LF NETWORKING
Developer & Testing Forum

ONAP : AI-powered Closed-loop Autonomous Networks

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Zhen Li （China Telecom）
Henry Yu （Huawei）

https://lfnetworking.org

Outline

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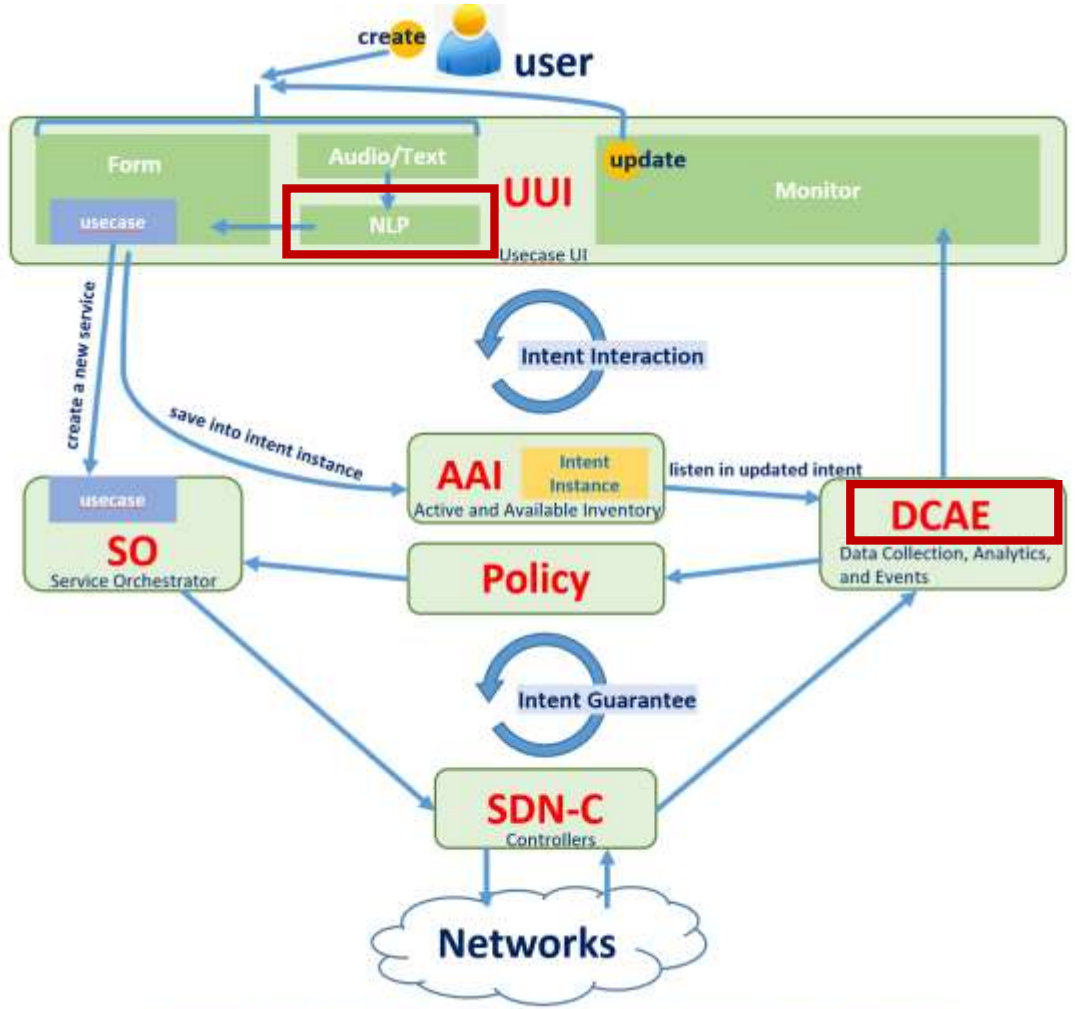
1. Introduction of Closed-loop Autonomous Networks
2. Enable AI/ML for Closed-loop Autonomous Networks
3. Enhancement plan

Closed-loop Autonomous Networks based on ONAP Projects

- A self-driving network that uses decoupling network control logic and closed-loop orchestration techniques to automate application intents.
- 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.



Architecture of Intent-driven Closed-loop Autonomous Networks

Collaborations among academics, open-source and SDOs

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Academics

IEEE

- SMART Intent-Driven Network Management
- 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

IETF/IRTF:

- Intent-Based Networking - Concepts and Definitions
- Intent Classification

ETSI

ETSI ZSM/ENI:

- ZSM 011 Intent-driven autonomous networks; Generic aspects
- ENI 017 Overview of Prominent Control Loop Architectures

tmforum

TMF:

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

3GPP

3GPP SA5:

- TS 28.312 Intent driven management services for mobile networks
- TR 28.912 Study on enhanced intent driven management services for mobile networks"

ITU

ITU-T:

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

CCSA

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

Contributions led by the team

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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-1214/ONAPARC-744** Maintenance and Enhancement of Intent-driven Closed-loop Autonomous Networks in **R11**
- ✓ **REQ-1411/ONAPARC-766** Intent-driven Operating for Cloud-network Convergence Services (**R12**)
- ✓ **REQ-1582** Enhancement of Intent Translation for Cloud-network Convergence Services in **R13**

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

- ✓ **TMF Catalyst C23.0.467**: Intent-driven closed-loop autonomous services towards next-generation networks
- ✓ **ETSI ENI PoC #18**: Intent-driven Operating for User-Centric Cloud-Network Convergence Services
- ✓ **ETSI ZSM PoC #3**: Automation of Intent-based cloud leased line service
- ✓ **ITU-T**: Scenarios and Requirements of Intent-Based Network for network evolution

ONE SUMMIT

https://sched.co/1BKrX

Panel Discussion: Evolution of Closed-loop Autonomous Networks by Open Source Use Cases - Dong Wang, China Telecom; Henry Yu, Huawei Technologies; Kevin Tang, ST; Ahila Pandaram, Wipro Limited & Chugang Yang, Xidian...

ISSAQUAH

- ☐ Focus on the evolution of future networks, and study new technologies, services and applications; based on the R&D of ONAP, provide a reference for the deployment of operators, verify new technologies with academics and promote the development of standardizations.
- ☐ For intent-driven closed-loop autonomous networks, verify the key technologies of intelligent networks based on the scenes of fixed networks, mobile networks and cloud-network convergence by CCVPN and E2E Slicing use cases.

TMF Catalyst C23.0.467

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C23.0.467 Intent-driven closed-loop autonomous services towards next-generation networks

Catalyst Project Goal :

a. Enhance the intent interaction between customers and operators so as to **perceive the users' real-time requirements**, and **translate the users' requirements** to the configuration of current network. Some new ideas and techniques could be considered, like ChatGPT/GPT-4, GSMA Open Gateway, Slicing/SLA.

b. Enhance the **closed-loop autonomous services of Orchestration and Management platform** by Native AI and Big data.

CHAMPIONS：

中国电信 CHINA TELECOM

China unicom中国联通

SLTMOBITEL The Connection

PARTICIPANTS：

AsiaInfo 亚信科技

CLARiTY

HUAWEI

UNIVERSITIES：

北京郵電大學

西安电子科技大学 XIDIAN UNIVERSITY

浙江大学 ZHEJIANG UNIVERSITY

ETSI ENI PoC #18

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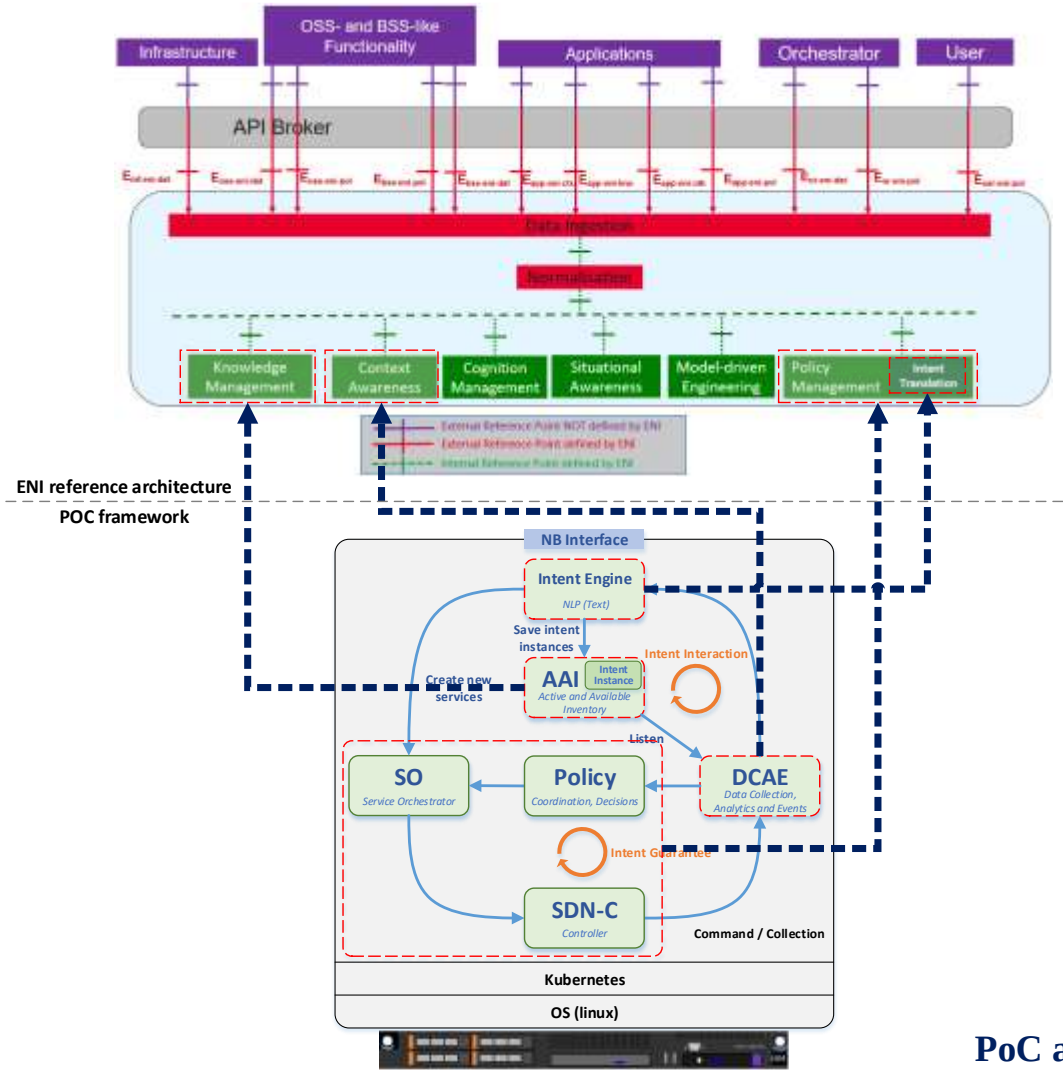
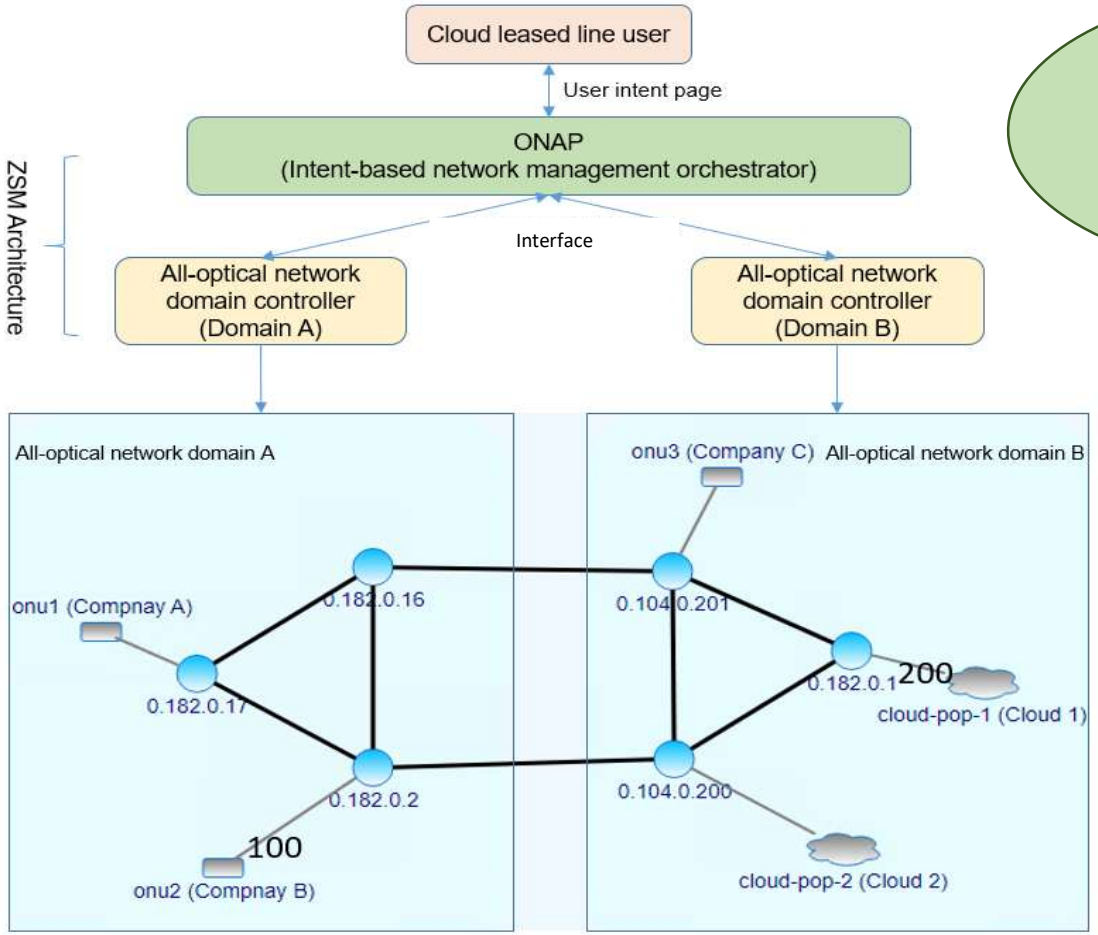


PoC architecture mapped to ENI reference architecture

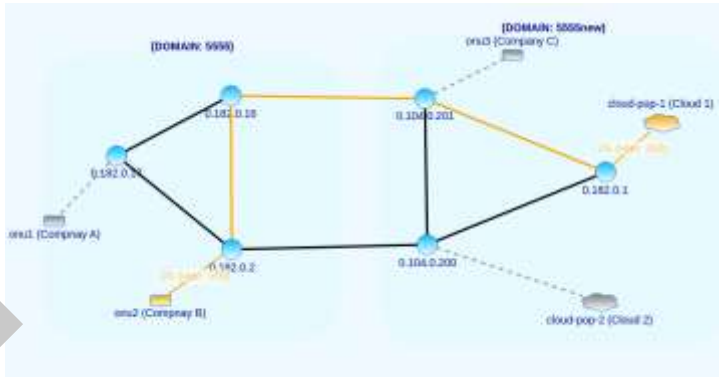
- **Intent translation and intent instance creation. The user expresses an intent of creating a cloud-network convergence service. This intent is then automatically fulfilled by provisioning the corresponding services and allocating the required resources.**
- **Intent interaction. The already fulfilled intent can be modified by the user. The new intent can be automatically fulfilled by provisioning the corresponding services and allocating the required resources.**
- **Intent guarantee. The Intent-based system monitors the parameters of the cloud-network convergence service (e.g., bandwidth usage), and automatically triggers the closed-loop actions (e.g., increase max bandwidth) in order to guarantee the intent.**

ETSI ZSM PoC #3



I need a connection from company B to Cloud one, with a bandwidth of 2Gbps

Translate and create



Bandwidth monitoring and guarantee

ETSI ZSM PoC #3: Automation of Intent-based cloud leased line service

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Enable AI/ML for Closed-loop Autonomous Networks

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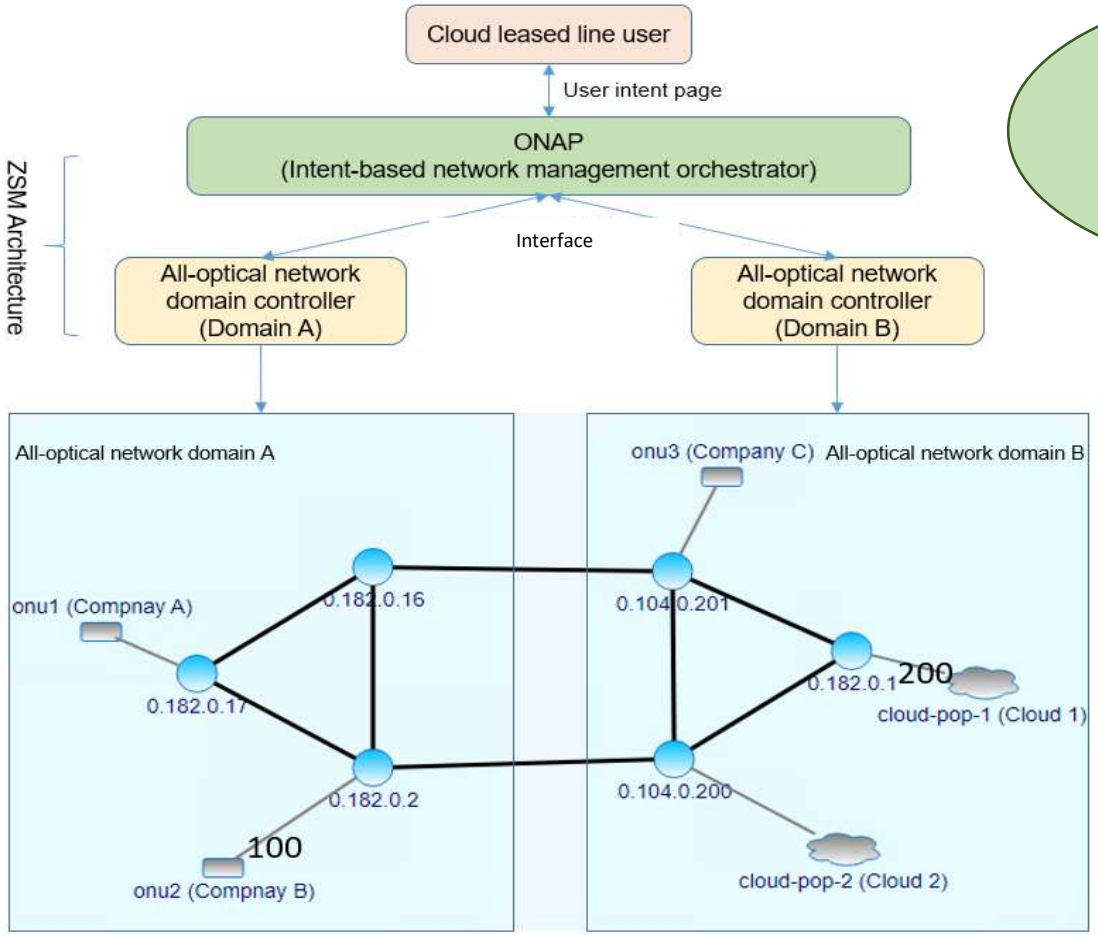

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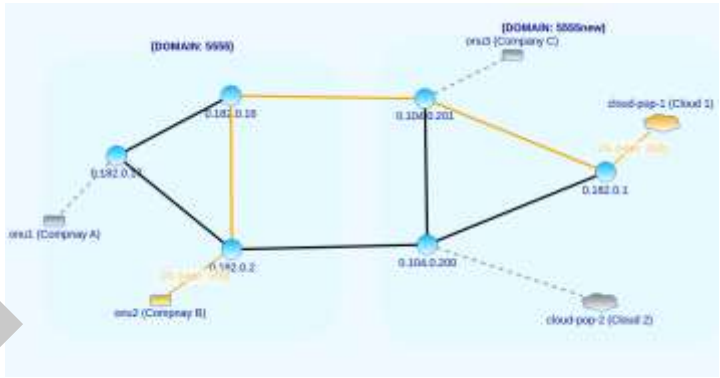

Bandwidth monitoring and guarantee

ETSI ZSM PoC #3: Automation of Intent-based cloud leased line service

Intent Translation by NLP Algorithms

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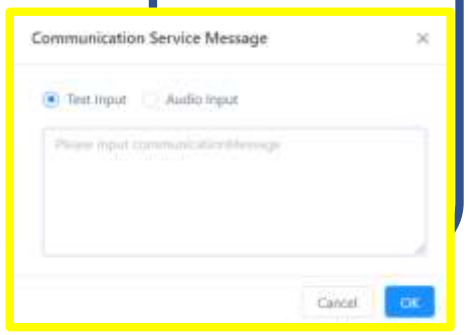
UUI

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

Input

Text

Voice



Nature Language Processing

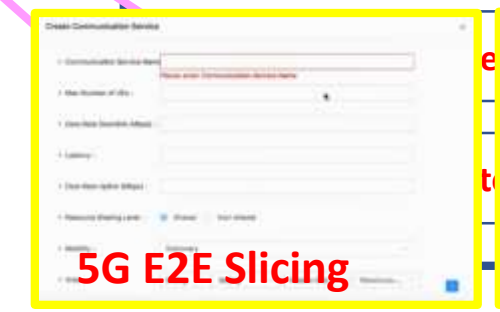
Parameter1: network service (5G / Fixed network)

Parameter2: scenario

Parameter3: throughput

Parameter4: latency

...



5G E2E Slicing

CCVPN

NLP Model Management

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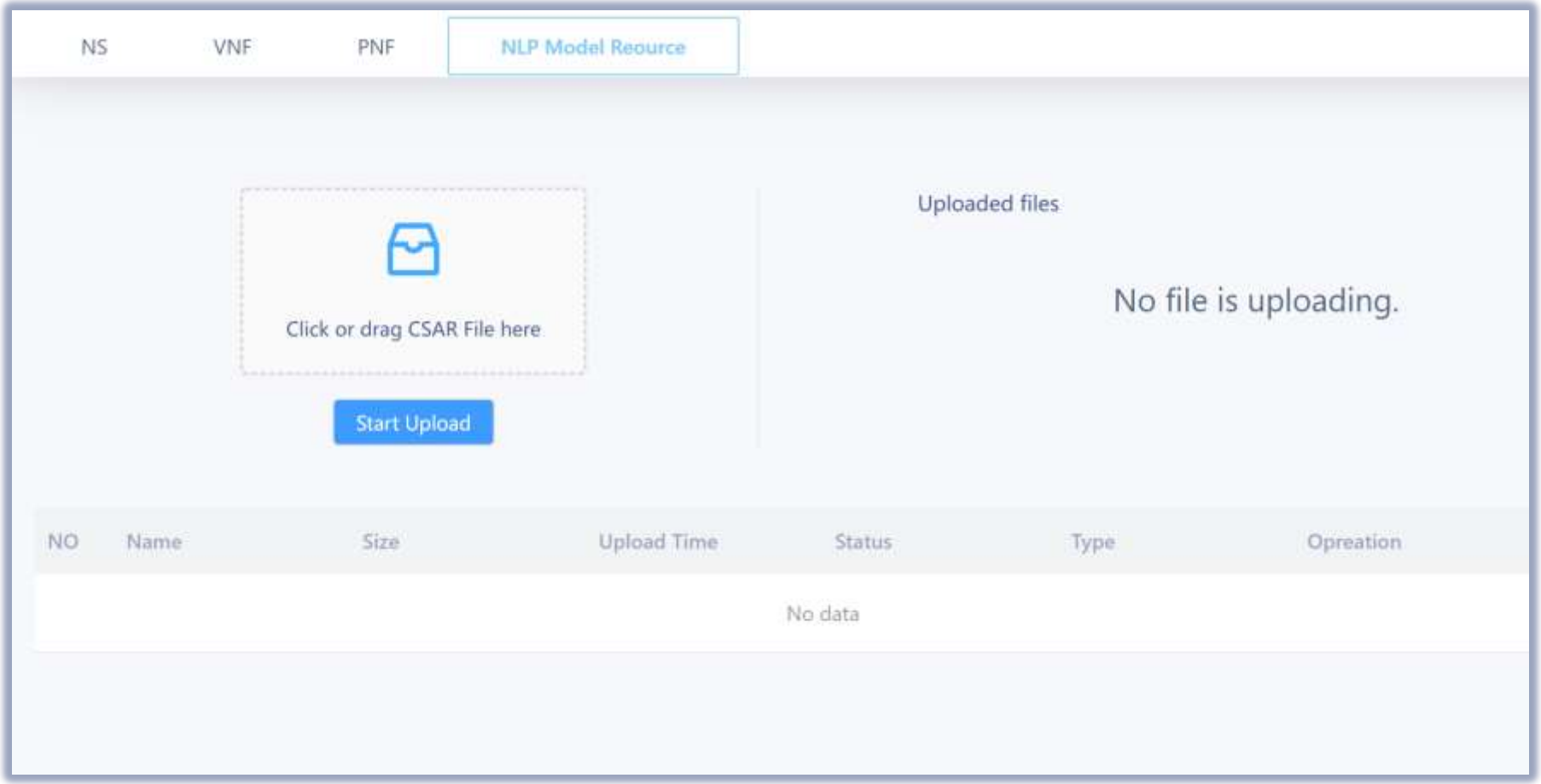
Key Features

NLP Model Management

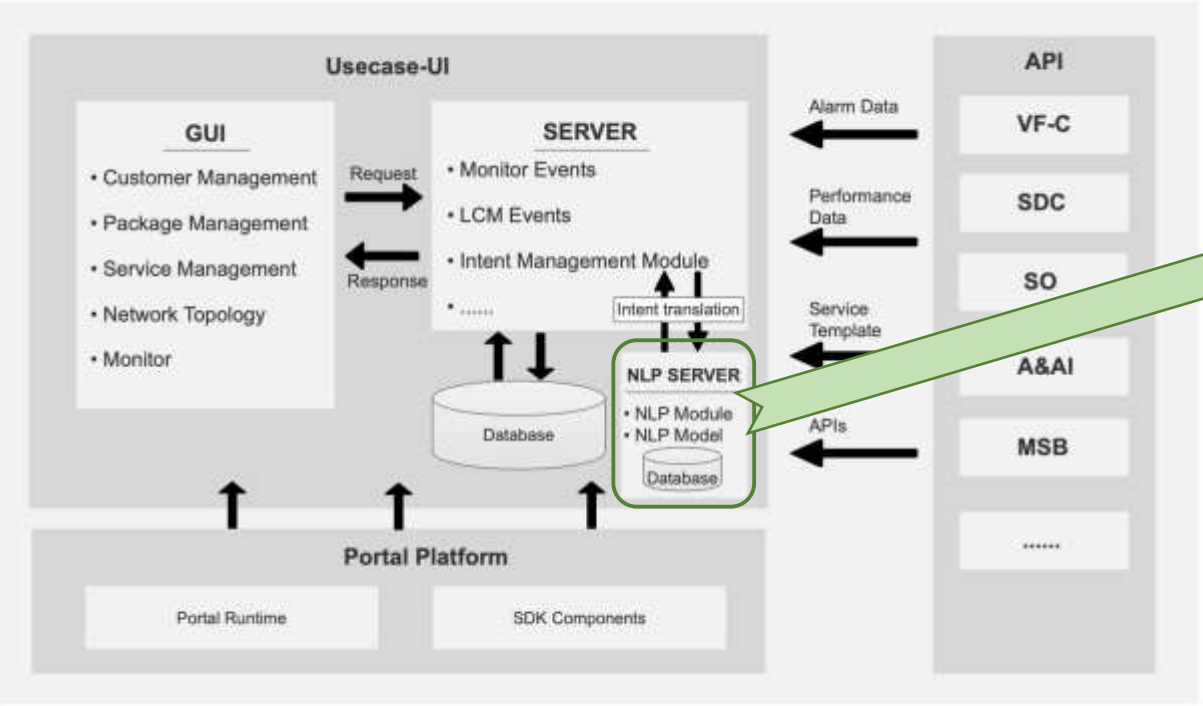
- ☐ Upload model
- ☐ Delete model
- ☐ Active/Inactive model
- ■ Select model for different usecases in same AI framework and microservice



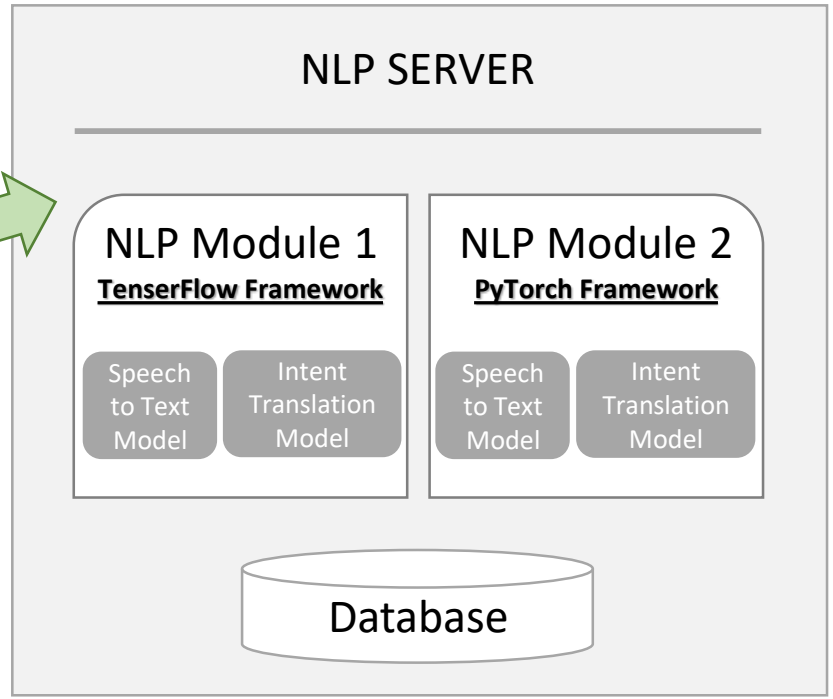
Screenshot of NLP Model Management

NLP platform and model in UUI

- **Support both TenserFlow and PyTorch frameworks to support more models**



Components of UUI since Honolulu Release



Enhancement of NLP microservice in UUI

Enhancement of Cloud-network Convergence Services

- **The intent translation is formulated as question answering(QA) problem.**

Text: A cloud line is required from Company A to Cloud One, 10Gbps.

Questions:
["bandwidth", "access point", "cloud point"]

Answers:
{“bandwidth”: “10Gbps”, “access point”: “Company A”, “cloud point”: ”Cloud One”}

Cloud leased line service:

- Bandwidth
- access point
- cloud point

+

Cloud service:

- CPU
- GPU
- Memory
- Hard-drive

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Add more AI/ML models in NLP server

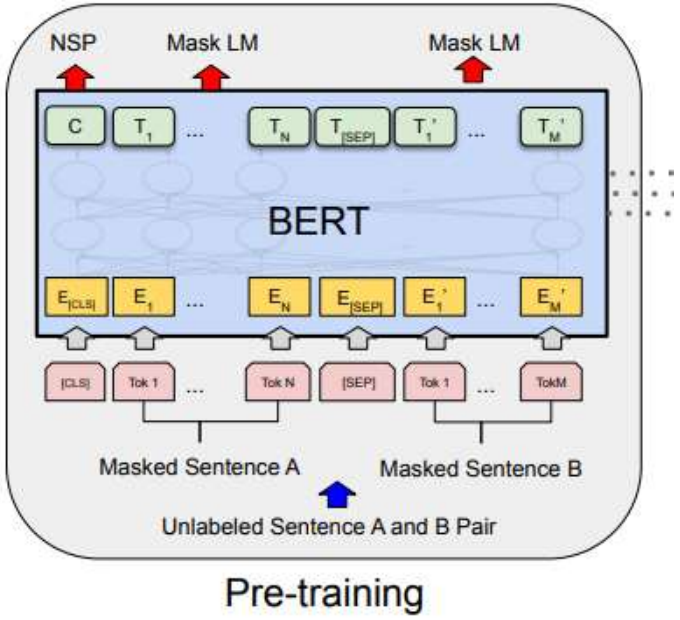
NLP SERVER

NLP Module 1
RoBERTa

NLP Module 2
ALBERT

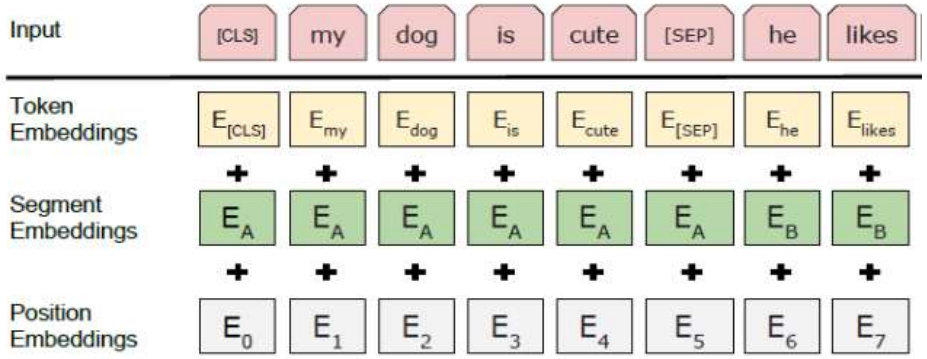
NLP Module 2
Word2Vec

An improved pretraining procedure to **improve accuracy**.

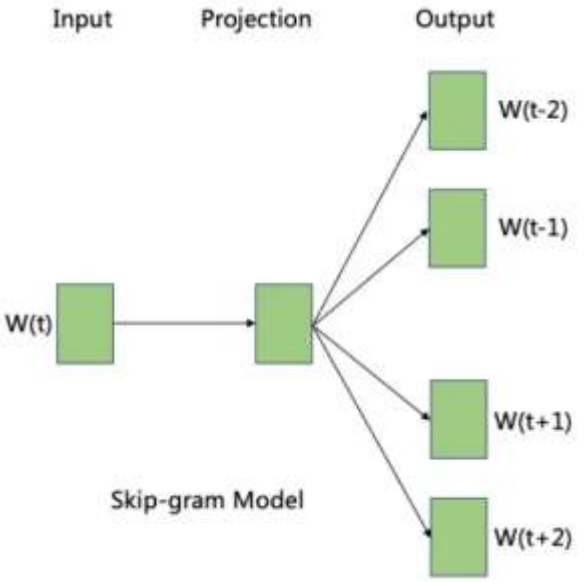


Pre-training

A simplified method to **reduce parameters**.



A machine learning algorithm to **eliminate the need of NLP Server**.



DRL-based Conflict Management

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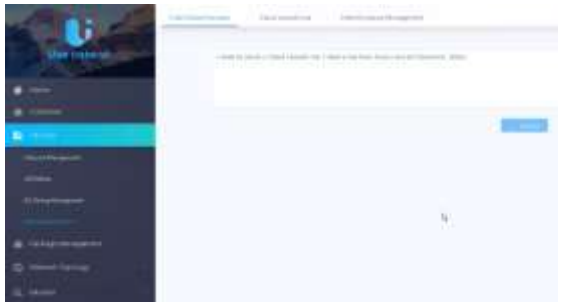
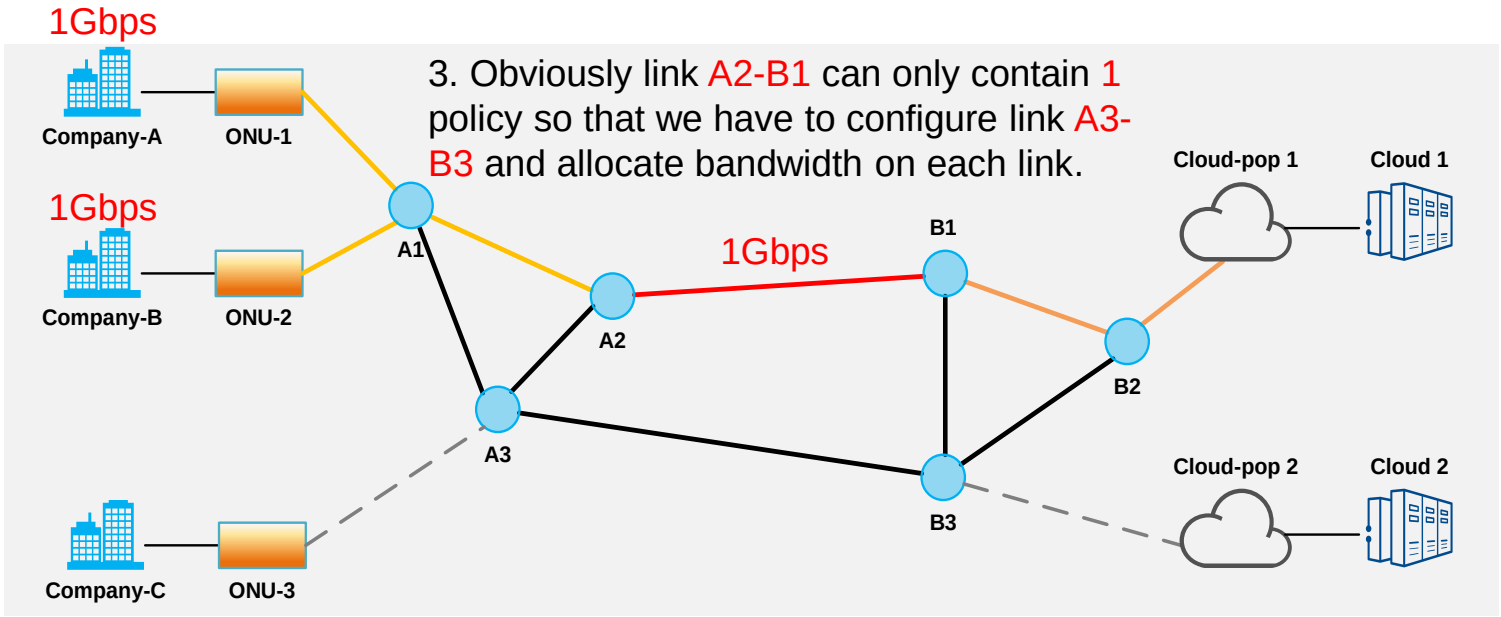
1. User 1: create a Cloud Leased Line from Company A to Cloud one, 1Gbps.

User 2: create a Cloud Leased Line from Company B to Cloud one, 1Gbps.



(1) Intent input



(3) Example topology for bandwidth conflict

2. The translated intents will be sent to the Intelligent policy mapping module, where the conflict management module will evaluate the potential conflicts, optimize the overall network performance, and generate a conflict-free policy set.

(2) Policy mapping

DRL-based Conflict Management

We formulate the configuration of conflict policies as an optimization problem under complex constraints.

We define objective:

$$\underset{B_f(t)}{\text{maximize}}\ \mathbb{E}\left[\sum_{t=1}^{T}\sum_{f\in F} h(a_b B_f(t),\ a_l L_f(t),\ a_q Q_f(t),\ a_y Y_f)\right]$$

bandwidth; packet loss rate; latency; types

under constraints :

$$\begin{cases} \sum_{f\in F}\sum_{p\in P} b_f^p K_e^p \leqslant B_e,\ e\in E \\ b_f^p \geqslant 0,\ \forall f\in F,\ p\in P_f \end{cases}$$ bandwidth constraint

$$\sum_{p\in P_f} L_f^p = 1,\ \forall f\in F$$

$$L_f(t) \leqslant L_f^{\max},\ \forall f\in F,\ t\in T$$ latency constraint

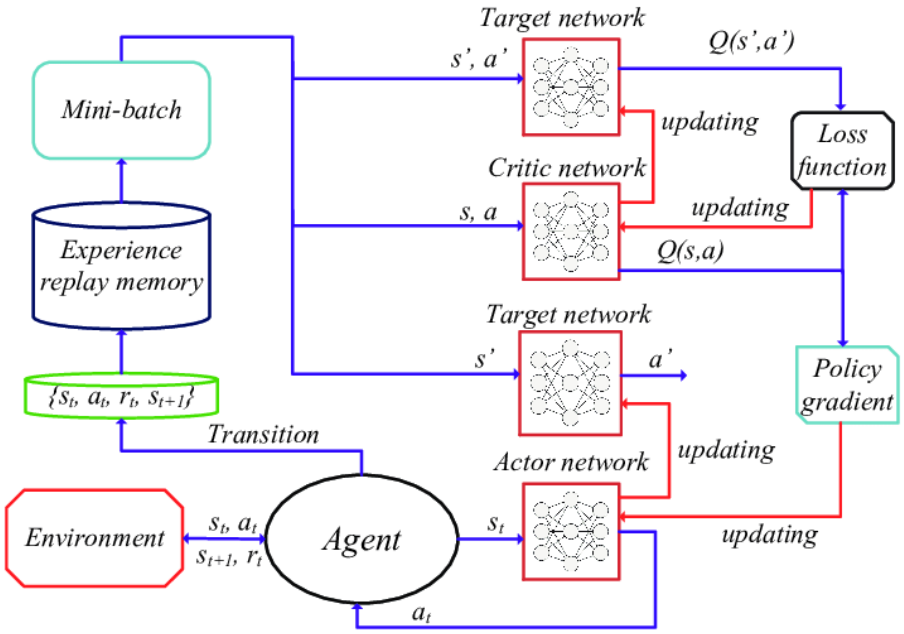
$$Q_f(t) \leqslant Q_f^{\max},\ \forall f\in F,\ t\in T$$ PLA constraint

To solve this problem, we further establish rewards, actions and states for RL.

Reward : $r_t = \frac{1}{n}\sum_{f\in F}\left(a_b \log\tilde{B}_f(t) - a_l\tilde{L}_f(t) - a_q\log\tilde{Q}_f(t)\right)$

State : $s_t = [(B_1(t),\ L_1(t),\ Q_1(t)),\ \cdots,\ (B_n(t),\ L_n(t),\ Q_n(t))]$

Action : $a_t = [(p_1(t),\ x_1(t)),\ \cdots,\ (p_n(t),\ x_n(t))]$

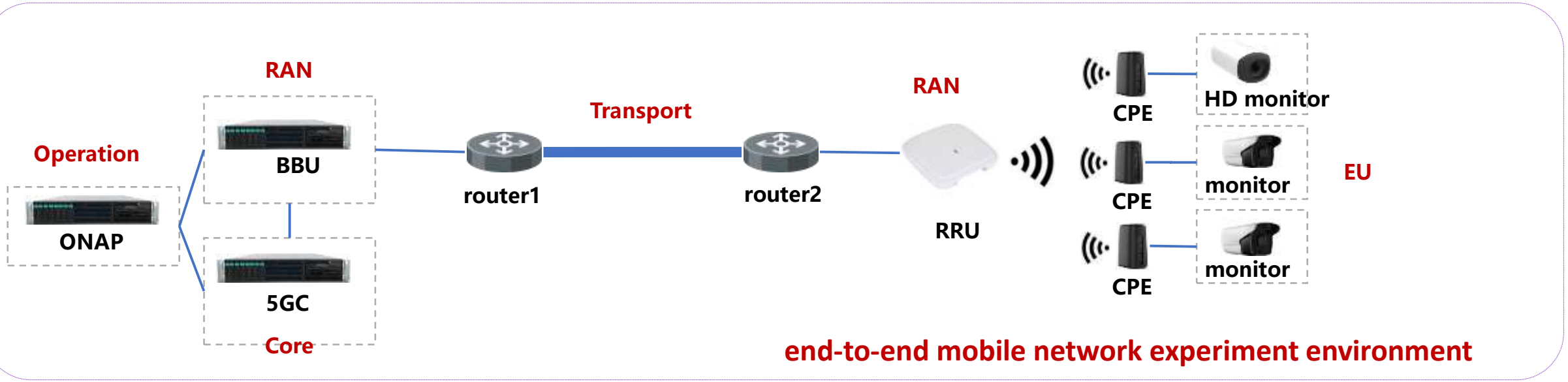


We employ DDPG algorithm to generate a new conflict-free policy that maximizes the mean utility of user intents.

Next step

1. Focus on enhancing AI ability of ONAP in UUI and DCAE

2. Apply ONAP as the operation platform of end-to-end experiment environment



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Thank you!