Design Choices for the 6G RAN and System

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NOKIA

Business values

TCO reduction

Using capabilities of AI and Cloud platforms, as well as intent-based automation

Cost effective migration to 6G

Performance & resiliency

Efficient support of different device types

Improve capacity with an efficient system design and new radio

Fully E2E resilient system towards zero downtime

Foster monetization

Programmable networks, unified API framework

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Societal values

Environmental sustainability

Substantial reduction in energy consumption, enabling sustainable use of AI and data

Green energy usage

Security, privacy and trust

Secured and privacy protected, Quantum safe system, AI trustworthiness

Highly automated identity management and scalable authentication

Digital inclusion

Ubiquitous connectivity via terrestrial and non-terrestrial access

Connectivity at reduced costs

6G Architecting Tomorrow

Nokia's 6G vision: four main points for future-proof networks

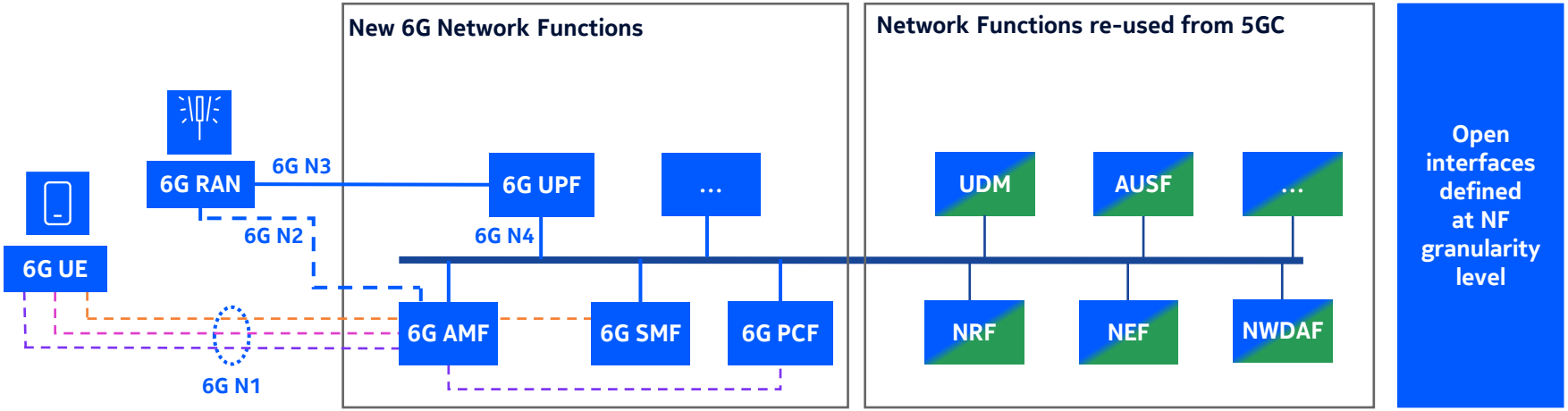
	Impactful	Intelligent	Sustainable	Cyber-resilient & secure
6G RAN & Radio	Superior performance with an efficient radio MRSS for optimized 5G-6G spectrum usage	AI/ML-enabled RAN optimization Universal access to data	Energy efficient radio and RAN Lean, implementation-friendly design	Enhanced lower layer security features Quantum-resistant encryption
6G System	Single standalone architecture Modularized design for different devices	Native support for full AI/ML lifecycle Architecture enablers for full automation	Energy-aware resource utilization (e.g. AI/ML) throughout the network	Privacy preserving technologies Integration of cloud-native security

Lean | Streamlined | Market-relevant

Value blueprint

We are designing the most impactful network ever.

Single 6G Standalone Architecture (1/2)



6G AMF: 6G Access and Mobility Management Function
6G SMF: 6G Session Management Function
6G PCF: 6G Policy Control Function

6G N1: 6G Modular NAS terminating at 6G AMF, 6G SMF, 6G PCF
6G N2: continue with P2P interface (replacing SCTP by QUIC is an option)
6G N3: based on GTP-U
6G N4: either adopt SBI or evolve PFCP (which is not shown in the figure)

5G SBI as the baseline, re-use NFs and introduce new NFs when justified

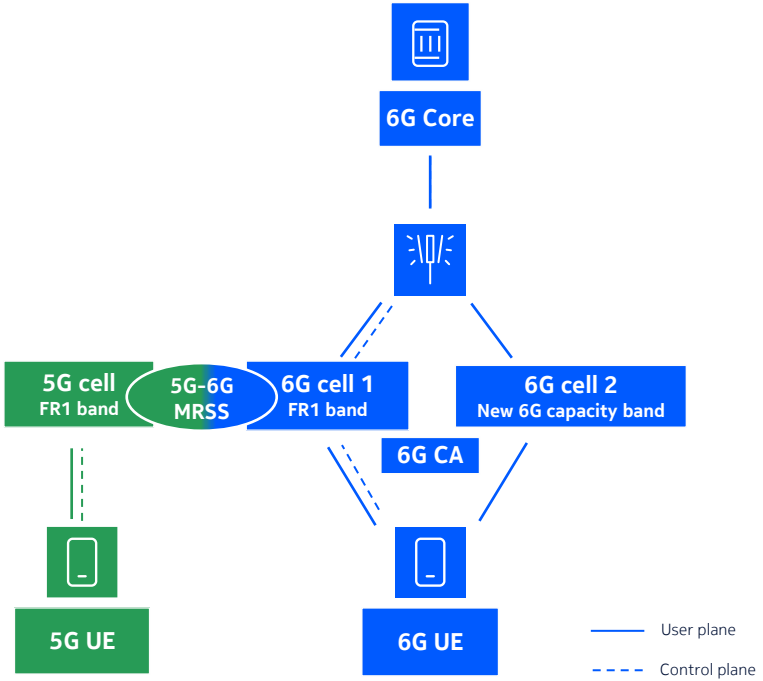
CA = Carrier Aggregation
MRSS = Multi-Radio Spectrum Sharing
SA = Standalone Architecture

Single 6G Standalone Architecture (2/2)

All 6G benefits available on day one

5G-6G Multi-Radio Spectrum Sharing (MRSS)

- 6G Core based on 5G SBA as the baseline
- Enables dynamic refarming on an existing 5G NR FR1 FDD or TDD band, e.g., 700MHz or 3.5 GHz
- Integral part of the 6G radio design
  - 6G radio built on 5G NR compatible waveform: MRSS efficiency can be maximized
- Significantly higher efficiency than 4G-5G Dynamic Spectrum Sharing (DSS)
- Transparent to the UE
- 6G CA including UL CA supported from day one
  - Connecting high 6G capacity and performance with coverage



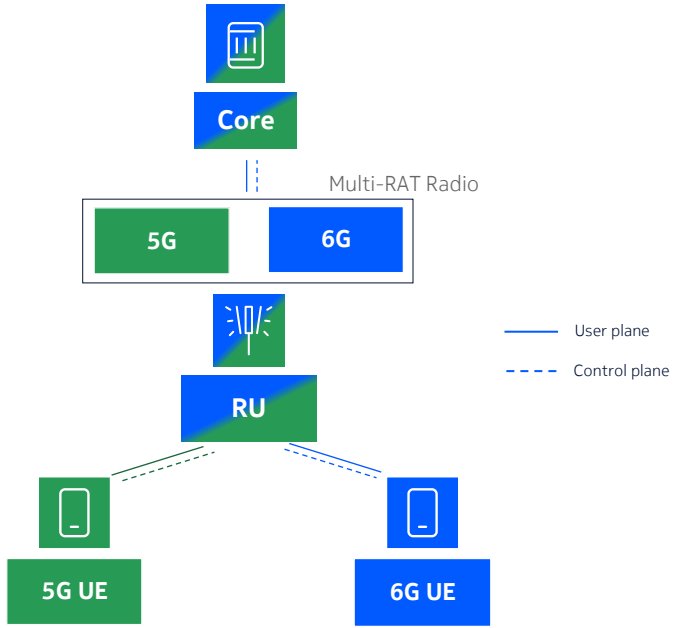
Single architecture as the baseline, with MRSS for smooth migration

Enhanced shared 5G-6G carrier performance with MRSS

5G-6G MRSS has very high efficiency and performance on all the existing FR1 TDD and FDD bands & easily deployable on 6G day one

When 6G with better radio performance than 5G is deployed on the same carrier with 5G using 5G-6G MRSS, the spectral efficiency and throughput performance of that carrier will increase

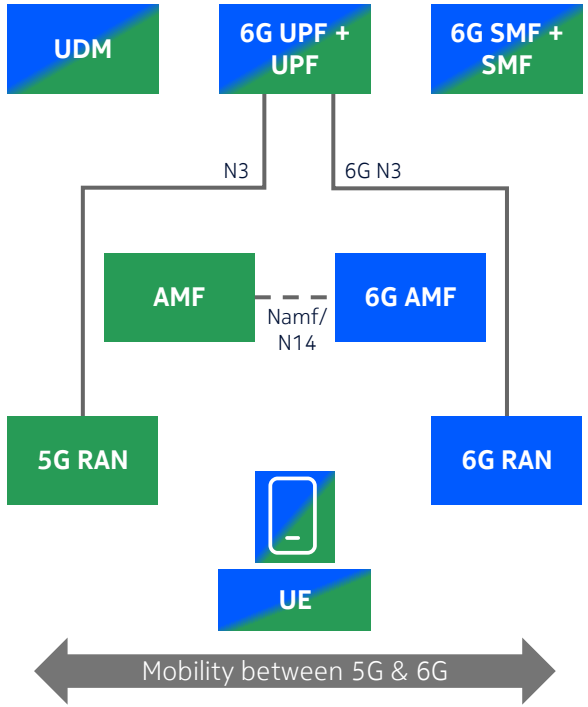
Flexible migration - 6G traffic can get directed to the shared carrier gradually → optimized utilization of that carrier throughout migration period, independent of migration speed



5G-6G MRSS enables significant 6G radio performance gains over 5G on the existing FR1 FDD and TDD bands

Seamless interworking with 5G

- Seamless service continuity between 5G and 6G quintessential for success of 6G
- Enable support for Single Registration (SR) based interworking between 5G and 6G
- Mandatory for all 6G UEs
- Enable common IP anchor (“combo” 6G UPF+UPF), context transfer (Namf/N14) and common (i.e., single) subscription for interworking
- Due to complexity, interworking with 4G should be avoided



Single registration based 5G-6G interworking

Introducing modular 6G protocol design

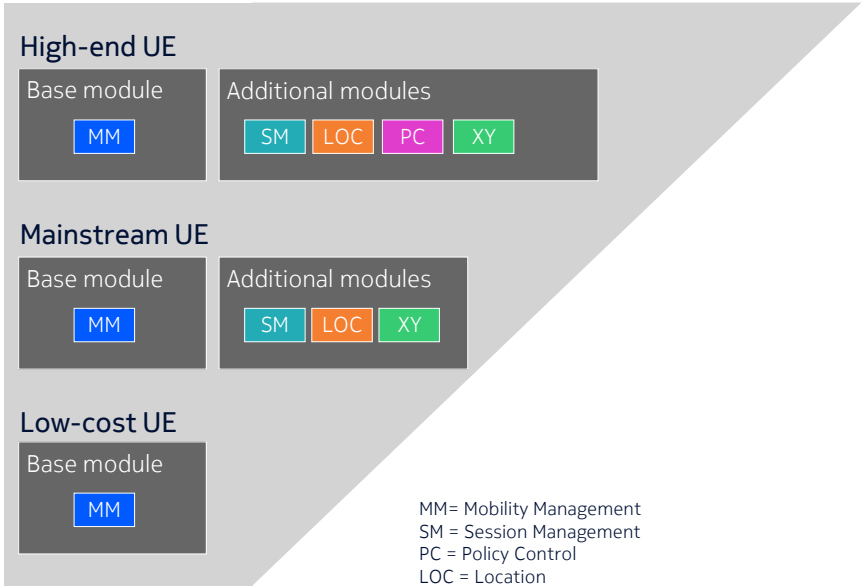
Modular protocol design (e.g., modular RRC and NAS) supports different device types in an efficient manner

- Baseline modules support low-cost devices
- Additional modules can be introduced on top

Modular NAS: independent and orthogonal NAS modules with distributed NAS security terminations

NAS modules: implementing independent functionality in an extensible manner

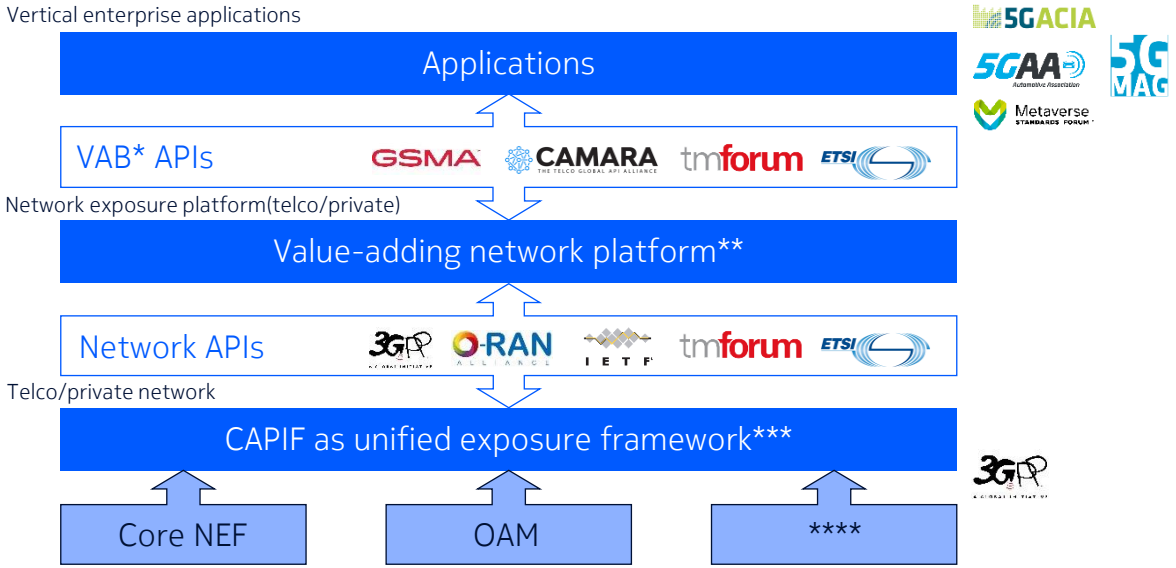
- Strict orthogonality avoids the need for overlapping features e.g., in MM and SM as in 5G
- Distinct security levels for different modules
- Modules supported in devices (FWA, eMBB, IoT, XR) when needed
- Easier integration of new functions leading to easier market uptake of new services (via NAS)



Modular NAS designed for scalable and efficient implementation

Unified northbound exposure for 6G

- CAPIF is the unified framework for exposure from Core and OAM
- CAPIF enables seamless integration between Value-adding platforms exposing APIs to 3rd parties and the underlying network domains
- CAPIF can evolve as needed



(*) Vertical Application Bound
(**) Consumes and transforms network APIs, exposes VAB APIs
(***) CAPIF may be centralized or distributed
(****) Exposure for other domains like O-RAN, Transport, Cloud, etc. are not in scope of this presentation but should also be considered

CAPIF as the unified framework for exposure

Superior 6G Radio

Key 6G PHY elements for BTS hardware re-use & migration

BTS evolution and hardware reuse enables smooth network upgrade from 5G to 6G

Key 6G physical layer elements enabling BTS evolution and hardware re-use:

- 5G NR compatible numerology
  - Time domain structure
  - Sub-carrier spacings
- 5G NR compatible waveforms
- 5G NR channel coding as baseline

5G NR compatible waveform, numerology and channel coding are also critical for enabling highly efficient spectrum sharing between 5G and 6G (MRSS) on the same FR1 carrier

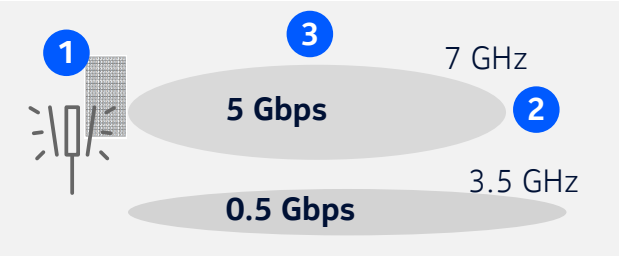
Superior 6G radio with new PHY & L2/3 procedures, new UE chipset platform

- Elevated capacity and user data rates with the existing macro grid on upper 6 GHz, 7.1 – 8.4 GHz
- Enhanced uplink coverage
- Energy-efficient network & device power savings
- Efficient support of small data and background data
- Implementation friendly low latency support
- Smooth migration
- Intelligent use of diverse spectrum (existing & new)

Superior 6G radio driving elevated UE baseline

- Elevated performance with new 6G UE baseline: Non-backward compatible for UE
- No legacy burden from 5G NR devices and legacy UE modem and RF design (still used for 5G-A features)

Superior 6G radio performance at 6.4-7.1 and 7.1-8.4 GHz

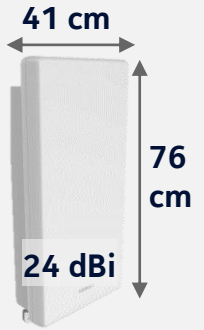


1 = Reuse of existing base station sites for new bands

2 = Similar coverage with 7 GHz as with 3.5 GHz

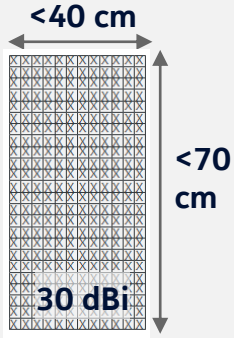
3 = Cell capacity 10-20x compared to 3.5 GHz with wider channel bandwidth up to 400MHz

5G at 3.5 GHz



8x12x2=192

6G at 6-8 GHz



16x24x2=768

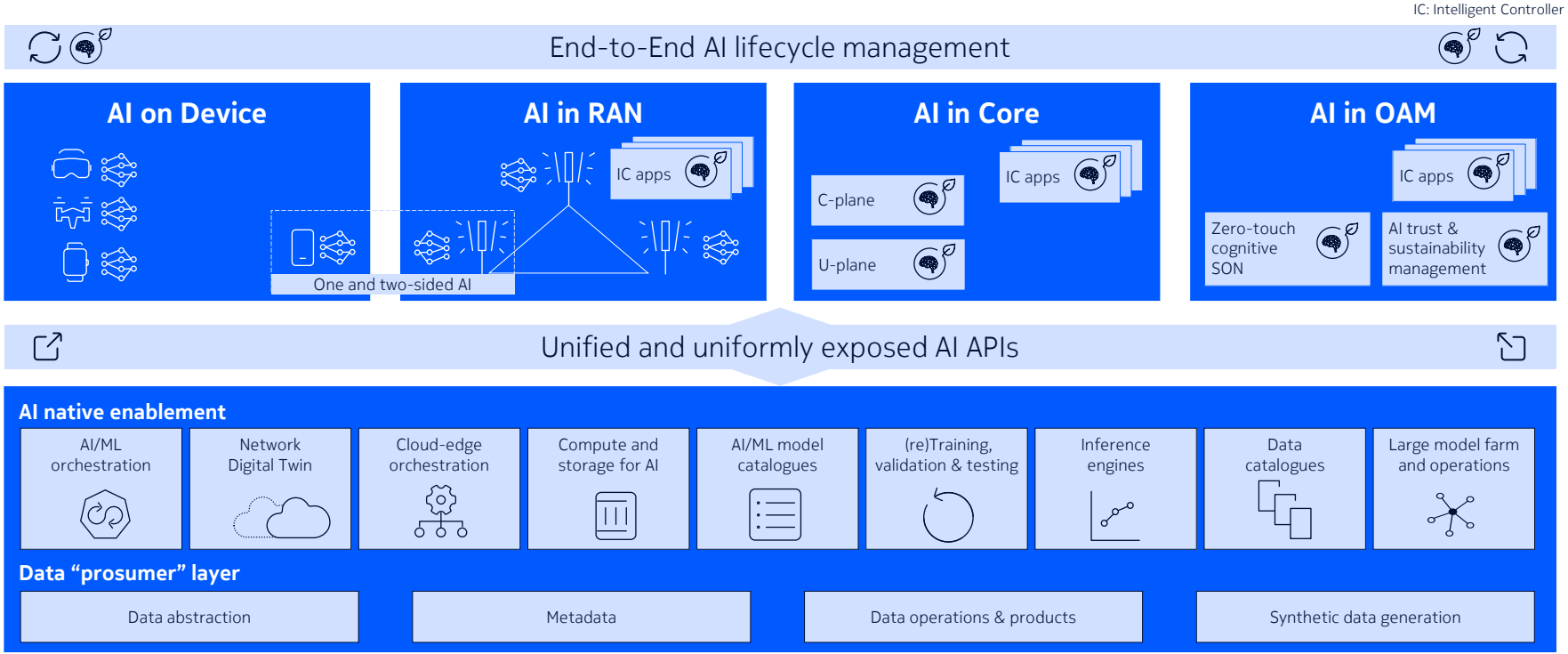
Coverage solution: 4x **more antenna elements** in the same physical area to boost antenna gain up to 6 dB

Capacity solution: 4x **more bandwidth** and 3x more spectral efficiency with **more TRXs & beamforming**

AI blueprint

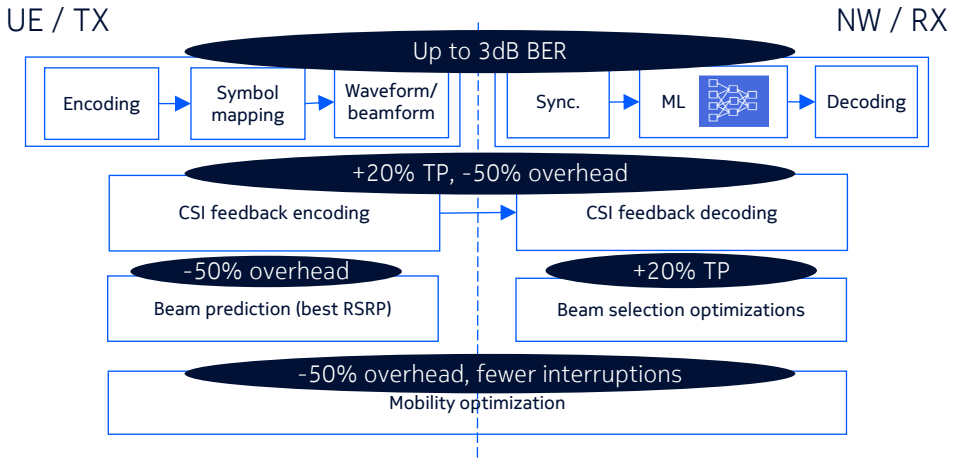
We are designing the most intelligent network ever.

AI-powered 6G network: holistic view



AI/ML enabled 6G radio

- Future-proof AI/ML framework enabling continuously improving 6G radio
- New and extended use cases for 6G radio
- Integrate AI/ML-based solutions into the fundamental design of the 6G Air-Interface to ensure that the 6G day one specifications enable AI/ML-based implementations alongside to conventional approaches



New 6G use case

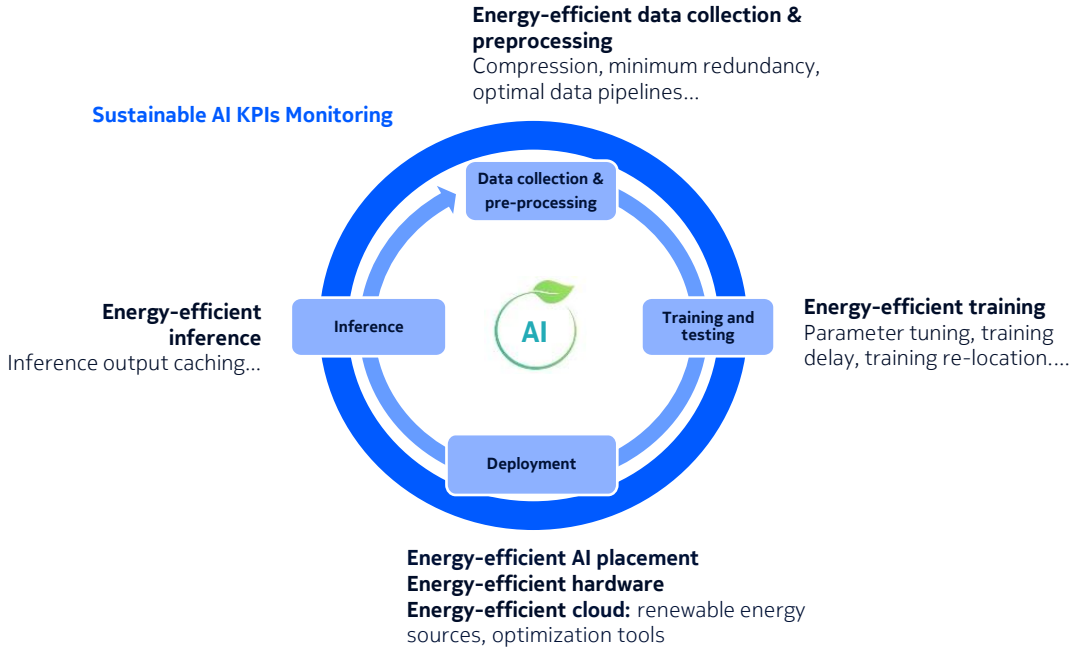
Extending 5G-Advanced use cases

Sustainability blueprint

We are designing the most sustainable network ever.

Towards “greener” AI and data management

- Energy- & carbon-aware (optimized) data production & exposure
- Energy- and carbon-aware AI/ML management through observability (e.g. complexity vs consumption) and optimized solutions over the entire AI/ML lifecycle



There is no “AI native” without “sustainable AI”

UE power savings on 6G day one

- A superior user experience for smartphone subscribers is not only about bandwidth and coverage, but also how long their devices can be used before needing a recharge.
- To achieve a longer battery life and decrease device carbon footprint, we must focus on reducing the energy consumption for all 6G devices types

Technology components

- Standalone-only operations for longer device battery lifetime from 6G day one
- Leverage key 5G-Advanced device energy saving features with leaner design for all 6G devices from 6G day one, including:
  - DRX, incl. irregular DRX cycle for XR and DCI-based wake-up signals
  - Low-power Wake-Up Signal
  - Low-power RRC Idle/Inactive and efficient support of background/small data
- Introduce 6G specific enhancements:
  - Leaner framework for efficient scaling of used bandwidth in single- and multi-carrier scenarios
  - Improved UE measurement framework incl. reporting in RRC connected mode
  - Uplink MIMO energy saving features

Longer UE battery lifetime for enabling superior user experience for all device types

Security blueprint

We are designing the most
cyber-resilient and secure network ever.

6G security improvements per domain

New in 6G
Evolved from 5G

UE to network

- Differentiated security for NAS modules, one authentication per UE
- Authentication framework: adding forward secrecy, support new device types, user centricity
- Radio security

Core

- SBA security: evolution of 5G approach; evaluation of emerging technologies (e.g., use of W3C identities for NFs)
- Roaming: keep 5G roaming concept using proxies, decouple authorization in VPLMN and HPLMN
- Exposure: evolutionary approach based on CAPIF
- Cloud: confidential computing (not specific to 6G 3GPP standardization)

Quantum safe

- 6G architecture must be quantum resistant (support Hybrid PQ/T algorithms)

AI/ML

- Native 6G AI/ML must be secured addressing the whole AI/ML lifecycle

Privacy

- User consent enhancements
- Privacy enhancing technologies (data minimization, homomorphic encryption, etc.)

Key take aways

Value – to society and business

Reuse

- Re-use 5GC NFs, only introduce new NFs when justified
- 6G radio built on 5G NR compatible waveform
- 6G physical layer elements enabling BTS evolution and hardware re-use

Redesign

- Modular NAS protocol enabling scalable and implementation friendly design, non-backward compatible 6G UE
- MRSS for smooth and efficient migration

Reinforce

- Single standalone architecture
- 5G SBI framework evolution leveraging cloud-friendly protocols
- Use of evolved CAPIF as the unified framework for exposure

AI

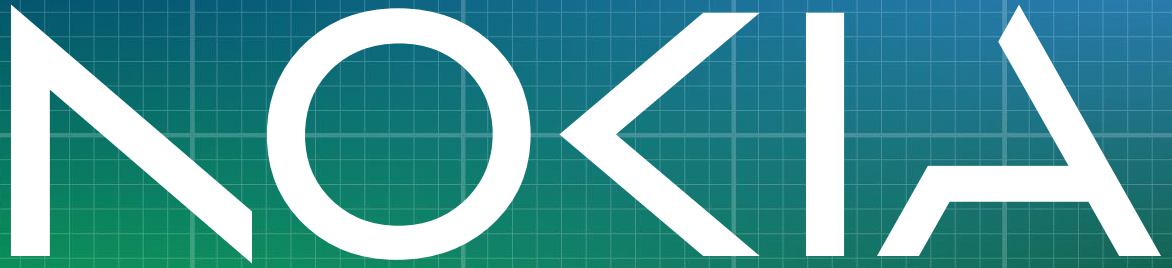
- Uniform data access for better efficiency & performance
- AI-enabled NFs for TCO reduction

Security

- Quantum-resistant system
- Extended security and privacy protected system

Sustainability

- Substantial reduction in RAN energy consumption
- Ensure sustainable use of AI and data



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