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RAN Intelligence Use Case, Architecture and Interface

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Bringing AI to the RAN: From “on the top” to “embedded”

Statistic/Semi-Statistic
Operation & Management Plane

- Network Planning
- Network Deployment
- Network Operation & maintenance

Real-Time
Control & Data Plane

- Protocol stack & Signaling
- Radio Resource Management
- PHY layer Optimization

Classic Communication Theory Meets Data Technology

Sensing

Multi-dimensional /cross-layer context info (user, application, network) Radio Environment Map…

Prediction

User behavior (trajectory, location) Traffic fluctuation Service type

Intelligent Decision Making

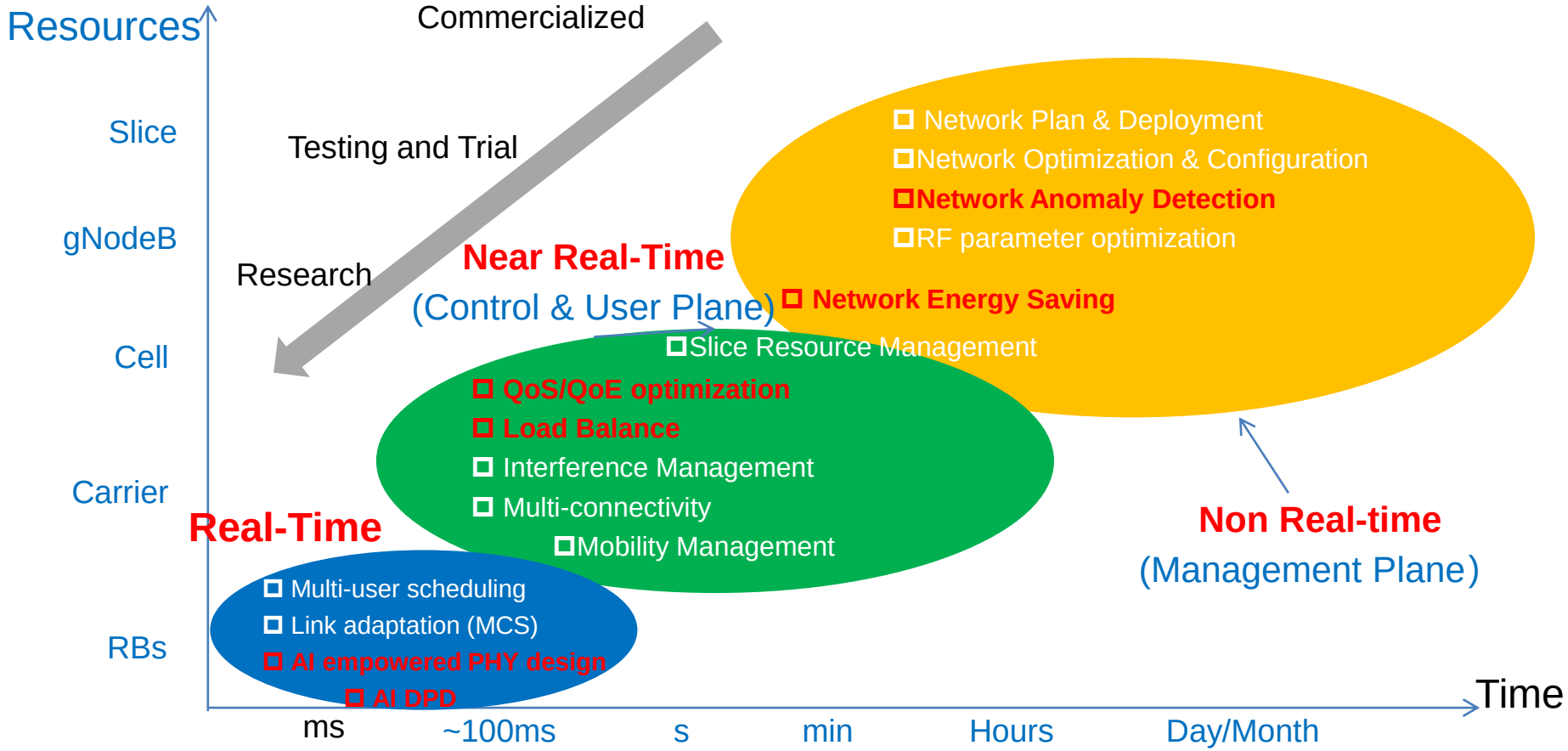
Machine/deep Learning Offline model training & online decision making

Customized Network Strategy

Data Driven Machine Learning Based Complex Network Optimization

Predication oriented configuration & Decision making

Use Cases: AI empowered RAN optimization-Time/Resource Categories



Standardization: Overview of Research, SDOs and Open Source Activity

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Research

WAIA

未来移动通信论坛 FuTURE MOBILE COMMUNICATION FORUM

WIRELESS WORLD RESEARCH FORUM

IEEE ETI

Network Intelligence

machine learning for Communications

Standardization

ITU FG ML5G

3GPP RAN3, SA2, SA5

O-RAN ALLIANCE WG1/2/3

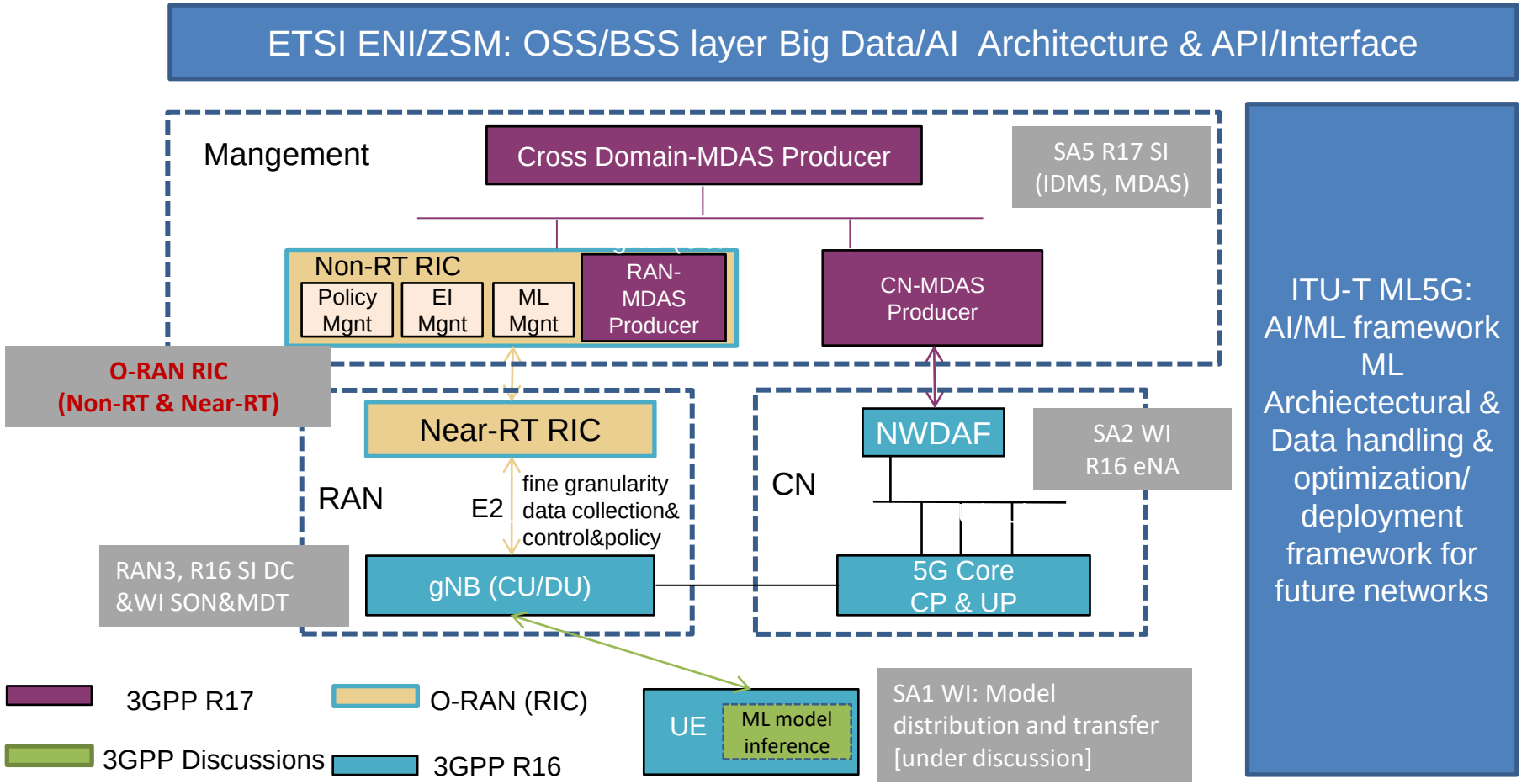
ETSI ENI, ZSM

Open Sources

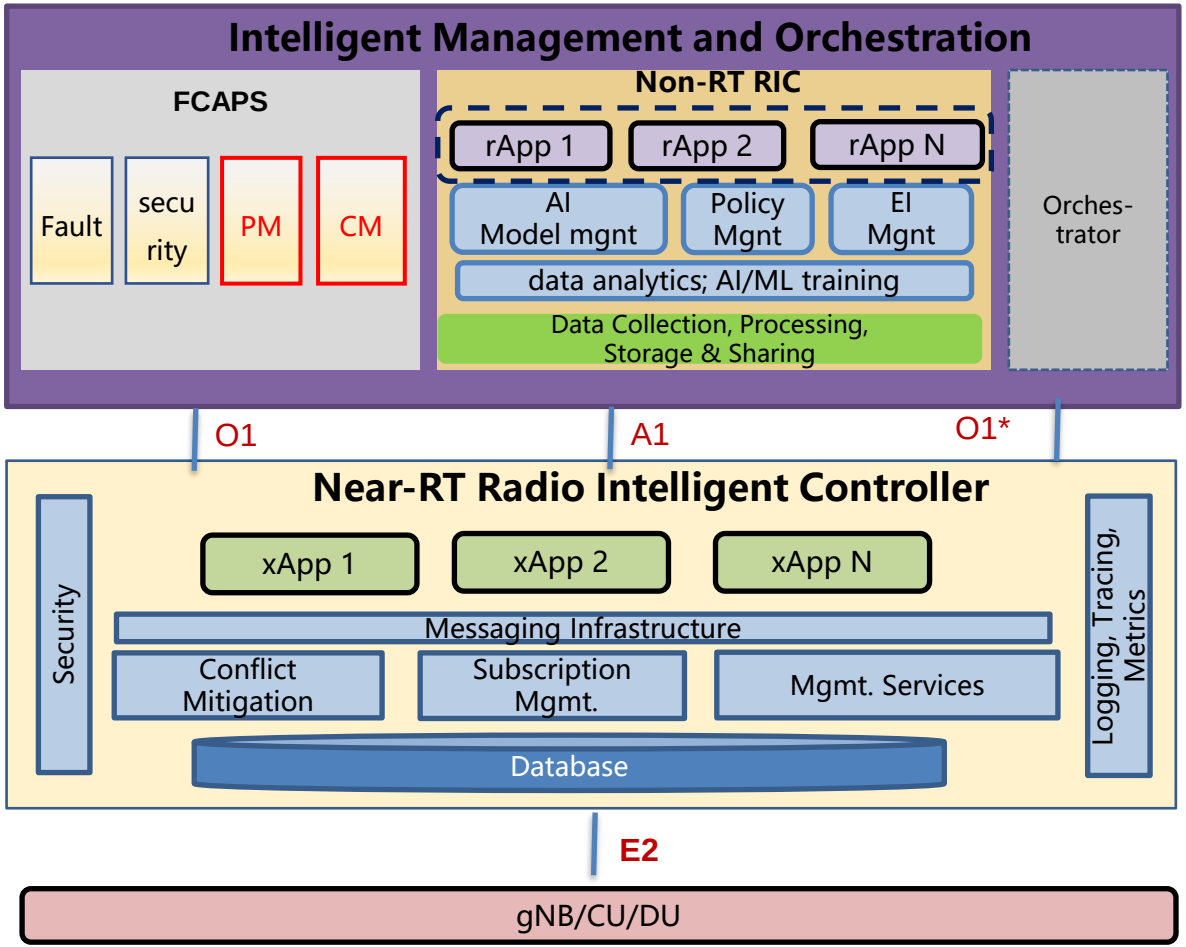
THE LINUX FOUNDATION

O-RAN
ONAP
Acumos
Adlik
PNDA

……


ETSI ENI/ZSM: OSS/BSS layer Big Data/AI Architecture & API/Interface
Mangement
Cross Domain-MDAS Producer
SA5 R17 SI
(IDMS, MDAS)
Non-RT RIC
Policy Mgnt
EI Mgnt
ML Mgnt
RAN-MDAS Producer
CN-MDAS Producer
O-RAN RIC
(Non-RT & Near-RT)
Near-RT RIC
RAN
E2
fine granularity
data collection&
control&policy
CN
NWDAF
SA2 WI
R16 eNA
RAN3, R16 SI DC
&WI SON&MDT
gNB (CU/DU)
5G Core
CP & UP
UE
ML model inference
SA1 WI: Model distribution and transfer [under discussion]
3GPP R17
O-RAN (RIC)
3GPP Discussions
3GPP R16
ITU-T ML5G:
AI/ML framework
ML
Archiectectural &
Data handling &
optimization/
deployment
framework for
future networks

Enable RAN Intelligence with Hierachical RIC



rApp 1 Non-real time ML application

xApp 1 Near-real time ML application

RAN Programmability

Intent (Goal, what) Declarative

Policy (/Behavior, How) Imperative

AI/ML Model (data driven algorithm)

Enrichment Data (UE Speed, service type)

Hierarchical Intents/Policy/Control

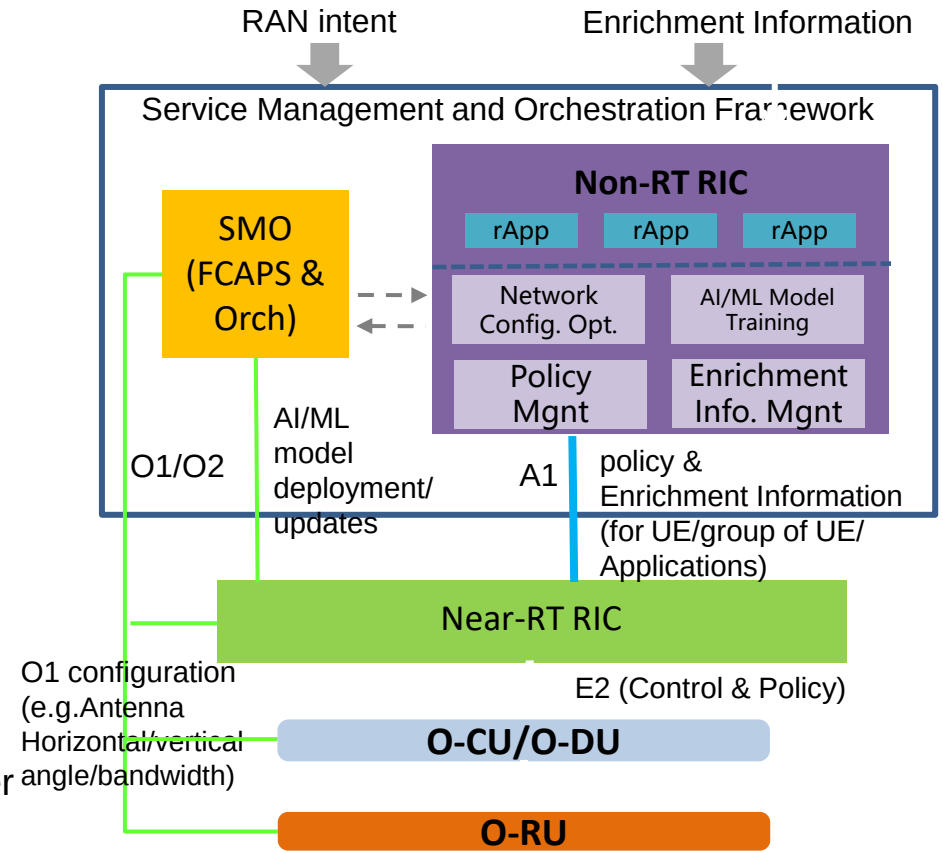
Imperative Policy Event, Condition, Action

Smart Control

Non-RT RIC and A1 interface

Goal: Enable closed-loop automation and optimization of RAN elements & resources, making it more intelligent (ML/AI), more granular (per-UE or group of UEs), more flexible (intents/policies).

- Main Use Cases
  - QoE Optimization
  - QoS Optimization
  - Traffic Steering
  - Network Slicing performance assurance
- A1 interface support
  - **A1-P – Policy Management Service**
  - A1-EI – Enrichment Information Service
  - A1-ML – ML Model Management Service
- Non-RT RIC framework
  - AI/ML model training
  - A1 policy management
  - Enrichment information management
  - Network Configuration Optimization
- rApp: **non-RT intelligence application,** e.g. Carrier license scheduling, energy saving, ...

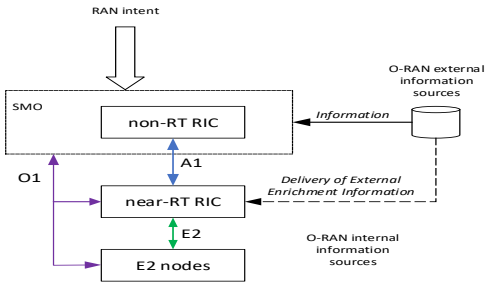


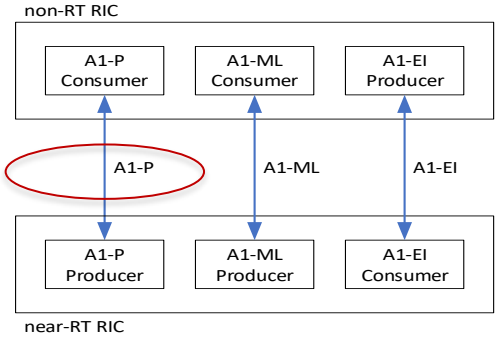
Non-RT RIC & A1 Standardization Progress

- **Non-RT RIC: Functional Architecture** under discussion
- **A1 interface:**
  - A1 specification **v1.0** published in Nov. 2019, **v1.1** published in Apr. 2020, **v2.0** in July 2020.

No.	Specification	Contents
1	A1 General Aspects and Principles (A1 GAnP)	• **General principles,** open A1 interface and interoperability • Define 3 types of services: A1 Policy, A1 Enrichment Information, A1 ML
2	A1 Transport Protocol (A1TP)	• A1 transport layer definition, **HTTP/JSON**
3	A1 Application Protocol (A1AP) v1.0	• A1 application layer definition, **A1 API Definition** and **Data models** • Support **UE/Slice/QoS/Cell** level QoS/QoE targets and cell/carrier access policy
4	A1 Application Protocol (A1AP) v1.1	• Add YAML format A1-P OpenAPI(s) standard • Improve A1 status & Notification operations

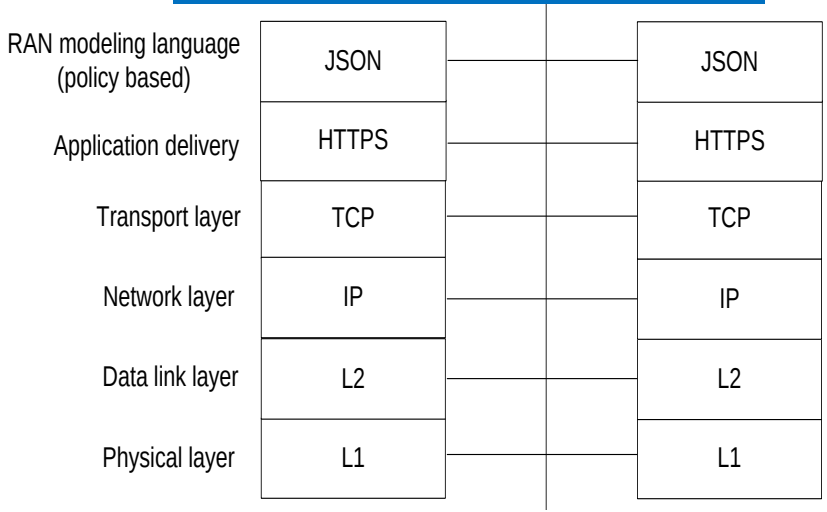
- **Ongoing activities**
  - A1 EI (enrichment information) API definition, exmaples including
    - radio fingerprint
    - video code rate/frame rate
    - UAV path
    - weather





A1 Policy Protocols, Procedures and Data Models

A1 interface protocol structure



A1 Policy Procedures

A1 policy procedure	HTTP method
Create policy	POST
Query policy	GET
Update policy	PUT
Delete policy	DELETE
Feedback policy	POST
Query policy type	GET

Policy Representation

Scope Identifier

+

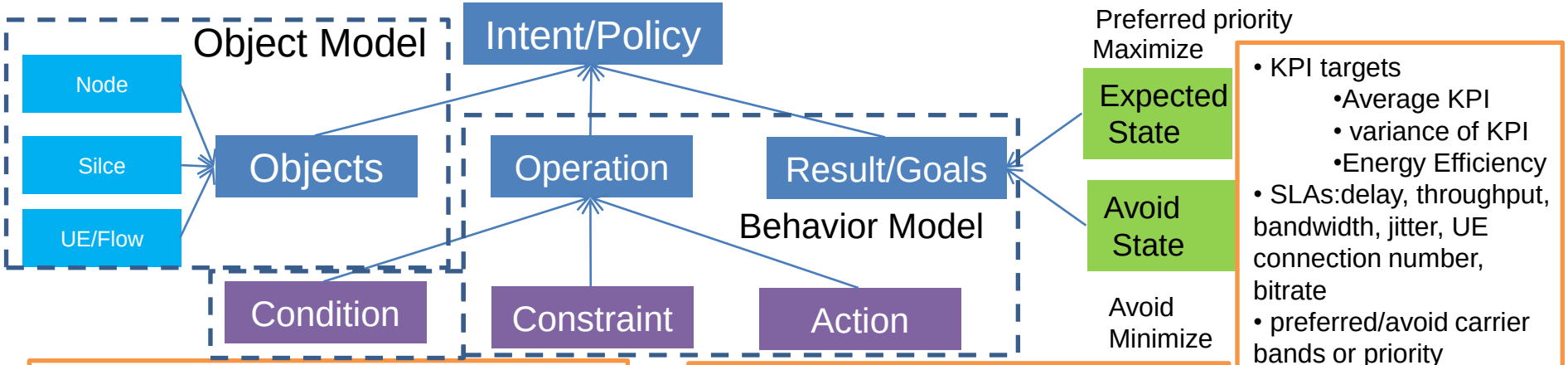
Policy Objective/Resource Statements

Data Models

ueId
groupId
sliceId
qosId
cellId

QosObjectives： GFBR,MFBR,Priority Level, PDB
QoeObjectives: qoeScore,initialBufferingreBuffFreq,stallRatio
TspResources: cellIdList,preference,primary

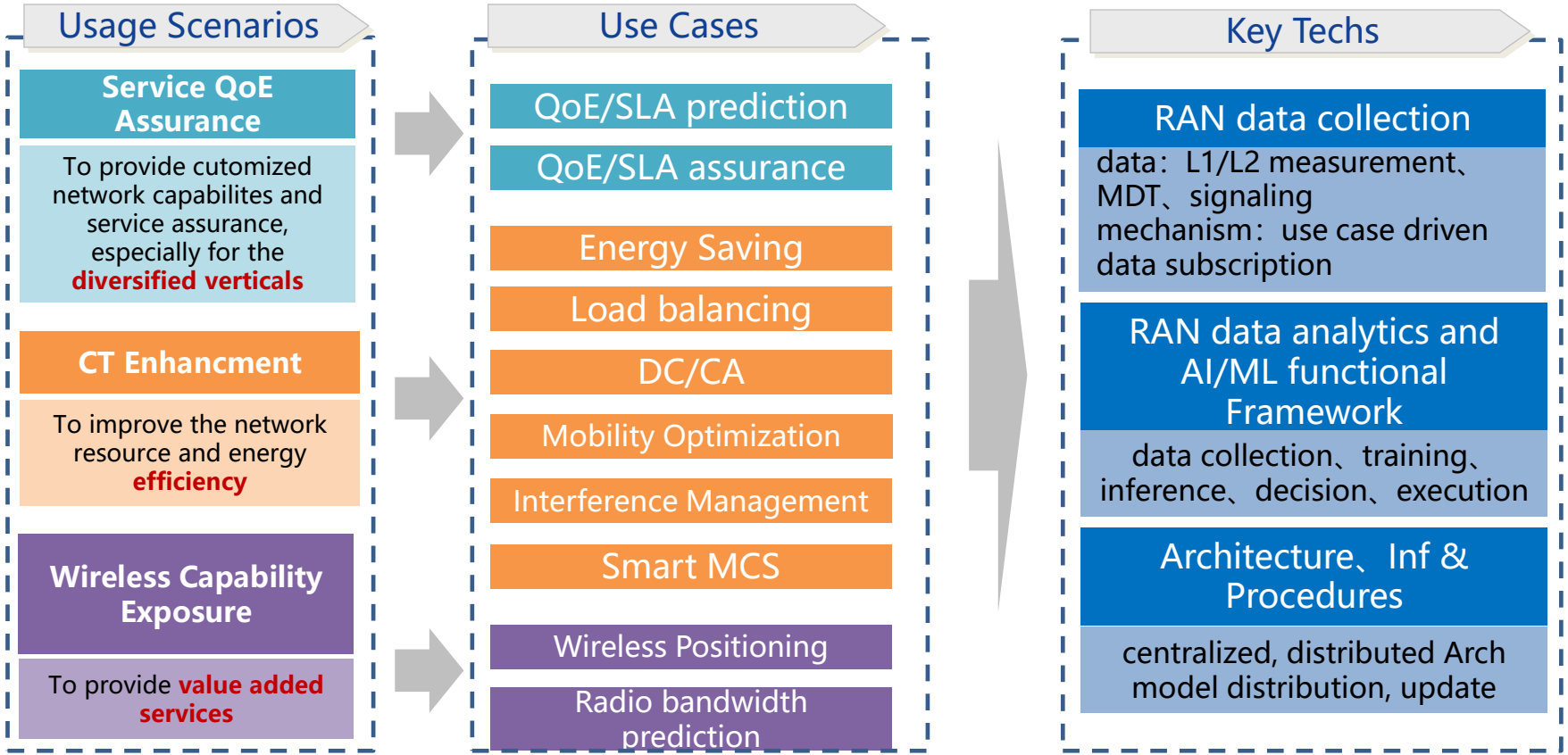
Further Thoughts on the Intent/Policy Modeling Enhancement



Note: condition and action may apply to different objects

RAN Model = Object Model + Behavior Model

Business Value Driven Use Cases: RAN Optimization and Capability Exposure



Key Issues and Future Work

- Usage Scenarios
  - RAN capability customization for the verticals
    - to make the network easy to be customized by the diversified requirements
    - e.g., Deterministic SLA assurance
  - RAN automation
    - to simplify the network operation and maintainance
    - e.g.,Network planning, optimizaiton, maintainance

- Intent/Policy Modeling
  - Hard to model the Intent/Policy Expression for varied usage scenarios
  - How to model the hierachical level of the Intent/Policy?

- Intent/Policy Engine Design
  - How to do the network control and optimization to fulfill the Intent and Policy?
  - How to leverage the wireless big data and AI/ML technologies?

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Thank you!

Discussion on the RAN programmability

- **Level 1**: **Configure the parameters** of an well designed algorithm to change the behavior (mainly used in the current OAM configuration management)
- **Level 2: Adding Policy rules/new Algorithm logics** of the optimization problem solution to guide the algorithm **behavior** (e.g. **condition/action/constraint /parameter rules**) **[Imperative policy]**
- **Level 3**: **Express the intent and Model the RAN optimization problem by setting the objectives, constraints. Let the system to figure out how to do accomplish the Intent. [Declarative Policy]**
  - **Need a intent engine (e.g., algorithm framework) to automatically solve the problem .**
- **Level 4: Depoly/on-board algorithms (can be AI/ML assisted software, containers, etc.) directly on the RAN to address specific RAN optimization**