Network Digital Twin based Architecture for AI driven Network Operations

draft-wmz-nmrg-agent-ndt-arch-00

IETF NMRG Meeting 07/25/2025

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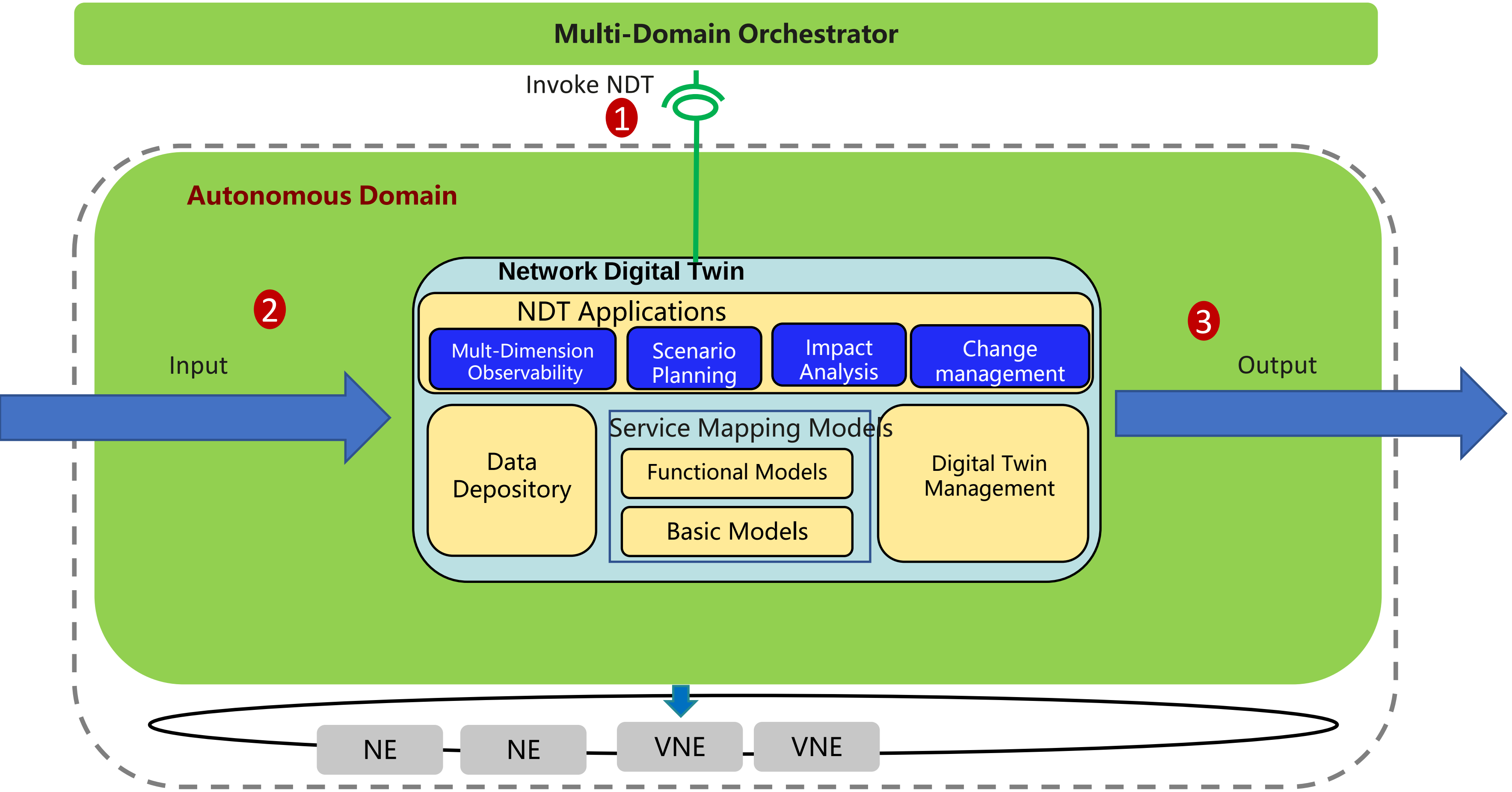
NDT: Data Driven Network Management



3 Key components for
Network Emulation Platform:

- Data Repository
- Service Mapping Models
- Digital Twin Management

Provide Data Driven tools for
A set of scenarios such as:

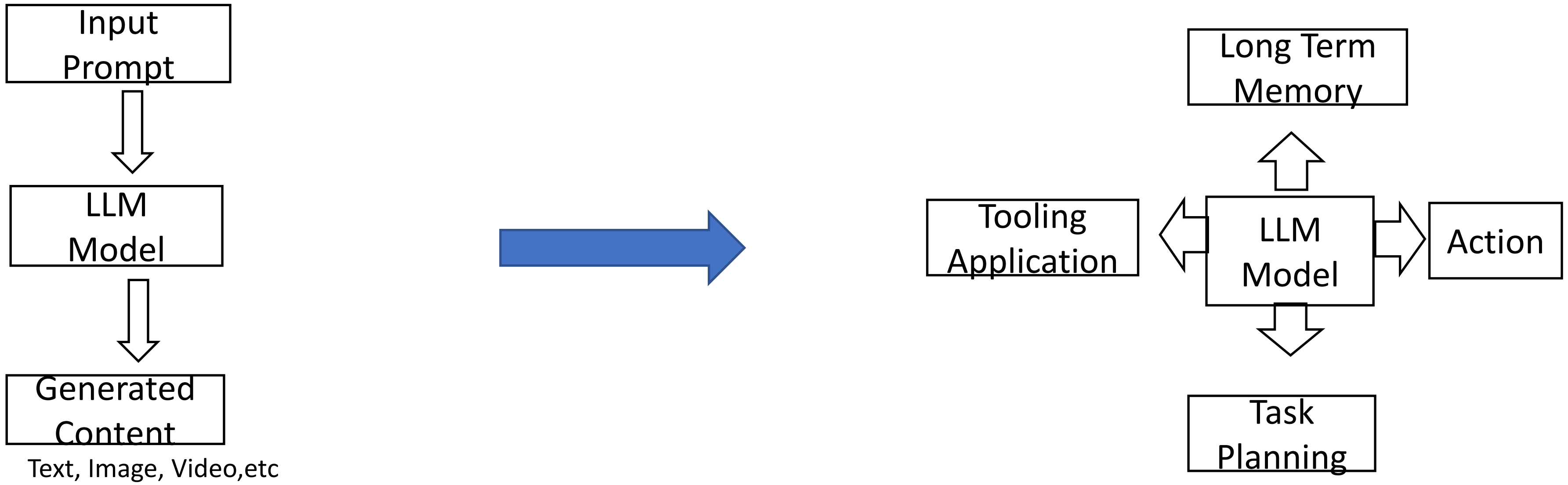
- Scenario Planning
- Impact Analysis
- Change Management

Source: **Network Digital Twin: Concepts and Reference Architecture**
draft-irtf-nmrg-network-digital-twin-arch

AI Agent： Moving from GenAI to Agentic AI

Content Generation
(text, code, images, etc.)

Goal-oriented action
& decision-making



Generative AI:
Reacts to prompt,
Ideal for content generation

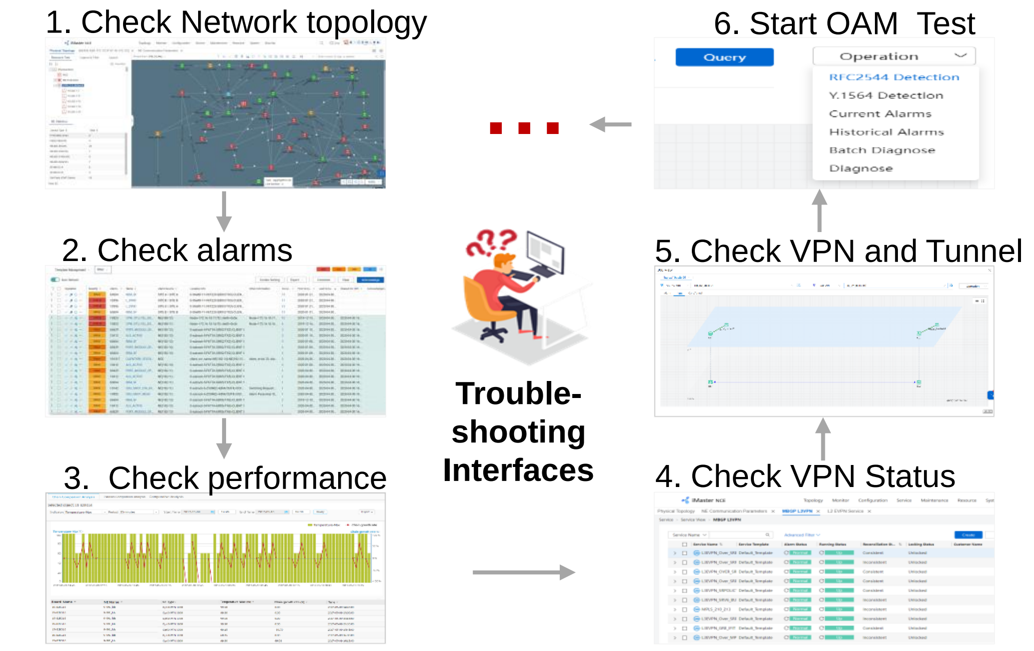
Agentic AI:
Initiate tasks autonomously
Suitable for proactive application

Motivation and Goal

- Motivation:
  - The rapid expansion of network scale and ever-changing service requirements necessitate of continuous network reconfiguration;
  - Network operators are increasingly cautious about making network changes, given that they need to
    - Review the solution design, evaluate all change impacts, before making any change.
    - Monitor traffic, and manually check table entries after making any change.
  - Human in the Loop: Usually NOC team and FME engineers need to participate in the O&M process.
- Goal:
  - Explore how Network Digital Twin can be integrated with AI Agent to drive **real** AI driven network operation and provide the following capabilities:
    - Network Health and Risk Check
    - Network Optimization Assurance
    - Network Capacity Planning
    - Disaster Recovery Drill
    - …

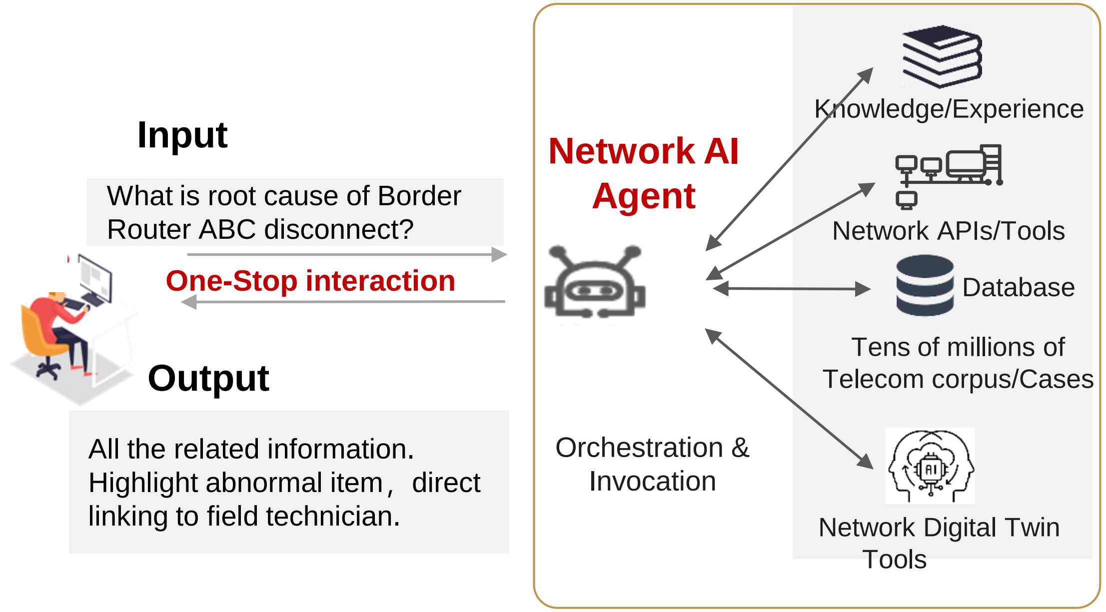
Use Case A: Intent based Fault Management

As-Is: Functions & Experience based Maintenance



1. Fault troubleshooting task: 6~10 separated GUIs.
2. Engineer training: 6-12 months

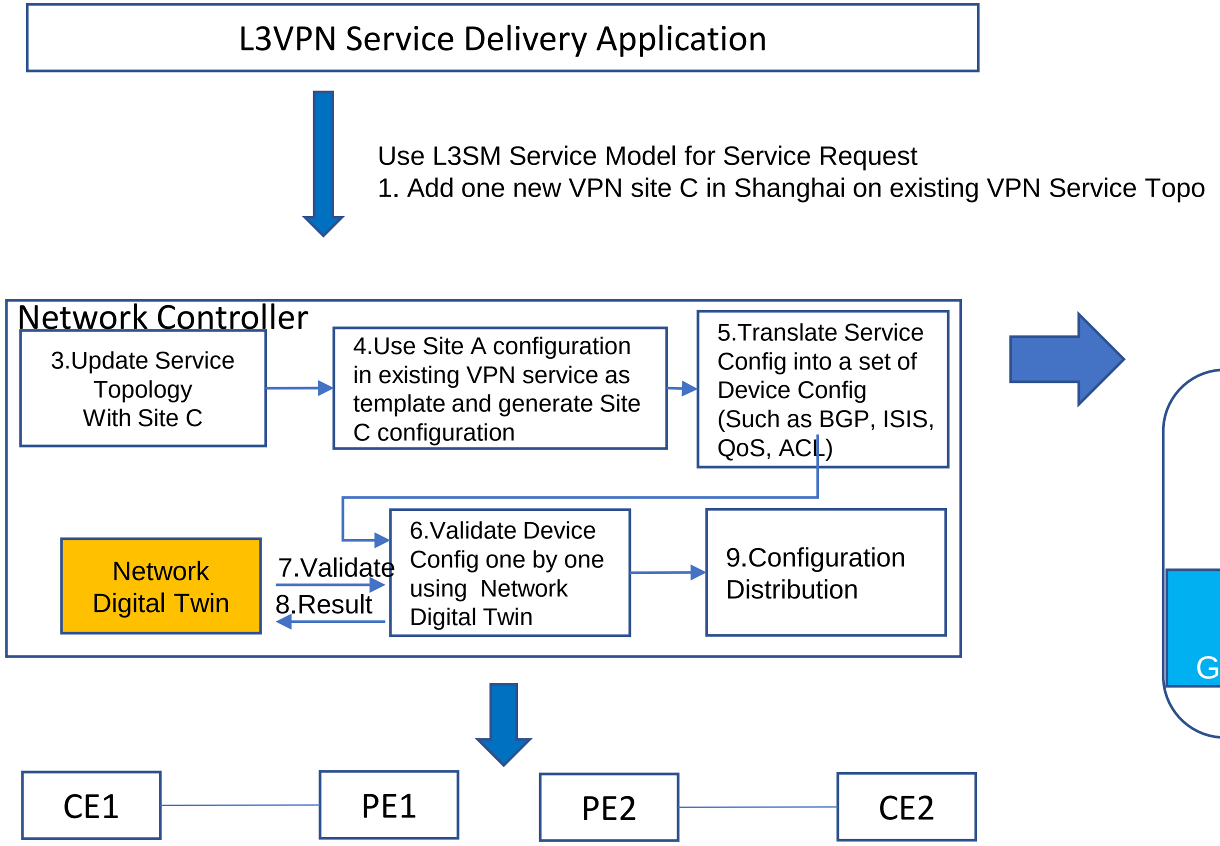
To-Be: Intent based Maintenance



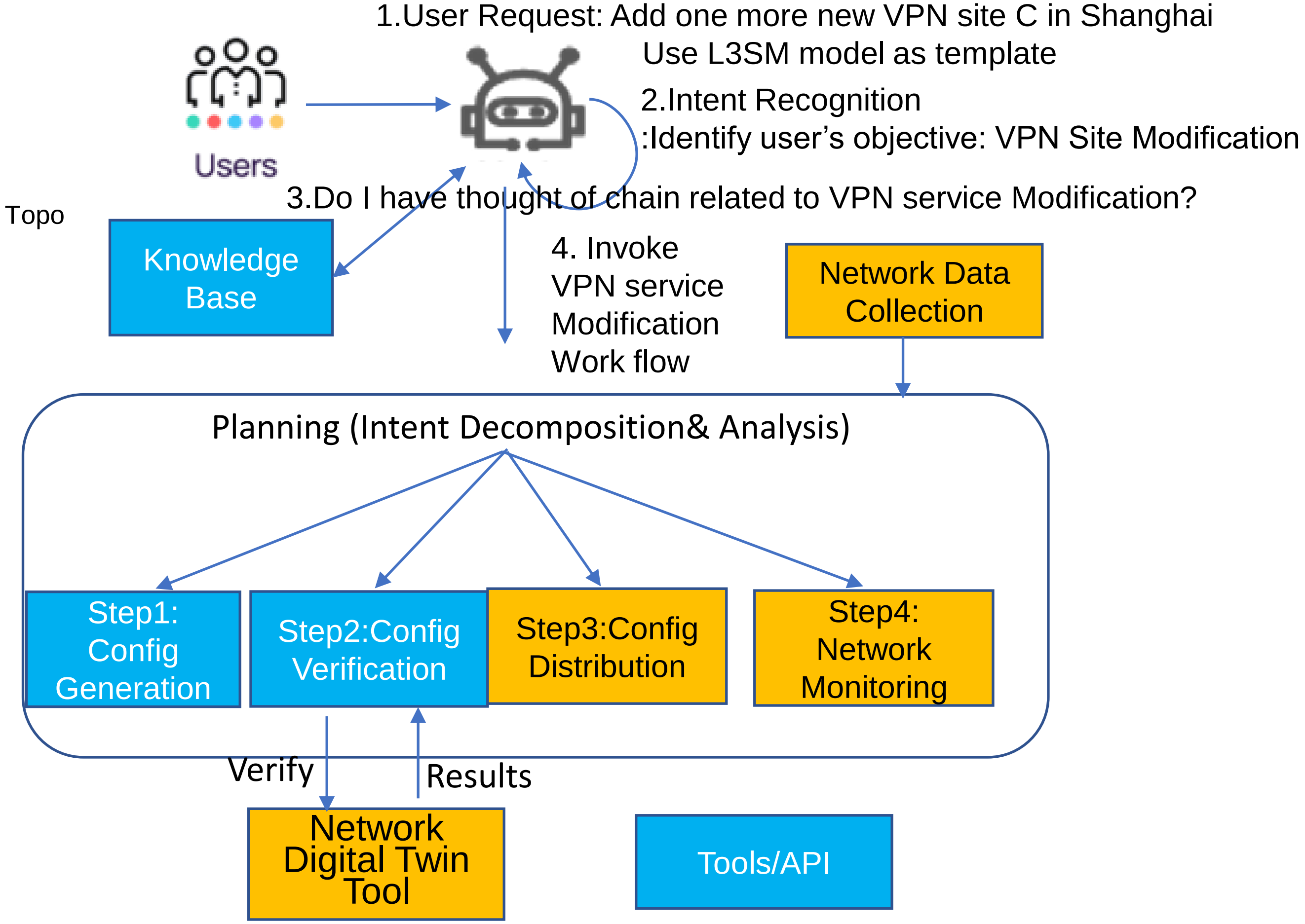
1. Enter user intent **requirement**, system automatically output all related the data and highlight abnormal item.
2. Experts' experience embedded in Vendor specific Knowledge Base.

Use Case B: Intent Based Change Management

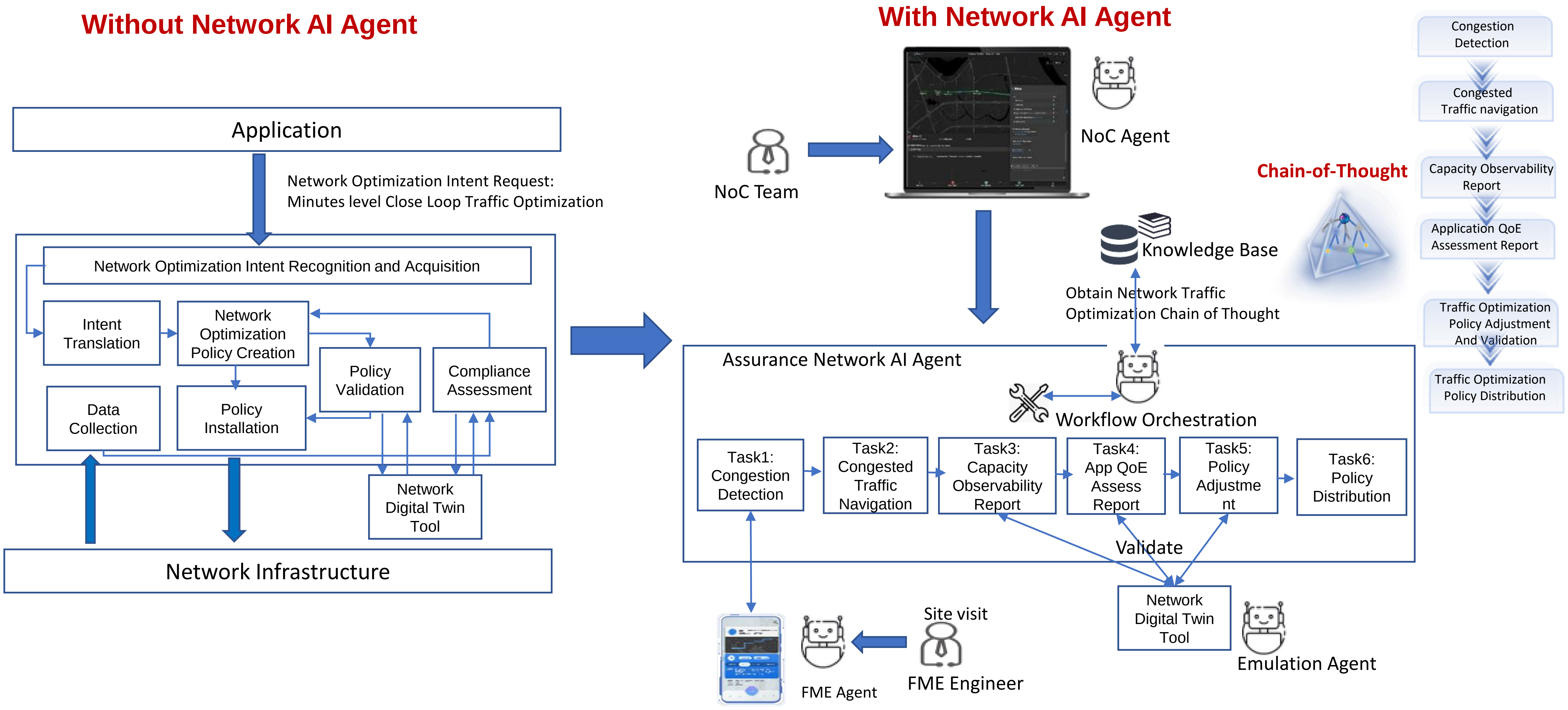
Without Network AI Agent



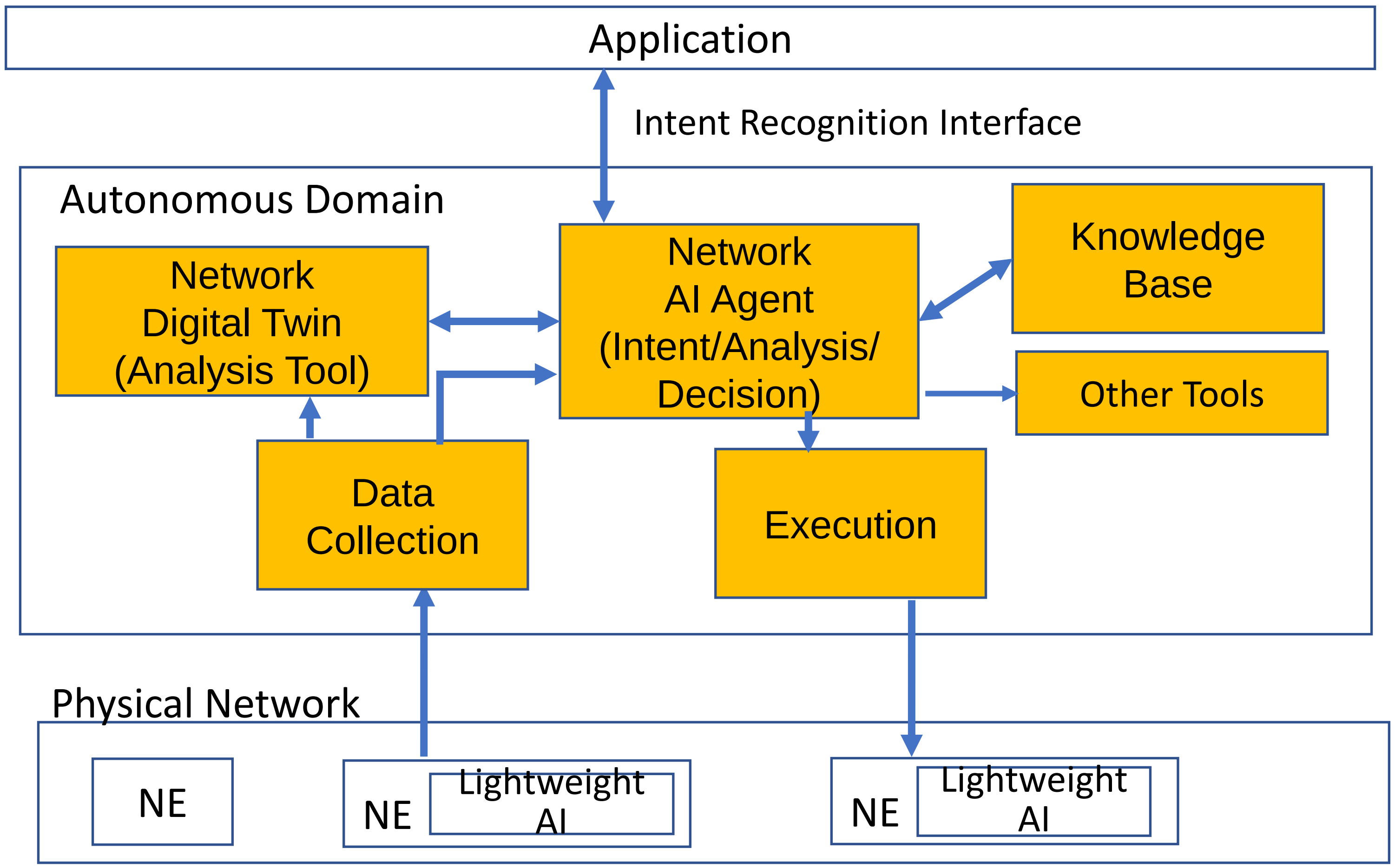
With Network AI Agent



Use Case C: Intent based Network Assurance



Architecture for AI Driven Network Operation



Application:

- Other Agent
- Human
- Other management component

Network AI Agent:

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

Network Digital Twin:

- Tools for emulation and analysis

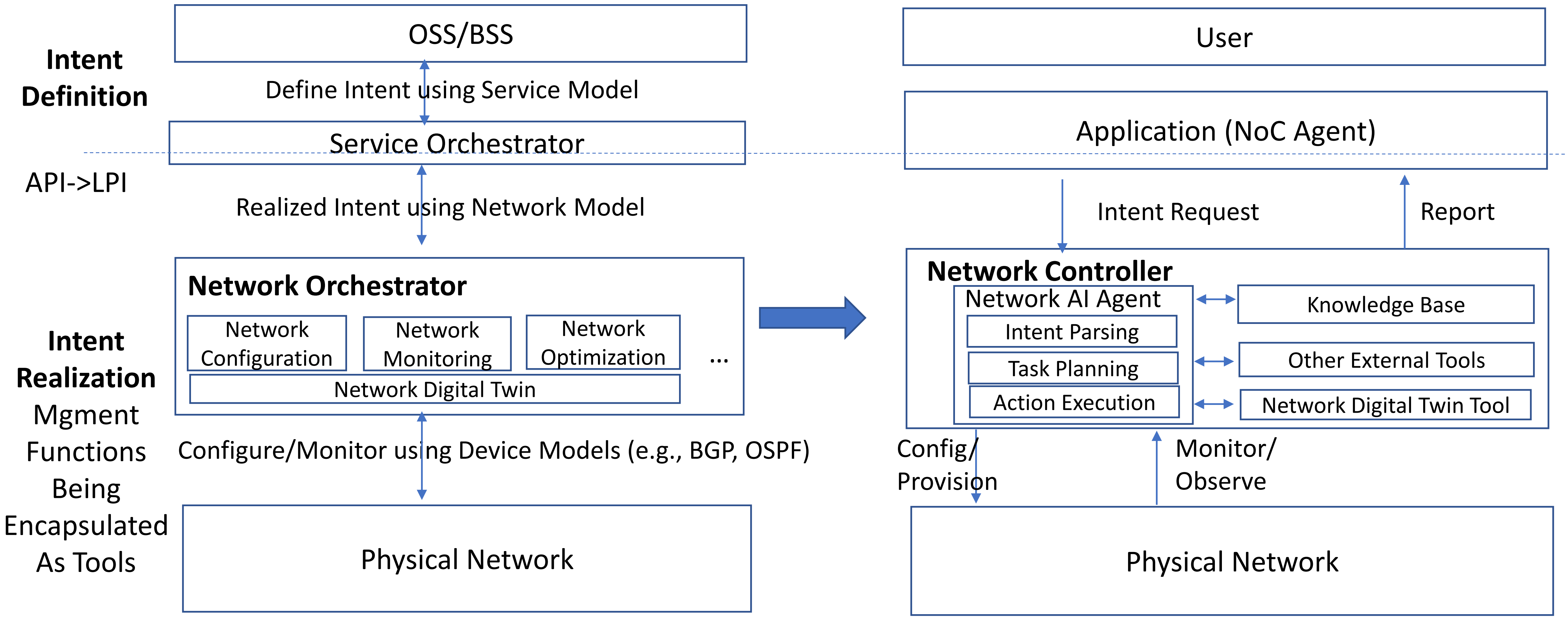
Interact with Physical Network:

- Data Collection->Perception
- Action->Execution

Interact with Knowledge base:

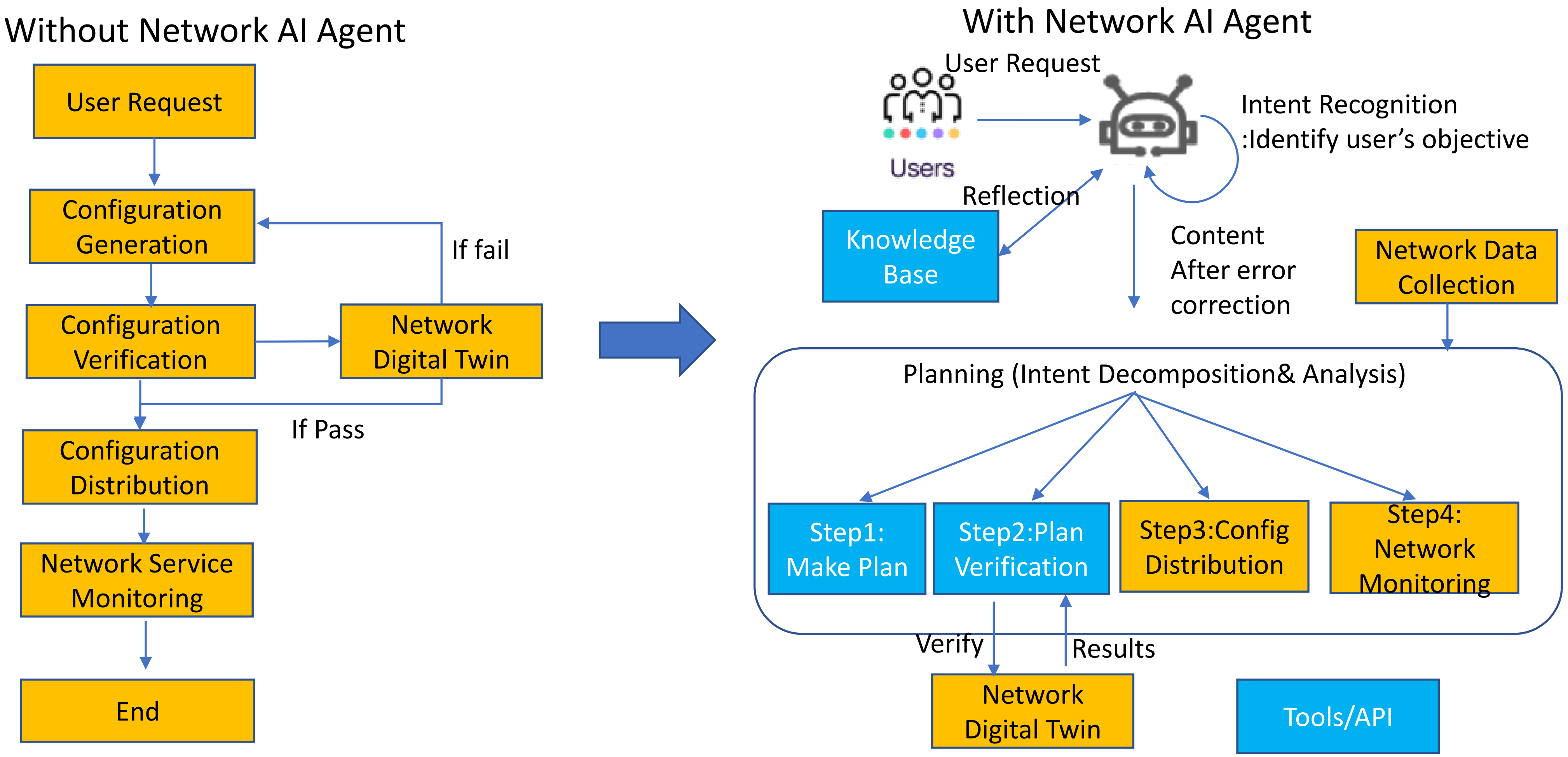
- Expand knowledge through learning
- Provide experience for decision making

Architecture Evolution

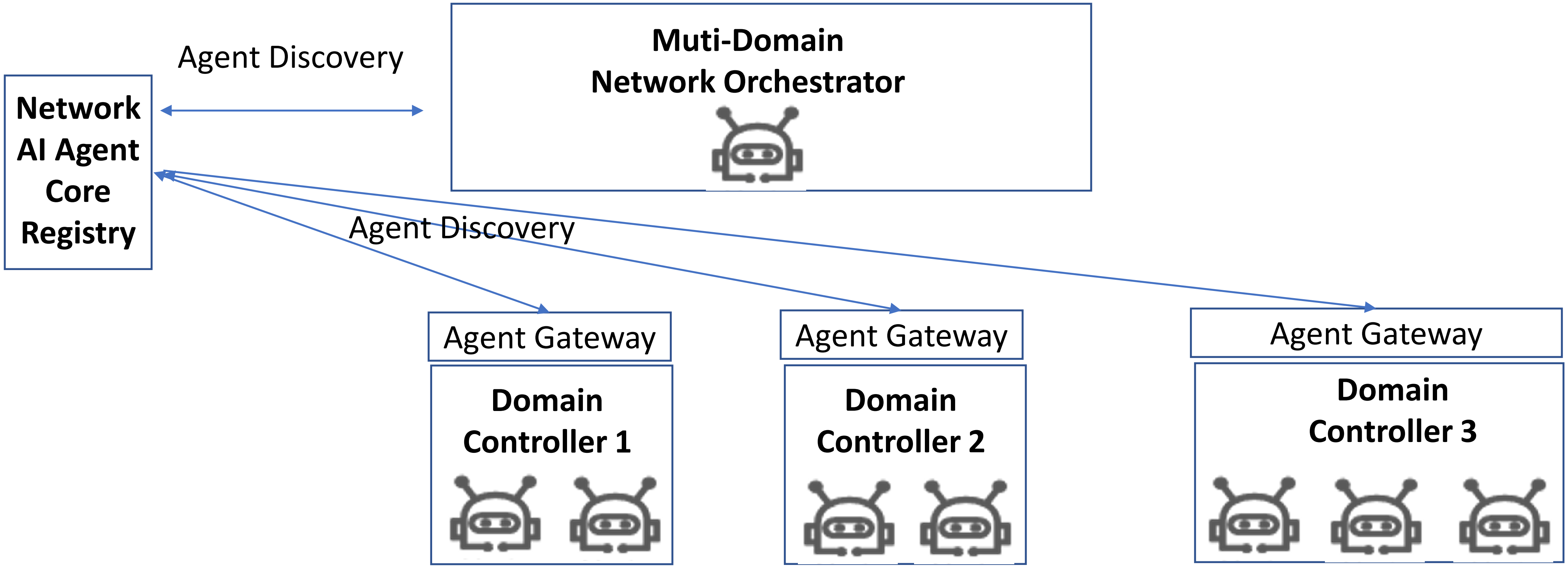


Source: A Framework for Automating Service and Network Management with YANG RFC8969

Interaction Workflow Evolution



What about Multi Network Management AI Agent Interaction?



Key Challenges to integrate Network AI Agent and Network Digital Twin

- **Explainability**
  - Difficult to troubleshoot or build trust without understanding the reasoning behind an agentic AI's decisions
- **Ethical Consideration**
  - Biased training data lead to discriminatory outcomes
  - The nature of AI-powered autonomous agents raises moral questions about responsibility, accountability, and the potential for misuse.
- **Data privacy and security**
  - Handle large amounts of sensitive data
- **Integration complexity**
  - Integrating into existing infrastructure and workflows can be challenging and time-consuming.
- **Security**
  - identify and mitigate potential risks associated with AI systems, including system failures, data breaches

Next Step

- Your comments and suggestions are welcome!
- Continue to explore multi-Network Management Agent Collaboration and impact of Agent to Agent Communication on Network management
  - Single-agent systems face constraints related to memory and processing power.
  - Scalability Consideration