Introduction of nGRG (O-RAN ALLIANCE 6G Initiative)
&
Sustainable Advance edge infra for NextGen Services

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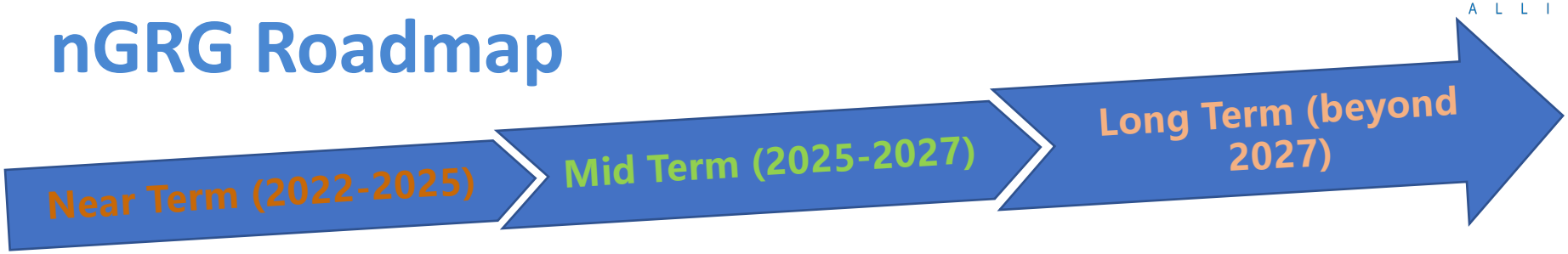
Co-Chairman, nGRG

O-RAN ALLIANCE OSAKA F2F Meeting
(07/24/2023)

nGRG Mission

Ambition	• Provide a forum to facilitate O-RAN related 6G research efforts and to publish research findings • Leverage industry and academic 6G research efforts and determine how O-RAN may evolve to support 6G and beyond, considering regional research efforts, ITU-R, and 3GPP development • Achieve O-RAN sustainability from 4G/5G to 6G and beyond • Consider the impact of 6G on O-RAN areas of interest and work with Industry Partners to unify the 6G technology path/timeline to avoid incompatibility b/w O-RAN and other SDOs
Operations	• Define the O-RAN nG research agenda and key priorities • Establish research streams based on defined research priorities, and solicit research items under corresponding research streams • Organize regular discussions and reviews of the progress/outcomes of research streams • Study interworking of O-RAN solutions across different technologies
Outcomes	• Publish white papers and research reports based on the outcomes of the studies in the Group • Recommend appropriate actions through white papers • Sponsor topical workshops, seminars, and summits with appropriate partners

nGRG Roadmap

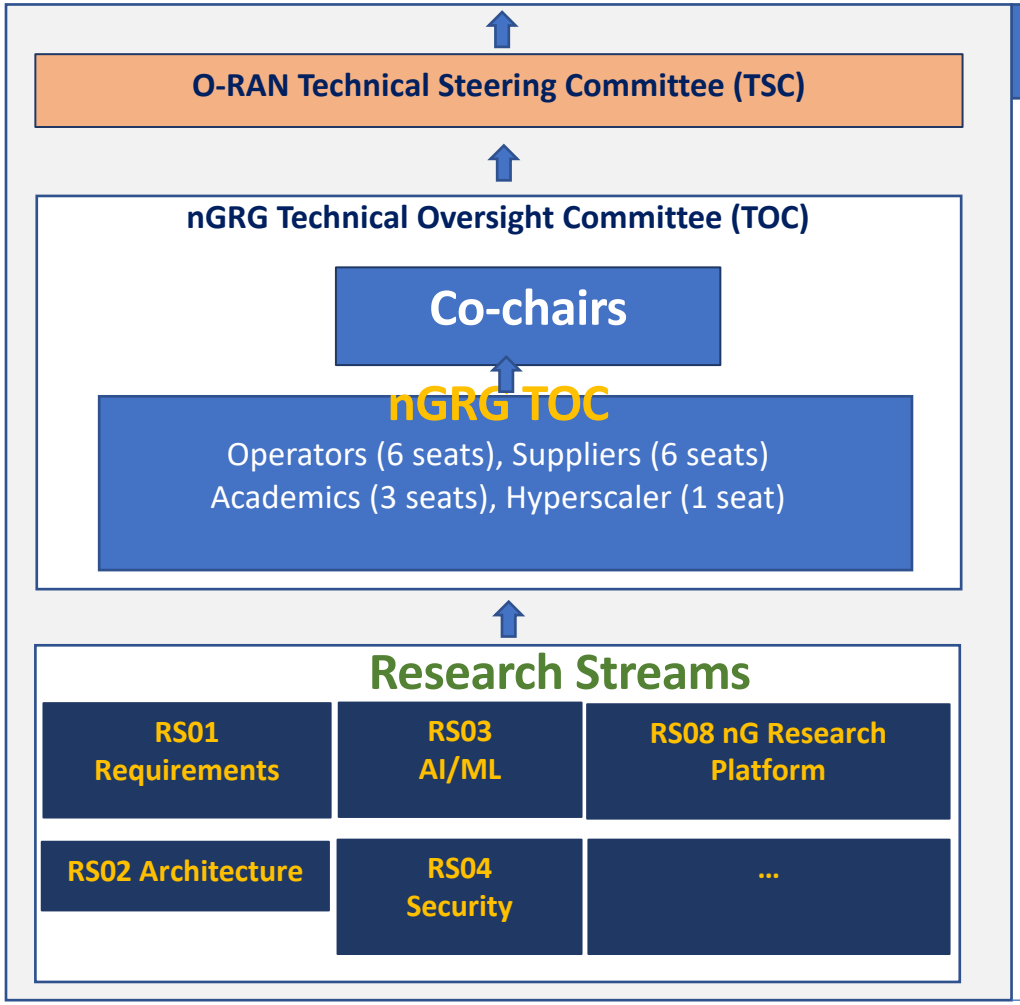


- **Near Term (2022-2025):** Align with Industry Partners and perform a high-level impact analysis of potential 6G technology trends and the ITU-R Vision for the next IMT on the O-RAN architecture and establish research items based on defined research priorities and the outputs include white papers and research reports.

- **Mid Term (2025-2027):** Based on the research findings, provide inputs to O-RAN WGs/FGs to prepare for O-RAN 6G standards studies and to coordinate O-RAN 6G collaborations with other SDOs.

- **Long Term (beyond 2027):** Align with other 6G research organizations, SDOs, and programs through liaisons via O-RAN SDFG and collaborate with O-RAN TIFG/IEEE/NSF etc. on potential 6G testbeds.

nGRG Structure



nGRG Technical Oversight Committee

AT&T, 中国移动 China Mobile, T-Mobile, 中国电信 China Telecom, vodafone, Jio, ERICSSON, NOKIA, DELL Technologies, Lenovo, NVIDIA, Microsoft, VTT

Academics

- **Prof. Vincent Poor**, Princeton University, USA
- **Prof. Khaled Ben Letaief**, Hongkong University of Science and Technology, China
- **Prof. Hans Schotten**, TU Kaiserslautern, Germany

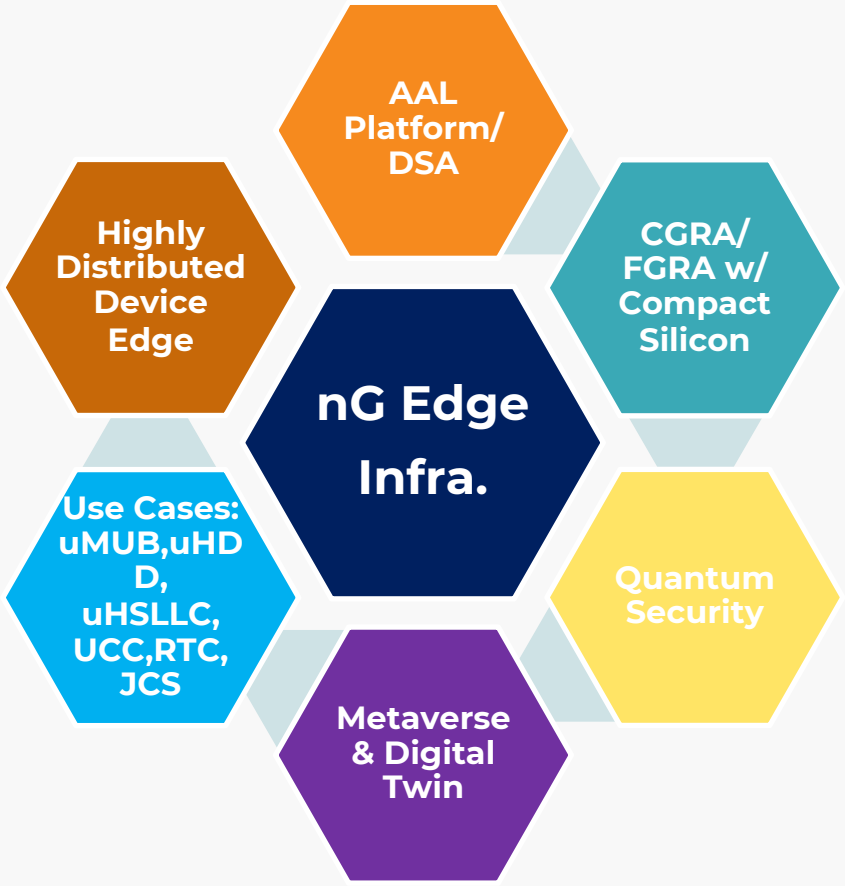
Ongoing Research Streams

	Research stream	Leader(s)	Status and planned activities
RS01	6G use cases and standard gap analysis	Jio, SK telecom, T-Mobile, Rakuten	Aim at exploring the area of 6G use cases and perform an analysis of the potential gaps in the O-RAN standards to enable them. The outcome of the work may take the form of research reports and/or white papers
RS02	Architecture towards 6G O-RAN	China Mobile, NOKIA, Qualcomm	Aim at exploring the area of network architecture and key architectural principles
RS03	Native AI and cross domain AI	China Telecom, Lenovo, Jio, VTT	Aims at research on how to support native AI and cross domain AI in 6G O-RAN
RS04	Native security	Jio, DELL, Qualcomm	Focus on the security landscape associated with nG work across the Telecom industry, academia, research institutions and industry alliances and its relevance to areas of interest of the O-RAN Alliance.
RS08	nG research platform	NOKIA, KEYSIGHT TECHNOLOGIES, VIAVI, AT&T, verizon	Explore requirements for the evaluation of nGRG concepts and influence the research platforms/testbed in industry and academia towards prioritized nGRG research areas aligned with O-RAN Alliance principles

The O-RAN ALLIANCE intends to provide seed funding up to an amount of $200,000 (plus applicable VAT) for research platforms that support research and development of next generation infrastructure, and invites proposals from academic and other research organizations for the development of such platforms.

NextGen Edge Infra: Key Technology Enablers

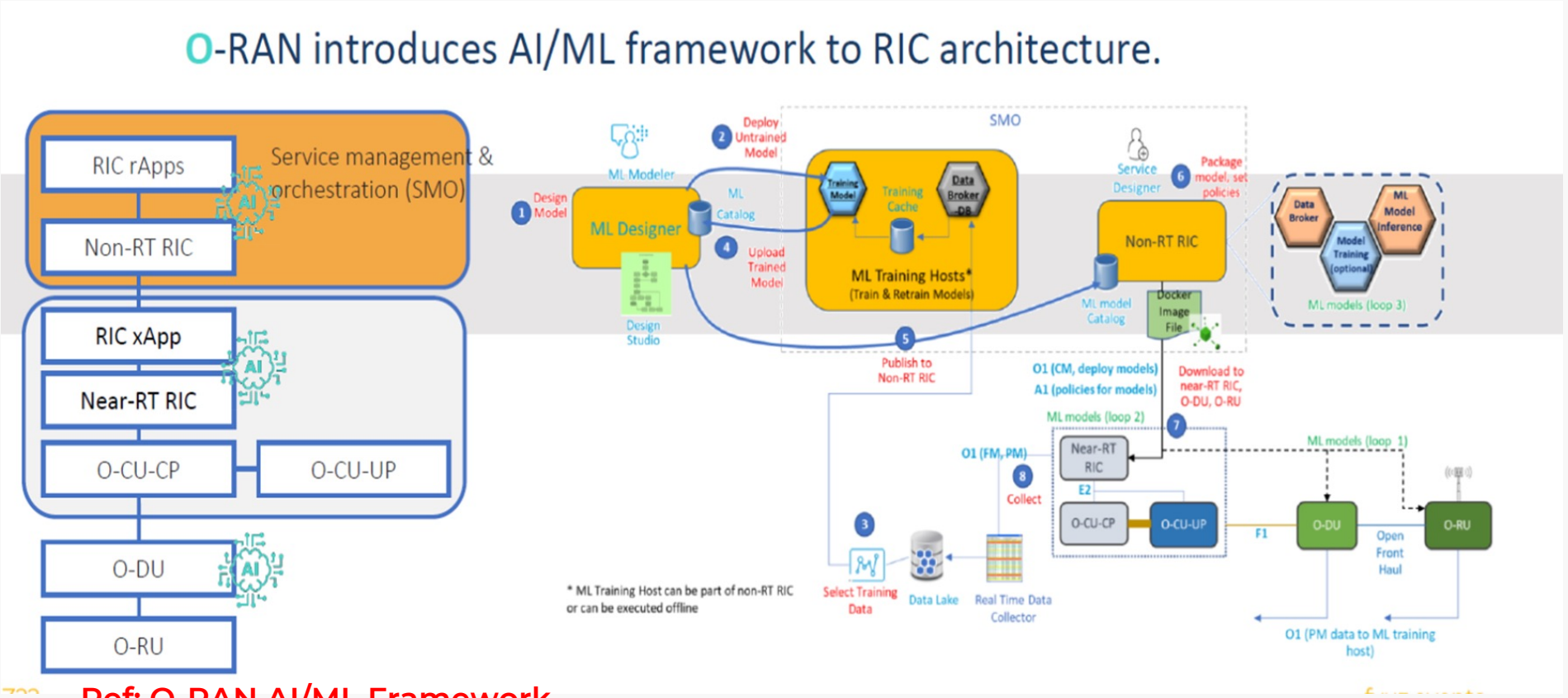
- As per an assessment by the ITU, the global mobile data traffic is expected to grow to 607 Exabytes (EBs) per month by 2025 and 5016 EB by 2030
- World is moving towards a Cyber Physical continuum.
- Due to the massive variation of Service slices , the basic DNA of NextGen Edge infrastructure is changing.
- Global Consensus is building towards a Sustainable and Environment-Aware Wireless Networks



uMUB: ubiquitous Mobile Ultra-Broadband
uHDD: ultra-High Data Density
uHSLLC: ultra-High Speed and Low-Latency Communications

UCC: Uplink Control Communication
JCS: Joint Communication and Sensing
CGRA: Coarse Grain Reconfigurable Architecture

AI infused 5G Edge : O-RAN Architecture



Ref: O-RAN AI/ML Framework.

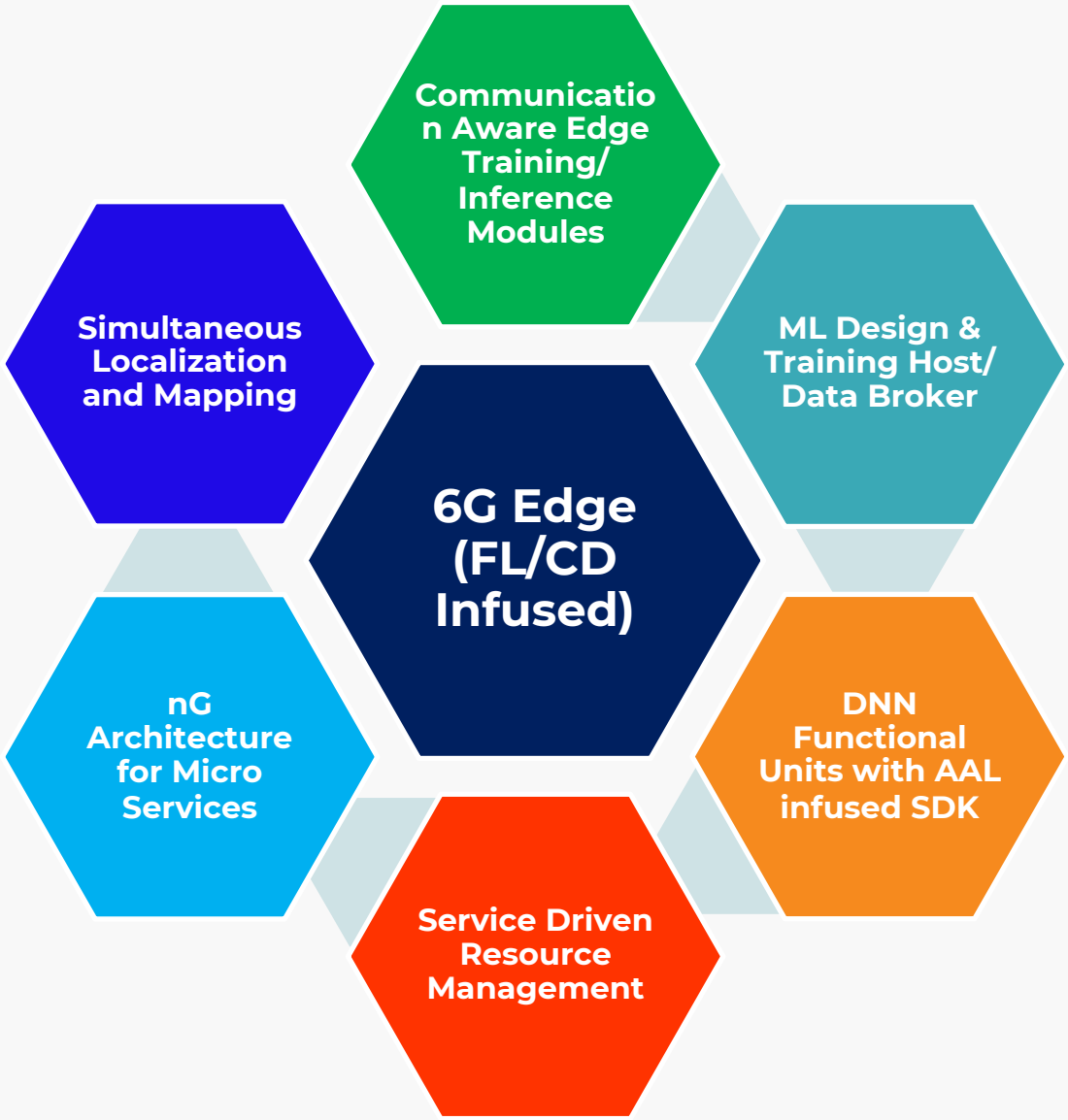
Note: AI infused nG Edge infra needs to extend the existing O-Cloud framework including IaaS, PaaS and SMO to O-Cloud 2.0 empowered with DNN Framework.

5G Adv/6G Features: 3GPP Rel 17 and Beyond

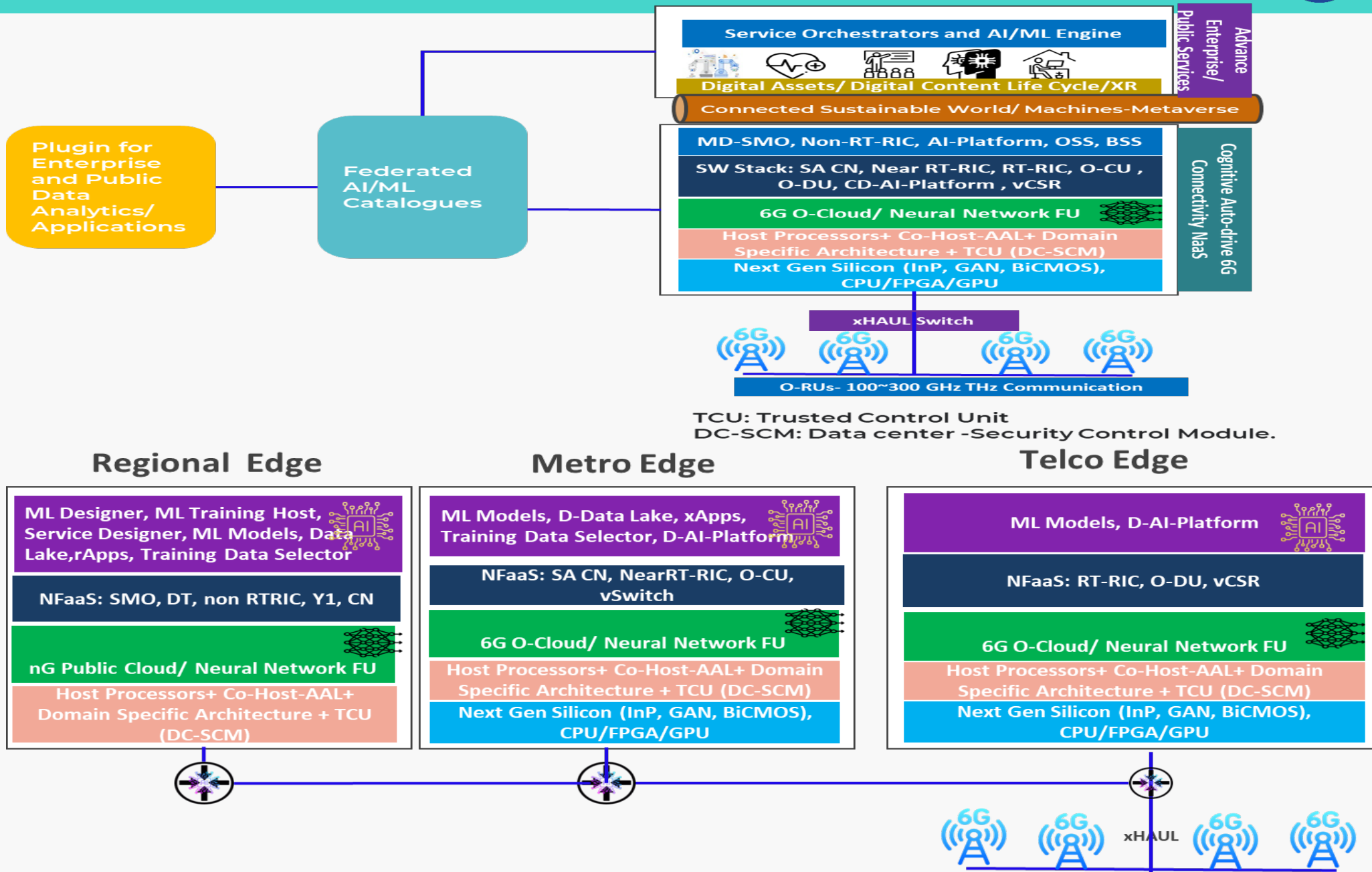
Features	
Multi- TRP (FR1/ FR2)	Intelligent Reconfigurable Surface (IRS)- Coverage and Capacity Expansion.
Enhanced Beam Control with mTRP	3D Coverage with TN, NTN and HAPS co-ordination.
THz communication: 100~300 GHz and Above 1 THz	Green Energy Communication (Including IoT)
Ultra Massive MiMo (2048 Antennas, 64 Transmission Layers, 512 TRXs)	AI Infused Control, User and Management planes.
Ultra Precision Positioning (<= 10 cm)	Visual Light Communication
ICS- Integrated Communication and Sensing	Simultaneous Localization and Mapping

Every upcoming feature listed here has a relevant requirement to design the nG Edge

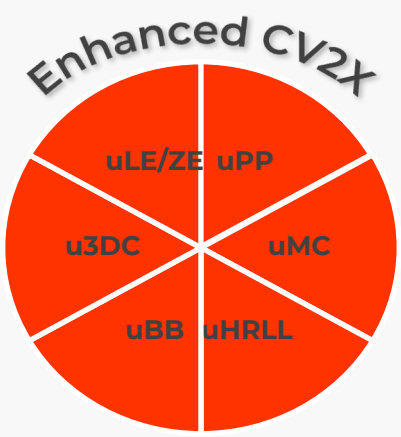
AI infused 6G Edge Platform

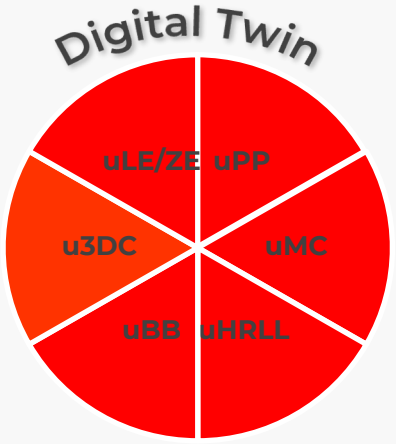


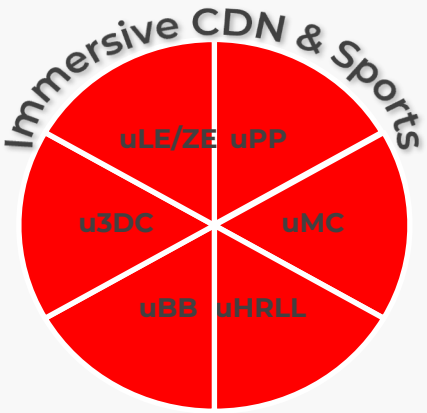
6G Network Overview: AI Framework

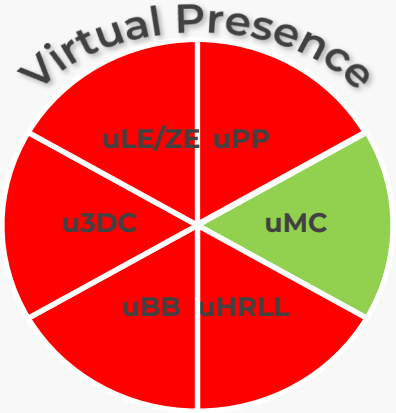


6G Use Cases and Edge infra-Evolution









Technology	Abbreviation	IaaS/AAL	PaaS	NFaaS-RU/DU	NFaaS-CU/NRT RIC	SMO-NonRT RIC	FL/AI
uLE/ ZE	Ultra Low Energy/ Zero Energy	√	√	√	√	√	√
uPP	Ultra Precision Positioning	√	√	√	√	√	√
uMC	Ultra Massive Connectivity	√	√	√	√	√	√
uHSLLC	Ultra High-Speed Lower Latency Communication	√	√	√	√	√	√
uBB	Ultra Broad Band	√	√	√	√	√	√
u3DC	Ultra 3D Communication	√	√	√	√	√	√

6G Edge : Major Challenges

O-RAN ALLIANCE Jio

Highly Distributed AI

- On-Device Edge AI (Distributed Device Inference)
- Telco and Metro Edge AI (Edge Device inference with Telco and Metro AI modules)
- Public Edge AI (Federated and Cross Domain AI)
- HW requirements for inference Management as one of the crucial need.

Joint Sensing and Communication

- Positioning, Recognition, Imaging and Reconstruction.
- Compute centric Semantic Communication
- Multi point sensing network co-ordination.

Network

- Deep infusion of information for nG Services.
- Cell Free massive MIMO, Visible Light Communication,
- Common infrastructure for TN, NTN and Space communication.
- Huge Baseband processing for Tera Hz communication.

Architecture

- Highly distributed architecture.
- Native Security and Native AI everywhere.
- Digital Twin a default for NW management/ Automation and Service enablement.
- Device Edge an evolving need for 6G

nG Edge Platform with AAL Architecture

- Highly distributed, DNN/ CNN FU enabled Edge Framework.
- The coarse grained reconfigurability to realization of heterogenous, dynamic, and elastic workloads, while the fine-grained reconfigurability will allow for ASIC like optimization for DSP/AI workloads.
- A single fabric should handle all computations, DSP kernels, AI-ML workloads in a dynamic real time elastic manner
- Performance: Massively Parallel.
- Software Controlled Hardware.
- Billion parallel threads
- High reliability, availability and adaptability
- Major Accelerator Types: Lookaside and Inline. Inline Acceleration has a better future due to heavy dependency of nG Applications on AAL Platforms

Edge Assisted RayTracing:6G Radio/Application

- Raytracing Technology evolved with high end gaming to generate light efficient images and graphics on a virtual screen by using graphics rendering techniques and methods that simulates the physical behavior of light.
- For 6G and 5G Advance, Ray Tracing is suitable for various use cases.

Massive MiMo Radio Channel Modeling with RIS

- nG HPC Edge infra maintains a balance between the speed and accuracy
- RIS based propagation models will make channel modeling more efficient for THz communication

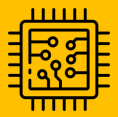
Location aware Communication and Gaming

- nG Edge provide HPC offloading to all high-capacity Gaming Devices which needs Location aware communication.
- Integration of Lidars abased communication is going to be an integral part of nG Edge (cV2X)

Accelerated Ray Tracing for High End Gaming

- Advance Accelerator platform - integral part of 6G Edge framework.
- Multi Modal SMO, NSSMF and tight integration of DL framework for Ray Tracing .

nG Edge Infra: Sustainability



HW Sustainability

- HW Driven AAL (CGRA/ DSA) platform
- Energy Efficient Massive MiMo and Beamforming Radios and Telco Server Framework with Dynamic Control.
- Multi Phase Immersion Cooling for Edge Servers

SW Sustainability

- AI/ML Driven Resource Management for 6G NaaS.
- Energy Efficient NW and Traffic Management SW Modules.
- Power efficient Slice management across Radio, Traffic and Core domains.

Open APIs and Standards

- Sustainable Open API for Telco Edge infra to build efficient Connectivity and Application experience.
- Energy efficient Distribution of Power among connectivity modules across all NFaaS modules (CU, DU, RU, Transport, Core)

nG Edge infra-Quantum Security

Great Risk

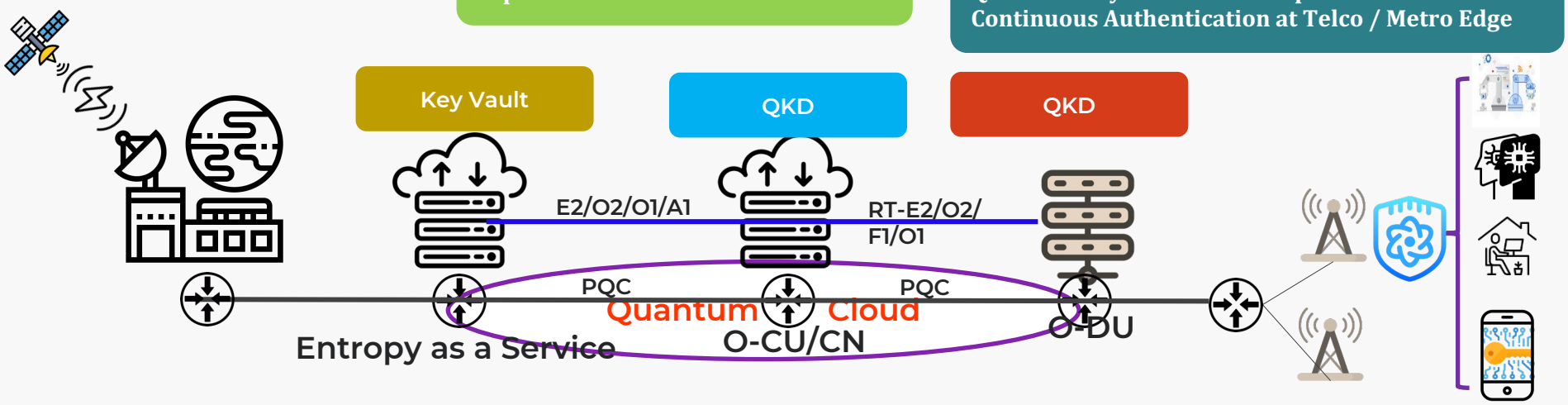
- Unprecedented breaches of privacy
- All prime factors encryption rendered useless.
- US National Security Agencies Deeply Concerned

Great Potential

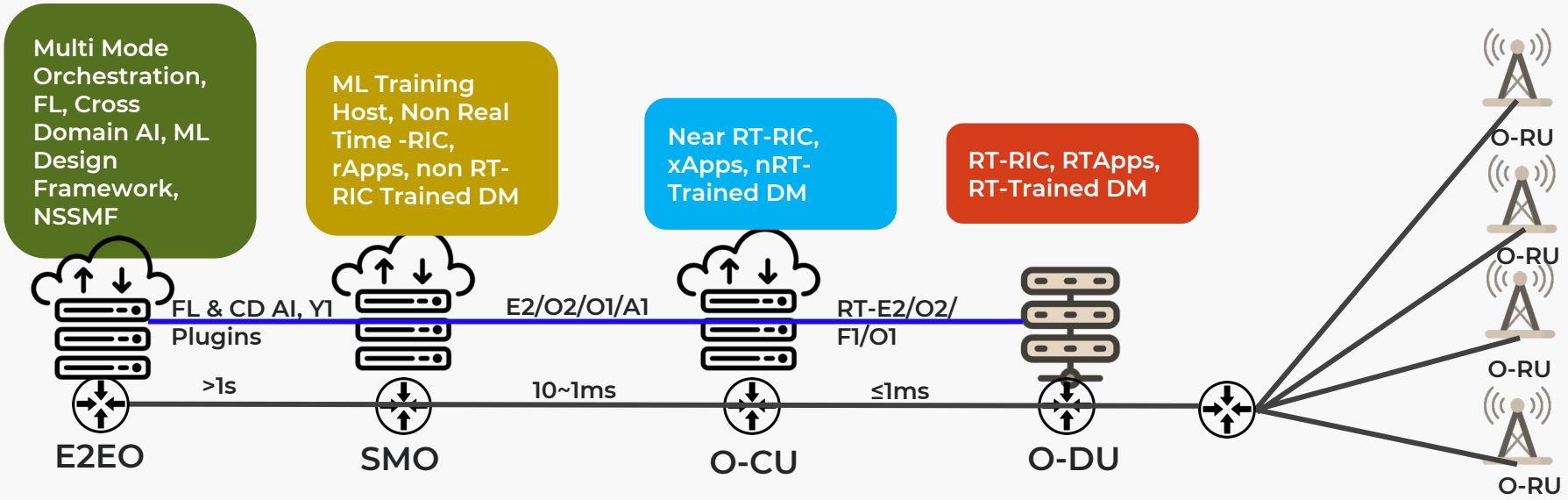
- Next Gen SASE (6G)
- Defense and Enterprise Infra Security
- Quantum Internet
- Quantum AI Powered space exploration

Major Challenges and Asks

- Quantum Cloud Compliance with HPC Fabric
- Secured Key Vault, Certificates, Tokens and Keys at Metro and Telco Edge
- Earth station enabled Regional Edge with Entropy aaS capabilities
- Quantum Key Distribution capabilities and Continuous Authentication at Telco / Metro Edge



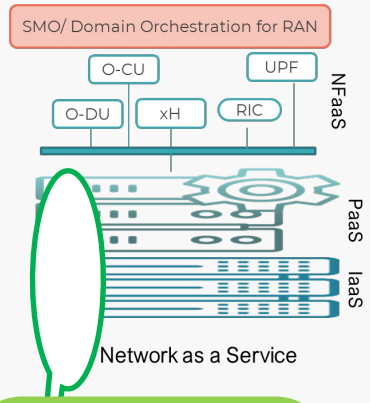
nG Edge infra-SMO & RIC Framework



- Standalone Core and Service based Architecture will be baseline for 6G. Support of Multi domain orchestration will be heavily needed due to the support of multiple services aligned to various types of slices supported by 6G NW.
- Addition of Real Time RIC framework- A Major Game Changer.
- Full support of AI driven Orchestration, since DNN FU (AIaaS) becomes the integral part of IaaS.
- To support connectivity and communication among multiple services and workload, smart integration of Network Service Mesh is required. Relevant changes to the SMO needed.
- Additional Modules and Interfaces for Cross Domain AI and Federated AI.
- Possibility of NSSMF integrated to Multi-Domain SMO
- Management aspects to support Dynamic Service Function Placement Based on DL.

Thanks

nG Edge infra-AAL, FGRA, CGRA, DSA



AAL-Abstraction and Acceleration Layer
FGRA-Fine Grain Reconfigurable Arch.
CGRA-Coarse Grain Reconfigurable Arch
DSA-Domani Specific Architecture

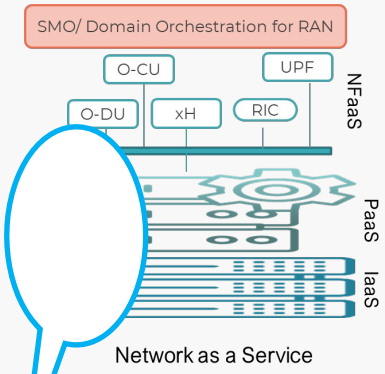
AAL-Next Generation Abstraction and Acceleration Layer compliant to O-RAN architecture will be the answer to relatively 10 to 1000 times higher bandwidth, high performance and energy efficient encoding and decoding (Channel Coding and FEC). Further design changes to support high performance 6G auto-drive connectivity is needed towards the AAL interfaces. Multimodal Semantic communication needs to be supported with a better designed AAL.

RA- Reconfigurable Architecture for silicon is the approach, where the performance of HW is perfectly aligned with the flexibility and modularity of the SW, a right step towards High Performance Compute. This approach also breaks some of the boundaries of ASIC, eASIC and GPP. Domain Specific Architecture is based on RA.

CGRA- Coarse Grain Reconfigurable Architecture is one of the two prongs of RA, where the number of components are fewer and larger. CGRA Subcomponents may contain several FGRA subcomponents. Surely it adds more design complexity and very effective to accommodate common services, which needs a dynamic scale. Here the sharing the cores are at a much higher level. CGRA is the future.

FGRA- Fine Grain Reconfigurable Architecture is another prong of RA, where the number of components are higher and smaller. FGRA subcomponents are also the major building blocks of CGRA components. Here the service distribution to these subcomponents are more granular and Threads are more aligned to the FGRA whereas processes are more communicating to CGRA. Design time and Run time customization is more flexible with FCGA

AI infused Edge infra-SLAM, AI TRX, DML & SRA



SLAM,AI Native- TRX

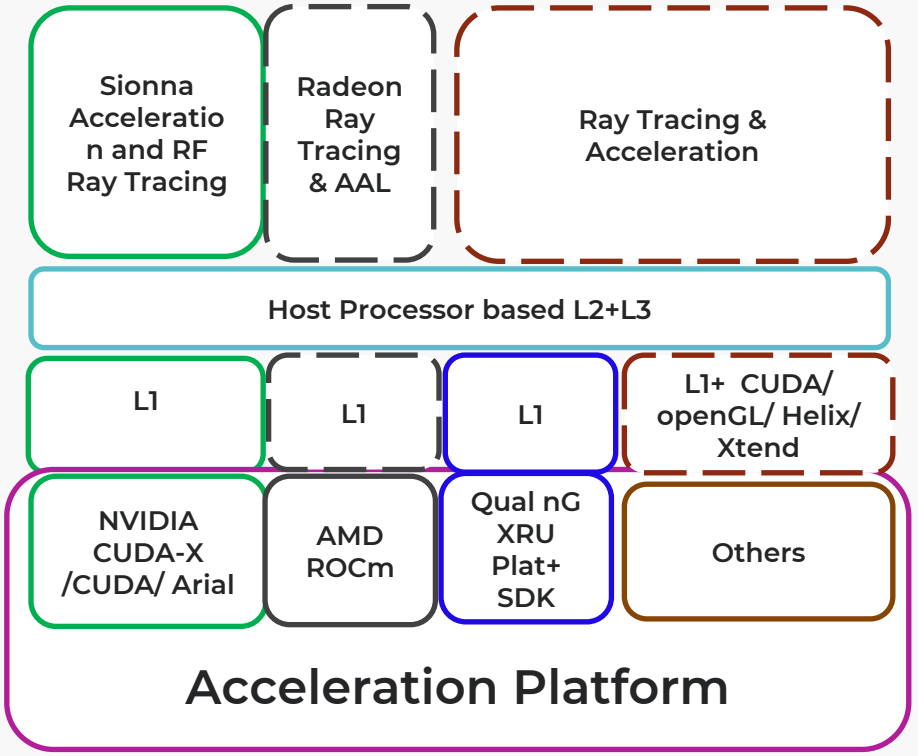
SLAM-Simultaneous Localization and Mapping is in huge demand for CV2X, Robotics, Gaming & Deep Learning based next generation use cases. Indoor SLAM will be heavily complemented by RIS (Reconfigurable Intelligent Surfaces). Additional support on cross domain optimization of RF Propagation path in synch with Dynamic RIS tuning. Edge needs to support Deep Neural Network capability in terms of Functional Units running at AAL or GPU based architecture.

AI TRX- AI Native Transceivers at Distributed 6G Edge is a must to support AI native semantic communication. Communication efficient training algorithms are also in huge demand for the DNN enabled Edge.

DML- Decentralized ML support is another area, which is being used in multiple flavors .

SRA- Smart Resource allocation to AI infused Edge network is another field to manage the resources in terms of Precision/ accuracy, latency, security and Energy efficiency for specific Service Slice.

nG Edge: HPC and ML Platforms



HPC ML Libraries and Tools
Parallel Algorithm Library
Math Libraries
Deep Learning Libraries
Communication Libraries
Partner Libraries (3rd Party Compliance Libraries)

Note: Compare to CPU Architecture GPU has many folds more ALUs (Arithmetic Logic Units- In thousands) with Common Cash and Control, with multi-Grid arrangements of ALUs.
Ref: NVIDIA,AMD & Qualcomm Public information.

nG Edge infra-Massive IoT Network

- Next Generation of Technologies and their Convergence to a flexi platform with Multi Modal SMO, Dynamic support of Network Slicing (NaaS) is heavily complemented by the Hyper framework of IoT enabled Automation.
- 6G-enabled HPC platforms become a de facto framework of Massive IoT catering Space-Air-Ground-Underwater Networks.
- Introduction and Development of Wireless brain-computer interfaces further complicates the IoT platform distribution and need of a robust Edge infrastructure.
- Expected Device Density for 6G is estimated as 10 million devices per SQ KM which is 10 times higher than 5G and 100 times higher than 4G.

IOT

- Industrial IoT (4.0 & 5.0)
- Vehicular IoT (CV2X)
- Health Care IoT
- Mobile IoT
- UAV IoT Framework
- Haptic IoT Framework