(one6G)

Taking communications
to the next level

PROTOTYPING IN 2024

Working group 4

WHITE PAPER

April 2025

one6g.org

Table of contents

1. Introduction

This is the 2nd White Paper of one6G Working Group 4 summaries the testbed and prototyping actives in 2024 showcased during the one6G summit 2024 in Valencia in cooperation with PIMRC2024.

Objectives of one6G association are to evolve, test and promote cellular and wireless technology-based communications solutions, to support future global 6G research directions and their standardisation and to accelerate their availability and global market penetration in order to address society's connected mobility and industry needs with regard to future applications such as advanced autonomous driving, advanced manufacturing, advanced wireless e-health and others.

Different working groups (WG) has been established to prepare, approve and maintain the association's reports, white papers, and other outputs within the overall scope of their activities e.g. on technology overviews [3] and vertical use cases like WG1 [4]. Saying this Working group 4 covers all the steps from development to deployment, defining of testing procedures, setup of testbeds and trials jointly with the one6G members. Evaluation guidelines for all simulation, emulation and prototyping activities has been compiled and are available for members since 2022 [2].

Besides the continues work one major goal is to organize events in particular the annual one6G summit since the founding in 2020 where one6G partners presents and demonstrates their achievements in prototyping of 6G technologies and testbeds.

It is significant for the continuously increasing number of members and the scientific cooperation between the partners that the 2023 one6G summit stood out especially for the diversity of the exhibitors.

At more than 10 stations the visitors of the one6G summit and the PIMRC conference examine the various technical solutions and discuss them with the developers and researchers. Perhaps it was due to the work items on robotics [1] launched in 2023 that a significant portion of the demo also had robotics as a new promising use case for 6G to core.

On behalf of one6G working group 4, the chairmen of the working group would like to thank all exhibitors whose assistances and supporters in the background for the one6G summit 2024 whose exhibits are described more closely in the following chapters. Of course, the expectations for 2025 are correspondingly high.

All demos and exhibitions are listed in order to match the list on the one6G 2024 Summit website [5]. It begins with a brief abstract, followed by a reference to the 6G cases and technologies with planned extensions and brief information from the operator including contact information.

Several 6G technologies has been demonstrated with different prototypes. The table below provides an overview of the demos and the addressed 6G technologies and use case.

Table 1: 6G technologies and use cases addressed by the demos

Demo	Demo title	6G technologies	Use Cases
1.1	Neural Network Receiver	AI	New RAN design
1.2	Rate-Splitting Multiple Access	6G MAC	New access schemes
2.1	THz Postal Scanner	THz	THz imaging
2.2	Sub-THz Thickness Gauge	THz	Material characterization
3	6G Robot Empowered by ISAC and LLM	THz ISAC, AI / LLM	ISAC for gesture recognition, AI and graph based semantic sensing for 6G robots
4	A Digital Twin Channel Platform Enabled by Environment Sensing	Sensing	Digital Twin, Environment sensing
5	VR Robot Integration	XR/VR	Digital Twin, XR
6	Explainable AI Techniques for Self-Organized Networking	AI	NetGPT
7	Dynamic Orchestration of Robot Functions in the 5G/6G cloud continuum	AI	6G Robotic, AI, LLM
8	Real-Time Tracking and Classification of Multiple Targets	Sensing, AI	Tracking and Classification
9	Beyond 5G Localization in 3GPP Compliant Scenarios	Localization	localization
10	Sub 6G presence and posture detection	Sensing, AI	Posture Detection
11	5G/6G AI empowered forest fire early detection	Sensing, AI	Drones, Emergency
12	Multi-User holoportation and virtual production	XR,	holoportation
13	Adaptive Remote Renderer for VR experiences	VR	VR
14	Holographic & Telepresence real-time remote tour	VR	Holographic, telepresence
15	Game-Engine Fast Ray Tracing	VR	Ray tracing, channel modelling
16	Integrated Sensing and Communication	ISAC, sensing	ISAC

2. Acknowledgement

The flagship event of one6G [5] was organized in 2024 in cooperation with IEEE PIMRC2025 conferences [5]. Special thanks to Prof. Narcis Cardona from the UPV and his excellent organization team for the outstanding support during the organization of the event and in particular for the joint exhibition with Exhibitors from PIMRC and one6G.

On behalf of one6G WG4 the exhibitors appreciate the outstanding support from the organization team in particular the chairs of WG3. Thanks to all supporters in the Backoffice helping to make this event so successful and impressive.

Contributors

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3. Abbreviations

6G	Sixth Generation of mobile communication system
ADC	Analog Digital Converter
AI	artificial intelligence
AR	Augmented Reality
BS	base station
CPU	central processing unit
ECA	error correction amplitude
eMBB	Enhanced Mobile Broadband
FDD	Frequency Division Duplex
GPGPU	general purpose graphics processing unit
GPU	graphics processing unit
Inatel	National Institute of Telecommunications
IPC	inter-process communication
ISAC	Integrated Sensing And Communication
ISAC	Integrated Communication And Sensing
LLM	Large Language Model
MAC	medium access control
MCS	modulation coding scheme
NN	Neural Network
OR	Operating Room (surgery)
PHY	physical layer
PIMRC	Personal, Indoor and Mobile Radio Communications
QoS	quality of service
RAN	Radio Access Network
RIS	Reconfigurable Intelligent Surfaces
RF	Radio Frequency
RSMA	Rate Splitting Multiple Access
SDR	software-defined radio
SIMD	single instruction multiple data
SNR	signal-to-noise ratio
TDD	Time Division Duplex
THz	TeraHertz Frequency
TVWS	TV white space
UE	user equipment
UHF	Ultra-High Frequency
URLLC	Ultra-Reliable Low Latency Communication
VLM	Vision Language Model
VR	Virtual Reality
XLA	Accelerated Linear Algebra

4. Demonstrators and Prototypes

Demo #1.1

Neural Network Receiver (Viavi)

Abstract

AI-Native Air Interface (AI-AI) has appeared as a shift in the conventional methods of developing, standardizing, and commercializing communication technologies with the goal of effectively supplying data to applications while addressing communication problems and hardware limitations. In the physical layer of wireless communications, the neural network (NN) receiver concept suggests replacing traditional signal processing blocks with trained AI models. In this demo, we demonstrate our in-house developed complete NN receiver in a downlink scenario with 5G-NR compliant OFDM signal (PDSCH) transmission. The BS employs an AI-aided constellation design, where the modulation block is replaced with an NN to design a custom constellation for the NN receiver. The UE has an NN receiver with two NNs: (1) First NN is replacing the channel estimation, interpolation and equalization, and signal demodulation blocks, and (2) Second NN is replacing the LDPC channel decoding block. For the 5G-NR baseline, we consider a signal processing-based receiver employing least square (LS) channel estimation with linear interpolation and LMMSE equalizer. We investigate and compare the performance of NN and signal processing-based receivers for transmissions with and without pilots.

Demo 1.1 will demonstrate a complete Neural Network (NN) receiver developed in-house in VIAVI in a downlink scenario with 5G-NR compliant OFDM signal (PDSCH) transmission and compare the performance of NN and signal processing-based receivers for transmissions with and without pilots.

The neural network (NN) receiver concept suggests replacing traditional signal processing blocks with trained AI models.

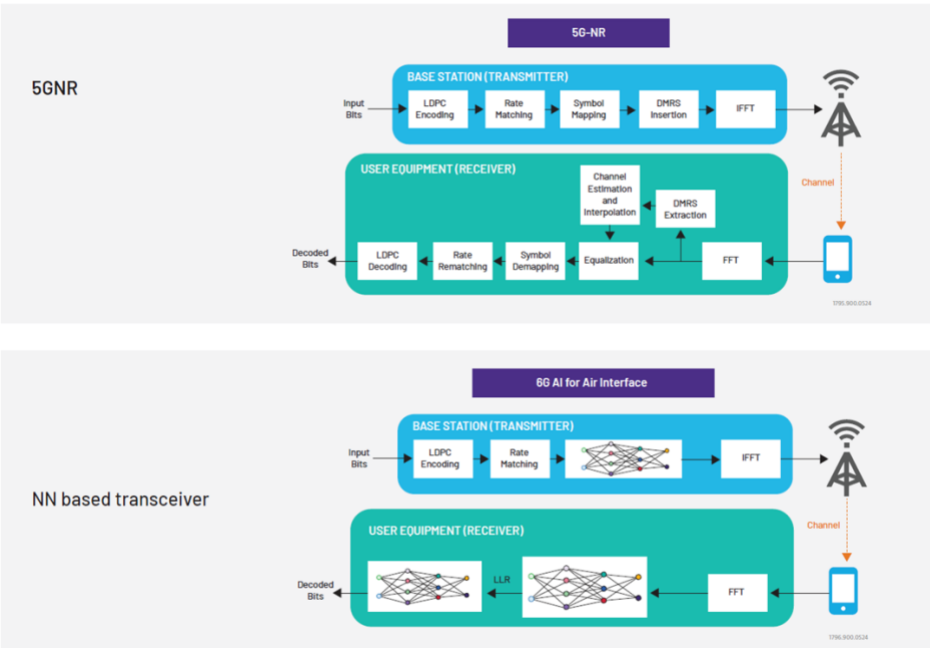

Figure 1: AI for the Air Interface - Neural Network-Based Transceiver

To enable comprehensive testing of neural receivers, VIAVI has developed a neural receiver in-house and demonstrated it as part of an end-to-end test and training environment (Figure 1).

For pilotless transmission, the base station employs an AI-aided custom constellation design, where the modulation block is replaced with a neural network to design a custom constellation for the receiver.

6G use cases and key technologies

Novel Receiver design based on AI-Native Air Interface (AI-AI) replacing traditional signal processing blocks with trained AI models

Exhibitor contact information and references

VIAVI Solutions is a global leader in communications test and measurement and optical technologies. VIAVI enables customer innovation in industries ranging from communication networks, hyperscale and enterprise data centers to consumer electronics and mission-critical avionics, transportation, aerospace and anti-counterfeiting systems.

One6G member since 2022

Contact for the one6G and PIMRC exhibition booth: Paul Harris (paul.harris@viavisolutions.com)

Demo #1.2
Rate-Splitting Multiple Access (Viavi)

Abstract

Rate Splitting Multiple Access (RSMA) is a multi-antenna multiple-access technique that is robust against the disruptive effects of multi-user interference. In this demo, we show the performance of an in-house RSMA downlink scheme for overloaded networks, where the maximum number of data streams at the transmitter is smaller than the number of users. To show the advantage of VIAVI's RSMA scheme, we also investigate the performance of Multi-User Multiple Input Multiple Output (MU-MIMO) with scheduling in overloaded networks, in which users are divided into smaller groups. These groups are allocated orthogonal time resources and the users in each group are served simultaneously by spatial multiplexing. We investigate and compare the performance of RSMA and MU-MIMO in a 2x4 system under perfect and imperfect Channel State Information (CSI) feedback assumptions.

Demo 1.2 will present the performance of an in-house RSMA downlink scheme for overloaded networks, where the maximum number of data streams at the transmitter is smaller than the number of users as depicted in Figure 2.

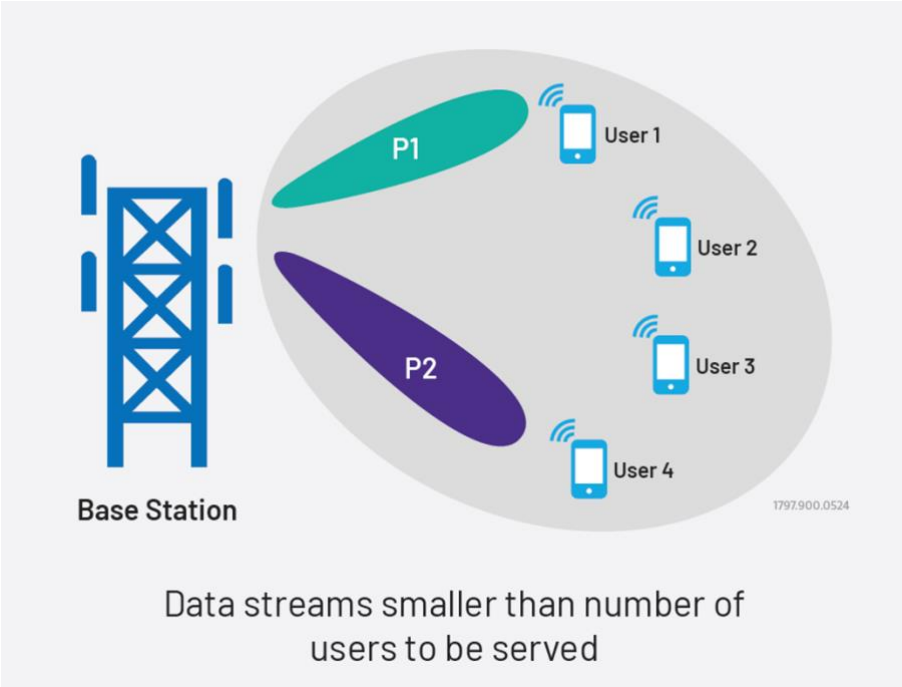

Figure 2: concept of rate splitting multiple access

Rate Splitting Multiple Access (RSMA) is

- A multi-antenna multiple access technique that is more robust against multi-user interference
- Employs Rate-Splitting at the transmitter and Successive Interference Cancellation at the receivers
- Achieves improved performance under a greater range of scenarios by blending between MU-MIMO and NOMA

VIAVI RSMA PoC demonstrates:

- RSMA downlink transmission scheme for overloaded networks
- Comparisons made between 2x4 RSMA and MU-MIMO for perfect and imperfect CSI feedback

Promising results shown in Figure 3 below.

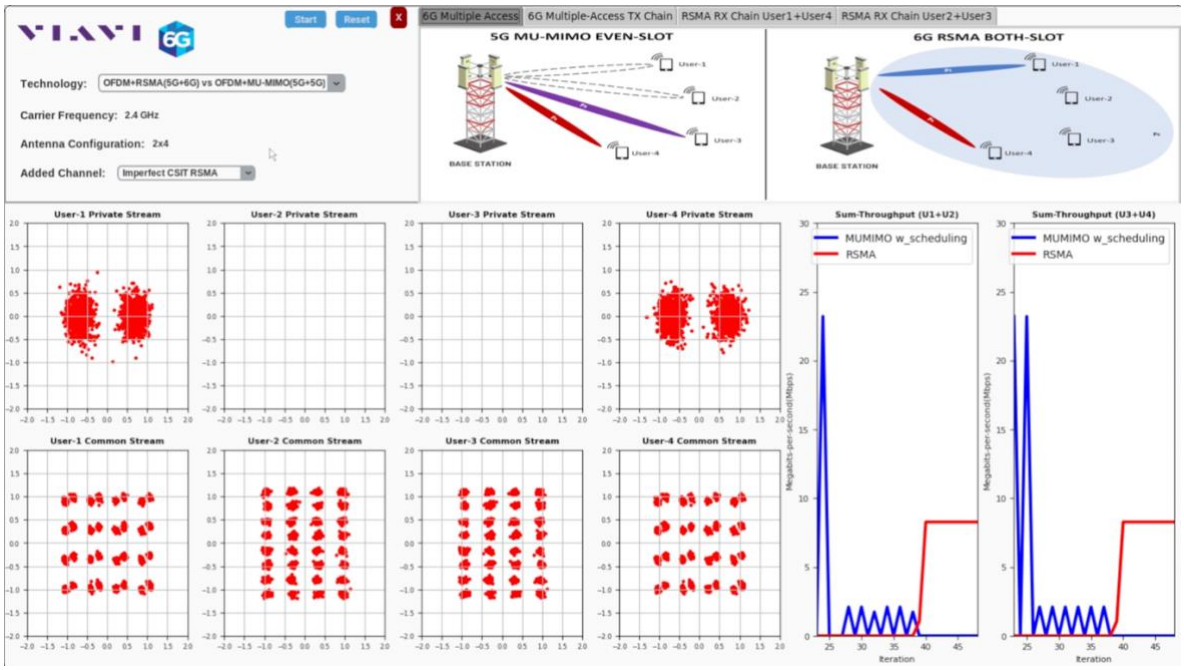

Figure 3: VIAVI RSMA PoC

6G use cases and key technologies

The demo explores enhanced Multiple Access schemes for 6G. Enhanced MA-schemes are discussed in one6G work items on "6G radio building blocks (6GRA)" and "Next generation multiple access (NGMA)" in WG2 and addressed in the published white papers [https://*one6G.org/resources/publications/*].

Exhibitor contact information and references

VIAVI Solutions is a global leader in communications test and measurement and optical technologies. VIAVI enables customer innovation in industries ranging from communication networks, hyperscale and enterprise data centers to consumer electronics and mission-critical avionics, transportation, aerospace and anti-counterfeiting systems.

One6G member since 2022

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Demo #2.1

THz Postal Scanner (CENTERA)

Abstract

CENTERA presents a demo of a tool for exploring terahertz imaging applications. The THz imaging system is a tabletop scanner based on a single THz detector-emitter pair and a motorized x-y table with the possibility of adjusting the focal point in the z-direction. An object moves over the emitter-detector scanned zone; during this process, we reconstruct an image of the scanned object in the terahertz range. It delivers down to 1 mm spatial resolution (x-y) with scans up to 150x210 mm large samples (format A5 letter envelope). Several hidden objects in a paper envelope will be scanned to demonstrate the capabilities of such a THz scanner system.

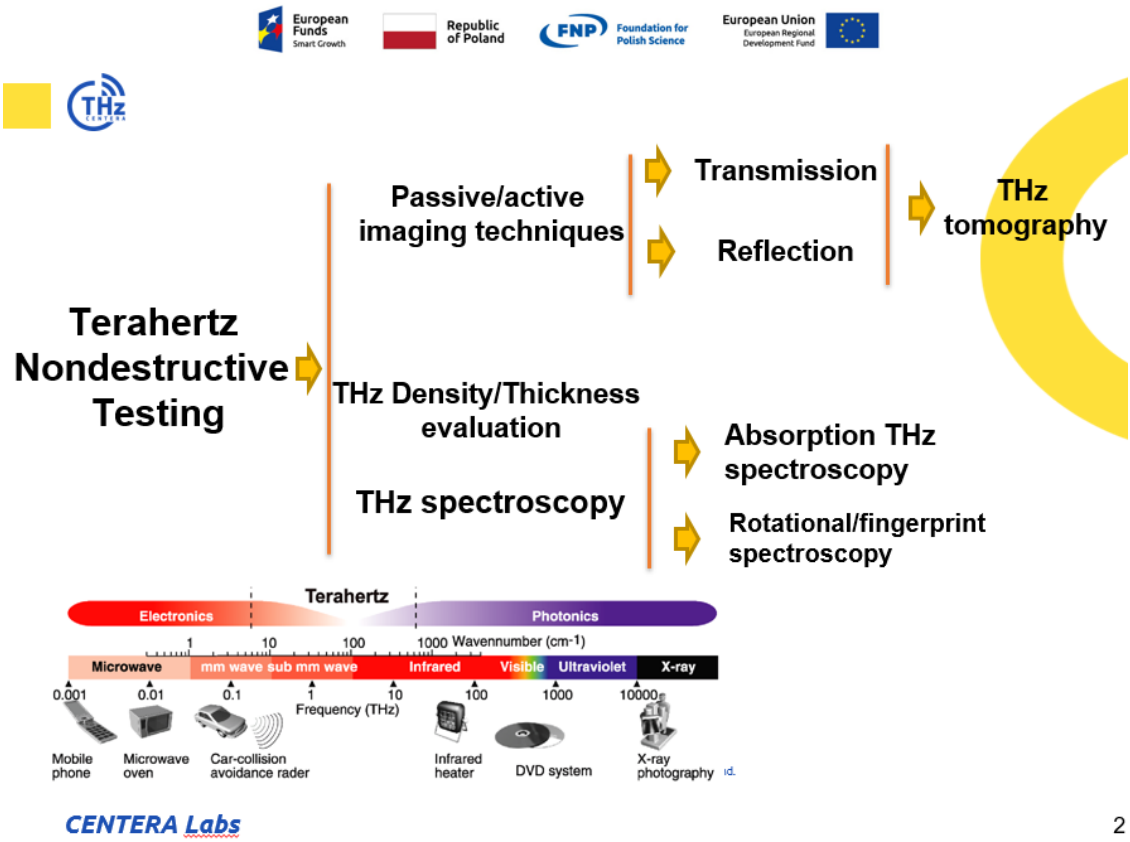

Figure 4: overview of subTHz techniques

Example applications are security screening, inspection and quality control in dielectric materials, non-destructive testing tool for different industries.

Figure 5: examples of scans

6G use cases and key technologies

Besides many new requirements and key technologies, 6G will consider extensions of the frequency bands. ITU-R has already agreed on the candidate band in the subTHz regime. ETSI has established a special interest group for research on THz spectrum called ETSI ISG THz. A dedicated work item in one6G is performing research on high frequencies beyond the FR2 band (>90GHz). This Work Item identifies relevant scenarios and frequencies of interest for communication, based on the overall one6G use cases and scenarios defined by Working Group 1. Then, it has performed a survey on existing channel measurements and modeling in selected frequencies.

Exhibitor contact information and references

Center for Terahertz Research and Applications (CENTERA) is a project carried out within the International Research Agendas programme of the Foundation for Polish Science co-financed by European Union under the European Regional Development Fund.

CENTERA is One6G member since: 2024

Contact for the one6G and PIMRC exhibition booth: Valeri Mikhniev (mvaleri@unipress.waw.pl)

Demo #2.2
sub-THz Thickness Gauge (CENTERA)

Abstract

CENTERA labs presents new method and device to measure the thickness of non-metallic coatings of metals. The device is not sensitive to the dielectric properties of the coating. The prototype can accurately measure any non-metallic coating on any metal without re-calibration. This increases the measurement accuracy and helps to avoid bad errors in the measurements. The thickness gauge is intended for accurate measurements of the thickness of paint, protective and other non-metallic coatings on any metal and alloys.

The sensor is nearly insensitive to the type of metal substrate, its thickness, and also to the dielectric properties of the paint. For that reason, the sensor does not require re-calibration when switching from one object under test to another.

The measurement method is intrinsically stable to the environmental temperature. The prototype supports a Measurement range of 0 to 500 micrometer. Possible extensions up to 2000 micro meter.

Expected measurement accuracy is about +/-2 micro meter + 0.01T, where T is the thickness.

In fact the sensor use frequencies in the so called 3GPP FR2 band.

Figure 6: prototype of the sub-THz Thickness Gauge presented at the one6G summit 2024

6G use cases and key technologies

Both demonstrations 2.1 and 2.2 demonstrates the capabilities of Sensing in the frequency bands allocated for mobile radio communications. it can be counted as monostatic sensing approach based on extensions of the future 6G smartphones and devices. In this regard the demo is linked to the one6G research in work item on high frequencies and also on the work item on ISAC (Integrated Sensing and Communication – WI210).

Exhibitor contact information and references

Center for Terahertz Research and Applications (CENTERA) is a project carried out within the International Research Agendas programme of the Foundation for Polish Science co-financed by European Union under the European Regional Development Fund.

CENTERA is One6G member since: 2024

Contact for the one6G and PIMRC exhibition booth: Valeri Mikhniev (mvaleri@unipress.waw.pl)

Demo #3

6G Robot Empowered by ISAC and Large Foundation Models (Huawei)

Abstract

The demo respectively PoC showcase next steps towards a 6G robotic framework. The journey has started with the demo at the one6G summit 2023 and other conferences as EuCNC, Hannover Fair, and Mobile World Congress. In 2023 the focus was on THz ISAC and robotic control enabled by the novel features of LLM and Generative AI. Human-robot collaboration is one of the highlighted use cases. Human – robot interaction was addressed in the one6G white paper in 2023 [6] by the use case "Collaborative robots in industrial environments" and "Service Robots for Healthcare assistance". All contributions to the one6G summit 2023 is available as recorded presentations on [7]

As continuation of the research tree new features has been demonstrated in 2024 during the one6G summit in Valencia (Figure 7).

1. Radio sensing for gesture recognition communication waveform OFDM
2. Semantic data management using 3D semantic scene graph and
3. Dynamic digital twin with context-aware environment reconstructions

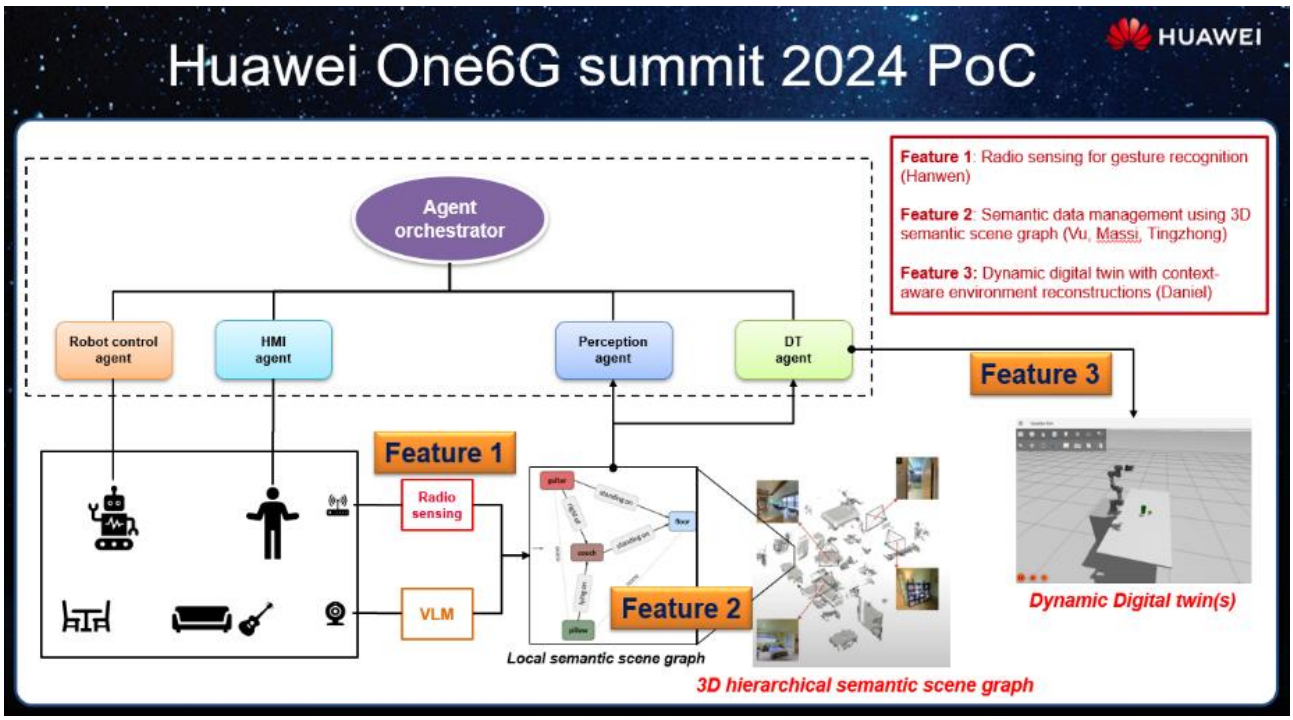

Figure 7: overview of the Huawei demo features

Visitors gets a presented the demo in 5 steps as shown on Figure 8

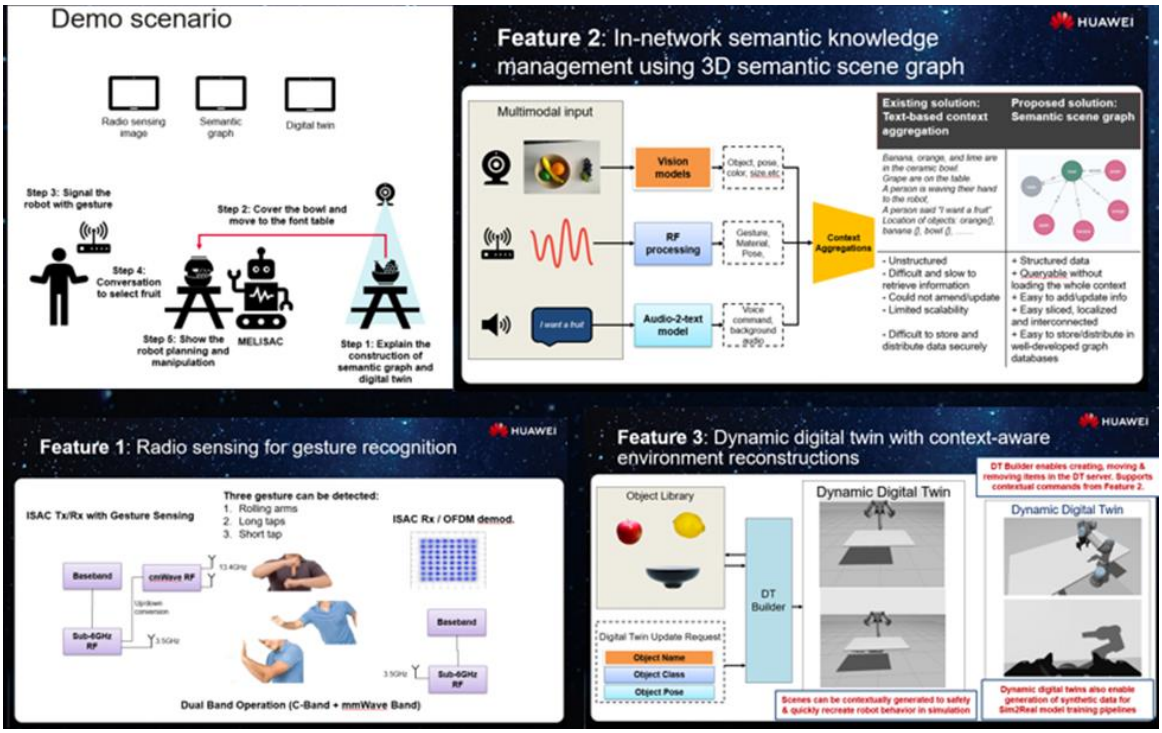

Figure 8: presentation flow

In the demo it is also clearly demonstrated that sensing is concurrently done with OFDM based communication as seen with the 16/64 QAM constellation diagram in Figure 8.

For the radio sensing, the demo use communication waveforms more specifically. A radio signal with 16QAM modulation has been used to sense the human gestures. Gestures can be captured, triggering the movement of the dual arm robot of the Huawei prototype.

Thanks to 3D sensing based semantic graph robots can understand the environment with semantic information. Basically, the robot will know what is actually going on in situations, and also based on that give the actions to the requirements to the use in a proper way.

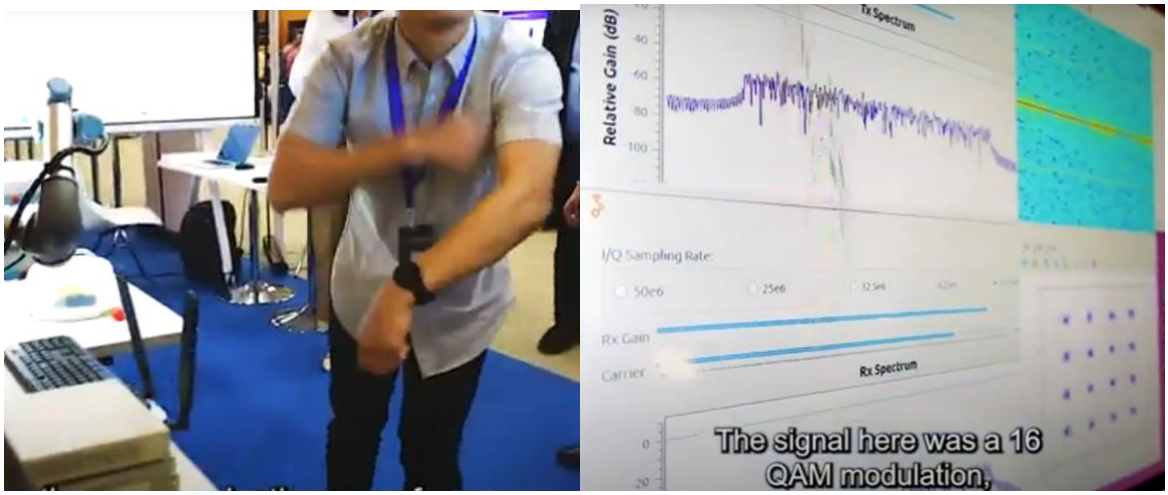

Figure 9: gesture, waveform and 3D sensing signal processing (right above)

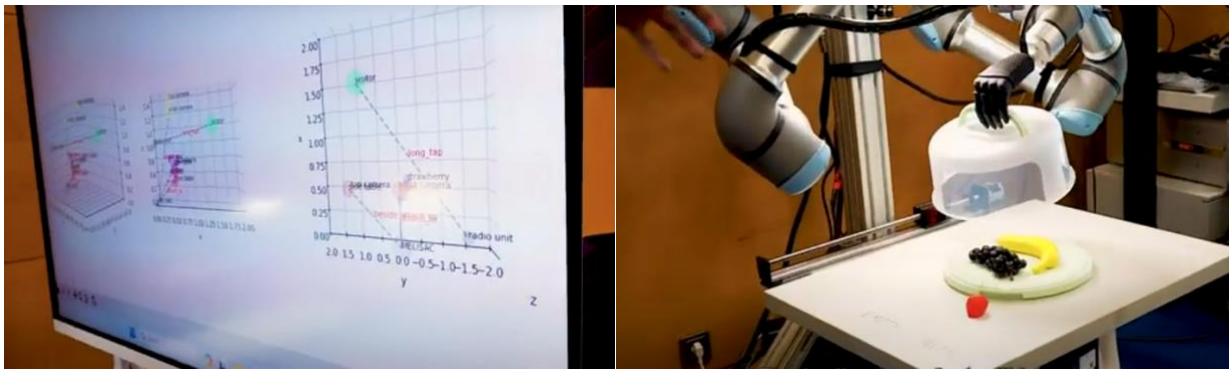

Figure 10: 3D sensing based semantic graph enables situation awareness of robots

6G use cases and key technologies

6G robotic enabled by ISAC and LLM is besides others the focus of the research and prototyping activities in the Advanced Wireless Technology lab located in the Munich Research Center of Huawei. The intention of the prototype is to demonstrate ISAC, Agents based network orchestration and LLM enabled reasoning of robot actions. Beside this a digital twin is the key hosted by the operator network.

Exhibitor contact information and references

Huawei Technologies Duesseldorf GmbH is the legal entity of the Munich Research Center where the research, implementation and test of the above described demonstration was done as part of the 6G robotic activities.

One6G founding member since: 2022

Contact for the one6G exhibition booth: Hanwen Cao (Hanwen.cao@huawei.com); Mohamed Gharba (mohamed.gharba@huawei.com)

References:

[6] Working Group 4. one6G.org, "one6G Prototyping in 2023," one6G.org, Munich, 2024.

[7] one6G.org and WG4, "Recordings - one6G - Taking communication to the next level," one6G.org, 2024. [Online]. Available: https://one6G.org/resources/recordings/. [Accessed 2024].

Demo #4

A Digital Twin Channel Platform Enabled by Environment Sensing (BUPT)

Abstract

Digital twin channel (DTC) is a digital virtual mapping of a wireless channel that reflects the entire process of channel fading states and variations in the physical world (Figure 11). DTC provides significant performance enhancements for air-interface design. It is expected to support the online optimization of transmission strategies and network performance, and improve the adaptability of the network to complex environmental changes. In this demo, we will show the proposed method to realize DTC and build a sensing-enhanced radio environment prediction platform. The platform uses depth camera to sense the environment and extract its feature. Then, the platform reconstructs the environment to realize the digital twin of the physical world. Based on hardware and software acceleration technologies such as space partitioning and GPU parallelism, the platform can perform electromagnetic calculating quickly in the twin world through the self-developed channel prediction methods. Finally, radio wave propagation is predicted and a DTC is obtained. We investigate and compare the propagation characteristics such as channel impulse response (CIR), power-delay profile (PDP) and power-azimuth spectrum (PAS) of DTC in Line of sight (LOS), Non line of sight (NLOS) scenarios in indoor environment.

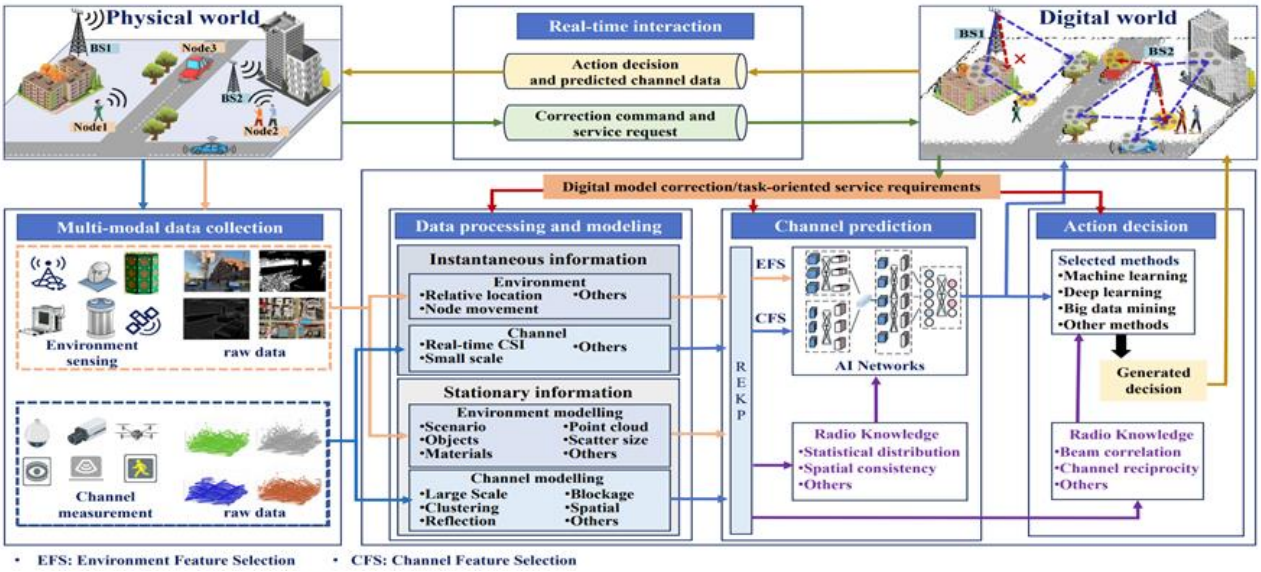

Figure 11: DTC Platform structure

This demo shows the proposed method to realize DTC and build a sensing-enhanced radio environment prediction platform (Figure 12). The platform uses sensing devices to sense the environment and extract features. Then, the platform reconstructs the environment to realize a digital twin of the physical world. With the aid of hardware and software acceleration, the platform rapidly performs electromagnetic calculations in the twin world. Finally, radio wave propagation is predicted, and a DTC is obtained to realize the digital twin communication.

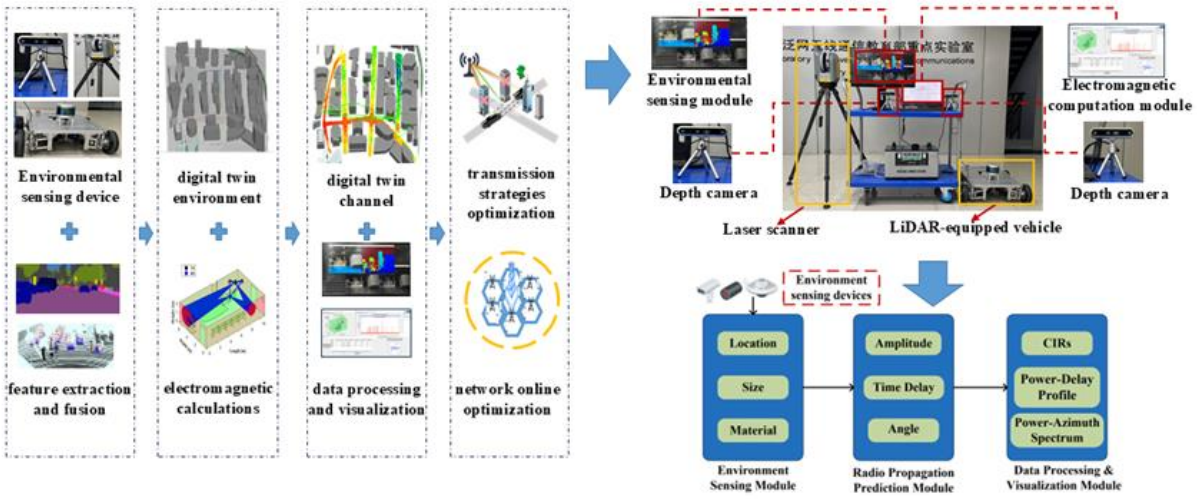

Figure 12: DTC Platform workflow

6G use cases and key technologies

DTC plays a key role in 6G, with applications in industrial automation, smart cities, vehicular networks, and emergency communications (Figure 13). In industrial automation, DTC predicts multipath effects in real-time, optimizing ultra-reliable low-latency communication (URLLC) for robot collaboration and digital twin factories. In smart cities, DTC enhances millimeter-wave and terahertz coverage through electromagnetic simulations. In vehicular networks, DTC predicts link degradation and supports dynamic spectrum sharing. In emergency communications, DTC generates disaster site channel models to assist in base station configuration.

Key technologies of DTC include using multimodal sensors to create digital twins, AI/ML-accelerated electromagnetic computation for efficient channel prediction, dynamic network optimization via digital twin feedback, high-frequency band channel modeling, and fault prediction triggering network self-healing. DTC supports 6G core technologies such as AI-native air interfaces, resilient networks, and intelligent reflecting surfaces (RIS), driving their practical implementation.

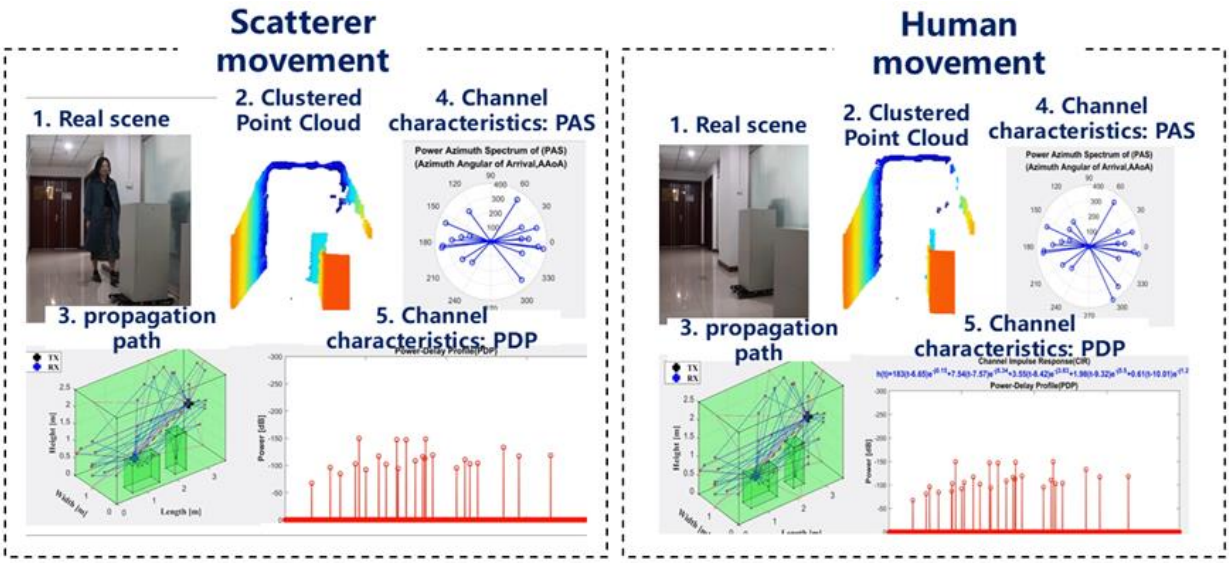

Figure 13: Application cases

Exhibitor contact information and references

Beijing University of Posts and Telecommunications, Beijing, China https://www.bupt.edu.cn/

Beijing University of Posts and Telecommunications is a leading academic institution in the field of information and communication technology. It is actively involved in research and development of advanced wireless communication technologies, including 6G. The research, implementation, and testing of the above-described DTC platform was conducted as part of the university's 6G research activities.

BUPT is One6G member since: 2023

Contact for the one6G and PIMRC exhibition booth: Li Yu (li.yu@bupt.edu.cn)

References:

[1] Y. Miao, Y. Zhang, J. Zhang, Y. Sun, Y. Tian, L. Yu and G. Liu, "Demo Abstract: Predictive Radio Environment for Digital Twin Communication Platform via Enhanced Sensing," in 2023 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS), 2023, pp. 1-2.

[2] H. Wang, J. Zhang, G. Nie, L. Yu, Z. Yuan, T. Li, J. Wang and G. Liu, "Digital Twin Channel for 6G: Concepts, Architectures and Potential Applications", *IEEE Communications Magazine*, early access.

[3] J. Wang, Y. Zhang, J. Zhang, Y. Sun, G. Nie, L. Shi, P. Zhang, G. Liu, "Towards 6G Channel Digital Twin Using Radio Environment Knowledge Pool," *IEEE Communications Magazine*, early access.

[4] G. Nie, J. Zhang, Y. Zhang, L. Yu, Z. Zhang, Y. Sun, L. Tian, Q. Wang, and L. Xia, "A Predictive 6G Network with Environment Sensing Enhancement: From Radio Wave Propagation Perspective," China Communications, vol. 19, no. 6, pp. 105-122, 2022.

[5] L. Yu, Y. Zhang, J. Zhang, and Z. Yuan, "Implementation Framework and Validation of Cluster-Nuclei Based Channel Model Using Environmental Mapping for 6G Communication Systems," China Communications, vol. 19, no. 4, pp. 1-13, 2022.

Demo #5

VR Robot Integration (ExtendRobotic)

Abstract

As an update of the showcase at one6G summit 2023, Extend Robotic has presented new capabilities and solutions.

Extend Robotics is building a highly intuitive human robot interface seamless connection between humans and robot using minimal hardware and with negligible latency. This kind of interface provides easy adoption of robots at affordable cost which is crucial for large scale deployment of robots in society and for industrial purposes.

In one6G summit 2024 event, we demonstrated improved visual perception and user interface with an easy-to-use data recording and playback feature. The improvements enabled more precise control of the arm and end effector, receiving positive responses from the visitors who thought it was very easy to train and use. Revolutionizing the control of robotic systems by building a human robot interface which is intuitive and accurate (Figure 14)

Figure 14: Demonstration at one6G summit 2024 in Valencia

The Advanced Mechanics Assistance System (AMAS) from Extend Robotics turns a real robot into a physical avatar with fully immersive remote workspace and 3D vision (Figure 15). Features such as added depth perception, flexible viewing angles, intuitive gesture control, ability to integrate with any third party ROS based robots and automation copilot make the system extremely versatile with unlimited scalability and customization options.

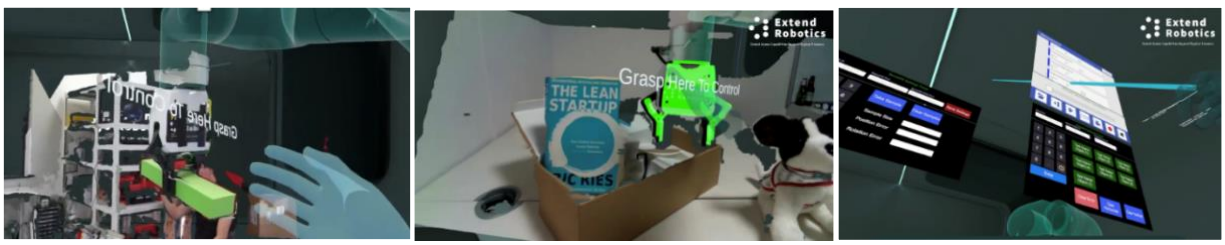

Figure 15: AMAS immersive workspace and 3D vision

We envision that it will unlock huge potential in for industrial applications, starting from hazardous areas to everyday tasks where robots will need to be trained and managed by human operators

remotely. As we integrate the system into complex applications, 6G technology will be essential to maintain the seamless remote connection especially in areas where multiple robots are deployed. 6G could provide even lower latency, higher bandwidth, and further computation support from within the network.

6G use cases and key technologies

A robotic arm (weight ~approximately 7.5 Kg) to be controlled through VR headset and gesture joystick control. High precision remote control e.g. for dangerous applications everywhere on Earth and in Space. AMAS VR Software lets you physically control robotics arms remotely over the internet, using intuitive gestures in an immersive 3D environment. UR5 robotic arm was used for the demonstration at the one6G summit 2023. Furthermore supports the solution xArm6 robotic arms and the TIAGo mobile robotic system from PAL robotic.

Extensions are planned regarding Extending Human Capability Beyond Physical Presence. Safer, Faster and Cheaper Remote Physical Workforce, with Metaverse, Robotics and Artificial Intelligence.

Exhibitor contact information and references

Extend Robotics Ltd, UK https://www.extendrobotics.com/

One6G member since: 2023

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Nitish Sharma, Nitish Sharma (Nitish@extendrobotics.com)

Demo #6

Explainable AI Techniques for Self-Organized Networking (AiVader)

Abstract

Machine Learning-powered Self-Organizing Network (SON) functions are revolutionizing 5G(+) network management by enabling systems to learn and optimize performance autonomously. However, despite their high efficiency, many state-of-the-art ML models operate as "black boxes," creating barriers to trust and delaying widespread operational deployment. Our collaborative project, driven by AiVader GmbH and Technische Universität Ilmenau, overcomes this challenge by leveraging Explainable-AI techniques. This innovative approach clarifies the decision-making processes of complex ML models, delivering transparent, actionable insights that verify the accuracy of critical network relationships. The outcome is a robust, trustworthy solution that accelerates the adoption of automated, self-optimizing network solutions for future networks.

As part of this research, Coverage and Capacity Optimization (CCO) was implemented as an xApp running on a Near-RT RIC to demonstrate their coordination using Explainable-AI methods. The setup was deployed on AiVader's 5G-in-a-Box, a fully integrated, portable private 5G solution designed for rapid deployment and real-world network testing. This demonstration highlights the potential of Explainable-AI in optimizing complex SON functions, ensuring greater transparency, reliability, and trust in AI-driven network automation.

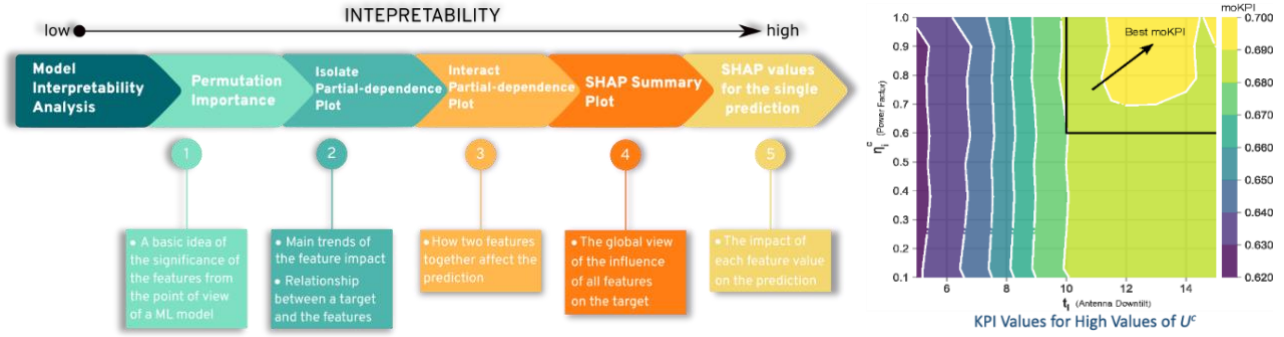
Demo #6: AiVader & TU Ilmenau - One6G Summit'2024

6G use cases and key technologies

- Enhanced Network Coordination: Our project tackles a pivotal coordination scenario between two essential SON functions—Coverage and Capacity Optimization (CCO) and Inter Cell Interference Coordination (ICIC). By applying Explainable-AI methods, we gain a deep understanding of how these functions interact, ensuring that our ML models capture all vital network dynamics accurately.
- Trustworthy Automation for 6G: As networks evolve towards 6G, the need for automated, reliable, and self-optimizing systems becomes critical. Our transparent AI driven approach builds the necessary confidence among Mobile Network Operators, paving the way for the next generation of intelligent network management.

Key Technologies Driving the Future:

- Machine Learning & Explainable-AI: Transforming complex models into understandable, actionable tools for real-world applications.
- Self-Organizing Networks (SON): Enabling networks to adapt dynamically and optimize performance without human intervention.
- Advanced Coordination Mechanisms: Ensuring seamless integration and conflict resolution between essential network functions to maximize efficiency and reliability.



This joint effort between AiVader and TU Ilmenau is setting the stage for a more transparent, efficient, and robust network management paradigm, directly addressing the challenges and opportunities of 6G and beyond.

Exhibitor contact information and references

AiVader is at the forefront of next-generation network management, delivering intelligent, AI-driven solutions for private 5G networks. With a strong focus on automation and optimization, AiVader provides an in-house built SMO and Non-RT RIC, seamlessly integrating with both commercial and open-source vendors of base stations and 5G core networks. Cutting-edge ML algorithms, deployed as xApps and rApps, drive real-time network optimization, ensuring seamless performance, security, and scalability.

The Integrated Communication Systems (ICS) Group at TU Ilmenau, led by Prof. Andreas Mitschele-Thiel, is a leading research hub specializing in cellular communication networks, with a strong focus on 5G, 6G, AI-driven network optimization, and Open RAN technologies. The group pioneers research in self-organizing networks, machine learning-based network automation, and digital twins for wireless systems, driving innovation in future mobile networks.

One6G member since: 2023

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Zubair Shaik (zubair.shaik@aivader.com)

Demo #7

Dynamic Orchestration of Robot Functions in the 5G/6G Edge-Cloud Continuum (Mobilenet)

Abstract

There has been an increase in the use of robots for all kinds of applications, from Industry 4.0 to surveillance and emergency scenarios. As a result, the variety and complexity of the applications that these robots need to perform has also increased. This, combined with the rise of artificial intelligence, means that many of the applications being developed in robotics are too computationally intensive to be run on the robots themselves. This has given rise to the cloud robotics paradigm, which aims to solve this problem by offloading these applications to the cloud. However, this paradigm depends on the quality of communications, which does not always allow functions to be offloaded. Real-time applications need to maintain a level of application performance quality that can be affected by variations in network quality.

Demo 7 presents a framework for monitoring various metrics such as network and service performance and edge and cloud computing capacity, and dynamically orchestrating robotic functions at the optimal location within the cloud-edge continuum based on these metrics. The demo consists of a quadruped robot, a laptop as the Edge and a server in Malaga as the Cloud. In this case, the demo shows the orchestration of different functions of a quadruped robot (further divided into atomic functions), including a voice chatbot with the ability to control some of the robot's movements. This orchestration is based on the quality of the network, the KPIs and KQIs of the services and the capacity of the robot, the edge and the cloud.

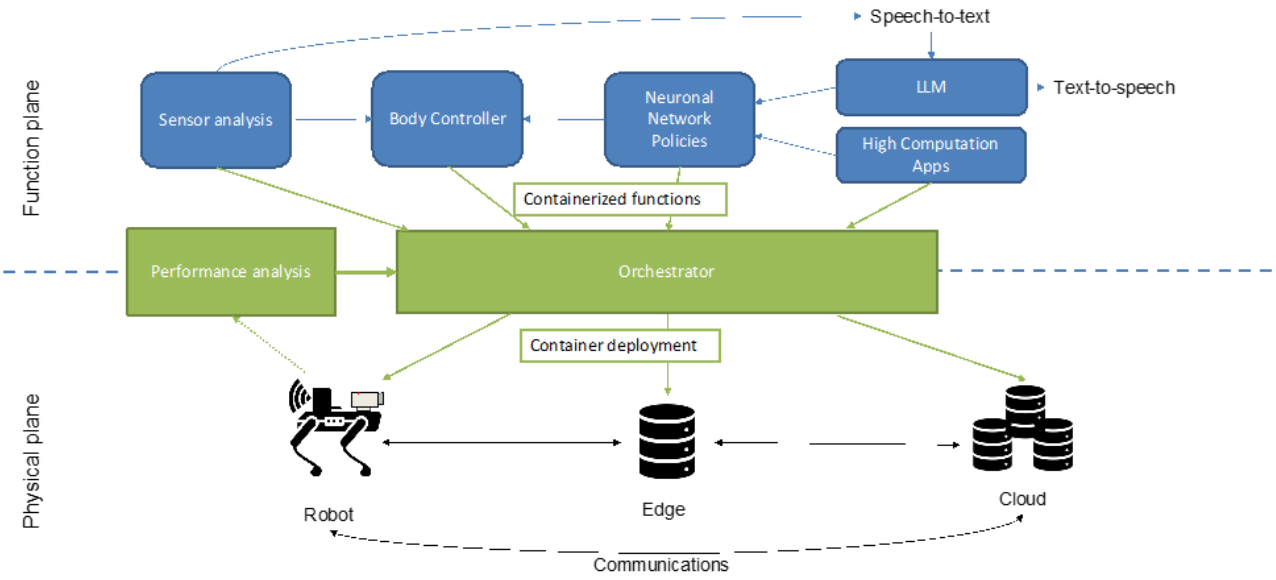

Figure 16: Architecture diagram of Dynamic Orchestration of Robot Functions in the 5G/6G Edge-Cloud Continuum

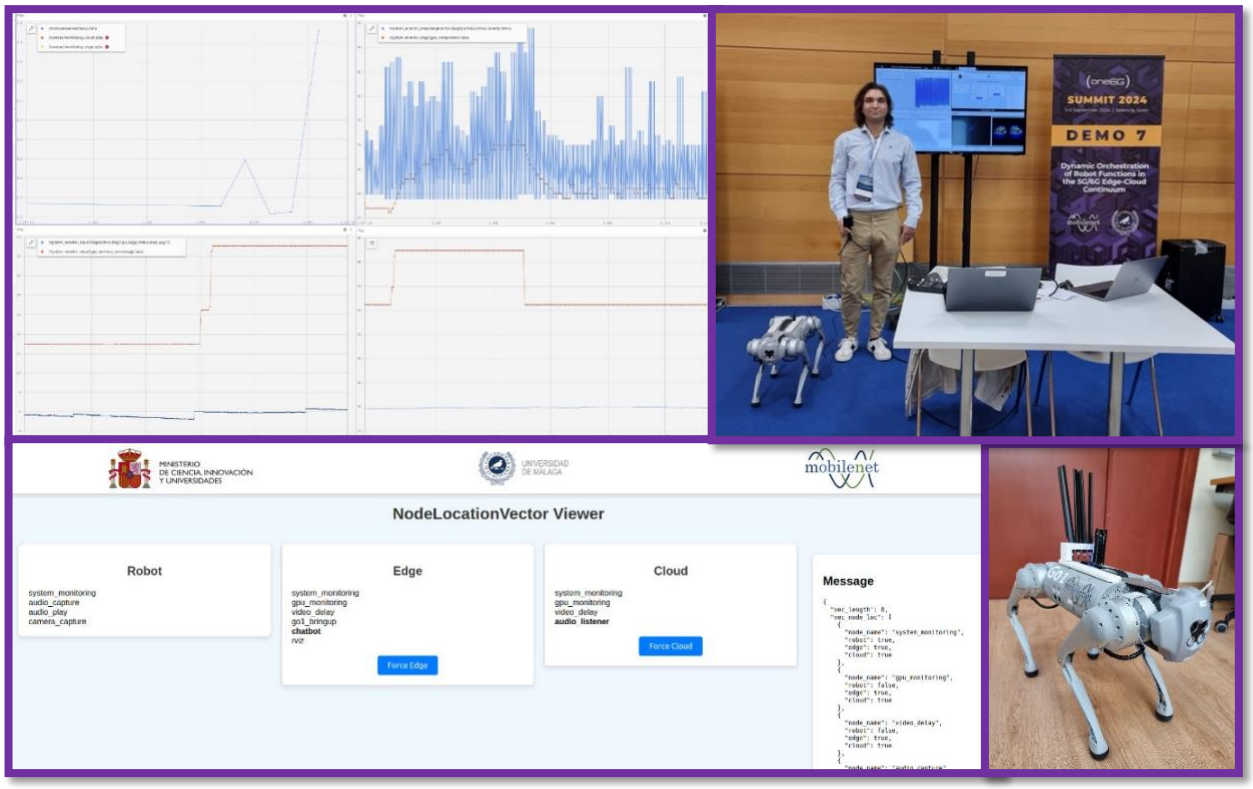

Figure 17:MobileNet Demo at one6G summit 2025

6G use cases and key technologies

This demo has a quadruped robot, a laptop with 8GB of vRAM acting as the Edge, and a server in Malaga with 48GB of vRAM acting as the Cloud. The services have been broken down into atomic functions to be reused and orchestrated in the Cloud Edge continuum. In this sense, the voice chatbot assistant service has been divided into the following atomic functions

- Audio capture: capturing the user's audio through the robot's microphone.
- Speech-to-text: using AI to translate voice commands into text commands.
- Chatbot: LLM to respond to voice commands by answering questions or giving commands to the robot.
- Text-to-speech: Language models to convert text into speech.
- Action: the robot performs the commanded action (stands up, sits down or dances).
- Audio playback: audio playback through the robot's speaker.

The demo monitors robot, edge and cloud performance metrics such as CPU and GPU usage or CPU temperature, service KPIs such as video delay and throughput, LLM computation delay, or network quality such as RSRP measured on the robot. With this information in mind, the various atomic functions of the services can be orchestrated in the edge-cloud continuum to maximise service performance. This dynamic orchestrator is presented as a way to guarantee the maximum possible performance of the robots in scenarios with variable conditions, such as assistance in emergency scenarios.

Exhibitor contact information and references

The research team MOBILENET (Mobile & Aerospace Networks Lab), from University of Malaga, has more than 20 years of experience in automatic optimization techniques for mobile communication networks and is an international reference in this field. In these 20 years since its creation, MOBILENET has continuously obtained funding from public national calls (6 projects), national calls with companies, regional calls (8 projects), 4 international projects (1 CELTIC project and 3 H2020 projects), 4 projects for the acquisition of scientific equipment (for more than 4 M€,) and several contracts with companies.

Funding in the last 10 years have been higher than 20 M€, having employed more than 1500 PMs researchers within projects. Currently, the group is composed of 35 researchers. MOBILENET has worked not only with the main international companies (Nokia, Ericsson, Telefónica, Orange, Vodafone, Indra, Intel, Samsung, Huawei, etc.), but also with SME, not only Spanish (LYNKA, tupl,...), but also from abroad (bwtech in Brasil, Wings in Greece...). The group has also participated in international networks, such as COST 2100 actions, IC1004 and IRACON and INTERACT.

The R&D capacity of the group is also supported by its contributions in books, journals and patents during the last years. It has more than 120 publications in JCR journals, most of which are in the first quartile, in addition to more than 150 contributions to conferences. In addition, the members of the group are authors of 15 patents exploited by companies (e.g., Nokia and Ericsson). As an example of the group's training capacity, the group has directed 15 doctoral theses, of which 7 have received awards from the Official College of Telecommunications Engineers (COIT).

One6G member since: 2023

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Demo #8

Real-Time Tracking and Classification of Multiple Targets (CNIT)

Abstract

Sensing is essential to enable civil, industrial, and military applications requiring situational awareness. Simultaneous tracking and identification of device-free targets (e.g., humans, objects, and vehicles) provides information superiority for different types of operations and surveillance tasks. In fact, the 3rd Generation Partnership Project (3GPP) is considering use cases and services, for integrated sensing and communication (ISAC), which require to localize and recognize targets that are non-collaborative (i.e., not equipped with any device nor participating to the localization process).

This demo demonstrates a real-time framework for tracking and identification of multiple targets moving in complex wireless environments (e.g., indoor environments) using a single MIMO radar operating at mmWaves. The proposed framework consists of (i) clutter mitigation and target detection relying on the estimated clutter intensity distribution of the environment; (ii) multitarget tracking relying on probabilistic data association; and (iii) neural network-based classification for target identification relying on time-domain representations of micro–Doppler signatures generated by target movements. Figure 18 shows the block diagram of the developed framework to track and classify multiple targets in a complex wireless environment.

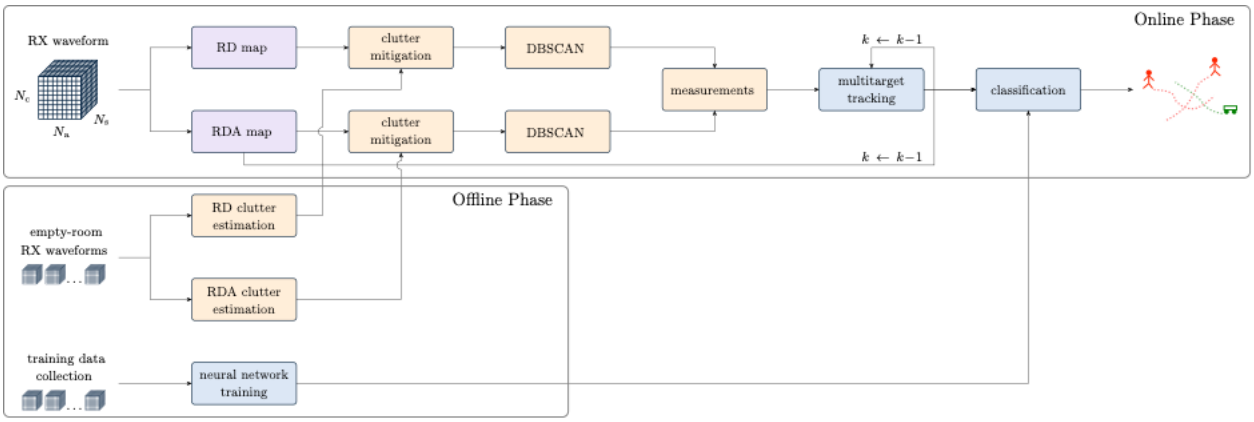

Figure 18: Block diagram of the proposed framework.

6G use cases and key technologies

Sensing via reflected radiofrequency (RF) signals is an enabler for 6G use cases, including human monitoring, factory of the future, and smart surveillance. However, to achieve accurate sensing from samples of reflected RF signals is challenging, especially in complex wireless environments characterized by multipath propagation and clutter conditions. High-accuracy sensing in complex wireless environments requires the development of probabilistic and machine learning (ML) based algorithms for signal denoising and clutter mitigation, as well as for multitarget detection, tracking and identification [1,2].

In cluttered environments, target detection is challenging due to the corruption of radar measurements caused by clutter conditions, multipath propagation, and noise. The employed technique for clutter mitigation is based on ML and consists of an offline (training) phase and of

an evaluation (online) phase associated with the measured range-Doppler (RD) map.Localization over time of device-free targets is performed in a recursive manner, referred to as multitarget tracking (MTT) filtering. At any time instant, MTT filtering consists of a positional prediction phase, based on a motion model, and a positional update phase based on the collected measurements. However, the positional update phase requires data association, which is the combinatorial problem of determining, which target generates a given measurement, if the measurement is due to false alarm, or if a target is misdetected. Target identification requires the classification of specific signal features for each tracked target. In particular, MTT filtering provides range-angle coordinates, which can be exploited to determine specific Doppler signatures for each target from reflected signals. Then, target identification is performed employing a convolutional neural network (CNN), which inputs a sequence of Doppler signatures collected over time and organized as a linear array for preserving the time correlations.

The framework has been demonstrated operating in real-time during the One6G Summit 2024 employing a single MIMO radar operating at 77 GHz with 2 transmitting antennas, 16 receiving antennas, and 1 GHz of bandwidth. The targets position estimation rate was of 10 estimates per second and the classification rate was of 1 classification per second. Fig.11 shows the demo setup at One6G Summit 2024. Single-target tracking, multitarget tracking, and multitarget tracking & identification videos of the proposed framework are available at wcln.unife.it/technology-readiness/

Figure 19: Demo setup at One6G Summit 2024

Exhibitor contact information and references

CNIT is funding member of One6G: 2022

Contact for the one6G: Andrea CONTI (andrea.conti@unife.it), Alessandro Vaccari (alessandro.vaccari@unife.it)

References:

[1] A. Vaccari, M. Z. Win and A. Conti, "Tracking and Identification of Targets via mmWave MIMO Radar," Military Communications Conf. (MILCOM), Washington, DC, USA, Oct. 2024, pp. 336-341

[2] S. Bartoletti, Z. Liu, M. Z. Win, and A. Conti, “Device-free localization of multiple targets in cluttered environments,” IEEE Trans. Aerosp. Electron. Syst., vol. 58, no. 5, pp. 3906–3923, Oct. 2022.

Demo #9

Beyond 5G Localization in 3GPP-Compliant Scenario (CNIT)

Abstract

Location awareness is a key enabler for a myriad of applications in beyond 5G (B5G) wireless networks, including autonomy, smart environments, assets tracking, internet-of-things (IoT), and Industrial-Internet-of-things (IIoT). However, fulfilling the 3GPP service level requirements for localization is challenging due to the complexity of the wireless environments for different applications and verticals. SI-based localization is able to effectively learn the environmental impairments via ML, providing a probabilistic representation of the relationship between radio measurements, user equipment position, and contextual information. This demo shows real-time simulations of beyond 5G localization fully compliant with 3GPP specifications and environments, in both microWaves (FR1) and mmWaves (FR2), with possibility to fuse different types of measurements. A menu-driven GUI enables to select environments, frequency range, bandwidth, and type of measurements according to 3GPP specifications.

6G use cases and key technologies

Location awareness is a key enabler for several applications in next-generation (xG) networks, including autonomous driving, assets tracking, Internet-of-things (IoT), virtual reality, public safety, and crowd sensing. Moreover, the positional information can be leveraged to evolve the cellular network capabilities by enabling location-aware radio resources management, integrated sensing and communication, and reconfigurable intelligent surfaces. However, fulfilling the requirements in xG networks is particularly challenging, calling for the development of innovative localization algorithms able to leverage richer positional information encapsulated in wireless signals to provide service-level localization accuracy in impaired wireless scenarios. In this context, the latest 3GPP releases are extending the network processing capabilities for localization by supporting the use of machine learning-based localization algorithms.

This demo shows a novel localization approach, namely soft information (SI)-based localization [1-3]. In particular, SI-based localization can effectively learn the environmental impairments via machine learning, providing a probabilistic representation of the relationship between radio measurements, user equipment position, and contextual information. The SI-based approach for localization enables overcoming the performance limitations of conventional localization algorithms currently deployed on commercial 5G networks. Figure 20 shows the graphical user interface for the demo. A video of SI-based localization in fully compliant 3GPP scenarios and settings is available at wcln.unife.it/technology-readiness/ .

Data generated with the same framework shown in this demo are publicly available in the xG-Loc datasets [4,5]. In particular, xG-Loc includes received localization signals, measurements, and analytics for different network and signal configurations in indoor and outdoor scenarios with center frequencies from micro-waves in frequency range 1 (FR1) to millimeter-waves in frequency range 2 (FR2), including data in frequency range 3 (FR3). The probabilistic approach of SI-based localization natively enables the extension of the algorithm to different types of data including radio access technology (RAT)-independent data, (e.g., information from accelerometers, Wi-Fi, ultra-wideband systems, etc.), and RAT-dependent data (e.g., other measurements from the 5G network such as channel impulse response (CIR) metrics and blockage intelligence (BI) [6]).

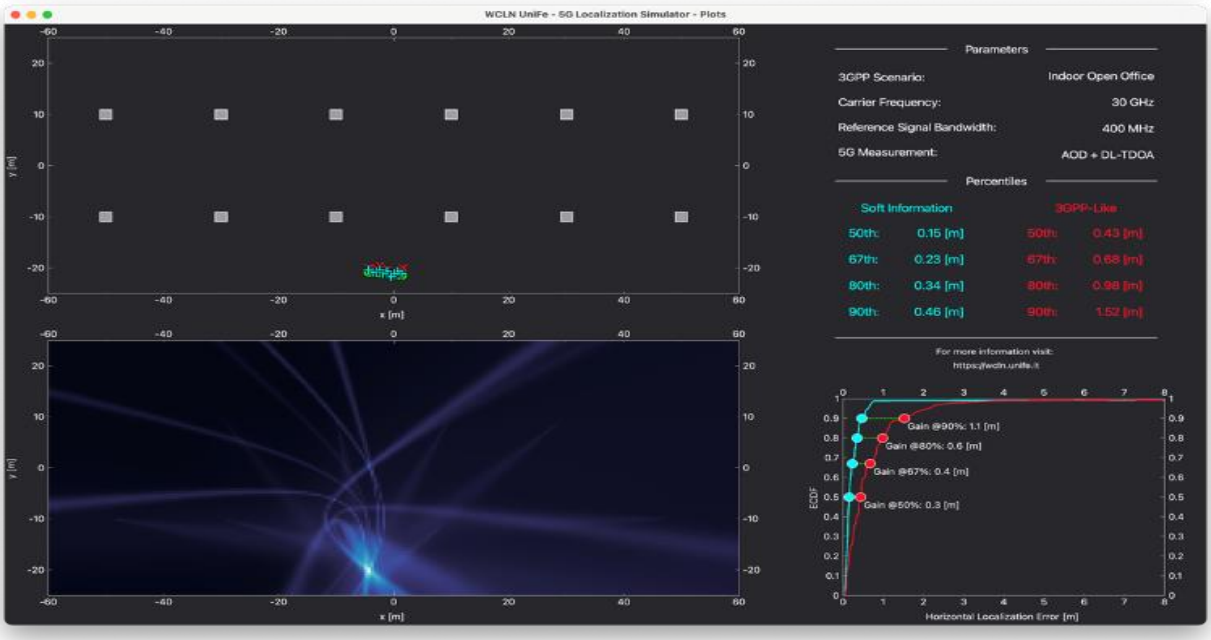

Figure 20: Graphical user interface of the B5G localization demo.

Exhibitor contact information and references

CNIT is funding member of One6G: 2022

Contact for the one6G: Andrea CONTI <andrea.conti@unife.it>, Alessandro Vaccari (alessandro.vaccari@unife.it

References:

[1] A. Conti, S. Mazuelas, S. Bartoletti, W. C. Lindsey, and M. Z. Win, “Soft information for localization-of-things,” Proc. IEEE, vol. 107, no. 11, pp. 2240–2264, Nov. 2019.

[2] A. Conti, F. Morselli, Z. Liu, S. Bartoletti, S. Mazuelas, W. C. Lindsey, and M. Z. Win, “Location awareness in beyond 5G networks,” *IEEE Communications Magazine*, vol. 59, no. 11, pp. 22–27, Nov. 2021, special issue on Location Awareness for 5G and Beyond.

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[5] A. Conti, G. Torsoli, C. A. G´omez-Vega, A. Vaccari, and M. Z. Win, “xG-Loc: 3GPP compliant datasets for xG location-aware networks,” IEEE Dataport, Dec. 2023. [Online]. Available: https://dx.doi.org/10.21227/rper-vc03.

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Demo #10

Sub 6G presence and posture detection (University of Thessaly)

Abstract

Integrated sensing and communication (ISAC) inherently combines the functions of sensing and communication, leveraging wireless and hardware resources for the mutual benefit. ISAC is widely expected to play a pivotal role in next-generation wireless networks, supporting a broad spectrum of emerging applications by transmitting signals that serve both data communication and sensing purposes. This dual functionality can be applied in various contexts, such as environmental monitoring, smart cities, and industrial automation. In this demo we present an experimental ISAC framework that serves as a proof of concept regarding the capabilities of this technology in future wireless networking environments. Furthermore, the acquired results corroborate that ISAC in combination with AI/ML techniques and in particular Convolutional Neural Networks (CNNs) is an important enabler for creating smart 6G communication environments.

Experimental set-up:

- We employ two USRPs with directional antennas.
- Frequency Modulated Continuous Wave (FMCW) chirp signals are generated from the USRP acting as transmitter.
- The USRP acting as receiver stores the power spectral density of the received signals and we obtain measurements to distinguish between different human postures (sitting and standing).
- A convolutional neural network (CNN) is trained from the obtained measurements (1000 per posture).
- The system can now automatically indicate the presence and the posture of the subject.

To ensure a realistic and practical assessment, we deployed the transmitter and receiver on separate node machines and we varied the distance between the antennas at 2, 3, and 4 meters. The experimental set-up is depicted in Figure 21. This setup simulated a typical communication scenario where nodes operate independently, akin to real-world communication systems. The scripts that controlled the transceivers to produce the required OFDM and FMCW waveforms as well as the realization of the CNN were written in Matlab.

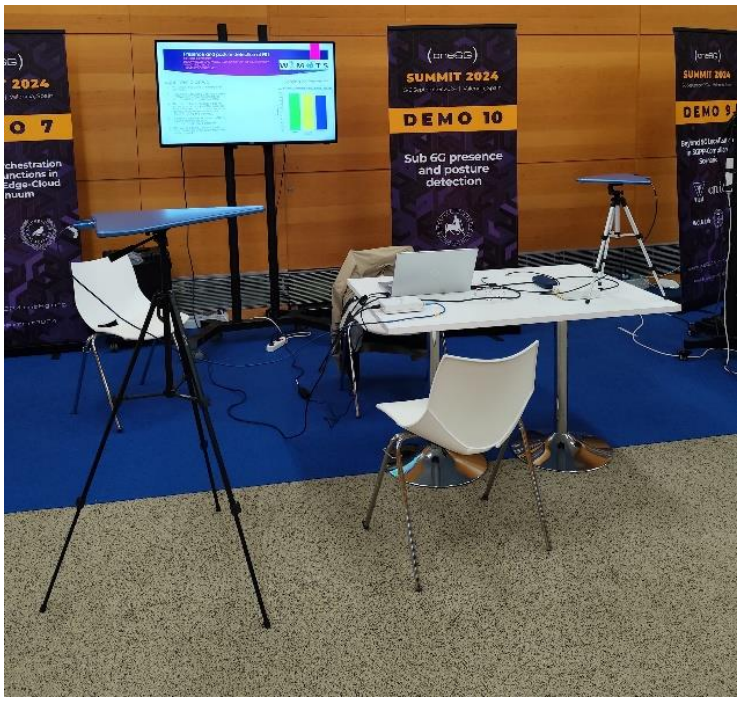

Figure 21: Experimental setup at the one6G summit 2024

Across all tested antenna distances, the error rate in detecting human posture was quite low and the sensing performance always above 90%. This consistency underscores the system's high accuracy and reliability in small area sensing applications. The ability to accurately distinguish between sitting and standing postures with minimal error demonstrates the effectiveness of combining FMCW radar signals with CNN-based analysis for real-time human motion detection. The sensing performance results are depicted in figure 18.

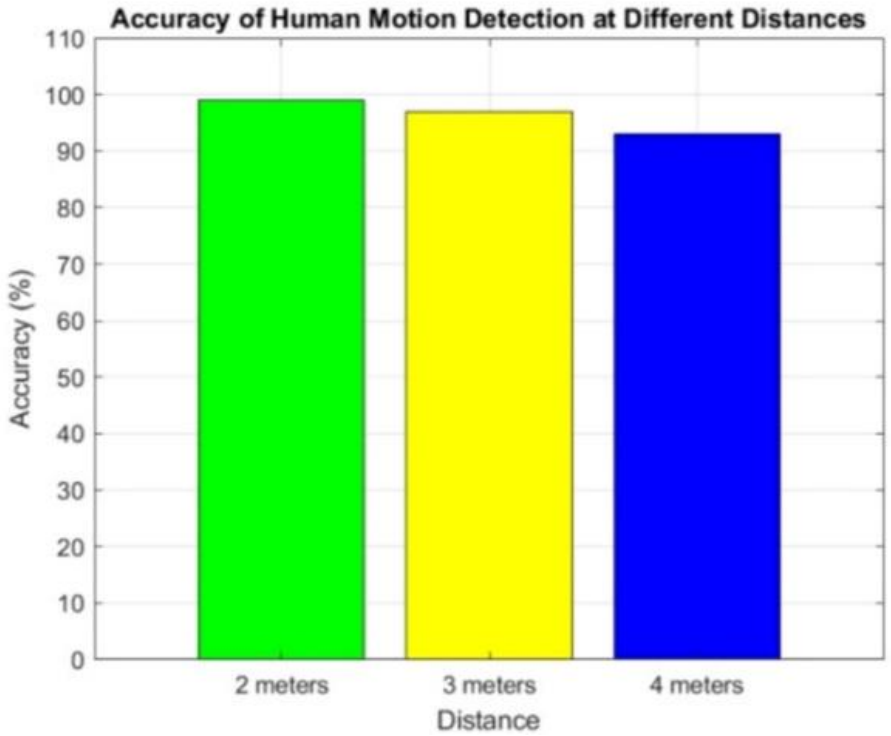

Figure 22: performance results of the presence and posture detection at FR1

6G use cases and key technologies

The potential applications of integrating ISAC into next generation wireless networks towards creating smart communication environments are diverse and can be classified into several major areas:

- Smart cities: Support for infrastructure monitoring, environmental sensing, public safety and efficient resource management, contributing towards the development of smarter and more responsive cities.
- Smart homes: Facilitation of intelligent home automation systems, security monitoring, energy management and health tracking e.g. recognition of human activities and fall detection, enhancing the functionality and convenience of modern living spaces.
- Industrial IoT: Use in process automation, equipment monitoring, asset tracking and predictive maintenance thus improving operational efficiency and reducing downtime.
- Environmental sensing: Monitoring of environmental conditions, such as air quality, weather patterns and pollution levels enhance the availability of valuable data related to environmental protection and disaster management.
- Sensing-assisted wireless communications: Integration of sensing capabilities into communication systems and networks can improve their management by alleviating some their inherent complexities, enhance coverage, optimize resource allocation, and support new communication paradigms.

We selected orthogonal frequency division multiplexing (OFDM) and frequency modulated continuous wave (FMCW) as the most suitable candidates to be employed in our system. Due to the constraints posed from the available hardware we had to stick in an indoor environment and we focused on detecting the presence and posture of human beings in between the transmitter and the receiver thus simulating a smart home environment. To enhance the system's ability to interpret the data collected from these waveforms, we incorporated a CNN module. The CNN is specifically designed to process the complex data patterns of the amplitude spectrum generated by the transmitted chirp signals over the objects that are the subject of sensing and received at the receiver.

Exhibitor contact information and references

Wireless and Mobile Telecommunications Laboratory, https://wimots.ds.uth.gr/, University of Thessaly

One6G member since: 2023

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Demo #11

5G/6G AI empowered forest fire early detection solution (NKUA)

Abstract

The FIRESAFE - Fire Incident Response and Emergency Safety Assurance System – project was presented as video report during the summit. By involving collaborative communication and distributed AI computation of UAVs under hazardous situations potential wild fire could be detected successfully. Terrestrial IoT sensors complements the perception of the area of interest.

The CiviCS (Civilian Centric System) is a custom multifaceted software platform of NKUA, designed to address a range of challenges in the domain of physical security and urban management. By utilizing data from a complex mesh of sensors, cameras, drones, and data analytics algorithms, the system is capable of automatically detecting and responding to a variety of critical incidents. These incidents include but are not limited to wildfires, floods, and earthquakes.

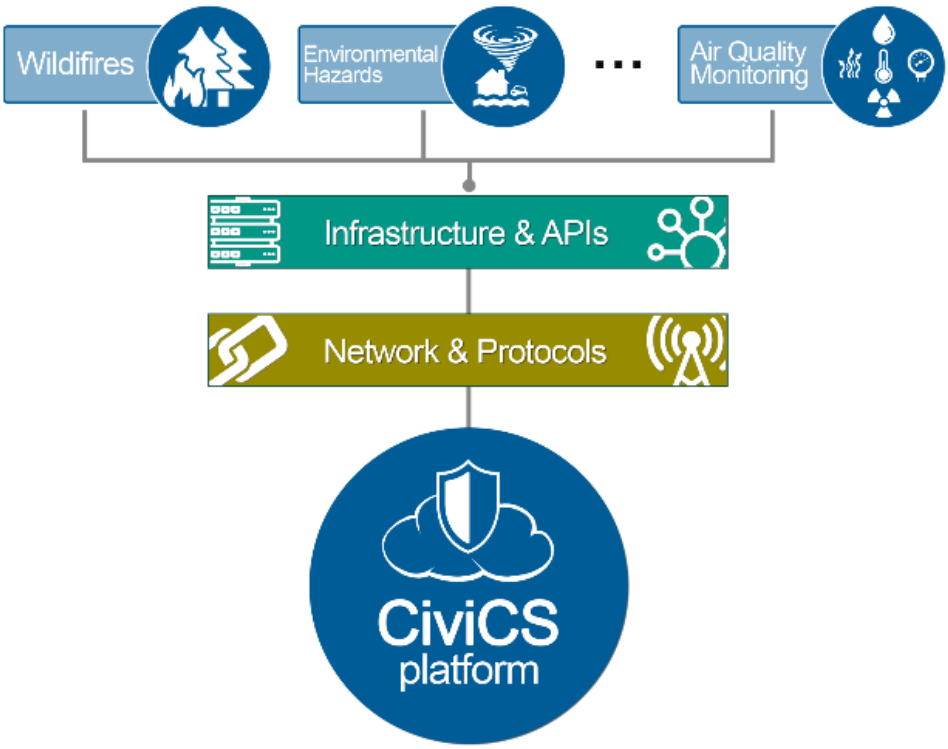

Figure 23: CiviCS logical architecture

CiviCS focus on a specific hazardous event type related to wildfires. The project, named FIRESAFE (Fire Incident Response and Emergency Safety Assurance System) is be based on the CiviCS platform in order to provide an integrated system for fire detection. The system was tested and validated under a pilot deployment on an area of interest in Greek and integrates HW and SW components from key stakeholders (e.g., drone provider, AI enabled SW).

6G use cases and key technologies

In this scenario two UAVs, heterogeneous on field sensors and the CiviCS control platform are cooperating together. The first UAV is capable of providing multi-modal input (e.g., geo-coordinates, alert notifications, still images, video feed). A perception of the monitored area of interest will provided, from which a contextual analysis (e.g. identification of an early wildfire, identification of geomorphological features, area obstacles) will be performed on the received UAV and sensor related information. An AI-driven wildfire detection model will exploit this information towards providing early predictions of the hazardous event for risk assessment. This analysis can either take place on the UAV itself or be offloaded (e.g. avoid battery drain, limited computational resources) to the CiviCS platform.

In case of hazardous event prediction and based on the contextual analysis, the first UAV or the CiviCS platform proceed with a decision making mechanism, in order to "call for aid" from a properly equipped second UAV. A direct (UAV-to-UAV) or indirect (UAV-CiviCS-UAV) communication with the "call for aid" UAV will be established to proceed with further instructions. Furthermore UAV and terrestrial sensor data are captured to train novel AI models to enable improved perception and decisions.

Exhibitor contact information and references

National and Kapodistrian University of Athens (NKUA), Public university in Zografou, Greece

One6G funding member since 2022

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Demo #12

Multi-user holoportation and virtual production: Toward a new era of distributed immersive experiences (i2CAT, Brainstorm)

Abstract

The demonstration will consist of the required software and hardware components to showcase a futuristic immersive media scenarios, in which remote users are captured in real-time and in a realistic manner to a shared virtual environment to socially interact and/or a conduct an activity together, while apart. In particular, it resembles a virtual TV debate that is enabled thanks to an strategic and effective integration between a real-time multiuser holographic communications platform – HoloMIT, by i2CAT – and a leading commercial virtual production engine – InfinitySet, by Brainstorm. In such a virtual experience, a live presenter captured with a broadcast quality from a Chroma key room is able to seamlessly and richly interact with remote panelists (or audience members) represented as 3D holograms captured by affordable off-the-shelf sensors, all integrated in a realistic and interactive virtual environment. Besides, the resulting composed scenario is prepared for its effective delivery to mass audiences via broadcast channels. In such a scenario, the availability of high bandwidth, low latency, edge computing and network prioritization (6G) enablers becomes essential to meet the required stringent requirements.

Figure 24: left: Deployment of the Exhibition. right: General View of the Resulting VR Experience

6G use cases and key technologies

- 6G Radio Access: to maximize bandwidth in uplink and downlink while minimizing latency
- Intelligent User Plan, with In-Network Computing: being able to prioritize media streams (e.g., due to congested QoS drops or congestion), and smart orchestration of virtualized network functions (performing intensive media processing tasks) over the Cloud Continuum
- Sustainability: the demonstrator showcases a relevant use case for increased economical, societal and environmental sustainability, while also fostering scalability and interoperability of media services.

Exhibitor contact information and references

The demo was part of the cooperation between one6G summit and IEEE PIMRC and presented to the one6G summit conference participants.

I2CAT Foundation: Mario Montagud, Sergi Fernández, Marc Martos, Álvaro Egea,

Brainstorm is testbed partner: Francisco Ibáñez, Javier Montesa, Andrea Castelli

I2Cat is One6G member since: 2022

Contact for the one6G and PIMRC exhibition booth: Mario Montagud (mario.montagud@i2cat.net)

References:

[1] M. Montagud, M. Martos, Á. Egea, S. Fernández, “Social VR with holographic comms: enablers for new engaging experiences within the TV / video consumption landscape”, IEEE Transactions on Broadcasting, 2025

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[3] IEEE PIMRC 2024 webpage: https://pimrc2024.ieee-pimrc.org/program/demonstrations

[4] Video Link: https://www.youtube.com/watch?v=97RWbrvu3Gg

[5] Video Link: https://www.youtube.com/watch?v=NAkTYyYxF1k

[6] Video Link: https://www.youtube.com/watch?v=ZX5zu1fVduo

Demo #13

Adaptive Remote Renderer for VR experiences in heterogeneous devices (i2CAT, Vicomtech)

Abstract

The demo presented a remote renderer capable of providing access to a VR experience from any device supporting Web technologies. The renderer processes the VR scene, including volumetric video, to create a personalized audio and rendered video stream for each user. The user employs a Web browser to run a media player to receive and play the stream and capture the 6 degree of freedom (6DoF) information. The 6DoF information is sent to the renderer, which employs it to personalize the rendered video stream. The renderer is installed in a highly capable laptop with GPU simulating a remote node, while the media player runs on heterogenous end devices such as laptops or VR headsets. Alternatives for the multimedia communication are presented: Web Real-Time Communication (WebRTC) for low latency and interactive VR experiences, Dynamic Adaptive Streaming over HTTP (DASH) for high scalability and passive VR consumption, and Media over QUIC (MoQ) to showcase a beyond state-of-the-art streaming protocol. The renderer also provides adaptive rate control capabilities such as adjusting the encoding of the video stream to the actual network performance. The renderer and the end devices are interconnected through wireless communications. A native player (without renderer) is also presented to show the comparison between local and remote rendering.

This demo has been funded by 6G-XR project (https://www.6g-xr.eu) and 6G-OpenVerso (https://i2cat.net/unico/6g-openverso/).

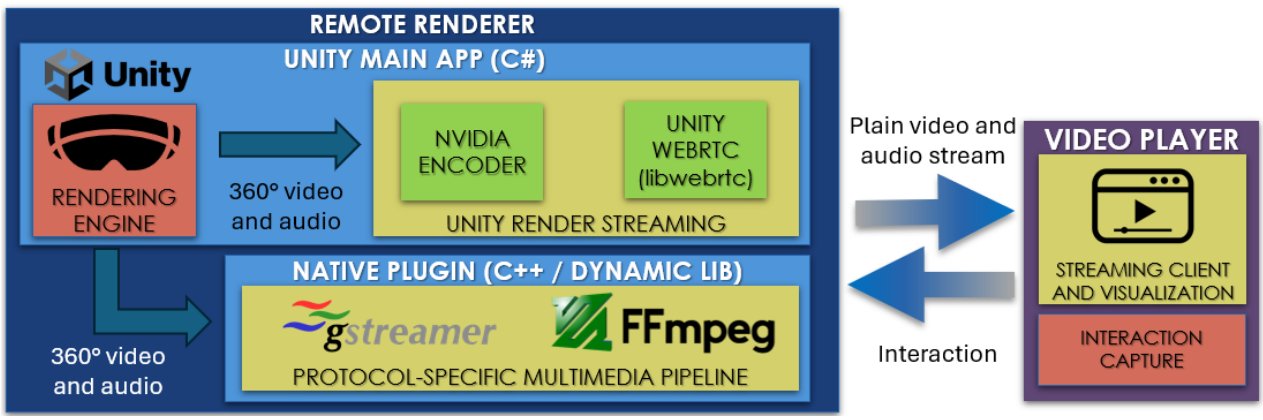

Figure 25: High-level architecture of the showcased Remote Renderer

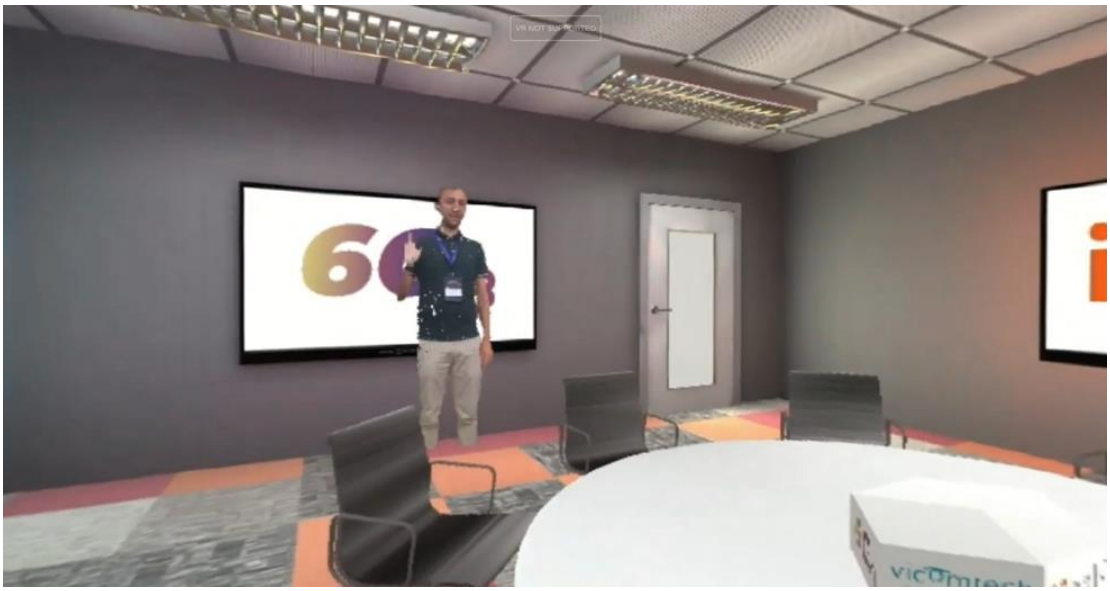

Figure 26: Rendered 360° video (including a 3D VR scene and a volumetric video hologram) presented on the Remote Renderer

6G use cases and key technologies

- VR technologies

Exhibitor contact information and references

The demo was part of the cooperation between one6G summit and IEEE PIMRC and presented to the one6G summit conference participants.

I2CAT Foundation: Mario Montagud, I2CAT is One6G member since: 2022

VICOMTECH: Roberto Viola, Daniel Mejías. VICOMTECH is partner of the testbed proposal

- Inhar Yeregui Arrieta, Roberto Viola, Daniel Mejías, Guillermo Pacho, Jasone Astorga and Mario Montagud, "Edge Rendering Architecture for multiuser XR Experiences and E2E Performance Assessment", IEEE BMSB 2024
- [IEEE PIMRC 2024 webpage: https://pimrc2024.ieee-pimrc.org/program/demonstrations
- Video Link: https://drive.google.com/drive/folders/15E-gPO0Qh18Ua26nU5tDpn9noMal75Og?usp=sharing

Contact for the one6G and PIMRC exhibition booth: Roberto Viola, Mario Montagud

Demo #14

Holographic & Telepresence real-time remote tour to UPV´s Immersive Communications Laboratory (iTEAM-UPV)

Abstract

The demo showed the iTEAM-UPV's 5G Immersive Communications Laboratory for Beyond 5G (B5G) trials and pilots, part of the SNS project IMAGINE-B5G. Through three open calls, IMAGINE-B5G makes this laboratory available to third parties for testing immersive technologies such as Telepresence, AR/XR, Volumetric/360 Capture, Haptics and Holographic. Experimenters can use the Private 5G network covering the laboratory and part of the UPV campus to test innovative use cases and experiments on the verticals Media & Entertainment and Education. In the demo, participants were able to move around a virtual copy (i.e., Digital Twin) of the laboratory and learn about the available equipment and solutions for immersive communications. As an example of immersive application that the laboratory can enable, the demo also included the cyber-physical remote driving of mobile robots located on the UPV campus. The robots, equipped with 360 cameras, LiDAR, and GNSS sensors, capture their environment and offload the information to the Edge over the Private 5G network to update the Digital Twin in real-time. The users, utilizing immersive cockpits equipped with wheel, pedals, VR headset, and haptic vest, receive the Digital Twin information together with the 360 video streaming as feedback to control the robots remotely. In the PIMRC event [1], the cockpits shown in Figure 28 were located in the congress hall and therefore were connected to a public 5G network, although they are normally located in the Immersive Laboratory connected to the Private 5G network.

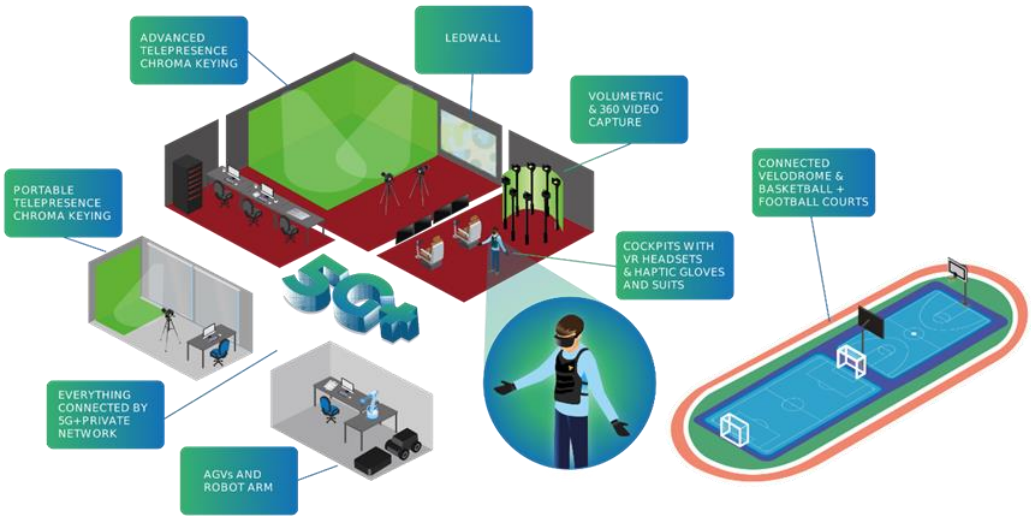

Figure 27: Holographic & Telepresence real-time remote tour

6G use cases and key technologies

The primary use case of the iTEAM-UPV's 5G Immersive Communications Laboratory is the cyber-physical remote driving of mobile robots. It consists of an immersive race between two mobile robots over 5G, remotely driven through a Digital Twin, where the robots interact with virtual objects in real-time. This use case features two outdoor robots, powered by Robot Operating System (ROS), and equipped with 360 cameras, LiDAR, Global Navigation Satellite Systems (GNSS), and Inertial Measurement Units (IMUs). They transmit real-time Digital Twin data to indoor immersive cockpits featuring racing seats, pedals, VR headsets, and haptic vests, which provide operators with an immersive remote driving experience through real-time 360 video, Digital Twin based user interface, and haptic feedback. The Digital Twin data displayed includes the status of the robots (e.g., battery level, speed, location, orientation, and human presence) as well as network metrics (e.g., signal strength, throughput, latency, band, and slice). Additionally, the video feed includes AR objects and power-up items that serve as bonuses or penalties, influencing the robot's dynamics. The impact of both AR elements and real-world obstacles is sensed in the form of haptic feedback through the haptic vest.

Figure 28: Cocpit and command center

Exhibitor contact information and references

The demo was part of the cooperation between one6G summit and IEEE PIMRC and presented to the one6G summit conference participants.

iTEAM-UPV: Raúl Lozano Teruel, David Gómez Barquero, Adrián Rodrigo Castillo,

UPV is One6G member since: 2022

Contact for the one6G and PIMRC exhibition booth: Raúl Lozano Teruel

References:

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[2] Video Link: https://youtu.be/Twq7jdMVdqM

[3] LinkedIn Post: https://www.linkedin.com/posts/raulote_5g-vr-ar-activity-7243912556375904256-tjH6

Demo #15

Game-Engine Fast Ray Tracing (iTEAM-UPV)

Abstract

This demo shows the performance of the Ray Tracing tool developed by the 6G Joint Innovation Centre iTEAM-Huawei. The tool is based on the Unreal Game Engine and runs faster than any other in the market on digital twins of several scenarios, indoors and outdoors.

Figure 29: Digital Twin of the Congress Centre in Valencia, outdoors and indoors, as seen in the RT tool interface

6G use cases and key technologies

Ray Tracing (RT) tools are one of the common approaches to simulate the behaviour of radiofrequency channels in deployment environments. RT models describe the multipath nature of the RF propagation and serve to create deterministic simulations of wideband communication channels. Anyway, many challenges are open for these kinds of tools in practice. The main limitation of RT is the computational load required to reach enough angular and spatial resolution of the calculated paths in 3D scenarios. Simulation times of minutes or even hours are usual in conventional RT tools, making them impractical for applications requiring faster channel estimation. The Rebel-Ray tool presented in this demo is developed with game-engine software to overcome the mentioned limitations, obtaining the multipath channel between any two points in 3D outdoor or indoor environments in less than a second. This allows digital twinning (DT) of radio channels, very fast massive MIMO matrices simulation, and dynamic tracking of multiple users' channels in the DT.

Rebel-Ray is a high-speed and realistic RT tool based on the UNREAL engine, which can be used for projects related to XL-MIMO channels analysis, RF Digital Twinning, and ISAC, among other topics. The output of the simulations is a detailed description of the wideband channel. It includes the collection of propagation paths from every transmitter antenna element to every receiver

antenna element, and each path data in the output file keeps all the information of angles of departure and arrival, bounce length, propagation phenomena (reflection, diffraction and refraction) occurred along the path, and materials on which -or through- the path has propagated. This allows any type of information post-processing for different purposes, like deterministic channel modelling, estimation of channel state information, clustering, spatial consistency analysis, XL-MIMO simulation, etc.

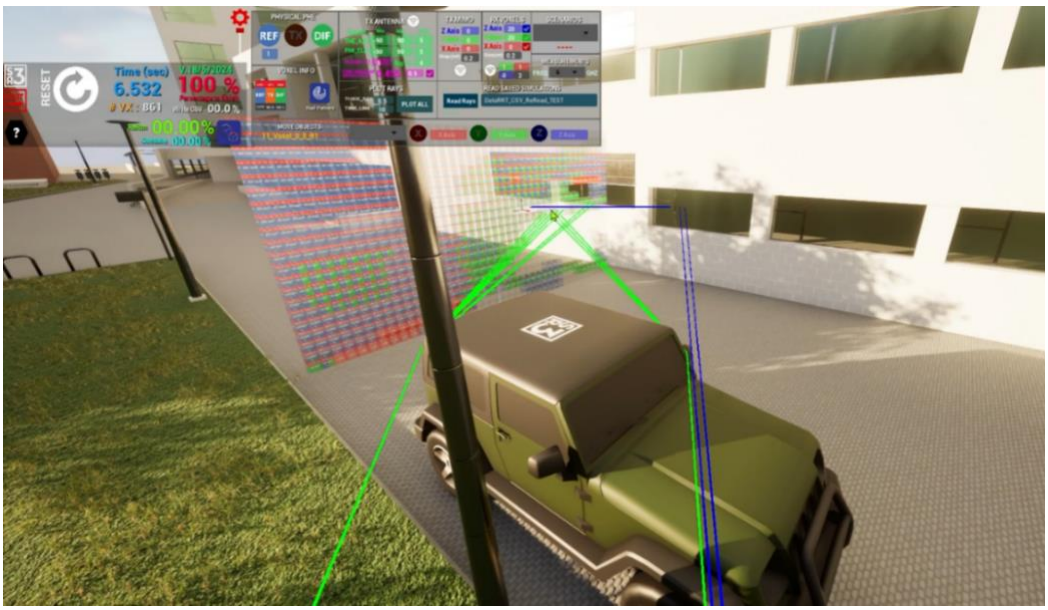

Figure 30: Detailed view of an XL-MIMO channel simulation for an array of 32x64 elements at FR3 band

The tool accounts for materials characterization for FR2 and FR3 based on measurements and the ITU-R recommendations. This allows for determining outdoor to indoor (penetration through materials) refraction, a realistic approach for edge diffraction, and, of course, specular reflection on any surface shape.

Since the tool includes the possibility of defining moving Ue terminals, dynamic simulation of multiuser channels is also possible. Overall, it completes a framework for radiofrequency digital twinning. It can be complemented by feeding the tool with real-time information captured by sensors or RAN elements so as to run as a DT layer for proactive optimisation of resources

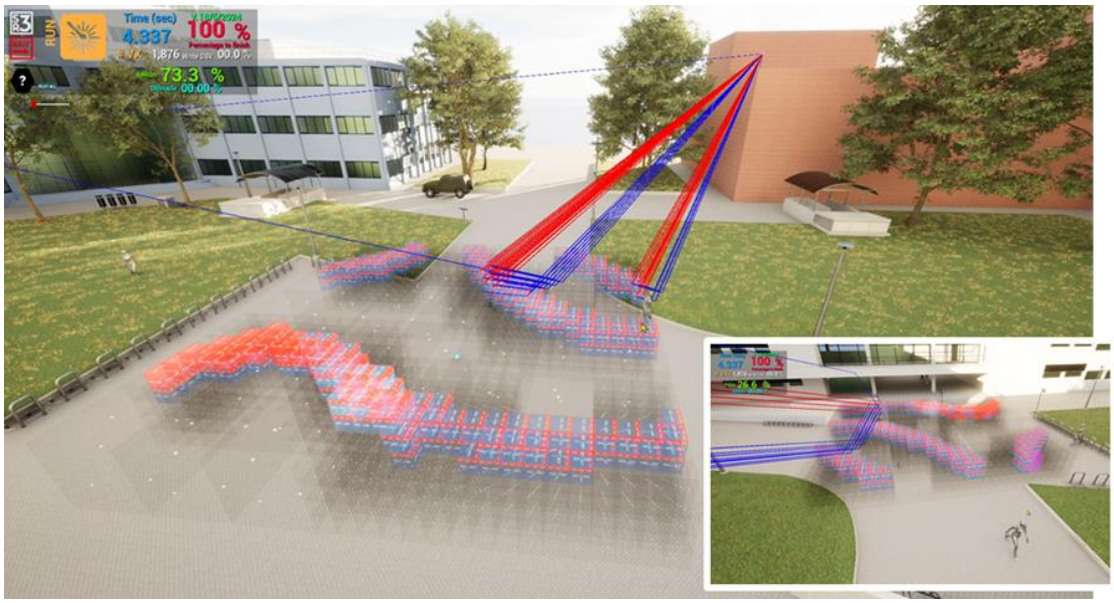

Figure 31: Real-time dynamic RT for multiuser MIMO channel simulation using Rebel-Ray

Exhibitor contact information and references

IEEE PIMRC 2024 webpage: https://pimrc2024.ieee-pimrc.org/program/demonstrations

The demo was part of the cooperation between one6G summit and IEEE PIMRC and presented to the one6G summit conference participants.

iTEAM-UPV: Samuel Romero, César Montaner Cardoso

UPV is One6G member since: 2022

Contact for the one6G and PIMRC exhibition booth: Samuel Romero

Demo #16

Integrated Sensing and Communication (ISAC): Accessing the sensing performance of ISAC devices (Rohde & Schwarz)

Abstract

Integrated sensing and communication (ISAC) enables the detection of objects in proximity of base stations or user devices and data communication within the very same technology, namely within 6G. This demonstration shows how to objectively measure sensing performance based on test instruments, which enable reliable and repeatable object emulation in terms of distance, speed and radar cross section (RCS) in the mmWave spectrum.

Figure 32: Exhibition setup of Rohde-Schwarz at PIMRC2025/one6G summit 2025 [R&S2]

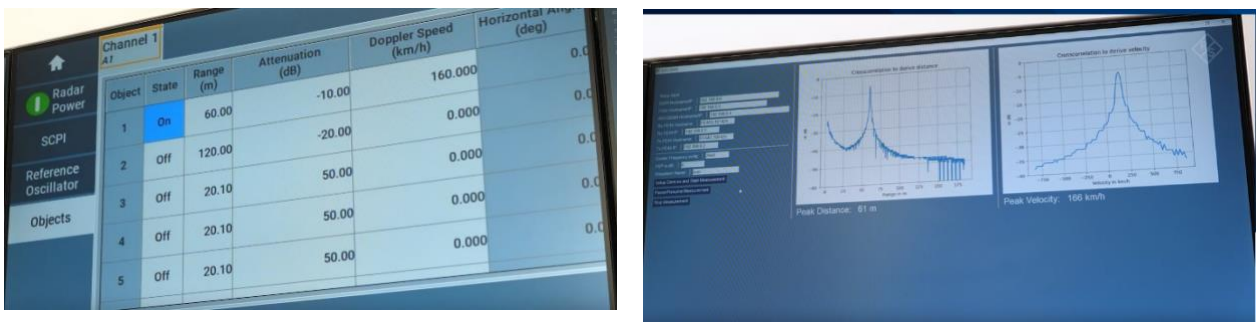

Figure 33: testing at FR2 frequency bands

Figure 33 shows at the left side the settings and on the right side the measured distance and speed of the configured object

The benefits of our leading-edge testing solutions at a glance [R&S1]:

- The R&S®AREG800A simulator from Rohde & Schwarz is used to generate artificial objects and can generate multiple dynamic targets with different distances, sizes and radial velocities
- The simulator can simulate azimuth angles from multiple target objects by increasing the number of frontends accordingly. Various frequency converter modules enable ISAC testing in the respective frequency bands

6G use cases and key technologies

ISAC Integrated Sensing And Communication

Exhibitor contact information and references

The demo was part of the cooperation between one6G summit and IEEE PIMRC and presented to the one6G summit conference participants.

Rhode & Schwarz: Rhenatta Rivera, Maik Kottkamp,

Rhode & Schwarz is One6G member since: 2023

Contact for the one6G and PIMRC exhibition booth: Rhenatta Rivera (rhenatta.rivera@rohde-schwarz.com)

[R&S1] For more information on the R&S Solution: https://www.rohde-schwarz.com/solutions/wireless-communications-testing/wireless-standards/6g/integrated-sensing-and-communication-isac/integrated-sensing-and-communication-isac_257028.html

[R&S2] IEEE PIMRC 2024 webpage: https://pimrc2024.ieee-pimrc.org/program/demonstrations

5. one6G Best Demo Award

First time one6G board will acknowledge the outstanding effort of the exhibitor teams by granting an award. One6G Exhibitors and also the Exhibitor of the collocated IEEE PIMRC conference are asked to present their demos and prototypes during the Demo Pitches session at the main stage of the one6G conference.

Figure 34: one6G Best Demo Award 2024

All conference participants got a QR code to vote via the smartphone for the best demo award. Finally 3 champions has been elected.

Figure 35: winning teams of the first one6G demo award

One6G honors the effort and pation of the exhibitors by the first one6G Best Demo Awards. In 2024 the awarded Exhibitors are IAVader GmbH represented by Prof. Andreas Mitschele-Thiel and Zubair Shaik (from right to left on the above Figure 35) . iTEAM-UPV represented by Cesar Montaner and Prof. Narcís Cardona. Huawei Technologies Duesseldorf represented by Dr. Vu Anh Vu.

Due to the very fruitful cooperation with IEEE PRIMC the exhibitors from one6G could also present their demo at the IEEE PIMRC demo pitch and apply for the best demo award of PIMRC conference.

As unexpected result the CNIT team with Prof. Andrea Conti and Dr. Alessandro were honored with the IEEE PIMRC demo award 2024.

6. Conclusions

6G is going to become a new mobile radio systems that combines high performance communication and novel solution to sense the environment of antenna systems. One6G association has started to discover new use cases and novel solutions with more than 140 partners from industry and academia.

This whitepaper compiles the achievements in the year 2024 of the joint work in one6G in particular with respect to demonstration and proof of concept of promising new use cases enabled by new 6G technologies such like ISAC and AI. In 5G new players has been identified and summaries in the term Vertical. This whitepaper indicates that many of the 6G key technologies are beneficial for many verticals like e-health, agribusiness, and industry. Robotic seems to become one of the main use cases in 6G in particular for applications outside of traditional scenarios like factories. One6G aims to integrate all of the new interest groups and applications at the beginning of the standardization of the 6th generation of mobile radio system.

The annual one6G summit has been utilized to show 16 exciting and outstanding demonstrations in the field of robotic, agriculture, subTHz, Human machine cooperation enabled by AI in particular large language models and XR technologies.

Last but not least the first time 3 Best Demo Awards has been hand overed to exiting demonstrations during the one6G summit 2024. Saying this it was a honor to be welcome by the IEEE PIMRC as co-exhibitors

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