

# THE ELEPHANT IN THE ROOM CALLED Wi-Fi

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Make ideas real





Connect

Mobile user subs

# The history of mobile wireless device experience is finally a story about convergence



**1999**  
Apple iBook  
802.11b




**2005**  
Nokia 9500  
GSM  
802.11b



**2007**  
iPhone 1  
GSM/GPRS/EDGE  
802.11b/g

**2024**

**60%**  
of Internet traffic comes from mobile devices




**90%**  
of screen time on mobile at home connected to Wi-Fi

Source: [OpenSignal 2024](#)



**80%**  
of screen time on mobile away from home connected to Wi-Fi

Source: [OpenSignal 2024](#)



In 2022, two in three Europeans consider Wi-Fi as important as electricity and gas

Source: Feb. 2022 surveyed by [Kantar](#) for Vodafone

# Drivers and solutions to achieve improved Wi-Fi/Cellular convergence from the customer point of view

## Loosely coupled networks

Allow secure and seamless Wi-Fi Access

## Tightly coupled networks

Wi-Fi networks providing indoor coverage/capacity



Institute of Electrical & Electronics Engineers

802.11u

Wi-Fi Alliance  
Passpoint

Wireless Broadband Alliance  
OpenRoaming

3GPP 5G NR  
Wi-Fi offload

3GPP 5G NR  
ATSSS

# Wi-Fi Alliance Passpoint<sup>®</sup>, the well-established standard for secure and seamless Wi-Fi network access



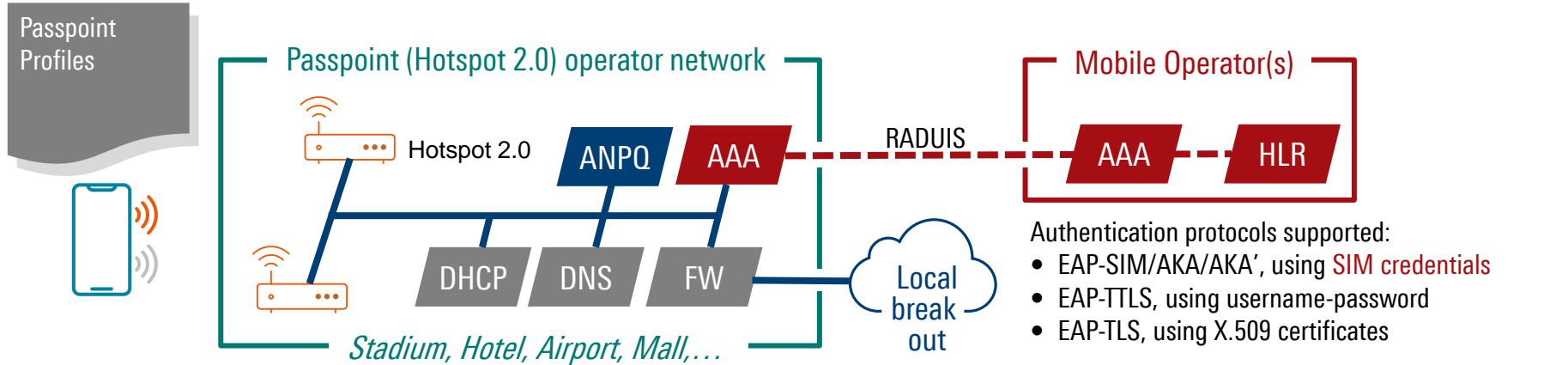
Automatic network discovery, selection and authentication



Security based on 802.11u, EAP & WPA2/3



Seamless roaming between wireless networks



Authentication protocols supported:

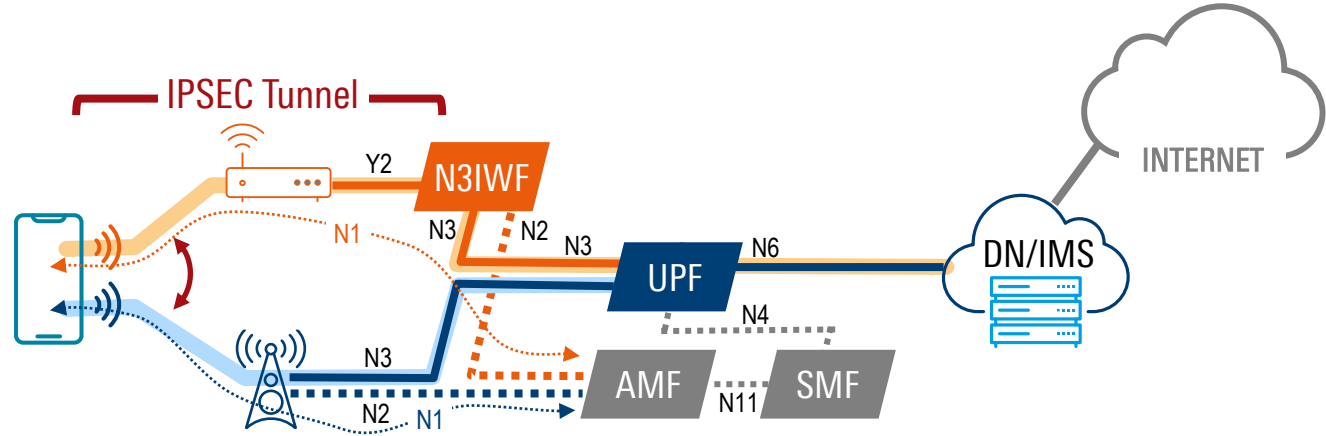
- EAP-SIM/AKA/AKA', using **SIM credentials**
- EAP-TTLS, using username-password
- EAP-TLS, using X.509 certificates

AAA	Authentication, authorization and accounting
ANQP	Access Network Query Protocol
EAP	Extensible Authentication Protocol
WPA	Wi-Fi protected access

# 3GPP 5G NR Wi-Fi offload

## Non-trusted access via N3IWF specified in Rel.15

- WLAN Selection Policy (WLANSF)
- N3AN node configuration.



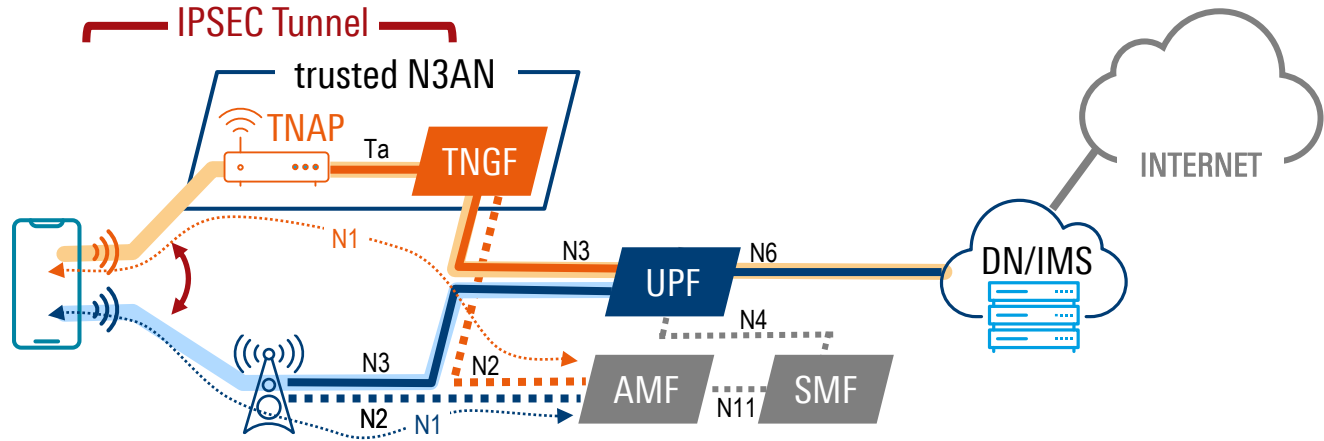
1. The UE selects and connects with a non-3GPP access network
  2. The UE selects a PLMN and an N3IWF in this PLMN.
- ⇒ PLMN/N3IWF selection and non-3GPP access selection are independent.

AMF	Access and Mobility Management Function
DN	Data Network
N3AN	non 3GPP Access network
N3IWF	non 3GPP Interworking Function
SMF	Session Management Function
UPF	User Plane Function

# 3GPP 5G NR Wi-Fi offload

## Trusted access via TNAP/TNGF specified in Rel.16

- WLAN Selection Policy (WLANSF)
- N3AN node configuration.

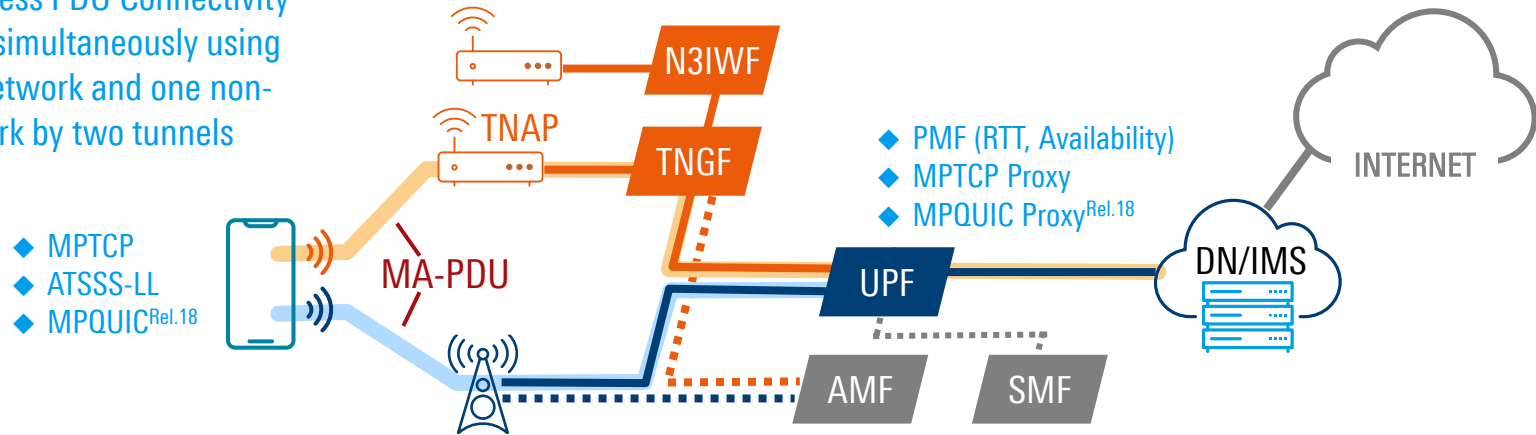


1. The UE selects a PLMN
  2. The UE selects a non-3GPP access network (a TNAN) that supports trusted connectivity to the selected PLMN.
- ⇒ The non-3GPP access network selection is affected by the PLMN selection

AMF	Access and Mobility Management Function
DN	Data network
TANF	Trusted non 3GPP Access Point
TNGF	Trusted non 3GPP Gateway Function
SMF	Session Management Function
UPF	User Plane Function

# Extended architecture to support Access Traffic Steering, Switching, Splitting (ATSSS, AT3S)

Enables a multi-access PDU Connectivity Service (MA PDU), simultaneously using one 3GPP access network and one non-3GPP access network by two tunnels



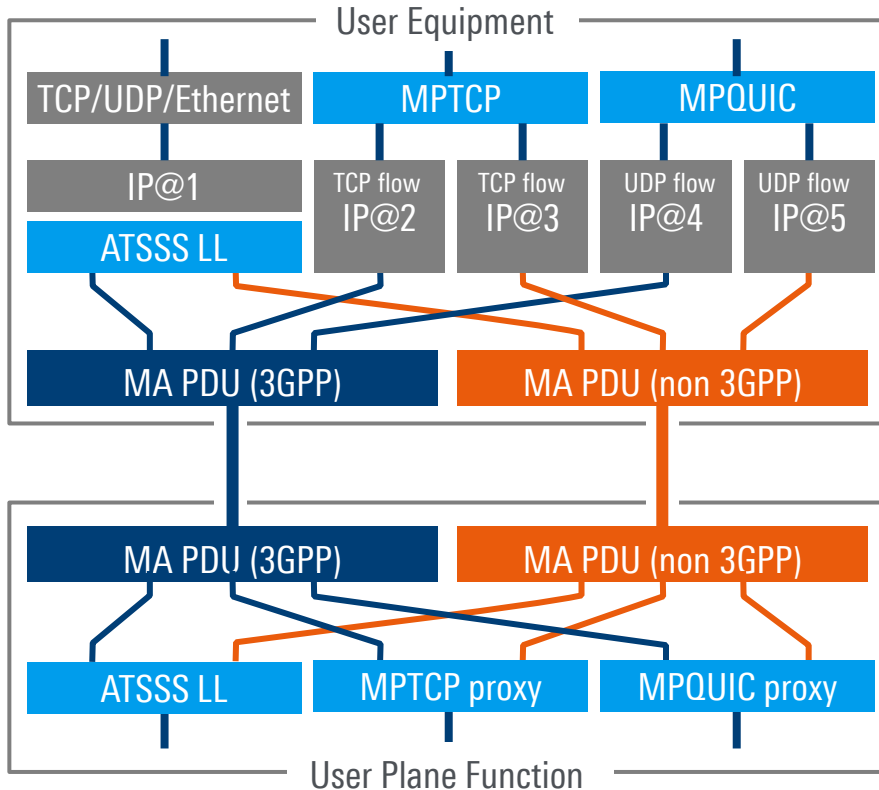
After the establishment of a MA PDU Session (types IPv4, IPv6, IPv4v6, or Ethernet):

- The UE applies network-provided policy (i.e. URSP, ATSSS rules) and considers local conditions for deciding how to distribute the **uplink traffic**
- Similarly, the UPF anchor of the MA PDU Session applies network-provided policy (i.e. N4 rules) and feedback information received from the UE for deciding how to distribute the **downlink traffic**

ATSSS Access Traffic Steering, Switching, Splitting  
MPTCP Multi Path TCP (RFC 8684)  
MPQUIC Multipath QUIC (RFC 9000)  
PMF Performance Measurement Function



# Different steering modes and steering functionalities to steer, split and switch traffic across two accesses



## Active-Standby

use the defined active access as long as available, otherwise switch to the standby access

## Smallest Delay

use the access with the lowest delay based on RTT measurements

## Load-Balancing

Distributes the traffic across both access based on defined distribution (e.g. 40% vs 60%) or autonomous, as long as both access are available

## Priority-based

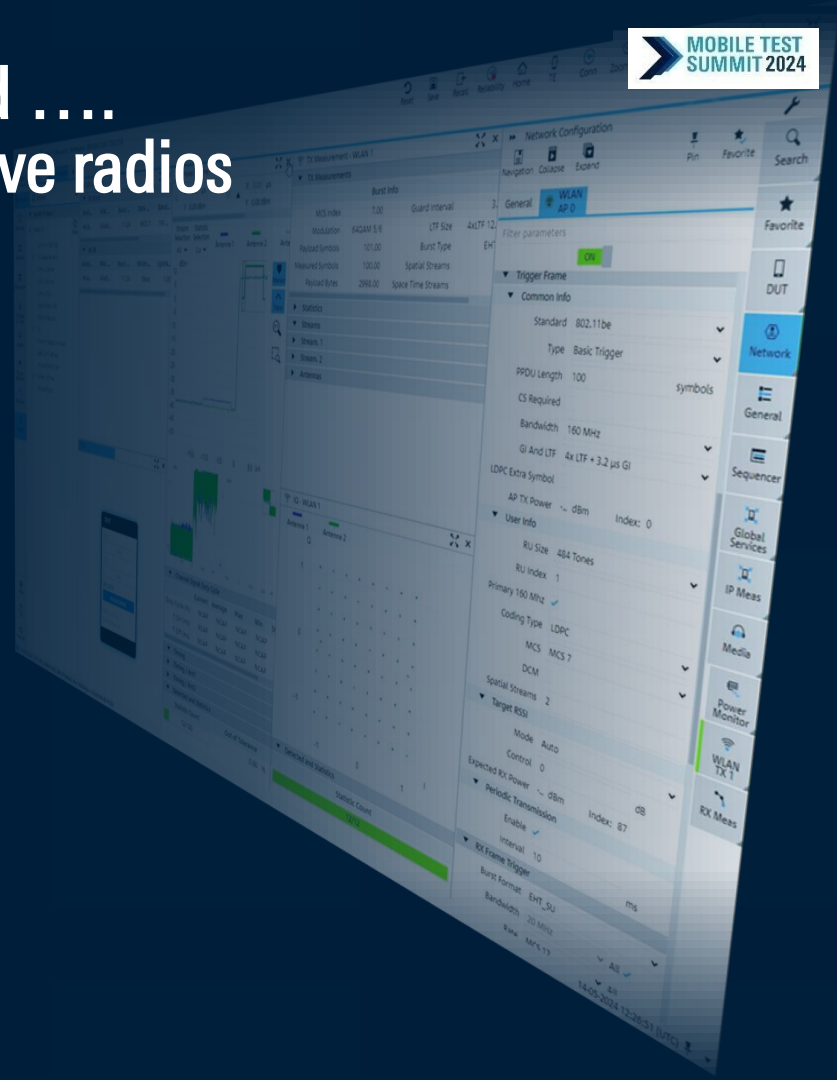
All traffic to the high-priority access as long as not congested and available

## Redundant

Duplicate traffic to both accesses based on actual PER with option to define primary and secondary access

# Convergence can become complicated .... especially with two very powerful active radios

- ◆ In-device **interference** with two active radios with huge amount of possible variants
- ◆ Limiting overall **radiated power** (SAR)
- ◆ Keep an eye on **power consumption** and **overheating**
- ◆ **Complex** convergence scenarios involving a lot of control components
- ◆ Seamless steering, switching incl. application **performance impact**



# We have THE solution for R&S® CMX500 Wireless signaling tester

- ◆ Up to Wi-Fi7 (IEEE802.11be) on all channels and all bands (2.4, 5, and 6 GHz).
- ◆ OFDMA multi-user and multi-link operation (MLO)
- ◆ Emulates access point (AP) or station (STA)
- ◆ Multi-Technology signaling tester allows testing of interference scenarios and 5G/Wi-Fi offloading
- ◆ Application testing incl. Voice over WLAN



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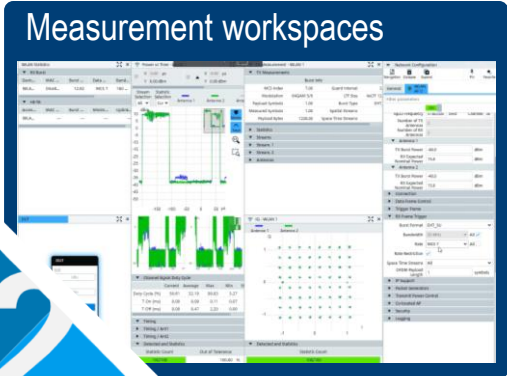
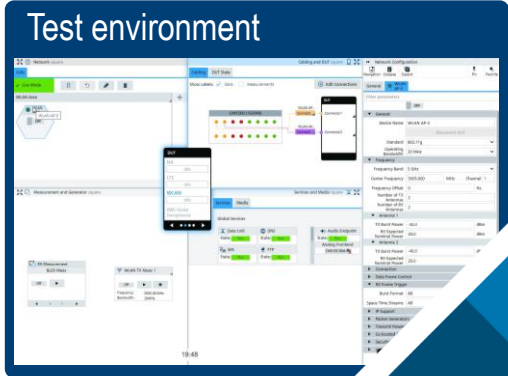


Rohde & Schwarz

Mobile Test Summit 2024

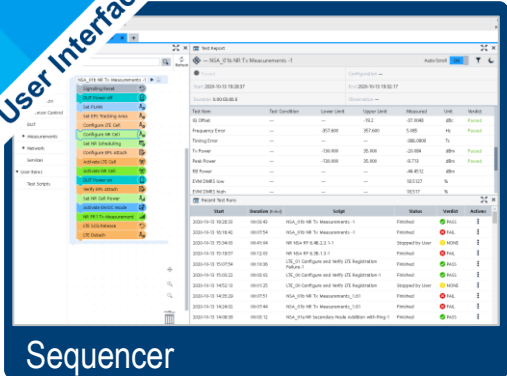
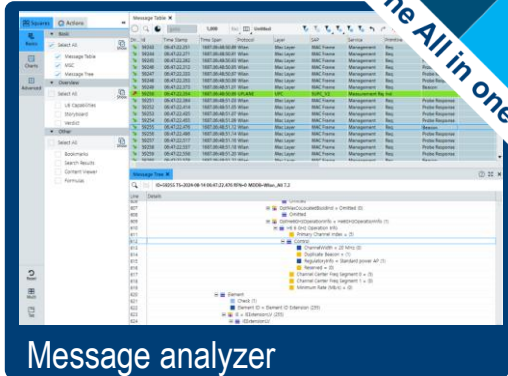


# The R&S® CMX500 provides an intuitive and flexible UI



optimized for manual interactive operation as well as for automatic sequence-controlled test procedures

The All in one User Interface





**INTERNET/  
USER BACKEND**  
IPv4/IPv6



**SERVER FUNCTIONALITY**  
Integrated web services

- DNS
- FTP
- IMS
- ePDG
- N3IWF
- HTTP
- Video

Wi-Fi offload



**APPLICATIONS**  
Measurements and tools



Iperf



IP tune



Slicing



DPI



Logging



DNS



QoS

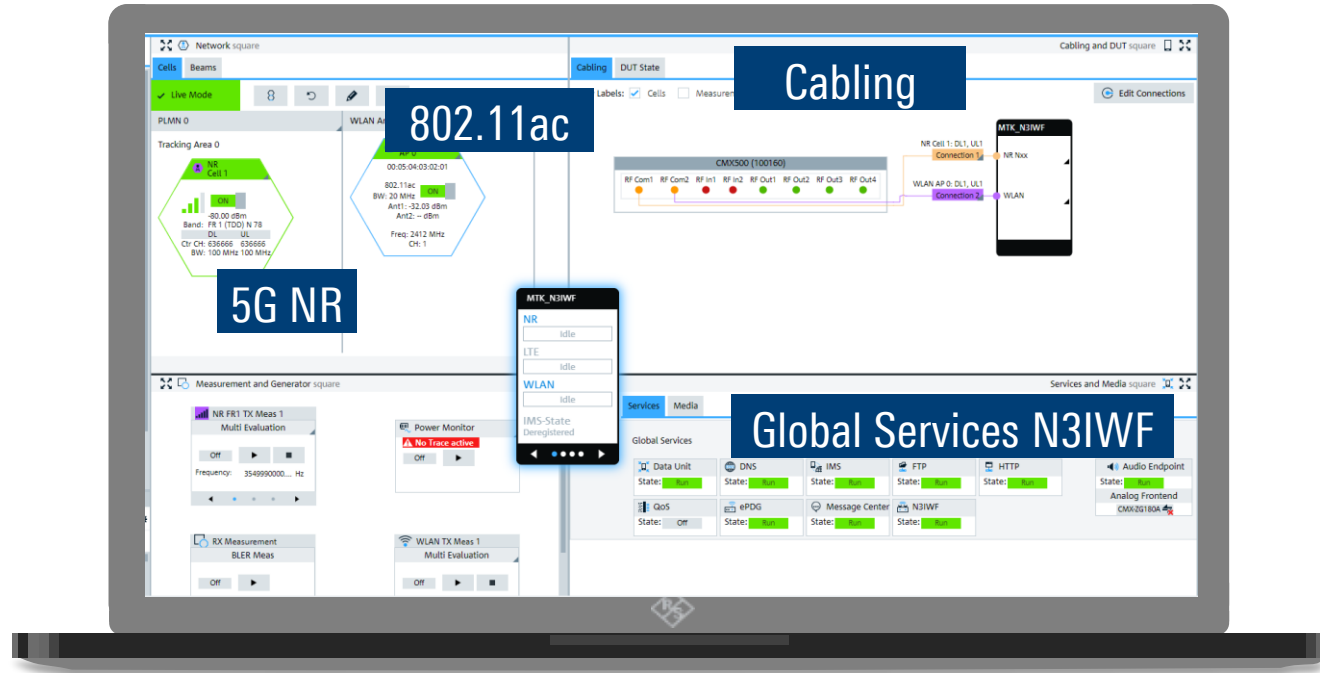


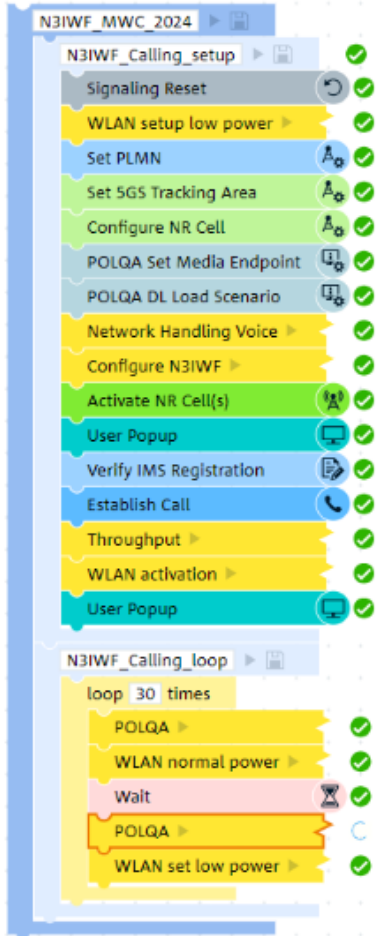
POLQA



DELAY

# Initial configuration for Wi-Fi offload test scenarios





## Test Scenario Setup

- ⇐ WLAN AP Setup
- ⇐ 5G Cell Setup
- ⇐ POLQA Measurement Setup
- ⇐ N3IWF Configuration
- ⇐ Activate 5G Cell
- ⇐ Device Registration & Call establishment
- ⇐ Activate TP Measurement
- ⇐ Activate WLAN AP with low power

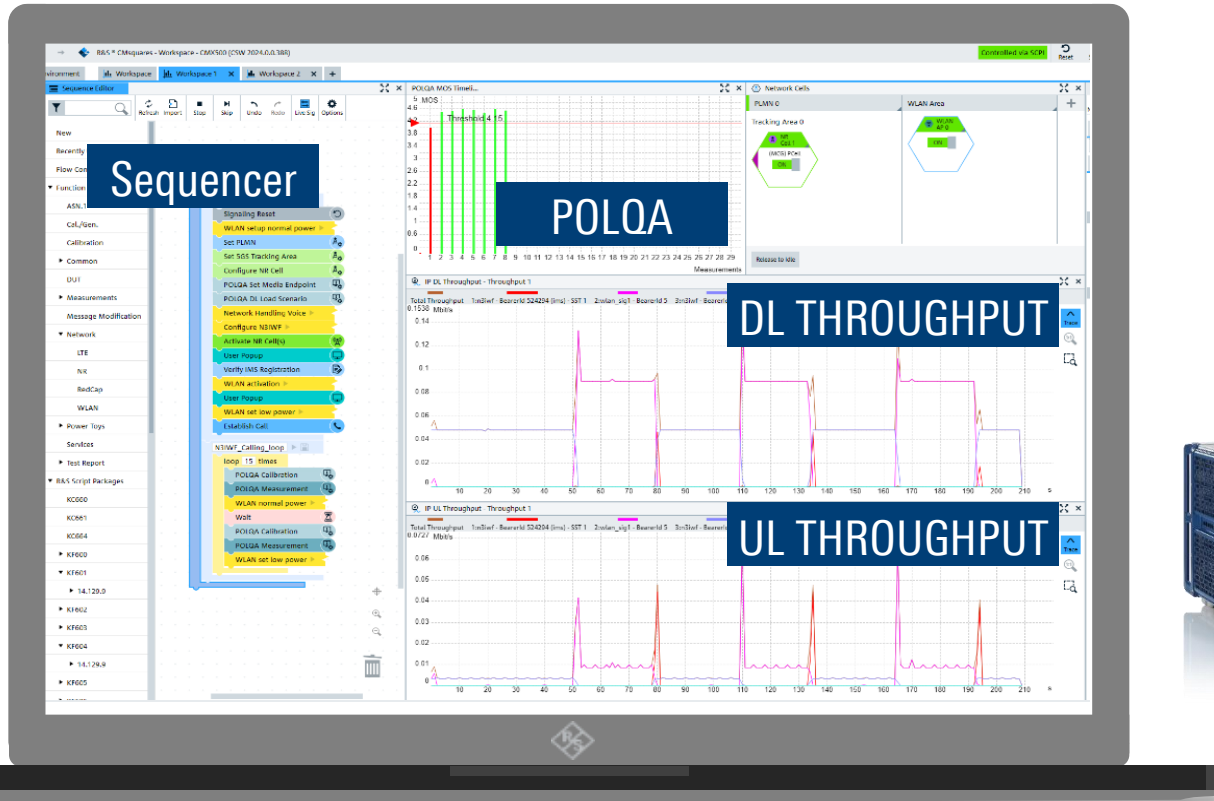
## Test Sequence Loop

- ⇐ POLQA Measurement
- ⇐ WLAN switch to NORMAL POWER
- ⇐ POLQA Measurement
- ⇐ WLAN switch to LOW POWER

## Demo Test Setup at MWC2024 with MTK device supporting Wi-Fi offload (N3IWF)



# Comprehensive testing of Wi-Fi offloading scenarios



The screenshot displays the R&S Sequencer software interface. On the left, a 'Sequencer' sidebar lists various test steps such as 'WLAN setup normal power', 'Set WLAN Tracking Area', and 'POLOA Calibration'. The main workspace shows a 'POLOA MOS Times...' graph with a y-axis from 0.0 to 4.0 and an x-axis from 1 to 29. Below this, two throughput graphs are visible: 'DL THROUGHPUT' (Downlink) and 'UL THROUGHPUT' (Uplink), both showing data over time. The DL graph has a y-axis from 0 to 0.14, and the UL graph has a y-axis from 0 to 0.06. A physical test equipment unit is shown to the right of the laptop, and a monitor displays a detailed view of the test results.



# Wi-Fi test solutions for today and tomorrow



## Conformance



R&S®TS8997

## RF performance



R&S®CMW500/270



R&S®CMX500 OBT



R&S®CMP180



R&S®CMW100



Make ideas real



R&S®TS7124



R&S®ZNA



R&S®FSW



R&S®SMM100A



R&S®VSE

## RF design and compliance



R&S®NGU



R&S®RTP

## Embedded design & power

Test. Measure. Innovate

THANK YOU  
VERY MUCH

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