Integration of Network Management Agent (NMA) into ACTN-Based Optical Network

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CCAMP, IETF 125

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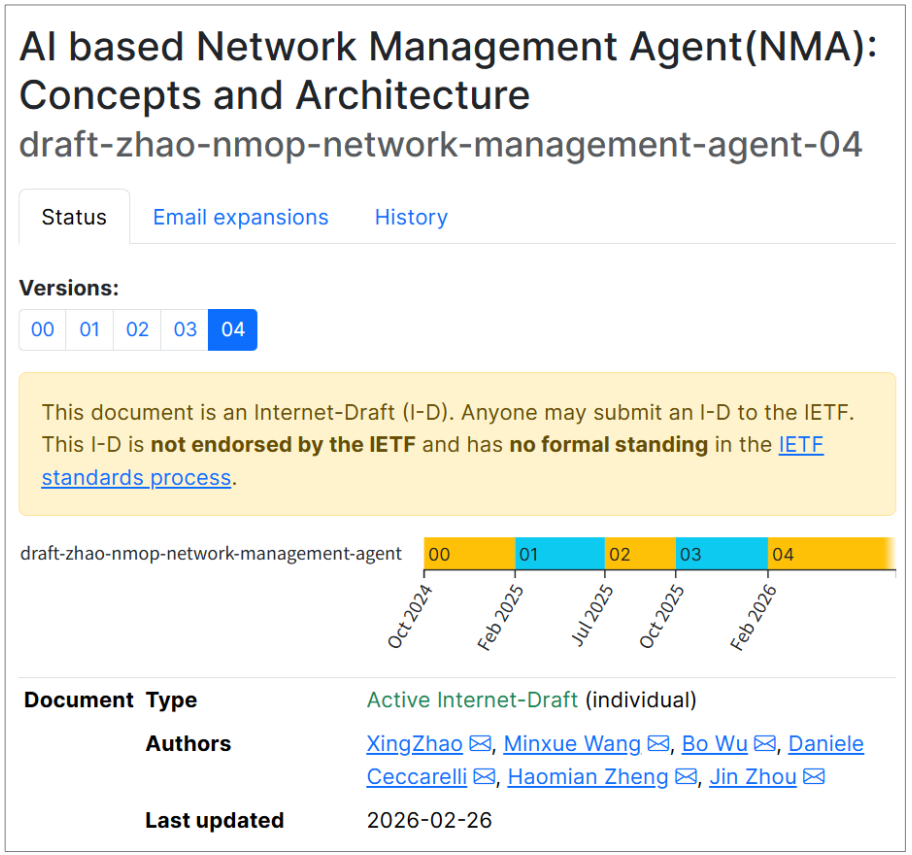
Background: NMA work in NMOP

- **Draft <AI based network management agent(NMA)> proposed in 2024.10. Latest: 04 version,** progressing its adoption as a WG document.
- **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.



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

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Status | Email expansions | History

Versions:

00 | 01 | 02 | 03 | 04

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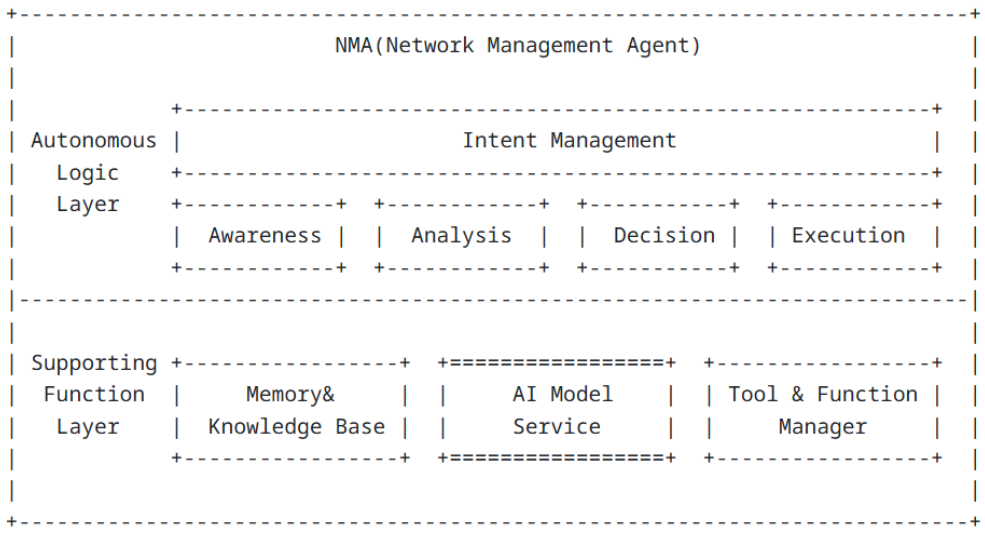


- **Autonomous Logic Layer:** embodies the intelligent loop of L4 autonomy, translating goals into network actions. The **functional modules correspond exactly to the IAADE control loop defined by TMF.**
- **Supporting Function Layer:** provides the foundational capabilities and resources necessary for the Autonomous logic Layer to function effectively.

Goal and scope of the draft

Background

- The existing ACTN architecture **lacks higher-level autonomous capabilities**. **AI agents widely accepted in industry. NMOP already has Network Management Agent (NMA) standardization work.**

Scope

- This document explores the introduction of AI based Network Management Agent (NMA) functions into ACTN-based optical networks to **achieve high-level autonomy of optical networks.**

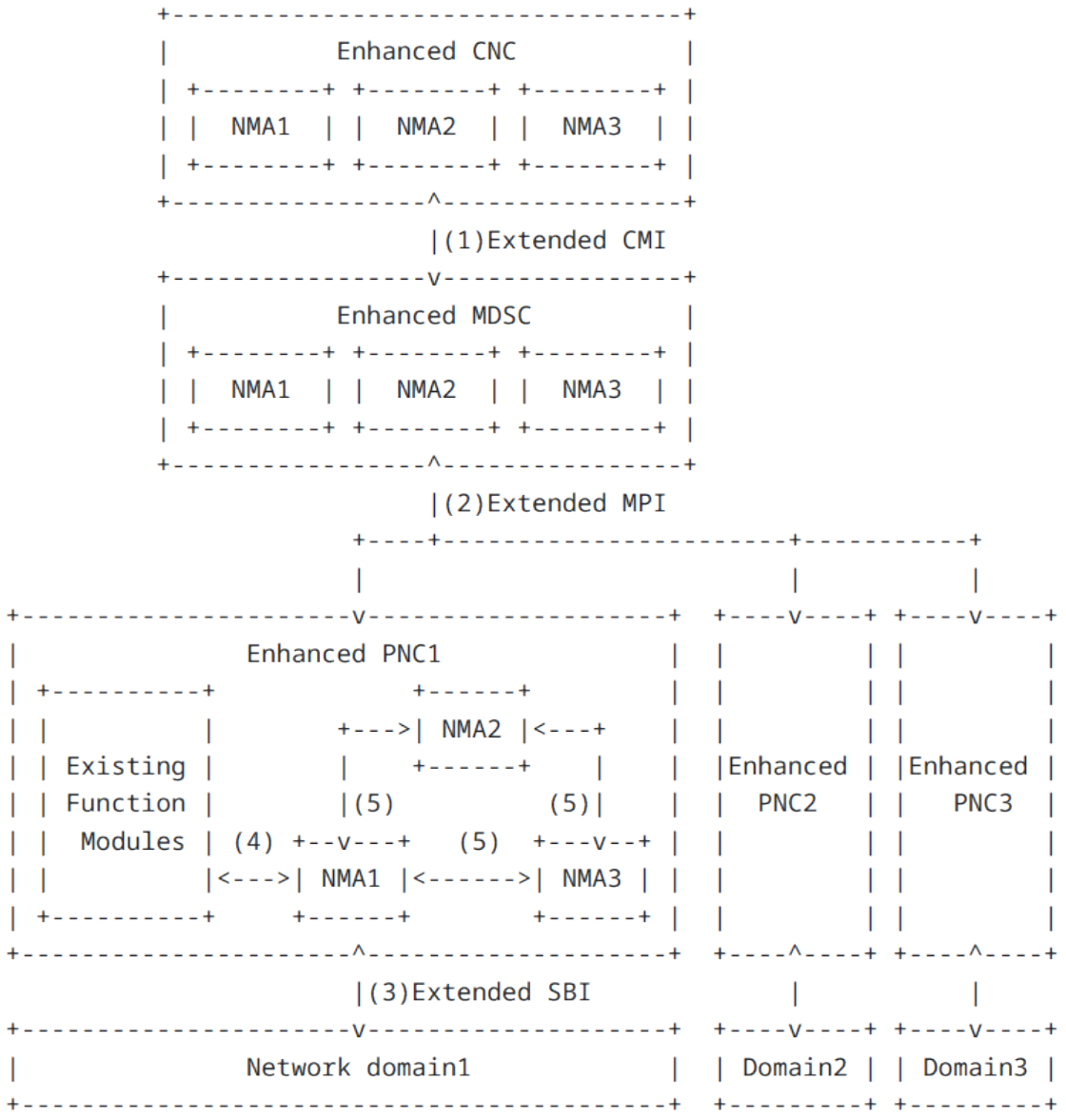
Goals

- **Define the NMA-enhanced ACTN framework** for optical networks.
- **Define new interface requirements** in the enhanced architecture.
- **Describe typical use cases** of NMA in ACTN based optical network.
- **As a starting point**, introduce AI/ AI Agents related standardization work for CCAMP.

Not Goals

- *Specific agent implementation details as well as interface protocol or model definition are out of scope.*

NMA-enhanced ACTN architecture



The NMAs are embedded as enhanced functional components into each layer of controllers, **forming enhanced CNC, MDSC, and PNC**.

- ✓ **NMA-Enhanced CNC:** enable intelligent service-domain capabilities such as automated work order flow, etc.
- ✓ **NMA-Enhanced MDSC:** strengthen cross-domain closed-loop task processing capabilities.
- ✓ **NMA-Enhanced PNC**: address single-domain OAM management needs and enhance the autonomous ability.
- ✓ **CMI/MPI/SBI** needs to be extended either.

Notes:

- ✓ The NMAs are introduced to augment and assist existing ACTN functional entities, **not to replace them**.
- ✓ The agents can interact with existing ACTN functional modules **through standardized protocols such as the MCP**, etc.
- ✓ This integrated design approach ensures **backward compatibility.**

Agent proxy mechanism

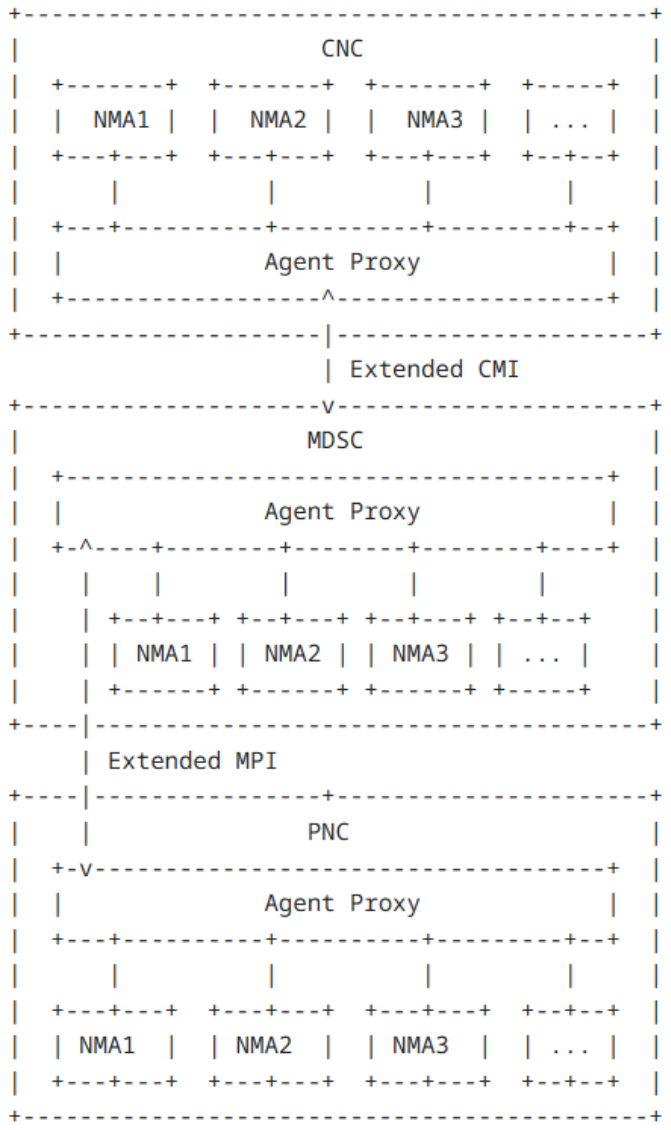


Figure 2: Diagram of Agent Proxy in each layer

The **Agent Proxy** shall be deployed to manage Agent-to-Agent (A2A) comm with agents external to the controller. **The agent proxy is for:**

- ✓ **Implementing the enhanced CMI** on the MDSC and the enhanced MPI on the PNC respectively.
- ✓ Allowing NMAs to **register capabilities** and **advertises** to external agents.
- ✓ Acting as a **gateway** for NMAs to communicate with external agents.

Why is agent proxy necessary?

- ✓ This mechanism standardizes the access mode of lower layer NMAs to the upper layer, **avoids multi-NMA access conflicts**, and improves the manageability and scalability of inter-layer NMA communication.

Deployment of NMAs in PNC

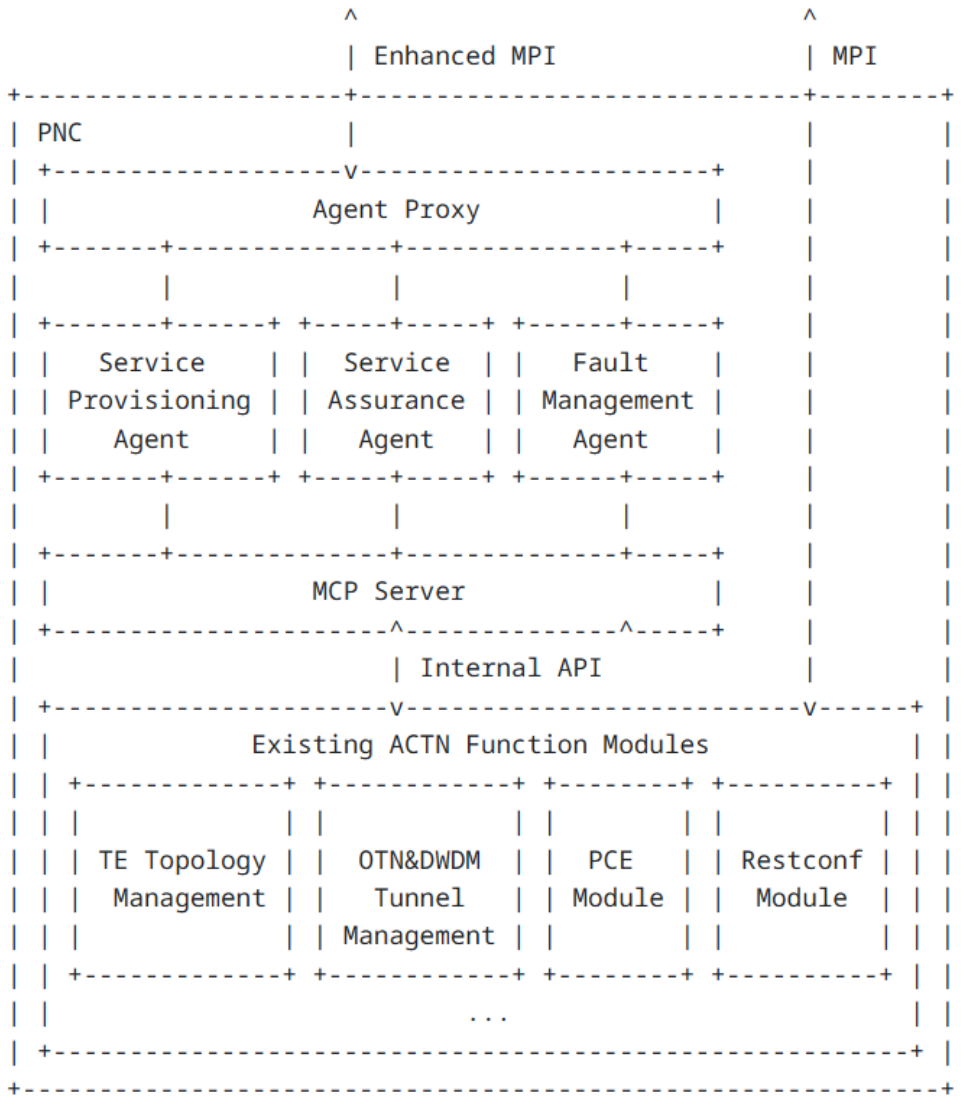
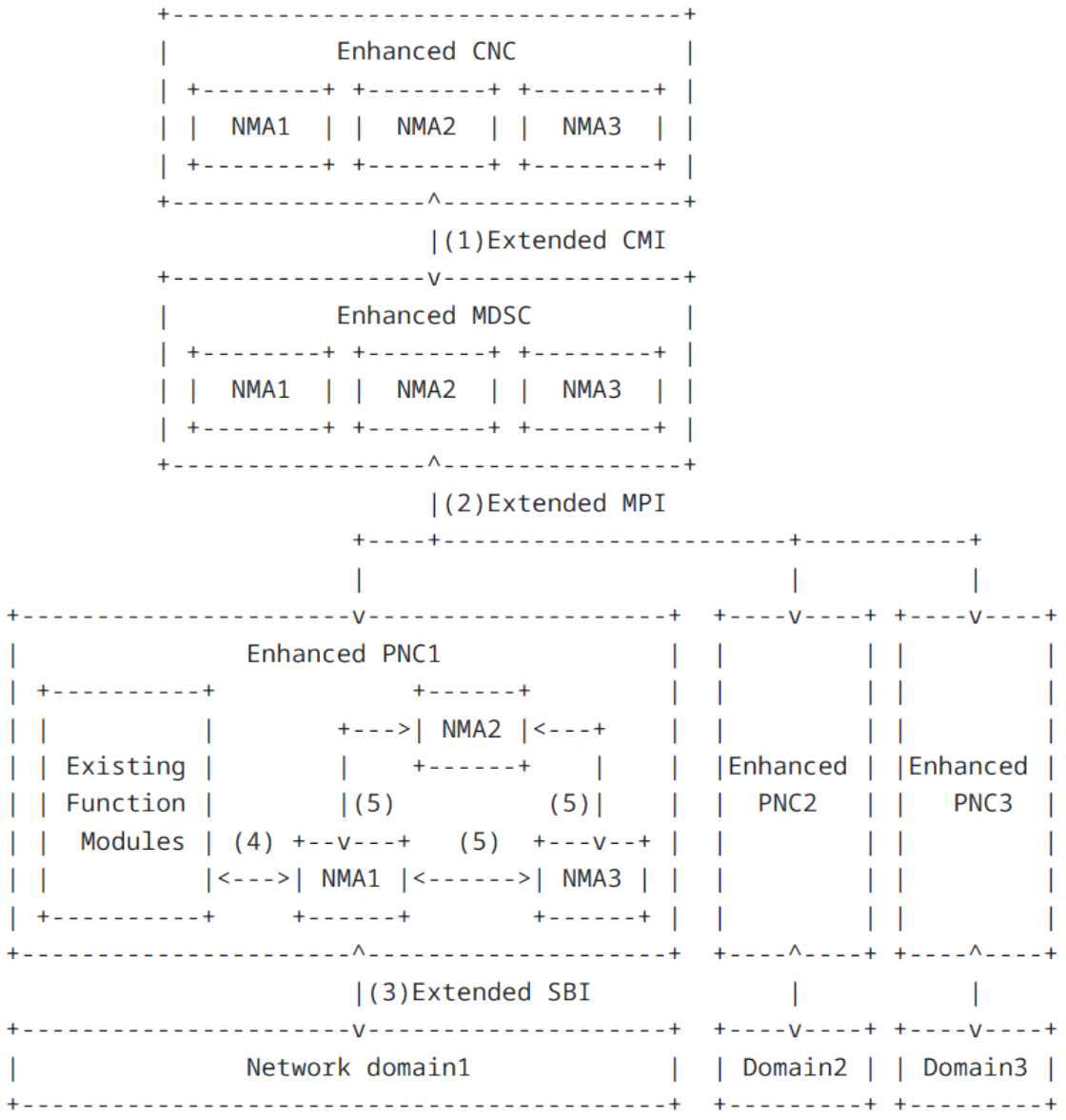


Figure 3: Sample illustration of NMAs in PNC

- ✓ **There could be multiple NMA instances** like service provisioning agent, service assurance agent, etc.
- ✓ The agents can interact with existing ACTN function modules **through standardized protocols (MCP, etc.)** or private API.
- ✓ **Existing ACTN function modules expose their capabilities** (e.g., TE Topology retrieval and OTN tunnel service creation) **as APIs**. **NMA instances can invoke and consume these APIs**.
- ✓ This integrated design approach ensures **backward compatibility** with the established ACTN framework.

Enhanced ACTN interfaces



1-2. Extended CMI/MPI:

- ✓ Will be enhanced **from traditional transactional comm to agent-oriented conversational comm**.
- ✓ Maintains **forward compatibility** and fully supports all functional capabilities of the original CMI/MPI interface, **ensuring that existing CNC/MDSC/PNC interaction logic without NMA deployment can still work normally based on the extended CMI**.

3. Extended SBI: out of scope of ACTN discussions.

4. Interfaces between NMAs and existing ACTN function modules at each layer: internal API, out of scope.

5. Interfaces between NMAs within same layers: internal system API that can use private interfaces or general protocols (e.g., A2A, ACP, etc.). Out of scope of this draft.

Inter-controller NMA interaction between MDSC and PN

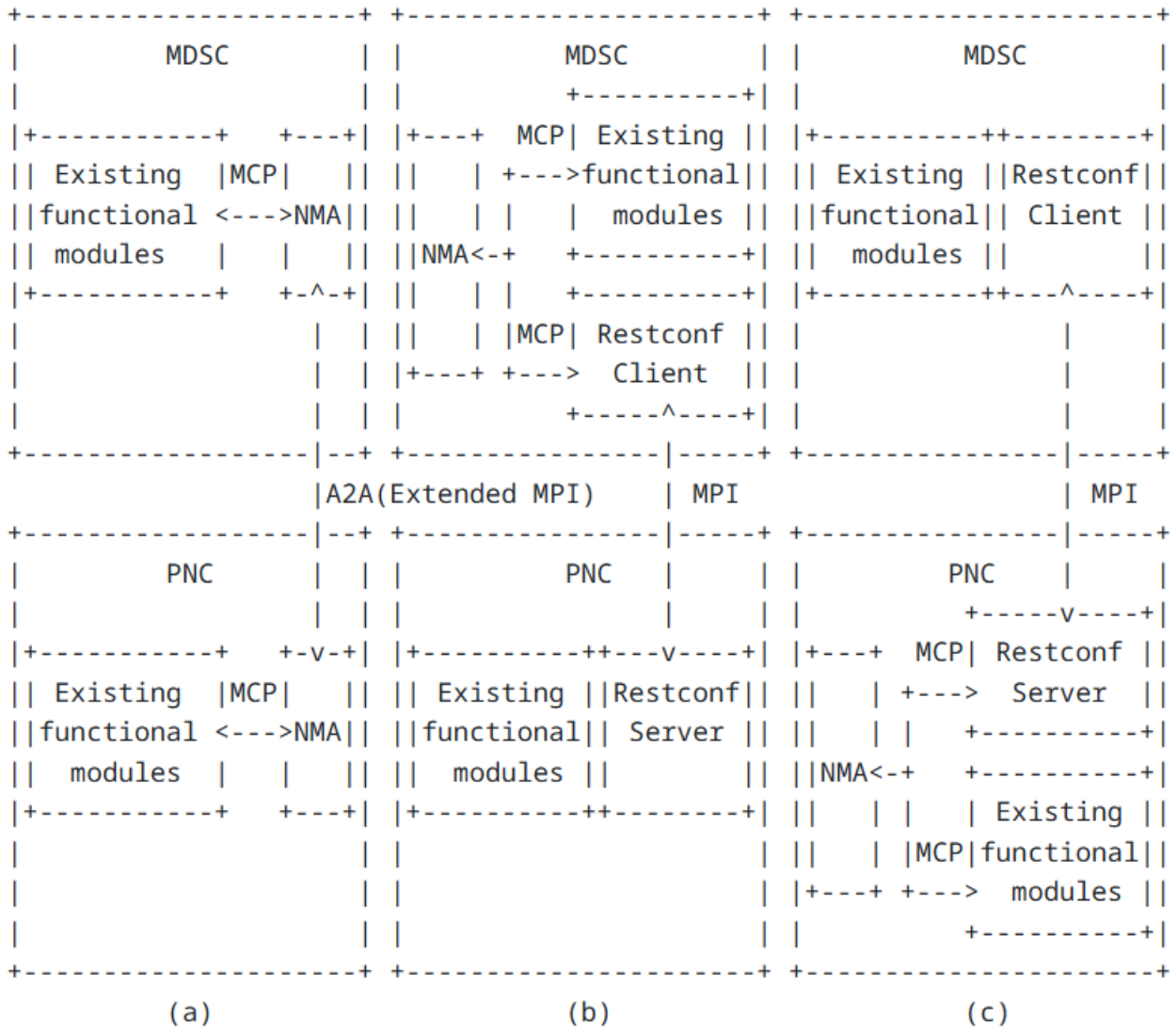


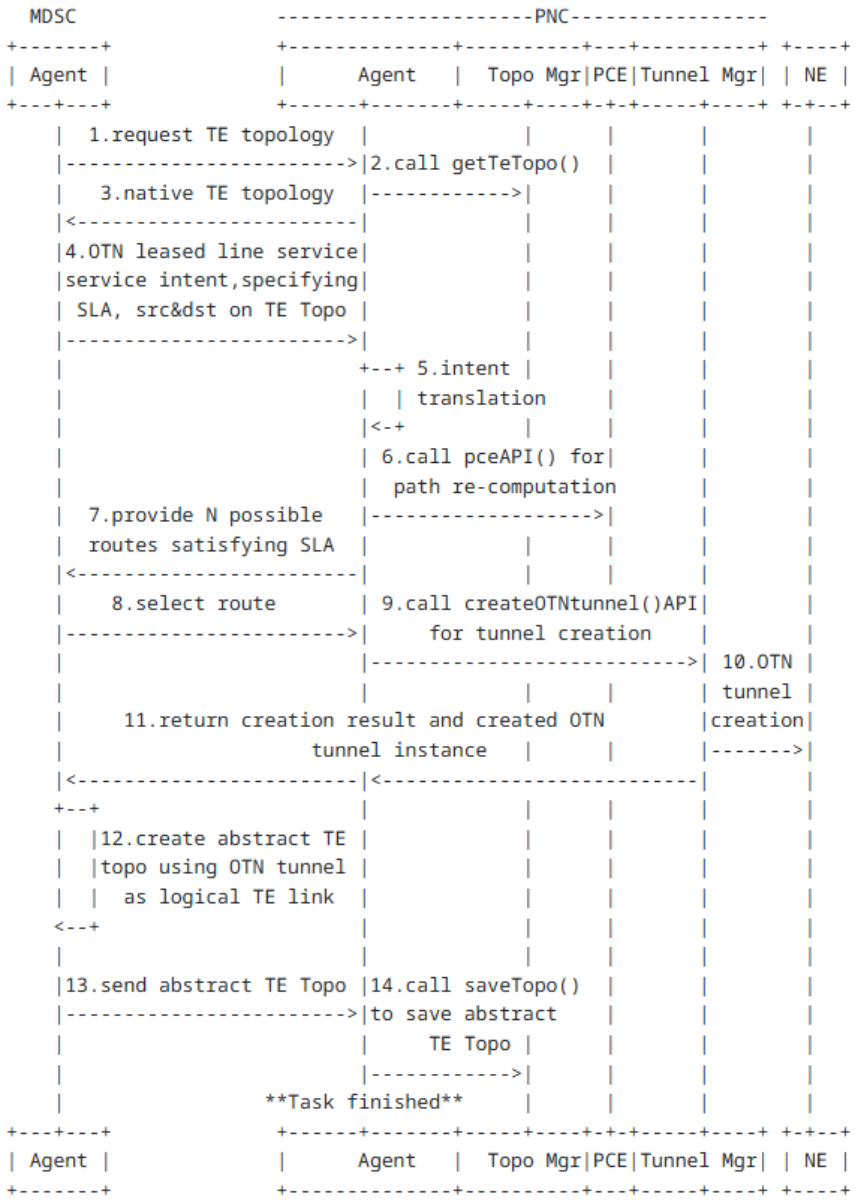
Figure 4: Inter-controller NMA communication scenarios between MDSC and PNC

The inter-controller NMA interaction based on extended ACTN interfaces is **forward compatible**:

- ✓ **NO NMA deployed at certain layer (figure b-c):** the NMA can still interact with the peer controller through the original Restconf mechanism based on extended CMI/MPI, without additional modification.
- ✓ **NMA deployed in both layers (figure a):**
  - ✓ **Conversational interaction between Agents :** A2A comm encapsulated over the extended MPI.
  - ✓ **Besides,** the NMAs can also interact via the original MPI using the Restconf mechanism.

**MCP is for illustration only and NOT mandatory.*

Use cases (1) Service Provisioning (SP)



- ✓ A2A comm supports a **bidirectional, conversational interaction**.
- ✓ The MDSC may convey **high-level, outcome-oriented service intent** to the PNC, and the PNC may respond with status, constraints, alternative proposals, or requests for clarification.
- ✓ The MDSC is **not constrained to invoke only the APIs pre-defined** by the PNC. **The A2A comm provides the flexibility to express service requirements that are not modeled in existing MPI.**

- ✓ **Steps:**
  - The MDSC expresses a high level OTN service creation intent (step 4).
  - The PNC responds with several possible routing options for the MDSC to select (step 7).
  - After a successful creation of the OTN tunnel, the MDSC creates a customized abstract TE topology (Step 12) and provides it to the PNC (Step 13) for subsequent orchestration purposes.

Use cases (2) Service Assurance (SA)

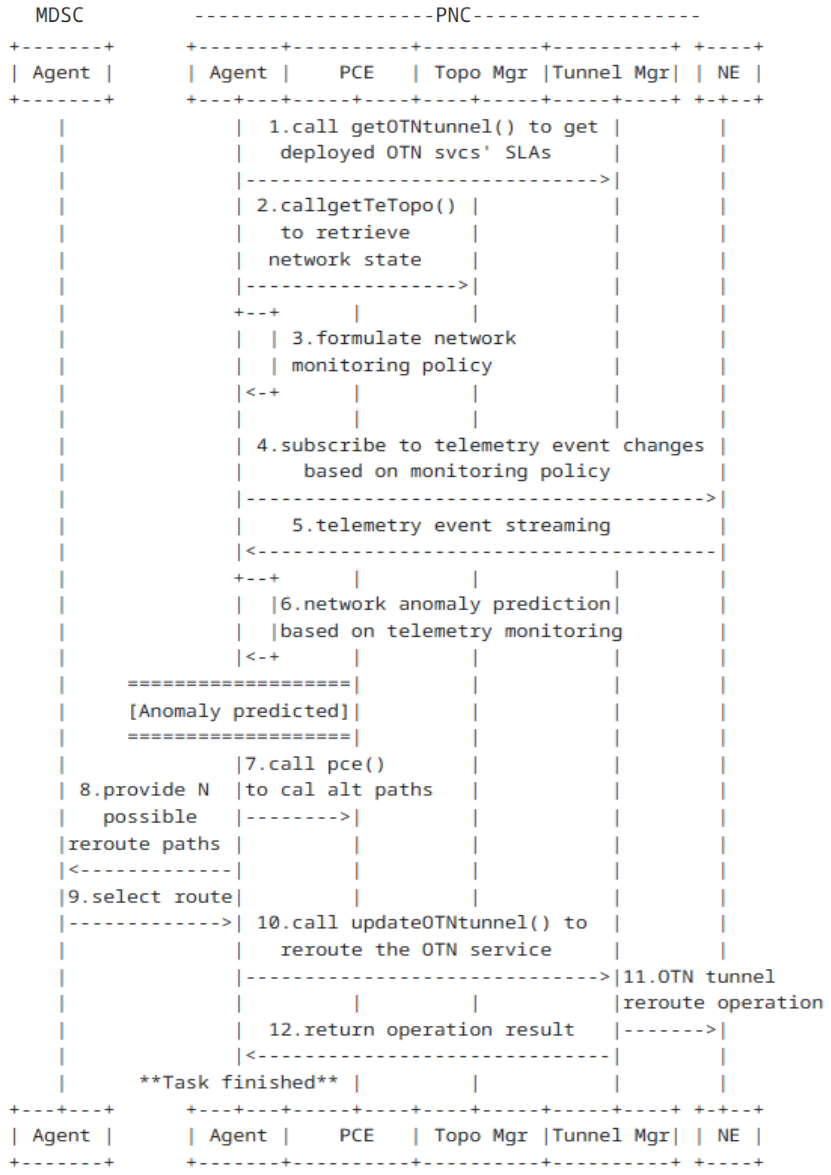


Figure 6: Sequence diagram of Service Assurance Agent use-case on OTN service assurance

A **Service Assurance Agent (SAA)** enables a transition toward **a closed-loop automation model**. The agent continuously monitors the network's observed state and ensures alignment with the user-defined intent state.

Steps:

- ✓ The SAA deployed on the PNC retrieves the OTN service SLA (Step 1) from the PCE and obtains network info (Step 2) from the topology manager.
- ✓ The agent formulates the corresponding network telemetry monitoring policy (Step 3) and subscribes to telemetry event notifications from the NEs (Step 4).
- ✓ The NEs stream real-time telemetry data to the agent (Step 5).
- ✓ SAA analyzes data in real time to detect and predict potential anomalies (Step 6).
- ✓ If an anomaly is predicted which may impact an existing OTN tunnel service, the agent invokes the PCE to calculate candidate alternative paths for service rerouting (Step 7).
- ✓ These candidate paths are provided to its peer agent on the MDSC (Step 8), which determines and selects the optimal rerouting option (Step 9).

Use cases (3) Fault Handling (FH)

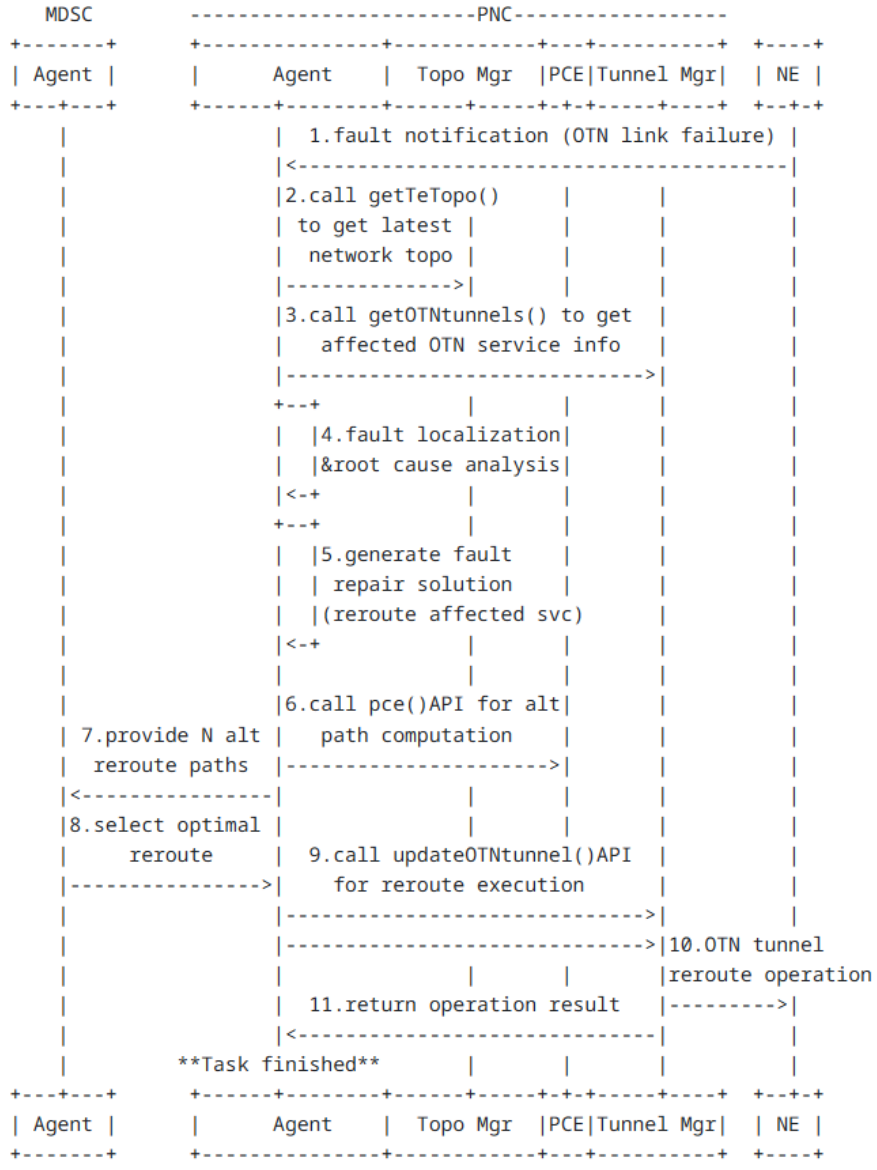


Figure 7: Sequence diagram of Fault Handling Agent use-case on

By integrating a **Fault Handling Agent (FHA)** into the ACTN framework, the FH can transition from manual to a closed-loop, automated model, which enables **proactive fault detection, rapid root cause identification, and automated repair**, minimizing service downtime and enhancing user experience..

Steps:

- ✓ FHA deployed on the PNC first receives a fault notification (Step 1) from NE.
- ✓ The agent then retrieves the latest network topo and service info (Steps 2 and 3) from the topology manager and PCE, respectively.
- ✓ The agent performs fault localization and root cause analysis (Step 4) to identify the exact location and nature of the fault.
- ✓ Based on the analysis, the agent generates a fault repair solution (Step 5).
- ✓ The agent then invokes the PCE to calculate alternative paths (Step 6) and provides these paths to its peer agent on the MDSC (Step 7).
- ✓ The MDSC selects the optimal path (Step 8) and instructs the PNC to execute.

NEXT STEPS

- Improve the content of the draft.
- Staring point for all AI/Agentic work in CCAMP. Looking forward to comments and contributions!

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THANK YOU