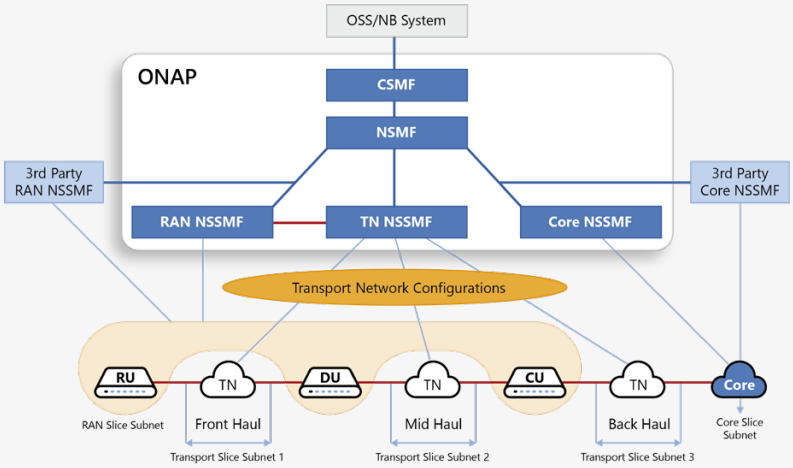
The essential prerequisite for network slicing is a fully integrated, automated SDN architecture. Increasingly, open source solutions and platforms, such as the Open Network Automation Platform (ONAP), are playing an important role for network operators. In addition, approaches built on Artificial Intelligence (AI) and Machine Learning (ML) are becoming more and more important for telecommunications providers (see InNOVAtion 01-2021).

Conclusion

The many years of experience in the area of automating network setup and network operation processes for two of the three German mobile network operators through COM5.Mobile, the continuous development/expansion of expertise in the area of AI/ML, as well as access to a completely open source-based ecosystem (OSNL) through its collaboration with 5G BERLIN e. V., all enable MicroNova with COM5.SDN to offer network operators an essential component of the SMO architecture and to thereby tap the advantages of network slicing technology.

The portfolio ranges from the automation of radio network-specific use cases such as site integration to network optimization using its COM5. Mobile products. Similarly, the COM5. SDN Mediator can be used to integrate an existing network into a leading-edge SDN architecture. Other possibilities include the integration and management of the specific network and service design, or of slice templates by means of policies through to the integration into functional components via microservices. ■

Slice lifecycle



An NSI is always considered end-to-end in the network, which is a key feature. An instance therefore includes all the necessary resources and functions, both physical (PNF - Physical Network Functions) and virtual (VNF - Virtual Network Functions), from the device to the air interface (radio) and through the backhaul and transport networks to the core network and management systems. Dynamic resource allocation in particular can also incorporate significantly more factors (e.g., traffic forecasts) with the help of AI or machine learning mechanisms (deep learning). The life cycle of an NSI is divided into four phases according to the 3rd Generation Partnership Project (3GPP, specification TS28.530):

1.) **Preparation:** This is where all key performance indicators (KPIs) relevant to the slice are defined. These KPIs describe the slice quality, capacity, class, design, etc. They also define the requirements for the network resources and serve as a guide for preparing and evaluating the network environment.
2.) **Commissioning:** This phase sees the creation of a slice instance, i.e. all required (network) resources from core to access are allocated and configured. These resources are distributed across different domains or subnets (core, x-haul, RAN), so the generic requirements must be mapped to the appropriate domain.
3.) **Operation:** The "Operation" phase includes activation and monitoring, KPI-based reporting, any necessary NSI adjustments due to capacity or topology changes, for example, and finally deactivation (terminates only the communication service, but not the NSI itself).
4.) **Decommissioning:** Decommissioning goes beyond deactivation and means the complete removal of the NSI-specific configuration along with the release of associated resources.

The above high-level overview, based on the open source framework ONAP, explains the most important functional components as specified by 3GPP. It describes the key components of the slice manager or slice orchestrator:

- **Communication Service Management Function (CSMF):** Responsible for translating communications service-specific requirements into network slice-specific requirements for forwarding to the NSMF (see below). The CSMF also has a user interface (web portal) to allow the complete creation and management of network services or slices.
- **Network Slice Management Function (NSMF):** Controls the management – including the life cycle – of NSIs. It infers requests sent to the network slice subnet from the requirements of the network slice. In addition to the CSMF interface, it has interfaces to the corresponding subnet management functions (NSSMF) for RAN, transport and core. The NSMF also handles the partitioning into subnet slices and their orchestration to form the NSSMFs (see below), which in turn is based on the relevant slice design templates (SD templates).
- **Network Slice Subnet Management Function (NSSMF):** The NSSMF, also known as the SDN Controller, is responsible for managing and orchestrating (including life cycle) NSIs. This function also establishes the relationship between the single slice service (Network Slice Selection Assistance Information, or S-NSSAI) and the NSI. NSSMFs are available for each slice subnet (RAN, transport, core). These can also be developed and integrated by third-party vendors, allowing direct integration of legacy networks (e.g., 4G).
- **Network Function Management Function (NFMF):** This is responsible for the application level management of VNFs and PNFs and also provides the "NF provisioning service", which in turn includes configuration management (CM), fault management (FM) and performance management.

From Network Automation to Orchestration Architecture

High network quality and new use cases: InNOVAtion 1-22 discussed the basic features of a service management and orchestration (SMO) architecture and network slicing. This article describes how many mobile network operators are driving practical implementation.

TEXT: Ingo Bauer **PICTURES: © Kitawit Jitaton / Shutterstock.com; © Kara / Fotolia.com**

The starting point of this SMO architecture is the automation solution developed by MicroNova over many years for radio access network configuration and optimization: COM5. Mobile and COM5.SDN. The complete mapping of the radio network design in the form of engineering policies/rules and templates in COM5.Mobile allows the vendor-specific models of Nokia, Ericsson and Huawei to be worked out in a fully automated way. This means that all relevant use cases can be automated to the greatest possible degree in a cost-effective and quality-enhancing manner, enabling the integration of new stations and their configuration, the activation of new features, and the optimization of network parameters.

By connecting the solution directly to the network, all changes made by a network planner or initiated by an orchestrator can be activated immediately and directly in the network after successful zero-touch validation. An integrated parameter database provides the core component of the automation solution. It contains the entire design of the network, operator-specific policies and rules, as well as default values and templates. The vendor-independent model, which is highly optimized for functional use cases, permits easy connection to higher-level planning systems.

From Web Interface directly to SMO

COM5.Mobile's complete functionality is mapped using an open web interface. This enables easy integration into a higher-level workflow, SON, or even orchestration system. This creates the basis for completely automating the processes that are relevant for network operators.

The parameter database, which has been developed and continuously

improved over the years, offers highly flexible adaptability to customer-specific requirements. What is more, vendor-specific legacy models can be mapped or integrated in a structured manner with little effort. Furthermore, mobile network operators (MNOs) can easily implement new approaches such as O-RAN. MicroNova had already implemented zero-touch provisioning in COM5.Mobile for all central RAN use cases, creating the basis for automatically setting up network slices and service management.

Added Value for MNOs in Operation

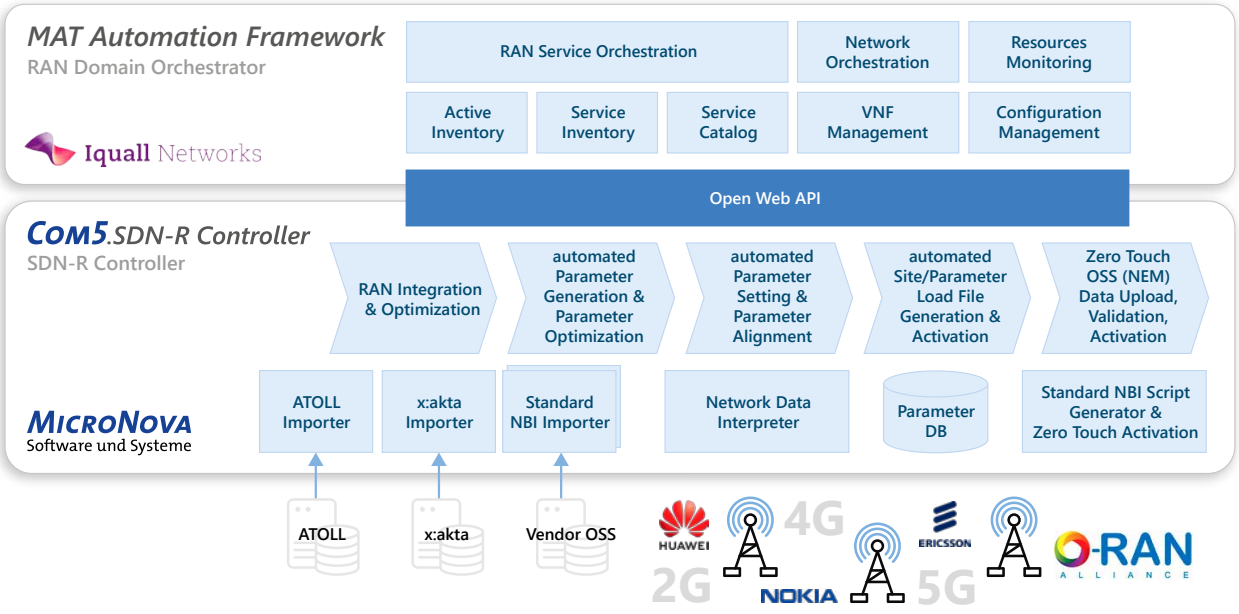
A major advantage of COM5.Mobile for MNOs is the reusability of existing models and policies, network equipment, etc., right through to the integration and automation of existing processes and use cases. This establishes a basis for subsequent integration of the existing network into an SMO-based architecture. The chosen path is technically low-risk and, moreover, cost-effective; at the same time, it can be followed in an iterative and agile manner.

Together with partner company Iquall (see box), MicroNova successfully implemented two exemplary use cases from the area of RAN configuration and optimization in the form of a fully functional proof of concept (PoC) within a very short period. One use case each from the area of integration (integration of a base station) and from the area of service-relevant parameter changes was selected, specified (cell parameter change) and implemented.

Iquall Networks

Iquall Networks

Iquall Networks specializes in providing software solutions to leading suppliers in the telecommunications market. The company has come a long way since releasing a global messaging and management solution in 2008 – all the way to today's fully agnostic network automation solutions. The Iquall team develops next-generation agile networks and guides its customers as they move into the era of automation and artificial intelligence.



1 System Overview

Key Focus for MNOs

The degree of automation mentioned above depends on the particular process group. Technologies such as ML and AI will continue to drive depth in the near future, as these are becoming increasingly important, especially with the increasing complexity and flexibility of the network and a variety of new methods to provide scalability at an economical cost structure. The COM5.SDN-R Controller, drawing on all of MicroNova's experience, can become the hub for the entire network and an essential part of an SMO architecture for MNOs.

MAT from Iquall

MAT is an open automation framework that cloud service providers (CSPs) use to create customized use cases. The basis for this is built on well-known standard programming languages and techniques such as Python or Ansible. The framework provides a deeper level of intelligence and insight into the intended state at every step of the network lifecycle – from planning and design to service assurance. MAT is highly customizable, which benefits communications service providers in particular when introducing and applying automation solutions, for example:

- **Intent Based Networking (IBN)** – for automating existing manual processes for network configuration, as well as for automated detection and resolution of network problems. It uses mechanisms such as machine learning and artificial intelligence.
- **Model Driven Networks (MDN)** – a common modeling language for translating between service-specific configuration (service/slicing) and vendor-specific device configuration. Modeling with YANG (Yet Another Next Generation) as in O-RAN can eliminate the need for proprietary network adapters.
- **Closed Loop Automation** – continuous assessment of network conditions, traffic, resource availability in real/near real time for optimal service quality and resource utilization according to operator guidelines. It provides continuous communication between network infrastructure and management systems for self-optimizing functions.

MAT offers excellent monitoring and traceability of all processes and tasks involved in the creation or other operation of the corresponding use case. There are many benefits to using MAT in automation processes:

- Fast learning curve
- No additional costs for NE scalability
- Multiple domains
- Independent of hardware vendors
- Highly available architecture
- Version control

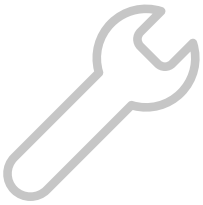
MicroNova has now been involved in telecommunications for almost two decades, automating processes and workflows with a focus on the radio access network (RAN). COM5.Mobile has always been a pioneering system in terms of functionality. With the COM5.SDN-R Controller, MicroNova has successfully transferred its cutting-edge power into a cloud-based solution, opening the door to future viability. The open web interface provides seamless integration into the new SMO-based architecture.

Summary

Together with its partner company Iquall, which provides a powerful orchestrator in the form of MAT (see box), MicroNova has been able to implement a fully functional PoC for a radio access network in a very short time. In doing so, the project team has shown that traditional vendors' legacy equipment can efficiently integrate into an orchestrated, fully automated environment – and that MNOs can maintain their existing design in a cost-effective, quality-enhancing manner. The COM5.SDN-R Controller is well prepared for integrating O-RAN thanks to its modular structure and model-based approach.

Process and Use Case Groups

Essentially, network operators distinguish between three groups of processes and use cases for network management – i.e., expanding and operating the mobile network: integration, optimization and service / slice management.



Integration

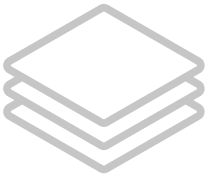
Integration comprises all network-related enhancements, such as the installation of new sites/base stations, the expansion of existing sites with new equipment, the modification of sites, etc. As a rule, this requires modifications to the hardware configuration, including on-site intervention by a technician. Upstream of this is a planning process. Maintaining consistency between "new v. existing configuration" is the biggest challenge throughout the entire process lifecycle.

COM5.SDN-R Controller supports this process from the moment the planning data is imported, including the necessary consistency. Some parts of the process require manual intervention by a technician, while others can be automated by COM5.Mobile in a cost-effective and quality-enhancing manner. The functionality of the COM5.Integrator was incorporated into the open web interface and consequently into the COM5.SDN-R Controller. It is possible to integrate it into the orchestration layers above it without any restrictions.

Optimization

It is very important not to conflate the optimization use cases with the service and network slice activation and optimization. While the processes may be similar, they differ fundamentally in terms of performance, runtime, network focus, and automation requirements. Optimization in this case is meant network-wide and cross-network. This includes, for example, handover management, frequency and PCI optimization, importing network-wide engineering and design specifications, (area-wide) consistency matching in the configuration, etc.

Only a configuration of the network that is optimally adapted to the operators' guidelines enables the subsequent setup and activation of services with correspondingly high quality. COM5.SDN-R Controller also offers the possibility to connect directly to external systems – ActixOne or SON systems, for example – to automate the transfer of parameters, to compare them with the operator-specific design and network, and finally to activate them automatically in the network via zero touch. As with the COM5.Mobile Integrator, the COM5.Mobile Optimizer functions have been fully incorporated into the COM5.SDN-R Controller.



Service / Slice Management

The transformation to a service-oriented architecture involves this group of use cases. The scenarios outlined above may appear similar at first sight, but it is easy to underestimate their complexity. However, they are clearly differentiated by very exacting requirements, particularly in terms of performance and runtime. The classes of service defined in the 5G standard (eMBB - enhanced Mobile BroadBand, URLLC – Ultra Reliable Low Latancy, mMTM – massive Machine To Machine communication) permit a variety of new services (see article Network Slicing, p. 020, InNOVAtion 1-21).

In the future, network operators must be able to define these services in a flexible and "straightforward" manner and make them available to selected customers in both the commercial and residential sectors on an ad hoc basis. This is only possible if provisioning is fully automated, while at the same time ensuring quality of service over the entire lifetime of the relevant services; technologies such as machine learning (ML) and artificial intelligence (AI) are a valuable aid here in the context of the RAN Intelligent Controller (RIC). The essential functions for this are implemented in the COM5.SDN-R controller and optimized with regard to the stipulated benchmarks – for leading-edge, automated RAN service management with a particular focus on quality and operating costs. ■

Interview with: Alexander Seitz (Telefónica Germany)

Alexander Seitz (Dipl.-Ing.) is Head of Access Network Design, Performance and Optimization at Telefónica Germany GmbH & Co OHG in Munich. In this interview he talks about network optimizations with a view to COM5.Mobile, which resulted, among other things, in the top grade "very good" in the major annual mobile network quality test done by Connect, a renowned German specialist journal

TEXT: Editorial staff PICTURE: © Have a nice day Photo / Shutterstock.com

InNOVAtion: Mr. Seitz, how was Telefónica Deutschland able to improve the ongoing optimization process of the Radio Access Network with COM5.Mobile Optimizer?

Alexander Seitz (AS): The simplifications that came with COM5.Mobile Optimizer allow us to work very closely to the live network. This means that at any time we can reliably determine the parameter values in our network. In particular, we can also ensure that any changes are applied to the network promptly and remain there exactly as we have configured them. Above all, this has significantly improved the time-to-market.

InNOVAtion: How exactly has the Radio Designer module in COM5.Mobile Optimizer improved the time-to-market?

AS: This is evident in two aspects: For one, we were able to improve the processes thanks to the proximity of COM5.Mobile Optimizer to the live network to such an extent that we now have a very prompt activation of site-specific optimizations. More importantly, however, we also have to adapt network-wide specifications promptly ourselves and now we no longer need to develop the software to do this. We are therefore able to test new design specifications first in a small region and then activate them directly throughout the network in a short time, without having to wait for new releases of COM5.Mobile. This also eliminates the need to package changes; we get feedback on changes immediately that can be clearly attributed to a design change. We are in a full CI/CD process here in network design.

InNOVAtion: What are you expecting from the Fastlane and ZeroTouch features of COM5.Mobile Optimizer?

AS: Above all, the process of site-specific optimizations will improve. For some optimization cases, we currently

still use the NMS solutions from the system technology vendors to directly see the customer impact, and we then maintain the optimal value in COM5.Mobile. Of course this process is time-consuming and becomes unnecessary with FastLane and ZeroTouch. The process is further simplified and we reduce possible errors with the universal use of COM5.Mobile. Moreover, this allows us to relieve the burden on our network operations, so that our team can respond to other time-critical matters more quickly and with more flexibility.

InNOVAtion: How does COM5.Mobile Integrator support you in the roll-out process and what are your expectations of COM5.Mobile Integrator's Radio Designer?

AS: By introducing COM5.Mobile Integrator, we have already taken a big step towards being able to create integration files on-demand and shortly before integration. This has eliminated many potential sources of error. With the Radio Designer, we will be able to design the process chain for changes completely independently of the release cycle, just like in COM5.Mobile Optimizer. In this way, we can drastically reduce the risk of errors as well as further reduce our time-to-market, especially for the introduction of new hardware components.

InNOVAtion: How can COM5.Mobile support you as you move toward SDN/NFV and where do you see the advantages of a fully automated solution for future topics like SDN/NFV?

AS: In recent years the COM5.Mobile software architecture has evolved from a specialized approach with dedicated use cases to a flexible platform. We are now at a stage where we can automate this platform. In this way, we are also creating the foundations to allow us to carry out network services and configurations on-demand and fully automatically. In the future, we will see a further decoupling of hardware and software, not just in Open-RAN. As advantageous as this decoupling is, it is also important to ensure holistic service provisioning here. The flexibilization and modularization of COM.5 Mobile is going in exactly the right direction.

InNOVAtion: Mr. Seitz, thank you very much for your time. ■

Telefónica Deutschland

„By introducing COM5.Mobile Integrator, we have already taken a big step towards being able to create integration files on-demand and shortly before integration."

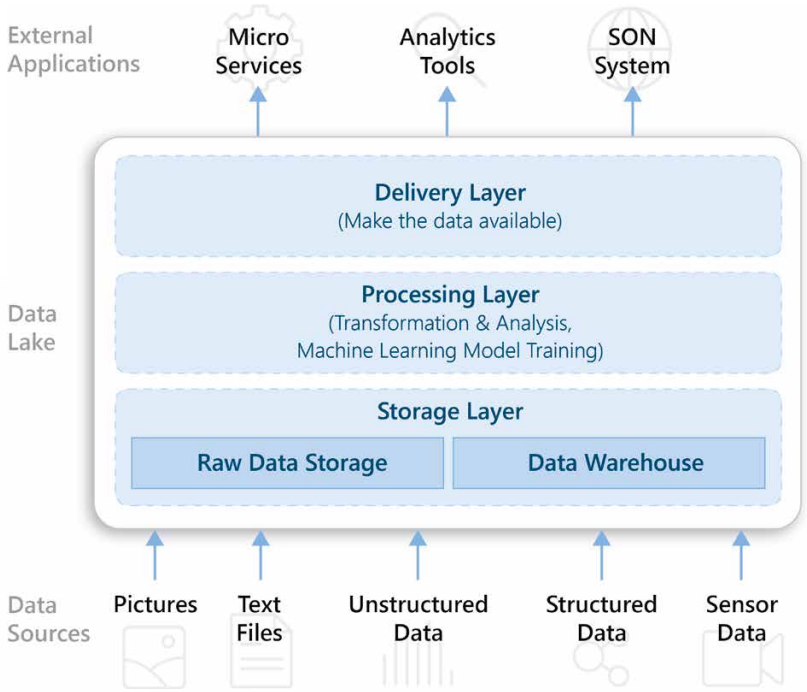
– Alexander Seitz, Telefónica Germany

Data Lake as a Basis for COM5.SDN

Data for smart orchestration and automation of mobile networks

TEXT: Ella Schmidtobreick, Ingo Bauer **PICTURE: © Dudarev Mikhail / Shutterstock.com**

COM5.SDN is the second product line of MicroNova's Telco Solutions division – alongside COM5.Mobile – and addresses in particular the transition of existing mobile communication technology into the new structures for 5G. Among other things, COM5.SDN relies on the Open Network Automation Platform (ONAP), an open source framework of the Linux Foundation, and mainly performs tasks for the orchestration and automation of mobile communication networks. Building on this, MicroNova and its partner company atesio are developing a SON solution (SON = Self-Organizing Network) to improve the performance and efficiency of mobile networks (p. 20).



1 Data lake structure

The central component of ONAP is the DCAE component (DCAE = Data Collection Analytics and Events), which is primarily responsible for the gathering, storage and analysis of data. Given the complexity of the concept, a 'data lake' is used. This approach that is becoming increasingly popular, especially in connection with Big Data and Machine Learning (ML) – key building blocks for automation not only in the mobile communication sector.

How a data lake works

A data lake is a sort of central storage environment with large amounts of data from different sources that can scale up to the petabyte range. It is unique in that the raw data is stored unstructured in its source format. In other words, the data is collected independently of its format and made available in a repository. In this way e. g. images, text files and sensor data can be taken from one consolidated date source.

Data lake vs. data warehouse

The use of a data lake and a data warehouse are not mutually exclusive; in fact, they are often operated in parallel. It is also possible to integrate different data warehouses into one data lake, creating structured areas in the unstructured data lake. The term data lake was first used in 2010 by James Dixon (CTO of Pentaho). The idea of stockpiling large amounts of data existed as early as the 1980s and coined the term data warehouse. The differences between data lake and data warehouse are shown in chart 2.

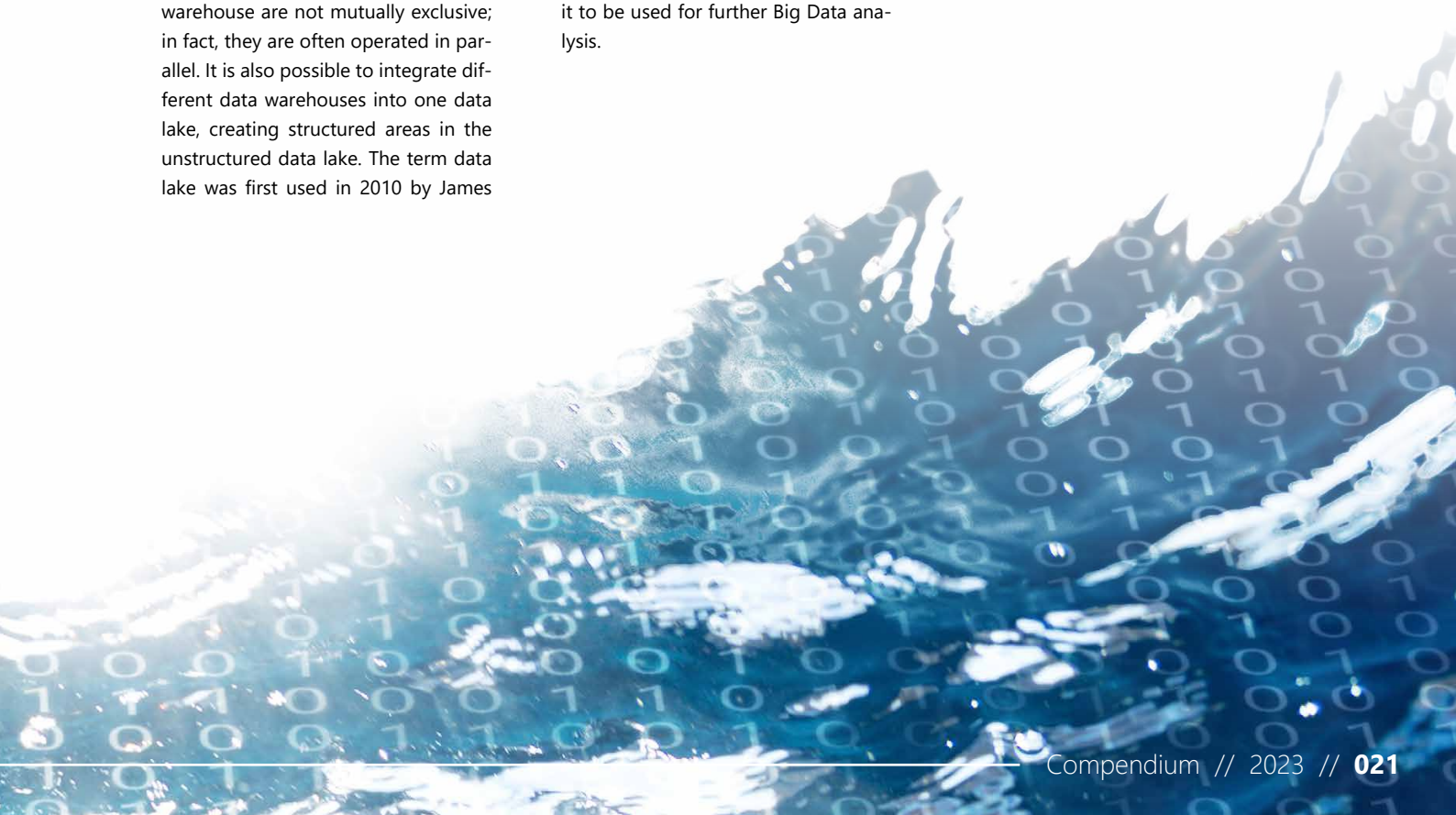
	Data lake	Data warehouse
Data structure	Unstructured	Structured
Purpose	Unclear	Clear
Benefits	Flexibility, scope of use	No maintenance, immediate analysis
Disadvantages	Complexity	Changes to stored information

2 Differences between data lake and data warehouse

One characteristic of a data lake is that data is initially stored without any concrete idea of its analysis or use. The intended use often only emerges over time – but if necessary, the data can be turned into valuable information. When the stored data is accessed, it is first duplicated and then formatted. Doing so retains the raw formats with all the original information. This allows it to be used for further Big Data analysis.

Data lake and SON

Since the quantity of usable data or valuable information is crucial for the desired automation and orchestration in the management of mobile communication networks, the concept of a data lake lends itself well to the mobile sector – especially for the more complex 5G variant. Therefore, its use for MicroNova and atesio's SON solution brings benefits accordingly, especially in view of the future integration of artificial intelligence as a basis for COM5.SDN. ■



Into the Mobile Radio Network with AI

With the extension of 5G technology, new network solutions are in demand – incorporating artificial intelligence (AI) into the radio network helps to make this a reality.

TEXT: Ella Schmidtobreick PICTURES: © metamorworks / Shutterstock.com; © telmanbagirov / Fotolia.com

The large-scale roll-out of the 5G network is not only bringing many benefits, but a few challenges too. For example, not all new services can be implemented with the technologies currently in use. MicroNova therefore relies on AI-based methods to analyze the network data managed via COM5.Mobile and implements corresponding functions in the new COM5.SDN product generation.

Limits of the current network

The radio network is becoming ever more complex due to the constantly increasing number of devices requesting access to it. In the future it will not just be smartphones accessing sites, but also various vehicles, machines, and so on. In addition, it will become increasingly important for future services to be executed in real time. For example, cars will have to be able to send and receive real-time information. Otherwise, the time lag will be too great to react appropriately to changing circumstances.

In addition, the quantity of data that needs to be processed is growing, not only because of the numerous devices that access the network, but also because the data being transmitted is becoming more and more complex, such as video streams. In order to be able to ensure a fast and agile network in the future, the use of AI is essential – because artificial intelligence opens up possibilities to overcome the aforementioned limitations.

Advantages of using AI

The use of AI in the telecommunications industry brings far-reaching benefits. The two key application areas for mobile network operators are Service Assurance, and optimization of their existing networks.

Service Assurance

The essential task of a network operator is to ensure a stable mobile network. If the network is not permanently available with sufficient bandwidth, customers will gradually switch to better performing competitors. To avoid this, every network operator must ensure its services are performing consistently. This is primarily achieved by predicting the upcoming data volume as reliably as possible and by detecting cyber attacks at an early stage.

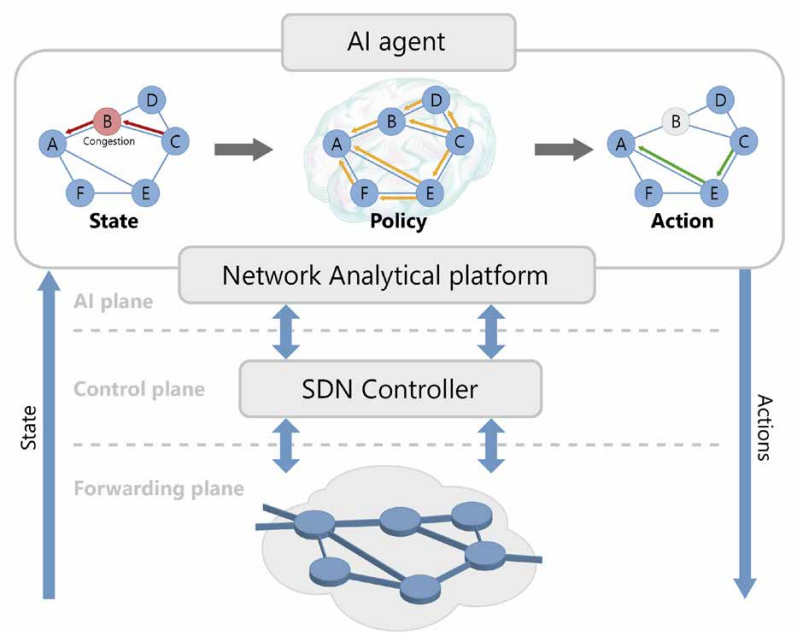
Prediction

The biggest advantage of using AI within the Radio Access Network (RAN) is the ability to predict future data volumes. This involves incorporating data generated both inside and outside the RAN. This means, for example, weather forecasts or the match schedule of the national football league can be included in network planning. What is designed is not just a forecast of the expected utilization, but also the appropriate positioning and dimensioning of antennas and nodes. The more precise planning, now also based on external data, results in better resource allocation and utilization in order to offer all users the best possible Quality of Experience (QoE).

Furthermore, on demand services and ultra-reliable low-latency communication (URLLC) can only be offered with the help of AI. These require both low latency and a very low error rate. To ensure this, faults must not occur in the first place – and must be detected in advance with the help of AI. To do this, conspicuous patterns before an imminent failure are identified and compensated for by a rapid redistribution of resources. But this requires a network that will be much more flexible in the future. This approach means that potential faults do not affect the end user, and all services are available without interruption.

Security

Another important aspect of Service Assurance is the early detection of cyber attacks. The introduction of new services also requires adapting the existing network architecture. Software Defined Networking (SDN) is primarily used here, whereby hardware and software are decoupled from each other. As already mentioned in a previous issue of InNOVAtion (02-2020), the core element of this structure is the orchestrator. Thanks to its central position, it has a comprehensive overall picture of the complete RAN, so that it immediately detects anomalies through the use of AI. Consequently, both the prediction and the innovative architecture itself contribute to the resilience of the entire mobile network by enabling the early detection of irregularities.



1 Possible application of AI in a Software Defined Network (SDN).

Optimization

Next to Service Assurance, optimization of the existing network is the most fruitful approach. Network operators can achieve this in various ways. AI also plays an important role here.

Automation

Automation within the mobile network plays a central role. Over time, more and more routine interventions will be carried out by machines. AI will understand more contexts on its own and make decisions itself on this basis. This means that in the future, networks will increasingly find solutions to complex problems on their own, gradually optimize themselves, and find approaches that experts have so far not considered. The result will be their reacting more and more quickly and efficiently to unknown situations, saving a lot of working time and reducing the risk of errors in manual optimizations – in summary, the ultimate result will be lower costs and a better network.

Time-to-market

Within the network, however, it is not only the ongoing processes that are optimized: The integration of AI will also significantly simplify and accelerate network roll-outs. Thanks to SDN, network operators no longer have to replace the hardware at considerable cost in every implementation phase – a simple software update is sufficient. This significantly shortens the time until new services and network configurations are available and therefore increases revenue.

AI integration

The topic of AI is a broad field. In the telecommunications industry, it is primarily the sub-discipline of machine learning (ML) that is used, in which the system learns to recognize patterns and to assign unknown data on the basis of such patterns. The myriad parameters within a radio network provide an ideal basis for training ML models. It is important to choose the right model. Due to the complexity of both the data involved and the models, this can be quite a challenge. All forms of ML are used in the telecommunications industry:

- Supervised learning
- Unsupervised learning
- Semi-supervised learning
- Reinforcement learning

Training

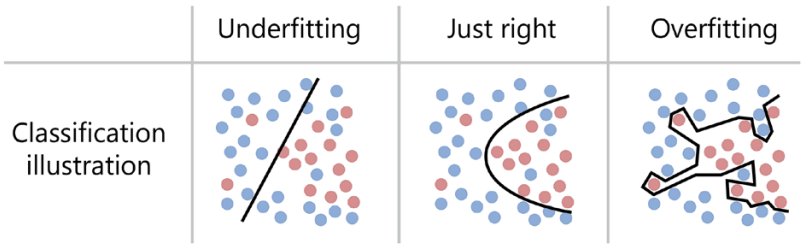
All of these learning methods require prior training so that systems can later make decisions in the desired way. In some cases training data is required, on the basis of which the model learns. Test data is also required, in order to check how good the decision-making ability of the model already is.

However, if too little information is available, the model cannot learn the correlations sufficiently well and the hit rate for correct decisions is too low (underfitting). On the other hand, if the model is provided with too much data the opposite occurs, known as overfitting. In this case the model gradually learns the properties of the datasets by heart, and only recognizes in a useful way information that is already familiar, while it struggles to classify new data appropriately.

To avoid this, both training and test data should be available and initially be unknown to the model. Using this data, measurements are taken at regular intervals to see how often the model makes correct decisions and whether further training is necessary. The requirements in this regard can be quite different.

Supervised learning

In supervised learning, the model learns on the basis of 'labeled' data: Before training begins, the data is labeled manually with the correct result. The decision made by the model



2 Principle of underfitting and overfitting

Supervised Learning

Classification

» Service requirements
» Operational data
» Data traffic

Example:
> Support Vector Maschine
> Neural Networks

Prediction

» Data volume (esp. traffic peaks)
» Untypical usage behaviour (Fraud prevention)
» Quality of experience
» Customer satisfaction
» Connection errors

Example:
> Predictive Maintenance

Unsupervised Learning

Clustering of data

» Nodes
» Users
» Devices
» User data

Example:
> k-Means Clustering
> Principal Component Analysis

Customer profiling

Anomaly detection

» Traffic analysis
» Network monitoring
» Security

Reinforcement Learning

Reconfiguration of network parameters

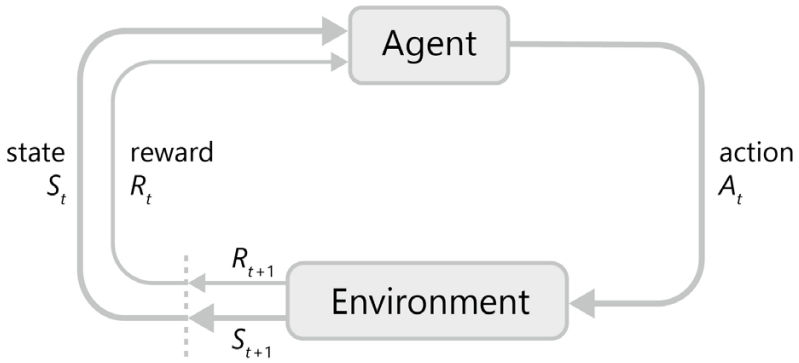
Decision making for dynamic resource control

after processing the respective input is compared with this label. If the assignments do not match, a step-by-step adjustment is made. In this way, the model continuously improves and, after training, correctly recognizes a large number of unknown datasets.

A classic use case for supervised learning in the telecommunications industry is the classification of service requests, operational data, or data traffic. Frequently used methods include, for example, Support Vector Machines, Artificial Neural Networks, or Deep Neural Networks. Such neural networks are used to realize various machine learning methods, including supervised learning. The structure of neural networks is, as the name suggests, based on the neuronal structure of the human brain. The different layers consist of several nodes, each of which is linked to nodes from the previous and subsequent layers.

Only the input and output layers are visible from the outside. The multi-level decisions are made in the intermediate, hidden layers. Here, the connections between the individual neurons are assigned random weights at the beginning. These are optimized through training by means of backpropagation – a form of error feedback following the delta rule. In this way, the neural network learns and makes the desired decisions in the end.

Another important field of application for supervised learning is the prediction mentioned above. This involves predicting expected data volumes, as well as traffic peaks or atypical usage behavior, for example to prevent telephone fraud. The correct prediction of possible connection errors can be used for predictive main-



3 Principle of reinforcement learning

tenance, so that potential sources of error can be eliminated before they occur. In addition, prediction enables forecasts about user behavior, quality of experience, and customer satisfaction – and continuous improvement of services as a result.

Unsupervised learning

In contrast to supervised learning, unsupervised learning does not use data that has already been labeled for training. The model does not at any time know whether the final decision is right or wrong. It relies exclusively on independently recognized patterns and correlations that occur between the training data, and makes its decisions on this basis. This type of machine learning can be particularly helpful if it is not possible to label the data, for example for resource reasons. Particularly with large amounts of data, prior assignment is very time-consuming, which is why it is often skipped.

Two important mathematical models that are used in unsupervised learning are the k-means algorithm and principal component analysis. Both methods focus on the classification of data into several groups based on their mean deviation. The methods are used in clustering nodes, end users, and devices, as well as various types of user data. They are also helpful in creating customer profiles and recognizing irregular behavior. The latter promotes security and supports network monitoring.

Semi-supervised learning

To avoid the laborious labeling work, often only a small part of the data is categorized. This results in a hybrid form of supervised and unsupervised learning, referred to as semi-supervised learning. After an initial very effective but also cost-intensive training with the labeled datasets, the model is then further developed with the unlabeled data.

This approach results in a good mix of initial effort and return. Both traffic classification and anomaly detection are important application areas. The latter is achieved primarily through the analysis of data traffic and comprehensive network monitoring.

Reinforcement learning

In contrast to the previous models, reinforcement learning does not use data generated in advance. An agent is placed in an environment predefined by a Markov decision process and performs actions independently. The goal is to induce the agent to perform an optimal combination of actions by means of a reward strategy based on maximizing the expected return. By continuously interpreting the autonomous movements, the agent is constantly exposed to new states and receives positive or negative rewards. In this way it learns which actions increase its reward function and performs them more frequently in order to reach the goal.

What is special about reinforcement learning is that the model learns without concrete instructions and often finds creative ways to solve problems on its own. This type of ML is used in the telecommunications environment primarily for reconfiguring network parameters and for formulating dynamic policies for resource management. In both cases, the environment plays a major role. For example, the configuration depends not only on the cell neighborhoods; consideration must also be given to the surrounding buildings and vegetation.

Conclusion

The use of AI is essential for future innovations in the mobile communications environment. Many of the planned functions of the 5G network, for example, cannot be realized without prediction and agility, and therefore the integration of AI. Network operators will have to get to grips with the various strategies in the field of machine learning in the near future; MicroNova can provide comprehensive support here. Because a successful combination of algorithms and training data creates the basis for a high-revenue and high-profit future. ■

AI for 5G

Interview with Prof. Dr.-Ing. Thomas Wiegand

TEXT: Editorial staff PICTURES: © metamorworks, Olivier Le Moal / Shutterstock.com

Prof. Dr.-Ing. Thomas Wiegand is one of the two directors of the Fraunhofer Heinrich Hertz Institute in Berlin and has been involved in mobile communications for many years. He was a driving force behind the foundation of the innovation cluster 5G BERLIN e.V., a partnership between research and industry to promote innovation relating to 5G. The editorial staff of InNOVAtion spoke with Prof. Wiegand about the association and about 5G technology.

InNOVAtion: What particular technological challenges do you see in the introduction of the 5G standard?

Wiegand: The technological challenges lie explicitly in the implementation of the ambitious key performance indicators (KPIs), such as 1 ms latency and a data transfer rate increased by a factor of 100-1000 compared to 4G. The better compression of future networks also poses a particular financial challenge.

InNOVAtion: MicroNova is especially active in the field of automatic rollouts and network configuration of multi-vendor and multi-technology radio access networks – what insights can you give our readers and customers with regard to 5G?

Wiegand: Operating future networks will become increasingly complex – networks must therefore configure themselves automatically. This will increasingly be realized automatically via software and artificial intelligence (AI). One challenge is the hardware-related design and alignment of base stations. Multi-vendor activities will only become interesting once regional and "private" 5G network licenses are awarded and will enable smaller providers to participate in the market for the first time.

InNOVAtion: What influence will AI have on network expansion and optimization?

Wiegand: 'Network slicing'[1] will for the first time provide a highly flexible virtual layer in the physical communication networks. In this case, for example, AI could predict demand in the specific network slices and optimize network utilization accordingly. Edge data centers[2] play a key role here, as they can perform latency-critical calculations locally. As a result, AI will have more and more influence on networks of the future. The 5G BERLIN association will intensively test network virtualization and network slicing on the 5G test field, where state-of-the-art edge data centers will use AI.

InNOVAtion: Many of our readers are from the automotive industry. What approaches do you see here through 5G? How can 5G BERLIN e.V. help to get these out onto the road?

Wiegand: The new mobile radio standard makes full use of its advantages in particular when it comes to latency-critical applications – i.e. applications in which there must be no delay in response time. 5G opens up completely new worlds here. The aim is to expand the network to a high degree of reliability so that safety-critical applications then become possible. In terms of autonomous driving, for example, a fast reaction time is essential, especially in dangerous situations. In addition, sensors generate an immense amount of data; the high transmission rate of 5G and the edge computing concept help to transfer and process these data volumes. Network slicing, mentioned previously, also allows networks to be divided up virtually according to requirements and applications – as flexibly as required and on demand. With its test field, 5G BERLIN can gain vital insights that can be used in a variety of ways – including for autonomous driving and networked driving with Car2X communication. The test field offers ideal conditions for developing and testing 5G test vehicles from the automotive sector in a real urban environment.

[1] *Editor's note: Here the network is divided into so-called slices with dedicated service quality. This ensures even ultra-reliable, delay-free services. See also article p.052 „Telco meets Automotive".*

[2] *Editor's note: A concept in which part of the cloud intelligence migrates back to the individual devices or sensors.*

"Purely decentralized data processing is not enough, networking must remain the focus if data is to be transferred and mobility guaranteed."

– Prof. Dr.-Ing. Thomas Wiegand, Executive Director, Fraunhofer HHI

InNOVAtion: Why do we need 5G when information is being processed locally again via edge computing?

Wiegand: Purely decentralized data processing is not enough, networking must remain the priority if we want to transfer data and thereby ensure mobility. However, latency-critical preprocessing can be carried out at very high speeds using decentralized processing. FPGAs are used as elements of edge computing. They supplement a "deep" cloud in such a way that latency-critical classification in real time is possible using AI, for example. The extension of the classic cloud to future "cloud layers" in 5G networks makes it possible to train AI in the deep cloud with large volumes of data, and to run it in the edge cloud for real time applications, where less storage resources are required. A flow of data into the deep cloud with a lot of memory can in turn be used for online training of AI. Communication with very high data rates remains a central element of 5G.

InNOVAtion: From experience, we know that area-wide radio networks in particular are highly susceptible to interference and have gaps in coverage. What do you consider the main challenges for network operators, and when and how can these be tackled?

Wiegand: We are not a network operator, but the challenges are probably that, in addition to the auction fees for the 5G frequencies, immense financial resources have to be made available for network expansion in order to achieve a higher reliability than with 4G networks.

InNOVAtion: 5G works in the millimeter wave range, meaning that range and penetration of solid objects are severely restricted. How can a network with high coverage be realized despite this?

Wiegand: In the 5G standard there are basically two different bands, one at 3.5 GHz and then at 28 GHz. Only the upper band represents the real millimeter wave range, where shading effects can occur more often. However, this band primarily serves to provide a very high data rate for a high subscriber density in very close proximity to terminals by means of small cells, and thus it is not intended for nationwide network coverage. Part of the activities of the 5G BERLIN association is to install and test such small cells.

InNOVAtion: With 5G, it is not only consumers who will have significantly more bandwidth – how can companies benefit from the new technology? Can 5G BERLIN provide help here?

Wiegand: Companies can definitely benefit from the new technology. We're not just talking about large corporates that may take advantage of "private" 5G networks for an Industrial Internet of Things (IIoT) in their factories, but also SMBs and start-ups that can use the novel infrastructure for their innovative products. The virtualization of networks makes 5G appealing for both hardware and software companies. With its test field, 5G BERLIN can try out this wide variety of developments in an urban environment, and thus thereby turning them into market-ready products faster. This "unfair advantage" will in particular help start-ups and SMBs to quickly establish themselves on the market with their products.

InNOVAtion: Do you expect 5G to boost concepts around mixed, augmented and virtual reality (MR, AR & VR)?

Wiegand: It is only with 5G and edge computing that AR, VR and MR really become possible in the high-resolution field. At the moment end devices are simply too large and bulky, since the computing power must be present on them. This will change fundamentally with the low latencies and edge computing of 5G. The complex calculations, for example of video signals per frame (fps), can be done in the edge cloud and transmitted to the end device – such as VR glasses – with very low latency. This allows smaller end devices with low computing power, which also benefits battery life. Real time transmission with very low latency allows VR glasses to be used without dizziness or headaches. Real time transmission to several VR glasses is also possible, e.g. for the business case of major events with all glasses being synchronized.

InNOVAtion: How much are you thinking about 5G's successor, and what takeaway can you give our readers?

Wiegand: Further technologies are already being researched. The trend is likely to be towards the continued use of higher frequency bands, from higher millimeter wave frequencies beyond 100 GHz to the use of terahertz transmission. However, this has been purely speculative so far and it remains exciting to see which developments will come out on top. ■

With SDN/NFV to a powerful 5G network

Software-defined networking and network functions virtualization provide a revolutionary way of configuring, optimizing and maintaining customer-oriented mobile networks. Background and options.

TEXT: Ingo Bauer PICTURE: © metamorworks, Andrew Krasovitckii, MSSA / Shutterstock.com

We have already reported in detail about 5G radio technology and its enormous importance for business and private life in recent customer magazines. There is no doubt that 5G is a key technology for a future-oriented infrastructure – and will contribute to economic development like no other. The all-pervasive coronavirus crisis shows us every day how important seamless, cross-border networking is for the continued existence of the globalized world. Even in global politics, 5G is seen as a critical element in the digital economy and in society.

Industry, agriculture, transport, healthcare, urban infrastructure, private households – 5G technology will link all the different domains of a country and enrich them with a wide range of new services. At the same time, demand for these new services is growing – driven mainly by industry – in the areas of real-time data acquisition from countless sensors and devices. Extremely high bandwidths with low, guaranteed latency and high reliability for critical applications are key to this.

New approaches to network design and architecture are required if these growing demands are to be met. Mobile network operators (MNOs) are facing increasing pressure to rapidly deploy new technologies to meet ever-increasing customer expectations. To achieve this, they must develop, scale up, and roll out innovations as quickly and cost-effectively as possible. However, in order to ensure economic efficiency and to protect previous investments, concepts are also needed to integrate or transfer the network's legacy technology into new forms of architecture in a cost-effective and efficient way.

Revolutionary Configuration Options

But how can MNOs meet these challenges? Two of the main methods or architectures addressing these network requirements are software-defined networking (SDN) and network functions virtualization (NFV). Together they represent a revolutionary opportunity for operators to configure, optimize and maintain a customer-oriented mobile network.

SDN is a network architecture that relies on control by software and is completely decoupled from the hardware. The underlying concept is the separation of the data layer (data plane or user plane) from the management and control layer (management plane or control plane). The associated opening of the previously restricted, proprietary network platforms creates the

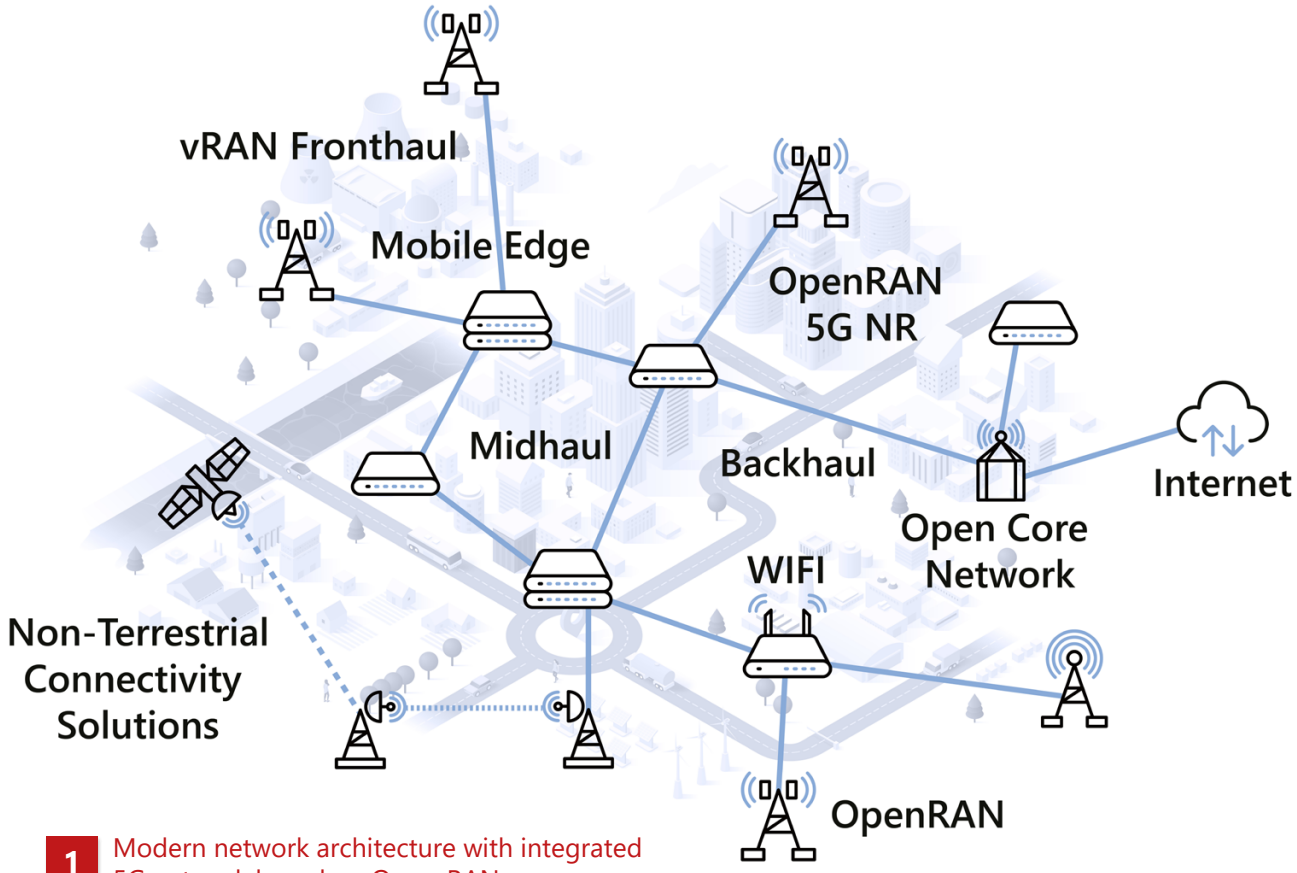
basis for a centrally managed and programmable network that can therefore be managed very flexibly: new components can be added with little effort and can automatically receive all information relevant to them. Changes made via a network controller are quickly applied to the components concerned and do not need to be configured or assigned individually.

As the name suggests, NFV is a method for virtualizing network functions and services. It is based on a technology that abstracts network functions (e.g. route calculation and traffic control), decouples them from the proprietary hardware, and allows them to run as independent software on virtual machines. NFV was first presented at the SDN World Congress in 2012. It laid the foundation for the development and use of vendor-independent, standardized hardware and software solutions for building networks. The use of commercial off-the-shelf (COTS) hardware and virtual networking capabilities provides significant benefits to operators in terms of cost, time to market, vendor independence, scalability, and agility.

Interaction between SDN, NFV and COM5.Mobile

The NFV and SDN technologies are not directly dependent on each other – but they are interrelated and share similarities. Both are based on the principles of virtualization and abstraction, which they implement differently with regard to functions and abstract resources. SDN separates forwarding functions and control functions within the network.

The idea underpinning this separation is to create a centrally managed network. As mentioned above, NFV is based on abstracting network functions from the hardware, which in turn supports SDN, as it provides the infrastructure to run SDN software. This allows a purpose-related joint use of both approaches, using standard hardware, thereby providing wireless service providers and, where applicable, campus network operators with a flexible, agile, and efficient network architecture.



1 Modern network architecture with integrated 5G network based on Open-RAN

MicroNova addresses these very requirements with its new product line, COM5.SDN. The main focus is on migrating existing technology to the new structures. This enables valuable integration of new network and service technologies into the network operators' ecosystem.

COM5.SDN forms the basis for various tools and products - starting with COM5.SDN Mediator, which offers an entry point into the SDN world, up to the future product COM5.SDN Radio Intelligence Controller, a non-real-time radio controller (or non-RT-RIC for short). A roadmap has thus been created covering the core areas of coming system architecture. The following sections describe the key functions of these product variants.

COM5.SDN Mediator

MicroNova is collaborating with its partner highstreet technologies (see page 14 f.) on the standardization of the interface for operation and maintenance within the O-RAN architecture (see page 11 f.) – the O1 interface. It forms an API between the service management and orchestration (SMO) platform and the network elements and managed elements defined in O-RAN.

COM5.SDN Mediator makes it possible to integrate different network technologies (2G, 3G, 4G, and 5G) into an SDN-/NFV- or Open-RAN-compliant architecture. It relies on the basic mechanisms developed in COM5.Mobile for automating integration and optimization use cases. These include, for example, existing vendor-specific network adapters for equipment from Nokia, Ericsson and Huawei, the existing policy engine, including operator policies in place, a connection to external planning tools and the zero touch configuration mechanism, to name but a few.

The northbound interface provides a fully functional, fully configurable Netconf/YANG server (YANG: "yet another next generation", a data modeling language) that can be filled with the corresponding YANG models. An internal parameter database is used to map the corresponding, vendor-specific models to it, and missing parameters are served via the stored policies and templates.

The COM5.SDN Mediator thus establishes the basis for the successful migration of existing architectures, including the network, to a sustainable consolidated next-generation architecture.

COM5.SDN Radio Controller

COM5.SDN Radio Controller follows the O-RAN paradigm by providing a global network view using a logical, centralized controller. The focus is on a vendor-independent, standardized southbound interface based on O1: a REST interface to a web-based user interface is supplemented by further such interfaces to other (RAN) apps, such as the COM5.SDN Radio Intelligence Controller. For a high degree of automation, the controller provides an abstraction of network keys, KPIs and configuration parameters. As this always involves a customer-specific mapping, corresponding clarification is necessary in the run-up to integration.

In its basic role, the COM5.SDN Radio Controller provides the functions of a classic element management system (EMS) with regard to fault, configuration, accounting, performance, and security management (FCAPS). The following overview lists the main functions of the COM5.SDN Radio Controller:

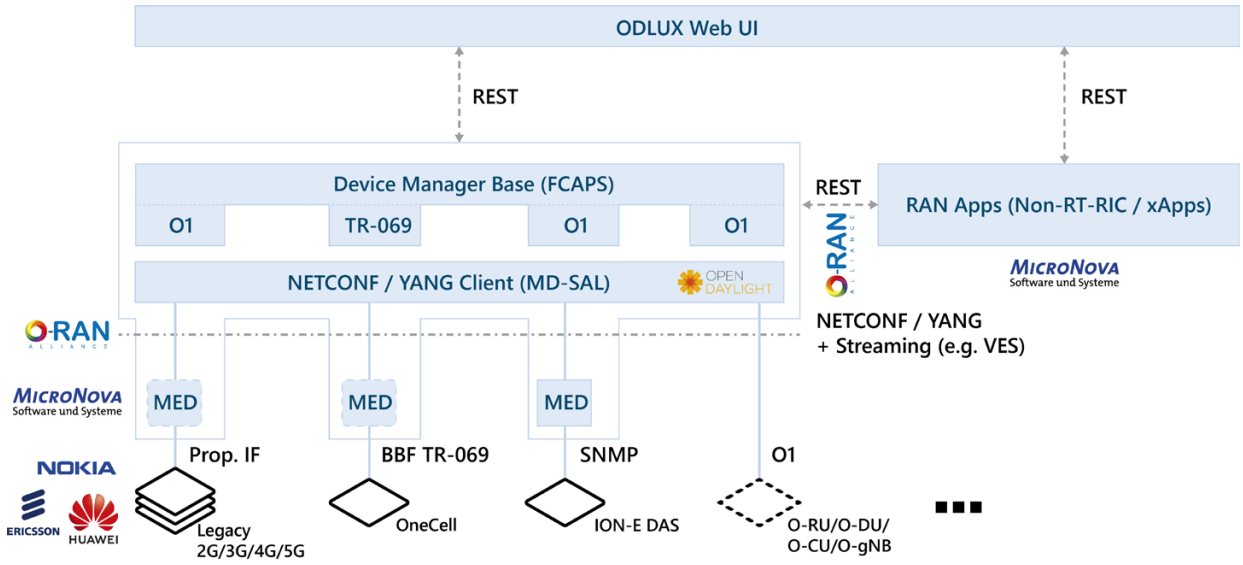
- Reading out the entire network configuration and topology
- Automatically adopting network planning data for the configuration of the static part of the network
- Supporting integration use cases for an initial configuration of the O-RAN components (roll out) while supporting different split scenarios
- Providing RAN resource management
- Reconfiguring and optimizing the network
- Performing RAN parameter changes
- Allowing RAN feature activation/deactivation
- Reading out performance parameters cyclically from the network
- Reading the RAN component error memory
- Providing all parameters and functions via a REST interface for other RAN apps

In its initial implementation, the COM5.SDN Radio Controller was integrated into an ONAP (open network automation platform) environment and realized on the basis of the OpenDaylight framework. The COM5.SDN Radio Controller essentially consists of the following components:

- RAN Configuration Manager
- RAN Statistic Manager
- RAN Topology and Inventory Manager

COM5.SDN Radio Intelligence Controller – AI & ML

The non-real-time-capable COM5.SDN Radio Intelligence Controller (non-RT-RIC) – latency greater than one second – extends the COM5.SDN Radio Controller to include methods from the field of artificial intelligence (AI) and machine learning (ML) or, more precisely, deep learning. The main goal is to support smart RAN optimization. This includes functions such as service & policy management,



2 Setup of the network management layer for an SDN-based RAN with COM5.SDN Mediator, COM5.SDN Radio Controller (device manager base) and COM5.SDN Radio Intelligence Controller

RAN analytics, and AI/ML model training for the near-RT-RIC (real-time controller, latency <1s). The non-RT-RIC can be seen as a closed loop for automated service provisioning including optimization.

Based on the data collected in the network for configuration, performance, and fault management, and combined with the stored operator policies, the COM5.SDN Radio Intelligence Controller generates and optimizes the AI/ML models that are transferred to the real-time controller (near-RT-RIC) for runtime execution via the standard interface (A1). Example models may include: spectrum utilization patterns, network traffic patterns, user mobility patterns, handover patterns, and service type patterns including the expected quality of service.

The combined controller function comprising non-RT-RIC and near-RT-RIC forms the core functionality of modern RAN management and provides the basis for efficient service and quality management (required for network slicing with quality-of-service delivery), as well as automated real-time optimization for mobility and handover management.

The open architecture provides for expansion possibilities through so-called RAN apps. This allows 5G-like RIC functions to be provided to their associated counterparts of these legacy networks using 2G-, 3G-, and 4G-related RAN apps.

Conclusion

In addition to the introduction of 5G, the transition to a complete SDN architecture will keep network operators busy over the next few years and require them to take many critical decisions. It is precisely the choice of new components and the associated vendors that will lay the foundation for the future of MNOs and their economic survival. Topics such as open source in commercial use or open, vendor-independent architectures, combined with political pressure, are creating greater challenges for network operators than ever before.

With the new product line for SDN, MicroNova is expanding its COM5 portfolio to meet these challenges. By partnering with highstreet technologies, and through its membership in 5G Berlin e. V., MicroNova has access to a complete 5G system environment for researching, developing and testing new functions from which mobile network operators and ultimately their customers benefit. Based on proven solutions, COM5.SDN Mediator ensures the secure transfer of legacy networks into an SDN architecture. COM5.SDN Radio Controller and COM5.SDN Radio Intelligence Controller provide solutions for the issues of the future discussed – with a powerful 5G network. ■

Open-RAN, SDN and NFV for Radio Access Networks

With the new COM5.SDN product line, MicroNova offers an O-RAN-compliant solution for operating the Open Radio Access Network.

TEXT: Ingo Bauer PICTURES: © Sylverarts Vectors, yum-yum / Shutterstock.com; © macrovector / Fotolia.com

O-RAN, or Open-RAN, lays the foundation for a standardized, open network architecture and hence for flexible, agile networks and innovative business models. SDN and NFV provide the basis for Open-RAN architecture. One of the biggest challenges in implementing an Open Radio Access Network is developing the necessary virtual network functions, where the focus is on indicators such as scalability and performance.

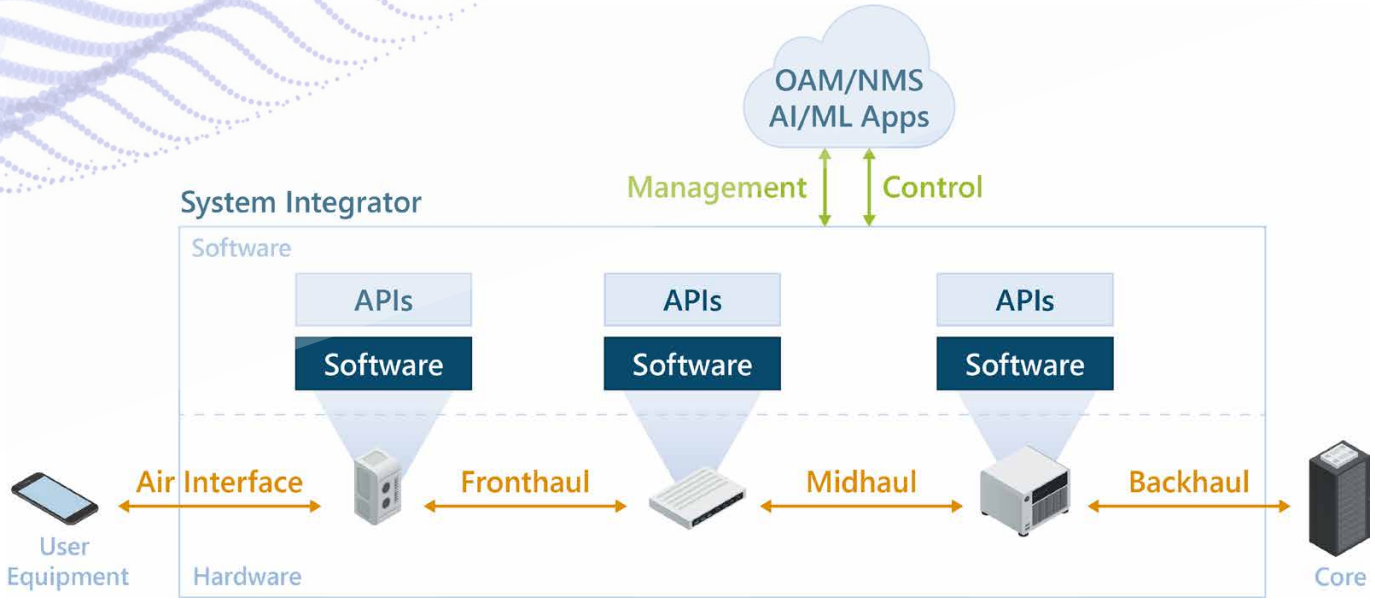
Compared to closed, proprietary systems, O-RAN offers significant advantages for the development and operation of increasingly complex mobile radio networks due to its openness. Studies show that savings of up to 50 percent are possible by using this type of architecture, in terms of both CAPEX and OPEX. The powerful trend towards professional platforms such as O-RAN, developed by the open source community and freely available, provides the basis for function-oriented solutions and apps.

Standardizing these apps allows them to interact seamlessly within their platform, thereby ensuring that specialist companies can develop cost-effective, highly flexible "partial" solutions. With over 15 years of experience in automating the configuration and optimization process for the radio access network, MicroNova is making a significant contribution to the standardization of the O-RAN-O1 interface. This Open RAN management standard forms the basis for the development of the COM5.SDN product family, and is already integrated into the first COM5 applications.

Virtualization as a basis

So far, the use of SDN/NFV has most notably been limited to the core and transmission network (transport). However, the Radio Access Network (RAN) infrastructure represents the largest part of the investment and operating costs of a mobile network operator. This network segment is nevertheless still tied to proprietary hardware and software, limiting companies' flexibility in its deployment and their possible choices. The current political debate on network security and equipment vendors in particular is presenting operators with new challenges.

The emergence of the virtual Radio Access Network (vRAN) and the Cloud/Centralized Radio Access Net-



1 Building a virtualized RAN - Open RAN architecture

work (C-RAN) saw the first attempts to also apply SDN/NFV to the Radio Access Network (RAN segment). The two technologies, or architectures, are primarily concerned with virtualizing and centralizing base band units (BBUs). However, these approaches are based on a proprietary implementation, and they do not eliminate vendor tie-in. Nevertheless, studies by mobile network operators show that the introduction of virtualization technologies can result in savings of up to 50% in OPEX and 30% in CAPEX.

This is why there are growing calls for an open RAN architecture based on standard interfaces. The APIs are intended to ensure that it is possible to interconnect RAN components – RRUs (remote radio units) and BBUs, including core connections – from different vendors. This so-called Open-RAN architecture is basically not a new concept. Major mobile network operators have invested heavily in research, development, and field trials in recent years. This topic has been essentially driven by two organizations.

» The Telecom Infra Project (TIP), founded in 2016, is an association of network operators, service providers, software vendors, and integrators that aims to redefine and drive forward classic concepts for the construction and provision of telecommunications infrastructure. An essential aspect is to develop, test, and provide standardized, open, and disaggregated solutions (with the separation of hardware and software components).

» The O-RAN Alliance is a consortium founded by international network operators in 2018 to further develop RAN technology. The focus is on the introduction or specification of a new, open, fully programmable RAN based on software modules and commercially available hardware (components-off-the-shelf; COTS), so that BBUs and RRUs from different vendors can communicate seamlessly with each other.

An important step in the development of the Open RAN ecosystem was an agreement between the two organizations to exchange information and reference specifications and to conduct joint proofs of concept and integration testing. The most important concepts of the O-RAN architecture are briefly outlined below:

Openness

The openness or standardization of interfaces is the most important aspect of the concept. For it is only then that easily adaptable, scalable, vendor-independent radio networks can be built. It is precisely the open interfaces that support the provision of multiple vendors, thereby enabling a competitive and dynamic vendor ecosystem. This is particularly important for smaller radio network operators in order for them to be able to introduce their own services or adapt the network to their requirements.

Intelligence

The network is becoming increasingly complex with the introduction of 5G and the flexibility it brings with new services, classes of service, assured quality, and network slicing, etc. Conventional methods do not allow this complexity to be controlled, and it is therefore more difficult and costly to deploy, optimize, and operate the network. Automating the most important use cases for integration as well as optimization and quality assurance is therefore vital to operate the network economically.

The use of new methods from the field of artificial intelligence is becoming increasingly important to enable the dynamic allocation of radio resources and to automatically optimize the efficiency of the entire network. AI-optimized closed-loop automation can be achieved in combination with open interfaces, potentially heralding a new era of network operation.

Software-Defined und RIC

The key principle of the O-RAN architecture is to extend the SDN concept, i.e. to decouple the control plane (CP) from the user plane (UP) to the RAN. Furthermore, the introduction of AI methods both on the network side (near-real-time-RIC) and on the management side (non-real-time-RIC) is an O-RAN Alliance paradigm.

RAN-Virtualization

An essential aspect of the O-RAN architecture concept is the "cloudification" of the RAN. It is based on a division (disaggregation) of the radio access network into two areas: firstly, a separation of hardware and software, or control plane and user plane (CP/UP-split), and secondly, a functional split of the base station into the following:

- **RU – Radio Unit:** The radio unit comprises the transmitting and receiving unit including the transformation of the analog radio signal into digital signals to be forwarded to the DU. In addition to functionality, factors such as size, weight, and power consumption are decisive criteria for the design of the RU.
- **DU – Distributed Unit:** This is the distributed unit located near the RU. It contains a subset of the classic eNB/gNB functions (RLC, MAC, and parts of the PHY layer). It is implemented in legacy systems on proprietary hardware (BBUs). As part of the O-RAN concept, it is planned to implement it as a software solution, executable as a virtualized element on standard COTS hardware.
- **CU – Centralized Unit:** The centralized unit contains all the functions of the higher protocol layers (RRC and PDCP layers).

The main benefits of this split architecture are scaling and the introduction of vendor-independent hardware components for the RAN. The latter aspect has a positive effect on CAPEX and OPEX. It also provides the basis for the introduction of new technologies such as mobile edge computing (MEC), which enables a significant increase in performance and less latency in the radio access interface.

Nevertheless, the implementation of a virtual RAN places enormous demands on the underlying infrastructure. Performance improvements, reliability, and low latencies can only be achieved with an appropriate fiber optic network between the units concerned.

Standardized Interfaces

The O-RAN architecture defines and standardizes interfaces between the individual components of the disaggregated RAN. The aim is to achieve true interoperability between the components and thus be able to use different device manufacturers. Besides the introduction of open source (see below), this is the most important issue for a flexible, vendor-independent network.

White-Box Hardware

In addition to the interfaces, the O-RAN Alliance has set itself the task of specifying and standardizing the hardware for base stations to a significant extent – so-called white-box hardware. The reference platform supports separate methods and provides detailed diagrams of the hardware and software architecture for BBUs and RRUs.

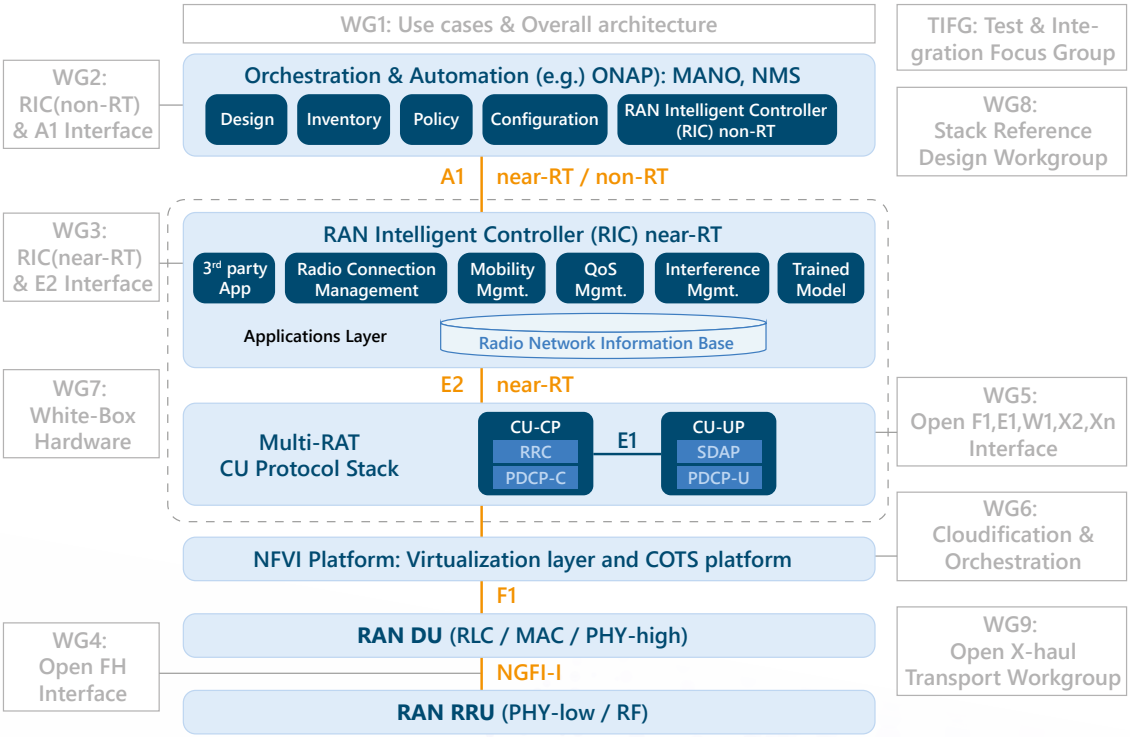
Open Source

The O-RAN Alliance mainly relies on the open source community for the implementation of a reference application and provides it with significant assistance. Many components of the O-RAN architecture are made available through the community as open source, including protocol stacks, PHY layer processing, the virtualization and orchestration platform, etc..

By transforming the RAN from a closed, vendor-specific system environment to an open, standardized, multi-vendor, AI-based, hierarchical controller structure, there is also the option of allowing third-party vendors access to the RAN. In this way, O-RAN also enables third-party providers such as MicroNova or network operators to develop innovative services as so-called RAN apps. The O-RAN platform (SMO – service management and orchestration framework) can thus be seen as a first RAN app store.

Conclusion

By participating in the standardization of the O1 interface, MicroNova is making a significant contribution to the development of the open RAN management standard. The resulting innovative strength benefits all parties involved – MNOs as well as other technology companies, since it enables them to develop new services and business models. ■



2 O-RAN-Alliance (Architecture in Workgroups)

COM5.Mobile – the Road to the Optimal Radio Access Network (RAN)

With the introduction of 5G, operators are once again facing the challenge of integrating a new radio technology into their existing network. COM5.Mobile offers powerful functions to automate this process in the RAN.

TEXT: Ingo Bauer

Besides optimum coverage, the consistent and error-free configuration of the Radio Access Network (RAN) is crucial for both the network quality and the quality ultimately perceived by the customer. Standard software provides mobile network operators (MNOs) with network and service monitoring as well as network optimization, albeit there is usually a gap in network configuration. However, this forms the basis for an efficient network structure and expansion as well as for the integration of new technologies – and consequently for a high-quality and profitable mobile communications network.

The reason for this gap lies in the complexity and versatility of network configuration, which is difficult for standard software to replicate. Mobile radio technologies are standardized specifically for UMTS, GSM, LTE and 5G within the framework of the 3rd Generation Partnership Project (3GPP). Yet worldwide cooperation between standards bodies in mobile communications can only ensure abstraction or certain network parameters that are independent of providers. Some figures illustrate this challenge: The 3GPP standard includes about 100 to 150

parameters, but the actual implementation of the specific manufacturer and supplier configuration requires several thousand settings.

Proprietary solutions are not agile

Network equipment providers have already tried to close this gap with various approaches. However, as soon as system boundaries between different vendors have to be taken into account (multi-vendor capability), the corresponding concepts usually reach their limits. As a result, network operators sometimes take action themselves by developing their own, often complicated, tools. However, the solutions that have emerged over the years are not only complex and expensive, they are also becoming increasingly outdated. This is all the more true when looking at the rapid development of mobile technologies. New functions and network technologies, software updates, switching to another network supplier – all of these are difficult to implement with concepts of this kind.

What's more, such in-house creations are often pure one-way solutions: the live network can be configured, but it is not possible to copy data from the live network to the planning network. This functionality, however, is invaluable for network operators when it comes to quality assurance, since reliable network auditing is only possible by alignment with planning data. A complete view of the network is essential for MNOs to both plan investments in the network and comply with quality guidelines.

More flexibility through open solutions

The configuration of mobile radio networks and in particular the Radio Access Network (RAN) is becoming increasingly complex for network operators – especially with the introduction of ever newer technologies, namely 5G.

Therefore open solutions such as COM5.Mobile are essential: they offer flexible and vendor-independent adaptability to new conditions while at the same time taking into account the main control parameters such as time-to-market, quality and efficiency. COM5.Mobile streamlines the visibility of the often heterogeneous regional network and management structures and allows for growth into a central database for overarching comparisons.

Newly designed for the optimum RAN: COM5.Mobile

MicroNova has redesigned its tried-and-tested COM5.Mobile to address these challenges. The product portfolio now includes COM5.Mobile Audit for monitoring and reviewing network consistency, COM5.Mobile Optimizer for optimizing the radio access network and COM5.Mobile Integrator for automated support of roll-out and integration processes, for example as part of the introduction of 5G.

The entire product range can be customized to the growing needs and network sizes of mobile operators and is ideally equipped for the integration of future mobile communications generations (5G). Investments can be quickly integrated into the live network, which has a direct positive effect on sales. COM5.Mobile makes network expansion much more efficient for operators, as the maintenance effort remains low even for larger networks.

COM5.Mobile Audit: Keeping an Eye on the Entire Network

A detailed, comprehensive view of the network configuration is not something that MNOs can take for granted. The problem: Incorrect or inconsistent base station configurations lead to considerable quality losses, which can also have a negative impact on end customers and their user experience. An increase in the dropped call rate is just as possible as connection problems or poor voice quality.

With COM5.Mobile Audit, MicroNova offers an out-of-the-box solution for the complete visualization of network parameters. The current live network with all relevant information for the MNOs can be read out independent of manufacturer, region and technology. The corresponding information is written to a central database in structured form so that it is available for audits and analyses at any time.

Network history

An automated delta calculation determines the configuration differences from the previous import and stores them in a cumulative database, which is especially helpful for MNOs. A logged history of the network configuration, including trends, can be displayed as configurable reports according to freely selectable criteria. In addition to logging network growth to manage it, the history database can also be used to troubleshoot specific network areas.

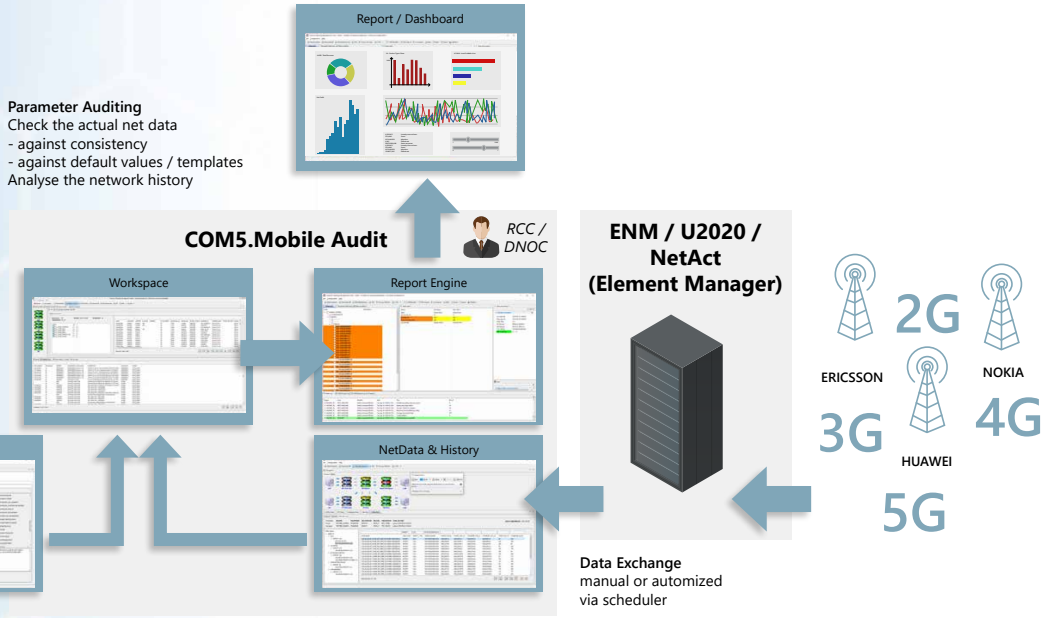
Content consistency check

The first step of network auditing takes place within COM5.Mobile Audit: The system checks the consistency of the imported live data via an integrated rule-based engine; a user-friendly graphical interface makes administration of the corresponding rules an easy task. Any violations are logged according to their severity (blocking/warning) and presented to the user via reporting mechanisms. An optional dashboard also allows the results to be displayed in a configurable overview for even greater ease-of-use and efficiency in troubleshooting.

COM5.Mobile Audit comes ready "out-of-the-box" with a set of standard consistency rules that the user can expand on as needed. The most common rules include checking handover connections (number of handovers per cell, target frequency, etc.), frequency plans, cell parameters, dependencies between parameters,

Added value with Artificial Intelligence

MicroNova's years of expertise provide the perfect foundation for mobile network operators' AI projects. MicroNova already successfully carries out corresponding consulting projects in other business areas – however, the large amount of data means it is possible to transform these into valuable information, especially in the mobile phone sector. Industry know-how is the key to transforming our experts technical knowledge into real added value for users.



user-specific dependencies and compliance with operator requirements. Basic functionality includes the creation, deletion and editing of consistency checks and rules. Users can also create new rules based on copies of existing ones. It is also possible to exchange rules with other users.

COM5.Mobile Audit considers all parameters available through the vendor's standard OSS Northbound Interface (NBI), including parameters that may have been configured automatically by a Self-Organizing-Network-System (SON). Thus the solution is "SON-ready", i.e. capable of interacting with and monitoring SON systems. With configurable rules, MNOs can generate reports and warnings at any time with COM5.Mobile Audit.

Network-wide management of standard templates

Another important functionality of COM5.Mobile Audit is the support of MNO-specific default values (default templates) across the entire network. Users can easily create configuration templates according to specific criteria and reconcile them with the live network. Possible configurations include on-premise and remote stations, stadiums, events, etc. All imported network configurations are archived and are available for further comparisons and analyses (history function). This also makes it possible to monitor service level agreements (SLAs) between network operators and third parties (managed service).

Thanks to vendor-neutral and cross-technology comparisons, MicroNova's audit system can exploit its strengths especially in a multi-vendor network. In this case, the standard functions of proprietary systems are usually inadequate. Since COM5.Mobile Audit already stores a complete map of the Radio Access Network (RAN) – including history – in a central database, the system can be used as a cross-network data source for comparison with other systems. Examples include inventory, optimization, and measurement.

Conclusion: Optimum user experience with COM5.Mobile Audit

Knowledge is power – Francis Bacon's axiom applies more than ever in the 21st century. And it also applies to MNOs: It is only with complete knowledge of all relevant parameters of their network that they have the power to maximize the user experience for their customers and – consequently – their own revenues. COM5.Mobile Audit ensures that network providers can get the most out of their network investments.

COM5.Mobile Optimizer – the Next Step toward an Optimized Network

COM5.Mobile Optimizer is based directly on the Audit solution. It is particularly suitable for optimizing radio parameters, which the user can access directly via a powerful data editor. Two different views are possible, either in the vendor-specific standard model or in a model customized to the user's requirements (simplified model).

The editing function also makes it possible to systematically change parameters and make associated global changes. In addition, new radio neighborhoods can be added, and existing ones edited or deleted. By integrating consistency checks, the solution detects deviations and data errors early so MNOs can fix them immediately.

Integration into the MNO's optimization processes

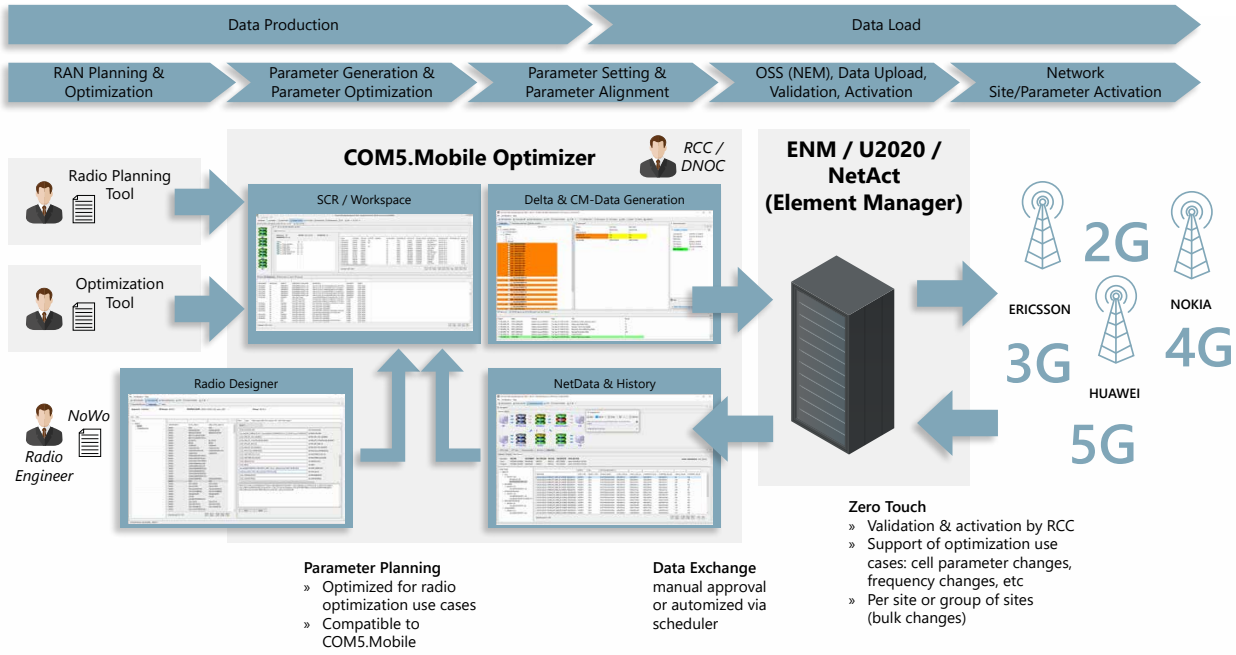
A configurable interface also allows third-party optimization tools or standard radio network planning tools to be connected directly – this simplifies integration into the network operator's processes. Engineering policies control the automated assignment or adaptation of parameters imported from these tools. The use cases supported during import can be completely adapted to the customer's needs or configured accordingly. All dependent parameters are automatically adjusted on the basis of the technical policies defined by the respective network operator. This ensures compliance with required KPIs.

During this process, the consistency of the altered data is checked again and finally reconciled with the current live network ("smart delta"). The system recognizes incorrect neighborhoods or inconsistencies with regard to technical specifications and displays them in this delta; the result is structured as a hierarchical tree and displayed according to use cases. Operators can use filter rules to delimit the set of configuration results, and activate them directly in the live network via the zero touch functionality.

The Radio Designer for better technical efficiency

In the Radio Designer, a technician or engineer can directly create or change engineering policies, as well as consistency rules and parameter templates. Classification of parameters reduces the complexity of their scopes, which can be adjusted manually by network planners/optimizers, by up to 90 percent. The basis for this increase in efficiency is the specified rules and standard requirements or network-wide parameter sets (NWP templates).

Before a new parameter configuration is released as a valid data set, COM5.Mobile Optimizer checks the new version for completeness and consistency using predefined and/or user-specific validation rules. The main advantage for mobile network operators is that it shortens development times and minimizes the impact of additional specification changes.



The operator or engineer can make minor changes to design and manufacturer specifications during the test and/or acceptance phase – thereby ensuring a significant increase in flexibility during these phases. This method ensures compliance with the standards prescribed and verified by the network operator, both in the planning process and during the subsequent transfer to the network.

Conclusion: Multi-vendor approach eliminates vendor dependency

The multi-vendor capability ensures compliance with the engineering rules across vendors, technologies, and regions. This shows that COM5.Mobile in general and COM5.Mobile Optimizer in particular are especially powerful, since tools both from equipment suppliers and SON solutions available on the market are reaching their limits in this regard. It remains to be said, that every MNO that operates equipment from more than one supplier or is active in more than one country benefits from COM5.Mobile in terms of efficiency, quality, and time-to-market.

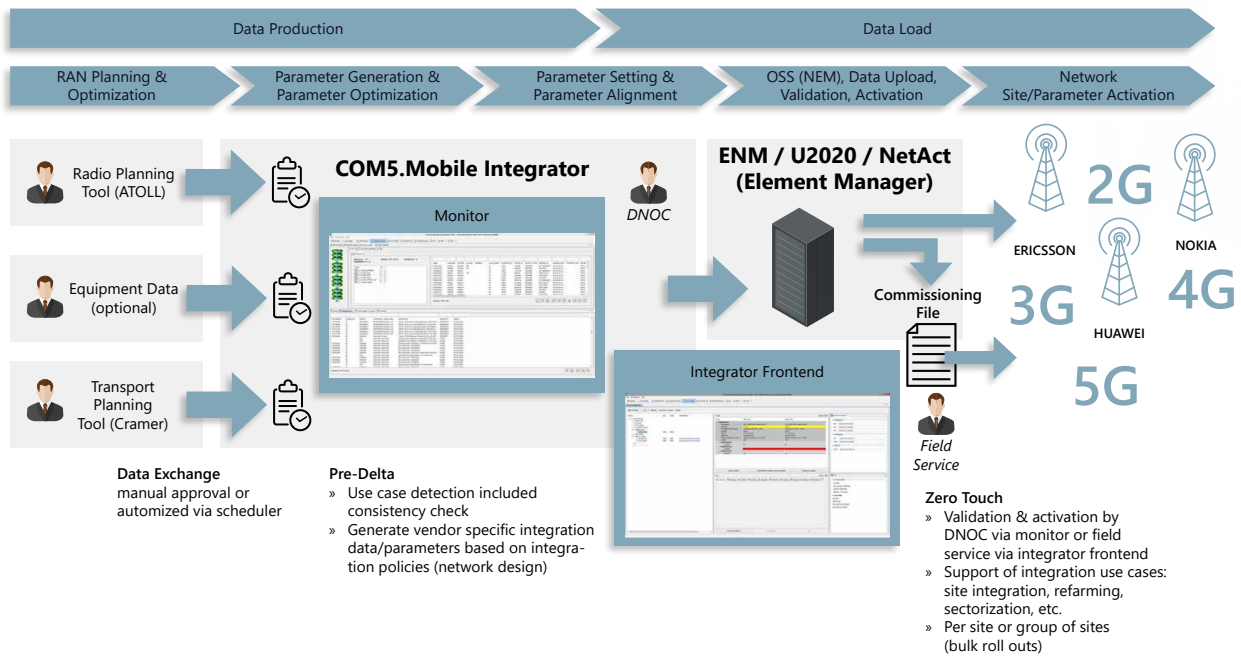
COM5.Mobile Integrator – for an Automated Network Roll-out Process

Like the Optimizer, Integrator is also based on Audit. This product from the COM5.Mobile family complements the capabilities of its sister solutions and is specially designed to handle use cases relating to the roll-out and integration of radio parameters. Site integrations, rehomings, network upgrades as well as changes in hardware and transmission are examples of areas of application.

To perform these tasks, the tool has connectivity to the radio, transmission, and equipment network planning tools. In addition, the active network can be addressed via the vendor-specific standard NVB interfaces. Similar to COM5.Mobile Optimizer, corresponding engineering policies form the basis for integration tasks in the respective fields of application.

Improving planning consistency

COM5.Mobile Integrator checks the consistency of radio, device and transport planning data during import. If there are variances, users can correct the relevant parameters directly in the tool. The respective data records can only be transferred to the net-



work after this delta analysis has been passed – provided that they have been approved by the respective operator. Additionally, a "pre-delta mechanism" calculates all open and valid integration tasks on the basis of the available planning and current live data.

Then COM5.Mobile Integrator creates the corresponding configuration files, which can be activated in the network if required. The commissioning file can be accessed remotely via a special front-end, e.g. by a field service technician, and downloaded if required. At the same time, a monitor displays the integration status of the tasks. This can also be provided in report form at any time. An integrated scheduler allows work steps to be bundled, opening up the possibility of automating most processes.

Conclusion: An investment to safeguard quality

Like the other products of the COM5.Mobile family, the Integrator follows the zero-touch concept. With this user-friendly approach and comprehensive functionality, MicroNova has created a tool for MNOs that maximizes roll-out efficiency and quality for current and future 5G networks. Thanks to automation and extensive testing, this is accompanied by a high level of quality in the network. ■

The Use of COM5.Mobile at Vodafone

Interview with Klaudius Koschella, Head of Central Optimization & Config Center at Vodafone GmbH in Düsseldorf, Germany. The editor talked to him about the use of COM5.Mobile at Vodafone.

TEXT: Editorial staff

Editor: Mr. Koschella, Vodafone operates mobile and fixed line networks in several countries, managed via the central Network Operations Center, also known as NOC. How does COM5.Mobile help you?

Klaudius Koschella (KK): At Vodafone we are continuously working on measures that will give us additional scaling effects. We have global organizational structures at our disposal for this reason. They combine the central functions of all Operative Companies, OpCos for short, i.e. the different legal entities in the different countries. With the NOC we can integrate a number of functions for several areas of our network into one central organization and for all OpCos. These include network monitoring, first level support, back office operations and config management. This results in numerous options for the best possible and most effective deployment of the tools used. COM5.Mobile is used in our Network Operations Center via the so-called Operating Model which organizes our processes and responsibilities.

Local teams have been interacting with the NOC for quite some time for Vodafone Germany and jointly they look after "production" and our mobile roll-out using COM5.Mobile, among other things. COM5.Mobile supports both this process and the associated division of work in the best possible way.

Editor: When looking at size and scope, questions about automation, zero touch, etc. come to mind almost automatically. What is the status quo here, and where do you want to go?

KK: I'd like to be a little more specific regarding this question. For us, the focus is on digitalization. This includes automation and zero touch, but also the use of Machine Learning (ML) and Artificial Intelligence (AI) on all levels of our processes. We are currently working very hard on digitalization options. This concerns the use of bots, which would allow us to have simple process steps completed by a "machine". We're also using machine learning to access pattern recognition or to identify anomalies in various application areas, and to integrate them successively into existing processes and procedures. With zero touch and automation, we have already handed over work steps completely to being processed by a "machine" in the context of COM5.Mobile. By now, we have some initial experience of how our technical experts can work with a fully automated process and increase their productivity. What's most important in this kind of digitalization hub: we create space for development. If competent employees can focus on more complex topics and ultimately solve tasks for the benefit of our end customers, this will bring much more benefit than a purely internal increase in productivity.

Editor: You mentioned Artificial Intelligence and Intelligent Automation. What potential and what steps do you expect here in general and in relation to COM5.Mobile?

KK: Currently, artificial intelligence is used maybe a bit hasty and thoughtless as the next logical step towards digitalization. In my opinion, most notably we're starting to get involved in machine learning. But of course this is not the same as AI – we are still a bit away from comprehensive applications. This can be explained by the fact that we do not yet have any experience where machines have made decisions, never mind that we wouldn't let them, unchecked as it were, lead to an action being taken in our networks for example. But we have already achieved good results with ML, and have already incorporated some of these results into production. One example of this is the recognition of image patterns. If we look at the potential, especially in the areas of configuration or general production processes, there are many possibilities for automation. Whether it is to enable tools such as COM5.Mobile in that respect and get them further developed, or to migrate analog processes to digital and automated ones.

Editor: What challenges do you see – not just in relation to COM5.Mobile?

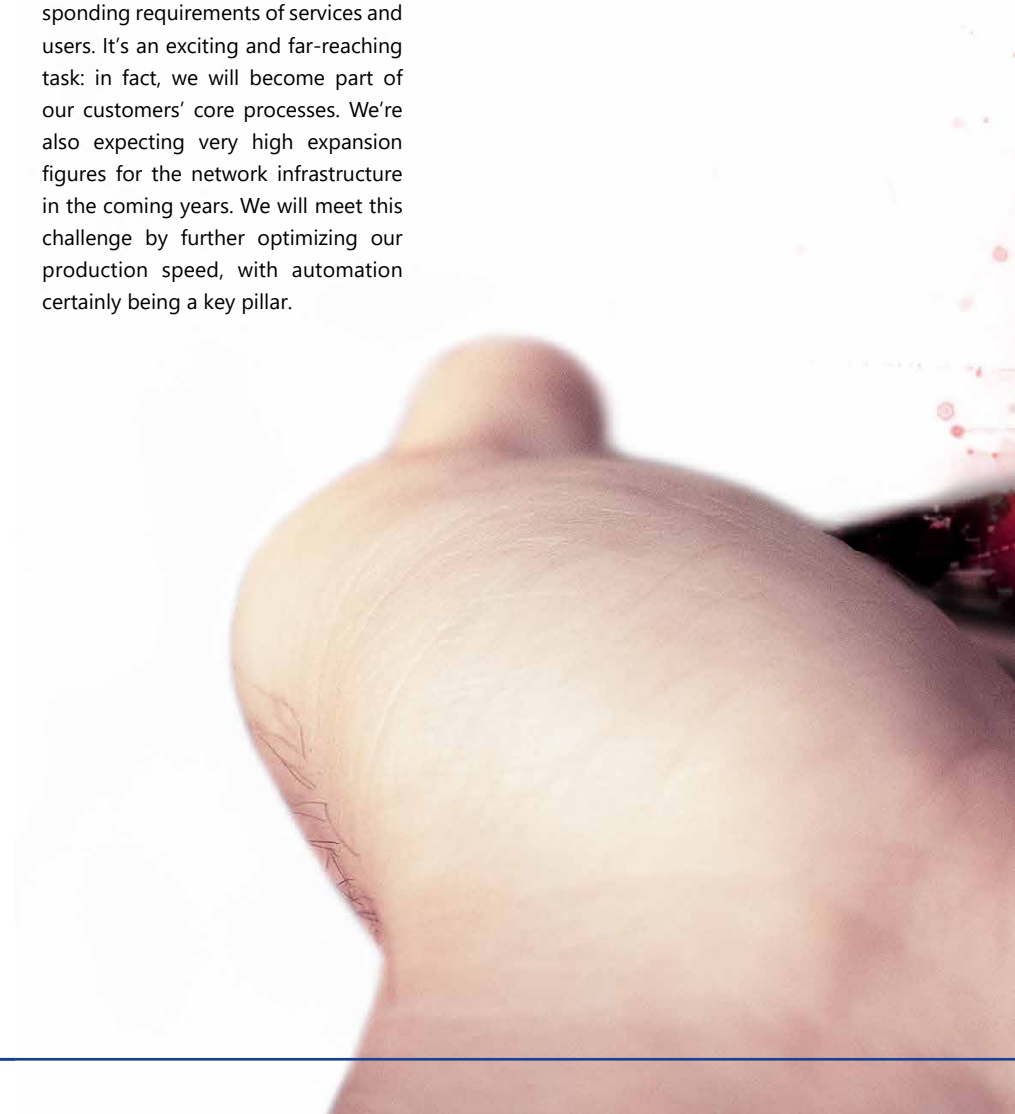
KK: First of all, we will succeed in dealing with the technological aspects for sure. One of the challenges rather is the fundamental decision whether we can make selective adjustments to current processes and tools, and consequently achieve initial automatisms and efficiency gains, or whether an overarching redesign of processes and tools is the better approach. Both approaches are equally valid! In any case, the goal must be to develop an end-to-end concept for digital processes and tool design. But we also have to include employees and stakeholders and consider their dependencies ... This means that with a selective approach, we have enough time and freedom to work with our colleagues to design automation and ultimately digitalization, and not to lose them on the way. I am convinced that digitalization starts in the mind and first has to gain a foothold there. A little more time is still needed in this respect. Nevertheless, we want to keep an eye on the overall end-to-end approach outlined above. In the medium term, the complete automation or digitalization of full process and tool chains must be considered. New technologies and the resulting processes should always be seen as an opportunity to apply all digitalization options from the outset. So we already take this into consideration when inviting tenders on new topics. 5G technology will not work without maximum automation. I am certain that COM5.Mobile will keep pace with a growing share.

Editor: Referring back to what has been said so far, what are your expectations and plans, and what are the challenges for the 5G roll-out or network expansion?

KK: 5G will make it possible to explore new horizons. New services and applications will emerge. I'm thinking, for example, of industrial applications that will allow production processes to be more flexible than previously imagined. 5G is also the key to self-driving vehicles. I also see potential in the end customer segment: completely new worlds of experience will become available to users, for example via augmented reality. At Vodafone, we have already implemented some of these new 5G-based capabilities. Many other services will soon follow and present us with new challenges and new potential. We intend to rethink our operating model and our production processes and focus on the corresponding requirements of services and users. It's an exciting and far-reaching task: in fact, we will become part of our customers' core processes. We're also expecting very high expansion figures for the network infrastructure in the coming years. We will meet this challenge by further optimizing our production speed, with automation certainly being a key pillar.

Editor: One last technical question: how would you rate Software Defined Networks (SDN) and Network Functions Virtualization (NFV) in the 5G context?

KK: SDN and NFV form the fundamental architectural basis of 5G standardization through 3GGP. The concepts introduced years ago from the "traditional" IT environment are increasingly changing telecommunications providers' network infrastructures and systems. Approaches for software-based networks, such as the virtualization of systems and network components, cloud computing or mobile edge, create the foundation for getting to grips with the flexibility



and new services called for by 5G, both from the point of view of operating costs and capital expenditure. At the same time, operational processes will have to adapt to these conditions and be automated as far as possible. The use of AI methods to secure future 5G services will play an essential role. Of course, it's a constant process, and further network topologies must be introduced. We will also rely on appropriate tool support, such as COM5.Mobile, for example. Because such tools are there to reconcile functionality and cost.

Editor: Mr. Koschella, thank you for this interview. ■

„With zero touch and automation, we have already handed over work steps completely to being processed by a "machine" in the context of COM5.Mobile. By now, we have some initial experience of how our technical experts can work with a fully automated process and increase their productivity.

– Klaudius Koschella,
Head of Central Optimisation
& Config Center,
Vodafone GmbH

Interview with: Reinhard Jahn (Telefónica Germany)

Reinhard Jahn is Head of OSS Engineering at Telefónica Germany GmbH in Munich. InNOVAtion talked to him about the "new" COM5.Mobile.

TEXT: Editorial staff PICTURE: © Corona Borealis Studio / Shutterstock.com

InNOVAtion: Mr. Jahn, Telefónica Germany is the "midwife" of COM5.Mobile, what does its productization mean for your company?

Reinhard Jahn (RJ): With MicroNova as our partner, we have been very successful over the last two decades in implementing the possibility of daily delivery of radio configuration data to our Telefónica radio network. Thanks to this long-term cooperation, we have of course been able to provide feedback on what future developments should look like. The aforementioned productization of COM5.Mobile has given us the necessary flexibility and a very good time-to-market to support the introduction of new features to our network in a fast and reliable way. This plays a very important role, especially with the rollout of 5G now beginning and our extensive 4G rollout.

InNOVAtion: The introduction of the COM5.Mobile Optimizer and Integrator has also brought about a conceptual reorientation. What is it that you find particularly convincing?

RJ: With the Integrator, we now can quickly and reliably carry out the daily configuration of new radio stations as well as modifications within the network. This gives us the necessary freedom and the technical possibility to execute both our continuing 4G rollout as well as the 5G rollout in a highly efficient manner. With the Optimizer, we have given our employees working to optimize the radio network an additional practical tool with direct added value. It allows them to make major improvements to the network on a daily basis, creating the best possible experience for our many millions of customers. It is a very significant step forward for us to be able to set essential parameters ourselves.

InNOVAtion: What functions would you like to see in the future? What potential do you see for future configuration systems?

RJ: Looking to the future, I would like to see further development towards zero touch integration. This capability will play an important role with the advancing "cloudification" of networks and the introduction of Open RAN. We expect fundamental changes in the entire software and network architecture, especially with a view to the future of 5G. The requirements and flexibility in mobile networks will need to increase significantly if the service classes standardized in 5G are to be used economically. In this respect, we are also focusing on future-oriented and expandable solutions. As complexity grows, the degree of automation in the integration and optimization process is becoming increasingly crucial in order to make the best possible use of the high network investments in the mobile communications market. This will therefore also be a key point in the catalog of requirements for such config systems.

InNOVAtion: The Radio Designer integrated into Optimizer significantly improves time-to-market. How important is this function for you and ultimately for your company's customers?

RJ: The introduction of a new technology in particular is always associated with a variety of tasks and challenges for network operators, which is a completely natural process. However, an enormous amount of experience is required to ensure smooth integration into existing networks – our employees have that experience. What is more, a great deal of flexibility is also required when it comes to the efficient adaptability of the tool landscape. And that is what our partners and their solutions achieve. Introducing Radio Designer, part of the COM5.Mobile Optimizer, enables us, for example, to integrate new features and functions into our network and make them available to our customers faster. This configurability naturally saves us costs, but above all it allows us to take our customers' network experience to an even higher level as quickly as possible, and to do so in a tangible and measurable way for all relevant areas of application.

InNOVAtion: Mr. Jahn, thank you very much. ■

Telefónica Deutschland

"The requirements and flexibility in mobile networks will need to increase significantly if the service classes standardized in 5G are to be used economically".

– Reinhard Jahn,
Telefónica Germany

New cooperation for 5G technologies

Cooperation on Software-defined Networking (SDN) and Network Function Virtualization (NFV) – 5G Technologies in Focus.

TEXT: Editorial staff PICTURE: © NanamiOu / Shutterstock.com

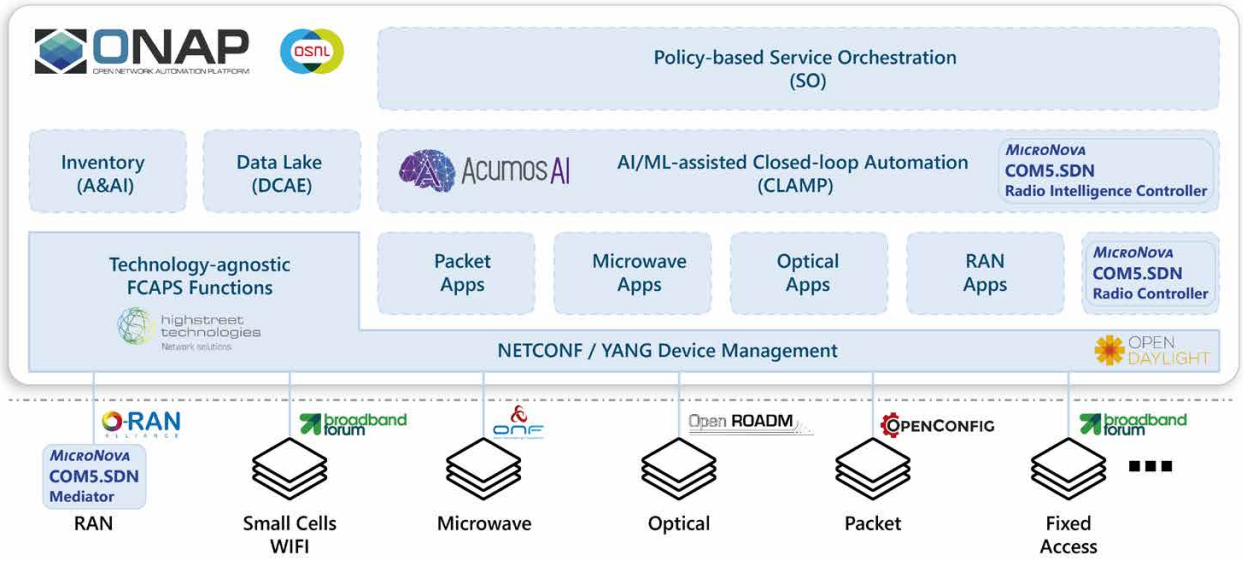
MicroNova and Berlin-based highstreet technologies GmbH have been officially working together as partners since October 2020. The particular objective is to support mobile network operators (MNOs) with the introduction and operation of 5G and the associated technology shift.

highstreet technologies and MicroNova aim to help major MNOs to further optimize the configuration and operation of their networks with projects based on SDN technology. In this context, MicroNova is already involved in the "Open SDN & NFV Lab" (OSNL) in Berlin, which was brought to life by highstreet technologies; the OSNL is also affiliated with the 5G Berlin e. V. innovation cluster, of which MicroNova is a founding member.

"Thanks to our partnership with highstreet technologies and the OSNL, we have been able to add COM5.SDN to our product portfolio alongside COM5.Mobile, with some key product variants for software defined networks. This puts MicroNova in a position to offer an integrated SDN solution to operators of public networks and especially in the new 5G-driven market segment of campus networks," explains Ingo Bauer, Head of Product Management Telecommunications at MicroNova.

Open Source Ecosystem for 5G Use Cases

The OSNL has a powerful infrastructure and an ecosystem based on open source, the Open Network Automation Platform ONAP, allowing SDN/NFV applications to be developed, tested and integrated. This enables highstreet technologies and MicroNova to map complete end-to-end use cases for 5G for MNOs – from the implementation of proofs of concept and the realization of research projects to the development of commercial carrier-grade solutions.



1 The OSNL Ecosystem

"The range of applications in the 5G sector, from the smart city to networked vehicles, appears to be unlimited," explains Alfons Mittermeier, Managing Director of highstreet technologies GmbH. "Our team has extensive knowledge of dedicated wireless technologies. Combined with MicroNova's long history in the mobile environment, this will enable us to jointly offer comprehensive end-to-end solutions, including training and support."

Supporting New Business Models for Mobile Network Operators

"Our companies have already been following a common path for a number of projects and customers for some time," explains MicroNova CEO Dr. Klaus Eder. "We will now further formalize and strengthen our partnership, both in technological terms as well as from a commercial point of view. We see an opportunity to work together to offer mobile communications companies in the 5G environment significant added value, for example in the areas of consulting for engineering, artificial intelligence, and machine learning or in the integration of services. This will ultimately help MNOs to offer their customers new services and enable new business models." ■

About highstreet technologies

The telecommunications and software experts at highstreet technologies have a long track record in developing network management systems. Since 2015 they have been applying their expertise to the new world of SDN & NFV. highstreet technologies has gained extensive experience in the integration of transport and RAN equipment into the SDN & NFV platforms OpenDaylight and ONAP through the technical management of ONF, ONAP and O-RAN PoCs. As an active member of the O-RAN Alliance, the highstreet technologies team makes a significant contribution to the standardization of APIs. In addition, highstreet technologies contributes open source software to ONAP and tests ONAP in OSNL, the Open SDN & NFV Lab in Berlin. The company, together with partners such as MicroNova, operates an ONAP installation as part of the 5G Berlin e.V. innovation cluster, an association of universities, research institutes, and companies, from which a largely O-RAN-compliant 5G network in central Berlin is managed. highstreet technologies is currently assisting several network operators in the USA and Europe with the introduction of ONAP.

Interview with: Professor Dr. Erich Zielinski (5G Berlin)

Professor Dr. Erich Zielinski is Chairman of the Board of 5G Berlin e. V., of which MicroNova is also a member. The editorial staff of InNOVAtion talked to him about the association's activities and test site as well as the Berlin 5G network.

TEXT: Editorial staff PICTURES: © Suwin, Iaremenko Sergii / Shutterstock.com; © 5G Berlin e. V.

InNOVAtion: Professor Dr. Zielinski, the 5G Berlin e. V. association was founded in September 2018. What have the association and its members – now a good one and a half years' later – been able to achieve?

Erich Zielinksi (EZ): A lot has happened, both in the acquisition of new projects as well as in the proof of concepts and networking. Among the new projects referred to above, it is worth mentioning that 5G Berlin is now an associate partner in the 'OTB-5G+' project, which is funded by the German Federal Ministry of Education and Research. This involved the joint development of 5G infrastructure on the campus of the TU Berlin and the Heinrich Hertz Institute, which also goes by the abbreviation HHI. We are currently planning the implementation of application scenarios for the smart city. In addition, we have started an industrial project with a well-known cloud company, where 5G infrastructure has also already been set up on the campus of the Fraunhofer Institute IPK in Berlin. Specifically, one 5G macro and a number of metro stations were set up. Initial trials were concerned with the implementation of industrial application scenarios, for example in the field of controlling automated guided vehicles (AGVs) and the use of artificial intelligence for video inspection.

InNOVAtion: These are indeed exciting projects – you also mentioned proof of concepts at the beginning?

EZ: At this juncture I can report on two proof of concepts. The first involves drone control via a 5G radio link in preparation for fire-fighting and emergency operations, with video streams transmitted using end-to-end encryption. The second aims to evalu-

ate the connectivity of emergency vehicles and the transmission of patient data over a 4G/5G infrastructure. As you can see, these are very practical approaches that quickly many people could benefit from.

InNOVAtion: And what has happened in terms of networking?

EZ: With regard to networking, 5G Berlin e. V. arranged a session for the first time as part of #Berlin5GWeek, which took place at Fraunhofer HHI on November 5, 2019. HHI hosted the workshop 'Machine Learning for 5G and Beyond' which was organized by the 'ITU-T Focus Group on Machine Learning for Future Networks including 5G'. The session with 5G Berlin offered members the opportunity to present their own topics. One of these topics was the OpenRAN Alliance, which is committed to establishing open interfaces within a 5G network.

We were also able to conclude a cooperation agreement with the Next Generation Mobile Networks Alliance, and we are planning to participate in the NGMN Industry Conference & Exhibition 2020 in Paris in September, if it takes place. One of the things we would like to do there is to present the activities of 5G Berlin e. V. at a joint stand with the Fraunhofer Gesellschaft. In addition, we were the speakers at the 15th Tagesspiegel 'Data Debates' with the topic '5G-Laboratory Berlin: How smart will the capital be'.

As you can see, we are quite an active association, which is also reflected in the increased number of members. Especially in the 5G Core competence area, the association was able to gain new members spanning a multitude of interfaces. These approaches will also be incorporated into the aforementioned OTB-5G+ project, resulting in a flexible infrastructure.

InNOVAtion: The 5G Berlin e.V. provides a fully-fledged 5G network where new use cases can be developed and tested under real conditions. What role do you think the automated configuration and optimization of networks via software plays, and to what extent will this be supported?

EZ: 5G Berlin e. V. is building a fully-fledged 5G network in the sense that the essential network components specified in the 3GPP releases are used, thus enabling application scenarios to be implemented. We are pursuing an open approach: the radio network consists of commercial solutions supplemented by an open source stack and proprietary hardware development. The optical network is made up of disaggregated optical networks and hardware that was also developed in-house. The whole thing is complemented by open source virtualization solutions such as OSM/ONAP and the software-defined transport network SDN.

Automated configuration and optimization of networks via software will play an extremely important role in the future, as this is a service-oriented architecture. A prerequisite for network slicing, for example, is the availability of stand-alone base stations. We expect solutions here in the second half of 2020.

InNOVAtion: The use cases will take a close look at "Vehicle to Everything" (V2X) with a focus on autonomous driving. Can you give us some insights into the current status quo and the next steps?

EZ: With regard to the networking of vehicles, 5G Berlin is pursuing two different application scenarios, namely automated guided vehicles (AGVs) and – potentially autonomous – vehicles in public spaces. The aforementioned AGVs are usually connected to 5G campus networks. Technical challenges are very precise positioning, safe and reliable radio connection, and service continuity when changing radio cells or roaming. The infrastructure for this application scenario is currently being procured and a first proof of concept is expected in the third quarter.

Besides the installation of appropriate slices, radio coverage naturally plays a crucial role in the secure and reliable networking of vehicles in public areas. Here, 5G macro cells will be supplemented by small radio cells, for example on street lights; these so-called small cells will operate at much higher frequencies than 'normal'

„Automated configuration and optimization of networks via software will play an extremely important role in the future, as this is a service-oriented architecture."

– Prof. Dr. Erich Zielinski, Chairman of the Board, 5G Berlin e. V.

mobile radio, at about 26 GHz. This will result in greater reliability and larger bandwidths. Extensions to the public infrastructure will be necessary for these application scenarios, for example in terms of the modification of street lighting masts. A proof of concept will therefore probably be available in 2021.

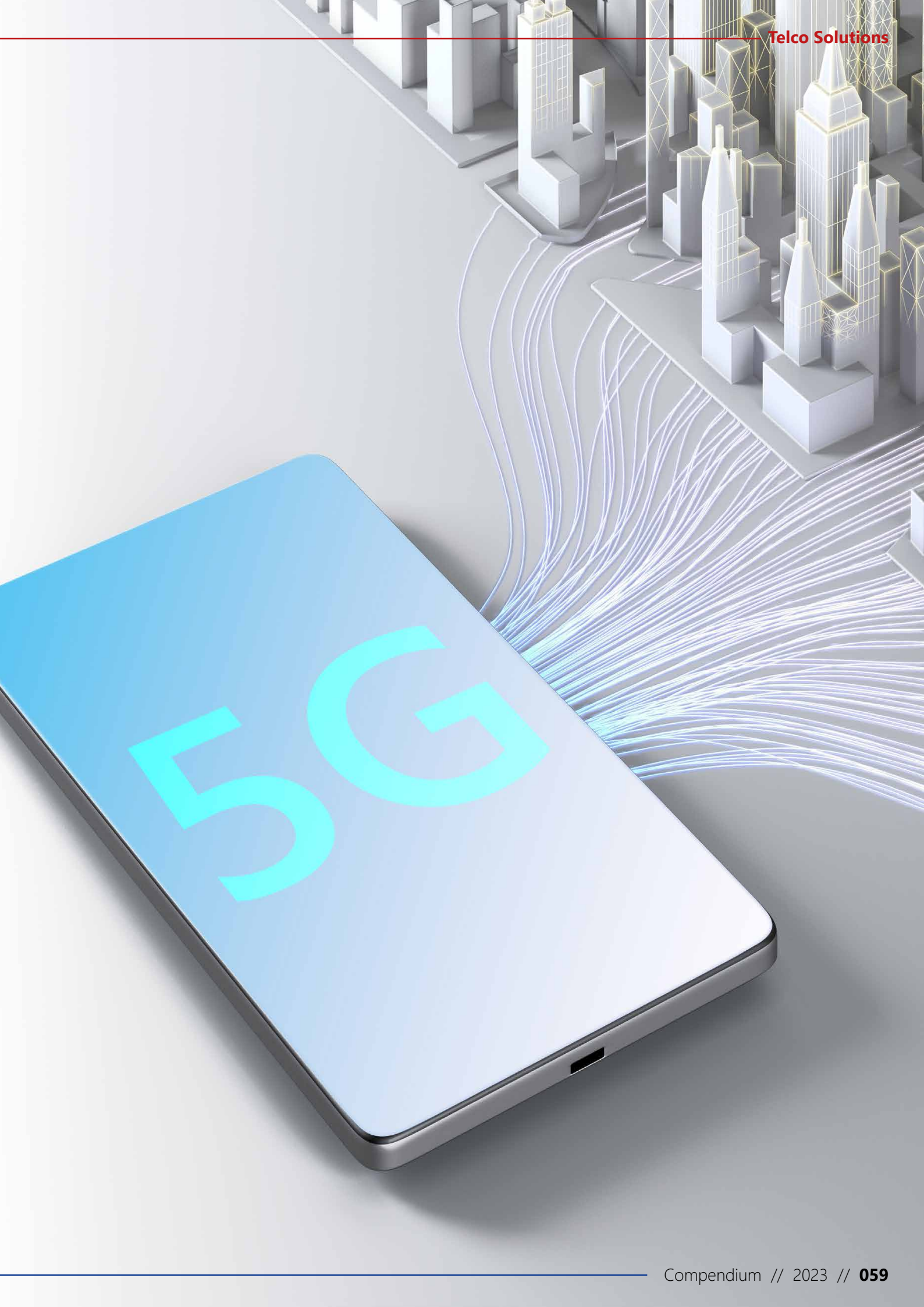
InNOVAtion: Security-critical applications from Industry 4.0 in particular are driving up demand for in-house network solutions, which is why the "non-public networks" or campus networks you mentioned are becoming increasingly important. How do you assess this development and how does the 5G Berlin e. V. consider possible use cases?

EZ: It has been possible to apply for frequencies for 5G campus networks from the "Bundesnetzagentur", Germany's Federal Network Agency, since the end of last year. The costs can be easily calculated and are very manageable. It is important to distinguish between a number of different operator models. The first is the acquisition of a local 5G frequency to build a dedicated infrastructure and operate a dedicated network. This option requires a deep understanding of 5G technology and network operations in order to realize the potential benefits of secure operations. This operator model is being implemented by 5G Berlin in connection with the above-mentioned use cases. The second model consists of renting a virtual slice from a public network operator, which is also responsible for network operation. And finally, there are hybrid solutions, for example shared RAN, with the operation of a separate core network or other partitioning. All operator models have their own specific advantages.

InNOVAtion: After this detailed information, what are your plans for 2020 onwards beyond the technological aspect? Is the association intending to continue to grow? Do you plan to expand the test network?

EZ: The direction for 2020 is clear. While the focus in 2019 was mainly on conceptual work and project acquisition, in 2020 it will be on implementation and development of the infrastructure. At the same time, a number of software-based tasks are pending, such as the integration of the 5G core network, ONAP interfaces, and management interfaces. Regardless of that, 5G Berlin is of course open for further project proposals from its members. The association's working groups are very active in this respect, and we have set ourselves the goal of implementing a proof of concept every quarter. Of course, all of this is subject to some reservation regarding possible restrictions intended to deal with the effects of the coronavirus crisis. It is important to remember that mobile communications and network technology have made us less dependent on fixed locations – in this respect, the importance of our activities is evident even here.

InNOVAtion: Professor Dr. Zielinski, thank you very much for talking to us. ■


5G

Telco meets Automotive – thanks to 5G

MicroNova has been successfully active in both the automotive and telco industries for several decades. This expertise is now benefiting an integrated project – a platform for the automated testing of mobile services.

TEXT: Ingo Bauer, Christoph Menhorn

5G wireless technology is seen as a key technology for the digital revolution in a wide range of industries and areas of life. New business models will emerge and existing ones will experience significant enhancements and added value. This also applies to the automotive and telecommunications industries.

In this digitalized world, reliability and quality must be proven to go together. In the context of agile or fluid developments, the importance of powerful test mechanisms is even greater than before. This is why EANTC AG (see box page 057) and MicroNova are working together on a platform for the automated testing of mobile services.

5G: From hype to market

As part of their surveys, market research and analyst companies regularly identify technology trends that are set to cause a sensation in the coming years. These trends are often represented in graphical diagrams – curves, matrices, and so on – and describe the phases of a technology in terms of its public attention or market penetration. According to various recent studies of this kind, 5G will be one of the most important trends in the coming years.

5G will therefore follow the familiar path from trend to ubiquitous solution with associated services. The technological triggers have happened, and so we are likely to be in a phase of high expectations and uncertain business models, somewhere between innovators and early adopters, comparable to the boom on the then new market at the time of the dot-com bubble. This also suggests that not all business models will survive. Nevertheless, the introduction of 5G over the next few years will bring a variety of new services and applications to market maturity and hence enable business success for their providers.

The financial potential of the technology alone will ensure this: According to estimates by one study, by 2035 ICT companies will be able to generate around twelve trillion US dollars in revenue from 5G technologies for ICT manufacturers. The potential spreads across basically all sectors.

Network Slicing

Some technologies within the 5G subject field are of particular importance. These include developments in radio interfaces such as beamforming, massive MIMO and mmWave. The realization of self-organizing networks (SON) through the use of artificial intelligence will significantly accelerate network slicing and thus the development of new services.

At present, mainly static network slices, such as those known from NB IoT, are still in use. Soon, flexible concepts that can be made available as and when in the network will prevail here: network slicing is the resulting key technology from 5G network architecture development with software-defined networking (SDN). The service classes determined in the 5G standard (eMBB, uRLLC, mMTC; see box for more details) can be paired to form functional, application-specific services and can be provided in the form of network slices in a dedicated way within the network (see also interview with Prof. Wiegand, page 028 ff).

Service classes

5G offers several service categories, each covering different mobile communications needs. Enhanced mobile broadband (eMBB) is one such service category that provides extremely high data rates of up to ten gigabits per second and therefore supports services with high bandwidth requirements. Ultra reliable low latency communications (uRLLC) focuses on services with low latency times of about one millisecond – important for the shortest response times with practically no service downtime; relevant applications include automatic driving assistants in motor vehicles or remote plant maintenance. Massive machine-type communications (mMTC) comprises services that require a high connection density of up to one million per square kilometer, for example for the design of smart cities, smart homes, and so on.

The key to diversified 5G services

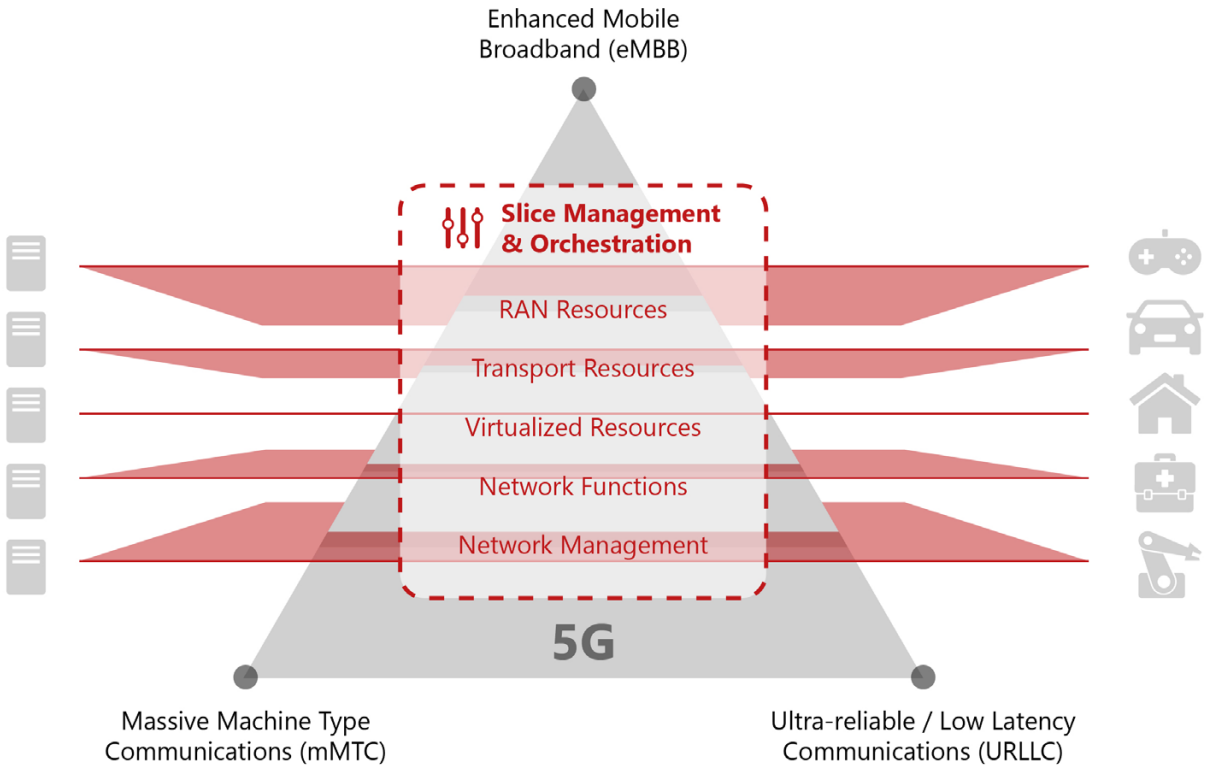
This technology therefore allows network operators to make more versatile use of their infrastructure and to offer performance-based, user-friendly mobile communications services. Whether a smart home communicating with its occupants, machines communicating with each other, or a vehicle communicating with its surroundings, an optimized network slice is set up for each of these applications. Network slicing functionality is therefore the key to supporting diversified 5G services.

Industry 4.0 and autonomous driving are certainly among the prominent examples associated with 5G. With the introduction of ever more intelligent driver assistance systems in mass production and the highly automated vehicles currently being developed or tested, expectations are rising among all those involved. The autonomous level 5 driverless car will certainly require a lot of research before it can be realized.

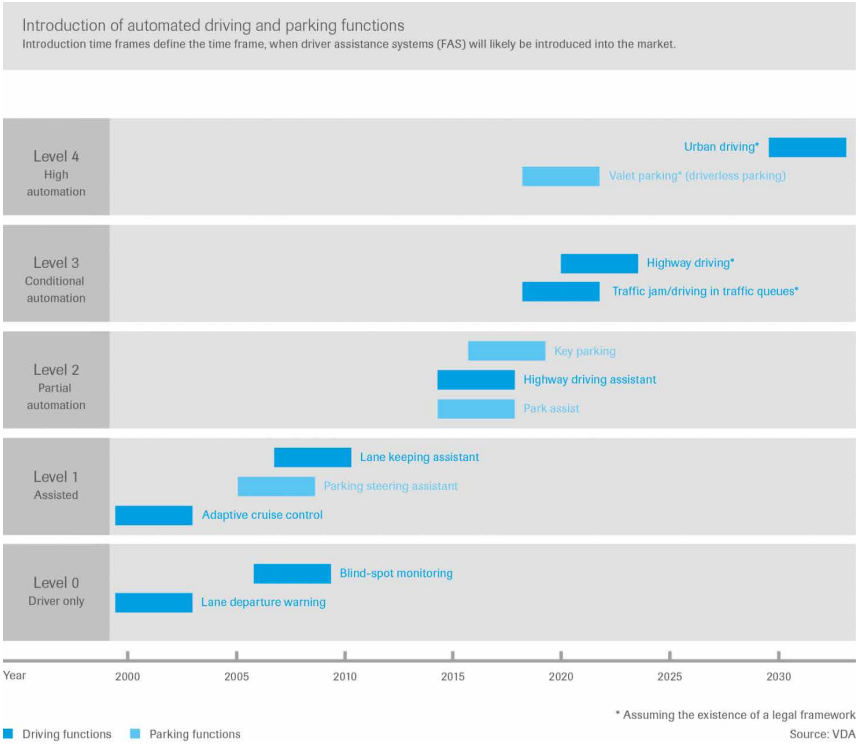
Automated tests

A completely driverless car will probably only appear on the roads with one of the next generations of mobile communications. Nevertheless, 5G is the first step toward a powerful, fully networked world – and thus the foundation for Car2X communication. Only 5G technology enables an extensive, practical, bidirectional networking of different sensors, actuators and control units via the air interface.

The development of apps, as they have been common on smartphones for a long time, will thus increasingly find its way into the car. The particular demands in terms of security and quality of all applications arising from communication between the vehicle and its surroundings, or the control of functions in the vehicle from outside, make an automated test environment indispensable.



1 The service classes of the 5G standard enable the provisioning of application-specific services and are provided as so-called network slices.



2 In recent years, not only the number of available driver assistance systems has increased, but also their degree of automation. The German Association of the Automotive Industry (VDA) assumes that automated functions will be successively developed over the next few years. As a result, automated driving will probably initially become possible in "controllable" situations (e.g. in multi-storey car parks or on the motorway). © VDA

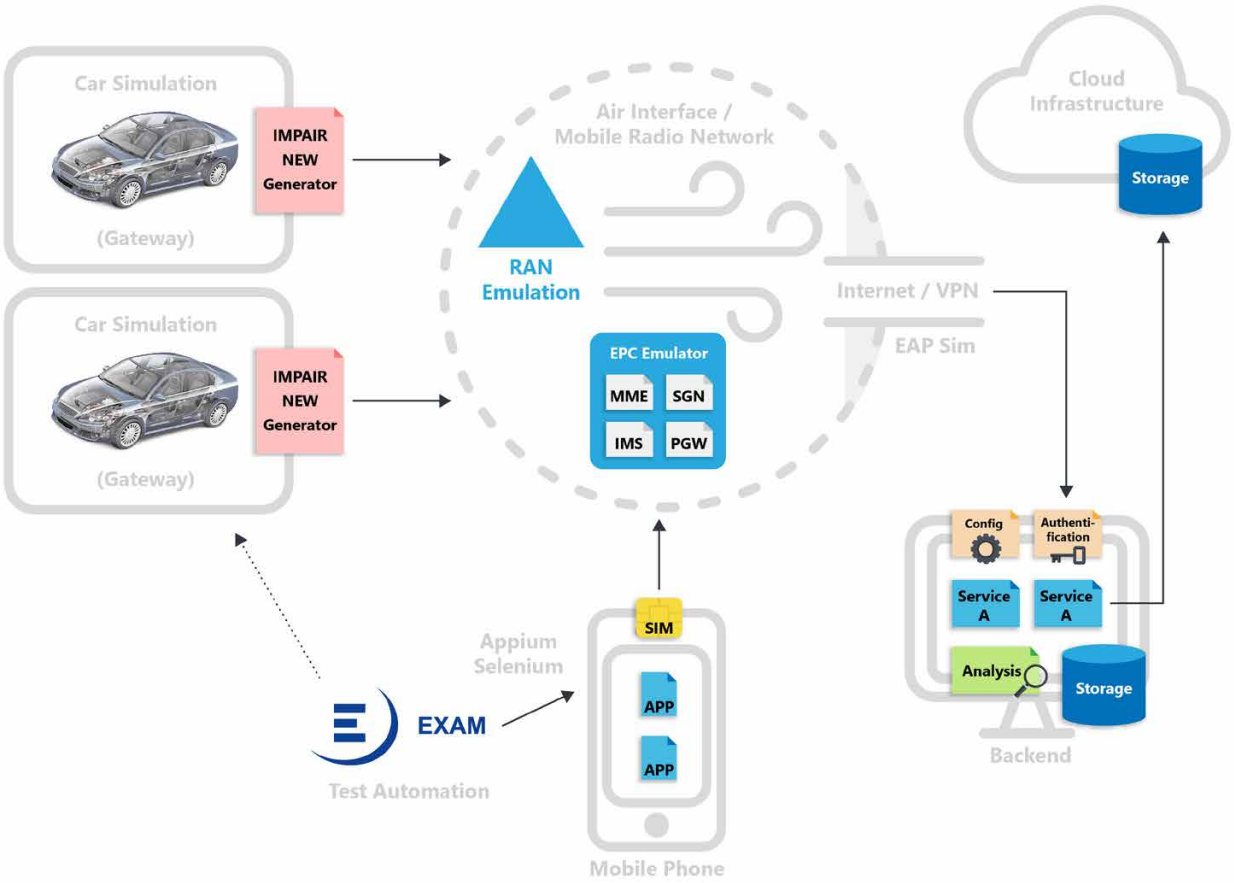
Test bench for mobile applications

This applies both to protecting against malicious hacking attacks and to a corresponding, clearly defined behavior in the event of failure of the basic mobile service. MicroNova is working together with EANTC on a solution for an automated test bench for testing mobile applications. This includes simulating the mobile network as well as the communication between vehicle, mobile UE and backend.

Whereas in the past the "device under test" (DUT) was the vehicle, new elements have been added in the age of networked cars. Besides the vehicle itself, mobile applications on the smartphone, the associated backend, and the mobile network are now also part of the overall system. This requires modified test systems to ensure the correct functioning of the overall system.

In the overall test, however, the mobile network in particular was only a "more complex" cable and played a rather subordinate role provided the data was transmitted correctly. The testing world will change in the context of software defined services – there will no longer be "one" service; rather, it will become more and more flexible and, as an essential component of the overall system, must nevertheless be tested accordingly. This requires more flexible simulations and test concepts.

Test systems that can be automated with EXAM, for example, are already used today to ensure overall system functionality or to guarantee end-to-end protection. The correct function of the backend interface and the function of the smartphone application are central aspects here. This process uses a test rack with corresponding real ECUs, which is addressed by EXAM. It is also possible to communicate with the smartphone application via interfaces like Appium or Selenium. In this way it is possible to check the entire communication chain, from app to backend to test rack – repeatably and reliably. The more complex the test environment, the more vital structured, tool-based testing becomes.



In order to be able to test the ever-increasing number of networked functions in future, it will be necessary to use virtualization and simulation much more – this is the only way that all test scopes can really be carried out with a high quality of results. Mechanisms such as the simulation of ECUs have long been established and used in industry, but other components such as the air interface or the backend are still facing challenges.

In addition, there are test requirements that are difficult to replicate in a real mobile network. This includes adjusting poor network coverage or incorrect or "swallowed" data, etc. So far, manufacturers and suppliers have implemented all such aspects by means of complex "drive tests". However, these scale poorly and testing effort rises – and it rises even higher the more complex functions are operated in the vehicle via networking. For this reason, it is necessary to integrate the possibilities resulting from 5G into the field of action of the established test mechanisms for vehicle electronics.

3 Test system architecture: Using EXAM, the test engineers can address both the test bench with real ECUs and the smartphone apps.

Conclusion

5G will open up a variety of options for making vehicles and traffic itself more intelligent and safer. Comprehensive tests are necessary to ensure that these options reach customers securely and reliably. The major task is to consolidate existing test approaches in such a way that the end result is an integrated test with the highest possible degree of automation. This is the only way to ensure traceability and structure in the tests. ■

EANTC AG

EANTC AG is an independent network technology competence center that offers its telecommunications services and solutions to both manufacturers and users. EANTC was founded in 1991 by Herbert Almus, the current Chairman of the Supervisory Board, at the Technical University of Berlin, with a research focus on network technologies and multimedia applications (PRZ / FSP-PV). In addition to research and development, EANTC initially tested and certified FDDI (fiber distributed data interface) systems. Starting in 1993, the tests offered were extended to include ATM (asynchronous transfer mode) and other high-speed network technologies. Clients at that time already included almost all leading manufacturers of network components. At the end of 1999, EANTC was spun off as a stock corporation with the support of the TU Berlin. The company still cooperates closely with the TU Berlin today. The spin-off expands the range of services to include technologies such as multi protocol label switching (MPLS), IP (Internet Protocol) switching, triple play and voice transmission via the internet (voice over DSL and voice over IP) as well as mobile radio technologies.

RAN Configuration Management since 2004

Configuration Management for Telefónica Germany

Telefónica Germany and MicroNova have been collaborating on the configuration of Telefónica's radio access network (RAN) for nearly **twenty** years.

Major milestones with Telefónica Germany for COM5.Mobile:

- 2021: „Designer" for COM5.Mobile Integrator
- 2021: Integration SA 5G sowie O-RAN
- 2020: Integration of NSA 5G
- 2019: Introduction of COM5.Mobile, COM5.Mobile Optimizer and COM5.Mobile Integrator
- 2017/2018: NB IoT Integration and NBI Upgrades for Huawei & Nokia
- 2016: Consolidation of the networks of O_2/e-plus
- 2015: Introduction of national roaming with e-plus
- 2013: Femto integration – Alcatel Lucent Femto Cells
- 2011/2012: Full LTE integration (Huawei and NSN)
- 2008: Integration of Huawei 2G, 3G & SWAP Automation (NSN -> Huawei)
- 2004: First introduction of CPCM for Nokia and Nortel (2G and 3G)
- Yearly upgrades per vendor and technology
- Fully compliant for an automatic mass rollout of base stations with CPCM

Centralized Network Management for Vodafone Germany

Vodafone uses MicroNova's COM5.Mobile to continuously monitor and optimize its German mobile communications network.

Major milestones with Vodafone Germany for COM5.Mobile:

- 2021: Integration SA 5G
- 2019/2020: Integration of NSA 5G
- 2019: Integration of NSA 5G
- 2017/2018: Integration of NB-IoT and & SON Alignment
- 2017/2018: SRAN Upgrade for Ericsson & Huawei
- 2016: Tool consolidation - Replacement of four different applications from former tool chain by CPCM
- 2016: New technologies - Implementing single O&M & ABIS
- 2016: Phase III - Integration of new Huawei'SRAN Releases
- 2015: Phase II - Deloyment of fully integrated solution with Integration into radio planning (Atoll), transport planning (Cramer), network optimization (ActixOne) and other OSS applications
- 2014: Implementation of hundreds of operator specific data consistency checks
- 2014: Validation against vendor and operator specific default values
- 2014: Phase I - First deployment of CPCM Network Audit at Vodafone Germany
  Network integration to Ericsson 2G, 3G and LTE, Huawei 2G, 3G and LTE and Nokia 3G
- 2013: Vodafone Group selects CPCM as preferred multi-vendor RAN planning and configuration solution

Network Management – a Part of MicroNova

About MicroNova

MicroNova provides process-driven solutions for the automated network expansion and optimization in mobile communications networks, and supports mobile operators in planning and configuring their radio access network. In addition, the quality and service availability for the mobile subscriber is analyzed, evaluated and on request even automatically optimized. These solutions support mobile network operators from the planning stage to configuration of their Radio Access Network (RAN) – vendor-independent and cross-technology. COM5.Mobile has established itself as the leading solution in the RAN environment.

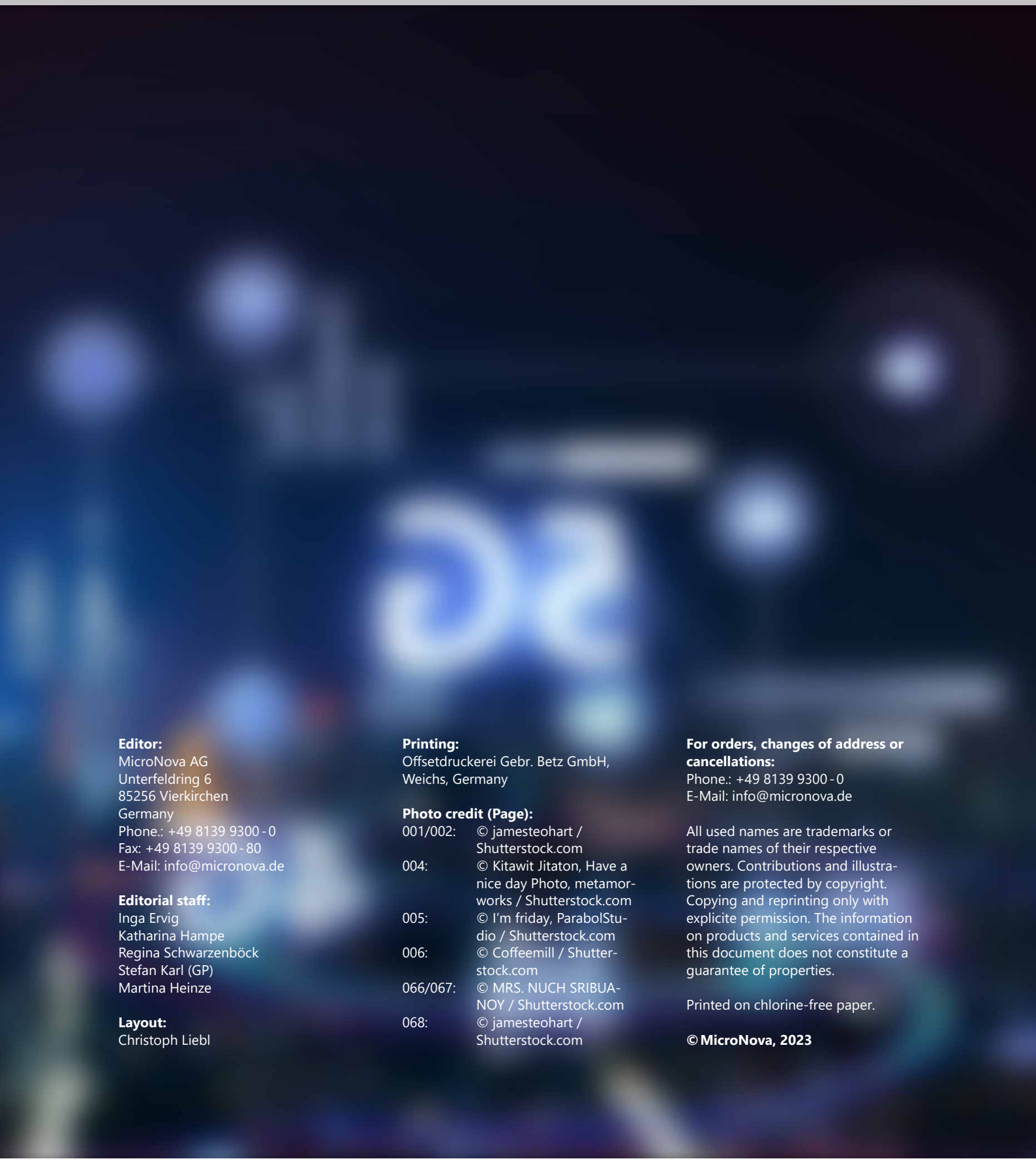
With the upcoming 5G technology and the inherent requirements for a flexible network architecture, Software-Defined Networking (SDN) and Network Function Virtualization (NFV) are becoming increasingly important. To ensure a successful transformation here, Mobile Network Operators (MNOs) must automate their processes for the expansion and operation of their networks. With more nearly 20 years of experience in automation, MicroNova is supporting MNOs with consulting services and with its new COM5.SDN product line to seamlessly integrate 5G and establish new business models. Currently two of the world's top five mobile phone operators, among others, rely on MicroNova's Telco solutions.

MicroNova has been a software and systems vendor since 1987 and offers products, solutions, and services in three business segments: management of mobile and heterogeneous communication networks, testing of automotive electronics and the distribution of IT management solutions. 300 experts work with technological expertise, ideas, and passion at the company's headquarters in Vierkirchen near Munich and at its sites in Braunschweig, Ingolstadt, Kassel, Leonberg, Wolfsburg, as well as in Jablonec nad Nisou, Mladá Boleslav and Pilsen in the Czech Republic. Renowned clients such as Audi, BMW, Continental, Telefónica Germany, Vodafone, and Volkswagen place their trust in the expertise and solutions of MicroNova.

MicroNovas group portfolio at a glance besides Telco Solutions:

Testing Solutions: MicroNova provides solutions for testing electronic control system components: From hardware-in-the-loop(HiL) test benches and proven software solutions for test automation to professional on-site support and comprehensive consulting services.

Enterprise Solutions: As the exclusive distributor of ManageEngine, MicroNova offers professional and user-friendly software for efficient IT management. The software helps IT managers in all industries to administer and monitor IT infrastructures.



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