5G & 6G research

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NEC Laboratories Europe

Harnessing the Environment with NEC Smart Surfaces

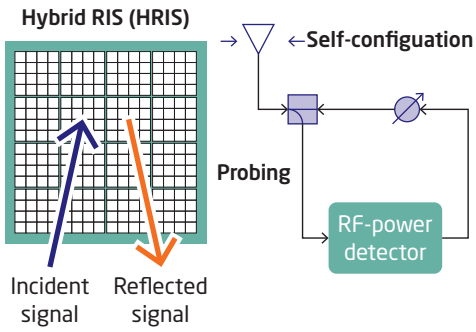
NEC Laboratories Europe

NEC Laboratories Europe is at the forefront of reconfigurable intelligent surface (RIS) technology, also called smart surfaces. NEC smart surfaces use reflector arrays to boost 5G signal strength in a wireless environment by redirecting signals to specific locations.

While 5G technology allows high-speed connectivity, high-frequency connections are weak and can be easily disrupted by obstacles. This represents a major challenge to implementing low latency 5G services. NEC's latest precommercial smart surface prototype resolves this issue by applying passive beamforming on a wide range of scanning angles that can be specifically directed to areas of need.

Controlling a signal with NEC smart surfaces

NEC smart surfaces self-configure the reflection of 5G signals, eliminating the need for a dedicated control channel to manage RIS configuration. The technology uses only local channel state information obtained by absorbing and processing a portion of impinging radio waves. This provides the smart surface device enough information to autonomously configure itself and reflect the non-absorbed portion of the signal to improve channel quality and communication performance. The innovative RIS design was published in the scientific paper titled "MARISA: A Self-configuring Metasurfaces Absorption and Reflection Solution Towards 6G," (Antonio Albanese et al.) presented at IEEE INFOCOM 2022.



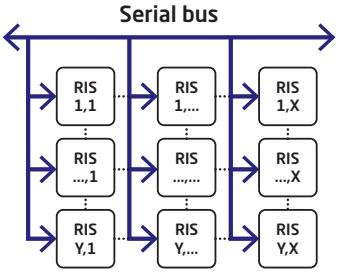
How a NEC smart surface works:

- **Design:** RIS is integrated with low-power sensing and self-configuring capabilities.
- **Signal:** A radio frequency (RF) power detector is enabled to infer the signal angle of arrival (AoA) of base stations and user equipment (UE).
- **Configuration:** NEC RIS self-configuration is triggered on AoA estimations.

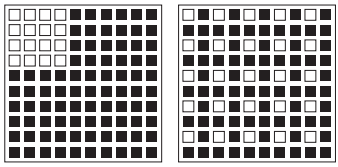
Figure 1: Characteristics of NEC smart surfaces

A modular design for flexible use

NEC smart surface devices are modular, which allow the size of the reflective surface to be altered for different uses. Individual prototype smart surface cells can be configured to fully absorb the energy of RF signals and are reconfigurable. For example, reflective components of RF signals can be switched off, making it possible to virtually optimize NEC smart surface devices to meet system constraints. The energy of impinging signals on the devices can also be repurposed, which can feed active electronic components, providing full autonomy for NEC smart surface devices.

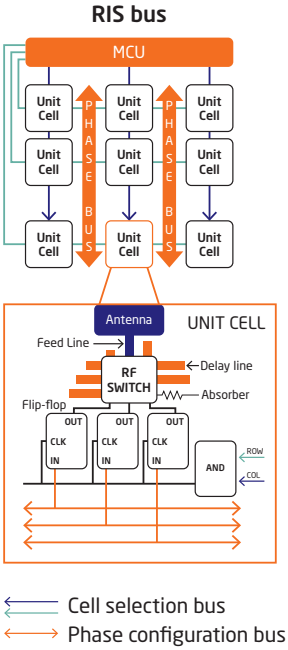


Multiple NEC RIS boards can be placed together to *adapt the reflective surface* to the needs of the use case.



Unit cells can be configured to *absorb RF energy* and prevent reflection to further *adapt the reflective surface*.

■ Disabled unit cell
□ Enabled unit cell



RIS board

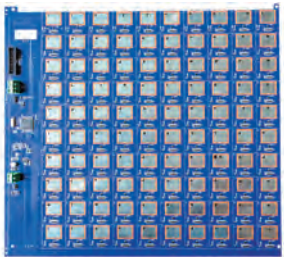


Figure 2: NEC smart surface design

Accelerating smart surface adoption with ease of use

Thanks to NEC smart surface technology, NEC smart surface devices can be integrated into preexisting cellular network infrastructure in a plug-and-play fashion, minimizing installation procedures. This enhances the entire end-to-end technology chain by enabling wireless network operators to easily extend coverage in large areas with low total cost of ownership. At the same time, it provides consumers (individuals and small businesses) with an effortless way to extend their coverage with little additional IT cost.

Compared to existing, state-of-the-art 5G hardware, NEC smart surfaces cost little to produce and can be scaled for different deployment scenarios.

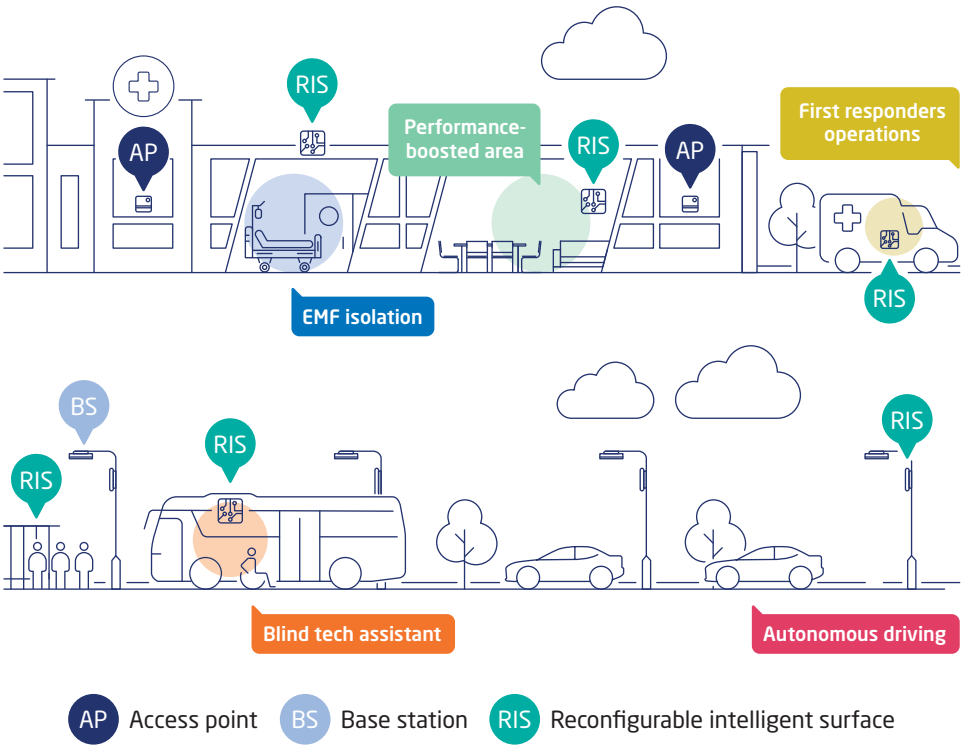


Figure 3: Deployment scenarios for NEC smart surfaces

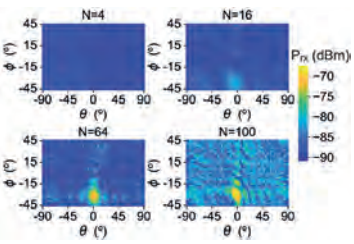
Preparing for beyond 5G

NEC smart surface technology includes a NEC RIS controller module, which makes it fully O-RAN compatible and interoperable with 5G RAN controllers. The NEC RIS controller module seamlessly integrates with existing O-RAN architecture to facilitate open teamwork based on O-RAN compliant interfaces. This helps future-proof upcoming 5G and 6G network technologies.

The accurate indoor geolocation capability of NEC smart surfaces makes them ideal for emerging 5G low latency use cases, including wireless virtual and augmented reality, 5G manufacturing and autonomous indoor drone fleets. The technology can be deployed for different services, including enhanced coverage for massive Internet of Things (IoT) scenarios.

NEC smart surface results from anechoic chamber

Power heatmaps



10x10 NEC RIS steering capacity ±60°, ~25dB beamforming gain over the noise floor, and an HPBW of 10°

Power scales with the number of antennas

Radiation patterns

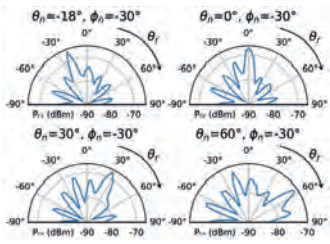


Figure 4: NEC smart surface (reconfigurable intelligent surface) 5G signal results from TU Darmstadt anechoic chamber in 2022

RIS scientific papers by NEC and research partners

Antonio Albanese, Francesco Devoti, Vincenzo Sciancalepore (et al.) *"MARISA: A Self-configuring Metasurfaces Absorption and Reflection Solution Towards 6G"*, IEEE Conference on Computer Communications (INFOCOM) 2022

Marco Rossanese, Placido Mursia, Andres Garcia-Saavedra (et al.) *"Experience: Designing, Building, and Characterizing a RF Switch-based Reconfigurable Intelligent Surface"*, ACM WiNTECH 2022 co-located with MobiCom 2022

Placido Mursia, Vincenzo Sciancalepore, Andres Garcia-Saavedra (et al.) *"RISMA: Reconfigurable Intelligent Surfaces Enabling Beamforming for IoT Massive Access"*, IEEE JSAC 2020

NEC smart surfaces technology

Ubiquitous: There is no need to set up explicit control planes. NEC smart surfaces can be installed everywhere.

Lower manufacturing cost: Electronics printing costs are kept affordable, while still providing IoT sensing capabilities.

Design simplicity: Simpler electronic circuit design enables rapid RIS reconfiguration in the configuration phase.

Enhanced performance: Performance is improved in terms of system efficiency with respect to theoretical RIS algorithms.

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