AI based Network Management Agent (NMA): Concepts & Architecture

draft-zhao-nmop-network-management-agent-04

NMOP, IETF 125

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Goal and scope of the draft

Background

- Concept of AI agent widely accepted in the industry. The evolution from Level 3 (assisted automation) to Level 4 (autonomous self-optimization) in Autonomous Networks (AN) introduces requirements for **Agentic** capabilities.

Scope

- This document defines the concept of the **Network Management Agent (NMA),** an AI-driven entity designed to embody these cognitive functions and **bridge the gap between service intent and network operations**.

Goals

- **Define the foundational framework** of the NMA.
- **Specify the relationship between the NMA and existing SDN controllers**.
- **Define interface requirements** after the introduction of NMA.

Not Goals

- Specific agent implementation details are out of scope.

Major updates since 03-version

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1. Resolve several issues from the mailing list

- ✓ **Add** comparison of two deployment modes.
- ✓ **Add Appendix** to describe the def of L0~L5 levels in AN.

2. Add more backgrounds

- Further **clarify the collaborative relationship between NMA and SDN Controllers** to facilitate evolution based on existing IETF work (RFC 8969).

3. Simplify and refine the description.

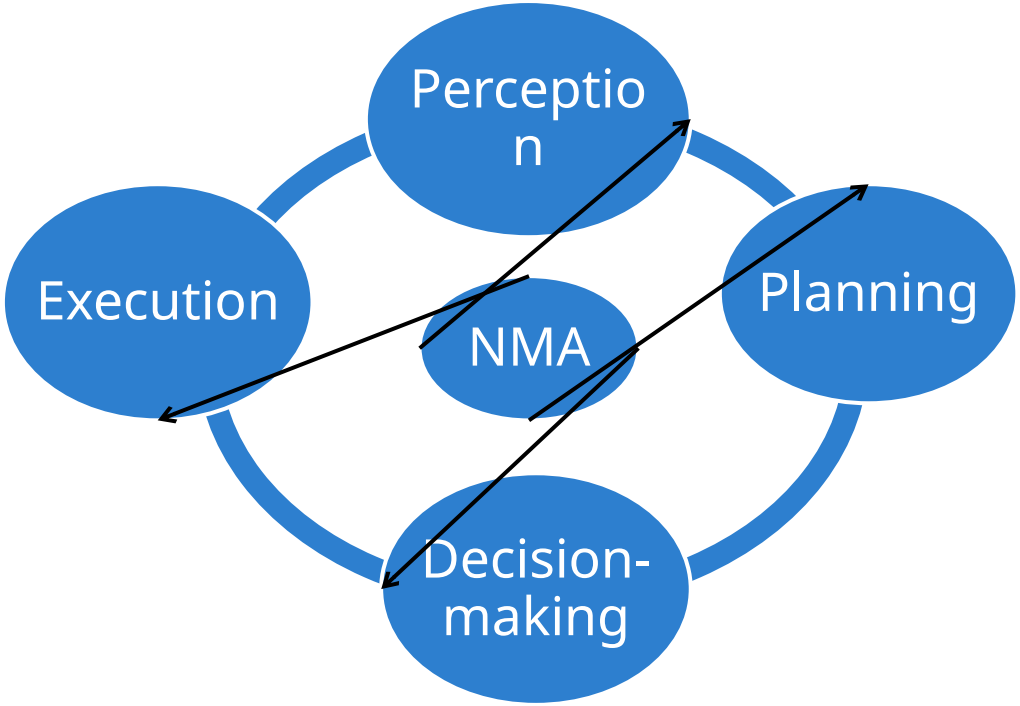
- Focus on the functional architecture of **a single network intelligent agent** at the **controller layer**.
- Supplement the specific capability requirements for Controller extended interfaces after introducing NMA..

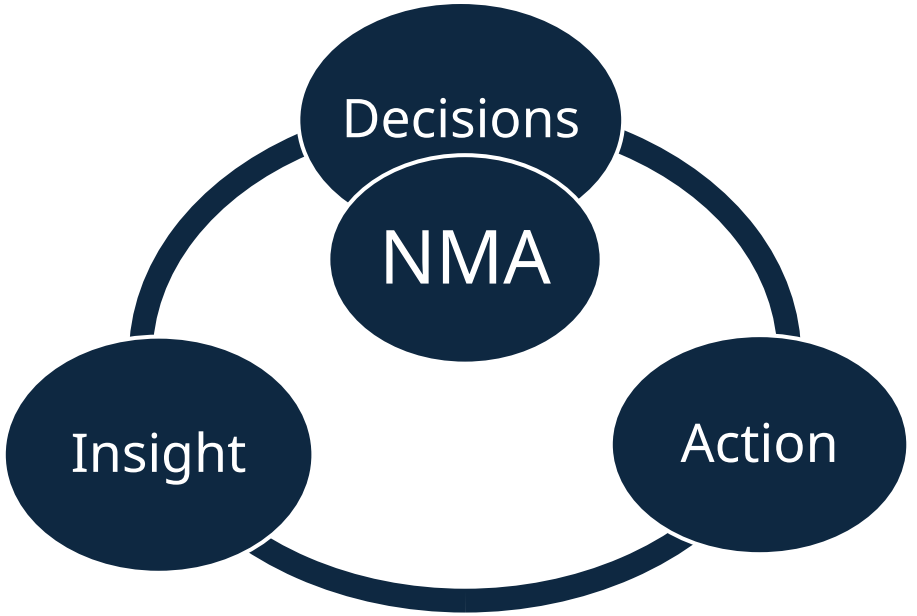
4. Revise the NMA functional architecture

- Align one-to-one with the **IAADE closed-loop** defined in TMF, better reflecting that NMA is a key enabler for advancing network autonomy from L3 to L4.

NMA definition

- **NMA = AI Agents for network management** = A network management entity built on ML/AI and equipped with the processing capabilities to create autonomous closed-loop.
- It interacts with other components of the NM tools to: carry out network perception, do task intent interpretation, task planning, decision-making and task execution operations based on user task intentions or preset goals, so as to achieve closed-loop operations.





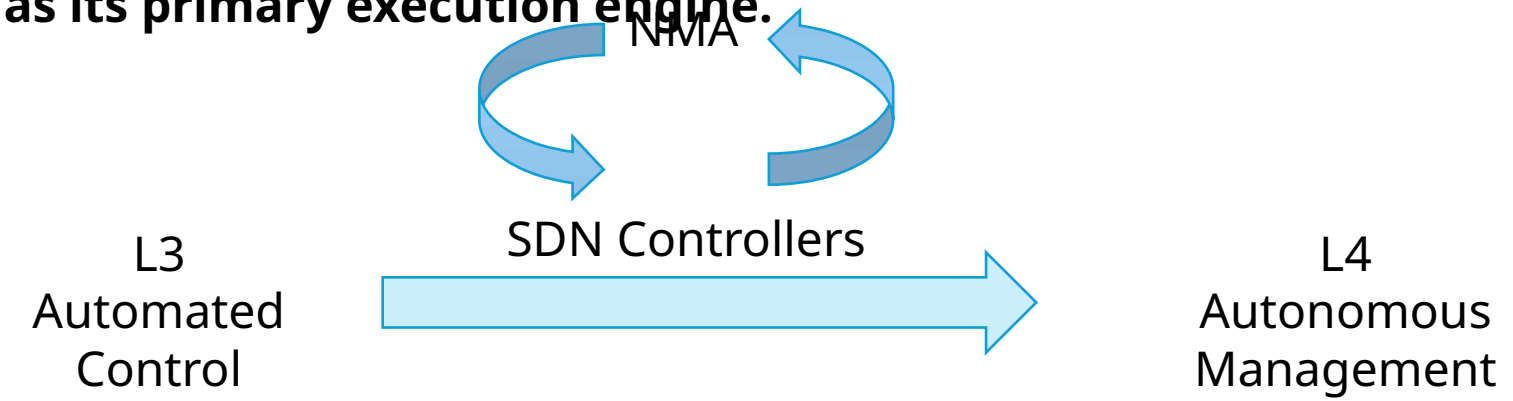
Why NMA is required & Relationship between NMA and SDN controller

Why NMA is required?

- **Achieving L4 autonomy requires a cognitive loop** of Intent Interpretation, Perception Analysis, and Decision- making capabilities that **extend beyond the native design of traditional SDN Controllers**.
- **NMA: serves as the Autonomous Brain (Cognitive Layer)-- what needs to do and why**
- **SDN Controllers: act as the Execution function (Control Layer)** --enforce decisions on the devices.

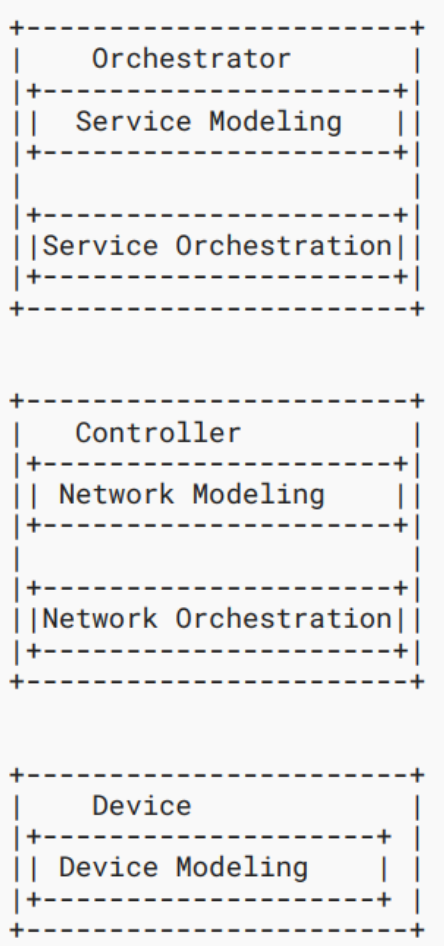
Relationship between NMA and SDN Controller:

- NMA leverages the mature, stable functions already in SDN Controllers rather than reinventing them.
- NMA is compatible with the YANG-based automation framework described in [RFC8969], and **utilizes the Controller as its primary execution engine.**



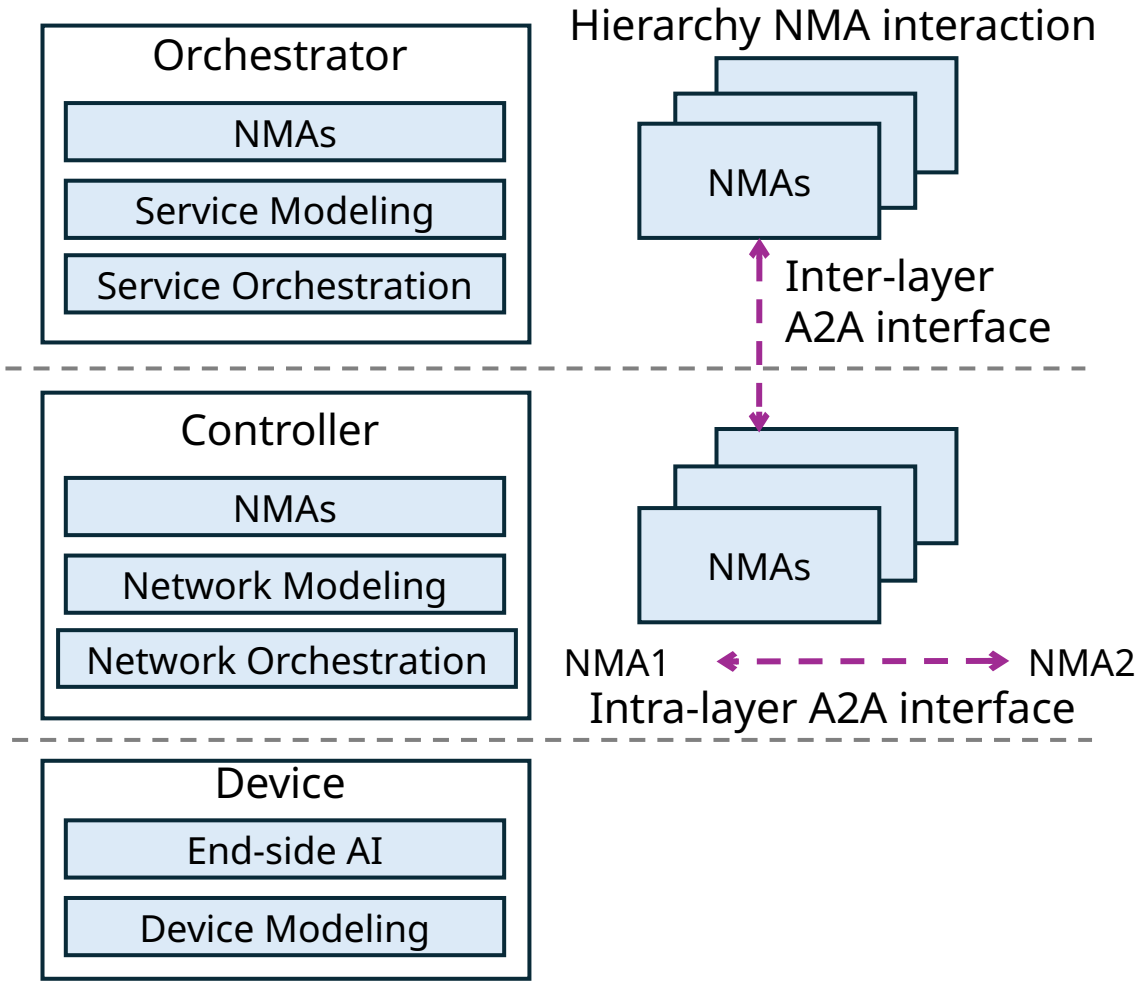
Relationship with RFC8969

- **RFC 8969**: A Framework for Automating Service and Network Management with YANG
- **Relation:** this draft enhances RFC 8969 with AI/ML “intelligent” capabilities



Layering and Representation withing a network operator defined in RFC8969

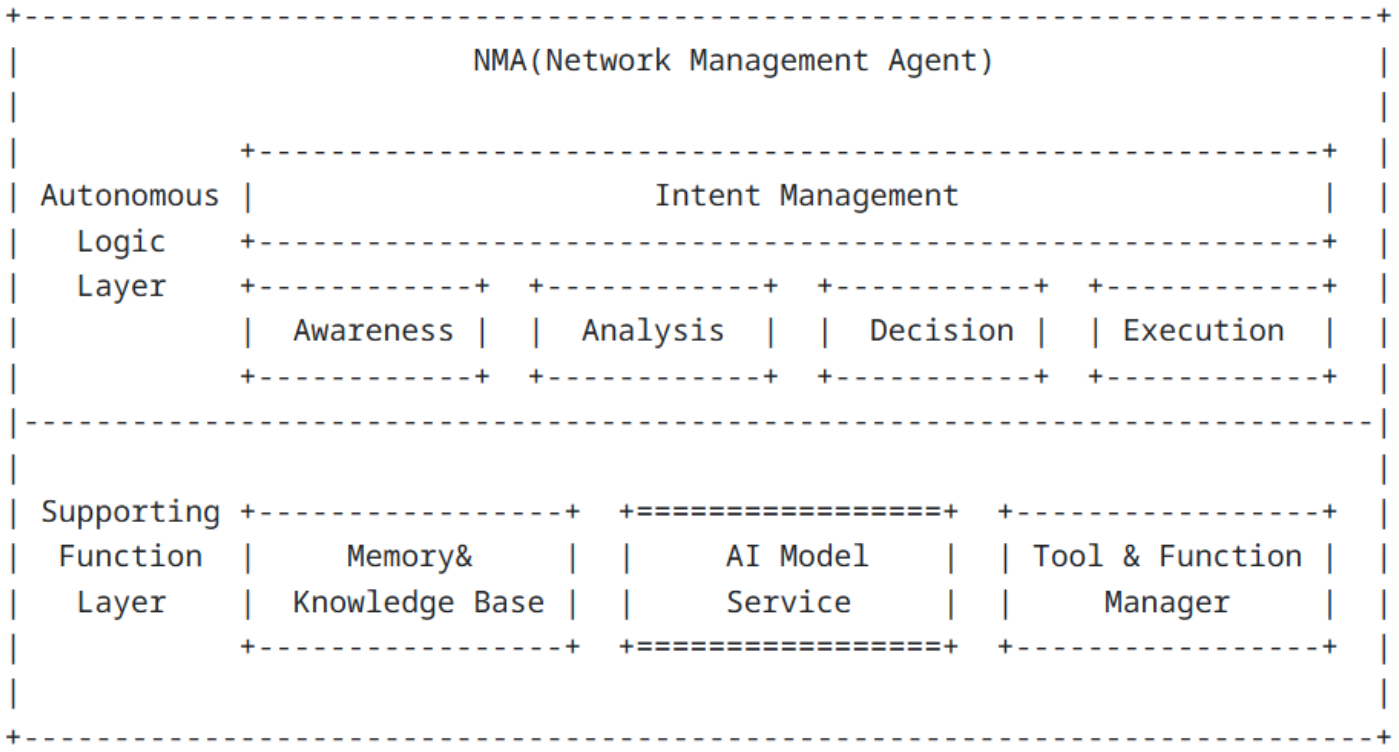
- NMA can exist at both Controller and Orchestrator levels.
- ***This draft mainly focus on the NMAs at the controller layer.***



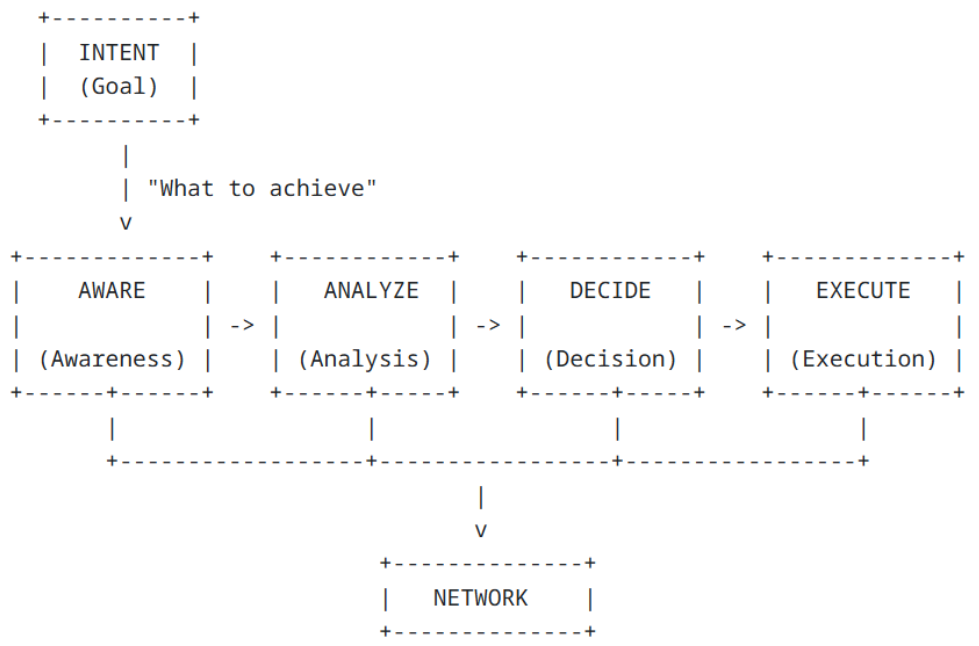
Enhanced intelligent network management and control framework based on NMA

Updated functional architecture of NMA

Reference function architecture of NMA

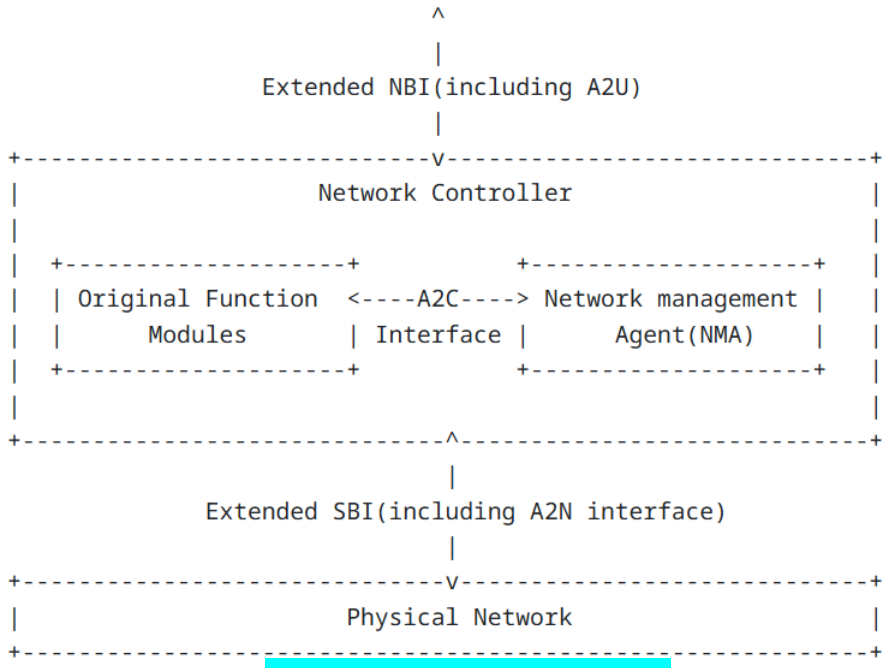


IAADE Control Loop for Autonomous Networks defined in TMF

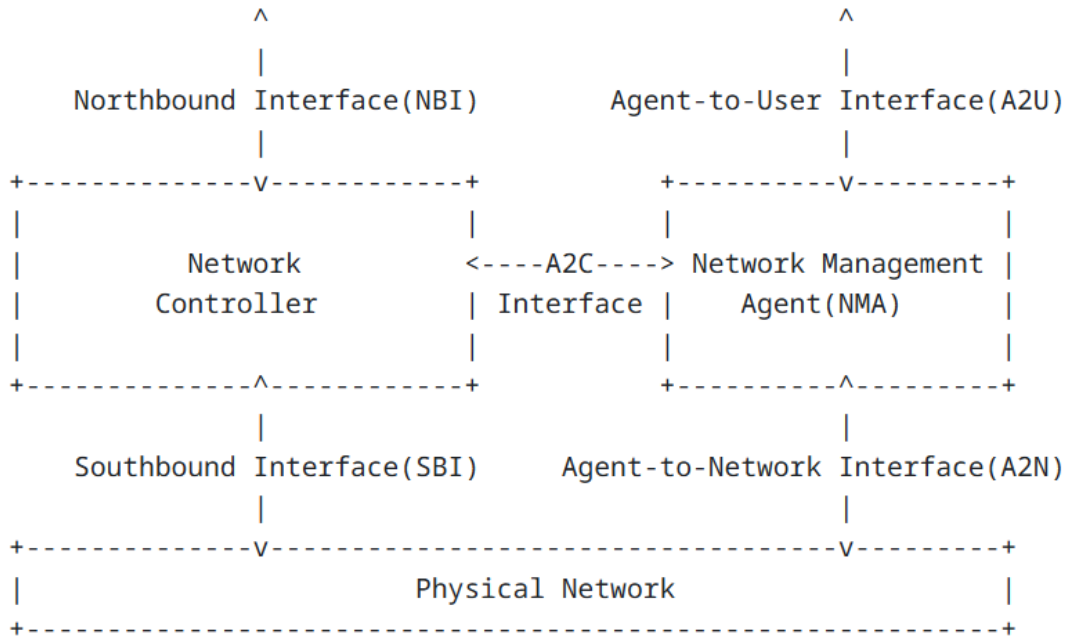


- **Autonomous Logic Layer:** embodies the intelligent loop of L4 autonomy, translating service goals into network actions. **The five functional modules correspond exactly to the IAADE control loop defined by TMF.**
- **Supporting Function Layer:** provides the foundational capabilities and resources necessary for the Autonomous logic Layer to function effectively. *(AI model service can be deployed out of NMA)*

Deployment models of NMA



Integrated Mode

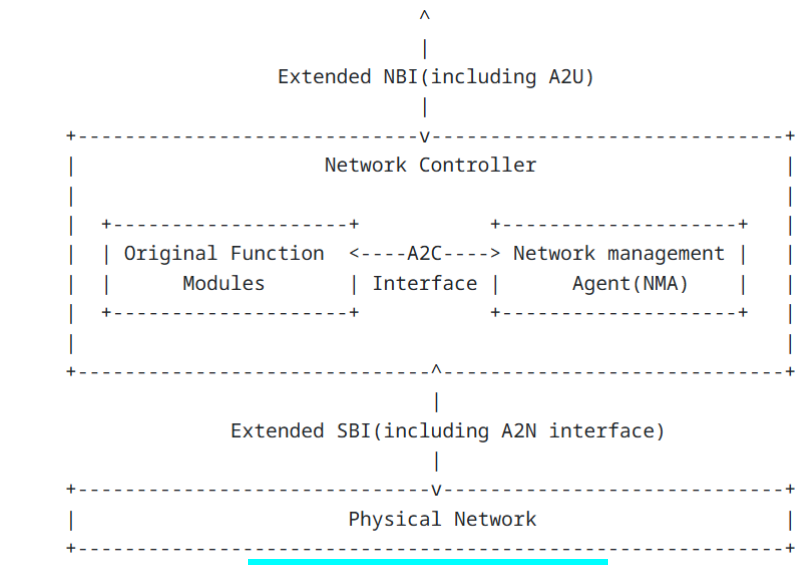


Independent Mode

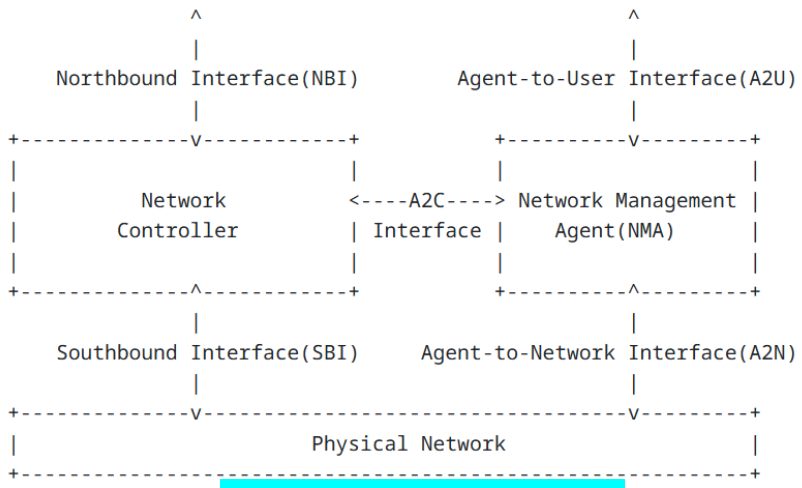
- **NMA is integrated and serves as a function of the controller**.
  - ✓ **Most vendors adopt this mode.**
  - ✓ **Suitable for single-vendor scenarios and easy to deploy.**
  - ✓ NMA interacts with original modules through **internal A2C API**.
  - ✓ NMA interacts with users through **extended NBI (including A2U)**
  - ✓ The enhanced SDN controller interacts with network devices through **extended SBI** (**including A2N**)

- **NMA is independent from the original controllers.**
  - ✓ New **A2C 、 A2N 、 A2U interfaces of NMA** need to be considered.
  - ✓ Suitable for multi-domain, multi-vendor scenarios with higher complexity.
  - ✓ **Potential issues** in practical deployment:
    - ✓ Configuration and policy conflicts
    - ✓ Inconsistent network state synchronization
    - ✓ …

NMA interfaces



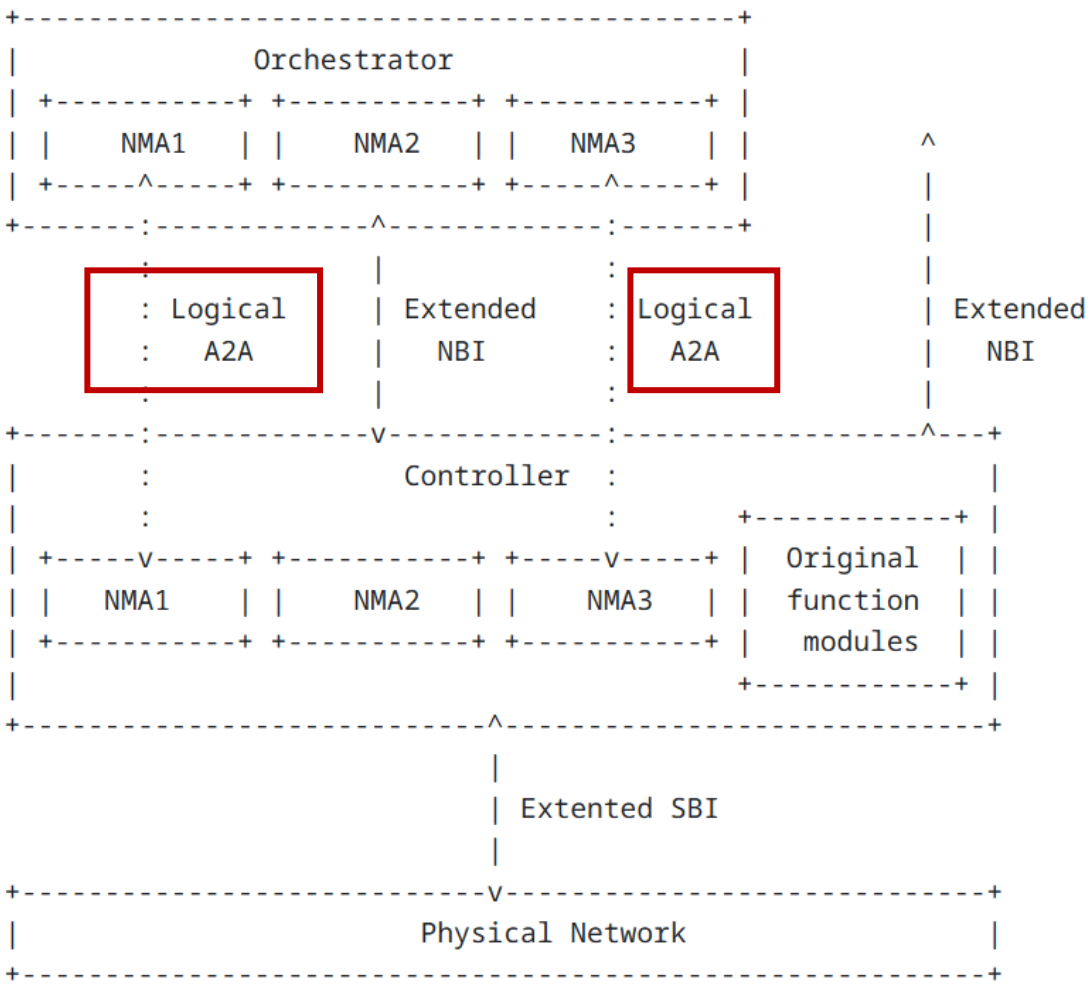
Integrated Mode



Independent Mode

- **Agent-to-User interface (A2U):**
  - **User: upper-layer NMA, controllers or orchestrators.**
  - Should support both **structured and natural language** modes. Should support Intent Submission and Status Reporting.
  - The **Agent-to-Agent (A2A) interface** between NMAs is included in the scope of this interface.
- **Agent-to-Controller interface (A2C):**
  - In the **independent** mode: a new east-west interface between controller and NMA;
  - In the **integrated** mode: an internal API of the controller and is out of scope of this document.
- **Agent-to-Network interface (A2N):**
  - **In the independent mode**: a new SBI between Agent and device;
  - **In the integrated mode:** can be extended based on the original SBI.

Interfaces to be extended on SDN controller



When NMAs are deployed within the controller, the related interfaces to be extended include:

- **Extended NBI of the controller**:
  - ✓ Needs to realize functions such as **capability discovery** and **invocation** between upper-and lower-layer NMAs.
  - ✓ Should expose **NMA's cognitive capabilities as Intent-Based RPCs**.
  - ✓ Upper and lower-layer NMA communication: **a single channel physically but multiple A2A communication logically**. Should handle **logical multi-process isolation**.
- **Extended SBI of the controller:**
  - Theoretically NMAs won't directly operate devices; They will call functions of the controller for device configuration.
  - Out of scope of this draft.

NEXT STEPS

- Improve the content of the draft.
- Collect comments and contributions from NMOP.

  https://github.com/xingzhao92/draft-zhao-nmop-network-management-agent/tree/main

  draft-zhao-nmop-network-management-agent@ietf.org

- As the starting point for all AI/Agentic work in NMOP, **start working on it as a WG?**

THANK YOU

Appendix: Definition of L0~L5 levels in AN

Level	Name	Description (Core Characteristics)	Human vs. Machine Role
L0	Manual	Fully manual processes. No automation.	Human does everything.
L1	Assisted	System provides tools (dashboards, alarms).	Human makes all decisions; tools assist.
L2	System-assisted	Automation of single tasks/scripts within a specific domain.	Human initiates tasks; system executes.
L3	**Partial Autonomy**	Closed-loop automation based on pre-defined policies/models within a domain.	"Human-in-the-Loop": Humans define rules/models and monitor; system executes and reports exceptions.
L4	**High Autonomy**	Cross-domain/cross-layer context analysis and closed-loop optimization based on Intents.	"Human-on-the-Loop": Humans define high-level intents; system self-configures and heals. Human only intervenes on system failure.
L5	Full Autonomy	Self-evolving, self-optimizing, fully driverless operations.	"Human-out-of-the-Loop": System requires no human intervention for business goals.