Hexa-X-II

Technological enablers for Management & Orchestration of 6G networks

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Hexa-X-II

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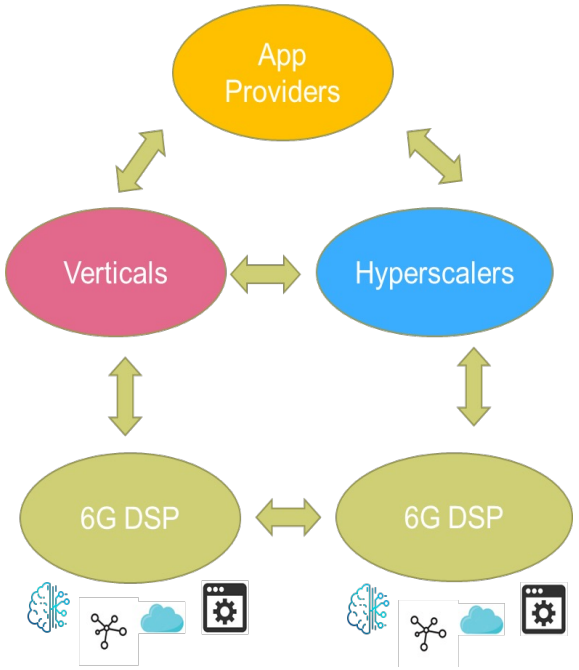
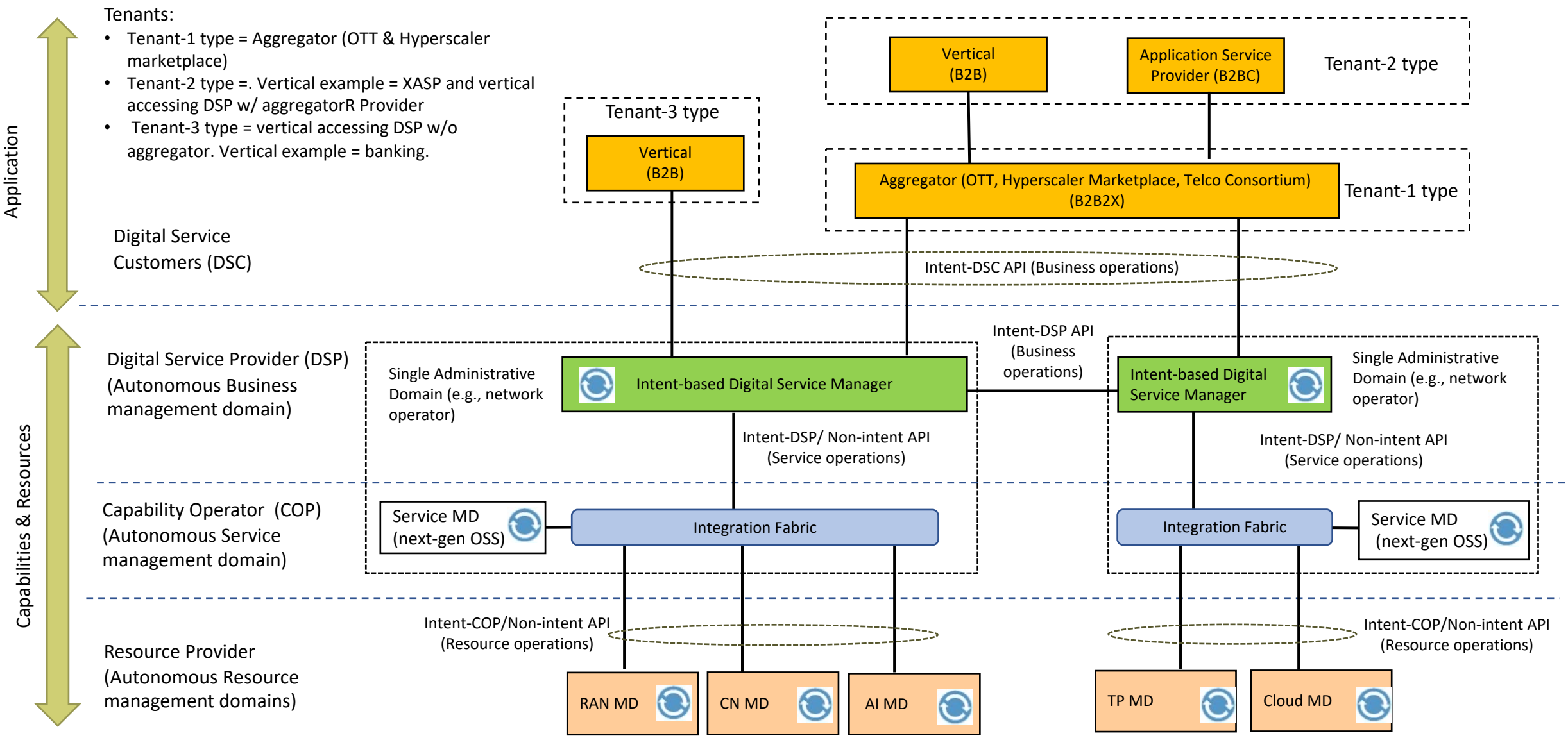
Multi-stakeholder Intent-based E2E service management automation

Intent-based E2E Service management automation

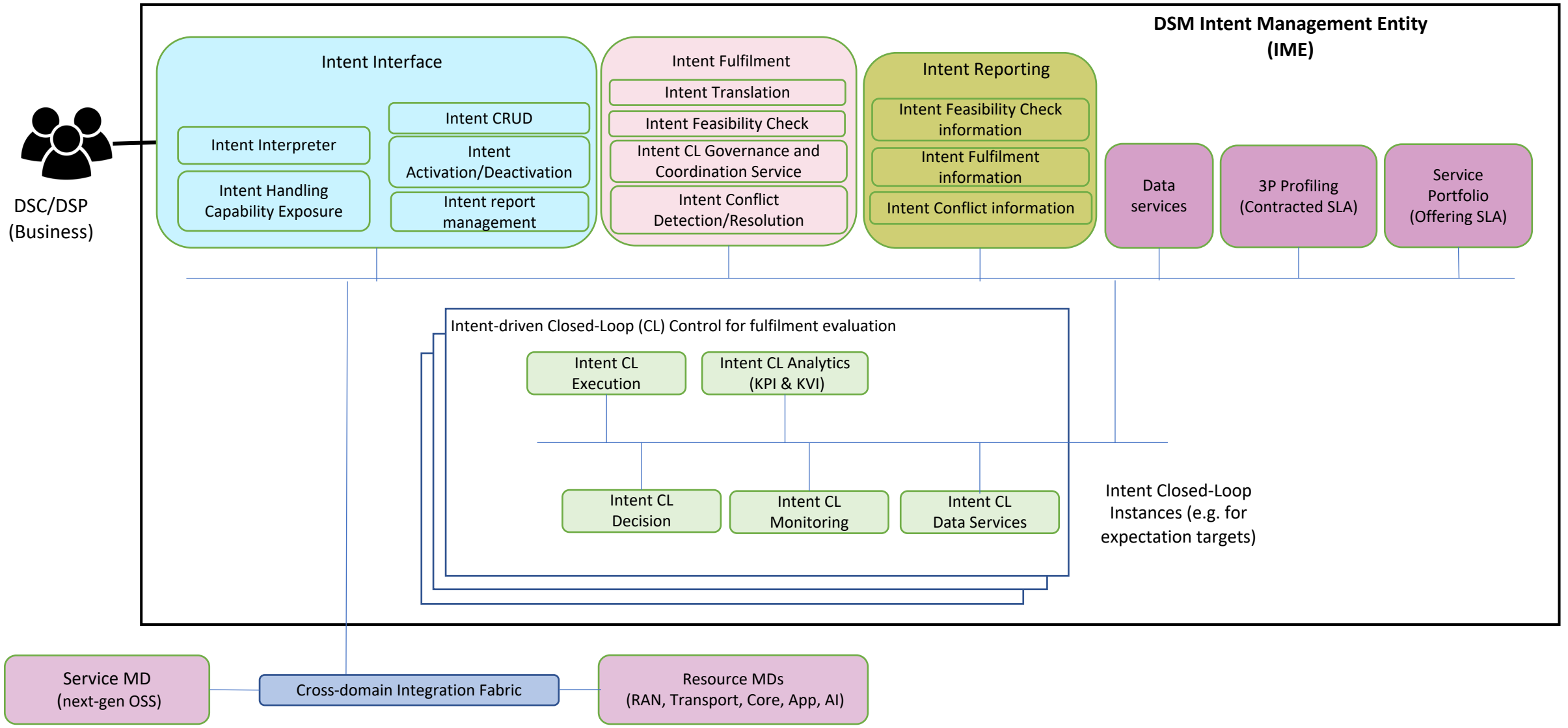
- Scope: Interaction between the network and application layer in multi-stakeholder scenarios based on network as a service (NaaS) to manage and expose services to multiple tenants by using Intent-based APIs
- *Network Layer*:
  - Evolution of 5G communication service providers (CSP) to 6G digital service providers (DSP) offering beyond communications services (e.g., network – RAN, transport, Core- , cloud, AI, applications).
- *Application layer*:
  - Multiple tenants like verticals, OTTs, Hy perscaler marketplaces and APP providers.
- Objective:
  - Design an intent-based end-to-end service management automation framework for multi-tenant support in multi-stakeholder scenarios by using Intent-based (dev-friendly easy-to-use) APIs.



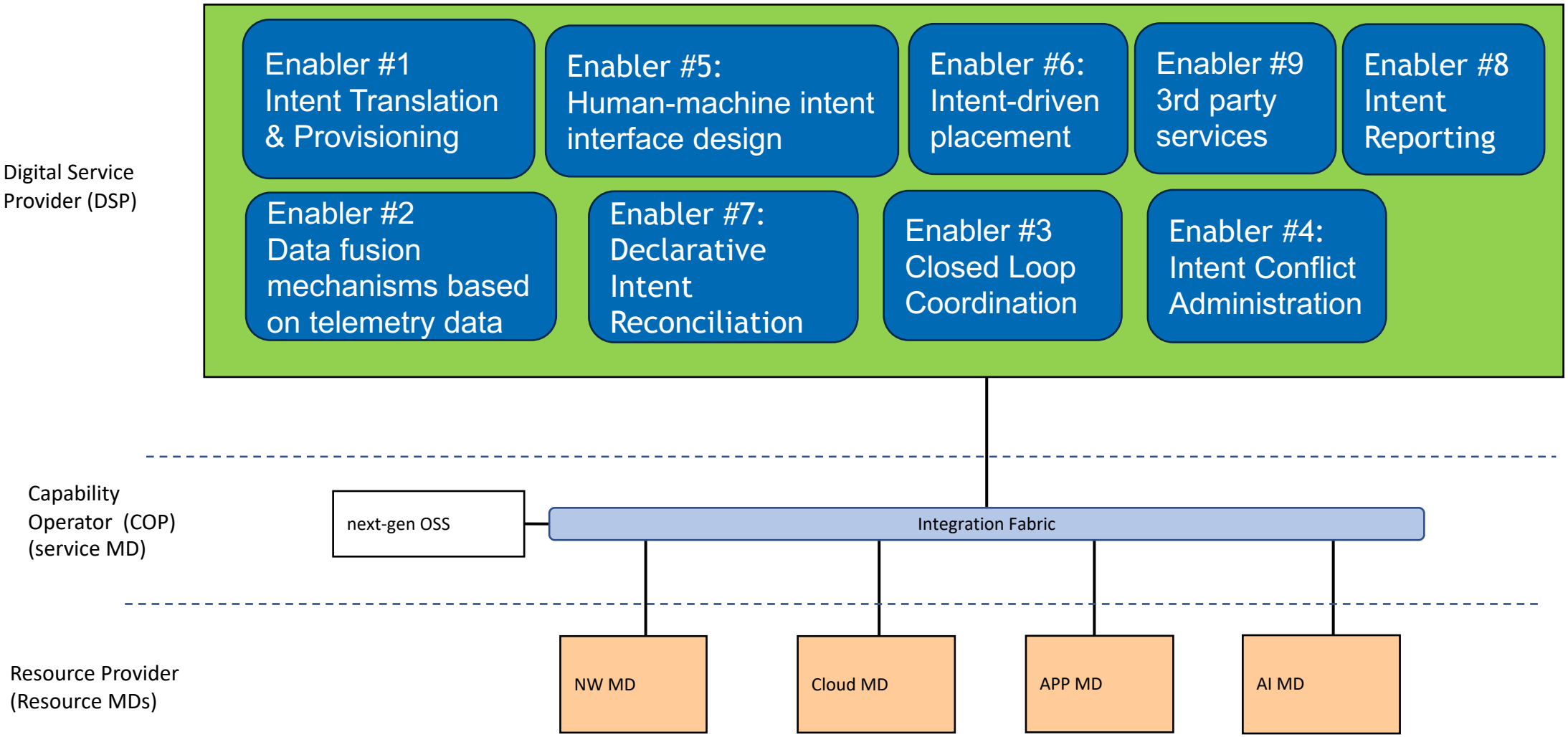
E2E Intent-based service management automation framework



Intent-based digital service manager functional architecture



Proposed Enablers



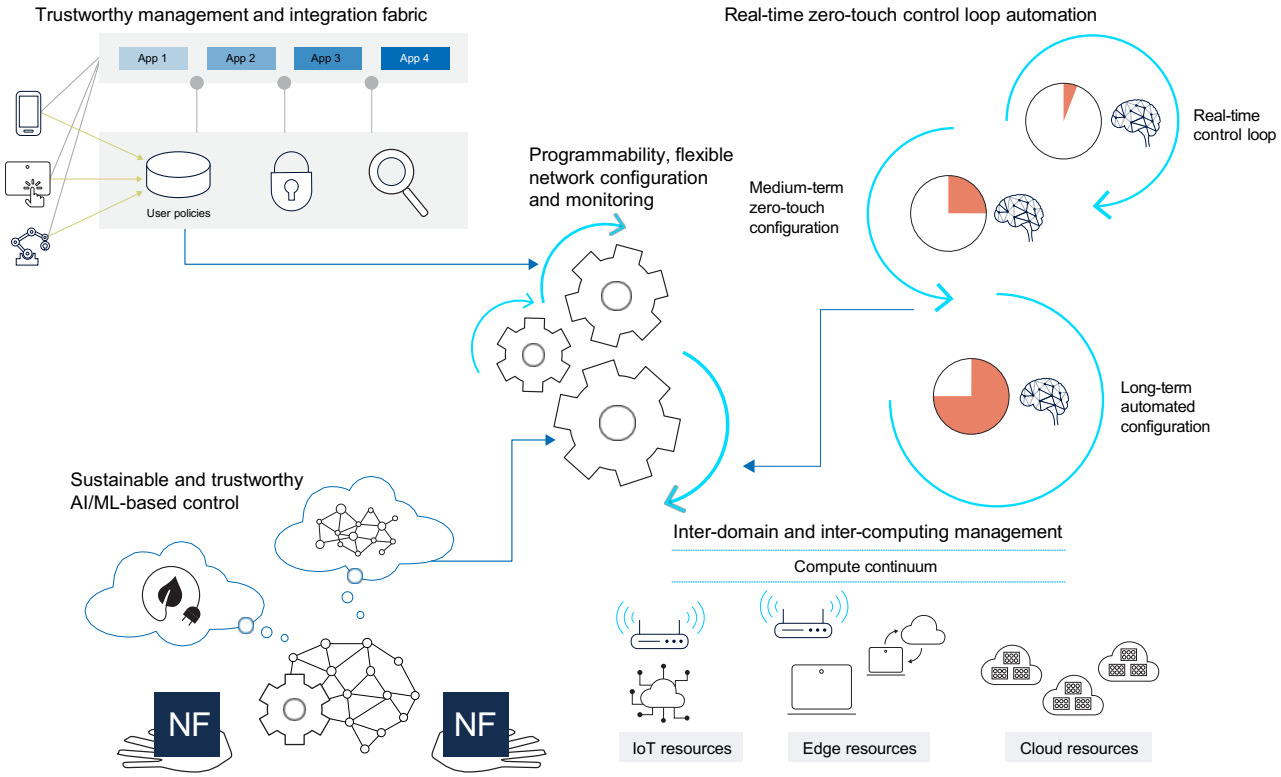
Coverage of the enablers and the intent-based DSP manager architecture

	Enabler #1 Intent Translation & Provisioning	Enabler #2 Data fusion mechanisms	Enabler #3 Closed Loop Coordination	Enabler #4: Intent Conflict Administration	Enabler #5: Human-machine intent interface	Enabler #6: Intent-driven placement	Enabler #7: Declarative Intent Reconciliation	Enabler #8 Intent Reporting	Enabler #9 9 3rd party services
Intent Interface									
Intent Fulfilment									
Intent Reporting									
Intent-driven Closed-Loop (CL) Control									
3P Profiling									
Service Portfolio									

Enablers for Management and Orchestration

Hexa-X-II Smart Network Management Objectives

- Obj.1: Design and develop a **programmable cloud-native micro-service-based Management and Orchestration (M&O) framework** for the future 6G networks, which is represented in the centre of the figure as all the rest of objectives/enablers will be relying on it.
- Obj.2: Design and develop mechanisms that collectively define a 6G enabled **trustworthy** environment, with a **user-centric integration fabric** that ensures **multi-tenancy** support and SLA verifiability.
- Obj.3: Develop **synergetic orchestration** mechanisms for managing the deployment of 6G services over heterogeneous resources **across the IoT-to-edge-to-cloud continuum**.

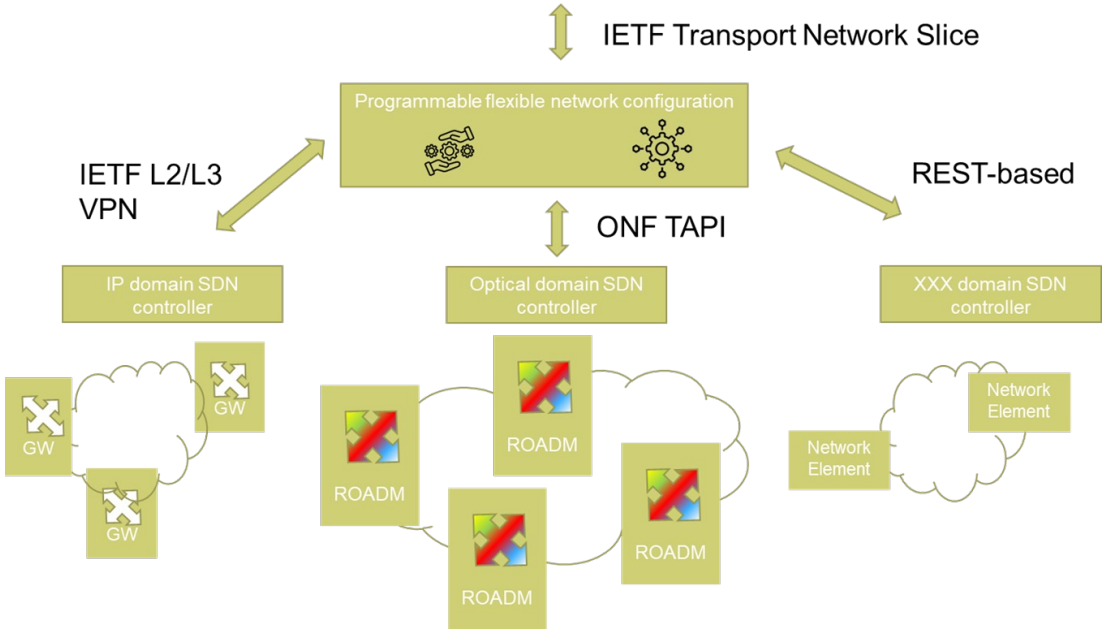


Hexa-X-II Smart Network Management Objectives

- Obj.4: Design and implement **robust and trustworthy AI/ML-based network control** solutions with optimal **energy efficiency and sustainability** targets.
- Obj.5: Design and develop **zero-touch M&O mechanisms for closed loop automation** and continuous service assurance, guaranteeing compliance with relevant 6G KPIs while reducing OPEX.

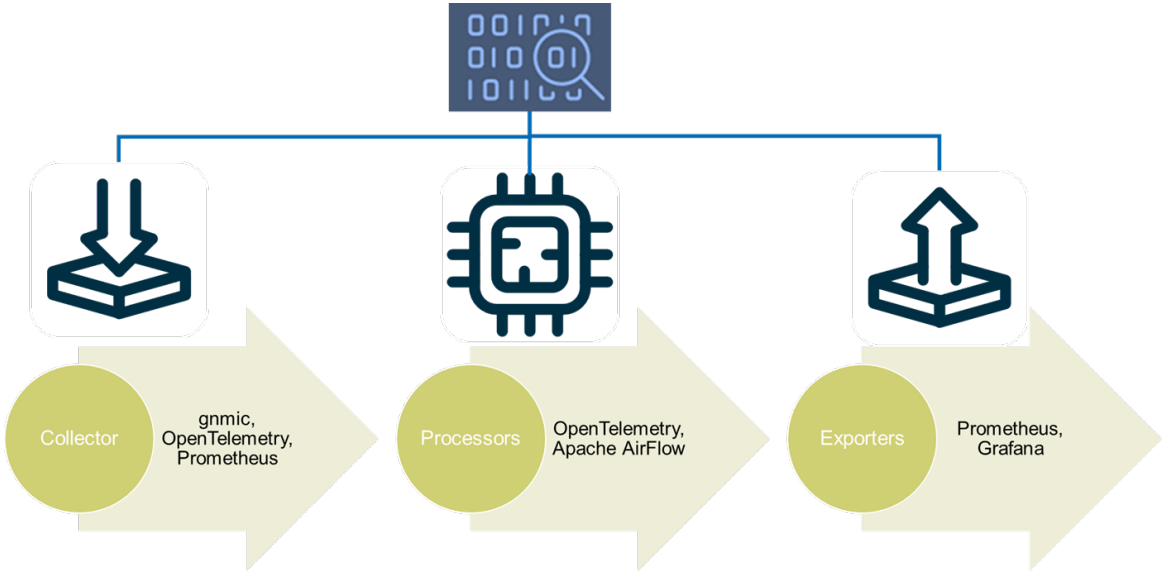
Programmability, flexible network configuration and monitoring

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.

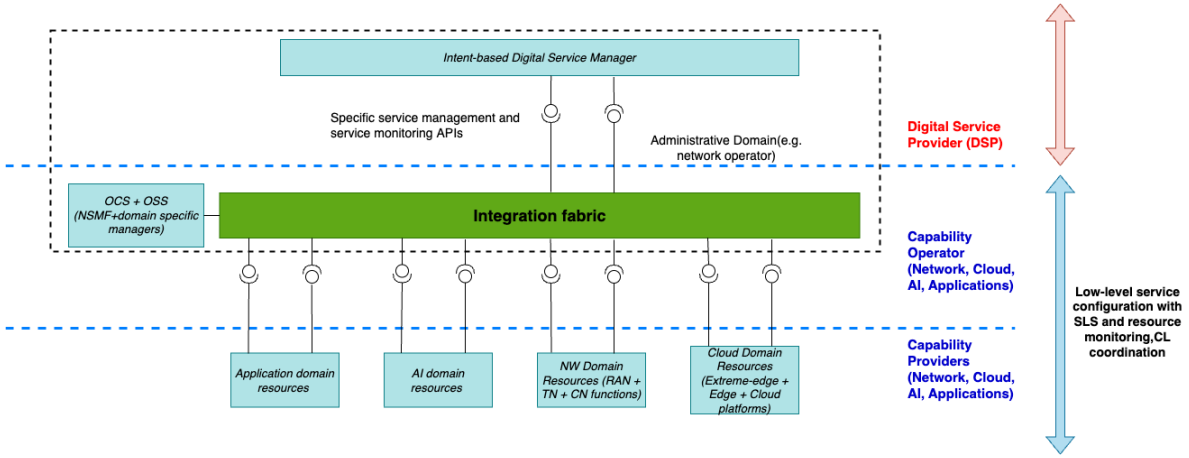
Enabler #2 - Programmable network monitoring and telemetry



- 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)

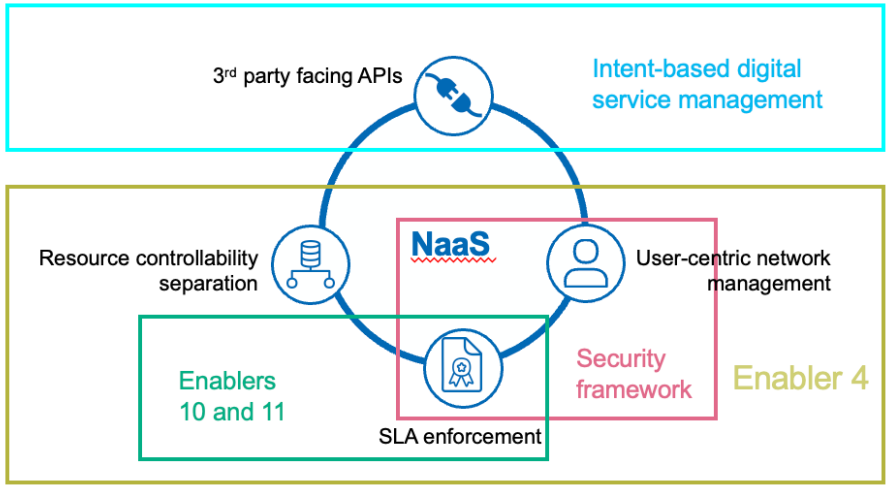
Trustworthy management and integration fabric

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.

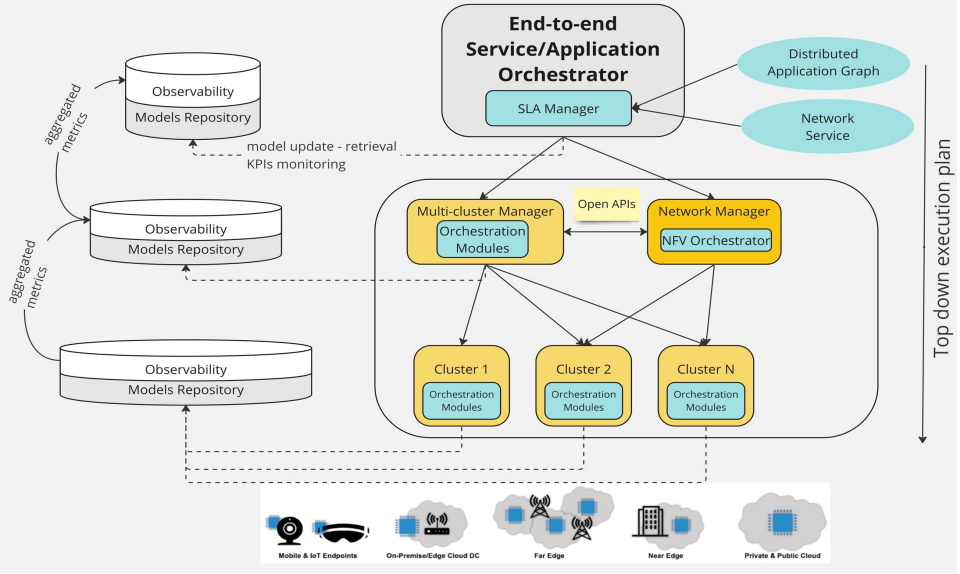
Enabler #4 - Trustworthy 3rd party management



- 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

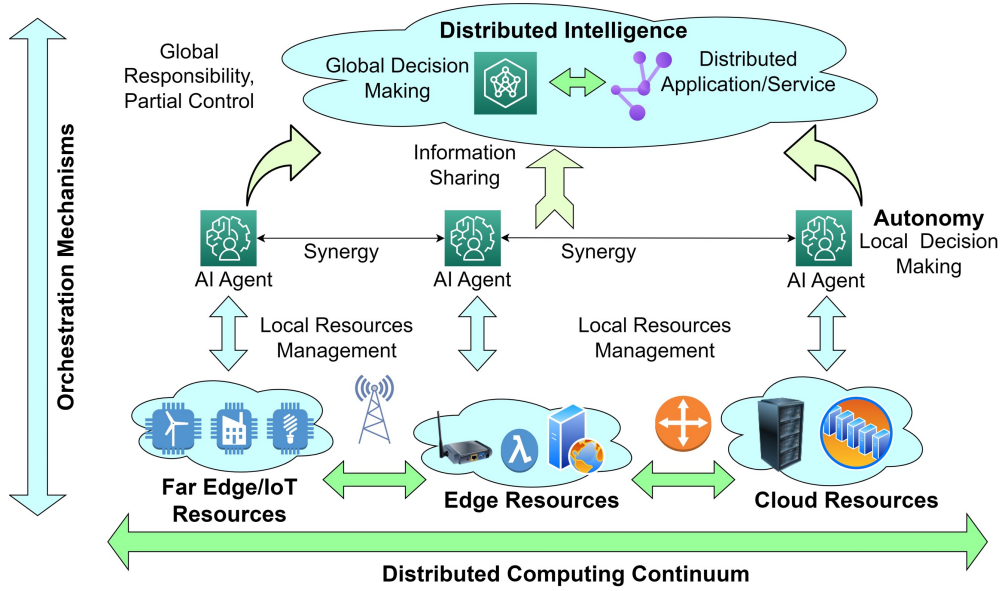
Inter-domain and inter-computing management

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

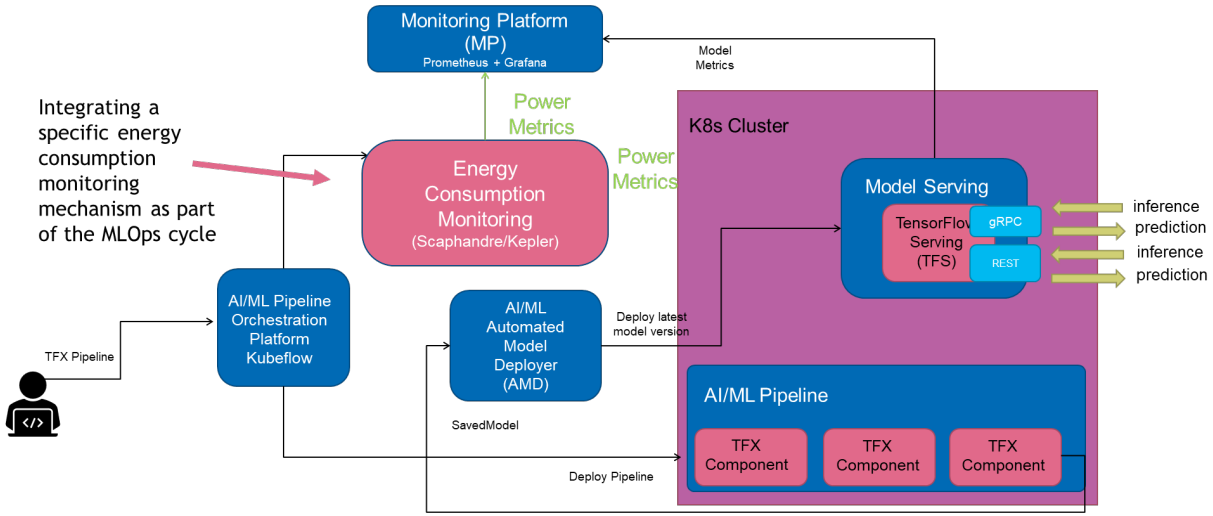
Enabler #6 - Orchestration mechanisms for the computing continuum

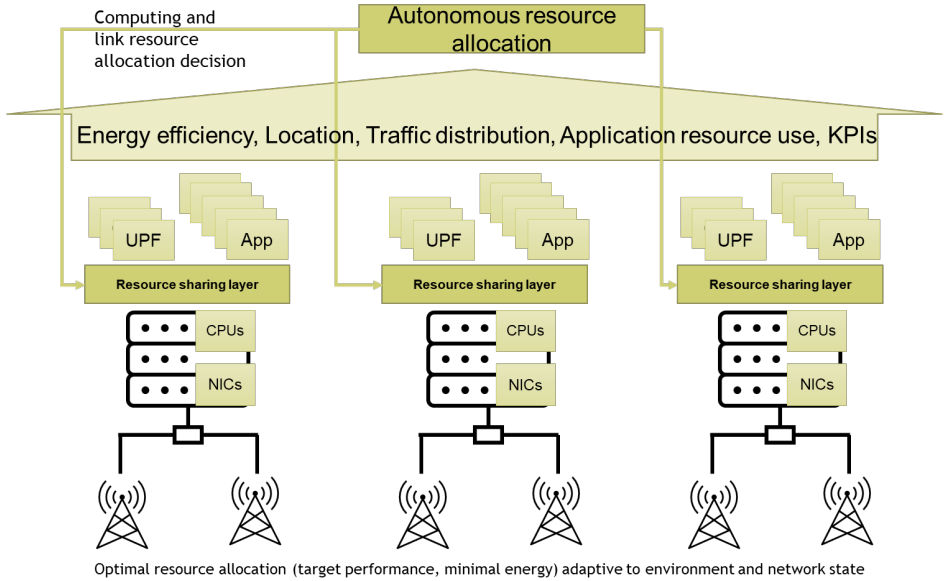


- Different types of synergies: among multiple cloud/network providers/MNO, among cloud application and network provider/MNO, among multiple management agents in a single provider
- Application/service graphs, features, characteristics and real-time performance
- Enhance orchestration in synergy with network SLAs, taking advantage of ML mechanisms and data fusion of observability/telemetry signals to assist orchestration

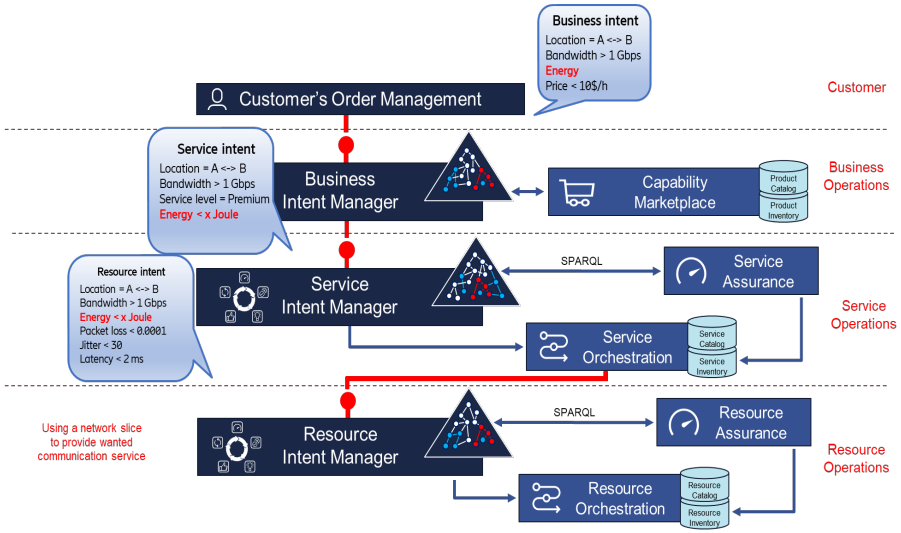
Sustainable and trustworthy AI/ML-based control

Enabler #7 - Sustainable AI/ML-based control



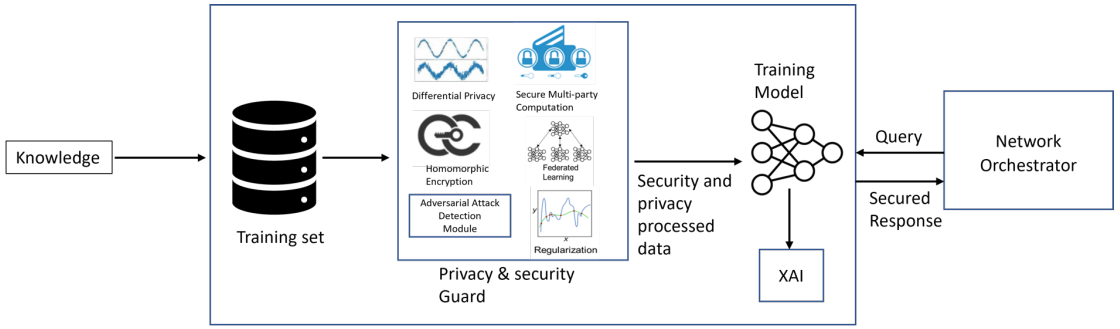


- Intent-based management including energy saving goals and translating SLA requirements with AI/ML algorithms
- AI/ML algorithms for optimal resource allocation (target performance, minimal energy) adaptive to environment and network state
- Sustainable MLOps to prevent ML training wasting more energy than saved in the network
- Federating AI/ML mechanisms for network management considering their energy footprint



Sustainable and trustworthy AI/ML-based control

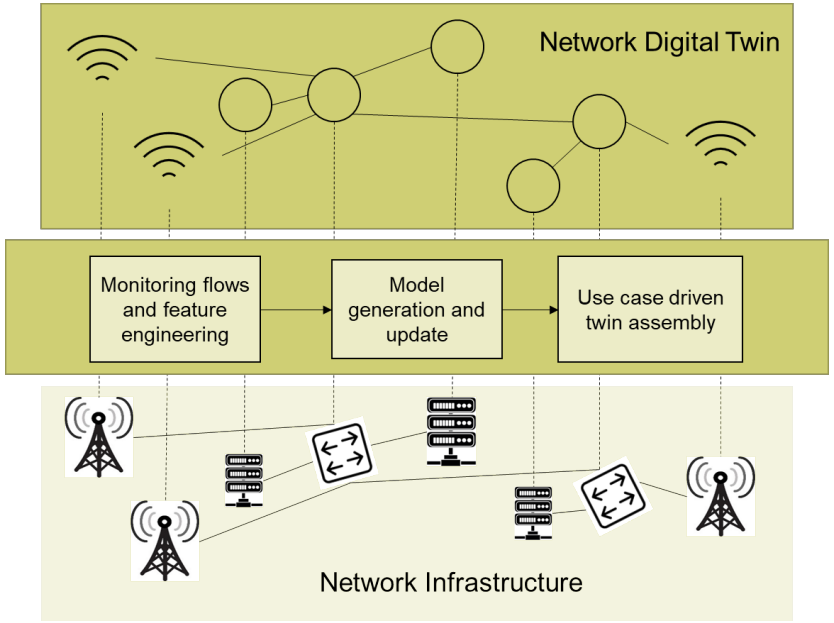
Enabler #8 – Trustworthy AI/ML-based control



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.

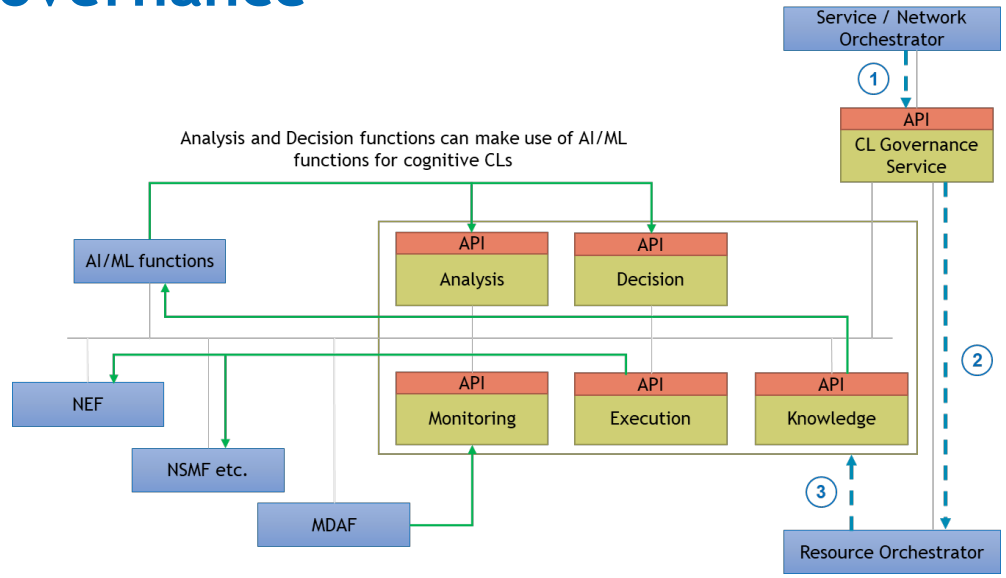
Enabler #9 - Network Digital Twins



- 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

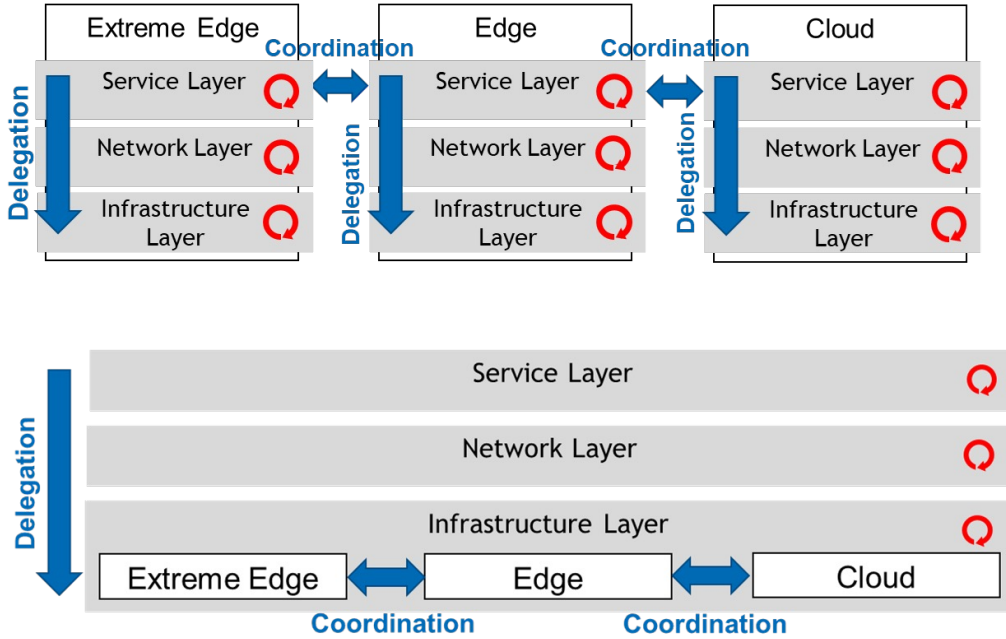
Real-time Zero-touch control loop automation

Enabler #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

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

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