Native Network Intelligence

5G-A baseline and 6G perspective

Henning Sanneck, Janne Ali-Tolppa, et al.
Nokia Standards

The technology we lead in: Networks that sense, think and act

Making high performance connectivity more consumable and sustainable

A transformation in how networks are deployed

Opening up networks for innovation and collaboration, securely

A transformation in how networks are applied

6G System Architecture

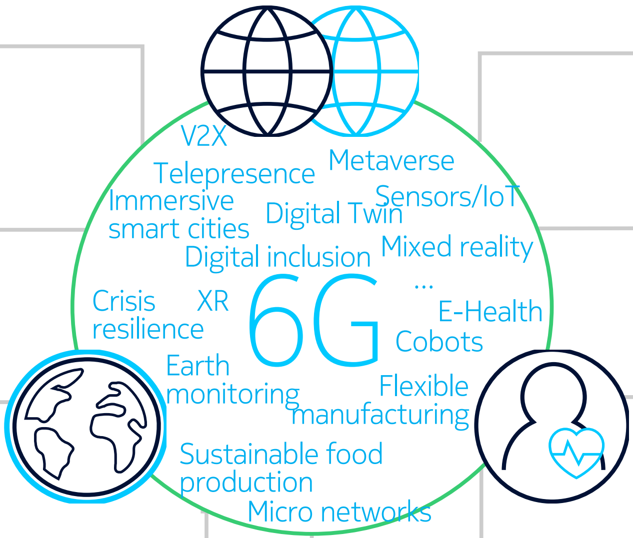
Drivers and Principles

New applications trends, e.g., requiring increased application awareness and adaptive QoS/QoE

New technology trends, e.g., joint communication and sensing

Architecture to suit ultra-dense and macro deployments

Privacy, Security, Trust and Resiliency.
Quantum safe design.
Ensure full protection for UE and network



Sustainability as integral part of 6G architecture design

Native AI/ML support

Cognitive Autonomous Network (Management) Functions

Leverage full potential of Service Based Architecture (SBA)

Radio Network disaggregation

Source: Simone Redana, ORAN nGRG Workshop – Architecture towards 6G

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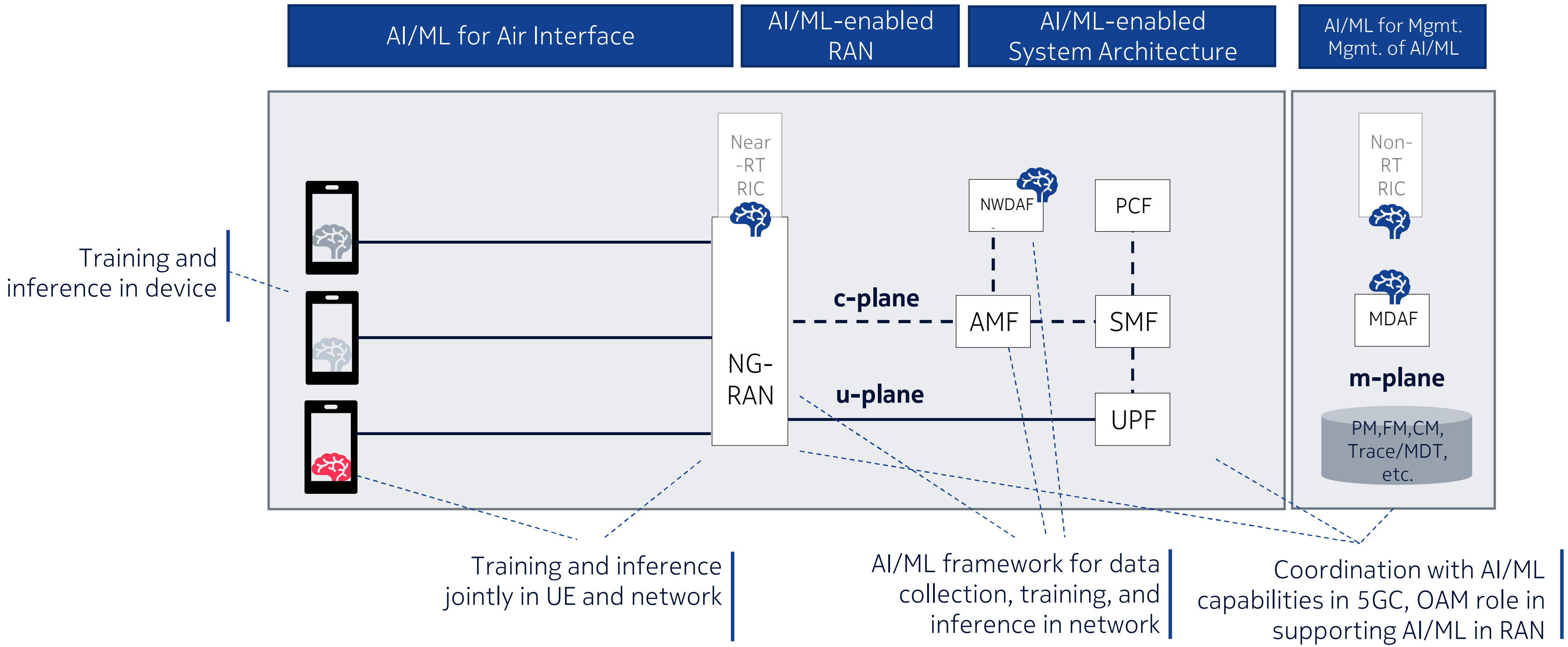
5G-Advanced / ORAN

AI/ML techniques will be enabled in all parts of the system



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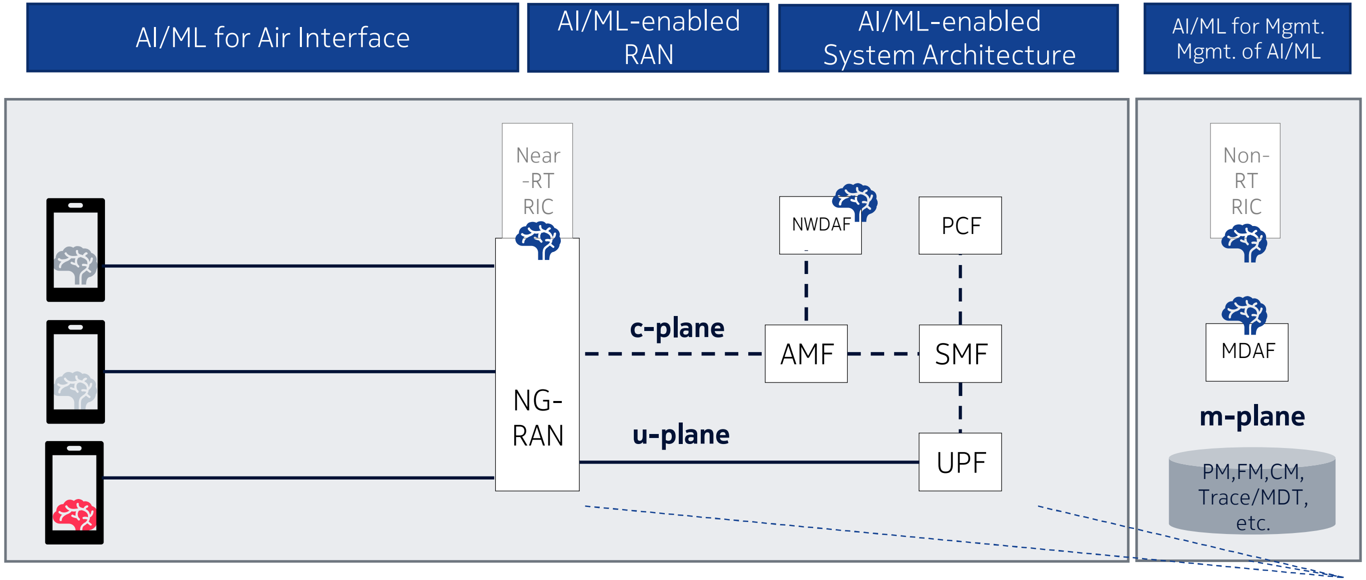
AI/ML-enhanced use cases



(UE-specific) load balancing and traffic steering
Mobility (proactive HO, pattern predictions)

UE / slice QoS & QoE
Mobility optimization

Traffic steering (cell load;policies)
Mobility robustness
Energy saving (cell switch off)
Anomaly detection and RCA

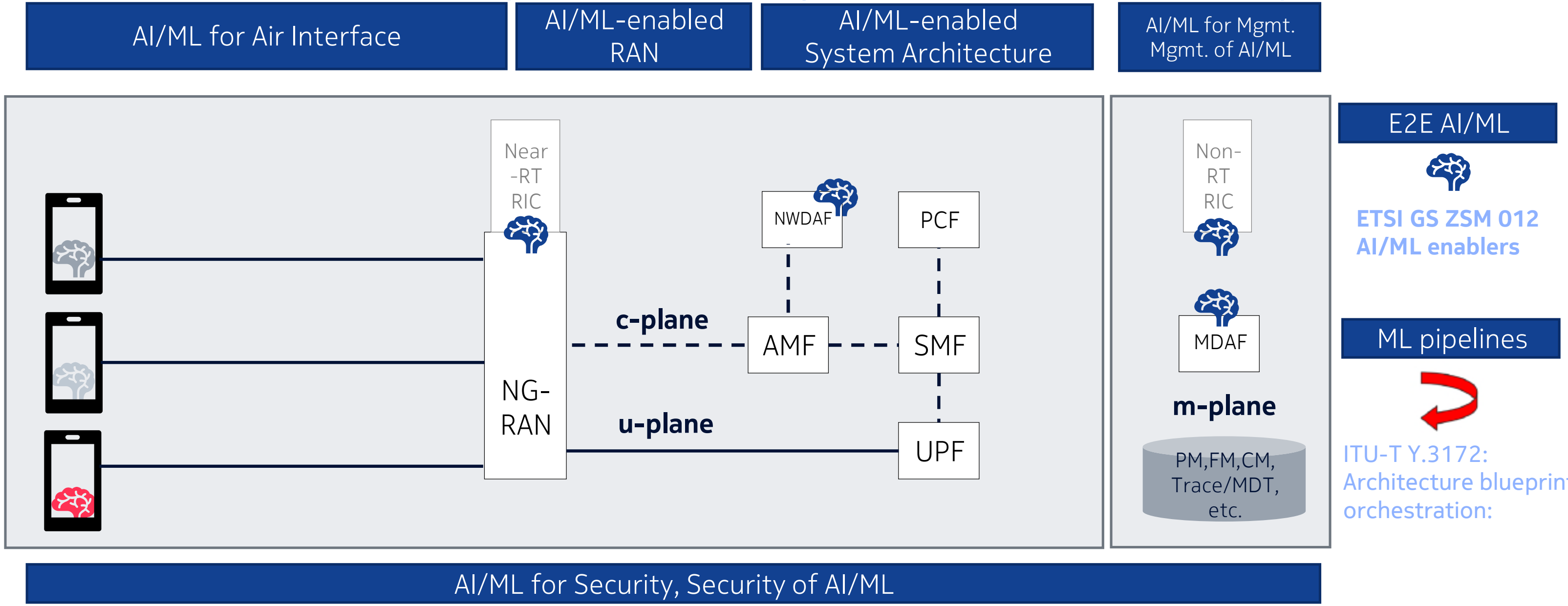
5G-Advanced / ORAN

AI/ML-related standards

3GPP RAN3: WI on AI/ML for NG-RAN
ORAN: WI on AI/ML

3GPP SA2:
WI on Enabler for Network Automation for 5G – Phase 3
WI on System Support for AI/ML-based Services

3GPP SA5: SI / WI on AI/ML Management
ORAN: WI on AI/ML



ETSI GS ZSM 012 AI/ML enablers

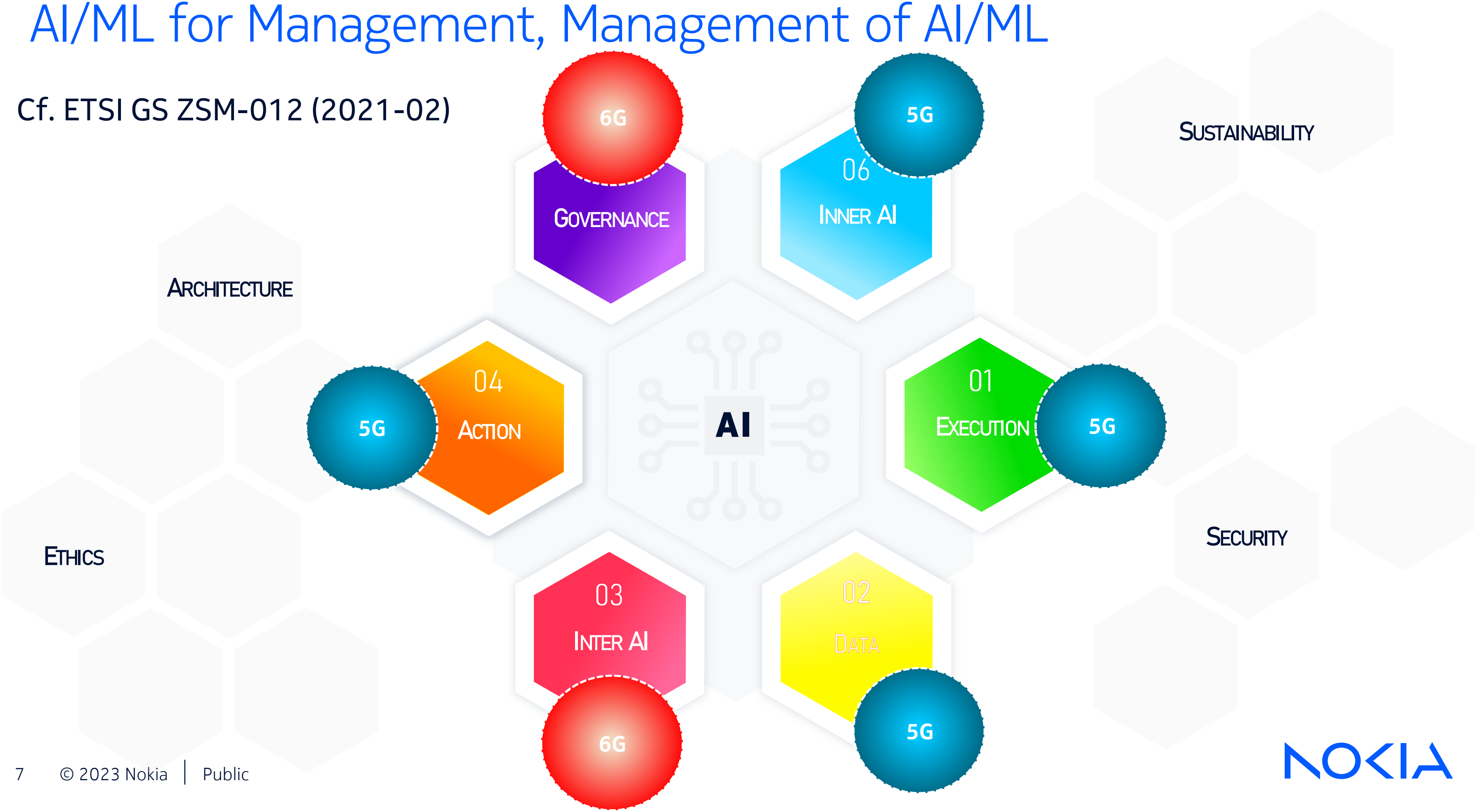
ITU-T Y.3172: Architecture blueprint, orchestration:

3GPP SA3:
- **SI/WI on Security Aspects of Enablers for Network Automation for 5G – Phase 3**
- **SI on Security and Privacy of AI/ML-based Services and Applications**
- **SI on Security Aspects of AI/ML for the NG-RAN**

ETSI GR ZSM 010 General Security Aspects (sec. 5.5)

AI/ML for Management, Management of AI/ML

Cf. ETSI GS ZSM-012 (2021-02)



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Cognition vs. Autonomy

- **Automation:** degree of machine- vs. human-level execution and supervision (→ "Autonomy")
- **Cognition:** degree of ability to perceive (conceptualize / contextualize events) and to reason

- → Cognition & Autonomy are inter-related, but conceptually separable properties
  - AI/ML technology (← Data) is the enabler for Cognition
  - Intent technology (← Labels) is the enabler for Autonomy

- → Actions can be taken at any step in the cognitive process
  - Simple, frequent tasks → high degree of automation with low level of cognition
  - Complex, rare tasks → low degree of automation with high level of cognition

- Opportunity to automate also the complex and frequent tasks (→ "Cognitive Autonomy")
  - and find new ways of system design and interoperability
    ("design through AI/ML" rather than "enhance with AI/ML") → **"Native AI/ML"**

- Challenges (for Technology and Standards adoption in Networks / Network Operations):
  - System legacy and diversity (existing architectures, tools), evolution
  - Technology novelty: new functionality (MLOps), trust

Cognition

Automation

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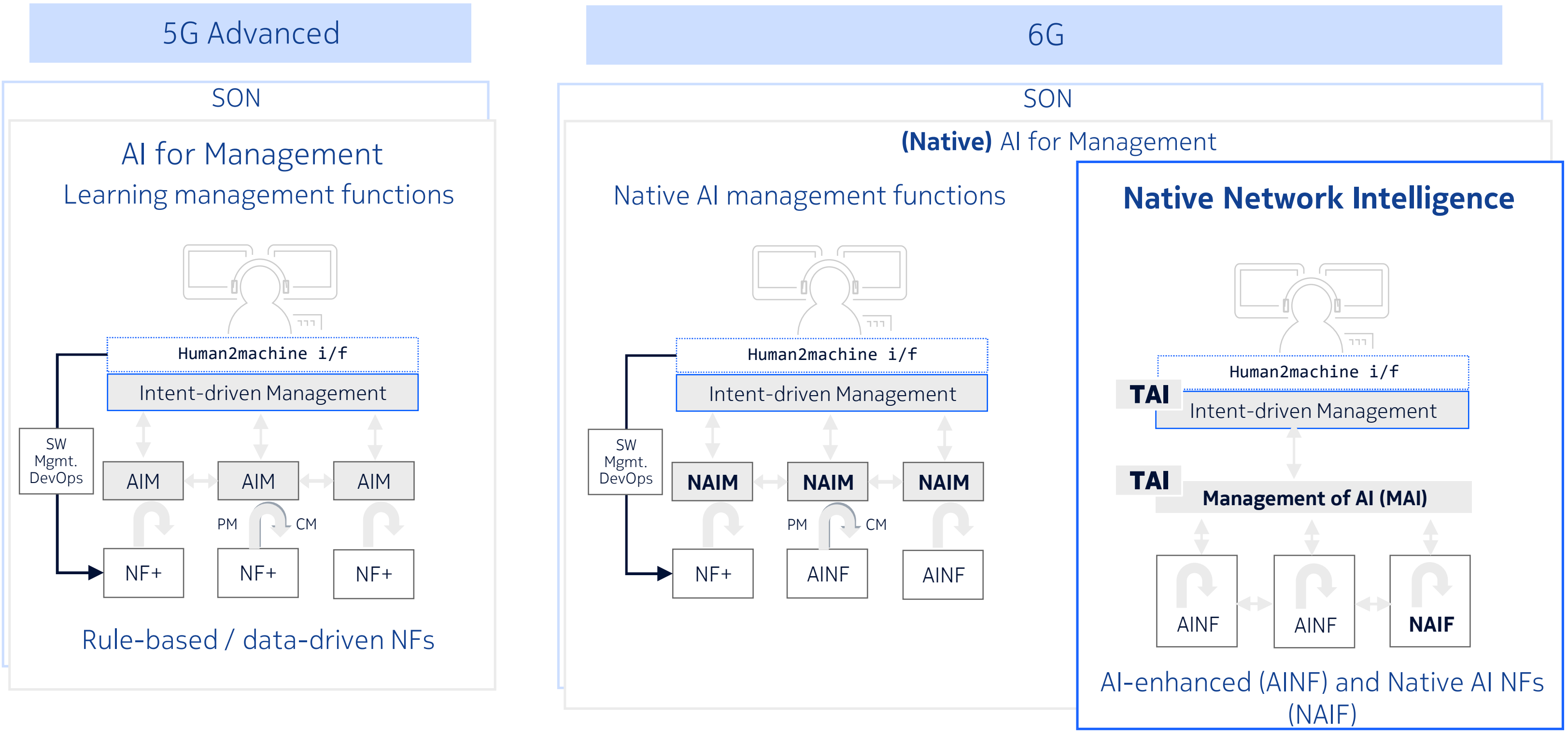
Technology evolution towards Native Network Intelligence



NAIM: Native AI Network Management

TAI: Trustworthy AI

  | Public

Example: QoS Prediction and Application Offloading

Use case

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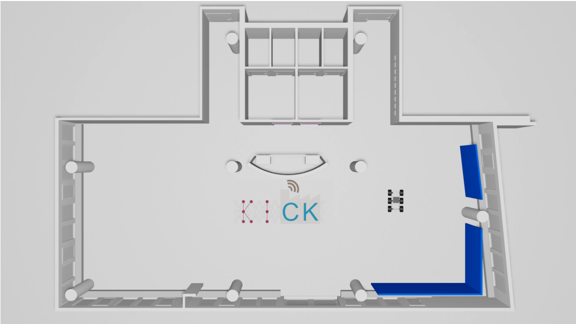
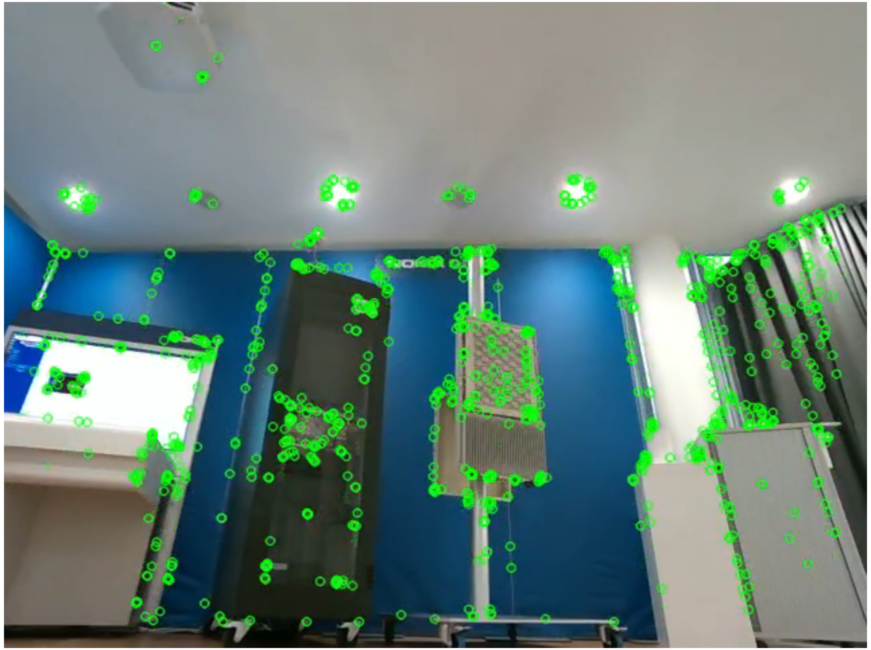
- Vision-based indoor positioning for industrial AGVs → compute-heavy → edge cloud offloading





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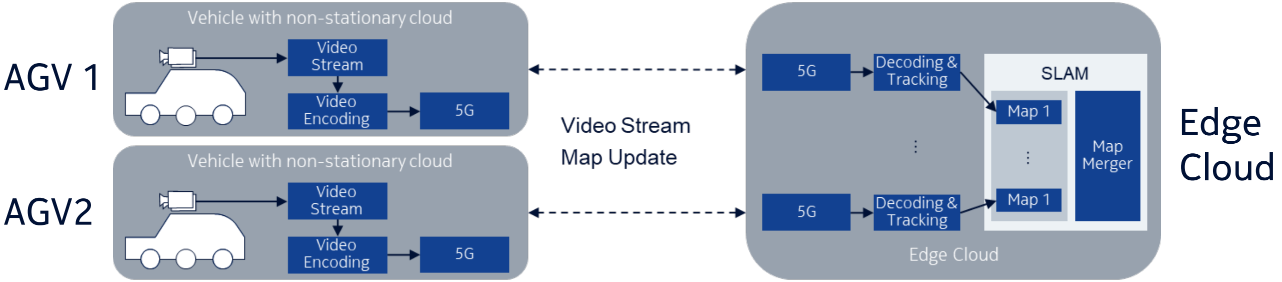
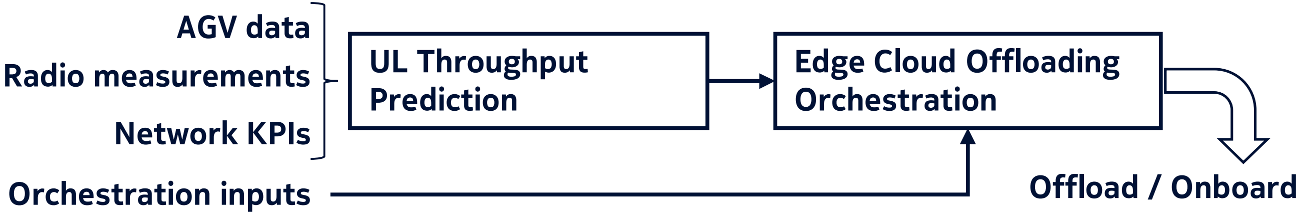
Example: QoS Prediction and Application Offloading

Optimization Problem & Solution

- Offload as much as possible, but only if network QoS is sufficient
  - Minimize the number of offloading operations; take the offloading delay into account



- Machine Learning Algorithm to predict the minimum achievable throughput (AGV → Edge Cloud) → pro-active offload decision considering the offloading delay



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Example: QoS Prediction and Application Offloading

Solution performance

AGV → Edge Cloud Throughput

SNR

Placement

State

Edge

AGV

OK

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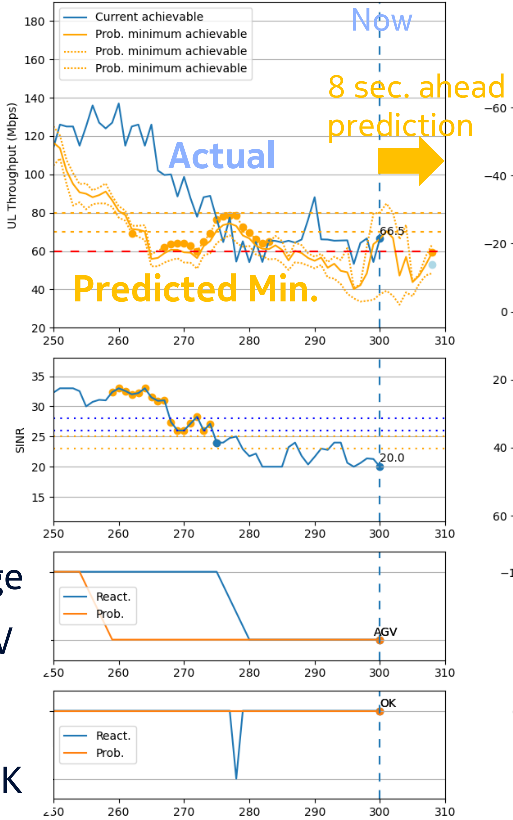
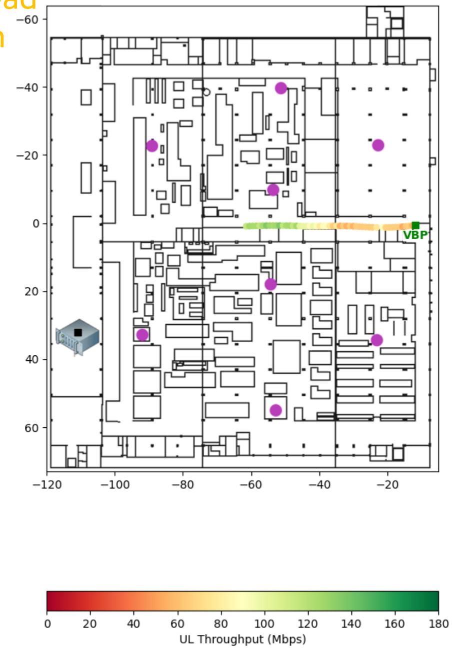
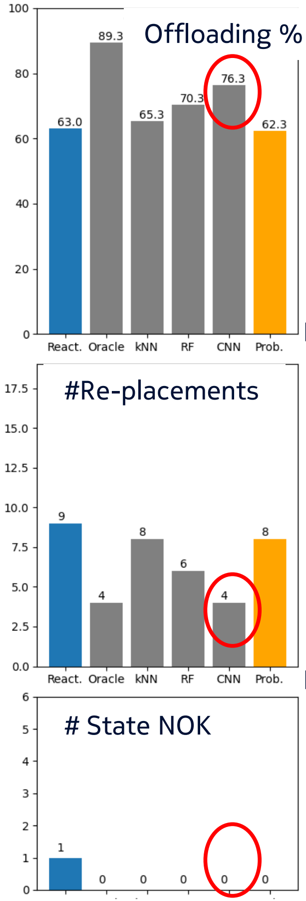


Factory floor





ML Algorithms

ML Algorithms

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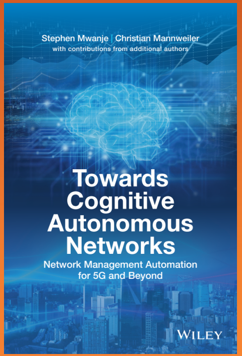
Native Network Intelligence: 5G-A baseline and 6G perspective

Takeaways

- “Native Network Intelligence”: Cognitive Autonomy with Native AI/ML system design
  - Machine-level understanding of system concepts and contexts to enable decision making
  - Across Radio / RAN / Core / Management / Security domains
    - Shift from “Network Management” to “Management of AI/ML”
    - Shift from enhancing individual network functions with AI/ML to re-designing them through AI/ML (“Native AI/ML”) and building AI/ML-enabled systems (“inter-AI/ML”, “AI/ML governance”)
- Challenges
  - Leveraging the (fast paced) AI/ML technology evolution for networks
  - Collaboration vs. IP protection along R&D and Ops lifecyles: datasets, models, …
  - Combination of AI/ML standards, network standards, open source initiatives, research communities, …

What is 6G? - Nokia Bell Labs (bell-labs.com)
Whitepaper "Technology Innovations for the 6G system"
Blog "The metaverse will never move beyond our living rooms without a powerful network"

S. Mwanje, C. Mannweiler (eds.), Towards Cognitive Autonomous Networks, Wiley



Cognition vs. Autonomy

Autonomy →

Cognition ↑

Cognition	Manual	Assisted	Partially automated	Automated	Partially autonomous	Autonomous
	Machine: None Human execution & supervision	Machine: assisted execution & supervision Human: partial execution	Machine: partial execution; Human: supervision via policy	Machine: execution; Human: supervision via policy	Machine: execution & partial supervision Human: policy & intent	Machine: execution & supervision; Human: intent-only
+ Anticipate correlated events	Human experience		+ Machine prediction	+ Machine automatic pro-action selection	+ Machine predi[illegible]ew	+ Machine reasoning
+ Anticipate individual events			+ Automatic pro-action		KICK PoC	
+ Context-ualize	Human diagnosis	Machine2human visualization	+ Machine profiling +Automatic re-act	+ Machine automatic re-action selection	[illegible] learning[illegible]new policies	+ Machine reasoning + General learning; +Trustworthiness
+ Diagnose events		Machine2human selective exposure	+ Machine mapping to causes (rules) +Automatic re-act	+ Human labelling of causes identified by machine	+ Model-free (Reinf- Learning) + Transfer learning	+ Machine explanation
+ Correlate events	Human correlation	Machine correlation	+Automatic re-action	(n.a. – due to limited - scalability of automation - feasibility of machine supervision in a system with low cognitive capability)		
Detect an event	Human detection	Machine detection	+Automatic re-action			

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