Hexa-X-II

Foundations on 6G Smart Network Management and Orchestration Enablers.

6G series workshop by Hexa-X-II
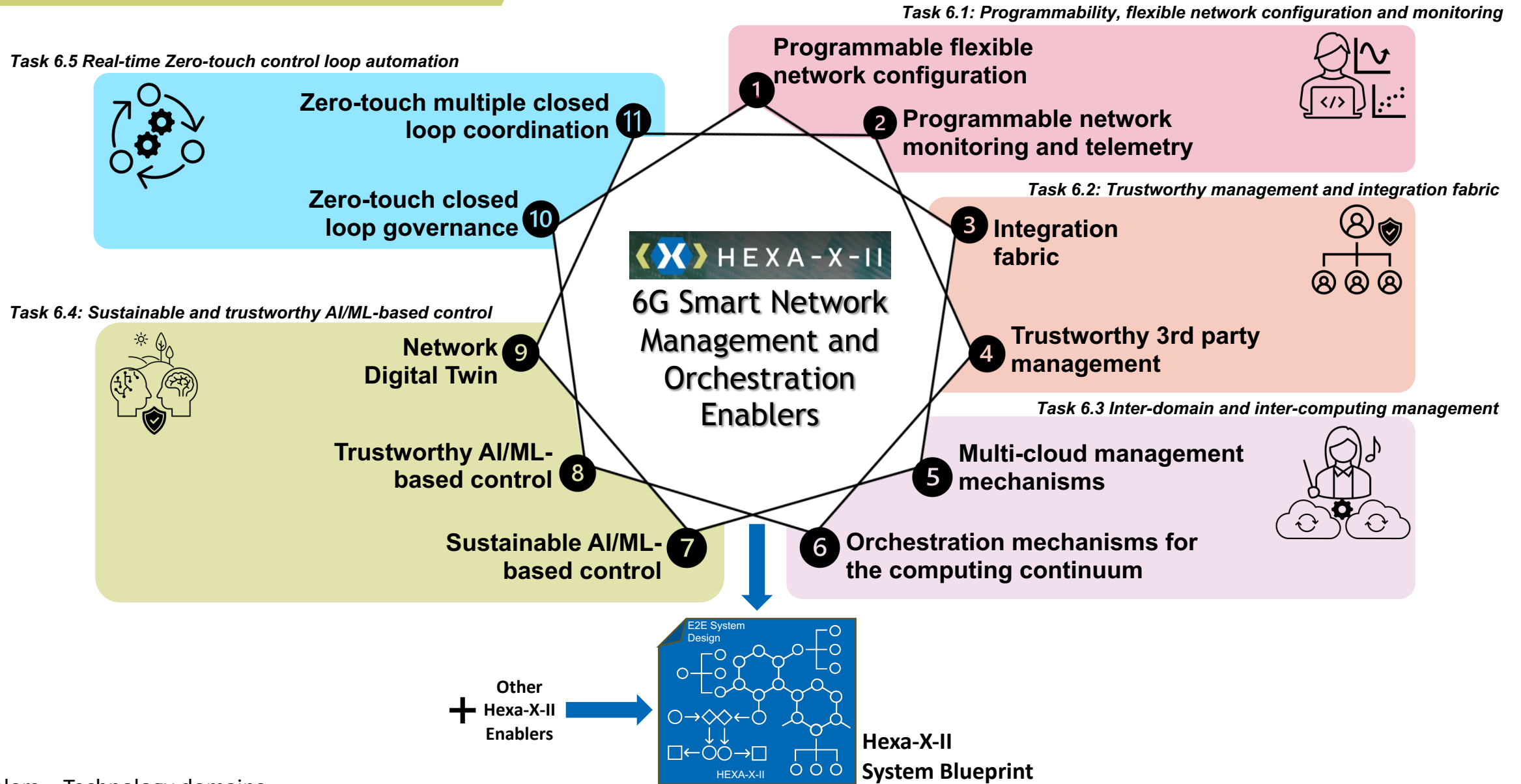
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hexa-x-ii.eu

Slides: Giada Landi (Nextworks)

Hexa-X-II Smart Network M&O Enablers

Task 6.1: Programmability, flexible network configuration and monitoring

Task 6.5 Real-time Zero-touch control loop automation

Task 6.2: Trustworthy management and integration fabric

Task 6.4: Sustainable and trustworthy AI/ML-based control

Task 6.3 Inter-domain and inter-computing management

6G Smart Network Management and Orchestration Enablers

1. Programmable flexible network configuration
2. Programmable network monitoring and telemetry
3. Integration fabric
4. Trustworthy 3rd party management
5. Multi-cloud management mechanisms
6. Orchestration mechanisms for the computing continuum
7. Sustainable AI/ML-based control
8. Trustworthy AI/ML-based control
9. Network Digital Twin
10. Zero-touch closed loop governance
11. Zero-touch multiple closed loop coordination

Other Hexa-X-II Enablers

Hexa-X-II System Blueprint

E2E System Design

Enablers ~ Technology domains

Programmability, flexible network configuration and monitoring
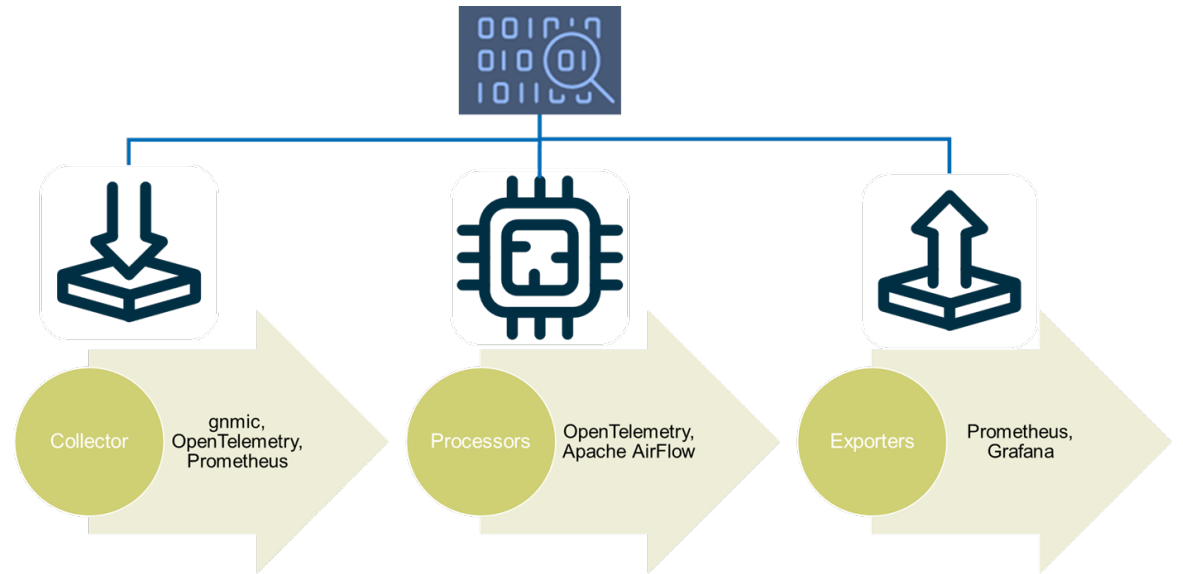
Enabler #1 – Programmable Flexible Network Configuration
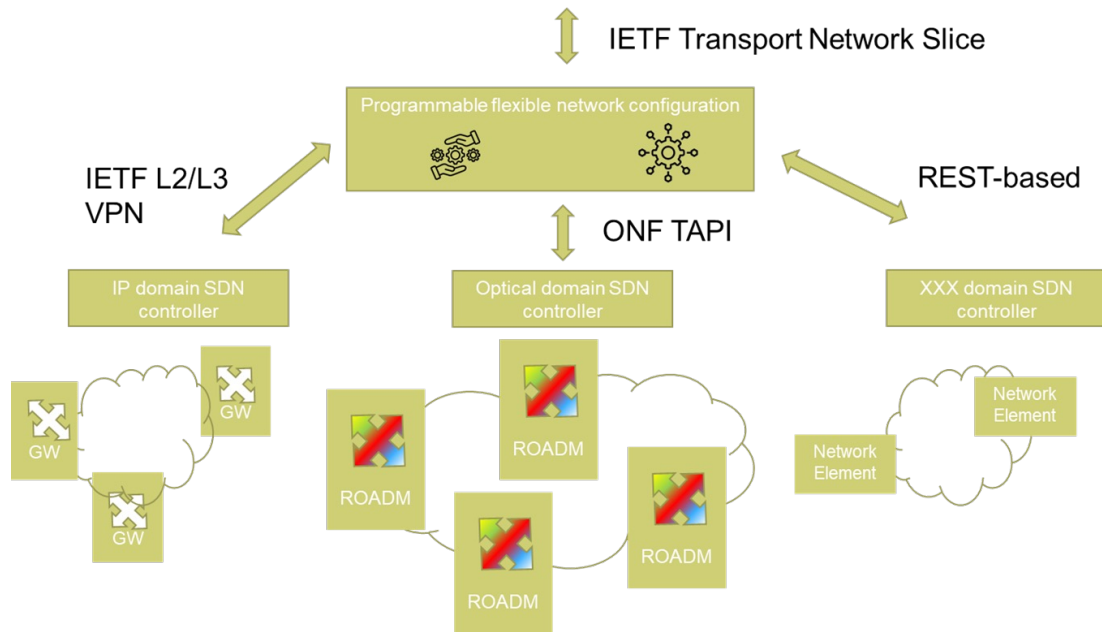
- Cloud-native Software Defined Networking (SDN) controller for programmable network configuration.
- APIs enable standard ways to interact with the network.
- Cloud-based (SDN) controller for network automation.

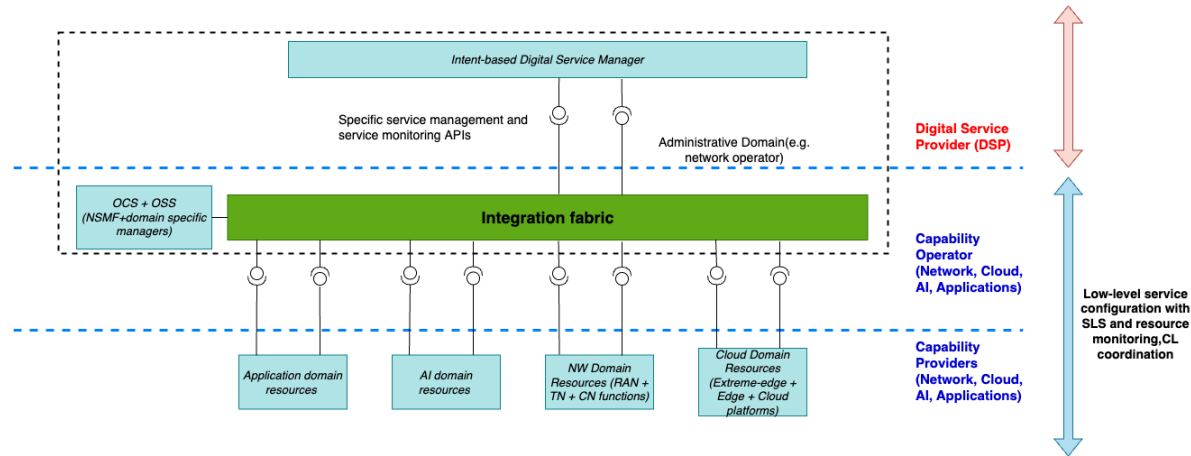## Enabler #2 - Programmable network monitoring and telemetry

- Real-time data for faster response to security and performance issues.
- Enabler for programable optimization across the whole network.
- Support for multiple monitoring protocols (NETCONF, REST, gRPC, gNMI, SNMP)

Trustworthy management and integration fabric

Enabler #3 – Integration Fabric

- Re-factoring the connectivity of today's capabilities, enabling cross-domain connectivity of loosely coupled and fine-grained services

- Adopting SBMA for interconnection of Hexa-X-II M&O systems, enabling more programmability and adopting a cloud-native paradigm.

- Service bus aligned with ETSI ZSM concept of cross-domain integration fabric.

Enabler #4 - Trustworthy 3rd party management
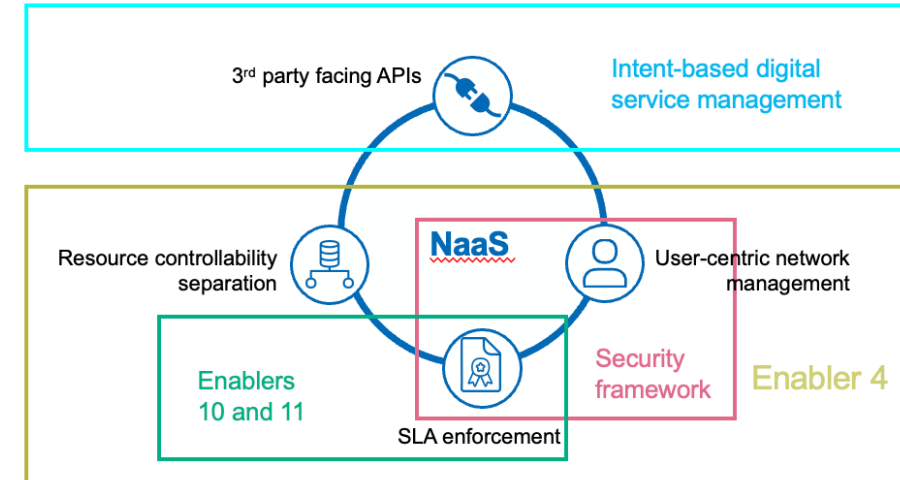
- Resource controllability separation track: provision of segregated yet customized management spaces to different 3rd parties

- User-centric network management track: 3rd party subscribers with personalized service experience, while being compliant with regulation in force.

- SLA enforcement track: covers SLA translation, assurance and verifiability from 3rd parties. SLA includes:
  - Key Performance Indicators (KPIs)
  - Key Value Indicators (KVIs)
  - Trust Level Agreement (TLA) components

# Inter-domain and inter-computing management

Enabler #5 – Multi-cloud management mechanisms
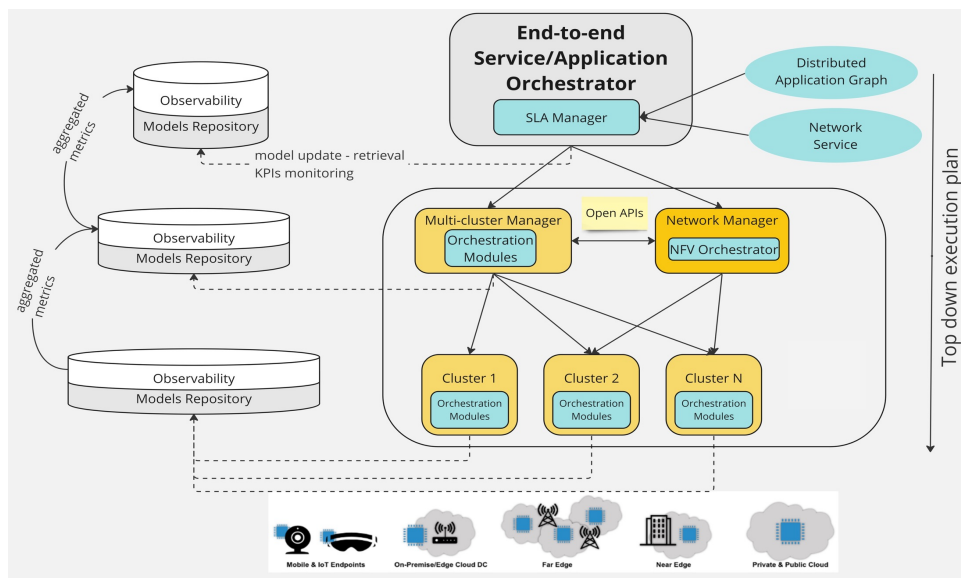
- Hierarchical decision-making solutions
- Interaction between network manager and Cloud Management Platform (CMP) or pure container orchestration solution (K8s)
- AI/ML for optimal resource allocation, load-balancing, predicting and preventing disruptions
- Distributed Ledger Technology (DLT) for multi-domain federation

## Enabler #6 - Orchestration mechanisms for the computing continuum
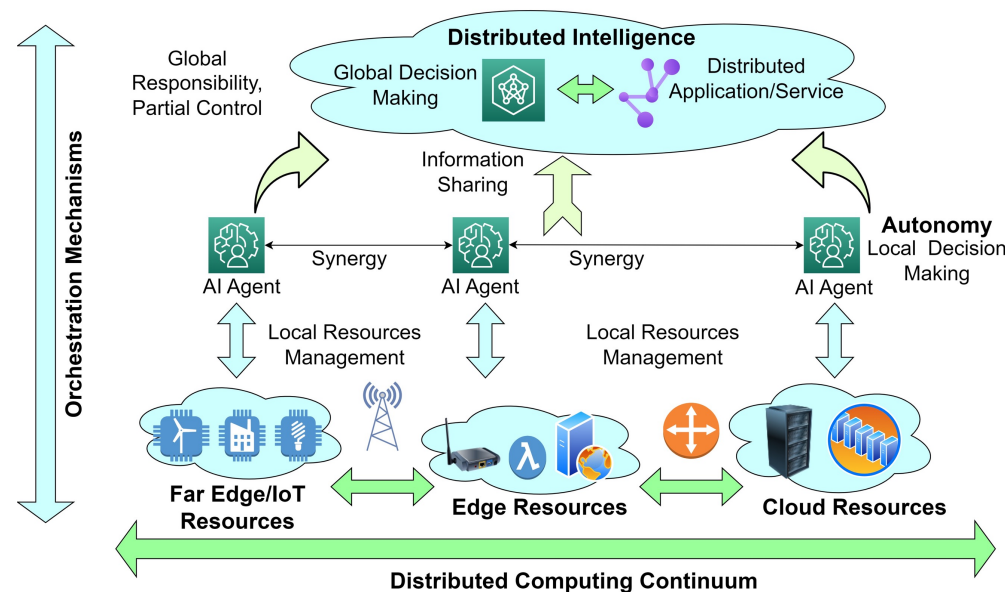
- Different types of synergies: among multiple cloud/network providers/MNO, among cloud application and network provider/MNO, among multiple management agents in a single provider
- Integration of the Extreme-Edge domain as part of the 6G cloud continuum.
- Enhance orchestration in synergy with network SLAs, taking advantage of ML mechanisms and data fusion of observability/telemetry signals to assist orchestration
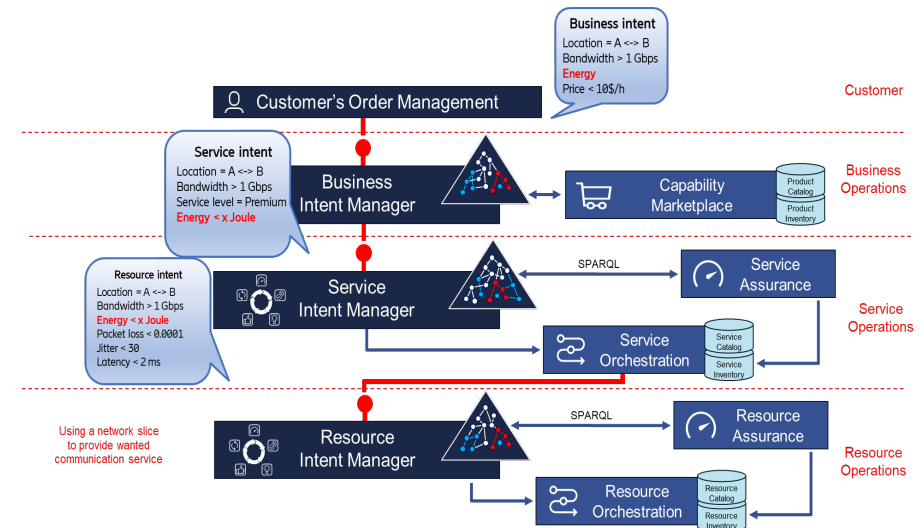
Sustainable and trustworthy AI/ML-based control

## Enabler #7 – Sustainable AI/ML-based control
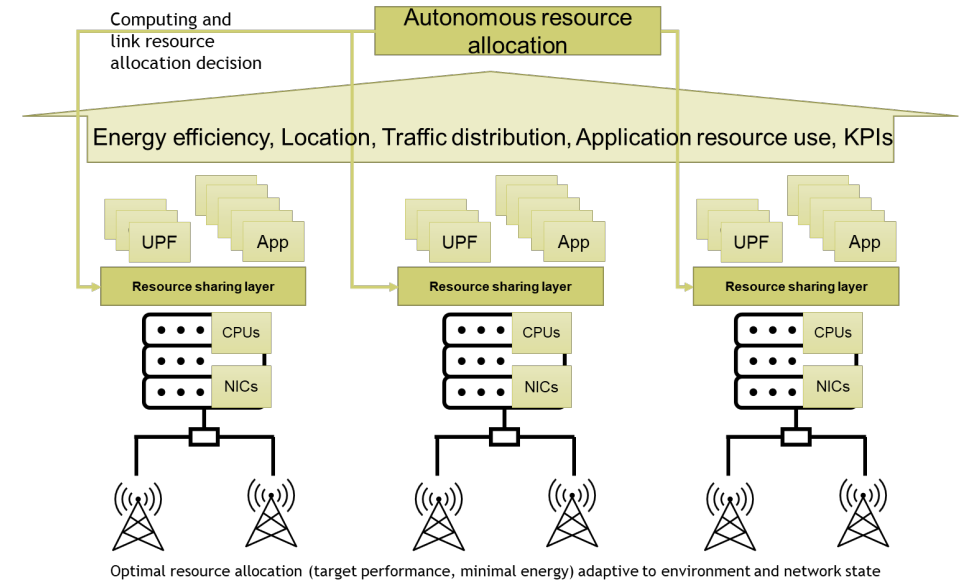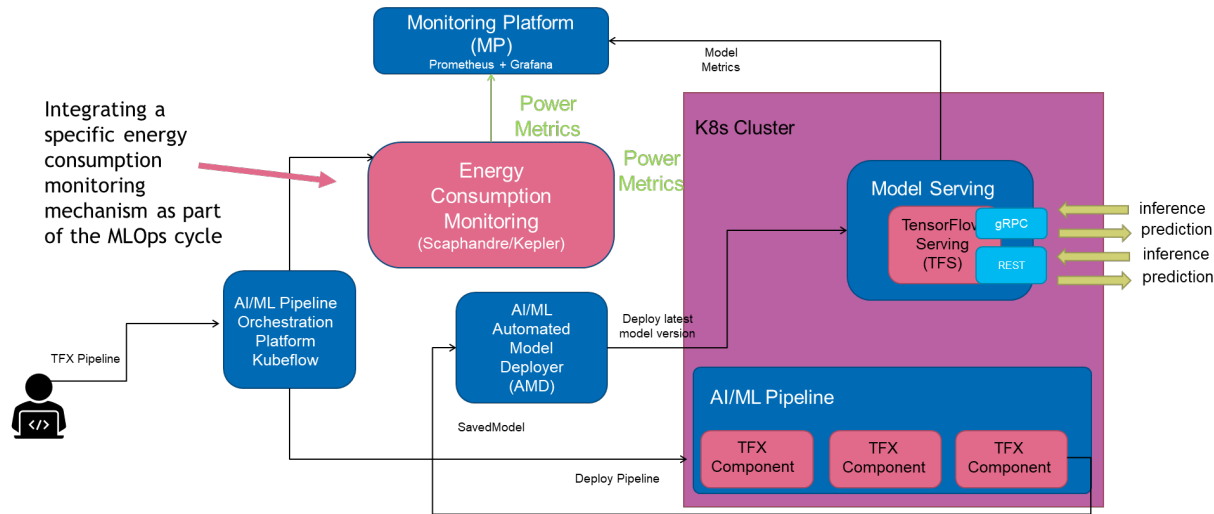
- Intent-based management including energy saving goals and translating SLA requirements with AI/ML algorithms

- AI/ML algorithms for optimal resource allocation (target performance, minimal energy) adaptive to environment and network state

- Sustainable MLOps to prevent ML training wasting more energy than saved in the network

- Federating AI/ML mechanisms for network management considering their energy footprint

# Sustainable and trustworthy AI/ML-based control

Enabler #8 – Trustworthy AI/ML-based control

Trustworthy AI/ML function
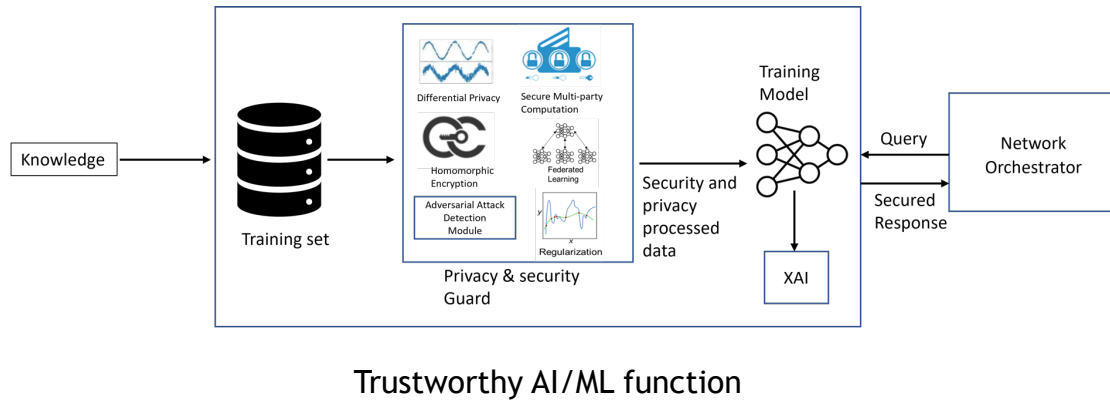
- Analyze vulnerability of AI/ML-driven systems against adversarial attacks and applicability of model regularization, defensive distillation and adversarial training in the mitigation of adversarial attacks on the management plane

- Use differential privacy, homomorphic encryption, secure multi-party computation or federated learning to minimize leakage of personal and sensitive data.

- Apply Explainable AI (XAI) techniques in AI-driven network management procedures to generate a human-understandable, interpretable, and transparent answer for a behavior.
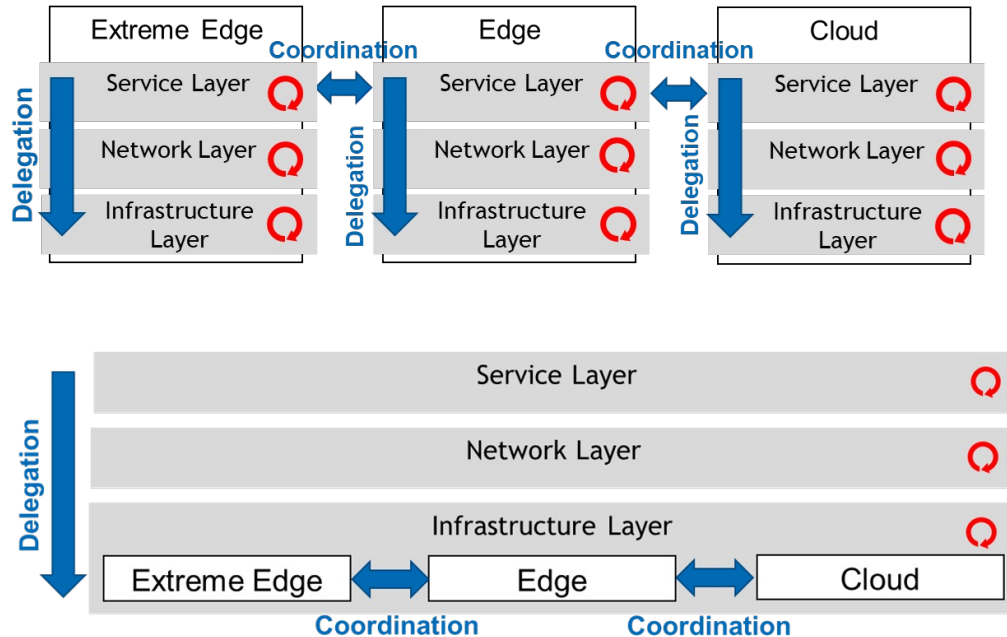
Enabler #9 - Network Digital Twins
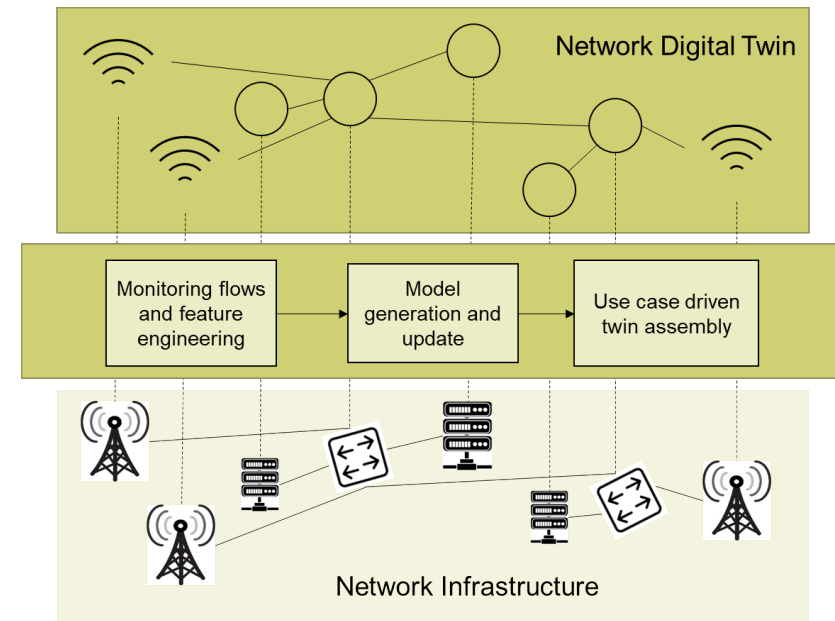
- Definition of control and monitoring flows for the generation and update of the twin

- Use of Graph Neural Networks (GNN) to create network models used as Digital Twins

# Real-time Zero-touch control loop automation

Enabler #9 - Zero-touch multiple closed loop coordination

- Different coordination models: peer-to-peer vs hierarchical models of multiple CLs

- Conflict detection, mitigation and resolution

- Delegation & escalation through the CL hierarchy

- Knowledge sharing among multiple CLs

Enabler #10 – Zero-touch closed loop governance
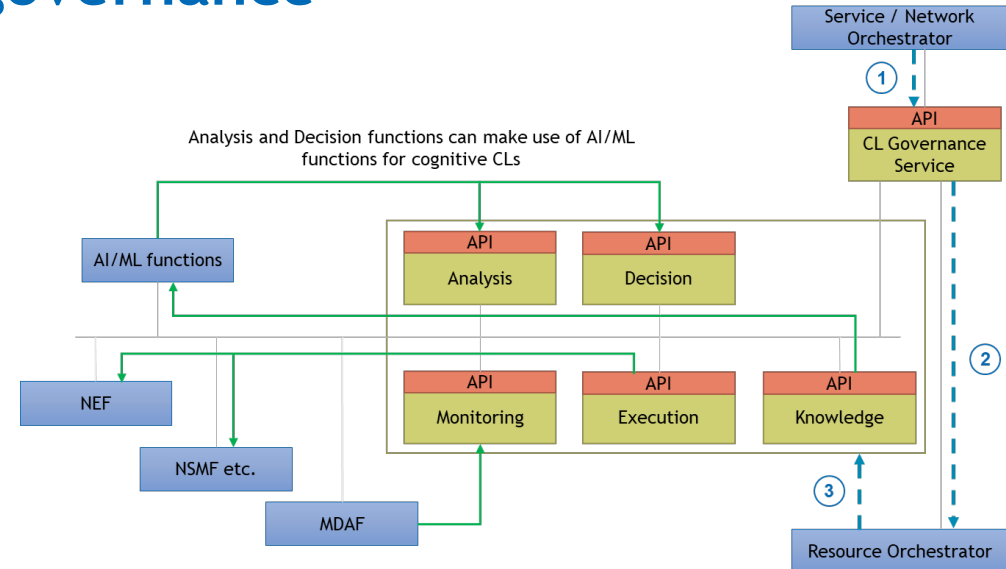
- Automation in provisioning, configuration, and operation of Multi-dimensional CLs for mobile network automation, with different time granularities and within different domain scopes and architecture layers

- AI/ML models for prediction within CL

- ML sandbox domains with Network Digital Twins models applied to CLs for preliminary decision validation

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