Network Digital Twin based Architecture for AI driven Network Operations

draft-wmz-nmrg-agent-ndt-arch-02

IETF NMRG Meeting 11/04/2025

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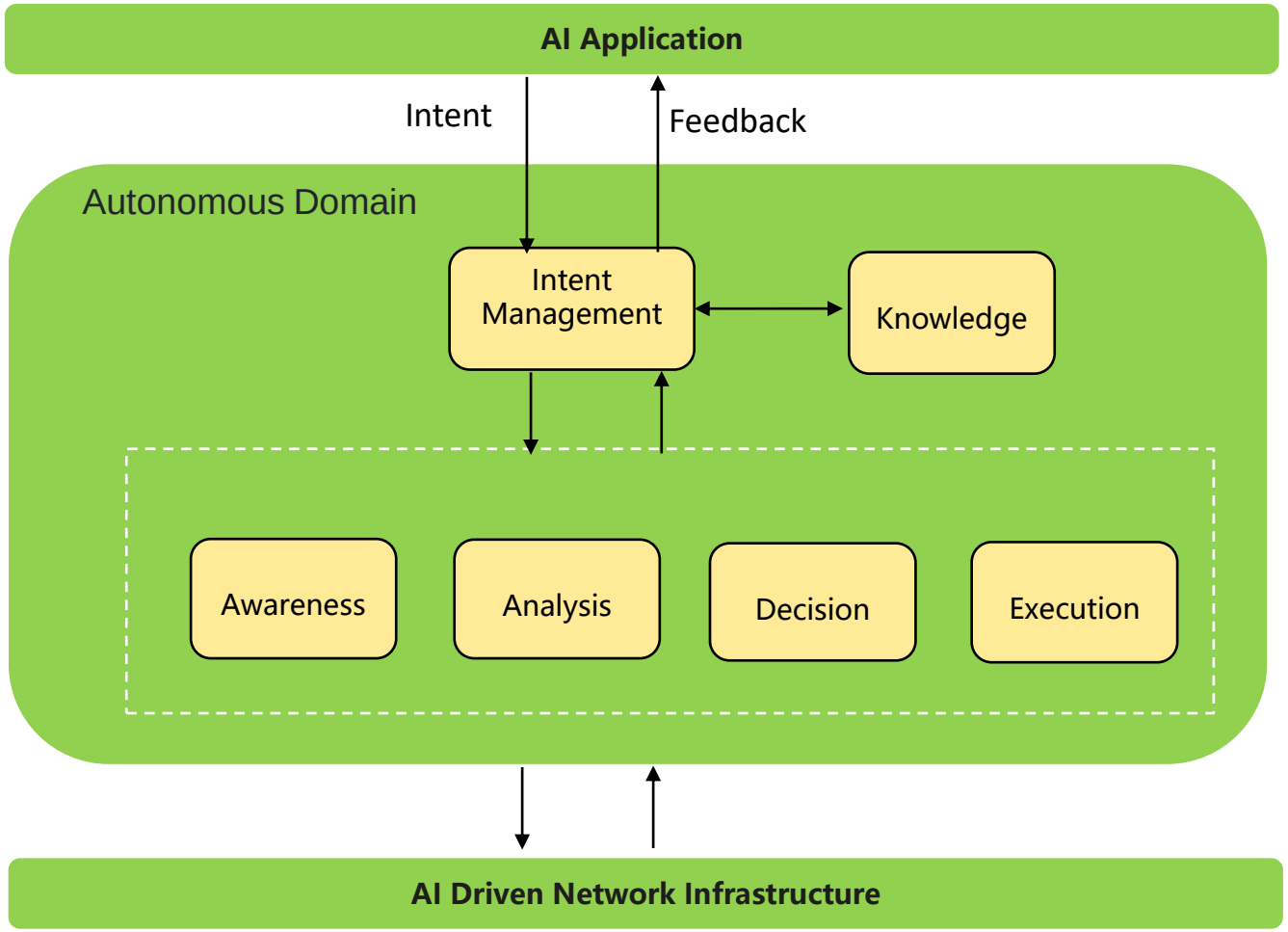
Recap

- This document focuses on exploring how Network Digital Twin can be integrated with AI Agent
  - Drive AI driven network operation
  - Support real intent based networking with GenAI and Agentic AI
- This work was briefly discussed in IETF 123 Madrid NMRG meeting
  - Some open discussions were conducted on Agentic AI/LLM related to NMRG
  - Follow up meeting/Workshop has been proposed
- NMRG Interim meeting (October 8th) on Agentic AI for Network Management
  - Problem statement, Design Consideration, Network management deployment and impact has been explored
  - The problem statement and use cases have been documented in [draft-hong-nmrg-agenticai-ps]
  - Proactive Lifecycle vs Passive Lifecycle was discussed, thanks to Chris for thoughtful inputs

Document Status Update

- The latest update is v-02, changes compared to the previous versions since Madrid meeting:
  - Add Security Consideration Section;
  - Add Acknowledge Section;
  - Clarify the relation between knowledge and tools;
  - Clarify the source of knowledge;
  - Clarify the key characteristics of Network AI Agent for adapting to environmental changes;
  - Additional text on collaboration between small AI model and large AI model.

Characteristics of AI driven network operation

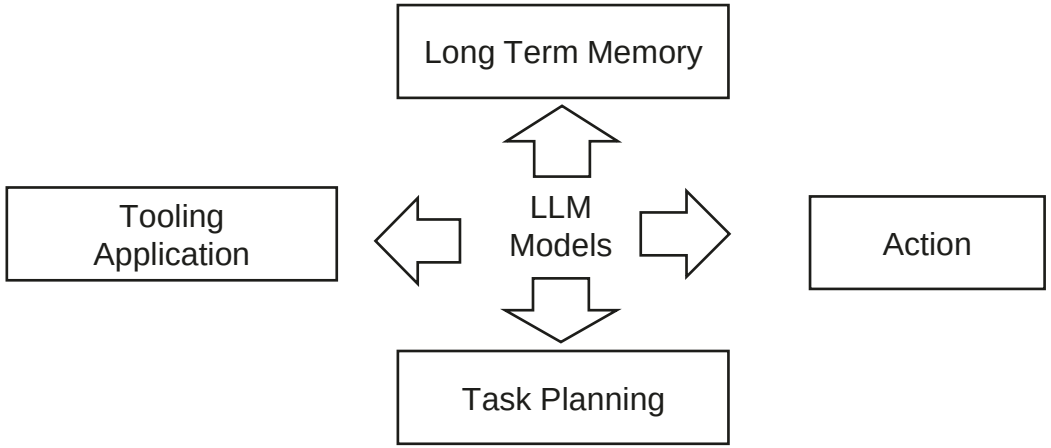


6 key Elements

- **Intent** (RFC9315)
  - Intent definition
  - Intent fulfillment
    - Intent ingestion with GenAI
    - Intent translation
    - Intent orchestration
- **Knowledge**
  - Expert experience
  - Extra-system experience related LLM
  - Manually or semi-manually entered knowledge
- **Awareness**
  - **Learning**
  - **Perception**
    - take input from both network and user
- **Analysis/Decision**
  - **LLMs**
  - **Reasoning :** Decide want to do
- **Execution**
  - **Act:** Respond, tools invocation, policy

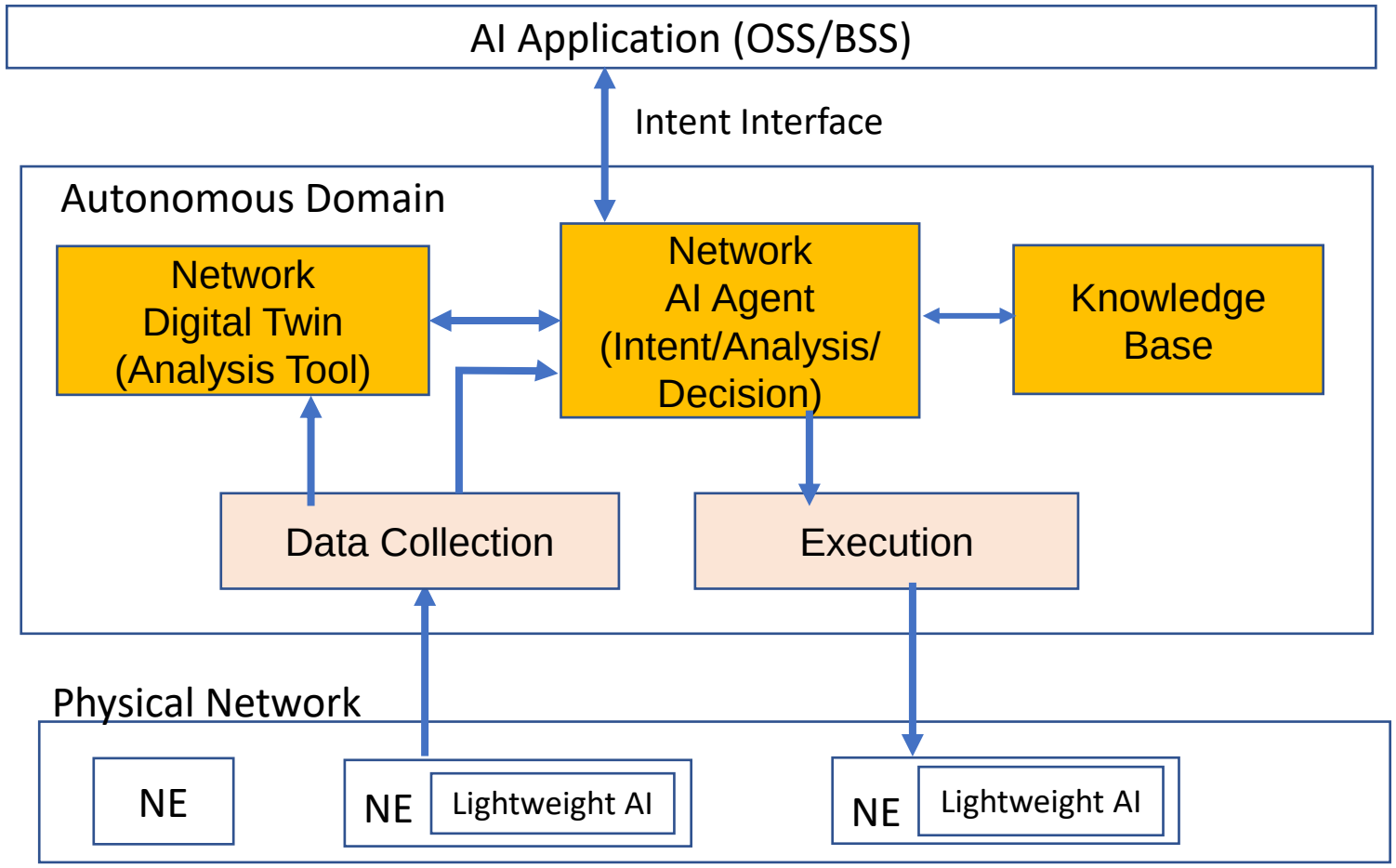
What is AI Agent?

AI Agent: Autonomous understanding, long-term memory, planning and decision-making, and perform complex tasks.



AI Agent=LLM X (Plan+ Memorize + Tooling+ Action)

Architecture for AI Driven Network Operation



Application:

- Other Agent
- Human
- Other management component

Network Digital Twin:

- Analysis
- Emulation

Network AI Agent:

- Intent Recognition
- Intent Classification and Analysis
- **Perception**
- **Action**
- **Task Planning**
- Memory (Procedure, Episodic, Semantic, etc)

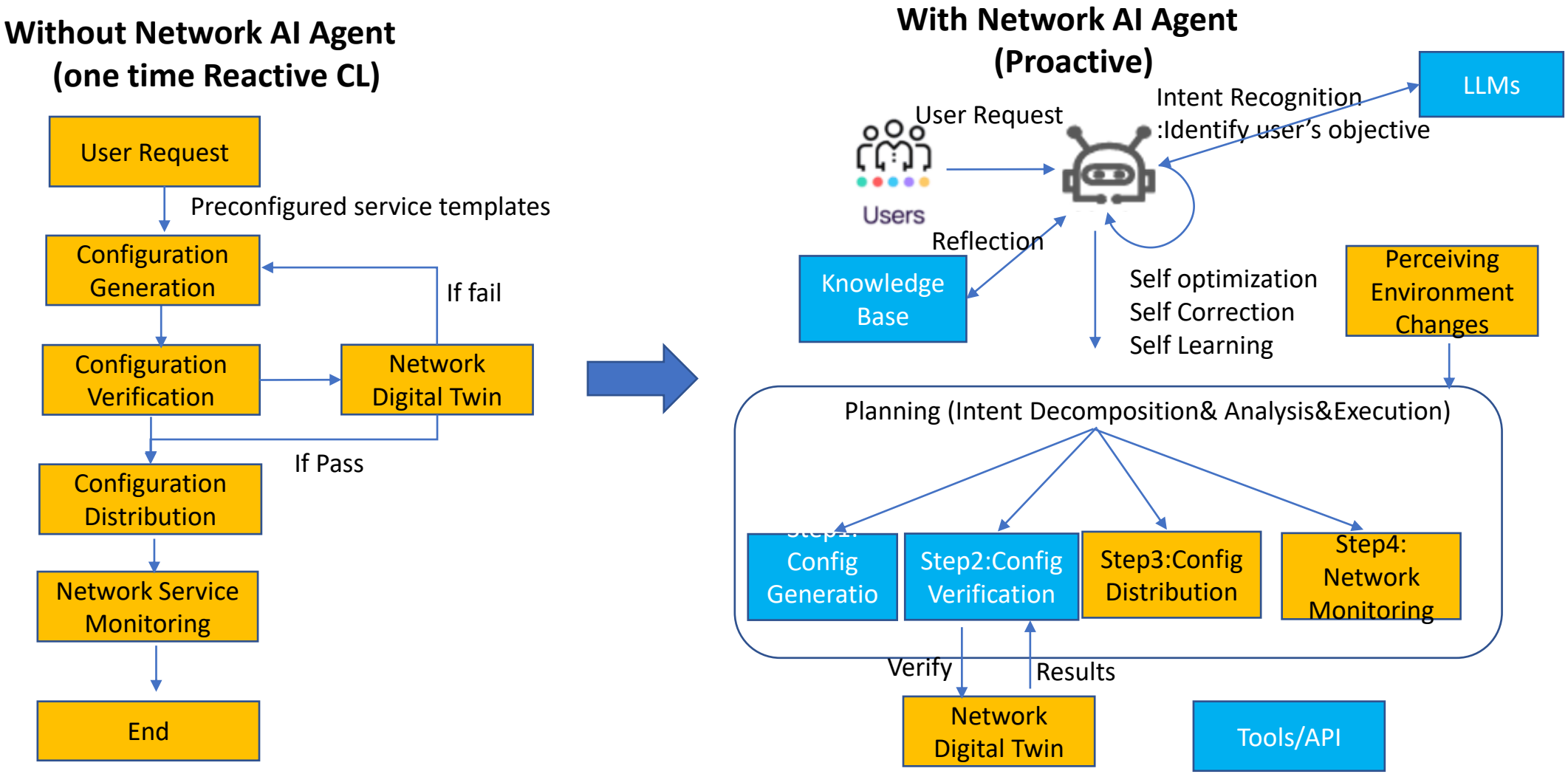
Knowledge base:

- Expand knowledge through learning
- Provide experience for decision making

Physical Network:

- **Data Collection->Perception**
- **Action->Execution**

Reactive Closed Loop vs. Proactive Closed Loop



Next Steps

- Continue to explore
  - Use cases of multi-Agent Collaboration on network management tasks
  - Interaction logic between AI Agents, the Knowledge Base, and tools
  - Agent Security
- Your comments and suggestions are welcome!