

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

*NMOP, IETF 123*

**draft-zhao-nmop-network-management-agent/  
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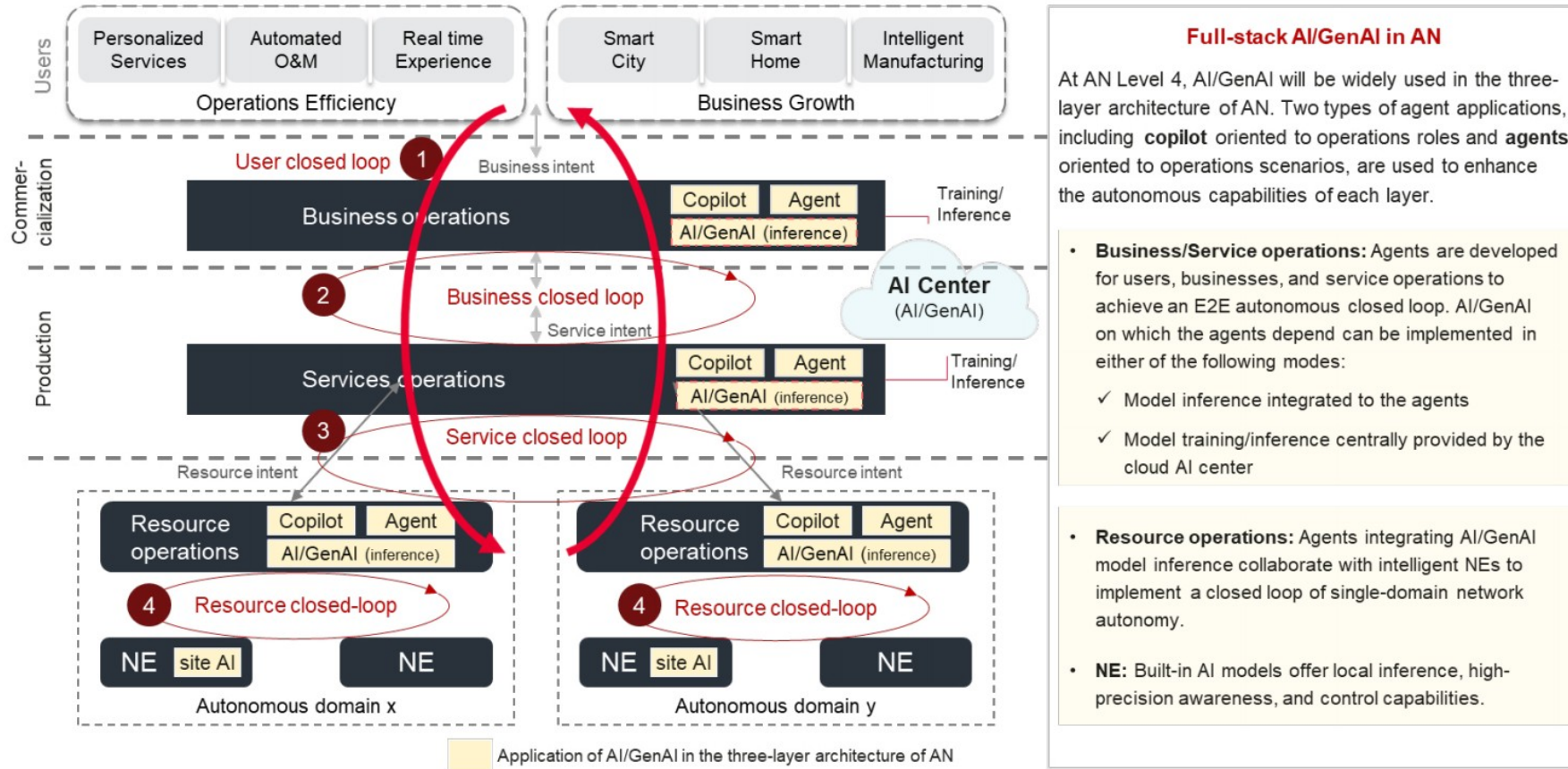
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# Background: Introducing AI agents into network operations has become a consensus

- As the concept of **AI agent** becomes widely accepted in the industry, it's expected to become one of the most feasible application forms of AI.
- TMF whitepaper "Level 4 industry blueprint - high-value scenarios" proposed the full-stack AI/GenAI in the three-layer architecture of AN, in which **Agents will be widely used in the operations**.



**Agents are proposed to achieve an E2E autonomous closed loop, well matching the demands of L4 AN.**

Figure 9: Full-stack AI / GenAI in the three-layer architecture of AN

# The goal and scope of this draft

- This draft is trying to **give a standardized common architecture for the use of AI in network--->Network Management Agent (NMA)**.
  - Provide the framework of **network management agent** (AI agent for network management)  
Clarify the relationship of NMA with existing controllers
  - Define **functional requirements** of NMAs for different scenarios and related interfaces

*This work is focus on the common framework of control plane.*

*The specific agent implementation details are not in the scope of this draft.*

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1) Supplement the background content in **Section 1.1**

2) **Add Section 1.2** to optimize the conceptual definition of NMA

3) **Revise Chapter 3** significantly, including:

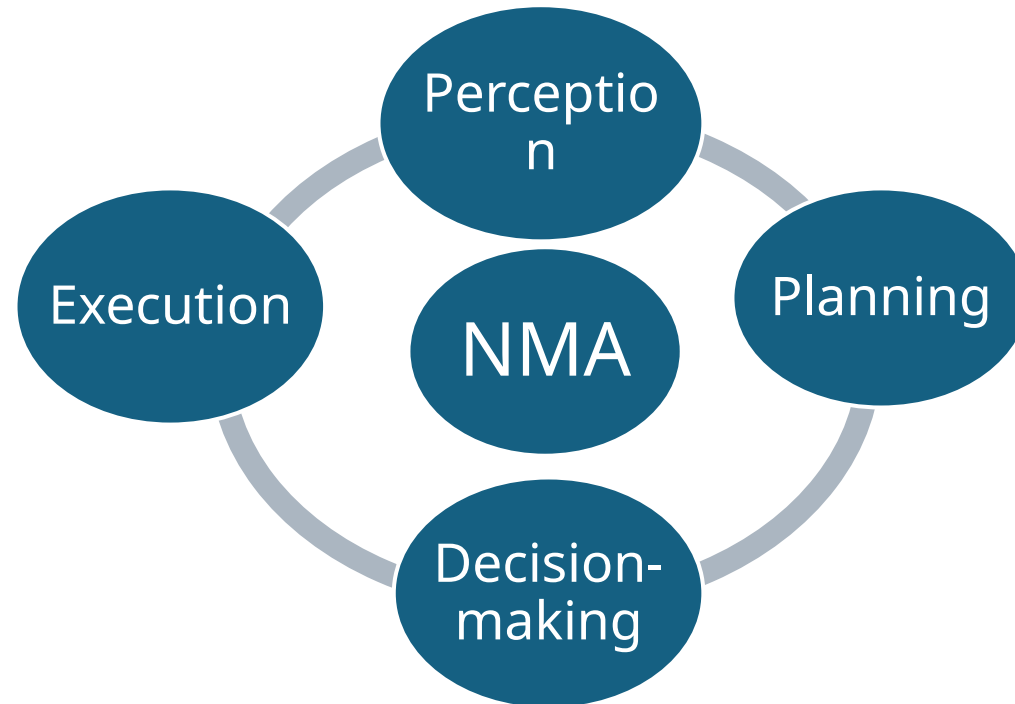
- ✓ Add Section 3.1 to describe the NMA-based intelligent network management and control framework, and explain the relationship of this draft with RFC 8969.
- ✓ Add Section 3.2 to describe the functional requirements of NMA.
- ✓ Revise Section 3.3 to streamline and optimize the definition of NMA's functional architecture.
- ✓ Add Section 3.4 to describe NMA's external interfaces.

4) **Add Chapter 4** to elaborate on application considerations under single-Agent and multi-Agent scenarios.

# Major updates since 00-version (1)

## Optimize the definition of Network management agent (NMA) - AI Agent for network management

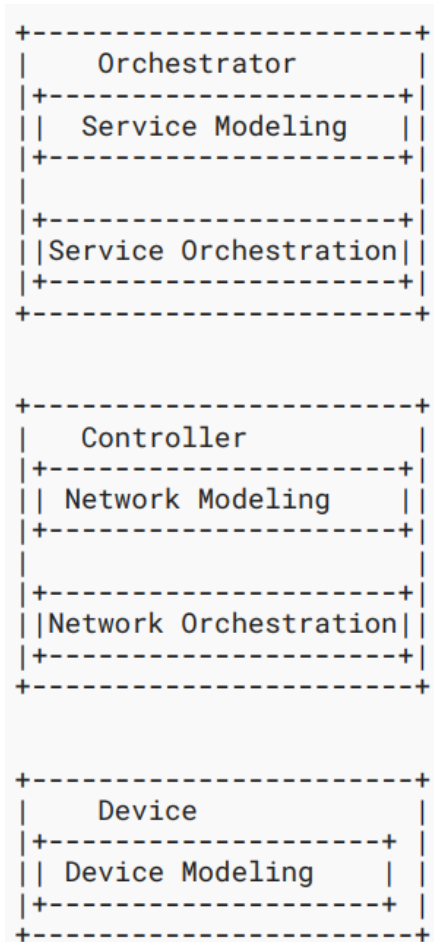
- A network management entity built based on ML/AI and equipped with the autonomous closed-loop task processing capabilities.
- It can automatically carry out network status perception, task intent interpretation, task planning, decision-making and task execution operations based on user task intentions or preset goals, so as to achieve closed-loop processing of scenarios-oriented network management tasks.



# Major updates since 00-version (2)

## Add the Intelligent Network Management and Control Framework Based on NMA

- **Relation with RFC8969:** this draft is an enhancement of intelligent capabilities of RFC8969.
- **Position of NMA:** NMA can exist at both the Controller and Orchestrator levels. Some end-side AI components may be added on the device instead of a complete NMA.



RFC 8969: Layering and Representation within a Network Operator

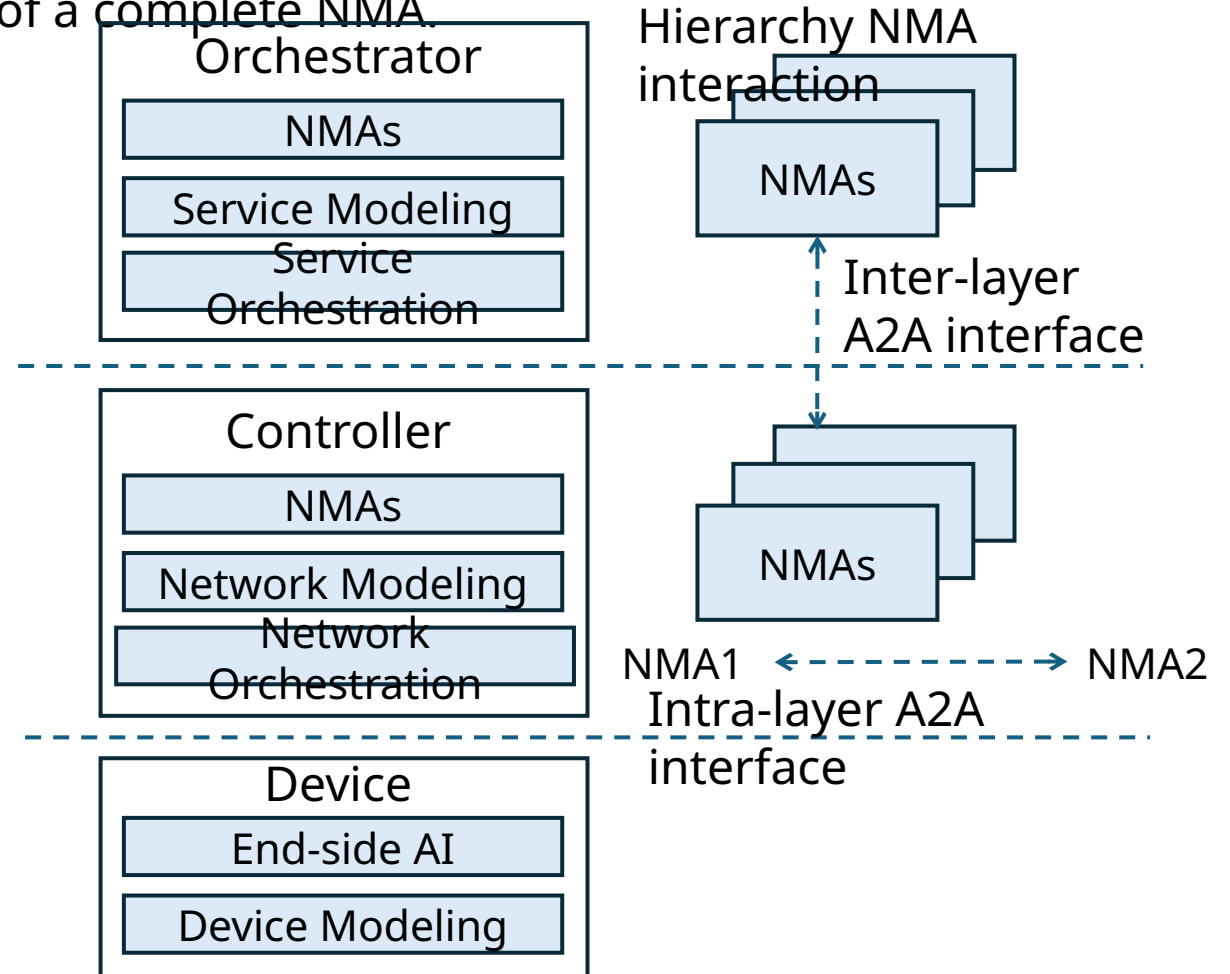
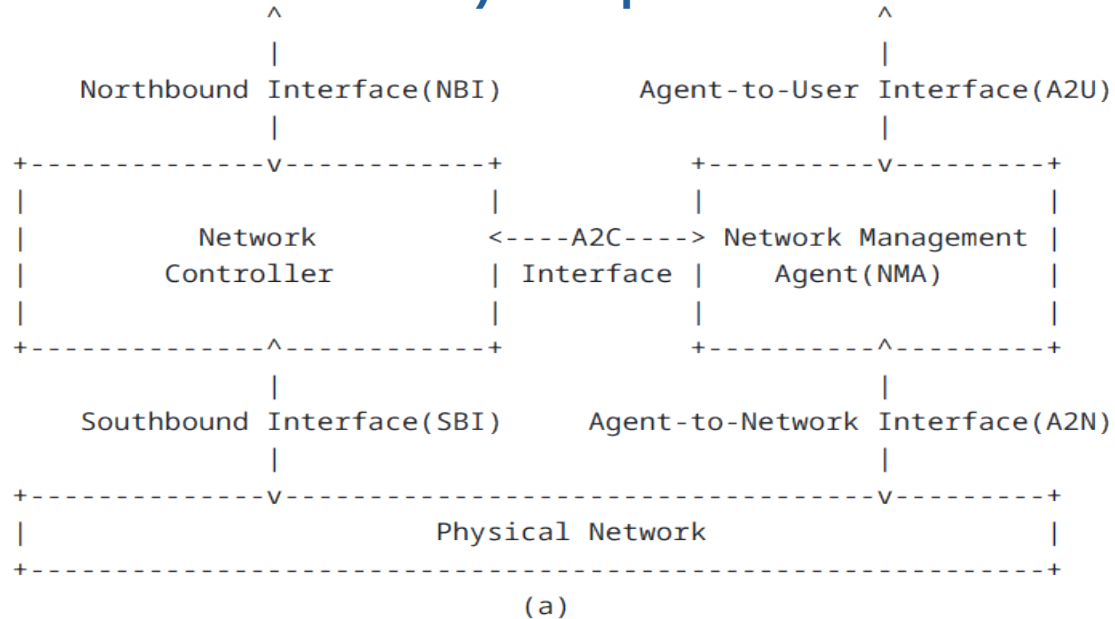


Fig.1 Enhanced intelligent network management and control framework based on NMA

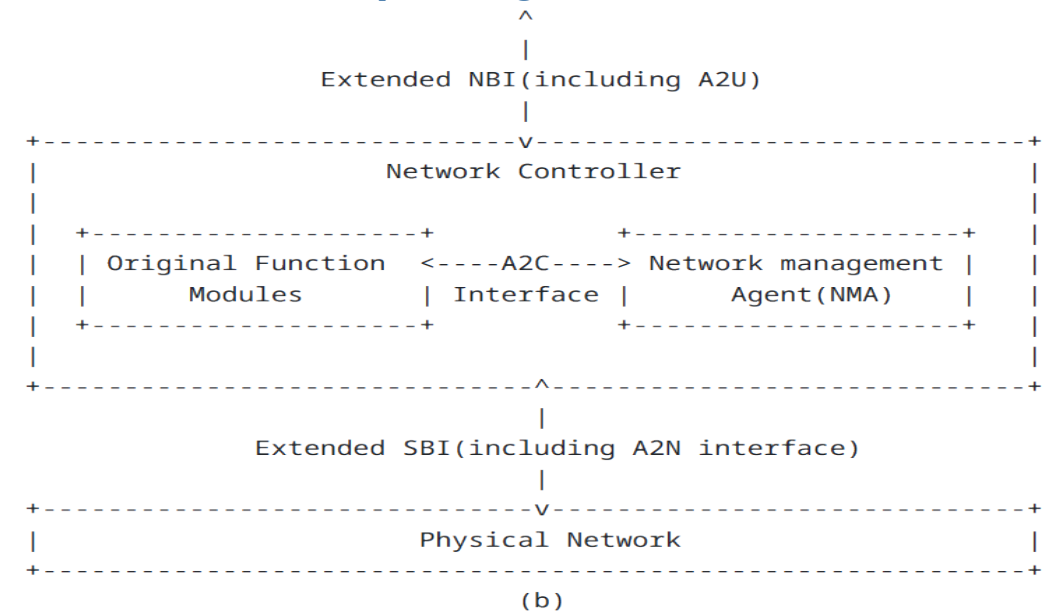
# Major updates since 00-version (3)

## Deployment modes of NMA:

### Mode a): Independent Mode



### Mode b): Integrated Mode



- **NMA is independent from the original controllers.**

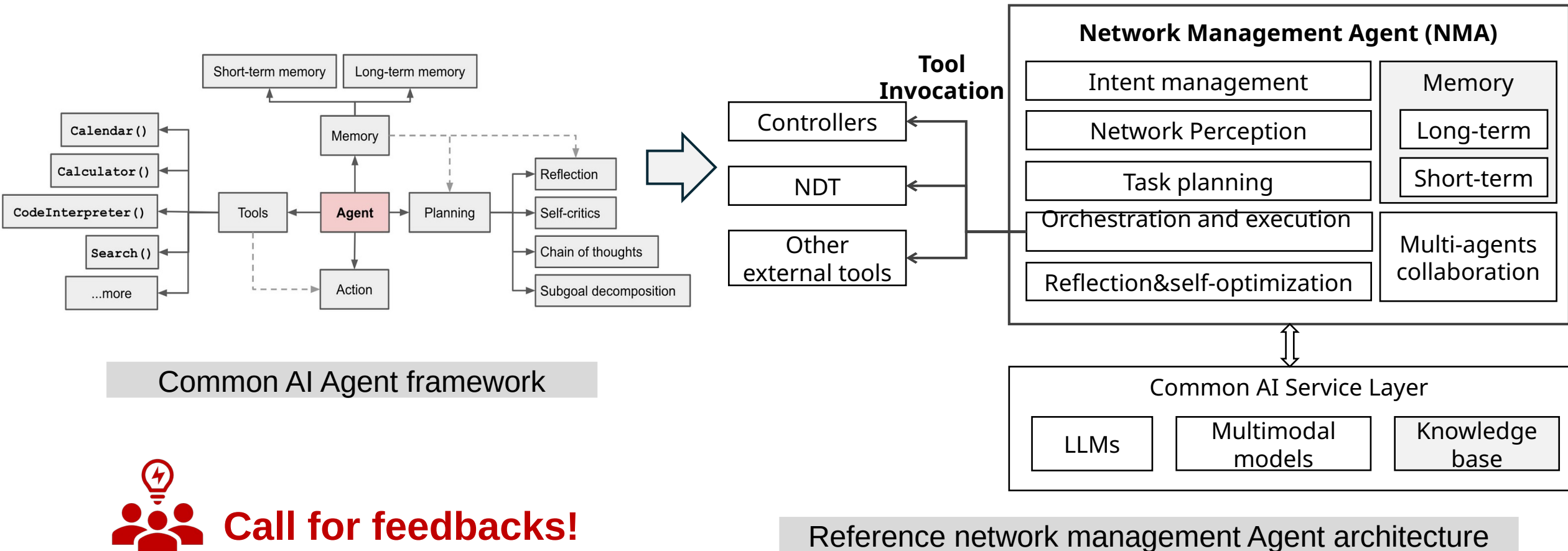
- A new east-west interface (**A2C**) needs to be added between NMA and controller to achieve capability calling and result feedback.
- An intelligent southbound interface (“**A2N**”) needs to be added between NMA and the physical network.
- NMA interacts with users (human or other agents) through a new **A2U** interface (**A2A interface** belongs to the scope of this interface)

- **NMA is integrated and serves as a function of the controller.**

- NMA interacts with original function modules through internal interface. NMA interacts with users through extended NBI (**including A2U**)
- The enhanced MCS interacts with underlay physical network through extended SBI (“**E\_SBI**” **including A2N**)

# Major updates since 00-version (4)

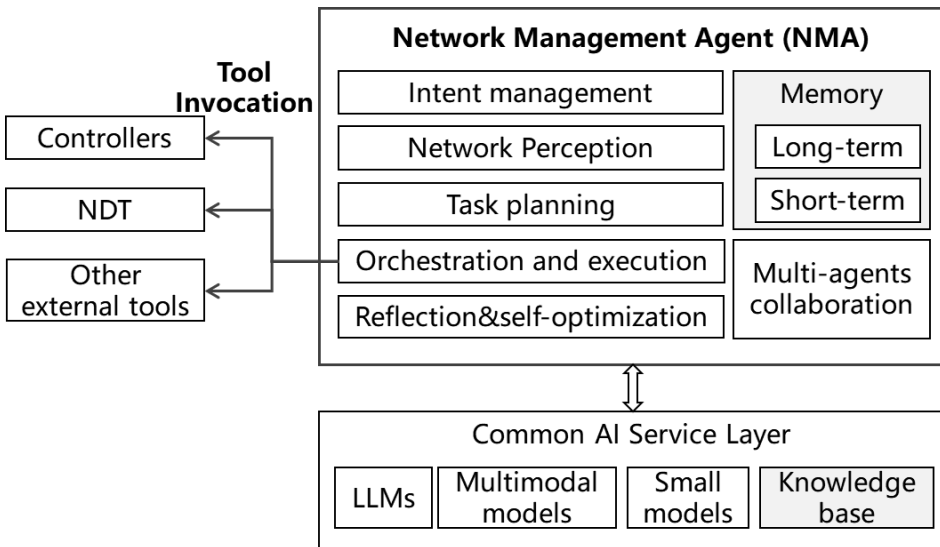
By referring to the common AI agent framework, the draft updates **the reference function architecture of NMA**.



**Call for feedbacks!**

Reference network management Agent architecture

# Function components of NMA

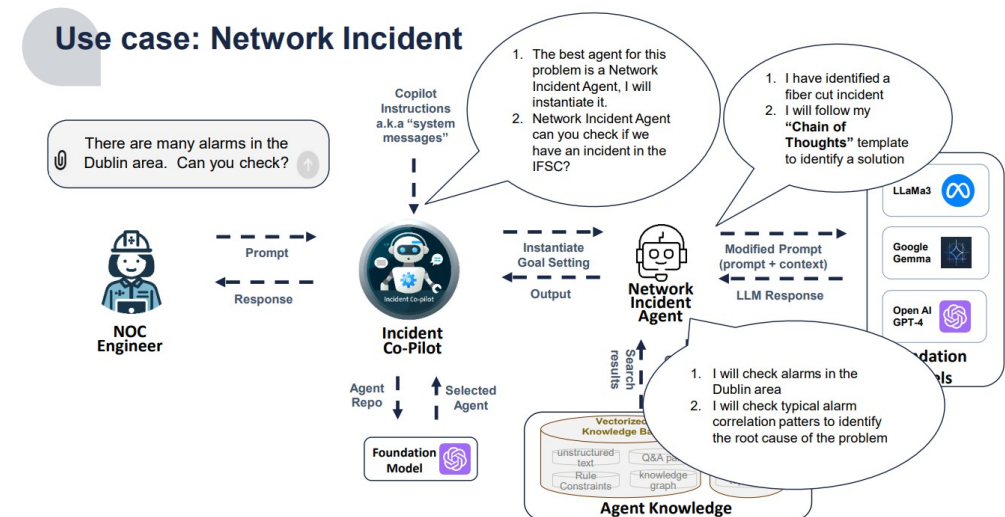


- **Intent Management:** Basic capability provided by AI models, responsible for collecting the input task and translate into intents through model reasoning.
- **Network Perception:** Achieve real-time query for network status information related to the task intent. Network status info are not limited to topology, service configurations, device status, alarms, performances, etc. The query source can be controller, NDT, etc.
- **Task Planning:** Based on the reasoning ability of AI models, break down the task intention into multiple sub operations.
- **Orchestration and execution:** Select the appropriate tools and automatically call the relevant tools or interfaces to perform the operation. After each sub operation is completed, the results of each operation are formed into task execution results.
- **Reflection and self-optimization:** Analyze and evaluate the historical decision-making process and execution results of the NMA. Based on the evaluation results, automatically adjust and optimize the NMA's strategies, parameters, etc. Artificial evaluation methods can be integrated to further optimize the NMA's performance through human supervision.
- **Memory:** Responsible for storing and processing data during the operation of NMA, including long-term memory (LTM) and short-term memory (STM).
- **Multi-agents collaboration:** Responsible for completing collaboration between multiple NMAs at different levels or in different application scenarios. The specific collaboration mechanism needs further research.

# Function components of NMA

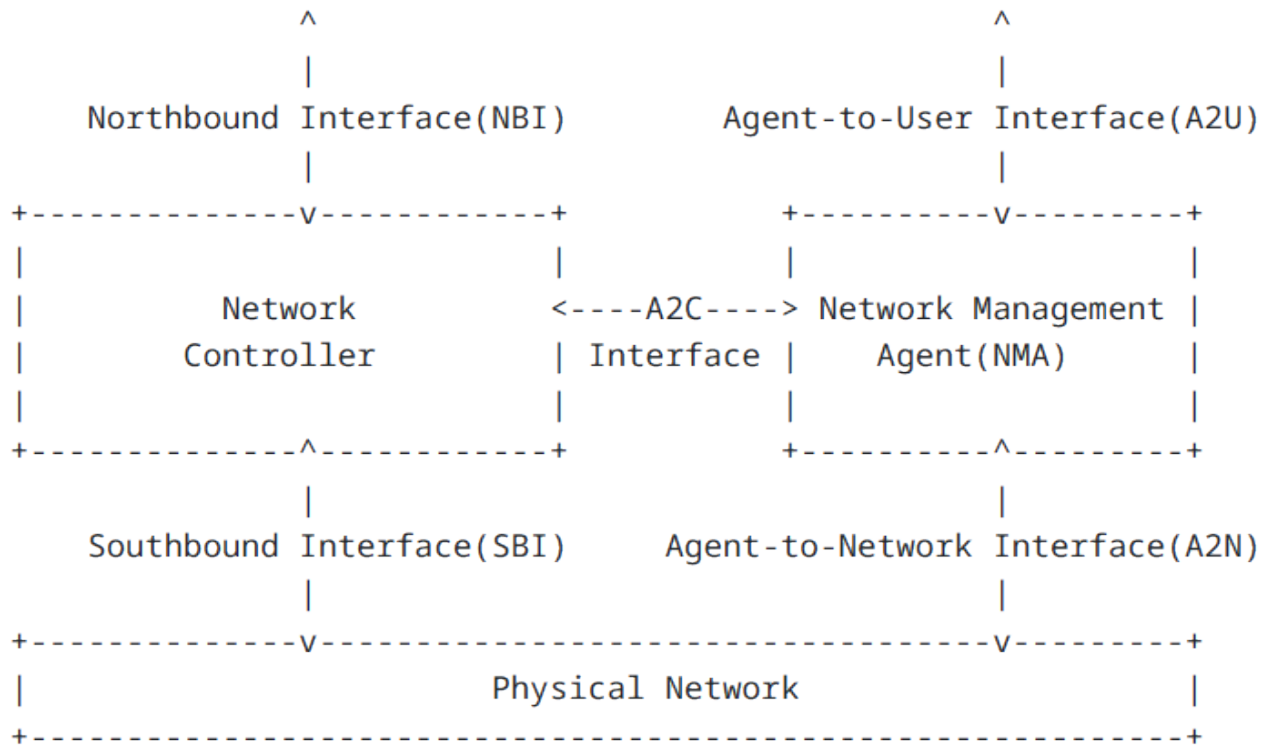
- **Common AI service layer:** including various large language models (LLMs), multimodal models, small models, and knowledge base. AI models provide public interactive intelligence capabilities as unified agent engine, to simplify NMA development. Knowledge base provides unified search for multi-type knowledge bases including vector knowledge base, system online help, operation and maintenance data logs), combines AI models to complete knowledge fusion and extraction, and improves the accuracy of NMA task execution.
- **Various NMAs can be constructed based on the common AI service layer.** During the operation of NMA, it leverages the model reasoning capabilities and knowledge base provided by the AI service layer to achieve functions such as intent parsing and task planning.
- Depending on the actual deployment requirements, **the AI basic service can also be deployed within the NMA.**
- For different application scenarios, there can be multiple scenario-oriented agents (like apps in the phone). **Aimed at the network planning, construction, maintenance, optimization, and operation scenarios, the main NMAs could include:**

- Network Fault Handling Agent
- Network Planning Agent
- Network Optimization Agent
- .....



# Major updates since 00-version (5)

## Interfaces of NMA



(a)

### ■ Agent-to-User interface (A2U):

- The interface between the NMA and the user, where the user can be a human or another system.
- Used to receive call requests from users and return task processing results.
- It should support both structured and natural language modes.
- 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, this interface is an east-west interface between the controller and NMA; in the integrated mode, this interface is an internal interface of the controller and is not within the scope of this document.

### ■ Agent-to-Network interface (A2N):

- The interface between the NMA and the physical network.
- In the independent mode, this interface is a new SBI between the Agent and the network; in the integrated mode, this interface can be extended based on the original SBI.

# Major updates since 00-version (6)

## Deployment modes considerations

- Due to an internal communication between the NMA and the controller, the independent deployment mode introduces several challenges to be analyzed, that can be grouped into “single agent” and “multi agent” challenges.

### Single Agent

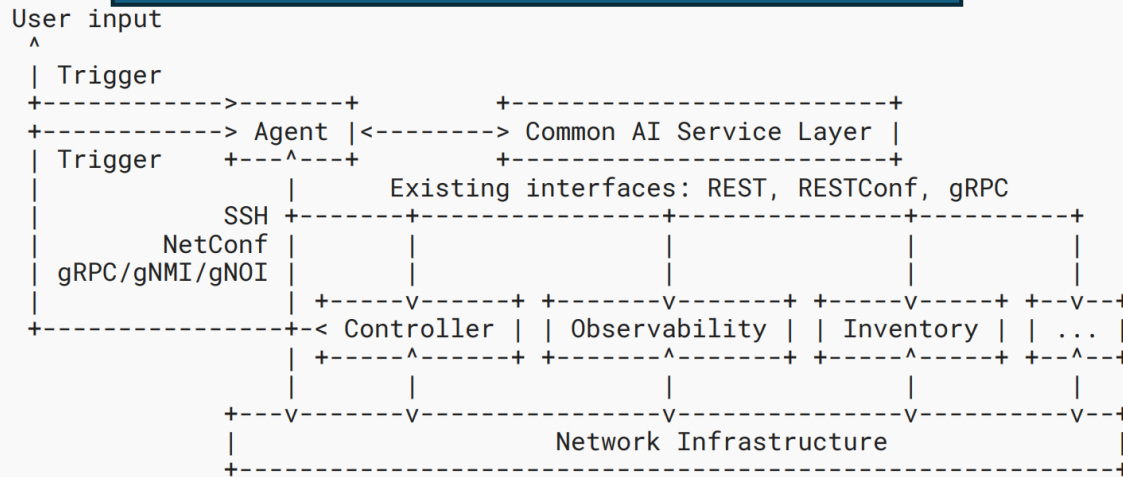


Figure 3: Network management architecture with single agent

### Multi Agents

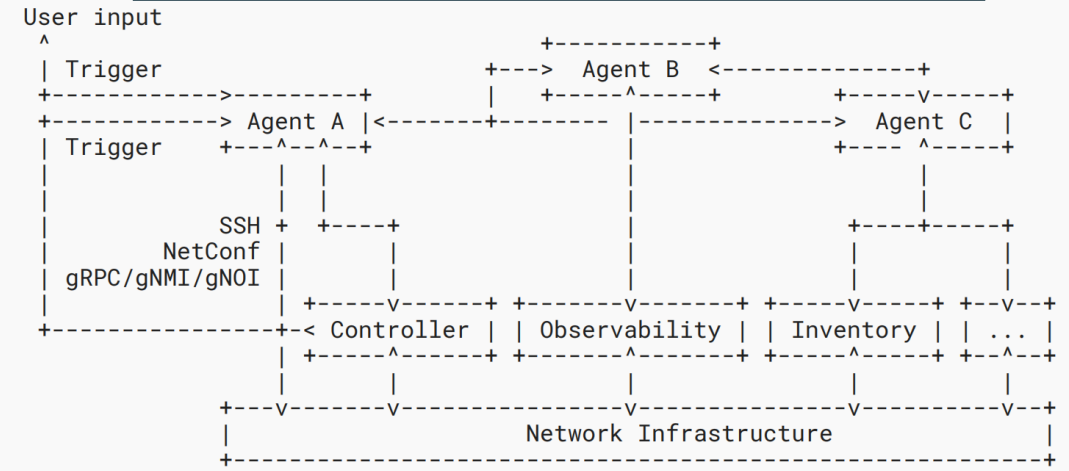


Figure 4: Network management architecture with multi agents

#### ■ Main issues to be addressed:

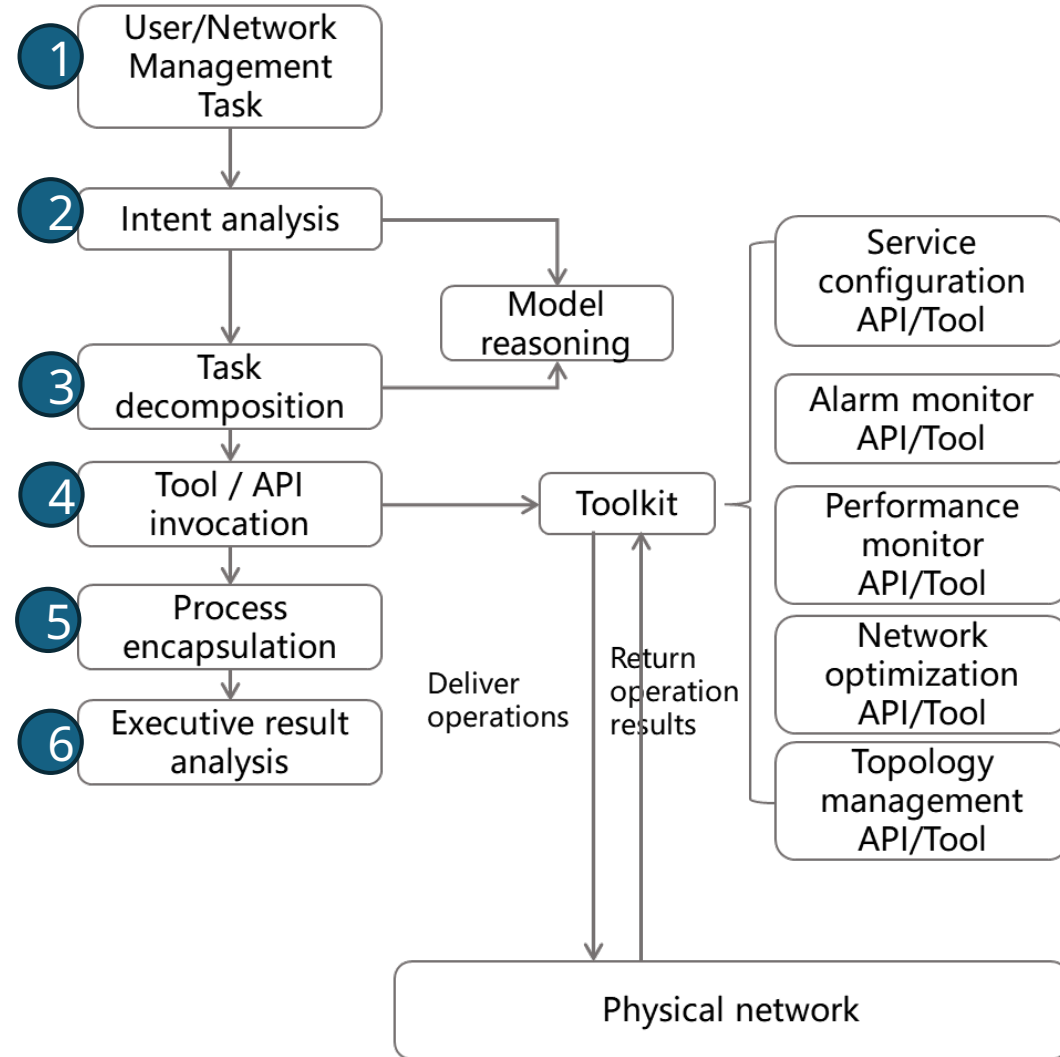
- **NMA APIs:** A gap analysis against existing APIs needs to be carried out to understand if the NMA API requirements can be met and if we can find a way to describe network APIs for LLMs.
- **NMA triggers:** The trigger can be initiated by a controller or a human readable string. Natural language input or something with a more structured format?

#### ■ Main issues to be addressed:

- **Inter NMA communication:** Necessary to support authentication.
- **NMA discovery:** NMA discovery and capability report mechanisms between multi-agents.

More complicated

# Common workflow of NMA (Unchanged)

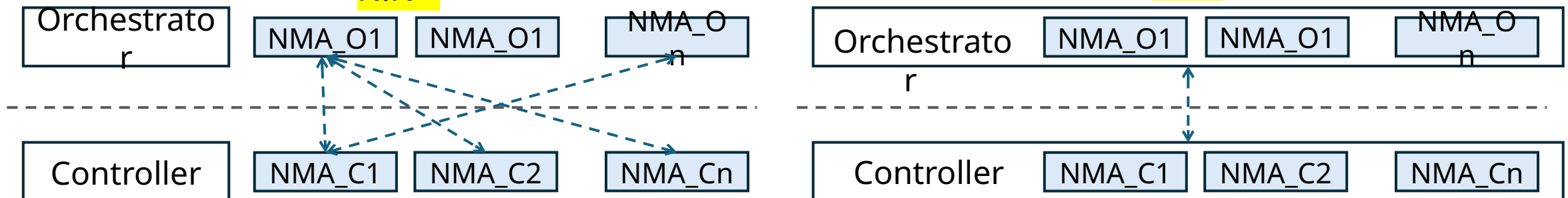


- ① **User/Network Management Task Input:** Input the user's task information through multiple rounds of natural language interaction.
- ② **Intent Analysis:** Analysis user task intent through AI model reasoning provided by the AI based basic services within NMA.
- ③ **Task Decomposition:** Split the task into detailed operations to be performed based on the analyzed intent of the task.
- ④ **Tool/API Invocation:** Call the corresponding tool or function API to complete the execution of each operation listed in step 3). The **toolkit** refers to the collection of all tools that can be used directly to manage and operate physical networks.
- ⑤ **Process Encapsulation:** Package the operation results of all steps into the execution result of the entire task.
- ⑥ **Executive result analysis:** Analyze the task processing results and return to the user.

*Goal: Achieve closed-loop automated processing of tasks and provide end-to-end intelligent network maintenance assistance.*

# Open issues

- **Interfaces scheme of NMA: MCP, A2A? Are they suitable for Network Management Agents?**
  - Glad to see that there are already related works:
    - *Applicability of A2A to the Network Management (draft-yang-nmrg-a2a-nm-00)*
    - *Applicability of MCP for the Network Management (draft-yang-nmrg-mcp-nm-00)*
- **Multi-agent collaboration scenarios and mechanism: N:N or 1:1?**
  - **N:N** : Adopting the independent mode results in many-to-many interaction relationships between multiple Agents at the Controller layer and multiple Agents at the Orchestrator layer, leading to complicated interaction.
  - **1:1**: Adopting the integrated mode enables one-to-one interaction between the controller and the orchestrator.



# Next Steps

- Improve the content of the draft, especially on the interfaces and workflows
- Collect comments and contributions from NMOP
- Update the 03-version at the next *IETF #124* meeting

## Thanks for listening !

Any feedbacks are welcome!

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