# IETF-122 I2ICF Side Meeting

# Interface to In-Network Computing Functions (I2ICF): Problem Statement

## (draft-jeong-opsawg-i2icf-problem-statement-00)

March 20, 2025

Bangkok in Thailand

**Jaehoon Paul Jeong, Yiwen Shen, Yoseop Ahn, Younghan Kim, Elias P. Duarte Jr., Kehan Yao**

**Email:** {pauljeong, chrisshen, ahnjs124}@skku.edu, younghak@ssu.ac.kr, elias@inf.ufpr.br, yaokehan@chinamobile.com

# Introduction to I2ICF

- **Interface to In-Network Computing Functions (I2ICF)**
  - I2ICF aims at making a standard framework and its interfaces for In-Network Computing Functions (ICF) like Programmable Network Devices (PNDs).
    - draft-jeong-opsawg-i2icf-problem-statement-00
  - I2ICF will work on the standardization of **Interface YANG Data Models (DMs)**:
    - In-Network Computing Function (ICF) Capability
    - Registration Interface, Consumer-Facing Interface, Service Function-Facing Interface, and Monitoring Interface

# Goal of I2ICF Group

- **Goal:** Standardization of **I2ICF for Computing in the Network**
  - **I2ICF Problem Statement**
    - https://datatracker.ietf.org/doc/draft-jeong-opsawg-i2icf-problem-statement/
  - **I2ICF Framework**
    - https://datatracker.ietf.org/doc/draft-jeong-opsawg-i2icf-framework/
  - **Use Cases**: Data Center and Intelligent Transportation Systems
    - https://datatracker.ietf.org/doc/draft-ywj-opsawg-i2icf-data-center-networking/
    - https://datatracker.ietf.org/doc/draft-ahn-opsawg-i2icf-cits/

# Motivation of this Draft

- **Motivation of I2ICF Problem Statement**
  - This draft defines the In-Network Computing Functions (ICFs) and Problems for Interface to In-Network Computing Functions (I2ICF).
  - This draft investigates the need for a standard framework with the interfaces for ICFs, in terms of applications with the need to run AI in the network and interoperability among multi-vendor ICFs.
    - AI can enable the creation of dynamic, adaptable network/security policies, which are important in the cloud-edge-core-continuum.
    - AI can learn from telemetry data collected from multiple networks and reach conclusions that can be applied globally or to individual networks.

# Scope of this Draft

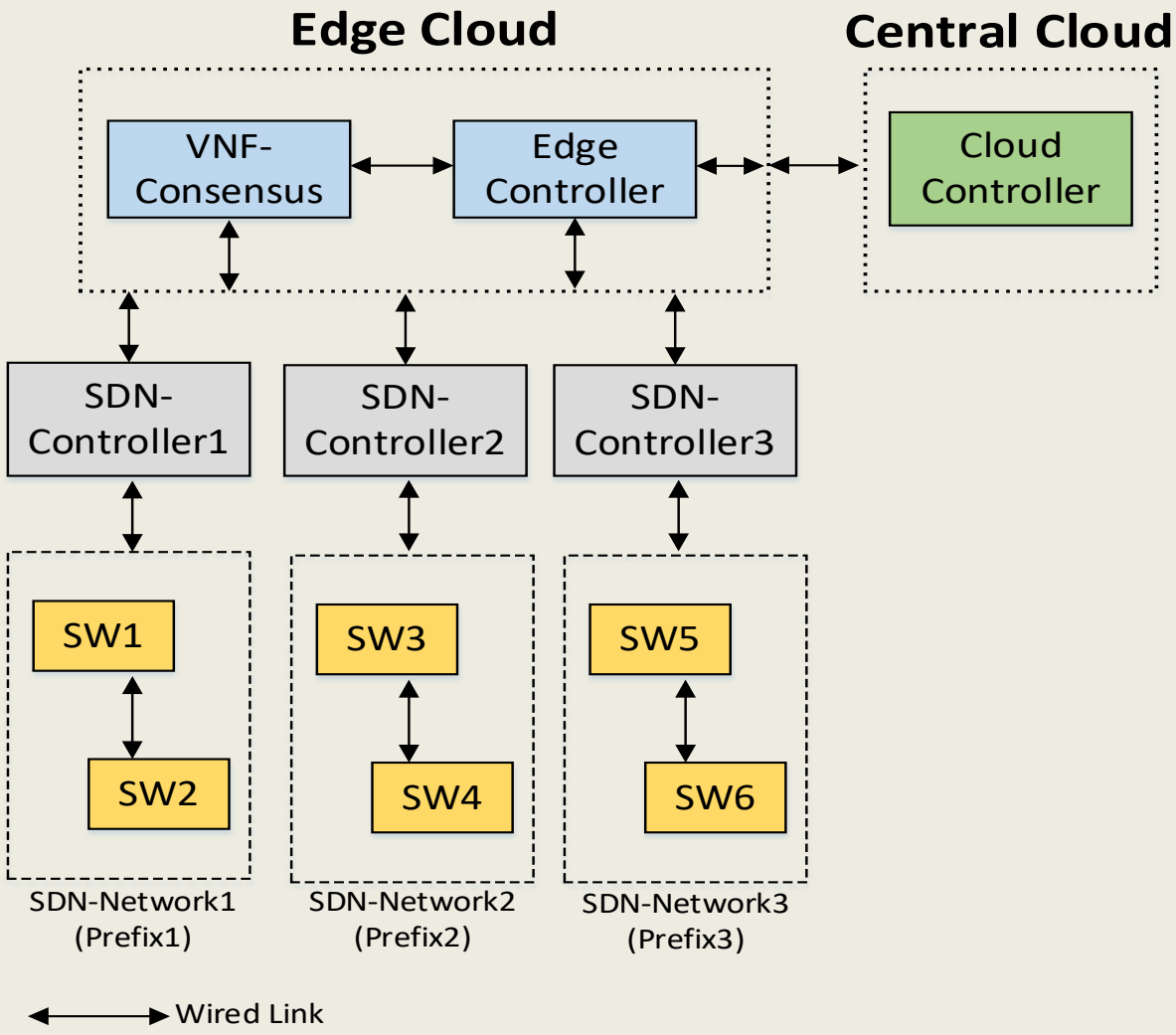
- **Scope of I2ICF Problem Statement**
  - ICF Capability Registration and Intent-Based Service Provisioning
    - For a given intent, an **Intent Translator** in the I2ICF framework can translate it into policies executable in ICFs in a target network.
    - For intent assurance, a **Closed-Loop Intent Control** can make sure that the I2ICF framework operates correctly according to the user's intent.
  - ICFs to be considered in I2ICF
    - **Programmable Network Devices** (e.g., P4 Switches)
    - **On-Device AI Devices** called Moving Objects (e.g., Robots and Software-Defined Vehicles)

# I2ICF Framework for ICF Management:

## (e.g., P4 Switch, VNF-Consensus, Failure Detector, and Reliable Broadcast)

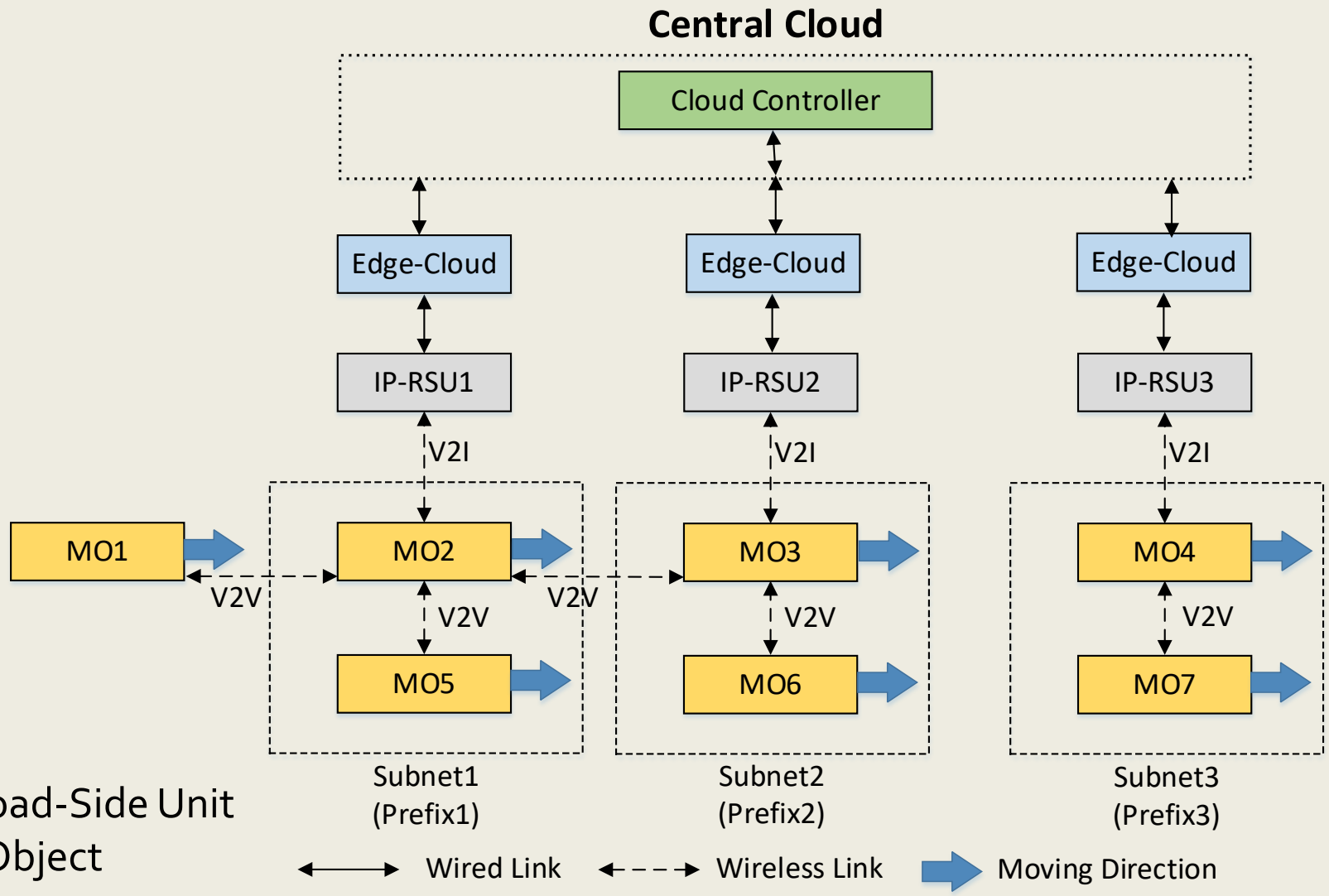
- This framework shows a **VNF-Consensus Architecture in an Edge Cloud** for I2ICF framework to synchonize the SDN Controllers for flow table information in the same Edge Cloud.

**VNF:** Virtual Network Function
**SW:** Switch




**VNF-Consensus Architecture in Edge Cloud for I2ICF Framework**

# I2ICF Framework for ICF Management
## (e.g., Mobile Objects (MOs) like On-Device AI Devices)




**IP-RSU:** IP Road-Side Unit
**MO:** Mobile Object

# In-Network Computing Functions (1/4)

- **The State of the Art in Computing in Network (COIN)**
  - **In-Network Computing Functions (ICF)** are proposed by COINRG with Network Softwarization (e.g., NFV and SDN).
- **Services in COIN**
  - **Providing New COIN Experiences**
    - Mobile application offloading and Extended Reality (XR) and immersive media.
  - **Supporting New COIN Systems**
    - In-Network Control, Time-Sensitive Application, Large Volume Applications, and Industrial Safety.

# In-Network Computing Functions (2/4)

- **Services in COIN (Con't)**
  - **Improving Existing COIN Capabilities**
    - Content Delivery Networks (CDN), Compute-Fabric-as-a-Service (CFaaS), and Virtual Networks Programming (e.g., P4 programs and OpenFlow rules).
  - **Enabling New COIN Capabilities**
    - Distributed AI Training among distributed endpoints for large-scale problems.

# In-Network Computing Functions (3/4)

- **Services in NFV-COIN**
  - **NFV Failure Detection**
    - It gets monitoring data from SDN Switches via SDN Controller and detects the failure of communication links.
  - **Virtual Network Function (VNF) Consensus**
    - It performs the synchronization of the control planes of multiple SDN Controllers (e.g., flow table sharing).
  - **NFV Reliable Broadcast**
    - It performs reliable and in-order delivery of broadcasted data packets with a VNF-Sequencer.

# In-Network Computing Functions (4/4)

- **In-Network Computing Functions (ICFs)**
  - Observation 1
    - Functionalities of each service need to be decomposed into Application Functions (AFs) and Network Functions (NFs).
  - Observation 2
    - The management and configuration of those AFs and NFs is a functionality that must be provided by a service coordinator in the context of COIN-based network services.
  - Observation 3
    - There is currently no framework or interfaces defined as standards specifying the life cycle of COIN-based services.

# Comparison I2ICF with CATS and NeoTec (1/3)

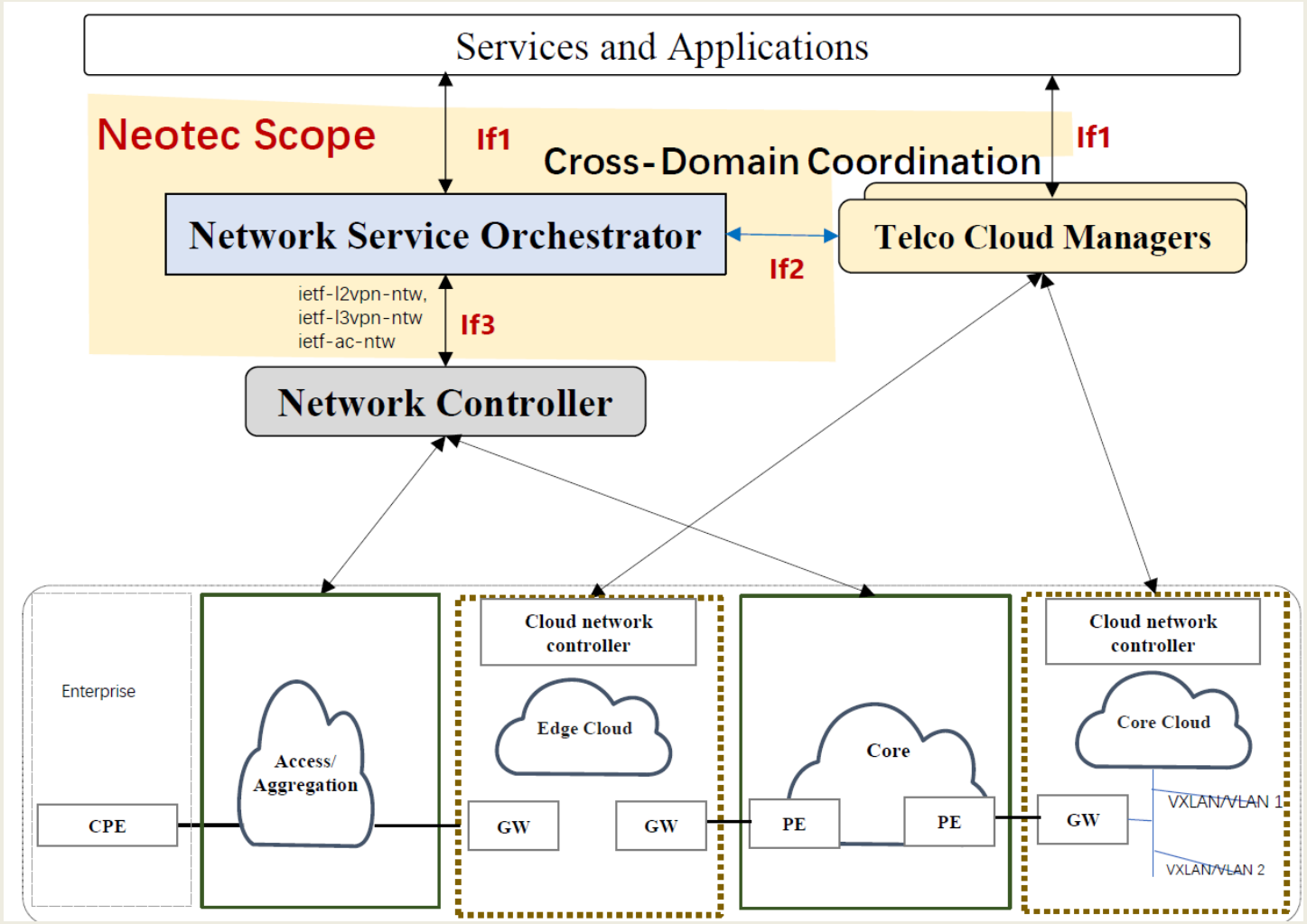
- Computing-Aware Traffic Steering (CATS)
  - **Goal**
    - CATS WG aims at handle how the network edge can steer traffic between clients of a service and sites offering the service.
  - **Assumption**
    - The configuration and monitoring of edge server instances are done by other services, so they are out of scope.
  - **I2ICF**
    - I2ICF aims the configuration and monitoring of those edge server instances according to a user's intent.

# Comparison I2ICF with CATS and NeoTec (2/3)

- Network Telco-cloud Orchestration Interfaces (NeoTec)
  - **Goal**
    - **Central Cloud:** Elastic Scaling on Demand (Millisecond-Level Scaling)
    - **Edge Cloud:** Deterministic Low Latency (<10ms End-to-End)
    - **Global Efficiency:** Cross-Domain Resource Utilization Improved, and agile Domain Coordination
  - **I2ICF**
    - I2ICF focuses on the configuration and monitoring of Programmable Network Devices (PNDs) and On-Device AI Devices (ODAIDs) rather than edge cloud and central cloud.

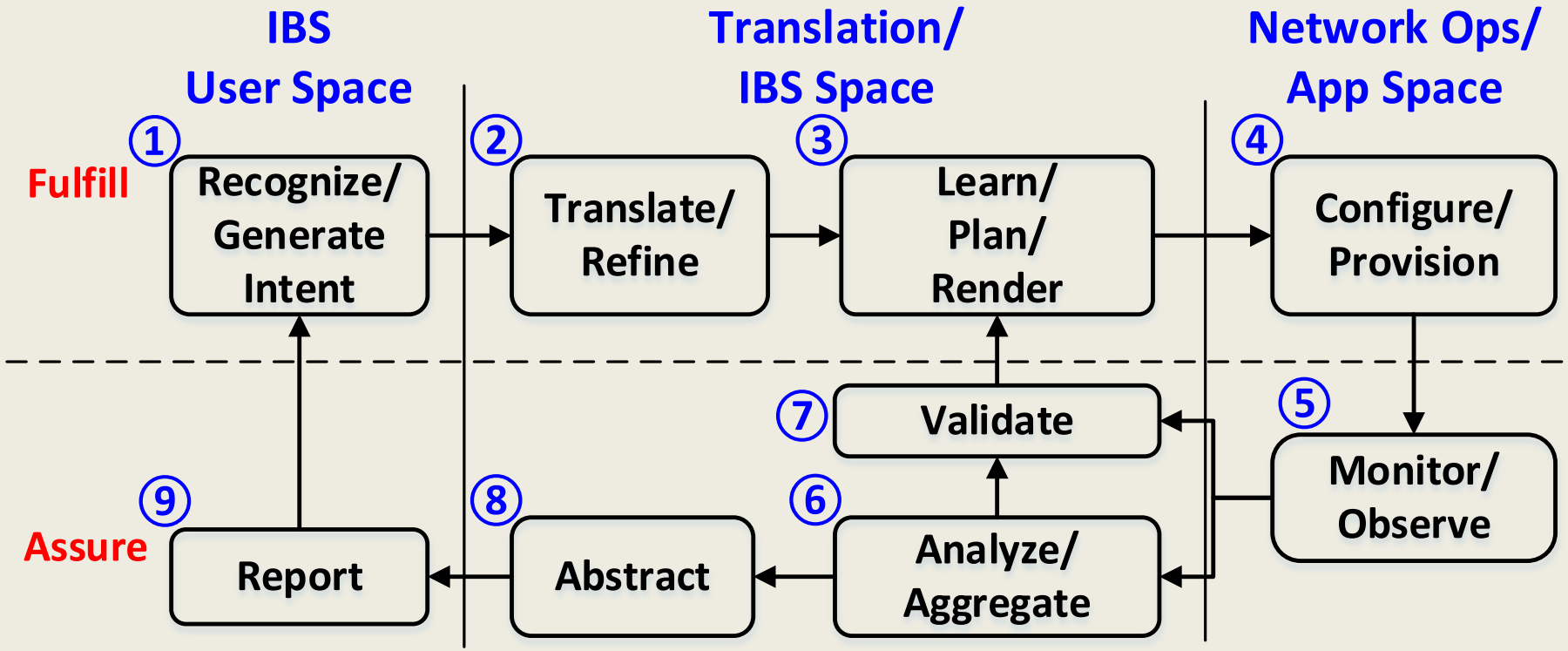
# Comparison I2ICF with CATS and NeoTec (3/3)

- Network Telco-cloud Orchestration Interfaces (NeoTec)



# Intent-Based Networking (IBN)

- **Intent-Based System (IBS)** can be based on **RFC 9315** (Intent-Based Networking - Concepts and Definitions).




The Life Cycle of IBS for Intent Management

# Problem Statement (1/5)

- **The goal of an Intent-Based System (IBS)**
  - To enforce the service corresponding to a user's intent with an appropriate application in a target network in terms of functionality and quality.

- **Enforcement Procedure of an Intent**
  - **① Intent Translation**
    - An intent needs to be translated into either a network policy and an application policy by an intent translator.

# Problem Statement (2/5)

- **Enforcement Procedure of an Intent (Con't)**
  - **② Delivery of Network and Application Policies**
    - The network policy and application policy needs to be delivered to a network controller and an application controller.
  - **③ Network Policy Translation**
    - The network controller translates the network policy into the network rules for network entities (i.e., NFs).
  - **④ Application Policy Translation**
    - The application controller translates the application policy into the application rules for application entities (i.e., AFs).

# Problem Statement (3/5)

- **Data Models for ICF Capability and Registration Interface (RI)**
  - The **Capability Data Model for ICFs (i.e., NFs and AFs)** are required to describe the ICF capabilities for usage.
  - A **Registration Interface** is required for a vendor to register the ICF Capability with an I2ICF Controller.
  - **YANG Data Models for ICF Capabilities and Registration Interface** should be specified to make a registration message for the Vendor's Management System (VMS).

# Problem Statement (4/5)

- **Data Model for Consumer-Facing Interface (CFI)**
  - An IBS user needs an interface to deliver its intent to an IBS Controller (e.g., Edge/Cloud Controller).
  - The IBS Controller translates the intent into a network policy and an application policy with an intent translator.
  - It dispatches the policies to appropriate destinations (e.g., NF Controller and AF Controller) with a dispatcher.
  - This interface is called a Customer-Facing Interface (CFI) for the IBS User.
  - **A YANG Data Model for the Customer-Facing Interface** should be specified.

# Problem Statement (5/5)

- **Data Model for Service Function-Facing Interface (SFI)**
  - Both an NF Controller and an AF Controller need an **SF-Facing Interface** to deliver the network and application rules to the appropriate NFs and AFs, respectively.

- **Data Models for Monitoring Interface (MI) and Analytics Interface (AI)**
  - **Monitoring Interface** collects monitoring data from either an NF or an AF to a Data Collector.
  - **Analytics Interface** delivers analysis results to either an NF Controller or an AF Controller.

# Planning for WG Scope

- **WG Phase 1**
  - I2ICF Problem Statement and Use Cases
  - I2ICF Framework
  - A YANG Data Model for ICF Capability
  - A YANG Data Model for Registration Interface

- **WG Phase 2 (Re-charter)**
  - YANG Data Models of Consumer-Facing Interface, Controller-Facing Interface, SF-Facing Interface, Monitoring Interface, and Analytics Interface

# Next Steps

- This draft will include use cases for I2ICF as follows:
  - A Use Case of I2ICF for Data Center Networking
    - https://datatracker.ietf.org/doc/draft-ywj-opsawg-i2icf-data-center-networking/
  - A Use Case of I2ICF for Cooperative ITS
    - https://datatracker.ietf.org/doc/draft-ahn-opsawg-i2icf-cits/
  - A Use Case of I2ICF for On-Device AI Devices
- I2ICF Group will prepare a WG-Forming BoF in the IETF 123 in Madrid in July, 2025.
- I2ICF Group will prepare IETF-123 Hackathon Project to clarify (i) the I2ICF Problem Statement & Use Cases and (ii) the I2ICF Framework.