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INTRACOM
TELECOM



INTERVIEW

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BUILDING A SUSTAINABLE CITY IN SERBIA



Intracom Telecom announced a Smart City project in Belgrade, Serbia, focusing on monitoring the city's air pollution and improving the overall air quality. Together with its partner Ecomaks Solutions, they have undertaken the implementation of this multi-year project, while first results are expected before the end of the year. Intracom Telecom is providing its state-of-the-art Unified IoT Orchestration platform (uiTOP™) for data acquisition & visualization and its innovative Cognitiva™ suite of AI-powered applications for data modeling & forecasting, while Ecomaks Solutions is supplying the air quality stations.

"Air pollution remains stubbornly high in many cities across Europe and we feel it is our obligation to contribute our innovative Smart Cities solutions portfolio to changing the breathing experience in our cities. Our IoT & AI technologies will help the City of Belgrade in having a healthier atmosphere and preventing many citizens from living in a polluted area. Through projects like this we aim at building a smart environment which will facilitate a sustainable and healthy life," Efthymios Partsalis, CEO of Intracom Telecom DOO Belgrade, notes.

BOTSWANA GOVERNMENT SELECTS OMNIBAS™ FOR PRIVATE NETWORK UPGRADE

The advanced OmniBAS™ microwave product family of Intracom Telecom is being supplied through Nextlan Pty Ltd, company's trusted reseller in Botswana, for the upgrade of the private network for Botswana government. The upgraded network will be used to support a wide range of broadband services carrying efficiently all telecommunication traffic, such as voice, video and data with full wireless and management redundancy, as well as backhauling the private TETRA network. Intracom Telecom's OmniBAS™ platform for wireless transmission includes compact high-performance outdoor and indoor units delivering reliable 4096-QAM two-way transmission, and a leading link budget for high availability. John Tenidis, Marketing Director of Intracom Telecom's wireless solutions portfolio, stated: *"This new project confirms that Intracom Telecom's wireless portfolio is stronger than ever. Our OmniBAS™ microwave product family has been chosen repeatedly for mission critical applications and sensitive communications. Local support and services by Nextlan are crucial to our success in the Botswanan market and we are committed to continue delivering the best technology to our growing list of satisfied customers."*



“SMART” WASTE SOLUTION CONTRIBUTES TO GREEN & SUSTAINABLE CITIES

Intracom Telecom's "smart" waste management solution, which supports cities' and municipalities' goals of conserving resources and protecting the environment, has been upgraded. The solution, on top of its existing features, such as filling level measurement, automated notifications to authorities when the preset waste bin fill limits are exceeded and determination of "zones of special interest" each with different priority, is now offering the optimization of garbage collection routing, access control to the bins and waste disposal monitoring per resident, as well as waste quality control. The solution is orchestrated & managed by Intracom Telecom's Unified IoT Orchestration Platform uiTOP™. Nikolaos Velentzas, General Manager of Intracom Telecom's Services Business Division, commented: *"Cities around the world are working intensively on changing their existing "culture" towards environmental protection and recycling, and we are here to give a helping hand. Our "smart" waste solution that achieves recycling goals set by the EU, conserves natural resources, promotes recycling and environmental awareness and helps municipalities to optimize their operations and improve their sustainability."*

📄 <http://www.intracom-telecom.com/campaign/wastemanagement/>

📺 <https://bit.ly/3mb1Tve>

ADVANCED WIRELESS SOLUTIONS AGREEMENT WITH NOVA

NOVA

Intracom Telecom signed an agreement with Nova, major service provider of business solutions and wide range of pay-TV, broadband internet, fixed telephony & energy services, for the supply of advanced network wireless equipment comprising, the WiBAS™ Point-to-MultiPoint (PtMP), the OmniBAS™ Point-to-Point (PtP), the UltraLink™ E-Band radio system and the uniMS™ network management platform. Looking for solutions and technologies that would augment the delivery of enterprise broadband, specially built for the private and public sector, Nova decided to invest in Intracom Telecom's MW & mmWave product families to better serve its corporate clients. Nikos Xanthopoulos, Head of Business Product & Presales in Nova: *"We are happy to continue our successful partnership with Intracom Telecom in order to provide secure, efficient and reliable services to our business customers through the adoption of appropriate and cost effective technologies."* *"Intracom Telecom has been supplying its leading-edge products to Nova since 2016 and we are delighted that we continue this trusting and long-lasting collaboration. Our company will provide a variety of products that will offer ultra-broadband connectivity to as many customers as possible, supporting Nova growing its enterprise network"*, John Tenidis, Marketing Director of Intracom Telecom's wireless solutions portfolio, continues.

M²EC 2021

The proceedings of the 34th International Conference on Advanced Information Networking and Applications (AINA-2021) were published this year, including Intracom Telecom's CDN department contribution. Within the framework of AINA-2021, Intracom Telecom presented the paper entitled "MEDAL: An AI-Driven Data Fabric Concept for Elastic Cloud-to-Edge Intelligence" at the 3rd International Workshop on Recent Advances for Multi-Clouds and Mobile Edge Computing (M²EC 2021). The focus of this work is on introducing an intelligent Cloud-to-Edge Data Fabric to support Data Operations (DataOps), seamlessly exploiting and federating IaaS/PaaS/SaaS resources across different Cloud and Edge Computing environments and automating management and orchestration operations. This publication is joint research work between Intracom Telecom, IBM Haifa Research Lab, Polytechnic University of Catalonia and VU University Amsterdam.

DISTRIBUTOR PARTNERSHIP WITH WINNCOM TECHNOLOGIES FOR N. AMERICA

Intracom Telecom announced a partnership with Winncom Technologies, a worldwide networking solutions distributor, to promote Intracom Telecom's advanced 5th generation Fixed Wireless Access (FWA) platform, the WiBAS™ G5, to address demand for cutting-edge business and residential solutions across North America. More specifically, Winncom Technologies, will be focusing on promoting the WiBAS™ G5, in 24 GHz and 28 GHz (24.25-29.50 GHz) frequency bands to enable its customers to provide Gigabit Tier throughput to subscribers. Igor Kurochkin, Vice President, Global Vendor Management & Marketing at Winncom, said: *"The addition of Intracom Telecom's FWA products will allow us to expand our broadband offerings as well as keep up with current demands of Gigabit speeds to our customers. We believe this new relationship and Intracom Telecom's WiBAS™ G5 Product Family operating at the unique frequency bands 24.25-29.50 GHz, will bring great value to our core customers in North America, and we look forward to expansion globally with Intracom Telecom in the future."* Dharminder Chanana, CEO of Intracom Telecom's subsidiary in USA, Conklin-Intracom, stated: *"We are looking forward to partnering with Winncom Technologies for our expansion in North America. Our FWA systems fit ideally into Winncom's product portfolio, allowing the distributor to perfectly meet the demands for the Gigabit business society, bridging the digital divide in rural and sub-urban areas in USA."*



US COMMISSIONER OF ATLANTA, GEORGIA, VISITS INTRACOM TELECOM'S HQ

Mr. Pat Wilson, Commissioner of the Georgia Department of Economic Development (GDECD), visited the Intracom Telecom's premises in Peania, Greece, so as to thank the company for its commitment and investment in Atlanta, Georgia State, through the Group's subsidiary Conklin-Intracom, and to learn more about the company and its plans for the US market. Pat Wilson, Commissioner of the Georgia Department of Economic Development, stated: *"During my visit to Intracom Telecom, I was able to see firsthand how its innovative software and ultra-broadband solutions will continue to shape the world of telecommunications and wireless technology. Intracom Telecom's location in Duluth, Georgia, uniquely positions their operation to reach customers throughout North America, while also tapping into the talent and resources the state continues to offer technology companies from around the world."* Kartlos Edilashvili, Acting CEO of Intracom Telecom Group, commented: *"It was our pleasure to host Mr. Pat Wilson in our premises and discuss ways to promote our full portfolio in a market that is of strategic interest for Intracom Telecom. I am confident that our discussion, apart from fruitful, has established a sincere and open communication channel that only positive results can bring for both parties."*

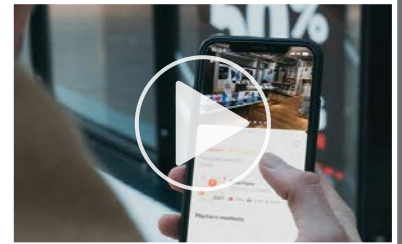


GREAT STEPS IN THE HORIZON 2020 PROGRAM

In the period June to September 2021, the research projects that Intracom Telecom participates in, made significant progress. In TERAway, 5GZORRO and ARIADNE, the company's "5G long-term evolution" projects, Intracom Telecom managed to proceed in a timely manner with the required hardware and software innovation activities despite the COVID-19 pandemic restrictions. After the successful reviews on June 29, July 01 & 08 respectively, and towards the final year of these projects, the system integration and construction of novel demonstrators along with other partners will follow in order to showcase the innovative results of the projects. In 5G-VICTORI, an "advanced 5G validation trials across multiple vertical industries" project, the first period review was held on September 09-10, while in both 5G-VICTORI and 5G-VINNI, significant progress was achieved on the preparations for the network services deployment across the Greek facility site in the city of Patras.

INTRODUCING ADVANCED SOLUTION TO DIGITALLY TRANSFORM RETAILING

Responding to the needs and challenges of any retail business, from individual to chain stores, Intracom Telecom introduced its innovative Smart Retail solution, raising the game for the retail industry, and offering a unique digital experience to the retail owners, their customers and their employees. This Smart Retail solution is highly flexible allowing physical stores to increase average revenue per customer, minimize costs, optimize inventory scheduling, automate processes, outperform physical and on-line competition, and increase employee and customer satisfaction. Moreover, offering an unprecedented digital experience to the consumers, the Smart Retail solution gives them the opportunity to truly interact with the store, through their smartphones. The information generated by the shoppers is collected by the Smart Retail solution, enabling retailers to gather insights, further analyze customer behavior, launch successful in-store marketing campaigns and drastically reduce queues.



➤ <http://www.intracom-telecom.com/smartretail>

▶ <https://bit.ly/3Cbrbyl>

CUSTOMER CARE “JOURNEYS” WITH GENESYS IN THE BALKANS



The 16th Customer Care Conference & Expo edition

During these unprecedented times that we are going through, when remote work has increased more than 300% and difficult customer calls by 100%, Cloud benefits create the right conditions to turn obstacles into growth opportunities. Having this in mind, Genesys together with Intracom participated, on June 24-25, in the 16th Customer Care Conference & Expo edition, where Patrik Ort, Senior Account Executive at Genesys, delivered a presentation entitled “Do you want your customers happy? Meet them in the Cloud!”. The audience had the chance to explore how to

dive deeper into Digital Engagement for the New Normal, and into Hybrid business models and how “Experience as a Service” and AI can help end users have a simple, intuitive, friction-free, effortless, customer experience. At this niche event Intracom lined up Genesys’ cloud solutions, which together with Intracom Telecom’s expertise can strategically steer the customer service operations away from the tides, towards safe, and rewarding sailing.

Modern and Empathetic Customer Experiences

Last month now, on September 21, Intracom Telecom together with Genesys organized a virtual conference entitled “Modern and Empathetic Customer Experiences: Transform Customer Care into a fascinating “journey””. Attendees, from the telecommunications, banking, energy, health, retail or any other sector, had the opportunity to learn about the innovative Customer Care solutions, jointly offered by the 2 companies, and explored new ideas and concepts that can boost their business further and increase their customers’ loyalty.

ETIP SNET REGIONAL WORKSHOP

FEVER project was invited to present its scope objectives and outcomes in the context of the 12th Regional Workshop of the European Technology & Innovation Platform (ETIP) on Smart Networks for Energy Transition (SNET). Dr. Ilias Lamprinos, Project Coordinator of FEVER, participated in a panel session focused on market-based energy systems and discussed issues related to novel mechanisms and tools for the aggregation, management and trading of energy flexibility as a means to cope with local problems of the electricity distribution grid (e.g. congestion avoidance, power quality regulation). Legal and regulatory barriers for real life deployment of these tools, as well as the role of the different stakeholders were also discussed.



RECOGNIZING THE GLOBAL ISSUE OF CLIMATE CHANGE

Intracom Telecom acknowledging the urgent global challenge of climate change has taken measures to align its policy with the Paris Agreement and reduce its carbon footprint. Since 2008 Intracom Telecom has participated to the CDP (formerly known as Carbon Disclosure Project) and has been reporting through CDP to specific customers / interested parties on its carbon footprint. The company is undertaking efforts to reduce its carbon footprint such as

infrastructure, equipment and electricity networks preventive maintenance programs, improved energy usage management with regard to air-condition units, elevators, water heaters etc., building insulation improvements, personnel awareness schemes regarding “save energy” attitude, use of teleconferencing facilities, teleworking etc. Its carbon footprint from Scope 1 (Heating, owned/controlled vehicles and other direct sources) and Scope 2 (electricity) emissions is largely dependent on energy consumption at company facilities (offices, labs and computer rooms). Therefore, the company has set targets to reduce its Scope 1 and 2 carbon footprint by 15% for 2021 and 2022 and 20% for 2023 – with respect to 2019 – by purchasing electricity from renewable sources. Further emissions reduction initiatives will be considered in due course.

5G MOBILE CONNECTED WORLD

On June 23 & 24, Intracom Telecom participated as a sponsor at the 11th 5G Mobile & Connected World virtual conference, entitled “5G: From prospects to reality”!. The conference focused, among other things, on the possibilities offered by 5G networks & how they can be exploited, what’s the new ecosystem that is being created, as well as which companies use 5G as a next step. Among the speakers was John Tenidis, Marketing Director of Intracom Telecom’s wireless solutions portfolio, who during the first part of the event called “5G: The ecosystem: Environment-Infrastructure-Synergies”, gave a presentation entitled “Disruptive and synergistic technologies for 5G operators”. During the presentation, he referred to the capabilities, innovative applications and the contribution of 5G networks in the 4th industrial revolution, analyzed relevant case studies, as well as Intracom Telecom’s WiBAS™ G5 solutions, which combined with other technologies aim at the utilization of the mmWave spectrum and are an important part of the evolving ecosystem.

2021 JOINT EUCNC & 6G SUMMIT

On June 9 & 11, Dr. Vasileios Theodorou, Senior Research Engineer of Intracom Telecom presented 2 conference papers in the 2021 Joint EuCNC & 6G Summit that brought together two successful conferences in the area of telecommunications: the 30th edition of the European Conference on Networks and Communications (EUCNC) 2021, supported by the European Commission and the 3rd edition of the 6G Summit, originated from the 6G Flagship programme. The first paper, entitled “PiEdge: An Edge-Driven PaaS Model for Network Slicing Automation”, is an outcome of the Edge Computing research work that Intracom Telecom is leading in context of the EU collaborative project 5G-VINNI, in collaboration with Telefonica and Universidad Carlos III de Madrid. The second paper, entitled “Blockchain-Based Zero Touch Service Assurance in Cross-Domain Network Slicing”, is a dissemination activity of our participation in the EU collaborative project 5GZORRO and more specifically it is part of our ongoing efforts on Service Level Agreement (SLA) Closed-Loop Automation in 5G and Beyond multi-domain Network Slicing environments.

ELEVATING NETWORK LIFECYCLE MANAGEMENT

WHAT'S NEW WITH UNI|MS™ R10!

With the General Availability (GA) of R10, Intracom Telecom's uni|MS™, elevates the concept of network management throughout Planning, Rollout, Optimization and Maintenance lifecycle phases of the radio transmission and access networks.

The platform is enriched with new network lifecycle automation applications (NLA Apps), advanced Planning-Physical Interworking and improved network assurance mechanisms that disengage the experts from repetitive activities and guide optimizing interventions in a closed-loop fashion, offering unprecedented efficiencies.

UNI|MS™ R10 HIGHLIGHTS

Redefining network lifecycle with NLA Apps

The new Auto-Licensing App speeds up the massive deployment of new licensed features from the NOC side with rule-based activation upon NE discovery and on-demand. The Correlation App escalates alarms to higher severity, if unacknowledged for a user-defined period. The NLA Apps effectively automate laborious activities throughout the network lifecycle that would otherwise engage experts.

Boosting user experience

Leveraging the Interworking of Planning & Physical Views of the platform, a new summary screen compares actual vs planned Link Performance coupled with NE Configuration & Installation characteristics to drastically improve collaboration and guide optimizing interventions.

Modernizing network control

The platform's SDN Controller capabilities expand dynamically, utilizing an embedded facility for new data models ingestion to eliminate lengthy integrations. Service Management is now supporting IP/MPLS system types and a new Status Report improves monitoring and management of Ring Instances to successfully streamline network services.

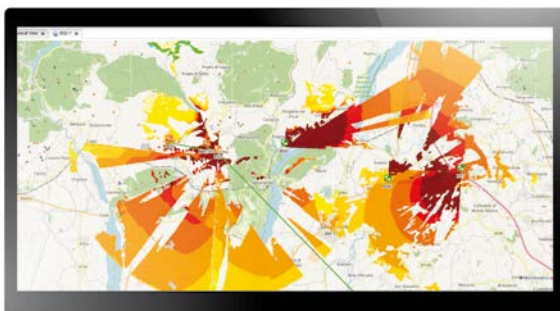
Simplifying operations

Software level maintenance at network scale is further enhanced with the Software Recovery mechanism that handles failed upgrades and extra checks performed during the upgrade job creation. The new Network-wide Health & KPIs thresholding deviation dashboards and the improved collection of Radio Utilization data, with reduced DCN traffic, are all intended to effortlessly conduct network operations.

Assuring stability

A new feature-set implementing flexible security administration together with the support of the VMware® fencing agent comply with strict security guidelines and efficiently enforce system robustness. ■

For more information on uni|MS™ Release Notes and status of previous uni|MS™ Releases, please contact us at unims_support@intracom-telecom.com.



Parameter	Planning	Actual	Delta
Tx Power (dBm)	18	18.8	-0.8
Modem RSSI (dBm)	-68.42	-53.71	-14.71
Modem SNR (dBm)	31.52	40.71	-9.19
QoS	-59.64	-50.96	-8.68
Pilot Mode	255 QAM	1024 QAM 8.823	3
Reference RSSI	-68.42	-48.22	-20.2
Reference SINR	13.15	44.58	-31.43

THE CHALLENGE OF MUNICIPAL SOLID WASTE MANAGEMENT

PANOS DIMOS

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INTRODUCTION

Municipal Solid Waste (MSW) Management is a common and challenging pain-point for Municipalities globally, especially affecting more densely populated and crowded cities. Inefficient waste management planning entails high operating costs, reduced public hygiene, environmental pollution, waste of natural resources and citizen frustration.

In recent years European legislation has imposed strict rules, goals and deadlines for member states to follow, which include high monetary penalties and sanctions for the ones that fail to meet them.

More specifically, Greece falls below the EU average in recycling, separation at the source and landfill-use targets. As a result, fines have exceeded €100 mil, with the Greek government announcing that the financial burden will soon be carried over to Municipalities. Moreover, the EU has suggested monitoring and recording of the performance of MSW management systems in order to evaluate and improve them. In addition, municipal authorities in Greece

and abroad have begun to recognize the multifaceted benefits of optimizing waste management and promoting recycling. Citizens have also increased their awareness regarding environmental issues and they are very positive towards relevant initiatives that promote circular economy principles. In addition, surveys show that citizens would prefer to pay municipal cleanup fees depending on how much garbage they produce in comparison to a flat universal charge. Another development that is now in favor of developing such systems is the availability of reliable technology solutions (hardware and software) that can fully support complex and interactive waste management systems.

An additional factor that hinders recycling efforts is the recycling contamination. Quite often organic waste ends up in the recycling bins, which when mixed with recyclable materials renders their recycling impossible. Also, many citizens throw their recyclables in waste bags, making it very hard or even impossible for recycling workers to properly sort them and recycle them. Therefore, even if a city implements a waste management strategy it will not

be able to improve recycling rates and earn income by trading them. Until now, there was no technological solution that could help detect and minimize recycling contamination.

Efficient waste management is a quintessential prerequisite for protecting the environment and improving cities sustainability. A smart MSW management system aims at decreasing fuel consumption and overall CO₂ emissions (fuel consumption can be reduced by 30-40% depending on the case). Also, traffic congestions are minimized due to the fact that waste collection routes are optimized and the areas that need special attention, are served with priority. With bin access control and real-time fill level alerts, waste bins overflowing will be practically eliminated, securing higher hygiene and aesthetic levels. In financial terms, the reduction in waste truck maintenance, fuel consumption and waste disposal costs, along with the increased revenues from recyclable sales, are expected to result to the reduction of waste management OPEX by 20-35%.

MARKET OVERVIEW OF IOT SOLUTIONS FOR MSW MANAGEMENT

At present, Municipalities in Europe and Greece, depending on their readiness in adopting smart IoT systems and solutions can be divided into the following categories:

1. European Municipalities that have implemented smart, IoT waste management systems, but still lack control over the quality of materials destined for recycling.
2. European Municipalities mainly (few in Greece), that apply complex or simple recycling, incentivizing or "the polluter pays" schemes without the extensive use of IoT technologies.
3. Municipalities involved in research / European programs that plan the promotion and implementation of Category (2) actions or the implementation of one-dimensional IoT solutions (only waste bin fill level measurements and waste pickup route optimization), with limited scope pilots implementation.
4. Municipalities that have not taken any action so far due to lack of information or know-how.

WORKING PRINCIPLE AND KEY BENEFITS OF INTRACOM TELECOM'S SMART WASTE MANAGEMENT SOLUTION

Intracom Telecom has designed an innovative system that encompasses all the traits required to assist Municipalities in addressing the challenges of waste management. It includes three different subsystems, aiming to:

1. **Reduce** the total OpEx of waste management;
2. **Increase** municipal revenue from recyclables sales;
3. **Protect** the environment and save natural resources;
4. **Achieve** recycling and landfilling objectives set by the EU and avoid relevant tariffs;
5. **Provide** full oversight of the performance of waste management systems and achieve efficient optimization and successful crisis management (e.g. COVID-19);
6. **Safeguard** public hygiene;
7. **Rationalize** municipal fees through "the polluter pays" schemes;
8. **Promote** recycling and environmental awareness through incentivizing recycling schemes;
9. **Increase** citizen satisfaction.

OUR APPROACH

Each household and local business uses a personalized RFID card in order to gain access to the blue bin and dispose their recyclable waste. After the waste disposal, an AI-based camera mounted inside the bin, which is GDPR compliant, evaluates the quality of the materials.

If waste bags or any non-recyclable materials are detected the user will not get any recycling points (award) and they will be recommended to make better use of the recycling bin. Also, Municipality personnel will be informed, in order to remove any non-recyclable materials from the bin, thus avoiding recycling contamination.

In any other case, recycling points will be credited and the user will be able to utilize them in incentivizing schemes offered by the Municipality (e.g. discounts at local shops, reduction of the standard fee etc.).

SENSOR SYSTEM OVERVIEW

Each Municipality has a different level of familiarization with IoT systems. Also, not all waste management strategies have reached the same level of maturity; some cities are just at the beginning of their digital transformation, while others have IoT system(s) already in place.

Intracom Telecom, recognizing this diversification, has designed, a modular solution that can be expanded, as the needs of the customer evolve. Similarly, it can be adjusted to enhance an already deployed waste management system. The complete solution includes the following hardware:

- » A **bin fill level sensor** equipped with GPS, temperature and tilt sensors, capable of identifying emptying events.
- » A **bin access control mechanism** that allows access only to the citizens assigned to the specific bin.
- » A **camera** utilizing computer vision and machine learning algorithms, which helps identify potential contamination of recyclable waste (i.e. presence of waste bags or non-recyclable objects that prohibit recycling).

The fill level sensor and the access control module can be installed inside any bin (green, blue, brown) enabling "pay-as-you-throw" schemes. All three modules will be installed inside blue (recycling) bins to increase recycling efficiency and implement incentivizing schemes.

The above hardware is accompanied by the following software modules:

1. Bin management and route optimization software:

This software is powered by Intracom Telecom's uiTOP™ Smart City platform and offers all the features required to monitor and manage the Municipality's waste management infrastructure and processes. The fill level of all bins is measured constantly, while notification and alarms are raised when predefined thresholds are reached/exceeded. As far as waste collection is concerned, special zones can be created (e.g. coastal-front, shopping district, etc.) in order to prioritize areas of the city that attract more visitors and should be treated with high priority.

Creating waste collection routes is just two-clicks away; the administrator selects the bin fill level threshold for collection and the type of waste (mixed, recyclables, bio-waste) that should be collected. Then the platform automatically generates the optimized route. The route enables the collection of all waste while minimizing the distance traveled, allowing thus for less fuel and emissions.

All waste trucks are registered in the platform, along with their characteristics. This way when a collection route is requested the platform selects the most suitable vehicle for each route (based on many factors, such as road width).

In a nutshell, Municipality employees can identify which bins need to be emptied and which areas produce the most waste. Also, data-rich visualizations in the form of maps, heat-maps and graphs provide detailed and historical data.

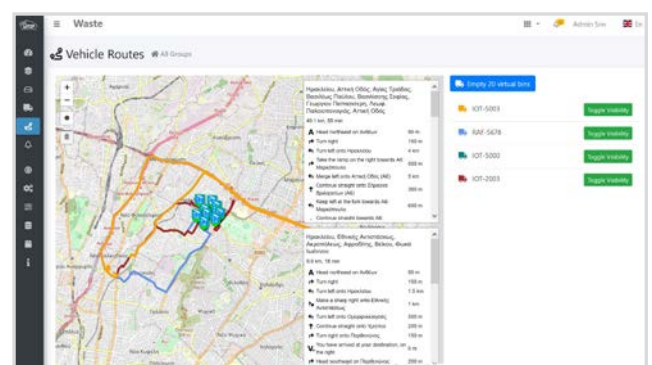
2. Bin lock control software:

This software is used to configure the access control mechanisms mounted inside the bins. It performs whitelisting/blacklisting of RFIDs that can access each specific bin. It also notifies when the lock is opened and which RFID was used.

3. Image recognition and machine learning classifier:

It runs on the device (MEC – Multi-access Edge Computing) and sends the classifier output along with a timestamp. Takes images of the bin's contents and decides whether the contents of the bin contain only recyclable materials or not.

Therefore, the solution can be provided as a basic offering with just the fill level sensor, or as an end-to-end complete and innovative solution that can support recycling incentives, by combining the access control mechanism and the camera.



THE RIGHT CHOICE

Intracom Telecom's innovative Smart Waste Management system constitutes a highly customizable solution that addresses all the challenges associated with MSW management. A variety of emerging technologies have been utilized, both in terms of software and hardware, in order to provide cost optimization, data-driven decision making and increased recycling performance across all vicinities, proving to be the right approach to support a holistic Waste Management Strategy. ■

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COGNITIVE AGENTS FOR SELF-OPTIMIZING NFV DEPLOYMENTS

TOWARD AUTONOMOUS RESOURCE MANAGEMENT IN MODERN TELCO NETWORKS

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INTRODUCTION

5G networks are becoming a reality across the globe, giving rise to new business models and innovative applications across several industries. This next generation of cellular networks is not simply an upgrade from previous ones but rather a structural evolution of contemporary telco networks, underpinned by emerging technologies.

One of these fundamental technologies is Network Functions Virtualization (NFV) which helps CSPs reduce the total cost of ownership and increase their service scalability and agility. These benefits are achieved by allowing functions from the 5G mobile core and radio to run as lightweight, cloud-native software on standardized commodity hardware.

Despite its advantages, NFV is confronted with a challenge that can easily break its promise for greater flexibility and cost efficiency. Making optimal use

of compute resources, in line with the runtime demand of network functions, is a very hard task which becomes harder as mobile networks expand from the core to the edge. Evidently, efficient resource management is a key prerequisite for NFV to deliver on its promises.

THE NEED FOR AUTONOMOUS RESOURCE MANAGEMENT

One of the key industry priorities, since the early days of NFV was, and still remains, to guarantee carrier-grade performance for certain Virtual Network Functions (VNFs). In many cases this leads to hardware overprovisioning. For example, a common practice of CSPs is to deploy performance-critical VNFs in isolation, reserving upfront a large portion of server resources for their exclusive use. In this way, the VNFs do have sufficient resources even for demand peaks, and are protected from contention with other workloads that could affect their Service Level Objectives (SLOs). The drawback, however, is that a significant amount of server resources remains unutilized, resulting thus in considerable OpEx and CapEx attributed to the NFV infrastructure.

To make things even more complicated, edge servers are expected to consolidate an unusually disparate mixture of mobile core functions, RAN components, over-the-top services and new types of applications requiring proximity to end users. This increase in software diversity and density will introduce uncertainty on how workloads on a single server will interfere with each other which, in turn, gives rise to the challenge of optimally distributing shared compute resources to meet SLOs with minimal resource footprint.

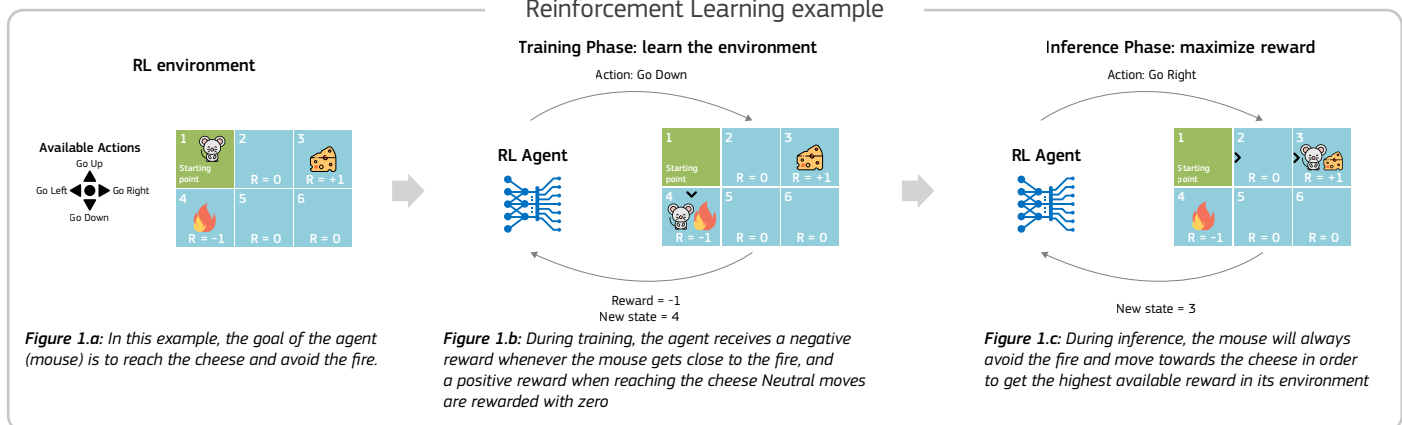
In this respect, CSPs can no longer depend on conventional approaches to manage resources efficiently, in real time and at scale. Techniques from rule-based automation to decision making based on analytics and historical data, would be inadequate as they would fail to capture the highly dynamic nature of 5G deployments. Preferably, an ideal solution must be able:

- » To handle multiple and diverse collocated services that have unpredictable interactions, independent load variations and, possibly, differentiated priorities.
- » To make resource allocation decisions accurately ("no more resources than needed for every service") and timely ("before SLA violations occur").
- » To dynamically adjust decisions in line with traffic load changes.

Such qualities suggest not simply an intelligent resource management solution but rather one that is able to autonomously learn and adapt to its environment.

Autonomous resource management at scale demands advanced cognitive agents able to learn by themselves in an initially unknown environment

Reinforcement Learning example



WHY REINFORCEMENT LEARNING?

Such an autonomous resource management solution demands advanced AI-powered cognitive agents, able to learn by themselves to make optimal resource decisions in a live telco network while starting from zero prior knowledge. Learned knowledge can potentially be then disseminated among agents across edge locations, to accelerate optimal decision making all over the entire network.

The only technology that, currently, meets the ambitious objectives of such requirements is Reinforcement Learning (RL). In RL, an agent gets trained in a way that rewards desired behaviors and/or punishes undesired ones. RL has two distinct phases: Training (or exploration) phase, and Inference (or exploitation) phase. During training the agent takes random actions in its environment, exploring which will lead to bigger reward. During inference the agent has already learned what the best actions in each different state are and leverages this knowledge to maximize the reward gathered. Recent advances in Deep Learning have led to a new approach, namely Deep RL, which leverages the power of Deep Neural Networks to tackle much more complex environments than "pure" RL method.

In the NFV context, RL can be used to determine the ideal distribution of shared resources among VNFs collocated on a server, so that:

- » SLOs of individual VNFs are always met, even when incoming traffic changes dynamically.
- » The amount of resources allocated to each VNF is the smallest possible, to prevent unnecessary resource usage and operational expenses.

Adopting RL in NFV signifies a promising step forward over other approaches for the following reasons:

- » The server resources on which a decision must be made can be many and may have tricky interdependencies.
- » The collocated VNFs for which a decision must be made can be many, as well, and may have conflicting resource requirements.

- » A resource decision cannot be one-off; it should be revised whenever a VNF's traffic changes.

These factors combined, lead to an explosion of the decision space to extreme numbers of state-action pairs. On top of that, decisions must be taken in real time. These two imperatives make Deep RL the only realistic solution.

RL CHALLENGES IN PRODUCTION SYSTEMS

Despite its great potential, RL comes with certain challenges in production environments:

1. Exploration is prohibitive

RL must observe and act randomly upon a certain state many times in order to determine which action is the optimum for each individual state. As an indication, full optimization of an application may require as many as 50,000 observations. Trying such a large number of random actions in a live system could lead to serious service degradation and even failure.

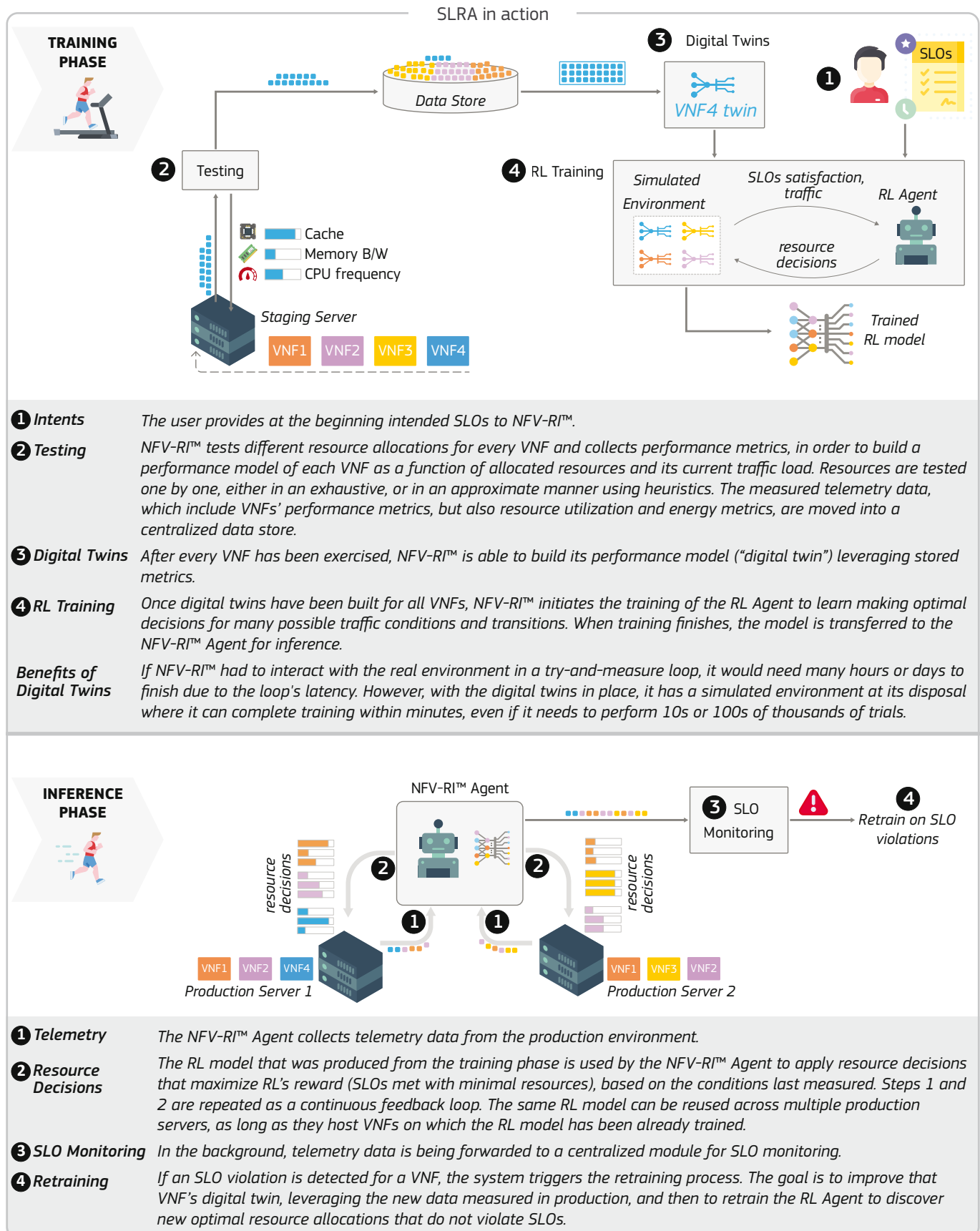
2. Training is very slow

In a production server, taking samples of performance metrics at less than a second frequency is usually impractical and of questionable value. On the contrary, it is very common that samples are collected at multi-second granularity (e.g. 10 to 60 secs), which results in an RL agent needing between 6 days to a month (!) to get fully trained.

3. Retraining is required if the environment changes

If the environment, in which the RL agent is trained, changes then there is a strong possibility that the VNFs can no longer meet their SLOs. Such changes may involve: amount or type of hardware resources, application incoming load, or performance constraints set by the user. Because of these changes, the agent has to be re-trained, which is a potentially very difficult task in the context of a large data center.

To overcome these challenges, Intracom Telecom created Self-Learning Resource Allocation (SLRA), an advanced Deep RL system capable of optimizing any application.



MAKING RL PRACTICAL

SLRA introduces three key innovations:

1. A **heuristic mechanism** able to narrow down the large set of random actions taken during training, to a much smaller subset of actions that look most promising for meeting VNF SLOs. This approach, applied before the actual RL training, not only shortens exploration space but also helps avoiding 'destructive' exploration by omitting actions that would very likely lead to SLO violations. Because of its moderated actions, the execution of this mechanism can easily take place on the production environment without much concern.
2. The **Digital Twin**, a 'digital clone' of an application that models its behavior under different hardware resource allocations and traffic conditions. With a Digital Twin in place for every deployed application, the RL agent can be trained outside the production environment in a simulated environment, avoiding thus direct interaction with the actual application. As expected, the latency of an observe-and-act loop during training decreases by several orders of magnitude (e.g. from seconds to milliseconds), while overall training time is reduced by 150x-9,000x, depending on the baseline (frequency of metrics collection on the production environment). A Digital Twin is created using telemetry samples of the application, acquired from the production server under different resource allocations and traffic conditions. These samples can be collected either from historical production data or through the heuristic mechanism or from a staging environment when no SLO violations at all are tolerated in production.
3. The **SLO monitoring module**, a feedback loop which addresses the burden of RL retraining in a fully automated fashion. After an RL agent is deployed to production, this module continuously checks for SLO violations. When one is detected for a certain application, a retraining process is automatically triggered, as follows: first the Digital Twin is recreated for this application leveraging the new production data and then the RL agent is retrained, against the new Digital Twin, in order to discover new optimal resource allocations that do not violate SLOs.

SLRA is a new feature of the NFV-RI™ solution and aspires to become the state-of-the-art paradigm for autonomous resource decisions in modern NFV deployments.

REAL-WORLD 5G & EDGE USE CASES

The potential of Deep RL has been revealed through a series of use cases and workloads that are representative in modern telco networks. In those, SLRA managed to minimize the use of resources, under varying load conditions, without incurring any SLO violations.

Specifically:

- » In an in-memory, data-intensive VNF accepting varying traffic, SLRA managed to dynamically shrink by a significant factor the amount of resources (last-level cache, memory bandwidth) needed by the VNF to maintain its latency under a certain threshold. Depending on the traffic level, SLRA achieved a mere 10-40% utilization of the resources in the baseline case, freeing up the remaining capacity for other workloads to use.
- » In a dataplane VNF accepting varying traffic, SLRA managed to adjust its CPU power in line with traffic, without incurring SLO violations (packet drops). Compared to the baseline case, where the VNF was operating at maximum CPU frequency, server energy was reduced by 10-30%.

These results indicate that Deep RL has great potential in dynamically optimizing various types of applications and can be generalizable across resources of different types and semantics, rendering it a more effective alternative over existing approaches.

At a larger scale, Intracom Telecom evaluates SLRA in a PoC project of the ETSI Experiential Networked Intelligence Industry Specification Group. In the PoC, SLRA is challenged to fine-tune resources for multiple colocated VNFs implementing differentiated 5G slices, in order to meet latency SLOs fully automatically and always in line with incoming traffic. ■

To find out more on the NFV Resource Intelligence (NFV-RI™) solution and the SLRA application, please visit www.intracom-telecom.com/nfvri.



GETTING THE MOST OUT OF LICENSED FWA NETWORKS

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INTRODUCTION

Fixed Wireless Access (FWA) market has experienced tremendous growth based on the soaring demand for ultra-broadband services, coming from residential and business subscriber segments. To satisfy the demand, Communication Service Providers (CSPs) are now exploiting solutions that utilize the worldwide allocation of harmonized frequency bands in the millimeter wave (mmWave) spectrum @ 24/26/28GHz (5G FR2 n257, n258).

From the physical resources perspective, the opportunity of using wider channels at mmWave bands makes these parts of spectrum very attractive in serving both coverage and capacity. However due to the intensive frequency re-use required, FWA networks are intrinsically prone to interference. From the business perspective, the need to achieve market penetration and deploy at an accelerated pace, requires insightful decision-making based on detailed technical analyses.

This article highlights the associated challenges and indicates how these can be managed by facilitating the appropriate RF Planning techniques throughout the entire FWA lifecycle in order to satisfy subscriber needs, fulfill business objectives and yield considerable returns to investors.

CHALLENGES ACROSS THE FWA NETWORK LIFECYCLE

Best area coverage and high bandwidth per customer are the key business objectives for a successful FWA network. In order to fulfil them, CSPs must optimize their processes throughout the FWA network lifecycle phases, over which, RF Planning's contribution is crucial.

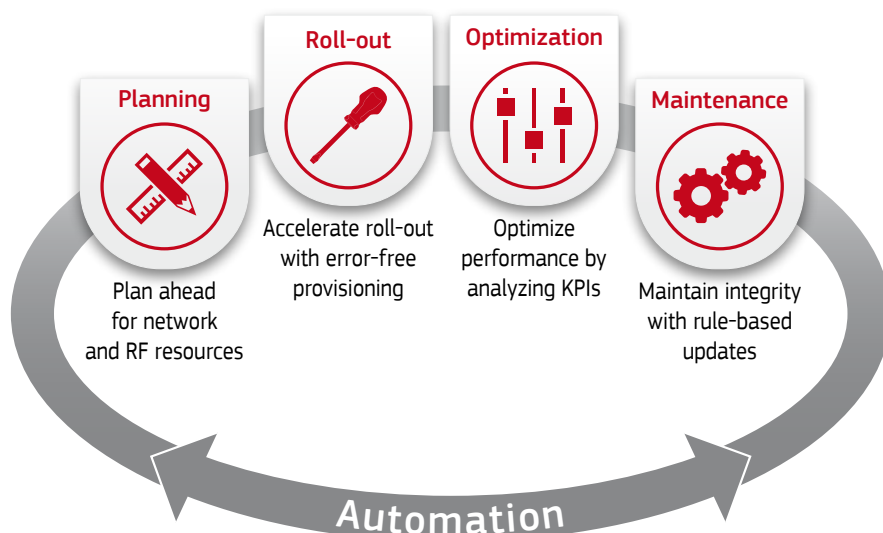
Starting from the FWA business plan formulation, RF planning needs to be utilized for technical dimensioning calculations including but not limited to maximum service range, number of customers per HUB definition and HUB configuration, so that attractive service packages can be offered to target customers in a cost-efficient manner.

In this regard, several conditions have to be examined, such as available spectrum resources, channelization restrictions, customer data rates, morphology as well as regulations in force (e.g. use of certain antenna diameters). All these available options are to be examined by the planning team that will provide performance analyses for a variety of scenarios usually within strict timeline.

Planning phase

Firstly, the area of interest with the potential end customers is identified. In addition, the candidate HUB locations with telecom infrastructure capability are considered. RF Planning's main focus at this phase is the selection of the proper location to build the HUBs so as to best serve the area. Usually HUBs selection is a challenging process where visibility conditions, installation and cost limitations, as well as network topology (i.e. HUBs optimum distribution) and possible network evolution have to be analyzed in detail and make the optimum decision.

In FWA network, RF Planning is not limited to the location selection, the real challenge is to find the frequency and polarization reuse pattern that mitigates the interference levels from near-by HUBs to the potential customers of



the new HUB and vice versa. Taking into account that in the majority of the real life cases, the exact customers locations are not known during this phase, the only way to find out the optimum frequency and polarization reuse scheme is to perform area coverage and interference simulations and compare different scenarios so as to achieve the highest Phy modes distributions in the service areas.

Roll-out phase

HUBs implementation sub-phase is typically the most easy-going period from planning point of view given that the every HUB has been designed as part of a network and not as a “stand-alone” point of access. However the real challenge here is to be confident that the plan has been followed so as to avoid Terminal Station installation failures and unnecessary revisits in customer premises. The verification of the HUBs implementation is really important and can take place either with field testing right after the finalization of a HUB installation or by taking advantage of the first customer that joins a HUB.

Apart from being confident about the installation of the HUBs and in order to exploit the spectrum resources and maximize performance, optimum Terminal Station installation is mandatory, too. For this purpose a detailed installation plan is derived. The installation work orders include specific KPIs to meet when the Terminal Station is activated and a list of alternative HUBs to be used in case a connection to the primary one cannot be established. The main

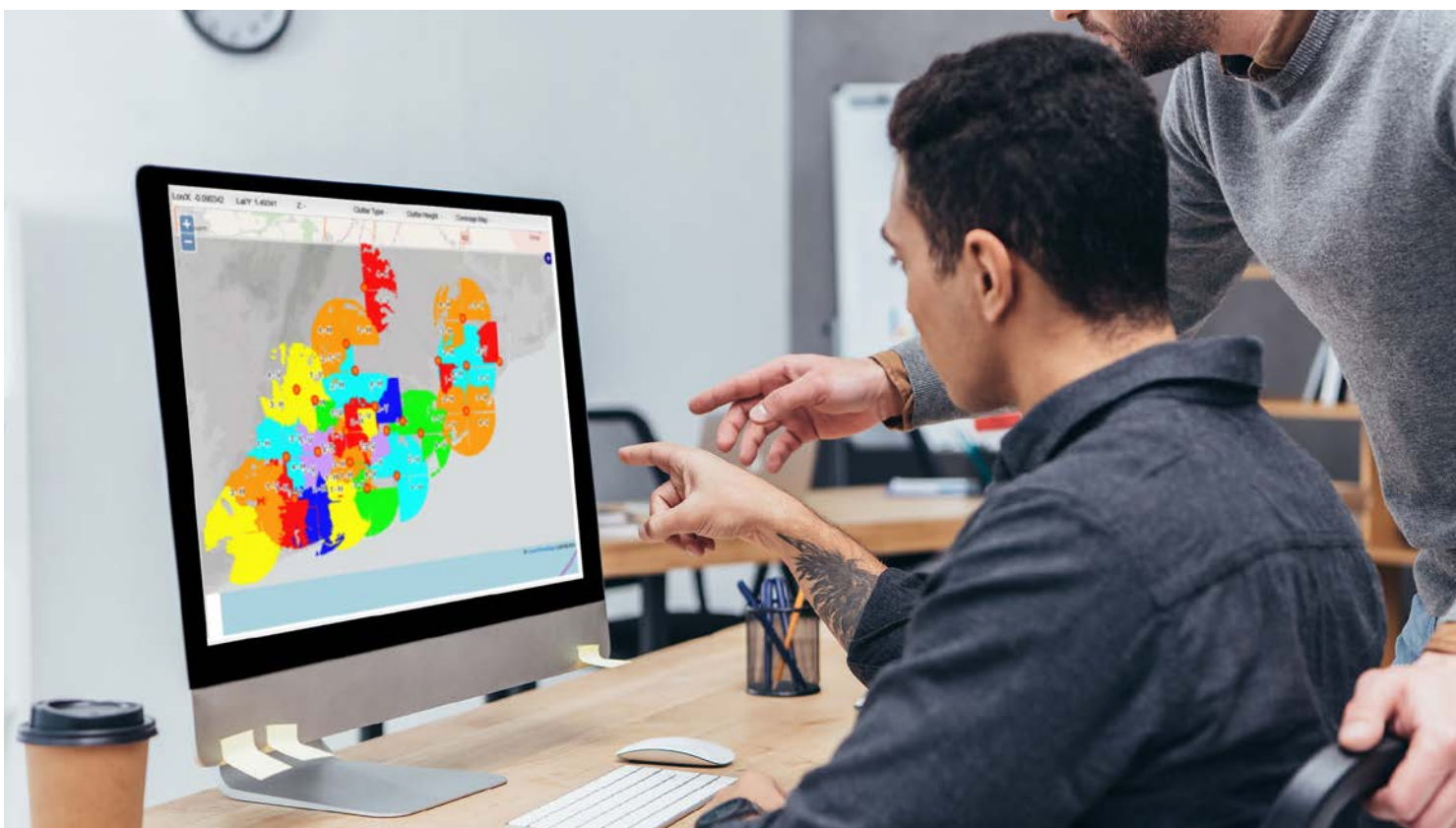
objective is to maximize the network performance, while the rollout is performed very quickly, avoiding possible field revisits.

Optimization phase

The scope at this phase is to perform optimization actions while eliminating down-time in either corrective interventions for dealing with performance degradation or deliberate actions for network evolution. A reliable as-built information database together with actual historical performance data has to be used to feed the analyses of the cases under investigation. This pool of data can be formulated by using various tools that are in place, after extracting and homogenizing the available data-sets. The challenge is to exploit information from a variety of fragmented sources within reasonable time-frame.

OPTIMUM DESIGN FOR SMOOTH OPERATION & BUSINESS SUCCESS

The challenges highlighted across the network lifecycle phases need to be addressed in order to serve the purpose of building and operating a reliable and efficient FWA network assuring the best quality for the end subscriber. Leveraging the licensed FWA comparative advantages of utilizing interference-free bands of the spectrum and without dealing with uncertainties of unlicensed alternatives, QoS-enabled services can be designed and delivered with



unmatched precision, given the following factors are met:

- » Best selection and detailed design of the HUBs
- » Controlling the Field Actions and delivering service-ready HUBs
- » Maintenance and update of as built information
- » Supervised installation of the Terminal Stations

HUBs designed as independent entities or even installed in an ad-hoc basis have always been proven to be the main reasons for a network to fail. Badly designed networks cannot expand and a radical reorganization of the entire HUBs and customers base is mandatory, imposing numerous and costly field actions. Careful planning is needed with examination of all possible scenarios so as to avoid those obstacles.

On the other hand, a well-designed network may suffer from improper installations of HUBs, resulting to customer connection failures till the origin of the problem is identified and resolved. Improper installations with incomplete communication of installation details or proofs of proper installation may result to time-consuming processes trying to identify the issue with repeatable site visits. To prevent such situations Interworking of Planning & Physical Views is needed.

Maintaining installation details and following the installation processes had always been the greatest challenge in the deployment of huge networks. The aforementioned Interworking of Planning & Physical Views, further enhanced with a global information database accessible by all involved parties, along with high level of automation for repetitive and/or time consuming tasks will provide the tools needed to meet these challenges.

A quite common situation is to end up with unbalanced capacity load between neighbor sectors. This may happen either due to lack of a plan for the Terminal Stations installation or due to field conditions that led to the assignment of many Terminals to a particular HUB. For example, a HUB installed on high elevation will be selected despite the fact that alternatives with better performance are available. Usually HUBs installed on easily distinguishable locations are accommodating a high number of subscribers even though their performance may be low. On the other hand, HUBs that are not easily distinguished due to buildings clutter and vegetation are usually underutilized. For this purpose smart tools, like Best Server Analysis (find the best HUB according to several KPIs), need to be utilized to identify the best option.

QUALITY ASSURED WITH UNIJMS™ RADIO PLANNER

The unijMS™ Radio Planner is a powerful Radio Network design tool supplying all the necessary facilities of Geo Data, Radios & Antennas Equipment, Frequency Channels, Waveguides and Couplers libraries, ITU and North-American design standards and climatic maps.

The rich variety of Analyses (Interference, Link Performance, Diffraction Loss, Reflections, Antenna Height Adjustment, Coverage Maps, and Capacity Analysis) offered in Reports and in the Map View can guide appropriately the Radio Planners for optimum radio design results.

The intuitive unijMS™ User Interface, the import/export functionalities along with smart algorithms for time-consuming processes facilitate the design alterations to be analyzed for the performance quantification of various scenarios.

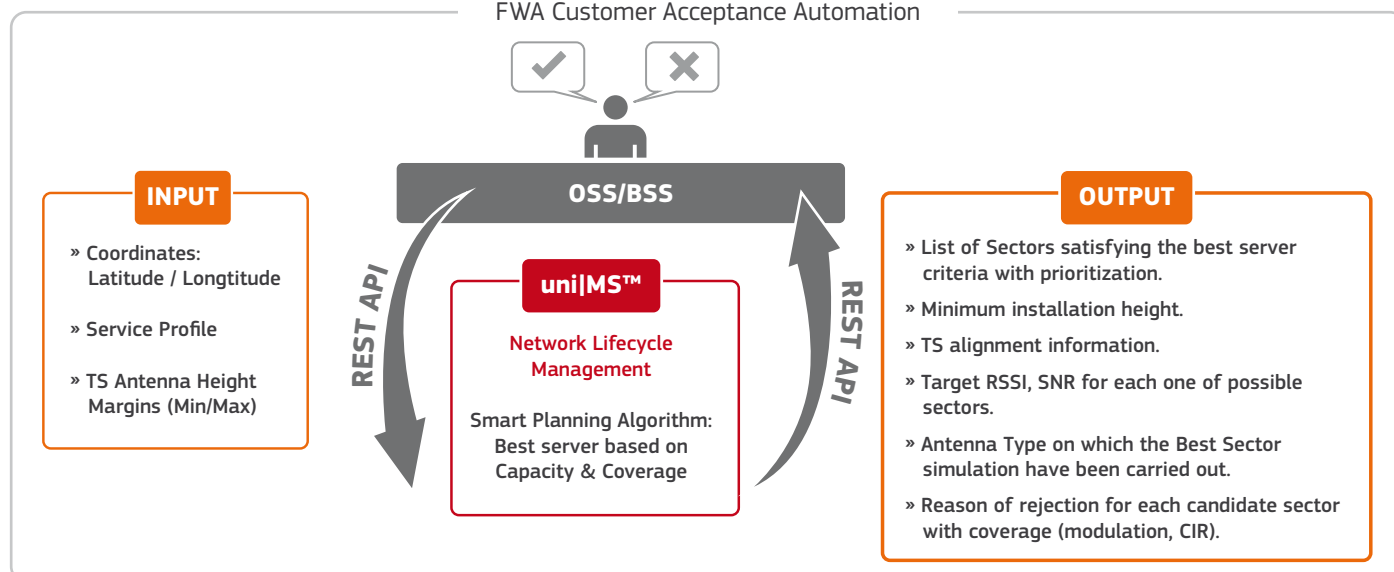
unijMS™ Radio Planner is a modern software application module of the unijMS™ platform, optimized for designing quality assured mmWave (26, 28 GHz) FWA networks

Coverage maps algorithms developed to serve FWA networks simulations and not mobile network simulations - as the majority of the available tools offering coverage functionalities - facilitate the HUBs design and optimization processes, while in collaboration with the smart algorithms developed to optimize the processes of properly adjusting the Azimuth and Tilt and Frequency Reuse of FWA sectors to cover certain area or customers assists the Radio Planning Engineers to provide reliable data for the network design.

For the Roll-out phase the powerful Best Server Analysis providing a complete capacity and coverage prioritization and KPIs fulfillment analysis boosts the Radio Planning Engineers' efficiency to analyze service requests and provide detailed guidance for the field actions so as to prevent unacceptable installations and costly customers' revisits.

The capacity analysis engine provides an adapting environment depending on the technology specification (time or capacity sharing) while for Intracom Telecom products a complete simulation of the resources allocation and the sector utilization is provided.

FWA Customer Acceptance Automation



EXCEEDING EXPECTATIONS WITH UNI|MS™ NETWORK LIFECYCLE MANAGEMENT

Interworking of Planning & Physical Views

The uni|MS™ Radio Planner can be facilitated as a standalone tool for RF Planning activities or it can leverage the network management application modules of the uni|MS™ platform for a closed-loop approach of the entire FWA network lifecycle activities, performed from a single User Interface.

uni|MS™ Radio Planner is seamlessly interworking with the other uni|MS™ platform application modules offering the great advantage of homogeneous data structure for Planning and Operational data, such as Sites naming convention, coordinates, installation/work-order details/actual service provisioning that can be accessed from all CSP departments that saves time with no error-prone manual data transformation compared to using various tools. Decision-making is efficient and based on data which is always up to date at a closed loop fashion. Consequently, accurate network evolution with physical network modelled in the RF planning tool, because Planners always have access on actual physical data.

Design and installation inconsistencies are directly inspected offering the advantage of proactive optimization rather

than being reactive and accelerated roll-out is achieved with automated Acceptance testing and audit activities avoiding site revisits.

Operational & Business Automations via API

The network lifecycle management concept, uniquely offered by the uni|MS™ platform, bridges the communication gap between Planners, Operators and Field Engineers accelerating insightful decision-making across the CSP organization. Elevating this concept, operational and business automations are offered via seamless integration with existing OSS/BSS infrastructure or via Network Lifecycle Automation Apps eliminating error-prone human involvement.

For operational automation, consider a case where the as-built information for Sites & HUBs is either not available in the uni|MS™ Radio Planner or a third-party tool has been utilized for Sites & HUBs planning. This information, critical for Terminal Station planning, can easily be inserted in a Planning Project via the uni|MS™ Rest API and can be created, modified and deleted.

For business automation, consider FWA customer acceptance in a way similar to xDSL, avoiding the lengthy evaluation process where RF planners would need to be engaged. Instead you can have your self-care portal to initiate the request and a uni|MS™ REST API providing the answer, making sure capacity and coverage KPIs are met based on smart planning algorithms that indicate the Best sector, the Terminal Station installation height and Antenna type, among other significant information at a touch of a button, while your RF Planning Expert could focus on supervising the automation and validating the relevant parameters. ■

With uni|MS™ NLA your RF Planning Expert could focus on supervising the automation and validating the relevant parameters

For more information, contact us at unims@intracom-telecom.com.

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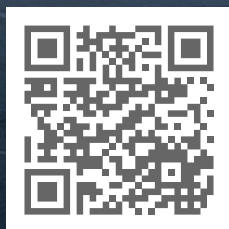


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