# Maintenance and Enhancement of Intent-driven Closed-loop Autonomous Networks in R11

**Requirements Subcommittee Review**
**25th April, 2022**

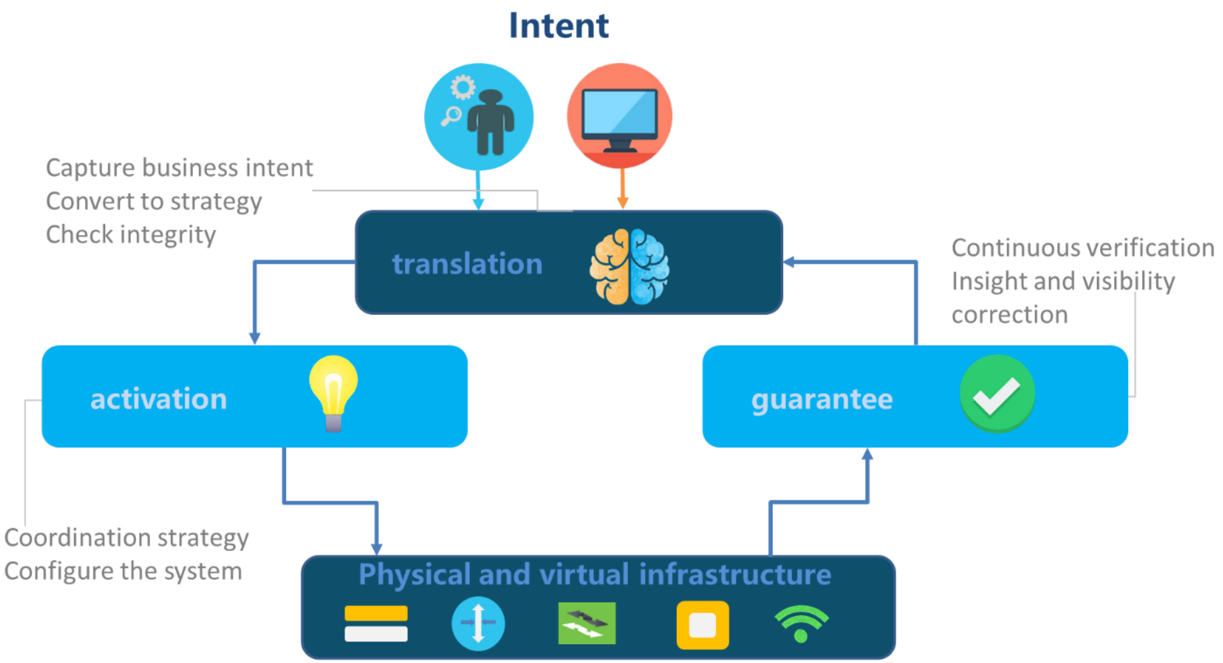
**REQ Owners:** Dong Wang (China Telecom), Keguang He (CMCC), Henry Yu (Huawei), Ahila Pandaram (Wipro), Kevin Tang (STL), Lei Shi (AsiaInfo)
**Academic Supervisor:** Prof. Chungang Yang (Xidian University)

# Outline

1. Overview of Intent-based Networking
2. Implementation of IBN from R8 (Honolulu) to R10 (Jakarta)
3. REQ of R11 Maintenance and Enhancement

# Intent-based Networking (IBN)

- Intent-based networking (IBN) is a self-driving network that uses **decoupling network control logic** and **closed-loop orchestration techniques** to automate application intents.
- An IBN is an intelligent network, which can **automatically convert, verify, deploy, configure, and optimize** itself to achieve target network state according to the intent of the operators, and can **automatically solve abnormal events** to ensure the network reliability.




A high-level framework of Intent-based Networking




- ITU-T Y.IBN-reqts "Scenarios and requirements of Intent-Based Network for network evolution".
- L. Pang, C. Yang, *et.al*, "A Survey on Intent-Driven Networks," in *IEEE Access*, vol. 8, pp. 22862-22873, 2020.

# Collaborations among Academics, SDOs and ONAP

**Academics**

IEEE
- A Survey on Intent-Driven Networks
- A Brief Survey and Implementation on Refinement for Intent-Driven Networking

**Academic exchanges**

**Open-source**

ONAP
OPEN NETWORK AUTOMATION PLATFORM

**Align with Multi-SDO**

**SDOs**

**IETF/IRTF:**
- Intent-Based Networking - Concepts and Definitions
- Intent Classification

**ETSI ZSM/ENI:**
- ZSM 011 Intent-driven autonomous networks; Generic aspects
- ENI 008 InTent Aware Network Autonomicity (ITANA)

**TMF:**
- IG1234 Intent Oriented Customer Engagement (IoCE) Guide
- IG1253 Intent in Autonomous Networks

**3GPP SA5:**
- TS 28.312 Intent driven management services for mobile networks
- TR 28.812 Study on scenarios for Intent driven management services for mobile networks

**ITU-T:**
- Scenarios and Requirements of Intent-Based Network for network evolution
- functional architecture of NGN evolution by adoption of Intent-Based Network

**CCSA:**
- 2015B58 Network Intelligent Capability Enhancement for SDN/NFV: Study of Key Technologies of Intent Network

## Autonomous Networks Multi-SDO Initiative

**Who we are**

| SDO | Group/Project | SDO | Role |
|---|---|---|---|
| 3GPP | SA5 | IETF | WG on AN |
| CCSA | TC7 | ITU-T | FG-AN |
| ETSI | ENI, F5G, MEC, NFV, PDL, TC INT/AFI, ZSM | Linux Foundation* | ONAP |
| GSMA | Future Networks | NGMN | Automation |
| IEEE | Future Networks | TM Forum | AN Project |

*Open Source Community

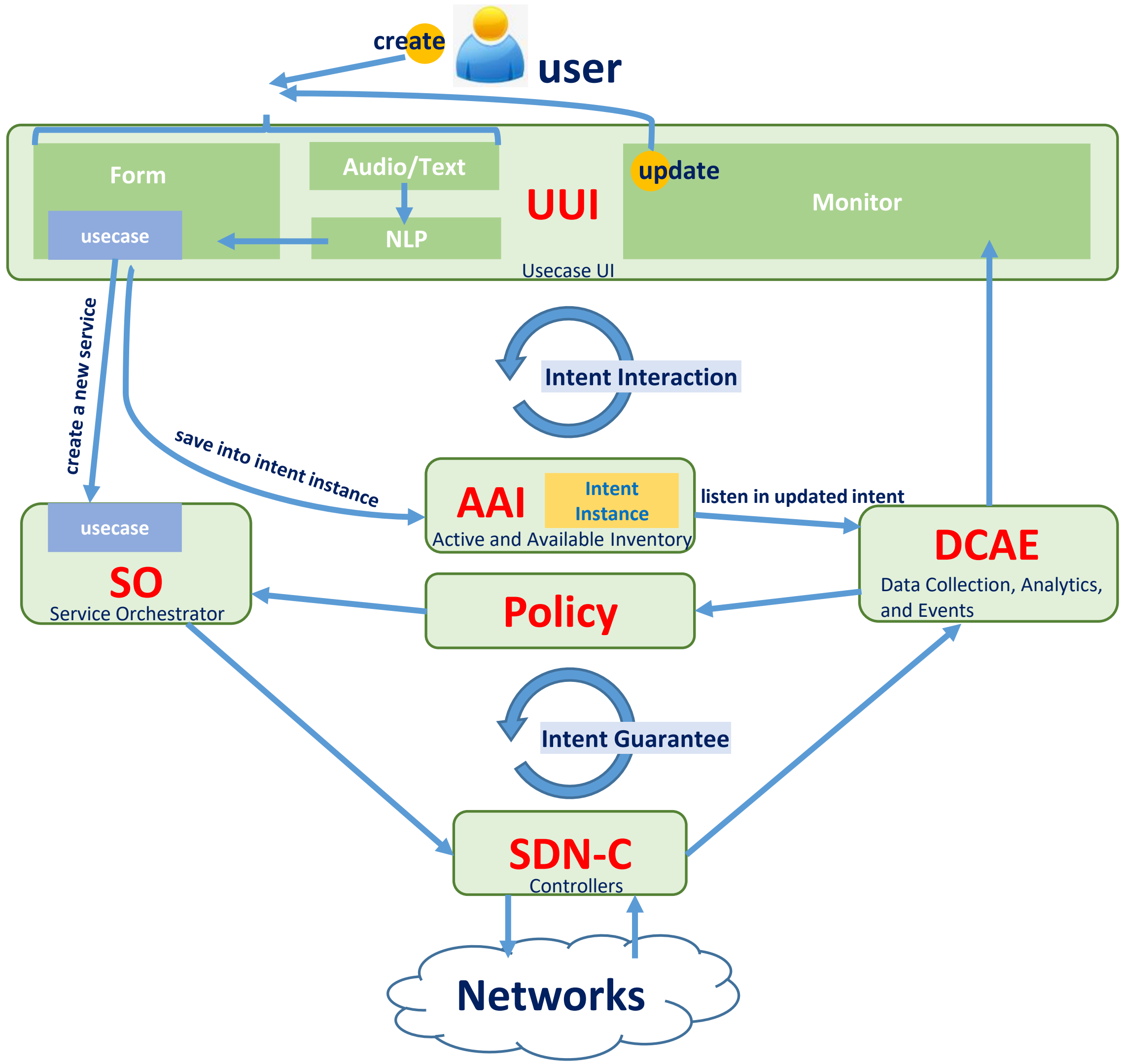
# Architecture of Intent-driven Closed-loop Autonomous Networks based on ONAP Projects

## Key Functions and Developments of Intent-based Networking in ONAP:

- ✓ **REQ-453/ONAPARC-641** Smart Operator Intent Translation in UUI based on IBN - R8 5G Slicing Support
- ✓ **REQ-861/ONAPARC-701** Smart Intent Guarantee based on IBN - R9 Intent Instance
- ✓ **REQ-1074/ONAPARC-729** Smart Intent Guarantee based on Closed-loop in R10
- ✓ **REQ-1075/ONAPARC-730** Network Services without Perception for Users based on IBN
- ➢ Maintenance and Enhancement of Intent-driven Closed-loop Autonomous Networks in R11

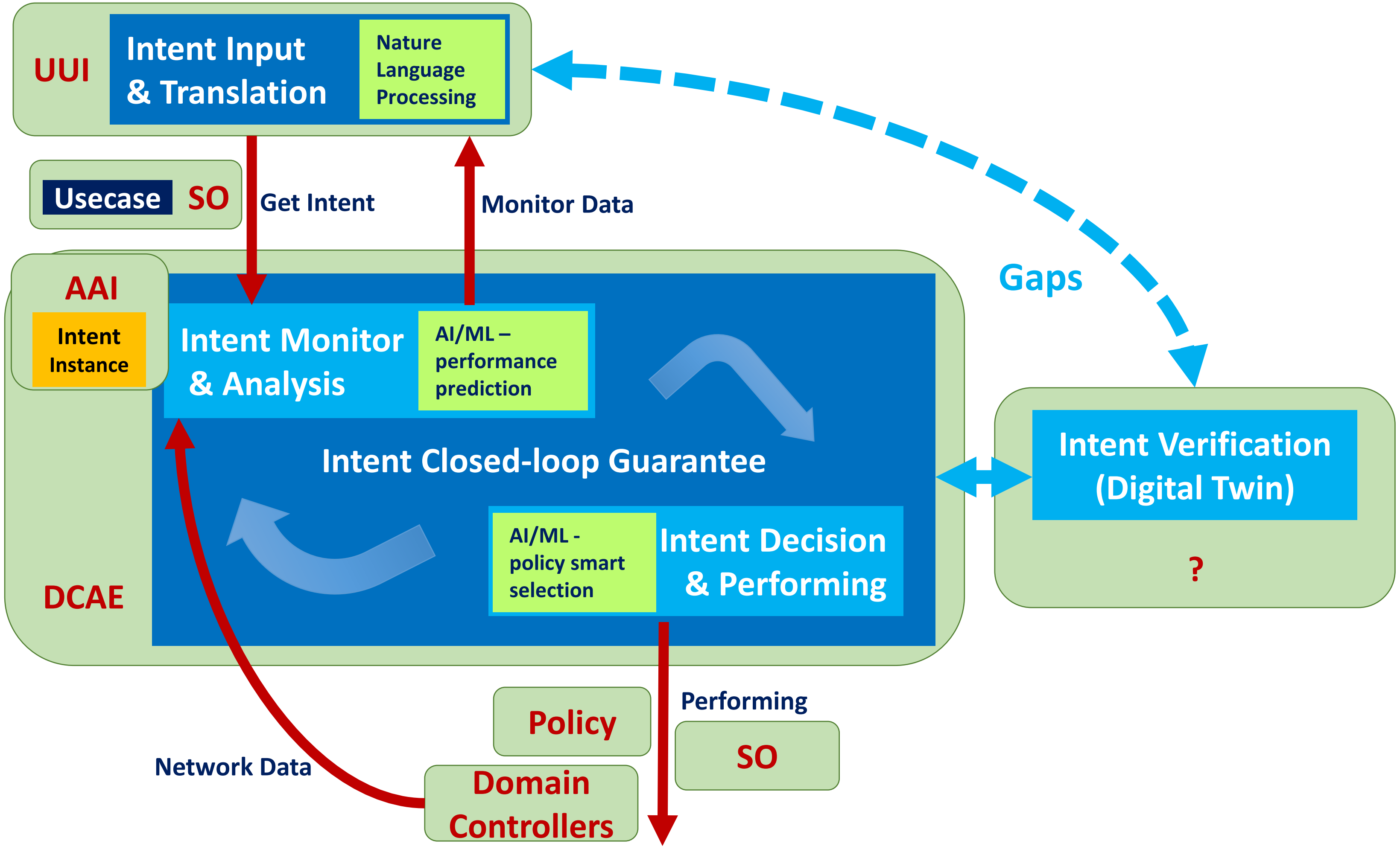
## Collaborations and Outputs with SDOs (ETSI ZSM / ITU-T):

- ✓ **ETSI ZSM PoC 003**: Automation of Intent-based cloud leased line service
- ✓ **ITU-T**: Scenarios and Requirements of Intent-Based Network for network evolution; functional architecture of NGN evolution by adoption of Intent-Based Network; signalling architecture of Intent-Based Network for network evolution




**Architecture of Intent-driven Closed-loop Autonomous Networks**

# Enable AI/ML for Intent-driven Autonomous Networks in ONAP




AI/ML Abilities for Intent-driven Autonomous Networks in ONAP

## Key Features

### AI/ML Algorithms

- ☐ Nature Language Processing
- ☐ STT (Speech to Text)
- ■ Prediction
- ■ Decision-making

### AI/ML Frameworks

- ➢ TenserFlow
- ➢ PyTorch

### AI/ML Platform

- ✓ Acumos AI

https://www.acumos.org/

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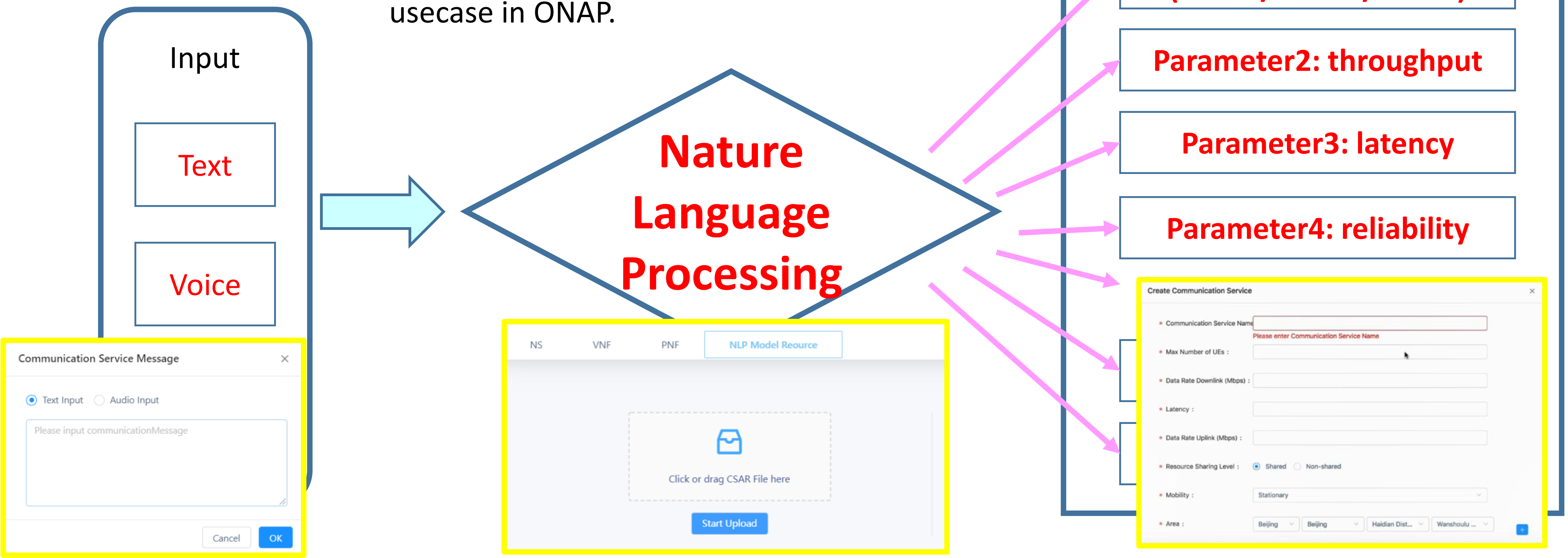
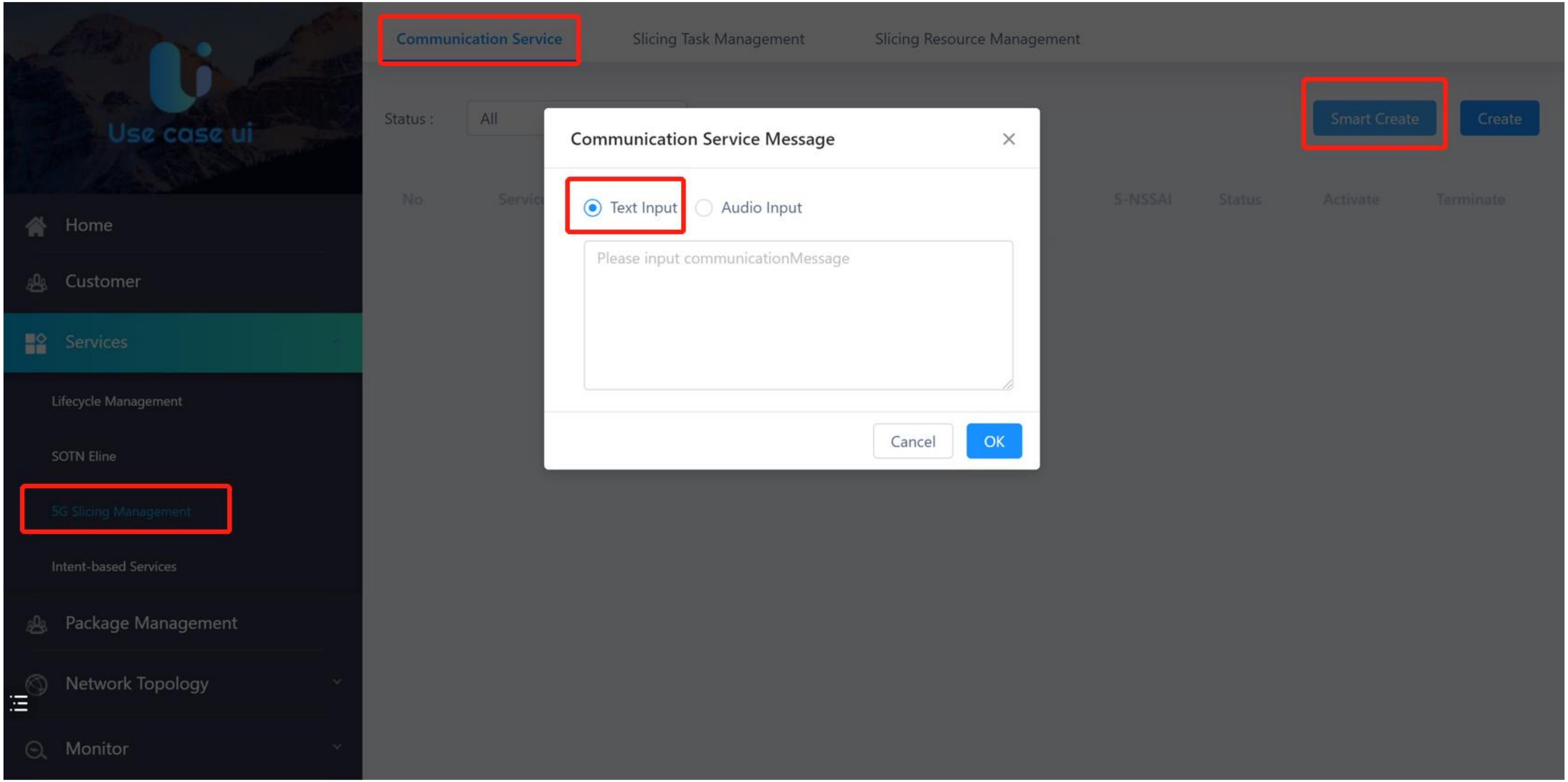
# 2.1-1 Intent Translation in UUI for E2E Slicing (R8)

## UUI

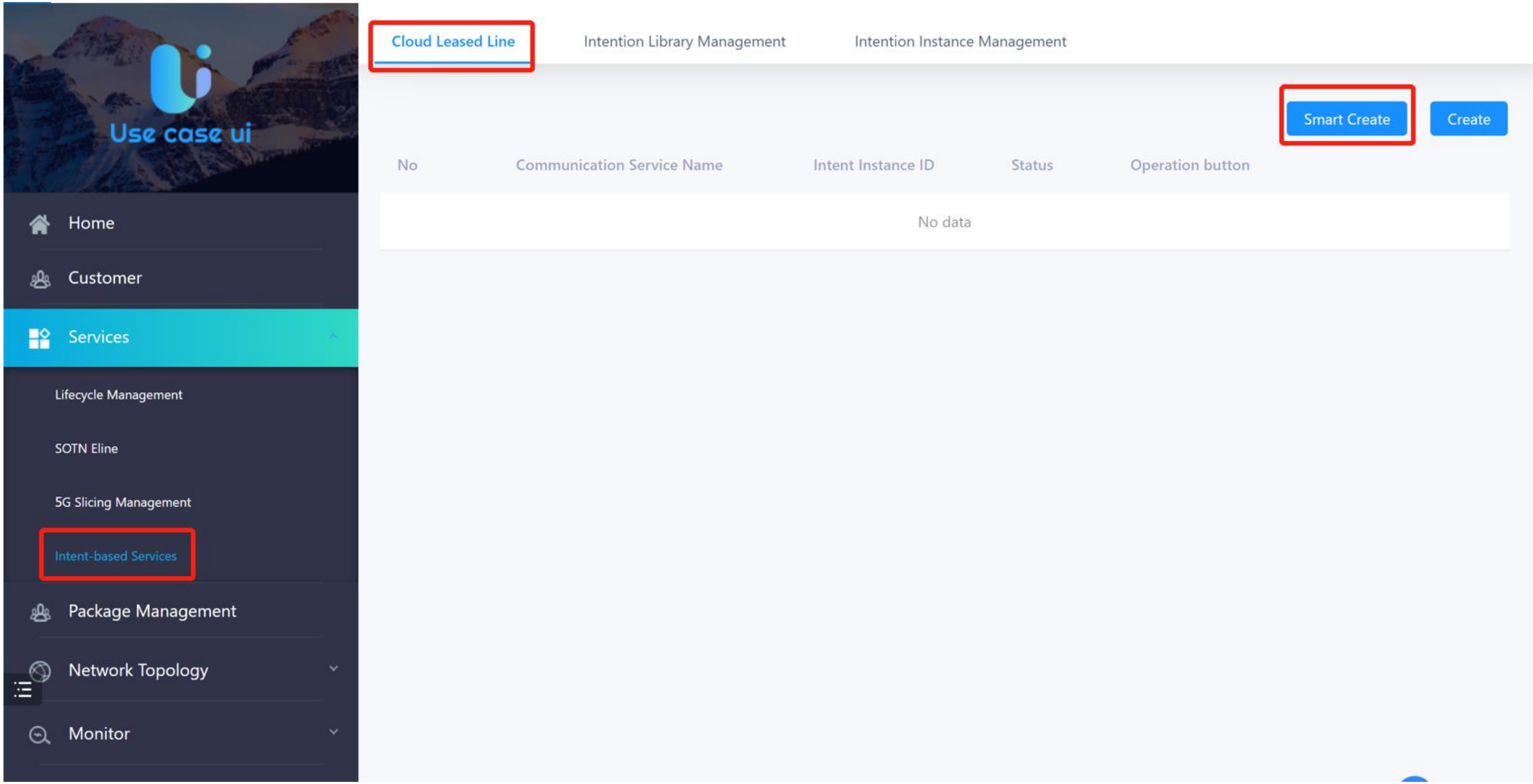
Target of R8: translate from human inputs to slice parameters based on NLP in UUI, and then run the E2E slicing usecase in ONAP.



# 2.1-2 Screenshot of Smart Create for E2E Slicing (R8)



# 2.1-3 Screenshot of Smart Create for CCVPN (R9)

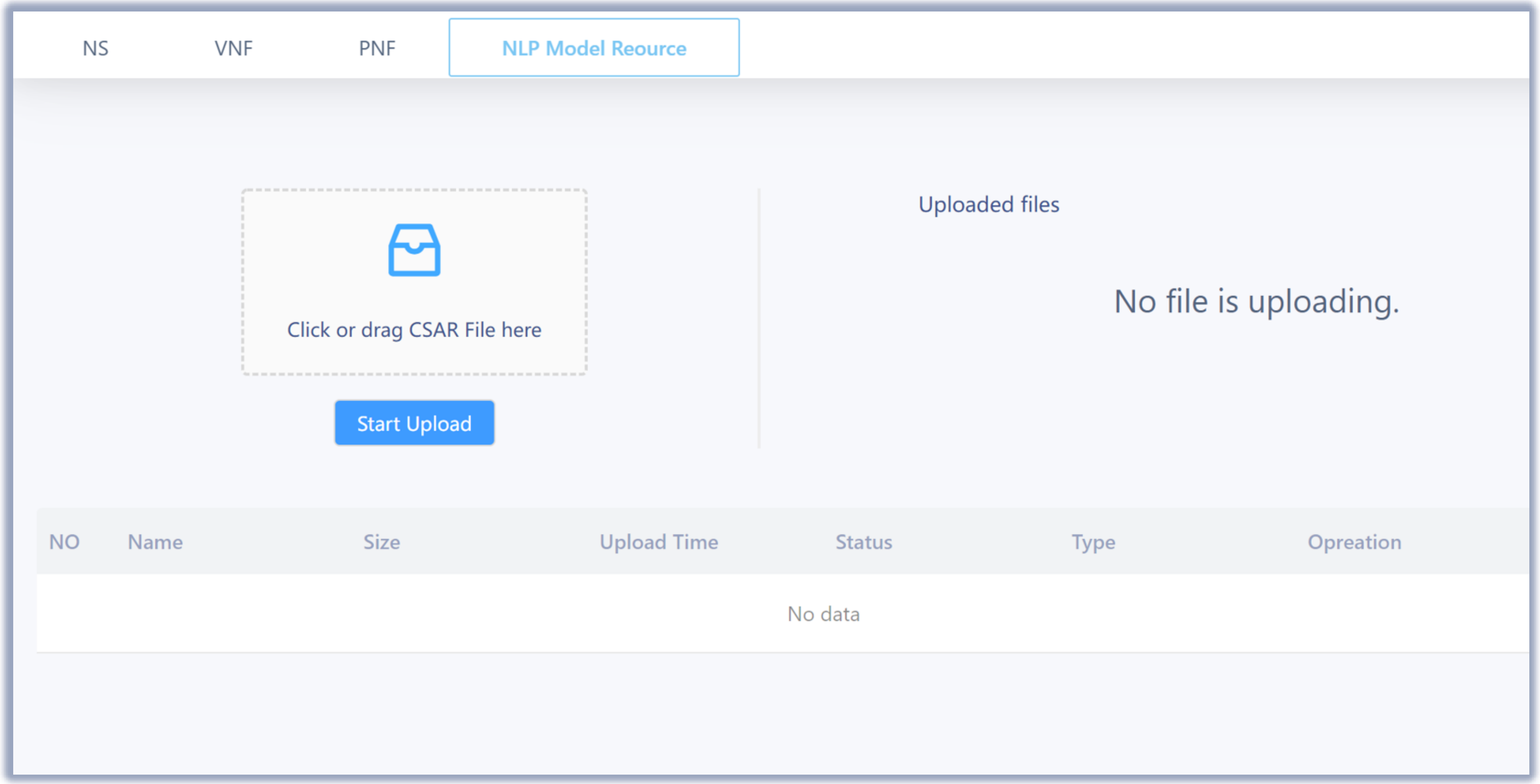


# 2.1-4 NLP Model Management (R8-R9)

**Key Features**

**NLP Model Management**

- ☐ Upload model
- ☐ Delete model
- ☐ Active/Inactive model
- ■ Select model for different usecases in same AI framework and microservice

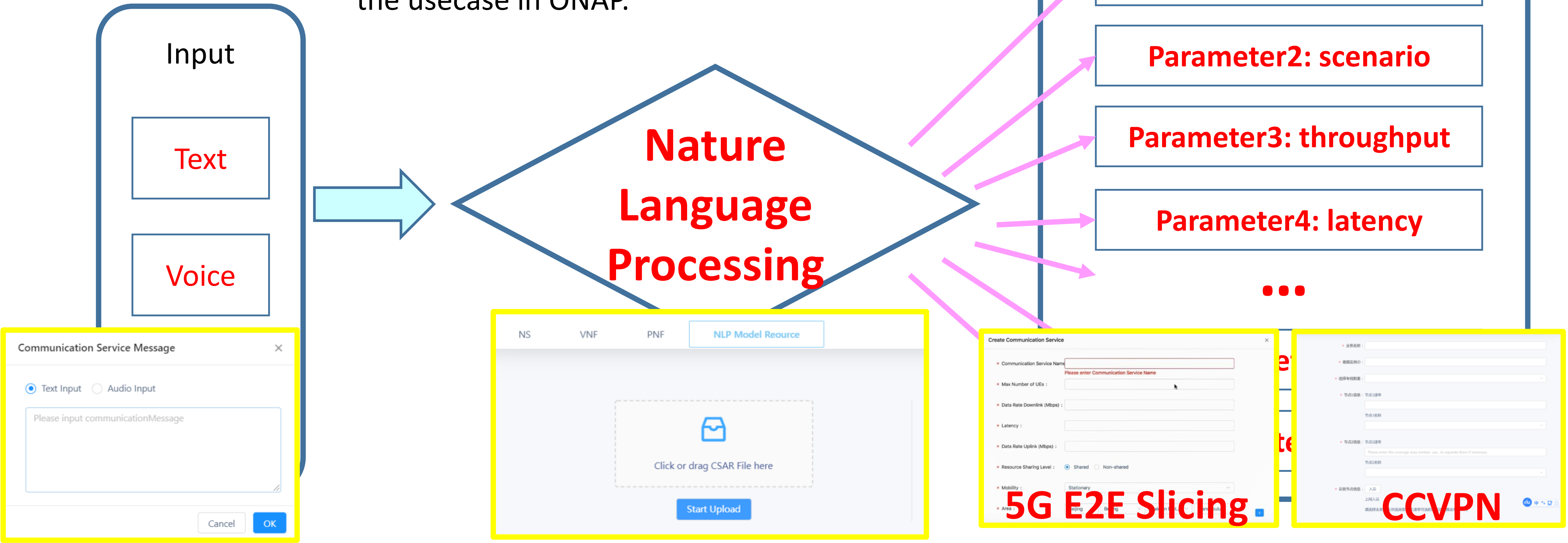



**Screenshot of NLP Model Management**

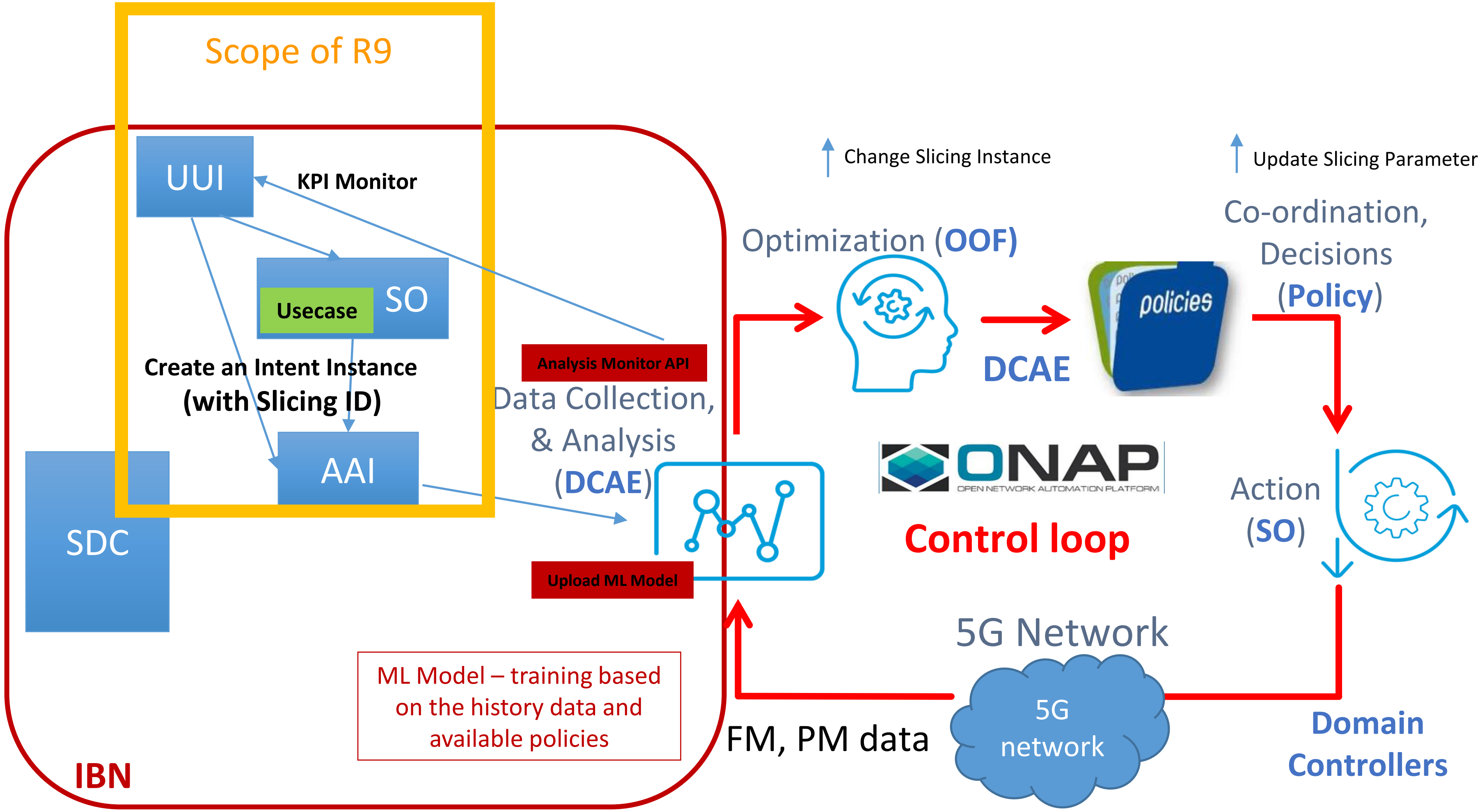
# 2.1-5 Network Services without Perception for Users (R10)

## UUI

Target: translate from human inputs to network parameters based on NLP in UUI, choose a suitable usecase and then run the usecase in ONAP.

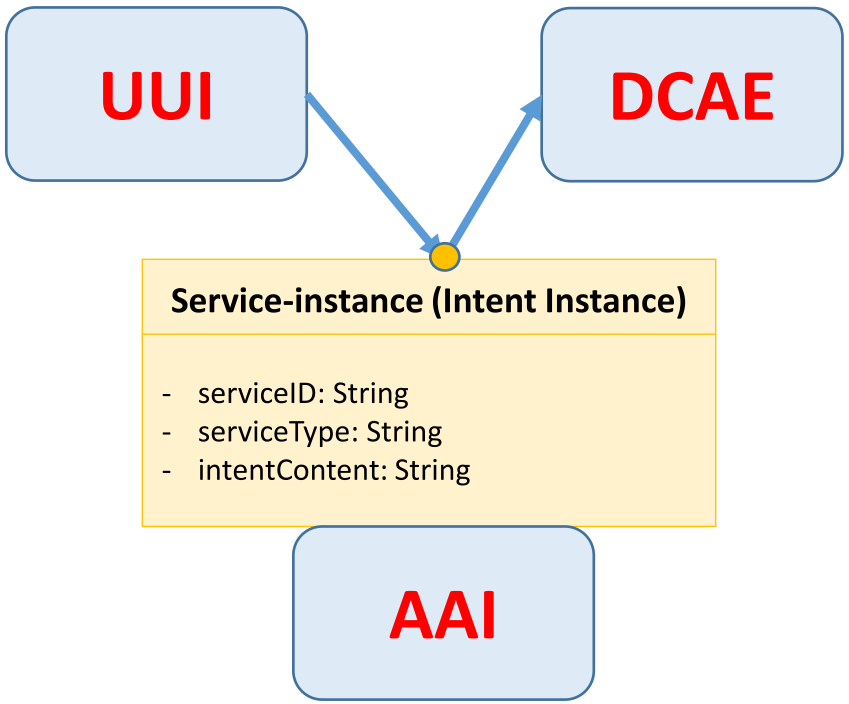


# 2.2-1 Intent-driving E2E Slicing Closed-loop (R9-R10)



# 2.2-2 Intent Instance in AAI (R9)

Functions: Intent Instance is created to save the users' **real-time intent** (network parameters) and connected service ID (CCVPN service ID / E2E Slicing CSI ID) in AAI.




serviceType: 'CCVPN', 'E2ESlicing'

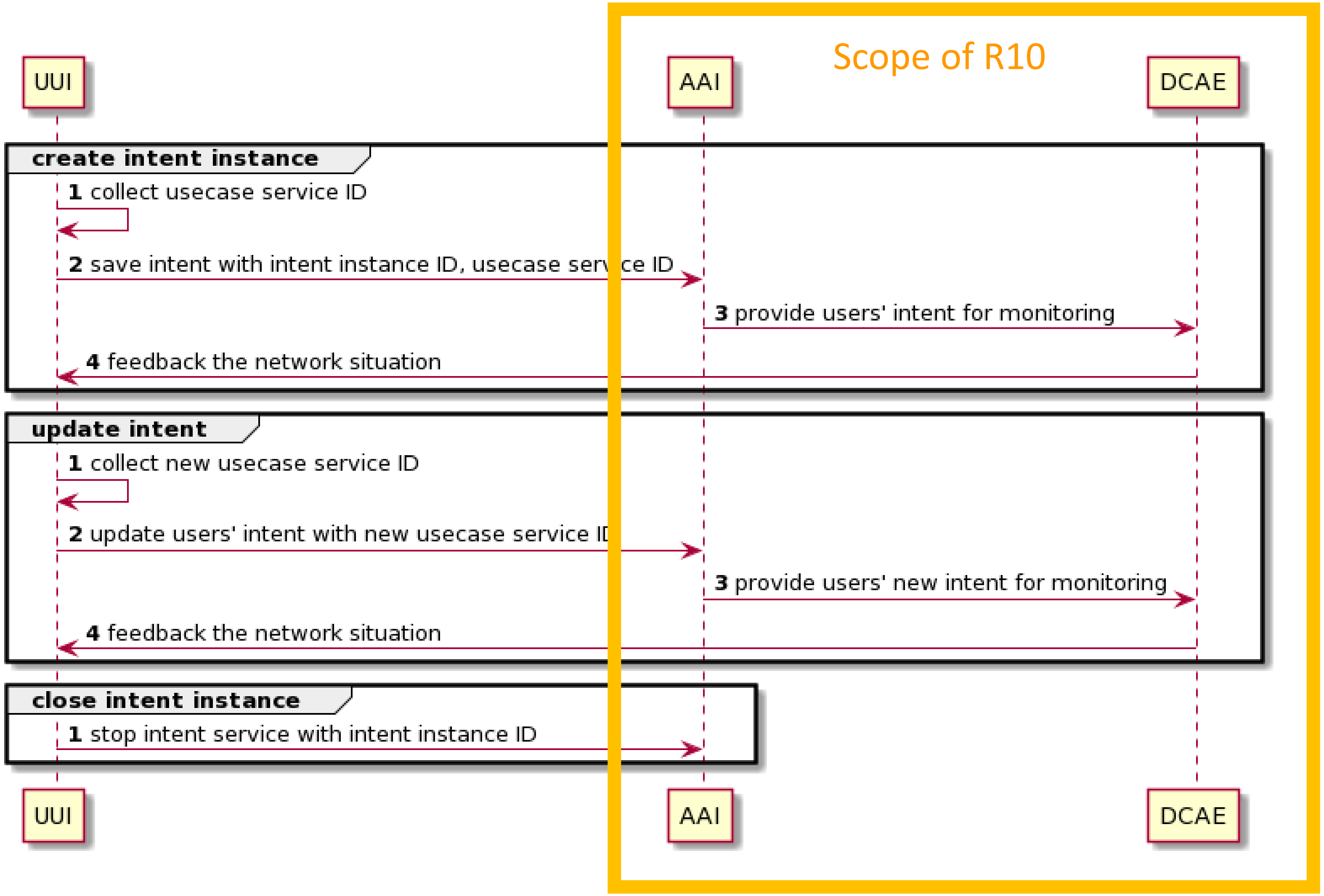
## Intent Instance Applied in AAI:

1. Intent Instance is created to save the users' real-time intent in Active and Available Inventory. The other records related to the intents are not real-time, which are saved in the independent database in UUI, and will be saved in CPS in further releases.

2. The target of Intent-based Networking is to develop to support multiple usecase services, so it is not a sub-node of any usecase in AAI. And the IBN will be expect to provide network services without perception for users. Multiple usecase services could be changed by IBN instead of the users.

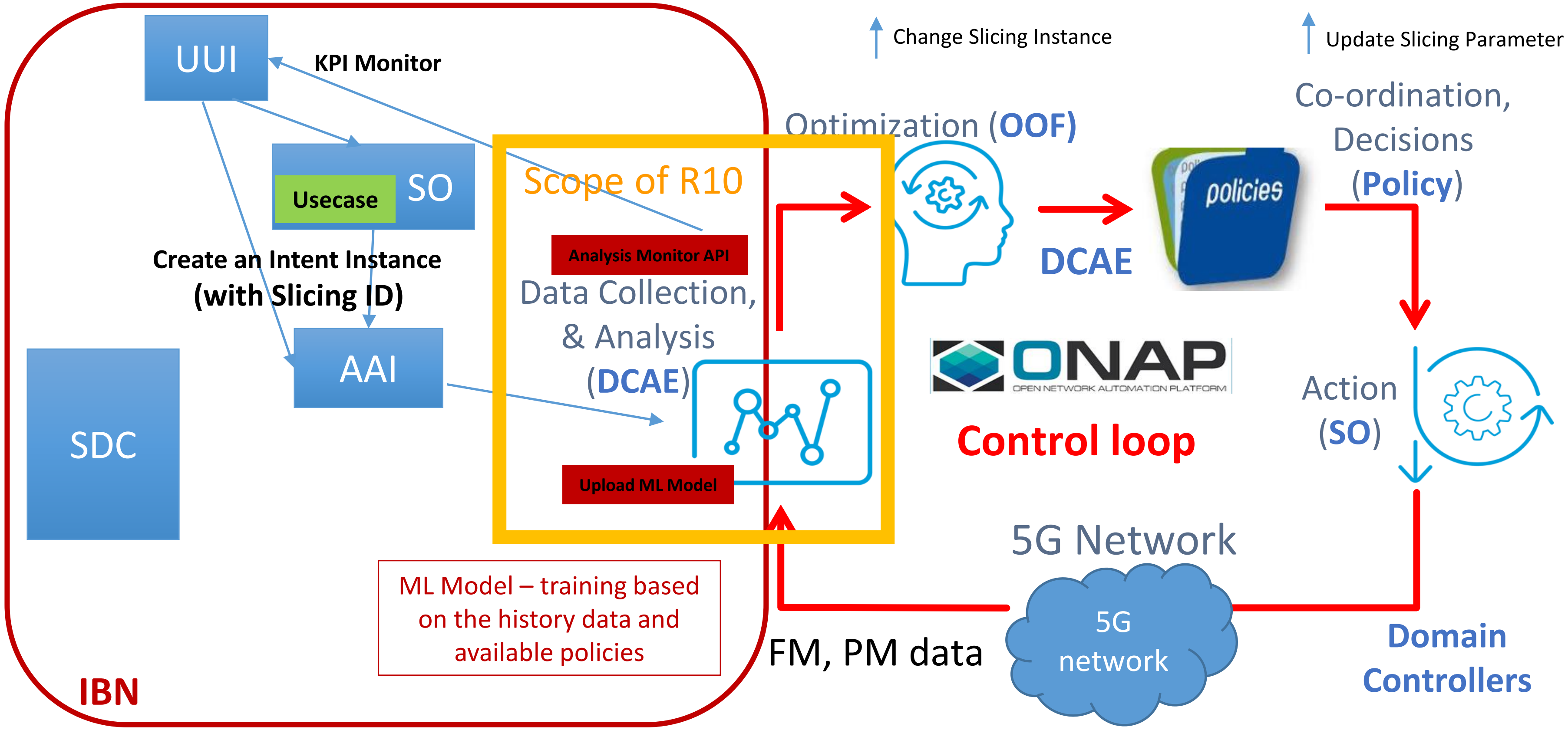
3. DCAE keeps calling the intent from AAI for monitoring.

# 2.2-3 Workflow of Intent Management (R9-R10)

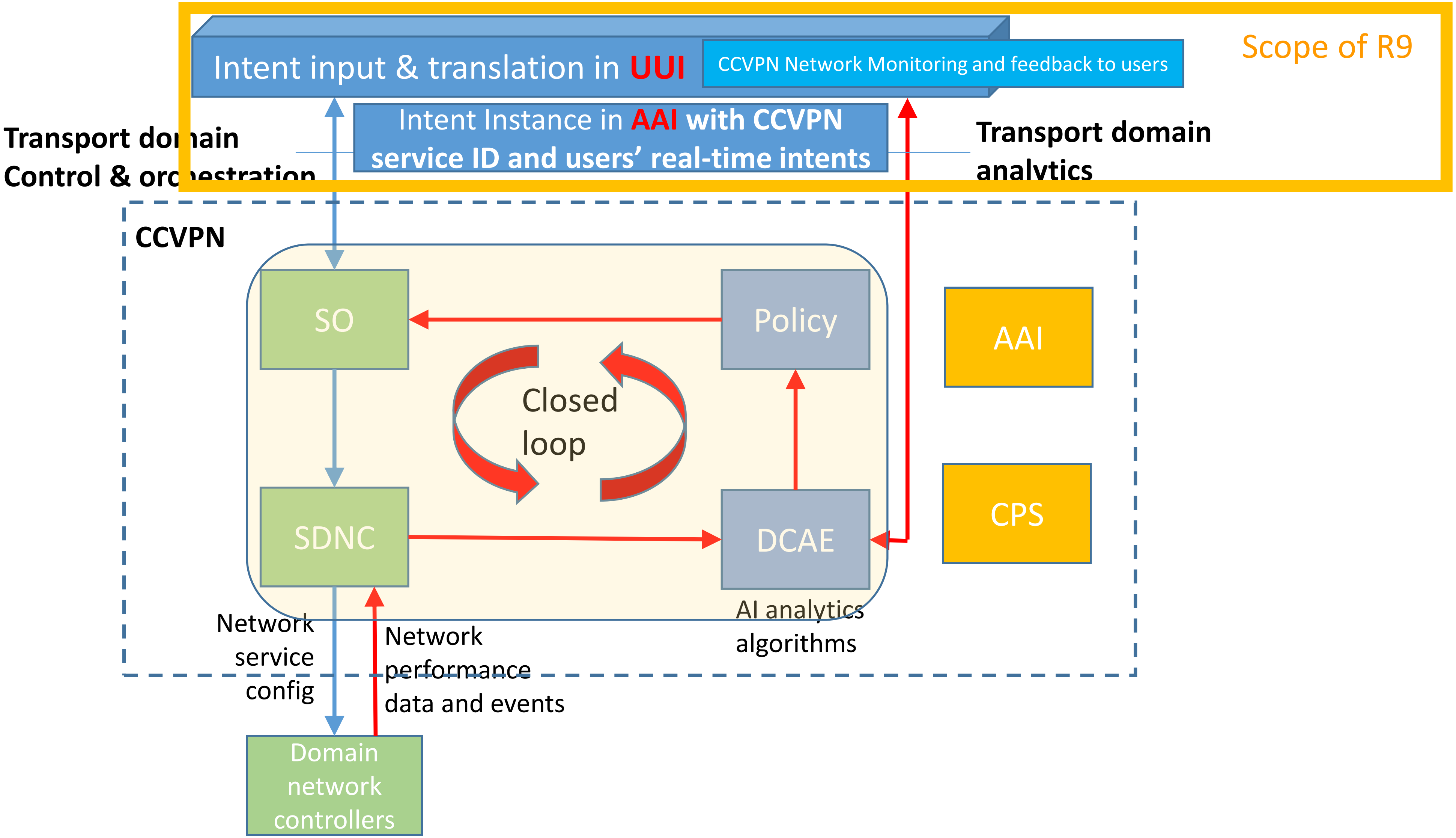



*1. A usecase service ID includes the service instance ID of CCVPN or CSI ID of E2E Slicing,  which is collected in UUI after creating a new service.

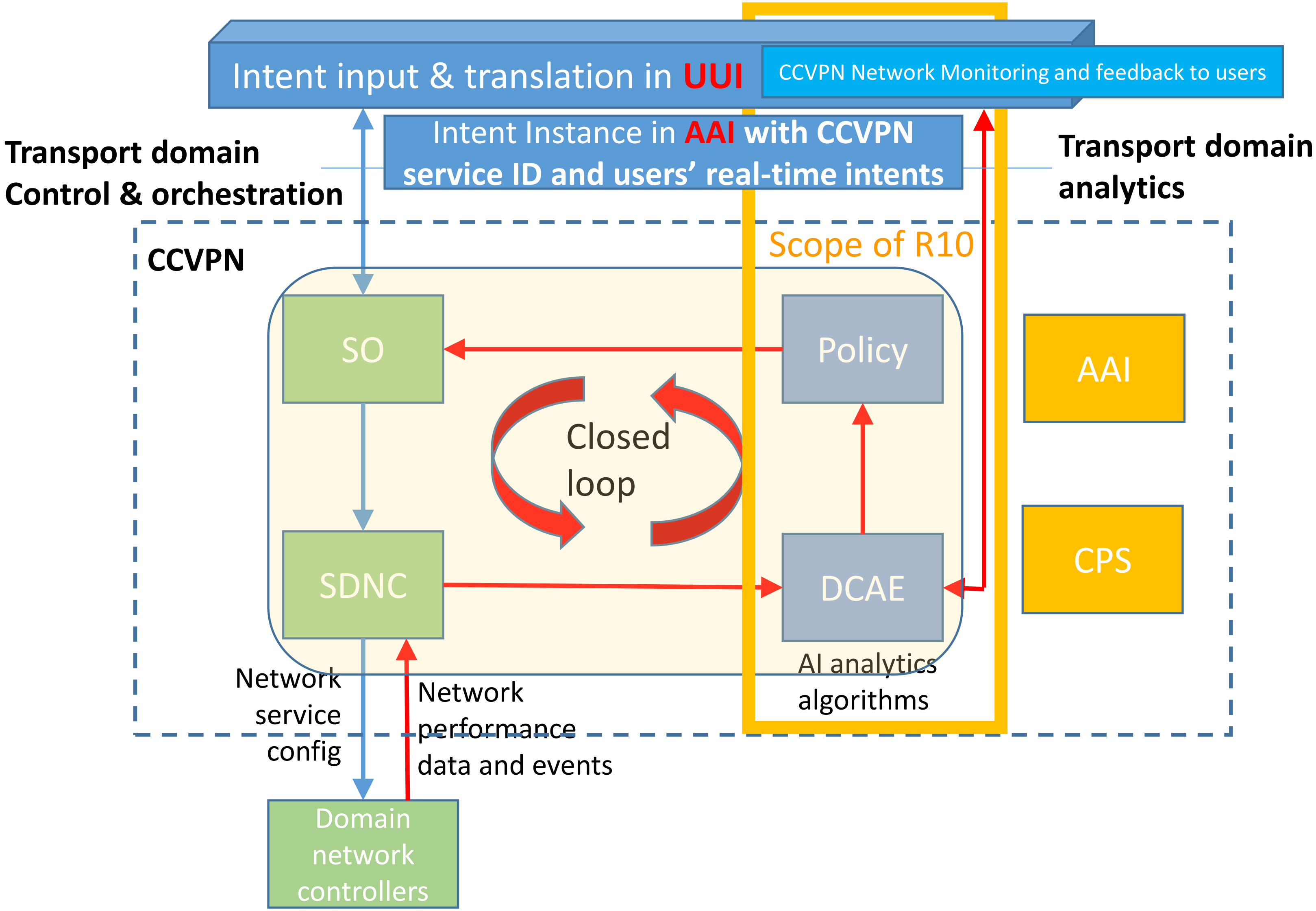
# 2.2-4 Smart Intent Guarantee by Closed-loop (R10)



# 2.3-1 Intent-driving CCVPN Closed-loop (R9 - Intent Instance)



# 2.3-2 Intent-driving CCVPN Closed-loop (R10 - Intent Guarantee)



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1 Overview of Intent-based Networking

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# 3. Scope of R11: Maintenance and Enhancement

- Maintain the **documentation** of Intent-driving Autonomous Networks
- Maintain the support of **CCVPN** usecase for ETSI ZSM PoC demo
- Enhance **NLP** platform and model
- Enhance the support of **E2E Slicing** usecase
- **Scene-based** end-to-end test and demo: Smart Energy Industry

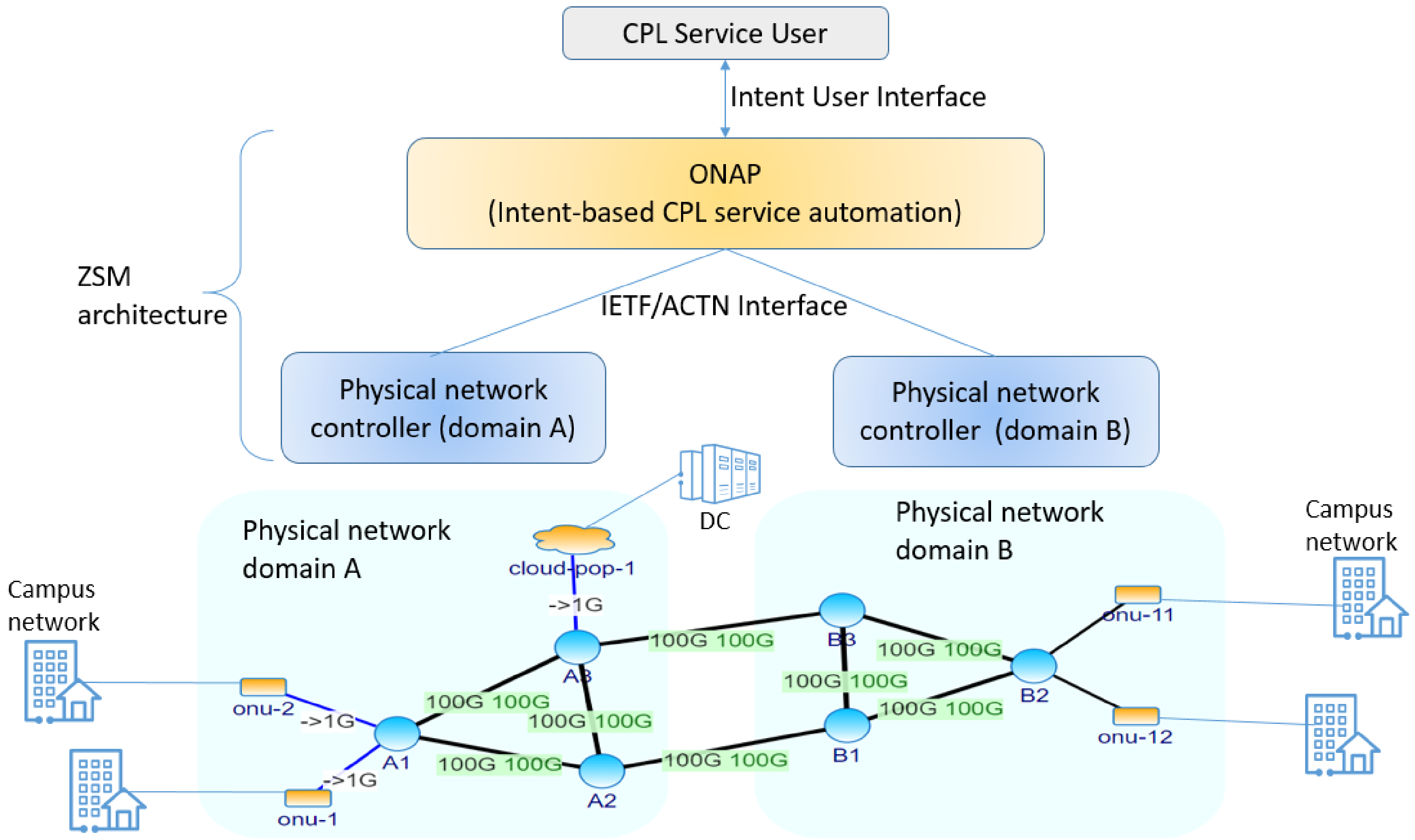
# 3.1 Documentation

**Maintain and update the documentation of full functions for user and developer guides in wiki and docs.**

## Contents

### Intent-driven Closed-loop Autonomous Networks

# 3.2 Support the demo: Automation of Intent-based cloud leased line service




ETSI ZSM PoC 003: Automation of Intent-based cloud leased line service

# ZSM PoC#3 Milestones



| Milestone | Date |
|---|---|
| **PoC project start** | Jan 2022 |
| **Demo 1**: Automated CLL service creation, modification and deletion (simulated hardware) | May 2022 (ZSM#19 tbc) |
| **Demo 2**: Closed-loop operations for CLL service assurance (simulated hardware) | May 2022 (ZSM#19 tbc) |
| **Interim report**: Contribution on lessons learned from Demo 1 & 2, and how to improve Demo 3 | July 2022 |
| **Demo 3**: CLL service automation and closed-loop operations with real hardware and real data traffic | Nov 2022 |
| **Final report**: Contribution on lessons learned from the PoC | Dec 2022 |
| **PoC project end** | Dec 2022 |

**ZSM PoC#3 Team Members**

China Telecom

China Mobile

China Unicom

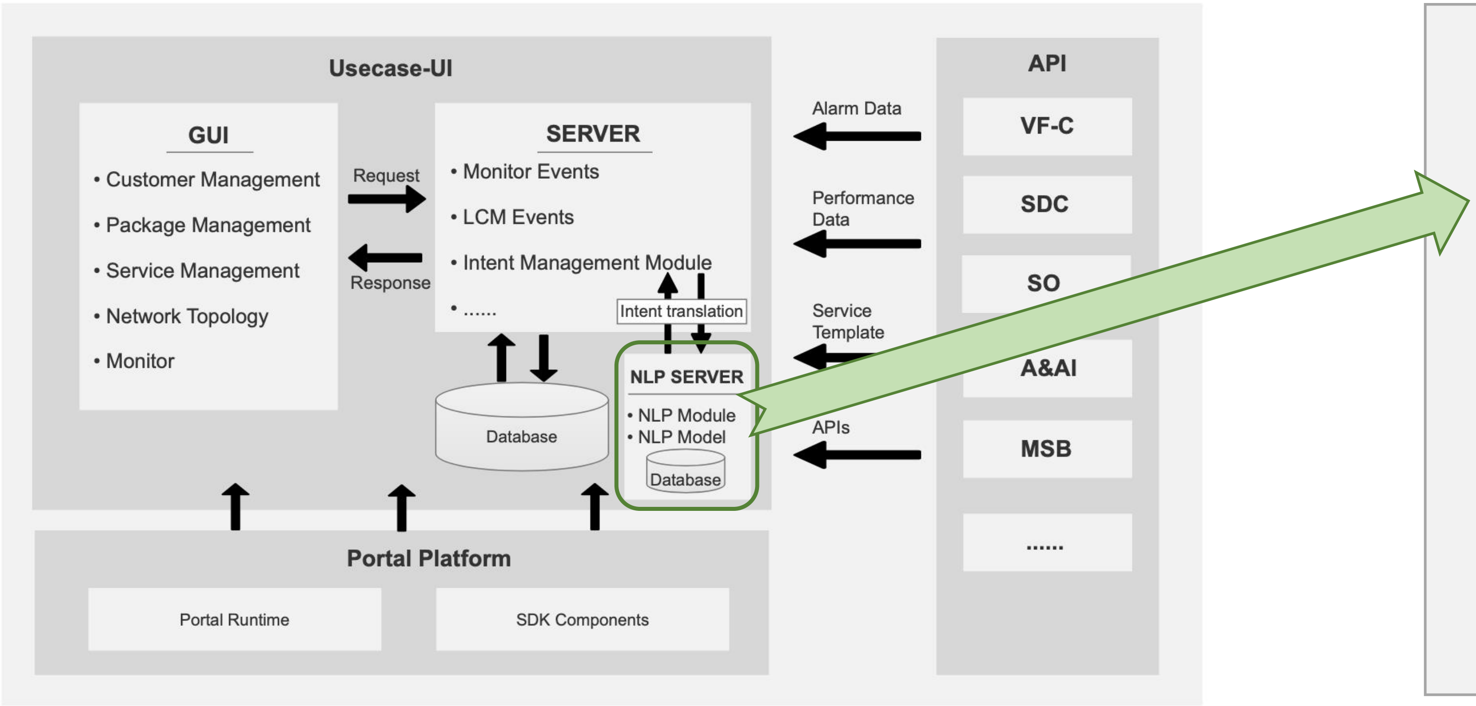
Huawei Technologies

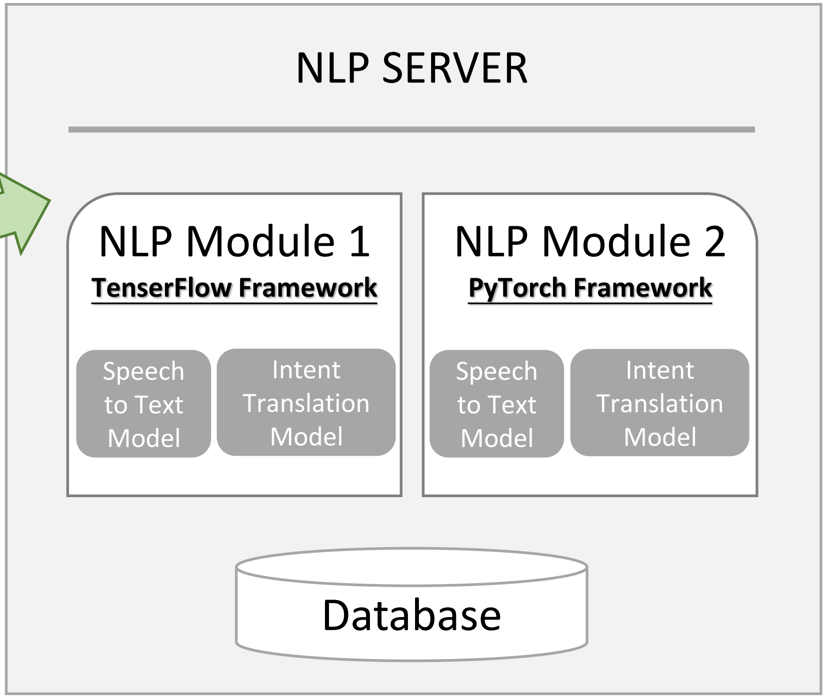
AsiaInfo Technologies

Xidian University

# 3.3 Enhancement of NLP platform and model in UUI

- **Task 1: Add PyTorch framework to support more models (TenserFlow framework has been added since Honolulu Release).**
- **Task 2: Improve the accuracy rate of intent translation with multiple models.**
- **Task 3: Enhance the function of STT (speech to text).**



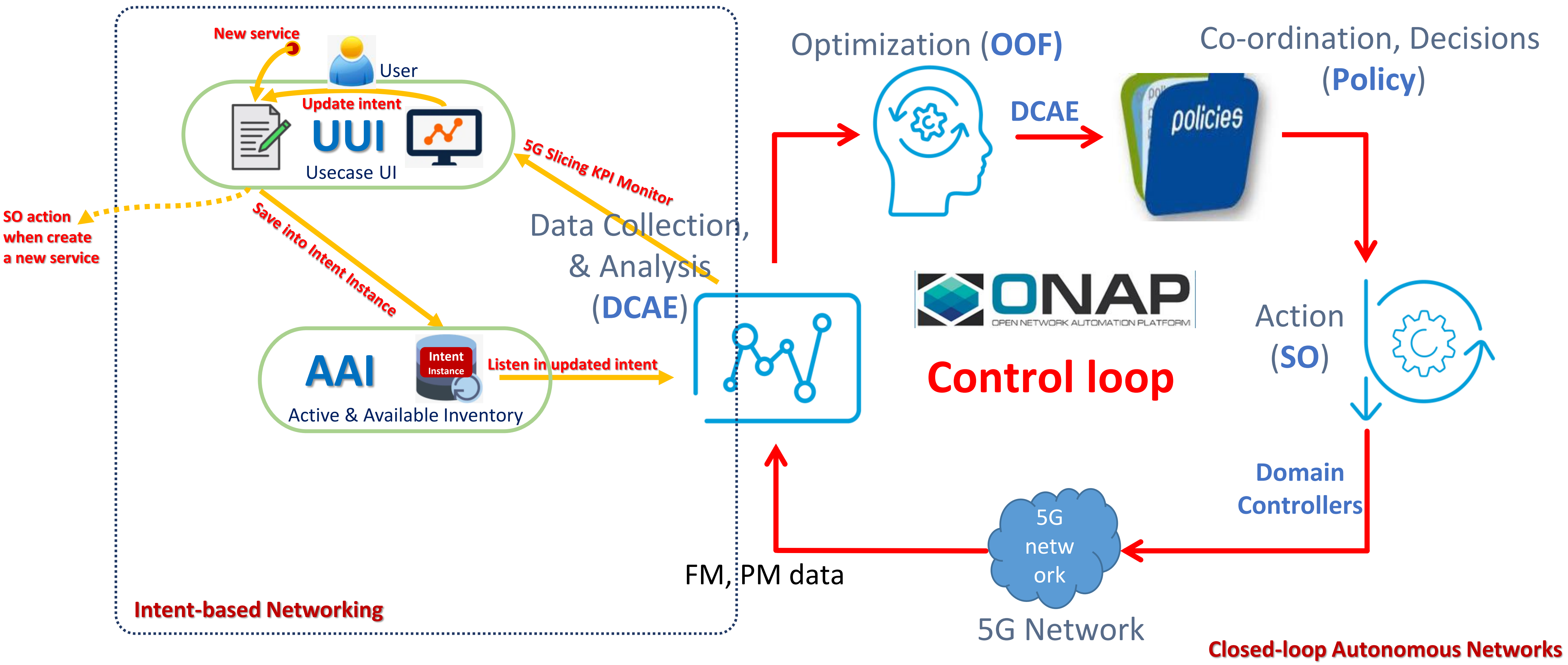

**Components of UUI since Honolulu Release**

**Enhancement of NLP microservice in UUI**



**Acknowledgement:** This work is supervised by the research team of GUIDE (Game, Utility, artificial Intelligent Design for Emerging Communications) in Xidian University.

# 3.4 Intent-driving E2E Slicing usecase



# E2E Network Slicing Meeting (Apr 12, 2022)

**Discussion on joint work proposal (IBN, CCVPN and NS)**

- Introduction of ML prediction MS
- Introduction of workflow and API of intent interaction
- Introduction of Intent-driven Closed-loop Autonomous Networks in R11
- Intent-driven E2E Network Slicing proposal with key tasks:
  - Integration of ML prediction MS with DCAE (IBN and network slicing teams)
  - Enhancement to intent creation and workflow to support E2E Network Slicing based on UUI, AAI and DCAE (IBN team)
  - Enhancement to the closed-loop and the ML prediction MS for 5G KPI monitoring to support IBN (NS team)

https://wiki.onap.org/display/DW/E2E+Network+Slicing+Meeting+Notes+for+Apr+12%2C+2022

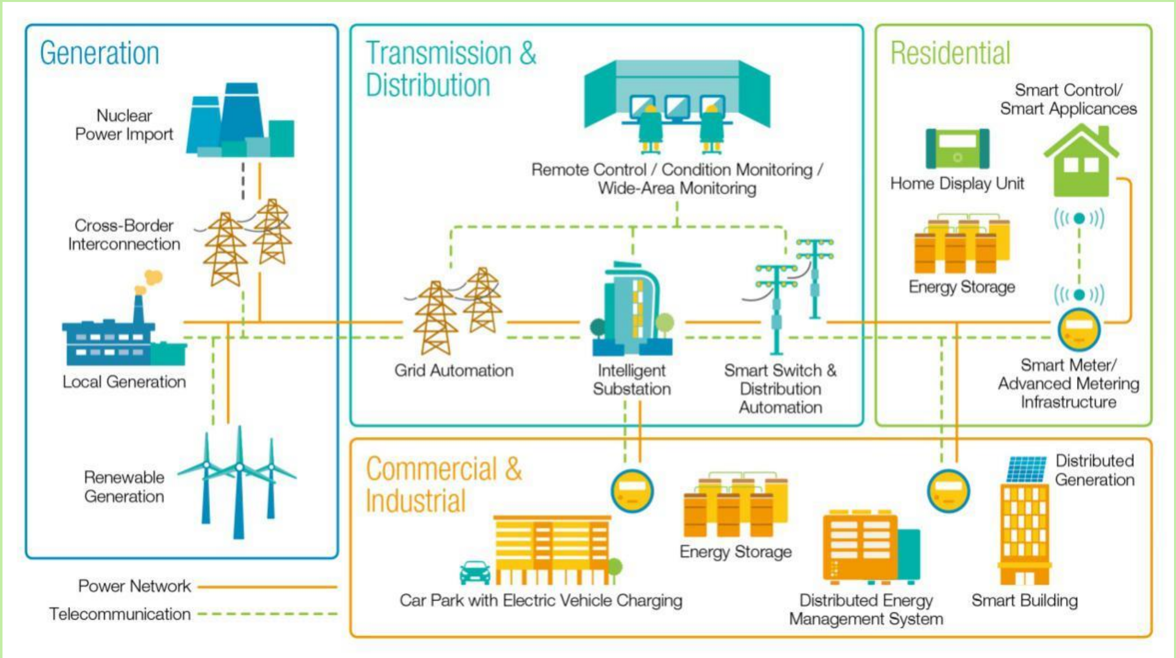
# 3.5 Application Scene: Smart Energy

An application scene, **Smart Energy**, is chosen for the end-to-end test and demo of intent-driven on-demand services based on fixed and mobile networks:

- ✓ Fixed Networks - CCVPN (Cloud leased line)
- ✓ Mobile Networks - 5G E2E Slicing

## A Vision of Smart Energy

**Ref. 3GPP TR 22.867 Study on 5G Smart Energy and Infrastructure**




## Network Performance KPIs of Smart Energy and Infrastructure

**Table 7.2-3 Clock Synchronization Service Performance Requirements**

| Use case | User-specific clock synchronicity accuracy level [65] | Number of devices in one Communication group for clock synchronisation | Clock synchronicity requirement | Service area | 5GS synchronicity budget requirement |
|---|---|---|---|---|---|
| 5.3 Distributed Feeder Automation | - | 54/km² (note 1) 78/km2 (note 2) | - | several km² | <10 µs |
| | | | | | ≤ 10 µs |
| | | | | | - |

**Table 7.2-2 KPI Table of Aperiodic Communication Services**

| ...liability | Storage node density # /km2 (note 2) |
|---|---|
| >99.90% | >[x]*100 |
| ...99% | |
| | - |
| | - |

### 7.2 Consolidated potential KPIs

**Table 7.2-1 KPI Table of Periodic Communication Services**

| Use case | Experienced data rate | availability | Transfer interval: target value | Message size | Service area | Max Allowed End-to-End latency | density |
|---|---|---|---|---|---|---|---|
| 5.1 Distributed Energy Storage - monitoring | UL: > 16 Mbit/s (urban), 640 Mbit/s (rural) DL: > 100 kbit/s (note 1) | DL: >99.90 % | UL: 10 ms | UL: 50 x 16 kbyte | - | DL:<10 ms UL:<10 ms | >10 /km2 (urban), >100 /km 2 (rural) (storage node density, note 2) |
| 5.1 Distributed Energy - Storage Data collection | UL: > 128 kbit/s (urban), 10.4 Mbit/s (rural) DL: > 100 kbit/s (note 1) | DL: >99.90 % | UL: 1000 ms | UL: 50 x 26 kbyte DL: >100 kbyte | - | DL:<10 ms UL:<1000 ms | >10 /km2 (urban), >[100 /km 2 (rural) (storage node density, note 2) |
| 5.2 advanced metering | UL:<2 Mbit/s DL:<1 Mbit/s | >99.99% | - | - | - | General information data collection: <3000 ms (note 3) | <10000/km² (connection density, note 4) |
| 5.3 Distributed Feeder Automation | 2 Mbit/s to 10 Mbit/s | 99.999% | Normal:-1s; Fault:2ms - | - | - | <10 ms (see note 6)- Latency jitter <50 µs (note 5) | 54/km² (see note 7) 78/km² (connection density, note 8) |
| **5.5** Distribution Automation (DA), centralized architecture | 9.6-100 kbit/s | 99.999% | - | - | - | 100 ms – 2 s | 100/km² concentrated rural, 10/km² semi-urban |

# 3.5 Application Scene: Smart Energy

An application scene, **Smart Energy**, is chosen for the end-to-end test and demo of intent-driven on-demand services based on fixed and mobile networks:

- ✓ Fixed Networks - CCVPN (Cloud leased line)
- ✓ Mobile Networks - 5G E2E Slicing

A story is provided for end-to-end test and demo:

An energy company opened a Cloud leased line (fixed network) and a 5G leased line (mobile network) to support its business. The cloud leased line could provide high bandwidth and high reliability. And the 5G leased line provides high mobility. For user's  intent-driven on-demand services in future networks, if the user want to start a new service (like virtual meeting), he just need to say 'I need the service for virtual meeting', and the intent-based networking could prefer to choose the CCVPN (Cloud leased line) for his service with high bandwidth and high reliability. If the user is moving, a high reliability and suitable bandwidth 5G slicing is chosen for the service. Moreover, the closed-loop autonomous networks provides closed-loop intent guarantee by keeping monitoring the network and updating the policies.

In order to support the above story, dataset and business survey are required for ML training and business analysis:

a. A dataset of users' service intents is required for training NLP model to support intent translation function.

b. Business survey and analysis is used to configure pre-defined Cloud leased line templates and 5G Slicing templates for a specialized industry (like smart energy).

This sub-REQ focuses on the solution of the above story.

# REQ-XXXX: Maintenance and Enhancement of Intent-driven Closed-loop Autonomous Networks in R11

Intent-based networking is applied to support the smart interaction between users (customers/operators) and networks. Based on the closed-loop automation of ONAP, the proposal of **Intent-driven Closed-loop Autonomous Networks** is proposed for the smart operation of networks. In R11, the proposal enhances the functions of intent interaction and intent guarantee for CCVPN and E2E Slicing usecases.

**Key Contacts** - Dong Wang (China Telecom), Keguang He(CMCC), Henry Yu (Huawei), Ahila Pandaram (Wipro), Kevin Tang (STL)

**Executive Summary** - Intent-based networking (IBN) is a self-driving network that uses decoupling network control logic and closed-loop orchestration techniques to automate application intents. An IBN is an intelligent network, which can automatically convert, verify, deploy, configure, and optimize itself to achieve target network state according to the intent of the operators, and can automatically solve abnormal events to ensure the network reliability. In R11, the proposal enhances the functions of intent interaction and intent guarantee for CCVPN and E2E Slicing usecases.

**Business Impact** - It is a challenging problem for networks to satisfy users' intents in real time. The REQ intent-based networking provides intent interaction and guarantee functions for users.

**Business Markets** - This REQ provides a novel solution of Intent-driven Closed-loop Autonomous Networks with two closed-loops, intent interaction closed-loop and intent guarantee closed-loop. And intent instance is used to manage users' real-time intents.

**Funding/Financial Impacts** - Intent-based networking simplifies interaction and network configuration to save OPEX cost. It also provides the services to satisfy users' real-time intents, so as to increase the income of operators with few investments.

**Organization Mgmt, Sales Strategies** - *There is no additional organizational management or sales strategies for this requirement outside of a service providers "normal" ONAP deployment and its attendant organizational resources from a service provider.*

# Projects Impact

| Project | Impact | Notes |
|---|---|---|
| UUI | • Enhance the functions in NLP microservice;<br>• Enhance the STT and Intent Translation models;<br>• Support the intent management for E2E Slicing usecase. | |
| AAI | n/a | re-use the Intent Instance node |
| DCAE | • Integrate the ML MS for Closed-loop (PoC of E2E Slicing in R10);<br>• Add the function of listening in updated intent for E2E Slicing. | re-use the **AAI-EVENT** |
| Doc | • Maintain the documentation. | |

ONAP

OPEN NETWORK AUTOMATION PLATFORM

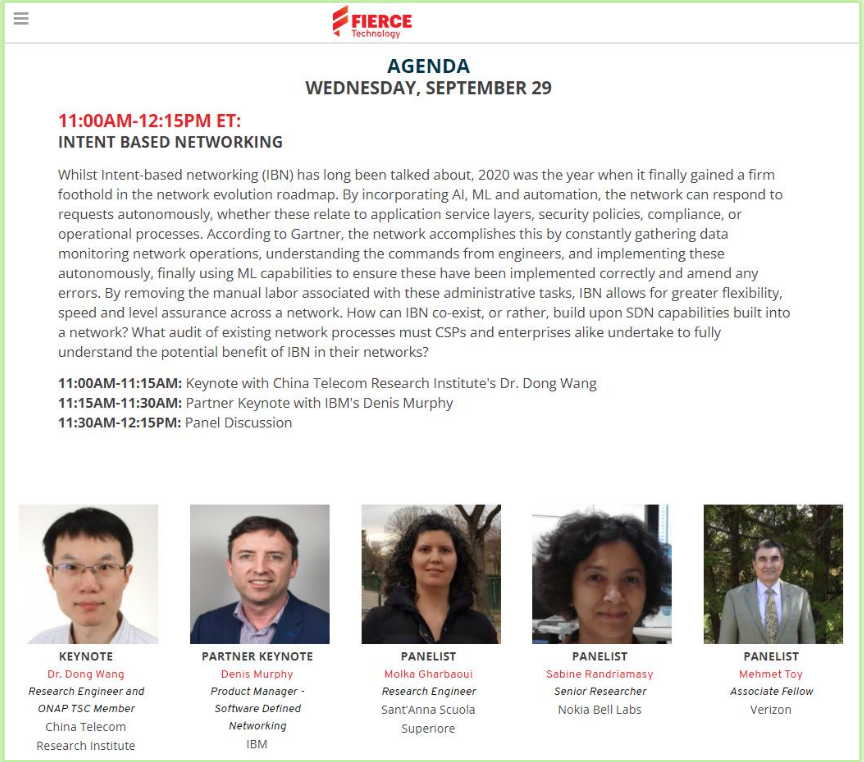
# Thanks!

# Influences

**Intent Based Networking. A major step towards autonomous networks, for operator and enterprise use cases.**

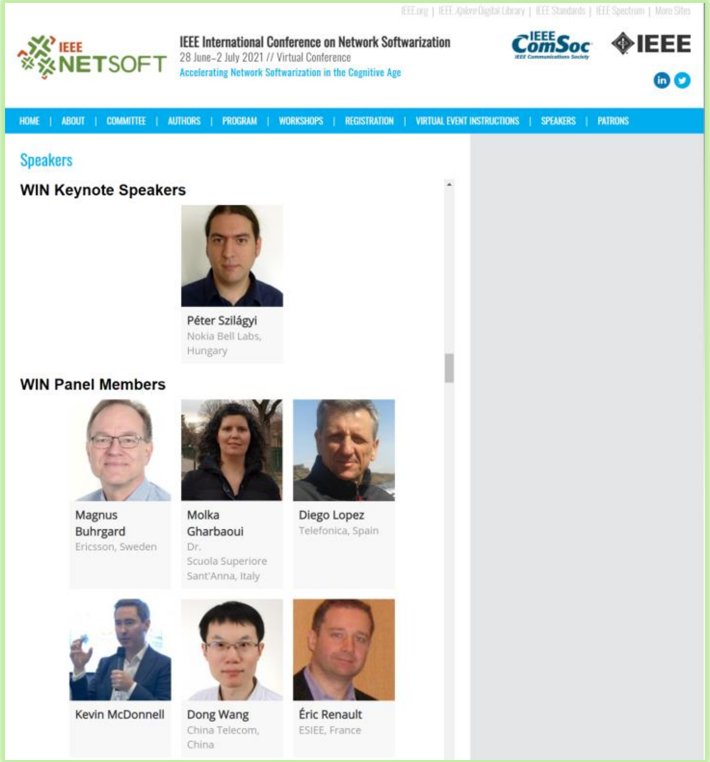
***ONAP Marketing Priorities 2021***


**ONAP Istanbul - Release Highlights**




**Fierce Wireless Presents: Network Automation Week**

https://www.fiercedigitaltechevents.com/fiercedigitaltechevent/network-automation-week




**International Workshop on Intent-Based Networking (WIN'2021)**

*In conjunction with IEEE Netsoft 2021*

http://www.adda-association.org/win-2021/Program.html