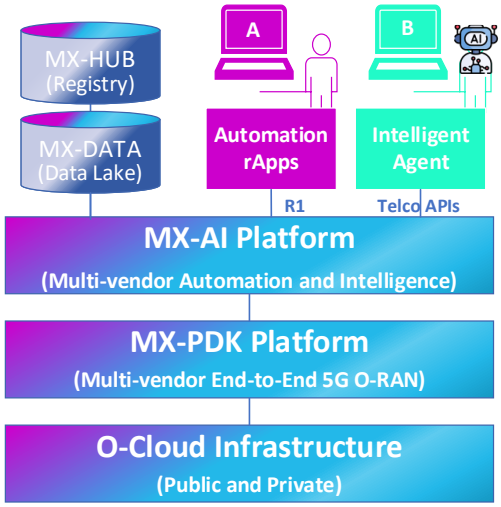
1 General Description and Features

The multi-x[1] platform development kit (MX-PDK) and Automation and Intelligent Platform (MX-AI) are an integrated HW-SW platform running on the top of CPU-GPU computing architecture, offering a turnkey 5G/6G network infrastructure featuring cloud-native O-RAN stack and telco specialized agents facilitating network operations and control. MX-PDK is interoperable with most types of 5G user equipment and devices. It supports Open Source 5G stacks (OpenAirInterface, SRSRAN, and Open5GS), and industrial-grade 5G stacks (Amarisoft and LITEON).



MX-PDK and MX-AI feature joint 3GPP and O-RAN Network slicing, Data-lake and observability stack, and open ecosystem of xApps/rApps/Agents with feature rich development kits.

1.1 MX-PDK Software Components

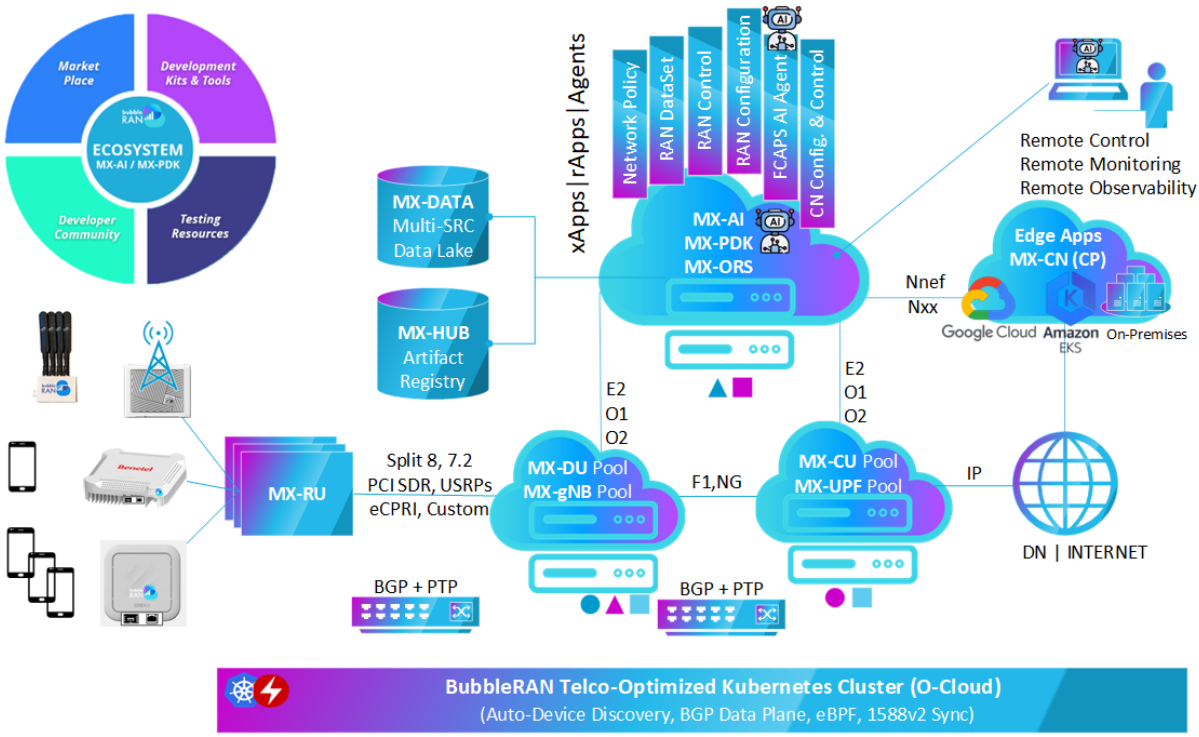
Figure below illustrates software components by means of a sample deployment model allowing you to operate and automate a high-performance, reliable, and secure 4G/5G O-RAN infrastructure at scale that is simple to use, customize and extend.

- **O-Cloud:** Telco-Optimized Kubernetes Cluster featuring synchronization, auto-device discovery, optimized data plane, and eBPF observability;
- **Multi-x 4G/5G Stack:** 5GC, IMS, and eNodeB, gNodeB, CU, DU in Non-standalone mode (NSA) and Standalone mode (SA) deployments in frequency range FR1 and FR2;
- **Multi-x O-RAN Stack:** SMO/OAM, Non-RT-RIC, Near-RT RIC, xApps, and rApps;
- **Multi-x Data:** Multi-source data lake and observability stack with metrics, stats, logs, traces from infrastructure, 5G network, 5G Terminal;
- **Multi-x Hub:** Artifact registry of reusable images, packages, and blueprints.
- **Multi-x AI stack:** Multi-agent Automation and Intelligence powered by GenAL/LLM with a set of specialized agents.

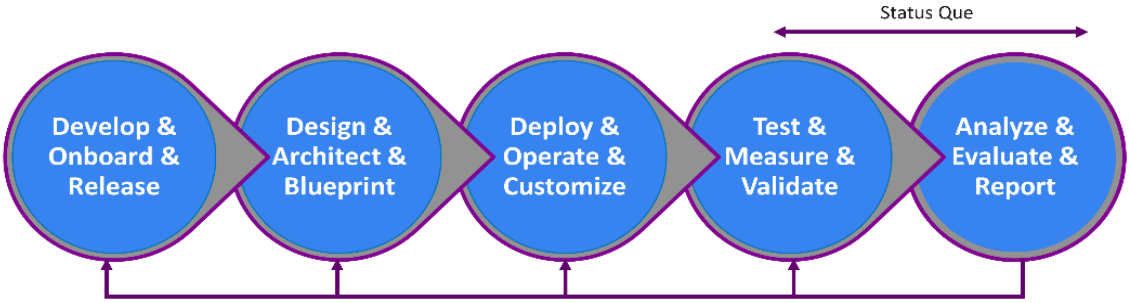
BubbleRAN MX-PDK is designed for R&D, PoC/MVP, and Test and Validation showcasing divers use-cases and business applications with guaranteed performance and reliability with the target TRL from 4 to 7. It also provides a built-in Open RAN studio (ORS)[2], ideal for learning and education and compliant with 3GPP and O-RAN specifications, allowing to develop, integrate, and test an end-to-end 5G/6G O-RAN with xApps/rApps/agents with the final user equipment in the loop.

[1] *What are the dimensions of Multi-X ?* Multi-vendor, Multi-version, Multi-RAT, Multi-Frequency, Multi-RF, Multi-cloud, Multi-OS, Multi-deployment.

[2] https://bubbleran.com/products/mx-ors/



The SMO/OAM comes with a set of user interfaces, including CLI, APIs, and GUI that facilitates the operation of the MX-PDK and MX-AI. As shown in the figure, users are able to (1) develop and deploy Apps/Agent and customize and extend the network, (2) design, mix-and-match, and deploy different vendors to create multiple networks, (3) perform full lifecycle operations from "Day 0 to Day 2" on an end-to-end 3GPP and O-RAN compliant network with user and application in the loop, and (4) collect user and network data, analyze and evaluate the results.



1.2 MX-PDK Hardware Components

The MX-PDK hardware platform is optional to allow customers to reuse their existing hardware and radio equipment to build and extend their multi-x 5G/6G O-RAN infrastructure.

- **O-Cloud:** high-performance compute nodes and PTP time-aware switching fabric and Grande-Master (GM) optionally with hardware accelerators, under Ubuntu

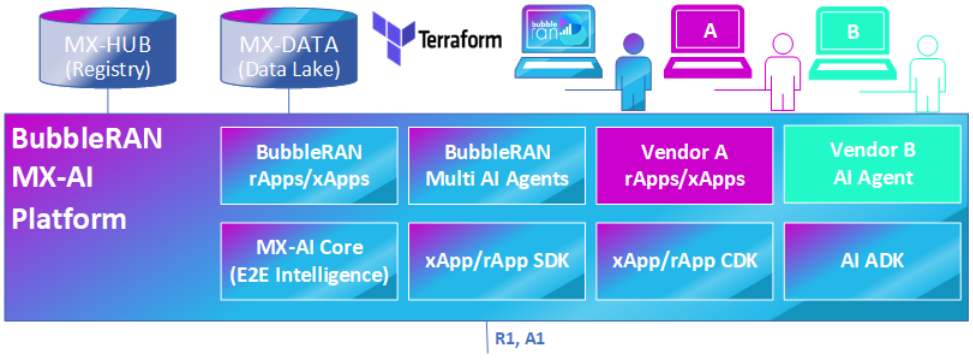
distribution (RHEL Possible). It is recommended to have at least three machines with intel-based or AMD-based;[3]

- **Radio Unit:** O-RAN 7.2 RU, eCPRI split 8 RRH, and SDRs;
- **5G Device:** Quectel Modem, SIM cards, and accessories;

2 MX-AI Software Stack

The software stack and components of MX-AI is shown below and includes:

- **MX-AI CORE:** an extendable and customizable Multi-Agent environment with task-specialized agents to facilitate network operations.
- **rApps/xApps:** xApps and rApps directory with their SDKs showcasing the O-RAN service models and use-cases.
- **AI ADK:** Specialized Telco Agent directory and AI Agent Development Kit (ADK).
- **UI:** A simple and intuitive GUI for easy interaction with the system.

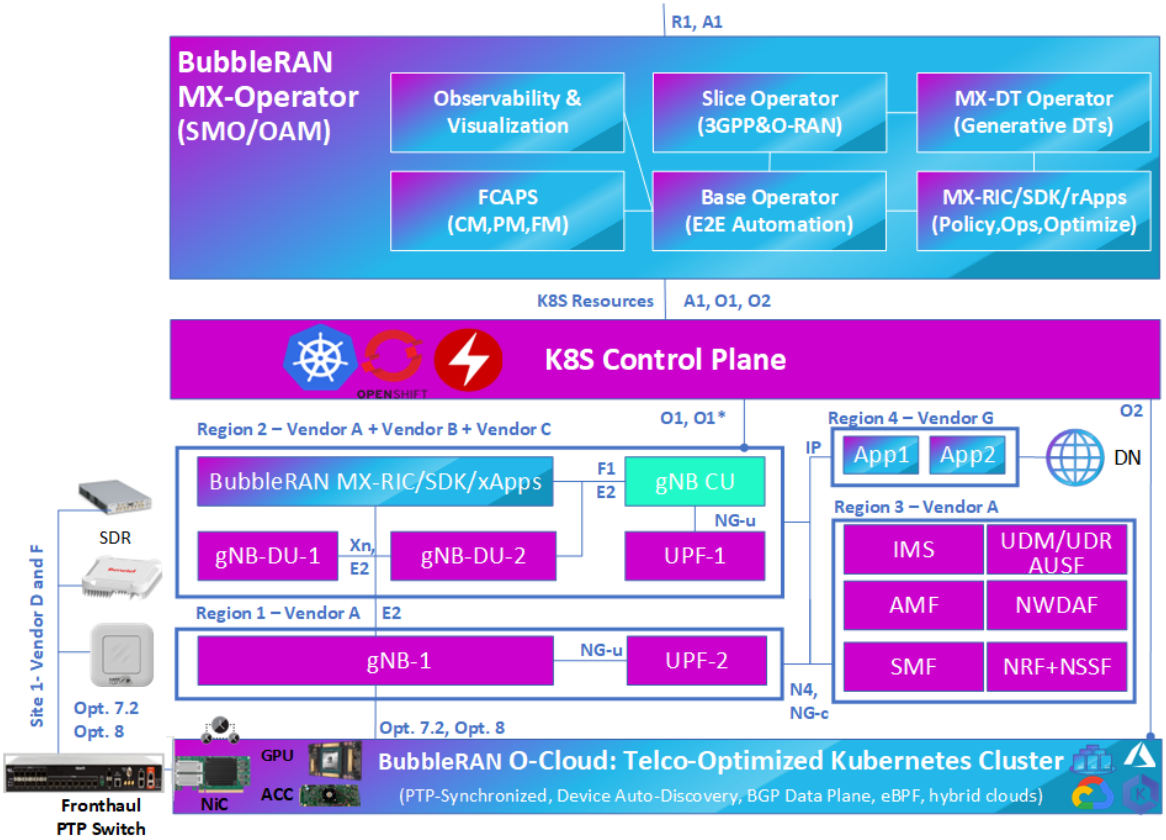


3 MX-PDK Software Stack

The software stack and components of MX-PDK is shown below. It includes multi-vendor 3GPP and O-RAN compliant software stacks running on the top of the same Multi-x hardware platform.

[3] Typical Min Spec: Ryzen/Epyc/i9/Xeon, AVX512 SIMD instructions, >3.7GHz/16C, 64RAM, SSD, **NIC:** 10Gbps (Intel E810-xxvda2), **Form Factor:** Tower or rack, **Cooling:** Fan or liquid cooling

- **3GPP MX-RAN**:
  - **Amarisoft:** 4G eNB, 5G gNB in FR1 and FR2
  - **OAI:** 5G gNB/CU/DU for FR1; 5G soft UEs.
  - **srsRAN:** 4G eNB; 5G gNB.
- **3GPP MX-CN:**
  - **Amarisoft:** 5GC; SA, and EPC for NSA
  - **OAI:** 5GC;
  - **Open5GS:** 4GC/5GC;
- **MX-HUB:** Artifact Registry serving archives, packages, images, models, Operator bundles, and configurations;
- **O-RAN O-Cloud:** optimized Kubernetes-based 4G/5G cloud infrastructure featuring synchronization, auto-device discovery, optimized data plane, and eBPF.
- **O-RAN SMO/OAM:** Cloud-native intelligence, full Life-cycle management and automation, observability stack and Multi-source data lake (MX-DATA), on-premises and public cloud deployment.
- **O-RAN MX-RIC:** near-RT-RIC and Non-RT-RIC supporting OAI, srsRAN, Amarisoft, and Lite-On. It includes the following O-RAN compliant service models with E2AP V2/v3 and A1AP v1: KPM (v2/v3), RAN control (RC v1.03), Cell configuration and Control (CCC v3.0), as well as BubbleRAN custom E2SM Monitoring, Sensing, and Slicing.
- **O-RAN xApps/rApps:** reusable and extensible of xApps and rApps directory showcasing the O-RAN and BubbleRAN service models.
- **Tool box:** realtime E2E performance measurement, logging, and tracing tools, CLI, API, and dashboard to instrument the network



4 3GPP MX-RAN (Major Highlight)

Features	Value
3GPP Release	Amarisoft: Release 17 OAI: Release 16 srsRAN: Release 16
Frequency Bands	All TDD bands in FR1
Bandwidth	Up to 100MHz
MIMO	2x2 and 4x4
Subcarrier Spacing	Data and SSB subcarrier spacing: 15,30, 60, and 120 KHz
Modulation and Coding Scheme	Up to 1024QAM in DL and 256QAM in UL
Number of UEs	16-1000
Handover	Amarisoft: NG interface (NGAP and GTP-U), XnAP, O-RAN RC
Supported Modes	SA
Deployment Scenario	Monolithic (gNB), Disaggregated (CU, DU)
Use case	eMBB, uRLLC, O-RAN
Network Interfaces	NG interface (NGAP and GTP-U), Xn, E2, F1, E1 (OAI)

5 3GPP MX-CN (Major Highlight)

Features	Value
3GPP Release	Amarisoft: Release 17 OAI : Release 16 Open5GS: Release 16 `
Network elements	AMF, SMF, AUSF, UDM, UPF, NRF, NSSF
AS integrity and encryption	Snow3G and AES
IP version	IPv4, IPv6
QoS	Configurable QFI
PDU Session	Multi PDU sessions support – Ipv4
Slicing	Multiple Slice (shared or dedicated NF)
Network Interface	NG, N2, N3, N4, N8, N10, N11, N12,N13

6 O-RAN MX-RIC

Features	Value
Multi-Vendor	Yes (OpenAirInterface, srsRAN, Amarisoft, LITEON)
NearRT RIC	Yes
Non-RT RIC	Yes
Service Models	O-RAN Key Performance Measurement (KPM V2.0/V3.0) O-RAN RAN Control (RC v1.3x) O-RAN Cell Configuration and Control (CCC v3.01) BubbleRAN Custom Service Models (ISAC, RAN slicing, statistics capture from MAC, RLC, PDCP, GTP sublayers)
xApps[4]	Data collections, performance monitoring, RAN stats, RAN slicing, RAN reconfiguration, load balancing. Handover, BWP reconfiguration
rApp	FlexMon, FlexPolicy rApp SDK
xApp Language	C, C++, Python. xApp SDK
E2	Yes, V3
A1	Partially
O1	Yes (supported for Lite-ON All-in-On gNB)

[4] https://github.com/bubbleran/xapp_sdk & https://bubbleran.com/docs/user-guide

7 O-RAN SMO/OAM (MX-Operator)

Features	Value
Level 1 life cycle operation	Resource detection/discovery (day 0), deploy (day 1), test (day 2)
Level 2 life cycle operation	Release and upgrade (day 2)
Level 3 life cycle operation	Full lifecycle control, including provisioning (day 0), configuration (day 1), and reconfiguration (day 2)
Level 4 life cycle operation	Observability stack, log processing, metrics, and alarms
Security	Isolation, Signed Artifacts, Unprivileged, Rootless, Access Control, RBAC
User Interface	API and CLI, GUI, and Dashboard.
Image registry	MX-HUB (hub.bubbleran.com)
Networking	Cilium, Multus. Optional: Calico.
Storage	Host storage, Rook and Ceph
CI/CD	Artifact generation, integration, validation, security.
Infrastructure	K8s distribution on Kubeadm. Optional: MicroK8s.
Container runtime	Docker and Snap Optional: Containerd, Podman.

7.1 Salient Features

- Full Day-0, Day-1, Day-2 Operations
- Slice definition, assignment, and scaling
- Multiple interfaces support for the RAN and CN
- Full scheduling control on the container placement
- DNS scoping and Edge services
- High scalability with minimum deployment time (E2E less than a minute)
- Reconfiguration and full-stack observability
- Very low overhead and high-performance containers
- Full customization and extensibility for both the Manager and Operators
- Fully cloud-native with non-privileged containers supporting both private (on-premise) and public cloud providers
- Automatic device discovery and mapping for GPUs, SDRs, RRHs, etc.
- Network terminal management
- Application in the loop [definition of the application for the terminals]
- Idempotent and declarative logic design

8 Sample Cloud-Native 5G/6G O-RAN Infrastructure

Figure below shows two samples of MX-PDK highlighting both hardware and software components, as described above.