

Leveraging AI/ML for Full Stack Autonomous Operation of 5G and Beyond Networks

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IEEE Future Networks Initiative

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Laurel, Maryland, USA

Outline

- Future Networks Initiative AI/ML WG
- Introducing Full Stack 5G Network
- Journey Towards Full Stack Autonomous Operation
- Standards in Support of Full Stack Operation of 5G Networks
- AI/ML based 5G E2E Full Stack Management & Orchestration Framework
- Towards an Autonomous Full Stack Operation of 5G Networks
- Summary

Future Networks Initiative AI/ML WG

- Provide the Roadmap based on research and industry advancement to deliver the AI/ML vision beyond 5G
- Identify and define the taxonomy and state of AI (*sense, think, and act like a human*) and ML (*detection, classification, segmentation, predictions, and recommendations*)
- Survey existing frameworks that support AI/ML workloads for different domains and identify a reference architecture to compare emerging protocol stacks and infrastructure elements
- This is provided under IEEE International Network Generations Roadmap (INGR)



IEEE INGR Artificial Intelligence / Machine Learning (AI/ML) WG

- Roadmap Details – Refer to INGR WG chapter
- WG Participation – 5GRM-
AIML@ieee.org

International Network Generations Roadmap (INGR)

Future network technologies (5G, 6G, etc.) are expected to enable fundamentally new applications that will transform the way humanity lives, works, and engages with its environment. Be a part of this transformation today!

- The INGR is a semi-annual technical document highlighting network technology evolutions over 3-, 5- and 10-year horizons.
- Created by a group of 100+ international IEEE experts from industry, academia and prominent research labs, organized across 15 distinct working groups.
- Every 12-18 months, INGR will release a new multi-chapter document highlighting development needs, the challenges/roadblocks to achieving those needs, and potential solutions to those challenges.
- At least twice a year, INGR leadership will do outreach to industry and hold presentations highlighting the most crucial future technical roadblocks, to engage industry to solve or avoid those risks and roadblocks.
- **FREE with Future Networks membership – Join today!**



Contact us to
get involved!
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IEEE INGR Structure and Working Groups

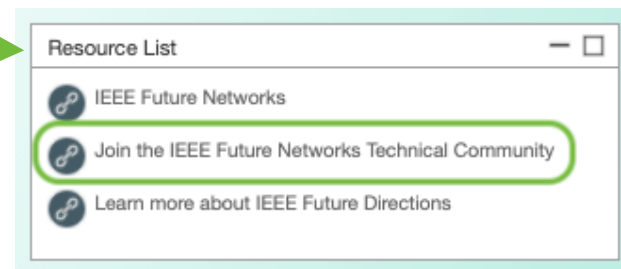
CATEGORY	DESCRIPTION	INGR WORKING GROUP CHAPTERS
Access	Describes how the users are able to reach the network	• Massive MIMO • mmWave and Signal Processing • Hardware • Energy Efficiency
Networks	Describes how the networks are interconnected	• Edge Automation Platform • Satellites • Optics
System and Standards	Describes system standards and testability	• Standardization Building Blocks • Testbed • Systems Optimization
Enablers and Users	Represents all the elements that enable deployment, assure functionality and security and address impact on society and environment	• Deployment • Applications and Services • Security and Privacy • Artificial Intelligence and Machine Learning (AI/ML) • Connecting the Unconnected (CTU)

- **E2E Orchestration & Automation**
- **Zero Touch Network & Service Management**
- **Network Slicing**
- **Network Digital Twins**
- **Security**
- **Network Reliability and Resiliency**
- **Dynamic Spectrum Access**
- **Distributed Cloud Computing**
- **Multi-access Edge Computing**

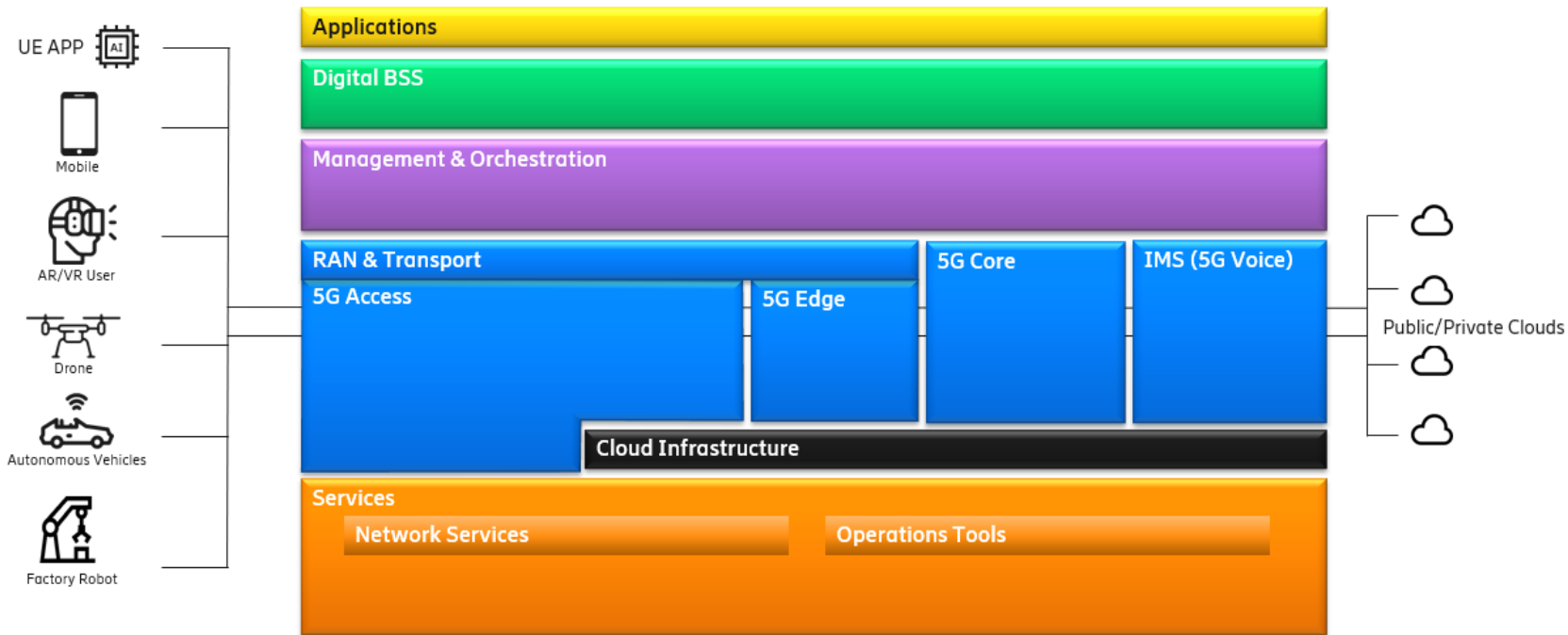
- **Consider application of AI/ML to all layers of network stack – Physical to Application Layer**
- **Identify and address range of options from monitoring, to learning, to actuation, while considering aspects of performance, security and reliability that run through all layers**
- **Cross-team collaboration with other FNI WGs for AI/ML augmentation**
- **Close gap for interpretability and trust and mitigate vulnerability and susceptibility to adversarial attacks**
- **Set priorities for future development** to include both technological advances and AI/ML developments that are being undertaken by other organizations (e.g., ETSI, 3GPP)
- **Develop an AI/ML based management and orchestration framework**
- **Define how open source and open architectures can be used and adopted** (e.g., O-RAN Alliance and Telecom Infra Project)
- **Demonstrate AI/ML 5G and Future Networks use cases**

Accessing INGR 2022 Chapters

1. Visit FutureNetworks.ieee.org/roadmap
 2. Sign in as an FNI member (IEEE account)
 3. Download all chapters
- Not a member of Future Networks?
 - Add it to your IEEE account
 - Membership is free for IEEE Society members
 - USD \$5 - \$15 annually for others
 - URL to join: bit.ly/fni-join



Introducing Full Stack 5G Network



Journey Towards Full Stack Autonomous Operation

1st phase - today



- Independent intelligence in parts of the network
- AI agents run on network functions for continuous operations optimization
- Developing capability for intent-based approach
- Large supervision needed
- Data availability and data infrastructure enabler for next phase

2nd phase – tomorrow



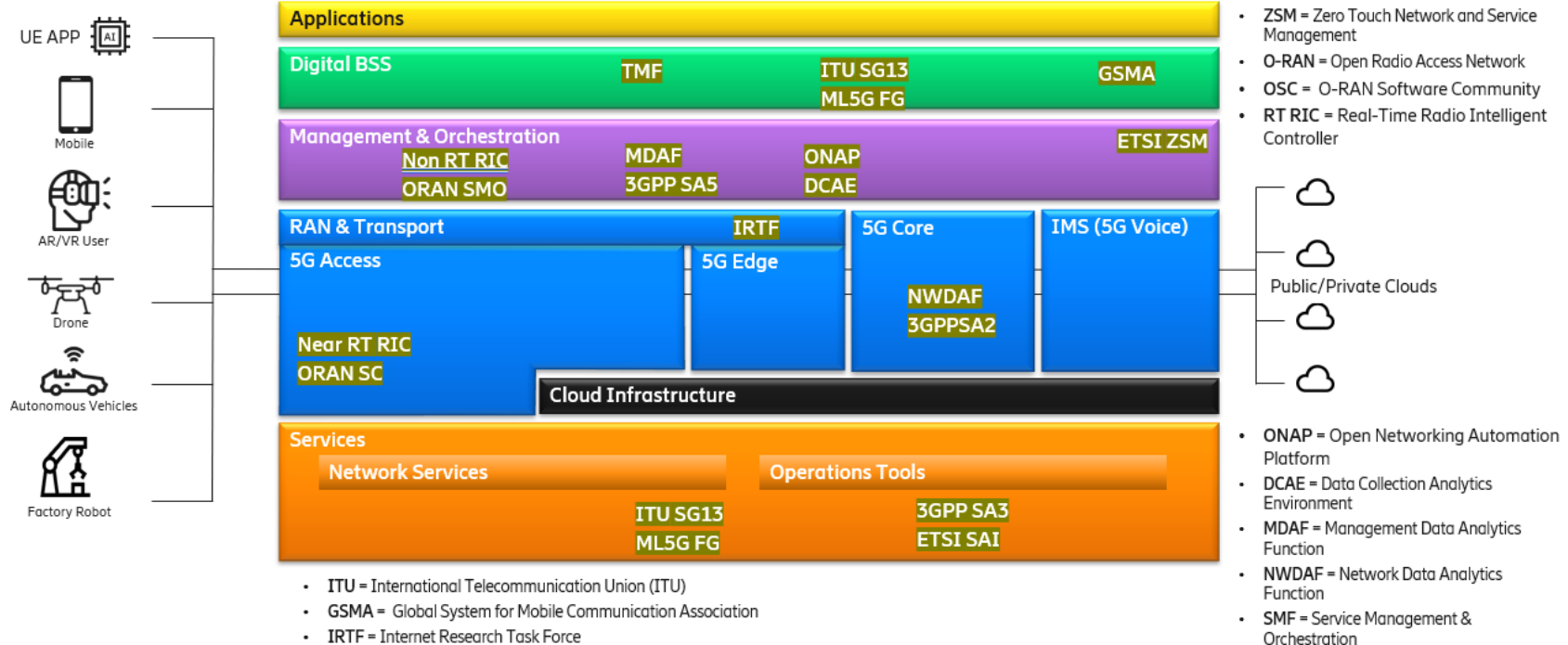
- Intelligence widely distributed in the network
- Most applications in mgmt. and business layers are intent-driven, allowing for automatic conflict resolution and predictive control
- Increased operation delegation and agile collaboration with human teams
- Advanced infrastructure with knowledge LCM

3rd phase – future

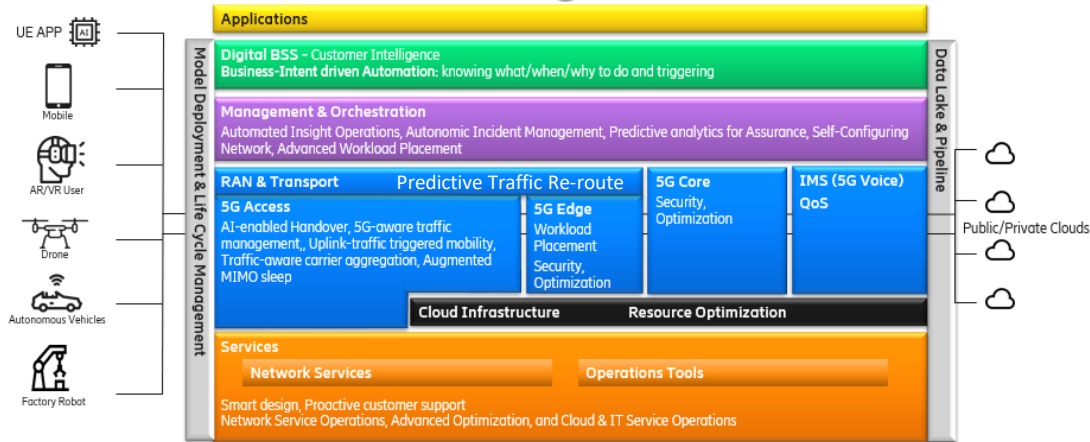


- All operations are intent driven
- Enabling fully autonomous, self-learning and trustworthy, intent-driven operations
- Network can run in zero-touch fashion and is widely robust and explainable
- Decision making can be done by the system, autonomous interference between closed loops
- Auto AI models, pipeline mgmt. & LCM

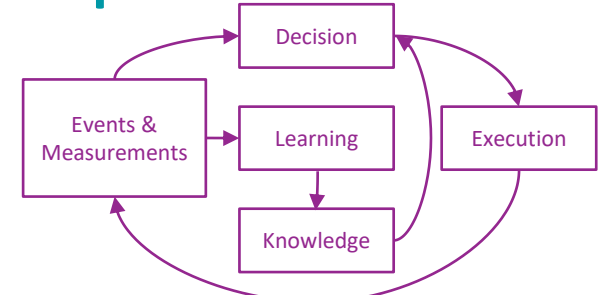
Standards in Support of Full Stack Operation of 5G Networks



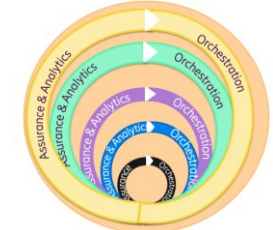
Leveraging AI/ML for Full Stack 5G Operation



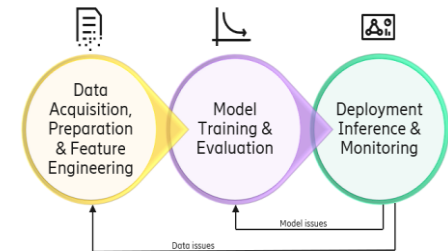
- Need for algorithms with high sample efficiency to deal with limited data sets and requirements for fast control loops – leverage Transfer Learning, Multi-task Learning, Meta Learning and Generative Adversarial Networks
- Federated Learning is a good fit for AI/ML at the Edge solving the issue of data privacy
- Reinforcement Learning from dynamic data (no data labeling required)
- Auto-ML for building, validating, iterating and exploring ML through an automated experience
- Robust Deep Learning to Adversarial Attacks
- Energy-Efficient Deep Machine Learning
- Quantum Machine Learning
- Time-Aware Machine Intelligence
- CPU -> GPU -> FPGA/TPU -> analog/neuromorphic/optical/quantum?



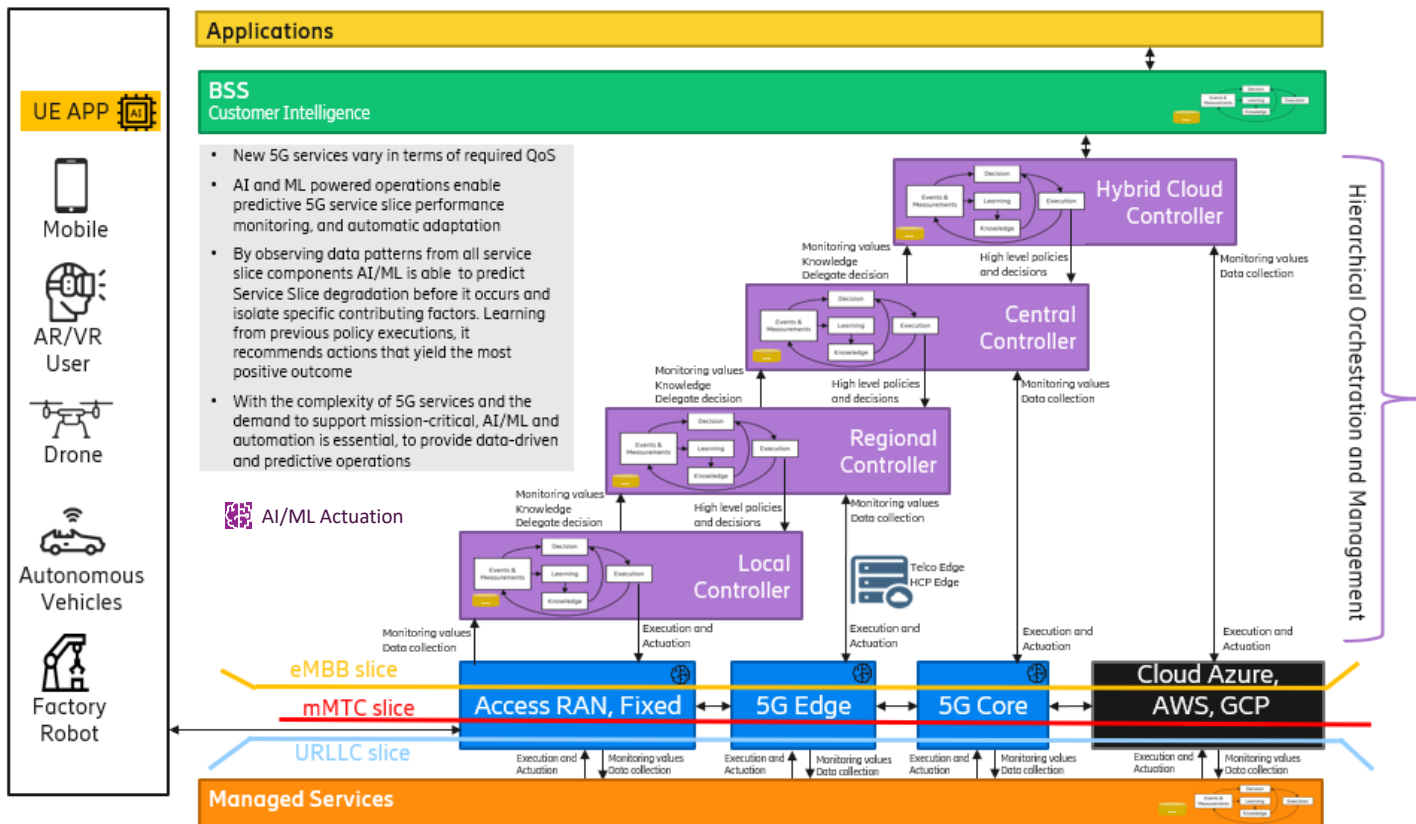
Leveraging AI and Machine Reasoning at all levels to drive closed-loop autonomy



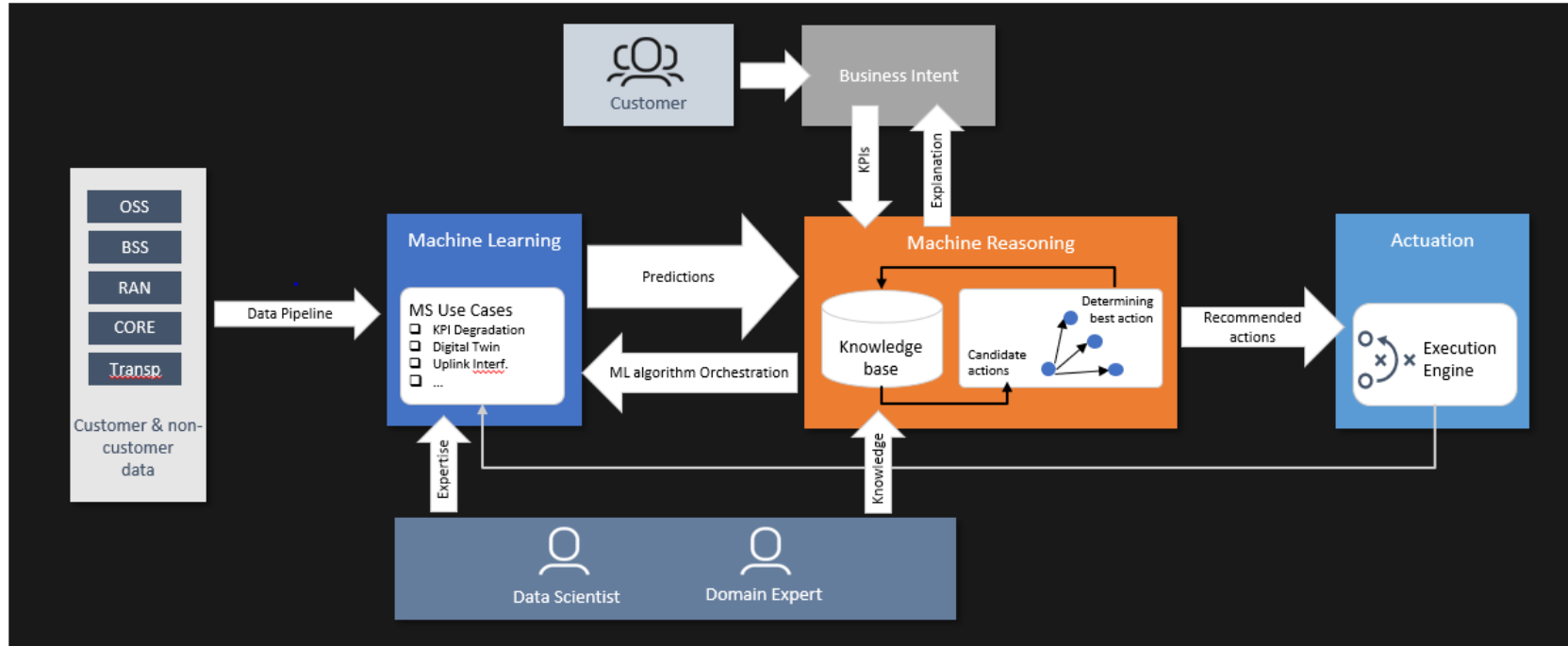
Multiple closed loops Operating in different timescales in Tandem



ITU-T Y.3172 has an example



With Machine Reasoning and Machine Learning working together, the vision of “Intent based networks” will soon become reality



Source: Ericsson Research

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Get involved!

Working Group Members

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If you would like to join the working group please send mail to:

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We look forward to active contributions from existing and new members

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