

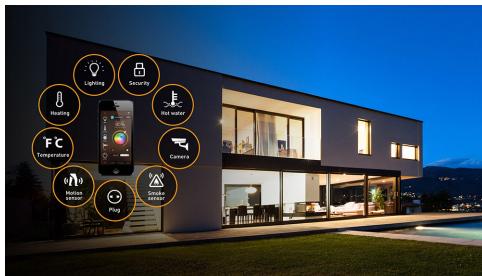
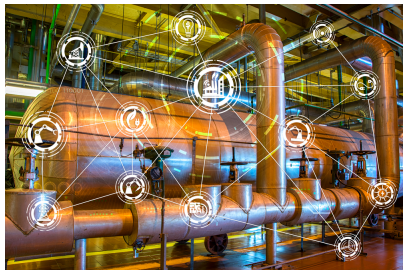
Programmable Radio Propagation Environments: The RISE-6G Perspective

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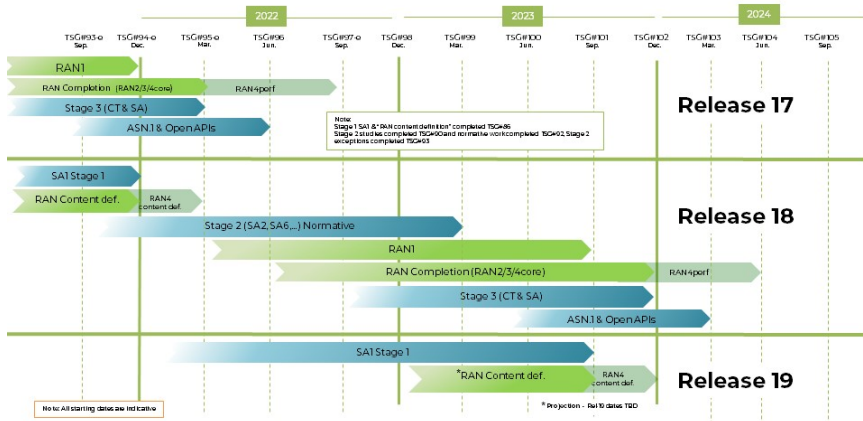
National and Kapodistrian University of Athens
Department of Informatics and Telecommunications

Applications of Wireless Communications



3GPP Release Timelines

Ongoing Release timelines (March 2022)



- R17 frozen in March 2022; R18 (5G-Advanced) is now the focus.

Content of 3GPP Release 18



Release 18



TSG SA priorities*

SA2 led - System Architecture and Services

- XR (Extended Reality) & media services
- Edge Computing Phase 2
- System Support for AI/ML-based Services
- Enablers for Network Automation for 5G Phase 3
- Enh. support of Non-Public Networks Phase 2
- Network Slicing Phase 3
- SOC Location Services Phase 3
- SG multicast-broadcast services Phase 2
- Satellite access Phase 2
- 5G System with Satellite Backhaul
- 5G Timing Resiliency and TSC & URLLC enh.
- Evolution of IMS multimedia telephony service
- Personal IoT Networks
- Vehicle Mounted Relays

SA3 led - Security and Privacy

- Privacy of identifiers over radio access
- SECAM and SCAS for 3GPP virtualized network products and Management Function (MnF)
- Mission critical security enhancements Phase 3
- Security and privacy aspects of RAN & SA features

SA4 led - Multimedia Codecs, Systems and Services

Systems & Media Architecture:

- 5G Media, Service Enablers
- Split-Rendering
- 5G AR Experiences Architecture

Media:

- Video codec for 5G
- Media Capabilities for Augmented Reality Glasses
- AI/ML Study

Real-Time Communications:

- XR conversational services
- WebRTC-based services and collaboration models

Immersive Voice & Audio:

- EVS Codec Extension
- For Immersive Voice and Audio Services (IVAS_Codec)
- Terminal Audio quality performance and Test methods for Immersive Audio Services (ATIAS)

Streaming & Broadcast services:

- SGMS Enh. (Network Slicing, Low latency, Background relaying, SGMS Uplink)
- Further MBS Enh. (Free to air, Hybrid unicast/broadcast)

*these are preliminary lists (As of SA#94-e)

- Access Traffic Steering, Switching & Splitting support in the 5G system architecture Phase 3
- Proximity-based Services in 5GS Phase 2
- UPF enh. for Exposure & SBA
- Ranging based services & sidelink positioning
- Generic group management, exposure & communication enh.
- 5G UE Policy Phase 2
- UAS, UAV & UAM Phase 2
- 5G AM Policy Phase 2
- RedCap Phase 2
- Support for 5WWC Phase 2
- System Enabler for Service Function Chaining
- Extensions to TSC Framework to support DelNet
- Seamless UE context recovery
- MPS when access to EPC/SGC is WLAN

SA5 led - Management, Orchestration and Charging

Operations, Administration, Maintenance and Provisioning (OAM&P):

- Intelligence and Automation: Self-Configuration of RAN NEs, Enh. autonomous network levels, Evaluation of autonomous network levels, Enh. intent driven management services for mobile networks, AI/ML management, Enh. of the management aspects related to NWDAF

- Management Architecture and Mechanisms: Network slicing provisioning rules, Enh. service based management architecture
- Support of New Services: Enh. Energy Efficiency for 5G Phase 2, New aspects of Energy Efficiency for 5G networks Phase 2, Enh. management of Non-Public Networks, Network and Service Operations for Energy Utilities, Key Quality Indicators (KQIs) for 5G service experience, Deterministic Communication Service Assurance

Charging:

- Charging Aspects for Enh. Support of Non-Public Networks

SA6 led - Application Enablement & Critical Communication Applications

Critical Communications:

- MCX Enhancements – MC over 5GS (5MBs, ProSe) Ad-hoc group comm., MCPTT Enh.
- Railways - Gateway UE, Interworking Service Frameworks
- Edge App Architecture Enh., SEAL Enh., Subscriber-Aware API (CAPI Enh.)
- Fused location, Application Data Analytics, App Layer NW Slicing
- Enablers for Vertical applications
- Enhancements to V2X, UAS application-enablement
- Future Factories, Personal IoT networks, Capability exposure for IoT platforms

TSG RAN priorities*

RAN1 led - Radio Layer 1 (Physical layer)

- NR-MIMO Evolution
- AI/ML - Air Interface
- Evolution of duplex operation
- NR Sidelink Evolution
- Positioning Evolution
- RedCap Evolution
- Network energy savings
- Further UL coverage enhancement
- Smart Repeater
- DSS
- Low power WUS
- CA enhancements

RAN2 led - Radio layer 2 & layer 3 Radio Resource Control

- Mobility Enhancements
- Enhancements for XR
- Sidelink Relay Enhancements
- NTN (Non-Terrestrial Networks) evolution - NR
- NTN (Non-Terrestrial Networks) evolution - IoT
- UAV (Uncrewed Aerial Vehicle)
- Multiple SIM (MUSIM) Enhancements
- In-Device Co-existence (IDC) Enhancements
- Small data
- MBS

RAN3 led - UTRAN/E-UTRAN/NG-RAN architecture & related network interfaces

- Additional topological improvements – IAB/VMR
- AI/ML for NG-RAN WI
- AI/ML for NG-RAN SI
- SON/MDT Enhancements
- QoE Enhancements
- Resiliency of gNB-CU-CP

RAN4 led - Radio Performance and Protocol Aspects

- RAN4-led spectrum items
- <5MHz in dedicated spectrum

Rel-18 Workplan for TSG CT

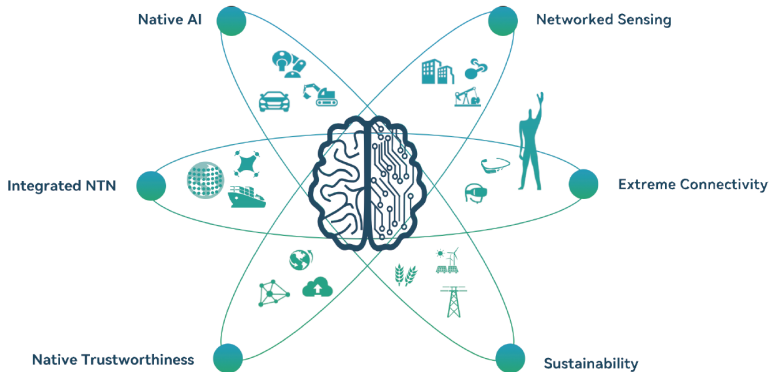
CT will work on Stage 3 completion and ASN.1 code and OpenAPI freeze of Rel-17 until June 2022 [TSG#94].
Work Item discussion on Rel-18 Stage 2 / Stage 3 (under CT) from June 2022.

*Source: RP-213697 (RAN#94-e)

See the 3GPP Work Plan for full details, as Release 18 develops:
www.3gpp.org/specifications/work-plan

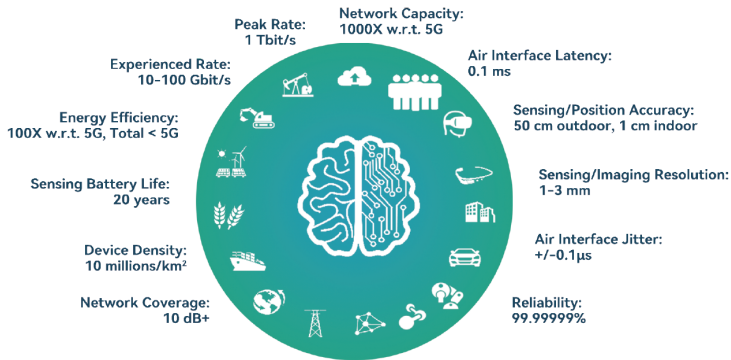
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6G Key Capabilities



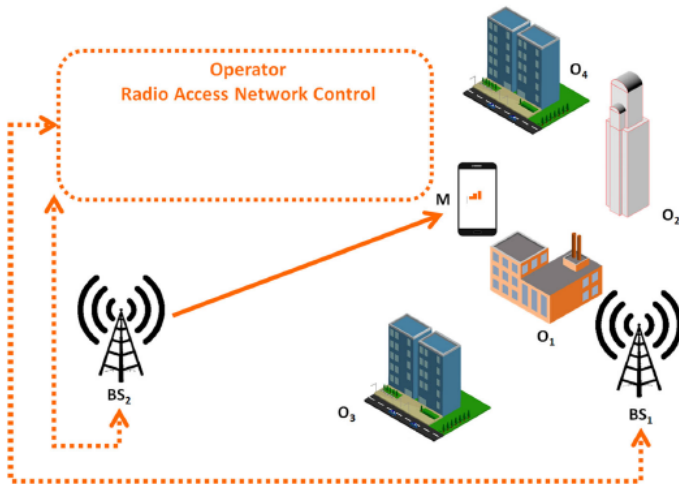
Huawei Technologies, Co. Ltd., "6G: The Next Horizon," *White Paper*, Sep. 2021.

6G RAN KPIs

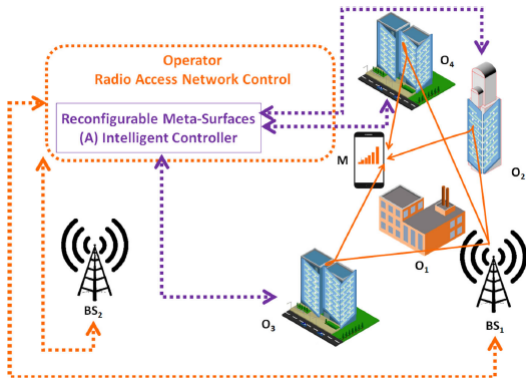


Huawei Technologies, Co. Ltd., "6G: The Next Horizon," *White Paper*, Sep. 2021.

The Wireless Environment is Currently Passive



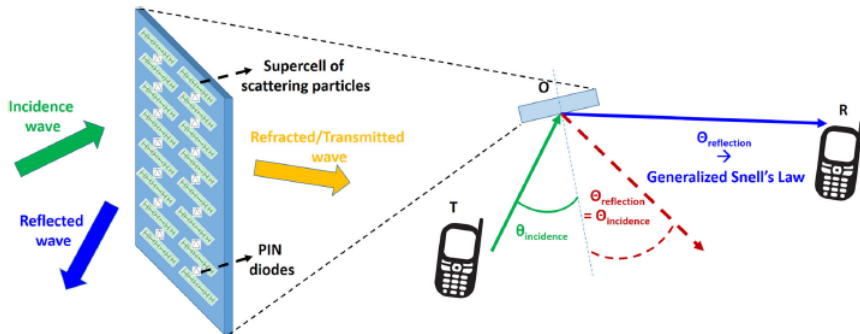
How Can It be Smart and Programmable?



M. Di Renzo *et al.*, "Smart radio environments empowered by AI reconfigurable meta-surfaces: An idea whose time has come," *EURASIP JWCN*, May 2019. (**EURASIP Best Paper Award 2021**)

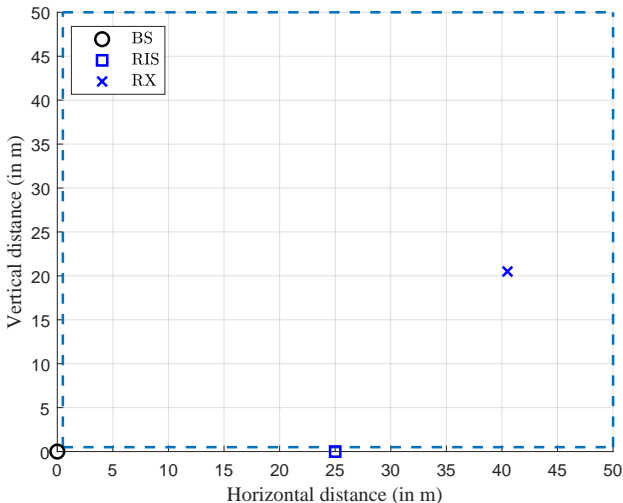
C. Huang, A. Zappone, G. C. Alexandropoulos, M. Debbah, and C. Yuen, "Reconfigurable intelligent surfaces for energy efficiency in wireless communication," *IEEE TWC*, 2019. (**IEEE Marconi Award 2021**)

Smart Wireless Environments? Cool! But How?



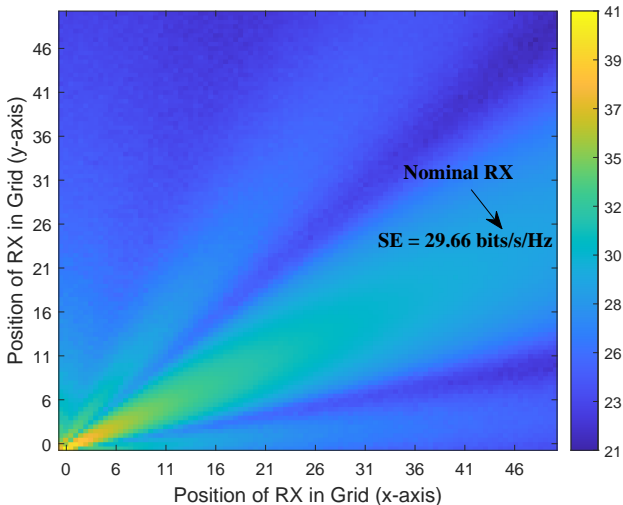
- Metasurfaces are available from a few MHz to THz.
- They operate at the basic level of propagation waves being capable of tuning the impinging electromagnetic field in the RF domain.
- No data encoding, received waveform decoding, conversion from RF to BB and vice versa, nor baseband signal processing.

A Toy Network Example



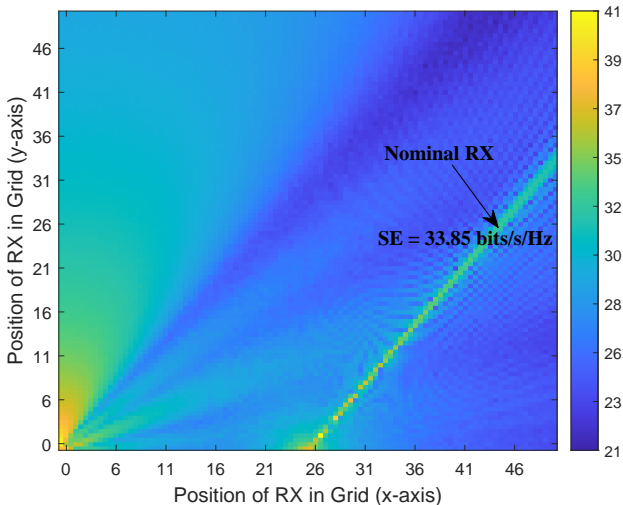
RISE-6G Deliverable D6.1, "Network architectures & deployment strategies with RIS for enhanced EE, EMFEU, and SSE," May 2022.

Spectral Efficiency Grid without an RIS



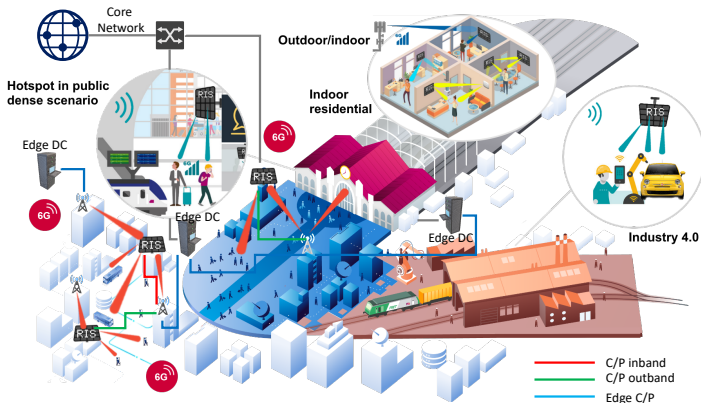
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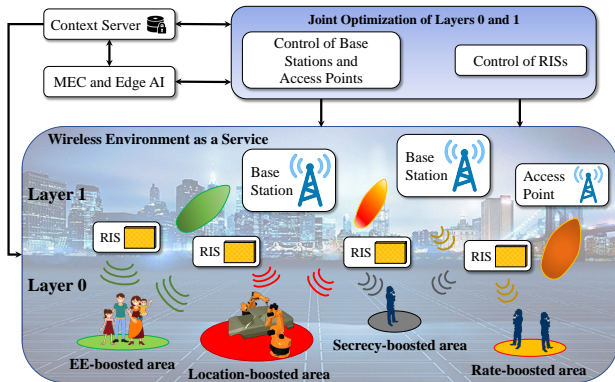
Smart Wireless Environment as A Service



E. Calvanese Strinati, G. C. Alexandropoulos *et al.*, "Wireless environment as a service enabled by reconfigurable intelligent surfaces: The RISE-6G perspective," *Joint EuCNC & 6G Summit*, 2021.

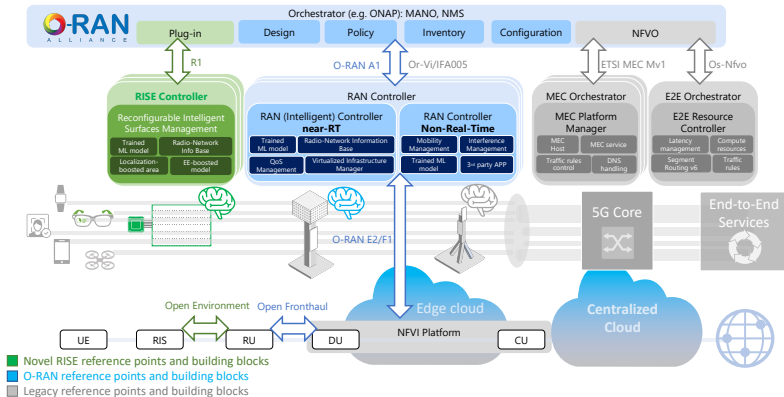
E. Calvanese Strinati, G. C. Alexandropoulos *et al.*, "Reconfigurable, intelligent, and sustainable wireless environments for 6G smart connectivity," *IEEE COMMAG*, 2021.

The RISE-6G Network Paradigm



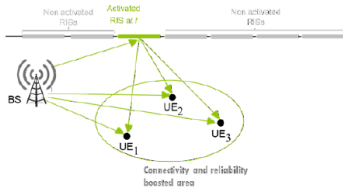
E. Calvanese Strinati, G. C. Alexandropoulos *et al.*, "Reconfigurable, intelligent, and sustainable wireless environments for 6G smart connectivity," *IEEE COMMAG*, 2021.

O-RAN Integration

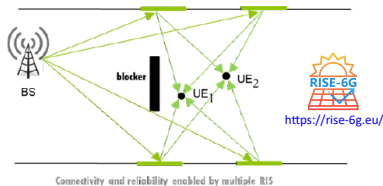


E. Calvanese Strinati, G. C. Alexandropoulos *et al.*, "Reconfigurable, intelligent, and sustainable wireless environments for 6G smart connectivity," *IEEE COMMAG*, 2021.

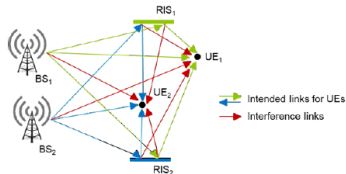
Open Challenges



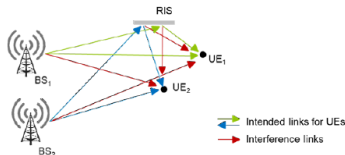
(a) Connectivity and reliability boosted by a single RIS.



(a) RIS-aided systems where connectivity is enabled by multiple RISs.



(b) RIS-empowered downlink communication of two BS-UE pairs, where each RIS can be controlled individually by each pair.



(b) A multi-tenancy scenario with two BS-UE pairs and a shared RIS that is optimized to simultaneously boost reliable communications.

G. C. Alexandropoulos *et al.*, "Smart wireless environments enabled by RISs: Deployment scenarios and two key challenges," *Joint EuCNC & 6G Summit*, 2022.

Thank you for your attention

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